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Aids to Navigation Service Force Mix 2000 Project

Volume I

Development and Application of an Aids to Navigation Service Force Mix Decision Support System

Final Report

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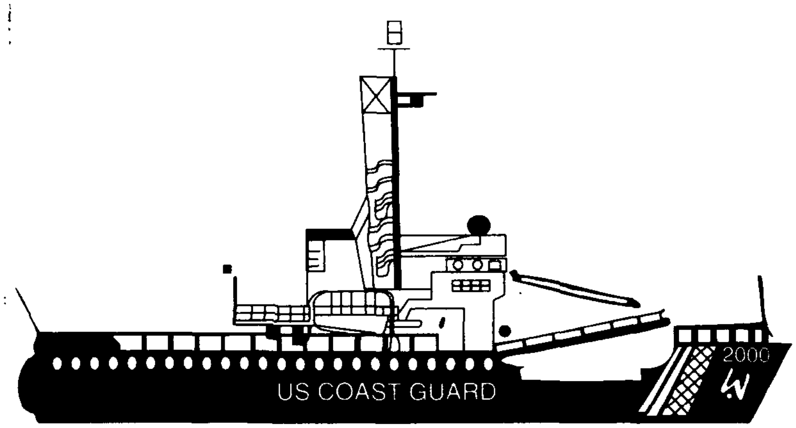

Research and
Special Programs
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Cambridge, MA 02142-1093

June 1992

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United States
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Office of Navigation Safety and Waterway Services
Washington, DC 20593

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**DEVELOPMENT AND APPLICATION OF AN
AIDS TO NAVIGATION
SERVICE FORCE MIX
DECISION SUPPORT SYSTEM**

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13. ABSTRACT (Maximum 200 words)

The Aids to Navigation (ATON) Service Force Mix (SFM) 2000 Project is documented in a Project Overview and three separately bound volumes.

The Project Overview describes the purpose, approach, analysis, and results of the ATON SFM 2000 Project conducted by the USCG's Office of Navigation Safety and Waterway Services, Short Range Aids to Navigation Division.

Volume I, "Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Final Report", documents the Volpe Center's analysis and development of the proposed replacement buoy tender fleet. The document describes current ATON operations, the concept, development, and operation of the Decision Support System (DSS), the data utilized by the DSS, validation of the DSS, and the proposed service force mix.

Volume II, "Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Aid Assignments and Vessel Summary Reports", contains the DSS outputs associated with the findings of Volume I. Included are maps of the aid assignments for each vessel in both the current and proposed fleets and the associated one-page DSS summary printouts.

Volume III, "Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet", documents the USCG's analysis and development of baseline multi-mission requirements of the replacement buoy tender fleet. The document describes buoy tender employment categories, historical tender employment data, the determination of underway hours per underway day, and projected impacts on multi-mission requirements resulting from alternative replacement fleet scenarios.

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ANB	aids to navigation boat
ANT	aids to navigation team
AOPS	abstract of operations
ATON	aids to navigation
ATONIS	aids to navigation information system
BRIDGE	bridge administration
BU	buoy boat
BUSL	buoy boat - stern loading
BUSLR	buoy boat - stern loading replacement vessel
CADET/OC	cadet and officer candidate training
CAPT	Captain
CDR	Commander
CO	commanding officer
COOP	cooperation with other agencies
COTP	Captain of the Port
DBN	day beacon
DGPS	differential global positioning system
DOM ICE	domestic icebreaking
DOT	Department of Transportation
DSS	decision support system
ELT	enforcement of laws and treaties
FY	fiscal year
G-CPA	USCG Programs Division
G-E	USCG Office of Engineering & Development
G-M	USCG Office of Marine Safety, Security, & Environmental Protection
G-N	USCG Office of Navigation Safety & Waterway Services
G-NSR	USCG Short Range Aids to Navigation Division
G-O	USCG Office of Law Enforcement & Defense Operations
G-P	USCG Office of Personnel & Training
G-R	USCG Office of Readiness & Reserve
GIS	geographical information system
I/O	in-port operations
KDP	key decision point
LB	lighted buoy
LCDR	Lieutenant Commander
LT	fixed light
MER	marine environmental response
MIL OPS	military operations
MIL TRA	military training
MIO	marine inspection operations
MISC	miscellaneous and other operations

MNS	mission needs statement
MTMC	Military Traffic Management Command
MSA	marine science activities
MSO	Marine Safety Office
NOAA	National Oceanic and Atmospheric Administration
O&M	operating and maintenance
OP TRA	operational training
PC	personal computer
PIA	public and international affairs
PSS	port safety and security
RADNAV	radionavigation
RBS	recreational boating safety
RESERVE	reserve training
RHIB	rigid hull inflatable boat
RSPA	Research and Special Programs Administration
SAR	search and rescue
SFM	service force mix
SRA	short range aids
SRD	sponsor's requirements document
TANB	trailerable aids to navigation boat
ULB	unlighted buoy
USCG	United States Coast Guard
USCGC	United States Coast Guard cutter
VNTSC	Volpe National Transportation Systems Center
WLB	seagoing buoy tender
WLBR	seagoing buoy tender replacement vessel
WLI	inland buoy tender
WLIC	inland construction buoy tender
WLM	coastal buoy tender
WLMR	coastal buoy tender replacement vessel
WLR	river buoy tender

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The Aids to Navigation Service Force Mix Decision Support System was developed and applied by the Research and Special Programs Administration's John A. Volpe National Transportation Systems Center, Office of Research and Analysis, Service Assessment Division for the United States Coast Guard, Office of Navigation Safety and Waterway Services, Short Range Aids To Navigation Division. The work was performed under Project Plan Agreement CG-69.

Invaluable contributions to this project were made by several Coast Guard officers under the overall direction of CAPT Leo Black, the Coast Guard project sponsor. Coast Guard project management was provided by CDR Dennis Ihnat, whose professionalism and dedication were instrumental to the project's success. CDR David Loerzel provided invaluable insight, direction, and support. Numerous representatives from the Coast Guard district offices provided the key data inputs that formed the foundation of the Decision Support System.

The Volpe Center is indebted to LCDR Al Stiles, Commanding Officer of the USCGC Spar, for his insight on buoy tender operations and past ATON modeling efforts. Although the cold winter day spent on the Spar off the coast of Maine may not be remembered with great affection, the Volpe Center project personnel gratefully acknowledge LCDR Stiles' patience, interest, and generosity in support of this project.

The expertise provided by Mr. Jonathan Brandon of Caliper Corporation in the areas of software development and vehicle routing algorithms was an essential ingredient in the development of the Decision Support System.

Finally, the insight provided by Dr. George Skaliotis of the Volpe Center in the areas of past ATON modeling efforts and Coast Guard operations are gratefully acknowledged.

EXECUTIVE SUMMARY

This report documents analyses undertaken to assist the United States Coast Guard (USCG) in estimating the optimum number of next-generation seagoing buoy tenders, coastal buoy tenders and buoy boats required to accomplish the work being performed by the current fleet of seagoing and coastal buoy tenders.

Background

One mission of the USCG is to provide and service short range aids to navigation (ATON). ATON are used by mariners to navigate U.S. waterways in and around the continental U.S., Alaska, Hawaii, and U.S. territories, such as those in the Caribbean and the western Pacific. To service ATON, the USCG utilizes a variety of ATON resources ranging from four-person Aids to Navigation Teams to 55-person 180-foot seagoing buoy tender vessels.

Of particular concern are 32 of the 37 buoy tenders in the two largest classes -- the seagoing buoy tenders, known as WLBs, and the coastal buoy tenders, known as WLMs. Built in the 1940s, these vessels are beyond their design service lives and the remaining five tenders will begin reaching the end of their design service lives in 1995. In addition, the smaller buoy boats (BUs) and stern loading buoy boats (BUSLs) used by the USCG to service ATON are of a similar vintage, and require replacement by a new-generation buoy boat. Procurements are underway for the design of the replacement WLBs (WLBRs) and replacement WLMs (WLMRs), with anticipated initial deliveries of these vessels in 1996. The preliminary design of the replacement buoy boat (BUSLR) is complete and delivery of the first new vessel is expected in 1993.

To develop estimates of the required number and mix of the new generation of seagoing and coastal buoy tenders for Key Decision Point Four (KDP-4) of the acquisition process, and prior to that for the March 1992 Congressional budget hearings, the USCG Office of Navigation Safety and Waterway Services, Short Range Aids to Navigation Division (G-NSR) undertook the "Aids to Navigation Service Force Mix 2000" (ATON SFM 2000) project. The Research and Special Programs Administration's Volpe National Transportation Systems Center (Volpe Center) was asked to assist.

The major objective of the study described in this report was to develop and apply a decision support system (DSS) that would help the USCG estimate the optimum fleet size and mix of WLBRs and WLMRs from several perspectives: performance of the USCG ATON mission; total life cycle cost; and vessel availability for non-ATON activities.

Because of the project schedule requirements and the complexity of ATON servicing and waterways management, the analysis was limited to ATON currently serviced by WLBs and WLMs. The analysis did, however, address the possibility of reassigning some of these ATON to the smaller, less-expensive BUSLRs. In these instances, an increase in the number of needed BUSLRs was estimated.

Based on USCG studies, the ATON system and servicing requirements are not expected to experience significant change during the life of the replacement fleet.

Current Operations

Federally owned ATON located throughout the U.S. waterway system fall into four categories: lighted buoys, unlighted buoys, lights, and day beacons. Buoy tenders perform four basic ATON services: inspection, recharge, mooring inspection, and relief. An inspection is generally done once a year, and consists of painting, cleaning, material and lamp replacement, position and voltage checks, and solar panel cleaning. A recharge occurs once every five years and involves the replacement of the batteries of a lighted aid (lighted buoys and lights). A mooring inspection occurs once every two years, and consists of the examination and, if necessary, the replacement, cleaning, and/or repair of the underwater buoy moorings. A relief occurs once every six years, and involves the replacement of a buoy. In addition to these regularly scheduled visits, ATON must also be visited when they become discrepant due to random events such as hurricanes, icy conditions, or collisions with commercial vessels, all of which can knock out a light, or drag an aid off station.

Currently, there are 26 WLBs servicing approximately 4,450 ATON. The WLBs are large, stable, heavy-lift vessels, and typically service the largest buoys in the U.S. waterway system located in the roughest waters farthest from shore. The WLB devotes about 59% of its underway hours to servicing ATON and is considered a multi-mission vessel due to its endurance and offshore seakeeping capabilities. WLB multi-mission operations currently account for 27% of the fleetwide WLB underway time, and consist of a variety of activities including enforcement of laws and treaties, deploying large offshore data buoys for the National Data Buoy Center, ice breaking, and marine environmental response.

The replacement WLB, the WLBR, will have improved and more efficient buoy tending capabilities, a smaller crew, and increased speed. The WLBRs also will be equipped with on-board oil recovery devices.

The WLM class of coastal buoy tenders consists of eleven vessels servicing about 3,050 ATON. Since the WLM cannot withstand as severe an environment as the WLB, the aids it services are generally smaller than those serviced by a WLB, and it typically does not travel far offshore. The WLM is a focused mission vessel devoting about 82% of its underway hours to servicing ATON. The replacement WLMs, the WLMRs, will be more efficient buoy tenders and will require smaller operating crews.

Figure E-1 shows the current WLB/WLM fleet distribution and home ports.

Analytical Approach

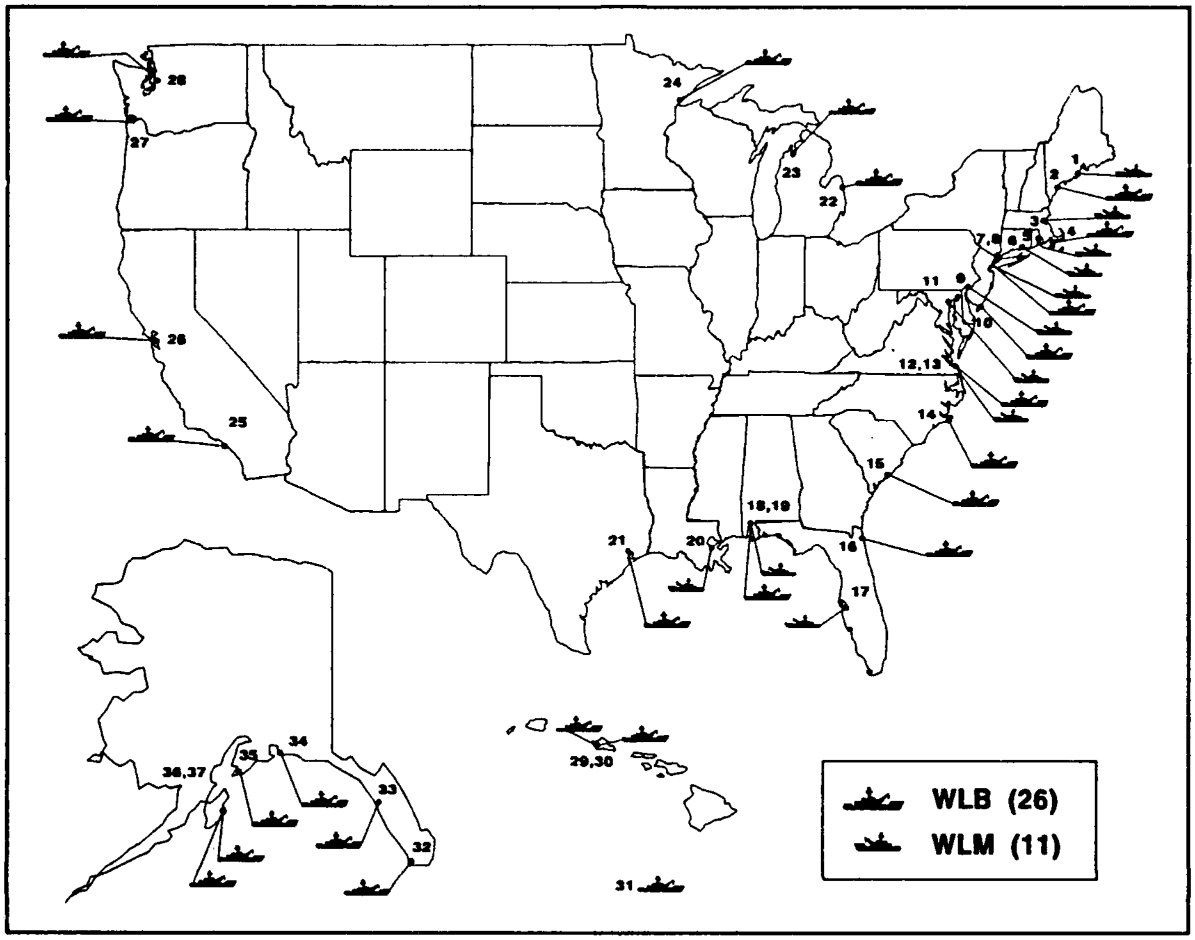
Determining the optimal size and mix of the buoy tender fleet is a complex task. ATON servicing requirements can be only approximately defined due to varying impacts of weather and other factors which are difficult to quantify and predict accurately. As the buoy tender fleet ages, maintenance requirements and availability of individual vessels become less predictable. The impacts of improved features being designed into the replacement fleets cannot be precisely forecast. To summarize, there is no simple best way to assign specific ATON to specific buoy tenders; there is some overlap in terms of the abilities of different classes of tenders to perform different types of service for specific types of buoys, in specific locations, under specific weather and sea conditions.

The USCG's need was for a flexible, computationally efficient set of analysis tools that could be used to model and analyze ATON operations, and to explore the likely performance of a variety of fleet size and mix options. The determination was made that an initial, useful DSS could be developed relatively quickly for ATON analysis by building on a commercial geographic information system (GIS). GISs are data base management systems for spatially oriented data (e.g., aid locations, shorelines, navigable waterways, home ports). The specific GIS selected was "TransCAD", a product of Caliper Corporation, Newton, MA. TransCAD has particularly strong built-in transportation analysis capabilities and, under contract to the Volpe Center, was modified by Caliper to reflect ATON-specific capabilities.

DSS Design and Operation

The DSS is designed to help develop and evaluate alternative fleet size, mix, and operating scenarios. Although the DSS incorporates a routing optimization component, the routes it generates are not actual itineraries that would be followed in the real world, but are instead representative routings, indicative of efficient travel times that could occur in the absence of unpredictable factors and constraints.

The DSS incorporates a number of parameters to account for key factors and constraints affecting buoy tender operations. These include: discrepancy occurrences; variations in servicing times for different types of ATON and services; duration of trips and workdays; simultaneous servicing of ATON by small boats carried on tenders; weather conditions; vessel speed; deck space limitations; buoy preparation times; special requirements of seasonal buoys; surge response; lighthouse maintenance requirements; and physical serviceability of buoys by specific platforms.



DISTRICT	MAP #	HOME PORT	TYPE
1	1	Rockland, ME	WLM
	2	South Portland, ME	WLB
	3	Boston, MA	WLM
	4	Woods Hole, MA	WLB
	5	Bristol, RI	WLM
	6	New London, CT	WLM
	7	New York, NY	WLM
	8	New York, NY	WLB
5	9	Philadelphia, PA	WLM
	10	Cape May, NJ	WLB
	11	Baltimore, MD	WLM
	12	Portsmouth, VA	WLM
	13	Portsmouth, VA	WLB
	14	Atlantic Beach, NC	WLB
7	15	Charleston, SC	WLB
	16	Mayport, FL	WLB
	17	St. Petersburg, FL	WLM
8	18	Mobile, AL	WLM
	19	Mobile, AL	WLB
	20	New Orleans, LA	WLM
	21	Galveston, TX	WLB

DISTRICT	MAP #	HOME PORT	TYPE
9	22	Port Huron, MI	WLB
	23	Charlevoix, MI	WLB
	24	Duluth, MN	WLB
11	25	San Pedro, CA	WLB
	26	San Francisco, CA	WLB
13	27	Astoria, OR	WLB
	28	Seattle, WA	WLB
14	29	Honolulu, HI	WLB
	30	Honolulu, HI	WLB
	31	Guam	WLB
17	32	Ketchikan, AK	WLB
	33	Sitka, AK	WLB
	34	Cordova, AK	WLB
	35	Homer, AK	WLB
	36	Kodiak, AK	WLB
	37	Kodiak, AK	WLB

Figure E-1. CURRENT USCG WLM/WLB FLEET

The DSS is run iteratively in a geographical area of interest to determine an efficient set of assignments of buoys to platforms and platforms to home ports. Completion of this process for all geographic areas produces a specific fleet size/mix/use configuration.

DSS Input Data

A large amount of data supports the DSS. Geographic data required for the GIS include digitized shoreline and waterway boundaries, home port and ATON locations, and water depths. The detailed shoreline data provided with TransCAD were simplified to facilitate the building of buoy tender travel networks. The USCG Aids to Navigation Information System (ATONIS) provided aid locations and water depths, as well as extensive information on aid types, characteristics, and servicing schedules. The USCG Light List was used to verify aid locations from ATONIS. The performance and operating characteristics of the ATON platforms were obtained from USCG Headquarters, and augmented with additional data from the USCG Annual Abstract of Operations. A survey of district personnel and buoy tender commanding officers was conducted to verify the accuracy of collected data and to provide additional information on current and projected buoy tender operations.

Validation of the DSS

Validation of any mathematical model and associated analytical procedures entails the testing of these models and procedures to help ensure their usefulness and reliability when applied for their intended purposes. The major effort in validating the DSS was to use it to "predict" current operations, a known situation. Although the ability to replicate existing conditions does not guarantee the accuracy of future-year forecasts, the failure to do this with reasonable accuracy would cast significant doubt on the model's reliability for use in evaluating alternative proposed future actions.

Overall, the model's predictions proved to represent current operations accurately. The primary measure used to assess the validity of the DSS was total ATON hours required by district to perform one year's ATON work. The model predicted 39,592 ATON hours for the fleet compared to the historical five year average fleet total of 41,358; i.e., the predicted hours were about 96% of the actual hours.

Baseline WLBR Requirements

Assessing the relative value of having USCG assets available for multi-mission uses when they are needed, versus accepting reduced performance standards and/or seeking alternative military or civilian assets on an as-needed basis, is complex. For purposes of this analysis, a minimum baseline number of WLBRs was specified for each district by the USCG based on forecasted <u>minimum</u> multi-mission and ATON requirements.

(See Table E-1 below.) Volume III of this report outlines the USCG's development of the baseline number of WLBRs.

Table E-1.
WLBR BASELINE REQUIREMENTS

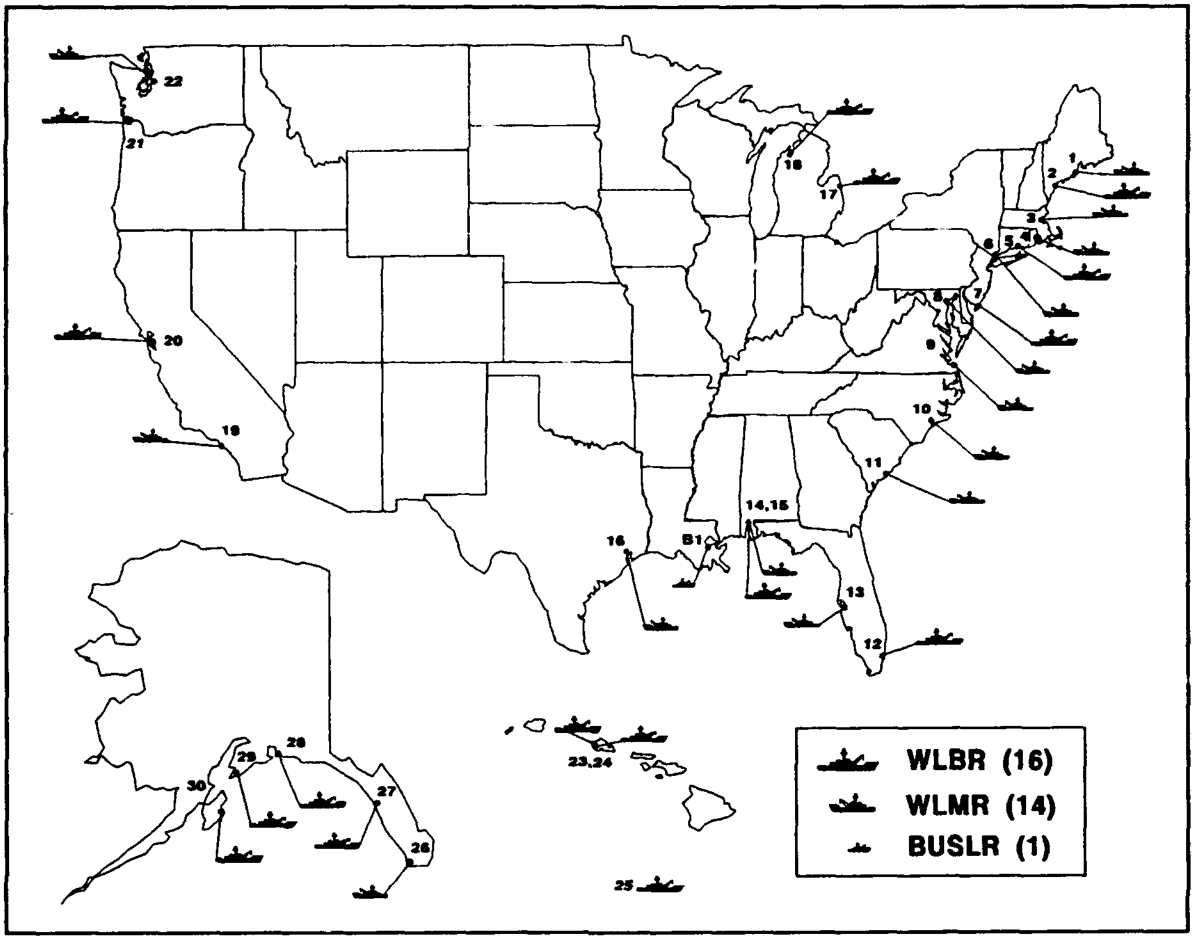
District	WLBR Requirement
1	2
5	1
7	1
8	1
9	2
11	1
13	1
14	3
17	4
Total	16

Proposed Service Force Mix

The proposed service force mix developed from the ATON Service Force Mix Decision Support System is 16 WLBRs, 14 WLMRs, and one BUSLR (in District 8). Excluding the BUSLR, this represents a reduction of seven buoy tenders from the current fleet of 26 WLBs and 11 WLMs. Figure E-2 shows the proposed replacement fleet distribution and home ports. The proposed home ports represent one set of locations that would permit the USCG to accomplish its ATON mission requirements efficiently with the proposed service force mix. It is probable that, based on local considerations, alternative home port locations also could accomplish the ATON mission requirements utilizing the same fleet size and mix. Also, additional BUSLRs may be required to provide secondary response capabilities where current WLB or WLM home ports are not projected as either WLBR or WLMR home ports. Analysis of future BUSLR requirements is being conducted by the USCG.

Life Cycle Costs

To analyse life cycle costs of the buoy tender fleet, all costs associated with the acquisition and operation of all system components -- i.e., capital costs plus operating and maintenance (O&M) costs -- were estimated over the expected lifetimes of the vessels. O&M and capital cost parameters were based on USCG estimates for the future



DISTRICT	MAP #	HOME PORT	TYPE
1	1	Rockland, ME	WLMR
	2	South Portland, ME	WLBR
	3	Boston, MA	WLMR
	4	Bristol, RI	WLMR
	5	New London, CT	WLBR
	6	New York, NY	WLMR
5	7	Cape May, NJ	WLBR
	8	Baltimore, MD	WLMR
	9	Portsmouth, VA	WLMR
	10	Atlantic Beach, NC	WLMR
7	11	Charleston, SC	WLMR
	12	Miami, FL	WLBR
	13	St. Petersburg, FL	WLMR
8	14	Mobile, AL	WLMR
	15	Mobile, AL	WLBR
	B1	New Orleans, LA	BUSLR
	16	Galveston, TX	WLMR

DISTRICT	MAP #	HOME PORT	TYPE
9	17	Port Huron, MI	WLBR
	18	Charlevoix, MI	WLBR
11	19	San Pedro, CA	WLMR
	20	San Francisco, CA	WLBR
13	21	Astoria, OR	WLBR
	22	Seattle, WA	WLMR
14	23	Honolulu, HI	WLBR
	24	Honolulu, HI	WLBR
	25	Guam	WLBR
17	26	Ketchikan, AK	WLMR
	27	Sitka, AK	WLBR
	28	Cordova, AK	WLBR
	29	Homer, AK	WLBR
	30	Kodiak, AK	WLBR

Figure E-2.
PROPOSED USCG WLMR/WLBR FLEET

fleet and historical expenditures for the current fleet. The annual costs were estimated in constant or base year (1992) dollars, then discounted back to the present. The most significant factors affecting the life cycle costs of the buoy tender fleet are the size of the fleet and the mix of WLBRs and WLMRs. Another factor is the phase-in schedule for replacing the current fleet with the replacement vessels. Based on the proposed fleet of 16 WLBRs, 14 WLMRs and 1 BUSLR, a 10% discount rate, and a phase-in schedule of 3 replacement vessels of each type per year beginning in 1996, the life cycle cost of the replacement buoy tender fleet for the period 1992 through 2025 is $1,233.2 million in constant 1992 dollars.

1. INTRODUCTION

This report documents analyses undertaken to assist the United States Coast Guard (USCG) in estimating the optimum number of next-generation seagoing buoy tenders, coastal buoy tenders and buoy boats required to accomplish the work being performed by the current fleet of seagoing and coastal buoy tenders.

1.1 BACKGROUND

One mission of the USCG is to provide and service short range aids to navigation (ATON), including lighted and unlighted buoys, lights, and day beacons. ATON are used by mariners to navigate U.S. waterways in and around the continental U.S., Alaska, Hawaii, and U.S. territories (Caribbean and western Pacific).

Within U.S. waterways, there are approximately 96,000 ATON administered by the USCG, of which about 48,000 are privately owned and maintained. Privately owned ATON typically benefit a single user and often serve a special purpose, such as marking offshore oil drilling platforms and private channels and docks. The other 48,000 ATON are federally owned, serve the public interest, and are the responsibility of the USCG. The USCG uses a variety of buoy tender classes to deploy the federal ATON, perform routine servicing, and respond to ATON outages or "discrepancies".

Of particular concern are 32 of the 37 buoy tenders in the two largest classes -- the seagoing buoy tenders, known as WLBs, and the coastal buoy tenders, known as WLMs. Built in the 1940s, these vessels are beyond their design service lives and the remaining five tenders will begin reaching the end of their design service lives in 1995. In addition, the smaller buoy boats (BUs) and stern loading buoy boats (BUSLs) used by the USCG to service ATON are of a similar vintage, and require replacement by a new-generation buoy boat. Procurements are underway for the design of the replacement WLBs (WLBRs) and replacement WLMs (WLMRs), with anticipated initial deliveries of these vessels in 1996. The preliminary design of the replacement buoy boat (BUSLR) is complete and delivery of the first new vessel is expected in 1993.

Optimum sizes of the new fleets have not yet been determined. Decisions on fleet size and mix will depend upon a variety of issues and assumptions related to, for example: the use of these vessels for search and rescue, marine environmental response, and other non-ATON missions; the location of vessel home ports; servicing intervals and schedules; and the availability of other buoy tending resources.

To develop acquisition estimates in support of Key Decision Point 4 of the acquisition process for the new buoy tenders, the USCG's Office of Navigation Safety and Waterway Services, Short Range Aids to Navigation Division (G-NSR), undertook the "Aids to Navigation Service Force Mix 2000" project to study alternative replacement fleet sizes and mixes. The Research and Special Programs Administration's Volpe National Transportation Systems Center (Volpe Center) was asked to assist with this study.

1.2 OBJECTIVES

The major objectives of this report are to:

- Determine the optimum WLBR/WLMR fleet size and mix from the perspective of performance of the USCG ATON mission, total life cycle cost, and vessel availability for non-ATON activities (multi-mission requirements).

- Estimate the sensitivity of the results to key input assumptions such as WLBR/WLMR transit speeds, ATON servicing times, weather impacts, etc.

- Document all results, procedures, and assumptions clearly and provide information to support decision-making by the USCG and other interested parties.

Because of the project schedule requirements and the complexity of overall ATON servicing and waterways management, the analyses were limited to those ATON currently serviced by WLBs and WLMs. ATON currently serviced by other ATON servicing resources (e.g., other types of tenders, shore-based Aids to Navigation Teams) were not included in this analysis, under the general assumption that efficiencies would not be achieved by reassigning any of these ATON to larger, more expensive WLB or WLM platforms.

The analyses did, however, address the possibility of reassigning ATON currently serviced by WLBs and/or WLMs to smaller, less-expensive BUSLRs. In these instances, an increase in the number of needed BUSLRs was estimated.

1.3 METHODOLOGY

An overall approach was designed to provide the USCG with needed information in a timely, cost-effective manner. The following activities were encompassed:

- *Problem specification* -- Describe current operations, issues, objectives, and relevant activities planned or underway. Identify specific analytical requirements, constraints, key variables, etc.

- *Data collection* -- Identify relevant information sources (e.g., Aids to Navigation Information System (ATONIS), survey of district ATON staff). Obtain, process, analyze, and edit data as needed.

- *Development of a decision support system (DSS)* -- Develop a geographic information system-based set of analytical tools to evaluate alternative fleet size and mix scenarios, including sensitivity of results to input variables and assumptions.

- *Scenario development and DSS application* -- Define necessary assumptions and develop basic "scenarios" or operating concepts (e.g., minimize fleet-wide use of WLBRs for ATON servicing, maximize use of WLMRs and BUSLRs, use multi-mission requirements to specify minimum WLBR requirements by district). Use the DSS to estimate optimal operations for each scenario, iterating as necessary to ensure efficient use of all vessels.

- *Evaluation of results* -- Estimate life cycle costs for the optimum set of alternative fleet size/mix scenarios. Estimate and describe, quantitatively and/or qualitatively, as appropriate, other relevant impacts. Compare and highlight differences among alternatives.

These activities were conducted by the Volpe Center in close coordination with USCG/G-NSR staff. Working through G-NSR, extensive contacts also were established with representatives of other USCG headquarters offices and USCG Districts; the purpose of these contacts was to inform interested parties of study objectives and approach, to solicit comments, and to gather information.

1.4 RELATIONSHIP TO PREVIOUS WORK

A similar analysis was performed by the Volpe Center for the USCG in 1986-87 and included the development of a Service Force Mix (SFM) simulation model for analyzing alternative scenarios. Although in principle this model could have been applied for the current analysis, its use could not have taken advantage of the enormous computer hardware and software advances of the past five years. Compared with the PC-based DSS developed for the current analysis (using "486" stand-alone workstations), the 1986-87 SFM model has a number of significant drawbacks. It is extremely time-consuming to run, since it is written in Pascal code for the USCG standard terminals accessing "8086" processors. It does not provide graphical displays and related geographical information system capabilities to aid data preparation and analysis of results. It requires extensive manual preparation of input data. Finally, it is limited in its ability to answer relevant "what-if" questions. Development of the DSS was therefore essential to ensure that all current study objectives were met within the established time frame.

2. CURRENT ATON OPERATIONS

2.1 AIDS TO NAVIGATION (ATON)

Federally owned ATON located throughout the U.S. waterway system fall into four basic categories.

- Lighted buoys are floating ATON with solar or electric battery-powered lights. The majority of the lighted buoys are solar-powered, and others will be solarized in the near future.

- Unlighted buoys are floating ATON without lights.

- Lights are lighted ATON which are fixed, located on pilings or on land.

- Day beacons are fixed signal devices, located on pilings or on land.

The vast majority of ATON that require servicing by USCG WLBs and WLMs are lighted and unlighted buoys.

2.2 BUOY TENDER VESSELS

This report focuses on the two largest classes of buoy tenders, the WLBs and WLMs. A much broader range of vessel types, however, is used by the USCG for its ATON mission. Some of the capabilities and performance characteristics of these vessels overlap, such that alternative vessel types can occasionally be used to service specific buoys. For example, a large tender can service buoys assigned to smaller tenders as long as the buoys are located in water deep enough for the large tender to operate. However, replacing smaller servicing platforms with larger, more expensive platforms is generally not cost effective. Conversely, some buoys assigned to large tenders are serviceable by smaller tenders when permitted by weather and sea conditions. However, if the buoys are located in remote or exposed locations, the use of a smaller platform is often impractical. Or, if the buoys are located near other buoys that are only serviceable by a large tender, it is often more efficient to have the large tender service the smaller buoys while in the area rather than force an additional visit by a smaller platform.

For this analysis, ATON currently assigned to WLBs or WLMs that are serviceable by buoy boats were examined for possible future assignment to the replacement buoy boats.

2.2.1 Seagoing Buoy Tenders (WLBs)

The WLB is the largest ATON vessel. It is 180 feet long, carries a crew of 49 to 57, has a maximum draft of 14 feet, and can service ATON in seas up to six feet. The WLB steams at an economical speed of 9-11 knots and has a maximum speed of 13 knots. The vessel has an endurance of 45 days, and a work trip of one to two weeks from home port is not unusual.

Currently, there are 26 WLBs (listed in Table 2-1) servicing approximately 4,450 ATON. The WLBs are stable, heavy-lift vessels with the capability to raise objects weighing 15 to 20 tons. Therefore, the buoys that they service typically are the largest in the U.S. waterway system and are located in the roughest waters, farthest from shore. Due to their size and/or location, some ATON can be serviced only by a WLB.

The WLB is considered to be a multi-mission vessel. Due to its endurance and offshore seakeeping capabilities, the WLB often is tasked to perform non-ATON related missions, particularly when bad weather and rough conditions make it hazardous for smaller vessels. This is particularly true in District 17 (Alaska) where the extended coast line and weather conditions often make the WLBs the only available resource for performing a variety of USCG missions.

WLB multi-mission activities vary. In District 1 (Boston), for example, where alternative resources are limited, WLBs are used for enforcement of laws and treaties (ELT). While the WLBs are not a particularly effective interdiction platform, their effectiveness in spotting and intercepting law enforcement targets has been demonstrated in District 7 (Miami).

The WLBs' wartime role is somewhat unique in comparison to the responsibilities of other USCG and Navy assets. Under a Memorandum of Understanding with the Department of the Navy, the WLBs have conducted "Q route" surveys in the strategic port entrance channels. The Q routes are pre-designated shipping lanes for sealift vessels and combatants moving in and out of militarily strategic ports. WLBs are particularly well suited for this operation because of their endurance, stable platform, and precision navigation capabilities. Another WLB wartime role is overseas ATON deployment.

WLBs are the primary resource for deploying the large offshore data-collection buoys utilized by the National Data Buoy Center. When necessary, WLBs are used in the Northeast and Great Lakes for domestic ice breaking activities.

Table 2-1.
CURRENT WLB FLEET

Area	Vessel Name	Home Port
East Coast (8)	Spar	South Portland, ME
	Bittersweet	Woods Hole, MA
	Sorrel	New York, NY
	Hornbeam	Cape May, NJ
	Cowslip	Portsmouth, VA
	Gentian	Morehead City, NC
	Madrona	Charleston, SC
	Laurel	Mayport, FL
Gulf Coast (2)	Sweetgum	Mobile, AL
	Papaw	Galveston, TX
Great Lakes (3)	Bramble	Port Huron, MI
	Acacia	Charlevoix, MI
	Sundew	Duluth, MN
West Coast (4)	Conifer	Long Beach, CA
	Blackhaw	San Francisco, CA
	Iris	Astoria, OR
	Mariposa	Seattle, WA
Alaska (6)	Planetree	Ketchikan, AK
	Woodrush	Sitka, AK
	Sedge	Homer, AK
	Sweetbrier	Cordova, AK
	Ironwood	Kodiak, AK
	Firebush	Kodiak, AK
Western Pacific (3)	Sassafras	Honolulu, HI
	Mallow	Honolulu, HI
	Basswood	Guam

WLBs play a key role in marine environmental response (MER). For example, for the Valdez oil spill, five WLBs logged 2,212 underway hours. In Valdez, WLBs were used as Command, Control and Communications platforms. They also provided air traffic coordination over the area, and served as platforms for small vessel operations in much of the spill area. WLBs were the only vessels that could deploy the protective boom in Prince William Sound.

Currently, about 59% of available WLB time is devoted to servicing ATON, and 14% is accounted for by standard Coast Guard vessel activities, such as operational training. The remainder of the WLBs' availability (27%) is absorbed by other missions, including ELT, defense operations, search and rescue (SAR), marine science activities, MER, and domestic ice breaking.

The replacement WLB, the WLBR, will have improved and more efficient buoy tending capabilities. The WLBR will require a smaller crew size (about 40) and will be capable of servicing ATON in seas up to eight feet. The vessel will steam at speeds of 12 to 15 knots and will have a draft of 14 feet. A dynamic positioning system will provide more precise station keeping capabilities. A chain in-haul system will allow moorings to be raised more quickly. A differential global positioning system (DGPS) will provide more precise positioning and reduce the impacts of poor visibility. The WLBR will be able to endure trips up to 21 days unreplenished and range 6,000 miles. To improve MER capabilities, the WLBRs also will be equipped with on-board oil recovery devices.

2.2.2 Coastal Buoy Tenders (WLMs)

The WLM class of coastal buoy tenders consists of eleven vessels in two classes. As listed in Table 2-2, there are five 157-foot tenders ("Red...") and six 133-foot tenders ("White..."). The 133-foot tender steams at an economical speed of 7.2 knots and has a maximum speed of 9.8 knots. The 157-foot tender has an economical speed of 9.3 knots and a maximum speed of 12.8 knots. The 133- and 157-foot WLMs require water depths of seven to nine feet. WLMs have smaller crews (24 to 33) than the WLBs, and less endurance, although work trips of three to five days are not unusual.

Table 2-2.
CURRENT WLM FLEET

Area	Vessel Name	Home Port
East Coast (8)	White Lupine	Rockland, ME
	White Heath	Boston, MA
	White Sage	Bristol, RI
	Red Wood	New London, CT
	Red Beech	New York, NY
	Red Oak	Philadelphia, PA
	Red Birch	Baltimore, MD
	Red Cedar	Portsmouth, VA
Gulf Coast (3)	White Sumac	St. Petersburg, FL
	White Pine	Mobile, AL
	White Holly	New Orleans, LA

Aids serviced by WLMs are generally smaller than those serviced by WLBs, and the WLMs cannot withstand as severe an environment. Therefore, WLMs typically do not travel far offshore. The 11 WLMs currently service approximately 3,050 ATON.

WLMs are focused-mission vessels devoting about 88% of their available hours to servicing ATON. The remainder of the WLMs' hours are devoted to standard Coast Guard vessel activities (9%), and a small portion to ELT, defense operations, SAR, and MER. The operational environment of the WLM is generally restricted to the more protected waters. Its shallow draft and limited endurance do not make it well suited for offshore operations.

The replacement WLMs, the WLMRs, are expected to be more efficient buoy tenders, requiring operating crews of only 18 persons and shore-based maintenance support of six persons. Like the WLBRs, the WLMRs will be equipped with dynamic positioning systems, chain in-haul systems, and DGPS. The WLMRs are anticipated to be approximately 150 to 160 feet in length and able to travel at a maximum speed of 12 knots.

2.2.3 Inland Buoy Tenders (WLIs and WLICs)

The WLI class of vessels includes both 100- and 65-foot inland tenders. These tenders are either self-contained boats or pusher boat/barge combinations. They work the smaller ATON located in rivers and less exposed inland waterways. Currently, the USCG has six WLIs that service approximately 2,350 ATON.

The WLIC class of vessels includes 160-, 100-, and 75-foot inland construction tenders. These tenders have specialized pile driving equipment, and their principal activity is the construction of fixed structures located in inland waterways. However, WLICs also service ATON located in protected inland waterways. Currently, the USCG has 16 WLICs that service approximately 4,950 ATON.

The WLIs and WLICs are older vessels that will require replacement in the near future. However, for the analyses described in this report, it was assumed that the WLIs and WLICs will continue to service their currently assigned ATON; i.e., these ATON were excluded from the set of ATON to be serviced by the WLBRs and WLMRs. ATON serviced by WLIs and WLICs will be examined during the Coast Guard's analysis of future BUSLR requirements.

2.2.4 ATON Tug Barges

ATON tug barges are being constructed for buoy tending use in the 9th District (Great Lakes). They are capable of carrying large numbers of ATON and therefore are ideal for the 9th District, where the majority of ATON are seasonal buoys. For the current analysis, it was assumed that one ATON tug barge would be available in the Great Lakes, and that this barge would be designated as the primary servicing platform for a number of ATON in the Great Lakes. Therefore, these ATON were removed from the set of ATON considered for servicing by the WLBRs, WLMRs, and BUSLRs.

The tug barges have a deeper draft than the WLMR and do not possess the seakeeping ability of a WLBR. The tug barge is therefore not considered to be an equivalent alternative to either of the two replacement platforms.

2.2.5 Aids to Navigation Teams (ANTs)

Whereas each WLB, WLM, WLI, and WLIC is staffed by a crew that works exclusively on its assigned vessel, aids to navigation teams are shore-based units composed of flexibly-sized teams that service the smaller ATON located in protected waterways. The ANTs also provide backup, or secondary support, to the WLBs and WLMs by responding to discrepancies not requiring a heavy lift capability.

Currently, there are 63 ANTs with crews ranging from 4 to 27. These ANTs service approximately 17,700 ATON, using a variety of vessel types including: 65-, 63-, 55-, and 34-foot aids to navigation boats (ANBs); 45-foot buoy boats (BUs); 46-foot BUSLs; and trailerable aids to navigation boats (TANBs). Frequently, based on weather conditions and other factors, ANTs use different types of vessels to service the same ATON.

ANTs are considered single mission units, devoting 89% of their available time to servicing short range ATON. The remainder of their time is taken by standard Coast Guard activities (8%), with a small portion for SAR, ELT, and defense operations.

2.3 ATON SERVICES

Each of the ATON platforms provides ATON servicing on a regularly scheduled basis and responds to ATON discrepancies.

2.3.1 Scheduled Servicing

There are four basic USCG ATON services: inspection, recharge, mooring inspection, and relief.

- An <u>inspection</u> consists of ATON painting, cleaning, material and lamp replacement, position and voltage checks, and solar panel cleaning. Inspections occur whenever an aid is visited, at least annually for lights, lighted and unlighted buoys, and day beacons.

- A recharge is the replacement of the batteries of a lighted aid (lighted buoys and lights). Recharges are scheduled every five years for solarized ATON and every three years for ATON powered by standard batteries.

- A mooring inspection is the examination and, if necessary, the replacement, cleaning, and/or repair of the underwater mooring of lighted and unlighted buoys. Mooring inspections are scheduled at least every two years.

- A relief is the replacement of the body of a lighted or unlighted buoy. Reliefs are scheduled every six years.

There are a number of factors, including visibility, sea state, temperature, wind, and current, that affect ATON servicing schedules. For example, ATON in northern climates are subjected to icy conditions, while ATON in the southeast encounter hurricanes. These circumstances can cause an aid to be damaged or dragged off station. Consequently, some ATON, such as those that can become icebound during winter, are either removed from the water prior to periods of harsh weather, or require more frequent visits by buoy tenders.

There also is a relatively small number of federally owned ATON that have unique servicing requirements. For example, lighthouses are maintained by the USCG buoy tender fleet. This usually requires extended visits by WLBs or WLMs of approximately two weeks, during which time a wide variety of tasks is performed, such as painting, carpentry, and landscaping. The servicing requirements of these special ATON must be factored into the buoy tender fleet size and mix analysis.

Federally owned ATON are deployed in a variety of ways, and the nature of their deployment can affect how the buoy tenders perform their ATON services. For example, the Northeast coast is densely populated with ATON, resulting in required trip lengths of only one to three days for the buoy tenders of Districts 1 and 5. In Districts 14 and 17, however, the area of operation for a single buoy tender can cover an area comparable to the entire East Coast, resulting in trip lengths of three to four weeks.

2.3.2 Unscheduled Servicing

In addition to performing scheduled maintenance on ATON, the USCG also responds to ATON outages or discrepancies. There are five levels of vessel response to ATON discrepancies: immediate; high priority (within 18 hours); priority (36 hours); routine (72 hours); and decision/deferred (when plans allow). The level of discrepancy response is based on two factors: the criticality of the ATON; and the nature and/or severity of the discrepancy. Responding to discrepancies can have a serious effect on buoy tender schedules and operating profiles.

2.4 OVERVIEW OF WLB AND WLM OPERATIONS BY DISTRICT

The numbers of WLBs and WLMs by district, and the numbers of ATON assigned to these tenders, are summarized in Table 2-3.

District 1 (Boston, MA). New England's long, hazardous, and often fogbound rocky shores, combined with high commercial, fishing, and recreational maritime activities, explain the large number of ATON and buoy tenders in District 1. Maintaining and restoring the many lighthouses that dot the coast is a significant activity of all the buoy tenders. Although unfavorable weather conditions are often anticipated and avoided, buoy tender operations once undertaken are sometimes hampered by fog, sudden changes in sea state, wind, and precipitation, adding hours to planned activities. Approximately every other year, the region is plagued by severe icing conditions, which cause discrepancies to occur at greater rates than normal.

Table 2-3.
SUMMARY OF WLB/WLM OPERATIONS BY DISTRICT

District	WLBs	WLB ATON	WLMs	WLM ATON
1	3	468	5	1,513
2	--	--	--	--
5	3	354	3	893
7	2	661	1	213
8	2	268	2	431
9	3	735	--	--
11	2	305	--	--
13	2	293	--	--
14	3	415	--	--
17	6	944	--	--
TOTAL	26	4,443	11	3,050

District 2 (St. Louis, MO). The 2nd District is responsible for over 15,000 ATON in an area of operations that includes the upper Mississippi River and the Missouri, Tennessee, and Ohio Rivers. The servicing of ATON is accomplished almost exclusively using river tenders (WLRs). The 2nd District has no WLMs or WLBs, and therefore was not included in this study.

District 5 (Portsmouth, VA). The Middle Atlantic coastal waters also host heavy maritime usage, but experience generally milder weather conditions than New England. District 5 is generally able to schedule its three WLBs and three WLMs around weather problems, consequently losing relatively few ATON resource hours to weather impacts.

District 7 (Miami, FL). Generally shallow waters and benign weather produce shorter buoy servicing times than in other regions. The area of coverage of its three buoy tenders includes the Florida Keys, the Bahamas, Puerto Rico, and the Greater Antilles. Each year, a three- to four-week trip is scheduled by each of the two WLBs to service assigned ATON in the Caribbean Sea.

District 8 (New Orleans, LA). Although buoy tender operations in Gulf waters are similar to those in District 7, District 8 has to contend with the lower Mississippi River, which presents unique challenges. In the beginning of the summer months, the White Holly places unlighted bar markers at the fifteen foot contour level of the river. As water levels fall throughout the summer and rise with autumn rains, the markers are repeatedly moved to maintain the contour. In high-water winter months, the markers are removed.

District 9 (Cleveland, OH). Great Lakes operations include the commissioning and decommissioning of a large number of seasonal buoys due to severe winter icing. The tenders employ local staging points to minimize the distances they must travel in picking up and storing seasonal buoys. Lighthouse restoration is also a significant activity, requiring a three- to four-week trip annually by each vessel. The Sundew also serves for two to three weeks as a "floating hotel" for an ANT unit while the ANT performs lighthouse maintenance activities.

District 11 (Long Beach, CA). The California coastline covered by District 11's two WLBs stretches over 800 miles. Because of entrance tides in the northern part of the district, many moorings are checked annually when inspections are performed, to reduce the possibility of discrepancies arising.

District 13 (Seattle, WA). The Pacific Northwest poses unique challenges to buoy tending operations. Normal working conditions consist of a six- to eight-foot swell in five knots of current. In some locations, such as the Columbia River bar, where the ocean swell meets river outflows, large breakers submerge buoys and trap tenders in bays for days. The deep waters of Puget Sound mandate exceptionally long chains, which add hours to buoy service times. Some buoys located in especially turbulent waters have double sinkers to hold them in place. This district, like District 11, has many buoys on a one-year mooring check cycle.

District 14 (Honolulu, HI). The distances that District 14's buoy tenders must travel to service its ATON are greater than those in any other district. Trips to distant islands, such as Midway Island, the Marshall Islands, American Samoa, the Philippines, and the Solomon Islands, are scheduled according to historical weather patterns, sometimes years in advance. Typically, such trips take three to four weeks. The rough waters around the islands and the great distances that must be traveled are the main reasons why District 14, like several other districts, performs annual mooring checks along with inspections. In addition, the district has a policy to use buoy servicing trips as crew training opportunities.

District 17 (Juneau, AK). The six WLBs in this District endure the most severe climate and sea conditions in the country. Daylight ranges from 18 hours per day in the summer to 6 hours per day in the winter. Tides range up to 38 feet. These challenges are combined with a coastline that extends over 4,000 miles. As a result, both travel and service times are longer than for other districts. One of the most time-consuming tasks occurs when a crew must place a buoy in a location where only National Ocean Service markers are available for sighting. The tender must send a small boat ashore, where the crew searches for the markers (which may be under snow or on a cliff's edge), and installs orange dayboards that can be seen from the tender. After completing the work, the crew must then return to shore to retrieve the dayboards. In addition to their buoy tending duties, the vessels perform a large amount of multi-mission work, with many SAR cases and fishery patrols.

3. CONCEPT AND OPERATION OF THE DSS

3.1 CONCEPTUAL APPROACH

Determining the optimal size and mix of the buoy tender fleet is a complex task. ATON servicing requirements can be only approximately defined due to varying impacts of weather and other factors that are difficult to quantify and predict accurately. As the buoy tender fleet ages, maintenance requirements and availability of individual vessels become less predictable. The impacts of improved features being designed into the replacement fleets cannot be precisely forecast. As discussed in Section 2.2, there is some overlap in the abilities of the different classes of tenders such that more than one tender type can sometimes be used to service specific ATON under specific circumstances. To summarize, there is no simple best way to assign specific ATON to specific buoy tenders.

The multi-mission nature of the buoy tenders, especially the WLBs, also plays a major role in determining the size and mix of the fleet. Some of these multi-mission requirements, such as responding to major oil spills, can be highly volatile in terms of demands placed on these vessels. While a reasonable attempt could be made to minimize life cycle costs for ATON activities based on a reasonable set of clearly stated assumptions (and indeed, that is what has been done in the present analysis), higher cost alternatives likely may produce greater benefits when viewed from the perspective of multi-mission and discrepancy response requirements. Incremental costs therefore need to be assessed in light of incremental benefits.

The need, then, was not for a "black box" that produces a single answer, but for a set of efficient, flexible, analytical tools with which to examine the likely performance of a variety of fleet size and mix options that can handle a variety of different operating conditions. The purpose was to develop one or more efficient fleet size and mix scenarios, and to estimate associated costs, performance measures, and other impacts. This information, along with estimates of the sensitivities of these measures to input assumptions, would then be organized for use by decision-makers and other interested parties. In essence, this is the concept of a decision support system (DSS) -- a set of analytical resources with which to generate information needed to support decision-making.

3.2 COMPUTER HARDWARE AND SOFTWARE PLATFORM

The acquisition and/or development of a computer hardware and software platform was influenced by two constraints: the need to minimize its cost and a very tight schedule that required initial results by the March, 1992 budget hearings.

From a hardware perspective, the system had to operate on the standard IBM-compatible PCs available at the Volpe Center (with Intel 486 processors). These PCs are relatively powerful machines in terms of processing speed and storage capacity. New versions of these machines are relatively inexpensive. Project staff were experienced in their use, as were others who might be called on to assist during peak analysis periods, when multiple machines were used simultaneously to perform multiple functions and analyze multiple alternatives.

From a software perspective, the ideal would have been to find an existing system that could have been applied with little or no modification. Several systems were evaluated, including the SFM Model developed by the Volpe Center in 1986-87 (discussed in Section 1.4), and the "ANGEL" model, a single vessel simulation tool developed more recently by the USCG R&D Center in Groton, CT. None of these systems provided the desired capabilities, but a determination was made that a DSS could be developed relatively quickly for ATON analysis by building on a commercial geographic information system (GIS). GISs are data base management systems for spatially oriented data (e.g., aid locations, shorelines, navigable waterways, home ports). They provide capabilities for manipulating and displaying point, line, and area databases overlaid on geographic areas.

The GIS selected was "TransCAD", a product of Caliper Corporation, Newton, MA. In support of work being done for the Military Traffic Management Command, Volpe Center staff had reviewed the various available GIS products, and had selected TransCAD as a result of a competitive procurement among GIS vendors. TransCAD has strong built-in transportation analysis capabilities (including shortest path and "traveling salesman" algorithms), and Volpe Center staff were already experienced in its use. Caliper Corporation also augmented and modified certain capabilities specifically for ATON analysis, under terms of an existing task order contract with the Volpe Center.

3.3 OVERVIEW OF DSS OPERATION

The DSS is used to help develop and evaluate alternative fleet size, mix, and operating scenarios. Even though the DSS incorporates a routing optimization component, it is unrealistic to expect that the routes will represent actual itineraries that could be followed routinely in the real world, due to weather impacts, currents, tides, discrepancies, vessel of opportunity missions (e.g., search and rescue), and other factors. Instead, these routes should be viewed as representative routings, indicative of efficient travel times and costs that would be incurred in the absence of these other factors, which must be accounted for subsequently in the analysis.

The DSS is run separately for each defined service area (e.g., district, set of adjacent districts, entire East Coast), for each specified operating scenario or concept (e.g., minimize use of WLBs, minimize use of WLBs subject to at least one WLB per district). For each area within each scenario, the DSS is used iteratively to seek an efficient set of assignments of ATON to platforms and platforms to home ports using the following steps:

1. Input data are developed for ATON, servicing platforms (vessels), home ports, travel networks, and service times.
2. Vessels are assigned to home ports.
3. ATON are assigned to vessels.
4. Using a modified "traveling salesman" algorithm, trip routes are developed and performed for each vessel. The DSS models the activities of each vessel over a one-year period.
5. Outputs are evaluated from the perspective of efficient use of vessels by comparing each vessel's available ATON hours with the hours needed to service all ATON assigned to that vessel. Where too many or too few ATON hours are projected for a particular vessel, appropriate inputs are adjusted -- such as aid assignments to specific platforms -- and the previous steps are repeated as necessary.

Completion of this process for all geographic areas produces a specific fleet size and mix.

3.4 DSS INPUTS

3.4.1 Aids to Navigation (ATON) Data

Each aid to be analyzed with the DSS is identified by the following attributes:

- ID (District+Aid Number)
- Longitude
- Latitude
- Aid Type (lighted buoy, unlighted buoy, light, day beacon)
- Aid Name
- Authorized Hull
- Primary Unit
- Environment
- Operation Mode (Permanent or Seasonal)
- Seasonal From/To Dates
- Date of Last Servicing
- Last Servicing Performed (Inspection, Mooring, Recharge, Relief...)
- Depth
- Maximum Lift Requirement

- BUSLR Serviceable Code
- WLMR Serviceable Code
- WLBR Serviceable Code
- Discrepancy Probability
- Current Weather Penalty Hours
- WLMR Weather Penalty Hours
- WLBR Weather Penalty Hours
- Percentage of Time Serviced by Small Boat
- Required Deck Storage Space
- Number of Required Annual Visits (Structures only)
- Current Platform Type (WLB or WLM)
- Assigned DSS Servicing Unit (Vessel Name)
- Assigned DSS Servicing Date

3.4.2 Platform Data

Each servicing platform to be analyzed with the DSS is identified by the following attributes:

- Vessel Name
- Historical (current fleet) or Target (future fleet) ATON Hours
- Maximum Cruise Length (Hours)
- Time of Day When ATON Servicing Begins (generally daylight)
- Time of Day When ATON Servicing Ends (generally nightfall)
- Prep/De-Prep Time (minimum clock time between servicing ATON)

3.4.3 Network Data

The vehicle routing algorithms utilized by the DSS use transportation networks that link ATON with home port locations via paths that avoid land objects and known unnavigable water. The networks are built using an intelligent network-building software routine developed specifically for this project. From the possible travel paths represented by the network, a two-dimensional table is built containing computed distances between all node pairs, where a node is either an aid or a home port. These tables are utilized by the vehicle routing algorithm to determine the associated travel times on possible ATON servicing routes.

The inputs to the network builder are a land mass polygon and a selected set of nodes consisting of ATON and home ports. Because the network size grows geometrically as the number of nodes increases (the number of possible links between a group of n nodes is roughly $n^2/2$), two parameters are used to limit the network size in order to produce reasonable performance on a microcomputer. The first parameter controls the number of links emanating from a node, and the second parameter controls the maximum link length.

Typically, the number of links emanating from a node is set to ten, which would divide the 360° around each node into ten 36° slices and generate a link between the node and the nearest node (if any) within each of the ten slices.

The maximum link length depends on the size of the area being covered and typically is set to the estimated maximum distance between nodes within the area.

3.4.4 Assignment of Platforms to Home Ports

The 37 home port locations utilized by the current fleet of WLMs and WLBs are represented within the DSS as unique ATON having no servicing requirements. The five cities that are homes to two tenders each (New York, Portsmouth, Mobile, Kodiak, and Honolulu) are assigned two home port locations in close proximity to each other, one for each of the tenders located there. When setting up a run of the DSS, the desired home port location for a vessel is specified by the DSS user through use of a unique identification number corresponding to the home port.

When evaluating alternatives to the current home ports, additional home port locations are created through GIS operations and are then included within the operation of the DSS through re-construction of the relevant transportation networks.

3.4.5 Assignment of ATON to Platforms

The determination of which ATON are to be serviced by individual platforms is made by the DSS user based upon geographic area, physical serviceability of individual ATON by different platform types, and prior outputs of the DSS (e.g., whether a vessel was over- or under-utilized). The determination is significantly aided by the GIS features of the DSS whereby, through "point-and-click" actions with a "mouse", the user can isolate individual ATON or groups of ATON by geographic area.

3.5 HOW THE DSS ADDRESSES KEY ATON ISSUES

3.5.1 Discrepancies

A discrepancy occurs when an aid is not operating according to its specifications. It may be off-station, have a defective light or an obscured number, or be missing altogether. Discrepancies have a variety of causes including vessel impacts, ice storms, hurricanes, and battery malfunctions. The nature of the discrepancy occurring to an aid assigned to a WLB or WLM generally determines which vessel will respond and how quickly the response will take place. A minor discrepancy that does not require lifting the aid or that occurs in unexposed water is often handled by an ANT instead of the larger vessel. A vessel typically will work a non-critical discrepancy into a scheduled trip to the area rather than conduct a special mission.

The DSS captures ATON resource hours spent by a vessel in responding to discrepancies using a model whose main inputs are: (1) the expected annual number of required discrepancy responses per aid; and (2) the average ATON resource hours per aid serviced by the vessel. The first input was developed using an algorithm that employed the historical number of discrepancies for each aid based on ATONIS discrepancy data combined with the results of the Buoy Tender Operations Survey. An average annual discrepancy rate was calculated and then adjusted according to the proportion of time the WLB or WLM responded, as opposed to a secondary servicing unit. The algorithm is fully described in Appendix A.

The second input is actually an output of the DSS and is, for each vessel, the quotient of the total DSS ATON resource hours (not including weather hours) divided by the number of ATON serviced. This figure encompasses transit time, overnight idle time, and service times. The DSS accumulates the first input over all the ATON assigned to a vessel, and then multiplies by the second input to obtain the number of ATON resource hours spent by the vessel in responding to discrepancies.

One advantage of this method is that it captures discrepancy rates for individual ATON. Although an in-depth study of the causes of high rates was not conducted, it is likely that frequent discrepancies for particular buoys may result from locations particularly vulnerable to damage from vessels or chronic weather conditions.

3.5.2 Service Times

The earlier Service Force Mix (SFM) Model used service times by type of service and aid environment that were compiled from a 10% sampling of ship logs in District 1. The results were used to represent service times for all districts. For the current analysis, because of a perception that service times probably vary with different climates and operating philosophies, an attempt was made to establish more reliable ATON service times.

The Buoy Tender Operations Survey was used for this purpose. The survey revealed that there are in fact significant differences among districts in the times required to service ATON. Within districts, reported service times vary not only between WLBs and WLMs, but also among WLMs and among WLBs.

The DSS permits varying service times to reflect buoy tender operations more realistically. Within each district, one set of current service times was developed for the WLBs, and one for the WLMs. For districts that provided service times for individual vessels of the current WLM/WLB fleet, the DSS contains a set of service times for each individual vessel. Each set contains service times for four types of buoys (lighted permanent, unlighted permanent, seasonal not replaced, and seasonal replaced), and two types of structures (lights and daybeacons). The service times are further broken down for both exposed and non-exposed environments ("non-exposed" corresponds to the ATONIS classifications of "semi-exposed" and "protected"). Service times for ATON with no recorded environment value are assigned service times based on weighted averages of the distribution of exposed and non-exposed ATON within the associated district.

For each district, the DSS also contains the projected service times obtained from the survey for WLBRs and WLMRs. These times reflect the improved positioning, navigation, seakeeping, and chain-hauling capabilities of the replacement vessels and their higher transit speeds. A table of the service times utilized by the DSS is included in Appendix B.

It was assumed that, when servicing the same aid, the service time of a WLMR would never be less than that of a WLBR. To enforce this constraint, two special cases are handled as exceptions by the DSS.

The first case involves a WLMR servicing an aid presently serviced by a WLB. If the projected WLMR service time is less than the projected WLBR time, the WLBR time is also used for the WLMR. This is done because it is generally not realistic to expect a WLMR to require less time to work a WLB aid than would be needed by a WLBR.

The second case is the opposite of the first and involves a WLBR servicing an aid presently serviced by a WLM. If the projected WLBR service time is greater than the projected WLMR time, the WLMR time is also used for the WLBR because it is generally not realistic to expect a WLBR to require more time to work a WLM aid than would be needed by a WLMR.

3.5.3 Service Types

The possible service type combinations for permanent lighted buoys in the DSS include: inspection; relief; inspection and mooring check; inspection and battery recharge; relief and mooring check; and inspection, mooring check and battery recharge. These combinations are based on several assumptions: (1) a mooring is rarely checked without also inspecting the buoy; (2) a battery is rarely recharged without also inspecting the buoy; and (3) when a buoy is relieved, an inspection or recharge is not necessary, but a mooring check may occur. These assumptions reduce the number of service type combinations to those most likely to occur in the field. Similar assumptions are made for permanent unlighted buoys.

Seasonal buoys that are not replaced are restricted to two service types: placing and removing. Seasonal buoys that are replaced are restricted to reliefs in Spring and Fall of the first year and in Fall of the second year, and to reliefs and mooring checks in Spring of the second year.

Lights and Daybeacons receive only annual inspections.

Appendix C contains a description of how the service types in the DSS were derived from the ATONIS.

3.5.4 Duration of Trips and Workday Hours

There are several important DSS operational issues related to the duration of buoy tender trips and workdays. These issues are complicated by differences in requirements and operating practices among the districts. Although buoy tenders in all districts seem to work a combination of multi-day trips and single-day trips during the year in tending their assigned ATON, the number of underway hours per trip varies considerably, even among single-day trips. On multi-day trips, the tendency to stay at sea overnight or to put into a nearby port differs from district to district, and typically is not consistent from vessel to vessel within a district. Crews of buoy tenders generally require daylight to work ATON, but they will travel to ATON sites at night, if necessary. The number of daylight hours varies from season to season, and from district to district. The extreme variability in operating practices makes it difficult to develop one set of parameters that works well for all districts.

The DSS utilizes a trip length parameter to control the maximum amount of time that a vessel can be underway on a single trip. For both the DSS validation and replacement runs, the trip length parameter was generally kept constant at 72 hours. Greater trip lengths of 10 days were used in the Caribbean, Alaska, and Hawaii due to the greater required steaming times. To accommodate seasonal servicing requirements, trip lengths of 10 days were also used for buoy tenders in the Great Lakes.

The DSS utilizes a workday hours window parameter to control the amount of time a vessel can work ATON during the day. A constant workday hours window of 6:00 AM to 4:00 PM was used for WLMs and WLMRs. Because WLBs and WLBRs generally have to steam longer distances to service ATON than do WLMs and WLMRs, WLBs and WLBRs will generally work ATON later in the day so that they can be en route during the night to the next aid. Therefore a workday hours window of 6:00 AM to 6:00 PM was used for WLBs and WLBRs. In the Great Lakes, however, seasonal servicing requirements required the use of a workday hours window of 16 hours.

3.5.5 Percentage of Time Serviced by Small Boat

Both WLBs and WLMs carry small boats that are used for various purposes, including servicing buoys and structures. When the small boats are used to service ATON, the buoy tender itself is usually nearby servicing other ATON at the same time. The small boats cannot perform the heavier servicing tasks, such as lifting buoys from the water, but they can accomplish lighter duties and can carry a crew ashore to perform lighthouse maintenance. This simultaneous servicing may significantly shorten overall ATON trip lengths.

The DSS accounts for simultaneous small boat service times by first determining the annual number of ATON resource hours the ATON would require from the primary unit alone, and then subtracting the estimated annual simultaneous service times. The Buoy Tender Operations Survey provided percentages of each primary unit's buoys and structures that are currently serviced simultaneously by its small boats. The appropriate percentage was included as a field on each DSS ATON record. This field is multiplied by the required service time of each affected ATON in the DSS run, and the product is accumulated over all ATON to produce an estimate of the number of ATON resource hours to subtract.

The assumption was made that ATON currently serviced by small boats will continue to be serviced by small boats in the future.

3.5.6 Weather Impacts

Weather and sea conditions significantly impact buoy tender operations. Favorable conditions ensure efficient conduct of a mission. Unfavorable conditions may either delay the mission or increase the time required for its completion. For example, a buoy tender may cut a trip short and return to port before completing all planned servicing because a sudden storm makes working conditions impossible. It may have to travel more slowly than normal because of fog. It may have to sit in a protected cove until a tidal surge subsides.

The replacement vessels will have features that reduce the impact of weather on operations. Both WLBRs and WLMRs will have DGPS and Dynamic Positioning Systems. In addition, both WLBRs and WLMRs will have improved seakeeping ability (from 6 to 8 feet, and from 2 to 3 feet, respectively).

The Buoy Tender Operations Survey asked the commanding officer (CO) of each buoy tender to estimate the current annual number of underway hours that would not have been spent if weather and sea conditions had been favorable. The COs were then asked to project the number of underway hours attributable to weather that they would incur if their buoy tender had the capabilities of a replacement vessel. The results of this survey were used in the DSS to estimate the effects of weather.

Each record in the DSS ATON data base contains a current weather penalty field and two projected weather penalty fields, one for servicing by a WLBR and one for servicing by a WLMR. The current weather penalty for each aid assigned to a buoy tender was calculated according to its environment: exposed, semi-exposed, or protected. The current annual weather hours for the tender and environment were divided by the corresponding number of assigned ATON, producing the current weather penalty.

The projected weather penalties are based on projected annual weather hours, but their calculation is more complicated. From NOAA wave height data for USCG operating areas across the country, the proportion of time seas were three feet or lower and the proportion of time seas were eight feet or lower were determined. (As noted above, these are the sea heights in which WLMRs and WLBRs, respectively, will be able to operate.) The projected weather penalty fields were calculated analogously to the current weather penalty field when the replacement vessel type corresponded to the vessel type currently servicing the buoy (WLMR and WLM, or WLBR and WLB). However, when the replacement vessel type was different from the current vessel type (WLMR and WLB, or WLBR and WLM), the ratio of the proportions was used to adjust the projected weather penalty. Using the ratios, the penalty was increased when a WLB buoy is serviced by a WLMR, and decreased when a WLM buoy is serviced by a WLBR. Appendix D shows the algorithms used to develop the weather penalties.

Associating weather penalties with ATON instead of vessels allows the weather penalty to be carried along with the ATON when alternative vessel assignments and scenarios are explored. When a scenario is run, the total ATON resource hours are calculated, the appropriate weather penalties are summed over all ATON in the scenario, and the sum is added to the total ATON resource hours to produce an estimate that incorporates the impact of weather on operations.

3.5.7 Multi-Mission Requirements

The DSS does not explicitly address multi-mission uses of current and replacement vessels. Although there are historical data that characterize multi-mission use of the existing WLB and WLM fleets, there appears to be no formal, detailed specification of multi-mission requirements. Many non-ATON activities conducted by buoy tenders, such as ice breaking and marine environmental response, can be highly variable from year to year. The relative value of having USCG assets available for these purposes when they are needed, versus accepting reduced performance standards and/or seeking alternative military or civilian assets on an as-needed basis, is complicated to assess.

For purposes of this analysis, a minimum number of WLBRs was specified by the Coast Guard for each district, based on forecasted <u>minimum</u> multi-mission and ATON requirements. (See Table 3-1.) Volume III of this report outlines the USCG's development of the baseline number of WLBRs. Because the WLBRs will have greater capabilities for performing ATON work than the WLBs, and because some WLB ATON work can be off-loaded to less expensive WLMRs, this approach was intended to project a lowest life cycle cost fleet from an ATON perspective. However, it probably also represents a minimum level of multi-mission capability. Given safety concerns, law enforcement concerns, and the Congressionally-mandated oil separation equipment on the WLBRs, a greater multi-mission capability (i.e., a greater number of WLBRs) may be desired.

Table 3-1.
WLBR BASELINE REQUIREMENTS

District	WLBR Requirement
1	2
5	1
7	1
8	1
9	2
11	1
13	1
14	3
17	4
Total	16

3.5.8 Replacement Fleet ATON Target Resource Hours

The underlying objective in exercising the DSS for a replacement fleet vessel is to generate a projected ATON resource hours figure equal to the vessel's target number of underway hours minus its expected number of multi-mission hours.

For the WLMRs, the underway target is 150 days, of which 85% are expected to be used for ATON (127.5 days). For the WLBRs, the underway target is also 150 days but with 60% being used for ATON (90 days). Using the historical average of underway hours per underway day (from the USCG Abstract of Operations) of 10 hours for the WLM and 14 hours for the WLB, the ATON Resource Hours Target was set at 1275 hours (150 * .85 * 10) for the WLMR and at 1260 hours (150 * .60 * 14) for the WLBR.

3.5.9 Vessel Speeds

Due to the wide range of average transit speeds that were provided in the Buoy Tender Operations Survey for the current buoy tenders and some apparent confusion over how to determine the average transit speed that was being asked for, the vessel speeds used for the validation runs were set at 9 knots for East and Gulf Coast WLBs, 10 knots for Great Lakes, Alaska, Hawaii, and West Coast WLBs, and 11 knots for the Sundew out of Duluth (due to engine improvements). The higher speed for the Great Lakes and Pacific WLBs was based on the survey responses. In the Pacific districts, the higher speed can be attributed to the presence of generally longer steaming distances that facilitate the operation of vessels at higher speeds.

For the WLM validation runs, the Northeast 133-foot WLMs were run at 9.5 knots, the 157-foot WLMs at 11.5 knots, and the Gulf Coast 133-foot WLMs at 8 knots. The difference between the northern and southern 133-foot WLMs was based upon the survey responses.

For the replacement vessels, average transit speeds of 12 knots were used for East Coast, Gulf Coast, and Great Lakes WLBRs and 13 knots for the West Coast, Hawaii, and Alaska WLBRs (due again to the greater steaming distances). Speeds of 10 knots were used for all WLMRs with no distinction made between East and West Coasts because WLMRs are not designed for the open ocean transits that facilitate higher transit speeds.

3.5.10 Buoy Deck Capacities

The size of the buoy deck directly limits the number of buoys a tender can carry at one time, and indirectly limits the number of placing, replacing, and removing services the vessel can perform on one trip. To represent this limitation, the DSS controls the amount of relief-type actions that can be performed on an individual tender trip by assigning to each buoy a deck storage space requirement equal to its height times width times an estimated "tie-down" factor of 1.5. The total buoy deck storage space requirements for buoys requiring relief actions can not exceed the total buoy deck square footage of the tenders. The buoy deck capacities are 1000 ft^2 for 133-foot WLMs, 1200 ft^2 for 157-foot WLMs, 1600 ft^2 for WLBs, 1200 ft^2 for WLMRs, and 2500 ft^2 for WLBRs.

To compensate for their limited buoy deck storage capacity, buoy tenders often store buoys near their location of deployment in staging areas, saving the transit time that would be required returning to home port to off-load and/or load buoys. This practice is especially prevalent in those areas with large numbers of seasonal buoys. To simulate this practice in the DSS, the size of the buoy tender deck is increased to several times its actual size. For example, in District 9 the buoy deck capacity for WLBs was increased from 1600 ft^2 to 9600 ft^2, and for WLBRs from 2500 ft^2 to 15000 ft^2. The

DSS then allows the vessel to carry more buoys without having to return to its home port to pick up more, thus simulating multi-day seasonal buoy trips.

3.5.11 Preparation/De-Preparation Times

Before a trip and while transiting between buoys, a buoy tender crew must prepare buoys for placement in the water. However, if buoy locations are closely spaced and transit time is too short, the tender must sit on site while buoy preparation is completed. The DSS includes a variable that causes a minimum transit time to be incurred for transits between closely spaced buoys to account for this activity. This variable is especially important in simulating the servicing of seasonal buoys, which do not require as much preparation as permanent buoys. The minimum amount of preparation time, which is typically set at thirty minutes, is reduced to fifteen minutes for vessels servicing large numbers of seasonal buoys.

3.5.12 Seasonal Buoys

A seasonal buoy requires at least two visits annually by buoy tenders, the first for placing the buoy, and the second for its removal or replacement. The DSS uses the "Seasonal From" and the "Seasonal To" dates in the ATON data base as the two servicing dates for seasonal buoys.

3.5.13 *Selection of ATON for Servicing on Vessel Trips*

A major factor in real-world buoy tender operations is determining which ATON will be serviced on individual buoy tender servicing trips. A buoy tender commanding officer (CO) must schedule his ATON missions based on the combination of regular ATON servicing requirements and other factors such as weather forecasts, tides, crew experience and stamina, required discrepancy responses, USCG visibility considerations, re-supply options (for food, water, and equipment), and the perceived reliability of his vessel. The DSS does not, nor can it be expected to, take into account all of the considerations that a CO is faced with in scheduling the performance of his mission requirements.

The DSS can generate vessel routes by using a servicing date window of a length specified by the DSS user to select ATON that require servicing based on the recorded last service dates. The DSS then uses a vehicle routing algorithm to determine the most efficient route, generally the route that services the most ATON in the shortest time.

Through adjusting the size of the servicing date window, the DSS can be directed to look forward for a desired number of days and select for servicing those ATON whose last dates of servicing are one year prior to the range of dates covered by the window. For example, if the DSS was run for a vessel with an assigned set of ATON beginning on January 1, 1992 using a 10 day servicing date window, for the first trip the DSS would select for servicing the subset of ATON whose last dates of servicing were less than or equal to January 10, 1991. In this manner, it was intended that the DSS would be able to approximate the trips made in the previous year by the current buoy tender fleet, as part of the DSS validation process.

In actual use, however, the application of the servicing date window proved to be unreliable. The problem was that in looking ahead for "n" number of days, the DSS could not determine where one actual trip had begun and where another one had ended, with the result being that when a window fell within the begin and end dates of an actual trip, it produced two trips to the same area rather than one logical and efficient trip. In addition, the recorded service dates could have been the result of a discrepancy response having been made by a secondary unit (another vessel or an ANT). This would result in the DSS sending the primary unit to an area at a time when it may have actually been far from the area, resulting in inaccurate and inefficient vessel trips.

The problem was overcome by adopting an optimal routing approach, whereby the servicing date window was set to 365 days. This causes the DSS to look at all of a vessel's assigned ATON at once and then proceed through an iterative process of generating possible routes, selecting the best route, performing that route, and then repeating the process for the remaining ATON until all assigned ATON have been serviced. The determination of an "optimal" route is discussed later (Section 3.5.15).

3.5.14 Overnight Idle Times

The optimal routing approach, when used with the DSS validation runs, resulted in projected ATON resource hours close to the historical values. Adoption of this approach, however, highlighted the significance of a key DSS parameter: the decision of whether or not to include a vessel's idle time (the time spent waiting at anchor overnight for daylight) as ATON resource hours.

In actual operations, vessels often pull into nearby ports, tie up for the night, and record only the steaming time -- not the associated overnight time -- as ATON resource hours. However, optimal routing results in fewer underway days than in actual operations because generated routes are almost always multi-day trips during which more work can generally be accomplished than on one-day trips. By incurring fewer underway days than actual operations, the DSS would be expected to project fewer total ATON resource hours, but by including all overnight idle time as ATON time, the total projected hours are close to the historical averages. The result is that the lower ATON resource hours resulting from optimal routing are offset by the higher overnight idle times produced from the greater number of multi-day vessel trips.

The nature of operations for WLMs in Districts 1 and 5, for WLBs in Districts 9 and 14, and for WLBs in District 7 covering the Caribbean Sea, are such that the vessels generally pull into ports overnight and do not accrue ATON resource hours. Appropriately, for these vessels the DSS produced more accurate results when overnight idle time was not included as ATON resource hours. These areas are characterized by either high concentrations of ATON (Districts 1 and 5), large seasonal servicing requirements (Districts 5 and 9), or long steaming distances (Districts 7 and 14) which require that associated vessel trips be close to the optimal vessel routes generated by the DSS in order to accomplish all of the ATON requirements in those areas. In District 17, even though as in District 14 the long steaming times produce inherently optimal routes, overnight idle times were included as ATON hours because there are far fewer remote ports available, forcing the District 17 tenders to remain underway overnight and continue to accrue ATON resource hours.

3.5.15 Determining an Optimal Route

ATON are considered for servicing on a given dispatch date based on whether they are permanent or seasonal ATON. Permanent ATON are selected if their last date of service was more than one year before the end date of the current service window; seasonal ATON are selected if their spring or fall service dates are within the current service window.

Generating and testing all possible routes for a buoy tender is beyond the practical capabilities of today's microcomputers. To overcome this limitation, the ATON SFM DSS utilizes the Clarke-Wright Savings[1] heuristic. The Clarke-Wright heuristic is an algorithm that has historically been shown to generate solutions that are reasonably close to the true optimum solution. It is a well-known and frequently used heuristic for vehicle routing problems. Figure 3-1 demonstrates a simple application of the algorithm.

The diagram shows one port and two aids. On the left side, a vessel makes two trips, one trip for each aid. The total distance travelled is 2A + 2B. On the right side, the vessel makes one trip to visit both aids. The total distance travelled in this case is A + B + C. The distance "savings" in making one route instead of two is A + B - C.

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[1] G. Clarke and J. Wright (1964), "Scheduling of Vehicles From a Central Depot to a Number of Delivery Points", *Operations Research*, Vol. 12, pp. 568-581.

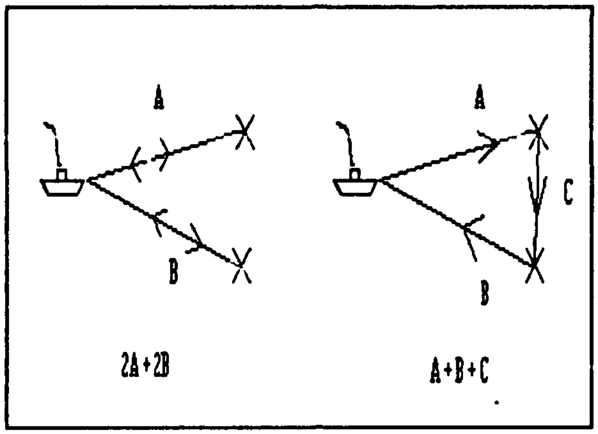

Figure 3-1.
CLARKE-WRIGHT EXAMPLE

For a problem with many ATON, a savings value is computed for all possible pairs of ATON. The pairs are ranked in descending order by their savings values to form a "savings list". The two aids of the first pair are then used to form an initial route. Each successive aid pair is then examined, with the result being one of three possible outcomes:

- If neither aid of the pair is already an end node of an existing route, then a new route is formed consisting of both aids of the pair, or

- If both aids of the pair are already end nodes of two different routes, then the routes are joined via the aid pair nodes to form a single route, or

- If one aid of the pair is already an end node of an existing route, then the route is extended to include the other aid of the pair.

All generated routes must conform to any imposed limits on length of cruise, length of work day, and buoy deck capacity. If one of the limits is exceeded, the resulting route is not accepted. If a route of just two aids violates one of the constraints, the two aids will be visited on separate, single-aid routes. If a single-aid route violates a constraint, the aid will not be serviced.

After examining all aid pairs and generating potential routes, the generated routes are put through an optimization procedure that alters the order in which the aids are visited to determine if any improvements in each route can be made. Subsequently, the route that results in the most aids being serviced in the shortest amount of time is selected. All aids included on this "optimum" route are removed from the savings list and the procedure is repeated for the remaining aids until all serviceable aids have been serviced.

Distances are recorded in nautical miles, and vessel speeds in nautical miles per hour (knots).

3.5.16 Surge Response

ATON surge response requirements place additional demands on the buoy tender fleet. Surge response refers to the need to service quickly large numbers of ATON discrepancies caused by weather extremes such as hurricanes, severe icing, and major coastal storms. Anticipating, preparing for, and responding to such requirements were not addressed directly in either the design or use of the DSS.

Indirectly, the need for surge response capability was acknowledged by generally steering the DSS-estimated ATON hours toward the lower side of the ATON resource hour targets of 1275 and 1260 hours for WLMRs and WLBRs, respectively. DSS district totals that showed average employment figures greater than the target figures were dismissed. DSS district totals that showed average employment figures between 80% and 100% of the target figures were considered acceptable in light of potential surge response requirements.

In the future, the discretionary multi-mission time component of the WLBRs is expected to provide additional surge response capability.

3.5.17 Lighthouse Maintenance

Historically, in Districts 1, 5, and 9, and since 1991 in District 13, WLMs and WLBs have been utilized to perform lighthouse maintenance and restoration functions. The tenders carry crews to the lighthouses, drop anchor, and generally remain until the crew has completed the required maintenance. The time spent on lighthouse maintenance generally ranges from 1 week for WLMRs to 2 weeks for WLBRs, of which the entire time is generally recorded as ATON resource hours.

Due to their relatively small number, the unique nature of the visits compared to normal ATON servicing, and the fact that lighthouses are generally not recorded in the USCG's Aids to Navigation Information System as being assigned to either WLMs or WLBs, lighthouse maintenance was not directly addressed in the design of the DSS. To incorporate its effect on current operations, the reported hours from the DSS validation runs for Districts 1 and 5 were augmented by 150 hours for WLMs and by 300 hours for WLBs. Because DSS validation runs were based on five-year data ending in 1989, no adjustments were made to District 13 results. For the replacement fleet DSS runs, it was assumed that approximately 250 hours per tender would be required in the future for lighthouse maintenance in Districts 1, 5, and 13. No distinction was made between WLMR and WLBR lighthouse maintenance requirements because any such distinction would result in the platform with the lower lighthouse maintenance requirement being more heavily favored in replacement fleet mix scenarios.

Complete lighthouse maintenance figures were not available for District 9. Thus, the validation results for District 9 did not take into account lighthouse maintenance. Nevertheless, DSS results indicated that accommodating 250 hours per replacement vessel would be feasible.

A concern that will need to be addressed by the USCG is that, in Districts 1, 5, 9, and 13, if the projected replacement fleet size is lower than the current size, the overall district buoy tender availability for lighthouse maintenance will be diminished.

3.5.18 Physical Serviceability

Four parameters are used in determining whether each of the three platform types -- BUSLR, WLMR, and WLBR -- are physically capable of servicing individual buoys: maximum lift weight, water depth, buoy height, and current primary unit. Other environmental considerations, such as currents, tides, winds and sea bottom types, are not a factor in the determination of physical serviceability, but are instead accounted for by the weather impact factor of the DSS.

Appendix E, "Physical Serviceability of Buoys by the BUSLR, WLMR, and WLBR" details the application of the four parameters and the resulting distribution of physical serviceability by the current primary units. The buoy types utilized in the determination of physical serviceability were based on the ATONIS "Authorized Hull" field, not on the ATONIS "On-Station Hull" field. This assumes that, where the two recorded hull types are different, the On-Station Hull will be replaced with the appropriate Authorized Hull.

The general assumption was made that all structures (lights and daybeacons) are physically serviceable by each of the three platforms.

3.5.19 Selection of Home Ports

There is no requirement to maintain present home ports. The selection of home ports is a function of ATON distribution and the suitability of potential sites (safe harbors, shore facilities, proximity of other USCG installations, etc.). When using the DSS, an attempt was made to assign WLBRs to current WLB ports and WLMRs to current WLM ports. This was done to acknowledge existing shore investments, relationships to local economies, and other factors that may have prompted the establishment of these sites as buoy tender home ports.

3.5.20 District Boundaries

There is no requirement to adhere to present Coast Guard district boundaries. These boundaries are, however, used as the logical starting points for replacement vessel areas of operation. Crossing district boundaries is possible when estimated ATON resource hours for a district fleet show either over- or under-utilization, and where district boundaries are adjacent (Districts 11 and 13, and Districts 1, 5, 7, and 8).

3.6 OPERATING THE DSS

3.6.1 Command Line Format

Once the DSS inputs have been prepared, the operation of the DSS is a straightforward process of preparing a one-line set-up command. A sample command is shown in Figure 3-2, along with a breakdown and brief description of its parameters.

```
USCG_BAT[1] W-10.SET[2], 9915508[3], "WLMR D7-A"[4], WLMR[5], SHIPS.TAB[6],
        GULF.NET[7], GULF.TAB[8], WLMR-D7A.SOL[9]
```

KEY

[1] Command name of buoy tender routing program.
[2] Name of program settings file containing:
- Off/On switch to control generation of trip displays;
- Size of servicing-date window (controls optimal routing feature);
- Number of days between vessel trip departure dates;
- First trip departure date;
- Time of vessel trip departure;
- Name of ATON database;
- Name of service times database;
- Off/On switch for adding overnight idle time to ATON hours total; and
- Off/On switch for adding weather impact time to ATON hours total.

[3] Home port ID number.
[4] Name of vessel (link to ATON database and vessels settings table).
[5] Type of vessel (part of link to service times database).
[6] Vessels settings table.
[7] Name of buoy tender travel network.
[8] Name of buoy tender travel network distances table.
[9] Name of solution file for program outputs.

Figure 3-2.
ATON SFM DSS COMMAND LINE FORMAT

Multiple vessels can be run by grouping their set-up commands and submitting them as a batch-type job. The run time required for an individual vessel depends primarily on the processing power of the computer being used, whether the optimal routing feature is active, the number of links in the travel network, and the number of ATON assigned to the vessel. Using 486-type MS-DOS microcomputers, the resulting run times ranged from one minute for a vessel with 30 aids to four hours for a vessel performing over 500 aid visits.

3.6.2 Conceptual Operation

When using the DSS to develop fleet size and mix scenarios, the following steps are followed:

1. Based on the district WLBR baseline requirements, WLBRs are allocated to home ports and assigned ATON until each WLBR's ATON hours is about equal to the WLBR ATON employment hours target of 1260 hours. Assignable ATON are first those that require WLBRs, and second, those that are serviceable by WLBRs. Selection of home ports is based on existing home port locations, location of assignable ATON, and probable WLMR locations.

2. If there are remaining unassigned ATON that require the use of WLBRs, adjacent districts (if any) are examined to determine if sufficient WLBR capacity is available, or could be made available, to meet the unmet WLBR requirement. If so, the remaining WLBR-only ATON are assigned accordingly to WLBRs from adjacent districts. If not, additional WLBRs are allocated, and Step 1 is repeated utilizing an appropriate increase to the baseline WLBR requirement.

   At the conclusion of Steps 1 and 2, all ATON requiring service by a WLBR will have been assigned to WLBRs. Therefore, due to the greater cost of a WLBR compared to a WLMR, the determination of the required number of WLBRs is generally complete. Potential exceptions can occur in those areas where the greater weather impact on a WLMR, when compared to a WLBR, significantly favors the use of the WLBR platform.

3. Based on the remaining unassigned ATON that are not serviceable by BUSLRs and therefore require the use of WLMRs, WLMRs are allocated to home ports and assigned ATON. As with WLBRs, the number of ATON assigned to each WLMR is modified until the ATON hours result is about equal to the WLMR ATON employment hours target of 1275 hours. Assignable ATON are first those that require WLMRs and second those that

are serviceable by WLMRs. At the conclusion of this step, all ATON requiring service by a WLMR will have been assigned to a WLMR.

4. Any remaining unassigned ATON are, by definition, capable of being serviced by BUSLRs. These ATON are individually examined to determine if actual assignment to a BUSLR is feasible based on proximity to existing USCG ATON units (ANTs and buoy tender home ports). If off-loading to a BUSLR is not feasible, Steps 1 through 3 are repeated with the goal of isolating aid groups that are candidates for either assignment to BUSLRs or to buoy tenders from adjacent districts. If such groupings cannot be made, the remaining ATON are designated as requiring WLMRs, and Step 3 is repeated utilizing an appropriate increase to the baseline WLMR requirement.

3.7 DSS OUTPUTS

3.7.1 Vessel Summary Report

The primary output from the DSS is the Vessel Summary Report, a sample of which is shown in Figure 3-3. This report summarizes the parameters under which the vessel was operated and provides the bottom-line determination of the number of hours required by a vessel to service its assigned set of ATON. The hours are broken down by transit time, service time, idle (waiting for daylight) time, additional preparation/de-preparation time, discrepancy response time, and weather impact time.

3.7.2 Vessel Detail Report

The Vessel Detail Report shows the itineraries followed by the vessel on each of its trips. Included on this report are departure and arrival times, idle time, type of servicing performed at each aid, total trip hours, and underway days. An example of this report is shown in Appendix F.

3.7.3 GIS-Based Trip Displays

As an optional feature for each DSS vessel run, the generated vessel routes can be captured and formatted for display through the GIS. This feature is most useful for validating the viability of generated routes and for presentation purposes. A sample for the WLM White Sumac out of St. Petersburg, FL is shown in Figure 3-4.

```
10:9:40
Friday 3/20/1992          ATON SERVICE FORCE MIX DSS          W-SUMAC.REP

VESSEL SUMMARY REPORT
=====================
Platform Characteristics
-----------------------
     - WLM WHITE SUMAC
     - Homeport ST PETERSBURG, FL
     - 8 knot average transit speed
     - 72 hour maximum cruise length
     - work day is  6:00 to  16:00
     - 1000 sq.ft. deck space available
     - Prep/Deprep time  0:30
     - Dispatch Tuesday 1/1/1991 at 6:00
       (Window size = 365 days, Step size = 10 days)

Summary Statistics
------------------
            Total ATON assigned         = 213  (  0 Seasonal)
            Total ATON serviced         = 213  (  0 Seasonal)
            Total trips                 =  19
            Underway days               =  56

            Deck Space Available        = 19000
            Deck Space Used             = 10707.2  (56.4% utilization)

            Avg buoys / trip            = 11.2
            Avg underway days / trip    = 2.9

            Total transit time          =  652:57
            Total service time          =  162:17
            Total idle time             =  160:50
                        Total time                     =  976:05
                                                         -------
            Total short transits        = 162
            Total length of short trips =   19:22
                        Additional prep/deprep time    =   61:38
                                                         -------
            Avg service time / ATON     =    0:46
            Avg transit time / ATON     =    3:21
            Avg total time / ATON       =    4:52

            Total discrepancies         = 40
                        Computed discrepancy hours     =  194:52
                                                         -------
            Additional Structure Visits = 0
                        Additional Structure hours     =    0:00
                                                         -------
                        Total weather hours            =   24:00
                                                         -------
                        Same time servicing (subtract) =    0:00
                                                         -------

                                    Total ATON hours used         = 1256:35
                                                                    =======

                                    Historical ATON hours used    = 1248:00
                                                                    =======
```

Figure 3-3.
VESSEL SUMMARY REPORT

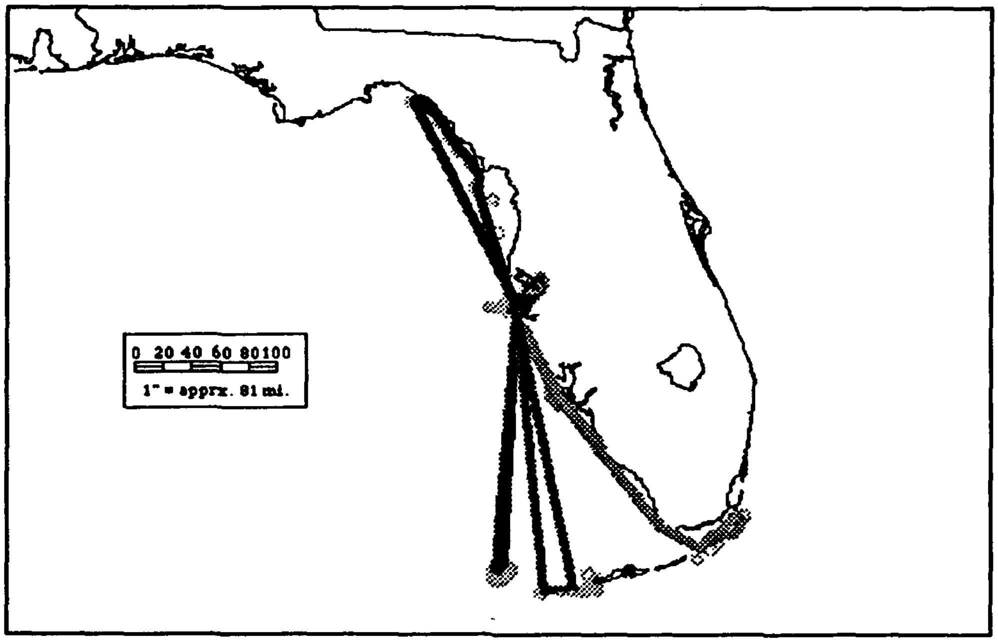

Figure 3-4.
SAMPLE WHITE SUMAC DSS TRIPS

4. DATA REQUIREMENTS AND SOURCES

The ATON Service Force Mix DSS requires extensive data on the underlying geographic and hydrographic characteristics of U.S. coastlines and waterways, on ATON, and on both existing and replacement ATON platforms.

4.1 GEOGRAPHIC DATA

United States shoreline and waterway data are the geographic underlays of the DSS. Once these data are established, it is possible to locate ATON and home ports and to develop vessel transit routes and servicing trips. The accuracy of these data are essential for producing reliable results with the DSS.

4.1.1 Shorelines

A digitized shoreline map that includes the U.S. mainland and island coastlines is a standard feature of the GIS software utilized by the DSS. This standard map was used as a baseline for the manual development of simplified coastline data that facilitated the development of the transportation networks required by the DSS' vehicle routing algorithms. The simplified coastlines still account for all relevant land formations, but disregard irregular coastlines in those areas not having ATON currently assigned to WLMs or WLBs. Figure 4-1 shows an example of the standard coastline used for the southern portion of District 1, Figure 4-2 shows the simplified version of the same coastline, and Figure 4-3 shows the buoy tender travel network produced using the simplified coastline.

The standard coastline data are primarily intended to represent the boundaries of the 50 states. The representation of waterways wholly contained within an individual state was often not sufficient for representing the areas of operation of the buoy tender fleet. As a result, in some areas the simplified coastline actually contains greater detail than the standard coastline. This can be seen in Figures 4-1 and 4-2 in the areas of the Hudson River and the Cape Cod Canal.

4.1.2 Home Port and Aid Locations

Navigation charts provided the approximate latitude and longitude coordinates for existing WLB and WLM home ports and for potential home ports for the replacement fleet. These sites were manually entered into the GIS.

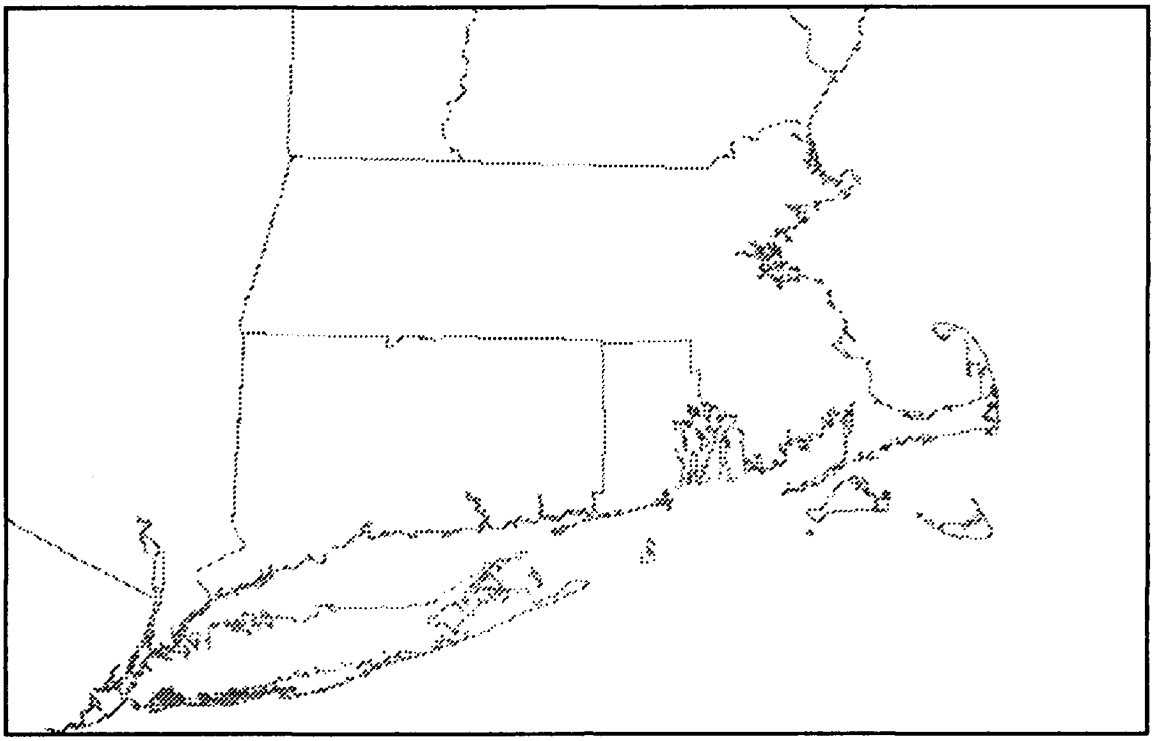

Figure 4-1. SOUTHERN NEW ENGLAND STANDARD COASTLINE

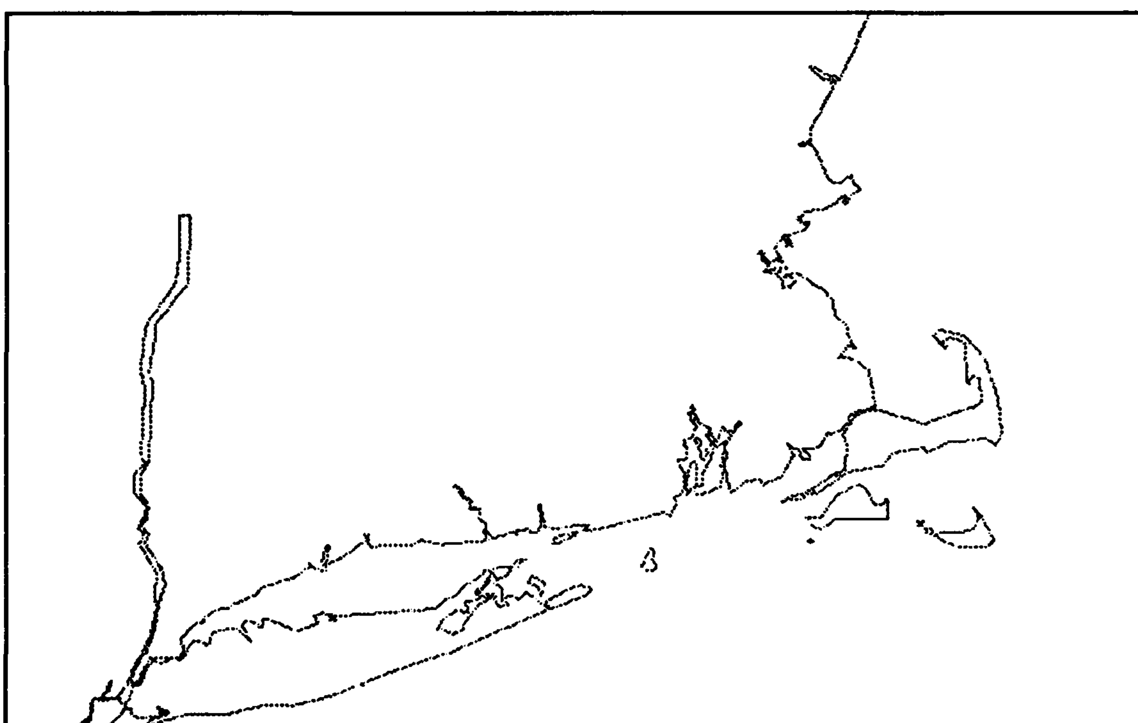

Figure 4-2. SOUTHERN NEW ENGLAND
SIMPLIFIED COASTLINE FOR NETWORK BUILDING

Figure 4-3. SOUTHERN NEW ENGLAND
BUOY TENDER TRAVEL NETWORK

Latitude/longitude coordinates for ATON were obtained from the Coast Guard's Aids to Navigation Information System (ATONIS).

4.1.3 Navigable Waters

Avoidance of land formations was the only restriction in determining what is and is not navigable water. All water was considered navigable for the purposes of building transportation networks. Depth of water constraints were imposed only when assigning vessels to ATON (a WLBR could not be assigned an aid located in less than 18 feet of water unless it was presently serviced by a WLB). The capability exists within the DSS to add waterway channels to the network building process in future versions of the DSS.

4.2 AIDS TO NAVIGATION (ATON) DATA

Virtually all of the ATON physical characteristics data were obtained from ATONIS and the Light List. ATONIS is a Coast Guard data base containing comprehensive information on all ATON in the U.S. The Light List is an annual Coast Guard publication. The majority of the operational procedures data was obtained from the Buoy Tender Operations Survey conducted by the Coast Guard and the Volpe Center in

October 1991. Additional operational information was taken from earlier technical reports produced by the Volpe Center[1].

Each district maintains, for its own ATON, an ATONIS data base that conforms to a standard data dictionary established by USCG headquarters. The data are organized into tables, two of which are significant to this project: (1) the AID Table, in which all ATON and their characteristics are recorded; and (2) the DISCREPANCY Table, which contains information related to non-scheduled servicing.

The Light List was used to check position locations specified in the AID Table. Differences between the two sources were electronically mailed to the appropriate districts for resolution. The correct positions were then updated in the DSS, as well as in the districts' own data bases, when necessary.

4.2.1 Aid Types and Characteristics

There are four basic aid types: lighted buoys, unlighted buoys, lights, and day beacons. Essential data for a description of each aid are from the ATONIS AID Table, which contains one record for each aid. The table is updated every time an aid is serviced and every time a characteristic of an aid changes.

The key data fields obtained from the AID Table relating to aid types and characteristics are as follows.

Aid identification information:
- aid number;
- aid name;
- district; and
- light list number.

Aid physical characteristics:
- aid type;
- authorized hull;
- chain length; and
- chain size.

[1] Factors Affecting Aid Service Times in the First Coast Guard District. Report Number DOT-TSC-CG-569-TM3, U.S. Department of Transportation, Transportation Systems Center. January, 1985.

Service Vessel Analysis Vol. I: Seagoing and Coastal Vessel Requirements for Servicing Aids to Navigation. Report Number DOT-TSC-CG-87-2,1, U.S. Department of Transportation, Transportation Systems Center. September, 1987.

Aid location:
- environment; and
- latitude/longitude.

4.2.2 Servicing Requirements and Schedules

The following information on scheduled servicing requirements also was obtained from the ATONIS database for each aid:

- primary unit;
- date of last inspection;
- date of last mooring inspection;
- date of last recharge;
- date of last relief; and
- seasonal placement and relief dates.

From this information it was possible to determine the name of the primary platform responsible for each aid, when ATON had last been serviced, the type of service performed, and the placement and relief dates (generally spring and fall) required for seasonal ATON.

4.2.3 Discrepancies

Information on discrepancy response servicing of ATON was obtained from two sources: the ATONIS DISCREPANCY Table; and the Buoy Tender Operations Survey.

The DISCREPANCY Table contains one record for each discrepancy. Information on the record includes identification of the discrepant aid, the cause of the discrepancy, the dates it occurred and was fixed, and the unit responding. The fields of significance to this analysis are:

- aid number; and
- responding unit.

The survey, discussed more fully below, provided the following discrepancy-related information:

- number of discrepancies to assigned ATON during ATONIS period, and average number per year;
- number of discrepancies responded to by vessel during ATONIS period, and average number per year; and
- average annual resource hours for discrepancy response.

4.2.4 Service Times

Information on service times was obtained from the two Volpe Center reports referenced earlier and from the Buoy Tender Operations Survey. The survey, which was conducted jointly by the Coast Guard and the Volpe Center, had three major objectives:

1. To validate buoy tender data contained in other Coast Guard data sources;
2. To obtain individual district and vessel perspectives on buoy tender operations; and
3. To gather data on buoy tender operations not available from any other source.

The Buoy Tender Operations Survey was designed to obtain information from the persons most qualified to respond because of their expert knowledge of and experience with buoy tender operations in the field: the vessel COs and representatives of each district's Aids to Navigation Branch. The survey forms, shown in Appendix G, consist of two sections: a district section requesting information on buoy service times; and a buoy tender section requesting information on operations, discrepancies, weather effects, and the fixed structures serviced by buoy tenders.

Telephone conference calls were jointly conducted with each district by personnel from the Volpe Center and G-NSR to review the survey. The calls proved to be an effective mechanism for resolving questions, clarifying the nature and intended use of the survey questions, completing the surveys, and discussing key ATON issues.

Hard copy or electronic versions of all survey forms were forwarded to the Volpe Center for input into a data base of survey responses. Appendix H contains the one-page summaries of the survey responses for all WLMs and WLBs. The service time results from the survey are shown in Appendix B. Key data fields relating to WLB and WLM buoy service times and to expected service times for WLBRs and WLMRs include the following:

For lighted buoys in both exposed and non-exposed locations:
- inspection time;
- inspection and mooring time;
- inspection, mooring, and recharge time;
- inspection and recharge time;
- mooring and relief time; and
- relief time.

For unlighted buoys in both exposed and non-exposed locations:
- inspection time;

- inspection and mooring time;
- mooring and relief time; and
- relief time.

For seasonal buoys (not replaced) in both exposed and non-exposed locations:
- place in spring time; and
- remove in fall time.

For seasonal buoys (replaced) in both exposed and non-exposed locations:
- relief time; and
- relief and mooring time.

Servicing of fixed structure ATON:
- number of annual visits;
- hours per visit;
- average visits and hours for lights;
- average visits and hours for day beacons; and
- indication whether structure could be serviced by ANT/BUSL.

4.3 PLATFORM DATA

The general performance and operating characteristics of the ATON platforms were obtained from G-NSR and are shown below in Table 4-1.

Table 4-1.
PLATFORM OPERATING CHARACTERISTICS

Performance Factor	133' WLM	157' WLM	WLMR	WLB	WLBR	BUSLR
Cargo deck capacity (ft^2)	1000	1200	1200	1600	2500	225
Lift capacity (tons)	10	10	10	20	20	2.25
Maximum speed (knots)	9.8	12.8	12	13	15	11.5
Transit speed (knots)	7.2	9.3	10	9.5	12	11.5
Target underway days per year	150	150	150	150	150	na
ATON work time/UW day (hrs)	10	10	10	14	14	10
Draft (feet)	9	6	8.5	12	14	5.5
Minimum operating depth (feet)	13	10	12	16	18	5.5
Sea-keeping ability (feet)	2	2	3	6	8	2

These data were augmented with additional data from the Coast Guard Annual Abstract of Operations and the Buoy Tender Operations Survey. The information from each of these sources was combined and, through discussions with personnel from G-NSR, a composite description of the platforms was developed.

The districts provided the following types of information on platform characteristics and operations.

Revisions to abstract of operations data:

- ATON resource hours;
- ATON in-port operations hours;
- USCG overhead resource hours;
- USCG overhead I/O hours;
- essential multi-mission resource hours;
- essential multi-mission I/O hours;
- other multi-mission resource hours;
- other multi-mission I/O hours;
- total underway resource hours;
- total underway days;
- average underway resource hours/day; and
- total high readiness days.

Buoy tender operating characteristics:

- average transit speed;
- average, maximum, and minimum length of ATON mission trip;
- average length of ATON work day; and
- percentage of buoys and structures regularly serviced by small boat.

Effects of weather on buoy tender operation:

- average ATON resource hours attributable to weather impacts;
- distribution of weather hours by environment;
- projected ATON resource hours attributable to weather impacts (based on replacement vessel features); and
- distribution of projected replacement vessel weather hours by environment.

5. VALIDATION OF THE DSS

5.1 OBJECTIVE

Validation of any mathematical model and associated analytical procedures entails testing the model and procedures to help ensure their usefulness and reliability when applied for their intended purposes. Some of these tests are conceptual or theoretical. For example, relationships imbedded in the model, as represented by embodied algorithms, mathematical structure, variables, coefficients, and other parameters, must conform to hypotheses related to these relationships. For instance, raising and lowering the values of input variables should result in expected changes in model outputs, in terms of direction (increase or decrease) and rough order of magnitude. Similarly, data needed to run the model must be available at reasonable cost, and with reasonable levels of precision and accuracy relative to the problem and application.

The major effort in validating a proposed model is the use of that model to predict or forecast a known situation. Although the ability to replicate existing conditions does not guarantee the accuracy of future-year forecasts, the failure to do this with reasonable accuracy would cast significant doubt on the model's reliability for use in evaluating alternative proposed actions, i.e., when used in a true forecasting mode. As a result, the DSS, which was designed to help evaluate alternative future buoy tender fleets, was applied to the present fleet and aid assignments to try to replicate current ATON operations.

5.2 MEASURES OF VALIDITY

The DSS is not intended to simulate individual trip routes in day-to-day vessel operations, but instead, to develop annual estimates of vessel resources required to service ATON in a timely and efficient manner. The primary measure used to assess the validity of the DSS is total ATON hours required to perform one year's ATON work. This value was generated for each of the 37 vessels in the current fleet, summed by district, and compared with the actual five-year average district ATON hours obtained from the Coast Guard FY86-FY90 Abstract of Operations.

The choice of ATON hours as the primary validity measure was primarily due to the fact that it was the only measure that could be obtained from the historical data describing vessel performance. Although "underway days" is the basis for buoy tender operations standards, the number of these days devoted to ATON purposes cannot be determined from the Abstract of Operations data. Similarly, the number of ATON trips made by a vessel cannot be determined. Furthermore, even if it were possible to determine either trips or days, both of these measures are less precise than hours.

Historical ATON hours were analyzed to identify and explain outliers. Unusually high or low ATON hours for a particular year are typically due to extenuating circumstances. For example, in 1989, when the WLB Iris was sent to Alaska to support the Valdez clean-up efforts, the remaining buoy tender in District 13, the 175-foot WLM Fir (since de-commissioned), recorded 50% more ATON hours than the previous year. Among districts, variations in ATON hours are sometimes due to differing interpretations of ATON hour reporting categories, with some districts including NOAA buoy time, and some including multi-mission time. To eliminate such differences, the Buoy Tender Operations Survey included a question which defined the various categories, and asked respondents either to confirm or to adjust the historical numbers appropriately.

The validation focuses on district total ATON hours rather than on individual vessel ATON hours, because of anomalies in ATON hour reporting at the vessel level. The types of situations described above, as well as other circumstances in which one vessel in a district might accrue more ATON hours than normal from performing additional work for another vessel in repair for much of the year, render reported ATON hours for individual vessels less stable than district totals. Information needed to adjust historical ATON hours at the vessel level was often unavailable, and the district level was considered appropriate.

5.3 REPLICATING CURRENT OPERATIONS

5.3.1 Key DSS Parameters

To run the DSS, three important input parameters must be set for each vessel:

- average transit speed in knots;
- cruise length in hours; and
- length of work day in hours.

The approach taken in setting these parameters was to standardize as much as possible. This ignores some of the known idiosyncratic factors and differences among vessels and operating environments, but is a better validation test because standardized values will have to be employed when the DSS is used in a forecasting mode.

Initially, the "white" WLM speeds were set at 10 knots, the "red" WLM speeds at 11.5 knots, and the WLB speeds at 9 knots. These values were obtained from G-NSR as average transit speeds for each vessel type, and do not include the time spent slowing down and speeding up when arriving at or departing from an aid or home port. The standard average cruise length was set at 72 hours, and the length of work day at 10 hours for the WLMs and 12 hours for the WLBs. (These parameters and values were discussed earlier in Chapter 3.)

In most instances, these standard parameters do not accurately represent actual operations. Usually, they are close enough that the DSS produces a reasonable result, but there are exceptions. For example, in operational areas characterized by extremely long transit distances and sparse aid density, a transit speed of 9 knots was too low for a WLB. Ships that must transit long distances to reach a group of island aids -- such as in Districts 14 and 17 -- face such situations. In both of these cases, the standard cruise length of 72 hours was too low, and thus was increased. Also, several vessels in Districts 7 and 14 were segmented to account for wide variances in the types of operations conducted during the course of a year, and lighthouse maintenance hours were added in Districts 1 and 5, where these constitute significant ATON activities. Thus, non-standardized parameter values were used where appropriate.

5.3.2 Validation Results

Table 5-1 summarizes, by vessel and by district, input assumptions and DSS results, including comparisons of historical ATON hours and ATON hours projected by the DSS assuming current aid assignments for each vessel. Overall, the DSS projected 39,592 ATON hours for the fleet compared to the historical fleet total of 41,358, i.e., the projected hours were about 96% of the actual hours.

A statistical analysis validated DSS results at the district level. Mean DSS hours were compared to historical means using three different ranges: (1) a 95% confidence interval about the survey mean; (2) the historical range of ATON hours from six years of Abstract data; and (3) the survey mean plus or minus ten percent. Mean DSS results for eight of the nine districts were well within the statistical ranges; only District 8 DSS results fell just below the ranges. Appendix I shows the detailed results of the comparisons, as well as the five years of Abstract of Operations data upon which the confidence intervals were based. Overall, by all three measures, the DSS projections represent current operations accurately.

5.4 SUBSTITUTION OF THE REPLACEMENT FLEET

A second validation test was carried out to examine DSS performance. This test assumed a one-for-one replacement of all current WLBs and WLMs with their corresponding replacement vessels (WLBRs and WLMRs). A one-for-one replacement is not expected from an ATON servicing perspective because of the improved capabilities of the replacement vessels. However, this was felt to be a useful additional validation in that it enabled the Coast Guard to judge whether the DSS-projected reductions in ATON times were consistent with the improved vessel capabilities.

Table 5-1.
ATON SFM DECISION SUPPORT SYSTEM
STANDARDIZED CURRENT FLEET RESULTS

Vessel	District & Type	ATON	Trip Length	Knots	Hours/ Day	DSS Hours	Historical Hours	Differ ence	Avg %
BITTERSWEET	1 -WLB	133	72	9.0	12	848	1047	-199.0	
SORREL	1 -WLB	145	72	9.0	12	927	1040	-113.0	
SPAR	1 -WLB	190	72	9.0	12	1251	1258	-7.0	
RED BEECH	1 -WLM	266	72	11.5	10	857	888	-31.0	
RED WOOD	1 -WLM	262	72	11.5	10	907	1045	-138.0	
WHITE HEATH	1 -WLM	294	72	9.5	10	1123	1072	51.0	
WHITE LUPINE	1 -WLM	417	72	9.5	10	1265	1089	176.0	
WHITE SAGE	1 -WLM	274	72	9.5	10	981	946	35.0	
District	1 Totals	1981				8159	8385	-226.0	97.3
	Avg	247.6				1020	1048	-28.3	
COWSLIP	5 -WLB	178	72	9.0	12	1179	1151	28.0	
GENTIAN	5 -WLB	85	72	9.0	12	751	997	-270.0	
HORNBEAM	5 -WLB	91	72	9.0	12	907	905	2.0	
RED BIRCH	5 -WLM	311	72	11.5	10	896	1071	-175.0	
RED CEDAR	5 -WLM	337	72	11.5	10	1008	1286	-278.0	
RED OAK	5 -WLM	245	72	11.5	10	861	1084	-223.0	
District	5 Totals	1247				5578	6494	-916.0	85.9
	Avg	207.8				930	1082	-152.7	
LAUREL	7 -WLB	166	72	9.0	12	1182	842	340.0	
LAUREL-SOUTH	7 -WLB	175	720	9.0	12	513	513	0.0	
MADRONA	7 -WLB	195	72	9.0	12	717	942	-225.0	
MADRONA-SOUTH	7 -WLB	125	720	9.0	12	516	516	0.0	
WHITE SUMAC	7 -WLM	213	72	8.0	10	1257	1248	9.0	
District	7 Totals	874				4185	4061	124.0	103.1
	Avg	291.3				1395	1354	41.3	
PAPAW	8 -WLB	148	72	9.0	12	719	1300	-581.0	
SALVIA	8 -WLB	120	72	9.0	12	954	1282	-328.0	
WHITE HOLLY	8 -WLM	221	72	8.0	10	1371	1404	-33.0	
WHITE PINE	8 -WLM	210	72	8.0	10	1372	1145	227.0	
District	8 Totals	699				4416	5131	-715.0	86.1
	Avg	174.8				1104	1283	-178.8	
ACACIA	9 -WLB	243	240	10.0	16	860	663	197.0	
BRAMBLE	9 -WLB	249	240	10.0	16	786	965	-179.0	
SUNDEW	9 -WLB	242	240	11.0	16	521	637	-116.0	
District	9 Totals	734				2167	2265	-98.0	95.7
	Avg	244.7				722	755	-32.7	
BLACKHAW	11 -WLB	170	72	10.0	12	1446	1200	246.0	
CONIFER	11 -WLB	135	72	10.0	12	761	1000	-239.0	
District	11 Totals	305				2207	2200	7.0	100.3
	Avg	152.5				1104	1100	3.5	
IRIS	13 -WLB	156	72	10.0	12	1350	1328	22.0	
MARIPOSA	13 -WLB	137	72	9.5	10	732	856	-124.0	
District	13 Totals	293				2082	2184	-102.0	95.3
	Avg	146.5				1041	1092	-51.0	
BASSWOOD GUAM	14 -WLB	54	120	10.0	12	292	395	-103.0	
BASSWOOD PHILIPP	14 -WLB	16	720	10.0	12	344	344	0.0	
BASSWOOD.SOLOMON	14 -WLB	62	720	10.0	12	232	232	0.0	
MALLOW HAWAII	14 -WLB	68	120	10.0	12	268	112	156.0	
MALLOW JOHNSTON	14 -WLB	30	720	10.0	12	210	210	0.0	
MALLOW MARSHALL	14 -WLB	41	720	10.0	12	541	541	0.0	
SASSAFRAS HAWAII	14 -WLB	99	120	10.0	12	501	281	220.0	
SASSAFRAS MIDWAY	14 -WLB	18	720	10.0	12	352	411	-59.0	
SASSAFRAS SAMOA	14 -WLB	28	720	10.0	12	596	618	-22.0	
District	14 Totals	416				3336	3144	192.0	106.1
	Avg	138.7				1112	1048	64.0	
FIREBUSH	17 -WLB	139	240	10.0	12	1148	1194	-46.0	
IRONWOOD	17 -WLB	94	240	10.0	12	1911	1769	142.0	
PLANETREE	17 -WLB	257	120	10.0	12	1097	1262	-165.0	
SEDGE	17 -WLB	97	120	10.0	12	914	867	47.0	
SWEETBRIER	17 -WLB	123	120	10.0	12	1181	948	233.0	
WOODRUSH	17 -WLB	234	120	10.0	12	1211	1454	-243.0	
District	17 Totals	944				7462	7494	-32.0	99.6
	Avg	157.3				1244	1249	-5.3	
CG Fleet	Totals	7493				39592	41358	-1766.0	95.7
	Avg	202.5				1070	1118	-47.7	

5.4.1 Input Assumptions

In the one-for-one replacement runs, the only DSS parameters changed were average transit speeds (generally higher), deck space available on WLBs, and service times reflecting the improved seakeeping and navigational capabilities of the new vessels. Each replacement vessel serviced the same set of assigned ATON as its current counterpart.

5.4.2 Projected ATON Hours

Table 5-2 summarizes the input assumptions and results of the one-for-one replacement tests, using the same format as in Table 5-1 (current fleet). Again, several vessels in Districts 7 and 14 were segmented, and lighthouse maintenance hours were added to DSS output in Districts 1 and 5. The results indicate that simply replacing the current vessels with their replacement counterparts would save 21% or 8,500 ATON hours. These savings are spread over all vessels and districts, with the greatest savings in Alaska where the replacement vessel service times are dramatically lower than those for the current vessels because of their improved seakeeping and positioning abilities.

Figure 5-1 summarizes by district the total historical ATON resource hours, the DSS current fleet validation results, and the one-for-one replacement vessel results.

Table 5-2.
ATON SFM DECISION SUPPORT SYSTEM
STANDARDIZED ONE-FOR-ONE REPLACEMENT RESULTS

Vessel	District & Type	ATON	Trip Length	Knots	Hours/ Day	DSS Hours	Historical Hours	Differ ence	Avg %
BITTERSWEET	1 -WLBR	133	72	12.0	12	834	1047	-213.0	
SORREL	1 -WLBR	145	72	12.0	12	716	1040	-324.0	
SPAR	1 -WLBR	190	72	12.0	12	870	1258	-388.0	
RED BEECH	1 -WLMR	266	72	10.0	10	707	888	-181.0	
RED WOOD	1 -WLMR	262	72	10.0	10	778	1045	-267.0	
WHITE HEATH	1 -WLMR	294	72	10.0	10	905	1072	-167.0	
WHITE LUPINE	1 -WLMR	417	72	10.0	10	1026	1089	-63.0	
WHITE SAGE	1 -WLMR	274	72	10.0	10	913	946	-33.0	
District	1 Totals	1981				6749	8385	-1636.0	80.5
	Avg	247.6				844	1048	-204.5	
COWSLIP	5 -WLBR	178	72	12.0	12	977	1151	-174.0	
GENTIAN	5 -WLBR	85	72	12.0	12	710	997	-287.0	
HORNBEAM	5 -WLBR	91	72	12.0	12	789	905	-116.0	
RED BIRCH	5 -WLMR	311	72	10.0	10	787	1071	-284.0	
RED CEDAR	5 -WLMR	337	72	10.0	10	875	1286	-411.0	
RED OAK	5 -WLMR	245	72	10.0	10	837	1084	-247.0	
District	5 Totals	1247				4975	6494	-1519.0	76.6
	Avg	207.8				829	1082	-253.2	
LAUREL	7 -WLBR	166	72	12.0	12	781	842	-61.0	
LAUREL-SOUTH	7 -WLBR	175	720	12.0	12	424	513	-89.0	
MADRONA	7 -WLBR	195	72	12.0	12	651	942	-291.0	
MADRONA-SOUTH	7 -WLBR	125	720	12.0	12	424	516	-92.0	
WHITE SUMAC	7 -WLMR	213	72	10.0	10	907	1248	-341.0	
District	7 Totals	874				3187	4061	-874.0	78.5
	Avg	291.3				1062	1354	-292.0	
PAPAW	8 -WLBR	148	72	12.0	12	552	1300	-748.0	
SALVIA	8 -WLBR	120	72	12.0	12	608	1282	-674.0	
WHITE HOLLY	8 -WLMR	221	72	10.0	10	1121	1404	-283.0	
WHITE PINE	8 -WLMR	210	72	10.0	10	990	1145	-155.0	
District	8 Totals	699				3271	5131	-1860.0	63.7
	Avg	174.8				818	1283	-465.0	
ACACIA	9 -WLBR	243	240	12.0	16	682	663	19.0	
BRAMBLE	9 -WLBR	249	240	12.0	16	614	965	-351.0	
SUNDEW	9 -WLBR	242	240	12.0	16	450	637	-187.0	
District	9 Totals	734				1746	2265	-519.0	77.1
	Avg	244.7				582	755	-173.0	
BLACKHAW	11 -WLBR	170	72	13.0	12	1076	1200	-124.0	
CONIFER	11 -WLBR	135	72	13.0	12	632	1000	-368.0	
District	11 Totals	305				1708	2200	-492.0	77.6
	Avg	152.5				854	1100	-246.0	
IRIS	13 -WLBR	156	72	13.0	12	1044	1328	-284.0	
MARIPOSA	13 -WLBR	137	72	13.0	12	492	856	-364.0	
District	13 Totals	293				1536	2184	-648.0	70.3
	Avg	146.5				768	1092	-324.0	
BASSWOOD GUAM	14 -WLBR	54	120	13.0	12	248	395	-147.0	
BASSWOOD PHILIPP	14 -WLBR	16	720	13.0	12	271	344	-73.0	
BASSWOOD SOLOMON	14 -WLBR	62	720	13.0	12	189	232	-43.0	
MALLOW HAWAII	14 -WLBR	68	120	13.0	12	203	112	91.0	
MALLOW JOHNSTON	14 -WLBR	30	720	13.0	12	171	210	-39.0	
MALLOW MARSHALL	14 -WLBR	41	720	13.0	12	429	541	-112.0	
SASSAFRAS HAWAII	14 -WLBR	99	120	13.0	12	432	281	151.0	
SASSAFRAS MIDWAY	14 -WLBR	28	720	13.0	12	280	411	-131.0	
SASSAFRAS SAMOA	14 -WLBR	18	720	13.0	12	468	618	-150.0	
District	14 Totals	416				2691	3144	-453.0	85.6
	Avg	138.7				897	1048	-151.0	
FIREBUSH	17 -WLBR	139	240	13.0	12	793	1194	-401.0	
IRONWOOD	17 -WLBR	94	240	13.0	12	1234	1769	-535.0	
PLANETREE	17 -WLBR	257	120	13.0	12	815	1262	-447.0	
SEDGE	17 -WLBR	97	120	13.0	12	673	867	-194.0	
SWEETBRIER	17 -WLBR	123	120	13.0	12	804	948	-144.0	
WOODRUSH	17 -WLBR	234	120	13.0	12	903	1454	-551.0	
District	17 Totals	944				5222	7494	-2272.0	69.9
	Avg	157.3				870	1249	-378.7	
CG Fleet	Totals	7493				31085	41358	-10273.0	75.2
	Avg	202.5				840	1118	-277.6	

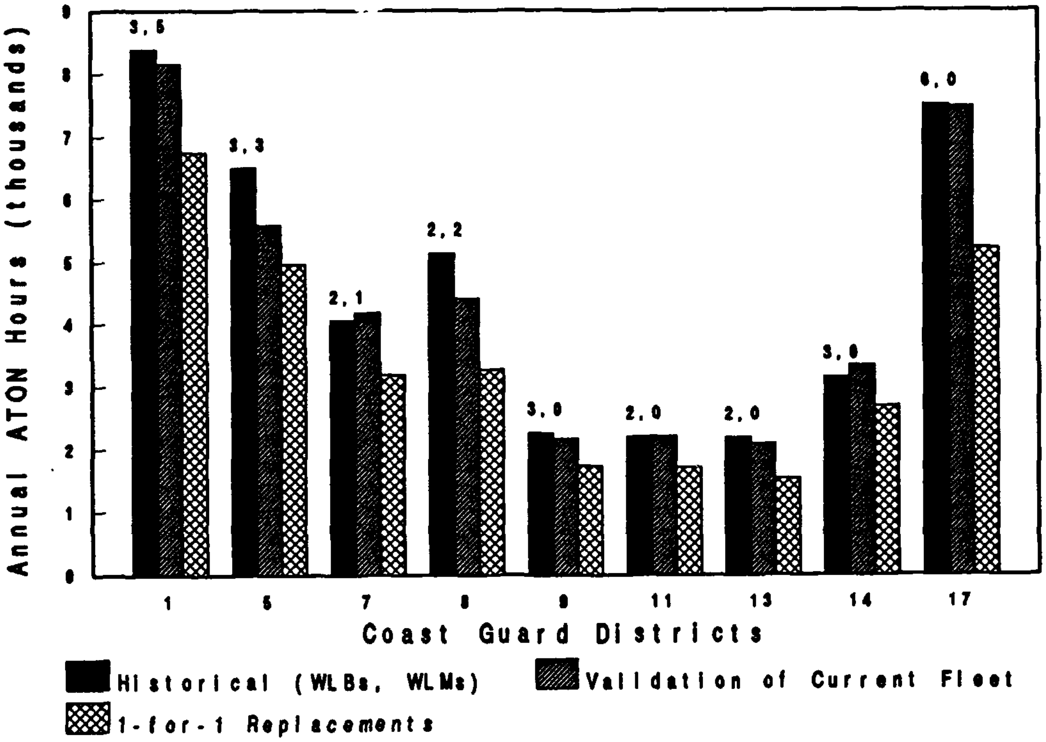

Figure 5-1.
DISTRICT FLEET VALIDATION RESULTS

6. PROPOSED SERVICE FORCE MIX

6.1 DISTRICT RESULTS

The proposed service force mix developed from the ATON Service Force Mix Decision Support System is 16 WLBRs, 14 WLMRs, and one BUSLR (in District 8). Table 6-1 summarizes the DSS results.

Table 6-1. SUMMARY OF PROPOSED BUOY TENDER FLEET

		------Current Fleet------			---------Proposed Fleet---------			
District	Home Port	Type	ATON	Historical Hours	Type	ATON	DSS Hours	
1	NEW YORK	WLB	145	1040	----			
	WOODS HOLE	WLB	133	1047	----			
	SOUTH PORTLAND	WLB	190	1258	WLBR	297	1153	
	NEW YORK	WLM	266	888	WLMR	390	1086	
	NEW LONDON	WLM	262	1045	WLBR	232	1076	
	BRISTOL	WLM	274	946	WLMR	344	1246	
	BOSTON	WLM	294	1072	WLMR	300	1202	
	ROCKLAND	WLM	417	1089	WLMR	418	1200	
	District 1 Totals		1981	8385		1981	6963	Avg: 1161
5	CAPE MAY	WLB	91	905	WLBR	244	1071	
	PORTSMOUTH	WLB	178	1151	WLMR	401	1263	
	ATLANTIC BEACH	WLB	85	997	WLMR	194	1267	
	PHILADELPHIA	WLM	245	1084	----			
	BALTIMORE	WLM	311	1071	WLMR	408	1120	
	PORTSMOUTH	WLM	337	1286	----			
	District 5 Totals		1247	6494		1247	4721	Avg: 1180
7	MAYPORT	WLB	341	1355	----			
	MIAMI	---			WLBR	407	1258	
	CHARLESTON	WLB	320	1458	WLMR	254	1292	
	ST PETERSBURG	WLM	213	1248	WLMR	213	916	
	District 7 Totals		874	4061		874	3466	Avg: 1155
8	GALVESTON	WLB	148	1300	WLMR	196	1127	
	MOBILE	WLB	120	1282	WLBR	243	1085	
	NEW ORLEANS	WLM	221	1404	BUSLR	49		
	MOBILE	WLM	210	1145	WLMR	211	1216	
	District 8 Totals		699	5131		699	3428	Avg: 1143
9	CHARLEVOIX	WLB	243	663	WLBR	391	1097	
	PORT HURON	WLB	249	965	WLBR	343	959	
	DULUTH	WLB	242	637	----			
	District 9 Totals		734	2265		734	2056	Avg: 1028
11	SAN FRANCISCO	WLB	170	1200	WLBR	175	1137	
	SAN PEDRO	WLB	135	1000	WLMR	130	1057	
	District 11 Totals		305	2200		305	2194	Avg: 1097
13	ASTORIA	WLB	156	1328	WLBR	135	1301	
	SEATTLE	WLB	137	856	WLMR	158	1284	
	District 13 Totals		293	2184		293	2585	Avg: 1293
14	HONOLULU	WLB	139	863	WLBR	139	803	
	HONOLULU	WLB	145	1310	WLBR	145	1181	
	GUAM	WLB	132	971	WLBR	132	708	
	District 14 Totals		416	3144		416	2692	Avg: 897
17	KETCHIKAN	WLB	257	1262	WLMR	259	1190	
	SITKA	WLB	234	1454	WLBR	240	932	
	CORDOVA	WLB	123	948	WLBR	164	1146	
	HOMER	WLB	97	867	WLBR	187	1201	
	KODIAK	WLB	139	1194	----			
	KODIAK	WLB	94	1769	WLBR	94	1234	
	District 17 Totals		944	7494		944	5703	Avg: 1141
	CG Totals		7493	41358		7493	33808	Avg: 1127
		WLBs: 26	WLMs: 11		WLBRs: 16	WLMRs: 14		BUSLRs: 1

6.1.1 District 1 Results

In District 1, the projected service force mix consists of two WLBRs with home ports in South Portland and New London, and four WLMRs with home ports in Rockland, Boston, Bristol, and New York City.

Although the projected speed of a WLMR is 1.5 knots lower than the current average speed of a 157-foot WLM, the projected WLMR for New York City can service 124 more aids than the 157-foot WLM currently located there (the Red Beech). This is possible because the ATON target resource hours of the WLMR (1275) are significantly higher than the historical ATON hours reported for the Red Beech (888), and the projected service times and weather penalty hours of the WLMRs are lower than those of the current 157-foot WLMs.

The area of operation for the New London WLBR ranges from Toms River, NJ to Nantucket. New London was selected as the home port due to its central location within the geographic area of operation, which resulted in fewer projected ATON resource hours than from either of the two current WLB home ports of New York City and Woods Hole.

The impact of assigning ATON to BUSLRs was investigated. According to the Physical Serviceability Report (Appendix E), 145 aids in District 1 are capable of being serviced by a BUSLR. However, due to the geographic distribution of these ATON, off-loading them onto BUSLRs would not affect the projected fleet size or mix of District 1. Therefore no BUSLRs were proposed for District 1.

Lighthouse maintenance requirements play a significant role in the District 1 replacement fleet. Collectively, the six proposed vessels were allocated 1500 hours annually for lighthouse maintenance (250 hours per vessel). This figure is roughly 20% of District 1's total projected ATON hours.

6.1.2 District 5 Results

For its future service force mix, District 5 will require one WLBR and three WLMRs to service the 1,247 aids currently being serviced by three WLBs and three WLMs. An estimate of 930 average annual ATON hours per vessel is projected, not including ATON hours for lighthouse maintenance and restoration.

The reduction in the number of vessels required and the reduced number of hours required from each were the result not only of the improved capabilities of the replacement vessels, but also of the reduced overlap of vessel areas of operation when compared with the current aid-to-vessel assignments. To the extent possible, home ports were centralized in relation to aid locations to minimize transit times to buoy sites. Cape

May was chosen as the home port for the WLBR because it was located nearest the buoys that could be serviced only by a WLBR and the buoys in exposed waters that could be handled more efficiently by a WLBR than a WLMR. Atlantic Beach is the most efficient home port for servicing the ATON along the southern Virginia and North Carolina coasts. Portsmouth and Baltimore were the optimal locations for the remaining two home ports, given the Cape May and Atlantic Beach choices.

It is possible that interchanging Philadelphia for one of these home ports with a corresponding reassignment of the ATON for the remaining vessels is also feasible, producing slightly higher DSS hours for the district, but not exceeding the target ATON hours for the district fleet as a whole.

Assigning the 95 buoys that can be serviced by a BUSLR to the smaller boats would not reduce the required buoy tender fleet size, because the resulting change in DSS ATON resource hours would not eliminate the requirement for any of the proposed four replacement vessels.

6.1.3 District 7 Results

The current fleet of two WLBs and one WLM was projected to require a replacement of one WLBR and two WLMRs. Historically, the two WLBs each make annual trips to the Caribbean. Under the future scenario, the one WLBR would be required to make two trips.

Miami was selected for the WLBR home port over the current WLB home port of Mayport. Although the DSS did show a slight preference for Miami (1,258 ATON hours vs. 1,299 hours for Mayport), Miami was selected primarily to provide a more balanced distribution of WLBRs along the East and Gulf coasts. Miami is already the location of a major USCG facility and is expected to be capable of supporting a WLBR in the future.

The Physical Serviceability Report (Appendix E) indicates that District 7 has 144 aids that are physically serviceable by a BUSLR. However, 124 of those are in the Caribbean near ATON that are not serviceable by BUSLRs. Based on the consideration that those areas would have to be visited by a WLBR, the BUSLR option for those areas was not pursued.

Although District 7 has no buoys physically requiring the lift capability of a WLBR, one WLBR is necessary in District 7 for open ocean transits to the Caribbean.

6.1.4 District 8 Results

The proposed future fleet for District 8 consists of one WLBR, two WLMRs and one BUSLR. District 8 has a baseline multi-mission requirement of one WLBR. Mobile was selected for the WLBR home port due to its central location within the geographical bounds of District 8 and proximity to the next adjacent district (District 7). The WLBR is projected to require only 1,085 hours out of its target of 1,260 hours. Therefore, any ATON assigned to the two WLMRs that might be more efficiently serviced by a WLBR could, if necessary, be re-assigned to the WLBR.

All scenarios attempted for District 8 indicated that one WLBR and two WLMRs fell slightly short of servicing all of the District 8 WLM/WLB ATON. Upon examination of BUSLR-serviceable ATON, the largest cluster exists in the Mississippi River north of New Orleans. By assigning those 49 aids to a BUSLR out of New Orleans, a WLMR home ported at the current White Pine Mobile location would be capable of covering the WLMR requirements from the Atchafalaya River to the eastern end of District 8.

The elimination of New Orleans as a WLMR home port was primarily the result of the more centrally located Mobile home port (once the western aids had been assigned to the Galveston WLMR). There are clusters of ATON on the eastern end of District 8 (St. Josephs, St. Marks, and St. Andrew Bays) serviceable by BUSLRs. However, the trip times required from New Orleans to service the non-BUSLR ATON produced DSS ATON resource hours approximately 300 hours greater than the WLMR ATON target of 1275 hours.

Under the projected DSS scenario, the Mobile WLMR would be assigned the non-BUSLR aids in the Mississippi River north of New Orleans. The Galveston WLMR's area of operations would extend from the Rio Grande to the Atchafalaya River.

6.1.5 District 9 Results

Two WLBRs are projected for the future service force in District 9. This district, due to its large seasonal aid population, required unique DSS operational parameter settings for both the validation and replacement runs. The maximum cruise length was 240 hours (10 days), the length of workday was 16 hours, and the buoy deck capacities were set to six times the actual vessel limits to represent the ability to re-supply at remote ports located near the seasonal aid populations.

District 9 has no aids that physically require the capabilities of a WLBR. However, due to the seasonal ice threat, it is probable that even without the baseline multi-mission requirements, District 9 would still require two WLBRs.

A comparison was made of the three possible combinations of two home ports from the three current WLB home ports. The results showed a slight preference for the ports of Port Huron and Charlevoix. The combined total DSS ATON hours for Port Huron and Charlevoix was 2056, for Port Huron and Duluth: 2097 hours, and for Charlevoix and Duluth: 2193 hours.

The final DSS District 9 scenario has the Charlevoix WLBR servicing the Acacia's aids and those of the Sundew located in and around Duluth. The Port Huron WLBR would be assigned the Bramble's aids and the remainder of the Sundew's Lake Superior aids.

The Physical Serviceability Report indicates that 172 of the 243 aids currently assigned to the Sundew could be assigned to BUSLRs. These ATON are primarily located around the Duluth, MN and Hancock, MI areas of Lake Superior. Although this large number of BUSLR-serviceable aids suggests the establishment of one or more BUSLRs on Lake Superior, the DSS projects that two WLBRs are capable of servicing the Lake Superior aids without the assistance of additional BUSLRs. However, given the unique nature of the District 9 seasonal servicing requirements, the establishment of at least one BUSLR between Duluth and Hancock and the subsequent off-loading of a subset of the Sundew's aids would reduce the peak seasonal demands placed on the two WLBRs, and thereby better assure the proper performance of the Great Lakes aids to navigation system.

6.1.6 District 11 Results

One WLBR and one WLMR can service the 305 aids of District 11 now being serviced by two WLBs. In addition to the aids currently serviced by the Blackhaw, a WLBR located in San Francisco would have to make one trip to the Conifer's current area of operations to service five WLBR-only aids. The off-loading of the latter buoys to the WLBR makes it possible to station a WLMR, instead of a second WLBR, in San Pedro to service the remaining Conifer buoys.

6.1.7 District 13 Results

District 13 requires one WLBR and one WLMR to replace its two current WLBs. The WLBR, stationed in Astoria, would handle the aids now serviced by the Iris as well as the seven WLBR-only aids of the Mariposa located in Puget Sound and several aids in the Straits of Juan de Fueca that are exposed to extreme tides and currents. The WLMR would be stationed in Seattle and would service the remaining Mariposa aids, located generally in the less exposed waters of Puget Sound.

The possibility of reducing the joint District 11 and District 13 fleet size to three vessels was explored; however, longer transits would make that option unfeasible.

6.1.8 District 14 Results

District 14 has a baseline requirement for three WLBRs. As a result, a one-for-one replacement of the three current WLBs (the Mallow, Sassafras, and Basswood) is projected.

6.1.9 District 17 Results

DSS results indicate that the current District 17 fleet of six WLBs can be replaced with one WLMR and four WLBRs. The WLMR would have its home port at Ketchikan and would represent approximately a one-for-one replacement of the WLB Planetree. Due to the greater weather impacts projected for the remaining five current WLB areas of operation, no additional WLMRs were projected for Alaska.

The baseline multi-mission requirement of four WLBRs is also the minimum number of WLBRs required to perform ATON mission requirements in District 17.

The DSS showed only a slight preference in ATON hours for locating two WLBRs at Kodiak rather than one at Kodiak and one at Homer. The projected difference of 60 hours between the two scenarios is not considered significant. To provide a balanced geographic distribution of home port locations across the large District 17 area of operations, Homer was selected over Kodiak as the second WLBR home port.

6.2 LIFE CYCLE COSTS

6.2.1 Cost Parameters

Annual operating and maintenance (O&M) and capital cost parameters for both the current and proposed fleets are shown in Table 6-2 in 1992 dollars. These are based on USCG estimates for the future fleet and actual expenditures for the current fleet.

The O&M figures assume crew sizes of 40 for the WLBRs, 53 for the WLBs, and 28 for the WLMs. Although the WLMR will require an operating crew of only 18, six persons will be required for land-based support (maintenance and repairs), so the costs in Table 6-2 reflect WLMR crew sizes of 24. The lead WLBR and WLMR costs are greater than those of the following vessels, because they include the costs of extensive in-the-water testing of the prototype vessels.

Table 6-2.
ASSUMED CAPITAL AND ANNUAL O&M COSTS
(thousands of 1992 dollars)

	WLBRs	WLMRs	WLBs	WLMs
Annual O&M Costs per Vessel				
Personnel	1,030	555	1,660	847
Fuel	357	129	62	35
Maintenance & repair	1,149	617	626	360
Total	2,536	1,301	2,348	1,242
Capital Cost per Vessel				
Lead vessel	70,000	25,000	---	---
Each following vessel	50,000	20,000	---	---

6.2.2 Analysis of Alternatives

Life cycle cost analysis of the buoy tender fleet includes estimating all costs associated with the acquisition and operation of all system components -- i.e., capital costs plus O&M costs -- over the expected lifetimes of the vessels. The annual costs are estimated in constant or base year dollars, then discounted back to the present to facilitate comparisons of alternative fleet sizes and mixes, as well as phase-in scenarios.

The most significant factors affecting the life cycle costs of the buoy tender fleet are the size of the fleet and the mix of WLBRs and WLMRs. The fleet size is a function of the number of ATON and their locations. The fleet mix is a function of platform-specific ATON requirements and multi-mission requirements for the buoy tender fleet.

Due to the substantial cost differences between WLMRs and WLBRs, the least costly replacement fleet includes only those WLBRs absolutely necessary for accomplishing both WLBR-specific ATON and minimum multi-mission requirements. (Construction lead time and expected service life, being about equal for the two platforms, would not affect the relative costs of the two.) The USCG specified a baseline multi-mission requirement for 16 WLBRs, which also proved to be sufficient for meeting the WLBR-specific ATON requirements. DSS results indicated 14 WLMRs were capable of performing the remaining ATON requirements. Further analysis showed that incremental increases in the baseline WLBR requirement from 16 to 19 would result in corresponding decreases in the WLMR requirement from 14 down to 11. Changing the mix of vessels by increasing the number of WLBRs would permit more multi-mission work to be performed, but would also increase the life cycle costs of the buoy tender fleet.

Other factors affecting the life cycle costs of the fleet include the phase-in schedule for replacing the current fleet with the replacement vessels, and the discount rate used to calculate the present value of the annual costs.

In Table 6-3, the life cycle costs are shown for four different fleet mixes with the number of WLBRs ranging from 16 to 19. (See Appendix J for detailed life cycle cost analysis spreadsheets.) The phase-in of the new vessels is based on the anticipated production contract award dates and delivery schedules. The first replacement vessels are expected by 1996, with approximately three of each type phased in per year until all current vessels have been replaced (by 2001 for the 19 WLBR scenario). The assumed useful economic life for the replacement vessels is 30 years. Life cycle costs are based on the period from 1992 through 2025. An OMB-prescribed 10% discount rate was used. (Lower discount rates of 4% and 7% were examined; these yielded greater life cycle costs, but did not alter the ranking of the costs of the four fleet mixes.)

Table 6-3.
SUMMARY OF LIFE CYCLE COSTS,
1992-2025
(millions of 1992 dollars, 10% discount rate)

WLBRs:	16	17	18	19
WLMRs:	14	13	12	11
BUSLRs:	1	1	1	1
-------------	-----	-----	-----	-----
O&M Costs	663	668	674	679
Capital Costs	571	581	589	598
Total	1,234	1,249	1,263	1,277
Incremental Difference	15	14	14	

The incremental cost for each additional WLBR over the 34 year analysis period is about $15 million at a 10% discount rate. To justify more than 16 WLBRs, the USCG would have to determine that the dollar benefits of increased availability of WLBRs for multi-mission activities exceed the incremental costs.

6.3 IMPACTS ON MULTI-MISSION REQUIREMENTS

The proposed number of 16 WLBRs represents a ten vessel decrease from the current WLB fleet size. The associated decrease in multi-mission availability will require alternative USCG resources to provide the difference. The source, nature, and cost of the resources required to deliver the remaining historical multi-mission hours are, however, beyond the scope of the DSS and this document.

Based on the significant decrease in the amount of multi-mission capacity represented by the proposed number of WLBRs, an increase in the baseline WLBR requirement may be warranted upon further USCG analysis of multi-mission requirements in light of alternative sources and costs of multi-mission resources.

Conversely, because the difference in life cycle costs significantly favors the deployment of WLMRs over WLBRs wherever conditions permit, a decrease in the baseline WLBR requirement would reduce total life cycle costs.

Just as there is a baseline WLBR fleet size needed to meet multi-mission requirements, there is a baseline WLBR fleet size needed to meet ATON requirements. DSS inputs, assumptions, and outputs indicate that the baseline ATON WLBR requirement potentially could be as few as eight vessels. District 14 and District 17 require two and four WLBRs, respectively, due to longer steaming times, open ocean transits, and generally high seas that prohibit the use of WLMRs. Initial indications are that one WLBR could cover the combined WLBR ATON requirements of Districts 11 and 13. For the East and Gulf coasts, one WLBR could provide the combined WLBR ATON requirements of Districts 1, 5, 7, and 8 and still service the Caribbean ATON currently assigned to District 7. Based solely on the physical servicing requirements of the District 9 ATON, no WLBRs are essential in the Great Lakes.

However, from a practical perspective, a replacement fleet with just eight WLBRs is unrealistic. Discrepancy response, surge response, and the inability of WLMRs to work reliably under the winter ice conditions associated with the Northeast and the Great Lakes necessitate a fleet of more than eight WLBRs to adequately perform the ATON mission. Based upon an analysis of routine ATON servicing requirements, discrepancy response requirements, surge response requirements, and winter operating conditions, the USCG determined that the baseline multi-mission requirement of 16 WLBRs would provide adequate WLBR geographic coverage for ATON requirements.

6.4 ADDITIONAL BUSLR SECONDARY RESPONSE CAPABILITY

It is possible that the larger geographic areas of operation for the vessels of the proposed smaller replacement fleet may produce an adverse effect on USCG discrepancy response capabilities. On average, the primary units of the replacement fleet will be located further from the sites of required discrepancy responses than the current buoy tender fleet. The possibility of an increase in the response times for discrepancies, particularly around current home ports being vacated by the replacement fleet, is a matter of USCG concern.

Currently, Aids to Navigation Teams (ANTs) are often designated as the secondary unit for aids assigned to WLMs and WLBs. In this capacity, ANTs will inspect a discrepant aid and, depending on the nature of the discrepancy, either permanently fix the discrepancy, provide a temporary remedy until it is convenient for the primary unit to respond, or take no action and thereby necessitate an immediate response by the primary unit.

In terms of assigned number of ATON, the proposed replacement fleet does not impose a greater secondary response requirement on ANTs. However, it is possible that the impact of the potentially greater discrepancy response times of the replacement fleet might be alleviated if selected ANTs were provided with BUSLRs. One possibility might be to place BUSLRs in the current home ports being vacated by the replacement fleet. Specifically, New York, Woods Hole, Philadelphia, Portsmouth, Mayport, and Duluth would be candidate locations for BUSLRs.

Further analysis of the need for additional BUSLRs to provide an improved secondary response capability is beyond the scope of this study. However, such an analysis is probably warranted in light of the USCG's current BUSLR acquisition initiative.

6.5 SENSITIVITY ANALYSIS

Sensitivity analysis has two intended purposes. The first is to provide an indication of the validity of a model by making sure that generated results match expected results when an input parameter is modified. The second is to assist decision makers in evaluating the effects of changes to assumed input values on generated results. This is especially useful when generated results depend on projected values of an input parameter that is subject to a relatively high degree of uncertainty.

6.5.1 Analysis of Projected ATON Hours

DSS-generated ATON hours consist of seven time components: vessel transiting, on-station servicing, overnight idle, discrepancy response, weather impact, lighthouse maintenance, and buffer/surge. Buffer/surge time is the difference between the sum of the first six components and the ATON target resource hours, and constitutes time available for surge response. Table 6-4 shows the proportion of ATON hours utilized by component and district for the proposed fleet.

Table 6-4.
PROPORTION OF PROJECTED ATON HOURS BY COMPONENT

District	Transit	Service	Idle	Discrep-ancy	Weather	Light-House	Buffer/Surge	Total
1	.25	.19	.06	.09	.13	.20	.08	1.00
5	.39	.16	.04	.09	.05	.20	.07	1.00
7	.39	.16	.18	.12	.07	.00	.09	1.00
8	.35	.12	.19	.16	.09	.00	.09	1.00
9	.42	.32	.00	.03	.05	.00	.18	1.00
11	.21	.15	.15	.16	.19	.00	.13	1.00
13	.25	.09	.13	.19	.16	.20	-0.02	1.00
14	.44	.16	.00	.06	.05	.00	.29	1.00
17	.29	.16	.25	.04	.16	.00	.10	1.00
Fleet Totals	.33	.17	.11	.11	.10	.07	.11	1.00

The two largest components of the fleet totals are transit time and service time, which together make up 50% of the total ATON hours. Each of the remaining five components contributes roughly 10% of the total ATON hours. Accordingly, changes to inputs affecting either transit or service times are expected to result in relatively more significant effects on DSS-generated ATON hours.

6.5.2 Approach to Sensitivity Testing

The inputs that affect a vessel's DSS ATON hours are aid and home port locations, transit speed, cruise length, work day hours, buoy deck capacity, service times, same-time servicing percentages, discrepancy responses, weather hours, lighthouse maintenance hours, whether or not to include overnight idle time, and the target ATON resource hours. Of these, transit speed, service times, weather hours, and target resource hours were selected for sensitivity testing because their replacement fleet values were different from those used to validate the DSS on current fleet operations. The replacement fleet values for these parameters were projected based on expected characteristics of future operations, and thus are subject to a higher potential for error. Buoy deck capacities, although different for the replacement fleet, are known quantities based on the design of the new vessels, and therefore were not tested in this analysis.

The sensitivity tests were conducted by altering the value of the input parameter being tested and then, where appropriate, running the projected replacement fleet of 16 WLBRs and 14 WLMRs at the new settings. No changes were made to the replacement fleet's aid assignments. The resulting change in total ATON resource hours was then divided by an ATON resource hours target of 1,250 to produce an estimated net fleet size impact.

By grouping geographically contiguous districts, the area of operations for the entire fleet was divided into 5 regions: the Atlantic/Gulf (Districts 1, 5, 7, and 8), the Great Lakes (District 9), the Pacific Coast (Districts 11 and 13), Hawaii (District 14), and Alaska (District 17). Fleet size impacts were rounded off at the region level into whole numbers of vessels (fractional values less than .5 were rounded down, those greater than or equal to .5 were rounded up). The rounded regional values were then summed to produce the total fleet size impact. This method is intended only to provide an estimate of projected fleet impacts. The problems and implications inherent in rounding were not considered.

6.5.3 Variations in Vessel Speeds

Table 6-5 shows the sensitivity test results for variations in vessel speed.

Table 6-5.
VESSEL SPEED SENSITIVITY

	ATON	Projected Hours with Standard Speeds [1]	Projected Hours at Higher Speeds [2]	Higher Speeds Minus Standard Speeds	Impact of Higher Speeds on Fleet Size (Hours/1250)	Projected Hours at Lower Speeds [3]	Lower Speeds Minus Standard Speeds	Impact of Lower Speeds on Fleet Size (Hours/1250)
District 1	1981	6963	6835	-128	-.1	7363	400	.3
District 5	1247	4721	4286	-435	-.3	5117	396	.3
District 7	874	3466	3252	-214	-.2	5233	1767	1.4
District 8	699	3428	3062	-366	-.3	3782	354	.3
ATLANTIC/GULF Totals	4801	18578	17435	-1143	-.9(-1)	21495	2917	2.3(2)
District 9	734	2056	1878	-178	-.1	2439	383	.3
GREAT LAKES Totals	734	2056	1878	-178	-.1(-0)	2439	383	.3(0)
District 11	305	2194	2093	-101	-.1	2500	306	.2
District 13	293	2585	2519	-66	-.1	3096	511	.4
PACIFIC COAST Totals	598	4779	4612	-167	-.1(-0)	5596	817	.7(1)
District 14	416	2692	2481	-211	-.2	3422	730	.6
HAWAII Totals	416	2692	2481	-211	-.2(-0)	3422	730	.6(1)
District 17	944	5703	5521	-182	-.1	6821	1118	.9
ALASKA Totals	944	5703	5521	-182	-.1(-0)	6821	1118	.9(1)
Fleet Totals	7493	33808	31927	-1881	-1.5(-1)	39773	5965	4.8(5)

[1] WLMRs: 10 knots; Atlantic, Gulf, & Great Lakes WLBRs: 12 knots; Pacific WLBRs: 13 knots
[2] WLMRs: 12 knots; WLBRs: 15 knots
[3] WLMRs: 9 knots; WLBRs: 9 knots

There is an inverse relationship between vessel transit speed and the projected replacement fleet size. As shown in the table, the standard speeds at which the replacement fleet is expected to operate are 10 knots for WLMRs, 12 knots for Atlantic, Gulf, and Great Lakes WLBRs, and 13 knots for Pacific WLBRs. At these speeds, the projected fleet of 16 WLBRs and 14 WLMRs would provide 33,808 ATON hours.

The vessel speed upper bound test was conducted using the projected maximum operating speeds for the replacement platforms of 12 knots for WLMRs and 15 knots for WLBRs. The resulting projected fleet would require only 1,881 fewer ATON hours than projected at the standard speeds. Overall, with a roughly 20% increase in speed, the fleet size would decrease by only one vessel.

The vessel speed lower bound test was conducted using 9 knots for both replacement platforms. The resulting projected fleet would require 5,965 more ATON hours than projected at the standard speeds. Overall, with a roughly 20% decrease in speed, the fleet size would increase by five vessels. Three of the five vessels would be deployed in districts characterized by long transit distances (Districts 7, 14, and 17).

6.5.4 Variations in Service Times

Table 6-6 shows the sensitivity test results for variations in service times.

Table 6-6.
SERVICE TIMES SENSITIVITY

		ATON	Projected Hours with Standard Service Times	Projected Hours with 25% Lower Service Times	25% Lower Times Minus Standard Times	Impact of Lower Times on Fleet Size (Hours/1250)	Projected Hours with 25% Higher Service Times	25% Higher Times Minus Standard Times	Impact of Higher Times on Fleet Size (Hours/1250)
District 1		1981	6963	6513	-450	-.4	7664	701	.6
District 5		1247	4721	4338	-383	-.3	5093	372	.3
District 7		874	3466	3069	-397	-.3	3824	358	.3
District 8		699	3428	3099	-329	-.3	3720	292	.2
ATLANTIC/GULF	Totals	4801	18578	17019	-1559	-1.2(-1)	20301	1723	1.4(1)
District 9		734	2056	1835	-221	-.2	2332	276	.2
GREAT LAKES	Totals	734	2056	1835	-221	-.2(-0)	2332	276	.2(0)
District 11		305	2194	1985	-209	-.2	2443	249	.2
District 13		293	2585	2471	-114	-.1	2868	283	.2
PACIFIC COAST	Totals	598	4779	4456	-323	-.3(-0)	5311	532	.4(0)
District 14		416	2692	2477	-215	-.2	2872	180	.1
HAWAII	Totals	416	2692	2477	-215	-.2(-0)	2872	180	.1(0)
District 17		944	5703	5223	-480	-.4	6346	643	.5
ALASKA	Totals	944	5703	5223	-480	-.4(-0)	6346	643	.5(1)
Fleet	Totals	7493	33808	31010	-2798	-2.2(-1)	37162	3354	2.7(2)

The standard service times for the replacement fleet were derived from the Buoy Tender Operations Survey. There is a direct relationship between service times and fleet size.

The service times lower bound test was performed by running the replacement fleet with 25% lower service times. The resulting fleet requires 2,798 fewer ATON hours. Although fleet-wide that amount of hours indirectly equates to 2.2 vessels, only one less vessel is projected (in the Atlantic/Gulf region) due to the regional distribution of the hours.

The service times upper bound test was performed by running the projected replacement fleet with 25% higher service times. The resulting fleet requires 3,354 more ATON hours and would require one additional vessel in both the Atlantic/Gulf and Alaska regions.

6.5.5 Variations in Weather Impacts

Table 6-7 shows the sensitivity test results for variations in weather impacts.

Table 6-7.
WEATHER IMPACT SENSITIVITY

		ATON	DSS Projected Hours	DSS Weather Hours	50% of Weather Hours	Impact on Fleet Size of +/- 50% of Weather Hours (Hours/1250)
District 1		1981	6963	965	483	.4 (0)
District 5		1247	4721	261	131	.1 (0)
District 7		874	3466	258	129	.1 (0)
District 8		699	3428	337	169	.1 (0)
ATLANTIC/GULF	Totals	4801	18578	1821	911	.7 (1)
District 9		734	2056	123	62	.0 (0)
GREAT LAKES	Totals	734	2056	123	62	.0 (0)
District 11		305	2194	484	242	.2 (0)
District 13		293	2585	411	206	.2 (0)
PACIFIC COAST	Totals	598	4779	895	448	.4 (0)
District 14		416	2692	180	90	.1 (0)
HAWAII	Totals	416	2692	180	90	.1 (0)
District 17		944	5703	998	499	.4 (0)
ALASKA	Totals	944	5703	998	499	.4 (0)
Fleet	Totals	7493	33808	4017	2009	1.6 (1)

The weather impact hours, like the service times, were derived from the Buoy Tender Operations Survey. There is a direct relationship between weather impact and fleet size.

The sensitivity test for weather impact was based on a 50% plus or minus change in weather hours. Because weather hours are determined by summing the individual weather impact values of a vessel's assigned ATON, no additional runs of the DSS were needed to determine the net change to ATON hours caused by a 50% change in weather impact. Instead, 50% of the projected weather hours were added to and subtracted from each district's total projected hours to obtain the effects of increased and decreased weather impacts.

A 50% change in the total projected weather impact equates to 2,009 hours. Of these, 991 hours are attributable to the Atlantic/Gulf region, which would cause a one vessel change to the Atlantic/Gulf's required fleet size.

The weather impact for the Great Lakes, although derived from District 9 survey inputs, is considered low. It does not appear to take into account the concentrated seasonal nature of District 9 ATON work. Therefore a significant storm during the peak spring or fall servicing months might have a greater impact than is indicated by the sensitivity analysis.

6.5.6 Variations in ATON Target Resource Hours

Table 6-8 shows the sensitivity test results for variations in ATON target resource hours.

Table 6-8.
ATON TARGET RESOURCE HOURS SENSITIVITY

		ATON	Projected Hours & Fleet Size	Fleet Size with Target = 1500 Hours (Projected Hours/1500)	1500 Hour Target Fleet Size Impact	Fleet Size with Target = 1000 Hours (Projected Hours/1000)	1000 Hour Target Fleet Size Impact
District 1		1981	6963(6)	4.6	-1.4	7.0	1.0
District 5		1247	4721(4)	3.1	-.9	4.7	.7
District 7		874	3466(3)	2.3	-.7	3.5	.5
District 8		699	3428(3)	2.3	-.7	3.4	.4
ATLANTIC/GULF	Totals	4801	18578(16)	12.4 (12)	-3.6 (-4)	18.6 (19)	2.6 (3)
District 9		734	2056(2)	1.4	-.6	2.1	.1
GREAT LAKES	Totals	734	2056(2)	1.4 (1)	-.6 (-1)	2.1 (2)	.1 (0)
District 11		305	2194(2)	1.5	-.5	2.2	.2
District 13		293	2585(2)	1.7	-.3	2.6	.6
PACIFIC COAST	Totals	598	4779(4)	3.2 (3)	-.8 (-1)	4.8 (5)	.8 (1)
District 14		416	2692(3)	1.8	-1.2	2.7	-.3
HAWAII	Totals	416	2692(3)	1.8 (2)	-1.2 (-1)	2.7 (3)	-.3 (0)
District 17		944	5703(5)	3.8	-1.2	5.7	.7
ALASKA	Totals	944	5703(5)	3.8 (4)	-1.2 (-1)	5.7 (6)	.7 (1)
Fleet	Totals	7493	33808(30)	22.5 (22)	-7.5 (-8)	33.8 (34)	3.8 (5)

There is an inverse relationship between the ATON Target Resource Hours and the projected replacement fleet size.

The target hours analysis used a straight division method in which the projected ATON hours were divided by a low target of 1000 hours and a high target of 1500 hours to determine net fleet impacts. The results of this method were validated by performing a service force mix analysis for Districts 7 and 8 using the lower and upper targets. In both cases, the DSS results supported the straight division method.

The test results indicate that a 20% increase in the target hours (1250 to 1500) produces a 27% decrease in required fleet size (30 to 22) and a 20% decrease in the target hours (1250 to 1000) produces a 17% increase (30 to 35) in fleet size.

6.5.7 Summary of Sensitivity Tests

Table 6-9 summarizes the results of the sensitivity tests. These results should be treated with caution. Again, the intent was to explore the relative sensitivity of results to varying values of certain types of inputs, not to optimize fleet mixes and utilization under these varying input assumptions. Because fractional results were rounded up or down in each region, overall sensitivity in some instances is somewhat under- or overstated (as can be observed in Tables 6-5 through 6-8).

Table 6-9.
SUMMARY OF SENSITIVITY TESTS

		CHANGE IN REQUIRED FLEET SIZE (ROUNDED)					
	Assumption	Atlantic/ Gulf	Great Lakes	Pacific Coast	Hawaii	Alaska	Total
WLBR/WLMR Speeds (knots)							
Standard	12-13/10						
Low	9/9	+2	0	+1	+1	+1	+5
High	15/12	-1	0	0	0	0	-1
Service Times							
High	+25%	+1	0	0	0	+1	+2
Low	-25%	0	0	0	0	-1	-1
Weather Impacts							
High	+50%	+1	0	0	0	0	+1
Low	-50%	-1	0	0	0	0	-1
ATON Target Resource Hours							
Standard	1250						
Low	1000	+3	0	+1	0	+1	+5
High	1500	-4	-1	-1	-1	-1	-8

Overall, the results appear most sensitive to the assumption regarding ATON target resource hours. If the assumed target (1250 hours per vessel) proves too low or too high, then the required fleet size could change noticeably.

Fleet size also is sensitive to assumed vessel speeds, but primarily in one direction. If attainable average speeds prove to be lower than assumed, additional tenders will be required. If higher average speeds were to be achievable, however, the potential reduction in fleet size appears minimal.

7. CONCLUSION

The primary objective of this project was to assist the Coast Guard in determining the optimal numbers of next-generation seagoing buoy tenders (WLBRs), coastal buoy tenders (WLMRs), and stern loading buoy boats (BUSLRs) required to accomplish the work being performed by the current fleet of WLMs and WLBs. Based on the analyses summarized in this report, a service force mix of 16 WLBRs, 14 WLMRs, and 1 BUSLR is proposed to replace the current fleet of 26 WLBs and 11 WLMs.

The proposed service force mix considered Coast Guard district boundaries as the logical starting points for replacement vessel areas of operation. Crossing district boundaries was investigated when estimated ATON resource hours for a district fleet showed either over- or under-utilization, and where district boundaries were adjacent (Districts 11 and 13, and Districts 1, 5, 7, and 8). Ultimately, the proposed replacement fleet did not result in the crossing of district boundaries.

The home port determinations were baselined from the current 32 home ports utilized by WLMs and WLBs. Only Miami, in District 7, was proposed as a new buoy tender home port. The home ports selected within each district were based upon the lowest combined total estimated ATON resource hours. It is probable that, based on local considerations, alternative home port locations could accomplish the ATON mission requirements utilizing the same fleet size and mix.

Sensitivity analysis results indicate that significant factors leading to a reduced fleet size include increased vessel availability, faster transit speeds of the replacement fleet, lower projected required ATON service times, and reduced weather impacts due to improved seakeeping and positioning capabilities.

The activities summarized herein included: the design of the DSS; extensive data base development utilizing the Coast Guard's ATONIS data base; a survey of the 37 current buoy tenders and the nine affected USCG Districts; development of customized software to represent and examine Coast Guard buoy tender operations; and hundreds of DSS vessel runs to validate the DSS and then to determine the optimal replacement fleet size and mix. The bulk of the effort expended was on DSS design, development, and validation. In terms of time and cost, the development and evaluation of alternative scenarios, although critical, were relatively small activities.

APPENDICES

APPENDIX A. ATON SFM DSS APPLICATION OF DISCREPANCY DATA

A.1 VARIABLES

A.1.1 Aids to Navigation

For each aid, we have:

AND: ATONIS Number of Discrepancies. This value was compiled from the ATONIS Discrepancy File and is the recorded number of discrepancies from the time the district began recording discrepancy information. The district time frames were generally about 4 years.

For each aid, we need:

RND: Revised Number of Discrepancies. This is the adjusted number based on the AND and the total number of discrepancies indicated on the survey.

RDRY: Required Discrepancy Responses per Year. This is the computed number of required responses based on the RND and total number of discrepancy responses indicated on the survey.

A.1.2 Platforms

For each WLM and WLB, we have:

ATDAA: ATONIS Total Discrepancies of Assigned Aids. The value is the sum of Assigned Aid ANDs.

STDAA: Survey Total Discrepancies of Assigned Aids.

ADRY: ATONIS Discrepancy Responses per Year. This is a very questionable value that will not be used.

SDRY: Survey Discrepancy Responses per Year.

A.2 PROCEDURES

For each aid:

RND = (STDAA / ATDAA) * AND

RDRY = (SDRY / STDAA) * RND

Alternatively, RDRY could be computed in one step:

Given: RND = (STDAA / ATDAA) * AND

and RDRY = (SDRY / STDAA) * RND

then: RDRY = (SDRY / STDAA) * (STDAA / ATDAA * AND)
= (SDRY / ATDAA) * AND

However, by computing and using the RND (rather than the AND), DSS discrepancy output totals will be in line with the survey responses rather than the questionable ATONIS values.

A.3 USAGE

The RDRY is the number of times an aid can be expected to be discrepant per year. For current operations, the sum of a ship's RDRYs is equal to the value of the ship's Survey Discrepancy Responses per Year (SDRY). For future operations, the Projected Discrepancies Responses per Year (PDRYs) for each WLMR/WLBR will be equal to the sum of the RDRYs of their assigned aids.

The SDRY values of the current fleet and the PDRY values for the replacement fleet will be multiplied by the average ATON resource hours spent per aid per ship (an output of the DSS) to determine Total Discrepancy Response Hours (TDRH) per ship. The total discrepancy hours derived from the survey will serve as a check on the TDRH values for the current fleet.

A.4 EXAMPLE

(a) Ship X has three assigned aids: A1, A2, and A3.

(b) The ATONIS Number of Discrepancies (AND) was:

Aid	AND
A1	10
A2	15
A3	20
Total	45 (ATDAA)

(c) The Survey Total of Discrepancies of Assigned Aids (STDAA) was 60.

(d) Then the Revised Number of Discrepancies is:

Aid	RND
A1	(60 / 45) * 10 = 13.33
A2	(60 / 45) * 15 = 20.00
A3	(60 / 45) * 20 = 26.67
Total	60 (STDAA)

(e) The Survey Discrepancy Responses per Year (SDRY) was 20.

(f) Then the Required Discrepancy Responses per Year (RDRY) is:

Aid	RDRY
A1	(20 / 60) * 13.33 = 4.44
A2	(20 / 60) * 20.00 = 6.66
A3	(20 / 60) * 26.67 = 8.89
Total	20 (SDRY)

APPENDIX B. BUOY TENDER SERVICE TIMES TABLE

1/28/92 Fleet/Vessel Service Times Page 1

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
1	WLB	BITTERSWEET					
			LB	I -A1	.70	.40	.48
			LB	IM -A2	1.10	.50	.66
			LB	IMC -A3	2.80	1.40	1.78
			LB	IC -A4	1.10	1.10	1.10
			LB	MR -A5	1.20	.60	.76
			LB	R -A6	.90	.40	.54
			ULB	I -B1	.50	.40	.43
			ULB	IM -B2	1.10	.50	.70
			ULB	MR -B3	1.20	.60	.80
			ULB	R -B4	.90	.40	.57
			SEAN	Sp -C1	.70	.40	.41
			SEAN	Fa -C2	.40	.20	.21
			SEAR	Sp -C3	.90	.45	.46
			SEAR	Fa -C4	.70	.40	.41
1	WLB	SORREL					
			LB	I -A1	1.00	.70	.78
			LB	IM -A2	1.50	1.20	1.28
			LB	IMC -A3	3.00	2.50	2.64
			LB	IC -A4	2.00	1.80	1.85
			LB	MR -A5	2.00	1.60	1.71
			LB	R -A6	1.00	.50	.64
			ULB	I -B1	.50	.40	.43
			ULB	IM -B2	1.00	.80	.87
			ULB	MR -B3	1.30	1.00	1.10
			ULB	R -B4	.50	.30	.37
			SEAN	Sp -C1	.70	.70	.70
			SEAN	Fa -C2	.50	.50	.50
			SEAR	Sp -C3	.90	.90	.90
			SEAR	Fa -C4	.80	.80	.80
1	WLB	SPAR					
			LB	I -A1	1.10	.90	.95
			LB	IM -A2	2.00	1.50	1.64
			LB	IMC -A3	3.00	2.50	2.64
			LB	IC -A4	2.50	2.00	2.14
			LB	MR -A5	1.50	.90	1.06
			LB	R -A6	.90	.90	.90
			ULB	I -B1	.80	.40	.54
			ULB	IM -B2	1.50	1.00	1.17
			ULB	MR -B3	1.50	.90	1.10
			ULB	R -B4	.90	.90	.90
1	WLB	Fleet Average					
			LB	I -A1	.93	.67	.74
			LB	IM -A2	1.53	1.07	1.19
			LB	IMC -A3	2.93	2.13	2.35
			LB	IC -A4	1.87	1.63	1.70
			LB	MR -A5	1.57	1.03	1.18
			LB	R -A6	.93	.60	.69
			ULB	I -B1	.60	.40	.47
			ULB	IM -B2	1.20	.77	.91
			ULB	MR -B3	1.33	.83	1.00
			ULB	R -B4	.77	.53	.61
			SEAN	Sp -C1	.70	.55	.55
			SEAN	Fa -C2	.45	.35	.35
			SEAR	Sp -C3	.90	.68	.68
			SEAR	Fa -C4	.75	.60	.60

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
1	WLBR	Fleet Average					
			LB	I -A1	.63	.43	.49
			LB	IM -A2	1.20	.80	.91
			LB	IMC -A3	2.20	1.53	1.72
			LB	IC -A4	1.40	1.13	1.21
			LB	MR -A5	1.10	.80	.88
			LB	R -A6	.70	.47	.53
			ULB	I -B1	.47	.27	.33
			ULB	IM -B2	.90	.53	.66
			ULB	MR -B3	1.03	.60	.75
			ULB	R -B4	.63	.43	.50
			SEAN	Sp -C1	.70	.45	.46
			SEAN	Fa -C2	.40	.30	.30
			SEAR	Sp -C3	.85	.55	.56
			SEAR	Fa -C4	.70	.50	.51
1	WLM	RED BEECH					
			LB	I -A1	1.80	1.80	1.80
			LB	IM -A2	2.50	2.50	2.50
			LB	IMC -A3	2.80	2.80	2.80
			LB	IC -A4	2.10	2.10	2.10
			LB	MR -A5	1.00	1.00	1.00
			LB	R -A6	.70	.70	.70
			ULB	I -B1	.70	.70	.70
			ULB	IM -B2	1.50	1.50	1.50
			ULB	MR -B3	1.00	1.00	1.00
			ULB	R -B4	.70	.70	.70
			SEAR	Sp -C3	1.00	1.00	1.00
			SEAR	Fa -C4	.70	.70	.70
			LT	I -F2	1.10	1.10	1.10
1	WLM	RED WOOD					
			LB	I -A1	.70	.40	.55
			LB	IM -A2	1.50	1.00	1.25
			LB	IMC -A3	2.20	1.60	1.90
			LB	IC -A4	1.40	1.10	1.25
			LB	MR -A5	1.50	1.00	1.25
			LB	R -A6	.90	.40	.65
			ULB	I -B1	.70	.40	.53
			ULB	IM -B2	1.10	.80	.93
			ULB	MR -B3	1.00	.80	.88
			ULB	R -B4	.90	.40	.61
			SEAN	Sp -C1	.70	.40	.52
			SEAN	Fa -C2	.70	.40	.52
			SEAR	Sp -C3	.90	.85	.87
			SEAR	Fa -C4	.70	.70	.70
1	WLM	WHITE HEATH					
			LT	I -F2	3.00	3.00	3.00
1	WLM	WHITE SAGE					
			LB	I -A1	.90	.80	.85
			LB	IM -A2	1.50	1.10	1.30
			LB	IMC -A3	2.10	1.40	1.75
			LB	IC -A4	1.80	1.10	1.45
			LB	MR -A5	1.50	.60	1.05
			LB	R -A6	.90	.40	.65
			ULB	I -B1	.70	.40	.53
			ULB	IM -B2	.90	.90	.90
			ULB	MR -B3	1.20	.60	.85
			ULB	R -B4	.90	.40	.61
			SEAN	Sp -C1	1.00	.90	.94
			SEAN	Fa -C2	.40	.40	.40
			SEAR	Sp -C3	1.05	1.00	1.02
			SEAR	Fa -C4	1.00	1.00	1.00

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
1	WLM	Fleet Average					
			LB	I -A1	1.13	1.00	1.07
			LB	IM -A2	1.83	1.53	1.68
			LB	IMC -A3	2.37	1.93	2.15
			LB	IC -A4	1.77	1.43	1.60
			LB	MR -A5	1.33	.87	1.10
			LB	R -A6	.83	.50	.67
			ULB	I -B1	.70	.50	.58
			ULB	IM -B2	1.17	1.07	1.11
			ULB	MR -B3	1.07	.80	.91
			ULB	R -B4	.83	.50	.64
			SEAN	Sp -C1	.85	.65	.73
			SEAN	Fa -C2	.55	.40	.46
			SEAR	Sp -C3	.98	.95	.96
			SEAR	Fa -C4	.80	.80	.80
			LT	I -F2	2.05	2.05	2.05
1	WLMR	Fleet Average					
			LB	I -A1	.97	.87	.92
			LB	IM -A2	1.47	1.27	1.37
			LB	IMC -A3	1.87	1.63	1.75
			LB	IC -A4	1.40	1.30	1.35
			LB	MR -A5	.93	.63	.78
			LB	R -A6	.70	.57	.63
			ULB	I -B1	.57	.47	.51
			ULB	IM -B2	.93	.83	.88
			ULB	MR -B3	.80	.73	.76
			ULB	R -B4	.60	.50	.54
			SEAN	Sp -C1	.45	.40	.42
			SEAN	Fa -C2	.45	.40	.42
			SEAR	Sp -C3	.71	.77	.74
			SEAR	Fa -C4	.49	.63	.58
			LT	I -F2	2.05	2.05	2.05

District	Type	Vessel	Aid Type	Service Type		Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
5	WLB	Fleet Average						
			LB	I	-A1	.70	.70	.70
			LB	IM	-A2	1.80	1.00	1.53
			LB	IMC	-A3	2.40	1.50	2.10
			LB	IC	-A4	1.90	1.00	1.60
			LB	MR	-A5	1.20	1.00	1.13
			LB	R	-A6	.40	.70	.50
			ULB	I	-B1	.50	.40	.46
			ULB	IM	-B2	1.50	.70	1.18
			ULB	MR	-B3	1.20	1.00	1.12
			ULB	R	-B4	.90	.70	.82
			SEAN	Sp	-C1	.70	.40	.67
			SEAN	Fa	-C2	.60	.40	.58
			SEAR	Sp	-C3	.95	.75	.93
			SEAR	Fa	-C4	.70	.50	.68
5	WLBR	Fleet Average						
			LB	I	-A1	.70	.70	.70
			LB	IM	-A2	1.50	.90	1.30
			LB	IMC	-A3	2.10	1.20	1.80
			LB	IC	-A4	1.90	1.00	1.60
			LB	MR	-A5	.90	.70	.83
			LB	R	-A6	.80	.60	.73
			ULB	I	-B1	.50	.40	.46
			ULB	IM	-B2	1.20	.60	.96
			ULB	MR	-B3	.90	.70	.82
			ULB	R	-B4	.80	.60	.72
			SEAN	Sp	-C1	.60	.30	.57
			SEAN	Fa	-C2	.50	.30	.48
			SEAR	Sp	-C3	.80	.70	.79
			SEAR	Fa	-C4	.70	.70	.70
5	WLM	Fleet Average						
			LB	I	-A1	.70	.70	.70
			LB	IM	-A2	1.80	1.00	1.06
			LB	IMC	-A3	2.40	1.50	1.56
			LB	IC	-A4	1.90	1.00	1.06
			LB	MR	-A5	1.20	1.00	1.01
			LB	R	-A6	.40	.70	.68
			ULB	I	-B1	.50	.40	.40
			ULB	IM	-B2	1.50	.70	.74
			ULB	MR	-B3	1.20	1.00	1.01
			ULB	R	-B4	.90	.70	.71
			SEAN	Sp	-C1	.70	.40	.40
			SEAN	Fa	-C2	.60	.40	.40
			SEAR	Sp	-C3	.95	.75	.75
			SEAR	Fa	-C4	.70	.50	.50
5	WLMR	Fleet Average						
			LB	I	-A1	.70	.70	.70
			LB	IM	-A2	1.50	.90	.94
			LB	IMC	-A3	2.10	1.20	1.26
			LB	IC	-A4	1.90	1.00	1.06
			LB	MR	-A5	.90	.70	.71
			LB	R	-A6	.80	.60	.61
			ULB	I	-B1	.50	.40	.40
			ULB	IM	-B2	1.20	.60	.63
			ULB	MR	-B3	.90	.70	.71
			ULB	R	-B4	.80	.60	.61
			SEAN	Sp	-C1	.60	.30	.30
			SEAN	Fa	-C2	.50	.30	.30
			SEAR	Sp	-C3	.80	.70	.70
			SEAR	Fa	-C4	.70	.70	.70

District	Type	Vessel	Aid Type	Service Type		Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
7	WLB	LAUREL						
			DBN	I	-F1	.30	.30	.30
			LT	I	-F2	.60	.60	.60
7	WLB	MADRONA						
			LT	I	-F2	.50	.50	.50
7	WLB	Fleet Average						
			LB	I	-A1	.90	.60	.74
			LB	IM	-A2	1.30	1.00	1.14
			LB	IMC	-A3	1.80	1.50	1.64
			LB	IC	-A4	1.40	1.20	1.30
			LB	MR	-A5	1.30	1.10	1.20
			LB	R	-A6	.90	.70	.80
			ULB	I	-B1	.70	.50	.58
			ULB	IM	-B2	1.00	.80	.88
			ULB	MR	-B3	1.10	.90	.98
			ULB	R	-B4	.80	.60	.68
			DBN	I	-F1	.30	.30	.30
			LT	I	-F2	.55	.55	.55
7	WLBR	Fleet Average						
			LB	I	-A1	.90	.50	.69
			LB	IM	-A2	1.20	.90	1.04
			LB	IMC	-A3	1.60	1.20	1.39
			LB	IC	-A4	1.30	1.00	1.14
			LB	MR	-A5	1.20	.80	.99
			LB	R	-A6	.90	.60	.74
			ULB	I	-B1	.70	.50	.58
			ULB	IM	-B2	1.00	.80	.88
			ULB	MR	-B3	1.00	.80	.88
			ULB	R	-B4	.70	.60	.64
			DBN	I	-F1	.30	.30	.30
			LT	I	-F2	.55	.55	.55

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
7	WLM	WHITE SUMAC					
			LB	I -A1	.70	.50	.57
			LB	IM -A2	1.00	.70	.81
			LB	IMC -A3	1.50	1.00	1.18
			LB	IC -A4	1.00	.80	.87
			LB	MR -A5	1.20	1.00	1.07
			LB	R -A6	.80	.50	.61
			ULB	I -B1	.60	.50	.53
			ULB	IM -B2	1.00	.50	.65
			ULB	MR -B3	1.00	.60	.72
			ULB	R -B4	.70	.50	.56
			LT	I -F2	.80	.80	.80
7	WLM	Fleet Average					
			LB	I -A1	.70	.50	.57
			LB	IM -A2	1.00	.70	.81
			LB	IMC -A3	1.50	1.00	1.18
			LB	IC -A4	1.00	.80	.87
			LB	MR -A5	1.20	1.00	1.07
			LB	R -A6	.80	.50	.61
			ULB	I -B1	.60	.50	.53
			ULB	IM -B2	1.00	.50	.65
			ULB	MR -B3	1.00	.60	.72
			ULB	R -B4	.70	.50	.56
			LT	I -F2	.80	.80	.80
7	WLMR	Fleet Average					
			LB	I -A1	.50	.40	.44
			LB	IM -A2	.80	.50	.61
			LB	IMC -A3	1.20	.80	.94
			LB	IC -A4	.80	.60	.67
			LB	MR -A5	1.00	.80	.87
			LB	R -A6	.60	.40	.47
			ULB	I -B1	.50	.40	.43
			ULB	IM -B2	.90	.40	.55
			ULB	MR -B3	.90	.50	.62
			ULB	R -B4	.60	.40	.46
			LT	I -F2	.80	.80	.80

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
8	WLB	PAPAW					
			LB	I -A1	.70	.70	.70
			LB	IM -A2	1.00	1.00	1.00
			LB	IMC -A3	2.00	2.00	2.00
			LB	IC -A4	1.50	1.50	1.50
			LB	MR -A5	1.00	1.00	1.00
			LB	R -A6	.80	.80	.80
			ULB	I -B1	.50	.50	.50
			ULB	IM -B2	.70	.70	.70
			ULB	MR -B3	.70	.70	.70
			ULB	R -B4	.50	.50	.50
			LT	I -F2	4.00	4.00	4.00
8	WLB	SALVIA					
			LB	I -A1	1.00	.50	.93
			LB	IM -A2	1.50	.70	1.38
			LB	IMC -A3	2.20	1.60	2.11
			LB	IC -A4	2.00	1.30	1.90
			LB	MR -A5	1.50	.60	1.37
			LB	R -A6	.90	.50	.84
			ULB	I -B1	.50	.50	.50
			ULB	IM -B2	1.00	.70	.89
			ULB	MR -B3	1.00	.80	.93
			ULB	R -B4	.60	.60	.60
8	WLB	Fleet Average					
			LB	I -A1	.85	.60	.81
			LB	IM -A2	1.25	.85	1.19
			LB	IMC -A3	2.10	1.80	2.06
			LB	IC -A4	1.75	1.40	1.70
			LB	MR -A5	1.25	.80	1.18
			LB	R -A6	.85	.65	.82
			ULB	I -B1	.50	[illegible]	.50
			ULB	IM -B2	.85	.70	.80
			ULB	MR -B3	.85	.75	.81
			ULB	R -B4	.55	.55	.55
			LT	I -F2	4.00	4.00	4.00
8	WLBR	Fleet Average					
			LB	I -A1	.55	.50	.54
			LB	IM -A2	.80	.70	.79
			LB	IMC -A3	1.75	1.50	1.71
			LB	IC -A4	1.40	1.00	1.34
			LB	MR -A5	.90	.60	.86
			LB	R -A6	.70	.50	.67
			ULB	I -B1	.45	.50	.47
			ULB	IM -B2	.55	.60	.57
			ULB	MR -B3	.55	.60	.57
			ULB	R -B4	.45	.50	.47
			LT	I -F2	4.00	4.00	4.00

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
8	WLM	WHITE HOLLY					
			LB	I -A1	.70	.40	.52
			LB	IM -A2	1.10	.50	.74
			LB	IMC -A3	2.80	1.40	1.95
			LB	IC -A4	2.30	1.10	1.57
			LB	MR -A5	1.20	.60	.84
			LB	R -A6	.90	.40	.60
			ULB	I -B1	.70	.40	.52
			ULB	IM -B2	1.10	.50	.74
			ULB	MR -B3	1.20	.60	.84
			ULB	R -B4	.90	.40	.60
			SEAN	Sp -C1	.40	.40	.40
			SEAN	Fa -C2	.20	.20	.20
			LT	I -F2	2.00	2.00	2.00
8	WLM	WHITE PINE					
			LB	I -A1	.70	.40	.52
			LB	IM -A2	1.10	.50	.74
			LB	IMC -A3	2.80	1.40	1.95
			LB	IC -A4	2.30	1.10	1.57
			LB	MR -A5	2.50	2.50	2.50
			LB	R -A6	2.50	2.50	2.50
			ULB	I -B1	.70	.40	.52
			ULB	IM -B2	1.10	.50	.74
			ULB	MR -B3	1.20	.60	.84
			ULB	R -B4	.90	.40	.60
8	WLM	Fleet Average					
			LB	I -A1	.70	.40	.52
			LB	IM -A2	1.10	.50	.74
			LB	IMC -A3	2.80	1.40	1.95
			LB	IC -A4	2.30	1.10	1.57
			LB	MR -A5	1.85	1.55	1.67
			LB	R -A6	1.70	1.45	1.55
			ULB	I -B1	.70	.40	.52
			ULB	IM -B2	1.10	.50	.74
			ULB	MR -B3	1.20	.60	.84
			ULB	R -B4	.90	.40	.60
			SEAN	Sp -C1	.40	.40	.40
			SEAN	Fa -C2	.20	.20	.20
			LT	I -F2	2.00	2.00	2.00
8	WLMR	Fleet Average					
			LB	I -A1	.55	.25	.37
			LB	IM -A2	.95	.35	.59
			LB	IMC -A3	2.65	1.25	1.80
			LB	IC -A4	2.15	.95	1.42
			LB	MR -A5	1.70	1.40	1.52
			LB	R -A6	1.55	1.30	1.40
			ULB	I -B1	.55	.25	.37
			ULB	IM -B2	.95	.35	.59
			ULB	MR -B3	1.05	.45	.69
			ULB	R -B4	.75	.25	.45
			SEAN	Sp -C1	.20	.20	.20
			SEAN	Fa -C2	.20	.20	.20
			LT	I -F2	2.00	2.00	2.00

District	Type	Vessel	Aid Type	Service Type		Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
9	WLB	BRAMBLE						
			LT	I	-F2	5.90	5.90	5.90
9	WLB	Fleet Average						
			ULB	I	-B1	1.00	.90	.97
			ULB	IM	-B2	1.50	1.40	1.47
			ULB	MR	-B3	1.50	1.40	1.47
			ULB	R	-B4	1.00	.90	.97
			SEAN	Sp	-C1	.65	.45	.59
			SEAN	Fa	-C2	.90	.80	.87
			SEAR	Sp	-C3	1.40	1.30	1.37
			SEAR	Fa	-C4	1.10	1.00	1.07
			LT	I	-F2	5.90	5.90	5.90
9	WLBR	Fleet Average						
			ULB	I	-B1	.70	.60	.67
			ULB	IM	-B2	1.20	1.10	1.17
			ULB	MR	-B3	1.20	1.10	1.17
			ULB	R	-B4	.70	.60	.67
			SEAN	Sp	-C1	.40	.40	.40
			SEAN	Fa	-C2	.90	.80	.87
			SEAR	Sp	-C3	1.20	1.10	1.17
			SEAR	Fa	-C4	1.00	.90	.97
			LT	I	-F2	5.90	5.90	5.90

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
11	WLB	Fleet Average					
			LB	I -A1	1.30	.80	1.00
			LB	IM -A2	2.20	1.60	1.84
			LB	IMC -A3	2.80	2.30	2.50
			LB	IC -A4	2.40	2.10	2.22
			LB	MR -A5	2.30	1.80	2.00
			LB	R -A6	.90	.50	.66
			ULB	I -B1	.70	.60	.63
			ULB	IM -B2	1.80	1.30	1.47
			ULB	MR -B3	1.80	1.50	1.60
			ULB	R -B4	.90	.50	.64
11	WLBR	Fleet Average					
			LB	I -A1	1.10	.60	.80
			LB	IM -A2	2.00	1.40	1.64
			LB	IMC -A3	2.70	2.20	2.40
			LB	IC -A4	2.10	1.80	1.92
			LB	MR -A5	2.00	1.60	1.76
			LB	R -A6	.80	.40	.56
			ULB	I -B1	.70	.50	.57
			ULB	IM -B2	1.60	1.10	1.27
			ULB	MR -B3	1.60	1.30	1.40
			ULB	R -B4	.80	.40	.54

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
13	WLB	IRIS					
			LT	I -F2	0.00	0.00	0.00
13	WLB	Fleet Average					
			LB	I -A1	.70	.40	.48
			LB	IM -A2	1.10	.80	.88
			LB	IMC -A3	2.80	1.40	1.78
			LB	IC -A4	2.30	1.10	1.43
			LB	MR -A5	1.20	.60	.76
			LB	R -A6	.90	.40	.54
			ULB	I -B1	.70	.40	.43
			ULB	IM -B2	.80	.80	.80
			ULB	MR -B3	1.20	.60	.66
			ULB	R -B4	.90	.40	.45
			SEAN	Sp -C1	.70	.40	.68
			SEAN	Fa -C2	.40	.20	.39
			SEAR	Sp -C3	1.30	.45	1.25
			SEAR	Fa -C4	1.10	.40	1.06
			LT	I -F2	0.00	0.00	0.00
13	WLBR	Fleet Average					
			LB	I -A1	.70	.40	.48
			LB	IM -A2	1.00	.80	.85
			LB	IMC -A3	2.50	1.40	1.70
			LB	IC -A4	2.30	1.10	1.43
			LB	MR -A5	1.00	.60	.71
			LB	R -A6	.90	.40	.54
			ULB	I -B1	.60	.40	.42
			ULB	IM -B2	1.00	.80	.82
			ULB	MR -B3	1.00	.60	.64
			ULB	R -B4	.90	.40	.45
			SEAR	Sp -C3	1.25	.45	1.21
			SEAR	Fa -C4	1.10	.40	1.06
			LT	I -F2	0.00	0.00	0.00

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
14	WLB	BASSWOOD					
			DBN	I -F1	1.00	1.00	1.00
			LT	I -F2	2.50	2.50	2.50
14	WLB	MALLOW					
			DBN	I -F1	1.32	1.32	1.32
			LT	I -F2	1.75	1.75	1.75
14	WLB	SASSAFRAS					
			DBN	I -F1	2.50	2.50	2.50
			LT	I -F2	4.00	4.00	4.00
14	WLB	Fleet Average					
			LB	I -A1	3.00	3.00	3.00
			LB	IM -A2	3.00	3.00	3.00
			LB	IMC -A3	3.00	3.00	3.00
			LB	IC -A4	3.00	3.00	3.00
			LB	MR -A5	3.00	3.00	3.00
			LB	R -A6	3.00	3.00	3.00
			ULB	I -B1	3.00	3.00	3.00
			ULB	IM -B2	3.00	3.00	3.00
			ULB	MR -B3	3.00	3.00	3.00
			ULB	R -B4	3.00	3.00	3.00
			DBN	I -F1	1.61	1.61	1.61
			LT	I -F2	2.75	2.75	2.75
14	WLBR	Fleet Average					
			LB	I -A1	2.50	2.50	2.50
			LB	IM -A2	2.50	2.50	2.50
			LB	IMC -A3	2.50	2.50	2.50
			LB	IC -A4	2.50	2.50	2.50
			LB	MR -A5	2.50	2.50	2.50
			LB	R -A6	2.50	2.50	2.50
			ULB	I -B1	2.50	2.50	2.50
			ULB	IM -B2	2.50	2.50	2.50
			ULB	MR -B3	2.50	2.50	2.50
			ULB	R -B4	2.50	2.50	2.50
			DBN	I -F1	1.61	1.61	1.61
			LT	I -F2	2.75	2.75	2.75

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
17	WLB	FIREBUSH					
			LB	I -A1	2.50	1.50	1.76
			LB	IM -A2	4.00	3.00	3.26
			LB	IMC -A3	5.00	3.50	3.89
			LB	IC -A4	5.00	3.50	3.89
			LB	MR -A5	4.00	3.00	3.26
			LB	R -A6	4.00	3.00	3.26
			ULB	I -B1	2.00	1.00	1.11
			ULB	IM -B2	3.00	2.00	2.11
			ULB	MR -B3	2.50	1.50	1.61
			ULB	R -B4	2.50	1.50	1.61
			DBN	I -F1	1.00	1.00	1.00
			LT	I -F2	2.00	2.00	2.00
17	WLB	IRONWOOD					
			DBN	I -F1	.90	.90	.90
			LT	I -F2	2.30	2.30	2.30
17	WLB	PLANETREE					
			DBN	I -F1	.50	.50	.50
			LT	I -F2	1.00	1.00	1.00
17	WLB	SEDGE					
			LB	I -A1	2.50	1.50	1.76
			LB	IM -A2	3.50	2.00	2.39
			LB	IMC -A3	4.00	3.00	3.26
			LB	IC -A4	3.00	2.00	2.26
			LB	MR -A5	3.00	2.00	2.26
			LB	R -A6	2.50	1.50	1.76
			ULB	I -B1	2.00	1.00	1.11
			ULB	IM -B2	3.00	2.00	2.11
			ULB	MR B3	2.50	1.50	1.61
			ULB	R -B4	2.00	1.00	1.11
			SEAN	Sp -C1	3.00	3.00	3.00
			SEAN	Fa -C2	2.00	2.00	2.00
			DBN	I -F1	3.00	3.00	3.00
			LT	I -F2	2.50	2.50	2.50
17	WLB	SWEETBRIER					
			LB	I -A1	2.50	1.20	1.54
			LB	IM -A2	3.50	1.50	2.02
			LB	IMC -A3	4.00	2.50	2.89
			LB	IC -A4	3.50	3.00	3.13
			LB	MR -A5	3.00	2.00	2.26
			LB	R -A6	2.50	1.20	1.54
			ULB	I -B1	2.00	1.00	1.11
			ULB	IM -B2	3.00	1.50	1.66
			ULB	MR -B3	2.50	1.50	1.61
			ULB	R -B4	2.00	1.00	1.11
			SEAN	Sp -C1	3.00	3.00	3.00
			SEAN	Fa -C2	2.00	2.00	2.00
			LT	I -F2	2.20	2.20	2.20
17	WLB	WOODRUSH					
			DBN	I -F1	.50	.50	.50
			LT	I -F2	1.50	1.50	1.50

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
17	WLB	Fleet Average					
			LB	I -A1	2.50	1.40	1.68
			LB	IM -A2	3.67	2.17	2.55
			LB	IMC -A3	4.33	3.00	3.34
			LB	IC -A4	3.83	2.83	3.09
			LB	MR -A5	3.33	2.33	2.59
			LB	R -A6	3.00	1.90	2.18
			ULB	I -B1	2.00	1.00	1.11
			ULB	IM -B2	3.00	1.83	1.96
			ULB	MR -B3	2.50	1.50	1.61
			ULB	R -B4	2.17	1.17	1.27
			SEAN	Sp -C1	3.00	3.00	3.00
			SEAN	Fa -C2	2.00	2.00	2.00
			DBN	I -F1	1.18	1.18	1.18
			LT	I -F2	1.92	1.92	1.92
17	WLBR	Fl-.t Average					
			LB	I -A1	.70	.70	.70
			LB	IM -A2	1.50	.90	1.06
			LB	IMC -A3	2.10	1.20	1.43
			LB	IC -A4	1.90	1.00	1.23
			LB	MR -A5	.90	.70	.75
			LB	R -A6	.80	.60	.65
			ULB	I -B1	.50	.40	.41
			ULB	IM -B2	1.20	.60	.66
			ULB	MR -B3	.90	1.00	.99
			ULB	R -B4	.80	.60	.62
			SEAN	Sp -C1	2.00	2.00	2.00
			SEAN	Fa -C2	1.00	1.00	1.00
			DBN	I -F1	1.18	1.18	1.18
			LT	I -F2	1.92	1.92	1.92

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
99	ALL	OLD SERVICE FORCE MIX MODEL TIMES					
			LB	I -A1	.70	.40	
			LB	IM -A2	1.10	.50	
			LB	IMC -A3	2.80	1.40	
			LB	IC -A4	2.30	1.10	
			LB	MR -A5	1.20	.60	
			LB	R -A6	.90	.40	
			ULB	I -B1	.70	.40	
			ULB	IM -B2	1.10	.50	
			ULB	MR -B3	1.20	.60	
			ULB	R -B4	.90	.40	
			SEAN	Sp -C1	.70	.40	
			SEAN	Fa -C2	.40	.20	
99	WLB	Fleet Average					
			LB	I -A1	1.43	.97	1.13
			LB	IM -A2	2.12	1.43	1.69
			LB	IMC -A3	3.01	2.23	2.50
			LB	IC -A4	2.44	1.90	2.11
			LB	MR -A5	2.02	1.46	1.67
			LB	R -A6	1.52	1.08	1.22
			ULB	I -B1	1.09	.76	.82
			ULB	IM -B2	1.70	1.21	1.33
			ULB	MR -B3	1.63	1.18	1.28
			ULB	R -B4	1.23	.86	.93
			SEAN	Sp -C1	1.46	1.32	1.40
			SEAN	Fa -C2	1.03	.94	.99
			SEAR	Sp -C3	1.06	.75	.93
			SEAR	Fa -C4	.86	.62	.77
			DBN	I -F1	1.18	1.18	1.18
			LT	I -F2	2.29	2.29	2.29
99	WLBR	Fleet Average					
			LB	I -A1	.97	.79	.86
			LB	IM -A2	1.46	1.11	1.26
			LB	IMC -A3	2.18	1.59	1.83
			LB	IC -A4	1.85	1.32	1.55
			LB	MR -A5	1.31	1.04	1.16
			LB	R -A6	1.01	.76	.87
			ULB	I -B1	.79	.67	.71
			ULB	IM -B2	1.24	.96	1.05
			ULB	MR -B3	1.19	1.02	1.08
			ULB	R -B4	.92	.74	.79
			SEAN	Sp -C1	.93	.79	.86
			SEAN	Fa -C2	.70	.60	.66
			SEAR	Sp -C3	1.03	.70	.93
			SEAR	Fa -C4	.88	.63	.81
			DBN	I -F1	1.03	1.03	1.03
			LT	I -F2	2.52	2.52	2.52

District	Type	Vessel	Aid Type	Service Type	Exposed Time	Non-Exposed Time	Weighted Time (Unknown Environment)
99	WLM	Fleet Average					
			LB	I -A1	.87	.69	.77
			LB	IM -A2	1.44	1.00	1.16
			LB	IMC -A3	2.33	1.54	1.84
			LB	IC -A4	1.79	1.16	1.39
			LB	MR -A5	1.45	1.11	1.26
			LB	R -A6	1.04	.81	.92
			ULB	I -B1	.66	.46	.54
			ULB	IM -B2	1.15	.75	.87
			ULB	MR -B3	1.11	.72	.86
			ULB	R -B4	.83	.49	.62
			SEAN	Sp -C1	.68	.53	.56
			SEAN	Fa -C2	.44	.33	.36
			SEAR	Sp -C3	.98	.91	.92
			SEAR	Fa -C4	.78	.74	.74
			LT	I -F2	1.68	1.68	1.68
99	WLMR	Fleet Average					
			LB	I -A1	.68	.55	.61
			LB	IM -A2	1.18	.75	.88
			LB	IMC -A3	1.95	1.22	1.44
			LB	IC -A4	1.56	.96	1.13
			LB	MR -A5	1.13	.88	.97
			LB	R -A6	.91	.72	.78
			ULB	I -B1	.53	.38	.43
			ULB	IM -B2	1.00	.55	.66
			ULB	MR -B3	.91	.60	.70
			ULB	R -B4	.69	.44	.52
			SEAN	Sp -C1	.42	.30	.31
			SEAN	Fa -C2	.38	.30	.31
			SEAR	Sp -C3	.76	.73	.72
			SEAR	Fa -C4	.59	.67	.64
			LT	I -F2	1.62	1.62	1.62

APPENDIX C. DERIVATION OF SERVICE TYPES FROM ATONIS

C.1 BACKGROUND

Analysis of ATONIS data shows that all possible combinations (16) of the four service types occur with varying frequency throughout the year for all types of buoys, including seasonal buoys. However, we know from discussions with COs and headquarters staff that some of these combinations either do not make sense or are artifices of data base usage to force proper indication of required services. Services other than placement and relief on seasonal buoys may represent services performed when discrepancies occur on these buoys. The mapping below was performed to reduce to a more manageable number the different times needed for model validation of current operations.

C.2 PERMANENT LIGHTED BUOYS AND SEASONAL BUOYS

ATONIS Combination	Recommended Combination	Source of Time
I + M + C + R	M + R	Survey
I + M + R		
M + C + R		
M + R		
I + M	I + M	Survey
M		
I + C	I + C	Survey
C		
I + M + C	I + M + C	Survey
M + C		
I + C + R	R	Survey
I + R		
C + R		
R		
I	I	Survey

C.3 PERMANENT UNLIGHTED BUOYS

ATONIS Combination	Recommended Combination	Source of Time
I + M + C + R I + M + R M + C + R M + R	M + R	Survey
I + M + C I + M M + C M	I + M	Survey
I + C I	I	Survey
I + C + R I + R C + R R	R	Survey

C.4 FUTURE OPERATIONS

Discussions with representatives from the districts revealed two practices that will affect the application of the DSS to future operations:

(1) In all the districts, all navaids not already converted are expected to be converted shortly to solar power. Consequently, recharges will occur less frequently, every 5 years for solar battery packs.

(2) In Districts 11, 13, 14 and 17, the standard practice is to perform a mooring inspection along with a navaid inspection annually.

As a consequence, the six-year service cycles below will replace the current versions for permanent lighted and unlighted buoys in WLBR and WLMR scenarios. Recharges, in parentheses, occur in the fifth year only for lighted buoys.

	Districts 1, 5, 7, 8, 9	Districts 11, 13, 14, 17
Year	Service	Service
1	Inspection	Mooring + Inspection
2	Mooring + Inspection	Mooring + Inspection
3	Inspection	Mooring + Inspection
4	Mooring + Inspection	Mooring + Inspection
5	Inspection (+ Recharge)	Mooring + Inspection (+ Recharge)
6	Relief	Relief

APPENDIX D. ATON SFM DSS APPLICATION OF WEATHER DATA

D.1 VARIABLES

D.1.1 Aids to Navigation and Weather Impacts

For each WLM and WLB, we have:

<u>From the survey</u>:

CTWH: Current Total Weather Hours impact

CWIPs (Current Weather Impact Percentages) --
- CEP: Current Exposed locations % of CTWH
- CSP: Current Semi-Exposed locations % of CTWH
- CPP: Current Protected locations % of CTWH

PTWH: Projected Total Weather Hours impact

PWIPs (Projected Weather Impact Percentages) --
- PEP: Projected Exposed locations % of PTWH
- PSP: Projected Semi-Exposed locations % of PTWH
- PPP: Projected Protected locations % of PTWH

<u>From ATONIS</u>:

NNEs (Number of ATON by Environment Types) --
- NEEN: Number of Exposed Environment ATON
- NSEN: Number of Semi-Exposed Environment ATON
- NPEN: Number of Protected Environment ATON
- NUEN: Number of Unknown (Missing) Environment ATON

For each aid, we need:

CWPH: Current Weather Penalty Hours
WLMR-PWPH: WLMR Projected Weather Penalty Hours
WLBR-PWPH: WLBR Projected Weather Penalty Hours

D.1.2 Wave Heights by District

For each District, from the 1984 NOAA Wind and Wave Summaries for Selected USCG Operating Areas, the following area-based 3-foot (for WLMRs) and 8-foot (for WLBRs) wave height occurrence frequencies and the ratio of the 3-foot frequency to the 8-foot frequency were derived:

Area		% Frequency Seas < = 3 ft	% Frequency Seas < = 8 ft	Area Wave Frequency Ratio (AWFR)
Cape Cod	D1	17.3	72.4	0.24
Long Island	D1	13.6	65.1	0.21
Gulf Maine	D1	33.9	83.0	0.41
Cape Hatteras	D5	18.4	74.8	0.25
Charleston	D5	35.9	91.2	0.39
Delaware	D5	37.8	89.9	0.42
Mayport	D7	40.6	94.4	0.43
Gulf Mexico	D8	49.6	94.9	0.52
Great Lakes	D9	70.3	96.7	0.73
Pt Arguella	D11	10.9	73.0	0.15
Astoria	D13	11.3	67.0	0.17
Hawaii	D14	1.3	58.0	0.02
Alaska	D17	7.0	54.0	0.13

D.2 PROCEDURES

For each ship, for each aid:

CWPH = CTWH * (appropriate CWIP) / (appropriate NNE) /100

If current Primary Unit is a WLM:

WLMR - PWPH = PTWH * (appropriate PWIP) / (appropriate NNE) /100
WLBR - PWPH = (WLMR - PWPH) * AWFR

If current Primary Unit is a WLB:

WLBR - PWPH = PTWH * (appropriate PWIP) / (appropriate NNE) /100
WLMR - PWPH = (WLBR - PWPH) / AWFR

D.3 USAGE

For current operations, the total ATON Resource Hours of a ship that were lost due to weather will be the sum of the CWPH values of its assigned aids (which will equal the Current Total Weather Hours (CTWH) obtained from the survey).

For the replacement vessels, the total ATON Resource Hours attributed to the impact of weather will be the sum of either the WLMR Projected Total Weather Hours (WLMR - PWPH) or the WLBR Projected Total Weather Hours (WLBR - PWPH), depending on platform type.

D.4 MISSING VALUES

Aids to Navigation in the ATONIS database that have no recorded environment value are allocated total weather penalty hours in proportion to the number of such aids. For example, a ship with 10% of its aids having no recorded environment values will have 10% of its current and projected weather penalty hours equally divided among the associated aids. The remaining 90% of the weather penalty hours will be allocated based upon the percentages of the total weather penalty hours attributable to each of three environment types and the corresponding number of associated aids.

D.5 EXAMPLE

(a) Ship X is a WLM operating in the Mid-Atlantic with three aids (A1, A2, and A3) that have the following recorded environments in ATONIS:

Aid	Environment
A1	Exposed
A2	Semi-Exposed
A3	Protected

(b) From the survey, the Current Total Weather Hours (CTWH) and the percent break-downs by environment were:

Current Total Weather Hours:	10 (CTWH)
Percentage at Exposed locations:	60 (CEP)
Percentage at Semi-Exposed locations:	30 (CSP)
Percentage at Protected locations:	10 (CPP)

(c) The resulting Current Weather Penalty Hours (CWPH) are:

Aid	Current Weather Penalty Hours
	CTWH * CWIP / NNE / 100
A1	10 * 60 / 1 / 100 = 6
A2	10 * 30 / 1 / 100 = 3
A3	10 * 10 / 1 / 100 = 1
Total	10 (CTWH)

The DSS will sum the CWPH values to produce Ship X's total weather impact hours (i.e., 10).

(d) From the survey, for Ship X the Projected Total Weather Hours (PTWH) and the percent break-downs by environment were:

Projected Total Weather Hours:	5 (PTWH)
Percentage at Exposed locations:	80 (PEP)
Percentage at Semi-Exposed locations:	15 (PSP)
Percentage at Protected locations:	5 (PPP)

(e) The resulting WLMR Projected Weather Penalty Hours (WLMR - PWPH) are:

Aid	WLMR Projected Weather Penalty Hours
	PTWH * PWIP / NNE / 100
A1	5 * 80 / 1 / 100 = 4.0
A2	5 * 15 / 1 / 100 = .75
A3	5 * 5 / 1 / 100 = .25
Total	5.0 (PTWH)

Whenever aids A1, A2, or A3 are assigned in the DSS to a WLMR, the respective WLMR-PWPH values will be added to the WLMR's total weather impact hours.

(f) The resulting WLBR Projected Weather Penalty Hours (WLBR - PWPH), using the Cape Hatteras Area Wave Frequency Ratio of .25, is as follows:

Aid	WLBR Projected Weather Penalty Hours
	WLMR-PWPH * AWFR
A1	4.0 * 0.25 = 1.00
A2	0.75 * 0.25 = 0.1875
A3	0.25 * 0.25 = 0.0625
Total	1.25 (25% of 5.0)

Whenever aids A1, A2, or A3 are assigned to a WLBR, the respective WLBR-PWPH values will be added to the WLBR's total weather impact hours.

APPENDIX E. PHYSICAL SERVICEABILITY OF BUOYS BY THE BUSLR, WLMR, AND WLBR

E.1 PARAMETERS

Four parameters are used in the determination of whether each of the three platform types of BUSLR, WLMR, and WLBR is physically capable of servicing individual buoys. The parameters are maximum lift weight, water depth, buoy height, and current primary unit.

In the determination of physical serviceability, recorded values of "0" for buoy weights and depths are considered to be unknown. Buoy weights of "0" are the result of missing values in the ATONIS Authorized Hull field.

The buoy types utilized in the determination of physical serviceability are based on the ATONIS Authorized Hull field and not the ATONIS On Station Hull field. This determination is based on the assumption that at some point, where the two recorded hull types are different, the On Staion Hull will be replaced with the appropriate hull type indicated by the Authorized Hull field.

The ATON Technical Manual was used as the source of the heights and weights of the Authorized Hulls and as the source of the wet and dry weights of buoy chains.

E.1.1. Maximum Lift Weight Limits

BUSLR:	> 0 and <= 4,500 lbs.
WLMR:	> 0 and <= 20,000 lbs.
WLBR:	None

Maximum Lift is the greater of either the sum of the weights of the Buoy plus Buoy Chain or the sum of the weights of Sinker1 plus Sinker2. It is estimated that the length of chain lifted when a buoy is lifted is equal to the water depth plus 10 feet (to account for the height of the buoy deck). The assumption is made that, of the two recorded chain types for each buoy, the lighter chain is attached to the buoy and the heavier chain is attached to the sinker. Therefore the lighter chain is used in calculating the buoy chain weight. The buoy chain weight is calculated as:

Buoy Chain Weight = (Depth * Wet_Chain_Weight)
+ (10 * Dry_Chain_Weight).

With the sinkers, although sinker wet weights are more appropriate, only sinker dry weights are recorded on the ATONIS Aid File. To offset the difference between the dry and wet sinker weights, the sinker chain weight is not considered.

Following is the distribution of the sources of the Maximum Lift parameter values (i.e., whether the source was the sum of the weights of the Buoy plus Buoy Chain or the sum of the weights of Sinker1 plus Sinker2):

Source	WLM/WLB Buoys
Buoy + Chain	1,934
Sinkers	4,587
None (missing values)	85
Total	6,606

E.1.2. Depth Limits

	Draft	Depth Limit
BUSLR	3 Feet	None
WLMR	8 Feet	>= 12 Feet
WLBR	14 Feet	>= 18 Feet
*WLM 133'	9 Feet	>= 13 Feet
*WLM 157'	6 Feet	>= 10 Feet

* Included for reference

E.1.3. Buoy Height Limits

BUSLR:	<= 11 Feet
WLMR and WLBR:	None

E.1.4. Current Primary Unit

The two limiting factors in determining physical serviceability by WLMRs and WLBRs are maximum lift and water depth. Applying these limits produces results showing that some buoys currently being serviced by WLMs or WLBs are not serviceable by either the WLMR or WLBR. Similarly, applying the limits associated with WLMs and WLBs indicates that some of those buoys are incapable of being serviced by the vessels to which they are currently assigned. This apparent inconsistency is attributable to factors that cannot currently be accounted for such as tides, the use of vessel sub-units (i.e., small boats), the Commanding Officer's ability to overcome vessel limitations under special circumstances, and errors in ATONIS.

With the WLMs, the number of buoys in question is relatively small. The 157-foot

WLM has a draft of 6 feet and generally wouldn't service buoys in less than 10 feet of water. Of the 1402 buoys serviced by 157-foot WLMs, 15 buoys appear to be unserviceable by the 157-foot WLM class. Of these, 4 buoys are recorded as being in less than 10 feet of water, 7 buoys have unknown depths (0), and 4 other buoys have maximum lifts exceeding the 157-foot WLM limit of 10 tons.

The 133-foot WLM has a 9 foot draft and generally wouldn't service buoys in less than 13 feet of water. Of the 1617 buoys serviced by 133-foot WLMs, 109 buoys appear to be unserviceable by the 133-foot WLM class. Of these, 76 are in less than 13 feet of water and 33 have unknown depths, but none has maximum lift exceeding 10 tons.

The existence of inconsistencies in the current buoy/vessel assignments combined with the relatively small number of buoys in question has resulted in the determination that all buoys currently serviced by WLMs will be serviceable by WLMRs. The underlying assumption is that if somehow the WLMs are servicing these buoys today, then WLMRs will be able to service them in the future. This determination covers the 124 buoys assigned to WLMs that appear to be unserviceable by WLMs. In addition, there are 8 buoys assigned to 157-foot WLMs with depths greater than the 157-foot WLM depth limit (10 feet) but less than the WLMR depth limit (12 feet). These 8 buoys will also be serviceable by the WLMRs.

With WLBs and WLBRs, the determination has also been made that all buoys currently being serviced by WLBs will be serviceable by WLBRs. Currently, there are 60 buoys being serviced by WLBs that fall below the acceptable WLB depth limit of 16 feet and there are 710 other buoys (mostly in District 9) that have no recorded depth values. As with the WLMs and WLMRs, the assumption is made that if WLBs are servicing these buoys today, then WLBRs will be able to service them in the future. In addition, there are 8 buoys assigned to WLBs with depths greater than the WLB depth limit (16 feet) but less than the WLBR depth limit (18 feet). These 8 buoys will also serviceable by the WLBRs.

An additional factor supporting the determination that all WLM buoys are serviceable by WLMRs and that all WLB buoys are serviceable by WLBRs is the dynamic positioning systems (DPS) of the replacement platforms. DPS will make it easier and safer to remain on station while working buoys and is especially important in locations characterized by nearby obstacles to safe vessel navigation.

E.2 RESULTS

BUSLR Serviceable	WLM/WLB Buoys
Yes	825
No	5,781
Total	6,606

WLMR Serviceable	
Yes	6,510
No	96
Total	6,606

WLBR Serviceable	
Yes	6,276
No	330
Total	6,606

Current WLM Aids to Navigation	
Aids:	3,050
Structures:	31
Buoys:	3,019
Buoys Serviceable by WLMR:	3,019 (-0)
Buoys Serviceable by WLBR:	2,689 (-330)

Current WLB Aids to Navigation	
Aids:	4,443
Structures:	854
Buoys:	3,587
Buoys Serviceable by WLBR:	3,587 (-0)
Buoys Serviceable by WLMR:	3,491 (-96)

E.3 OBSERVATIONS

1. The 330 WLM buoys that are not serviceable by WLBRs are the result of recorded depths being less than the WLBR limit of 18 feet. There are also 40 other WLM buoys that had unknown depth values (0). Due to the small number in question, it is assumed that the WLBR can service those 40 buoys.

2. The 96 WLB buoys that are not serviceable by WLMRs are the result of maximum lift values in excess of 10 tons.

E.4 PHYSICAL SERVICEABILITY BY CURRENT PRIMARY UNIT

Following is the distribution of physical serviceability of all ATON by current primary unit. These totals reflect both buoys and structures. The assumption was made that all structures (lights and daybeacons) are physically serviceable by each of the three platforms.

			BUSLR	BUSLR	WLMR	BUSLR			
Dist			BUSLR	WLMR	WLBR	or	or	or	WLMR
rict	Vessel	ATON	Only	Only	Only	WLMR	WLBR	WLBR	or WLBR
1	BITTERSWEET	134			13			120	1
1	RED BEECH	267		8		3		198	58
1	RED WOOD	263		25		1		210	27
1	SORREL	146			8			137	1
1	SPAR	191			7			183	1
1	WHITE HEATH	295		17		2		243	33
1	WHITE LUPINE	418		12		1		393	12
1	WHITE SAGE	275		11				259	5
	District 1 Totals	1989	0	73	28	7	0	1743	138
5	COWSLIP	179			1			177	1
5	GENTIAN	86						85	1
5	HORNBEAM	92			3			88	1
5	RED BIRCH	312		26		4		242	40
5	RED CEDAR	338		29		9		280	20
5	RED OAK	246		10				217	19
	District 5 Totals	1253	0	65	4	13	0	1089	82
7	LAUREL	167						165	2
7	LAUREL2	175						85	90
7	MADRONA	196						195	1
7	MADRONA2	125						91	34
7	WHITE SUMAC	214		6		1		191	16
	District 7 Totals	877	0	6	0	1	0	727	143
8	PAPAW	149						147	2
8	SALVIA	121			1			119	1
8	WHITE HOLLY	222		49		44		76	53
8	WHITE PINE	211		12		59		130	10
	District 8 Totals	703	0	61	1	103	0	472	66
9	ACACIA	244						204	40
9	BRAMBLE	250						104	146
9	SUNDEW	243						71	172
	District 9 Totals	737	0	0	0	0	0	379	358
11	BLACKHAW	171			4			166	1
11	CONIFER	136			5			128	3
	District 11 Totals	307	0	0	9	0	0	294	4
13	IRIS	157			32			120	5
13	MARIPOSA	138			7			118	13
	District 13 Totals	295	0	0	39	0	0	238	18
14	BASSWOOD GUAM	55						32	23
14	BASSWOOD MALAKAL	62						9	53
14	BASSWOOD PHILIPP	16						14	2
14	MALLOW HAWAII	68			1			34	33
14	MALLOW JOHNSTON	30						7	23
14	MALLOW MARSHALL	41						33	8
14	SASSAFRAS HAWAII	100			1			49	50
14	SASSAFRAS MIDWAY	28						23	5
14	SASSAFRAS SAMOA	18						4	14
	District 14 Totals	418	0	0	2	0	0	205	211
17	FIREBUSH	140			5			59	76
17	IRONWOOD	95			2			38	55
17	PLANETREE	258						99	159
17	SEDGE	98						30	68
17	SWEETBRIER	124			3			38	83
17	WOODRUSH	235			3			69	163
	District 17 Totals	950	0	0	13	0	0	333	604
	CG Totals	7529	0	205	96	124	0	5480	1624

APPENDIX F. VESSEL DETAIL REPORT

VESSEL DETAIL REPORT

Platform Characteristics

- WLM WHITE SUMAC
- Homeport ST PETERSBURG, FL
- 8 knot average transit speed
- 72 hour maximum cruise length
- work day is 6:00 to 16:00
- 1000 sq.ft. deck space available
- Prep/Deprep time 0:30
- Dispatch Tuesday 1/1/1991 at 6:00
  (Window size = 365 days, Step size = 10 days)

Departure Date Tuesday 1/1/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002283	6:45	0:00	7:38	1	A4
7002308	8:22	0:00	9:33	1	A3
7002316	10:03	0:00	10:39	1	A6
7002317	11:09	0:00	11:53	1	B3
7002320	12:23	0:00	13:11	1	A2
7002330	13:41	0:00	14:13	1	B1
7002329	14:43	0:00	15:16	1	B4
7002326	15:46	0:00	16:35	1	A2
7002324	17:05	12:55	6:34	2	A1
7002315	7:04	0:00	7:57	2	A4
7002314	8:27	0:00	9:15	2	A2
7002313	9:45	0:00	10:34	2	A2
7002310	11:04	0:00	11:52	2	A2
7002309	12:22	0:00	13:26	2	A5
7002392	13:56	0:00	14:35	2	B2
7002391	15:05	0:00	15:54	2	A2
7002307	16:24	13:36	6:34	3	A1
7002390	7:04	0:00	7:48	3	B3
7002306	8:18	0:00	8:49	3	B1
7002305	9:19	0:00	9:51	3	B1
7002304	10:21	0:00	11:10	3	A2
7002303	11:40	0:00	12:32	3	A4
7002302	13:02	0:00	13:38	3	A6
7002301	14:08	0:00	15:01	3	A4
7002300	15:31	0:00	16:35	3	A5
9915508	17:54			3	

Departure Date Friday 1/11/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002344	6:36	0:00	7:46	1	A3
7002345	8:16	0:00	9:05	1	A2
7002342	9:35	0:00	10:23	1	A2
7002343	10:53	0:00	11:42	1	A2
7002282	12:12	0:00	13:00	1	A2
7006610	13:30	0:00	14:23	1	A4
7006611	14:53	0:00	15:27	1	A1
7002286	15:57	0:00	16:31	1	A1
7002288	17:01	12:59	7:04	2	A5
7002291	7:34	0:00	8:23	2	A2
7002293	8:53	0:00	9:45	2	A4
7002296	10:15	0:00	11:19	2	A5
7002297	11:49	0:00	12:24	2	A1
7006312	12:54	0:00	13:26	2	B1
7002299	13:56	0:00	15:00	2	A5
7002292	15:30	0:00	16:18	2	A2
7002290	16:48	13:12	6:34	3	A1
7002287	7:04	0:00	7:39	3	A1
7006609	8:09	0:00	8:57	3	A2
7002338	9:27	0:00	10:01	3	A1
7002339	10:31	0:00	11:20	3	A2
7002280	11:50	0:00	12:54	3	A5
7002281	13:24	0:00	14:13	3	A2
7002277	14:43	0:00	15:19	3	A6
7002276	15:49	0:00	16:24	3	A1
9915508	17:08			3	

Departure Date Monday 1/21/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002218	7:30	0:00	8:18	1	A2
7002216	8:48	0:00	9:22	1	A1
7002217	9:52	0:00	10:27	1	A1
7002214	10:57	0:00	11:45	1	A2
7002212	12:15	0:00	12:50	1	A1
7002208	13:20	0:00	14:08	1	A2
7002206	14:38	0:00	15:42	1	A5
7002204	16:12	13:48	6:34	2	A1
7002202	7:04	0:00	7:53	2	A2
7002200	8:23	0:00	9:11	2	A2

7000166	9:41	0:00	10:30	2	A2
7002201	11:00	0:00	12:04	2	A5
7002203	12:34	0:00	13:08	2	A1
7002205	13:38	0:00	14:31	2	A4
7002207	15:01	0:00	15:35	2	A1
7002209	16:05	13:55	6:48	3	A2
7002213	7:18	0:00	8:23	3	A5
7002215	8:53	0:00	9:41	3	A2
7002219	10:11	0:00	11:00	3	A2
9915508	12:30			3	

Departure Date Thursday 1/31/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002430	6:09	0:00	6:53	1	B3
7002273	7:25	0:00	8:29	1	A5
7002274	8:59	0:00	9:33	1	A1
7002269	10:03	0:00	10:38	1	A1
7002270	11:08	0:00	11:42	1	A1
7002265	12:12	0:00	13:23	1	A3
7002266	13:53	0:00	14:27	1	A1
7002264	14:57	0:00	15:50	1	A4
7002259	16:20	13:40	7:04	2	A5
7002258	7:34	0:00	8:39	2	A5
7002256	9:09	0:00	9:43	2	A1
7002257	10:13	0:00	11:01	2	A2
7002249	11:31	0:00	12:36	2	A5
7002253	13:06	0:00	13:40	2	A1
7002252	14:10	0:00	14:44	2	A1
7002428	15:14	0:00	15:46	2	B1
9915508	16:16			2	

Departure Date Sunday 2/10/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002432	6:10	0:00	6:45	1	A1
7002351	7:15	0:00	7:51	1	A6
7002354	8:21	0:00	9:10	1	A2
7002359	9:40	0:00	10:28	1	A2
7002363	10:58	0:00	11:32	1	A1
7002365	12:02	0:00	12:51	1	A2
7002368	13:21	0:00	14:09	1	A2

7002370	14:39	0:00	15:18	1	B2
7002369	15:48	0:00	16:53	1	A5
7002366	17:23	12:37	7:04	2	A5
7002364	7:34	0:00	8:23	2	A2
7002362	8:53	0:00	9:27	2	A1
7002353	9:57	0:00	10:34	2	A6
7002431	11:04	0:00	11:38	2	A1
9915508	12:08			2	

Departure Date Wednesday 2/20/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7000168	8:36	0:00	9:24	1	A2
7000170	10:59	0:00	11:52	1	A4
7000171	15:23	0:00	16:11	1	F2
7000173	18:54	11:06	7:11	2	A3
7000167	15:43	0:00	16:35	2	A4
7002237	17:50	12:10	7:04	3	A5
7002238	7:34	0:00	8:39	3	A5
7002241	9:09	0:00	9:57	3	A2
7002245	10:27	0:00	11:01	3	A1
7002244	11:31	0:00	12:06	3	A1
7002248	12:36	0:00	13:28	3	A4
7002425	13:58	0:00	14:41	3	B3
9915508	15:11			3	

Departure Date Saturday 3/2/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002235	6:56	0:00	7:31	1	A1
7002236	8:01	0:00	8:35	1	A1
7002232	9:05	0:00	9:42	1	A6
7002227	10:12	0:00	10:48	1	A6
7002228	11:18	0:00	11:52	1	A1
7001763	11:01	0:00	11:33	2	B1
7001765	12:03	0:00	12:34	2	B1
7001766	13:04	0:00	13:43	2	B2
7001764	14:13	0:00	14:52	2	B2
7001759	15:22	0:00	16:11	2	A2
7002225	15:11	0:00	16:16	3	A5
9915508	17:32			3	

Departure Date Tuesday 3/12/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002068	14:53	0:00	15:42	1	A2
7000100	9:44	0:00	10:18	2	A1
7000098	11:44	0:00	12:18	2	B4
7000096	12:51	0:00	13:35	2	B3
7002069	8:29	0:00	9:01	3	B1
7002071	9:31	0:00	10:10	3	B2
7002070	10:40	0:00	11:17	3	A6
7002074	11:47	0:00	12:21	3	A1
7002073	12:51	0:00	13:25	3	A1
7002072	13:55	0:00	14:44	3	A2
7002077	15:14	0:00	16:18	3	A5
9915508	1:06			4	

Departure Date Friday 3/22/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002230	7:06	0:00	7:40	1	A1
7002229	8:10	0:00	9:02	1	A4
7002136	11:46	0:00	12:50	1	A5
7000161	13:20	0:00	14:09	1	A2
7000130	9:14	0:00	10:19	2	A5
7000133	10:59	0:00	11:38	2	B2
7000132	12:08	0:00	12:56	2	A2
7000131	13:26	0:00	14:30	2	A5
7000165	11:57	0:00	13:08	3	A3
7002222	13:44	0:00	14:19	3	A1
7002221	14:49	0:00	15:53	3	A5
9915508	17:16			3	

Departure Date Monday 4/1/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7001813	5:50	0:10	6:32	2	B1
7000123	7:02	0:00	7:41	2	B2
7000122	8:11	0:00	9:15	2	A5
7000121	9:45	0:00	10:24	2	B2

7000120	10:54	0:00	11:31	2	A6
7000136	12:01	0:00	12:32	2	B1
7000135	13:02	0:00	13:46	2	B3
7001801	14:16	0:00	15:04	2	A2
7000134	15:34	0:00	16:23	2	A2
7000129	17:18	12:42	6:39	3	B2
9915508	5:36			4	

Departure Date Thursday 4/11/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7001749	7:37	0:00	8:16	2	B2
7001750	8:46	0:00	9:25	2	B2
7001751	9:55	0:00	10:34	2	B2
7001752	11:04	0:00	11:36	2	B1
7001756	12:06	0:00	12:38	2	B1
7001757	13:08	0:00	13:51	2	B3
7001758	14:21	0:00	15:00	2	B2
7001753	15:30	0:00	16:09	2	B2
7002199	15:58	0:00	17:02	3	A5
9915508	18:36			3	

Departure Date Sunday 4/21/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7006356	7:23	0:00	8:02	1	B2
7001768	7:08	0:00	7:39	2	B1
7001754	8:29	0:00	9:08	2	B2
7001755	9:38	0:00	10:17	2	B2
7001699	10:47	0:00	11:20	2	B4
7001701	11:50	0:00	12:25	2	A1
7001704	12:55	0:00	13:43	2	A2
7001705	14:13	0:00	15:05	2	A4
7001706	15:35	0:00	16:46	2	A3
9915508	17:54			3	

Departure Date Wednesday 5/1/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7000182	2:02	3:58	6:48	2	F2
7000181	8:02	0:00	8:50	2	F2
7000180	10:11	0:00	10:59	2	F2
7000179	12:38	0:00	13:26	2	F2
7000178	14:42	0:00	15:30	2	F2
7000177	17:00	13:00	6:48	3	F2
7000175	8:21	0:00	9:09	3	F2
7000174	9:39	0:00	10:27	3	A2
9915508	22:06			3	

Departure Date Saturday 5/11/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7001721	6:59	0:00	7:36	2	A6
7001715	8:06	0:00	9:10	2	A5
7001714	9:40	0:00	10:15	2	A1
7001713	10:45	0:00	11:37	2	A4
7001711	12:07	0:00	12:46	2	B2
7001710	13:16	0:00	13:55	2	B2
7001707	14:25	0:00	15:29	2	A5
7006343	15:59	0:00	16:48	2	A2
9915508	17:57			3	

Departure Date Tuesday 5/21/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7001748	7:22	0:00	8:01	2	B2
7000111	8:31	0:00	9:05	2	A1
7001689	9:35	0:00	10:28	2	A4
7001690	10:58	0:00	12:08	2	A3
7001693	12:38	0:00	13:15	2	A6
7001695	13:45	0:00	14:19	2	A1
7001696	14:49	0:00	15:24	2	A1
7001700	15:54	0:00	16:46	2	A4
9915508	18:09			3	

Departure Date Friday 5/31/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7000128	4:57	1:03	7:04	2	A5
7000127	7:34	0:00	8:09	2	A1
7000126	8:39	0:00	9:10	2	B1
7000125	9:40	0:00	10:24	2	B3
7000124	10:54	0:00	11:58	2	A5
7002226	10:15	0:00	10:52	3	A6
9915508	12:08			3	

Departure Date Monday 6/10/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7000094	11:24	0:00	12:03	2	B2
7000091	13:57	0:00	14:45	2	A2
7000149	6:39	0:00	7:31	3	A4
7000150	8:24	0:00	8:59	3	A1
7000154	14:31	0:00	15:07	3	A6
9915508	0:04			4	

Departure Date Thursday 6/20/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7000114	7:25	0:00	8:09	2	B3
7000116	8:58	0:00	9:37	2	B2
7000117	11:07	0:00	11:55	2	A2
9915508	13:12			3	

Departure Date Sunday 6/30/1991

Buoy	Arrive	Wait	End	Day	Service
9915508	6:00			1	
7002348	6:30	0:00	7:34	1	A5
7002347	8:04	0:00	9:09	1	A5
7002346	9:39	0:00	10:27	1	A2
9915508	10:59			1	

APPENDIX G. BUOY TENDER OPERATIONS SURVEY FORM

The goal of the Buoy Tender Operations Survey is to capture the knowledge of experts for input into the Aids to Navigation Service Force Mix Decision Support System (DSS). You are asked in this survey to provide data on current and projected future ATON operations.

Inputs on current operations are essential to validating the DSS. When data on current service times, vessel speeds, discrepancy response, and weather impacts are combined with the current fleet mix and navaid assignments (which have been taken from the District ATONIS files), the DSS outputs must equate to current fleet employment figures.

Inputs on projected future ATON service times and weather effects will be combined in the DSS with the capabilities of the new buoy tenders to assist in determining the future buoy tender fleet size and mix.

Throughout the survey, the two new classes of buoy tenders are referred to as the WLMR and the WLBR. Included in the survey is the latest update on the operational features of the new tenders.

The Buoy Tender Activity Survey consists of a District Section and a Buoy Tender Section. The survey forms contained in each section are as follows:

District Section
- WLB/WLBR District ATON Buoy Service Times Form
- WLM/WLMR District ATON Buoy Service Times Form (to be completed if applicable)

Buoy Tender Section (1 per District Buoy Tender)
- Buoy Tender Operating Profile Form
- Buoy Tender Discrepancy Response Form
- Buoy Tender Effects of Weather Form
- Fixed Structure Navaids Currently Assigned to WLMs or WLBs

Please review the survey forms and provide comments, new information, or corrections as indicated.

Thank you for your efforts.

WLBR Planned Operational Features

195-220 ft
1500-2000 tons
2500 sq ft buoy deck
15 ton crane/boom at rated speed
20 ton crane/boom at any speed
15 knots sustained speed
14 ft draft
14-36" icebreaking
21-45 day endurance
6000 mile range
Seakeeping capability to work buoys in seas of 8 foot
significant wave heights (WLB has 6 foot capability)
Dynamic positioning system
Chain in-haul system
Automation (MPCMS, integrated bridge, GPS, latest electronics)
Installed oil skimming capability
40 person operating crew

WLMR Planned Operational Features

150-160 ft
550-650 tons
1200 sq ft buoy deck
10 ton crane
12 knots sustained speed
8.5 ft draft
9-12" continuous icebreaking
3-10 day endurance
2000 mile range
Seakeeping capability to work buoys in seas of 3 foot
significant wave heights (WLM has 2 foot capability)
Dynamic positioning system
Unmanned engineroom
Chain in-haul system
Automation (MPCMS, integrated bridge, GPS, latest electronics)
18 person operating crew
6 person shore based maintenance team
LT/CWO Commanding Officer

WLB/WLBR DISTRICT ATON
BUOY SERVICE TIMES FORM

Please review the current average buoy service times (derived from previous ATON studies) for WLBs in exposed and non-exposed locations, and revise them if you think they are not typical of operations in your district. Then provide estimates of the service times you expect the new WLBRs to require for the same operations. All times are in hours.

The service times should reflect the vessel trip time required to perform each service. For example, if a vessel with an average speed of ten knots takes three hours to travel twenty nautical miles and perform one lighted buoy inspection, then the lighted buoy inspection time would be one hour.

	WLB				WLBR	
	EXPOSED CURRENT	EXPOSED REVISED	NON-EXPOSED CURRENT	NON-EXPOSED REVISED	EXPOSED ESTIMATE	NON-EXPOSED ESTIMATE
LIGHTED BUOYS						
Inspection	0.7	_____	0.4	_____	_____	_____
Inspection+Mooring	1.1	_____	0.5	_____	_____	_____
Inspection+Mooring+Recharge	2.8	_____	1.4	_____	_____	_____
Inspection+Recharge	2.3	_____	1.1	_____	_____	_____
Mooring+Relief	1.2	_____	0.6	_____	_____	_____
Relief	0.9	_____	0.4	_____	_____	_____
UNLIGHTED BUOYS						
Inspection	0.7	_____	0.4	_____	_____	_____
Inspection+Mooring	1.1	_____	0.5	_____	_____	_____
Mooring+Relief	1.2	_____	0.6	_____	_____	_____
Relief	0.9	_____	0.4	_____	_____	_____
SEASONAL BUOYS (NOT REPLACED)						
Place (Spring)	0.7	_____	0.4	_____	_____	_____
Remove (Fall)	0.4	_____	0.2	_____	_____	_____
SEASONAL BUOYS (REPLACED)						
Relief (Spring Year 1, Fall Year 1, and Fall Year 2)	0.7	_____	0.4	_____	_____	_____
Relief+Mooring (Spring Year 2)	1.1	_____	0.5	_____	_____	_____

WLM/WLMR DISTRICT ATON
BUOY SERVICE TIMES FORM

If presently there are WLMs homeported in your district, please review the current average buoy service times (derived from previous ATON studies) for WLMs in exposed and non-exposed locations, and revise them if you think they are not typical of operations in your District. Then provide estimates of the service times you expect the new WLMRs to require for the same operations. All times are in hours.

As with the WLBs and WLBRs, the service times should reflect the vessel trip time required to perform each service.

If presently there are no WLMs homeported in your district but you feel you have sufficient past experience with WLMs, your inputs to this form are welcome (if so, please indicate your WLM experience).

	WLM				WLMR	
	EXPOSED CURRENT	EXPOSED REVISED	NON-EXPOSED CURRENT	NON-EXPOSED REVISED	EXPOSED ESTIMATE	NON-EXPOSED ESTIMATE
LIGHTED BUOYS						
Inspection	0.7	____	0.4	____	____	____
Inspection+Mooring	1.1	____	0.5	____	____	____
Inspection+Mooring+Recharge	2.8	____	1.4	____	____	____
Inspection+Recharge	2.3	____	1.1	____	____	____
Mooring+Relief	1.2	____	0.6	____	____	____
Relief	0.9	____	0.4	____	____	____
UNLIGHTED BUOYS						
Inspection	0.7	____	0.4	____	____	____
Inspection+Mooring	1.1	____	0.5	____	____	____
Mooring+Relief	1.2	____	0.6	____	____	____
Relief	0.9	____	0.4	____	____	____
SEASONAL BUOYS (NOT REPLACED)						
Place (Spring)	0.7	____	0.4	____	____	____
Remove (Fall)	0.4	____	0.2	____	____	____
SEASONAL BUOYS (REPLACED)						
Relief (Spring Year 1, Fall Year 1, and Fall Year 2)	0.7	____	0.4	____	____	____
Relief+Mooring (Spring Year 2)	1.1	____	0.5	____	____	____

DISTRICT BUOY TENDER OPERATIONS SURVEY
BUOY TENDER SECTION

For all WLMs and WLBs in the district, the following three forms are provided:

Buoy Tender Operating Profile Form
Buoy Tender Discrepancy Response Form
Buoy Tender Effects of Weather Form

For WLMs and WLBs that have fixed structures assigned to them in ATONIS, the following form is also provided:

Fixed Structure Navaids Currently Assigned . to WLMs or WLBs

The instructions for this form are as follows:

Please review the list of fixed structure navaids and, if feasible, indicate for each structure the approximate number of scheduled servicing visits required per year and the average number of hours per visit. Then, if any structure is currently located within the general area of operations of an existing ANT unit, please provide a Yes(Y) or No(N) response under the "ANT/BUSLR Can Do?" column of whether the required servicing could be performed by the ANT if it were provided with additional ATON servicing resources.

If, for each primary unit's list of structures, it is not feasible to provide the number of scheduled visits, hours per visit, and whether or not an ANT could perform the servicing, please estimate the averages per primary unit in the space provided at the end of each primary unit list. If averages can be determined for the different structure types (lights and daybeacons), please indicate those averages accordingly.

If you choose to provide averages but there are some structures whose servicing requirements deviate significantly from the averages, please mark those structures accordingly.

BUOY TENDER OPERATING PROFILE FORM

PRIMARY UNIT: COWSLIP

Please review the information printed below, which is based on five years of data from the Abstract of Operations. If you think any of the items do not reflect "typical" vessel operations because of unusual circumstances that occured during the time period, please comment and provide a more "typical" value.

	Current Value	Changed Value
ATON Resource Hours:	1108.6	________
ATON Inport Operations (I/O) Hours:	323.0	________
CG Overhead Resource Hours:	128.8	________
CG Overhead I/O Hours:	276.0	________
Essential Multi-Mission Resource Hours:	41.2	________
Essential Multi-Mission I/O Hours:	4.0	________
Other Multi-Mission Resource Hours:	155.4	________
Other Multi-Mission I/O Hours:	41.4	________
Total Underway Resource Hours:	1434.0	________
Total Underway Days:	112.6	________
Average Underway Resource Hours/Day:	12.7	________
Total High Readiness Days:	14.2	________

NOTE: Overhead includes MIO, RBS, CADET/OC, PSS, PIA OP TRA, RESERVE and BRIDGE operations.
Essential multi-mission includes SAR, DOM ICE, MER and MSA operations.
Other multi-mission includes ELT, MIL OPS and COOP operations.

COMMENTS: ____

____

____

Please provide the following information on the operating characteristics of the primary unit.

1. Average transit speed: ________ knots

2. Average length of ATON mission trip: ________ days

   Minimum length of ATON mission trip: ________ days

   Maximum length of ATON mission trip: ________ days

3. Average length of ATON work day: ________ hours
   (Sum of steaming and ATON servicing times.)

BUOY TENDER OPERATING PROFILE FORM (Continued)

4. Percentages of buoys and structures assigned to the primary unit whose scheduled servicing is regularly performed by small boats of the primary unit at the same time the primary unit is engaged in other ATON work:

Buoys: _____ Structures: _____

BUOY TENDER DISCREPANCY RESPONSE FORM

PRIMARY UNIT: COWSLIP

If you think any of the Data Items 1 through 4, based on ATONIS, are inaccurate, please correct them in the space provided. Also, please provide an estimate for Item 5.

	DATA ITEM	ATONIS VALUE	CORRECTION
1.	Number of assigned navaids	178	________
2. a.	Reported number of discrepancies of assigned navaids from 1/01/87 to 10/09/90	0	________
b.	Average per year	0.0	________
3. a.	Number of discrepancies responded to by the vessel (as opposed to teams from the vessel) from 1/08/87 to 10/05/90	200	________
b.	Average per year	53.4	________
4.	Average Discrepancy Response Level	3.3	________
5.	Average annual resource hours for discrepancy response		________

BUOY TENDER EFFECTS OF WEATHER FORM

PRIMARY UNIT: COWSLIP

1. Average annual ATON resource hours: 1108.6 hours
(Based on 5 years of data, when available, from the Abstract of Operations)

2. Estimate the number of annual ATON resource hours in Item 1 above attributable to weather impact on operations (i.e., how many of the Item 1 hours would have been saved if you always had perfect weather): __________ hours

3. What percentages of weather hours in Item 2 are attributable to navaids located in the environments below?

Exposed Water ______%

Semi-exposed Water ______%

Protected Water ______%

NOTE: The three percentages should add up to 100%.

4. Given a vessel with differential GPS, improved seakeeping abilities (from 6 to 8 ft. for WLB's), and a Dynamic Positioning System (DPS), re-estimate the number of annual ATON resource hours in Item 2 above that would now be attributable to weather impact on servicing operations for your currently assigned navaids. (This estimate is expected to be lower than the original estimate.) __________ hours

5. What percentages of weather hours from Item 4 would be attributable to navaids located in the environments below?

Exposed Water ______%

Semi-exposed Water ______%

Protected Water ______%

NOTE: The three percentages should add up to 100%.

APPENDIX H. BUOY TENDER OPERATIONS SURVEY RESULTS

12/03/91 BUOY TENDER SUMMARY Page 1

Primary Unit:	BITTERSWEET	District:	1
Type:	WLB	City:	WOODS HOLE
OpFac Code:	15204	State:	MA

	Recorded	Revised
Number of Assigned Navaids:	133	139
Discrepancy Responses:	4	
Avg Per Year:	2.7	25.0
Discrepancies of Assigned:	236	191
Avg Per Year:	4.2	38.2
Avg Discrepancy Response Level:	3.0	
Avg Discrepancy Response Hours:		120.0
ATON Resource Hours:	878	1047
ATON Inport Operations Hours:	111	138
CG Overhead Resource Hours:	182	198
CG Overhead I/O Hours:	261	245
EMM Resource Hours:	189	357
EMM I/O Hours:	11	20
OMM Resource Hours:	255	122
OMM I/O Hours:	18	6
Total Underway Resource Hours:	1504	1788
Total Underway Days:	116	134
Total High Readiness Days:	12	10

Comments: Numbers are calculated excluding FY 90 as ship underwent longest maintenance period in ship's history. Would have skewed numbers and not reflected true operations of ship.

Avg Transit Speed:	12 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	12 hours	Min:	1 days
		Max:	10 days

Buoys:	133	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		0	5	11
Current Weather Hours:	157	10 %	27 %	63 %
Projected Weather Hours:	125	15 %	35 %	50 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	SORREL	District:	1
Type:	WLB	City:	NEW YORK
OpFac Code:	15231	State:	NY

	Recorded	Revised
Number of Assigned Navaids:	145	146
Discrepancy Responses:	3	
Avg Per Year:	.2	50.0
Discrepancies of Assigned:	374	
Avg Per Year:	4.2	110.0
Avg Discrepancy Response Level:	3.0	2.0
Avg Discrepancy Response Hours:		400.0
ATON Resource Hours:	1040	1040
ATON Inport Operations Hours:	300	
CG Overhead Resource Hours:	216	
CG Overhead I/O Hours:	624	
EMM Resource Hours:	74	
EMM I/O Hours:	8	
OMM Resource Hours:	186	
OMM I/O Hours:	32	
Total Underway Resource Hours:	1539	
Total Underway Days:	131	131
Total High Readiness Days:	11	

Comments: None

Avg Transit Speed:	10 knots	Length of Trip Avg:	2 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	5 days

Buoys:	145	% Serviced by Small Boat:	10 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		26	90	29
Current Weather Hours:	100	70 %	20 %	10 %
Projected Weather Hours:	20	90 %	5 %	5 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	SPAR	District:	1
Type:	WLB	City:	SOUTH PORTLAND
OpFac Code:	15232	State:	ME

	Recorded	Revised
Number of Assigned Navaids:	190	
Discrepancy Responses:	0	8
Avg Per Year:		16.0
Discrepancies of Assigned:	125	125
Avg Per Year:	4.2	
Avg Discrepancy Response Level:	0.0	151.0
Avg Discrepancy Response Hours:		80.0
ATON Resource Hours:	1152	1258
ATON Inport Operations Hours:	164	169
CG Overhead Resource Hours:	236	334
CG Overhead I/O Hours:	396	460
EMM Resource Hours:	131	135
EMM I/O Hours:	8	9
OMM Resource Hours:	202	207
OMM I/O Hours:	16	21
Total Underway Resource Hours:	1721	1934
Total Underway Days:	119	134
Total High Readiness Days:	4	4

Comments: *05 OCT 90- 23 MAR 91 unscheduled maintenance and repair Newport Offshore, RI.
*Based on last 18 months of ops excluding 6 months SPAR was broken due to thrust bearing.

Avg Transit Speed:	9 knots	Length of Trip Avg:	4 days
Avg Length of Work Day:	12 hours	Min:	1 days
		Max:	13 days

Buoys:	190	% Serviced by Small Boat:	11 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		71	84	32
Current Weather Hours:	250	72 %	28 %	0 %
Projected Weather Hours:	110	100 %	0 %	0 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	RED WOOD	District:	1
Type:	WLM 157'	City:	NEW LONDON
OpFac Code:	15401	State:	CT

	Recorded	Revised
Number of Assigned Navaids:	262	260
Discrepancy Responses:	1	80
Avg Per Year:	0.0	20.0
Discrepancies of Assigned:	144	160
Avg Per Year:	4.2	40.0
Avg Discrepancy Response Level:	2.0	
Avg Discrepancy Response Hours:		107.0
ATON Resource Hours:	1045	1045
ATON Inport Operations Hours:	531	
CG Overhead Resource Hours:	104	
CG Overhead I/O Hours:	216	
EMM Resource Hours:	33	
EMM I/O Hours:	11	
OMM Resource Hours:	10	28
OMM I/O Hours:	0	26
Total Underway Resource Hours:	1191	
Total Underway Days:	130	130
Total High Readiness Days:	1	

Comments: Misc. hours were added to the "Other Multi-Mission" Categories.

Avg Transit Speed:	12 knots	Length of Trip Avg:	°3 days
Avg Length of Work Day:	11 hours	Min:	1 days
		Max:	10 days

Buoys:	262	% Serviced by Small Boat:	15 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		250	2	1
Current Weather Hours:	260	50 %	30 %	20 %
Projected Weather Hours:	150	60 %	20 %	20 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit: RED BEECH
Type: WLM 157'
OpFac Code: 15402

District: 1
City: NEW YORK
State: NY

	Recorded	Revised
Number of Assigned Navaids:	266	
Discrepancy Responses:	4	140
Avg Per Year:	2.4	60.0
Discrepancies of Assigned:	430	505
Avg Per Year:	4.2	121.0
Avg Discrepancy Response Level:	2.3	2.5
Avg Discrepancy Response Hours:		242.0
ATON Resource Hours:	888	888
ATON Inport Operations Hours:	357	566
CG Overhead Resource Hours:	181	
CG Overhead I/O Hours:	218	223
EMM Resource Hours:	12	
EMM I/O Hours:	7	
OMM Resource Hours:	9	47
OMM I/O Hours:	5	
Total Underway Resource Hours:	1090	
Total Underway Days:	126	126
Total High Readiness Days:	4	7

Comments: None

Avg Transit Speed: 10 knots
Avg Length of Work Day: 12 hours

Length of Trip Avg: 1 days
Min: 1 days
Max: 21 days

Buoys: 247 — % Serviced by Small Boat: 45 %
Structures: 19 — " 95 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		0	2	4
Current Weather Hours:	100	15 %	50 %	35 %
Projected Weather Hours:	30	0 %	0 %	100 %

Lights(LTs): 19
LT Visits: 1.20
LT Hours: 1.10
LT ANT?: Y

Daybeacons(DBNs): 0
DBN Visits: 1.00
DBN Hours: .50
DBN ANT?: Y

(Database: Survey.db Report#: 6)

Primary Unit:	WHITE HEATH	District:	1
Type:	WLM 133'	City:	BOSTON
OpFac Code:	15503	State:	MA

	Recorded	Revised
Number of Assigned Navaids:	294	290
Discrepancy Responses:	1	200
Avg Per Year:	0.0	68.0
Discrepancies of Assigned:	240	267
Avg Per Year:	4.2	89.0
Avg Discrepancy Response Level:	4.0	
Avg Discrepancy Response Hours:		101.0
ATON Resource Hours:	964	1072
ATON Inport Operations Hours:	807	957
CG Overhead Resource Hours:	49	74
CG Overhead I/O Hours:	2	4
EMM Resource Hours:	7	4
EMM I/O Hours:	0	1
OMM Resource Hours:	119	26
OMM I/O Hours:	6	17
Total Underway Resource Hours:	1139	1292
Total Underway Days:	119	136
Total High Readiness Days:	10	3

Comments: Discrepancies were in beginning years of survey. Primary batteries still in use and solar power being installed- average over past year: 6.

Avg Transit Speed:	11 knots	Length of Trip Avg:	4 days
Avg Length of Work Day:	16 hours	Min:	1 days
		Max:	5 days

Buoys:	291	% Serviced by Small Boat:	0 %
Structures:	3	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		141	56	91
Current Weather Hours:	236	45 %	30 %	25 %
Projected Weather Hours:	100	70 %	30 %	0 %

Lights(LTs):	3	Daybeacons(DBNs):	0
LT Visits:	1.00	DBN Visits:	0.00
LT Hours:	3.00	DBN Hours:	0.00
LT ANT?:	N	DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	WHITE LUPINE	District:	1
Type:	WLM 133'	City:	ROCKLAND
OpFac Code:	15505	State:	ME

	Recorded	Revised
Number of Assigned Navaids:	417	
Discrepancy Responses:	0	344
Avg Per Year:		86.0
Discrepancies of Assigned:	364	
Avg Per Year:	4.2	86.0
Avg Discrepancy Response Level:	0.0	
Avg Discrepancy Response Hours:		246.0
ATON Resource Hours:	1089	1089
ATON Inport Operations Hours:	746	
CG Overhead Resource Hours:	200	
CG Overhead I/O Hours:	132	
EMM Resource Hours:	8	
EMM I/O Hours:	1	
OMM Resource Hours:	11	
OMM I/O Hours:	23	
Total Underway Resource Hours:	1308	
Total Underway Days:	120	120
Total High Readiness Days:	28	

Comments:

Avg Transit Speed:	10 knots	Length of Trip Avg:	5 days
Avg Length of Work Day:	15 hours	Min:	1 days
		Max:	10 days

Buoys:	417	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		82	162	153
Current Weather Hours:	0	0 %	0 %	0 %
Projected Weather Hours:	0	0 %	0 %	0 %

Lights(LTs):		Daybeacons(DBNs):	
LT Visits:		DBN Visits:	
LT Hours:		DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	WHITE SAGE	District:	1
Type:	WLM 133'	City:	BRISTOL
OpFac Code:	15507	State:	RI

	Recorded	Revised
Number of Assigned Navaids:	274	
Discrepancy Responses:	4	90
Avg Per Year:	2.3	30.0
Discrepancies of Assigned:	205	
Avg Per Year:	4.2	
Avg Discrepancy Response Level:	4.8	
Avg Discrepancy Response Hours:		200.0
ATON Resource Hours:	946	946
ATON Inport Operations Hours:	555	200
CG Overhead Resource Hours:	100	
CG Overhead I/O Hours:	36	
EMM Resource Hours:	2	
EMM I/O Hours:	2	
OMM Resource Hours:	5	
OMM I/O Hours:	3	
Total Underway Resource Hours:	1052	
Total Underway Days:	108	108
Total High Readiness Days:	22	

Comments: None

Avg Transit Speed:	10 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	14 days

Buoys:	274	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		54	183	24
Current Weather Hours:	400	10 %	40 %	50 %
Projected Weather Hours:	60	50 %	40 %	10 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	COWSLIP	District:	5
Type:	WLB	City:	PORTSMOUTH
OpFac Code:	15213	State:	VA

	Recorded	Revised
Number of Assigned Navaids:	178	190
Discrepancy Responses:	200	
Avg Per Year:	3.7	53.4
Discrepancies of Assigned:	291	
Avg Per Year:	3.8	
Avg Discrepancy Response Level:	3.3	
Avg Discrepancy Response Hours:		230.0
ATON Resource Hours:	1109	1151
ATON Inport Operations Hours:	323	241
CG Overhead Resource Hours:	129	81
CG Overhead I/O Hours:	276	244
EMM Resource Hours:	41	81
EMM I/O Hours:	4	6
OMM Resource Hours:	155	125
OMM I/O Hours:	41	40
Total Underway Resource Hours:	1434	1505
Total Underway Days:	113	112
Total High Readiness Days:	14	15

Comments: None

Avg Transit Speed:	13 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	16 hours	Min:	1 days
		Max:	5 days

Buoys:	178	% Serviced by Small Boat:	30 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		104	24	22
Current Weather Hours:	40	50 %	50 %	0 %
Projected Weather Hours:	25	80 %	20 %	0 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	GENTIAN	District:	5
Type:	WLB	City:	ATLANTIC BEACH
OpFac Code:	15216	State:	NC

	Recorded	Revised
Number of Assigned Navaids:	85	86
Discrepancy Responses:	72	
Avg Per Year:	3.7	19.3
Discrepancies of Assigned:	167	167
Avg Per Year:	3.8	
Avg Discrepancy Response Level:	3.2	
Avg Discrepancy Response Hours:		150.0
ATON Resource Hours:	997	997
ATON Inport Operations Hours:	67	
CG Overhead Resource Hours:	186	
CG Overhead I/O Hours:	243	
EMM Resource Hours:	14	
EMM I/O Hours:	0	
OMM Resource Hours:	262	
OMM I/O Hours:	46	
Total Underway Resource Hours:	1459	
Total Underway Days:	118	118
Total High Readiness Days:	22	

Comments: None

Avg Transit Speed:	11 knots	Length of Trip	Avg:	3 days
Avg Length of Work Day:	12 hours		Min:	1 days
			Max:	5 days

Buoys:	85	% Serviced by Small Boat:	1 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		43	12	29
Current Weather Hours:	12	0 %	0 %	100 %
Projected Weather Hours:	12	0 %	0 %	100 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	HORNBEAM	District:	5
Type:	WLB	City:	CAPE MAY
OpFac Code:	15217	State:	NJ

	Recorded	Revised
Number of Assigned Navaids:	91	105
Discrepancy Responses:	115	
Avg Per Year:	3.4	33.9
Discrepancies of Assigned:	167	204
Avg Per Year:	3.8	54.1
Avg Discrepancy Response Level:	3.7	
Avg Discrepancy Response Hours:		330.0
ATON Resource Hours:	902	905
ATON Inport Operations Hours:	281	
CG Overhead Resource Hours:	130	132
CG Overhead I/O Hours:	164	
EMM Resource Hours:	89	
EMM I/O Hours:	16	
OMM Resource Hours:	329	
OMM I/O Hours:	62	
Total Underway Resource Hours:	1449	
Total Underway Days:	14	101
Total High Readiness Days:	8	12

Comments: None

Avg Transit Speed:	10 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	14 hours	Min:	1 days
		Max:	14 days

Buoys:	91	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		71	18	2
Current Weather Hours:	135	35 %	45 %	20 %
Projected Weather Hours:	70	60 %	25 %	15 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	RED BIRCH	District:	5
Type:	WLM 157'	City:	BALTIMORE
OpFac Code:	15403	State:	MD

	Recorded	Revised
Number of Assigned Navaids:	311	310
Discrepancy Responses:	299	298
Avg Per Year:	3.7	25.0
Discrepancies of Assigned:	320	
Avg Per Year:	3.8	
Avg Discrepancy Response Level:	3.4	
Avg Discrepancy Response Hours:		122.0
ATON Resource Hours:	1071	1071
ATON Inport Operations Hours:	596	
CG Overhead Resource Hours:	57	
CG Overhead I/O Hours:	144	
EMM Resource Hours:	9	
EMM I/O Hours:	2	
OMM Resource Hours:	26	
OMM I/O Hours:	28	
Total Underway Resource Hours:	1163	
Total Underway Days:	121	121
Total High Readiness Days:	3	

Comments: None

Avg Transit Speed:	12 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	12 hours	Min:	1 days
		Max:	10 days

Buoys:	311	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		5	172	113
Current Weather Hours:	90	60 %	30 %	10 %
Projected Weather Hours:	10	33 %	33 %	33 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	RED CEDAR	District:	5
Type:	WLM 157'	City:	PORTSMOUTH
OpFac Code:	15404	State:	VA

	Recorded	Revised
Number of Assigned Navaids:	337	329
Discrepancy Responses:	208	301
Avg Per Year:	3.8	25.0
Discrepancies of Assigned:	403	
Avg Per Year:	3.8	106.8
Avg Discrepancy Response Level:	3.4	
Avg Discrepancy Response Hours:		120.0
ATON Resource Hours:	1286	1286
ATON Inport Operations Hours:	318	
CG Overhead Resource Hours:	130	
CG Overhead I/O Hours:	291	
EMM Resource Hours:	10	
EMM I/O Hours:	0	
OMM Resource Hours:	24	
OMM I/O Hours:	10	
Total Underway Resource Hours:	1450	
Total Underway Days:	126	126
Total High Readiness Days:	11	

Comments: None

Avg Transit Speed:	12 knots	Length of Trip Avg:	2 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	14 days

Buoys:	337	% Serviced by Small Boat:	45 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		23	147	164
Current Weather Hours:	175	25 %	25 %	50 %
Projected Weather Hours:	25	70 %	30 %	0 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	RED OAK	District:	5
Type:	WLM 157'	City:	PHILADELPHIA
OpFac Code:	15405	State:	PA

	Recorded	Revised
Number of Assigned Navaids:	245	249
Discrepancy Responses:	429	431
Avg Per Year:	3.4	25.0
Discrepancies of Assigned:	530	
Avg Per Year:	3.8	
Avg Discrepancy Response Level:	3.2	85.0
Avg Discrepancy Response Hours:		
ATON Resource Hours:	1084	1084
ATON Inport Operations Hours:	306	
CG Overhead Resource Hours:	137	
CG Overhead I/O Hours:	250	
EMM Resource Hours:	18	
EMM I/O Hours:	1	
OMM Resource Hours:	6	
OMM I/O Hours:	5	
Total Underway Resource Hours:	1245	
Total Underway Days:	132	132
Total High Readiness Days:	2	

Comments: None

Avg Transit Speed:	12 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	14 days

Buoys:	245	% Serviced by Small Boat:	15 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		9	71	165
Current Weather Hours:	80	50 %	40 %	10 %
Projected Weather Hours:	40	50 %	50 %	0 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	LAUREL	District:	7
Type:	WLB	City:	MAYPORT
OpFac Code:	15220	State:	FL

	Recorded	Revised
Number of Assigned Navaids:	341	345
Discrepancy Responses:	101	
Avg Per Year:	1.6	61.5
Discrepancies of Assigned:	311	685
Avg Per Year:	5.8	
Avg Discrepancy Response Level:	2.9	
Avg Discrepancy Response Hours:		126.0
ATON Resource Hours:	1355	1355
ATON Inport Operations Hours:	122	130
CG Overhead Resource Hours:	259	
CG Overhead I/O Hours:	176	
EMM Resource Hours:	61	
EMM I/O Hours:	1	16
OMM Resource Hours:	327	30
OMM I/O Hours:	13	
Total Underway Resource Hours:	2002	1705
Total Underway Days:	132	125
Total High Readiness Days:	2	

Comments: Since D7 became a two WLB district, we are no longer able to devote WLB time to many Mil Ops, ELT and COOP hours as we did in the past.
*Average buoys per day:5 , Max per day:8

Avg Transit Speed:	11 knots	Length of Trip Avg:	6 days
Avg Length of Work Day:	12 hours	Min:	1 days
		Max:	30 days

Buoys:	256	% Serviced by Small Boat:	5 %
Structures:	85	"	60 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		0	0	0
Current Weather Hours:	35	70 %	20 %	5 %
Projected Weather Hours:	20	80 %	15 %	5 %

Lights(LTs):	51	Daybeacons(DBNs):	34
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	.60	DBN Hours:	.30
LT ANT?:	Y	DBN ANT?:	Y

(Database: Survey.db Report#: 6)

Primary Unit:	MADRONA	District:	7
Type:	WLB	City:	CHARLESTON
OpFac Code:	15221	State:	SC

	Recorded	Revised
Number of Assigned Navaids:	320	324
Discrepancy Responses:	56	55
Avg Per Year:	1.8	30.0
Discrepancies of Assigned:	278	600
Avg Per Year:	5.8	
Avg Discrepancy Response Level:	3.5	
Avg Discrepancy Response Hours:		129.0
ATON Resource Hours:	1458	1458
ATON Inport Operations Hours:	220	130
CG Overhead Resource Hours:	173	250
CG Overhead I/O Hours:	165	250
EMM Resource Hours:	139	10
EMM I/O Hours:	14	3
OMM Resource Hours:	363	15
OMM I/O Hours:	36	0
Total Underway Resource Hours:	2133	1733
Total Underway Days:	155	120
Total High Readiness Days:	1	

Comments: Since D7 became a two WLB district, we are no longer able to devote WLB time to many Mil Ops, ELT and COOP hours as we did in the past.
* Average buoys per day:5 , Max buoys per day:8

Avg Transit Speed:	10 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	12 hours	Min:	1 days
		Max:	21 days

Buoys:	295	% Serviced by Small Boat:	10 %
Structures:	25	"	100 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		0	0	0
Current Weather Hours:	135	75 %	20 %	5 %
Projected Weather Hours:	120	85 %	10 %	5 %

Light (LTs):	25	Daybeacons(DBNs):	0
LT Visits:	1.00	DBN Visits:	0.00
LT Hours:	.50	DBN Hours:	0.00
LT ANT?:	Y	DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	WHITE SUMAC	District:	7
Type:	WLM 133'	City:	ST PETERSBURG
OpFac Code:	15508	State:	FL

	Recorded	Revised
Number of Assigned Navaids:	213	224
Discrepancy Responses:	71	
Avg Per Year:	1.8	40.0
Discrepancies of Assigned:	459	
Avg Per Year:	5.8	79.8
Avg Discrepancy Response Level:	2.9	
Avg Discrepancy Response Hours:		90.0
ATON Resource Hours:	1248	1248
ATON Inport Operations Hours:	586	
CG Overhead Resource Hours:	63	
CG Overhead I/O Hours:	63	
EMM Resource Hours:	3	10
EMM I/O Hours:	0	8
OMM Resource Hours:	113	70
OMM I/O Hours:	20	
Total Underway Resource Hours:	1426	1433
Total Underway Days:	122	122
Total High Readiness Days:	7	

Comments: Average buoys worked per day:5-6 , Max on good day:8.

Avg Transit Speed:	10 knots	Length of Trip Avg:	6 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	13 days

Buoys:	205	% Serviced by Small Boat:	0 %
Structures:	8	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		0	0	0
Current Weather Hours:	24	85 %	10 %	5 %
Projected Weather Hours:	8	100 %	0 %	0 %

Lights(LTs):	8	Daybeacons(DBNs):	0
LT Visits:	1.00	DBN Visits:	0.00
LT Hours:	.80	DBN Hours:	0.00
LT ANT?:	Y	DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	PAPAW	District:	8
Type:	WLB	City:	GALVESTON
OpFac Code:	15225	State:	TX

	Recorded	Revised
Number of Assigned Navaids:	148	143
Discrepancy Responses:	37	40
Avg Per Year:	4.3	15.0
Discrepancies of Assigned:	74	180
Avg Per Year:	6.0	
Avg Discrepancy Response Level:	1.0	2.5
Avg Discrepancy Response Hours:		350.0
ATON Resource Hours:	1181	1300
ATON Inport Operations Hours:	106	
CG Overhead Resource Hours:	404	
CG Overhead I/O Hours:	640	
EMM Resource Hours:	259	
EMM I/O Hours:	16	
OMM Resource Hours:	229	
OMM I/O Hours:	81	
Total Underway Resource Hours:	2073	
Total Underway Days:	118	118
Total High Readiness Days:	6	2

Comments:

Avg Transit Speed:	12 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	14 hours	Min:	1 days
		Max:	10 days

Buoys:	147	% Serviced by Small Boat:	0 %
Structures:	1	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		116	18	13
Current Weather Hours:	90	100 %	0 %	0 %
Projected Weather Hours:	80	100 %	0 %	0 %

Lights(LTs):	1	Daybeacons(DBNs):	0
LT Visits:	1.00	DBN Visits:	0.00
LT Hours:	4.00	DBN Hours:	0.00
LT ANT?:	Y	DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	SALVIA	District:	8
Type:	WLB	City:	MOBILE
OpFac Code:	15228	State:	AL

	Recorded	Revised
Number of Assigned Navaids:	120	126
Discrepancy Responses:	218	
Avg Per Year:	5.3	41.4
Discrepancies of Assigned:	622	
Avg Per Year:	6.0	
Avg Discrepancy Response Level:	2.6	
Avg Discrepancy Response Hours:		290.0
ATON Resource Hours:	1282	1282
ATON Inport Operations Hours:	162	
CG Overhead Resource Hours:	224	
CG Overhead I/O Hours:	176	
EMM Resource Hours:	298	
EMM I/O Hours:	30	
OMM Resource Hours:	492	
OMM I/O Hours:	34	
Total Underway Resource Hours:	2296	
Total Underway Days:	132	132
Total High Readiness Days:	3	

Comments: No changes

Avg Transit Speed:	11 knots	Length of Trip Avg:	5 days
Avg Length of Work Day:	16 hours	Min:	1 days
		Max:	10 days

Buoys:	120	% Serviced by Small Boat:	2 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		105	11	2
Current Weather Hours:	170	84 %	12 %	4 %
Projected Weather Hours:	56	90 %	9 %	1 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	WHITE HOLLY	District:	8
Type:	WLM 133'	City:	NEW ORLEANS
OpFac Code:	15504	State:	LA

	Recorded	Revised
Number of Assigned Navaids:	221	
Discrepancy Responses:	459	
Avg Per Year:	5.6	81.4
Discrepancies of Assigned:	581	
Avg Per Year:	6.0	
Avg Discrepancy Response Level:	0.0	2.5
Avg Discrepancy Response Hours:		400.0
ATON Resource Hours:	1404	1404
ATON Inport Operations Hours:	456	
CG Overhead Resource Hours:	27	
CG Overhead I/O Hours:	23	
EMM Resource Hours:	45	
EMM I/O Hours:	2	
OMM Resource Hours:	39	
OMM I/O Hours:	9	
Total Underway Resource Hours:	1514	
Total Underway Days:	115	115
Total High Readiness Days:	10	

Comments: No changes

Avg Transit Speed:	7 knots	Length of Trip Avg:	6 days
Avg Length of Work Day:	15 hours	Min:	2 days
		Max:	37 days

Buoys:	220	% Serviced by Small Boat:	5 %
Structures:	1	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		91	25	87
Current Weather Hours:	100	95 %	5 %	0 %
Projected Weather Hours:	70	95 %	5 %	0 %

Lights(LTs):	1	Daybeacons(DBNs):	0
LT Visits:	1.00	DBN Visits:	0.00
LT Hours:	2.00	DBN Hours:	0.00
LT ANT?:	Y	DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	WHITE PINE	District:	8
Type:	WLM 133'	City:	MOBILE
OpFac Code:	15506	State:	AL

	Recorded	Revised
Number of Assigned Navaids:	210	225
Discrepancy Responses:	188	
Avg Per Year:	4.9	38.4
Discrepancies of Assigned:	507	
Avg Per Year:	6.0	
Avg Discrepancy Response Level:	0.0	2.5
Avg Discrepancy Response Hours:		300.0
ATON Resource Hours:	1078	1145
ATON Inport Operations Hours:	308	345
CG Overhead Resource Hours:	50	
CG Overhead I/O Hours:	144	
EMM Resource Hours:	13	
EMM I/O Hours:	2	
OMM Resource Hours:	61	73
OMM I/O Hours:	8	12
Total Underway Resource Hours:	1201	1265
Total Underway Days:	101	101
Total High Readiness Days:	7	

Comments:

Avg Transit Speed:	9 knots	Length of Trip Avg:	5 days
Avg Length of Work Day:	15 hours	Min:	1 days
		Max:	10 days

Buoys:	210	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		51	58	90
Current Weather Hours:	110	65 %	25 %	10 %
Projected Weather Hours:	80	65 %	25 %	10 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	ACACIA	District:	9
Type:	WLB	City:	CHARLEVOIX
OpFac Code:	15201	State:	MI

	Recorded	Revised
Number of Assigned Navaids:	243	
Discrepancy Responses:	15	
Avg Per Year:	2.6	34.0
Discrepancies of Assigned:	122	49
Avg Per Year:	3.0	34.0
Avg Discrepancy Response Level:	3.3	
Avg Discrepancy Response Hours:		24.0
ATON Resource Hours:	544	663
ATON Inport Operations Hours:	259	
CG Overhead Resource Hours:	333	344
CG Overhead I/O Hours:	320	315
EMM Resource Hours:	162	263
EMM I/O Hours:	3	3
OMM Resource Hours:	393	
OMM I/O Hours:	21	
Total Underway Resource Hours:	1433	1663
Total Underway Days:	107	128
Total High Readiness Days:	4	10

Comments: Averages based on abstracts for four years.
Average buoys worked per day: Spring 4-6,
Fall 10-12.

Avg Transit Speed:	12 knots	Length of Trip Avg:	6 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	14 days

Buoys:	243	% Serviced by Small Boat:	5 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		217	12	13
Current Weather Hours:	90	60 %	30 %	10 %
Projected Weather Hours:	30	40 %	30 %	30 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	BRAMBLE	District:	9
Type:	WLB	City:	PORT HURON
OpFac Code:	15207	State:	MI

	Recorded	Revised
Number of Assigned Navaids:	250	254
Discrepancy Responses:	3	3
Avg Per Year:	1.1	6.0
Discrepancies of Assigned:	233	
Avg Per Year:	3.0	
Avg Discrepancy Response Level:	4.3	
Avg Discrepancy Response Hours:		18.0
ATON Resource Hours:	826	965
ATON Inport Operations Hours:	376	432
CG Overhead Resource Hours:	211	
CG Overhead I/O Hours:	117	
EMM Resource Hours:	197	
EMM I/O Hours:	12	
OMM Resource Hours:	475	
OMM I/O Hours:	10	
Total Underway Resource Hours:	1709	1848
Total Underway Days:	128	138
Total High Readiness Days:	10	

Comments: OPAREA change with result of longer steaming time and more aids.

Avg Transit Speed:	10 knots	Length of Trip Avg:	6 days
Avg Length of Work Day:	14 hours	Min:	2 days
		Max:	7 days

Buoys:	227	% Serviced by Small Boat:	15 %
Structures:	23	"	95 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		159	15	70
Current Weather Hours:	88	80 %	15 %	5 %
Projected Weather Hours:	18	90 %	5 %	5 %

Lights(LTs):	21	Daybeacons(DBNs):	0
LT Visits:	2.10	DBN Visits:	0.00
LT Hours:	5.90	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	SUNDEW	District:	9
Type:	WLB	City:	DULUTH
OpFac Code:	15233	State:	MN

	Recorded	Revised
Number of Assigned Navaids:	242	232
Discrepancy Responses:	1	3
Avg Per Year:	0.0	4.0
Discrepancies of Assigned:	65	
Avg Per Year:	3.0	
Avg Discrepancy Response Level:	1.0	
Avg Discrepancy Response Hours:		3.0
ATON Resource Hours:	550	1913
ATON Inport Operations Hours:	229	333
CG Overhead Resource Hours:	307	986
CG Overhead I/O Hours:	229	205
EMM Resource Hours:	307	496
EMM I/O Hours:	268	5
OMM Resource Hours:	96	381
OMM I/O Hours:	2	110
Total Underway Resource Hours:	1409	3994
Total Underway Days:	106	310
Total High Readiness Days:	11	62

Comments: The above data is a reflection of 3 years of abstracts. Fairly normal operations occured including ATON, NORR OPS, and considerable domestic icebreaking.

Avg Transit Speed:	14 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	14 hours	Min:	1 days
		Max:	21 days

Buoys:	242	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		135	64	43
Current Weather Hours:	100	90 %	10 %	0 %
Projected Weather Hours:	75	100 %	0 %	0 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	BLACKHAW	District:	11
Type:	WLB	City:	SAN FRANCISCO
OpFac Code:	15205	State:	CA

	Recorded	Revised
Number of Assigned Navaids:	170	176
Discrepancy Responses:	229	
Avg Per Year:	3.2	72.4
Discrepancies of Assigned:	382	
Avg Per Year:	5.1	
Avg Discrepancy Response Level:	4.3	
Avg Discrepancy Response Hours:		312 0
ATON Resource Hours:	1072	1200
ATON Inport Operations Hours:	369	
CG Overhead Resource Hours:	227	
CG Overhead I/O Hours:	225	
EMM Resource Hours:	309	
EMM I/O Hours:	26	
OMM Resource Hours:	236	
OMM I/O Hours:	52	
Total Underway Resource Hours:	1844	
Total Underway Days:	155	155
Total High Readiness Days:	4	

Comments: Believe 5 yr average for ATON Resource Hours is low. ATON hours for FY88 and FY90 were lower than expected. Based on current operations schedule and future plans recommend using 1200 as average.

Avg Transit Speed:	12 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	12 days

Buoys:	170	% Serviced by Small Boat:	20 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		58	64	46
Current Weather Hours:	240	70 %	20 %	10 %
Projected Weather Hours:	160	70 %	20 %	10 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	CONIFER	District:	11
Type:	WLB	City:	SAN PEDRO
OpFac Code:	15212	State:	CA

	Recorded	Revised
Number of Assigned Navaids:	135	
Discrepancy Responses:	88	
Avg Per Year:	3.9	22.6
Discrepancies of Assigned:	195	
Avg Per Year:	5.1	38.3
Avg Discrepancy Response Level:	4.3	
Avg Discrepancy Response Hours:		200.0
ATON Resource Hours:	929	1000
ATON Inport Operations Hours:	144	
CG Overhead Resource Hours:	286	
CG Overhead I/O Hours:	386	
EMM Resource Hours:	139	
EMM I/O Hours:	15	
OMM Resource Hours:	556	
OMM I/O Hours:	38	
Total Underway Resource Hours:	1911	
Total Underway Days:	139	139
Total High Readiness Days:	2	

Comments: Believe FY 90 is most representative of typical year. Recommend increasing ATON resource hrs. to 1000, a more accurate figure for future operations which may include more lighthouse maintenance work

Avg Transit Speed:	10 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	13 hours	Min:	1 days
		Max:	21 days

Buoys:	135	% Serviced by Small Boat:	2 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		57	34	43
Current Weather Hours:	72	34 %	33 %	33 %
Projected Weather Hours:	50	34 %	33 %	33 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	IRIS	District:	13
Type:	WLB	City:	ASTORIA
OpFac Code:	15218	State:	OR

	Recorded	Revised
Number of Assigned Navaids:	156	146
Discrepancy Responses:	397	280
Avg Per Year:	5.9	56.0
Discrepancies of Assigned:	622	448
Avg Per Year:	5.9	89.6
Avg Discrepancy Response Level:	3.1	3.4
Avg Discrepancy Response Hours:		280.0
ATON Resource Hours:	1328	1328
ATON Inport Operations Hours:	182	
CG Overhead Resource Hours:	154	
CG Overhead I/O Hours:	272	
EMM Resource Hours:	192	279
EMM I/O Hours:	7	
OMM Resource Hours:	247	185
OMM I/O Hours:	34	
Total Underway Resource Hours:	1921	
Total Underway Days:	135	135
Total High Readiness Days:	16	

Comments: Essential Multi-Mission Resource Hours- A more typical value is 279 hrs. 279 hrs. was 5 yr. average for Iris. Mainly due to NOAA data buoy operations.

Avg Transit Speed:	12 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	22 hours	Min:	1 days
		Max:	12 days

Buoys:	155	% Serviced by Small Boat:	10 %
Structures:	1	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		73	36	43
Current Weather Hours:	265	43 %	17 %	40 %
Projected Weather Hours:	130	60 %	30 %	10 %

Lights(LTs):	1	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	MARIPOSA	District:	13
Type:	WLB	City:	SEATTLE
OpFac Code:	15223	State:	WA

	Recorded	Revised
Number of Assigned Navaids:	137	141
Discrepancy Responses:	244	
Avg Per Year:	5.8	65.0
Discrepancies of Assigned:	381	
Avg Per Year:	5.9	
Avg Discrepancy Response Level:	3.3	
Avg Discrepancy Response Hours:		120.0
ATON Resource Hours:	1041	1226
ATON Inport Operations Hours:	158	192
CG Overhead Resource Hours:	182	150
CG Overhead I/O Hours:	92	401
EMM Resource Hours:	87	290
EMM I/O Hours:	1	6
OMM Resource Hours:	278	257
OMM I/O Hours:	5	12
Total Underway Resource Hours:	1587	1491
Total Underway Days:	117	118
Total High Readiness Days:	6	3

Comments: Using FIR's hours which are more reflective of Mariposa's new OPAREA.

Avg Transit Speed:	13 knots	Length of Trip Avg:	3 days
Avg Length of Work Day:	12 hours	Min:	1 days
		Max:	21 days

Buoys:	137	% Serviced by Small Boat:	0 %
Structures:	0	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		5	83	43
Current Weather Hours:	100	50 %	25 %	25 %
Projected Weather Hours:	70	75 %	25 %	0 %

Lights(LTs):	0	Daybeacons(DBNs):	0
LT Visits:	0.00	DBN Visits:	0.00
LT Hours:	0.00	DBN Hours:	0.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	BASSWOOD	District:	14
Type:	WLB	City:	GUAM
OpFac Code:	15203	State:	

	Recorded	Revised
Number of Assigned Navaids:	132	
Discrepancy Responses:	131	
Avg Per Year:	4.0	13.0
Discrepancies of Assigned:	166	158
Avg Per Year:	5.3	39.5
Avg Discrepancy Response Level:	4.4	
Avg Discrepancy Response Hours:		
ATON Resource Hours:	971	971
ATON Inport Operations Hours:	518	
CG Overhead Resource Hours:	242	
CG Overhead I/O Hours:	309	
EMM Resource Hours:	116	
EMM I/O Hours:	29	
OMM Resource Hours:	305	
OMM I/O Hours:	4	
Total Underway Resource Hours:	1634	
Total Underway Days:	110	110
Total High Readiness Days:	11	

Comments: None

Avg Transit Speed:	11 knots	Length of Trip Avg:	days
Avg Length of Work Day:	8 hours	Min:	days
		Max:	days

Buoys:	55	% Serviced by Small Boat:	5 %
Structures:	77	"	85 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		31	67	34
Current Weather Hours:	45	80 %	20 %	0 %
Projected Weather Hours:	40	60 %	20 %	20 %

Lights(LTs):	25	Daybeacons(DBNs):	52
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	2.50	DBN Hours:	1.00
LT ANT?:	N	DBN ANT?:	N

(Database: Survey.db Report#: 6)

Primary Unit:	MALLOW	District:	14
Type:	WLB	City:	HONOLULU
OpFac Code:	15222	State:	HI

	Recorded	Revised
Number of Assigned Navaids:	138	
Discrepancy Responses:	97	
Avg Per Year:	4.0	3.0
Discrepancies of Assigned:	97	160
Avg Per Year:	5.3	
Avg Discrepancy Response Level:	4.0	
Avg Discrepancy Response Hours:		
ATON Resource Hours:	863	863
ATON Inport Operations Hours:	338	
CG Overhead Resource Hours:	129	
CG Overhead I/O Hours:	295	
EMM Resource Hours:	278	
EMM I/O Hours:	16	
OMM Resource Hours:	692	
OMM I/O Hours:	40	
Total Underway Resource Hours:	1982	
Total Underway Days:	139	139
Total High Readiness Days:	3	

Comments: None

Avg Transit Speed:	11 knots	Length of Trip Avg:	days
Avg Length of Work Day:	18 hours	Min:	days
		Max:	days

Buoys:	91	% Serviced by Small Boat:	30 %
Structures:	47	"	90 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		31	87	18
Current Weather Hours:	80	40 %	40 %	20 %
Projected Weather Hours:	60	20 %	70 %	10 %

Lights(LTs):	25	Daybeacons(DBNs):	20
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	1.75	DBN Hours:	1.32
LT ANT?:	N	DBN ANT?:	N

(Database: Survey.db Report#: 6)

Primary Unit:	SASSAFRAS	District:	14
Type:	WLB	City:	HONOLULU
OpFac Code:	15229	State:	HI

	Recorded	Revised
Number of Assigned Navaids:	145	
Discrepancy Responses:	117	
Avg Per Year:	3.6	24.0
Discrepancies of Assigned:	173	194
Avg Per Year:	5.3	
Avg Discrepancy Response Level:	4.1	50.0
Avg Discrepancy Response Hours:		
ATON Resource Hours:	1084	1084
ATON Inport Operations Hours:	541	
CG Overhead Resource Hours:	227	
CG Overhead I/O Hours:	240	
EMM Resource Hours:	299	
EMM I/O Hours:	15	
OMM Resource Hours:	237	
OMM I/O Hours:	63	
Total Underway Resource Hours:	1897	
Total Underway Days:	118	118
Total High Readiness Days:	4	

Comments: None

Avg Transit Speed:	12 knots	Length of Trip Avg:	days
Avg Length of Work Day:	10 hours	Min:	days
		Max:	days

Buoys:	88	% Serviced by Small Boat:	20 %
Structures:	57	"	15 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		30	64	50
Current Weather Hours:	360	70 %	20 %	10 %
Projected Weather Hours:	298	70 %	20 %	10 %

Lights(LTs):	40	Daybeacons(DBNs):	16
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	4.00	DBN Hours:	2.50
LT ANT?:	Y	DBN ANT?:	Y

(Database: Survey.db Report#: 6)

Primary Unit:	FIREBUSH	District:	17
Type:	WLB	City:	KODIAK
OpFac Code:	15215	State:	AK

	Recorded	Revised
Number of Assigned Navaids:	139	
Discrepancy Responses:	22	8
Avg Per Year:	1.5	5.0
Discrepancies of Assigned:	26	50
Avg Per Year:	2.8	15.0
Avg Discrepancy Response Level:	3.7	
Avg Discrepancy Response Hours:		180.0
ATON Resource Hours:	1194	1500
ATON Inport Operations Hours:	70	200
CG Overhead Resource Hours:	533	
CG Overhead I/O Hours:	220	
EMM Resource Hours:	118	
EMM I/O Hours:	1	
OMM Resource Hours:	190	
OMM I/O Hours:	6	
Total Underway Resource Hours:	2035	2400
Total Underway Days:	122	150
Total High Readiness Days:	1	

Comments: None

Avg Transit Speed:	11 knots	Length of Trip Avg:	18 days
Avg Length of Work Day:	18 hours	Min:	5 days
		Max:	24 days

Buoys:	78	% Serviced by Small Boat:	2 %
Structures:	61	"	20 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		27	72	40
Current Weather Hours:	300	50 %	35 %	15 %
Projected Weather Hours:	240	75 %	25 %	0 %

Lights(LTs):	49	Daybeacons(DBNs):	12
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	2.00	DBN Hours:	1.00
LT ANT?:	Y	DBN ANT?:	Y

(Database: Survey.db Report#: 6)

Primary Unit:	IRONWOOD	District:	17
Type:	WLB	City:	KODIAK
OpFac Code:	15219	State:	AK

	Recorded	Revised
Number of Assigned Navaids:	94	98
Discrepancy Responses:	6	
Avg Per Year:	.9	6.9
Discrepancies of Assigned:	17	6
Avg Per Year:	2.8	
Avg Discrepancy Response Level:	3.7	28.8
Avg Discrepancy Response Hours:		140.0
ATON Resource Hours:	1769	1987
ATON Inport Operations Hours:	264	
CG Overhead Resource Hours:	447	
CG Overhead I/O Hours:	176	
EMM Resource Hours:	160	304
EMM I/O Hours:	75	0
OMM Resource Hours:	206	
OMM I/O Hours:	34	
Total Underway Resource Hours:	2583	2864
Total Underway Days:	144	160
Total High Readiness Days:	2	0

Comments: Seven month re-engine project and Exxon Valdez response took place during this 5 yr. period.

Avg Transit Speed:	10 knots	Length of Trip Avg:	20 days
Avg Length of Work Day:	10 hours	Min:	1 days
		Max:	45 days

Buoys:	58	% Serviced by Small Boat:	0 %
Structures:	36	"	0 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		32	41	20
Current Weather Hours:	250	60 %	30 %	10 %
Projected Weather Hours:	180	80 %	20 %	0 %

Lights(LTs):	31	Daybeacons(DBNs):	5
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	2.30	DBN Hours:	.90
LT ANT?:	N	DBN ANT?:	N

(Database: Survey.db Report#: 6)

Primary Unit:	PLANETREE	District:	17
Type:	WLB	City:	KETCHIKAN
OpFac Code:	15226	State:	AK

	Recorded	Revised
Number of Assigned Navaids:	257	
Discrepancy Responses:	2	27
Avg Per Year:	1.4	15.0
Discrepancies of Assigned:	39	91
Avg Per Year:	2.8	
Avg Discrepancy Response Level:	4.5	200.0
Avg Discrepancy Response Hours:		80.0
ATON Resource Hours:	1262	1262
ATON Inport Operations Hours:	337	
CG Overhead Resource Hours:	394	
CG Overhead I/O Hours:	471	
EMM Resource Hours:	151	
EMM I/O Hours:	2	
OMM Resource Hours:	331	
OMM I/O Hours:	30	
Total Underway Resource Hours:	2139	
Total Underway Days:	135	135
Total High Readiness Days:	6	3

Comments: Several high readiness days accrued during Valdez oil spill, inflated average value.

Avg Transit Speed:	11 knots	Length of Trip Avg:	5 days
Avg Length of Work Day:	11 hours	Min:	1 days
		Max:	19 days

Buoys:	102	% Serviced by Small Boat:	5 %
Structures:	155	"	85 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		34	135	87
Current Weather Hours:	137	0 %	0 %	100 %
Projected Weather Hours:	7	0 %	0 %	100 %

Lights(LTs):	109	Daybeacons(DBNs):	46
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	1.00	DBN Hours:	.50
LT ANT?:	Y	DBN ANT?:	Y

(Database: Survey.db Report#: 6)

Primary Unit:	SEDGE	District:	17
Type:	WLB	City:	HOMER
OpFac Code:	15230	State:	AK

	Recorded	Revised
Number of Assigned Navaids:	97	
Discrepancy Responses:	15	
Avg Per Year:	1.7	8.8
Discrepancies of Assigned:	24	20
Avg Per Year:	2.8	8.0
Avg Discrepancy Response Level:	3.2	
Avg Discrepancy Response Hours:		150.0
ATON Resource Hours:	867	867
ATON Inport Operations Hours:	141	
CG Overhead Resource Hours:	360	
CG Overhead I/O Hours:	293	
EMM Resource Hours:	307	
EMM I/O Hours:	38	
OMM Resource Hours:	345	
OMM I/O Hours:	11	
Total Underway Resource Hours:	1879	
Total Underway Days:	121	121
Total High Readiness Days:	5	

Comments: Exon Valdez Spill OPS effected 1989
D'7-wide tender operations causing added v/w time
and based ATON serving disturbations.
Extended seven month project occured duing paid
(Oct89-May 90), includes transit.

Avg Transit Speed:	10 knots	Length of Trip	Avg:	7 days
Avg Length of Work Day:	16 hours		Min:	1 days
			Max:	14 days

Buoys:	32	% Serviced by Small Boat:	10 %
Structures:	65	"	10 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		20	52	25
Current Weather Hours:	240	60 %	40 %	0 %
Projected Weather Hours:	200	75 %	25 %	0 %

Lights(LTs):	60	Daybeacons(DBNs):	5
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	2.50	DBN Hours:	3.00
LT ANT?:		DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	SWEETBRIER	District:	17
Type:	WLB	City:	CORDOVA
OpFac Code:	15234	State:	AK

	Recorded	Revised
Number of Assigned Navaids:	123	
Discrepancy Responses:	19	
Avg Per Year:	1.6	6.0
Discrepancies of Assigned:	27	19
Avg Per Year:	2.8	6.0
Avg Discrepancy Response Level:	3.7	
Avg Discrepancy Response Hours:		150.0
ATON Resource Hours:	948	1200
ATON Inport Operations Hours:	268	
CG Overhead Resource Hours:	429	
CG Overhead I/O Hours:	429	
EMM Resource Hours:	277	
EMM I/O Hours:	27	
OMM Resource Hours:	407	
OMM I/O Hours:	56	
Total Underway Resource Hours:	2062	
Total Underway Days:	129	129
Total High Readiness Days:	2	

Comments: Exxon Valdez and re-engine project (FY-90) occured in the 5 year time frame.

Avg Transit Speed:	7 knots	Length of Trip Avg:	7 days
Avg Length of Work Day:	24 hours	Min:	1 days
		Max:	21 days

Buoys:	60	% Serviced by Small Boat:	0 %
Structures:	63	"	5 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		34	38	51
Current Weather Hours:	350	45 %	30 %	25 %
Projected Weather Hours:	175	85 %	10 %	5 %

Lights(LTs):	63	Daybeacons(DBNs):	0
LT Visits:	1.30	DBN Visits:	0.00
LT Hours:	2.20	DBN Hours:	0.00
LT ANT?:	Y	DBN ANT?:	

(Database: Survey.db Report#: 6)

Primary Unit:	WOODRUSH	District:	17
Type:	WLB	City:	SITKA
OpFac Code:	15238	State:	AK

	Recorded	Revised
Number of Assigned Navaids:	234	
Discrepancy Responses:	40	
Avg Per Year:	2.8	14.4
Discrepancies of Assigned:	49	
Avg Per Year:	2.8	
Avg Discrepancy Response Level:	3.3	
Avg Discrepancy Response Hours:		
ATON Resource Hours:	1454	1454
ATON Inport Operations Hours:	336	
CG Overhead Resource Hours:	312	
CG Overhead I/O Hours:	502	
EMM Resource Hours:	43	
EMM I/O Hours:	13	
OMM Resource Hours:	385	
OMM I/O Hours:	9	
Total Underway Resource Hours:	2194	
Total Underway Days:	131	131
Total High Readiness Days:	2	

Comments: Extended re-engine project during this period.

Avg Transit Speed:	11 knots	Length of Trip Avg:	9 days
Avg Length of Work Day:	24 hours	Min:	1 days
		Max:	17 days

Buoys:	73	% Serviced by Small Boat:	11 %
Structures:	161	"	62 %

		Exposed	Semi-Exposed	Protected
Navaids by Environment:		38	74	120
Current Weather Hours:	260	70 %	23 %	7 %
Projected Weather Hours:	130	79 %	18 %	3 %

Lights(LTs):	125	Daybeacons(DBNs):	36
LT Visits:	1.00	DBN Visits:	1.00
LT Hours:	1.50	DBN Hours:	.50
LT ANT?:	Y	DBN ANT?:	Y

(Database: Survey.db Report#: 6)

APPENDIX I. STATISTICAL ANALYSIS OF VALIDATION RESULTS

I.1 DISTRICT LEVEL STATISTICS

	95% Confidence Interval[1] Historical Range[2] +/- 10% of Historical Mean[3]	DSS Hours	Are DSS Hours Within the Interval?
DISTRICT 1	(7453, 9317)	8159	YES
	(7147, 8797)		YES
	(7547, 9224)		YES
DISTRICT 5	(4925, 8063)	5578	YES
	(5361, 7617)		YES
	(5845, 7143)		NO
DISTRICT 7	(3015, 5107)	4185	YES
	(3318, 5474)		YES
	(3655, 4467)		YES
DISTRICT 8	(4565, 5697)	4416	NO
	(4781, 5558)		NO
	(4618, 5644)		NO
DISTRICT 9	(1659, 2872)	2167	YES
	(1577, 2547)		YES
	(2039, 2492)		YES
DISTRICT 11	(1599, 2801)	2207	YES
	(1660, 2616)		YES
	(1980, 2420)		YES
DISTRICT 13	(1890, 2478)	2082	YES
	(2041, 2486)		YES
	(1966, 2402)		YES
DISTRICT 14	(2531, 3758)	3336	YES
	(2295, 3243)		NO
	(2830, 3458)		YES
DISTRICT 17	(6796, 8192)	7462	YES
	(6927, 8169)		YES
	(6745, 8243)		YES

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[1]This 95% confidence interval for mean annual ATON hours is based on the t distribution with 4 degrees of freedom, with the standard error based on 5 years of Abstract of Operations data from FY-86 through FY-90, and the mean annual ATON hours from the Buoy Tender Operations Survey. Although the Abstract was the only source for data on the variability in annual ATON hours, the Survey asked respondents to revise mean ATON hours from the Abstract if necessary, thus making the Survey a better source for the midpoint of the confidence interval.

[2]The historical range is the maximum and minimum value recored in the Abstract of Operations for the six year period FY-86 through FY-91.

[3]This range uses annual ATON hours from the Buoy Tender Operations Survey.

I.2 ABSTRACT OF OPERATIONS DATA FOR FY86 THROUGH FY90

DISTRICT 1

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Bittersweet	826	1199	890	959	518	878.4	110.0
Sorrel	1110	1127	1045	997	1032	1062.2	24.4
Spar	1294	794	1431	1177	1063	1151.8	108.3
Red Wood	1047	1256	1100	883	937	1044.6	65.4
Red Beech	1087	868	898	852	735	888.0	56.9
White Heath	907	958	1054	1008	894	964.2	30.2
White Lupine	928	933	1508	1261	814	1088.8	128.7
White Sage	1034	865	871	805	1154	945.8	64.4
Total	8233	8000	8797	7942	7147	8023.8	266.2

DISTRICT 5

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Cowslip	1143	654	1496	1570	680	1108.6	194.2
Gentian	855	998	1070	1267	794	996.8	83.5
Hornbeam	824	879	720	642	1443	901.6	141.4
Red Birch	1148	1034	1096	1007	1072	1071.4	24.5
Red Cedar	776	1205	1583	1547	1321	1286.4	145.6
Red Oak	615	824	1341	1582	1054	1083.2	173.6
Total	5361	5594	7306	7617	6364	6448.4	448.4

DISTRICT 7

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Sagebrush	881	870	485	0	0	447.2	196.0
Sweetgum/Laurel	1012	748	1725	2005	1284	1354.8	229.2
Papaw/Madrona	1072	1354	1661	2144	1060	1458.2	203.7
White Sumac	1080	1266	1040	1325	1529	1248.0	88.5
Total	4045	4238	4911	5474	3873	4508.2	298.8

DISTRICT 8

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN*	STND ERR*
Buttonwood	978	101	1355	1819	1653	1451.3	165.2
Salvia	2059	684	1071	1055	1541	1431.5	212.5
White Holly	1344	1668	1615	1217	1174	1337.5	88.8
White Pine	1143	1007	742	1306	1190	1095.3	109.7
Total	5524	3460	4783	5397	5558	5315.5	161.8

* FY-87 not included in mean and standard error.

DISTRICT 9

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Acacia	177	592	429	587	934	543.8	123.3
Bramble	1008	356	1023	783	959	825.8	125.0
Sundew	626	629	203	640	654	550.4	87.0
Total*	1811	1577	1655	2010	2547	1920.0	173.3

* Buoys for Mariposa and Mesquite transferred to tugs-
not included in Total.

DISTRICT 11

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Blackhaw	1160	1496	714	1204	785	1071.8	144.1
Conifer/Laurel	570	607	946	1412	1112	929.4	158.1
Total	1730	2103	1660	2616	1897	2001.2	171.6

DISTRICT 13

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Fir	1065	1242	852	1286	652	1019.4	119.5
Iris	1230	1244	1189	1150	1829	1328.4	126.2
Total	2295	2486	2041	2436	2481	2347.8	84.1

DISTRICT 14

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Basswood	922	1035	878	1269	752	971.2	87.2
Mallow	674	769	1038	847	1082	882.0	78.0
Sassafras	1581	1349	1153	179	1409	1134.2	248.4
Total	3177	3153	3069	2295	3243	2987.4	175.3

DISTRICT 17

VESSEL	FY-86	FY-87	FY-88	FY-89	FY-90	MEAN	STND ERR
Ironwood	2222	1832	1793	2408	592	1769.4	316.5
Firebrush	624	1088	814	1054	2388	1193.6	310.3
Sedge	999	730	1002	1005	597	866.6	85.5
Sweetbriar	776	924	953	916	1173	948.4	64.0
Woodrush	1430	1956	1663	810	1411	1454.0	188.8
Planetree	876	1639	1308	1279	1208	1262.0	121.7
Total	6927	8169	7533	7472	7369	7494.0	199.3

APPENDIX J: LIFE CYCLE COSTS OF BUOY TENDER FLEET
16 WLBR SCENARIO
($000)

		TOTAL	1992	1993	1994	1995	1996	1997
# VESSELS IN FLEET:								
WLBs		--	26	26	26	26	24	21
WLMs		--	11	11	11	11	10	8
WLBRs		--	0	0	0	0	3	5
WLMRs		--	0	0	0	0	1	3
BUSLRs		--	0	0	0	0	1	1
Total w/o BUSLRs		--	37	37	37	37	38	37
O&M COSTS:								
WLBs		420,292	61,048	61,048	61,048	61,048	56,352	49,308
WLMs		84,456	13,662	13,662	13,662	13,662	12,420	9,936
WLBRs		1,118,376	0	0	0	0	7,608	12,680
WLMRs		499,584	0	0	0	0	1,301	3,903
BUSLRs		7,650	0	0	0	0	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		820,000	0	0	0	0	170,000	100,000
WLMRs		285,000	0	0	0	0	25,000	40,000
BUSLRs		1,000	0	0	0	0	1,000	0
CONSTANT 1992 $								
ALL O&M COSTS		2,130,358	74,710	74,710	74,710	74,710	77,936	76,082
ALL CAPITAL COSTS		1,106,000	0	0	0	0	196,000	140,000
TOTAL COSTS		3,236,358	74,710	74,710	74,710	74,710	273,936	216,082
DISCOUNTED 1992 $								
Discount factor	4	--	1.000	0.960	0.922	0.885	0.849	0.815
ALL O&M COSTS		1,215,240	74,710	71,722	68,853	66,099	66,195	62,035
ALL CAPITAL COSTS		853,009	0	0	0	0	166,472	114,152
TOTAL COSTS		2,068,249	74,710	71,722	68,853	66,099	232,667	176,187
Discount factor	7	--	1.000	0.930	0.865	0.804	0.748	0.696
ALL O&M COSTS		869,478	74,710	69,480	64,617	60,094	58,300	52,929
ALL CAPITAL COSTS		699,019	0	0	0	0	146,618	97,396
TOTAL COSTS		1,568,497	74,710	69,480	64,617	60,094	204,918	150,326
Discount factor	10	--	1.000	0.900	0.810	0.729	0.656	0.590
ALL O&M COSTS		662,608	74,710	67,239	60,515	54,464	51,134	44,926
ALL CAPITAL COSTS		570,625	0	0	0	0	128,596	82,669
TOTAL COSTS		1,233,233	74,710	67,239	60,515	54,464	179,729	127,594
CAPITAL BUDGET								
3% inflation rate		1,338,355	0	0	0	0	220,600	162,298
5% inflation rate		1,516,919	0	0	0	0	238,239	178,679
7% inflation rate		1,716,785	0	0	0	0	256,916	196,357
10% inflation rate		2,061,488	0	0	0	0	286,964	225,471

16 WLBR SCENARIO (cont.)
($000)

	1998	1999	2000	2001	2002	2003	2004
# VESSELS IN FLEET:							
WLBs	17	10	3	0	0	0	0
WLMs	4	2	0	0	0	0	0
WLBRs	8	11	14	16	16	16	16
WLMRs	6	10	14	14	14	14	14
BUSLRs	1	1	1	1	1	1	1
Total w/o BUSLRs	35	33	31	30	30	30	30
O&M COSTS:							
WLBs	39,916	23,480	7,044	0	0	0	0
WLMs	4,968	2,484	0	0	0	0	0
WLBRs	20,288	27,896	35,504	40,576	40,576	40,576	40,576
WLMRs	7,806	13,010	18,214	18,214	18,214	18,214	18,214
BUSLRs	255	255	255	255	255	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	150,000	150,000	150,000	100,000	0	0	0
WLMRs	60,000	80,000	80,000	0	0	0	0
BUSLRs	0	0	0	0	0	0	0
CONSTANT 1992 $							
ALL O&M COSTS	73,233	67,125	61,017	59,045	59,045	59,045	59,045
ALL CAPITAL COSTS	210,000	230,000	230,000	100,000	0	0	0
TOTAL COSTS	283,233	297,125	291,017	159,045	59,045	59,045	59,045
DISCOUNTED 1992 $							
Discount factor 4	0.783	0.751	0.721	0.693	0.665	0.638	0.613
ALL O&M COSTS	57,324	50,441	44,017	40,891	39,255	37,685	36,177
ALL CAPITAL COSTS	164,379	172,833	165,920	69,253	0	0	0
TOTAL COSTS	221,703	223,274	209,937	110,144	39,255	37,685	36,177
Discount factor 7	0.647	0.602	0.560	0.520	0.484	0.450	0.419
ALL O&M COSTS	47,381	40,389	34,144	30,728	28,577	26,576	24,716
ALL CAPITAL COSTS	135,868	138,391	128,704	52,041	0	0	0
TOTAL COSTS	183,249	178,780	162,848	82,769	28,577	26,576	24,716
Discount factor 10	0.531	0.478	0.430	0.387	0.349	0.314	0.282
ALL O&M COSTS	38,919	32,106	26,266	22,875	20,588	18,529	16,676
ALL CAPITAL COSTS	111,603	110,008	99,007	38,742	0	0	0
TOTAL COSTS	150,522	142,114	125,273	61,617	20,588	18,529	16,676
CAPITAL BUDGET							
3% inflation rate	250,751	282,871	291,357	130,477	0	0	0
5% inflation rate	281,420	323,633	339,815	155,133	0	0	0
7% inflation rate	315,153	369,330	395,183	183,846	0	0	0
10% inflation rate	372,028	448,205	493,025	235,795	0	0	0

16 WLBR SCENARIO (cont.)
($000)

	2005	2006	2007	2008	2009	2010	2011
# VESSELS IN FLEET:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	16	16	16	16	16	16	16
WLMRs	14	14	14	14	14	14	14
BUSLRs	1	1	1	1	1	1	1
Total w/o BUSLRs	30	30	30	30	30	30	30
O&M COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	40,576	40,576	40,576	40,576	40,576	40,576	40,576
WLMRs	18,214	18,214	18,214	18,214	18,214	18,214	18,214
BUSLRs	255	255	255	255	255	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	0	0	0	0	0	0	0
WLMRs	0	0	0	0	0	0	0
BUSLRs	0	0	0	0	0	0	0
CONSTANT 1992 $							
ALL O&M COSTS	59,045	59,045	59,045	59,045	59,045	59,045	59,045
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	59,045	59,045	59,045	59,045	59,045	59,045	59,045
DISCOUNTED 1992 $							
Discount factor 4	0.588	0.565	0.542	0.520	0.500	0.480	0.460
ALL O&M COSTS	34,730	33,341	32,007	30,727	29,498	28,318	27,185
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	34,730	33,341	32,007	30,727	29,498	28,318	27,185
Discount factor 7	0.389	0.362	0.337	0.313	0.291	0.271	0.252
ALL O&M COSTS	22,986	21,377	19,881	18,489	17,195	15,991	14,872
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	22,986	21,377	19,881	18,489	17,195	15,991	14,872
Discount factor 10	0.254	0.229	0.206	0.185	0.167	0.150	0.135
ALL O&M COSTS	15,008	13,508	12,157	10,941	9,847	8,862	7,976
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	15,008	13,508	12,157	10,941	9,847	8,862	7,976
CAPITAL BUDGET							
3% inflation rate	0	0	0	0	0	0	0
5% inflation rate	0	0	0	0	0	0	0
7% inflation rate	0	0	0	0	0	0	0
10% inflation rate	0	0	0	0	0	0	0

16 WLBR SCENARIO (cont.)
($000)

		2012	2013	2014	2015	2016	2017	2018
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# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		16	16	16	16	16	16	16
WLMRs		14	14	14	14	14	14	14
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		40,576	40,576	40,576	40,576	40,576	40,576	40,576
WLMRs		18,214	18,214	18,214	18,214	18,214	18,214	18,214
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								

ALL O&M COSTS		59,045	59,045	59,045	59,045	59,045	59,045	59,045
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		59,045	59,045	59,045	59,045	59,045	59,045	59,045
DISCOUNTED 1992 $								

Discount factor	4	0.442	0.424	0.407	0.391	0.375	0.360	0.346
ALL O&M COSTS		26,098	25,054	24,052	23,090	22,166	21,280	20,428
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		26,098	25,054	24,052	23,090	22,166	21,280	20,428
Discount factor	7	0.234	0.218	0.203	0.188	0.175	0.163	0.152
ALL O&M COSTS		13,831	12,862	11,962	11,125	10,346	9,622	8,948
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		13,831	12,862	11,962	11,125	10,346	9,622	8,948
Discount factor	10	0.122	0.109	0.098	0.089	0.080	0.072	0.065
ALL O&M COSTS		7,178	6,461	5,815	5,233	4,710	4,239	3,815
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		7,178	6,461	5,815	5,233	4,710	4,239	3,815
CAPITAL BUDGET								

3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

16 WLBR SCENARIO (cont.)
($000)

		2019	2020	2021	2022	2023	2024	2025
# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		16	16	16	16	16	16	16
WLMRs		14	14	14	14	14	14	14
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		40,576	40,576	40,576	40,576	40,576	40,576	40,576
WLMRs		18,214	18,214	18,214	18,214	18,214	18,214	18,214
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								
ALL O&M COSTS		59,045	59,045	59,045	59,045	59,045	59,045	59,045
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		59,045	59,045	59,045	59,045	59,045	59,045	59,045
DISCOUNTED 1992 $								
Discount factor	4	0.332	0.319	0.306	0.294	0.282	0.271	0.260
ALL O&M COSTS		19,611	18,827	18,074	17,351	16,657	15,991	15,351
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		19,611	18,827	18,074	17,351	16,657	15,991	15,351
Discount factor	7	0.141	0.131	0.122	0.113	0.105	0.098	0.091
ALL O&M COSTS		8,322	7,739	7,198	6,694	6,225	5,789	5,384
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		8,322	7,739	7,198	6,694	6,225	5,789	5,384
Discount factor	10	0.058	0.052	0.047	0.042	0.038	0.034	0.031
ALL O&M COSTS		3,433	3,090	2,781	2,503	2,253	2,027	1,825
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		3,433	3,090	2,781	2,503	2,253	2,027	1,825
CAPITAL BUDGET								
3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

17 WLBR SCENARIO
($000)

	TOTAL	1992	1993	1994	1995	1996	1997
# VESSELS IN FLEET:							
WLBs	--	26	26	26	26	24	21
WLMs	--	11	11	11	11	10	8
WLBRs	--	0	0	0	0	3	5
WLMRs	--	0	0	0	0	1	3
BUSLRs	--	0	0	0	0	1	1
Total w/o BUSLRs	--	37	37	37	37	38	37
O&M COSTS:							
WLBs	422,640	61,048	61,048	61,048	61,048	56,352	49,308
WLMs	84,456	13,662	13,662	13,662	13,662	12,420	9,936
WLBRs	1,181,776	0	0	0	0	7,608	12,680
WLMRs	465,758	0	0	0	0	1,301	3,903
BUSLRs	7,650	0	0	0	0	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	870,000	0	0	0	0	170,000	100,000
WLMRs	265,000	0	0	0	0	25,000	40,000
BUSLRs	1,000	0	0	0	0	1,000	0
CONSTANT 1992 $							
ALL O&M COSTS	2,162,280	74,710	74,710	74,710	74,710	77,936	76,082
ALL CAPITAL COSTS	1,136,000	0	0	0	0	196,000	140,000
TOTAL COSTS	3,298,280	74,710	74,710	74,710	74,710	273,936	216,082
DISCOUNTED 1992 $							
Discount factor 4	--	1.000	0.960	0.922	0.885	0.849	0.815
ALL O&M COSTS	1,229,671	74,710	71,722	68,853	66,099	66,195	62,035
ALL CAPITAL COSTS	873,208	0	0	0	0	166,472	114,152
TOTAL COSTS	2,102,879	74,710	71,722	68,853	66,099	232,667	176,187
Discount factor 7	--	1.000	0.930	0.865	0.804	0.748	0.696
ALL O&M COSTS	877,749	74,710	69,480	64,617	60,094	58,300	52,929
ALL CAPITAL COSTS	713,848	0	0	0	0	146,618	97,396
TOTAL COSTS	1,591,597	74,710	69,480	64,617	60,094	204,918	150,326
Discount factor 10	--	1.000	0.900	0.810	0.729	0.656	0.590
ALL O&M COSTS	667,500	74,710	67,239	60,515	54,464	51,134	44,926
ALL CAPITAL COSTS	581,386	0	0	0	0	128,596	82,669
TOTAL COSTS	1,248,886	74,710	67,239	60,515	54,464	179,729	127,594
CAPITAL BUDGET							
3% inflation rate	1,378,258	0	0	0	0	220,600	162,298
5% inflation rate	1,564,937	0	0	0	0	238,239	178,679
7% inflation rate	1,774,344	0	0	0	0	256,916	196,357
10% inflation rate	2,136,514	0	0	0	0	286,964	225,471

17 WLBR SCENARIO (cont.)
($000)

	1998	1999	2000	2001	2002	2003	2004
# VESSELS IN FLEET:							
WLBs	17	10	4	0	0	0	0
WLMs	4	2	0	0	0	0	0
WLBRs	8	11	14	17	17	17	17
WLMRs	6	10	13	13	13	13	13
BUSLRs	1	1	1	1	1	1	1
Total w/o BUSLRs	35	33	31	30	30	30	30
O&M COSTS:							
WLBs	39,916	23,480	9,392	0	0	0	0
WLMs	4,968	2,484	0	0	0	0	0
WLBRs	20,288	27,896	35,504	43,112	43,112	43,112	43,112
WLMRs	7,806	13,010	16,913	16,913	16,913	16,913	16,913
BUSLRs	255	255	255	255	255	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	150,000	150,000	150,000	150,000	0	0	0
WLMRs	60,000	80,000	60,000	0	0	0	0
BUSLRs	0	0	0	0	0	0	0
CONSTANT 1992 $							
ALL O&M COSTS	73,233	67,125	62,064	60,280	60,280	60,280	60,280
ALL CAPITAL COSTS	210,000	230,000	210,000	150,000	0	0	0
TOTAL COSTS	283,233	297,125	272,064	210,280	60,280	60,280	60,280
DISCOUNTED 1992 $							
Discount factor 4	0.783	0.751	0.721	0.693	0.665	0.638	0.613
ALL O&M COSTS	57,324	50,441	44,772	41,746	40,076	38,473	36,934
ALL CAPITAL COSTS	164,379	172,833	151,492	103,880	0	0	0
TOTAL COSTS	221,703	223,274	196,264	145,626	40,076	38,473	36,934
Discount factor 7	0.647	0.602	0.560	0.520	0.484	0.450	0.419
ALL O&M COSTS	47,381	40,389	34,730	31,370	29,174	27,132	25,233
ALL CAPITAL COSTS	135,868	138,391	117,512	78,062	0	0	0
TOTAL COSTS	183,249	178,780	152,242	109,432	29,174	27,132	25,233
Discount factor 10	0.531	0.478	0.430	0.387	0.349	0.314	0.282
ALL O&M COSTS	38,919	32,106	26,717	23,354	21,018	18,917	17,025
ALL CAPITAL COSTS	111,603	110,008	90,398	58,113	0	0	0
TOTAL COSTS	150,522	142,114	117,115	81,467	21,018	18,917	17,025
CAPITAL BUDGET							
3% inflation rate	250,751	282,871	266,022	195,716	0	0	0
5% inflation rate	281,420	323,633	310,266	232,699	0	0	0
7% inflation rate	315,153	369,330	360,819	275,769	0	0	0
10% inflation rate	372,028	448,205	450,154	353,692	0	0	0

17 WLBR SCENARIO (cont.)
($000)

		2005	2006	2007	2008	2009	2010	2011
# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		17	17	17	17	17	17	17
WLMRs		13	13	13	13	13	13	13
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		43,112	43,112	43,112	43,112	43,112	43,112	43,112
WLMRs		16,913	16,913	16,913	16,913	16,913	16,913	16,913
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								
ALL O&M COSTS		60,280	60,280	60,280	60,280	60,280	60,280	60,280
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		60,280	60,280	60,280	60,280	60,280	60,280	60,280
DISCOUNTED 1992 $								
Discount factor	4	0.588	0.565	0.542	0.520	0.500	0.480	0.460
ALL O&M COSTS		35,457	34,039	32,677	31,370	30,115	28,910	27,754
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		35,457	34,039	32,677	31,370	30,115	28,910	27,754
Discount factor	7	0.389	0.362	0.337	0.313	0.291	0.271	0.252
ALL O&M COSTS		23,467	21,824	20,296	18,876	17,554	16,325	15,183
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		23,467	21,824	20,296	18,876	17,554	16,325	15,183
Discount factor	10	0.254	0.229	0.206	0.185	0.167	0.150	0.135
ALL O&M COSTS		15,322	13,790	12,411	11,170	10,053	9,048	8,143
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		15,322	13,790	12,411	11,170	10,053	9,048	8,143
CAPITAL BUDGET								
3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

17 WLBR SCENARIO (cont.)
($000)

		2012	2013	2014	2015	2016	2017	2018
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# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		17	17	17	17	17	17	17
WLMRs		13	13	13	13	13	13	13
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		43,112	43,112	43,112	43,112	43,112	43,112	43,112
WLMRs		16,913	16,913	16,913	16,913	16,913	16,913	16,913
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								

ALL O&M COSTS		60,280	60,280	60,280	60,280	60,280	60,280	60,280
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		60,280	60,280	60,280	60,280	60,280	60,280	60,280
DISCOUNTED 1992 $								

Discount factor	4	0.442	0.424	0.407	0.391	0.375	0.360	0.346
ALL O&M COSTS		26,644	25,578	24,555	23,573	22,630	21,725	20,856
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		26,644	25,578	24,555	23,573	22,630	21,725	20,856
Discount factor	7	0.234	0.218	0.203	0.188	0.175	0.163	0.152
ALL O&M COSTS		14,120	13,132	12,212	11,357	10,562	9,823	9,135
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		14,120	13,132	12,212	11,357	10,562	9,823	9,135
Discount factor	10	0.122	0.109	0.098	0.089	0.080	0.072	0.065
ALL O&M COSTS		7,329	6,596	5,936	5,343	4,808	4,327	3,895
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		7,329	6,596	5,936	5,343	4,808	4,327	3,895
CAPITAL BUDGET								

3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

17 WLBR SCENARIO (cont.)
($000)

		2019	2020	2021	2022	2023	2024	2025
		----	----	----	----	----	----	----
# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		17	17	17	17	17	17	17
WLMRs		13	13	13	13	13	13	13
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		43,112	43,112	43,112	43,112	43,112	43,112	43,112
WLMRs		16,913	16,913	16,913	16,913	16,913	16,913	16,913
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								

ALL O&M COSTS		60,280	60,280	60,280	60,280	60,280	60,280	60,280
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		60,280	60,280	60,280	60,280	60,280	60,280	60,280
DISCOUNTED 1992 $								

Discount factor	4	0.332	0.319	0.306	0.294	0.282	0.271	0.260
ALL O&M COSTS		20,021	19,221	18,452	17,714	17,005	16,325	15,672
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		20,021	19,221	18,452	17,714	17,005	16,325	15,672
Discount factor	7	0.141	0.131	0.122	0.113	0.105	0.098	0.091
ALL O&M COSTS		8,496	7,901	7,348	6,834	6,355	5,911	5,497
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		8,496	7,901	7,348	6,834	6,355	5,911	5,497
Discount factor	10	0.058	0.052	0.047	0.042	0.038	0.034	0.031
ALL O&M COSTS		3,505	3,155	2,839	2,555	2,300	2,070	1,863
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		3,505	3,155	2,839	2,555	2,300	2,070	1,863
CAPITAL BUDGET								

3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

18 WLBR SCENARIO
($000)

	TOTAL	1992	1993	1994	1995	1996	1997
# VESSELS IN FLEET:							
WLBs	--	26	26	26	26	24	21
WLMs	--	11	11	11	11	10	8
WLBRs	--	0	0	0	0	3	5
WLMRs	--	0	0	0	0	1	3
BUSLRs	--	0	0	0	0	1	1
Total w/o BUSLRs	--	37	37	37	37	38	37
O&M COSTS:							
WLBs	432,032	61,048	61,048	61,048	61,048	56,352	49,308
WLMs	84,456	13,662	13,662	13,662	13,662	12,420	9,936
WLBRs	1,242,640	0	0	0	0	7,608	12,680
WLMRs	430,631	0	0	0	0	1,301	3,903
BUSLRs	7,650	0	0	0	0	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	920,000	0	0	0	0	170,000	100,000
WLMRs	245,000	0	0	0	0	25,000	40,000
BUSLRs	1,000	0	0	0	0	1,000	0
CONSTANT 1992 $							
ALL O&M COSTS	2,197,409	74,710	74,710	74,710	74,710	77,936	76,082
ALL CAPITAL COSTS	1,166,000	0	0	0	0	196,000	140,000
TOTAL COSTS	3,363,409	74,710	74,710	74,710	74,710	273,936	216,082
DISCOUNTED 1992 $							
Discount factor 4	--	1.000	0.960	0.922	0.885	0.849	0.815
ALL O&M COSTS	1,246,385	74,710	71,722	68,853	66,099	66,195	62,035
ALL CAPITAL COSTS	891,421	0	0	0	0	166,472	114,152
TOTAL COSTS	2,137,806	74,710	71,722	68,853	66,099	232,667	176,187
Discount factor 7	--	1.000	0.930	0.865	0.804	0.748	0.696
ALL O&M COSTS	887,775	74,710	69,480	64,617	60,094	58,300	52,929
ALL CAPITAL COSTS	726,013	0	0	0	0	146,618	97,396
TOTAL COSTS	1,613,787	74,710	69,480	64,617	60,094	204,918	150,326
Discount factor 10	--	1.000	0.900	0.810	0.729	0.656	0.590
ALL O&M COSTS	673,729	74,710	67,239	60,515	54,464	51,134	44,926
ALL CAPITAL COSTS	589,254	0	0	0	0	128,596	82,669
TOTAL COSTS	1,262,984	74,710	67,239	60,515	54,464	179,729	127,594
CAPITAL BUDGET							
3% inflation rate	1,420,856	0	0	0	0	220,600	162,298
5% inflation rate	1,618,239	0	0	0	0	238,239	178,679
7% inflation rate	1,840,586	0	0	0	0	256,916	196,357
10% inflation rate	2,227,226	0	0	0	0	286,964	225,471

18 WLBR SCENARIO (cont.)
($000)

		1998	1999	2000	2001	2002	2003	2004
# VESSELS IN FLEET:								
WLBs		17	11	5	2	0	0	0
WLMs		4	2	0	0	0	0	0
WLBRs		8	11	14	17	18	18	18
WLMRs		6	9	12	12	12	12	12
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		35	33	31	31	30	30	30
O&M COSTS:								
WLBs		39,916	25,828	11,740	4,696	0	0	0
WLMs		4,968	2,484	0	0	0	0	0
WLBRs		20,288	27,896	35,504	43,112	45,648	45,648	45,648
WLMRs		7,806	11,709	15,612	15,612	15,612	15,612	15,612
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		150,000	150,000	150,000	150,000	50,000	0	0
WLMRs		60,000	60,000	60,000	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								
ALL O&M COSTS		73,233	68,172	63,111	63,675	61,515	61,515	61,515
ALL CAPITAL COSTS		210,000	210,000	210,000	150,000	50,000	0	0
TOTAL COSTS		283,233	278,172	273,111	213,675	111,515	61,515	61,515
DISCOUNTED 1992 $								
Discount factor	4	0.783	0.751	0.721	0.693	0.665	0.638	0.613
ALL O&M COSTS		57,324	51,228	45,528	44,097	40,897	39,261	37,691
ALL CAPITAL COSTS		164,379	157,804	151,492	103,880	33,242	0	0
TOTAL COSTS		221,703	209,032	197,019	147,977	74,139	39,261	37,691
Discount factor	7	0.647	0.602	0.560	0.520	0.484	0.450	0.419
ALL O&M COSTS		47,381	41,019	35,316	33,137	29,772	27,688	25,750
ALL CAPITAL COSTS		135,868	126,357	117,512	78,062	24,199	0	0
TOTAL COSTS		183,249	167,376	152,828	111,199	53,971	27,688	25,750
Discount factor	10	0.531	0.478	0.430	0.387	0.349	0.314	0.282
ALL O&M COSTS		38,919	32,606	27,167	24,669	21,449	19,304	17,374
ALL CAPITAL COSTS		111,603	100,442	90,398	58,113	17,434	0	0
TOTAL COSTS		150,522	133,049	117,565	82,782	38,883	19,304	17,374
CAPITAL BUDGET								
3% inflation rate		250,751	258,274	266,022	195,716	67,196	0	0
5% inflation rate		281,420	295,491	310,266	232,699	81,445	0	0
7% inflation rate		315,153	337,214	360,819	275,769	98,358	0	0
10% inflation rate		372,028	409,231	450,154	353,692	129,687	0	0

18 WLBR SCENARIO (cont.)
($000)

	2005	2006	2007	2008	2009	2010	2011
# VESSELS IN FLEET:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	18	18	18	18	18	18	18
WLMRs	12	12	12	12	12	12	12
BUSLRs	1	1	1	1	1	1	1
Total w/o BUSLRs	30	30	30	30	30	30	30
O&M COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	45,648	45,648	45,648	45,648	45,648	45,648	45,648
WLMRs	15,612	15,612	15,612	15,612	15,612	15,612	15,612
BUSLRs	255	255	255	255	255	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	0	0	0	0	0	0	0
WLMRs	0	0	0	0	0	0	0
BUSLRs	0	0	0	0	0	0	0
CONSTANT 1992 $							
ALL O&M COSTS	61,515	61,515	61,515	61,515	61,515	61,515	61,515
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	61,515	61,515	61,515	61,515	61,515	61,515	61,515
DISCOUNTED 1992 $							
Discount factor 4	0.588	0.565	0.542	0.520	0.500	0.480	0.460
ALL O&M COSTS	36,183	34,736	33,346	32,013	30,732	29,503	28,323
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	36,183	34,736	33,346	32,013	30,732	29,503	28,323
Discount factor 7	0.389	0.362	0.337	0.313	0.291	0.271	0.252
ALL O&M COSTS	23,947	22,271	20,712	19,262	17,914	16,660	15,494
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	23,947	22,271	20,712	19,262	17,914	16,660	15,494
Discount factor 10	0.254	0.229	0.206	0.185	0.167	0.150	0.135
ALL O&M COSTS	15,636	14,073	12,665	11,399	10,259	9,233	8,310
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	15,636	14,073	12,665	11,399	10,259	9,233	8,310
CAPITAL BUDGET							
3% inflation rate	0	0	0	0	0	0	0
5% inflation rate	0	0	0	0	0	0	0
7% inflation rate	0	0	0	0	0	0	0
10% inflation rate	0	0	0	0	0	0	0

18 WLBR SCENARIO (cont.)
($000)

		2012	2013	2014	2015	2016	2017	2018
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# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		18	18	18	18	18	18	18
WLMRs		12	12	12	12	12	12	12
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		45,648	45,648	45,648	45,648	45,648	45,648	45,648
WLMRs		15,612	15,612	15,612	15,612	15,612	15,612	15,612
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								

ALL O&M COSTS		61,515	61,515	61,515	61,515	61,515	61,515	61,515
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		61,515	61,515	61,515	61,515	61,515	61,515	61,515
DISCOUNTED 1992 $								

Discount factor	4	0.442	0.424	0.407	0.391	0.375	0.360	0.346
ALL O&M COSTS		27,190	26,102	25,058	24,056	23,094	22,170	21,283
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		27,190	26,102	25,058	24,056	23,094	22,170	21,283
Discount factor	7	0.234	0.218	0.203	0.188	0.175	0.163	0.152
ALL O&M COSTS		14,409	13,401	12,463	11,590	10,779	10,024	9,323
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		14,409	13,401	12,463	11,590	10,779	10,024	9,323
Discount factor	10	0.122	0.109	0.098	0.089	0.080	0.072	0.065
ALL O&M COSTS		7,479	6,731	6,058	5,452	4,907	4,416	3,975
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		7,479	6,731	6,058	5,452	4,907	4,416	3,975
CAPITAL BUDGET								

3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

18 WLBR SCENARIO (cont.)
($000)

		2019	2020	2021	2022	2023	2024	2025
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# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		18	18	18	18	18	18	18
WLMRs		12	12	12	12	12	12	12
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		45,648	45,648	45,648	45,648	45,648	45,648	45,648
WLMRs		15,612	15,612	15,612	15,612	15,612	15,612	15,612
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								

ALL O&M COSTS		61,515	61,515	61,515	61,515	61,515	61,515	61,515
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		61,515	61,515	61,515	61,515	61,515	61,515	61,515
DISCOUNTED 1992 $								

Discount factor	4	0.332	0.319	0.306	0.294	0.282	0.271	0.260
ALL O&M COSTS		20,432	19,614	18,830	18,077	17,354	16,659	15,993
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		20,432	19,614	18,830	18,077	17,354	16,659	15,993
Discount factor	7	0.141	0.131	0.122	0.113	0.105	0.098	0.091
ALL O&M COSTS		8,670	8,063	7,499	6,974	6,486	6,032	5,609
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		8,670	8,063	7,499	6,974	6,486	6,032	5,609
Discount factor	10	0.058	0.052	0.047	0.042	0.038	0.034	0.031
ALL O&M COSTS		3,577	3,219	2,897	2,608	2,347	2,112	1,901
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		3,577	3,219	2,897	2,608	2,347	2,112	1,901
CAPITAL BUDGET								

3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

19 WLBR SCENARIO
($000)

	TOTAL	1992	1993	1994	1995	1996	1997
# VESSELS IN FLEET:							
WLBs	--	26	26	26	26	24	21
WLMs	--	11	11	11	11	10	8
WLBRs	--	0	0	0	0	3	5
WLMRs	--	0	0	0	0	1	3
BUSLRs	--	0	0	0	0	1	1
Total w/o BUSLRs	--	37	37	37	37	38	37
O&M COSTS:							
WLBs	436,728	61,048	61,048	61,048	61,048	56,352	49,308
WLMs	84,456	13,662	13,662	13,662	13,662	12,420	9,936
WLBRs	1,303,504	0	0	0	0	7,608	12,680
WLMRs	396,805	0	0	0	0	1,301	3,903
BUSLRs	7,650	0	0	0	0	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	970,000	0	0	0	0	170,000	100,000
WLMRs	225,000	0	0	0	0	25,000	40,000
BUSLRs	1,000	0	0	0	0	1,000	0
CONSTANT 1992 $							
ALL O&M COSTS	2,229,143	74,710	74,710	74,710	74,710	77,936	76,082
ALL CAPITAL COSTS	1,196,000	0	0	0	0	196,000	140,000
TOTAL COSTS	3,425,143	74,710	74,710	74,710	74,710	273,936	216,082
DISCOUNTED 1992 $							
Discount factor 4	--	1.000	0.960	0.922	0.885	0.849	0.815
ALL O&M COSTS	1,260,686	74,710	71,722	68,853	66,099	66,195	62,035
ALL CAPITAL COSTS	910,235	0	0	0	0	166,472	114,152
TOTAL COSTS	2,170,921	74,710	71,722	68,853	66,099	232,667	176,187
Discount factor 7	--	1.000	0.930	0.865	0.804	0.748	0.696
ALL O&M COSTS	895,948	74,710	69,480	64,617	60,094	58,300	52,929
ALL CAPITAL COSTS	739,020	0	0	0	0	146,618	97,396
TOTAL COSTS	1,634,968	74,710	69,480	64,617	60,094	204,918	150,326
Discount factor 10	--	1.000	0.900	0.810	0.729	0.656	0.590
ALL O&M COSTS	678,548	74,710	67,239	60,515	54,464	51,134	44,926
ALL CAPITAL COSTS	598,079	0	0	0	0	128,596	82,669
TOTAL COSTS	1,276,627	74,710	67,239	60,515	54,464	179,729	127,594
CAPITAL BUDGET							
3% inflation rate	1,462,717	0	0	0	0	220,600	162,298
5% inflation rate	1,670,135	0	0	0	0	238,239	178,679
7% inflation rate	1,904,580	0	0	0	0	256,916	196,357
10% inflation rate	2,314,042	0	0	0	0	286,964	225,471

19 WLBR SCENARIO (cont.)
($000)

	1998	1999	2000	2001	2002	2003	2004
# VESSELS IN FLEET:							
WLBs	17	11	6	3	0	0	0
WLMs	4	2	0	0	0	0	0
WLBRs	8	11	14	17	19	19	19
WLMRs	6	9	11	11	11	11	11
BUSLRs	1	1	1	1	1	1	1
Total w/o BUSLRs	35	33	31	31	30	30	30
O&M COSTS:							
WLBs	39,916	25,828	14,088	7,044	0	0	0
WLMs	4,968	2,484	0	0	0	0	0
WLBRs	20,288	27,896	35,504	43,112	48,184	48,184	48,184
WLMRs	7,806	11,709	14,311	14,311	14,311	14,311	14,311
BUSLRs	255	255	255	255	255	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	150,000	150,000	150,000	150,000	100,000	0	0
WLMRs	60,000	60,000	40,000	0	0	0	0
BUSLRs	0	0	0	0	0	0	0
CONSTANT 1992 $							
ALL O&M COSTS	73,233	68,172	64,158	64,722	62,750	62,750	62,750
ALL CAPITAL COSTS	210,000	210,000	190,000	150,000	100,000	0	0
TOTAL COSTS	283,233	278,172	254,158	214,722	162,750	62,750	62,750
DISCOUNTED 1992 $							
Discount factor 4	0.783	0.751	0.721	0.693	0.665	0.638	0.613
ALL O&M COSTS	57,324	51,228	46,283	44,822	41,718	40,050	38,448
ALL CAPITAL COSTS	164,379	157,804	137,064	103,880	66,483	0	0
TOTAL COSTS	221,703	209,032	183,347	148,702	108,202	40,050	38,448
Discount factor 7	0.647	0.602	0.560	0.520	0.484	0.450	0.419
ALL O&M COSTS	47,381	41,019	35,902	33,682	30,370	28,244	26,267
ALL CAPITAL COSTS	135,868	126,357	106,321	78,062	48,398	0	0
TOTAL COSTS	183,249	167,376	142,222	111,744	78,768	28,244	26,267
Discount factor 10	0.531	0.478	0.430	0.387	0.349	0.314	0.282
ALL O&M COSTS	38,919	32,606	27,618	25,075	21,880	19,692	17,722
ALL CAPITAL COSTS	111,603	100,442	81,789	58,113	34,868	0	0
TOTAL COSTS	150,522	133,049	109,407	83,188	56,747	19,692	17,722
CAPITAL BUDGET							
3% inflation rate	250,751	258,274	240,686	195,716	134,392	0	0
5% inflation rate	281,420	295,491	280,717	232,699	162,889	0	0
7% inflation rate	315,153	337,214	326,455	275,769	196,715	0	0
10% inflation rate	372,028	409,231	407,282	353,692	259,374	0	0

19 WLBR SCENARIO (cont.)
($000)

	2005	2006	2007	2008	2009	2010	2011
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# VESSELS IN FLEET:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	19	19	19	19	19	19	19
WLMRs	11	11	11	11	11	11	11
BUSLRs	1	1	1	1	1	1	1
Total w/o BUSLRs	30	30	30	30	30	30	30
O&M COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	48,184	48,184	48,184	48,184	48,184	48,184	48,184
WLMRs	14,311	14,311	14,311	14,311	14,311	14,311	14,311
BUSLRs	255	255	255	255	255	255	255
CAPITAL COSTS:							
WLBs	0	0	0	0	0	0	0
WLMs	0	0	0	0	0	0	0
WLBRs	0	0	0	0	0	0	0
WLMRs	0	0	0	0	0	0	0
BUSLRs	0	0	0	0	0	0	0
CONSTANT 1992 $							

ALL O&M COSTS	62,750	62,750	62,750	62,750	62,750	62,750	62,750
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	62,750	62,750	62,750	62,750	62,750	62,750	62,750
DISCOUNTED 1992 $							

Discount factor 4	0.588	0.565	0.542	0.520	0.500	0.480	0.460
ALL O&M COSTS	36,910	35,433	34,016	32,655	31,349	30,095	28,891
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	36,910	35,433	34,016	32,655	31,349	30,095	28,891
Discount factor 7	0.389	0.362	0.337	0.313	0.291	0.271	0.252
ALL O&M COSTS	24,428	22,718	21,128	19,649	18,274	16,994	15,805
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	24,428	22,718	21,128	19,649	18,274	16,994	15,805
Discount factor 10	0.254	0.229	0.206	0.185	0.167	0.150	0.135
ALL O&M COSTS	15,950	14,355	12,920	11,628	10,465	9,418	8,477
ALL CAPITAL COSTS	0	0	0	0	0	0	0
TOTAL COSTS	15,950	14,355	12,920	11,628	10,465	9,418	8,477
CAPITAL BUDGET							

3% inflation rate	0	0	0	0	0	0	0
5% inflation rate	0	0	0	0	0	0	0
7% inflation rate	0	0	0	0	0	0	0
10% inflation rate	0	0	0	0	0	0	0

19 WLBR SCENARIO (cont.)
($000)

		2012	2013	2014	2015	2016	2017	2018
# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		19	19	19	19	19	19	19
WLMRs		11	11	11	11	11	11	11
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		48,184	48,184	48,184	48,184	48,184	48,184	48,184
WLMRs		14,311	14,311	14,311	14,311	14,311	14,311	14,311
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								
ALL O&M COSTS		62,750	62,750	62,750	62,750	62,750	62,750	62,750
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		62,750	62,750	62,750	62,750	62,750	62,750	62,750
DISCOUNTED 1992 $								
Discount factor	4	0.442	0.424	0.407	0.391	0.375	0.360	0.346
ALL O&M COSTS		27,736	26,626	25,561	24,539	23,557	22,615	21,710
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		27,736	26,626	25,561	24,539	23,557	22,615	21,710
Discount factor	7	0.234	0.218	0.203	0.188	0.175	0.163	0.152
ALL O&M COSTS		14,698	13,670	12,713	11,823	10,995	10,226	9,510
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		14,698	13,670	12,713	11,823	10,995	10,226	9,510
Discount factor	10	0.122	0.109	0.098	0.089	0.080	0.072	0.065
ALL O&M COSTS		7,629	6,866	6,179	5,561	5,005	4,505	4,054
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		7,629	6,866	6,179	5,561	5,005	4,505	4,054
CAPITAL BUDGET								
3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0

19 WLBR SCENARIO (cont.)
($000)

		2019	2020	2021	2022	2023	2024	2025
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# VESSELS IN FLEET:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		19	19	19	19	19	19	19
WLMRs		11	11	11	11	11	11	11
BUSLRs		1	1	1	1	1	1	1
Total w/o BUSLRs		30	30	30	30	30	30	30
O&M COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		48,184	48,184	48,184	48,184	48,184	48,184	48,184
WLMRs		14,311	14,311	14,311	14,311	14,311	14,311	14,311
BUSLRs		255	255	255	255	255	255	255
CAPITAL COSTS:								
WLBs		0	0	0	0	0	0	0
WLMs		0	0	0	0	0	0	0
WLBRs		0	0	0	0	0	0	0
WLMRs		0	0	0	0	0	0	0
BUSLRs		0	0	0	0	0	0	0
CONSTANT 1992 $								

ALL O&M COSTS		62,750	62,750	62,750	62,750	62,750	62,750	62,750
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		62,750	62,750	62,750	62,750	62,750	62,750	62,750
DISCOUNTED 1992 $								

Discount factor	4	0.332	0.319	0.306	0.294	0.282	0.271	0.260
ALL O&M COSTS		20,842	20,008	19,208	18,440	17,702	16,994	16,314
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		20,842	20,008	19,208	18,440	17,702	16,994	16,314
Discount factor	7	0.141	0.131	0.122	0.113	0.105	0.098	0.091
ALL O&M COSTS		8,844	8,225	7,649	7,114	6,616	6,153	5,722
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		8,844	8,225	7,649	7,114	6,616	6,153	5,722
Discount factor	10	0.058	0.052	0.047	0.042	0.038	0.034	0.031
ALL O&M COSTS		3,649	3,284	2,956	2,660	2,394	2,155	1,939
ALL CAPITAL COSTS		0	0	0	0	0	0	0
TOTAL COSTS		3,649	3,284	2,956	2,660	2,394	2,155	1,939
CAPITAL BUDGET								

3% inflation rate		0	0	0	0	0	0	0
5% inflation rate		0	0	0	0	0	0	0
7% inflation rate		0	0	0	0	0	0	0
10% inflation rate		0	0	0	0	0	0	0