Waterway User Groups Characterized According to the Navigational Requirements of the Vessel Operators

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1. INTRODUCTION

As part of the multi-year Volpe Center project to assist and support the Coast Guard Research and Development Center in evaluating current Coast Guard policies and development plans for Waterways Management, a "Waterways Management Research and Planning" task plan was established as Task Area A in FY '94. The purpose of this task area is to develop decision support tools to assist Coast Guard waterways managers in improving the way they meet the waterway users' requirements for aids to navigation and waterway services. A Waterways Users research topic was established in 1994 and a Baseline Analysis report on Waterway Users was presented in April, 1995. This analysis defined the waterway users to be "vessels of various types, sizes and uses, not the humans operating the vessels", and went on to consider the most important attributes of the vessels. The attributes were defined, for the most part, in physical terms (size and number of vessels, cargo carried, maneuverability, etc.) but consideration was given to the human dimension as well. One of the research tasks proposed in the Baseline Analysis was Task 2-6, User Requirements - Human Factors Critical to Assessment of Effectiveness of Coast Guard Aids to Navigation and Waterways Services. That Task, in turn, was divided into two subtasks, 2-6.1 Define Waterway Users by Navigational Requirements and 2-6.2 Select User Groups for In-Depth Study, which were funded in FY '95.

This project memorandum is the product of subtasks 2-6.1 and 2-6.2. It is a categorization of the various groups of mariners who use the U.S. waterways, defined according to their distinct navigational requirements. It reports the results of the Volpe Center researchers' efforts to develop categories and data collection tools required to understand how various mariners use ATON. This has been done in order to help the Coast Guard anticipate mariners' responses to changes in the mix of aids to navigation (ATON). The intention is to complement the WAMS process by categorizing the vessel operators on the waterways in terms of their navigational environments, skills, and available navigational equipment

In this project memorandum we have established, for the purpose of this study, basic categories of waterway users (vessel operators), based on potentially differing requirements for navigational information, various modes of navigational information reception, and varying levels of navigational expertise, all of which influence the use of available information. In order to avoid confusion in terms betwen the "Waterway Users", which are discussed in the Baseline Analysis (and elsewhere) as the vessels which traverse the waterways, and the "Users of ATON", who are the persons operating the vessels and the subjects of this report, we will use the generic term "operator" in this paper to refer to vessel owner/operators, pilots, masters, captains, and all other individuals who operate vessels on the waterways.

1.1 Objectives

The primary objective of this project memorandum is to document our hypotheses of how mariners use aids to navigation, how use varies among the various categories of waterway users and how use varies with meteorological and other conditions. Another objective is to identify specific groups as candidates for in-depth study. Thirdly, the memorandum provides the instruments to be used for data collection. Whether they are called boaters, masters, pilots or captains, these operators of vessels in U.S.-managed waterways are the ultimate users of the Coast Guard Aids to Navigation (ATON), and we have relied on their experience in making our assessment of user requirements.

This characterization focuses on the vessel **operators** who use the information provided by the existing U.S. Coast Guard ATON, in contrast to the Baseline Analysis report on Waterway Users, which focuses on the vessels themselves. This characterization is undertaken to make better use of the operators' navigational experience to help us assess the effectiveness of current ATON and to assist the Coast Guard as it projects future requirements for USCG-provided aids and services by providing a means to assess operator expectations. We have considered the increased availability of low cost electronic navigation systems (LORAN-C and GPS) to a broader spectrum of operators to learn whether the Coast Guard should reexamine the requirements for some short-range (physical) ATON.

"The term **aid to navigation** . . . means any device external to a vessel intended to be of assistance to a navigator in his determination of position or safe course, or to provide him with a warning to dangers or obstructions to navigation. This term includes lighthouses, beacons, lightships, sound signals, buoys, marine radio beacons, racons, and the medium and long range radio navigation systems." (Bowditch, American Practical Navigator 1977 Edition, p.90) For this preliminary work we will define ATON very broadly, to include short-range (buoys, etc.), radio aids (LORAN-C, etc.) and publications (Nautical Charts, Notices to Mariners, etc.).

For most mariners, the primary purpose of ATON is to reduce the risk of grounding or colliding with fixed objects, charted or uncharted. This is accomplished by providing warning of fixed (temporary or permanent) obstructions, and by providing information necessary for mariners to establish their position and confirm their course. The secondary purpose is to aid the traffic flow by delineating a path for deep draft vessels; yet another function, for some mariners, might be to provide ancillary information on factors such as current velocity and direction.

1.2 Test Hypothesis

We can expect that changes in the mix of aids to navigation made available to the users of U.S. Coast Guard-managed waterways will occur as the result of improved fixed physical ATON technology and of broadening acceptance and use of wide area positioning systems. The degree to which these changes will be accepted and incorporated by the various

categories of waterway operators will vary greatly. The major factors that will influence acceptance of change will be:

1. Current dependence (real and perceived) upon specific types of ATON;
2. Level of training/experience in navigation principles and ATON use;
3. Perceived improvement in capabilities of "newer" technology;
4. Economic ability to take advantage of improved aids.

There are two parallel technological drivers to changes in the mix of ATON. First are several improvements in physical ATON, resulting in shore-mounted or fixed equipment that show the potential to provide equal or better navigation guidance than floating ATON. Among the improvements now being introduced are laser-light navigation ranges, low-pressure sodium light ranges, and sector lights, and also improvements in dayboard visibility, and various types of "buoyant beacons," floating, articulated markers permanently attached to the sea floor. The other driver is the broad acceptance and use of wide area navigation systems (GPS, LORAN-C) among recreational and smaller scale commercial maritime operators. The significant market penetration by LORAN and GPS in the 1980's has been followed more recently by the availability of low cost/ high utility onboard electronic aids to navigation (LCD Radars, Integrated Electronic Charts, hand held GPS, 3-D fathometers). Such aids are entering common use not only because of improved capabilities and lowering cost, but because they are becoming physically smaller, easier to install and maintain, they are using much less power and are more convenient to use.

2. BACKGROUND

"**Navigation** is the process of directing the movements of a craft, expeditiously and safely, from one point to another . . . **Dead Reckoning** is the determination of position by advancing a known position for courses and distances . . . **Piloting** is navigation involving frequent or continuous determination of position or a line of position relative to geographic points, and usually requiring need for close attention to the vessel's draft with respect to the depth of water . . . **Radio navigation** is navigation using radio waves for determination of position or a line of position. Radar navigation and satellite navigation are parts of the radio navigation division." (Bowditch, American Practical Navigator 1977 Edition, p.56)

To make use of the experience and insight of practical navigators to assist in improving the mix of Coast Guard-provided aids to navigation, we must identify the various significant groups of waterway operators as to their various navigational requirements.

This characterization used information derived through face-to-face and telephone interviews with representatives of Boat/US, the USCG 1st District staff, and interviews with more than 20 experienced mariners who represent the various categories. In preparing this material we also have spoken with representatives of the National Academy of Sciences Marine Board, MARAD, and the National Marine Fisheries Service.

2.1 Interface with Baseline Analysis

This characterization of user groups can be cross-referenced against the Categories of Waterway Users defined in the Phase 1 Baseline Analysis Report on Waterway Users (August 15, 1994).

The Baseline Report categorized the vessels as "Users" by their type, the cargo they carry, and their size. The five basic Operator categories we have established in this memorandum correspond closely to the user/vessel categories of the Baseline Report as follows:

- "Recreational Boaters" own and operate the Recreation boats;
- "Working Vessel Operators" run the Fishing & Working vessels
- "Transport Vessel Operators" are masters of the Cargo ships;
- "Passenger Vessel Operators" are masters of the Commercial Passenger ships; and
- "Other Operators" captain the Patrol, Survey, and Combat ships.

Our categorization of "Working Vessel Operators," includes the masters of vessels engaged in Maintenance & Improvement Work (this is the one difference from the *Baseline Analysis Report).*

3. APPROACH

Our initial categorization of the Operators was based on the literature and interviews with industry experts. We then conducted structured interviews with "representative mariners," vessel operators who have first-hand, current knowledge of the vessels, operating conditions, and navigational requirements. The appendix contains the data collection instruments used in this project. Our initial characterization of the five waterway operator groups and subgroups follows roughly the correspondences to the Baseline Report as mentioned above. Although using the five basic categories for grouping types of operators is convenient for descriptive purposes, when the operators are considered in terms of vessel operations and navigational capability, it appears that the groups have less in common than might be expected.

After reviewing the expert judgment available on the operators and the results of our interview data gathering, we established two organizing principles for grouping the various categories of operators. The first we titled "Vessel Operations", and included in it five operational characteristics which serve to differentiate clearly the "work situation" of the various operators. The notion here is that vessel operators' situations can be quantified based on a finite number of identifiable factors. Vessel size, the area in which the vessel is typically operated, the environmental conditions under which the vessel is typically operated, the type of "mission" which the operator undertakes with the vessel, and, finally, the length of time the vessel is typically underway from port are identified, weighted, and computed for

each vessel operator. (See Table 2 for Vessel Operation scales.) This information is then considered across a "Challenge Spectrum" ranging from least challenge (e.g., the operator of a small recreational boat who stays close to shore, avoids bad weather, sails when it is convenient, and rarely stays out more than a few hours) to most challenging (e.g., the captain of a large Navy ship engaged in mid-ocean operations on a tightly controlled schedule, underway for months at a time).

The other organizing principle we settled on is "Navigational Capability". This is an index of the degree of navigational capability possessed by various types of operators, as indicated by three characteristics. The type of navigational equipment available to the operator, his or her sophistication in the use of available equipment, and the licensing requirements (if any) for operation are identified, weighted, and computed for each vessel operator. (See Table 3 for Navigational Capability scales.) The "Capability Spectrum" ranges from least capability (e.g., a coastal recreational boater with no electronic aids, minimal training, and no license required) to greatest capability (e.g., the captain of a merchant vessel with highly sophisticated electronic navigation equipment, the training to use it, and an unlimited master's license).

Table 1 is our ranking of operators in ascending order of "Operational Challenge". It is readily apparent that when the operators' working environment is followed strictly as the organizing or "ranking" tool, the descriptive groupings (Recreational Boaters, Working Vessel Operators, etc.) are no longer definitive.

The two scatterplot diagrams which follow (Figures 1 and 2) display an analysis of all categories of operators against both scales (vessel operation and navigational capability). Figure 1 is based on expert judgment while Figure 2 is based on the interviews conducted with mariners. They demonstrate graphically that most of the operator groups fall along an expected axis, i.e., as the operational challenge increases, so does the operators' navigational capability. They also point out a few groups which may require closer attention, those operators engaged in challenging operations who may be lacking in navigational capability. The "vulnerable" operator groups appear in the lower right-hand quadrant in both figures.

In order to follow up on those "vulnerable" operator groups, we reviewed our interviews with representative operators from four of the groups and provide a detailed profile of how each of them reported his dependence on the aids to navigation and on-board navigation equipment. Figures 3 through 6 display the results.

The "descriptive" categorization which follow the figures includes brief descriptions of the size of the population, the types of vessels they operate and their onboard navigational equipment, the conditions in which they operate, typical navigational situations, and the navigational equipment which each are likely to have available. The letters in parentheses following each subcategory description refer to the Table 1 "Identifiers".

TABLE 1: Operator Categories Ranked According to Vessel Operation

IDENTIFIER	CATEGORY	Expert Judgement		Interview	
		VESSEL OPERATIONS	NAVIGATION ABILITY / CAPABILITY	VESSEL OPERATIONS	NAVIGATION ABILITY / CAPABILITY
A	Organizers of marine events	6.1	3.1	7.1	5.3
B	Livery and rental operators	6.1	3.1	*	*
C	Coastal boaters	6.6	3.1	9.6	6.6
D	Inshore Commercial fishing vessel	8.1	6.3	*	*
E	Offshore sport fisherman	8.3	7.4	11.5	8.6
F	Harbormasters, LE and Envir. Officls	8.8	6.3	8.4	6.1
G	Lightering Operations	9.4	8.8	11.2	8.9
H	Oceangoing yachtsman	9.8	8.6	12.5	6.6
I	Rescue service vessel ops	10.0	11.1	11.5	12.1
J	Fishing charters	11.4	11.9	12.5	12.3
K	Tour boat masters	11.7	12.8	11.5	11.9
L	Pilots	12.0	10.2	13.3	8.9
M	Sm. ferry, commuter boat, water taxi	12.2	8.8	13.9	11.1
N	Tug operators - harbor	12.5	8.8	10.2	11.1
O	Barge Operations	12.5	8.8	13.6	8.8
P	Large &/or Auto Ferry	13.8	10.9	*	*
Q	Constr. vessel and dredge ops	14.2	12.3	16.7	14.0
R	Offshore Commercial fishing vessel	14.5	9.8	16.9	8.6
S	USCG Buoy Tenders/Ice Breakers	16.3	15.0	20.6	14.2
T	Coastal liner	16.3	13.2	14.0	13.2
U	Ocean going tugs	18.9	12.8	*	*
V	Research / Survey	20.3	14.0	19.6	15.0
X	Ocean liner masters	22.5	15.0	23.0	15.0
Y	Ocean Transport Masters	23.5	15.0	22.0	15.0
Z	Military	25.0	15.0	25.0	15.0
	Median	12.2	10.2	13.3	11.1

* no interview conducted

TABLE 2: Vessel Operation

Category 1		Category 2		Category 3		Category 4		Category 5	
	VESSEL TYPE		AREA OF OPERATION		OPERATIONAL ENVIRONMENT		MISSION		LENGTH OF VOYAGE (Time U/W)
1	< 16'	1	Local	1	Avoid Bad Wx	1	Recreation	1	1 day
2	16' - <26'	2	Near shore (w/i 7 mi	2	All Wx; w/ choice	2	Respond to demand	2	1 - 3 days
3	26' - <40'	3	Coastal (7-25 mi)	3	All Wx; No Choice	3	Flexible Schedule	3	4 - 7 days
4	40' - <65'	4	Offshore (25+ mi)				Rigid Schedule	4	8 - 30 days
5	65' - < 100'	5	Trans Oceanic				Preplanned Command	5	over 30 days
6	100' - <250'								
7	250' - unlimited								

TABLE 3: Navigational Capability

Category 6		Category 7		Category 8	
	NAV EQUIP		OPERATOR SOPHISTICATION W/ NAV EQUIP		LICENSING
1	No electronic	1	Minimal, if any	1	None
2	Electronic Fix	2	Little	2	6 or < PASS.
3	Radar	3	Moderate	3	> 6 PASS.
4	Elect. Fix & Radar	4	Sophisticated	4	Inshore
5	Sophisticated			5	Coastal
				6	Oceanic

Figure 1: Scattterplot of Mariner Groups (Expert Judgement)

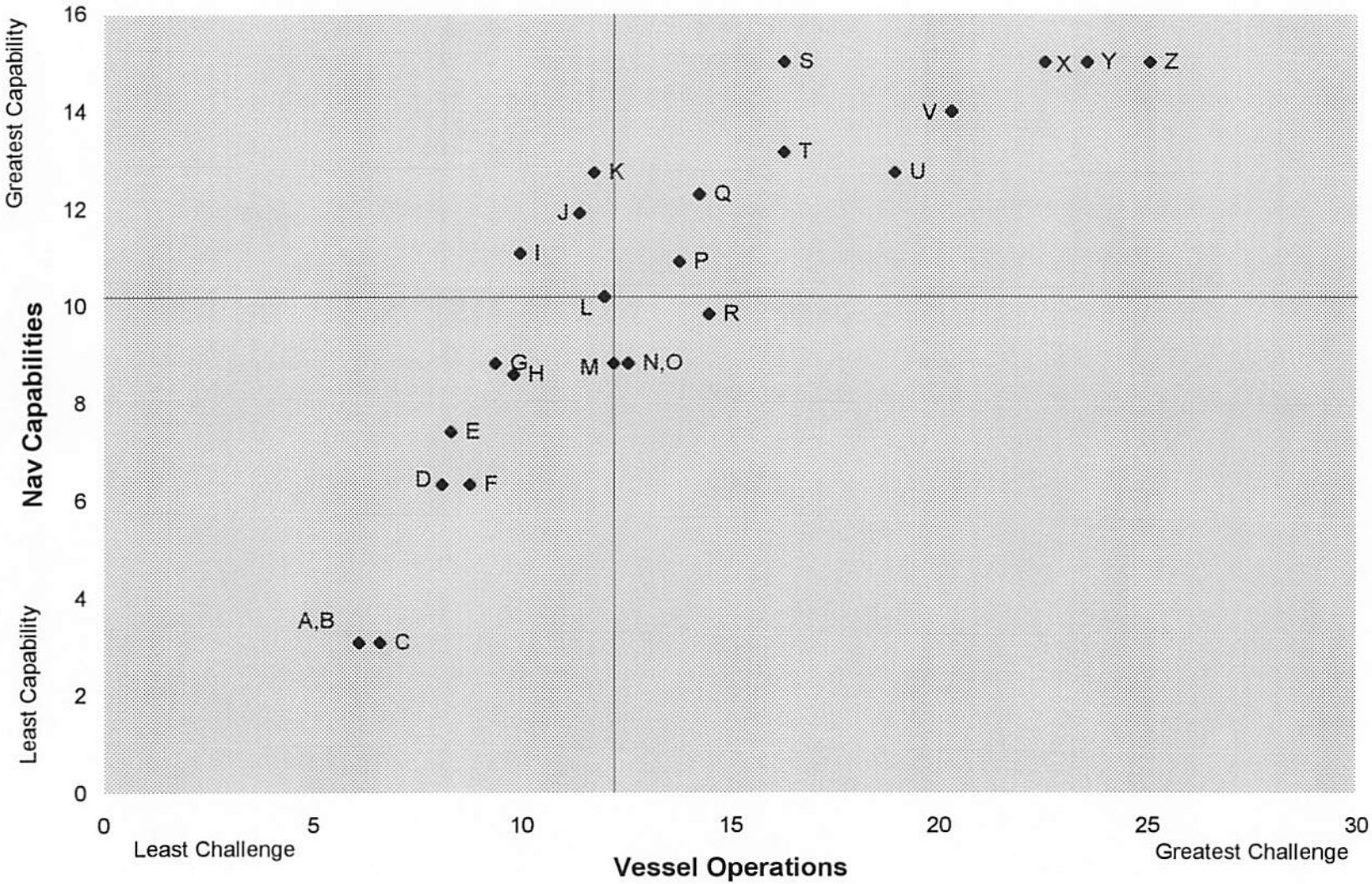


Figure 2: Scatterplot of Mariner Groups (Interview Data)

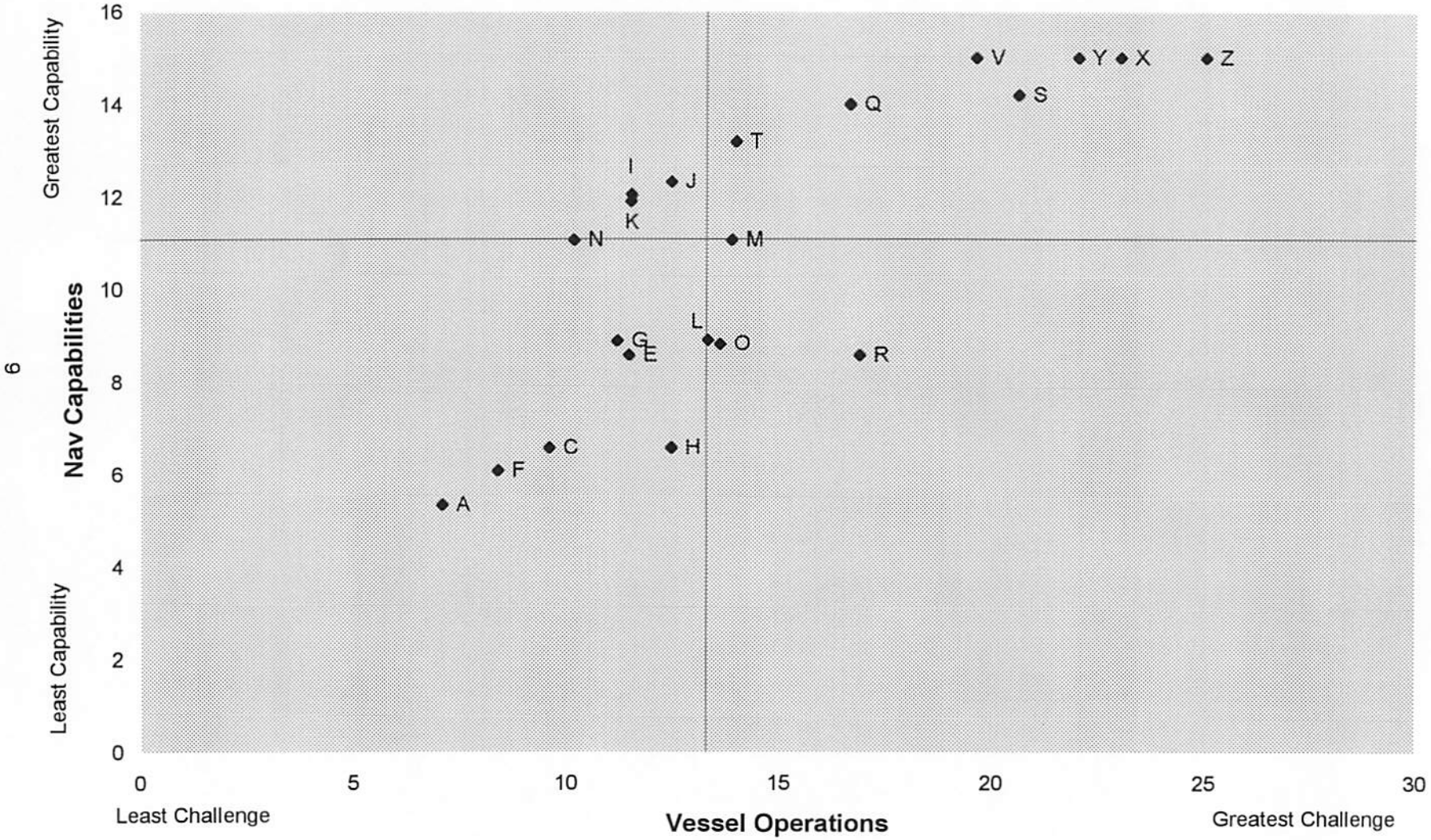


FIGURE 3: Profile of Offshore Commercial Fisherman (Boston Harbor)

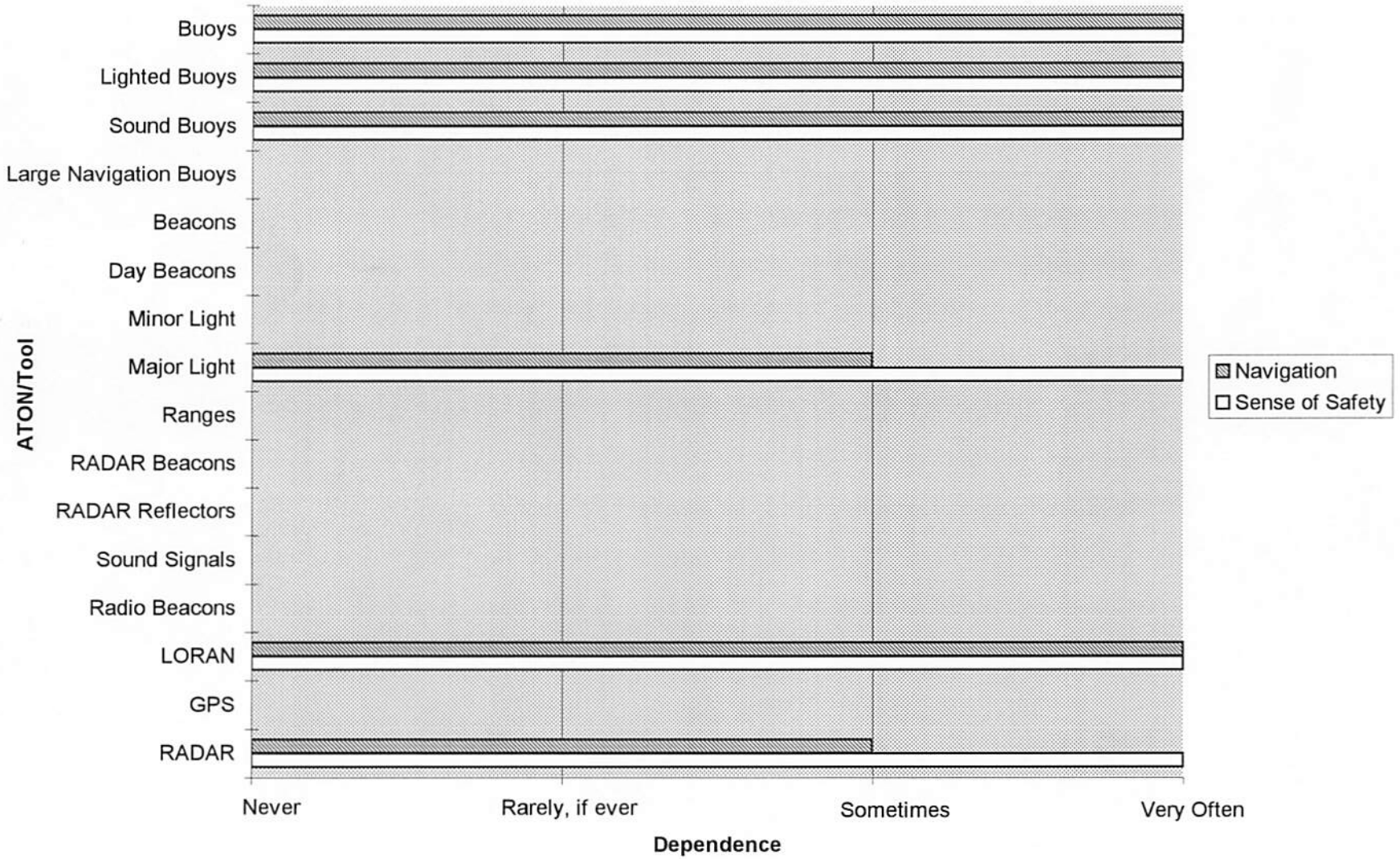


FIGURE 4: Profile of Barge Operator (Hudson River)

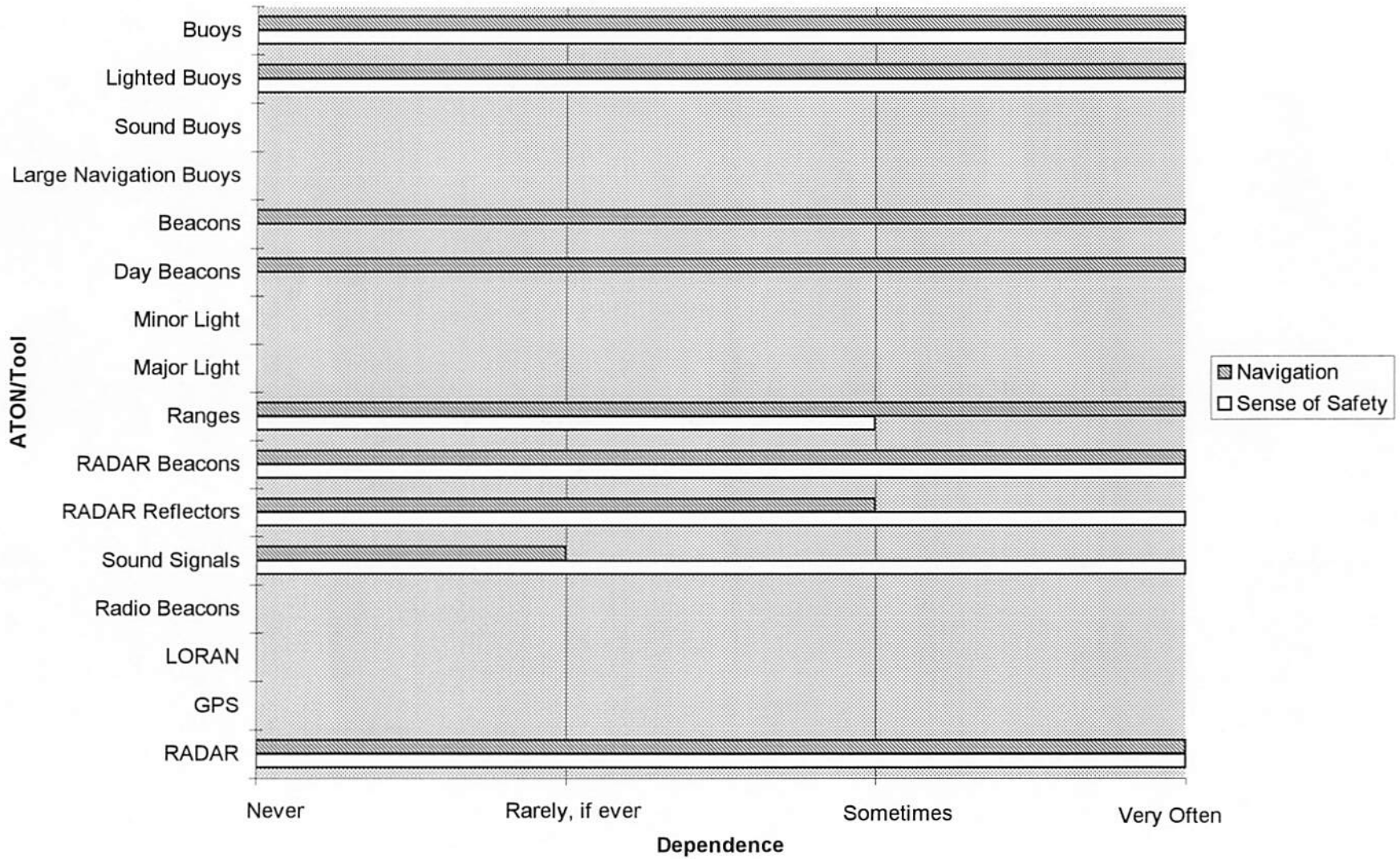


FIGURE 5: Profile of Harbor Tug Operator (Boston)

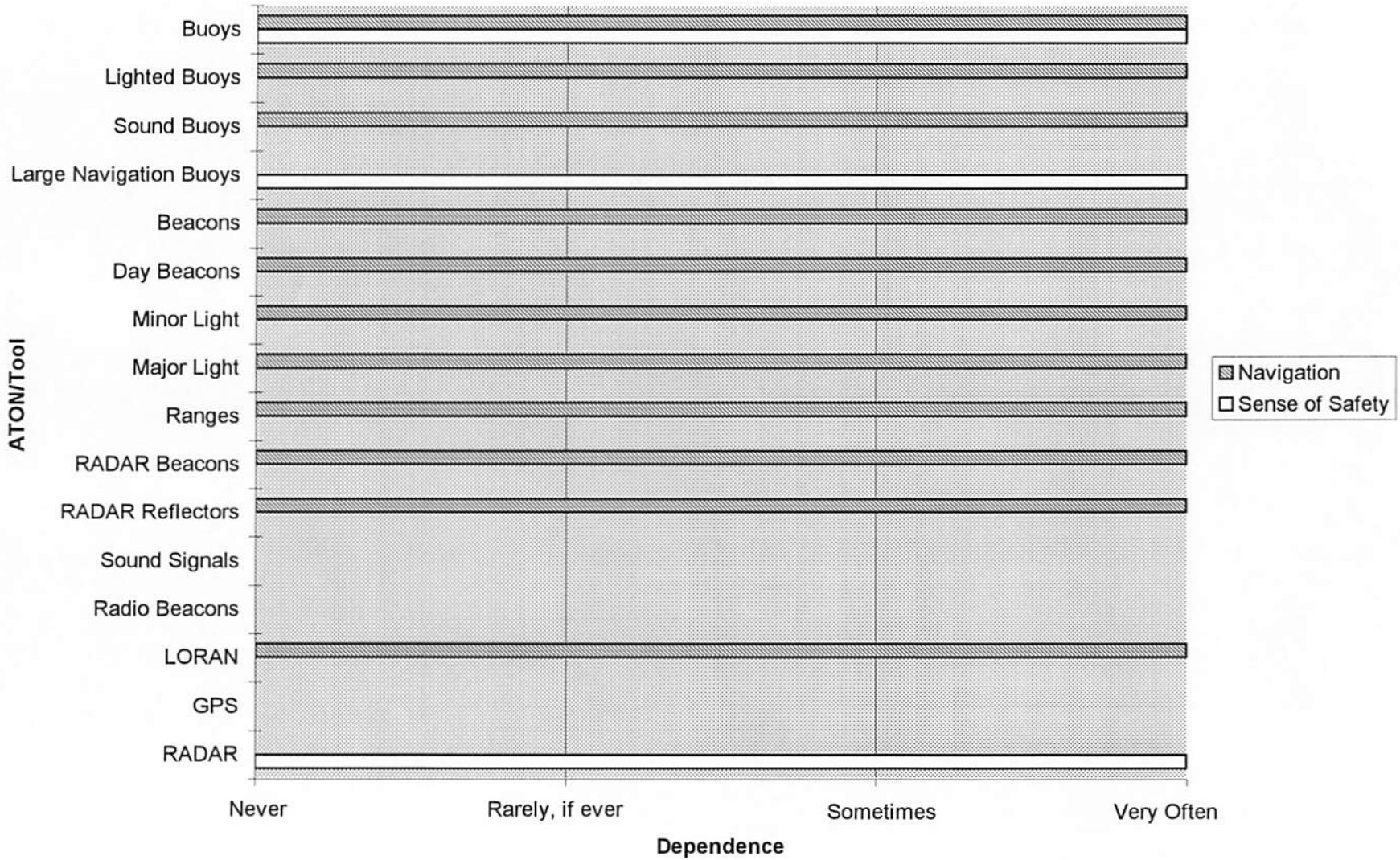
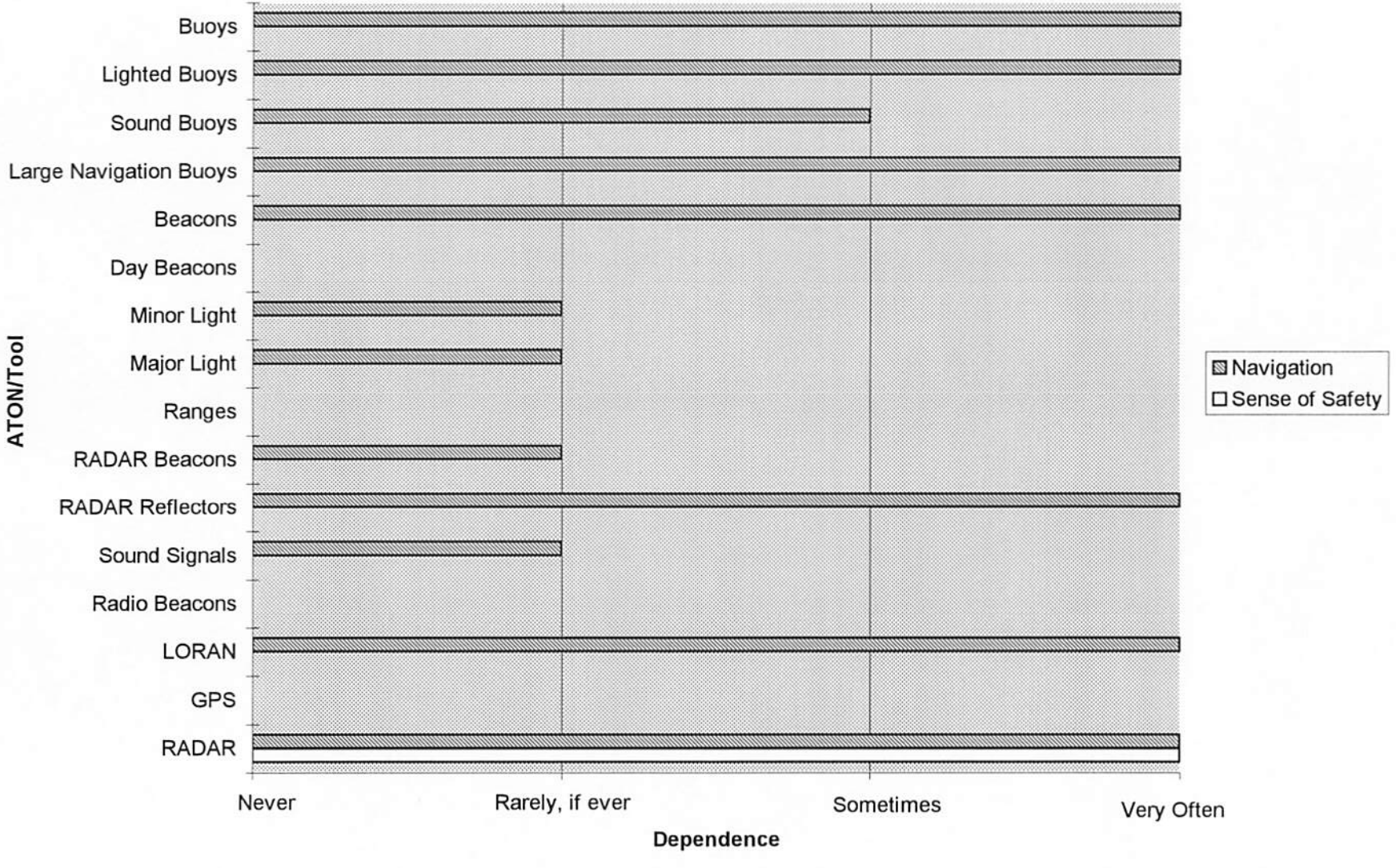


FIGURE 6: Profile of Commuter Boat Operator (NY Harbor)



4 DESCRIPTIVE CHARACTERIZATION

4.1 Recreational Boaters

4.1.1 Recreational Boaters (Basic Characterization)

Recreational boaters represent the largest and most heterogeneous of the groups. According to the 1993 Coast Guard Boating Statistics, there were more than 10 million reported numbered motorboats and powered sailboats in US waters. Boat/US, the largest association of recreational boat owners, estimates that there are 20 million recreational boaters. The National Marine Manufacturers Association, a recreational boating manufacturer's trade group, published a 1994 estimate of 16.6 million boats in use with 78 million "people participating in recreational boating." This "boats in use" figure is based on state and Coast Guard statistics and "estimates of non-registered boats"; it includes more than four million canoes, dinghies, and other non-motorized craft. Boaters on small vessels (under 16') represent the vast majority of accidents, injuries and boating fatalities. Personal Water Craft (Jet Skis, etc.) are currently the fastest-growing segment of the recreational boating market, as to new sales.

By definition, recreational boaters use the waterways for discretionary, non-economic purposes. The choice of whether or not to navigate the waterway on a given day or hour is driven by the recreational boater's personal preference, rather than by economic, military, law-enforcement, or other "mission" requirements. This element of discretion strongly influences the demand which recreational boaters impose on the Coast Guard system of aids to navigation. Recreational boaters differ greatly in experience, skill and training. Access to electronic gear varies greatly. Voyages are of short duration, usually one day or less, and boaters typically return to familiar waters at the end of the voyage (except for the oceangoing yachtsman). Formal navigational training for recreational boaters is available through the Coast Guard Auxiliary, the U.S. Power Squadron, and, more recently, through commercially available videotape courses. While there is no clear evidence on what proportion of recreational boaters take formal training, discussions with individuals involved in providing the training suggest that is probably a tiny percentage of the total.

4.1.2 Recreational Boaters (Onboard Equipment)

Contemporary recreational boats can be surprisingly well equipped with onboard navigation aids. The following is a "maximum" equipment list, relatively few recreational vessels would be equipped with all of the following:

Electronic Aids

Flux-gate compass
GPS receivers
LORAN- C receivers

Auto-pilot
Depth-finders
"Consumer-grade" Electronic Charts
Marine radars, S-band

Non-Electronic Aids

Standard compass
Binoculars
Piloting (User processing of visual, sound and other aids to decide position and course without electronic equipment)
Nautical charts of transit area
Light Lists
Coast Pilots, Port, and other guides and books
USCG Notices to Mariners/Local Notices
Sextants/stopwatches (rarely)

Communications gear

VHF/FM
CB radio
SSB radio
Cellular telephones

4.1.3 Recreational Boaters (Subcategories)

The following subcategories of recreational boaters are considered to have distinct navigational requirements:

Coastal boaters (C)

Inshore power and sail boaters typically stay within 7 miles of land (ref. BOAT US). With small boats (16' and less) operating in marine environments, the owners are most likely to operate in very familiar waterways. They will generally operate in daylight under favorable weather conditions, relying mainly on visual short-range ATON, generally buoys and daymarkers. Although coastal boaters may not choose to be out in conditions of reduced visibility, circumstances may force them to operate under fog or night conditions, and to depend upon available ATON and onboard aids. The smallest recreational boats are equipped with minimal onboard navigation equipment and personal watercraft are generally without onboard equipment. Larger power and sailboats can venture further into unfamiliar waterways, with a greater demand on the boaters' ability to use both Coast Guard ATON

(where present) and charts.

Oceangoing yachtsmen (H)

Offshore yachtsmen, under sail for the most part (although some long-range power boats are certainly capable of making voyages well beyond the sight of land) operate under a wider variety of weather conditions. They often sail in the dark, and deliberately seek out new, unfamiliar waterways. Such yachtsmen are frequently equipped with the more sophisticated onboard navigation aids (see list above) ,although some "purists" pride themselves on their ability to navigate without the use of electronics.

Offshore sport fishermen (E)

The category of offshore fishermen, though largely recreational, includes a number of small-scale "party-boat" owner-operators, and charters. Fishermen typically operate from a port or marina and are very familiar with their "home" waterway. Their "mission" takes them offshore, even out to the Atlantic Continental Shelf, often in the very early hours before dawn and/or after dark. Contemporary sport fishermen are often very sophisticated users of electronic aids, especially LORAN-C, due to its ability to "repeat," i.e., bring them back to the same spot on another outing, and video-display fathometers ("fish-finders").

Livery and rental operators (B)

Typically, rental companies work in an environment where the boaters are very unsophisticated about navigation, and their range of operation is limited and well-marked. Rental boats are often not equipped with even the simplest navigational equipment, often not even a compass is provided. Boaters usually take day trips of two to eight hours, in relatively protected waters in good weather conditions, but are often completely unfamiliar with the waterways. Voyages are completely discretionary.

Organizers of marine activities (A)

While not actually boat operators, organizers of races, regattas, and other marine activities are a distinct waterway user group with special ATON requirements. Depending upon the event, organizers often use temporary physical ATON, alone or in combination with USCG ATON, as race marks. These groups make effective use of charts and "local knowledge." Marine activities of these types often require publication of special notices to alert other mariners of temporary waterway use restrictions, safety zones, etc

4.2 Working Vessel Operators

4.2.1 Working Vessel Operators (Basic Characterization)

Working vessel operators operate under all conditions. Their transits of waterways are motivated by economic or other "mission" requirement, and are not discretionary. Operators are often "on call" and must be prepared to navigate unfamiliar waters, sometimes on short notice. Voyages are usually of limited duration, frequently overnight. In the case of commercial fishermen, voyages may last for 7-10 days. Also, restrictions on familiar fishing grounds are a reality and frequently demand navigation and operation in completely new and unfamiliar areas. Training for working vessel operators is often obtained from correspondence-type courses and on-the-job apprenticeship. The exception to this is the Federally mandated "Radar Observer Course" taken by those operators who have a Radar endorsement.

4.2.2 Working Vessel Operators (Onboard Equipment)

Typical navigational equipment to be found on commercial vessels of this type may include those found on recreational boats plus:

Electronic Aids

Depending on economics, distance from home ports, or visibility conditions the prudent smaller commercial mariner may have
- Radar -average performance, X-band
- Radar -average performance. S-band
- Gyrocompass

Non-electronic Aids

Largest scale nautical charts of transit area (these charts may be individually annotated and otherwise customized by the users)
Local Notices to Mariners

4.2.3 Working Vessel Operators (Subcategories)

Tug operators - harbor (N)

Harbor tug operators work in well-known waters and have some discretion, or, at least, advance notice regarding scheduled work. Operators are highly trained, very experienced and familiar with local waters.

Tug operators - ocean going (U)

Oceangoing tug operators frequently work in unfamiliar waters, and are likely to operate in severe weather during retrievals. They are more likely than harbor tug operators to have sophisticated collision avoidance RADAR (ARPA) and gyro-stabilization inertial guidance-based navigational systems onboard.

Salvage/rescue service vessel operators (I)

The vessels operated range from basic power boats to small tugs that provide emergency service to recreational boaters and to some inshore commercial vessels. The operators work on-call, frequently in difficult weather, at night, etc. often in shallow and difficult waters. Their most typical tasks are towing boats and delivering fuel to stranded boats. Operators have various levels of skills and training. Most have a Coast Guard license with towing endorsement. Vessels and equipment are being improved through imposition of certification standards by the Committee for Private Offshore Rescue and Towing (C-PORT). C-PORT reports 145 member organizations using 319 boats (most 25' or less in length). They estimate that there are approximately 200 operators nationwide, with about 440 boats.

Construction vessel and dredge operators (Q)

Operators work with vessels that are often not independently mobile (towed) but very wide-ranging in their areas of operation (generally close to shore). They require accurate positioning of equipment, which may stay stationary for long periods of time. They usually do not work at night or in bad weather. One unique navigational consideration for operators is that these vessels, when operating, are hazards to navigation, and must be so marked. Large dredges are operated by Coast Guard licensed mariners and are usually well-equipped with onboard aids.

Commercial fishermen - inshore (D) and offshore (R)

Fishermen work with many vessel types and differing navigational equipment. Unlike other working vessel operators they often have little formal training and no certification although many operate well offshore under extreme weather conditions. This is in part due to their narrow profit margin and in part due to tradition. There are no Coast Guard licensing requirements for commercial fishermen on vessels less than 70 feet, and most have only on-the-job training

Although fishermen operate from a home port, fishing ground conditions and legal restrictions require them to be very mobile in their areas of operations. It is common for offshore commercial fishermen to put to sea for a week or more; inshore fishermen, especially shell fishers, return to port daily. Equipment is often minimal, although few commercial fishermen venture offshore without Radar and many carry LORAN-C. The National Marine Fisheries Service reported in May 1994, an estimate of 94,462 U.S. commercial fishing vessels and boats operating in 1992.

Coast Guard Buoy Tenders and Icebreakers (S)

Captains of these specialized working vessels must operate under all types of weather conditions; icebreakers, especially, have severe-weather mission requirements. These vessels are usually well staffed and often equipped with state of the art navigational equipment including DGPS, which is an essential tool for buoy placement. Vessels are usually well-maintained and operate for day long or extended (two to four weeks) voyages.

4.3 Transport Vessel Operators

4.3.1 Transport Vessel Operators (Basic Characterization)

The operators of transport vessels work in a highly competitive environment, some with relatively narrow profit margins. Other than Naval vessels, transport vessels include the largest variety of vessel sizes, ranging from river barges of less than 100 feet to 1000+ foot supertankers. Although some operate on published schedules, many work on some form of charter arrangement. Voyage length varies from a few hours for harbor pilots to a week or more for merchant vessel officers. Transport vessels make money only while they are under way, reducing the master's ability to choose optimum sailing conditions. Transport vessel operators are among those mariners most subject to licencing requirements and are likely to have the most formal training (except for military crews).

4.3.2 Transport Vessel Operators (Onboard Equipment)

Large commercial transport vessels would be equipped with onboard equipment listed under recreational and working vessels as well as:

<u>Electronic Aids</u>

OMEGA (soon to be terminated)
Anti-collision radar (ARPA)
Inertial guidance systems
Electronic Chart Display and Information Systems (ECDIS)
Shore-based navigation support personnel (VTS) in selected ports

On many newer large commercial vessels, integrated electronic bridge systems have been introduced, incorporating electronic charting systems, radar, Differential Global Positioning System (DGPS) capabilities, collision-avoidance software, and propulsion and steering system monitors.

<u>Non-electronic Aids</u>

Gyroscopic and magnetic compasses
Celestial navigation equipment

4.3.3 Transport Vessel Operators (Subcategories)

Pilots (L)

While not a ship's master, the pilot has responsibility for navigation in the most restricted of waterways, in heavy ship traffic, guiding unfamiliar ships through busy areas for relatively short periods (less than eight hours). Highly experienced, trained, and certified, pilots have extensive and detailed knowledge of local waterways. They rely on binoculars to access visual ATON. The Marine Board report on marine navigation and piloting, Minding the Helm (1994), reported that 4,500 individuals hold Federal First Class Pilots Licenses or endorsements.

Oceangoing Tug Operators (U)

Operators work offshore, in unfamiliar waters, under variable, frequently severe, weather conditions doing salvage work and towing barges. Crews are small, voyages away from port frequently last two to five days. Oceangoing tug operators are more likely than harbor tug operators to have sophisticated collision avoidance RADAR (ARPA) and gyro-stabilizer gear onboard.

Barge / lightering Operators (G)

Operators have limited maneuverability, operate in inland waterways and also coastal marine environments, in shallow waters, and in bad currents. They must operate at night and in most weather conditions. Voyages last from one to three days between port calls. The Army Corps of Engineers reports more than 5,000 tugboats and pushboats in operation in 1994 and a total domestic fleet of more than 30,000 barges of all types. The level and quality of training for this group vary widely; training requirements are set by employers.

Ocean transport masters (Y)

Masters and bridge officers are highly trained and experienced, they are licensed by their home jurisdiction (U.S. or foreign). Many also hold pilot certificates. They operate on the open seas in every type of condition. They may be at sea for several days to a week between port calls. Within most restricted waterways they are assisted by local pilots (cf. above). As of September 1993, the Maritime Administration reported a U.S. Flag oceangoing merchant fleet of 376 active vessels, employing 1,551 bridge officers. Army Corps of Engineers figures as of August 1994, show 675 tankers and dry cargo vessels (inland and oceangoing), but do not account for the number of bridge officers. If we use the MARAD ratio of 4.12

bridge officers per merchant vessel, we can project a population of 2,781 active, licensed officers navigating and operating U.S. merchant vessels.

4.4 Passenger Vessel Operators

4.4.1 Passenger Vessel Operators (Basic Characterization)

Passenger vessel masters work in a highly regulated environment, where passenger safety is the primary consideration. Most such vessels operate on a fixed schedule, with serious economic sanctions (i.e., loss of future business) if schedules are not closely followed. Vessels are usually well-maintained and fully staffed. Voyages range from less than an hour for water taxis and some ferries to a week or more for ocean liners. According to Army Corps of Engineers figures, there were 1,243 U.S. Flag passenger vessels as of August 29, 1994. All but a few of these fall into the non-ocean liner categories. As with cargo vessel operators, passenger vessel operators are among those mariners most subject to licensing requirements and are likely to have the most formal training of any group (except military crew)

4.4.2 Passenger Vessel Operators (Onboard Equipment)

Passenger vessels are equipped with the same range of navigational equipment listed for Transport Vessels. They are being considered in a separate category largely because their "mission" of carrying passengers places additional demands on the operators in terms of safety, passenger comfort, and maintaining schedule.

4.4.3 Passenger Vessel Operators (Subcategories)

Ferry, commuter boat, tour boat, and water taxi operators (M)

These operations are typically limited as to the number and variety of waterways traversed. Masters are usually very familiar with waterway features and conditions. They must contend with heavy traffic, are tightly scheduled, and often operate at high speed. Ferries usually operate as an adjunct to the roadway system, usually carrying vehicles as well as passengers. "Commuter boats" designates ferries operating in urban environment, usually at higher speeds and without carrying vehicles. Water taxis operate in urban as well as in more recreational environments, as do tour boats. "Whale Watching" is one variety of tour boat operation.

Coastal liner masters (T)

These masters are responsible for operating higher-speed vessels making more frequent port calls. They often operate in shallow inshore waters. Coastal liners may make overnight voyages. Tour boats, included in another category, more commonly make shorter (2-4 hours)

trips and return to the same port each trip.

Ocean liner masters (X)

Masters and deck officers of passenger liners are highly trained and experienced, licensed by their home jurisdiction; some hold pilot certificates. They operate on the open seas in every type of condition; within most restricted waterways they are assisted by local pilots (cf. above). The vessels they operate are among the most well-equipped on the seas; many are fitted with integrated electronic bridge systems. There are only seven U.S. Flag oceangoing passenger vessels (two privately-owned, five owned by the government) according to the 1994 Maritime Administration Annual Report. Thus, only about 30 licensed bridge officers are engaged in navigating and operating the American-flag oceangoing passenger fleet. Approximately 300 foreign-flagged oceangoing passenger vessels make regular calls at U.S. ports.

4.5 Other Mariners

4.5.1 Other Mariners (Basic Characterization)

This category includes the operators of military, research, and law-enforcement vessels of various types. For the most part, the vessels they operate are "platforms" for specialized activities (warfare, education, law enforcement) which are not intrinsically maritime; the navigational activities are often subordinate to the mission requirements (e.g., the most "direct" route may not be taken in favor of a course that offers better training opportunities).

4.5.2 Other Mariners (Onboard Equipment)

Military vessels and many research and training vessels are equipped with the same range of navigational aids listed for Transport Vessels; smaller research and law enforcement boats are likely to carry similar onboard aids to those found in the Working Vessel category.

4.5.3 Other Mariners (Subcategories)

Military Captains (Z)

Military captains operate in a highly structured environment with a strong mission focus. Military vessels, including Coast Guard patrol cutters, are usually well staffed (usually two to five times as many bridge staff as a similar size merchant ship) and equipped with state of the art (or close to S-O-A) navigational equipment. Vessels are usually well-maintained and must operate in all weather conditions, often for very extended (two weeks to six months) voyages between ports. Bridge officers receive extensive formal and on-the-job training in navigation. Navigation on military vessels under some circumstances does not involve physical ATON. During war time and training for war, captains must perform their navigation using bearing sites from known objects rather than ATON that may have been intentionally displaced.

Military ships also have access to higher accuracy GPS signals than those available for civilian use.

Research, education and survey vessel operators (V)

The masters of research and educational vessels, similar to military captains, operate in a highly structured environment, but with a focus on intellectual pursuits. Staffing is significantly less than on military vessels. The vessels serve as platforms for exploration, information-gathering, and training. They operate in "blue water" environments, sometimes on extended (two to four-week) voyages between port calls.

Law enforcement, environmental vessel operators, harbor masters (F)

State and local law enforcement and environmental protection agencies operate in harbor and coastal environments, and also on inland waterways. Small boats (20 to 45 feet) predominate in this category; and they must operate in various weather conditions. Most voyages from port are short, less than a day. Coast Guard small boat operations would be included in this category.

5. PRELIMINARY FINDINGS REGARDING THE PROCESS

Operator Dependence on Specific ATON Types

The following figures outline our preliminary findings regarding how well the data-gathering process identifies the dependence of the various categories of operators on specific types of navigation aids. The first two tables are a distillation of the preceding narrative, presenting expert judgment on operator characteristics and on their use of short-range and electronic aids to navigation. Table 4 focuses on the operators' varying levels of ability to use navigational aids, while Table 5 portrays their expected usage of various short- and long-range ATON, as evidenced by the available literature and expert opinion. As a corrective, the five following figures (Figures 7 through 11) present the responses of the operators actually interviewed. Each operator responded to questions about his use of various ATON, ranging from buoys through fixed marks to electronic positioning systems, and was asked to indicate on a relative scale how important each ATON used is to the operator's day-to-day navigation tasks and how critical it is to the operator's sense of safety.

The five figures display interview results for the twenty categories of operators we were able to interview. Data for all floating aids (buoys, lighted buoys, sound buoys, large navigational buoys) is aggregated under Buoys; a variety of fixed marks, including beacons, daymarks, minor and major lights, and ranges are aggregated under Fixed Marks; while the GPS, LORAN, and RADAR data are not aggregated.

TABLE 4: VESSEL OPERATOR CHARACTERISTICS

	Characteristic					
	Train/Qual	Nav Aids	Water	Weather	Local Knowl	Pop
OPERATOR TYPE						
RECREATIONAL BOATERS						
Coastal	V	V	C	N	V	L
Oceangoing yachtsman	V	ER	O	N	E	M
Offshore sport fisherman	V	ER	O	N	E	M
Livery / Rental	L	B	C/I	N	L	S
Organizers of marine activities	H	B	C/I	N	E	S
WORKING VESSEL OPERATORS						
Tug operators (harbor)	P	ER	H	R	E	S
Rescue service vessel operators	P	ER	C	R	E	S
Construction & dredge operators incl CoE	P	ER	H/I	N	V	S
Commercial fishermen	V	B	H/I	R	E	M
USCG Buoy Tender /Icebreaker Capt.	P	EC	C	A	V	S
TRANSPORT VESSEL OPERATORS						
Pilots	P	ER/EC	H	R	E	S
Ocean going tug operators	P	ER	C	R	V	S
Barges / lightering operators	P	ER	C	R	E	M
Ocean going (tankers, liners auto carriers, bulk carriers)	P	EC	O	A	L	S
PASSENGER VESSEL OPERATORS						
Ferry, commuter boat, water taxi masters	P	ER	H	A	E	S
Coastal liner, tour boat, charter boat master	P	ER	C	R	V	S
Ocean liner masters and bridge crew	P	EC	O	A	L	S
OTHER						
Military/ CG Patrol Vessels	H	EC	O	A	V	S
Research, education survey	V	ER	O	R	V	S
Law enforcement, environmental , harbor master, CG Small Boats	L	ER	H	A	E	S

TABLE 4 LEGEND

Training qualification	L=Limited	V=Variable	H=High	P=Professional/licensed
Nav. Aids	B=Basic	V=Variable	ER=Elex Rec boat	EC=Elex Commercial
Water	H=Harbor	C=Coastal	O=Offshore	I=Inland
Weather	N=Normal	R=Rough		A=Any
Local Knowledge	V=Variable	E= Extensive		L=Little
Population	L=Large (1M+)	M=Medium (10K-1M)		S=Small (less than 10K)

TABLE 5: WATERWAY OPERATOR / SHORT-RANGE and ELECTRONIC AID MATRIX

OPERATOR CATEGORY / SUBCATEGORY	Buoys	Day Beacons	Lights	Ranges	RADAR Beacons	RADAR Reflectors	LORAN-C	GPS	DGPS
RECREATION BOATERS									
Coastal boaters	●	⊙	⊙	O	O	⊙	⊙	O	O
Oceangoing yachtsman	●	⊙	⊙	O	O	⊙	⊙	⊙	O
Offshore sport fisherman	●	⊙	⊙	O	O	O	●	O	O
Organizers of marine events	●	●	●	O	O	O	O	O	O
Livery and rental operators	●	⊙	⊙	O	O	O	O	O	O
WORKING VESSEL OPERATORS									
Tug operators - harbor	●	⊙	⊙	⊙	⊙	⊙	●	O	O
Rescue service vessel ops	●	⊙	●	O	O	●	●	O	O
Constr. vessel and dredge ops	●	⊙	⊙	●	⊙	●	●	●	O
Commercial fishing vessel masters	O	O	O	O	O	O	●	O	O
USCG Buoy Tenders/Ice Breakers	⊙	⊙	⊙	●	⊙	⊙	●	●	●
TRANSPORT VESSEL OPERATORS									
Pilots	●	●	⊙	●	O	⊙	O	O	O
Barge / Lightering Operations	●	●	O	●	●	⊙	O	O	O
Other Transport Masters	●	O	O	⊙	●	●	O	O	●
PASSENGER VESSEL MASTERS									
Ferry, commuter boat, water taxi ops	●	⊙	●	⊙	O	●	⊙	O	O
Coastal liner, tour boat masters	●	●	O	O	O	●	●	O	O
Ocean liner masters	●	O	O	⊙	●	●	O	O	●
OTHER VESSEL OPERATORS									
Military	●	⊙	⊙	⊙	⊙	⊙	●	●	O
Research / Survey	⊙	⊙	⊙	●	⊙	⊙	⊙	●	⊙
Harbormasters, Law Enforcement and Environmental Officials	●	●	●	O	O	⊙	●	●	O

This matrix outlines the degree to which the various groups of vessel operator rely upon the major categories of ATON, as indicated by expert opinion.

●	- Indicates that the operator REGULARLY uses the ATON
⊙	- Indicates that the operator is LIKELY to use the ATON
O	- Indicates that the operator is UNLIKELY to use the ATON

FIGURE 7: Dependence on Buoys

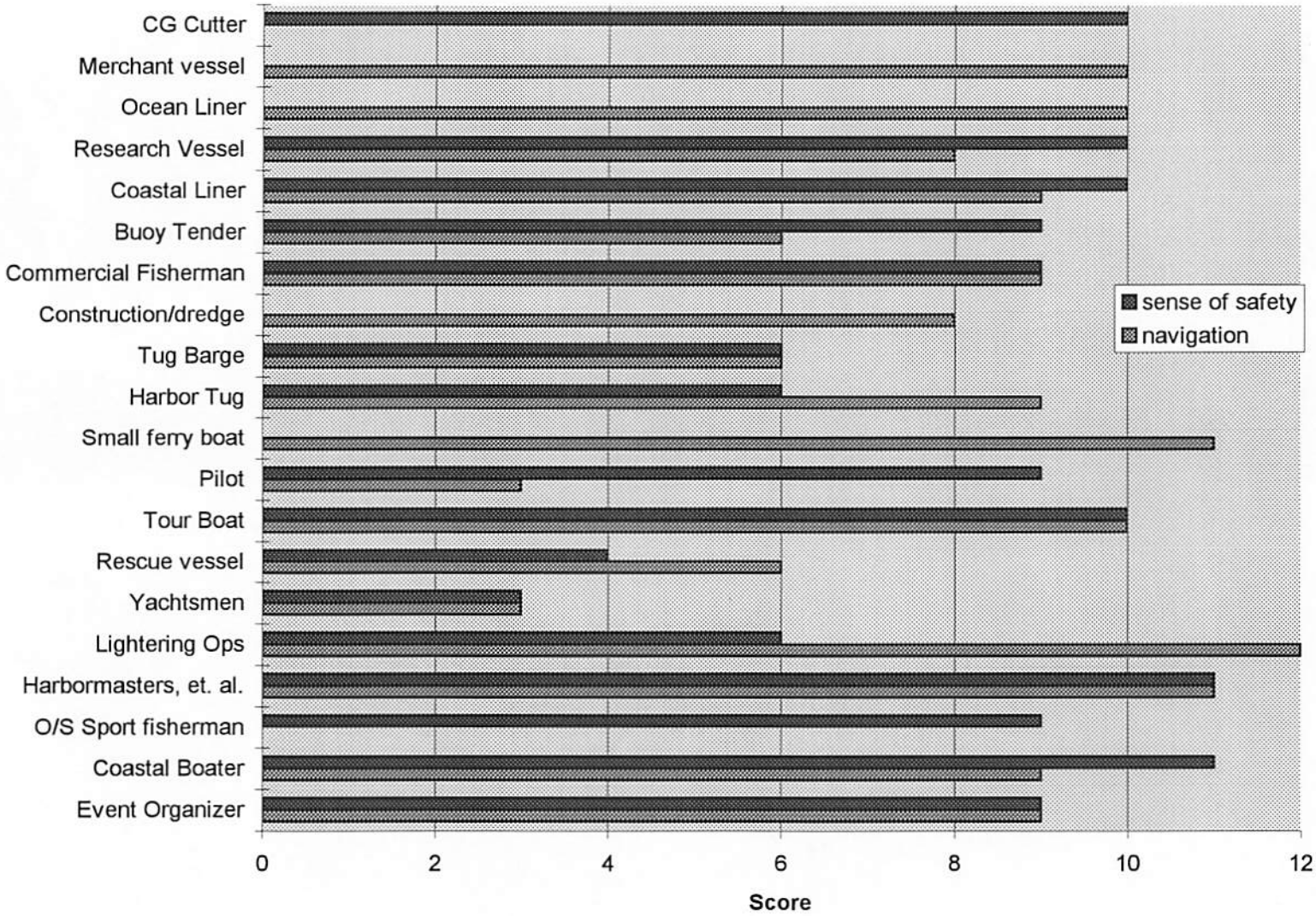


FIGURE 8: Dependence on Fixed Marks

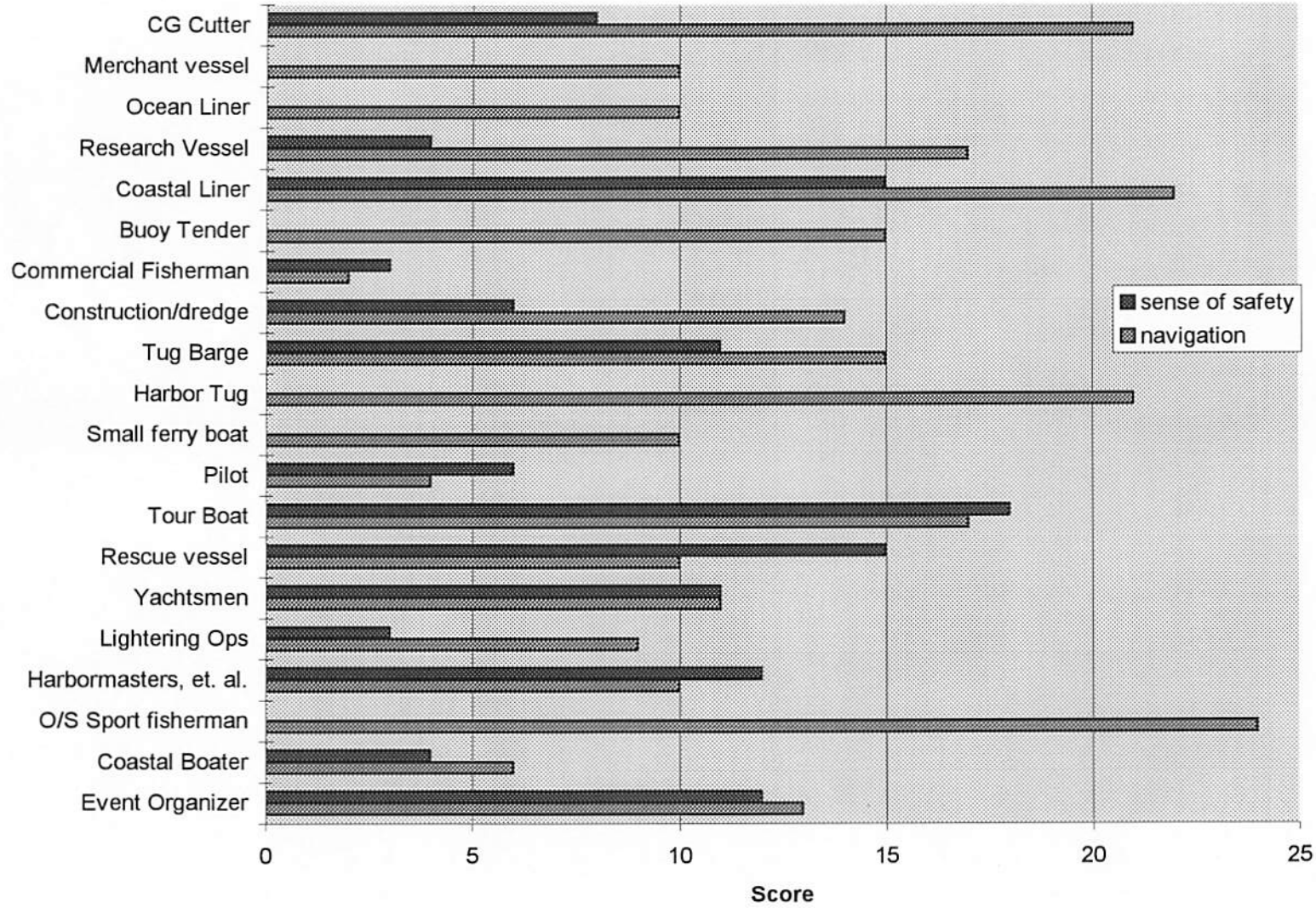


FIGURE 9: Dependence on GPS

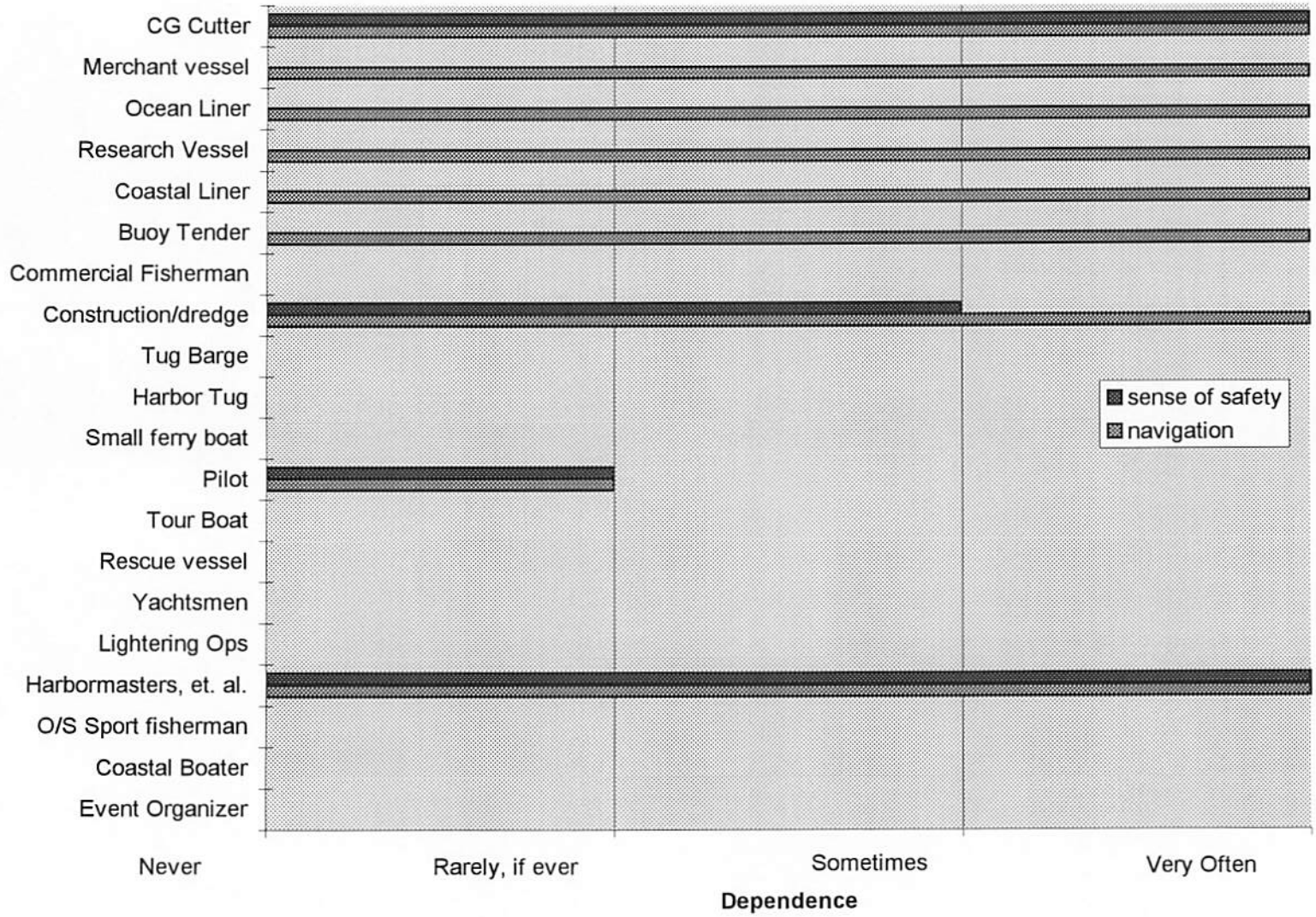


FIGURE 10: Dependence on LORAN

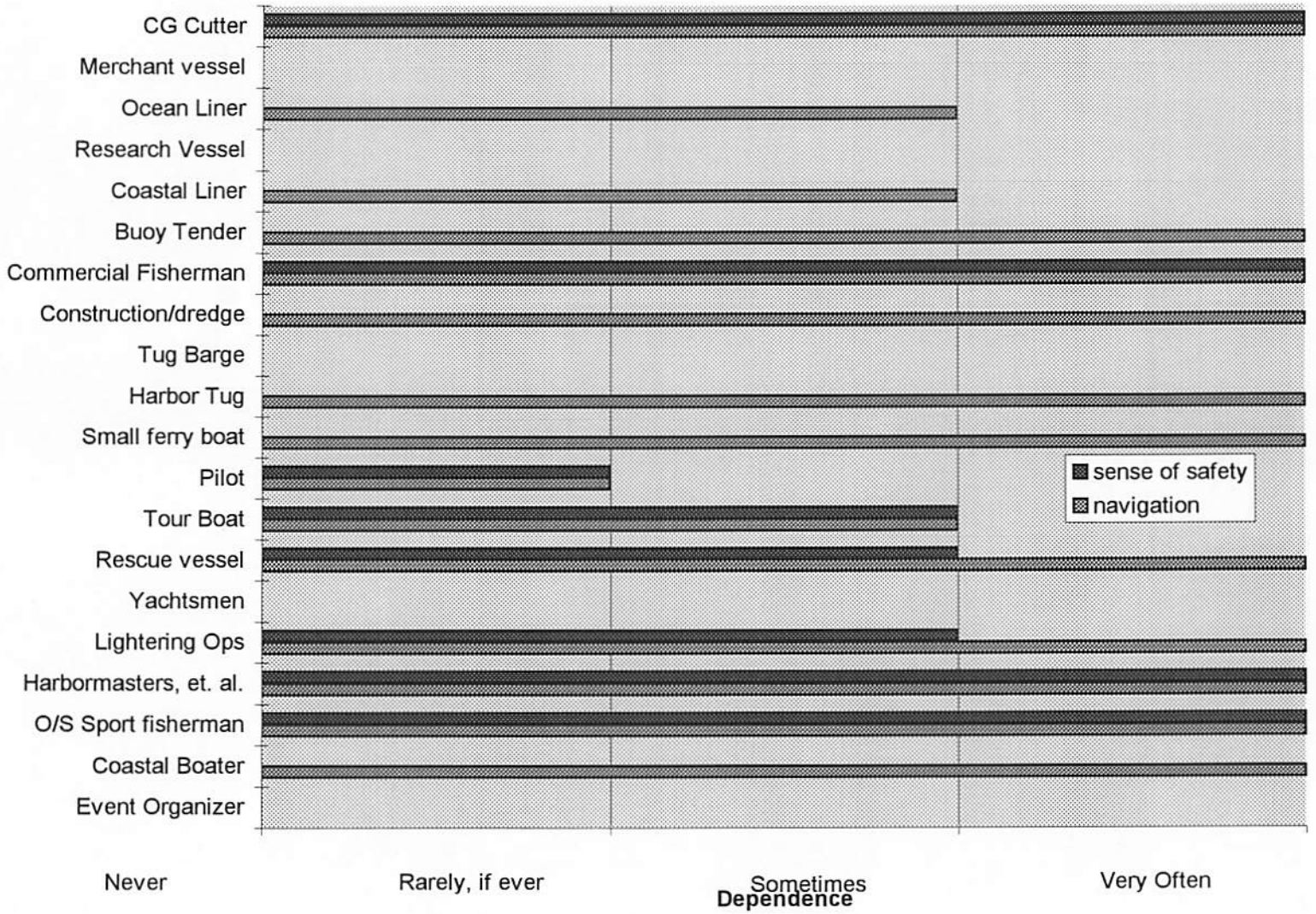
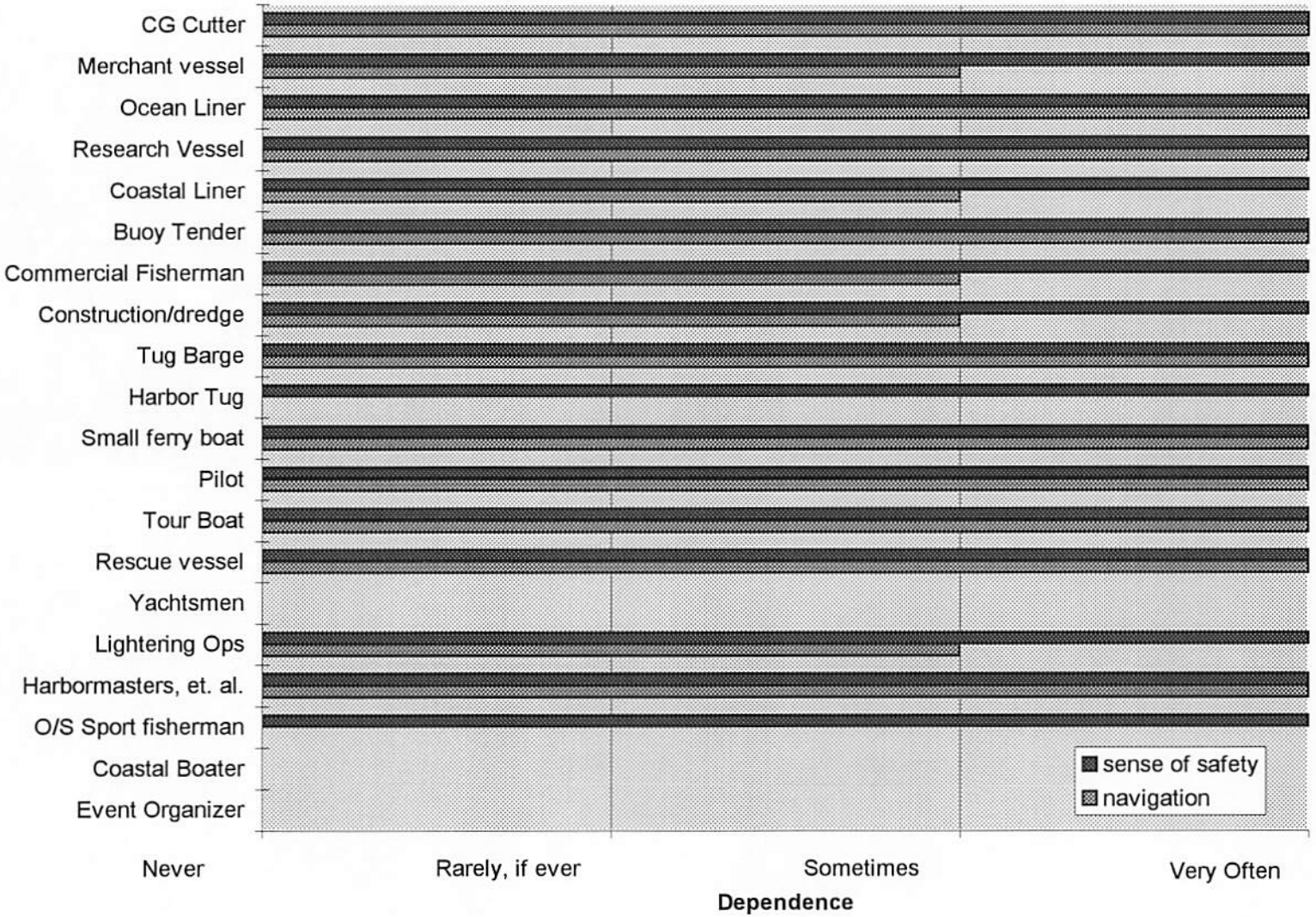


FIGURE 11: Dependence on RADAR



6. POTENTIAL APPLICATIONS

Potential application of the interview procedure would involve testing and validating our preliminary characterization of the waterway users and of specific hypothesis of how planned changes in ATON mix will be accepted by various types of mariners. This would be accomplished through interviews with navigational experts and with representative samples of the user groups as available in particular waterways. When the Coast Guard has a specific proposal to change of substitute aids to navigation in a particular waterway, this process could be used to help identify which groups of operators would be most vulnerable. The interview protocols appended to this report are intended for use with experts and with representatives of the various types of mariners. The data derived from the interview instruments will allow the Coast Guard to deepen its understanding of the actual ATON use and the perceived ATON requirements across the various categories.

In considering the various groups for more in-depth study, we have considered the following:

- Demographics (population size and, significantly, potential growth in the population)

- Relative consequences from grounding or collisions with fixed objects that might arise in conjunction with changes in ATON provided.

- Frequency and intensity of ATON use

- Real need for ATON information

- Perceived need for ATON information

It is clear that some groups will be especially critical to our consideration of changes in the ATON mix, and we recommend that data collection efforts be concentrated among them.

They include recreational boaters who may be very vocal opponents of any changes that appear to reduce ATON coverage and represent a huge and growing population. Their skill levels vary so widely that we must assume a low level of ATON familiarity. This group accounts for the majority of marine accident fatalities.

Another group is smaller coastal passenger boat operators. They are a very fast-growing segment of the commercial maritime trade. The small passenger vessels represent the potential for human casualties because passengers must frequently be off-loaded when groundings occur. Further, they frequently operate at high speeds in congested conditions increasing the risk of collision.

The tug-barge trade includes a substantial portion of the nation's carriage of hazardous and toxic materials. Any grounding here has the potential for significant environmental consequences. Further, tows are often cumbersome, difficult to maneuver, work narrow and congested channels, and they represent a significant and growing proportion of America's waterborne commerce.

We do not suggest closely considering deep draft vessel masters as a group in general because their dependence on ATON is counterbalanced by the fact that when they enter C G-controlled waterways they must carry a pilot with extensive and detailed local knowledge. Also, they are under legal mandates to be equipped with navigation systems and crew trained to operate them. Finally, the deep draft vessels have already been the subject of many other similar studies. However, in cases where the changes in ATON effect masters of deep draft vessels who must navigate narrow channels in congested waters, relying on qualified crew rather than pilots, it may be critical to include the masters in the interview process.

Except for the very large recreational boating population, we anticipate that information required for the study would be gathered using structured interviews and focus group techniques. Final data gathering for the largest groups may require formal surveys, including written questionnaires.

The data gathered through questionnaires can then be used to test the hypotheses that:

- those specific categories of mariners who will be the most dependent on the current system of physical ATON, will include operators of vessels with limited maneuverability, operators unfamiliar with the area, operators who must operate in reduced visibility, and operators who cannot make proper use of electronics,

- other categories of mariners, e.g., recreational boaters, will show higher resistance to ATON changes because of a **perceived** reduction in safety and convenience particularly in establishing position and course, and

- where the level of navigational expertise (and confidence) increases among the operator groups, we should find greater acceptance of ATON changes, such as the substitution of a relatively small number of fixed markers in place of more extensive buoy systems.

APPENDIX

Interview Instruments

The interview protocols developed for this project are attached. These forms, or an earlier version, were used for all face-to-face interviews conducted with the operators. An abbreviated questionnaire was used for telephone interviews. Instruments C and D, which seek to tease out the various purposes for which a mariner may be using each specific aid or navigation tool, was difficult for many operators to answer without further elucidation by the interviewer. By and large, the interviewees were interested and cooperative even though the average interview took 35 to 40 minutes to complete.

Interview Instruments:

Interview Instrument A. (Short-Range ATON: Frequency)

Interview Instrument B. (Navigational tools: Frequency)

Interview Instrument C. (ATON and Tools: Purposes)

Interview Instrument D. (Navigation Tools: Purpose

Interview Instrument E. (Background and Communications)

Interview Instrument F. (Environmental Factors)

Interview Instrument G. (Opinions on ATON Changes)

APPENDIX C: INTERVIEW INSTRUMENTS

INTERVIEW INSTRUMENT A. (Short-Range ATON:Frequency)

We would like to ask you how frequently you use the following types of "Short Range" ATON (aids to navigation) in your boating, how important are they to your day-to-day navigation, and how critical are they to your sense of safety. Please use the following scales:

Frequency of use:
1= very often (on almost every trip), 2 = sometimes, 3= rarely if ever
Importance in day-to-day navigation:
1= critical 2= somewhat important 3= not at all important
Sense of Safety and security:
1= critical 2= somewhat important 3= not at all important

Type of ATON	Frequency of Use	Day to Day Nav	Sense of Safety
Buoys			
Lighted Buoys			
Sound Buoys			
Large Navigation Buoys			
Beacons			
Day Beacons			
Minor Light			
Major Light			
Ranges			
RADAR Beacons			
RADAR Reflectors			
Sound Signals			
Radio beacons			
Other (specify)			

INTERVIEW INSTRUMENT B. (Navigational tools: Frequency)

We would like to ask you how frequently do you use the following types of navigational tools in your boating how important are they to your day-to-day navigation, and how critical are they to your sense of safety. Please use the following scales:

Frequency of Use:
1= very often (on almost every trip), 2 = sometimes, 3= rarely if ever, 4=don't have
Importance in day-to-day navigation:
1= critical 2= somewhat important 3= not at all important, 4=don't have
Sense of Safety and security:
1= critical 2= somewhat important 3= not at all important, 4=don't have

Navigational Tool	Frequency of use	Day to day Nav	Sense of safety
Compass			
Nautical charts of transit area (small scale)			
Large Scale Charts			
Light Lists			
Coast Pilots, Port, and other guides and books			
USCG Local Notices to Mariners			
Binoculars			
Sextant			
Marine RADAR			
Global Positioning System (GPS) receiver			
Differential Global Positioning System (DGPS)			
LORAN- C			
Auto-pilot			
Depth-finder or Fathometer			
Consumer-type Electronic Chart System			
Chart Digitizer			
Night vision system			

INTERVIEW INSTRUMENT C. (ATON: Purposes)
We would also like to ask you about the purposes for which you use various ATON and other navigational tools. For each ATON which you answered 1 under "Frequency of Use on Instrument A, please indicate how frequently you use it to determine each of the following: Course/Heading, Absolute Position or Position relative to a channel or physical feature, Vessel speed, Hazard and/or Collision avoidance:

1= very often (on almost every trip),
2 = sometimes,
3= rarely if ever,
4=don't use

Type of ATON	Course/ Heading	Abs./Rel Position	Speed/ ETA	Warning of Hazard	Collis Avoid.
Buoys					
Lighted Buoys					
Sound Buoys					
Large Navigation Buoys					
Beacons					
Day Beacons					
Minor Light					
Major Light					
Ranges					
RADAR Beacons					
RADAR Reflectors					
Sound Signals					
Radio beacons					
Other (specify)					

INTERVIEW INSTRUMENT D. (Navigation Tools: Purposes)

For each Navigational Tool which you answered 1 under "Frequency of Use on Instrument A, please indicate how frequently you use it to determine each of the following: Course/Heading, Absolute Position or Position relative to a channel or physical feature, Vessel speed, Hazard and/or Collision avoidance:

1= very often (on almost every trip),
2 = sometimes,
3= rarely, if ever,
4=don't use

Navigational Tool	Course/ Heading	Abs./Rel. Position	Speed /ETA	Warning of Hazard	Collis avoid.
Compass					
Nautical charts of transit area					
Large Scale Charts					
Light Lists					
Coast Pilots, Port, and other guides and books					
USCG Local Notices to Mariners					
Binoculars					
Sextant					
Marine RADAR					
GPS Receiver					
DGPS receiver					
LORAN- C					
Auto-pilot					
Depth-finder or Fathometer					
Consumer-type Electronic Chart System					
Chart digitizer					
Night vision system					

Interview Instrument E. (Background and Communications)

Navigational training/education:
How did you learn to use the following types of navigational tools.
1= primary learning method, 2= secondary, 3=Not used

	Charts/ Books	Non-electronic tools	Electronic tools
Formal training			
Informal training			
Manuals			
Observing others			
Experience			

Communications systems:
How Frequently do you use the following communications systems:
1= very often (on almost every trip), 2 = sometimes,
3= rarely if ever, 4=don't have

VHF FM marine band radio	
HF AM marine band radio	
CB radio	
SSB radio	
Cellular telephone	
INMARSAT telephone	
Sound devices (e.g. horns)	
Other systems (specify)	

Interview Instrument F (Environmental Factors)

We would like to ask you some questions about the waterway areas and conditions in which you navigate. Please use the following scale:

1= frequently, 2= sometimes, 3= never,
4= I am required to navigate in any weather in any type of water

Type of Water	
Lakes and Rivers	
Bays, inlets and protected Water	
Nearshore (to 7 miles)	
Coastal (7-25 miles)	
Offshore (25 miles+)	
Weather conditions	
Calm weather < 10kts	
Moderate conditions 15-25kts	
Extreme weather (high winds)	
Fog	
Night	

We would like to get some information about the type of vessel(s) you operate. Indicate which apply

Vessel Dimension	Primary vessel	Secondary vessel	
LENGTH			
BEAM			
DRAFT			
Type of power			
Manually powered			
Sail/Sail W Auxiliary Engine			
Diesel, Gas, Steam			

Interview Instrument G. (Opinions on ATON Changes)

Finally we would like to ask your opinion. If the Coast Guard had to decrease its emphasis on some classes of ATONs, in order to increase its emphasis on others which would you recommend it increase emphasis on, decrease emphasis on, or keep the same.

Type	Increase Emphasis	Decrease emphasis	Keep the same
Buoys			
Lighted Buoys			
Sound Buoys			
Large Navigation Buoys			
Beacons			
Day Beacons			
Minor Light			
Major Light			
Ranges			
RADAR Beacons			
RADAR Reflectors			
Sound Signals			
Radio beacons			
LORAN			
GPS			
VTS			
OMEGA			
SATNAV			
Other			