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*REPORT TO THE SUBCOMMITTEE
ON COAST GUARD AND NAVIGATION
COMMITTEE ON
MERCHANT MARINE AND FISHERIES
UNITED STATES
HOUSE OF REPRESENTATIVES*

74-052



LM095943

Summary Of GAO Study Of
Radionavigation Systems:
Meeting Maritime Needs

B - 180715

Department of Transportation

*BY THE COMPTROLLER GENERAL
OF THE UNITED STATES*

~~701900~~

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MARCH 26 1974



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-180715

The Honorable John M. Murphy, Chairman
Subcommittee on Coast Guard and Navigation
Committee on Merchant Marine and Fisheries
House of Representatives

H. 02700

Dear Mr. Chairman:

In response to your letter of February 22, 1974, here is a summary of information gathered during our study of radionavigation systems for general-purpose users with particular emphasis on the Coast Guard's plan to serve the navigation needs of the maritime community. A copy of this letter is also being forwarded to the Chairman, Transportation Subcommittee, House Appropriations Committee.

Our study of radionavigation systems was undertaken because of the seeming proliferation of navigation systems, some appearing to be overlapping or duplicative of each other. In our study we contacted officials of various Government departments and agencies in Washington, D.C., as well as spokesmen of user groups and industry representatives.

We obtained information on operational long-range systems which include Loran A, Loran C, Omega, and TRANSIT. (See app. I.) We also looked into systems proposed for maritime use in the coastal confluence region and harbors and estuaries of the United States.

The Coast Guard is requesting funds for fiscal year 1975 to begin expansion of Loran C coverage. They have estimated the capital cost for the total expansion to be about \$55 million. In addition, modernizing existing stations will cost another \$10 million.

Our study centered upon an apparent Coast Guard course leading to distinct marine radionavigation systems for (1) the high seas, (2) the coastal confluence, and (3) harbors and estuaries. However, recently the Coast Guard decided in favor of two systems. No one existing system would satisfy all three areas. The Coast Guard believes that:

--Omega is the most cost-effective solution to the medium accuracy and worldwide coverage requirements for all users on the high seas.

--Loran C can best satisfy the precision navigation requirements resulting from heavy traffic in the coastal confluence and harbors and estuaries, thereby, eliminating the requirement for Loran A.

We found no basis to question the two systems selected by the Coast Guard. We are providing information on these systems and observations on

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actions the Department of Transportation and the Coast Guard could take to (1) provide much needed authoritative information to manufacturers and users on the future operation of navigation systems and (2) improve coordination of the overlapping requirements and systems of the several Government agencies involved in the navigation field.

ALTERNATIVES

High seas

The Coast Guard has concluded that space satellite systems, such as the Navy's TRANSIT, are not yet economical or readily available for civil users of long range navigation systems. Omega, which is being implemented with six other countries, will provide worldwide coverage with only eight transmitting stations. Originally developed to meet military requirements, Omega is considered to be the most cost-effective solution for the high seas.

Coastal confluence

Loran A was one of the alternatives considered by the Coast Guard for the coastal confluence. Most maritime users of Loran A tend to support its continued operation and desire expanded coverage because of their investment in equipment and their familiarity with the system. (See app. II.) Users seem to be generally satisfied with Loran A and object to the expense of changing to Loran C. However, Loran A does not provide the accuracy needed in the coastal confluence and the Coast Guard is doubtful it could be made accurate enough for this use without even considering the still greater accuracies needed for harbors and estuaries. Loran C might be more acceptable to the user community if they had more information as to the relative benefits and costs of the two systems.

Coast Guard cost analysis indicates that for the first 10 years the Government would have some increased expense to shift from Loran A to Loran C; thereafter, Loran C operation would cost less. Implementing Loran C will eliminate the financial and operational burden of a separate harbors and estuaries system. In addition, the Coast Guard stated that studies have shown that accident risks in several geographical areas require navigation accuracy and coverage which Loran A and other available systems are not capable of providing.

Although Loran C receivers now cost more than Loran A receivers, industry sources have indicated that selection of Loran C as the maritime system for the U.S. and adjoining waters should stimulate sales volume and encourage the production and use of newer and lower cost receivers

The Coast Guard sponsored a study of other alternatives, including differential Omega which uses monitor stations to broadcast local corrections to enhance the accuracy of Omega. Considering accuracy, coverage, and cost,

the study concluded that Loran C was the best alternative. Since Loran C would satisfy harbors and estuaries requirements and differential Omega would not, that conclusion appears valid. On the basis of the limited test data available, it is doubtful that differential Omega would meet the established accuracy requirements for the coastal confluence at night and would have little potential for use in harbors and estuaries.

Harbors and estuaries

The Coast Guard has sponsored developmental tests and evaluations of three candidate systems to satisfy navigation requirements within our harbors and estuaries. On the basis of test results, the Coast Guard recently decided to adopt Loran C for both the coastal confluence and harbors and estuaries. The Coast Guard is terminating the Rivers and Harbors Navigation System development program at the completion of the current contracts, and it is conducting a study to determine how Loran C can best be configured to meet even higher accuracy needs for specific harbors and estuaries.

GAO observations

Various new systems are being developed and proposed for satisfying civil maritime navigation requirements. GAO has not evaluated these systems, however, the time needed by the Coast Guard to develop, test, and evaluate all possibilities could delay implementing Loran C and phasing out Loran A.

Loran C offers several benefits in addition to maritime navigation. For example, it provides very precise time and time interval signals, which are highly useful for space flights and communications. The National Weather Service wants to use the expanded Loran C for tracking its upper-air weather balloons. Loran C is essential for certain national defense purposes.

There are other potential uses of Loran C for which total U.S. coverage would be needed such as land vehicle locator systems. If Loran C stations were optimally configured for national coverage, four additional stations would be needed. These would cost about \$12.5 million more than the current expansion program. The planned expansion of the west coast stations (fiscal year 1975 request) would not be affected if it were decided that national coverage was needed. However, this decision would likely affect the selection of stations for the gulf coast and Great Lakes.

Since Loran C will provide coverage in harbors and estuaries as well as for a considerable distance at sea, the majority of marine operators will need to invest in user equipment for only one radionavigation system. (Potential user populations are discussed in app. III.)

Although the Coast Guard intends to use Loran C in the harbors and estuaries, there is currently no cost or configuration data available on

the system augmentation which may be needed to insure the necessary higher accuracies for some of these areas. The Coast Guard does not expect these costs to be significant; thus, the elimination of a separate harbors and estuaries system should reduce costs for both the Government and users.

A further consideration is the possibility of establishing a common Loran C system for North America. Coast Guard officials have indicated that Canadian and Mexican participation in the Loran C program might provide economic benefit as well as enhance Loran C coverage. The Coast Guard has taken the position, however, that until Loran C expansion is funded, it cannot enter into meaningful negotiations with Canada or Mexico. Canada has expressed interest in pursuing this matter. To obtain the economic and coverage benefits, the optimum Loran C configuration should be agreed upon before stations are constructed.

LORAN A PHASEOUT

The Department of Defense (DOD) is phasing out Loran A in favor of Omega. The Federal Aviation Administration (FAA) is evaluating Loran C and Omega to replace Loran A for civil aviation use and the Coast Guard is proposing to replace Loran A with Loran C for civil maritime use. It seems reasonable and equitable to phase out Loran A over some appropriate time period to allow users to amortize their investment in receivers and become familiar with the new system.

The Coast Guard has an internal plan to announce the closing date for Loran A operations, by area, in the coastal confluence as Loran C funds are approved. The plan is to allow 5 years from the time the announcement is made. Assuming normal time for budget action and construction, this will provide at least 2 years of dual Loran A and Loran C operation in each area to be converted. For instance, if fiscal year 1975 funds were appropriated to implement Loran C on the west coast, the Coast Guard would announce that the closing date for west coast Loran A operations would be in July 1979.

Although certain Loran A stations outside U.S. waters are scheduled to be phased out by the end of 1975, the Coast Guard does not have a phaseout plan for some Loran A stations outside the coastal and harbor regions of the United States. An official indicated that phaseout of these stations would be determined by FAA and International Civil Aviation Organization requirements. He stated that the foreign operated stations would be turned over to the host countries or shut down.

GAO observations

If the Coast Guard Loran C plan is approved, immediate announcement of the Loran A phaseout is needed to enable industry to produce lower cost Loran C equipment for sale. The announcement should include the phaseout timetable for the entire system rather than an area at a time. This would

provide users more notice for planning their equipment amortization and changeover.

The 2 years of dual operations appear reasonable, particularly since the fishing industry needs a period of dual operations to translate its Loran A position numbers into Loran C numbers.

To prevent the prolonged operation of Loran A stations outside the United States, we believe that the Department of Transportation should continue action to turn over additional stations to host countries and announce a phaseout plan for the remaining stations.

EFFORTS TO DEVELOP A NATIONAL NAVIGATION PROGRAM

Knowledgeable Government and industry observers are concerned about the proliferation of radionavigation systems whose mounting costs must be borne by Government and users alike. This growth of systems appears to have two principal causes. First, as new and improved navigation systems come into being, old systems cannot be shut down without economic loss to a substantial population of users. Second, Government planners of navigation systems have been unable to reconcile the differences in requirements between and within both civil and military aviation and maritime communities. A third community of potential users, land vehicle operators, may further compound this problem.

In February 1972 the Director of the Office of Telecommunications Policy (OTP) wrote to the Secretaries of Defense and Transportation proposing the selection of the Omega system as the approved U.S. general purpose navigation system

"* * * in keeping with U.S. policy to 'standardize on the minimum number of long distance radio navigation aids and in the interest of frequency conservation, overall economies, and avoidance of unnecessary duplication.'"

Both Secretaries responded that a selection of Omega at that time would have been premature since its implementation was incomplete, as was the verification of its capabilities. Currently there appears to be DOD and Department of Transportation consensus that Omega is the most cost effective system for long-range, high seas navigation.

OTP has initiated steps to develop a national navigation program to eliminate and preclude the apparent duplication of navigation systems. OTP is undertaking a contractual study of navigation systems to identify key issues and develop appropriate policies. OTP issued Circular 12 in October 1973 which prescribed policies and procedures designed to improve coordination among Federal agencies in their planning for communication systems in

mission-related areas. Transportation, including navigation, is one such area.

OTP designated the Department of Transportation as lead agency of the interagency committee on navigation with DOD, Commerce, and NASA as participants. The navigation committee held its first meeting in August 1973. An official of OTP said he thought it would take at least 2 years before committee action results could be measured. Meanwhile DOD is attempting to coordinate its interservice navigation plans through the Defense Navigation Planning Group, sponsored by the Director of Defense Research and Engineering. 29

In a separate effort the Department of Transportation maintains its "National Plan for Navigation." Despite its title the plan is not concerned with defense navigation matters other than identifying those systems having civilian uses. In fact it covers chiefly Coast Guard sponsored marine navigation matters and considers only long-range (transoceanic) aviation requirements. The plan does not include maritime surveillance and navigation requirements and systems currently being pursued by the Maritime Administration nor the Department of Transportation's St. Lawrence Seaway Development Corporation. The plan does not deal with the growing experimentation in land vehicle navigation or locator systems being sponsored by such diverse agencies as Urban Mass Transit Authority, the Department of Justice, the Atomic Energy Commission, and the Federal Railroad Administration. Until operational requirements are established, the Department of Transportation does not feel that land navigation and surveillance should become part of the National Plan for Navigation.

GAO observations

Although DOD and the Department of Transportation exchange plans with one another, no integration of plans into a single national system framework has evolved. A Department of Transportation spokesman stated that efforts were being made through the new interagency navigation committee to integrate national planning but that it would take some time to produce notable progress. He also stated that national planning would not be fully effective until an official decision on Loran C is made. We believe that integrated planning could and should be made before establishing new systems and that the Department of Transportation, since it chairs the committee, should establish a national system framework.

While the Coast Guard's plan to use Loran C for both the coastal confluence and harbors and estuaries appears to be a move in the right direction, we believe more needs to be done in the area of interagency coordination and reconciliation of views to achieve the minimum number of navigation systems consistent with Government and civil requirements.

It appears that the time has arrived for the selection of long range general purpose systems to be designated as national systems and others as

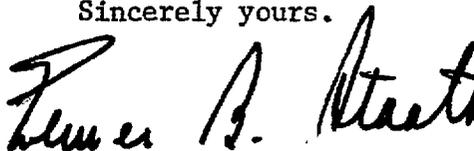
special purpose systems, which are subject to termination when superseded by other systems or when no longer needed. Systems such as the Navy's TRANSIT satellite system may be faced with the same difficulty of termination that the Government now faces with Loran A. The interagency navigation committee could be a suitable forum for the designation of national systems and special purpose systems and the Department of Transportation's National Plan for Navigation could be a convenient means of making the designations official policy.

The National Plan for Navigation should include the requirements and systems to be used by all Federal agencies for air, sea, and land areas. Certain DOD and other classified requirements could be issued in a separate volume to limit its distribution and use. We believe that the Department of Transportation should promptly become involved in the testing and experimenting being conducted by several agencies for land vehicle locator systems. Although Loran C is only one of several candidate techniques for this purpose, its potential and the need for its total coverage should be determined before the gulf coast and Great Lakes stations are selected.

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The appendixes are intended to provide more information on this subject. If necessary we would be pleased to discuss this information with you or your office.

Sincerely yours.



Comptroller General
of the United States

NAVIGATION SYSTEMS OPERATED
BY THE UNITED STATES AND
USED BY MARITIME INTERESTS

The current status of radionavigation systems relating to maritime requirements is:

LORAN A

--Loran A has been the primary radio aid to maritime navigation since World War II. It is used in the coastal confluence and on the high seas by both military and civil users. Loran A is used extensively in the civil air industry for transoceanic flights. Loran A's geographical coverage is limited to about 75 percent of the Northern Hemisphere and is provided by about 80 stations. The Coast Guard supports half these stations at an annual cost of about \$12 million, which includes indirect costs for support and overhead. The remaining stations are supported principally by other countries and international organizations, but some U.S. Navy support is provided through NATO.

DOD is phasing out its marine and air use of Loran A in favor of Omega. The Air Force and NATO want to retain Loran A through 1977. Civil aviation also wants to retain Loran A until the late 1970s. The Coast Guard plans to phase out Loran A because the equipment is becoming obsolete, coverage is duplicated by other systems, and it does not meet the accuracy required in the coastal confluence. The Coast Guard estimates that to continue the existing Loran A system in the coastal confluence for another 10 years will require a capital investment of over \$20 million.

LORAN C

--Loran C is operated by the Coast Guard for tactical military requirements. The 31 transmitter and 11 monitor stations provide navigation coverage of about 65 percent of the Northern Hemisphere but provide only partial coverage of the United States coastal confluence. DOD requires the existing

coverage through the mid 1980s but has not established a requirement for additional coverage of the coastal confluence. DOD sources state that if additional coverage became available it could be used. The Coast Guard's Loran C plans are to: (1) add 11 stations to meet stated civil maritime requirements in the coastal confluence and harbor and estuaries of the United States, including the Great Lakes, and (2) modernize the entire existing Loran C system to provide additional reliability and coverage and reduce personnel and operating costs. The annual cost of the existing Loran C system is over \$20 million, which includes indirect costs for support and overhead. The Coast Guard estimates that their planned expansion program will cost about \$55 million for construction and about \$3.7 million for direct annual operating costs.

OMEGA

--The Omega navigation system was developed in response to a DOD requirement and is being expanded by the United States and six other countries. The system will provide worldwide coverage with only eight transmitting stations. The Department of Transportation and DOD recognize it as the most cost effective system for the high seas. Two of the eight stations will be operated by the Coast Guard, and one of the six foreign operated stations will be funded by the United States. The system has been in limited operational status since 1966. Two of the permanent full-powered stations are on the air, and two more are scheduled to become operational by the summer of 1974 to provide total coverage in the Northern Hemisphere. The remaining stations are scheduled to begin operations in 1975 and 1976.

TRANSIT

--TRANSIT is a Navy Navigation Satellite System implemented in 1964 to provide precise navigation information to the Navy. Presently five satellites and four ground stations are supplying worldwide coverage at an annual cost of \$10 million. In 1967 TRANSIT details were released to permit commercial use. Because position fixes are not continuously available (approximately 90 minutes apart) and user equipment

APPENDIX I

is expensive, TRANSIT is not well suited for general use. DOD projects requirements for TRANSIT until it can be replaced by a more advanced military satellite system which is under development.

MARINE RADIO BEACONS

--The Coast Guard operates over 200 marine radio beacons along the U.S. coast. These beacons provide a low cost navigation aid to recreational boaters and other users, but they do not satisfy the coastal zone and harbor area accuracy requirements established by the Coast Guard for commercial maritime industries. The Coast Guard plans to improve and continue to operate the radio beacon system since the other systems described above would be generally cost prohibitive for small boats which do not require greater accuracies.

VESSEL TRAFFIC SYSTEM

--The Coast Guard is developing vessel traffic systems in San Francisco, Puget Sound, Houston, New Orleans, New York, and Valdez, Alaska. These systems are not pure navigation systems; rather, they are harbor surveillance and control systems. Initial costs for these six systems will be nearly \$20 million for acquisition and \$10 million for research and development. Annual operating costs for the six systems in fiscal year 1976 are estimated to be over \$4 million. The Coast Guard has identified vessel traffic system needs for 17 other U.S. ports.

CURRENT ATTITUDES TOWARD LORAN C

The majority of marine radionavigation aid users do not support the Coast Guard's proposed Loran C expansion program because of their limited experience with, or lack of information about, Loran C and anxiety over the phaseout of the widely used Loran A.

The opinions of users contacted indicate that there is a lack of knowledge within the user community regarding Loran C. The Coast Guard informed us that there is also considerable misinformation on Loran C among these users. Unless this "information gap" is bridged by the Coast Guard, there could be considerable resistance to changing to Loran C. The major issues of concern to the users are discussed below.

CHANGE

The feelings of many users seem to be based in part on a resistance to change from use of a familiar system to one with which they have little or no experience. This attitude may change once Loran C is operationally proven to them.

ACCURACY

Many users contend that Loran C will not improve the accuracy currently available with Loran A. This belief is based upon experience with Loran C receivers (sometimes called Loran A/C) which employ the same signal processing techniques which are used in Loran A and hence are no more accurate. The Coast Guard, however, is proposing the use of Loran C equipment which employs more complex signal processing techniques and has been conclusively proven to be much more accurate than Loran A.

AMORTIZATION

Since radionavigation equipment represents a sizeable capital investment to many users, they are very concerned that they will have to immediately replace their Loran A receivers. Industry representatives have informed us that the average life of radionavigation equipment is 5 to 10 years under operational conditions aboard most vessels.

The Coast Guard intends to implement a 5-year Loran A phaseout plan. This will give Loran A users 5 years to amortize currently owned equipment. This should provide a

2-year overlap of Loran A and Loran C operations, assuming a normal amount of time for budgeting and construction. This should smooth the transition from one system to another.

COST

There are different views on what constitutes a low cost Loran C receiver. Most users define low cost Loran C as envelope-matching equipment costing about \$1,500. The Coast Guard refers to low cost Loran C as a "phase lock, cycle match" receiver costing about \$3,000.

Industry representatives feel confident that, given a formal announcement of Loran A phaseout, industry will be able to produce Loran C cycle-matching receivers for a price comparable to current Loran A receivers. They indicate that this will be made possible by volume production and the use of new technology which will greatly reduce unit costs.

GROUP ATTITUDES

The attitudes of the various user groups contacted during our review are summarized below.

Fishermen

The majority of fishermen contacted, especially on the west coast (including Alaska and Hawaii), are opposed to phasing out Loran A. It is their opinion that Loran A meets their navigation requirements and that improved accuracy using cycle-matching Loran C receivers would be too expensive. Loran C cycle-matching receivers cost from \$3,000 to \$8,000 each. One fishing fleet operator in Florida stated that to replace Loran A on his fleet of 100 boats would cost almost \$500,000.

Commercial shippers

Commercial shippers contacted, both coastal and international, generally oppose the shift to Loran C. A few would accept Loran C because they have Loran A/C receivers. International shippers who do not have Loran A/C receivers prefer Omega for enroute navigation due to its worldwide coverage.

International shippers generally already carry Decca (an English short range navigation system) receivers because Decca is widely used in other countries. Those shippers object to the added financial burden of Loran C in addition to Omega and Decca.

Recreational boats

The sales of Loran A receivers to pleasure boat operators is increasing. A recent estimate places the size of this user population between 12,000 and 25,000. According to a Marine Radio Council spokesman, pleasure boat operators would raise considerable objection to terminating Loran A.

Aviation

FAA and airline officials informed us that they are testing Omega and Loran C for long-range navigation. An FAA spokesman was skeptical of using Loran C due to the possible loss of coverage in case of station failure. He favors using Omega because of its worldwide coverage and sufficient redundancy to provide coverage in case a station fails. There could eventually be a mix of both systems if flight tests are successful.

Scientific and ocean industries

Loran C has been useful in applications for the scientific community. These users, who can afford extremely accurate and expensive equipment, find it valuable in surveying and other precision-position applications. This group represents a small portion of the radionavigation aid user population.

Military

The U.S. Navy has a specific requirement for the currently operating Loran C configuration until the 1980's. They have no requirement for expanding Loran C. The majority of Navy vessels will use Omega as soon as it is available.

The Air Force, although purchasing modified Loran C equipment for short-range tactical applications, has no other requirement for Loran C. The Military Airlift Command, Strategic Air Command, Tactical Air Command, and Air National Guard plan to use Omega for their long-range navigation.

APPENDIX II

The Army, although experimenting with Loran C for short-range tactical use, has no established requirement for expanding Loran C.

Although DOD does not require expanded Loran C coverage of the United States, it states that the coverage could be used by the services.

VESSEL POPULATION AND 1973 REPLACEMENT COSTS

When considering radionavigation systems, thought must be given to the boating public to be served. This appendix gives the latest figures available from Coast Guard records. Foreign flag vessels are not included. It should be noted that of about 8 million vessels of U.S. registry, some 94.9 percent of the total are in Class I or smaller (i.e. less than 26 feet long). With some exceptions, only the remaining 5.1 percent or about 409,000 craft would be potential users of radionavigation systems. It may be of interest to note that a Coast Guard survey found that about 41 percent of Class II boats (26 feet to less than 40 feet) carry radio direction finders whose average cost is about \$150.00.

Only the larger vessels, that is those measuring 26 feet and longer, Class II and Class III motorboats and documented (5 tons and over) commercial vessels, would be likely to carry or use Loran navigation equipment. It is likely that pleasure boat cruising patterns, more than the cost of Loran equipment, would influence larger vessels' use of Loran.

While such vessels represent only 5.1 percent of the 8 million vessels bearing State or Coast Guard registry in 1973, it should be noted that in the pleasure craft population alone this 5.1 percent represents some \$15 billion, or 38 percent of the estimated 1973 replacement cost of all pleasure craft.

Table 1U.S. Vessel Population

	<u>Number</u>
Total commercial (5 tons or more) as of 1-1-73 (19,350 fishing craft included)	54,436
Pleasure Craft (end of 1973):	
Class A (less than 16 feet)	5,262,391
Class I (16 feet to 26 feet)	2,336,904
Class II (26 feet to 40 feet)	^a 285,317
Class III (40 feet to 65 feet)	<u>^b68,952</u>
Total	<u>8,008,000</u>
Percentage of total by types:	
Commercial	.70%
Class II or larger	4.40%
Class I or smaller	<u>94.90%</u>
Total	<u>100.00%</u>

^aIncludes 25,485 documented yachts as of 1-1-73.

^bIncludes 6,371 documented yachts as of 1-1-73.

Table 2Pleasure Craft 1973 Costs or Replacement Costs

	<u>Range</u>	Estimated 1973 average replacement <u>costs</u>
Class A	\$1,000 to \$8,000	\$2,000
Class I	\$6,000 to \$15,000	\$6,000
Class II	\$12,000 to \$80,000	\$32,000
Class III	\$65,000 to \$250,000	\$85,000

Public Investment at 1973 Replacement Costs

Class A	\$10.5 billion
Class I	14.0 billion
Class II	9.1 billion
Class III	<u>5.9 billion</u>
Total	<u>\$39.5 billion</u>

Notes:

1. Population. The figures used are based on State or Coast Guard registrations as reported by the Coast Guard. The Coast Guard rules covered boats which used engines of 10 horsepower or more. Some States required registry for boats using engines of 5 or 7.5 horsepower. New rules, effective in 1974, require boats carrying any kind of power to be registered, but the population figures used in table 1 probably reflect the older rules.
2. Documentation. Vessels of 5 tons or over may be documented with the Coast Guard. All commercial vessels, 5 tons and over, must be documented. For practical purposes pleasure craft must measure about 28 feet in length and about 10 feet in beam (or larger) to be documented.

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