0203.02.002

February 16, 2007

Mr. John Mueller
Office of Transportation and Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105

Dear John:

Enclosed for your review is the Revised Category 1/2 Report. Please give me a call at (919) 468-7812 with any questions or comments you may have about this report.

Richard Billings
Project Manager

RSB/jt

Enclosures

cc: Penny Carey, EPA/OTAQ
Leigh Roller, ERG/ Chantilly
Sam Wells, Consultant
Roger Chang, ERG/Morrisville
WA 2-02 File/Category 2 Vessel Census Activity Report-Final.doc

CATEGORY 2 VESSEL CENSUS, ACTIVITY, AND SPATIAL ALLOCATION ASSESSMENT AND CATEGORY 1 AND CATEGORY 2 IN-PORT/AT-SEA SPLITS

Prepared for:

John Mueller and Penny Carey
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
Ann Arbor, MI 48105

Prepared by:

Eastern Research Group, Inc.
1600 Perimeter Park Drive
Morrisville, NC 27560

February 16, 2007

Table of Contents

Section **Page**

Table of Contents (Continued)

Table of Contents (Continued)

List of Tables and Figures

Tables **Page**

Figures		Page

1.0 OVERVIEW

U.S. Environmental Protection Agency (EPA) defines the three engine categories for commercial marine vessels' main propulsion engines and auxiliary engines as:

- Category 1: 1-5 liters per cylinder displacement
- Category 2: 5-30 liters per cylinder displacement
- Category 3: over 30 liters per cylinder displacement

Category 2 is a transitional engine category between Category 1 engines (used by most harbor and fishing vessels) and Category 3 engines (used by larger ocean going vessels). Previous studies have accounted for vessels with Category 1 and 3 engines nationwide, but vessels with Category 2 engines have not been studied as thoroughly.

The objectives of this study are to: 1) estimate total U.S. activity by vessel type for propulsion engines used on Category 2 vessels, 2) develop in-port/at-sea (underway) splits to apportion the total activity to port and underway operation, and 3) spatially allocate the port and underway activity to the county and Federal lease block level. The project overview is presented in Figure 1-1. While the focus of this study is on Category 2 vessels, in-port/at-sea splits at the national level were also developed for propulsion engines used on Category 1 vessels.

Category 2 vessel activity is defined as the total horsepower hours associated with each vessel type. Total horsepower hours primarily takes into consideration the vessel population, number of engines per vessel, days of operation, the vessel horsepower, and appropriate engine load factors. The basic equation used to estimate total horsepower hours for this study is noted below:

$$Thp\text{-}hr_{ij} = VP_i \times UR_i \times EN_i \times HP_{ij} \times DO_{ij} \times 24 \times LF_{ij}$$

Where:

$Thp\text{-}hr_{ij}$	=	Total horsepower hours for vessel type i in mode j
VP_i	=	Population of vessel type i
UR_i	=	Utilization rate for vessel fleet i
EN_i	=	Average number of engines on vessel type i
HP_{ij}	=	Horsepower of vessel type i
DO_{ij}	=	Days of operation for vessel type i in mode j
24	=	Hours per day
LF_{ij}	=	Load factor of vessel type i propulsion engines in mode j
i	=	Vessel type (i.e., deep water, tow, ferries commercial fishing, Great Lakes, Coast Guard, offshore support, and research)
J	=	Mode of operation (i.e, underway cruise, underway idle)

Section 2 of this report first summarizes the data sources analyzed in this study, the methods used, and population estimates developed for each vessel type. One of the first tasks is to identify databases and sources that will help identify the vessels with Category 2 marine diesel propulsion engines in the contiguous states as well as Alaska, and Hawaii. It was discovered early in the project that there is no single data base that tracks vessels that are equipped with these engines. In order to capture the Category 2 vessel population, multiple data sources needed to be reviewed, compiled, and analyzed.

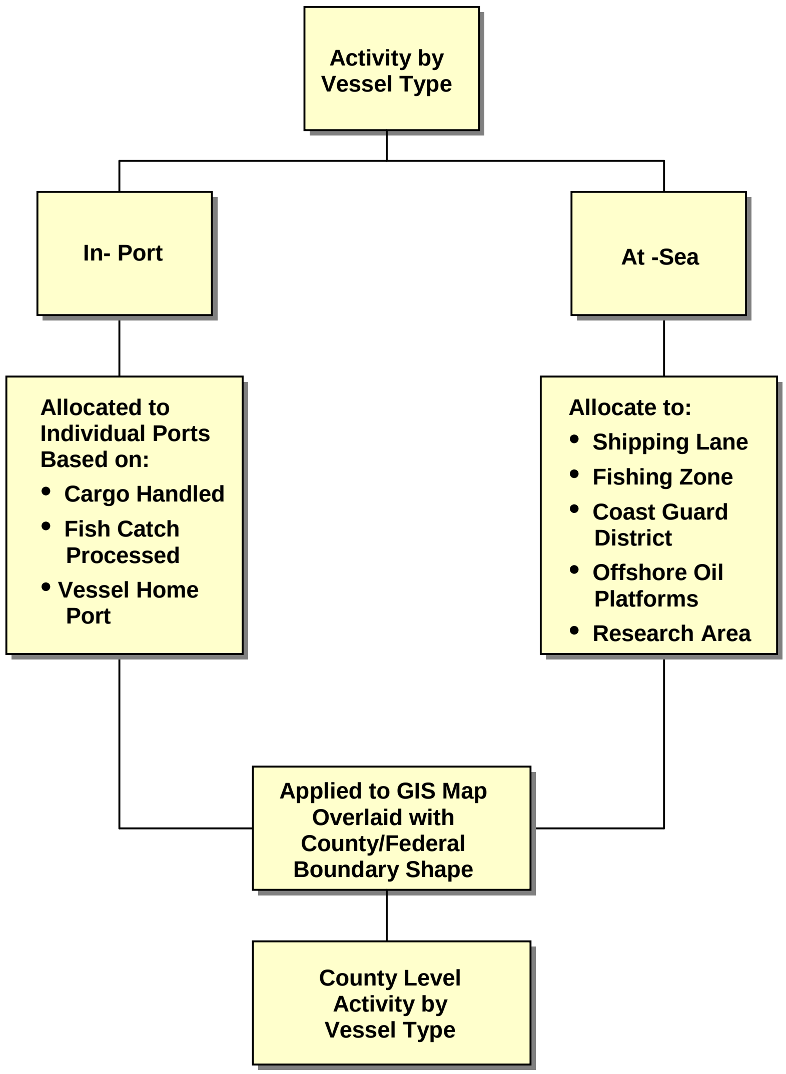


Figure 1-1. Project Overview

As the available data for the different vessel types can be significantly different, the project evaluated the available data for the following eight vessel types separately:

- Towboats;
- Offshore Support Vessels;
- Commercial Fishing Vessels;
- Coast Guard Vessels;
- Ferry Vessels;
- Deep Water Cargo Vessels;
- Research Vessels; and
- Great Lakes Vessels and Vessels Not Otherwise Included.

Most of these vessels are not ocean going vessels (except the deep water cargo vessels) as defined in the EPA's *Current Methodologies and Best Management Practices in Preparing Port Emission Inventories.* Most of these vessel types would be considered harbor craft as defined in the above report. Tow boats include push boats and tug boats that operate within and outside the port. Coast Guard vessels are a subset of government vessels. In this study, offshore vessels include both crew boats and work boats. Research vessels discussed in this Category 2 study are a subset of workboats.

Where ever possible, vessel specific data such as the make and model number of the propulsion engines were evaluated individually to accurately identify Category 2 vessels. Unfortunately, for most vessels such data proved to be difficult to identify. Instead information was pieced together by appropriately linking the different data sets that were compiled. For example, when vessel identification data were provided, these data were linked to the Lloyd's Registry of Ships (ROS), American Bureau of Ships (ABS), or Bureau Veritas vessel classification data files to get vessel characteristics data. These vessel characteristics were either used directly to calculate the cylinder volume or they could be linked up to a dataset of Category 2 propulsion engines that was developed for this project and is included in Appendix A of this report.

To implement this study, data from a variety of sources were used. Though every attempt was made to obtain the most recent data available, the compiled data represents different base years as noted in Table 1-1.

Table 1-1. Vessel Type Base Year

Vessel Type	Base Year of Population and Activity Data
Towboats	2002-2004
Offshore Support Vessels	2005
Commercial Fishing Vessels	2000-2004
Coast Guard	2004-2005
Ferry	2000-2004
Deep Water Cargo Vessels	2005
Research Vessels	2004
Great Lake Vessels and Others	2004

Where engine displacement data were not readily available, several different methods were used to estimate the engine category of a vessel. This included evaluating the relationship of a variety of variables such as engine horsepower, vessel gross ton weight (GTW), and vessel length so as to identify correlations that would help categorize the vessel's propulsion engine classification.

Identification of Category 2 fishing vessels was particularly challenging. The data sources for this fleet are difficult to evaluate due to limited information available to characterize fishing vessels and the fact that there are over 30,000 U.S. flagged fishing ships currently in operation.

For some of the vessel type categories, there were national databases of vessels, such as for deep water cargo vessels, ferries, research ships, offshore support vessels, and Coast Guard vessels, which made a good starting point to identify vessels that are potentially equipped with Category 2 propulsion engines.

Table 1-2 summarizes the Category 2 vessel population based on this compilation and analysis of available data. Towboats and Offshore vessels represent the most significant Category 2 vessel groups and as such considerable resources were applied to these components of the study to develop the most accurate vessel inventory possible with publicly available data.

Table 1-2. Category 2 Summary

Vessel Type	Category 2 Vessel Count	Percent of Total
Towboats	1,057	42.6
Offshore Support Vessels	603	24.3
Commercial Fishing Vessels	333	13.4
Coast Guard Vessels	157	6.3
Ferry Vessels	99	4.0
Deep water cargo vessels	89	3.6
Research Vessels	31	1.3
Great Lake Vessels and Vessels Not Otherwise Included	112	4.5
Total	2,481	100

Section 3 of this study then compiles the vessel census and characteristics data into a Monte Carlo simulation to estimate activity for each vessel type. As described above, activity in this report is defined as horsepower hours of operation for the Category 2 propulsion engines.

Results from this analysis are noted in Table 1-3. As Table 1-3 indicates, offshore vessels account for a large portion of Category 2 vessel activity.

These activity data were split for each vessel type into in-port and at sea components. For the purposes of this study, the port area includes the area within a 25 mile radius from the outer edge of the harbor where vessels dock at terminals and shift cargo. The splits developed for this study are discussed in Section 4 and presented in Table 1-4. The in-port time for some of these vessel types is relatively small, as the propulsion engines for these vessels are shut off while dockside.

Table 1-3. Category 2 Propulsion Horsepower Hours by Vessel Type

Vessel Type	Mean Values (million hp-hrs)	Standard Deviation (million hp-hrs)
Deep Water	2,666	698
Towboat	7,920	3,020
Ferry	1,464	443
Fishing	3,413	1,143
Great Lakes	1,393	405
Coast Guard	1,441	496
Offshore	27,810	11,933
Research	654	217

Section 4 also provides splits for propulsion engines used on Category 1 vessels.

Table 1-4. Average In-Port and At-Sea Fraction by Vessel Type for Vessels Equipped with 2 Propulsion Engines

Vessel Type	In-Port	At-Sea
Towboats	17%	83%
Fishing	5%	95%
Offshore	4%	96%
Ferries	65%	35%
Deepwater	1%	99%
Research	1%	99%
Great Lakes	1%	99%
Government	59%	41%
Weighted Average	**10%**	**90%**

Once activity data could be disaggregated into the in-port and at-sea components, then the activity data were further disaggregated into county and federal lease blocks. Section 5 discusses the techniques and surrogate data used to spatially allocate Category 2 activity by vessel type to individual counties and federal lease blocks.

The port activities were spatially allocated to individual ports based on an appropriate surrogate such as the amount of cargo handled (for tow boats, deepwater cargo vessels and Great Lakes vessels), fish catch processed (for commercial fishing boats) and the vessel's home port (for offshore, research and government vessels and ferries).

Underway activities were spatially allocated to shipping lanes (for tow boats, deepwater vessels, Great Lakes vessels), fishing zones (for commercial fishing), coast guard districts (for government vessels), offshore oil platforms (for offshore support vessels) and research areas (for research vessels).

The port and underway activities were mapped using Geographic Information Systems tools. County and Federal boundaries were mapped on top of the port and underway activities to allow for aggregation of activity estimates to the county level.

Figure 1-2 shows total Category 2 activity for in-port and at-sea operations. It should be noted that county waters in the Great Lakes represent significantly larger areas than coastal county blocks which only extend three to seven miles to the state/federal water boundary. This difference in the block size makes it difficult to visually compare activity levels in the Great Lakes with activity levels in coastal areas.

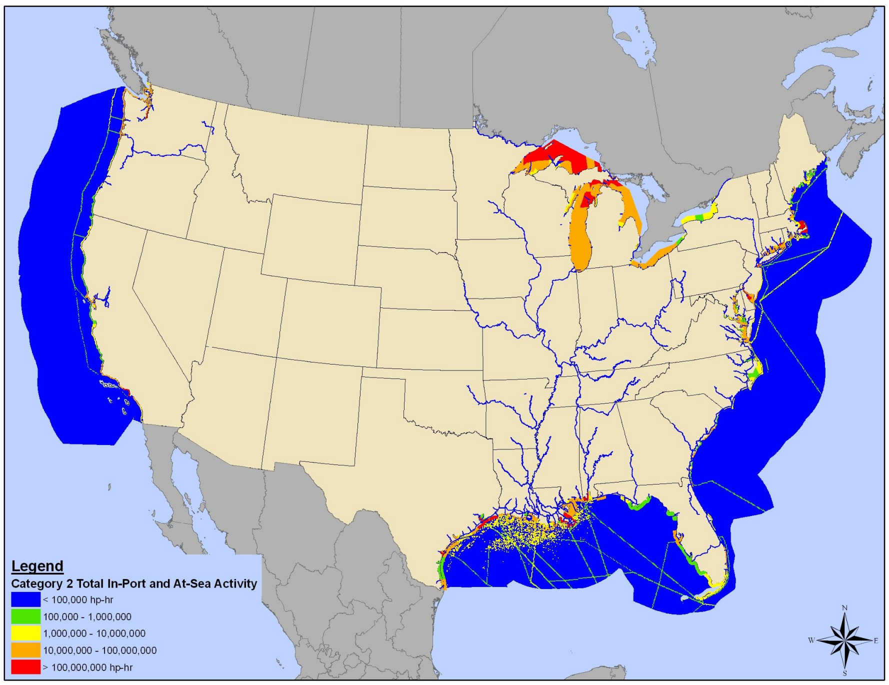


Figure 1-2. Combined In-Port and At-Sea Activities for Category 2 Vessels

In addition to this report, this project produced a set of data files that contain the compiled county and federal lease block activity data developed for this project. The database structure used for this study is discussed in Section 6 of this report. Note that the data included in the database are vessel specific. Because the EPA's category determinations are based on the volume of the marine diesel engine cylinder, and such data are generally not readily available for all U.S. flagged vessels, assumptions had to be made based on statistical review of the compiled data and engineering judgment. Given that detailed engine data were not always available, some of the individual vessels included in this data base may not actually be equipped with Category 2 engines. Some vessels which do have Category 2 engines may be missing. This vessel listing should be considered a preliminary census, which should be validated in the future with a detailed commercial marine vessel survey.

2.0 VESSEL TYPE EVALUATION

2.1 Tugboat

One of the objectives of this project was to identify the population of all tugboats registered in the U.S. and estimate the number of Category 2 engines. Previous inventories of tug-related emissions were mainly based on fuel consumption, a ton-mile method, or other surrogates that did not relate very well to identifying tugboat emissions.

Technically, there are two kinds of towboats that are commonly referred to as tugboats. One type has a rounded bow at the front of the vessel (towboat) and the other a square bow used exclusively for pushing barges (pushboat). The terms tugboat and towboat are often used interchangeably. Specialized types of towboats, such as the integrated tug-barge (ITB), are not considered to be true towboats, but rather ocean-going vessels as they carry cargo on the open seas.

According to the American Waterways Operators (AWO), the main industry group, towboats and barges moved 20 percent of America's coal, 60 percent of U.S. gain exports, and most of the heating oil in the Northeast.

Statistics from the AWO indicate approximately 4,000 line-haul vessels. A line haul vessel is one that pushes or pulls barges. There are a smaller, but significant number of towboats engaged in ship maneuvering, channel dredging, and construction activities.

The EPA categorizes towboats as being harbor vessels so as to distinguish them from ocean-going ships. Although most of the traffic is restricted to U.S. territorial waters, it should be noted that towboats can travel hundreds of miles, and some are considered to be more similar to ships such as the ITB or ocean-going salvage tugs.

2.1.1 Tugboat Data Sources

Most of the key data is from the U.S. Army Corps of Engineers and is available on their Internet site. Other sources include the U.S. Coast Guard's Merchant Vessels of the U.S. and Lloyd's Register of Ships. Available data used in this study are summarized below in Table 2-1 and discussed in greater detail below.

Table 2-1. Available Databases

Data Source	Records	Notes
Merchant Vessels of the U.S.	6,619	2004 data may contain workboats
Waterborne Transportation Lines of the U.S.	5,180	2002 baseline
Merged WTLUS Operators File	4,711	397 did not match
Inland River Record	3,280	Mississippi and Gulf Intracoastal
Lloyd's Register of Ships	864	International vessel records
American Bureau of Shipping	414	Mainly U.S. vessel records
Bureau Veritas	< 20	Mostly foreign ships

- Merchant Vessels of the U.S. (MVUS) – This reference is prepared by the U.S. Coast Guard (USCG) and reflects all documented vessels in the U.S., excluding any foreign or non-documented vessels, in accordance with U.S. laws. The database contains some limited horsepower data, but is mainly oriented towards hull specifications and owner information. It is thought that the code for "towing vessels" used in this database may include more than CMV towboats and pushboats.

- Waterborne Transportation Lines of the U.S. (WTLUS) – This reference serves as the basis for documenting the number of active and inactive towboats and pushboats in the U.S., as compiled by the U.S. Army Corps of Engineers. Once the vessel file was merged with the operator/owner file there was a slight loss of information, but the merge proved useful to assign tugboats to industry types and geographic area.

- Inland River Record (IRR) – This reference contains all towboats and pushboats operating on the waterways of the Mississippi, its tributaries, and the Gulf Intracoastal Waterway. This accounts for approximately half of the tug population in the U.S. It has very good records, but the text format was a challenge to convert into in a database format.

- Lloyd's Register of Ships (ROS) – Tugboats flagged in the U.S. were queried from a very large file containing over 70,000 international vessels. Lloyd's is a marine research company as well as a vessel classification, similar to the next two entries.

- American Bureau of Shipping (ABS) – Similar to the ROS although this data only includes those vessels classified by its company standards.

- Bureau Veritas (BV) – This database was purchased in order to develop a comprehensive dataset of vessel characteristics. Unfortunately, very few U.S. tugboats were found in this data set.

2.1.2 Initial Coding of WTLUS Data

Initially, the WTLUS was coded by visually inspecting the data and creating separate data fields for industry type and geographical area of operation. This was a subjective task. Since there were many empty (or "null") values for industry type, the default was set to all boats being engaged in towing, a generic term used in the industry for pulling or pushing barges over long stretches of water. The following industry types were used in this study:

- Assisting – pushing large ocean-going ships to or from the dock;
- Bunkering – providing fuel barge service to refuel large, ocean-going ships;
- Charter – these are towboats that are for rent by the day, week, month, or year;
- Construction – engaged in hauling construction materials and machinery;
- Dredging – related to assisting non-propelled dredges;
- Fleeting – moving around barges within a harbor or short waterway segment;
- Idle – not working;
- Logging – more common to the Northwest and Alaska, includes shifting log rafts;

- Oil and Gas – services inland or offshore oil and gas production platforms;
- Passenger – tugs that push passengers on barges; and
- Towing – called "line haul barge units," these are by far the most common.

While all companies tend to have a preferred market such as hauling petrochemicals, grain, or coal, the industry type assignments should be viewed with a certain caution: a line haul towboat can also be used for ship assisting, salvage work, shipyard work, or a number of other duties.

Geographic variables were also included in our data set. Assigning vessels to geographic areas was a cumbersome task because the WTLUS has three separate data sources that had to be integrated into our data set. These data sources included:

1. WTLUS of the Great Lakes
2. WTLUS of the Mississippi River System and the Gulf Intracoastal Waterway
3. WTLUS of the Atlantic, Gulf, and Pacific coasts

The Great Lakes data included a small number of towboats in a relatively small domain. The Mississippi and Intracoastal waterways had the highest number of towboats, but all operated on known shipping channels. The third section was far more complex, since the terms "offshore" or "coastwise" simply do not fit. Many of these boats were in fact in-shore towboats or even river pushboats (e.g., Delaware Bay in the east or the Columbia/Snake rivers in the west). What was missing was a descriptor for inland versus offshore Atlantic/Gulf/Pacific towboats, which is important because the offshore vessels tended to have larger engines and with presumably more EPA Category 2 engines relative to the in-shore towboats.

To get a sense of the magnitude of where tugboats are operating and what they are doing, an initial pass was taken from the WTLUS towboat data, stratifying boats into industry and geographical types, as shown in Table 2-2.

Table 2-2. Industry and Region Query of the Operator Database

JOB	Lakers	Inland	Coastwise	Total
ASSIST	0	25	66	91
BUNKERING	0	16	16	32
CHARTER	1	71	43	115
CONSTRUCTION	22	115	114	251
DREDGING	5	9	41	55
FLEETING	1	153	8	162
IDLE	0	28	19	47
LOGGING	0	0	73	73
OIL_GAS	0	144	29	173
PASSENGER	0	34	6	40
TOWING	102	2691	1348	4141
	131	3,286	1,763	5,180

It is evident that the majority of the tugboats are involved in line-haul barge transportation in the inland and coastal regions. According to the U.S. ACE, there were 5,180 towboats and pushboats operating in 2002 in the U.S. that were tracked for the purposes of regulatory compliance. As is also indicated by the "IDLE" entry, some companies have vessels which were inactive.

Further evaluation of the WTLUS data identified an additional 400 vessels that could be undocumented, working overseas, or were coded with invalid codes. As is recorded in Table 2-1, 397 vessels did not match with the WTLUS towboat data which lists each specific towboat or pushboat. This is probably due to the reporting of incorrect operator identification codes. It should be noted that many of these 397 vessels are engaged in oceanic traffic such as moving cargo to and from Hawaii, Puerto Rico, and other U.S. territories.

These tugboat estimates are consistent with estimates developed by the American Waterway Operators (AWO). The AWO estimates that there are 4,000 to 5,000 towboats operating in U.S. waters.

Additional geographic differentiations are summarized in Table 5 for the following geographic areas:

- Lakers – The Great Lakes. No Canadian towboats are included here. Some boats operate on inland waterways connected to the Ohio and Mississippi rivers, the Erie canal, etc.

- Inland – Mainly the Mississippi River and Ohio River, the largest concentration of towboats in the U.S.

- Atlantic – The entire seaboard between Key West, Florida and upper Maine. The U.S. ACE database was not coded to determine inland versus offshore towboats.

- Gulf Inland – These are mainly towboats operating on the Gulf Intracoastal Waterway (GIWW) between Brownsville, Texas and Mobile, Alabama.

- Gulf Offshore – The U.S. ACE dataset did allow us to distinguish between "inland" and "offshore" where the primary area was "Gulf of Mexico."

- Pacific – This region covers the area between San Diego and the Puget Sound; again, there is no available code for "inland" operations such as on the Columbia-Snake River waterways.

The statistics shown in Table 2-3 should be viewed with caution because the industry type code is related to the entire towboat company, not individual towboats. For example, we know that bunkering occurs very often in the harbors near Los Angeles and New York, but the companies involved with bunkering were primarily engaged in assisting or harbor towing.

Table 2-3. Regional Breakdown Using Port District Codes

JOB	Lakers	Inland	Atlantic	Gulf_Inland	Gulf_Offshore	Pacific	Total
ASSIST	0	27	39	20	0	5	91
BUNKERING	0	15	1	16	0	0	32
CHARTER	1	61	25	14	11	3	115
CONSTRUCTION	22	119	47	39	3	21	251
DREDGING	5	25	15	1	6	3	55
FLEETING	1	129	0	32	0	0	162
IDLE	0	20	1	15	0	11	47
LOGGING	0	0	0	0	0	73	73
OIL_GAS	0	2	0	142	29	0	173
PASSENGER	0	32	3	5	0	0	40
TOWING	102	1804	277	1360	106	492	4141
	131	2234	408	1644	155	608	5180

2.1.3 Determination of EPA Category

Significant work was required to determine the engine category of identified towboats. After combining the U.S. ACE operator and vessel files, vessel identifying codes such as Coast Guard number or IMO number were used to match vessel characteristics data to individual vessels. For example, both the ROS and ABS data sets had engine make and model information, which was useful in determining the EPA category. The ROS data also contained valid cylinder bore and stroke information in case the engine make and model could not be matched to engines in the Category 2 engine database. Figure 2-1 shows how the different data elements were linked.

The method to determine a vessel's EPA engine category is based on cylinder displacement, which requires specifications for bore (piston diameter) and stroke (piston travel). The equation for estimating the volume of a cylinder was used to calculate cylinder displacement:

$$\pi \; r^2 h$$

$$\text{Disp} \;=\; \pi \times (\text{bore}/2)^2 \times \text{stroke}$$

In the cases where this information was not available from ROS, engine specifications were obtained over the Internet and bore and stroke values were applied to the spreadsheet. It became evident that one could identify engine characteristics by collecting data on an engine family rather than each variant of the engine model. For example, all Caterpillar engines were Category 1 with the exception of the 3600 series (3606, 3608, and 3612).

An attempt was made to use horsepower (HP) to help make engine category determinations about towboats that did not have a known engine make and model, but this approach was not always accurate. The California Air Resource Board uses a cut-point of 750 HP, below which engines are classified as Category 1. This approach misidentifies many large Category 1 engines, such as the larger engines in the Caterpillar 3500 series, as being Category 2 engines. Using a cut-off such as 2,000 HP would be similarly inaccurate because there are many Category 2 engines below 2,000 HP, including popular models such as:

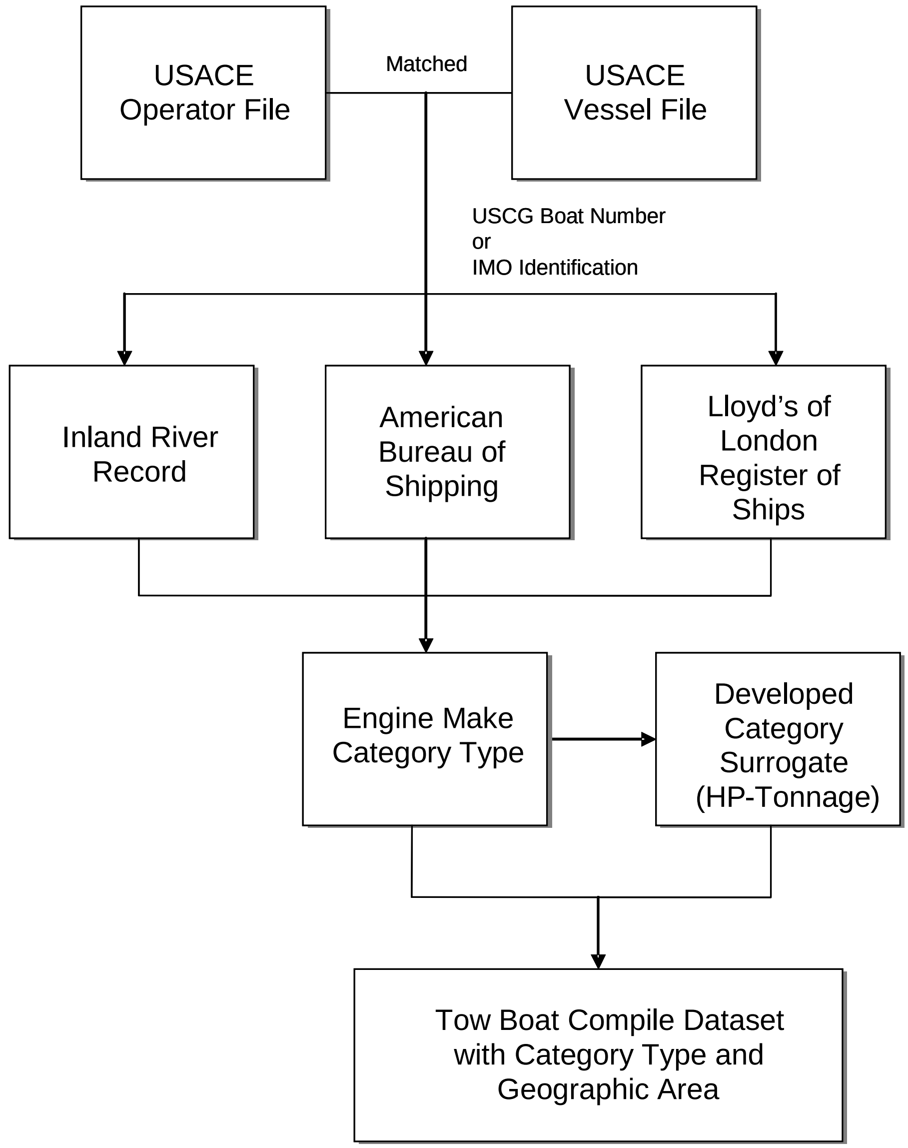


Figure 2-1. Organization of Towboat Data

- Fairbanks 6-38 and 8-38 series
- EMD 12-278 and 16-278 series
- Some EMD 12-645 models

After concluding that individual cylinder displacement has little relationship to horsepower, it was decided that a more complex profiling approach was needed.

Use of HP and Hull Displacement Metric

After removing vessels that are included in other vessel categories and then matching engine models to known EPA categories there were a significant number of "Unmatched Boats," as is reported in Table 2-4.

Table 2-4. Vessel Matching

Data	Count	Percent
Matched	2,883	68%
Remaining	1,338	32%
	4,221	

A new approach was developed to help determine whether a vessel was Category 1 or 2 based on total towboat HP and hull displacement (in net registered tons). In this approach, vessel HP is multiplied by hull displacement and divided by 1,000. Figure 2-2 shows the results of the calculation for matched vessels where the EPA engine category was known.

The vast majority of boats with HP-Tonnage scores below 250 were Category 1 vessels. Those with HP-Tonnage values above 1,000 were mostly Category 2 vessels. The area in between 250 and 1,000 was problematic, but only seemed to account for 10 percent of the fleet. Efforts to further refine the cutpoint based on number of installed engines, hull design (model towboat or pushboat), and vessel length were not successful. A preliminary decision to use 250 as the cutpoint was made knowing that this could conceivably overestimate the number of Category 2 engines – although there seemed little basis to apply probability statistics in this case. It should be emphasized that the surrogate HP-Tonnage method was only applied to the unmatched boats, which represented about 31 percent of the fleet. Thus the gross error was plus or minus 5 percent for the unmatched vessels or +/- 2 percent for the matched and unmatched data combined.

Database preparation also included gap filling. In a limited number of cases inspection of the data revealed a few (50-80) duplicate rows. This can be explained in part because a towboat could have two different engine models on board, as well as a function of how the data were merged. Given the low gross error rate and the fact that it was unclear which records should be removed, these few boats were retained in the tugboat database.

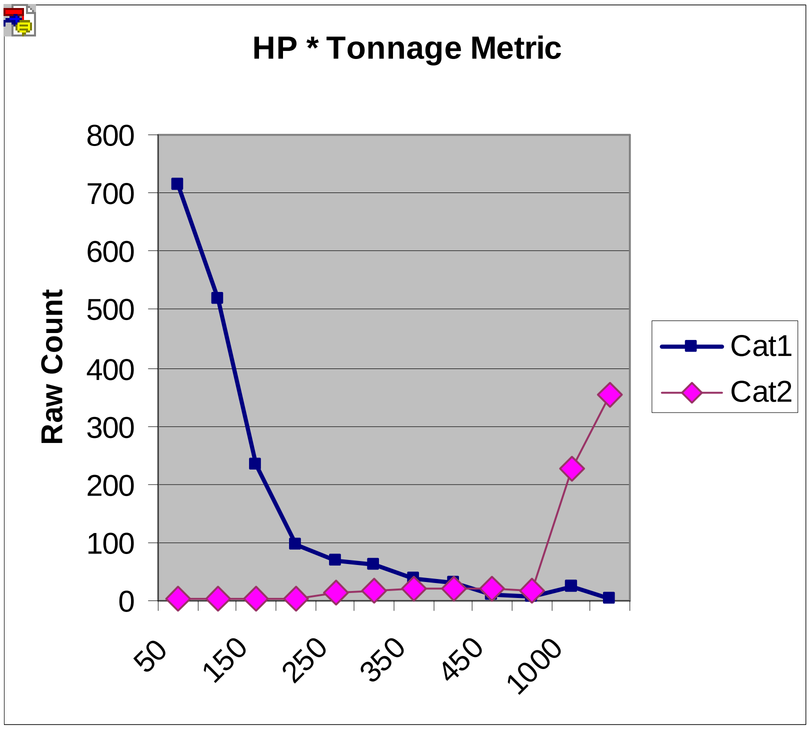


Figure 2-2. Distribution of Test Matched by Count and HP-Tonnage

2.1.4 Analysis of Tugboat Data

Table 2-5 below summarizes the commercial towboat fleet in the U.S., stratified by operating area.

Table 2-5. Category 1 and 2 Tug and Towboat Vessel Population Estimates

Area	C1Boats	C2Boats	Total Towboats
Atlantic	247	103	350
Great Lakes	88	21	109
Gulf Inland	1,281	251	1,532
Inland	1,135	441	1,576
Offshore Gulf	69	70	139
Pacific	344	171	515
Total	3,164	1,057	4,221

The last two columns sum up Category 1 and 2 towboats and engines, respectively. Approximately 27 percent of the fleet of towboats was classified as having Category 2 main propulsion engines. Note that no Category 3 engines were found.

The authors wish to acknowledge Mr. Doug Scheffler of the AWO for his suggestions regarding use of the U.S. ACE databases. Our finding of 4,221 active towboats, of which 1,057 are identified as being Category 2 equipped, is consistent with AWO projections for the U.S. towboat fleet.

2.1.5 Tugboat References

American Bureau of Shipping Bureau – 2004 Data query available by negotiation only, http://www.eagle.org/.

American Waterways Operators, call with Mr. Sam Wells and Mr. Doug Scheffler, 2004.

Bureau Veritas – 2004 Data query available by negotiation only, Paris, France, 2004.

California Air Resource Board, call with Sam Wells of Starcrest and Kirk Rosenkranz of ARB June 6, 2004.

Inland River Record – The Waterways Journal, Inc., 319 N. Fourth Street, Suite 650, St. Louis, MO, 2004.

Lloyd's Register of Ships, Fairplay, Ltd. 8410 N.W. 53rd Terrace, Suite 207, Miami, FL, 2004.

U.S. Coast Guard, Merchant Vessels of the U.S., NTIS, (CG 408), 2004.

U.S. Army Corps of Engineers, Waterborne Statistics Division, Waterborne Transportation Lines of the U.S., New Orleans, LA. 2004 http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm

2.2 Commercial Fishing Vessels

Commercial fishing vessels are self-propelled ships dedicated to procuring fish for the purpose of sale at a market. There are various kinds of fishing vessels that use different types of fishing gear. The main kinds of gear include seine nets, crab pots, trolling lines, otter net trawling, gill netting, and long-lines. The main distinction between fishing vessels is whether the boat tows a net or is engaged in "hook and line" fisheries, or falls into a miscellaneous category that can include dive boats, clam dredges, and even aquaculture support vessels. Gear type is not a good predictor of horsepower requirements or the category classification of the propulsion engine. In fact, many fishing boats are "multi-purpose" so as to be able to participate in as many different fishing activities as possible. In addition to smaller fishing vessels, there are a number of large, ocean-going vessels that serve as factory ships and are equipped with blast freezers, some of which are capable of processing over a hundred metric tons of fish per day. The fishing vessel fleet varies from port to port in size, design, and targeted fish species.

2.2.1 Commercial Fishing Vessel Data Sources

The principal data source for the commercial fishing vessels is the MVUS database. By law, the vessels need to be registered with the U.S. Coast Guard. The database was queried for "commercial fishing vessels" and this file was used as the starting point. Out of a total 29,679 commercial fishing vessels found in the file, roughly 3,000 vessels had horsepower data. If we assume that the port of registry is a surrogate for where the boat is based, the states with the most commercial fishing vessels are listed in Table 2-6. Because fishing boats move seasonally with fish populations, their area of operation are typically large areas and they visit several different ports.

Table 2-6. State Fishing Vessel Registration Comparisons

State	Percentage of National Registered Fishing Vessels Fleet
Alaska	18%
Washington	8%
Texas	8%
California	7%
Florida	7%
Louisiana	7%
Maine	7%
Massachusetts	6%
Maryland	4%
Oregon	4%
Virginia	4%
North Carolina	3%
Mississippi	2%
New York	2%
Others	13%

The MVUS database documented U.S. commercial fishing vessels, but it could not be used solely to identify vessels with EPA Category 2 propulsion engines since it has limited horsepower data and no engine make and model data. In fact, no data source was identified that included engine make and model for registered commercial fishing vessels. Therefore, the engine category identification could not be based on engine specific data. Instead, horsepower, vessel length, geographic area, and type of fishing activities were considered in determining the engine category.

In evaluating the approximately 30,000 rows of data, the vessels were given category codes based on classifications noted in Table 2-7.

Table 2-7. Commercial Fishing Vessel Category Assumptions

Category	Description	Vessel Count
0	0 HP	101
1	Rated HP less than 1,000	2,818
Possible 1	HP not given; length less than 100' length	26,103
2	Rated HP greater than 1,000	301
Possible 2	HP not given; length greater than 100'	356
	Total	29,679

The 1,000 HP and 100 foot length break-points were used to help sort the data and divide it into manageable groups. From previous experience with commercial fishing vessel surveys, it was assumed that vessels with less than 1,000 HP and less than 100 foot in length were generally Category 1 vessels.

Alternative data sources were identified to address the data gap for the horsepower field. The databases that have detailed commercial fishing vessel data and were used in this study are summarized in Table 2-8, and are discussed in great detail below.

Table 2-8. Summary of Commercial Fishing Vessel Data Sources

Data Source	Vessel Count	Comments
Merchant Vessels of the U.S.	Approximately 30,000 vessels	Used as primary file
American Bureau Shipping	Matched 10 vessels	Vessel classification database
California Commercial Fishing File	Approximately 300 fishing vessels identified of which 25 to 30 had horsepower data that could be used to evaluate engine category	Matched for Los Angeles area
Alaska CFEC 2003 Permits	23,000 permits matched to 5,000 vessels	Matched for Alaska and Pacific NW
Washington Department Fish and Wildlife	Matched approximately 700 vessels	Matched for Washington Coastal fishing operations

An internet search was done for the main fishing states to find usable vessel data files. A downloadable file from the State of Alaska's Commercial Fisheries Entry Commission (CFEC) was found and matched to the existing commercial fishing vessel file. The CFEC keeps track of individual permits and vessel information by year for the state of Alaska and has downloadable comma separated data files that can be used in spreadsheets. The 2003 year data were downloaded and approximately 23,000 permits for resident and non-residents were compared to the project's commercial fishing vessel database.

The Washington Department of Fish and Wildlife (WDFW) was contacted for information on their commercial fishing permits since the state of Washington had the highest percentage of vessels with possible Category 2 engines. The WDFW provided us with a list of commercial fishing vessels that had applied for permits. The commercial fishing vessel project database was compared to the WDFW file to append the missing horsepower data and determine whether the vessel was equipped with a gas or diesel engine. These data were used to help fill in the missing horsepower data for over 700 vessels. A total of 431 vessels with known gasoline engines were deleted from the project database and a new "Excluded" code was added for vessels from territories outside the project's area of interest (e.g., Guam, Samoa, U.S. Virgin Islands).

This matching of vessels of data from the MVUS with local state and vessel classification data was continued on a smaller scale by incorporating data from the ABS and the Los Angeles inventories. The final vessel matching is summarized in Table 2-9 below:

Table 2-9. Summary of Commercial Fishing Vessel Categories

Category	Vessel Count
HP 0	110
Definite 1	8,130
Possible 1	21,328
Definite 2	412
Possible 2	227
Excluded	48
Total	30,255

It is unclear what the "HP 0" represents in these databases. Initially it was assumed that the vessels were not self-propelled, but further study revealed that this was not the case. Given that the HP 0 group is such a small portion of the fleet and the Category 2 vessels represent the largest vessels in the fishing fleet, it was assumed that these HP 0 vessel were probably Category 1 ships and were not included in this analysis.

Even after removing the gasoline powered vessels, the total number of vessels went up by about 500 because commercial fishing vessels with valid permits from the states of Alaska and Washington were added to the project database. It is unclear if these were foreign boats such as ones from Canada or if the (USCG) database was missing some vessels that should have been classified as "fishing" instead of another vessel type, such as "recreational."

2.2.2 Analysis of Commercial Fishing Vessel Data

After further review of the data, the definite Category 2 and possible Category 2 vessels were separated from the rest of the file for further study. This separate list contained about 639 vessels. Table 2-10 shows the vessels sorted by the length and horsepower groups.

Table 2-10. Commercial Fishing Vessels Sorted by Length and Horsepower Groupings

Total HP	under 100’	100-124’	125-149’	150-199’	200+
1000-2000	137	79	52	51	5
2000-3000	2	0	4	24	8
3000-4000	2	0	0	8	5
4000-5000	0	0	1	3	6
5000+	0	0	0	6	12
Blank	0	78	41	86	24
Total	**141**	**157**	**98**	**178**	**60**

In order to make a better determination of which of the above vessels had Category 2 engines, the national brokerage websites that post commercial fishing vessels for sale were researched for vessels with known engine make and model data. These websites post vessel specifications such as length, main engine make and model, and sometimes horsepower. They do not list names of vessel or any Coast Guard or IMO number that could be linked to a particular vessel characteristic. Numerous national and international websites were reviewed to see if the information provided could help in determining engine categories based on vessel characteristics. Some websites contained vessels from around the world, which showed the difference in engine manufacturers between U.S. and foreign flagged vessels. American commercial fishing vessels tend to have main engines manufactured in the United States, such as Caterpillar, Cummins, Detroit Diesel, and Perkin Engines.

The brokerage website data verified the assumption that vessels equipped with engines rated with less than 1,000 HP were Category 1 engines. A spreadsheet of U.S. vessels for sale that had a total engine horsepower of 1,000 HP or greater was compiled. The 103 vessels for sale with known engine make and model data found in the web search were sorted into engine category, vessel length, and horsepower. The results showed that U.S. commercial fishing vessels under 100 feet in length typically contained one main Category 1 engine. Vessels with lengths between 100 and 125 feet are generally equipped with one or two Category 1 engines. In the 125 to 200 feet length range, the vessels were equipped mostly with one or more Category 2 engines. There were a few exceptions for larger vessels that were equipped with twin Category 1 engines in the 1,000-2,000 total horsepower range. All vessels over 200 feet long were Category 2 engines with more than 1 engine per vessel. The vessels over 200 feet in length found for sale were mostly fish processors, while the vessels with lengths between 125 and 200 feet were mostly trawlers.

Figure 2-3 summarizes the results from the 103 vessels for sale with known engine make and model:

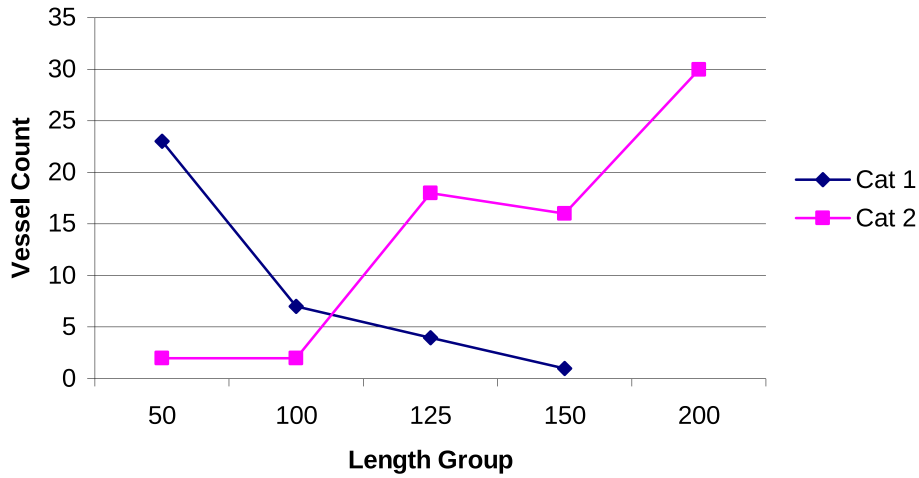


Figure 2-3. Vessel Sale Data

From the main engine information gathered about the vessels from brokerage websites, it was assumed that the 141 vessels with lengths under 100 feet and the 157 vessels with lengths between 100 and 124 feet (noted in Table 12) have Category 1 engines. The 336 vessels with lengths greater than 125 feet are likely to have Category 2 engines. These assumptions are not inconsistent with the horsepower data reported in Table 2-10 and summarized in Table 2-11.

Table 2-11. Commercial Fishing Vessels by Horsepower

Total HP	Category 1	Category 2
1000-2000	216	108
2000-3000	2	36
3000-4000	2	13
4000-5000	0	10
5000+	0	18
Unknown	78	151
Total	**298**	**336**

This analysis shows that approximately 1 percent of the total commercial fishing vessels are equipped with Category 2 engines. The possible Category 2 list was also sorted by state and region. The state of Washington had the most commercial fishing vessels with Category 2 engines (46%), followed by the states of Louisiana (14%), Alaska (8%), and California (6%). The Pacific Coast accounts for 64 percent of the Category 2 commercial fishing vessels, followed by the Gulf region with 19 percent, and the Atlantic coast with 14 percent.

Our data did not allow us to investigate foreign ships that may be fishing within the U.S. territorial waters, legally or otherwise. It is common for vessels within the U.S. water to be U.S.-flagged, but this is not always true; for example, it is possible to obtain permits to fish in the waters of Mexico, which typically occurs when U.S. waters are closed (e.g., charter boat snapper fishery).

In conclusion, a few commercial fishing vessels that resemble factory processors were identified as having Category 2 main engines. However, the typical fishing vessel in the U.S. is quite small, generally 30 to 50 feet in length and powered by Category 1 diesel engines.

2.2.3 Commercial Fishing Vessel References

American Bureau of Shipping (ABS) database.

Eastern Research Group (ERG) (2004), Update to the Commercial Marine Inventory for Texas to Review Emissions Factors, Consider a Ton-Mile EI Method, and Revise Emissions for the Beaumont-Port Arthur Non-Attainment Area.

Research Fishing Vessels website.

Starcrest (2000), Houston-Galveston Area Vessel Emissions Inventory (HGAVEI).

Starcrest (2004), Port of Los Angeles Port-Wide Baseline Air Emissions Inventory (PWBAEI).

State of Alaska, Commercial Fisheries Entry Commission, 2003 permit database, see www.cfec.state.ak.us/veslist.

State of Washington, Department of Fish and Wildlife commercial fishing license database.

U.S. Coast Guard, Merchant Vessels of the U.S. database.

Websites used:
Alaskan Leader
National Fisherman
Ocean Marine
Ships USA
Trident Seafoods
Tidewater Brokerage

2.3 Coast Guard Vessels

To account for all Category 2 military vessels, it is necessary to include all branches of the military service that operate marine vessels. This would include the U.S. Navy and Coast Guard. To include naval data is particularly challenging as it is necessary to consider only those vessels that are operating in navigable waters of the U.S., which requires detailed information about vessels and their location. Unfortunately, details concerning the Naval fleet are currently not publicly available and therefore can not be included in this analysis. Only data from the U.S. Coast Guard could be considered in this report. The actual military fleet of vessels equipped with Category 2 engines operating in U.S. waters is underestimated in this study.

The U.S. Coast Guard uses a variety of vessels throughout the United States to conduct its daily business. The vessels can be separated into cutters and small boats.

The 1,400 small boats that range in length from 12' to 64' and operate close to shore were determined to be equipped with Category 1 engines and therefore were not included in the list of vessels that required more detailed research. These small boats include motor lifeboats and surf boats, utility, rescue, and Port security boats.

A cutter is a Coast Guard vessel that is at least 65' in length. For this study, the cutters were researched to determine their engine category. Cutters include icebreakers, river, inland, coastal, and seagoing buoy tenders, construction tenders, large patrol boats, and harbor tugs. Twelve Coast Guard vessels that are equipped with gas turbine engines were removed from this analysis as they do not meet the Category 2 definition.

2.3.1 Coast Guard Data Source

The main source of information for this U.S. Coast Guard fleet was the U.S. Coast Guard webpage (www.uscg.mil/datasheet/dataindx.htm) which lists its fleet of cutters, small boats and airplanes. The cutters are presented individually grouped by their vessel class. Many had their own websites that provided information needed to make an engine category determination. The websites also provided other vessel characteristics data including vessel horsepower and the districts where they patrol. Where data were missing, vessel characteristics were estimated by matching the vessels to other vessels in the same class which did report vessel characteristics.

2.3.2 Analysis of Coast Guard Data

Approximately 158 of the 235 cutters currently in service had Category 2 engines.

2.3.3 Coast Guard Reference

Coast Guard official website - www.uscg.mil/datasheet/dataindx.htm.

2.4 Ferry Vessels

Ferries are self-propelled vessels that carry passengers from one location to another. Some ferries have the capability to also carry motor vehicles. These vessels are owned and operated by both State Agencies, usually State Department of Transportation, and private firms.

2.4.1 Ferry Vessel Data Sources

The main data source for ferries was the 2000 Bureau of Transportation Statistics (BTS) National Ferry Database. There were a total of 680 vessels included in the National Ferry Database. The database provided vessel horsepower, the name of the vessel, and the city and state were the vessel operates. Main engine make and model data for individual ferries were not included in the BTS database, and so a number of other sources were used to determine the engine category.

The data sources used to determine engine category included the IRR that listed passenger vessels operating along the Mississippi River and Gulf Coast, and the ABS dataset that listed registered ferries. Appropriate websites were also identified and lists of ferries with engine specifications were downloaded. Information about ferries at several of the major ports was obtained from published studies. To address the remaining data gaps, it was necessary to contact individual ferry operators to obtain readily available information about their vessels. New ferries built and operated since 2000 and containing Category 2 main engines were added to the project's ferry database.

2.4.2 Analysis of Ferry Data

The original BTS database included 685 ferries. The non-Category 2 vessels were identified and flagged based on knowledge of the ferry fleet obtained from work performed at major ports. Where engine make and model data were identified, these engine data were compared with the engine database developed for this project. Vessels were also flagged that are not self-propelled or do not use diesel fuel. Lastly vessels operating in the Virgin Islands, Puerto Rico, and other U.S. protectorates were noted as they were not included in the project's scope of work. For 53 vessels there was insufficient data to determine the engine category. For these vessels, calls were made to the operators which revealed that 16 of the 53 remaining ferries were equipped with Category 2 engines.

Table 2-12 summarizes the vessel category profile for ferries. Note that "0" represents ferries that are not self-propelled and "excluded" represents ferries operating outside the study area, such as the U.S. Virgin Islands and Mariana Islands, or were duplicates with vessels reported in the deep water vessel category.

Table 2-12. Ferry Population by Engine Category

Engine Category	No. of Vessels
Not self-propelled	44
1	508
2	99
Excluded	34
Total	685

Out of the 685 ferries, 99 ferries (14%) had Category 2 engines. The states with the most Category 2 ferries are summarized in Table 2-13.

Table 2-13. Distribution of Ferries by State

State	Percentage
Washington	19
California	12
New York	11
Connecticut	10
Massachusetts	9
Alaska	8
Delaware	5
Texas	5

2.4.3 Ferry References

American Bureau of Shipping (ABS) database.

Bureau of Transportation (2000), National Ferry Database.

Corbett, J.J. et al (2003), Air Pollution from Passenger Ferries in New York Harbor.

Inland River Record (IRR) (2004).

Starcrest (2003), New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine Vessel Emissions Inventory (PANYNJ CMVEI), Volume 1.

Starcrest (2000), Houston-Galveston Area Vessel Emissions Inventory (HGAVEI).

Starcrest (2004), Port of Los Angeles Port-Wide Baseline Air Emissions Inventory (PWBAEI).

<u>Cities and States contacted:</u>

City of Vallejo
State of Alaska
State of North Carolina
State of Washington

<u>Companies contacted:</u>

Cross Sound Ferries
Bridgeport & Port Jefferson Steamboat Company
Catalina Clipper
Blue & Gold Fleet
Miller Boat Line
Hydrolines Express, Inc.
Jet Express

2.5 Deep Water Cargo Vessels

Ocean going vessels carry international cargo and passengers to and from major ports around the world. Category 2 vessels account for approximately 8 percent of international ship trips.

2.5.1 Deep Water Cargo Vessel Data Sources

In an earlier project, vessels included in the U.S. ACE Clearance and Entrance (C&E) data set were matched to vessel characteristics from the ROS, ABS, and Bureau Veritas databases. These files include data flags for the different engine categories as derived from cylinder displacement data as discussed in the tugboat section of this report. All deep water cargo vessels that have been identified as being equipped with Category 2 engines have been extracted from the U.S. ACE C&E data set and pulled into this project's database.

2.5.2 Analysis of Deep Water Cargo Vessel Data

The matching of the C&E data with vessel characteristic data from vessel classification companies identified 520 deep water cargo vessels that are equipped with Category 2 Engines. 300 foreign flagged vessels were removed when the data for each of the vessels types were combined into the database discussed in Section 3 of this report, the deep water vessel listing was compared with the other vessel data to ensure that no vessels were double counted in this project. Special attention was given to vessel types such as tugs and Great Lakes Vessels as they were likely to have duplicate vessel data. When duplicates were removed, 89 vessels were remaining. Because the data provided by the U.S. ACE is vessel specific, additional analysis of the engine category was not necessary.

2.5.3 Deep Water Cargo Vessel References

American Bureau of Shipping Bureau – 2004 Data query available by negotiation only, http://www.eagle.org/.

Bureau Veritas – 2004 Data query available by negotiation only, Paris, France, 2004.

Lloyd's Register of Ships, Fairplay, Ltd. 8410 N.W. 53rd Terrace, Suite 207, Miami, FL, 2004.

U.S. Army Corps of Engineers, Vessel Clearance and Entrance Data, Waterborne Statistics Division, New Orleans, LA. 2006

2.6 Research Vessels

A variety of marine research vessels ply the coastal waters of the United States. These vessels are equipped with a wide range of scientific equipment used to track marine wildlife, map geographic formations, monitor coastal coral reefs, investigate changing meteorological conditions, and test water quality parameters. Some of these vessels are fairly large and would be equipped with Category 2 propulsion engines.

2.6.1 Research Vessel Data Sources

The University of Delaware maintains an inventory of U.S. flagged research vessels operating in the U.S. This University of Delaware database was an excellent starting point as it includes many, though not all, research vessels. The vessels that were included in the database were matched with research vessels included in the ROS and ABS databases. For the matched research ships engine specific data were associated with these vessels to accurately flag the Category 2 vessel population.

These data were supplemented with data obtained from internet web searches. The University-National Oceanographic Laboratory System (UNOLS) website was particularly useful as it listed other research vessels besides those included in the University of Delaware's database. Many smaller research vessels were identified but not included in the database as the focus of this project is Category 2 powered vessels. Vessels were also evaluated to ensure only active ships are included; this led to the removal of vessels that have been decommissioned or are in cold storage. An addition research vessel was removed as documents indicated that it spends all of its time in Antarctica, outside U.S. territorial waters.

2.6.2 Analysis of Research Vessel Data

Through this effort 31 research vessels were identified as equipped with Category 2 engines.

2.6.3 Research Vessel References

The UNOLS website is found at www.unols.org. It has a research vessel index found at www.unols.org/info/vessels.htm

2.7 Offshore Support Vessels

Most offshore vessels represent a variety of boats that provided different support services to the offshore oil platforms. These services include geophysical surveys, exploratory drilling, platform construction and removal, pipeline construction and maintenance, and continuous transfer of people, equipment and supplies to and from the platforms. These activities use the following vessel types:

- Anchor handling tugs;
- Crew boats;
- Drilling rigs;
- Lightering escort vessels;
- General purpose tugs;
- Liftboats;
- Pipe laying vessels;
- Supply boats;
- Support vessels; and
- Survey vessels.

Because offshore oil platform needs vary, the support vessel fleet composition includes boats with a wide range of propulsion engine sizes and operating speeds with approximately half of fleet equipped with Category 2 propulsion engines.

2.7.1 Offshore Support Vessel Data Sources

As with the other vessel types included in previous Category 2 studies, there is no single comprehensive database that includes a complete listing of all active support vessels and their engine characteristics. The Offshore Marine Service Association (OMSA), which is the trade organization for offshore support vessel operators, maintain records of the number of American flagged vessels currently operating the Gulf of Mexico, unfortunately, they do not have detailed data about the propulsion engines for each vessel. The Oilfield Publications Limited's (OPL) ***A-Z*** *Offshore Support Vessels of the World Data Set*, contain detailed data on specific offshore vessels; but unfortunately, this data set did not identify which vessels are actually operating in U.S. waters.

A two phase approach was developed that used these complementary data sets to quantify the population of U.S. flagged Category 2 offshore vessels operating in U.S. waters. In the first phase, national estimates were developed for each vessel type for U.S. flagged support vessels by extrapolating the OMSA Gulf of Mexico data. In the second phase, detailed vessel specific data were obtained from the OPL and evaluated to develop estimates of the proportion of each offshore vessel type that is equipped with Category 2 propulsion engines. These Category 2 ratios were applied to the offshore vessel population data providing reasonable estimates of the Category 2 offshore vessels. The following sections of this report discusses in greater detail the approaches used in this study.

2.7.2 Support Vessel Analysis

During the course of this study two offshore vessel types were investigated and discovered to not be equipped with Category 2 propulsion engines and were not included in this study. These two non-Category 2 vessel types included drilling rigs and escort vessels.

Once a survey vessel has identified an area that may have oil bearing strata, a drilling rig is commissioned and sent to the site. Drilling rigs are sometimes considered to be offshore vessels as they operate in shallow as well as deep waters. Some drilling rigs are self-propelled, while others are towable. Drilling rigs were not included in any of the other Category 2 vessel groups, but were considered in this study due to their involvement with offshore oil exploration. There are several different types of drilling rigs, from drill barges that operate in shallow waters, jack-ups that operate in waters with depths less than 100 meters, semi-submersibles that operate in water depths greater than 300 meters, and drill ships that operate in waters with depths up to 1,200 meters. Though all drilling rigs are equipped with large diesel engines, only semisubmersibles and drilling ships are self-propelled, all of the others are towed to the site using oceangoing support tugs.

The self-propelled drilling rig population for the Gulf of Mexico, Alaska, and California was obtained from RigZone, which is a trade group that monitors global activity of individual drilling rigs. It should be noted that no self-propelled drilling rigs were identified operating in Californian or Alaskan waters and 16 drill ships and semisubmersible rigs were identified as operating in the Gulf of Mexico. Upon further study of the propulsion engines associated with the self propelled drilling rigs, three of these vessels could be match to propulsion engine characteristics and all three used Category 3 diesel engines for propulsion; therefore it was decided to exclude drilling rigs as a vessel type from this offshore assessment.

Similarly, escort vessels were also excluded from this study as all identified escort vessels were equipped with Category 3 propulsion engines. Escort vessels are offshore vessels that shuttle products to and from tankers afloat in the Coast Guard monitored lightering zones. These tankers may be too large to safely operate in a port area or they may chose to offload their product to escort vessels in a lighter zone to avoid congested harbors. Such escort vessels tend to have Category 3 engines in order to quickly move product to shore and return to the tanker for additional transfers.

As noted earlier, the OMSA provided an estimate of U.S. flagged vessels currently operating in the Gulf of Mexico. Crew boats, supply and support vessels, and utility boats were combined in this report as these vessels often provide multiple overlapping services and needed to be matched to the vessel categories used in the OPL dataset. The OMSA vessel population data are summarized in Table 2-14.

Table 2-14. OMSA U.S. Flagged Vessel Population by Offshore Vessel Type for the Gulf of Mexico

Offshore Vessel Type	Minimum Horsepower	Maximum Horsepower	Vessel Count
Anchor Handling Vessels	10,000	14,000	25
Crew/Supply/ Support/Utility Boats	900	6,000	660
Lift Boats	1,000	1,500	113
Tugs/Towing	1,000	5,000	200
		Total	**998**

These OMSA offshore vessel population estimates only cover the Gulf of Mexico. Though more than 90% of the offshore oil and gas comes from platforms in the Gulf, there are active platforms in Alaskan waters and off the coast of California. Offshore oil production data for each region were obtained from the Department of Interior’s Mineral Management Services’ Offshore Oil Program. These oil production values were compared to the Gulf’s U.S. flagged offshore vessel fleet estimates to approximate the U.S. flagged vessel population in each region using the following equation:

$$VP_{ij} = OP_i/OP_g \times VT_{gj}$$

Where:

VP_{ij} = Population for vessel type j in geographic area i
OP_i = Offshore oil production for geographic area i (millions of barrels)
OP_g = Offshore oil production for the Gulf of Mexico (millions of barrels)
VT_{gj} = the population of vessel type j in the Gulf of Mexico – Table 2-14
i = Geographic area (i.e., Pacific or Alaska)
j = Vessel type (i.e., anchor handling vessels, crew boats, lift boats, supply vessels, tugs, utility boats)
g = Gulf of Mexico

Result of these vessel population equations are summarized in Table 2-15.

Table 2-15. OMSA U.S. Vessel Population by Offshore Vessel Type for the Gulf of Mexico

	Vessel Count				
Offshore Vessel Type	**Gulf of Mexico**	**Pacific**	**Alaska**	**U.S. Waters (Unknown Location)**	**Total**
2004 Oil Production (Million of Barrels)	**534.969**	**27.510**	**25.078**	**---**	**585.557**
Anchor Handling Vessels	25	1	1	---	27
Crew/Supply/ Support/Utility Boats	660	33	31	---	724
Lift Boats	113	6	5	---	124
Tugs/Towing	200	10	9	---	219
Survey	---	---	---	62	62
Pipe/Cable laying	---	---	---	24	24
Total	**998**	**50**	**46**	**86**	**1,180**

Survey vessels and pipe laying vessels were handled differently than the other offshore vessel types. The survey vessels include geotechnical, hydrographic, and seismic vessels, therefore the survey vessels are not limited to the oil and gas industry activities and can be found in many navigable waters. The vessel population data for survey vessels were obtained from the OPL database.

Similarly for pipe laying vessels, research concerning the design and uses of pipe laying vessels indicated that pipe laying and cable laying vessels are essentially the same type of vessels and can be quickly modified to perform any laying activity. Basically only the material being laid has to be changed out and most of the remaining equipment stays the same. Because of this, pipe laying and cable-laying vessels are considered together. The vessel population data for pipe/cable laying vessels was obtained from the OPL database. As the survey vessel and pipe laying categories may operate outside the areas where offshore oil platforms operate, only national total numbers were used for this study.

During this project a copy of the OPL data set was obtained to help quantify the Category 2 offshore vessel populations. Unfortunately, the OPL data did not arrive during the project's period of performance. Upon reviewing the OPL data set, 1,407 vessels were identified that may operate in U.S. waters. This determination was based on vessels that were flagged as U.S. vessels or listed the vessel manager's address as being in the United States. This data set may over represent U.S. flagged vessels as it includes vessels that may not necessarily be operating in U.S. waters.

Offshore vessels use a large number of tugs to tow drilling rigs and components of the platforms for construction or removal. Tugs and barges also are used to carry supplies and equipment to the offshore platforms. The vessels included in the OPL listing were matched with vessels in the Category 2 tug data set. Nineteen vessels were identified as being in both data sets and were removed from the towboat dataset to eliminate any double counting of vessels.

After drilling rigs and escort vessels were removed from the OPL data, the offshore vessel population was 1,254, which is similar to, but slightly higher than the adjusted OMSA vessel population data. The difference between these two values represent the uncertainty associated with the number of U.S vessels operating overseas.

The remaining OPL offshore vessels were compared to the Coast Guard's ***Marine Vessel Register*** to pull in as many vessel ID codes as possible and obtain any available engine propulsion data to identify those vessels equipped with Category 2 propulsion engines. The primary engine data that were sought were the engine's bore and stroke dimensions. These data were used to calculate the cylinder displacement.

If engine bore and stroke data were not available, engine make and model information was compared to records in the Category 2 engine database developed for this project. This database lists all known Category 2 engines.

The vessels were matched by name, gross tonnage, and year of construction or modification. Of the 1,254 OPL vessels, 205 had engine data in the Marine Vessel Registry.

The vessels identification codes obtained from the OPL data set and the Marine Vessel Registry were used to link the vessels to data from the American Bureau of Shipping, Bureau Vertas, and Lloyds Register of Ships to get bore and stroke data or engine make and model information.

Table 2-16 summarizes the vessel engine data compiled for offshore support vessels. As this table indicates, approximately half of the vessels could be matched to their propulsion engine characteristics. Most (>80%) of the matched vessels were matched to data in the Marine Vessel Registry and the American Bureau of Shipping's data.

Table 2-16. Results from Matching Vessels to Engine Characteristics

Data Source	Vessel Count with Engine Data	Percentage of Total	Percentage of Total Excluding Blanks
Unknown Engines	609	48.6	---
Marine Vessel Registry	205	16.3	31.8
American Bureau of Shipping	318	25.4	49.3
Lloyds Registry of Ships	121	9.6	18.8
Bureau Veritas	1	0.1	0.2
Total Excluding Tug Data Set	1,254	100	---
Total Excluding Unknown Engines	645	---	100

Based on the compiled engine characteristic data, the split between Category 1, 2, and 3 engines can be summarized in Table 2-17.

Table 2-17. Support Vessel Category Mix

	Vessel Count	Percentage of Total	Percentage of Total Excluding Blank or Invalid
Unknown Categories	812	64.8	---
Category 1	198	15.8	44.8
Category 2	**226**	**18**	**51.1**
Category 3	18	1.4	4.1
Total	1,254	100	---
Total Excluding Unknown Categories	442	---	100

As Table 2-17 indicates approximately half of the offshore vessel fleet is composed of vessels equipped with Category 2 engines. It should be noted that this value is based on matching of 35.2 percent of the vessels. For the purpose of this study it is assumed that the unmatched vessels have the same category profile as the matched vessels. Alternatively, the unmatched vessels may include a larger fraction of smaller boats that may not be Category 2 vessels, and are not insured through the three larger vessel classification companies, which was the data source for this component of the study. Additional data could not be obtained that would validate or negate the assumption used in this study.

The larger value was not seen as surprising as many of these offshore support vessels are designed to carry large loads and travel up to two hundred miles offshore for extended periods of time. Instead of using the aggregated value, a somewhat more accurate estimate was developed by disaggregating the data by offshore vessel types as noted in Table 2-18.

Table 2-18. Category Mix by Support Vessel Type

Type	Count	Category	Percent
Unknown Vessel Type	343	Unknown	--
	2	Category 3	--
Anchor Handling	22	Unknown	--
	7	Category 1	15.9
	34	**Category 2**	**77.3**
	3	Category 3	6.8
Liftboat	98	Unknown	--
	1	Category 1	33.3
	2	**Category 2**	**66.7**
Pipe/Cable Laying	18	Unknown	--
	1	Category 1	20.0
	3	**Category 2**	**60.0**
	1	Category 3	20.0
Crew/Supply/ Support/Utility Boats	232	Unknown	--
	176	Category 1	60.1
	116	**Category 2**	**39.6**
	1	Category 3	0.3
Survey	49	Unknown	
	6	Category 1	46.2
	5	**Category 2**	**38.5**
	2	Category 3	15.4
Tugs/Tow	50	Unknown	--
	7	Category 1	8.5
	66	**Category 2**	**80.5**
	9	Category 3	11.0

It is appreciated that for some of the categories a large number of vessels could not be matched to propulsion engine categories. These vessel categories, such as survey vessels, lift boats, and pipelaying vessels, had relatively small vessel populations; therefore, the overall error in the Category 2 fleet population estimate will be relatively small. According to OMSA most of the Gulf support vessels are crew/supply/support vessels, where engine matches were somewhat better. By disaggregating the fleet into individual vessel types, slightly more accurate Category 2 vessel population estimates were possible, than if the general Category 2 split noted in Table 2-17 was used.

The Category 2 percentages from Table 2-18 were applied to the vessel population data summarized in Table 2-15 to estimate the number of Category 2 vessels in each geographic area using the following equation:

$$OC_i = (CP_i /100)\times VP_i$$

Where:

OC_i = The population of offshore support vessel type i equipped with Category 2 propulsion engines

CP_i = The percentage of offshore support vessel type i equipped with Category 2 propulsion engines (%) – Table 2-18

VP_i = The population of U.S. flagged offshore support vessels for vessel type i – Table 2-15

$_i$ = Offshore support vessel type (e.g., anchor handling, liftboat, pipe laying, supply/crew boats, survey vessels, tugs/tow boats

Results from the application of this equation are presented in Table 2-19.

Table 2-19. U.S. Flagged Category 2 Vessel Populations

Vessel Type	Gulf of Mexico	California	Alaska	Unknown Location	Total
Anchor Handling	19	1	1	---	21
Liftboat	75	4	3	---	82
Pipe/Cable Laying	---	---	---	14	14
Crew/Supply/ Support/Utility Boats	261	13	12	---	286
Survey	---	---	---	24	24
Tugs/Tow	161	8	7	---	176
Total	516	26	23	38	603

2.7.3 Offshore Support Vessel References

American Bureau of Shipping, *2004 Vessel Information*, Houston Texas.

Fairplay, Ltd. 2004, *Lloyd's Register of Ships,* Miami, FL.

Offshore Marine Service Association (OMSA), 2006, *2005 Offshore Vessel Population and Activities*, Harahan, LA.

Oilfield Publications Limited (OPL) 2004, *A-Z of Offshore Support Vessels of the World – Second Edition*, Houston, Texas.

RigZone, *2006 Drilling Rig Regional Summary*. Houston, TX, http://www.rigzone.com/data/

U.S. Department of Interior, Minerals Management Service (MMS). 2006. Oil and Gas Production. http://www.mms.gov/stats/xlsExcel/OCS%20Production-Sep05.xls

U.S. Coast Guard/Office of Information Resources, October 2004, *Merchant Vessels of the United States*, NTIS No PB2004-594361, Springfield, Virginia. U.S. DOI, Minerals Management Service (MMS). 2004b. Gulfwide Emission Inventory Study for the Regional Haze and Ozone Modeling Effort: Final Report. New Orleans, LA. OCS Study MMS 2004-072.

U.S. Department of Interior, Minerals Management Service (MMS). 1995. *Gulf of Mexico Air Quality Study: Final Report, Volumes I-III.* New Orleans, LA. OCS Study MMS 95-0038, 95-0039, and 95-0040.

U.S. Environmental Protection Agency (EPA), December 2004, *Category 2 Vessel Census – Draft Report*, Ann Arbor, MI.

Workboat Publications, 2006, Mandeville, LA.

2.8 Great Lake Vessels and Vessels Not Otherwise Included

The Great Lake Vessels includes a variety of ships that are designed specifically to operate in that area and navigate the lochs of the St. Lawrence Seaway, the Welland Canal, and the St. Clair River. The “Laker” vessel design is also particularly appropriate for the unique regional products that they transport. The Great Lake ship traffic also includes ocean going vessels that are not restricted to operating in the Great Lakes. These vessels transport cargo internationally or to domestic ports on the East coast of the U.S. Given the diverse population of vessels, it became necessary to develop an approach that would capture a wide range of vessel types, several of which were not included in the vessel types discussed above.

- Auto Carriers;
- Break Bulkers;
- Containerships;
- Cruise/Passenger Vessels;
- General Cargo Ships;
- Special Carriers;
- Roll On/Roll Off; and
- Tankers.

2.8.1 Remaining Vessel Data Sources

In order to identify the U.S. flagged vessels operating in the Great Lakes, the U.S. ACE database for self-propelled vessels was queried and boats under 100 tons were removed. The 100 tons threshold was used so as to reduce the overall impact of smaller, Category 1 harbor craft. Fishing, offshore, and self-propelled barges were also filtered out as they are accounted for in other components of this study. Yachts (recreational vessels) were also removed. This left over 500 vessels that have yet to be evaluated to determine their EPA category. Note that this approach not only includes Great Lake vessels, but other vessels that were not captured by the other vessel types included in this study.

This data set of "Remaining Vessels" was merged with ROS by ship name. Matching the vessels using IMO numbers was not practical as the vast majority of these vessels are considered to be part of the domestic fleet and therefore do not travel in international shipping lanes. As their activities are limited to domestic shipping lanes, they would not have an IMO number. Conversely, any ship included in this group of vessels that did not have a Coast Guard identification number was deleted as they were assumed to be a foreign cargo vessel and would have already been included in the U.S. ACE's E&C data set. Once the foreign cargo vessels have been removed the number of Remaining Vessels amounted to 514 ships.

2.8.2 Analysis of Remaining Vessel Data

Where the vessels could be matched to the ROS data, the EPA engine category was determined for each vessel by the volume of the cylinder in liters as described earlier in this report. There were 264 vessels (51%) that could be matched and 250 (49%) that could not be matched. Results of this analysis of remaining vessel engine categories are summarized in Table 2-20. Vessel characteristics data from ABS were evaluated, but no additional vessel matches were identified.

Table 2-20. Summary of Remaining Vessel Engine Classification

Type	Matched Vessels				Unmatched Vessels	Total
	C1	C2	C3	Steam		
Auto	0	0	1	0	0	1
Bulk	1	19	20	18	12	70
Containership	1	2	46	19	7	75
Cruise	0	1	0	0	20	21
General Cargo	5	4	10	3	72	94
RORO	1	1	5	5	20	32
Special Carrier	6	23	7	0	94	130
Tanker	4	6	28	28	25	91
Totals	18	56	117	73	250	514
Percentage of Total	3.5%	10.9%	22.8%	14.2%	48.6%	
Combined total Percentage	51.4%					

As is evident in this table, the matching for general cargo and special carriers is especially poor. Further investigation revealed that many of these vessels had low horsepower levels, indicating that they were more similar to small harbor crafts rather than ocean-going ships. A preliminary analysis using average horsepower is presented in Table 2-21. It should be noted the standard deviation for these averages would be expected to be reasonably large.

Table 2-21. Average HP for Missing Boats

Type	Avg_HP
Bulk	1,534
Cruise	1,582
General Cargo	2,087
RORO	1,830
Special Carrier	1,498
Tanker	1,565
	1,683

Total horsepower data for each vessel were extracted from the U.S. ACE data set and was used to evaluate the vessel engine category for the 250 unmatched vessels. After some analysis, the threshold between Category 1 and Category 2 was determined to be 2,000 HP and the threshold between Category 2 and Category 3 was established at 7,500 HP. Such values were admittedly subjective, as many ships probably had more than one engine and the U.S. ACE did not report the number of propulsion engines.

For the few entries that did have a valid CG Number but no horsepower rating, if deadweight tonnage was over 12,000 short tons the vessel was classified as being Category 3; otherwise the few (less than 15) remaining vessels were classified as Category 1 vessels. These vessels were compared to the other vessel categories and 29 ships were removed because they were duplicates with deep water vessels and tow boats. After these fixes, Table 2-22 summarizes the likely distribution of commercial marine vessels by EPA engine category:

Table 2-22. Allocation of Missing Vessels

Type	C1	C2	C3	STEAM	Total
Auto	0	0	1	0	1
Bulk	6	18	23	18	65
Containership	1	2	53	19	75
Cruise	14	5	1	0	20
General Cargo	36	35	11	3	85
RORO	6	2	18	5	31
Special Carrier	68	43	8	0	119
Tanker	9	7	45	28	89
	140	112	160	73	485
	28.8%	23.1%	33.0%	15.1%	100.0%

Further research is recommended for this category to help refine these estimates as they include a very diverse vessel fleet which poorly matches available vessel specific characteristics.

2.8.3 Remaining Vessels References

Lloyd's Register of Ships, Fairplay, Ltd. 8410 N.W. 53rd Terrace, Suite 207, Miami, FL, 2004.

U.S. Army Corps of Engineers, Waterborne Statistics Division, Waterborne Transportation Lines of the U.S., New Orleans, LA. 2004 http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm

3.0 CATEGORY 2 VESSEL ACTIVITY ASSESSMENT

Category 2 vessel activity is defined as the total horsepower hours associated with each vessel type. Total horsepower hours primarily takes into consideration the days of operation, the vessel horsepower, and appropriate engine load factors. The basic equation used to estimate total horsepower hours for this study is noted below:

$$\text{Thp-hr}_{ij} = VP_i \times UR_i \times EN_i \times HP_{ij} \times DO_{ij} \times 24 \times LF_{ij}$$

Where:

Thp-hr_{ij}	= Total horsepower hours for vessel type i in mode j
VP_i	= Population of vessel type i
UR_i	= Utilization rate for vessel fleet i
EN_i	= Average number of engines on vessel type i
HP_{ij}	= Total Horsepower of vessel type i
DO_{ij}	= Days of operation for vessel type i in mode j
24	= hours per day
LF_{ij}	= Load factor of vessel type i propulsion engines in mode j
i	= Vessel type (i.e., deep water, tow, ferries commercial fishing, Great Lakes, Coast Guard, offshore support, and research)
j	= Mode of operation (i.e., underway cruise, underway idle)

The following section explains the data sources used to quantify these variables and limitations associated with their use. Normal variance is one of the more significant data limitations encountered in estimating total horsepower hours for each vessel type. For example, Category 2 engines can have a horsepower rating from 500 to 8,600. Similarly, engine operating days can vary significantly between the different vessel types. To account for the variance intrinsic in this calculation, a Monte Carlo simulation was used to define the range of possible total propulsion horse power hours. Note, in this Monte Carlo analysis, horsepower and days of operation were varied based on the minimum, maximum, and most likely values. Other variables in the above equation change by vessel type or mode of operation, but they were held constant for a given vessel type in the Monte Carlo analysis.

3.1 Vessel Population and Characteristics

To calculate the total horsepower hours, the Category 2 vessel population used in this calculation was quantified as described in Section 2 of this report and these vessel population values are summarized in Table 3-1. It is recognized that there is some uncertainty associated with these population figures, but the estimates provided in this report represent a reasonable approximation of the Category 2 vessel population.

Engine horsepower data were compiled into the project database during the data collection phase of the project for each vessel type. The horsepower data were reviewed to insure that all data were reasonable. A number of values were considered inappropriate for Category 2 engines and were removed from this analysis. For example, a number of deep water vessels had engines

Table 3-1. Vessel Population and Characteristics

Vessel Type	Vessel Population	Utilization Rate	Equivalent Vessels	Engines		Horsepower			Displace-ment (cu l/cyl)
				Avg #	Total	Min	Likely	Max	
Deep Water Cargo	89	80%	89	2.09	148	1,860	3,603	7,200	10.75
Tow Boats	1,057	74%	782	1.96	1,533	900	2,207	7,420	
Ferries	99	85%	84	2.2	185	865	2,412	4,400	
Commercial Fishing	333	85%	283	1.21	342	1,000	1,924	4,313	10.55
Great Lake	112	85%	95	2.43	231	518	2,505	3,600	11.16
Coast Guard	157	100%	157	2.04	320	1,250	2,289	3,650	
Offshore	603	97%	585	2.22	1,299	740	2,016	7,502	12.05
Research	31	100%	31	1.95	60	600	1,622	3,750	
Total	2,481		2,106		4,118				
Weighted Average		87%		2.08		891	2,227	7,007	11.45

with a horsepower rating less then 500 horsepower were considered too small for a Category 2 engine and were probably a data entry error. Deepwater vessel horsepower data was obtained from one of the major tow boat companies (as the majority of the Deepwater vessels were towboats). Additionally, many of the fishing vessel horsepower ratings pulled into the project database were for total vessel horsepower (possibly including auxiliary engines). Where total horsepower could not be disaggregated into individual propulsion engines, these horsepower ratings were flagged as possibly incorrect values and not used in this analysis. Fishing vessel horsepower data from vessel classification databases were extracted for vessels that were classified as Category 2 vessels and used to characterize the range of horsepower ratings associated with the fishing fleet.

Vessels equipped with Category 2 propulsion engines could have a horsepower rating from 500 to 8,600, therefore, horsepower was considered a variable in the Monte Carlo analysis. The horsepower profile varied by vessel type. Table 3-1 shows the minimum, maximum, and likely values used for each vessel type. The likely values are averages of the valid compiled horsepower ratings.

The number of propulsion engines for different Category 2 vessels were compiled for each vessel type during the data collection phase of this project. The number of engines associated with a specific vessel was not always provided. Thus, the number of propulsion engines by vessel type was evaluated using only the records in the project database that had this data field populated. Some large ferries in the Seattle area have four propulsion engines. Ten of these ferries were identified in this study and are included in the average of engines. Although the numbers of propulsion engines varied between individual vessels, most vessels were equipped with two propulsion engines, therefore, for the purpose of this project the average number of propulsion engines was used, as noted in Table 3-1. Fishing vessels are an exception, for vessels with engines with HP rating greater than 1,500 it was assumed that these ships are equipped with two propulsion engines. For vessels with engines rated below 1,500 it was assumed that those vessels have one engine.

To quantify the total number of annual horsepower hours that Category 2 propulsion engines operate, it was necessary to determine the percentage of the fleet that is active—this is often referred to as the utilization rate. Utilization rates for the different vessel types were obtained from a variety of sources. For example, the publication *Workboat* reports monthly fleet utilization values for a variety of offshore vessel types. For vessels such as ferries, research vessels and U.S. Coast Guard ships, the utilization rate was assumed to be high. The data collection approach used for deep water vessels used for this study captured only those vessels that were actually visiting ports and transferring cargo through customs, vessels that were not active were not included in the dataset, therefore the deepwater vessel data were obtained only for the utilized portion of the deepwater fleet. For towboats, the utilization rate was provided by Doug Schaffer of the American Waterways Operators Association. For fishing vessels and Great Lakes and other vessels, data on vessel utilization was not readily available, instead a default value of 85 percent was used. This value of 85 percent was considered a conservative value because it represents a low utilization rate at which point the fleet is over capitalized and there are a surplus of vessels. Actual utilization rates may be higher, particularly for the Great Lakes and in water around other vessels category, or lower for fishing vessels operating in restricted fishing zones, such as in waters around New England.

Within a vessel type, utilization rates vary relative to geography, changes in the industry and weather events. For example, offshore vessel utilization rates increased significantly between 2001 and 2004 when some of the larger offshore vessel service providers reduced their fleet size, scrapping or putting vessels into storage. Utilization rates further increased in 2005, when two major hurricanes swept through the Gulf of Mexico, destroying 115 platforms and damaging 52 platforms and 183 pipeline segments. These storms increased the demand for offshore support vessel which did not occur in California or Alaska where offshore platforms also exist. The utilization rates used in this study are presented in Table 3-1. These rates were applied to the vessel population estimates to approximate the number of vessels currently operating, referred to in Table 3-1 as the equivalent vessels.

3.2 Operating Days and Load Factors

Vessel operators and groups that monitor vessel activities, tend to track the number of days that vessels operate rather than actual hours. The days of operation were compiled and later converted to hours of operation based on the assumption that a vessel equipped with Category 2 engines can operate 24 hours per day. The hours of operation should be considered conservative; actual hours of operation may be somewhat less.

Operating days for each vessel type were obtained from a variety of data sources. For example, because most of the deepwater vessels equipped with Category 2 propulsion engines were ocean going tugs similar to large tow boats, the same operating days value was used for both categories. The average value reported in Table 3-2 for deep water tugs and tow boats was obtained from one of the larger tug companies. These operation data were adjusted for the Great Lakes vessel category to reflect the period of time when the Great Lakes are frozen and vessel activity are temporarily stopped.

The annual underway days for ferries was obtained from Corbett, J.J., J.J. Winebrake, and P. Woods, An Evaluation of Public-Private Incentives to Reduce Emissions from Regional Ferries: Synthesis Report, pp. 15, Rutgers, State University of New Jersey and University of Delaware, New Brunswick, NJ, 2005. and Winebrake, J.J., J.J. Corbett, C. Wang, A.E. Farrell, and P. Woods, Optimal Fleetwide Emissions Reductions for Passenger Ferries: An Application of a Mixed-Integer Nonlinear Programming Model for the New York-New Jersey Harbor, *Journal of Air and Waste Management, 55* (4), 458–466, 2005.

Ferries operating in Alaska may have a significantly different schedule than vessels operating in the New York harbor area; for example the Alaskan ferries may spend more time at sea than New York harbor ferries. At this time there were insufficient data to account for Alaska's unique ferry operations.

Days of operation for fishing vessels were obtained from a study by Corbett and Koehler, *Considering Alternative Input Parameters in an Activity-based Ship Fuel Consumption and Emissions Model: Reply to Comments by Øyvind Endresen et al. on "Updated Emissions from Ocean Shipping"* (2004). These fishing vessel values may under-represent the activity levels of larger commercial fishing vessels equipped with Category 2 engines as these larger vessels tend to remain at sea for longer periods of time. The Coast Guard provided estimates for the number of days per year that individual vessels operate at sea for the past 8 years, these vessels were matched with the list of Category 2 Coast Guard vessels that was developed as described in Section 2.0. Only those vessels that were match to the Category 2 vessel list were used in this evaluation of days of operation.

The estimate for days of operation for offshore support vessels was provided by James Mcgill, Coast Guard Technical Representative for the National Offshore Safety Advisory Committee (NOSAC). Mr. Mcgill has worked on offshore vessel activities for over 18 years and has considerable insight into their operations. In addition, Dr. Tommy Dickey, Dr. Grace Chang and Frank Spada of the Ocean Physics Laboratory (OPL) at the University of California – Santa Barbara provided the estimates of typical operating schedules for research vessels for which they are familiar. Dr. Dickey, Dr. Chang and Mr. Spada are involved with inter-university research vessel planning and are very knowledgeable about research vessel operations. These vessel operating day data are summarized in Table 3-1.

Operating days can vary significantly for individual vessels depending upon the activity, market force, and local fleet operating characteristics. For these reasons days of operation was considered a variable in the Monte Carlo analysis.

When Category 2 vessels come to port they tend to shut off propulsion engines to reduce cost and use only auxiliary engines to generate electricity, run refrigeration units, or assist in loading and offloading. Therefore, there are no operating days for the propulsion engines while the vessels are hoteling in port.

Vessels such as offshore support vessels, research vessels, fishing boats, and Coast Guard ships spend some time idling at sea. Idling at sea is significant because these vessels operate at lower load factors than they do while cruising at sea. Offshore support vessels are not allowed to come in contact with drilling rigs or platforms. Therefore, they must run their propulsion engines during unloading and loading operations, which run from 4 to 6 hours per trip, based on information provided by Mr. Mcgill. Research vessels also idle at sea depending on the study being implemented. Staff at OPL provided an estimate of the typical period that research vessels spend idling at sea. Fishing boats idle at sea when nets or lines are being hauled in and the catch is moved to storage. Coast Guard vessels idle at sea while inspecting cargo ships or during search and rescue operations. For fishing vessels and Coast Guard ships, idling at sea values were not readily available and were developed based on professional judgment. The period of time that vessels idle at sea are summarized in Table 3-2 and presented in Figure 3-1.

Table 3-2. Operating Days and Load Factors

Vessel Type	Annual Underway			Underway Idling		Annual Port Days	Load Factor		
	Min Days	Likely Days	Max Days	Percentage	Likely Days		Min	Likely	Max
Deep Water Cargo		219		0	0	146	0.10	0.80	0.90
Tow Boats		219		0	0	146	0.10	0.44	0.90
Ferries	152	174	243	0	0	137	0.53	0.68	0.80
Commercial Fishing	250	271	292	30	81	94	0.27	0.70	0.80
Great Lake		136		0	0	229	0.53	0.84	0.84
Coast Guard	29	88	157	20	18	277	0.10	0.80	0.90
Offshore	280	299	317	22	66	31	0.10	0.85	0.87
Research		220		40	88	145	0.10	0.85	0.90

Activity data for days of operation were also used to quantify the amount of time vessels equipped with Category 2 engines spend in port, as presented in Figure 3-1. The time spent in port includes seasonal down time, normal maintenance activities, time spent loading or discharging cargo, or in-port delays associated with weather or vessel traffic. These values should be considered rough approximations; actual time spent underway and in port for specific vessels may be significantly more or less than that shown in Figure 3-1.

Load factors were also derived from a variety of references. In many cases, the data source for load factors was the same as the data source for operating days. Load factors for tugs were provided by Doug Schaffer of the American Waterways Operators. Load factors for ferries were obtained from Corbett, et al (2003). These ferry load factors were considered appropriate for use for Great Lakes vessels. Typical load factors for fishing vessels were obtained from Corbett and Koehler (2004). The load factor estimates for offshore support vessels were provided by James Mcgill and staff at OPL provided load factors for research vessels. In some cases, vessel type specific load factors were not readily available, such as for deep water vessels and Coast Guard ships. Typical load factors found in other EPA documents were used for this study. These load factor estimates should be seen as rough approximations of actual engine loads. It should be

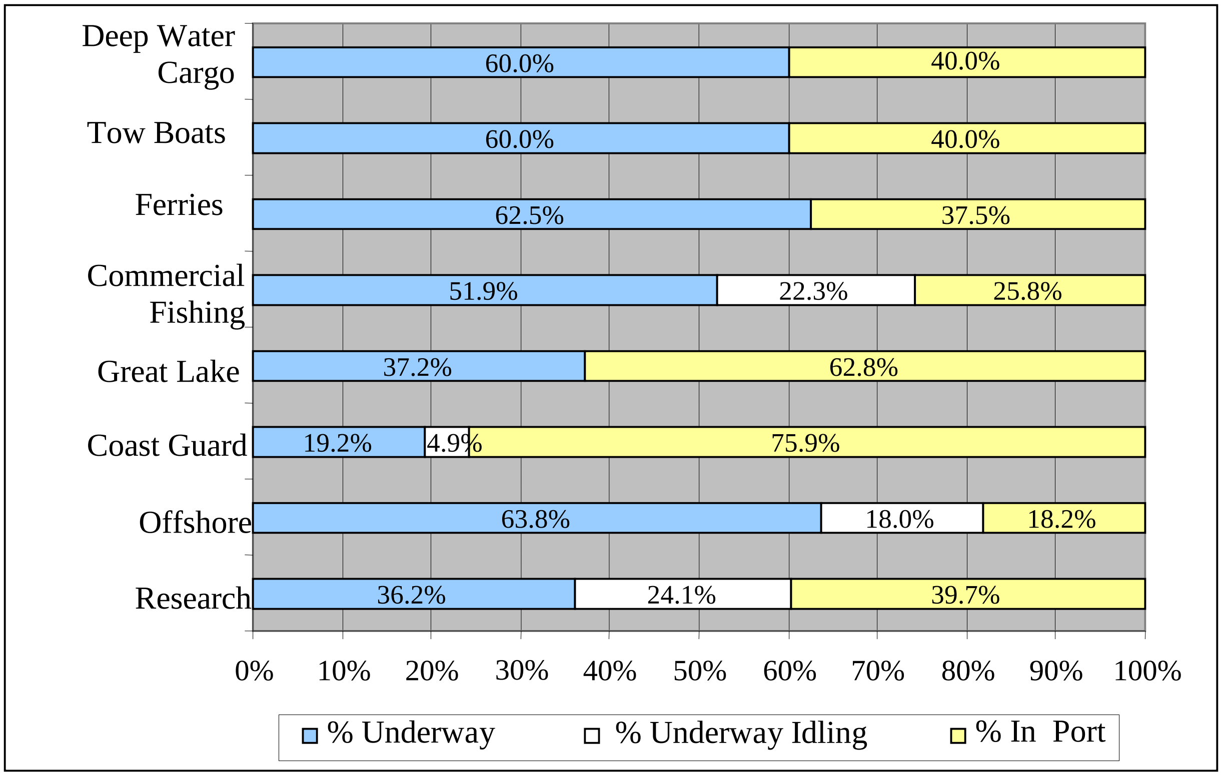


Figure 3-1. Underway, Idling, and In Port Fractions by Vessel Type

noted that the California Air Resource Board has developed load factors for a variety of different vessels that are significantly lower than the load factors used in this study. The California load factors were not used as they include vessels other than Category 2 vessels that have different usage and operation patterns.

As noted earlier, Category 2 vessels do not run their propulsion engines while hoteling in port. During the period in port that vessels are maneuvering, their propulsion engines operate under a wide variety of loads. The period that these larger Category 2 vessels spend maneuvering is not easily documented, and is assumed to be a short period relative to the period of time that Category 2 vessels are underway, therefore, the maneuvering period is not included in this assessment. It is assumed that amount of in port activity and associated emissions from the propulsion engines is small.

When Category 2 vessels are cruising underway, they tend to operate at the most fuel efficient load, which is around 80 percent. Vessels can operate at maximum load levels briefly to negotiate a difficult turn in a river or avoid an accident; again these episodes tend to be relatively short and were not included in this analysis. For the purpose of this study, the likely load factors noted in Table 3-2 were used in the calculation of the horsepower hours while vessels are cruising under way, and the minimum load factors were used while vessels were idling at sea.

The load factor was not considered a variable in the Monte Carlo analysis, though it was varied by vessel type.

3.3 Horsepower Hours

The equation used to calculate horsepower hours is provided in Section 3.0. To use this equation all operating days were converted to hours by assuming that an operating day is equivalent to 24 hours. As mentioned earlier, this equation was applied to a Monte Carlo analysis. The Monte Carlo methodology is a system that incorporates variable data that have a uniform distribution in order to measure the level of uncertainty associated with a calculated value. This is done by running the model repeatedly using values from the identified distribution for each variable. In this project we used a triangle distribution for our variables based on the minimum, maximum and most likely values for horsepower and operation days. These minimum, maximum, and most likely values for horsepower and operating days are presented in Tables 3-1 and 3-2, respectively. Graphic representations of these distributions are also presented in Appendix B. Crystal Ball® software was used in this analysis. The model was set to run 10,000 trials for each vessel type. The distribution of the calculated horsepower hours are presented in Figures 3-2 through 3-9 and summarized in Table 3-3. Summary output statistics are also provided in Appendix B.

As Table 3-3 suggests, given the variance within the input data, the distribution of total horsepower hours is fairly large ranging from ± 26 percent for Deep Water Ships to ± 43 percent for offshore vessels. The sensitivity analysis included in Appendix B, notes that most of the variance is due to the wide range of horsepower ratings that vessels equipped with Category 2 engines represent. The exception to this observation concerns Coast Guard vessels, where the operating days accounted for a similar amount of variance as horsepower rating.

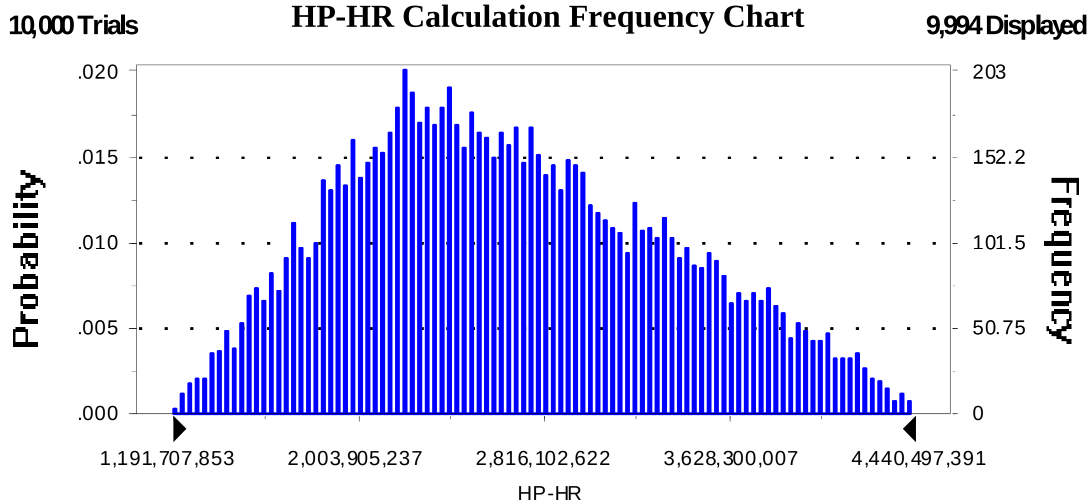
Quantifying the underlying level of uncertainty is important because it helps define the likely range of activity associated with Category 2 vessels. In the future, uncertainty may be able to be reduced by using disaggregated horsepower categories for each vessel type and compiling better days of operation for each of the horsepower categories.

Table 3-3. Category 2 Propulsion Horsepower Hours by Vessel Type

Vessel Type	Mean Values (million hp-hrs)	Standard Deviation (million hp-hrs)
Deep Water	2,666	698
Towboat	7,920	3,020
Ferry	1,464	443
Fishing	3,413	1,143
Great Lakes	1,393	405
Coast Guard	1,441	496
Offshore	27,810	11,933
Research	654	217

As a quality check for this vessel activity assessment, data from the California Air Resource Board's (CARB) Commercial Harbor Craft Survey were compared to data in this study. The comparison showed differences in operating hours and load factors. Some of the differences could be explained due to the different vessels included in each inventory. The CARB study includes all vessel types and sizes, while this report only considered vessels equipped with Category 2 propulsion engines. The CARB study also only considered vessels that operate within surrounding waters and should be considered California-specific data, while this report attempted to capture vessels used throughout the country. An example of this difference is offshore support vessels; California has relatively few of these vessels, while states like Texas and Louisiana have a large number of these vessels because the vast majority of offshore oil platforms operate in the Gulf of Mexico. Considering these observations, it appears that the estimates included in this study, particularly with regard to the load factors, are higher than the CARB data. CARB developed their load factors from fuel usage reported in their survey, as such the estimate of total horsepower hours are higher than similar estimates developed by CARB.

Figure 3-2 - Deep Water Vessel HP-HR Calculation Frequency Chart



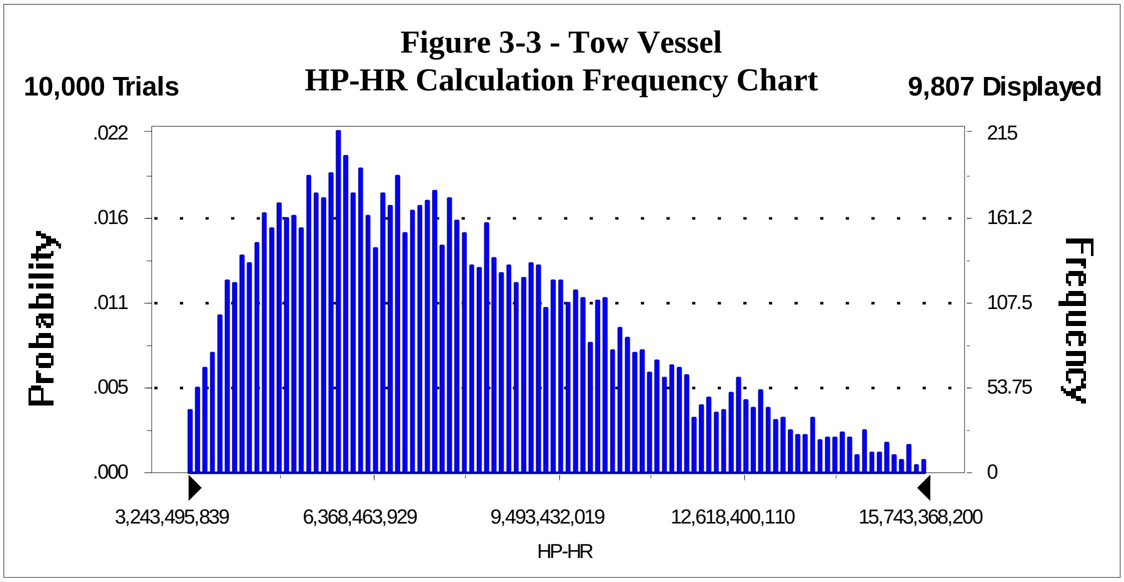


Figure 3-3 - Tow Vessel
HP-HR Calculation Frequency Chart
10,000 Trials
9,807 Displayed
Probability
Frequency
.022
.016
.011
.005
.000
215
161.2
107.5
53.75
0
3,243,495,839
6,368,463,929
9,493,432,019
12,618,400,110
15,743,368,200
HP-HR

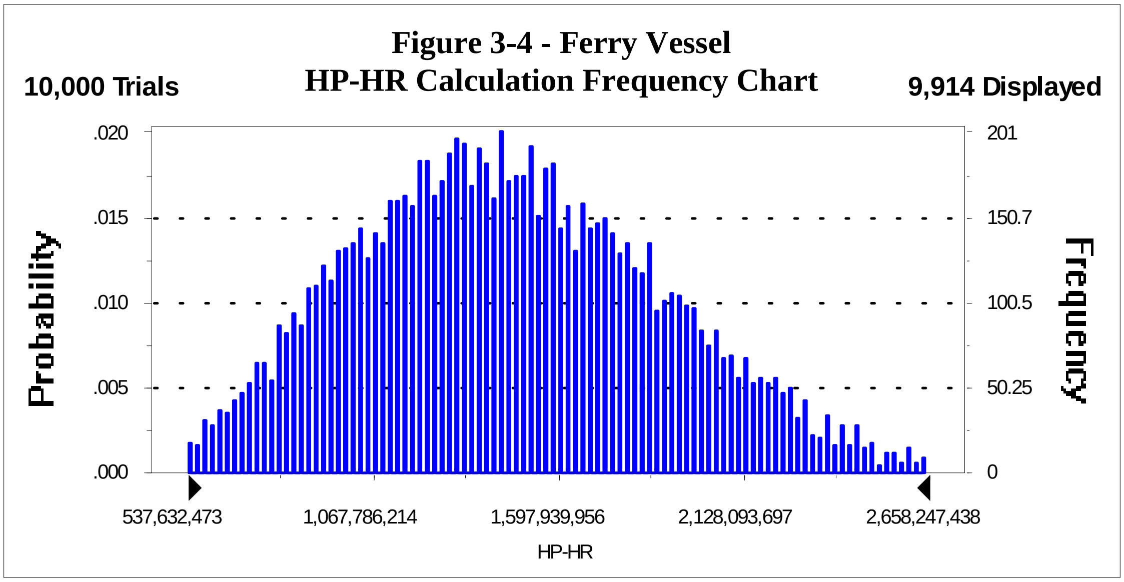


Figure 3-4 - Ferry Vessel
HP-HR Calculation Frequency Chart
10,000 Trials
9,914 Displayed
Probability
Frequency
.020
.015
.010
.005
.000
201
150.7
100.5
50.25
0
537,632,473
1,067,786,214
1,597,939,956
2,128,093,697
2,658,247,438
HP-HR

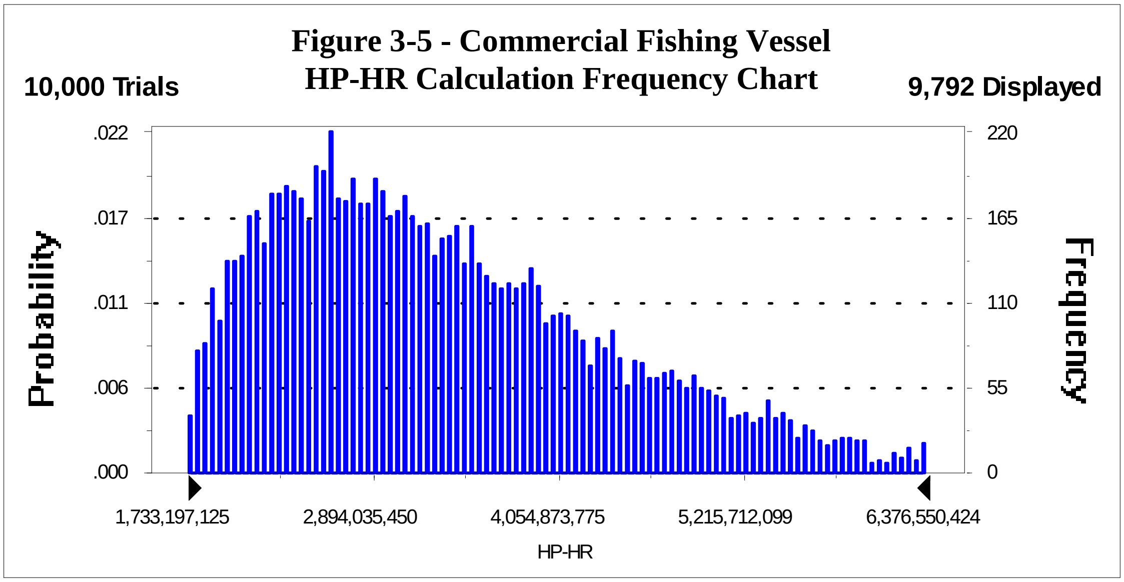


Figure 3-5 - Commercial Fishing Vessel
HP-HR Calculation Frequency Chart
10,000 Trials
9,792 Displayed
Probability
Frequency
.022
.017
.011
.006
.000
220
165
110
55
0
1,733,197,125
2,894,035,450
4,054,873,775
5,215,712,099
6,376,550,424
HP-HR

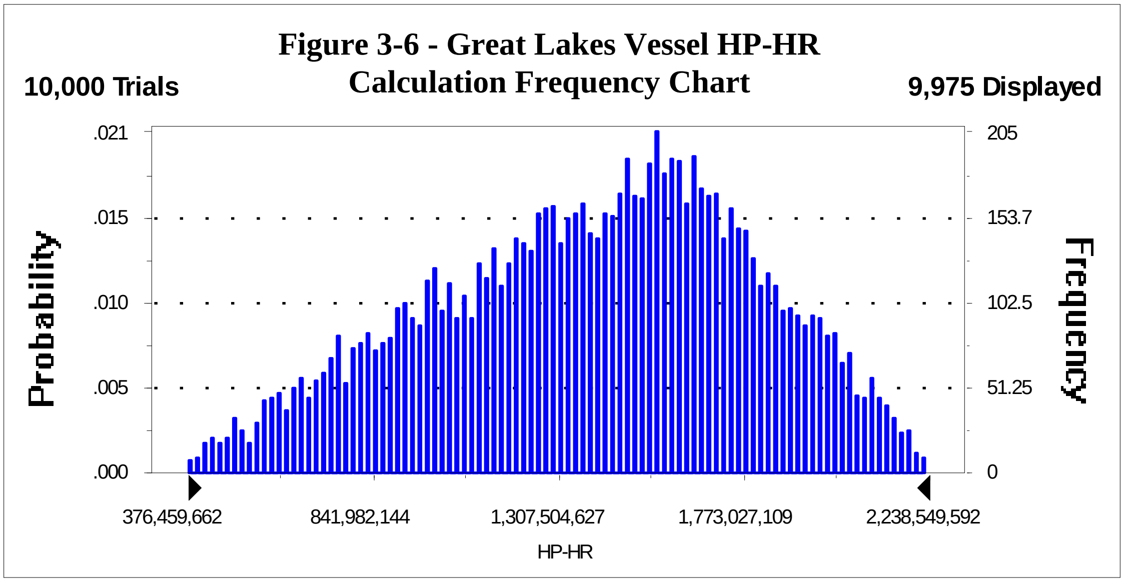


Figure 3-6 - Great Lakes Vessel HP-HR
Calculation Frequency Chart
10,000 Trials
9,975 Displayed
Probability
Frequency
.021
.015
.010
.005
.000
205
153.7
102.5
51.25
0
376,459,662
841,982,144
1,307,504,627
1,773,027,109
2,238,549,592
HP-HR

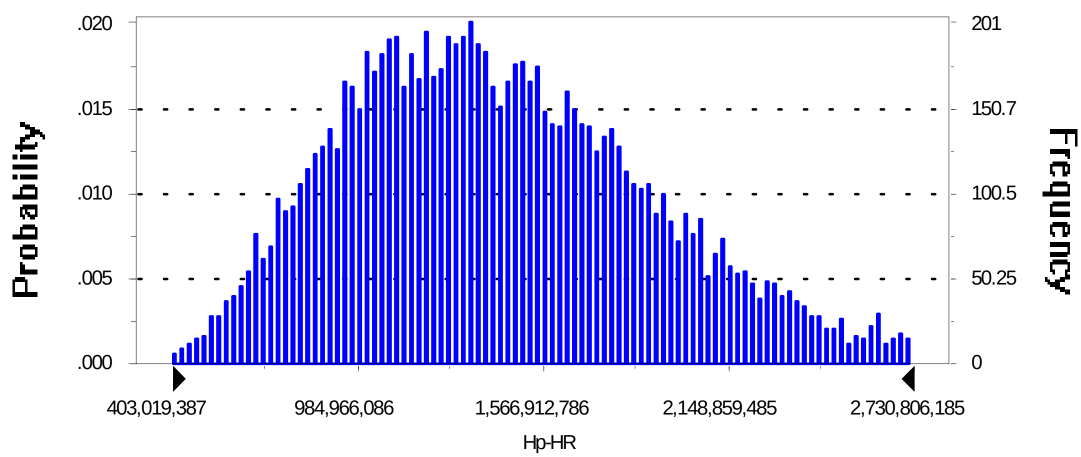


Figure 3-7 - Coast Guard Vessel
HP-HR Calculation Frequency Chart

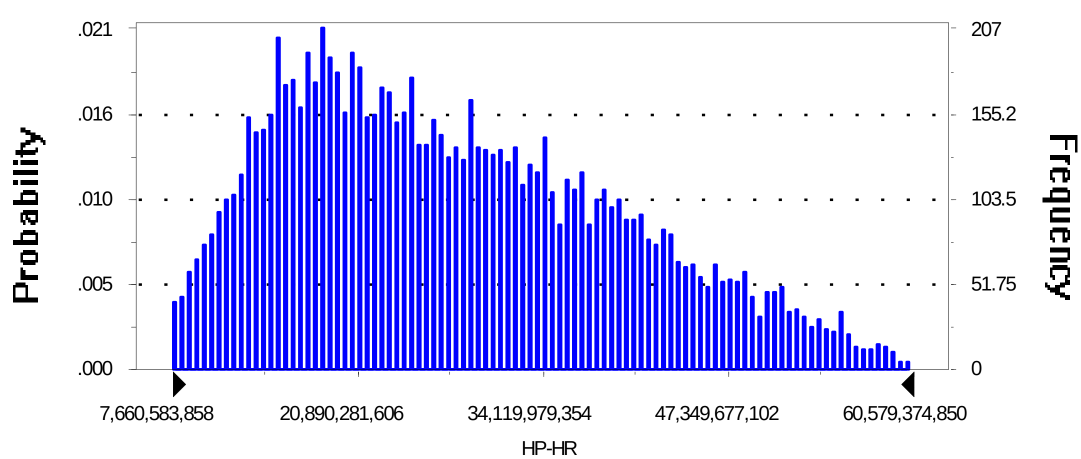
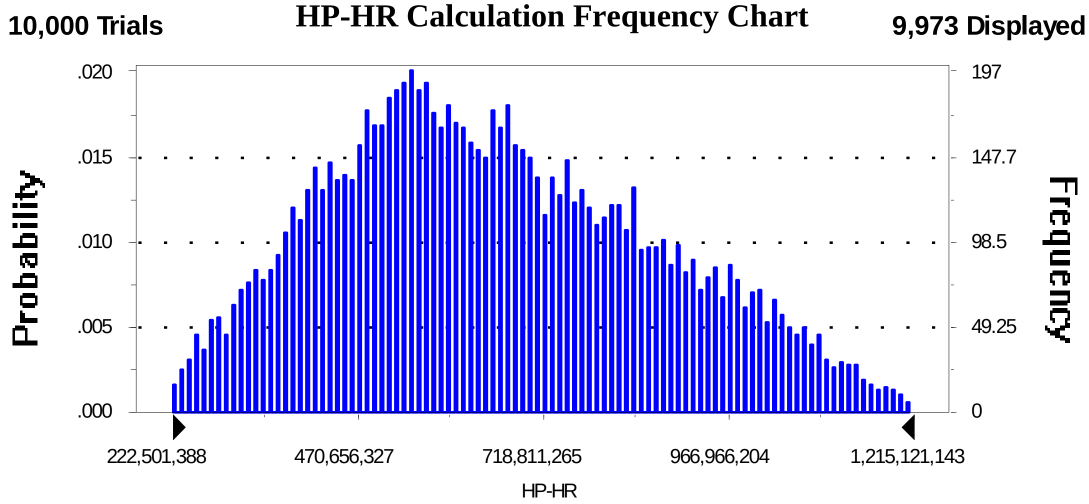


Figure 3-8 - Offshore Vessel
HP-HR Calculation Frequency Chart

Figure 3-9 - Research Vessel
HP-HR Calculation Frequency Chart



3.4 Vessel Activity References

American Waterways Operators, call with Roger Chang and Mr. Doug Scheffler, April 2006.

Corbett, J.J., J.J. Winebrake, and P. Woods, An Evaluation of Public-Private Incentives to Reduce Emissions from Regional Ferries: Synthesis Report, pp. 15, Rutgers, State University of New Jersey and University of Delaware, New Brunswick, NJ, 2005.

Corbett, Jim and Horst Koehler, *Considering Alternative Input Parameters in an Activity-based Ship Fuel Consumption and Emissions Model: Reply to Comments by Øyvind Endresen et al.on "Updated Emissions from Ocean Shipping"*, Journal of Geophysical Research, Vol 109, D23303 (2004).

Ocean Physics Laboratory (OPL), University of California - Santa Barbara, call with Roger Chang and Dr. Tommy Dickey, Dr. Grace Chang, and Frank Spada, April 2006.

American Public Transportation Association, Public Transportation Fact Book – Ferry Boats, http:www.apta.com/rearch/stats/factbook/index.cfm. May 8, 2006.

U.S. Coast Guard /National Offshore Safety Advisory Committee, call with Richard Billings and James Mcgill, April 2006.

Winebrake, J.J., J.J. Corbett, C. Wang, A.E. Farrell, and P. Woods, Optimal Fleetwide Emissions Reductions for Passenger Ferries: An Application of a Mixed-Integer Nonlinear Programming Model for the New York-New Jersey Harbor, *Journal of Air and Waste Management*, *55* (4), 458–466, 2005.

4.0 IN-PORT / AT-SEA SPLITS

4.1 Introduction

Vessel activities can be divided between in-port and at-sea activities. The in-port activities include approaching or departing the port, maneuvering within the port area and between terminals, and hoteling operations while cargo is being removed or added to the vessel. At-sea activities are dominated by underway operations. For the purposes of this study the port area includes the area within a 25 mile radius from the outer edge of the harbor where vessels dock at terminals and shift cargo. This definition of a port area works reasonably well for coastal ports, but can be problematic for inland ports where adjacent ports are less than 25 miles away, such that the port areas conflict. For Category 2 vessels, that tend to shut off their propulsion engines while at dock, in port propulsion engine activity is limited to time spent maneuvering up to and within the port area. The data obtained to estimate propulsion engines operating within the port area were all in terms of time spent maneuvering. It should be noted that actual maneuvering times vary significantly between individual ports.

The Category 2 vessel list primarily includes medium to large commercial vessels and as such this listing excludes certain Category 1 vessel types such as smaller excursion vessels and private recreational boats.

4.2 In-Port / At-Sea Methodology

In developing the in-port / at-sea splits for Category 1 and Category 2 vessels, each vessel type was evaluated separately as the operations for each vessel type can be significantly different. The data sources used to estimate the splits also varied by vessel type and are discussed in greater detail in Section 3 of this report. For most vessels, in-port propulsion engine operations are limited to the amount of time vessels spending maneuvering. While at dockside auxiliary engines are used to maintain power or assist in the loading and unloading. Operation of these auxiliary engines was not included in this evaluation.

The period of time that propulsion engines were involved in in-port maneuvering was estimated for each vessel type and converted to a percentage based on a typical vessel's total propulsion operating hours. This value was used to estimate the at-sea percentage using the following equation:

$$AS_i = (1-(IP_i / TH_i)) \times 100$$

Where:

AS_i = At-sea hours of operation for vessel type i
IP_i = In-port hours of operation for vessel type i
TH_i = Total vessel hours of operation for vessel type i
i = Vessel type i (e.g, tug/towboat, commercial fishing vessel, offshore support vessel)

For many of the vessel types included in this study, there are sub-types that have significantly different operations. For example, assist tugs help bring larger vessels into port, so their in-port activities are significantly more than line haul and ocean going tugs that shift barges from port-to-port and operate their propulsion engines within a port for relatively short periods of time. Where possible, this evaluation was preformed at the sub-vessel type level. To calculate a weighted average for the vessel type that takes into consideration differences at the sub-type level the fractions were weighted relative to the vessel populations using the following equations:

$$WAS_i = \sum AS_{ij} \times ST_{ij}$$

Where:

WAS_i = Weighted at-sea split for vessel type i;
AS_{ij} = At-sea percentage for vessel type i and subtype j;
ST_{ij} = The percentage of the vessel population for type i and subtype j;
i = Vessel type (e.g, tug/towboat, commercial fishing vessel, offshore support vessel);
j = Vessel subtype (e.g., ocean going tug, line haul tug, assist tug, dredge support tugs).

These procedures were repeated for in-port weighted splits. The in-port and at-sea splits were checked to ensure that they summed to 100 percent.

Activity data at the subtype level would have been preferred for weighting purposes, but were not available at the vessel sub-type level. The calculations by vessel subtype are noted in Appendix C for Category 1 vessels and Appendix D for Category 2 Vessels.

It should be noted that innocent passage of vessels through a port area without stopping was not considered in this assessment. Vessels at-sea are to be allocated relative to shipping lane segment and therefore will be included in the overall calculation, but were not handled as an in-port activity.

4.3 Vessel Type Overview

The following sections discuss the vessel population data used in this analysis and the basis for the in-port / at-sea split for each vessel type.

4.3.1 Tugs/Towboats

The Category 2 Vessel Census and Activity Report quantified that there are approximately 3,164 Category 1 tugs and towboats and 1,057 Category 2 tugs and tow boats.

For in-port maneuvering, the European Commission report estimate 300 annual hours was used. This value combined with the assumption that propulsion engines for these vessels operate 2,000 hours per year, as noted in the CARB harbor study to provide an in-port fraction of 15%. Assist tugs and support vessels for dredging activities mostly occur within or near ports, so their in-port fractions were adjusted to reflect the increase in the in port activity.

4.3.2 Commercial Fishing

As noted in Section 2.2, Commercial fishing is dominated by 29,346 smaller crafts equipped with Category 1 propulsion engines; many of these are smaller fishing boats and charter fishing operations. The Category 2 commercial fishing vessel population noted in Section 2.2 was 333 vessels.

The commercial fishing in-port activity was obtained from the CARB harbor study; 62 % of smaller fishing vessels (Category 1) and 5% of larger fishing vessels (Category 2) propulsion engine operations occur within the port area. The nature of the Category 1 fishing vessels represent a mixture of input maneuvering and active fishing operations within the 25 mile area considered to be the port.

4.3.3 Offshore Support Vessels

The Category 2 vessel population was presented in Section 2.7 of this report. The report also noted that the Category 1 fleet was approximately 87% of the Category 2 value; therefore the Category 1 vessel population was estimated for each offshore category based on this assumption.

To estimate time spent maneuvering in-port the assumption in the European Commission report that support vessels require two hours per trip and other offshore vessels require 0.5 hours was used. The estimate for typical number of trips for offshore vessels was derived from information provided from the Coast Guard's offshore vessel consultant. Typically an offshore support vessel cycle to and from the ports is between one and two days.

4.3.4 Ferries

Section 2.4 noted that there are 508 Category 1 and 99 Category 2 ferries. The in-port value of 65% was obtained from the ARB Harbor study. It was assumed that smaller Category 1 ferries probably spend more time operating in-port than the Category 2 vessels, so the in-port fraction was increased to 80%.

4.3.5 Deep Water Vessels

The vast majority of deep water vessels are larger Category 3 vessels, but Section 2.5 identified 23 Category 1 and 45 Category 2 vessels. These deep water vessels are primarily oceangoing tugs and general cargo vessels that go through U. S. Customs entrance and clearance procedures. Given their relative size these vessels are probably visiting adjacent countries such as Canada, Mexico, other Central and South American countries and the Caribbean islands.

It was assumed that the majority of these vessels probably operate on a seven day cycle with five days at-sea followed by two days in-port loading and unloading, providing a rough estimate of 52 trips per year. Many of these vessels shut off their main propulsion engines while hoteling at dockside. The European Commission report estimates that such vessels maneuver in-port an average of 1.1 hours per trip. Assuming these vessels' propulsion engines operate approximately 6,240 hours per year then the in-port /at-sea fraction for the propulsion engines is approximately 1% / 99%, respectively.

4.3.6 Research

For research vessels, 107 Category 1 vessels and 31 Category 2 vessels were identified in Section 2.6 of this report.

Data from the European Commission report were used that suggested that research vessels maneuver in-port between 0.5 (likely to be Category 1 vessels) and 1.3 (Category 2 vessels) hours per port trip. Activity data from the research vessel database were evaluated and it was estimated that Category 1 vessels make 27.5 trips per year and Category 2 vessels make 16. Assuming an annual hours of operation of 5,280 as provided in the Category 2 Vessel Census and Activity report, this provides an in-port fraction of 0.3 % for Category 1 vessels and 0.4% for Category 2 vessels. These values were rounded to 1% to reflect the relative accuracy of assumptions used in this calculation.

4.3.7 Great Lakes and Other Vessels

The Category 1 and 2 vessel population estimates were taken directly from Section 2.8 of this report. It was assumed that the Great Lakes vessels would be similar to deepwater vessels so their in-port/at-sea split was 1% / 99%.

4.3.8 Government Vessels

The Coast Guards web site provided an estimate of 291 smaller diesel powered patrol boats which are likely to be Category 1 vessels. Unfortunately the list did not include navigational aid vessels or harbor tugs and as such, this estimate for Category 1 Coast Guard boats should be considered an underestimation of the vessel population; the actual Category 1 vessel count is probably significantly higher than the value reported here.

There are also a number of pilot boats, police vessels, and firefighting boats that probably are equipped with Category 1 engines, but were not evaluated in this effort.

For the purpose of the assessment, it is assumed that patrol boats and buoy tenders operate in and around the harbor area. The bigger cruisers and smaller icebreakers probably maneuver to and from the dock, but once at the dock, their main propulsion engines are shut off so their in-port fraction is much less than patrol boats and buoy tenders.

4.4 Summary

Appendix C compiles the calculations developed for the Category 2 vessel types in-port/at-sea splits, while Appendix D compiles the calculations for the Category 1 vessel in-port/at-sea splits. Table 4-1 below summarizes the in-port and at-sea activity splits by vessel type for vessels equipped with Category 1 and 2 propulsion engines. Averages were provided by vessel type and aggregated averages for each vessel category for state and local agencies to use to estimate vessel activity where detailed data are not readily available.

Table 4-1. Average In-Port and At-Sea Fraction by Vessel Type for Vessels Equipped with Category 1 and 2 Propulsion Engines

Vessel Type	In-Port	At-Sea
Category 1		
Towboats	15%	85%
Fishing	62%	38%
Offshore	4%	96%
Ferries	80%	20%
Deepwater	1%	99%
Research	1%	99%
Great Lakes	1%	99%
Government	95%	5%
Average	**32%**	**68%**
Category 2		
Towboats	17%	83%
Fishing	5%	95%
Offshore	4%	96%
Ferries	65%	35%
Deepwater	1%	99%
Research	1%	99%
Great Lakes	1%	99%
Government	59%	41%
Weighted Average	**10%**	**90%**

The averages developed for Category 1 vessels were a straight average based on vessel type data. The straight average was considered a more useful value for state and local agencies as weighted average had a significant bias toward fishing vessels as they represent a very large portion of the Category I fleet. It is recognized that fishing vessel activity is not uniformly distributed through out the United States, furthermore activity levels can vary significantly from year-to-year for a specific port. If vessel population was used as a weighting factor that the aggregated weight factor for Category 1 vessels would be 6 percent for in-port activity and 94 percent for at-sea activities, while Category 2 vessels the in-port fraction would be 10 percent for in-port activities and 90 percent for at-sea. It is recommended that port specific estimates be developed for ports with significant Category 1 commercial fishing vessel traffic.

For Category 2 vessels, weighted averages were calculated based on activity level of each vessel type as estimated in the Category 2 Vessel Census and Activity report using the following equation:

$$AAS_i = \sum WAS_i \times ST_i$$

Where:

AAS_i = Activity weighted at-sea split for vessel type i;
WAS_i = Weighted at-sea percentage for vessel type i;
ST_i = The percentage of activity associated with vessel type i;
i = Vessel type (e.g, tug/towboat, commercial fishing vessel, offshore support vessel);

The data used for these calculations are provided in Appendix C. These steps were repeated to estimate the in-port fractions. In-port and at-sea values were checked to insure that they sum to 100 percent.

The uncertainly associated with the Category 1 data is much greater than the uncertainty associated with the Category 2 data and as such the Category 1 in-port and at-sea values should be viewed as rough approximation of the actual in-port / at-sea activity.

It should be noted that these values are intended for use in developing national activity data sets and as such do not necessarily reflect in-port and at-sea splits for a specific port. Where a port has non-typical traffic patterns such as a large amount of fishing boat traffic or offshore support vessel traffic, in-port and at-sea splits should be developed for these ports using local data.

4.5 References

California Air Resource Board, *2002 Statewide Commercial Harbor Craft Survey – Draft Report*. December 2003.

European Commission, *Quantification of Emissions From Ships Associated with Ship Movements between Ports in the European Community*. Brussels, Belgium. 2002.

Fairplay, Ltd *Lloyd's Register of Ships*. 8410 N.W. 53rd Terrace, Suite 207, Miami, FL. 2004.

U.S. Army Corps of Engineers / Waterborne Statistics Division, *Vessel Clearance and Entrance Data*. New Orleans, LA. 2006.

U.S. Coast Guard official website - www.uscg.mil/datasheet/dataindx.htm

U.S. Coast Guard /National Offshore Safety Advisory Committee, call with Richard Billings and James Mcgill, April 2006.

U.S. Department of Transportation, Bureau of Transportation Statistics, *National Ferry Database*. 2000.

University National Oceanographic Laboratory System website - www.unols.org/info/vessels.htm

U.S. Environmental Protection Agency, May 15, 2006, *Category 2 Vessel Census and Activity–Draft Report*, Ann Arbor, MI.

5.0 CATEGORY SPATIAL ALLOCATIONS

This section discusses how the in-port and at-sea components were spatially allocated to county and federal waters for Category 2 vessels. It is anticipated that spatial allocations for Category 1 vessels may be significantly different than the allocation developed in this section for Category 2 vessels. County waters include all navigable waterways within and surrounding all 50 states, including Hawaii and Alaska. In some of the figures Hawaii and Alaska are not shown due to space limitations or the source category is not associated with these states (e.g., Great Lakes Vessels, Tugs and Towboats). Federal Waterways extend from the boundary of the state waters 200 miles out to sea, including the area around Hawaii.

In general, the port activities were spatially allocated to individual ports based on surrogate data such as the amount of cargo handled for tow boats, deepwater cargo vessels and Great Lakes vessels; fish catch processed for commercial fishing boats; and the vessel's home port for offshore, research and government vessels, and ferries. A complete list of ports included in this study is provided in Appendix E. At-sea activities were spatially allocated to shipping lanes for tow boats, deepwater vessels, and Great Lakes vessels; fishing zones for commercial fishing; Coast Guard districts for Coast Guard vessels; active offshore oil platforms for offshore support vessels; and research areas for research vessels. The allocation approaches for each vessel type are summarized in Table 5-1 and discussed in greater detail in Section 5.1.

Table 5-1. Summary of Spatial Allocation Approaches Used

Memo Section	Vessel Type	In-Port Approach	At-Sea Approach
2.1	Tugs/Towboats	Cargo handled at individual ports	Ship traffic on commercial shipping lanes
2.2	Commercial Fishing	Annual commercial landings at individual fishing ports	State and federal waters by fishing zone
2.3	Offshore Support Vessels	Equally to ports that provide services to offshore support vessels	Active lease blocks based on number of offshore oil platforms
2.4	Ferries	Home port associated with individual vessels	Same county as home port
2.5	Deepwater	Ports calls for individual vessels at individual ports	Individual commercial shipping lanes
2.6	Research	Ports that individual vessels visit	Distributed to research districts
2.7	Great Lakes & Others	Cargo handled at individual ports in the Great Lakes area	Ship traffic on Great Lakes commercial shipping lanes
2.8	Government	Home port of individual vessels	Distributed to Coast Guard districts

The in-port and at-sea activities were mapped using Geographic Information Systems (GIS) tools. County and federal boundaries were developed and mapped on top of the port and underway activities to allow for aggregation of activity estimates to the county level. The GIS map projection used for this project was the North America Albers Equal Area Conic projection. Figure 5-1 summarizes the approach used to disaggregate national activity data to individual county and federal waters.

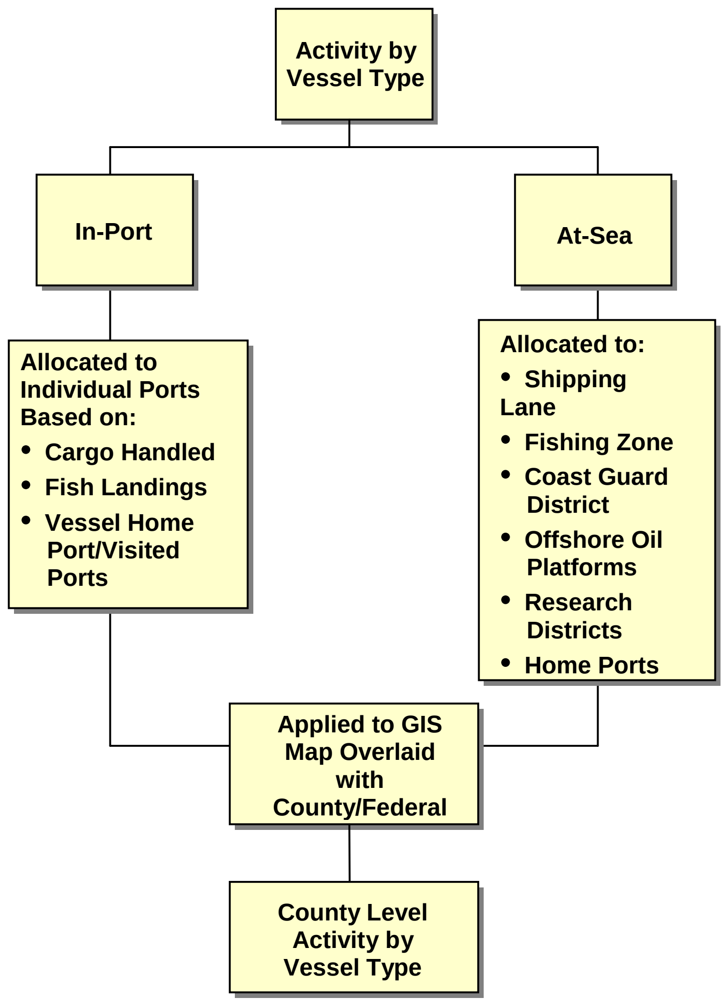


Figure 5-1. Overview of Approach Used to Develop and Spatially Allocate Annual Activity of Vessels Equipped with Category 2 Engines

The county waterway boundary file was developed based on Census Department's county maps. To disaggregate federal waters into smaller grids, the Department of Interior's Mineral Management Services' (MMS) "lease blocks" were used. This lease block system of geographic blocks is used to identify offshore locations for the installation of offshore oil platforms. These blocks extend from the state waters boundary to 200 miles out and include all U.S. coastal waters, except surrounding the Hawaiian Islands. As there are no lease blocks associated with the Hawaiian Islands, a single area that extends 200 miles from the shore was used. Each block has a unique identifier, which vessel activity data can be linked to in the GIS metafile. The MMS lease block shape file is readily available from MMS's Web site.

Each vessel type was handled separately in order to apply the most appropriate spatial surrogate to the vessel's activity. Section 5.1 discusses the surrogates used for each vessel type. The surrogate data are the latest publicly available data. This section also presents the derived in-port and at-sea activity maps. Section 5.2 summarizes the results and provides national maps that include all vessel activities.

5.1 Vessel Type Overview

The following sections discuss the approach used to spatially disaggregate the national or regional activity to individual ports, shipping lanes, counties, or federal blocks. In general, activity is disaggregated by using an appropriate surrogate. Use of surrogate data intrinsically has limitations and bias because the actual activity level may be greater than or less than that estimated using the surrogate. These limitations are noted in each section.

5.1.1 Tugs/Towboats

In-Port – Tugs/Towboat

Tug and towboat activity in the port area was estimated by apportioning the national tug/towboat in-port hours of operation to individual ports based on the amount of cargo handled at the designated port. The port cargo handling data were obtained from the U.S Army Corps of Engineers and included cargo data for the top 150 ports.

The following equation was used for this allocation approach:

$$TTip_a = HOttip \times CH_a / CH_n$$

Where:

$TTip_a$ = Estimate of 2004 activity for tugs and towboats for port a (hp-hrs/year)
$HOttip$ = National estimate of 2004 in-port hours of operation for tugs and towboats (hp-hrs/year)
CH_a = Amount of cargo handled at port a in 2004 (tons per year)
CH_n = Amount of cargo handled at all ports in 2004 (tons per year)
a = Port a

The county in which each cargo port is located was identified for each cargo port included in this study. County FIPS codes were matched to each county and retained in the project database. Three ports, Matagorda Ship Channel, Duluth, and Camden/Gloucester, crossed county or state lines, so their activity was split equally between the adjacent counties. Results of this approach are presented in Figure 5-2 and the associated data are included in the project database.

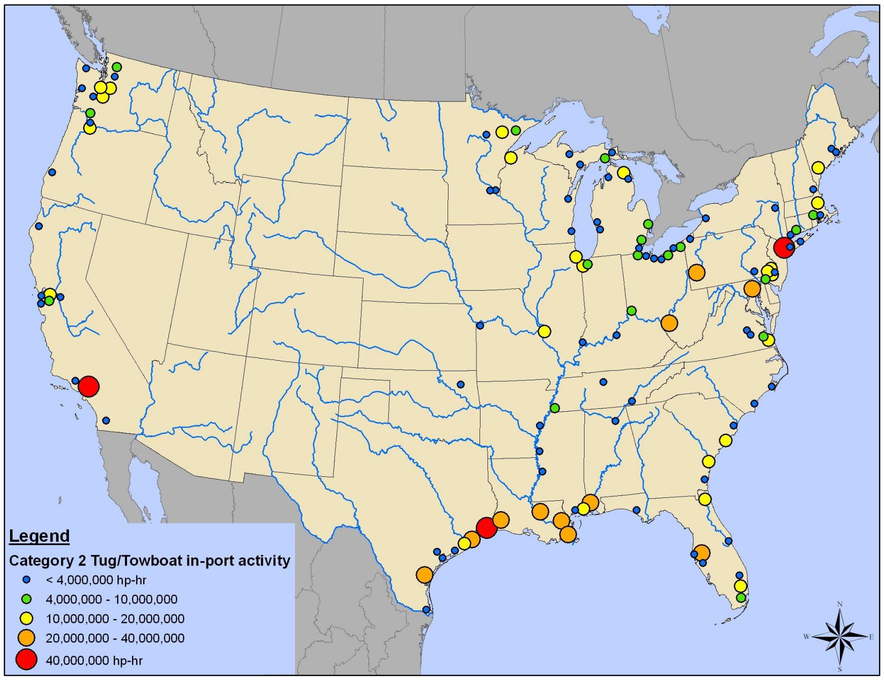


Figure 5-2. Tug/Towboat In-Port Activity

At-Sea – Tugs/Towboats

Tug and towboat activity while at sea was estimated by apportioning the national tug/towboat at-sea hours of operation to individual shipping lanes based on the amount of cargo traffic associated with the shipping lane segment. The shipping lane GIS data were obtained from the Department of Transportation and the cargo traffic data were obtained from the U.S. Army Corps of Engineers.

The following equation was used to allocate tug and towboat at-sea activity:

$$TTas_i = HOttas \times CT_i / CT_n$$

Where:

$TTas_i$ = Estimate of 2004 activity for tugs and towboats for sea shipping lane segment i (hp-hrs/year)
HOttas = National estimate of 2004 at-sea hours of operation for tugs and towboats (hp-hrs/year)
CT_i = Amount of cargo traffic for at-sea shipping lane segment i for 2004 (tons)
CT_n = Amount of cargo traffic for all at-sea shipping lanes for 2004 (tons)
i = At-sea shipping lane segment i

Some of the tugs and towboats included in this study are assist tugs or fleeting tugs that remain in port longer than other tugs such that actual activity may be slightly overestimated along shipping lanes and underestimated near major ports. Results of this approach are presented in Figure 5-3 and the associated data are included in the project database.

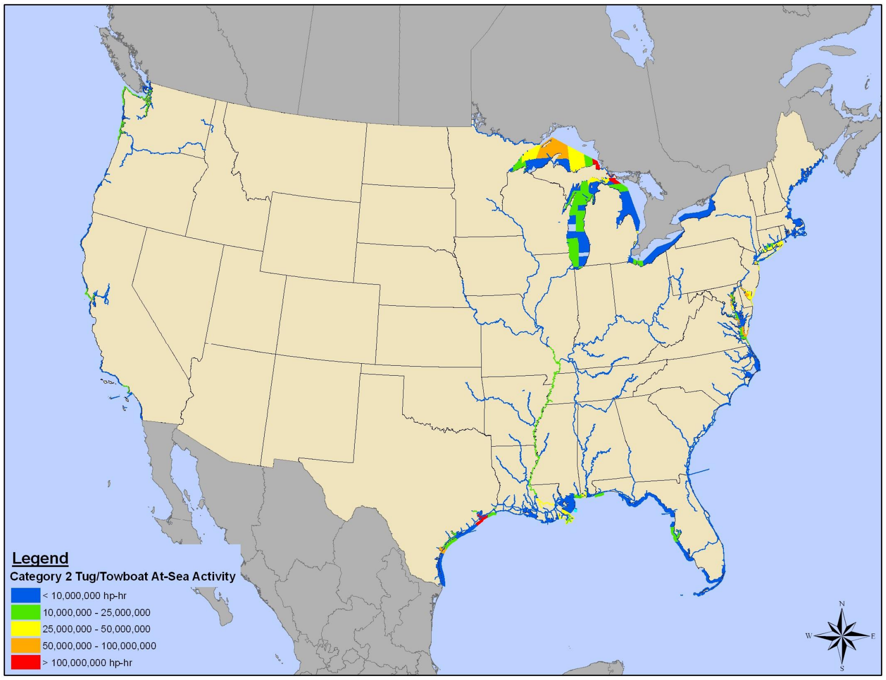


Figure 5-3. Tug/Towboat At-Sea Activity

5.1.2 Commercial Fishing

In-Port – Commercial Fishing

Commercial fishing activity in the port area was estimated by apportioning the national commercial fishing in-port hours of operation to individual ports based on the annual commercial fishing landing statistics at a designated port. The fish landing data include 715 fish species handled at 97 ports. The annual commercial fish landings data were obtained from the National Marine Fisheries Service.

The following equation was used for this allocation approach:

$$CFip_a = HOcfip \times FH_a / FH_n$$

Where:

$CFip_a$ = Estimate of 2004 activity for commercial fishing for port a (hp-hrs/year)

HOcfip	= National estimate of 2004 in-port hours of operation for commercial fishing (hp-hrs/year)
FH_a	= Annual commercial fish landing at port a in 2004 (tons per year)
FH_n	= Amount of fish handled at all ports in 2004 (tons per year)
a	= Port a

The county was identified for each fishing port included in this study. County FIPS codes were matched to each county and retained in the project database.

Category 2 vessels tend to be large commercial fishing ships and may not be visiting all 97 ports included in the National Marine Fisheries Service data. Thus, actual activity at major ports may be underestimated, while activity at smaller ports may be overestimated. Results of this approach are presented in Figure 5-4 and the associated data are included in the project database.

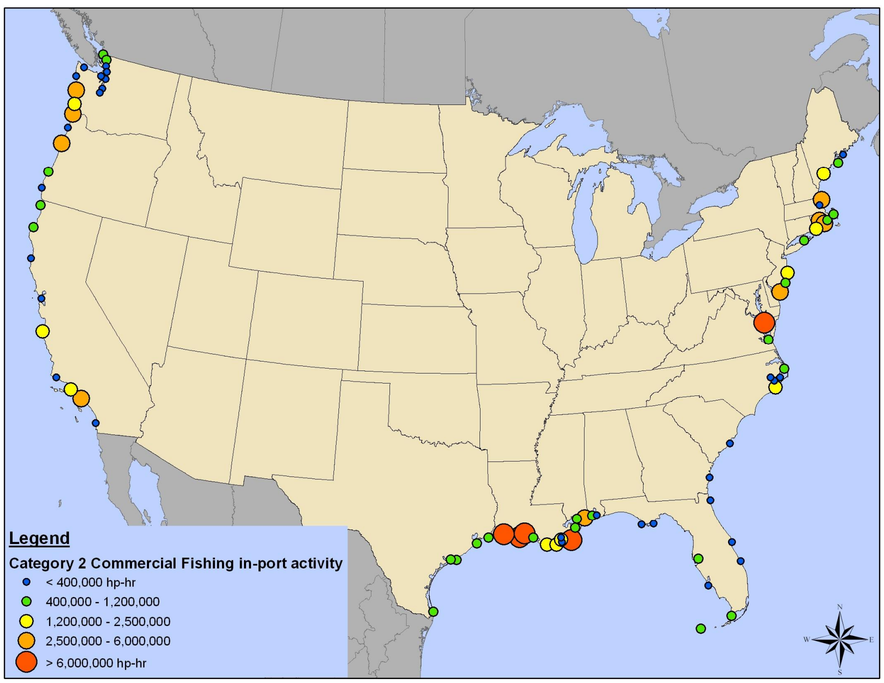


Figure 5-4. Commercial Fishing In-Port Activity

At-Sea – Commercial Fishing

Commercial fishing activity while at sea was estimated by apportioning the national commercial fishing at-sea hours of operation to state or federal fishing waters based on the amount of fish catches associated with each area. The at-sea fish catch data were obtained from National Marine Fisheries Service.

The following equation was used for this allocation approach:

$$CFas_j = HOcfas \times FC_j / FC_n$$

Where:

$CFas_j$ = Estimate of 2004 activity for commercial fishing at sea for fishing area j (hp-hrs/year)
$HOcfas$ = National estimate of 2004 at-sea activity for commercial fishing (hp-hrs/year)
FC_j = Amount of fish caught for fishing area j in 2004 (tons)
FC_n = Amount of fish caught for all fishing areas for 2004 (tons)
j = At-sea fishing area j

Some fishing areas restrict or ban fishing and these areas were not identified by the National Marine Fisheries Service and could not be considered in this analysis. Thus; at-sea activities in these areas may be overestimated and activity levels in other areas may be slightly underestimated. Results of this approach are presented in Figure 5-5 and the associated data are included in the project database. This map clearly notes a reduction in commercial fishing activities around the areas in the Gulf where oil platforms are operating.

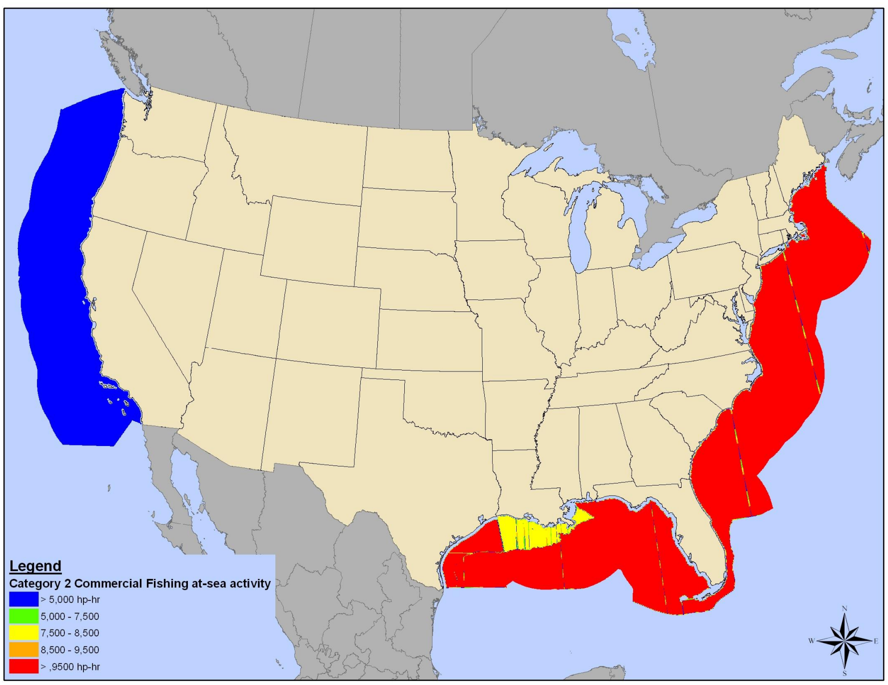


Figure 5-5. Commercial Fishing At-Sea Activity

5.1.3 Offshore Support Vessels

In-Port – Support Vessels

Twenty ports were identified that provide services to offshore support vessels. Support vessel activity in the port area was estimated by apportioning the regional offshore in-port hours of operation equally to individual ports. For the Gulf of Mexico, listing of offshore support vessel ports was provided by Tidewater, one of the larger offshore support vessel companies. As most of the offshore platforms in Alaska are in the Prudhoe Bay area, all Alaskan offshore vessel activity was assigned to the port of Barrow. For California, most of the oil platforms are located off the coast of Ventura and Santa Barbara counties, therefore, port activities were split equally between the ports of Ventura and Santa Barbara.

The following equation was used for this allocation approach:

$$OSip_a = HOosip / OSp_r$$

Where:

- $OSip_r$ = Average activity for an offshore support vessel for port in region r (hp-hrs/year-port)
- $HOosip_r$ = Estimate of 2005 in-port hours of operation for offshore support vessels in region r (hp-hrs/year)
- OSp_r = Number of ports in region r
- r = Region r (Gulf of Mexico, Alaska, and California)

These port averages were assigned to each port in the region. The county was identified for each offshore support vessel port included in this study. Note some counties have more than one port, individual ports were combined to get county totals as noted in Figure 5-6. County Federal Information Processing Standards (FIPS) codes were matched to each county and retained in the project database. Some ports such as Houston probably have considerably more offshore vessel traffic than smaller ports, suggesting that activity is underestimated at large ports and overestimated at smaller ports.

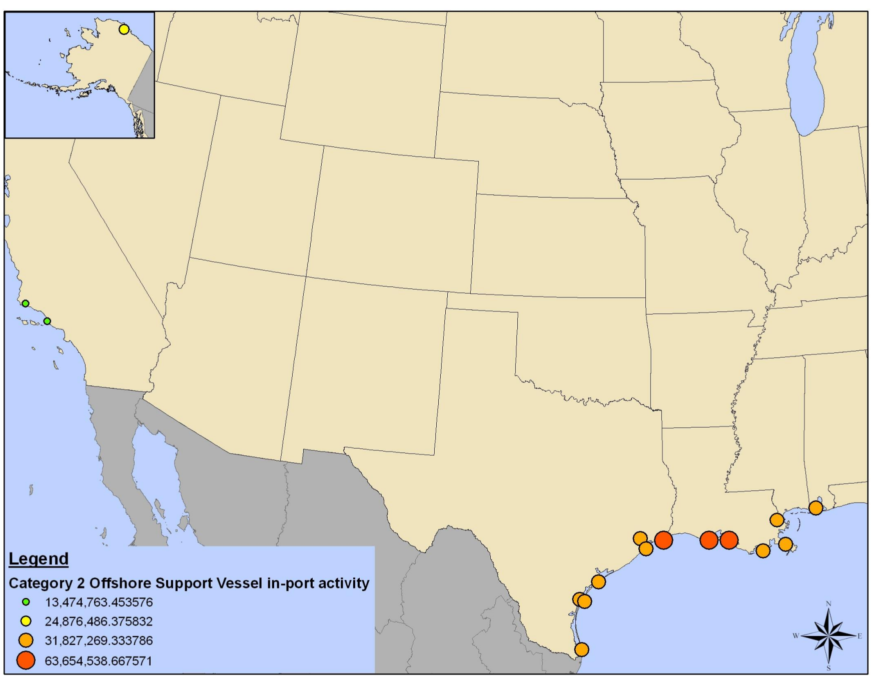


Figure 5-6. Offshore Support Vessel In-Port Activity

At-Sea – Offshore Support Vessels

Offshore support vessel activity while at sea was estimated by apportioning the regional offshore support vessel at-sea hours of operation to lease blocks based on the number of active offshore oil platforms operating in a given lease block. The offshore oil platform data were obtained from the MMS.

The following equation was used for this allocation approach:

$$OSas_{kr} = HOosas \times OP_k / OP_r$$

Where:

$OSas_k$	= Estimate of 2005 activity for offshore support vessels at sea for lease block k in region r(hp-hrs/year)
HOosas	= National 2005 estimate of at-sea hours of operation for offshore support vessels (hp-hrs/year)
OP_k	= Number of active offshore oil platforms operating in lease block k in 2005 for region r
OP_r	= Total number of active offshore oil platforms operating in region r for 2005
k	= At-sea lease block or county area k
r	= Region (Gulf of Mexico, California, Alaska)

Results of this approach are presented in Figure 5-7 and the associated data are included in the project database.

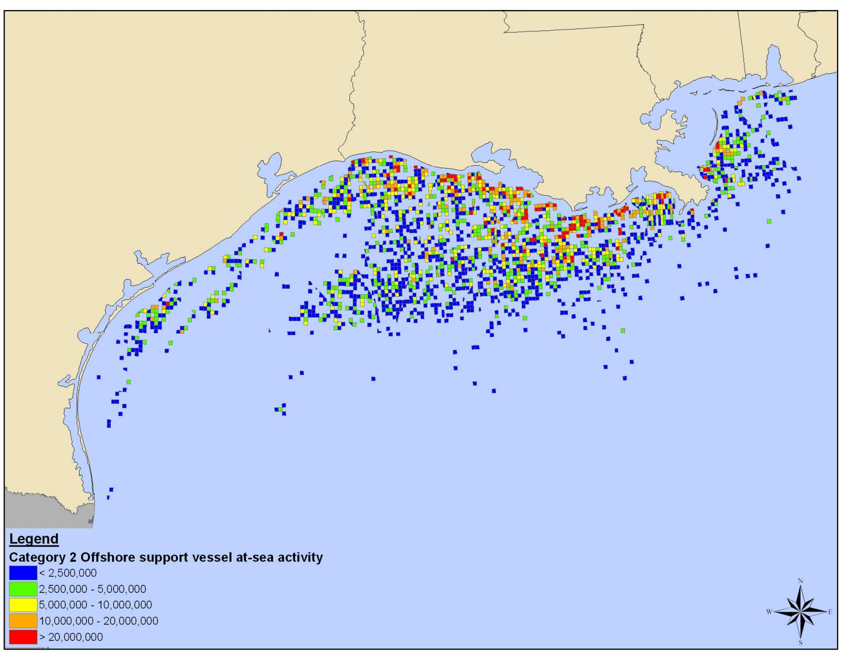


Figure 5-7. Offshore Support Vessel At-Sea Activity

5.1.4 Ferries

Hours of operation for ferries for both in-port and at-sea were assigned to the county in which the ferry provides services which was defined by the vessel's home port. The ferry boat population was obtained from Bureau of Transportations National Ferry Database and the American Public Transportation Association. Thirty-four (34) ports were identified that provide services using Category 2 propelled vessels and are listed in Table 5-2. County FIPS codes were matched to each county and retained in the project database. Ferry activity was apportioned to individual counties by developing an average hours of operation and applying those hours to each vessel using the following equation:

$$AF = HOf / FP$$

Where:

AF = Average activity per ferry for 2004 (hp-hrs/year-vessel)
HOf = National 2004 estimate of in-port and at-sea hours of operation for ferries (hp-hrs/year)
FP = National ferry population for 2004

Table 5-2. List of Ferry Ports

Alameda, CA	Orient Point, NY
Balboa, CA	Port Clinton, OH
Bellevue, WA	Port Jefferson, NY
Charlottetown, ME	Portland, ME
Chatham, Ontario, Canada	Port Townsend, WA
Columbus, OH	Provincetown, MA
Freeland, WA	Riviera, FL
Galveston, TX	Salt Lake City, UT
Highlands, NJ	San Francisco, CA
Hyannis, MA	San Juan, PR
Juneau, AK	San Pedro, CA
Larkspur, CA	Seattle, WA
Little Falls, NJ	Staten Island, NY
Ludington, MI	Surry, VA
Mackinac Island, MI	Vallejo, CA
New London, CT	Wilmington, DE
Newburyport, MA	Woods Hole, MA

The average annual activity was applied to each vessel. The estimated activity levels of multiple ferries that service a port were summed to get a port total. Similarly, multiple ports within the same county were summed to get a county total of Category 2 ferry activity.

Some larger ferries travel outside of the home port area or to adjacent counties, thus the activity estimates for a given county may be overestimated. Results of this approach are presented in Figure 5-8 and the associated data are included in the project database.

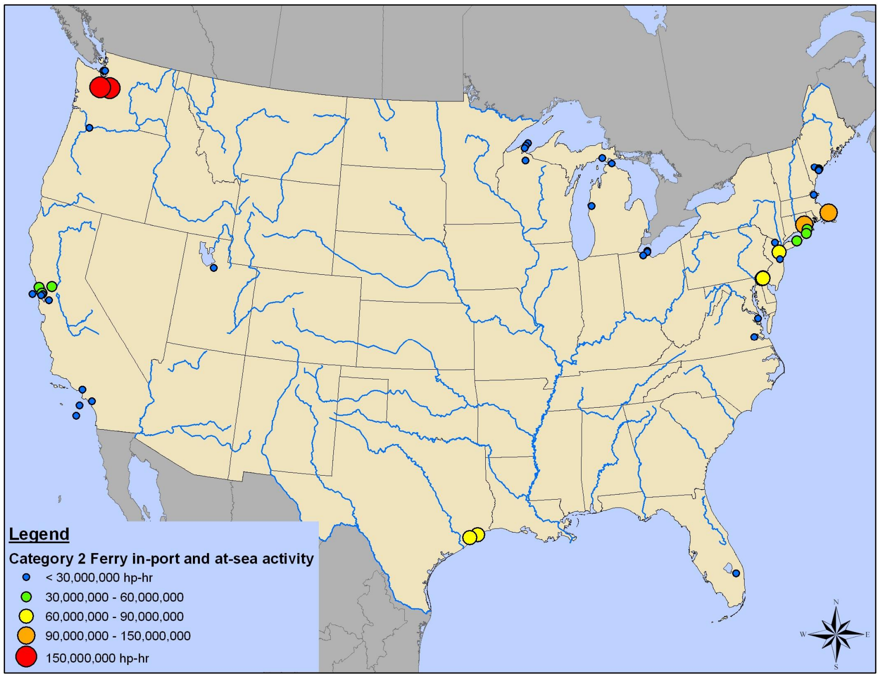


Figure 5-8. Ferry In-Port and At-Sea Activity

5.1.5 Deep Water Vessels

In-Port – Deep Water Vessels

Deep water vessel activity in the port area was estimated by developing average vessel in-port hours of operation for a port call. The U.S. Maritime Administration (MARAD) 2005 entrance and clearance data were used to quantify the number of calls to each port for each vessel identified as being equipped with Category 2 engines. The average in-port hours of operation were applied to the number of Category 2 vessel calls to estimate deep water vessel in-port activity for each of the 80 deep water ports. The 80 deep water ports are located in 78 counties that were identified as having Category 2 traffic.

The following equation was used for this deep water allocation approach:

$$DWip_a = \sum(HOdwip_n / VC_n) \times VC_{aq}$$

Where:

$DWip_a$ = Estimate of 2005 activity for deep water vessels for port a (hp-hrs/year)

$HOdwip_n$ = National estimate of 2005 in-port hours of operation for deep water vessels (hp-hrs/year)
VC_n = National number of vessel calls to all ports in 2005
VC_{aq} = Number of vessel calls for vessel q at port a in 2005
q = Specific vessel equipped with category 2 engines
a = Port a

The county was identified for each port where deep water vessels comply with U.S. entrance and clearance requirements. County FIPS codes were matched to each county and retained in the project database. In-port maneuvering times vary significantly between ports and type of cargo being handled, thus actual hours of operation for a specific port may be higher or lower than the average value used in this assessment. Results of this approach are presented in Figure 5-9 and the associated data are included in the project database.

At-Sea – Deep Water Vessels

Deep water vessel activity while at sea was estimated by apportioning the national deep water vessel at-sea hours of operation to individual shipping lanes based on the amount of cargo traffic associated with the shipping lane segment. The shipping lane GIS data were obtained from the Department of Transportation and the cargo traffic data were obtained from the U. S. Army Corps of Engineers.

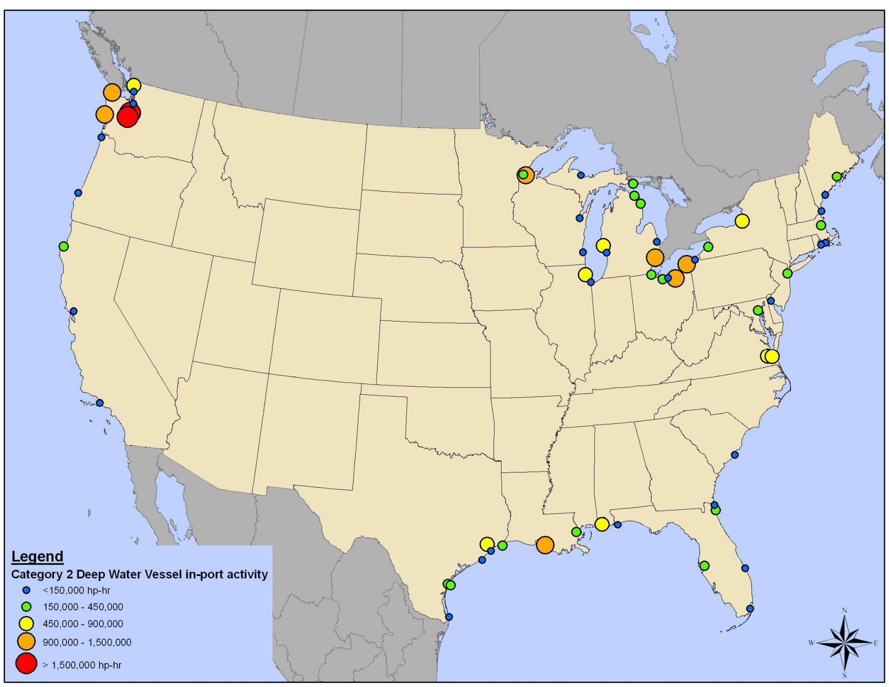


Figure 5-9. Deep Water Vessel In-Port Activity

The following equation was used to allocate deep water at-sea activity to individual shipping lanes:

$$DWas_i = HOdwas \times CT_i / CT_n$$

Where:

$DWas_i$ = 2005 estimate of activity for deep water vessels for at-sea shipping lane segment i (hp-hrs/year)
HOdwas = National 2005 estimate of at-sea hours of operation for deep water vessels (hp-hrs/year)
CT_i = Amount of 2005 cargo traffic for at-sea shipping lane segment i (tons)
CT_n = Amount of cargo traffic for all at-sea shipping lanes for 2005 (tons)
i = At-sea shipping lane segment i

Results of this approach are presented in Figure 5-10 and the associated data are included in the project database. It should be noted that some counties, specifically in the Great Lakes, have relatively large areas of water that include a larger number of shipping lanes compared with coastal areas where state waters only extend from 3-7 miles.

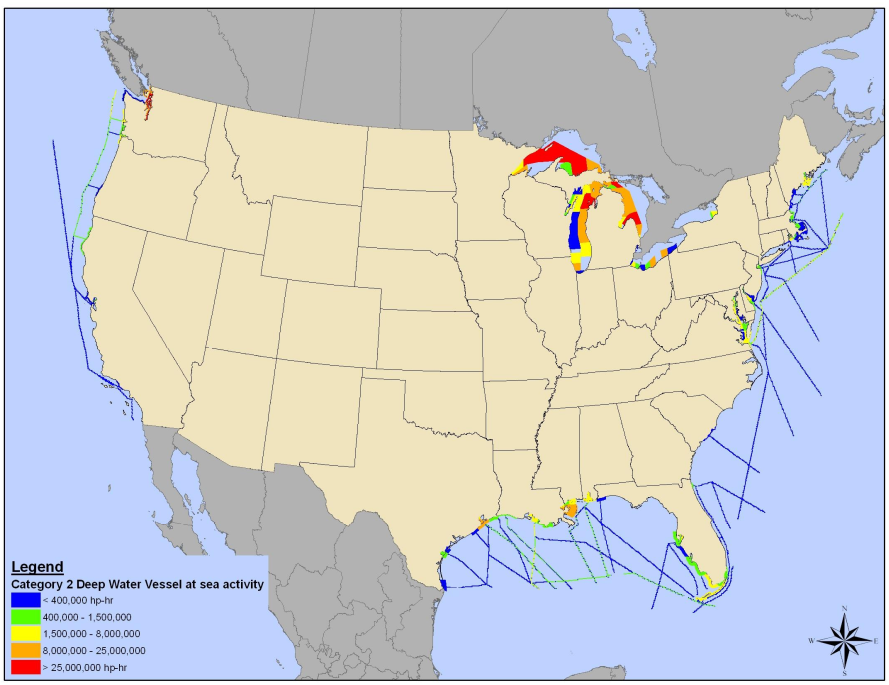


Figure 5-10. Deep Water Vessel At-Sea Activity

5.1.6 Research Vessels

In-port – Research

Research vessel activity in the port area was estimated by apportioning the national research vessel in-port hours of operation to individual ports based on the ports that research vessels visit. The research vessel port data was obtained from the University National Oceanographic

Laboratory System (UNOLS). This system identified 12 ports that research vessels frequent. Note that the available port data were project specific and the number of port calls was not directly quantified; thus, if a vessel had a project that extended over a long period of time, the port was identified, but not the number of visits. If a vessel had a different project every time it left the port, each port call would be identified. Also note that the UNOLS research vessel port data did not seem to be complete. Because alternative data were not readily available and because research vessels represent a small portion of the fleet of vessels equipped with Category 2 engines, the UNOLS data was used to estimate in-port hours of operation, despite its limitations.

The following equation was used for this allocation approach:

$$RVip_a = (HOrvip_n / RV_n) * VC_a$$

Where:

$RVip_a$ = Estimate of 2004 in-port activity for research vessels for port a (hp-hrs/year)

$HOrvip_n$ = National estimate of 2004 in-port hours of operation for research vessels (hp-hrs/year)

RV_n = Total number of research vessels operating in 2004

VC_a = Number of vessels that visit port a in 2004

a = Port a

The county was identified for each port from which research vessels operate. County FIPS codes were matched to each county and retained in the project database. Results of this approach are presented in Figure 5-11 and the associated data are included in the project database.

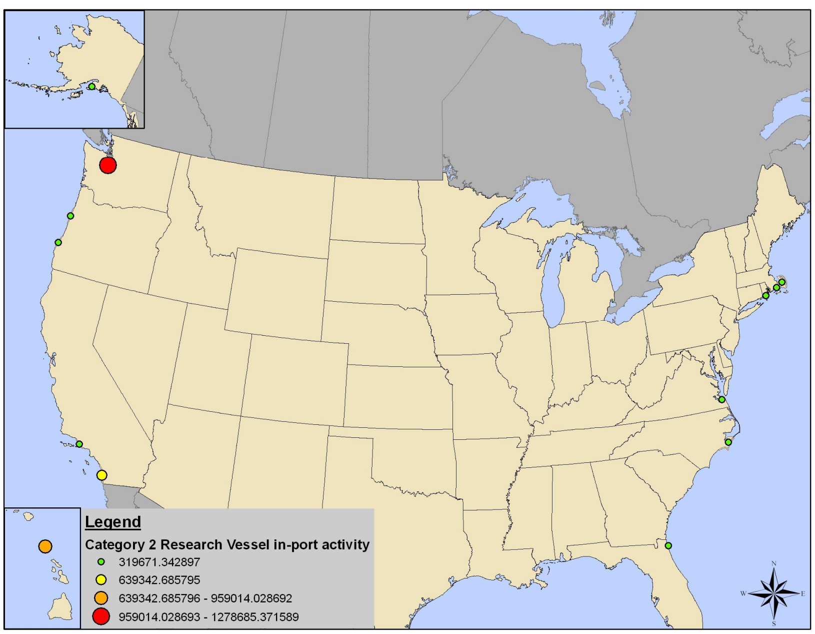


Figure 5-11. Research Vessel In-Port Activity

At-Sea – Research

Research vessel activity while at sea was estimated by apportioning the national research vessel at-sea hours of operation to broad study areas based on the surface area of the study district. The research vessel study area data were obtained from UNOLS.

The following equation was used for this allocation approach:

$$RVas_l = HOrvas \times CT_p / CT_n$$

Where:

$RVas_l$	= Estimate of 2004 research vessel activity at sea for research area l (hp-hrs/year)
HOrvas	= National estimate of 2004 at-sea hours of operation for research vessels (hp-hrs/year)
CT_p	= Surface area of study districts p (square kilometers)
CT_n	= Total area of all study districts (square kilometers)
p	= At-sea research study area l.

Results of this approach are presented in Figure 5-12 and the associated data are included in the project database.

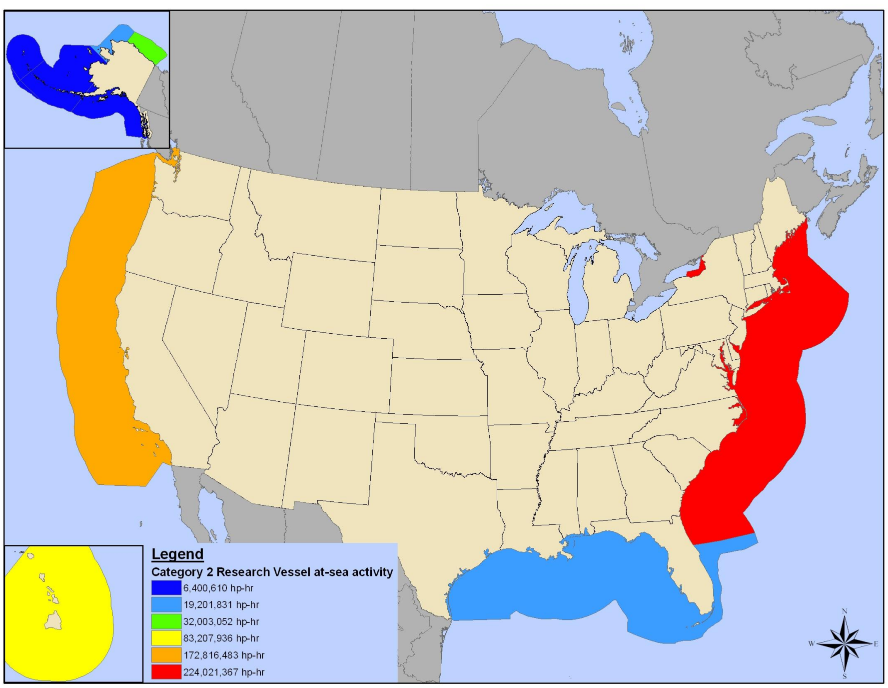


Figure 5-12. Research Vessel At-Sea Activity

5.1.7 Great Lakes and Other Vessels

In-port – Great Lakes and Other Vessels

Great Lake and other vessel activity in the port area was estimated by apportioning the national Great Lake in-port hours of operation to individual ports based on the amount of cargo handled at the designated Great Lake ports. The U.S. Army Corps of Engineers provided cargo handling data for 35 ports on the Great Lakes.

The following equation was used for this allocation approach:

$$GLip_a = HOglip \times CH_a / CH_n$$

Where:

$GLip_a$ = Estimate of 2004 activity for Great Lake vessels for port a (hp-hrs/year)
$HOglip$ = National estimate of 2004 in-port hours of operation for Great Lake vessels (hp-hrs/year)
CH_a = Amount of cargo handled at port a in 2004 (tons)
CH_n = Amount of cargo handled at all Great Lake ports in 2004 (tons)
a = Port a

The county was identified for each Great Lake port included in this study. County FIPS codes were matched to each county and retained in the project database. Note that even though the tugs and towboat in-port activity data overlap with the Great Lake vessel data, there is no double counting of activity as duplicate tug/towboats and Great Lake vessels were identified and removed. Results of this approach are presented in Figure 5-13 and the associated data are included in the project database.

At-Sea – Great Lakes and Other Vessels

Great Lake vessel activity while at sea was estimated by apportioning the national Great Lake at-sea hours of operation to individual shipping lanes in the Great Lakes based on the amount of cargo traffic associated with the shipping lane segment. The shipping lane GIS data were obtained from the Department of Transportation and the cargo traffic data were obtained from the U. S. Army Corps of Engineers.

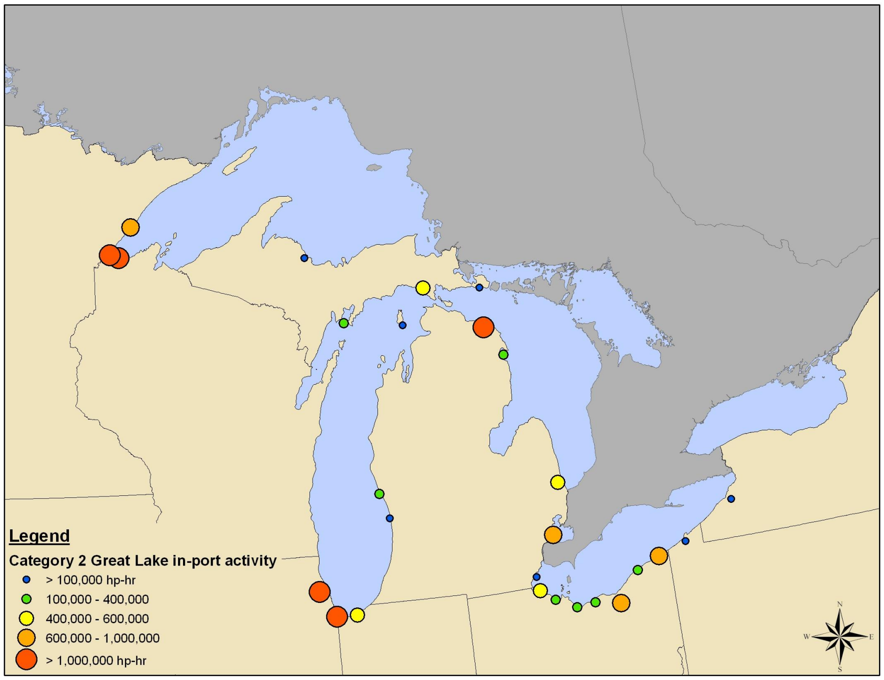


Figure 5-13. Great Lake and Other Vessel In-Port Activity

The following equation was used for this allocation approach:

$$GLas_i = HOglas \times CT_i / CT_n$$

Where:

$GLas_i$	= Estimate of 2004 activity for Great Lakes vessels for at sea shipping lane segment i (hp-hrs/year)
HOglas	= National estimate of 2004 at-sea hours of operation for Great Lake Vessels (hp-hrs/year)
CT_i	= Amount of cargo traffic for at-sea shipping lane segment i in the Great Lakes for 2005 (tons)
CT_n	= Amount of cargo traffic for all at-sea shipping lanes for 2005 in the Great Lakes (tons)
i	= At-sea shipping lane segment i in the Great Lakes.

Results of this approach are presented in Figure 5-14 and the associated data are included in the project database. Note that some counties that have relatively large areas of water include a larger number of shipping lanes than counties with smaller areas of water. Also note in the U.S. Army Corps of Engineer's shipping lane data, vessel activity is not quantified for shipping lanes in Canadian waters, specifically vessels travel through the Saint Lawrence Seaway; such that, there are counties in New York that are adjacent to Lake Erie, Lake Ontario, and the Saint Lawrence River that do not have marine vessel activities as ship traffic is shifted to Canadian waters.

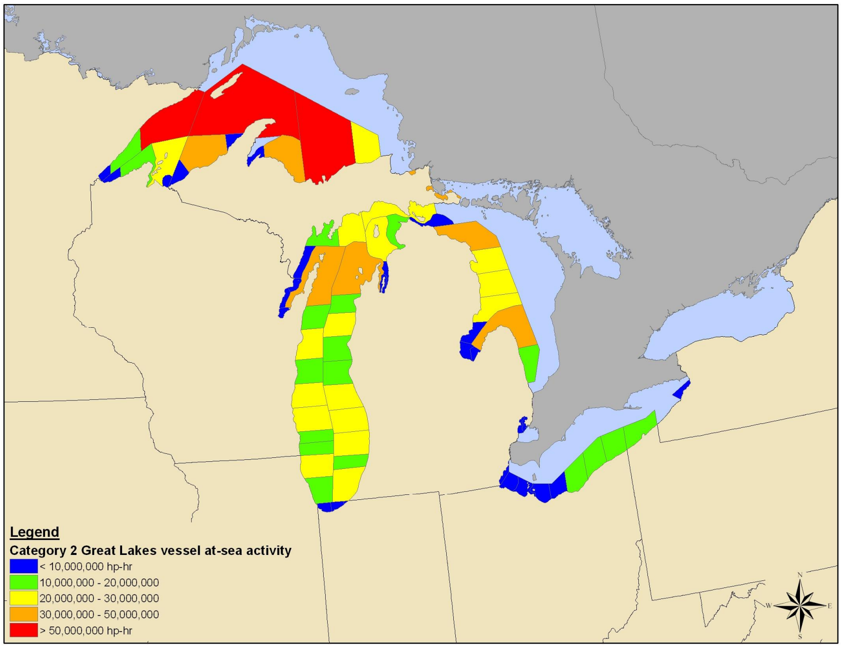


Figure 5-14. Great Lakes and Other Vessel At-Sea Activity

5.1.8 Government Vessels

In-Port – Government Vessels

Coast Guard activity in the port area was estimated by apportioning the national Coast Guard in-port hours of operation to individual ports based on each vessel's home port of call. The home port for each Category 2 Coast Guard vessel was obtained from the Coast Guard Web site. Eighty-three (83) ports were identified as having Category 2 Coast Guard vessels. Note that a home port was not identified for 10 percent of the Category 2 Coast Guard vessels. Activity from these ports was allocated equally to the other home ports where Coast Guard vessels operate.

The following equation was used for this allocation approach:

$$CGip_a = (HOcgip_n / CG_n) \times CG_a$$

Where:

$CGip_a$ = Estimate of 2005 activity for Coast Guard vessels for port a (hp-hrs/year)

$HOcgip_n$ = National estimate of 2005 in-port hours of operation for Coast Guard vessels (hp-hrs/year)

CG_n = Total national Category 2 Coast Guard vessels (for which the home ports were identified) operating in 2005

CG_a = Number of Coast Guard vessels associated in port a

a = Port a

This average in-port estimate of activity was applied to each Category 2 Coast Guard vessel's home port. The county was identified for each Coast Guard home port included in this study. County FIPS codes were matched to each county and retained in the project database. Coast Guard vessels sometimes visit multiple ports in a district; thus in-port activity may be overestimated for the home port and underestimated for other ports that these vessels visit. More detailed data on Coast Guard vessel activities were not readily available due to security concerns. Results of this approach are presented in Figure 5-15 and the associated data are included in the project database.

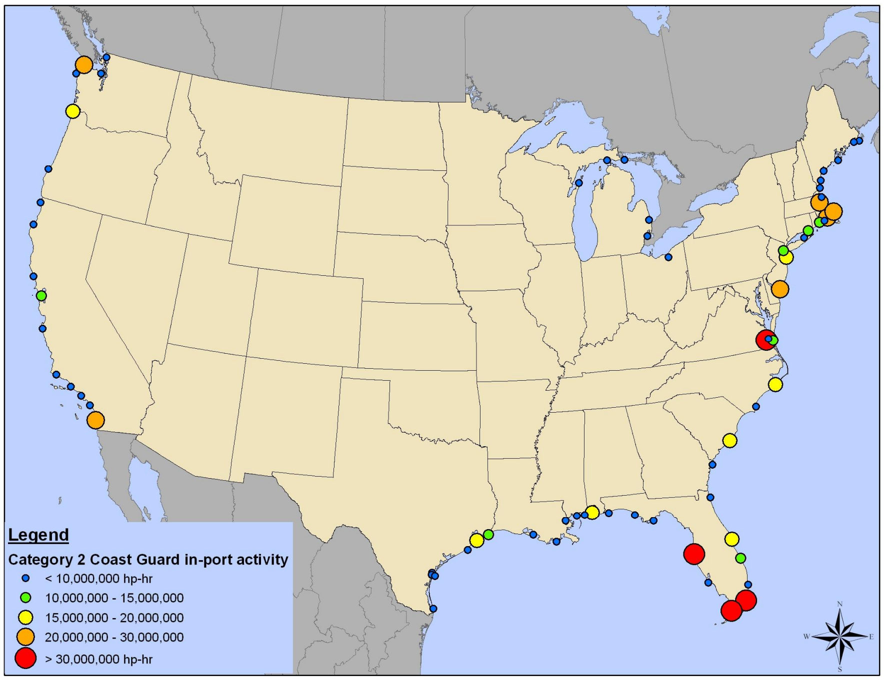


Figure 5-15. Coast Guard In-Port Activity

At-Sea – Government Vessels

Category 2 U.S. Coast Guard vessel activity while at sea was estimated by apportioning the national Coast Guard at-sea hours of operation to individual districts based on the water surface area of each district. Currently, there are nine U.S. Coast Guard districts, District 1 includes waters from Maine to New Jersey, the 5th District includes the mid-Atlantic states, the 7th District includes the southeastern states, the 8th District includes the Gulf of Mexico and the Mississippi River Basin, the 9th District includes the Great Lakes, the 11th District includes California, while the 13th District contains the Pacific Northwest, the 14th District is Hawaii, and the 17th District is Alaska. Information about vessels assignments to each district and the geographic area of each district was obtained from Coast Guard Web sites.

The following equation was used for this allocation approach:

$$CGas_d = HOcgas \times SA_d / SA_n$$

Where:

$CGas_d$	= Estimate of 2005 activity for Coast Guard Vessels while at sea for District D (hp-hrs/year)
HOcgas	= National estimate of 2005 at-sea hours of operation for Coast Guard Vessels (hp-hrs/year)
SA_d	= Surface area of Coast Guard district d (square kilometers)
SA_n	= Total surface area of all Coast Guard Districts (square kilometers)
d	= District d

Some of the districts are very large and it is likely that vessels do not transit the whole district. Vessels may actually spend slightly more time closer to shore, thus deep water activity may be overestimated and coastal activity may be underestimated using this approach. More detailed data on Coast Guard vessel activities were not readily available due to security concerns. Results of this approach are presented in Figure 5-16 and the associated data are included in the project database.

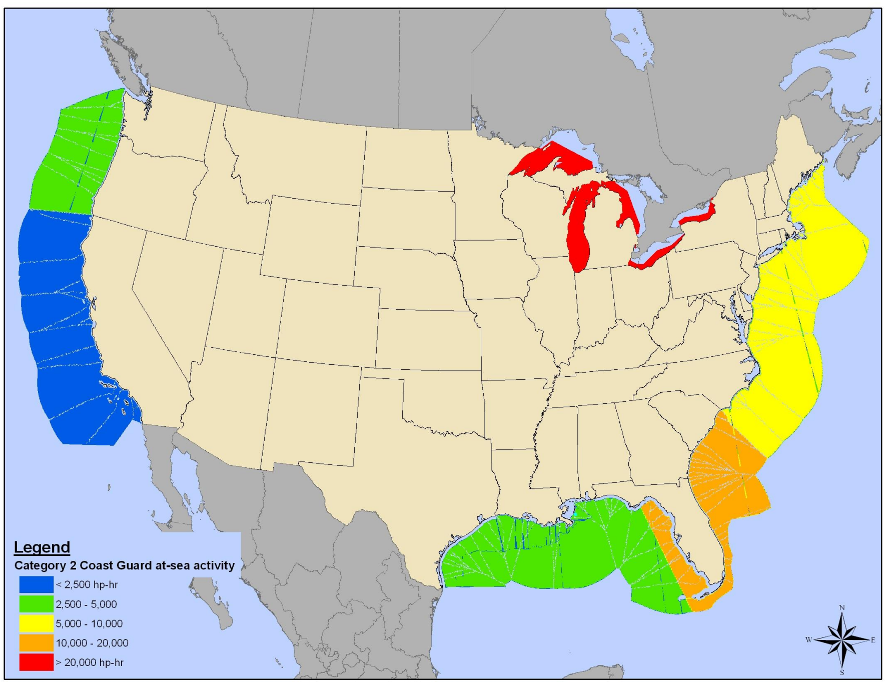


Figure 5-16. Coast Guard At-Sea Activity

5.2 Summary

The county waterway boundary file was developed based on Census Department county and state maps. County boundaries were extended perpendicular to the coast out to the state water boundary. Where adjacent counties shared an inland waterway, the boundary was considered to be at mid-stream running parallel to the shore. If the shared boundary was in a larger body of water such as a bay, the area was split between the two counties based on the amount of shore associated with each county.

To disaggregate federal waters into smaller grids, the Department of Interior's Mineral Management Services' lease blocks were used. The MMS lease block shape file is readily available from MMS's Web site. Lease blocks are located in all U.S. coastal waters, regardless of whether or not there are active oil and gas activities occurring in the area. Lease blocks extend from the state waters boundary to 200 miles out to sea. The areas around Hawaii and U.S. protectorates such as Puerto Rico and the U.S. Virgin Islands do not have lease blocks.

This approach using MMS lease blocks in conjunction with state county boundary data matched up well for all states except Alaska, where a slight gap between federal and state boundaries. The gap was noticeable, but not considered significant.

The spatial allocations discussed in Section 2 were developed as GIS shape files and the state/county and lease block boundary files were applied to them. Activity within a county or lease block boundary was summed by vessel type and activity. Each county/lease block has a unique identifier; for counties, the county identifier is the associated county FIPS code.

Vessel activity data were linked by the unique county/lease block code in the GIS metafile, such that some county blocks include port and underway activities for each of the vessel types included in this study. Lease blocks are in Federal waters and tend to include only at-sea activities.

Summary results from combining all of the Category 2 vessel type data are presented in the following maps. Figure 5-17 shows combined port activities for all vessel types.

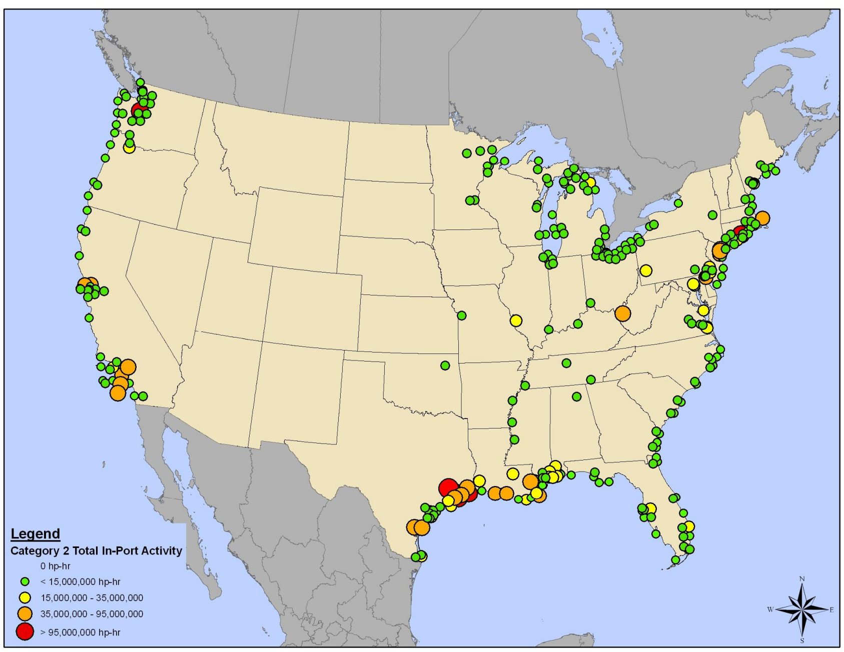


Figure 5-17. Combine Category 2 In-Port Activities

Figure 5-18 shows combined at-sea activities for all vessel types. Again, the Great Lakes appear elevated due to the size of the county waters in comparison to coastal state and federal lease blocks which represent significantly smaller ones.

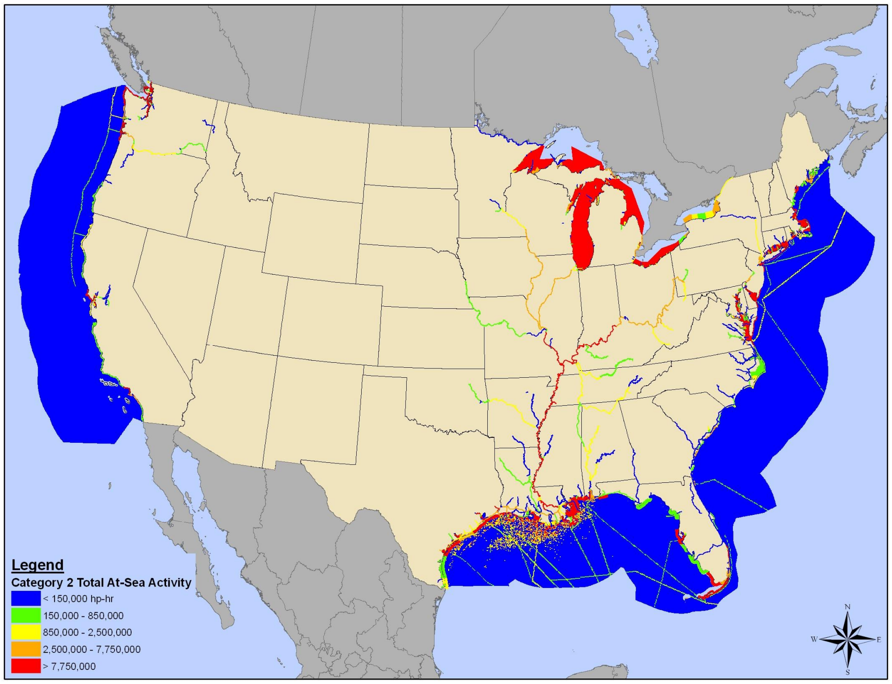


Figure 5-18. Combined Category 2 At-Sea Activities

Figure 5-19 shows what the Category 2 vessel activity looks like when in-port and at-sea activities are combined.

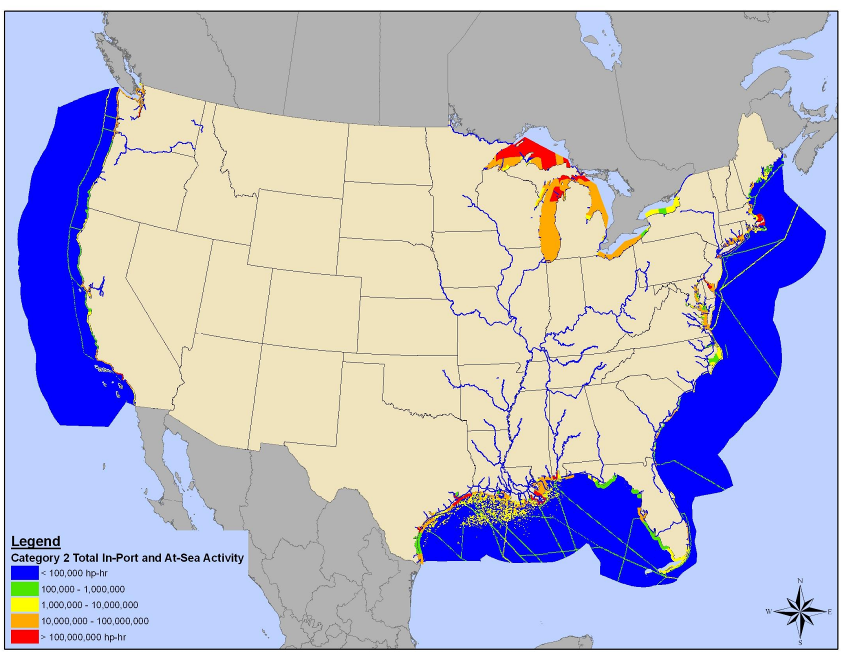


Figure 5-19. Combined In-Port and At-Sea Activities for Category 2 Vessels

5.3 References

U.S. Maritime Administration (MARAD), Office of Data and Economic Analysis, *Vessel Movement 2005 Database*. July 2006.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, National Annual Commercial Landings by Group. Downloaded June 2006 http://www.st.nmfs.gov/st1/commercial/landings/gc_runc.html

National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *2004 United States Commercial Landings*. 2006.

U.S. Army Corps of Engineers / Waterborne Statistics Division, *Vessel Clearance and Entrance Data*. New Orleans, LA. 2004.

U.S. Army Corps of Engineers, Navigation Data Center, Waterway Network Link Commodity Data. Downloaded September 2006.

U.S. Coast Guard official Web site. Downloaded August 2006; www.uscg.mil/datasheet/dataindx.htm

U.S. Department of Census, GIS maps Downloaded June 2006; http://www.census.gov/geo/www/cob/cs2000.html
U.S. Department of Interior, Mineral Management Services, Digital Geographic Mapping Data. downloaded September 2006. http://www.gomr.mms.gov/homepg/pubinfo/repcat/arcinfo/index.html

U.S. Department of Transportation, Bureau of Transportation Statistics, *National Ferry Database*. 2000.

University National Oceanographic Laboratory System Web site. Downloaded May 2006. www.unols.org/info/vessels.htm

6.0 CATEGORY 2 VESSEL DATABASE

To organize the compiled data it was necessary to merge the data into a single database. This data merge was challenging because the different vessel types had different data sources that included different data fields in different formats. The data were reviewed to see how all the fields could be aggregated into common field names. In the end the data were compiled into a database containing 28 fields. It was important to retain any data fields dealing with identification of the vessels, the vessel characteristics, the engine identification, and the engine characteristics.

6.1 Data Matching

Table 6-1 shows how the different data sources were matched into the aggregated database. It should also be noted that not all the data fields were populated, this generally indicates that the data source used to quantify the Category 2 vessels population did not compile all of the same data elements. Those fields that were not filled are denoted with NA's in Table 6-1.

The group type field was populated to mirror the vessel types discussed in Section 2 of this report. This field included the following vessel types codes: "fishing," "ferry," "deepwater," "offshore," "research," "tug," "US CG," or "Great Lakes and others."

Data elements from the individual vessel type databases were occasionally in different units. These units had to be converted so that they were reported consistently in the aggregated database. This occurred for length, draft, and breadth. Most sources were in feet. However, ocean going vessels were in meters. Therefore, ocean going vessels were converted to be consistent with the other data sources.

It should be noted that data gaps for individual vessels that existed in the individual database were carried over into the aggregated database. One example is Great Lakes Vessels did not have the displacement filled in for all of its entries. And in another case, U.S. Coast Guard vessels had gross tons as one of their data fields, but it was blank for all of its entries. As in the Coast Guard example, the data fields or entries that were blank were retained in the aggregated database to maintain consistency in the database structure.

Table 6-1. Mapping of Database Field Names by Vessel Type

Aggregated	Towboats	Offshore	Comm ercial Fishing	US CG	Ferry	Deepwater	Research	Great Lakes & Other Vessels
Eng Cat	Category	Category	Eng Cat	Eng Cat	Eng Cat	Revised Category	Eng Cat	Category
Group Type	"Tug"	Offshore	"Fishing"	"US CG"	"Ferry"	"Ocean Going"	"Research"	"Other"
Vessel ID	*NA*	*NA*	Vessel ID	Vessel ID	Vessel ID	*NA*	*NA*	*NA*
CG Number	USACE_CG_No	CG Number	CG Number	CG_Number	USCGNumber	*NA*	*NA*	CG Number
IMO Number	*NA*	IMO Number	IMO Number	IMO_Number	*NA*	IMO	*NA*	IMO
Call Sign	*NA*	Call Sign	*NA*	*NA*	CallsignCG	Call Sign	Call Sign	*NA*
Vessel Name	VS Name	Name	Vessel Name	Vessel Name	Vessel Name	Ship Name	ShipName	Name
Vessel Type	Job	Type 2	Vessel Type	Vessel Type	*NA*	ShipType	*NA*	Type
HP	HP	NA	HP	HP	HorsePowerCG	*NA*	Engine Power	HP
Total Kw	*NA*	Total Kw	*NA*	*NA*	*NA*	Total Power	*NA*	Total Power
Length (ft)	*NA*	*NA*	Length	Length	RegisteredLengthCG	Length	Length	*NA*
Fuel Type	*NA*	*Fuel*	*NA*	*NA*	*NA*	Revised Fuel	*NA*	*NA*
Propulsion Type	*NA*	NA	Propulsion	Propulsion	*NA*	Propulsion Type	*NA*	Engine Type
Gross Ton	NT	NA	Gross Ton	Gross Tons	RegisteredGrossTonsCG	Deadweight	Gross Tons	Deadweight
Build	MY	*NA*	*NA*	*NA*	*NA*	Date of Build	Year Built	*NA*
Engine Number	Engine	NA	*NA*	Notes	*NA*	Mains	Engine Number	Mains
Engine Make	*NA*	Engine Builder	*NA*	*NA*	*NA*	Engine Builder	Engine Make	*NA*
Engine Model	Model	Engine Designation	*NA*	*NA*	*NA*	Engine Designation	Engine Model	*NA*
State	*NA*	*NA*	Port State	Port State	State NM	*NA*	*NA*	*NA*
Port	*NA*	*NA*	Port Name	Port Name	City	*NA*	*NA*	*NA*
Area	Area	NA	Region	*NA*	*NA*	Flag	Country	Area
Speed (kph)	*NA*	*NA*	*NA*	*NA*	Speed Typical	Speed	Speed Cruise	*NA*
Notes	Hull	*NA*	Comment	Notes	*NA*	*NA*	*NA*	*NA*
Source	Data	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	Source
Displacement	*NA*	Displace	*NA*	*NA*		Displace	*NA*	Displace
Draft (ft)	*NA*	*NA*	RegisteredDepthCG	Draft	Draft	*NA*	*NA*	*NA*
Breadth (ft)	*NA*	*NA*	RegisteredBreadthCG	*NA*	Beam	*NA*	*NA*	*NA*

6.2 Data Augmentation and Assurance

Once all of the data sources were compiled into one database, the data were checked for quality assurance. In checking the database, certain data were also augmented to fill in blanks, when possible. It should also be noted that at this point, the data had already been checked by the people who obtained and formatted the data and reviewed by the project manager.

The quality assurance at this stage dealt mostly with checking for duplicates in the database. Vessels from one vessel type may overlap with vessels from another, but this might not be apparent until all of the data are merged. For example, tugs or fishing vessels may be ocean going tugs or ocean going fishing vessels and be included in both the tug or fishing vessel database and ocean going vessel database. Duplicates were matched based on the identification data, which included Vessel ID, CG Number, IMO Number, Call Sign, and Vessel Name. Identified duplicates were double checked to make sure they were in fact duplicates. Duplicates were confirmed by checking other data fields to see if the vessels were actually the same. The other fields usually included the engine characteristics and/or the engine make and model.

Vessels sometimes had Coast Guard identification numbers, IMO numbers, or Call Signs. These identification numbers are unique and useful in flagging duplicates. But, there were also other vessel identification numbers provided by the reference which were not necessarily unique and sometimes conflicted with other data sources, therefore these vessels IDs could not be used to identify duplicates. Where the same name is attributed to a vessel also did not necessarily indicate a duplicate. When it was unclear if the matches were actually the same vessel, the entries were kept. Whereas, matches between the IMO number, the CG Number, and the Call Signs were actually duplicates.

When duplicates were found the data fields were merged to ensure that the retained data contained was as complete as possible. At this point the duplicate entry was deleted. For example, in most cases the ocean going vessels had more vessel and engine characteristics than the other datasets so those entries were retained, but some of the duplicate data included geographic information, so these data elements were first appended to the ocean going data before being deleted.

Once all of the duplicates were removed, the rest of the data were cleaned up so the data could be easily grouped and summarized. For example port names like Boston and Boston, MA were changed to Boston. The state names were changed into their abbreviations for consistency. When the area field was empty, it was filled in with appropriate data for the state and port where the vessel operated. States on the East coast were identified as Atlantic, the West coast states were identified as Pacific, Gulf states were identified as Gulf, Great Lake states were identified as Great Lakes, and depending on which side of Florida vessels were identified as being based, they were either flagged as Atlantic (east coast of Florida) or Gulf (west coast of Florida).

Finally the data were checked to make sure that only commercial Category two domestic vessels were included in the compiled database. Other vessels, like yachts, foreign vessels, or Category 1 vessels, were deleted.

As noted above, not all of the data fields were filled in. The quality of the database could be improved significantly if more time and resources were made available to implement a formal survey of the vessel owners for the missing information.

6.3 Compiled Database Structure

The Category2Activiy_FINAL database is comprised of 17 separate tables.

There are two tables, one for port activity and one for sea (underway) activity for the each of the 8 different vessel types, in the final project database. The 8 vessel types are: deepwater vessels, ferries, fishing vessels, government vessels, Great Lake vessels, offshore vessels, research vessels, and tugs. All 16 of these tables have the same format and have the same naming convention, Vessel Type_Operating Area. There are only two fields for these tables: BLOCKID and Activity. The BLOCKID links to the BLOCKID used in the GIS files. The activity field is the total hp-hr for that BLOCKID and vessel type.

The final table is a summary table called ALL Activity Summary Table, which has 7 fields: Type, In Port %, At Sea %, Port Activity, Sea Activity, and Total Activity. Type is the vessel type. In Port % and At Sea % are the percent time the vessel type operates in port or at sea. The percent adds up to 100% in all cases and the port activity and sea activity are derived on the percentages. The activity data are all in hp-hrs.

Appendix A. Identified Category 2 Marine Diesel Engines

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
1026MTBF-40	260	400	21.2	10	600.0	1820.5
1038D8-1/8	207	254	8.5	10	814.0	1293.7
1038TD-1/8	207	254	8.5	10		1854.0
10ASL25D s	250	300	14.7	10	883.3	1632.8
10DNL120/500	190	350	9.9	10	500.0	772.0
10DNL150 s	190	350	9.9	10		898.3
10DNL170/600	190	350	9.9	10		1103.0
10DNL190/600	190	350	9.9	10		1398.0
10RUB215	215	260	9.4	10		735.5
10RVB215	215	260	9.4	10		1033.5
10T23 s	225	300	11.9	10	804.5	971.2
10V28 s	280	360	22.2	10	625.7	3497.0
10V29 s	225	300	11.9	10		919.0
10VDNL150/600	190	350	9.9	10		1103.0
10VDNL190/600	190	350	9.9	10		1398.0
1226MTB s	260	400	21.2	12	600.0	1506.4
12278 s	220	267	10.2	12		893.0
1238D8-1/8	207	254	8.5	12	800.0	1487.6
1238TD-1/8	207	254	8.5	12	750.0	2158.0
12567-BC	216	254	9.3	12	825.0	846.2
12645 s	230	254	10.6	12	883.3	1258.1
12ASV25/30	250	300	14.7	12	958.3	1988.7
12ATCM	318	368	29.2	12		2276.3
12CHSP18/20	180	200	5.1	12		772.5
12CSVM	254	305	15.5	12		1398.0
12DRN23/30	230	300	12.5	12	750.0	1573.3
12DRPN23/30	230	300	12.5	12		2115.5
12DVDA	200	260	8.2	12		441.0
12GV s	220	380	14.4	12	381.3	905.6
12M282AK	240	280	12.7	12	1000.0	2163.3
12MB275	275	305	18.1	12		2869.5
12MGV28BX	280	320	19.7	12		2207.0
12NVD18/21A3	180	210	5.3	12	1500.0	1176.0
12PA4V185VG	185	210	5.6	12	1340.0	1075.5
12PA4V200 s	200	210	6.6	12	1466.7	1919.5
12PA6V280	280	290	17.9	12	1033.3	2794.9
12PBVCS12F	241	305	13.9	12		1519.0
12PSN s	260	280	14.9	12	825.0	1645.4
12PVBCS12 s	242	305	14.0	12	750.0	1280.5
12RK s	254	305	15.5	12	900.0	1664.0
12RVB215	215	260	9.4	12	950.0	1097.4
12SW280	280	300	18.5	12	1000.0	3089.3
12TD200	220	380	14.4	12		1553.8
12U28L s	280	320	19.7	12	775.0	2192.7

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
12UEV30/40C	300	400	28.3	12		2648.0
12V1163TB62	230	280	11.6	12		2207.0
12V190ZC	190	210	6.0	12		900.0
12V20/27	200	270	8.5	12	975.0	1133.0
12V200	200	240	7.5	12	1400.0	2126.7
12V22 s	220	240	9.1	12	923.3	1615.4
12V23 s	225	300	11.9	12	757.7	1339.9
12V25 s	234	275.426	11.9	12	906.8	1729.6
12V27	275	320	19.0	12		1688.3
12V28 s	280	326.452	20.1	12	713.4	2685.7
12V32 s	320	350.159	28.2	12	739.1	4346.3
12V538TB82	185	200	5.4	12	670.0	1284.5
12V645 s	230	254	10.6	12	900.0	1103.0
12V652TB s	190	230	6.5	12	1410.0	1142.6
12VDL75/475	190	350	9.9	12		662.0
12VDNL s	190	350	9.9	12	600.0	1457.0
12VP185	185	196	5.3	12	1892.5	2209.3
12VSHTB26D	260	320	17.0	12		956.0
12YJCM	197	216	6.6	12		716.5
12YLCM	248	267	12.9	12	75.0	1083.7
12ZLST	280	340	20.9	12		2354.0
1426MTBF-40V	260	400	21.2	14	600.0	1863.7
14T23LVO	225	300	11.9	14		1390.0
14U28LVO	280	320	19.7	14	775.0	2728.5
14V s	200	270	8.5	14	610.0	1400.5
14V23 s	225	300	11.9	14	811.7	1498.1
14V28/32	280	320	19.7	14		2729.0
14VDNL150/600	190	350	9.9	14		1996.3
1626MTBF-40V	260	400	21.2	16		2118.0
16278 s	222	267	10.3	16		1187.1
16567 s	216	254	9.3	16	803.3	1261.6
16645 s	230	254	10.6	16	855.1	1681.1
16710-G7	230	279	11.6	16	900.0	3089.3
16ASV25/30	250	300	14.7	16	745.7	2904.3
16ATV25D	250	300	14.7	16	750.0	1589.0
16CSVM	254	305	15.5	16		2501.0
16DPN23/30	230	300	12.5	16		3310.0
16GV s	220	380	14.4	16	362.5	1157.3
16MB275	275	305	18.1	16	900.0	4104.0
16MGV28BXE	280	320	19.7	16		2942.0
16PA4 s	192	210	6.1	16	1432.1	2180.3
16PA5V	255	270	13.8	16	900.0	2574.0
16PA6V280	280	290	17.9	16	1016.7	4162.6
16PSN3	260	280	14.9	16		2207.0
16PVBCS12F	242	305	14.0	16	750.0	2057.1
16RK s	260	305	16.2	16	853.5	3063.4
16RP200	197	216	6.6	16		2176.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
16SW280	280	300	18.5	16		4644.3
16T23LVO	225	300	11.9	16	825.0	1824.0
16TD200	220	380	14.4	16		2354.0
16U28LVO	280	320	19.7	16	775.0	2973.2
16V1163 s	230	280	11.6	16		3823.5
16V190ATC	190	230	6.5	16	1450.0	1931.0
16V22 s	220	240	9.1	16	948.3	2290.4
16V23 s	225	300	11.9	16	741.0	1646.4
16V25 s	234	274.8	11.8	16	932.1	2244.3
16V27 s	275	320	19.0	16		2930.0
16V28 s	280	320	19.7	16	747.5	3359.0
16V32 s	320	350	28.1	16	730.0	5368.2
16V358TB82	185	200	5.4	16	1710.0	1415.5
16V538TB91	185	200	5.4	16	1790.0	1986.0
16V595TE70	190	210	6.0	16	1800.0	3565.0
16V652TB s	190	230	6.5	16	1425.0	1589.4
16VBCS12F	242	305	14.0	16		2060.0
16VDNL150/600	190	350	9.9	16		1765.0
16Y s	231	250	10.8	16		1627.7
18PA6V280	280	290	17.9	18		4413.0
18RP2002	197	216	6.6	18	1550.0	3020.0
18V20/27	200	270	8.5	18		1800.0
18V200	200	240	7.5	18		3600.0
18V23 s	225	300	12.0	18	795.8	1975.1
18V251F	229	267	11.0	18	1066.7	2879.6
18V32	320	350	28.1	18	720.0	6695.8
18VDNL150/600	190	350	9.9	18		2096.5
194MARS	190	240	6.8	4	1000.0	199.0
195V12 s	195	180	5.4	12	1397.5	1314.8
195V16RVR	195	180	5.4	16	1600.0	2689.0
196/RS	190	240	6.8	6		375.0
20645 s	230	254	10.6	20	900.0	2587.3
20RK270	270	305	17.5	20	1018.8	6818.6
20V1163TB s	230	280	11.6	20	1238.9	6541.5
240G12VS	240	220	10.0	12		1442.0
240G16VS	240	220	10.0	16		1673.3
240G20VS	240	220	10.0	20		2901.5
240G8LS	240	220	10.0	8		1029.7
240V16ESHR	240	220	10.0	16		2501.5
240V20ESHR	240	220	10.0	20		3531.0
27DH42	270	420	24.0	6		662.0
2M32	210	320	11.1	2	450.0	44.0
3427 s	270	400	22.9	3	425.0	202.7
342FO	200	340	10.7	2	450.0	146.0
343 s	200	340	10.7	3	450.0	102.3
344 s	200	340	10.7	4	410.8	154.8
3606 s	280	300	18.5	6	922.2	1700.5

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
3608 s	280	300	18.5	8	940.0	2119.8
3612 s	280	300	18.5	12	966.3	6176.0
3616 s	280	300	18.5	16	905.2	4683.1
3ACA s	280	420	25.9	3	300.0	285.4
3DCT	200	300	9.4	3		147.0
3M421	280	420	25.9	3		121.0
3TC(TL)	240	360	16.3	3		110.0
3VCBM	203	273	8.8	3		75.0
40224VO	240	400	18.1	2	375.0	93.5
403VO	230	400	16.6	3	375.0	143.0
404 s	230	400	16.6	4	376.3	197.8
40424VO	240	400	18.1	4	375.0	203.9
40426VO	260	400	21.2	4		268.5
405 s	230	400	16.6	5	375.0	236.0
40524VO	240	400	18.1	5	375.0	256.8
40526VO	260	400	21.2	5	400.0	353.4
40624VO	240	400	18.1	6	380.0	307.0
40626VO	260	400	21.2	6	403.3	443.8
406VO	230	400	16.6	6	383.3	257.7
40724VO	240	400	18.1	7	375.0	406.0
40726VO	260	400	21.2	7	413.0	532.0
40824VO	240	400	18.1	8	370.0	434.0
40826VO	260	400	21.2	8	406.5	536.0
40926VO	260	400	21.2	9	400.0	735.8
40MX-8	232	267	11.3	8		736.0
40S2X-8	232	267	11.3	8		655.0
414T	240	310	14.0	4		301.0
422VF-37	220	370	14.1	4		221.0
424TS	240	310	14.0	4		441.0
438D8-1/8	207	254	8.5	4		477.3
4427-DO s	270	400	22.9	4	425.0	264.7
4ACA	280	420	25.9	4	337.5	330.9
4CK	270	340	19.5	4		118.0
4DCT	200	300	9.4	4		230.0
4DNL190/600	190	350	9.9	4	600.0	149.0
4ED	290	450	29.7	4		164.0
4GB	220	380	14.4	4	350.0	165.0
4L20	200	280	8.8	4		1300.0
4L28A	280	360	22.2	4	600.0	1200.0
4L50/430	190	350	9.9	4		147.0
4M351A	240	350	15.8	4		
4M36	215	360	13.1	4		88.0
4MS	200	280	8.8	4		88.0
4NVD262	180	260	6.6	4	750.0	99.0
4PSN3L	260	320	17.0	4	850.0	699.0
4R22 s	220	250	9.5	4	720.0	576.5
4R32 s	320	350	28.1	4	735.0	1609.3

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
4R538	185	200	5.4	4		346.5
4S275	275	360	21.4	4	500.0	191.0
4SAC1	200	240	7.5	4		289.3
4SGAC1	220	240	9.1	4		441.0
4SN3	260	280	14.9	4		954.0
4TAD24	240	400	18.1	4		309.0
4TD24	240	400	18.1	4		221.0
4VCBM	203	273	8.8	4		100.0
4VD6A	280	400	24.6	4	330.0	145.0
4ZU421	290	420	27.7	4		368.0
524TS	240	310	14.0	5	720.0	605.0
525MTBF-40	250	400	19.6	5		327.5
526MTBF-40	260	400	21.2	5		607.0
538D8-1/8	207	254	8.5	5		635.5
5427 s	270	400	22.9	5	425.0	401.1
5ACA	280	420	25.9	5		529.2
5AR25	250	300	14.7	5		441.0
5ASL25/30	250	300	14.7	5		342.0
5D6	250	350	17.2	5		202.0
5DL75/475	190	350	9.9	5	237.0	257.0
5DNL s	190	350	9.9	5	533.3	533.2
5DR210	210	300	10.4	5		302.0
5ED	290	450	29.7	5		221.0
5EN	260	380	20.2	5		191.0
5GVH	220	380	14.4	5		239.0
5L20/27	200	270	8.5	5	966.7	438.0
5L23/30	225	300	11.9	5	825.0	612.0
5M	200	240	7.5	5		132.0
5S28LU	280	320	19.7	5		975.0
5T23LKVO	225	300	11.9	5	816.7	557.7
5VCBM	203	273	8.8	5		122.5
5VEBCZ	260	368	19.5	5		482.0
614TK	240	310	14.0	6		596.0
6190ZLC	190	210	6.0	6	1000.0	275.5
61MS28	280	400	24.6	6	400.0	552.0
6200Z	200	225	7.1	6	950.0	343.3
621MTBH-30	205	300	9.9	6	300.0	449.0
6230ZC	230	300	12.5	6		736.0
624 s	240	334	15.1	6		534.8
6250 s	250	303.6	14.9	6	714.3	591.2
6267	267	330	18.5	6	350.0	184.0
626MTBF-40	260	400	21.2	6		728.0
6275 s	275	330	19.6	6		700.0
6278 s	221	267	10.3	6	1.0	380.5
6300	300	380	26.9	6	453.3	473.8
638D8-1/8	207	254	8.5	6	720.0	735.6
6427 s	270	400	22.9	6	431.4	530.3

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
6ACA s	280	420	25.9	6	375.0	517.0
6AL s	203	243.2	7.9	6	830.0	512.6
6AP2 s	219	273	10.3	6		623.4
6AP3 s	203	273	8.8	6		642.3
6AR s	260	368	19.5	6	750.0	917.1
6ASL s	250	300	14.7	6	905.0	916.4
6AT s	313	362.8	28.1	6	760.0	1075.1
6BA22	220	320	12.2	6		177.0
6BCAH22	220	320	12.2	6	600.0	327.5
6CH25 s	250	340	16.7	6	500.0	286.5
6CHN1A30/38	300	380	26.9	6		1100.0
6CHN25/34	250	340	16.7	6	500.0	225.3
6CHN30/38	300	380	26.9	6		1076.8
6CHN31.8/33	318	330	26.2	6	740.0	736.0
6CHNSP18 s	180	220	5.6	6	221.0	211.5
6CHNSP2A18/22	180	220	5.6	6	750.0	232.0
6CHRP25/34	250	340	16.7	6	500.0	230.2
6CHSP18/22	180	220	5.6	6		141.7
6CHSP23/30	230	300	12.5	6		349.5
6CHSPN18/22	180	220	5.6	6		165.5
6CHSPN2A s	180	220	5.6	6		202.8
6CSVM	254	305	15.5	6		713.5
6D6	250	350	17.2	6		221.0
6D6DH	250	350	17.2	6	300.0	993.0
6DA	200	260	8.2	6		221.0
6DCT	200	300	9.4	6		349.5
6DH27SS	270	420	24.0	6	390.0	533.5
6DK20	200	300	9.4	6	950.0	846.0
6DKM26	260	380	20.2	6	715.5	1372.7
6DKM28	280	390	24.0	6	660.0	1504.8
6DKM32	320	360	28.9	6	720.0	1986.0
6DL20	200	260	8.2	6		515.0
6DL75/475	190	350	9.9	6		309.0
6DLM19	190	230	6.5	6	900.0	560.8
6DLM20 s	200	260	8.2	6	900.0	558.8
6DLM22 s	220	300	11.4	6	784.2	732.9
6DLM24 s	240	320	14.5	6	1208.8	818.4
6DLM26 s	260	340	18.0	6	691.2	1027.8
6DLM28 s	280	362.3	22.3	6	654.1	1194.7
6DM28FS	280	360	22.2	6		1250.0
6DNL s	190	350	9.9	6	500.0	497.0
6DRO210K	210	300	10.4	6		420.3
6DS18	180	230	5.9	6		441.0
6DS22	220	280	10.6	6		613.2
6DS26 s	260	320	17.0	6		836.8
6DS28	280	340	20.9	6	720.0	882.5
6DSM18 s	180	230	5.9	6		374.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
6DSM19A	190	230	6.5	6	900.0	533.5
6DSM22 s	220	280	10.6	6	900.0	756.2
6DSM26 s	260	318	16.9	6	736.9	876.1
6DSM28 s	280	340	20.9	6	668.3	1178.1
6DV26A	260	300	15.9	12		1820.0
6DVM26 s	260	313.333	16.6	12		2010.3
6DZC	256	310	16.0	6	851.1	1125.3
6EF	290	450	29.7	6		284.0
6F/SW240	240	260	11.8	6		647.3
6F24 s	240	288.571	13.1	6	500.0	440.4
6FAHD240	240	260	11.8	6		929.0
6FCHD240	240	260	11.8	6	750.0	635.3
6FDHD240	240	260	11.8	6	793.0	772.8
6FEHD240	240	260	11.8	6	950.0	758.8
6FFHD240	240	260	11.8	6		943.4
6FGHD240	240	260	11.8	6	915.0	898.8
6FHD240 s	240	260	11.8	6	898.8	858.3
6FR24TK	240	300	13.6	6	750.0	719.3
6GAET / 6GALET	240	290	13.1	6	820.0	919.7
6GB	220	380	14.4	6	525.0	267.6
6GDT	240	290	13.1	6	553.0	583.0
6GLDT	240	290	13.1	6	740.0	625.0
6GLET	240	290	13.1	6		858.3
6GLHT	240	290	13.1	6		570.0
6GLST	240	290	13.1	6		735.7
6GLUT	240	290	13.1	6		674.3
6GST	240	290	13.1	6		639.3
6GUT	240	290	13.1	6		625.0
6GV	220	380	14.4	6	320.0	290.7
6GVH	220	380	14.4	6	375.0	523.8
6HM1558	290	380	25.1	6		439.5
6K28FD	280	480	29.6	6	379.0	875.0
6L18CX	180	240	6.1	6	925.0	537.3
6L19HX	190	260	7.4	6		736.0
6L20 s	200	268.837	8.4	6	924.6	740.4
6L22 s	220	272.5	10.4	6	900.8	800.0
6L23 s	225	300	11.9	6	740.9	801.6
6L24 s	240	400	18.1	6	400.0	398.6
6L25 s	250	320.25	15.7	6	765.4	945.3
6L26	260	320	17.0	6	956.7	1902.2
6L26A s	260	391.579	20.8	6	593.3	550.0
6L26B s	260	400	21.2	6	396.1	498.0
6L26H s	260	312.5	16.6	6		1250.0
6L27 s	274	347.5	20.5	6	640.4	868.8
6L28	280	360	22.2	6	600.0	1200.0
6L28/32 s	280	320	19.7	6	746.0	1350.9
6L28ASH	280	430	26.5	6	390.0	566.3

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
6L28B s	280	332.5	20.5	6	689.5	1309.9
6L28HX	280	370	22.8	6	636.7	1519.5
6L28X	280	440	27.1	6	385.0	854.1
6L31 s	310	380	28.7	6	600.0	1209.1
6L32 s	320	355	28.5	6		2871.0
6L50/430	190	350	9.9	6		221.0
6LB26 s	260	440	23.4	6	387.1	523.8
6LDSR28K	280	360	22.2	6	750.0	883.0
6LH26 s	260	440	23.4	6	397.0	690.6
6LH28 s	280	460	28.2	6	353.0	811.4
6LN28G	280	480	29.6	6		1030.0
6LU24 s	240	410	18.5	6	395.0	514.7
6LU26 s	260	439.42	23.3	6	382.5	653.7
6LU28 s	280	440	27.1	6	388.8	820.2
6LUD24 s	240	410	18.5	6	400.0	514.9
6LUD26 s	260	440	23.4	6	393.8	728.4
6LUK27	270	420	24.0	6	390.0	736.0
6LUN28 s	280	480	29.6	6	361.2	916.0
6LUS24 s	240	405	18.3	6	400.0	610.2
6LUS28 s	280	440	27.1	6	392.5	874.7
6M20	200	300	9.4	6	992.5	1042.7
6M200LET	200	260	8.2	6		625.0
6M22EGT	220	380	14.4	6		392.0
6M23C s	230	260	10.8	6		613.2
6M23L	230	260	10.8	6		809.5
6M24 s	240	410	18.5	6		514.7
6M25	255	400	20.4	6	764.1	1726.6
6M26A s	260	460	24.4	6	364.0	642.7
6M26B s	260	460	24.4	6	400.0	547.1
6M26CHS	260	400	21.2	6		331.0
6M26EGT	260	460	24.4	6		625.0
6M26GX	260	440	23.4	6	380.0	956.0
6M26HET	260	460	24.4	6	405.0	680.0
6M26HS	260	400	21.2	6	385.0	417.0
6M26K s	260	400	21.2	6	373.8	491.9
6M26X	260	440	23.4	6		588.0
6M26Z s	260	400	21.2	6	377.5	529.5
6M27.5 s	275	320	19.0	6		827.3
6M281AK	240	280	12.7	6	850.0	662.0
6M282AK	240	280	12.7	6	840.0	701.8
6M28A s	280	479.149	29.5	6	376.5	816.4
6M28B s	280	479.512	29.4	6	362.6	758.7
6M28DHS	280	440	27.1	6		625.0
6M28GX	280	440	27.1	6	380.0	833.3
6M28H s	280	480	29.6	6	414.5	1072.1
6M28K s	280	440	27.1	6	380.0	685.3
6M28X	280	440	27.1	6	380.0	846.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
6M30 s	300	350	24.7	6	750.0	1743.0
6M322AK	240	330	14.9	6	900.0	1200.0
6M331AK	240	330	14.9	6	635.0	638.3
6M332 s	240	330	14.9	6	701.8	817.7
6MA s	200	240	7.5	6	900.0	257.3
6MADT	200	240	7.5	6	825.0	381.0
6MAHT	200	240	7.5	6		232.5
6MAL s	200	240	7.5	6	905.0	384.2
6MAUT	200	240	7.5	6		441.0
6MB275	275	305	18.1	6	1000.0	1637.4
6MBHTS	200	240	7.5	6		280.0
6MD27.5 s	275	320	19.0	6		506.2
6MD28	280	400	24.6	6		257.0
6MDX s	242	320	14.7	6	700.0	502.7
6MDZC	256	310	16.0	6	789.0	1040.8
6MG18 s	180	233.333	5.9	6	925.0	525.8
6MG19HX	190	260	7.4	6	1000.0	711.0
6MG20 s	200	260	8.2	6	775.3	507.2
6MG22 s	220	285.714	10.9	6	887.3	718.9
6MG25 s	250	321.176	15.8	6	707.0	803.7
6MG26 s	275	354.524	21.2	6	713.3	1329.2
6MG31 s	310	380	28.7	6	601.5	1332.9
6MG32CX	320	360	28.9	6		1214.0
6MH20SS	200	360	11.3	6		265.0
6MH25SSR	250	400	19.6	6	382.5	499.0
6MHL / 6MHLUT	200	240	7.5	6	611.0	539.7
6MHT s	200	240	7.5	6	742.5	273.1
6ML s	200	240	7.5	6	750.0	257.5
6MMG20HS	200	260	8.2	6		294.0
6MMG25 s	250	320	15.7	6		938.0
6MMG31EZ	310	380	28.7	6		1471.0
6MT s	200	240	7.5	6	750.0	198.7
6MU281AK	240	280	12.7	6		221.0
6MU351A s	240	350	15.8	6	350.0	279.4
6MUH28	280	340	20.9	6	630.0	1042.0
6MUT	200	240	7.5	6		368.0
6MX28	280	380	23.4	6	680.0	1498.0
6MZ28	280	420	25.9	6		405.0
6N18A s	180	280	7.1	6	900.0	698.5
6N21AEN	210	290	10.0	6		800.0
6N260 s	260	360	19.1	6	730.5	1261.9
6N280 s	280	380	23.4	6	735.0	1511.3
6NHLUT	200	240	7.5	6		552.0
6NL190	190	350	9.9	6	475.0	441.0
6NSCM	190	260	7.4	6	906.8	541.1
6NSFZ	190	260	7.4	6		268.5
6NVD 361U	240	360	16.3	6		

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
6NVD24	175	240	5.8	6		95.5
6NVD26 s	180	260	6.6	6	778.8	255.2
6NVD36 s	240	360	16.3	6	428.9	219.9
6PA4L185VG	185	210	5.6	6		495.5
6PA4V185VG	185	210	5.6	6		625.0
6PA5 s	254	270	13.7	6	913.9	1154.3
6PA6L s	280	290	17.9	6	925.0	1523.7
6PBC512DX	241	305	13.9	6		633.0
6PBCS12C	241	305	13.9	6		390.0
6PS12F	241	305	13.9	6		397.0
6PSHT26D	260	320	17.0	6		479.1
6PSHT6M26DF	260	320	17.0	6		515.0
6PSHTB s	250	310	15.6	6	313.0	528.9
6PSHTC s	255	314.651	16.2	6	665.0	569.8
6PSN3 s	260	297.143	15.8	6	805.0	1131.3
6PST6M26D	260	320	17.0	6		340.0
6PSTB s	264	324	17.8	6	720.0	555.4
6PSTC s	235	296.364	13.3	6	800.0	435.4
6PSTLM26DLS	260	320	17.0	6		386.5
6R20	200	280	8.8	6	937.3	928.0
6R22 s	220	240	9.1	6	978.3	883.4
6R25	250	300	14.7	6	975.0	1199.2
6R26L	260	320	17.0	6	780.0	1167.0
6R32 s	320	350	28.1	6	724.5	2180.6
6RK215	215	275	10.0	6		927.0
6RK270M	270	305	17.5	6	866.7	1388.3
6RK3CM	254	305	15.5	6		976.0
6RKC s	254	305	15.5	6	900.0	814.5
6RKX	254	305	15.5	6		456.0
6S23 s	230	370	15.4	6		240.0
6S26N s	260	410	21.8	6	400.0	493.0
6S27.5 s	275	410	24.3	6	380.0	620.5
6S275 s	275	372.5	22.1	6		390.3
6S27F	270	510	29.2	6	300.0	618.0
6S28 s	277	320	19.3	6		1013.9
6SAC	200	240	7.5	6	900.0	552.0
6SD26 s	260	407.5	21.6	6	400.0	448.8
6SD27.5 s	275	410	24.3	6		669.4
6SD27BH	270	400	22.9	6		346.0
6SH20/26AC	200	260	8.2	6		306.7
6SH24AC	240	280	12.7	6		221.0
6SL28LVO	280	320	19.7	6	746.0	1079.7
6SN s	260	280	14.9	6	850.0	930.6
6SW240	240	260	11.8	6		580.0
6SW28 s	280	300	18.5	6	885.6	1561.7
6T23L s	225	300	11.9	6	800.0	603.6
6T240 s	240	310	14.0	6	750.0	662.3

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
6T260LET	260	330	17.5	6	750.0	1103.3
6T260LST	260	330	17.5	6	720.0	956.3
6T329	290	430	28.4	6		463.0
6TD200	220	380	14.4	6		816.5
6TD24	240	400	18.1	6		331.0
6TM270	270	500	28.6	6		294.0
6TM290	290	400	26.4	6		1103.0
6TR240CO	241	305	13.9	6	1000.0	1103.0
6U28	280	340	20.9	6	720.0	1839.0
6U28AK	280	380	23.4	6		1471.0
6UAL s	200	240	7.5	6	900.0	726.3
6UAUT	200	240	7.5	6	900.0	498.4
6UHLUT	200	240	7.5	6		640.0
6UL s	200	240	7.5	6		496.5
6UST	200	240	7.5	6	750.0	437.5
6UUT	200	240	7.5	6	750.0	416.7
6VCBM / 6VCRM	203	273	8.8	6		150.0
6VD26/20A s	200	260	8.2	6	980.0	581.0
6VD29/24A s	240	290	13.1	6	850.0	946.0
6VD36/241 / 6VD36/24A1	240	360	16.3	6	500.0	423.8
6VDS24/24AL1	240	240	10.9	6		800.0
6VDS26/20AL1	200	260	8.2	6	1000.0	441.0
6VDS29/24AL2	240	290	13.1	6	1000.0	1050.0
6VEBCZM	260	368	19.5	6	600.0	633.3
6VEBXM	260	368	19.5	6		386.5
6VJMS	255	300	15.3	6	750.0	513.0
6VJS	255	300	15.3	6		485.5
6Z280A s	280	360	22.2	6	720.0	1422.3
6Z280E s	280	360	22.2	6	676.3	1268.0
6Z280L s	280	360	22.2	6	679.4	1183.9
6Z280ST	280	360	22.2	6	650.0	1317.8
6Z36 s	220	360	13.7	6		176.5
6ZDT	280	340	20.9	6	680.0	1030.0
6ZET	280	340	20.9	6	680.0	1275.0
6ZL s	280	340	20.9	6	680.0	1091.4
6ZL20/24	200	240	7.5	6		419.0
6ZST	280	340	20.9	6		1177.0
721MTBF-30	205	300	9.9	7	350.0	548.5
726MTBF s	260	400	21.2	7	600.0	886.4
7AC s	280	420	25.9	7		676.8
7ATCM	318	368	29.2	7		927.0
7DNL120/500	190	350	9.9	7		618.0
7DNL150/600	190	350	9.9	7	600.0	772.0
7DNL190/600	190	350	9.9	7	600.0	908.0
7FDM12 s	229	267	11.0	12		1839.0
7FDM16	229	267	11.0	16		1765.3

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
7FDS12A2	229	267	11.0	12	1000.0	1618.0
7FDS16A2	229	267	11.0	16	1200.0	2832.0
7L20/27	200	270	8.5	7	705.7	548.3
7L28/32 s	280	320	19.7	7	769.9	1707.3
7L32/36	320	360	28.9	7	750.0	2589.0
7SM	250	300	14.7	7	600.0	276.0
7T23LKVO / 7T23LVO	225	300	11.9	7	803.3	763.3
7V233LH	225	300	11.9	7		800.0
7V23LVO	225	300	11.9	7		750.0
7VEBC s	260	368	19.5	7		699.3
7VEBXM	260	368	19.5	7		
7VHK	230	330	13.7	7		243.0
814TK	240	310	14.0	8	750.0	794.0
8185CU	185	260	7.0	8	1000.0	588.0
823MTBF	225	300	11.9	8		721.0
824TS	240	310	14.0	8	757.5	910.9
8250	250	320	15.7	8	750.0	1030.0
826MTBF-40	260	400	21.2	8		971.0
8278 s	221	267	10.3	8	675.0	574.4
8300	300	380	26.9	8	527.2	662.2
838D8-1/8	207	254	8.5	8		1020.2
8427-HT s	270	400	22.9	8	594.3	691.4
8567	216	254	9.3	8	750.0	633.4
8645 s	230	254	10.6	8	900.0	892.3
8ACA	280	420	25.9	8	350.0	735.7
8AL20/24	200	240	7.5	8	750.0	591.5
8ASL25 s	250	300	14.7	8	930.0	1350.9
8ATC s	318	368	29.2	8	600.0	1505.8
8ATL25 s	250	300	14.7	8	1000.0	1679.5
8BAH22	220	320	12.2	8	500.0	294.5
8CHNP25/34	250	340	16.7	8	310.0	638.5
8CHNRP30/38	300	380	26.9	8		515.0
8CHNSP18/22 s	180	220	5.6	8	750.0	230.2
8CHNSP25/34	250	340	16.7	8		885.0
8CHNSP2A18/22	180	220	5.6	8		232.0
8DKM28	280	390	24.0	8	660.0	1569.3
8DKM32L	320	360	28.9	8		2427.0
8DL75/475	190	350	9.9	8		441.0
8DNL150/600	190	350	9.9	8		883.0
8DNL170/600	190	350	9.9	8		1000.0
8DNL190/600	190	350	9.9	8		
8DRO21 s	210	300	10.4	8		494.1
8DS26	260	320	17.0	8	720.0	956.5
8DSM26 s	260	320	17.0	8	726.0	1149.2
8DSM28	280	340	20.9	8	720.0	1765.0
8DV26	260	320	17.0	8	720.0	1177.0

Appendix A. Identified Category 2 Marine Diesel Engines
(U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
8DVM26	260	320	17.0	16	720.0	2391.0
8DZC	256	310	16.0	8		1768.0
8EF	290	450	29.7	8	320.0	419.3
8F/SW240	240	260	11.8	8		794.5
8FAHD240	240	260	11.8	8		908.0
8FBHD240	240	260	11.8	8	900.0	821.0
8FCHD240	240	260	11.8	8		805.0
8FDHD240	240	260	11.8	8		1214.0
8FDM240G	240	260	11.8	8	965.0	1445.0
8FEHD240	240	260	11.8	8		1250.0
8FGHD240	240	260	11.8	8	825.0	1247.5
8FHD240	240	260	11.8	8	873.7	1025.2
8GV s	220	380	14.4	8	356.7	584.1
8H27.5	275	300	17.8	8		2104.0
8L20 s	200	275.8	8.7	8	987.8	1016.0
8L23/30 s	225	300	11.9	8	815.3	960.9
8L25 s	250	314.7	15.4	8	809.0	1267.4
8L26	260	320	17.0	8	950.0	2540.0
8L27.5 s	275	320	19.0	8		1614.7
8L27/38	270	380	21.8	8	800.0	2482.8
8L28 s	280	320	19.7	8	766.5	1759.0
8L31 s	310	380	28.7	8	600.0	1809.2
8L32 s	320	356.7	28.7	8		3090.5
8L50/430	190	350	9.9	8		
8M20	200	300	9.4	8	933.8	1288.1
8M23C	230	260	10.8	8		1118.0
8M25	255	400	20.4	8	750.0	2264.0
8M27.5	275	320	19.0	8		680.0
8M281AK	240	280	12.7	8	750.0	721.8
8M282AK	240	280	12.7	8	750.0	919.5
8M331AK	240	330	14.9	8		901.0
8M332AK	240	330	14.9	8	835.7	1246.4
8M332C	240	330	14.9	8	825.0	1506.7
8MB275	275	305	18.1	8	916.7	2032.7
8MD s	251	313.8	15.5	8	850.0	1183.0
8MD27.5H	275	320	19.0	8		827.5
8MG25 s	250	320	15.7	8	705.7	1083.6
8MG28HX	280	370	22.8	8	750.0	1839.0
8MG31 s	310	380	28.7	8	600.0	1520.8
8N21A s	210	290	10.0	8	850.0	1152.3
8N280EN	280	380	23.4	8	720.0	2354.0
8NVD26 s	180	260	6.6	8	750.0	496.5
8NVD36 s	240	360	16.3	8	459.7	305.3
8NVDS36/24A1	240	360	16.3	8	500.0	494.3
8PA4V185 s	185	210	5.6	8	1475.0	798.7
8PA4V200VG	200	210	6.6	8	1337.5	1219.0
8PA5	255	270	13.8	8	986.0	1581.1

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
8PA6L280	280	290	17.9	8	940.0	1995.5
8PBCS12 s	242	305	14.0	8	750.0	903.3
8PS12F	242	305	14.0	8		734.0
8PSHSM26D	260	320	17.0	8		736.0
8PSHT26D	260	320	17.0	8	680.0	680.5
8PSHT6M26D	260	320	17.0	8		587.3
8PSHTB26D	260	320	17.0	8		700.8
8PSHTBM26D	260	320	17.0	8		721.5
8PSHTC s	263	323.9	17.6	8	703.6	723.0
8PSHTM26D	260	320	17.0	8		736.0
8PSN3 s	260	300	15.9	8	772.5	1259.5
8PSTBM s	268	332	19.0	8		806.0
8PSTCM30 s	300	380	26.9	8	600.0	917.3
8PSTM26D	260	320	17.0	8		620.3
8PSTM30	300	380	26.9	8		978.0
8R20	200	280	8.8	8	1000.0	1160.0
8R22 s	220	242	9.2	8	966.7	1177.7
8R32 s	320	350	28.1	8	738.5	3054.9
8R530TZ	175	220	5.3	8		349.0
8RDV136	240	360	16.3	8		221.0
8RK s	255	304	15.6	8	875.0	1258.3
8S12D	241	305	13.9	8		1269.0
8S28LU	280	320	19.7	8	750.0	1496.5
8SL28LVO	280	320	19.7	8	766.7	1502.4
8SN s	258	280	14.7	8	750.0	909.9
8SW28 s	280	300	18.5	8	866.7	2177.7
8T23HU	225	300	11.9	8		782.5
8T23LVO	225	300	11.9	8	800.0	957.8
8TAD24	240	400	18.1	8	400.0	621.5
8TM270	270	500	28.6	8	380.0	660.4
8TR240CO	241	305	13.9	8		1214.0
8U28HU	280	320	19.7	8	775.0	1681.0
8V190C	190	210	6.0	8	1200.0	471.0
8V22 s	220	240	9.1	8	1000.0	1299.3
8V23 s	225	300	11.9	8	812.5	823.0
8V25 s	247	295.1	14.2	8	841.7	1636.7
8V28 s	280	360	22.2	8	597.0	2261.0
8VD26/20AL s	200	260	8.2	8	1000.0	788.0
8VD29/24AL2	240	290	13.1	8	900.0	1600.0
8VD36/24 s	240	360	16.3	8	500.0	364.9
8VDS29/24AL2	240	290	13.1	8	950.0	1736.2
8VDS36/24A1	240	360	16.3	8		442.3
8VEBCM	260	368	19.5	8	600.0	724.5
8VJMS	255	300	15.3	8		
8VJS	255	300	15.3	8		485.0
8VKL60/475	190	350	9.9	8		353.0
8VSHTBM26D	260	320	17.0	16		1368.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
8YJCM	197	216	6.6	8		993.0
8YLC s	248	267	12.9	8	630.0	762.6
8Z280 s	280	360	22.2	8	566.5	1637.5
8ZST	280	340	20.9	8	680.0	1496.0
8ZU421AK	290	420	27.7	8		1030.0
938D8-1/8	207	254	8.5	9		1265.0
9ACA s	280	420	25.9	9	350.0	901.3
9ASL25/30	250	300	14.7	9		1927.0
9ATCM	318	368	29.2	9	587.5	1659.2
9DNL120/500	190	350	9.9	9		794.0
9DNL150/600	190	350	9.9	9		993.0
9DNL170/600	190	350	9.9	9	600.0	978.0
9DNL190/600	190	350	9.9	9		1260.0
9F/SW240	240	260	11.8	9	900.0	1041.9
9FBHD240	240	260	11.8	9		898.7
9FCHD240	240	260	11.8	9		983.5
9FDHD240	240	260	11.8	9		1136.8
9FHD240 s	240	260	11.8	9	918.0	1421.5
9L20 s	200	276.9	8.7	9	983.3	1322.6
9L25/30	250	300	14.7	9		1760.7
9L26	260	320	17.0	9	825.0	2811.0
9L27/38	270	380	21.8	9		3061.0
9L28/32 s	280	320	19.7	9	780.0	2209.1
9L32/36	320	360	28.9	9	750.0	3330.0
9M20	200	300	9.4	9	961.7	1402.0
9M25	255	400	20.4	9	732.0	2568.0
9R20	200	280	8.8	9	1000.0	1478.0
9R26	260	320	17.0	9	950.0	2761.7
9R32 s	320	350	28.1	9	738.0	3305.1
9SW280	280	300	18.5	9		2477.3
9VD29/24AL2 / 9VDS29/24AL2	240	290	13.1	9	1000.0	2100.0
9VDS29/24AL2	240	290	13.1	9	1000.0	2225.0
A2216VIS	220	340	12.9	16		1103.0
A230.12 s	230	270	11.2	12	1000.0	1518.5
A230.8 s	230	270	11.2	8	1000.0	963.7
A238S s	230	270	11.2	8		993.0
A24 s	240	450	20.4	6		521.0
A245 s	245	450	21.2	6	399.0	662.0
A320.12V	320	360	28.9	12	750.0	4413.0
AH25 s	250	410	20.1	6	390.0	662.0
AH27 s	270	420	24.0	6	345.0	809.0
AH28 s	280	442.5	27.2	6	379.2	966.3
B230 s	230	270	11.2	11	1100.0	1937.7
BL230 s	230	310	12.9	11	944.4	1972.3
BR218	210	300	10.4	8		276.0
BRG8	320	360	28.9	8	720.0	3370.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
BRM6	320	360	28.9	6	734.1	2427.4
BRM8	320	360	28.9	8	744.0	3187.8
BRM9	320	360	28.9	9	748.2	3198.5
BV6M536	270	360	20.6	8		662.0
BVM12	320	360	28.9	12	750.0	5298.0
C25:33L s	250	330	16.2	8	900.0	2610.0
D440 s	230	270	11.2	8		600.8
D441V12	230	270	11.2	12		596.0
DB6	290	410	27.1	6		386.5
DM26K s	260	440	23.4	6	410.0	639.1
DM26R	260	440	23.4	6	405.0	551.8
DM28A s	280	460	28.3	6	400.0	862.9
DM28AR	280	460	28.3	6	390.0	927.6
DM28R	280	460	28.3	6	390.0	956.0
DM330	300	410	29.0	3		168.3
DMG36	304	381	27.6	6		936.0
DMG38	305	381	27.8	8	550.0	661.7
DMG6	305	381	27.8	6	400.0	319.0
DMG8	305	381	27.8	8		448.1
DMT330	300	410	29.0	3		254.0
DMT530	300	410	29.0	5		405.0
DMT630	300	410	29.0	6		518.5
DN6	290	410	27.1	6		331.0
DR218	210	300	10.4	8		485.0
DR329	290	410	27.1	3		154.0
DRO216K	210	300	10.4	6		383.0
DRO218 s	210	300	10.4	8	736.7	487.6
DVX12 s	185	200	5.4	12	1250.0	524.0
DY25 s	250	440	21.6	6	420.0	680.5
DY26 s	260	440	23.4	6		735.5
E6	222	292	11.3	6	900.0	368.7
E8	222	292	11.3	8		
ECSL8	222	292	11.3	8		735.0
EGL6	178	229	5.7	6		177.0
EK6	270	400	22.9	6		368.0
ELS16MK2	222	292	11.3	16		1471.0
EM6	260	400	21.2	6		291.7
EMB5	216	343	12.6	5		
ER4M	222	292	11.3	4		166.0
ER6 s	222	292	11.3	6	750.0	256.4
ER8 s	222	292	11.3	8		453.7
ERL4	178	229	5.7	4		
ERL5	178	229	5.7	5		
ERL6	178	229	5.7	6		184.0
ERMGR6	222	292	11.3	6	750.0	372.3
ERN6	178	229	5.7	6		147.0
ERS4 s	222	292	11.3	4	750.0	233.8

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
ERS4MGR	222	292	11.3	4		243.0
ERS6	222	292	11.3	6	725.0	354.6
ERS8 s	222	292	11.3	8	696.2	474.7
ES4 s	222	292	11.3	4		243.0
ES6	222	292	11.3	6		308.8
ES8	222	292	11.3	8	660.7	632.6
ESHC629	290	440	29.1	6	370.0	662.0
ESL12M s	222	292	11.3	12	796.7	1216.7
ESL16 s	222	292	11.3	16	1153.7	1774.3
ESL4MK2	222	292	11.3	4		235.0
ESL5M s	222	292	11.3	5	900.0	515.8
ESL6 s	222	292	11.3	6	815.0	572.4
ESL8 s	222	292	11.3	8	887.0	757.4
ESL9M s	222	292	11.3	9	1333.3	1398.2
ESS4M	222	292	11.3	4		294.0
ESS6	222	292	11.3	6		415.5
ESS8	222	292	11.3	8	670.0	588.0
ESSL12	222	292	11.3	12		883.0
ETS8	222	292	11.3	8	300.0	579.3
ETSL16	222	292	11.3	16		1250.0
ETSL8	222	292	11.3	8		601.0
EV6M	222	292	11.3	6		210.0
EV8M	222	292	11.3	8		250.0
EVS4M	222	292	11.3	4		194.0
EVS6M	222	292	11.3	6		291.0
EVS8M	222	292	11.3	8		370.7
EWSL12M	222	292	11.3	12		883.0
EWSL16 s	222	292	11.3	16		1472.4
EWSL6	222	292	11.3	6		640.0
EWSL8 s	222	292	11.3	8	900.0	703.0
EWZL8	222	292	11.3	8		897.0
EZSL8	222	292	11.3	8	1000.0	758.7
F212V	250	300	14.7	12	844.4	1694.9
F216V	250	300	14.7	16	862.5	2438.7
F26R s	250	300	14.7	6	787.5	894.9
F2896D s	216	216	7.9	6		330.0
F28V	250	300	14.7	8	775.0	1190.3
F312V	250	300	14.7	12	735.0	2077.9
F316V	250	300	14.7	16	825.0	3111.7
F38V	250	300	14.7	8	825.0	1459.0
F4AUDM s	305	380.3	27.8	7		646.3
F6S27.5FH4C	275	450	26.7	6		783.5
FMD98	228	292	11.9	8		390.0
FNS626	280	400	24.6	6		405.0
FSCMGR6	305	381	27.8	6		772.0
FSHC6275	275	400	23.8	6	400.0	588.0
FSM5	305	381	27.8	5		493.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
FSM6	305	381	27.8	6		637.3
FSM8	305	381	27.8	8		868.0
FSSAM6	305	381	27.8	6		853.0
FSSM6	305	381	27.8	6		772.0
G16VS240	240	220	10.0	16		2501.0
G20VS240	240	220	10.0	20		2942.0
G250E s	250	290	14.2	6	719.8	966.7
G5V235/330 s	235	330	14.3	5		392.3
G6V23/33	235	330	14.3	6		321.5
G6V235/330 s	235	330	14.3	6		365.8
G6V285/42	285	420	26.8	6		257.0
G6V42	280	420	25.9	6		375.0
G7235/330ATL	235	330	14.3	7		618.0
G7V235/330ATL	235	330	14.3	7	600.0	602.7
G7V235/33AT	235	330	14.3	7		515.0
G8V23/33	235	330	14.3	8		441.0
G8V235/33 s	235	330	14.3	8		536.8
GN24	240	410	18.5	6	410.0	478.0
GNLH623	230	410	17.0	6		552.0
GNLH624	240	410	18.5	6	410.0	527.0
GNLH625	250	420	20.6	6	400.0	736.0
GNLH6275	275	450	26.7	6	390.0	805.6
GSHC6275	275	450	26.7	6		736.0
GSLH6275	275	450	26.7	6		723.7
HGN4	267	343	19.2	4	400.0	286.0
HGN5	267	343	19.2	5		316.0
HGN6	267	343	19.2	6	345.0	412.8
HGN8	267	343	19.2	8	435.0	750.6
HGP6	267	343	19.2	6		827.5
HGP8	267	343	19.2	8		1177.0
HRL5	265	290	16.0	5	300.0	243.0
HRN4	267	343	19.2	4	300.0	235.5
HRN5	267	343	19.2	5		255.4
HRN6	267	343	19.2	6		374.3
HRN8	267	343	19.2	8		563.4
HRN9	267	343	19.2	9		651.0
HRP8	267	343	19.2	8		750.0
HS6MZ28	280	420	25.9	6	450.0	478.0
HS6NV229	290	430	28.4	6		481.8
HS6X19	240	330	14.9	6		257.0
HSC6MZ28	280	420	25.9	6		552.0
HSN8	267	343	19.2	8	450.0	613.0
JLSSGMR6	248	318	15.4	6		521.5
JLSSGMR8	248	318	15.4	8		771.0
JSSMR8	248	267	12.9	8		636.0
JVSSM12	248	267	12.9	12		919.0
K26S s	260	480	25.5	6	376.6	731.9

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
K28B s	280	480	29.6	6	358.3	797.6
KA6 s	230	360	15.0	6	410.0	270.0
KGRMR265	250	380	18.6	6		235.0
KL21B	185	260	7.0	6		235.0
KMBV12	250	300	14.7	12	750.0	3703.0
KMVB12	250	300	14.7	12		2207.0
KNLH625	258	430	22.6	6	395.0	814.0
KNLH6275	275	450	26.7	6	390.0	956.0
KR2285U / KR228SU	295	420	28.7	6		250.5
KRGB6	250	300	14.7	6	787.5	1011.5
KRGB9	250	300	14.7	9	850.0	2435.6
KRM6	250	300	14.7	6	750.0	990.0
KRM8	250	300	14.7	8	775.0	1494.0
KRM9	250	300	14.7	9	841.7	1817.3
KRMB6	250	300	14.7	6	841.4	1026.6
KRMB8	250	307.5	15.1	8	840.0	1617.4
KRMB9	250	300	14.7	9	818.8	2007.2
KSHC6275	275	400	23.8	6		588.0
KV6M536	270	360	20.6	6		265.0
KVGB12	250	300	14.7	12	850.0	2221.3
KVGB16	250	300	14.7	16	825.0	2977.7
KVGB18	250	300	14.7	18		3358.0
KVM12	250	300	14.7	12	765.0	1646.4
KVM16	250	300	14.7	16	750.0	1840.0
KVMB12	250	300	14.7	12	778.4	1992.2
KVMB16	250	300	14.7	16	800.0	2469.7
KVMB18	250	300	14.7	18		3010.3
KVMB8	250	300	14.7	8	825.0	1460.0
L20710-G7B	230	279	11.6	20	900.0	1839.0
L230 s	230	350	14.5	6.5	600.0	382.5
L5792DS s	216	216	7.9	12	1057.5	998.2
L6670DS s	232	216	9.1	12		839.0
LA230.8SS	230	350	14.5	8		577.0
LDM5	250	300	14.7	5		515.0
LDM6	250	300	14.7	6	750.0	670.8
LDM8	250	300	14.7	8		992.4
LDM9	250	300	14.7	9	780.0	1054.8
LDMB6	250	300	14.7	6	825.0	766.3
LDMB8	250	300	14.7	8	213.0	1088.4
LDMB9	250	300	14.7	9	780.0	1170.8
LDMC6	250	300	14.7	6	787.5	627.0
LDMC8	250	300	14.7	8	750.0	809.0
LDMCB6	250	300	14.7	6	825.0	625.0
LH26G	260	440	23.4	6		
LH28G s	280	460	28.3	6		1177.0
LSMC5	250	300	14.7	5		478.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
LSMC6	250	300	14.7	6		574.0
LSMC8	250	300	14.7	8	750.0	769.8
LSMC9	250	300	14.7	9		1986.0
LSMCB9	250	300	14.7	9	825.0	993.0
LZ6	260	400	21.2	6		331.0
M200 s	200	260	8.2	6	861.8	524.7
M220 s	220	300	11.4	6	789.4	752.9
M24UT	240	420	19.0	6		588.0
M400	180	200	5.1	12	1625.0	686.4
M401 s	180	200	5.1	12	1561.1	709.5
M412	180	200	5.1	12	1500.0	627.0
M416	180	200	5.1	12		810.0
M419AM3	180	200	5.1	12	1600.0	791.3
M421	180	200	5.1	12		990.0
M423	290	420	27.7	8	375.0	552.0
M44I	250	420	20.6	4		228.4
M45I	250	420	20.6	5		334.5
M46 s	253	422.2	21.3	7	320.0	372.5
M47 s	241	405	19.0	7	325.0	392.8
M470	180	200	5.1	12		990.0
M50	180	200	5.1	12		735.5
M6D20B s	200	240	7.5	6	750.0	368.7
M6D26B s	260	320	17.0	6	720.0	551.8
MA301FA	230	300	12.5	8	750.0	605.3
MA423	290	420	27.7	8		555.5
MA424AK	290	420	27.7	8	425.0	736.0
MA6SS	270	400	22.9	6	390.0	456.0
MAS278	270	500	28.6	8		427.0
MAU423 s	290	420	27.7	8	370.0	444.4
MB518C	185	250	6.7	20	1720.0	2207.0
MB839	190	230	6.5	16		1398.0
MD1081	185	200	5.4	20		2530.0
MD330	185	200	5.4	6	1500.0	436.7
MD36	215	360	13.1	3		74.0
MD655 s	185	200	5.4	9	1450.0	662.5
MDS623S	230	380	15.8	6		221.0
MF24 s	234	390.8	17.2	6	411.4	445.3
MF26 s	260	500	26.5	6	349.1	613.5
MF28 s	280	450	27.7	6	364.3	687.6
MH22 s	220	390	14.8	6		416.7
MH23 s	230	390	16.2	6	433.3	479.4
MK6 s	300	420	29.7	6	370.0	400.0
ML624GA s	240	400	18.1	6		257.0
ML624GHS s	240	400	18.1	6	405.0	370.8
ML624GS s	240	400	18.1	6	398.8	386.7
ML626GS s	260	480	25.5	6	340.0	551.7
ML627GS s	270	480	27.5	6	340.0	652.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
MNL28M	280	480	29.6	6	328.0	676.8
MS24	180	240	6.1	6		162.0
MS245G s	245	470	22.2	6		791.0
MS25GSC s	250	470	23.1	6	320.0	563.1
MS25GTSC s	250	470	23.1	6	420.0	698.7
MS26GSC s	260	470	24.9	6	346.7	565.5
MS26GTSC2	260	470	24.9	6		956.0
MS27SC	270	420	24.0	6		625.0
MS28FSC	280	420	25.9	6	400.0	956.0
MS28GFSC	280	420	25.9	6		790.5
MS28SC	280	420	25.9	6	400.0	736.0
MS423	290	420	27.7	6		412.0
MS726	260	400	21.2	6		184.0
MSU36 s	215	360	13.1	6		174.0
MSU423 s	290	420	27.7	6	341.7	304.9
MSU424 s	290	420	27.7	6		345.0
MU323CG s	230	380	15.8	5		294.5
MU323CGS1	230	380	15.8	3		147.0
MU323DGSC	230	380	15.8	3	420.0	267.3
MU36	215	360	13.1	6		147.0
MU623 s	230	380	15.8	6	420.0	353.0
MU625HS	260	420	22.3	6		368.0
MU626HS	270	420	24.0	6		496.5
MU627 s	270	420	24.0	6		496.5
MV36	215	360	13.1	4		103.0
MV421	280	420	25.9	4		110.0
MV423	290	420	27.7	4		226.7
Q265/3	265	410	22.6	3		110.0
R321	210	330	11.4	3		
R4A7	229	305	12.6	7		390.0
R4AUUN5	229	305	12.6	5	750.0	355.0
R6DV136	240	360	16.3	6		205.3
R6Z133U	225	330	13.1	6	600.0	308.0
R8DV136	240	360	16.3	8	350.0	238.3
R8V22/30ATL	220	300	11.4	8		791.0
R8Z133	225	330	13.1	8	500.0	368.0
RA6M428	220	280	10.6	6		176.3
RA6M528	220	280	10.6	6		186.3
RA8M428	220	280	10.6	8		228.0
RA8M528	220	280	10.6	8		287.0
RBA12M528	220	280	10.6	12		1066.5
RBA6M428	220	280	10.6	6		268.5
RBA6M528	220	280	10.6	6	807.0	362.2
RBA8M528	220	280	10.6	8	810.0	507.2
RBV6M536	270	360	20.6	6		353.2
RBV6M628	240	280	12.7	6		1235.0
RDV136	240	360	16.3	6		221.0

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
RH230 s	215	300	10.9	5	475.0	126.0
RH235	250	350	17.2	4		110.0
RH330 s	215	300	10.9	6	600.0	182.4
RH335SU	250	350	17.2	6	500.0	216.0
RH435SU	250	350	17.2	6		239.0
RH526A	180	260	6.6	8		173.0
RHO215	210	300	10.4	5		280.0
RHO216K	210	300	10.4	6		204.5
RHO218K	210	300	10.4	8		485.0
RHS435 s	250	350	17.2	7		294.5
RHS526 s	180	260	6.6	7	900.0	196.5
RSBA12M528	220	280	10.6	12	829.7	1058.3
RSBA16M528	220	280	10.6	16		1588.5
RSBA6M528	220	280	10.6	6	900.0	551.0
RSBA8M528	220	280	10.6	8	784.3	701.9
RSP5	250	360	17.7	5		331.0
RSP6	250	360	17.7	6	425.0	397.0
RTG 8	250	360	17.7	8	445.0	373.7
RTG7	250	360	17.7	7		386.0
RTG8	250	500	24.5	8		364.0
RV6M	270	360	20.6	6		147.0
RV6M436	240	360	16.3	6		177.0
RV6M536	270	360	20.6	6	506.3	233.7
RV8M536	270	360	20.6	8	500.0	625.0
RZI6	210	330	11.4	6	430.0	221.0
S12UMTK	240	260	11.8	12		2354.0
S185 s	185	230	6.2	6	848.8	402.4
S23G	230	400	16.6	6	404.3	385.9
S25G	250	450	22.1	6		426.8
S26G	260	470	24.9	6	379.5	603.1
S27G	270	480	27.5	6	380.0	855.3
S623 s	230	400	16.6	6	410.0	277.5
S6EDSS	240	400	18.1	6		441.0
S6MBHS	220	400	15.2	6		331.0
S6MBTHS	220	400	15.2	6	380.0	343.3
S6MUH28	280	340	20.9	6		1177.0
S6NDTE	270	400	22.9	6		294.0
S6UCT s	260	400	21.2	6		324.0
S6UDT s	260	400	21.2	6	397.5	544.0
S6UFGSS	260	400	21.2	6		427.0
S6UFTSS	260	400	21.2	6	410.0	625.0
S6UMPTK	240	260	11.8	6	900.0	978.5
S6UMTK	240	260	11.8	6	2000.0	978.1
S6YDTSS	280	420	25.9	6		644.0
S6YFSS	280	440	27.1	6		956.0
S8UMTK	240	260	11.8	8		1839.0
SA4M428	220	280	10.6	4		

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
SA6M428	220	280	10.6	6		158.0
SBA12M528	220	280	10.6	12	867.0	1050.8
SBA4M428	220	280	10.6	4		
SBA6M528	220	280	10.6	6	830.5	381.0
SBA6M628	240	280	12.7	6	763.7	670.3
SBA8M528	220	280	10.6	8.21621622	812.8	640.7
SBV12M628	240	280	12.7	12	800.0	1976.8
SBV16M628	240	280	12.7	16	950.0	3097.1
SBV6M536	270	360	20.6	6	600.0	542.5
SBV6M628	240	280	12.7	6	864.7	935.2
SBV8M536	270	360	20.6	8	500.0	736.8
SBV8M628	240	280	12.7	8	841.3	1230.4
SBV9M628	240	280	12.7	9	867.2	1376.0
SF112V s	250	300	14.7	12	750.0	1584.1
SF116V s	250	300	14.7	16	800.0	2259.5
SF13RSF	250	300	14.7	3		357.0
SF14RS	250	300	14.7	4		331.0
SF15RSC	250	300	14.7	5		508.0
SF16RS s	250	300	14.7	6	750.0	725.9
SF18VS s	250	300	14.7	8	766.7	943.0
SIIB	280	420	25.9	6		239.0
SOD629 s	290	420	27.7	6	420.0	736.0
SODCHS6S25	250	410	20.1	6	420.0	552.0
SODHS6S24	240	390	17.6	6		379.7
SODHS6S25	250	410	20.1	6		552.0
SODHS6S26	260	410	21.8	6	420.0	588.0
SODHS6X26	260	410	21.8	6		600.3
SODHS6X29	290	440	29.1	6		717.5
SR4Z127	160	270	5.4	4		110.0
SR8	260	330	17.5	8		552.0
SV3M345	280	450	27.7	3		110.0
SV6M536	270	360	20.6	6	500.0	279.0
T12RS18/22	180	220	5.6	12	1200.0	496.5
T220 s	222	289.2	11.2	6	801.0	698.0
T220AL s	220	280	10.6	6		686.7
T240 s	240	310	14.0	6	766.7	701.6
T260 s	260	330	17.5	6	703.3	978.9
T26S s	260	440	23.4	6	447.0	602.3
T5B26YC	260	400	21.2	5		199.0
T6EKA	270	400	22.9	6		257.0
TARHS335AU	250	350	17.2	8		530.0
TB12RS18/22	180	220	5.6	12	1250.0	699.0
TB16RS18/22	180	220	5.6	16	1300.0	949.0
TBD4406 s	230	270	11.2	6	831.6	625.8
TBD4408 s	230	270	11.2	8	798.7	799.7
TBD441V12 s	230	270	11.2	12	810.0	1121.5
TBD441V16 s	230	270	11.2	16		1465.2

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

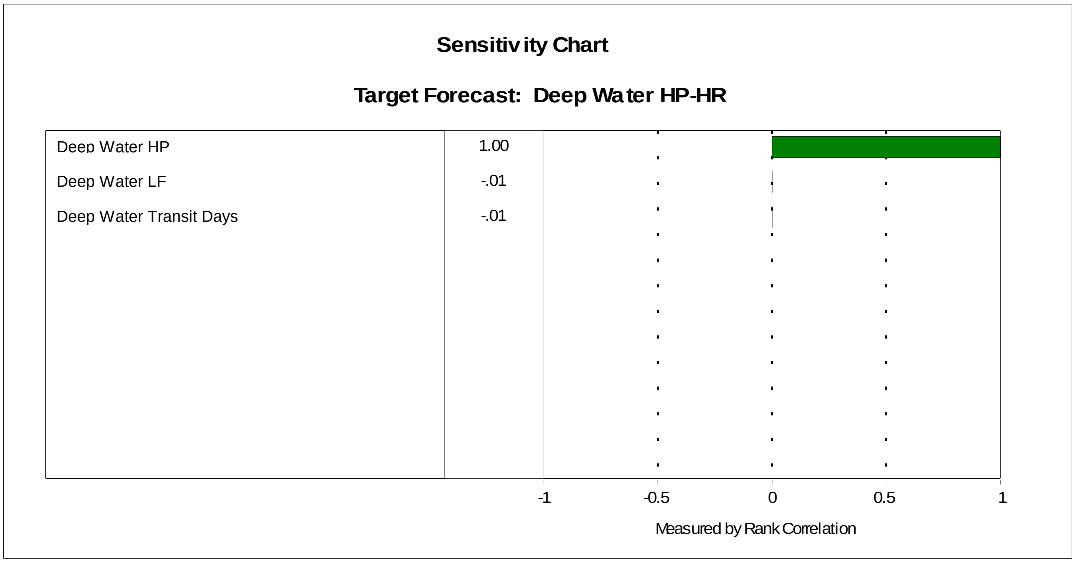
Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
TBD4446	230	320	13.3	6	750.0	809.3
TBD4448	230	320	13.3	8	750.0	1157.5
TBRH526SU	180	260	6.6	6		220.0
TBRS18/22V12	180	220	5.6	12		721.0
TD4406	230	270	11.2	6		463.3
TD4408	230	270	11.2	8		603.5
TD441V12	230	270	11.2	12		1067.0
TD441V16	230	270	11.2	16		1103.0
TEB296	290	400	26.4	6		1132.5
TEBF296	290	400	26.4	6		1103.0
TLADM4	216	349	12.8	4		150.0
TLSDMR6	216	330	12.1	6		269.0
TMAB276	270	500	28.6	6		607.0
TMAB278	270	500	28.6	8		691.0
TMABS278	270	500	28.6	8	380.0	752.0
TMAS276	270	500	28.6	6	375.0	307.0
TMBAS276	270	500	28.6	6		291.0
TRH435 s	250	350	17.2	7	437.5	395.9
TRHS435 s	250	350	17.2	7		504.4
TRHS518V16	180	220	5.6	16	1500.0	471.0
TRHS526A	180	260	6.6	8		206.0
UHS27	270	420	24.0	6	390.0	736.0
V12A/12	185	210	5.6	12		993.0
V12TR240CO	241	305	13.9	12	225.0	1888.3
V16A/12	185	210	5.6	16		1353.0
V16A/9	185	210	5.6	16		1236.0
V16TR240CO	241	305	13.9	16	1000.0	3118.0
V18A/10	185	210	5.6	18		1566.5
V18B/12	210	210	7.3	18	1200.0	2111.0
V6A/12	185	210	5.6	6		662.0
V6A/9	185	210	5.6	6		423.0
V6B	210	210	7.3	12	1663.0	1957.0
V6V22/30 s	220	300	11.4	12	780.0	868.2
V8A s	185	210	5.6	8		588.0
V8V22/30ATL	220	300	11.4	16	850.0	1350.7
V8V30/42AL	300	420	29.7	16		2700.0
VC8M	203	273	8.8	8		150.0
W4VSLM	175	220	5.3	4	666.5	156.0
W6LSR	180	220	5.6	6		221.0
W6V175/22A	175	220	5.3	6		122.5
W6V22/30A	220	300	11.4	6		515.0
W6VBSLM	175	220	5.3	6	670.0	284.7
W8V175/22 s	175	220	5.3	8	950.0	188.9
W8V30/38	300	380	26.9	8		1102.5
W8VBSLM	175	220	5.3	8	1182.9	382.6
W8VCSLM	175	220	5.3	8	386.0	386.0
WX28 s	280	390	24.0	7	548.8	1593.7

Appendix A. Identified Category 2 Marine Diesel Engines (U.S. and Foreign Manufacturers) (Cont.)

Engine Model	Bore	Stroke	Displace	Cylinders	RPM	kW
YYYY	240	400	18.1	8	1.0	618.0
Z27 s	270	420	24.0	6	390.0	588.0
Z280EN	260	280	14.9	6	720.0	1209.0
Z3	300	360	25.4	3	375.0	154.0
Z35	235	300	13.0	6		405.0
Z4	300	360	25.4	4		206.0
Z4EM	260	400	21.2	4		
Z6235SH	235	300	13.0	6		429.0
Z626SH	260	330	17.5	6		496.5
Z627ASH	270	400	22.9	6		441.4
Z66	260	330	17.5	6		496.5
Z68	260	330	17.5	8		736.0
Z6L28ASH	280	430	26.5	6		588.0
Z6UK27	270	420	24.0	6		74.0
Z6VSH	280	450	27.7	6		637.3
Z76	270	400	22.9	6		441.3

Appendix B. Summary of Monte Carlo Input and Output data

Deep Water Vessel



Forecast: Deep Water HP-HR

Summary:

Display Range is from 1,191,707,853 to 4,440,497,391 HP-HR
Entire Range is from 1,169,729,099 to 4,465,240,444 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 6,989,695

Statistics:	Value
Trials	10000
Mean	2,666,159,213
Median	2,596,210,614
Mode	---
Standard Deviation	698,969,510
Variance	5E+17
Skewness	0.30
Kurtosis	2.36
Coeff. of Variability	0.26
Range Minimum	1,169,729,099
Range Maximum	4,465,240,444
Range Width	3,295,511,345
Mean Std. Error	6,989,695.10

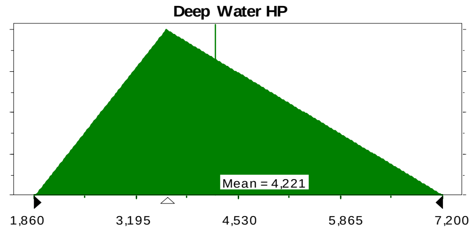
Deep Water Vessel Assumptions

Assumption: Deep Water HP

Triangular distribution with parameters:

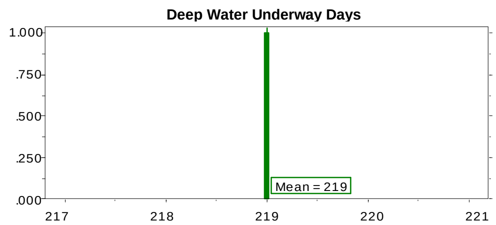
Minimum	1,860
Likeliest	3,603
Maximum	7,200

Selected range is from 1,860 to 7,200



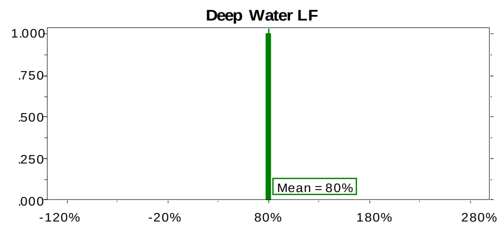
Assumption: Deep Water Underway Days

Custom distribution with parameters:		Relative Prob.
Single point	219	1.000000
Total Relative Probability		1.000000

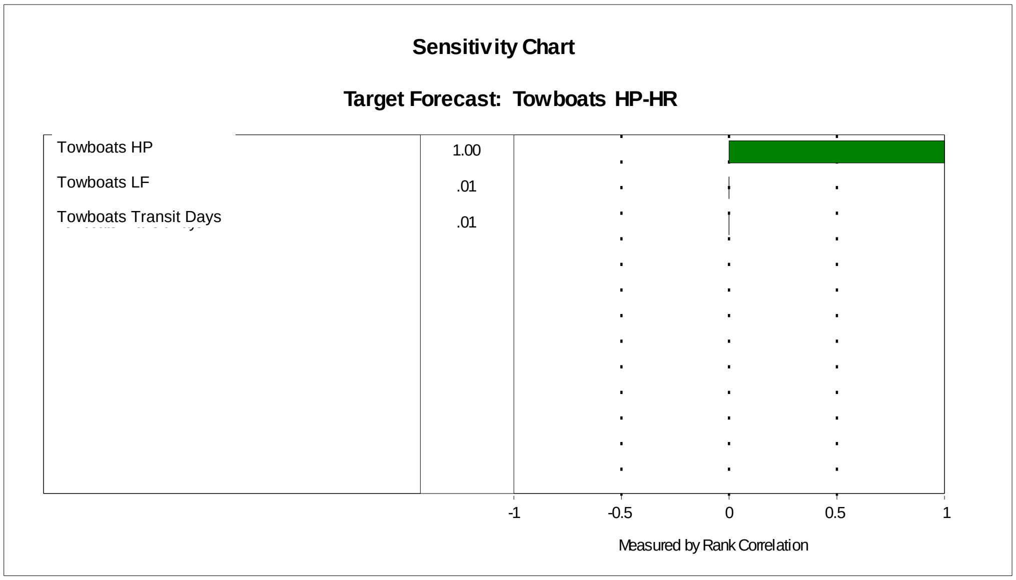


Assumption: Deep Water LF

Custom distribution with parameters:		Relative Prob.
Single point	80%	1.000000
Total Relative Probability		1.000000



Towboats



Forecast: Towboat HP-HR

Summary:

Display Range is from 3,243,495,839 to 15,743,368,200 HP-HR
Entire Range is from 3,213,901,615 to 25,888,889,076 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 30,200,146

Statistics:

	Value
Trials	10000
Mean	7,920,359,723
Median	7,390,600,445
Mode	---
Standard Deviation	3,020,014,562
Variance	9E+18
Skewness	0.95
Kurtosis	3.99
Coeff. of Variability	0.38
Range Minimum	3,213,901,615
Range Maximum	25,888,889,076
Range Width	22,674,987,462
Mean Std. Error	30,200,145.62

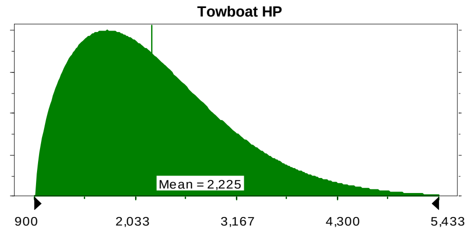
<u>**Towboat Assumptions**</u>

Assumption: Towboat HP

Weibull distribution with parameters:

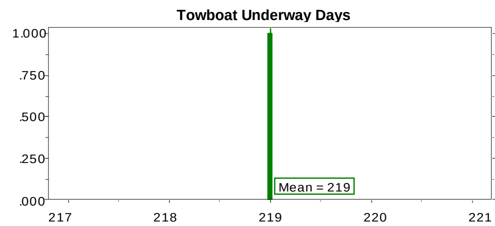
Location	900
Scale	1,477
Shape	1.596695

Selected range is from 900 to +Infinity



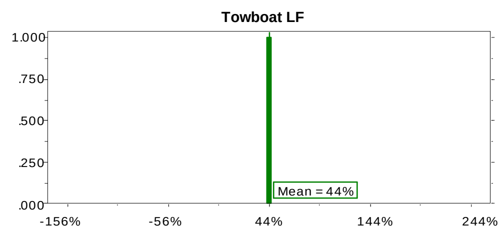
Assumption: Towboat Underway Days

Custom distribution with parameters:		Relative Prob.
Single point	219	1.000000
Total Relative Probability		1.000000

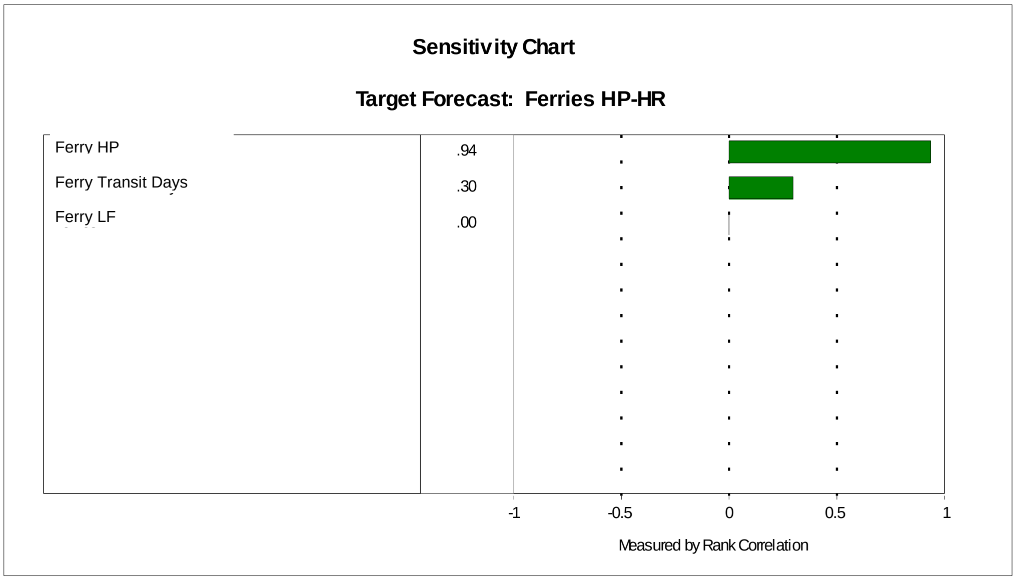


Assumption: Towboat LF

Custom distribution with parameters:		Relative Prob.
Single point	44%	1.000000
Total Relative Probability		1.000000



Ferry Vessels



Forecast: Ferry HP-HR

Summary:

Display Range is from 537,632,473 to 2,658,247,438 HP-HR
Entire Range is from 462,593,200 to 3,055,815,023 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 4,432,935

Statistics:	Value
Trials	10000
Mean	1,464,293,131
Median	1,438,633,302
Mode	---
Standard Deviation	443,293,456
Variance	2E+17
Skewness	0.31
Kurtosis	2.71
Coeff. of Variability	0.30
Range Minimum	462,593,200
Range Maximum	3,055,815,023
Range Width	2,593,221,823
Mean Std. Error	4,432,934.56

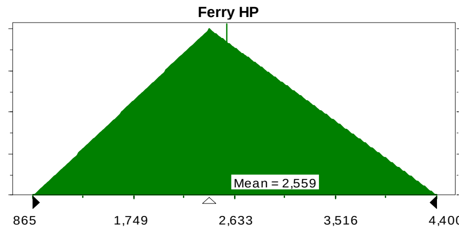
Ferry Vessel Assumptions

Assumption: Ferry HP

Triangular distribution with parameters:

Minimum	865
Likeliest	2,412
Maximum	4,400

Selected range is from 865 to 4,400

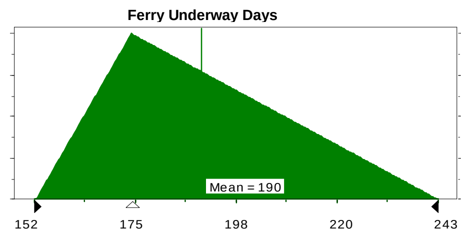


Assumption: Ferry Underway Days

Triangular distribution with parameters:

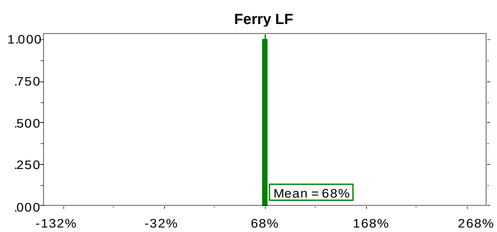
Minimum	152
Likeliest	174
Maximum	243

Selected range is from 152 to 243

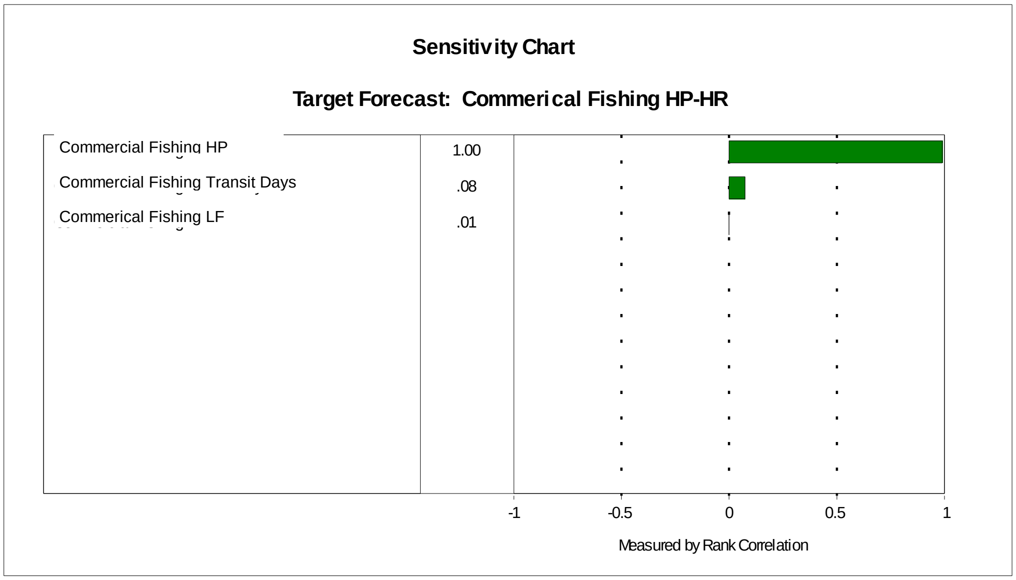


Assumption: Ferry LF

Custom distribution with parameters:		Relative Prob.
Single point	68%	1.000000
Total Relative Probability		1.000000



Commerical Fishing Vessels



Forecast: Commerical Fishing HP-HR

Summary:

Display Range is from 1,733,197,125 to 6,376,550,424 HP-HR
Entire Range is from 1,658,213,722 to 10,825,122,187 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 11,426,276

Statistics:

Statistics	Value
Trials	10000
Mean	3,412,840,776
Median	3,183,342,782
Mode	---
Standard Deviation	1,142,627,610
Variance	1E+18
Skewness	1.05
Kurtosis	4.29
Coeff. of Variability	0.33
Range Minimum	1,658,213,722
Range Maximum	10,825,122,187
Range Width	9,166,908,466
Mean Std. Error	11,426,276.10

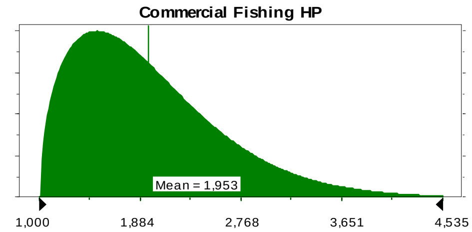
Commercial Fishing Assumptions

Assumption: Commercial Fishing HP

Weibull distribution with parameters:

Location	1,000
Scale	1,054
Shape	1.478789

Selected range is from 1,000 to +Infinity

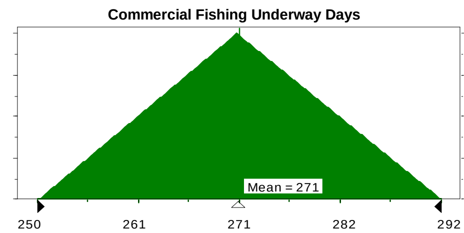


Assumption: Commercial Fishing Underway Days

Triangular distribution with parameters:

Minimum	250
Likeliest	271
Maximum	292

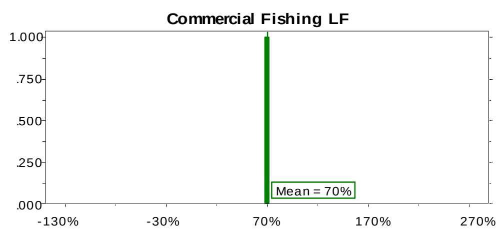
Selected range is from 250 to 292



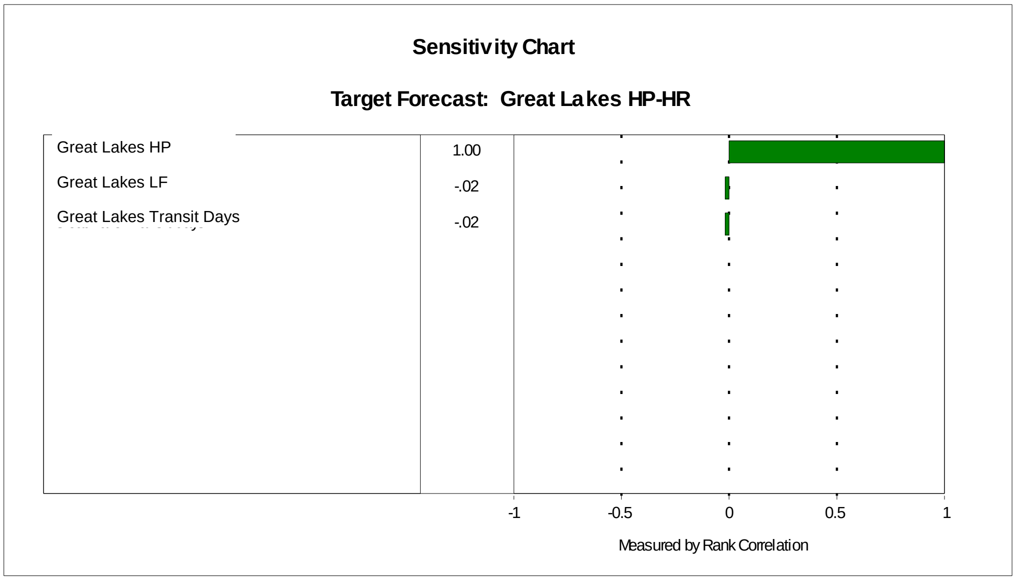
Assumption: Commercial Fishing LF

Custom distribution with parameters:

		Relative Prob.
Single point	70%	1.000000
Total Relative Probability		1.000000



Great Lakes Vessels



Forecast: Great Lakes HP-HR

Summary:

Display Range is from 376,459,662 to 2,238,549,592 HP-HR
Entire Range is from 332,637,421 to 2,273,199,755 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 4,051,230

Statistics:	Value
Trials	10000
Mean	1,393,243,855
Median	1,433,115,004
Mode	---
Standard Deviation	405,123,010
Variance	2E+17
Skewness	-0.27
Kurtosis	2.38
Coeff. of Variability	0.29
Range Minimum	332,637,421
Range Maximum	2,273,199,755
Range Width	1,940,562,333
Mean Std. Error	4,051,230.10

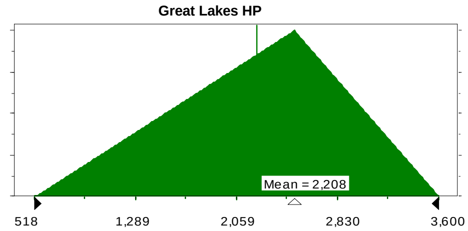
Great Lakes Vessel Assumptions

Assumption: Great Lakes HP

Triangular distribution with parameters:

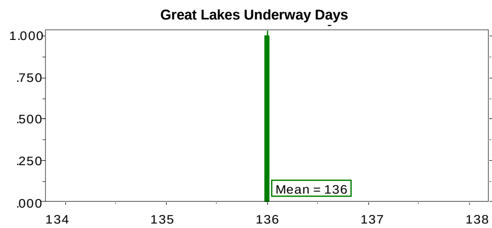
Minimum	518
Likeliest	2,505
Maximum	3,600

Selected range is from 518 to 3,600



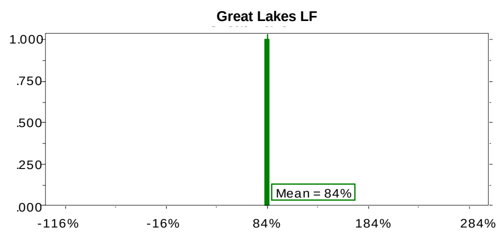
Assumption: Great Lakes Underway days

Custom distribution with parameters:		Relative Prob.
Single point	136	1.000000
Total Relative Probability		1.000000

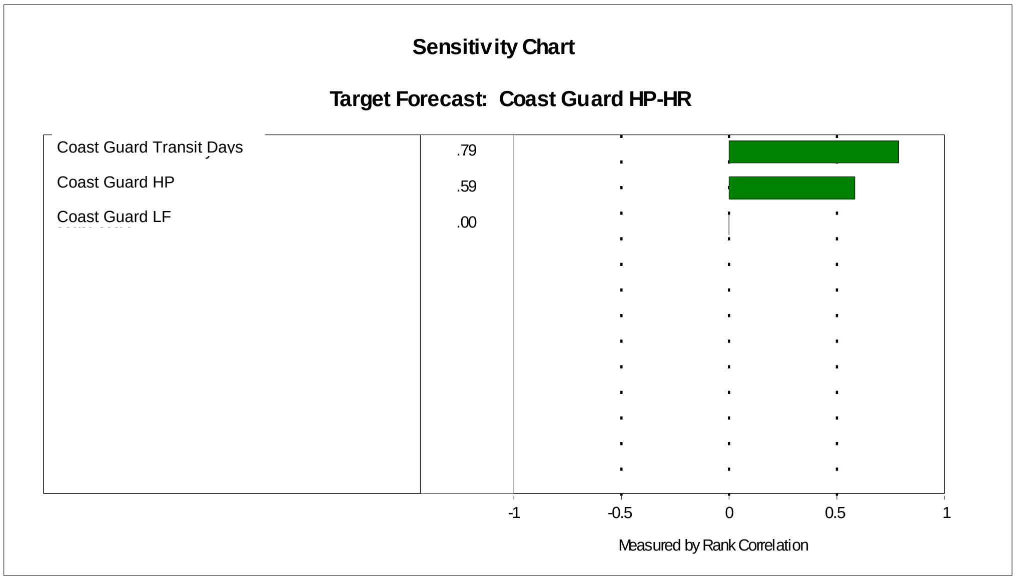


Assumption: Great Lakes LF

Custom distribution with parameters:		Relative Prob.
Single point	84%	1.000000
Total Relative Probability		1.000000



Coast Guard Vessels



Forecast: Coast Guard HP-HR

Summary:

Display Range is from 403,019,387 to 2,730,806,185 Hp-HR
Entire Range is from 357,200,211 to 3,319,883,788 Hp-HR
After 10,000 Trials, the Std. Error of the Mean is 4,955,407

Statistics:

	Value
Trials	10000
Mean	1,441,432,575
Median	1,387,144,416
Mode	---
Standard Deviation	495,540,718
Variance	2E+17
Skewness	0.53
Kurtosis	3.01
Coeff. of Variability	0.34
Range Minimum	357,200,211
Range Maximum	3,319,883,788
Range Width	2,962,683,577
Mean Std. Error	4,955,407.18

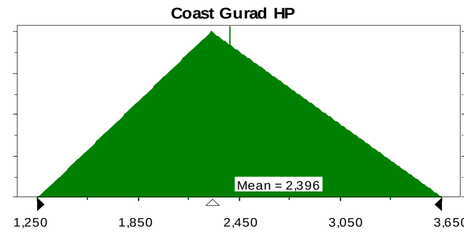
Coast Guard Vessel Assumptions

Assumption: Coast Guard HP

Triangular distribution with parameters:

Minimum	1,250
Likeliest	2,289
Maximum	3,650

Selected range is from 1,250 to 3,650

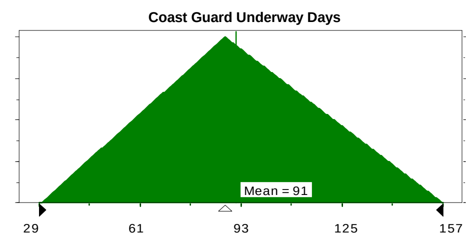


Assumption: Coast Guard Underway Days

Triangular distribution with parameters:

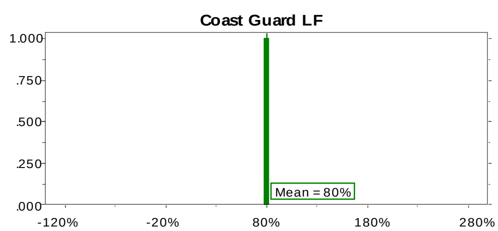
Minimum	29
Likeliest	88
Maximum	157

Selected range is from 29 to 157

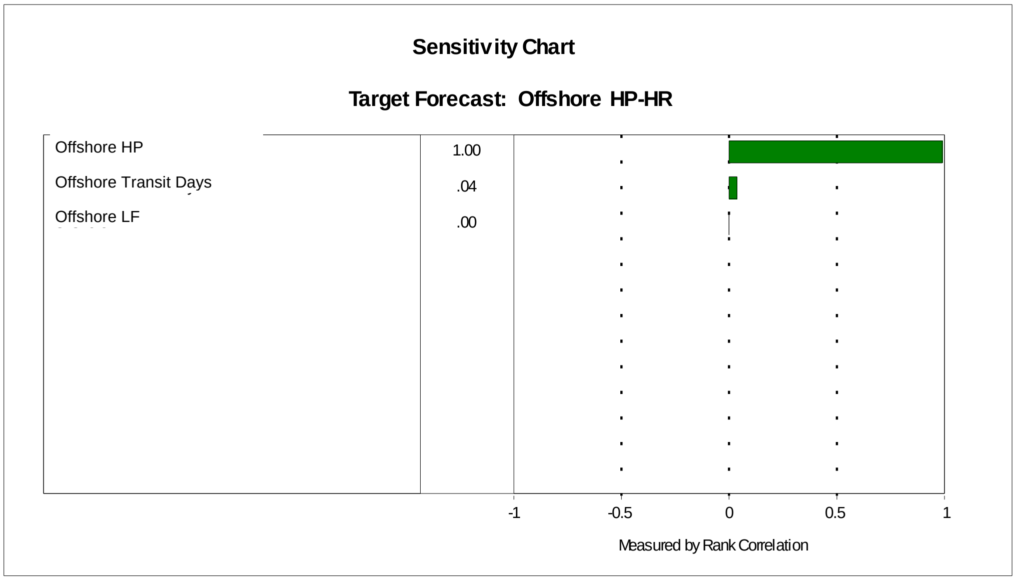


Assumption: Coast Guard LF

Custom distribution with parameters:		Relative Prob.
Single point	80%	1.000000
Total Relative Probability		1.000000



Offshore Vessels



Forecast: Offshore HP-HR

Summary:

Display Range is from 7,660,583,858 to 60,579,374,850 HP-HR
Entire Range is from 6,009,238,235 to 61,335,988,555 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 119,330,949

Statistics:	Value
Trials	10000
Mean	27,810,331,286
Median	26,052,108,450
Mode	---
Standard Deviation	11,933,094,915
Variance	1E+20
Skewness	0.49
Kurtosis	2.43
Coeff. of Variability	0.43
Range Minimum	6,009,238,235
Range Maximum	61,335,988,555
Range Width	55,326,750,320
Mean Std. Error	119,330,949.15

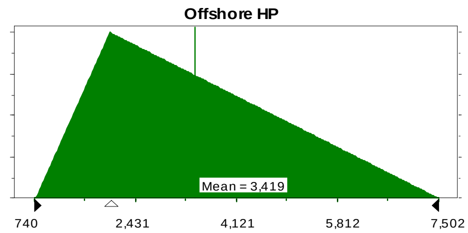
Offshore Vessel Assumptions

Assumption: Offshore HP

Triangular distribution with parameters:

Minimum	740
Likeliest	2,016
Maximum	7,502

Selected range is from 740 to 7,502

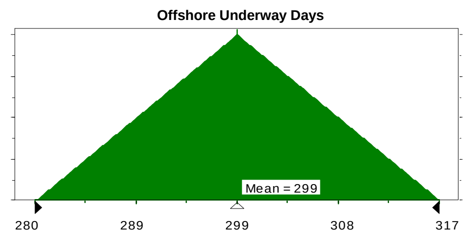


Assumption: Offshorse Underway Days

Triangular distribution with parameters:

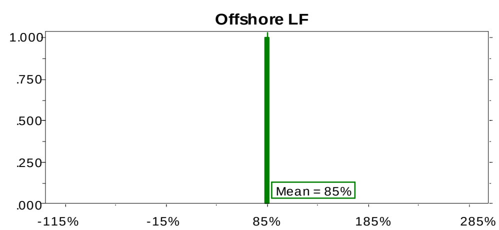
Minimum	280
Likeliest	299
Maximum	317

Selected range is from 280 to 317

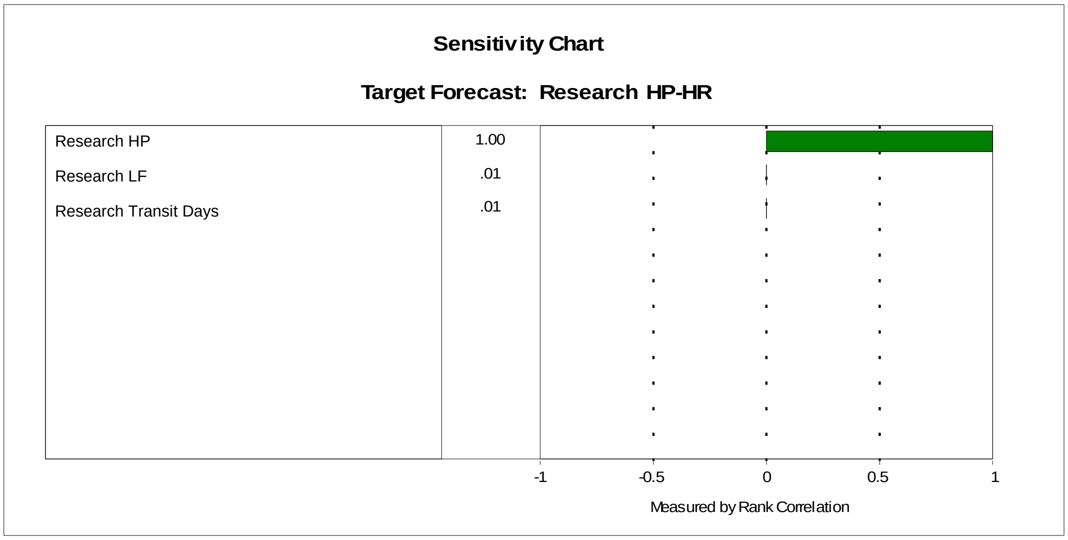


Assumption: Offshore LF

Custom distribution with parameters:		Relative Prob.
Single point	85%	1.000000
Total Relative Probability		1.000000



Research Vessels



Forecast: Research HP-HR

Summary:

Display Range is from 222,501,388 to 1,215,121,143 HP-HR
Entire Range is from 204,627,058 to 1,231,848,504 HP-HR
After 10,000 Trials, the Std. Error of the Mean is 2,170,568

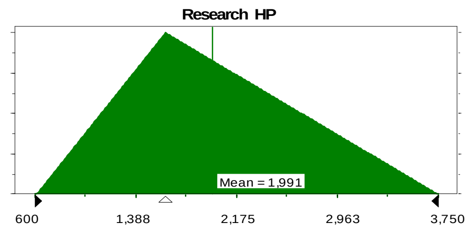
Statistics:	Value
Trials	10000
Mean	654,876,718
Median	632,414,746
Mode	---
Standard Deviation	217,056,751
Variance	5E+16
Skewness	0.31
Kurtosis	2.38
Coeff. of Variability	0.33
Range Minimum	204,627,058
Range Maximum	1,231,848,504
Range Width	1,027,221,446
Mean Std. Error	2,170,567.51

Research Vessel Assumptions

Assumption: Research HP

Triangular distribution with parameters:

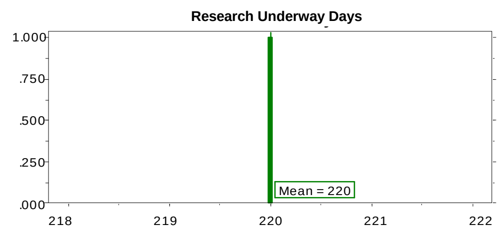
Minimum	600
Likeliest	1,622
Maximum	3,750



Selected range is from 600 to 3,750

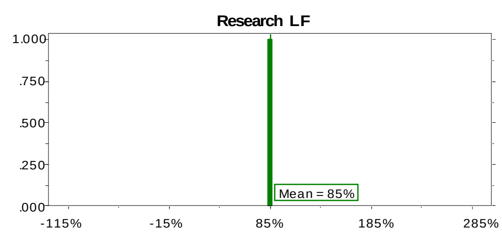
Assumption: Research Underway Days

Custom distribution with parameters:		Relative Prob.
Single point	220	1.000000
Total Relative Probability		1.000000



Assumption: Research LF

Custom distribution with parameters:		Relative Prob.
Single point	85%	1.000000
Total Relative Probability		1.000000



Appendix C. Category 2 In-Port / At-Sea Splits

In-Port and At Sea Summary (weighted by Activity, HP-HR)					
Category 2	Straight Average In-Port	Straight Average At-Sea	Activity (HP-HR)	Weighted Fraction In-Port	Weighted Fraction At-Sea
Towboats	**17%**	**83%**	**1,387,249,658**	**0.87%**	**4.22%**
Fishing	**5%**	**95%**	**3,341,826,590**	**0.61%**	**11.65%**
Offshore	**4%**	**96%**	**16,406,300,754**	**2.59%**	**57.63%**
Ferries	**65%**	**35%**	**1,267,998,585**	**3.02%**	**1.63%**
Deepwater	**1%**	**99%**	**1,387,249,658**	**0.05%**	**5.04%**
Research	**1%**	**99%**	**534,376,948**	**0.02%**	**1.94%**
Great Lakes	**1%**	**99%**	**1,588,928,635**	**0.06%**	**5.77%**
Government	**59%**	**41%**	**1,332,989,402**	**2.86%**	**2.03%**
Total	--	--	27,246,920,230	10.09%	89.91%
Average	19%	81%	--	--	--

1. Towboats, Tugs, and Tractors

Subgroup	Population	Population Fraction	In-Port	At-Sea
Assist Vessel	**19**	**1.8%**	**95.0%**	**5.0%**
Line Haul Tug – Inland	**713**	**67.5%**	**15.0%**	**85.0%**
Line Haul Tug – Oceanic	**314**	**29.7%**	**15.0%**	**85.0%**
Dredge Support	**11**	**1.0%**	**85.0%**	**15.0%**
Total	1057	100.0%		

Subgroup	In-Port	At-Sea
Assist Vessel	**1.7%**	**0.1%**
Line Haul Tug - Inland	**10.1%**	**57.3%**
Line Haul Tug - Oceanic	**4.5%**	**25.3%**
Dredge Support	**0.9%**	**0.2%**
Total	17.2%	82.8%

2. Commercial Fishing

Subgroup	Population	Population Fraction	In-Port	At-Sea
Commercial Fishing	**333**	**100.0%**	**5.0%**	**95.0%**
Total	333	100.0%		

Subgroup	In-Port	At-Sea
Commercial Fishing	**5.0%**	**95.0%**
Total	5.0%	95.0%

3. Offshore

Subgroup	Population	Population Fraction	In-Port	At-Sea
Crewboat/supply/crane	**462**	**76.6%**	**5.0%**	**95.0%**
Survey	**24**	**4.0%**	**2.0%**	**98.0%**
Pipelayer	**14**	**2.3%**	**2.0%**	**98.0%**
Anchor	**21**	**3.5%**	**2.0%**	**98.0%**
Liftboat	**82**	**13.6%**	**2.0%**	**98.0%**
Total	603	100.0%		

Subgroup	In-Port	At-Sea
Crewboat/supply/crane	**3.8%**	**72.8%**
Survey	**0.1%**	**3.9%**
Pipelayer	**0.0%**	**2.3%**
Anchor	**0.1%**	**3.4%**
Liftboat	**0.3%**	**13.3%**
Total	4.3%	95.7%

4. Ferries

Subgroup	Population	Population Fraction	In-Port	At-Sea
Passenger Ferry	**99**	**100.0%**	**65.0%**	**35.0%**
Total	99	100.0%		

Subgroup	In-Port	At-Sea
Passenger Ferry	**65.0%**	**35.0%**
Total	65.0%	35.0%

5. Deepwater

Subgroup	Population	Population Fraction	In-Port	At-Sea
US Flagged	**45**	**100.0%**	**1.0%**	**99.0%**
Total	45	100.0%		

Subgroup	In-Port	At-Sea
US Flagged	**1.0%**	**99.0%**
Total	1.0%	99.0%

6. Research

Subgroup	Population	Population Fraction	In-Port	At-Sea
Univesity	**31**	**100.0%**	**1.0%**	**99.0%**
Total	31	100.0%		

Subgroup	In-Port	At-Sea
Univesity	**1.0%**	**99.0%**
Total	1.0%	99.0%

7. Great Lakes and others

Subgroup	Population	Population Fraction	In-Port	At-Sea
Auto	*0*	**0.0%**	**1.0%**	**99.0%**
Bulk	*18*	**16.1%**	**1.0%**	**99.0%**
Container	*2*	**1.8%**	**1.0%**	**99.0%**
Cruise	*5*	**4.5%**	**1.0%**	**99.0%**
General Cargo	*35*	**31.3%**	**1.0%**	**99.0%**
RORO	*2*	**1.8%**	**1.0%**	**99.0%**
Special Carrier	*43*	**38.4%**	**1.0%**	**99.0%**
Tanker	*7*	**6.3%**	**1.0%**	**99.0%**
Total	112	1.0		

Subgroup	In-Port	At-Sea
Auto	**0.0%**	**0.0%**
Bulk	**0.2%**	**15.9%**
Container	**0.0%**	**1.8%**
Cruise	**0.0%**	**4.4%**
General Cargo	**0.3%**	**30.9%**
RORO	**0.0%**	**1.8%**
Special Carrier	**0.4%**	**38.0%**
Tanker	**0.1%**	**6.2%**
Total	1.00%	99.00%

8. Government

Subgroup	Population	Population Fraction	In-Port	At-Sea
USCG - Cruiser/Ice Breaker	**37**	**23.6%**	**4.0%**	**96.0%**
USCG - Patrol	**106**	**67.5%**	**80.0%**	**20.0%**
USCG - Buoy Tender	**14**	**8.9%**	**40.0%**	**60.0%**
Total	157	100.0%		

Subgroup	In-Port	At-Sea
USCG - Cruiser/Ice Breaker	**0.9%**	**22.6%**
USCG - Patrol	**54.0%**	**13.5%**
USCG - Buoy Tender	**3.6%**	**5.4%**
Total	58.5%	41.5%

Appendix D. Category 1 In-Port / At-Sea Splits

1. Towboats, Tugs, and Tractors

Subgroup	Population	Population Fraction	In-Port	At-Sea
Line Haul Tug - Inland	**2504**	**79.1%**	**15.0%**	**85.0%**
Line Haul Tug - Oceanic	**660**	**20.9%**	**15.0%**	**85.0%**
Total	3164	100.0%		

Subgroup	In-Port	At-Sea
Line Haul Tug - Inland	**11.9%**	**67.3%**
Line Haul Tug - Oceanic	**3.1%**	**17.7%**
Total	15.0%	85.0%

2. Commercial Fishing

Subgroup	Population	Population Fraction	In-Port	At-Sea
Commercial Fishing	**29346**	**100.0%**	**3.0%**	**97.0%**
Total	29346	100.0%		

Subgroup	In-Port	At-Sea
Commercial Fishing	**3.0%**	**97.0%**
Total	3.0%	97.0%

3. Offshore

Subgroup	Population	Population Fraction	In-Port	At-Sea
Crewboat/supply/crane	**405**	**76.6%**	**5.0%**	**95.0%**
Survey	**21**	**4.0%**	**2.0%**	**98.0%**
Pipelayer	**12**	**2.3%**	**2.0%**	**98.0%**
Anchor	**18**	**3.5%**	**2.0%**	**98.0%**
Liftboat	**72**	**13.6%**	**2.0%**	**98.0%**
Total	529	100.0%		

Subgroup	In-Port	At-Sea
Crewboat/supply/crane	**3.8%**	**72.8%**
Survey	**0.1%**	**3.9%**
Pipelayer	**0.0%**	**2.3%**
Anchor	**0.1%**	**3.4%**
Liftboat	**0.3%**	**13.3%**
Total	4.3%	95.7%

4. Ferries

Subgroup	Population	Population Fraction	In-Port	At-Sea
Ferries	**508**	**100.0%**	**80.0%**	**20.0%**
Total	508	100.0%		

Subgroup	In-Port	At-Sea
Ferries	**80.0%**	**20.0%**
Total	**80.0%**	**20.0%**

5. Deepwater

Subgroup	Population	Population Fraction	In-Port	At-Sea
US Flagged	**23**	**100.0%**	**15.0%**	**85.0%**
Total	23	100.0%		

Subgroup	In-Port	At-Sea
US Flagged	**15.0%**	**85.0%**
Total	15.0%	85.0%

6. Research

Subgroup	Population	Population Fraction	In-Port	At-Sea
Univesity	**107**	**100.0%**	**1.0%**	**99.0%**
Total	107	100.0%		

Subgroup	In-Port	At-Sea
Univesity	**1.0%**	**99.0%**
Total	1.0%	99.0%

7. Great Lakes and others

Subgroup	Population	Population Fraction	In-Port	At-Sea
Auto	**0**	**0.0%**	**15.0%**	**85.0%**
Bulk	**6**	**4.3%**	**15.0%**	**85.0%**
Container	**1**	**0.7%**	**15.0%**	**85.0%**
Cruise	**14**	**10.0%**	**15.0%**	**85.0%**
General Cargo	**36**	**25.7%**	**15.0%**	**85.0%**
RORO	**6**	**4.3%**	**15.0%**	**85.0%**
Special Carrier	**68**	**48.6%**	**15.0%**	**85.0%**
Tanker	**9**	**6.4%**	**15.0%**	**85.0%**
Total	140	1.0		

Subgroup	In-Port	At-Sea
Auto	**0.0%**	**0.0%**
Bulk	**0.6%**	**3.6%**
Container	**0.1%**	**0.6%**
Cruise	**1.5%**	**8.5%**
General Cargo	**3.9%**	**21.9%**
RORO	**0.6%**	**3.6%**
Special Carrier	**7.3%**	**41.3%**
Tanker	**1.0%**	**5.5%**
Total	15.00%	85.00%

8. Government				
Subgroup	Population	Population Fraction	In-Port	At-Sea
Pilot Boat		**0.0%**		
USCG - Patrol	**291**	**100.0%**	**95.0%**	**5.0%**
USCG - Buoy Tender		**0.0%**		
USCG - Harbor Tugs		**0.0%**		
Total	291	100.0%		

Subgroup	In-Port	At-Sea
Pilot Boat		
USCG - Patrol	**95.0%**	**5.0%**
USCG - Buoy Tender		
USCG - Harbor Tugs		
Total	95.0%	5.0%

Appendix E. Individual Ports Included in the In-port Component of the Spatial Allocation Assessment

Appendix E. Ports Included by Vessel Type

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Alameda, CA			X					
Albany, NY								X
Alpena, MI					X			X
Amelia, LA						X		
Anacortes, WA		X		X				X
Anchorage, AK				X				X
Apalachicola, FL				X				
Ashtabula, OH		X			X			X
Astoria, OR	X			X				
Atlantic Beach, NC	X							
Atlantic City, NJ				X				
Auke Bay, AK	X							
Balboa, CA			X					
Baltimore, MD		X						X
Barbers Point, HI								X
Barrow, AK						X		
Baton Rouge, LA								X
Bay Center-South Bend, WA				X				
Bayonne, NJ	X							
Bayou La Batre, AL		X		X				
Beaufort-Morehead City, NC				X				
Beaumont, TX		X						X
Belhaven-Washington, NC				X				
Bellevue, WA			X					
Bellingham, WA	X	X		X				
Biloxi, MS								X
Blaine, WA				X				
Bodega Bay, CA	X							
Bon Secour-Gulf Shores, AL				X				
Boston, MA	X			X				X
Bridgeport, CT								X
Brookings, OR				X				
Brownsville, TX				X		X		X
Brunswick, GA								X
Buffalo, NY					X			X
Buffington, IN					X			X
Burns Waterway Harbor, IN					X			X
Calcite, MI		X			X			X
Camden-Gloucester, NJ								X
Cameron, LA				X				
Cameron, TX						X		
Cape Canaveral, FL	X	X		X				
Cape May, NJ	X			X				
Carrabelle, FL	X							
Charleston, SC	X			X				X

Appendix E. Ports Included by Vessel Type (Cont.)

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Charlevoix, MI		X			X			X
Charlottetown, ME			X					
Chattanooga, TN								X
Cheboygan Harbor, MI		X						
Chester, PA								X
Chicago, IL					X			X
Cincinnati, OH								X
Cleveland, OH	X	X			X			X
Columbus, OH			X					
Conneaut, OH					X			X
Coos Bay, OR	X	X		X			X	X
Cordova, AK	X			X				
Corona Del Mar, CA	X							
Corpus Christi, TX	X	X						X
Craig, AK				X				
Crescent City, CA	X			X				
Dania, FL	X							
Darien-Bellville, GA				X				
Delacroix-Yscloskey, LA				X				
Delcambre, LA				X				
Detroit, MI	X	X			X			X
Dillingham-Togiak, AK				X				
Drummond Island, MI					X			X
Dulac-Chauvin, LA				X				
Duluth-Superior, MN and WI		X			X			X
Dutch Harbor-Unalaska, AK				X				
Ecorse, MI		X						
Empire-Venice, LA				X				
Engelhard-Swanquarter, NC				X				
Erie, PA					X			X
Escanaba, MI					X			X
Eureka, CA	X			X				
Everett, WA		X		X				X
Fairport Harbor, OH					X			X
Fall River, MA								X
Fernandina Harbor, FL		X						
Fort Bragg, CA				X				
Fort Myers, FL	X			X				
Fort Pierce, FL	X							
Freeland, WA			X					
Freeport, TX	X							X
Freshwater City, LA						X		
Ft. Pierce-St.Lucie, FL				X				
Galveston, TX	X	X	X	X		X		X
Gary, IN					X			X
Georgetown, SC								X
Gloucester, MA	X			X				

Appendix E. Ports Included by Vessel Type (Cont.)

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Golden Meadow-Leeville, LA				X				
Grand Haven, MI					X			X
Grand Isle, LA	X			X				
Grays Harbor, WA		X						X
Green Bay, WI								X
Greenville, MS								X
Gulfport, MS	X	X		X				X
Guntersville, AL								X
Hampton Bay-Shinnicock, NY				X				
Hampton Roads Area, VA				X				
Helena, AR								X
Hempstead, NY								X
Highlands, NJ	X		X					
Hilo, HI	X							X
Homer, AK	X			X				
Honolulu, HI	X	X		X			X	X
Hopewell, VA								X
Houston, TX		X				X		X
Humboldt, CA		X						X
Huntington, WV								X
Hyannis, MA			X					
Ilwaco-Chinook, WA				X				
Indiana Harbor, IN					X			X
Ingleside, TX	X							
Intracoastal City, LA				X		X		
Jacksonville, FL		X					X	X
Jonesport, ME	X							
Juneau, AK			X	X				
Kahului, HI								X
Kalama, WA								X
Kansas City, MO								X
Kawaihae Harbor, HI								X
Kenai, AK				X				
Ketchikan, AK	X	X		X				
Key West, FL	X			X				
Kittery, ME	X							
Kivilina, AK								X
Kodiak, AK	X			X				
La Push, WA				X				
Lafitte-Barataria, LA				X				
Lake Charles, LA		X				X		X
Larkspur, CA			X					
Little Creek, VA	X							
Little Falls, NJ			X					
Long Beach, CA								X
Long Beach-Barnegat, NJ				X				
Longview, WA								X

Appendix E. Ports Included by Vessel Type (Cont.)

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Lorain, OH					X			X
Los Angeles, CA				X				X
Louisville, KY								X
Ludington, MI		X	X					
Mackinac Island, MI			X					
Manistee Harbor, MI		X						
Marblehead, OH					X			X
Marcus Hook, PA								X
Marina Del Rey, CA	X							
Marine City, MI					X			X
Marquette, MI		X			X			X
Marysville, MI					X			X
Matagorda Ship Channel, TX								X
Mayport, FL	X			X				
Memphis, TN								X
Miami Beach, FL	X							
Miami, FL	X	X						X
Milwaukee, WI								X
Minneapolis, MN								X
Mobile, AL	X	X				X		X
Monroe, MI					X			X
Montauk, NY	X			X				
Monterey, CA	X			X				
Morehead City, NC							X	X
Morgan City, LA	X			X		X		
Moss Landing, CA				X				
Mount Vernon, IN								X
Muskegon, MI					X			X
Naknek-King Salmon, AK				X				
Narragansett, RI							X	
Nashville, TN								X
Nawiliwili, HI	X							X
Neah Bay, WA				X				
New Bedford, MA	X			X				
New Castle, DE								X
New Haven, CT								X
New London, CT	X		X					
New Orleans, LA	X					X		X
New York, NY		X						X
Newburyport, MA			X					
Newport News, VA								X
Newport, OR				X			X	
Newport, RI	X							
Nikiski, AK							X	X
Norfolk, VA	X						X	X
Oakland, CA		X						X
Olympia, WA		X		X				X

Appendix E. Ports Included by Vessel Type (Cont.)

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Orient Point, NY			X					
Oriental-Vandemere, NC				X				
Oswego Harbor, NY		X						
Oxnard, CA	X							
Palacios, TX				X				
Palm Beach, FL		X						X
Panama City, FL	X							X
Pascagoula, MS	X			X				X
Paulsboro, NJ		X						X
Penn Manor, PA								X
Pensacola, FL	X	X						
Petersburg, AK	X			X				
Philadelphia, PA		X						X
Pittsburgh, PA								X
Point Judith, RI				X				
Point Pleasant, NJ				X				
Port Angeles, WA	X	X		X				X
Port Aransas, TX	X					X		
Port Arthur, TX		X		X		X		X
Port Canaveral, FL	X							X
Port Clinton, OH			X					
Port Dolomite, MI					X			X
Port Everglades, FL		X						X
Port Fourchon, LA						X		
Port Hueneme, CA				X			X	X
Port Huron, MI	X	X						
Port Inland, MI					X			X
Port Jefferson, NY			X					X
Port Manatee, FL		X						X
Port O'Connor, TX						X		
Port of Astoria, OR		X						
Port of Boston, MA		X						
Port of Buffalo, NY		X						
Port of Chicago, IL		X						
Port of Longview, WA		X						
Port of New Orleans, LA		X						
Port of Newport News, VA		X						
Port of Plaquemines, LA		X						X
Port of Portland, OR		X						
Port of South Louisiana, LA		X						X
Port of Vancouver, WA		X						
Port Orford, OR				X				
Port St. Joe, FL				X				
Port Townsend, WA	X			X				
Portland, ME		X	X	X				X
Portland, OR								X
Portsmouth, NH	X							X

Appendix E. Ports Included by Vessel Type (Cont.)

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Portsmouth, VA	X							
Presque Isle, MI		X			X			X
Providence, RI								X
Provincetown, MA			X	X				
Redwood City, CA								X
Reedville, VA				X				
Richmond, CA		X						X
Richmond, VA								X
Riviera, FL			X					
Rochester Harbor, NY		X						
Rockland, ME	X			X				
Sabine, TX	X	X				X		
Salt Lake City, UT			X					
San Diego, CA	X			X			X	X
San Francisco, CA	X	X	X	X				X
San Pedro, CA			X					
Sandusky, OH					X			X
Sandy Hook, NJ	X							
Santa Barbara, CA	X			X		X		
Sault Ste. Marie, MI	X							
Savannah, GA		X						X
Searsport, ME		X						X
Seattle, WA		X	X	X			X	X
Seward, AK	X			X				
Shelton, WA				X				
Silver Bay, MN					X			X
Sitka, AK	X			X				
South Padre Island, TX	X							
South Portland, ME	X							
St. Clair, MI					X			X
St. Ignace, MI	X							
St. Louis, MO								X
St. Paul, MN								X
St. Petersburg, FL	X							
Stamford, CT								X
Staten Island, NY			X					
Stockton, CA								X
Stoneport, MI		X			X			X
Stonington, ME				X				
Sturgeon Bay, WI	X							
Surry, VA			X					
Tacoma, WA		X		X				X
Taconite, MN								X
Tampa, FL		X		X				X
Texas City, TX								X
Tillamook, OR				X				
Toledo, OH		X			X			X

Appendix E. Ports Included by Vessel Type (Cont.)

Port	Coast Guard	Deepwater	Ferry	Fishing	Great Lakes	Offshore	Research	Tug
Tulsa, OK								X
Two Harbors, MN		X			X			X
Tybee Island, GA	X							
Valdez, AK								X
Vallejo, CA			X					
Vancouver, WA								X
Venice, LA						X		
Ventura, CA						X		
Vicksburg, MS								X
Victoria, TX								X
Wanchese-Stumpy Point, NC				X				
Weedon Island, FL								X
Westport, WA				X				
Wilmington, DE		X	X					X
Wilmington, NC	X							X
Woods Hole, MA	X		X				X	
Wrangell, AK		X		X				
Yakutat, AK				X				
Yaquina Bay and Harbor, OR		X						
Total Count	**81**	**73**	**31**	**97**	**35**	**20**	**12**	**147**