Assessment of Vessel Inventory Available for Offshore Wind Energy Development

April 12, 2023

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MEMORANDUM

TO: U.S. Environmental Protection Agency/Office of Air Quality Planning and Standards

FROM: Eastern Research Group, Inc.

DATE: April 12, 2023

SUBJECT: Assessment of Vessel Inventory Available for Offshore Wind Energy Development

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This document and the associated spreadsheet are deliverables under EPA Contract EP-W-15-011, Work Assignment 5-03. The intent of this document is to provide general descriptions of the vessel types noted in the vessel dataset (spreadsheet) that accompanies this document.[1] The provided dataset is derived from Clarksons' latest global inventory of vessels[2] that support offshore wind projects. The dataset includes vessel type information, vessel size data, build and keel laying dates, and various engine data including piston stroke and cylinder diameter. Piston stroke and cylinder diameter were used to calculate cylinder displacement to align the marine engine to the correct EPA engine categories (1, 2, & 3)[3]. Piston stroke and cylinder diameter along with the number of cylinders in an engine allowed for estimates of total engine displacement. Due to confidentiality concerns, vessel identifiers were removed, but vessel type information was retained, and vessels are grouped into types generally included in offshore wind air permits (i.e., Outer Continental Shelf (OCS) permits). This memo also includes summaries of vessel characteristics derived from the Clarksons dataset for each vessel type being discussed.

The memo is divided into four sections. All sections include information on the different kinds of vessels involved in the construction, operation, and maintenance of offshore wind turbines. A general overview of the fleet is provided in Section 1.0 (Offshore Wind Fleet). The remaining sections provide information about the function of each vessel type as well as summary

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1 Note that vessel identifiers such as International Maritime Organization (IMO) identification numbers and Maritime Mobile Service Identity (MMSI) codes are removed from the dataset as required by the vendor.

2 Please note that all Wind Turbine Installation Vessels (WTIVs) included in the dataset are jack-up vessels. Jack-up vessels consist of a buoyant hull with movable legs that can be extended to the seabed allowing the hull to be lifted above of the sea surface. All jack-up vessels in the Clarksons dataset were distilled into the associated dataset (spreadsheet).

3 Category 1 engines have cylinder displacement less than 7 L/cylinder, Category 2 engines have a displacement greater than or equal to 7 L/cylinder but less than 30 L/cylinder, and Category 3 engines have a displacement greater than 30 L/cylinder. See 40 CFR 1042 at https://www.ecfr.gov/current/title-40/chapter-I/subchapter-U/part-1042. Engines in each category are also divided by Tier (1, 2, 3 and 4) and in general higher tiered engines have less air emissions.

information about the number of vessels for each vessel type, statistics regarding the gross tonnage and vessel speed and the power (kilowatts) of different main and auxiliary operations.

Section 2.0 focuses on vessels that are typically used for preliminary site assessments prior to any construction:

- Research/survey vessels
- Remotely operating vehicles

Section 3.0 describes vessels typically required for site preparation and construction:

- Wind Turbine Installation Vessels (WTIVs)
- Derrick Lay Vessels
- Anchor Handling Tugs (AHTs)
- Supply Vessels
- Heavy lift/Crane Vessels
- Support Vessels
- Dredgers
- Cable Laying Vessels

Other types of support vessels that may be used throughout the process are discussed in Section 4.0:

- Accommodation Vessels
- Crew Transfer Vessels
- Diving Support Vessels
- Emergency Rescue Vessels
- Self-Elevating Barges

The report also includes a series of appendixes which provide more details pertaining to:

A-1 Clarksons data dictionary.

A-2 Summary of WTIVs and self-elevating barges that have contact with the seabed.

A-3 Summary of U.S. flagged vessels included in Clarksons dataset.

1.0 OFFSHORE WIND FLEET

In this document, a variety of typical vessel types are discussed in terms of their function relative to their support in the development of offshore wind farms. However, it is important to note that vessels are not necessarily limited to the specific roles noted in this summary and are likely to provide a mixture of services. For example, a diver support vessel can also provide accommodations for the divers and other technical staff or may be used to ship supplies to the designated site.

In general, the vessel fleet available for offshore wind development is primarily composed of non-U.S. registered vessels. Only 22 out of 1,145 vessels included in the Clarksons dataset were

U.S. registered vessels and all are equipped with U.S. EPA Category 1 and 2 marine engines, representing a range of Tiers[4] (five Tier 0's (marine engines built prior to implementation of Tier 1); six Tier 1's; eight Tier 2's; one Tier 3; and two Tier 4's).

A critical consideration in developing offshore wind farms is that there are a limited number of WTIVs with high lift capabilities that can support the installation of turbines[5] rated above 12 megawatts[6]. Turbines greater than 12 megawatts require a lift height of 150 meters. Currently the largest operating offshore turbines are rated up to 16 megawatts[7] and developers are anticipating that turbines up to 20 megawatts may be available by 2024[8], which will require a lift height greater than 200 meters. Though crane height is not well populated in the Clarksons dataset, based on the information in the dataset it is estimated that worldwide there are only 2 WTIV's capable of installing the larger turbines.

Rated lift capacity is also a factor as a 20-megawatt turbine is likely to weigh approximately 900 tonnes[9] which should not be an issue for some of the new mega WTIVs. Additionally, operating depths and leg length of WTIVs are a factor in matching vessel to installation locations. For example, vessel Voltaire can operate in waters 80 meters deep and has a crane capacity of 3,000 tonnes. Vessel Les Alizes is noteworthy as it is not a jack-up vessel but instead uses dynamic positioning to remain stationary and has a crane capacity of 5,000 tonnes. Approximately 60 percent of the U.S. offshore wind resources are in deep waters, and vessels such as Les Alizes allow for the development of these sites.

Regarding vessel contact with the seabed; WTIVs and jack-up barges have direct contact with the seabed when their legs are extended and/or anchors are used. Most of the other support vessels are equipped with dynamic positioning systems that use transversal thrusters in conjunction with satellite tracking data to accurately maintain vessel position without anchoring. Dynamic positioning systems are often preferred over anchoring as the anchoring process can be time consuming and unfavorable depending upon vessel weight, water depth, seabed conditions, and location of subsea pipelines and power lines. Nearby subsea pipelines and power lines could be damaged when anchors do not take hold and are dragged along the seabed. Conversely, dynamic positioning systems can be more expensive than anchoring due to the cost of the fuel necessary to run the thrusters that maintain the vessel's position.

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[4] Tier 1, 2, 3, and 4 emission standards for Category 1 and 2 Engines are provided in 40 CFR 1042 https://www.ecfr.gov/current/title-40/chapter-I/subchapter-U/part-1042.

[5] Bocklet, Herbosa, Loweth, Griswold, Quickel, Gideon, Borkland, Weitz, Kates-Garnick and Hines,Wind Turbine Installation Vessels: Global Supply Chain Impacts on the U.S. Offshore Wind Market. June 28, 2021. OSPRE-2021-02

[6] Nick Blenkey, Giant wind turbines could face installation bottlenecks (Feb 7, 2022). https://www.marinelog.com/offshore/offshore-wind/giant-wind-turbines-could-face-installation-bottlenecks/

[7] NES Fircroft, The Biggest Wind Turbines in the World December 8, 2021. https://www.nesfircroft.com/blog/2021/12/the-biggest-wind-turbines-in-the-world?source=google.com

[8] NL Netherlands, Purpose Built Vessel to Install 20MW Offshore Wind Turbines, 1 October 2021. https://www.dutchwatersector.com/news/purpose-built-vessel-to-install-20-mw-offshore-wind-turbines

[9] Jos Beurskens, Netherland Energy Research Centre Achieving the 20 MW Wind Turbine. https://www.renewableenergyworld.com/storage/achieving-the-20-mw-wind-turbine/#gref

2.0 PRELIMINARY SITE ASSESSMENT

2.1 Research/Survey vessels

Research vessels include seismic survey vessels, which are some of the first vessels deployed to a possible wind farm site. They are tasked with mapping the seabed using hydrographic and geophysical survey techniques. These survey methods provide critical information used to design the wind turbine structure and assess site preparation. Seabed data are also useful in mapping cable routes. These vessels are only on site prior to construction. After construction of a wind farm, these vessels are not needed unless additional substations or power cables need to be added later.

These vessels typically take seismic readings along a predetermined grid pattern which can be pieced together to get a contiguous view of the seabed. Each survey vessel tows an array of sensors (sometimes referred to as streamers) that pick-up sound waves generated by air guns operated from the vessel. The difference in how the sound waves is received by the sensors provide detailed information about the geology of the seabed[10]. Given underwater acoustic, there are concerns that the noise generated from the air guns may impact local fauna, including migrating mammals.

Survey vessels tend to be large ships capable of staying at sea for extended periods. Because these vessels pull a large array of equipment, they are often equipped with larger propulsion engines operating at higher engine loads. Table 2-1 summarizes some of the key survey vessel characteristics.

Currently, there is interest and research in unmanned survey vessels. These vessels are much smaller and more nimble than larger manned survey vessels, providing a fuel savings of 95%. There are unmanned survey vessels that are completely electrically powered.[11]

Table 2-1. Summary of Select Survey Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
52	Minimum	20	9	228	228	800	120	77
	Average	1,314	13	3,557	2,140	3,186	886	940
	Maximum	4,800	28	15,232	13,189	7,000	3,000	3,200

[10] NOIA Basics of Offshore Oil and Gas (Accessed 7/1/2022) https://www.noia.org/basics-offshore-oil-gas/
[11] https://www.fugro.com/about-fugro/our-expertise/remote-and-autonomous-solutions/remote-and-autonomous-vessels

2.2 Remotely Operated Vehicles (ROVs)

ROVs are unmanned highly maneuverable underwater machines that can be used to explore ocean depths while being operated by a technician at the water surface. Typically, cables or tethers, connect the ROV to the surface ship, allowing signals to be sent back and forth between the operator and the vehicle.[12]

Most ROVs are equipped with:

- Thrusters for maneuvering
- Lights and cameras (still and video)
- Sonar and light detection and ranging (LiDAR) imaging
- Manipulator or cutting arm
- Water samplers and instruments that directly measure parameters such as water clarity and temperature.

ROVs are classified based on their size and operations, from "micro" weighting less than three kilograms, to larger "trench and burial" ROVs equipped with propulsion engines up to 500 hp. These larger ROVs are equipped with multiple manipulators or cutting arms and can be used to move cable laying sleds at depths up to 6,000 meters.

ROVs are limited by the tether which is generally 500 to 1,000 meters long. Therefore, there is growing interest in autonomous underwater vehicles that are not limited by a tether and can operate independent of a vessel; in fact, they can be programmed to meet a vessel at a predetermined location when the survey is completed.[13]

When an ROV is used to survey a site, check conditions of underwater power lines, or perform simple maintenance activities, there is a larger surface vessel operating nearby that is fully staffed with technicians and engineers to operate the ROV. These vessels can have facilities to accommodate the staff and even allow them to dock at a turbine or an installation vessel. Table 2-2 summarizes some of the vessel characteristics for ROV support vessels.

Table 2-2. Summary of Select ROV Support Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
9	Minimum	325	11	969	969	2,400	660	1,014
	Average	3,102	14	10,014	1,508	6,650	876	1,111
	Maximum	9,680	18	19,200	2,046	9,000	1,000	1,200

12 NOAA Ocean Exploration (Accessed 7/1/2022) https://oceanexplorer.noaa.gov/facts/rov.html

13 NOAA What is the difference between an AUV and an ROV? (Updated 3/18/2022) https://oceanservice.noaa.gov/facts/auv-rov.html

3.0 VESSELS TYPICALLY REQUIRED FOR SITE PREPARATION AND CONSTRUCTION

3.1 Wind Turbine Installation Vessels

A wind turbine installation vessel (WTIV) is specifically designed for the construction of offshore wind turbines. Most WTIVs are self-elevating jack-up rigs also referred to as lift boats. Generally, WTIVs are equipped with azimuth thrusters that are used to position the vessel often using dynamic positioning systems at the location where the wind turbine is to be installed. These vessels may carry foundation, tower, nacelle, and blades for up to five wind turbines, and are equipped with heavy duty cranes capable of lifting heavy components up to 125 meters above deck. Most WTIVs are also designed to receive and even lift barges that allow for resupply.

A WTIV provides a stable platform for installation by extending from three to six legs to the seabed and then lifting the vessel above sea level. They use a heavy lift crane to drop the foundation at the prepared site, securing it to the bottom. Next, they position the tower onto the foundation. The nacelle which contains the turbine is attached to the top of the tower and the blades are attached to the nacelle. Once the installation is completed, the WTIV retracts its legs and moves to the next site where it repeats the process.

These vessels though developed specifically for offshore wind, are similar to jack-up rigs used in the Gulf of Mexico for oil and gas exploration. Table 3-1 summarizes some of the vessel characteristics for WTIVs, documenting that these are large vessels with large auxiliary engines needed to operate the installation equipment. Figure 1 shows the distribution of WTIVs based on gross tonnage. There appears to a bimodal distribution between smaller vessels (less than 15,000 Gross Tonnage (GT[14]) and larger vessels (greater than 15,000 GT). Smaller vessels account for 72 percent of the WTIVs. The smaller vessels appear to have a normal distribution, while the larger vessels indicate a linear distribution with more vessels in the 15,000 to 17,500 GT bin than for larger vessels (27,500 GT to 30,000 GT).

[14] Gross tonnage is a measure of a ship's overall internal volume and is determined by dividing by 100 the cubic feet of a vessel's enclosed spaces.

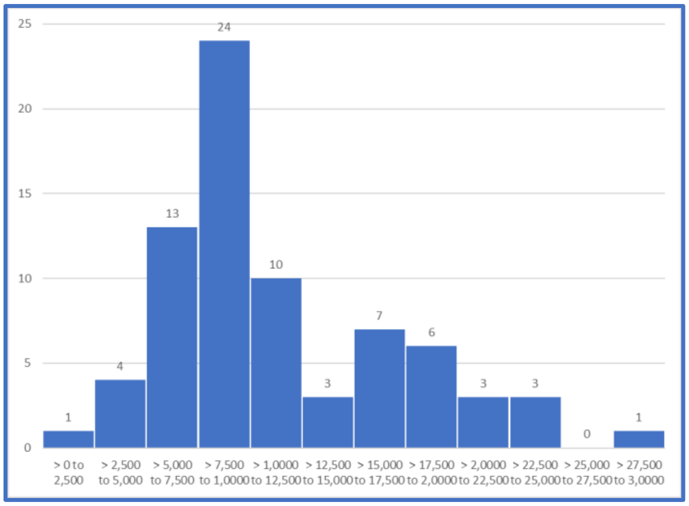

Figure 1. Distribution of Wind Turbine Installation Vessels by Gross Tonnage.

It should also be noted that this category includes wind install vessels that are not jack-ups but are vessels that are able to ground themselves near shore rather than use legs to secure them to the seabed–these vessels are currently used in shallow waters in Asia.

Given the increase in demand for WTIVs, Clarksons dataset has noted that sometimes very large offshore pipelaying vessels typically used for offshore oil and gas are being used as WTIVs as they typically are equipped with heavy lift cranes.

Oil and gas jack-up rigs have been constructed in the U.S. for offshore operations in the Gulf of Mexico for decades. This domestic experience of building jack-up rigs is useful in manufacturing Jones Act[15] compliant WTIVs. For example, the Charybdis vessel is being constructed at Keppel, Texas and expected to be operational by 2023 specifically for use in Dominion Energy's Coastal Virginia Offshore Wind project.[16]

Most new jack-up designs feature a battery hybrid system that includes diesel generators (gen sets) that can be shut off when power requirements are reduced. Several companies such as NED[17] and SHI hope to adapt these systems to incorporate hydrogen powered fuel cell systems.[18]

Daewoo Shipbuilding and Marine Engineering is currently building WTIVs that can operate in depths up to 60 meters and able to support installation of 20 megawatt turbines using a 2300-tonnes heavy lift crane. These vessels are also designed to run on alternative fuels such as Liquified Natural Gas (LNG) or ammonia. To improve efficiency, these vessels also include regenerative power for the jack-up system (energy stored in elevating the platform is used to retract the legs when the installation is completed). Scheduled delivery for the first of these

[15] The Jones Act, also known as the Merchant Marine Act of 1920, is a federal statute establishing support for the development and maintenance of a merchant marine in order to support commercial activity and serve as a naval auxiliary in times of war or national emergency (see 46 USC § 50101). Under the Jones Act, foreign carriers and crews are banned from domestic water routes. Cabotage from one U.S. port to another is restricted to U.S.-built, -crewed and registered vessels.

[16] Elizabeth McGowan Energy News Network March 8, 2022. https://energynews.us/2022/03/08/giant-turbine-installing-ship-is-dominion-energys-500m-bet-on-u-s-offshore-wind/

[17] Adrijana Buljan, NED-Project Introduces Hydrogen-Ready, Jones Act Compliant Offshore Wind Installation Vessel. 24 September 2021. https://www.offshorewind.biz/2021/09/24/ned-project-introduces-hydrogen-ready-jones-act-compliant-offshore-wind-installation-vessel/

[18] SHI unveils LNG Fuel Cell-Powered WTIV, Maritime Executive, April 8, 2021 https://ulstein.com/news/zero-emission-turbine-installation-is-todays-reality

vessels is in 2025.[19] Eneti, which has commissioned this project, is considering several U.S. shipyards for future construction of these WTIVs to be Jones Act compliant.[20]

Samsung Heavy Industries has also received approval from classification societies for an LNG-fueled fuel cell powered WTIV. Additionally, Wärtsilä has recently received an order to build a WTIV for Van Oord that operates on methanol scheduled for delivery in 2024.[21]

WTIVs that use biodegradable hydraulic fluids to minimize ecosystem impact during leaks have also been developed.

Table 3-1. Summary of Select Wind Turbine Installation Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
75	Minimum	800	5	664	3,520	2,200	1,328	747
	Average	7,117	9	11,328	5,116	7,255	3,712	3,983
	Maximum	25,927	13	29,762	6,712	14,000	10,320	15,150

3.2 Derrick Lay Vessels

While most WTIVs are large vessels primarily designed to operate in deeper waters, those vessels are not appropriate for shallow waters that are 3 meters deep. On the other hand, derrick lay vessels can install wind turbines in very shallow waters. These vessels can be propelled or unpropelled barges equipped with a heavy lift crane. They can be equipped with a ballast system that allow the hull to be lowered onto the seabed providing a stable platform for the installation.[22] These vessels typically have direct contact with the seabed via the hull-ballast system.

Once the installation is complete the vessel can be refloated and moved to the next shallow water site where the process can be repeated. Table 3-2 summarizes some of the vessel characteristics for derrick lay vessels.

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19 Eneti Exercises Option for Second WTIV to be Built in South Korea, December 2, 2021 Maritime Executive, https://maritime-executive.com/article/eneti-exercises-option-for-second-wtiv-to-be-built-in-south-korea

20 IHS Markit (S&P Global), US Offshore Wind WTIV Construction Race Heats Up. 13 May 2021. https://cleanenergynews.ihsmarkit.com/research-analysis/us-offshore-wind-wtiv-construction-race-heats-up.html

21 Wärtsilä Marks First New Build Methanol Engine Order with Van Oord WTIV, January 2022. https://gcaptain.com/wartsila-marks-first-newbuild-methanol-engine-order-for-van-oord-wtiv/

22 Mammoet, Unable to access shallow waters with conventional methods. (Accessed 7/12/2022) https://www.mammoet.com/news/mammoet-installs-four-wind-turbines-at-nissum-bredning-near-shore-wind-farm/

Table 3-2. Summary of Select Derrick Lay Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
11	Minimum	1,938	10	320	0	9,000	387	320
	Average	10,858	13	20,693	0	12,667	3,323	3,423
	Maximum	28,265	15	73,460	0	18,000	6,000	6,260

3.3 Anchor Handling Tugs (AHTs)

Originally these tugs were used to handle anchors for offshore oil rigs that are towed to a specified location and secured at the site using a system of anchors. Similar services are needed for floating wind turbines that are moored to the seabed; AHTs are specifically designed to install these moorings and anchors. They can also assist in towing large components for both floating and fixed bottom structures or turbines to the site or installing bubble curtains to mitigate underwater construction noises.[23]

AHTs typically have dynamic positioning systems to ensure that the mooring lines are located correctly. These tugs are also fitted with winches for towing and anchor handling – these winches are driven by low to medium pressure hydraulic systems or electric variable motors.[24] Having an open stern allows for the decking of anchors and provides storage for the chains that connect the anchors to the structure. These vessels are specifically designed for these activities, having more power than most ocean-going tugs to ensure sufficient bollard pull to manage the anchors. In the design and testing of the AHT's winch systems the static bollard pull ranges from 50 to over 180 tonnes.[25] Larger AHTs not only provide more power but they often have larger capacity to store the heavy chain which connects the anchor and the turbine. These vessels also are equipped with quick anchor releases, which is operable from the bridge or other manned locations in direct communication with the bridge.

These vessels typically have direct contact with the seabed when placing the anchor; additionally, they may be anchored to the seabed when installing an anchor if they do not have dynamic positioning; or they may be attached to a WTIV during cargo transfers.

23 Pasztor, Ferenc, Floating Wind farms: the new driver of the AHTS market (Accessed 7/6/82022) https://dvzpv6x5302g1.cloudfront.net/AcuCustom/Sitename/DAM/091/2A_Presentations_Floating_wind_farms_webinar.pdf
Rouxel, Noe Learning from Experts Webinar Series, Vessel Types, May 11, 2022. file:///E:/EPA%20Offshore%20WInd/NYSERDA_Webinar_Vessel%20Types_11May2022.pdf

24 Macgregor Anchor Handling Tugs and Towing Vessels (accessed 7/6/2022) https://www.macgregor.com/Products/Offshore-oil-and-gas-and-renewables/anchor-handling-tugs-and-towing-vessels/

25 Boskalis, Anchor Handling Tugs (accessed 7/6/2022) https://boskalis.com/about-us/fleet-and-equipment/offshore-vessels/anchor-handling-tugs.html

In addition to securing offshore platforms to the seabed, these tugs have been used in a variety of applications including shuttling supplies between mainland and offshore installations, providing support for ROVs, safety/rescue services, or installing bubble curtains to help control underwater construction noises.[26] Table 3-3 summarizes some of the vessel characteristics for AHTs.

Smaller ocean-going tugs may also be used to shift barges out of site or tow nonpropelled vessels to the site. Because these vessels provide general marine services that are unrelated to offshore wind, they are not included in the Clarksons dataset.

Table 3-3. Summary of Select Vessel Characteristics for Anchor Handling Tugs

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
39	Minimum	655	10	2,648	2,648	3,200	224	270
	Average	2,172	14	9,190	7,216	5,733	1,232	1,426
	Maximum	4,500	18	21,926	16,000	10,000	3,540	3,720

3.4 Supply Vessels

Vessels that are specifically identified as supply vessels (sometimes referred to as feeder vessels) are designed to transfer equipment and cargo from a port terminal to an offshore site where they offload the cargo to a WTIV, turbine platform, or substation. They tend to have a large deck to carry a variety of cargo, or they can be designed with racks to specifically carry blades, turbines, or tower sections needed to construct a wind turbine tower. These vessels typically do not have direct contact with the seabed, although if needed they can anchor to the seabed. They can also attach to a WTIV during cargo transfer operations.

Regarding alternatively fuel vessels, Wartsila has developed an offshore supply vessel (Viking Lady) equipped with a dual fuel (LNG/Diesel) hybrid system where the engines provide power to recharge the vessel batteries which powers all propulsion and auxiliary operations. This allows the engines to operate at a constant optimized load for battery charging. The vessel can also be equipped with a fuel cell to provide power and reduce emissions while in port.[27] Clarksons dataset has identified one supply vessel that uses LNG as an alternative fuel. Table 3-4 summarizes some of the vessel characteristics for supply vessels.

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[26] Wikipedia, Anchor Handling Tugs (accessed 7/1/2022) https://en.wikipedia.org/wiki/Anchor_handling_tug_supply_vessel#:~:text=Anchor%20Handling%20Tug%20Supply%20(AHTS,ERRVs)%20and%20as%20supply%20transports.

[27] Wartsila Viking Lady (accessed 7/12/2022) https://www.wartsila.com/marine/customer-segments/references/offshore/view/viking-lady

Table 3-4. Summary of Select Supply Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
33	Minimum	1,044	10	2,516	2,354	1,470	490	544
	Average	3,766	13	6,179	4,074	4,175	719	801
	Maximum	5,200	16	9,334	6,000	7,000	1,500	1,639

3.5 Heavy lift/Crane Vessel

Essentially, heavy lift vessels are floating cranes that transport bulking structures such as foundations and structural jackets to the site. These vessels are equipped with heavy duty cranes rated from 3,000 to 20,000 tonnes and can be a large barge or a self-propelled vessel. Some of these vessels are also submersible which allow for structures to be transported to the site, then floated off the vessel and positioned at the designated location. Newer versions of these vessels are equipped with dynamic positioning systems to ensure that the structure is in the correct location.[28] These vessels generally do not have direct contact with the seabed, although, if necessary, they can anchor to the seabed. Also, they may tie up to WTIVs to transfer equipment.

Sometimes these heavy lift vessels are also considered WTIVs, but for the purposes of this document we assume that they are a heavy-duty version of a supply vessel. Clarksons dataset has identified two heavy lift vessels that use LNG as an alternative fuel. Table 3-5 summarizes some of the vessel characteristics for heavy lift/crane vessels.

Table 3-5. Summary of Select Vessel Characteristics for Heavy lift/Crane Vessels

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
135	Minimum	120	5	655	655	1,600	12	330
	Average	24,312	13	14,188	8,288	13,618	2,563	4,007
	Maximum	260,870	18	96,000	25,487	44,000	32,490	34,200

28 Zhiyu Jiang, Installation of Offshore Turbines: a technical review Renewable and Sustainable Energy Reviews 139 (2021) 110576.

3.6 Support Vessels

Though offshore support vessels (sometimes referred to as service operations vessels) can carry equipment and cargo to a site and may provide accommodations, they differ from some other vessel types in that they are generally considered to be multi-purpose vessels that can assist with seismic surveys including ROV activities, support wind turbine servicing and repair, help with dive activities, provide general utility and workboat functions, assists with site safety/security, and even monitoring aquatic mammal activities. These vessels can be anchored to the seabed though they may stay stationary using dynamic positioning systems. They can also tie up to WTIV's to transfer equipment. Some of these vessels may also have small cranes (9 tonnes) for equipment transfers; and even have "walk to work" gangways.[29] Table 3-6 summarizes key characteristics of support vessels.

To reduce the carbon footprint of these vessels, there has been work in Europe to use a plug-in hybrid system in vessels that recharge their batteries using power from the turbines.[30] There is also interest in using biofuels for these vessels.[31]

Table 3-6. Summary of Select Support Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
102	Minimum	39	9	406	406	1,800	80	164
	Average	4,027	14	8,924	3,443	5,504	1,204	1,809
	Maximum	13,500	25	26,638	16,000	13,200	8,920	9,000

3.7 Dredgers

Dredging is often used for site preparation for wind turbine and substation construction; this includes excavating for the foundation boreholes or cleaning the pile area prior to driving the structural jacket into the seabed.

Dredging is also used to excavate the trench where power lines are to be buried and can be used to cover the trench once the powerlines are in place. Depending on the vessel being used, the excavation technology can be very different ranging from mechanical dredgers, hydraulic dredgers, trailing suction hoppers, or a towable plough which inserts the cable while it excavates and covers the trench. A mechanical dredger scoops up the material to be removed while hydraulic dredgers use jets of water to excavate a trench. Trailing suction hopper dredgers suck

[29] USCG Offshore Wind Support Vessels (Accessed 7/12/2022) https://www.dco.uscg.mil/OCSNCOE/Renewable-Energy/Support-Vessels/

[30] Jan Westhoeve, Zero Emission SOVs: the need for renewables https://www.royalihc.com/offshore-energy/offshore-innovations/zero-emission-sovs-need-renewable-offshore-wind-operations

[31] European Union Horizon 2020; NEXUS: Towards game-changer service operation vessels for offshore windfarms (May 17, 2021) https://cordis.europa.eu/project/id/774519 (https://www.youtube.com/watch?v=PWqNfPwUiLA)

up the excavated material and store it in an on-board hopper. There are variants of each of these dredging vessels that can be used to support the development of offshore wind based on the required application and water depth.[32] Because of the work they perform, these vessels typically have direct contact with the seabed. There is also an increased interest in using ROVs for trenching and inspection of excavated areas.[33] Clarksons dataset has identified two dredgers that use LNG as an alternative fuel. Table 3-7 summarizes some of the vessel characteristics for dredgers.

Table 3-7. Summary of Select Dredger Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
19	Minimum	183	6	169	169	1,100	296	430
	Average	13,512	12	8,635	5,222	7,733	1,497	1,986
	Maximum	35,930	17	24,436	16,000	13,400	6,950	7,005

3.8 Cable Laying Vessels

Power cables transmit energy from the turbines to an offshore substation and then to the onshore grid. Cable laying vessels store, transport and install the required cable. These vessels tend to work in coordination with several other vessel types included in this summary, such as dredgers, diver support vessels, and ROVs.

Cable laying vessels are equipped with a large cable carousel capable of handling 5,000 tonnes of cable. The carousel can be located on the deck of the vessel or within the hold. They may also have a crane to help position the cable as it is installed.

As with most other offshore wind vessels, cable laying ships tend to be equipped with dynamic positioning systems to ensure that the cable is installed in the correct location. Because of the work they perform, typically these vessels have direct contact with the seabed via the cable. Once the cable is laid it is covered with the excavated material from the trench.[34] Clarksons dataset identified one cable layer vessel that uses LNG as an alternative fuel. Table 3-8 summarizes some of the vessel characteristics for cable layer vessels.

[32] Brantz von Mayer. Dredgers and Dredging (Accessed 7/12, 2022) http://www.dredgebrokers.com/html/dredging/dredging-and-dredgers

[33] Seatool, subsea excavation (Accessed 7/12/22) https://www.seatools.com/subsea-solutions/subsea-excavation/

[34] Van Oord, Cable laying Equipment, (accessed 7/6/2022) https://www.vanoord.com/en/activities/cable-installation/

Table 3-8. Summary of Select Cable Laying Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
43	Minimum	983	10	634	964	2,400	120	634
	Average	8,393	13	10,396	2,428	5,688	1,690	1,971
	Maximum	27,937	16	24,477	5,220	10,000	3,200	3,570

4.0 OTHER SUPPORT VESSEL TYPES

4.1 Accommodation Vessels

Sometimes referred to as a floatel, these vessels or barges provide accommodation to technicians that support construction or ongoing wind farm operating and maintenance activities. These vessels can stay at sea for up to a month at a time. The accommodation options range from 50 to over 300 single cabins with private bathrooms. In addition to beds and showers, these vessels can have meeting rooms, in-cabin video systems, game rooms, cinemas, TV lounges and fitness centers on board. These vessels are often designed for stability even in rough weather conditions. Passengers are transferred to the turbines or WTIVs by means of crew transfer vessels or using "walk to work" gangway systems.[35] If necessary, they may also be anchored to the seabed. Table 4-1 summarizes some of the vessel characteristics for accommodation vessels.

Table 4-1. Summary of Select Accommodation Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
40	Minimum	120	9	125	4,800	1,200	1,650	2,080
	Average	2,914	13	6,581	6,060	3,154	2,646	2,511
	Maximum	8,014	18	13,805	8,639	7,000	4,500	2,988

4.2 Crew Transfer Vessels

These vessels are designed to transport staff to turbines and offshore substations quickly and safely. Though they can vary in size they tend to be smaller vessels ranging from 18 to 30 meters. These vessels are equipped with high-speed diesel engines able to maintain speeds up to

[35] Offshore Wind Accommodation Vessels: the Past, Present and the Future, 2015 https://www.offshorewind.biz/2015/10/05/accommodation-vessels-the-past-present-and-the-future/

40 knots. Fuel efficiency is particularly important as these charges are paid in addition to the vessel's day rate. Many of these vessels are Jones Act and Right Whale[36] compliant.

Crew transfer vessels are often equipped with fenders that allow them to have contact with the WTIVs, turbine foundation/tower, or substation base.[37] These transfers can occur between ports, accommodation vessels, or other turbine locations. Clarksons dataset has identified four crew boats that use alternative fuels: three use hydrogen and one uses biofuel. Table 4-2 summarizes the vessel characteristics for crew transfer vessels.

Table 4-2. Summary of Select Crew Transfer Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
540	Minimum	1	8	245	234	1,100	2	11
	Average	38	23	1,591	1,558	1,661	41	98
	Maximum	346	40	14,516	14,400	3,344	290	1,192

4.3 Diving Support Vessels

Divers are often needed to assist with inspecting seabed preparations, grounding foundation structures, attaching mooring lines to anchor points, installing electrical cable, or to assist in operation and maintenance activities.

When divers are needed, they require appropriate vessel support. These vessels can be temporarily moored to the seabed or equipped with dynamic positioning equipment.

For depths greater than 50 meters, saturation diving is used for long duration dives. This system reduces the number of decompressions a diver must go through by transferring the diver to the seabed using a diving bell which is a sealed chamber that is pressurized with a mixture of helium and oxygen to mitigate decompression sickness. Diver support vessels are equipped to safely

[36] 2008 North Atlantic right whale vessel speed regulations (50 CFR § 224.105): NMFS established regulations to implement speed restrictions of no more than 10 knots applying to all vessels 65 ft (19.8 m) or greater in overall length in certain locations and at certain times of the year along the east coast of the U.S. Atlantic seaboard. The purpose of the regulations is to reduce the likelihood of deaths and serious injuries to endangered North Atlantic right whales that result from collisions with ships. In 2022, NOAA Fisheries is proposing changes to the regulations: 1) modify the spatial and temporal boundaries of current speed restriction areas, currently referred to as Seasonal Management Areas (SMAs), 2) include most vessels greater than or equal to 35 ft (10.7 m) and less than 65 ft (19.8 m) in length in the vessel size class subject to speed restriction, 3) create a Dynamic Speed Zone framework to implement mandatory speed restrictions when whales are known to be present outside active SMAs, and 4) update the speed rule's safety deviation provision. The comment period for this amendment was October 31, 2022. https://www.fisheries.noaa.gov/action/amendments-north-atlantic-right-whale-vessel-strike-reduction-rule

[37] BMT, Crew Transfer Vessels, (accessed 7/6/2022) https://www.bmt.org/how-we-work-with-you/maritime-design-consultancy/concept-design-to-bespoke-solution/offshore-support-and-crew-transfer-vessels/#:~:text=CTVs%20are%20explicitly%20designed%20to,explicitly%20suited%20to%20wind%20turbines.

support saturation diving which typically includes a moon pool at the bottom of the vessel from which the diving bell is launched, winched to lower and raise the diving bell and provide a supply of gases and gas mixture system.[38] Additionally, these vessels are often equipped with on-board recompression facilities. Diving support vessels typically work in conjunction with other vessels such as ROVs. Table 4-3 summarizes some of the vessel characteristics for diving support vessels.

Table 4-3. Summary of Select Diving Support Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
7	Minimum	184	10	786	662	4,400	71	110
	Average	4,992	12	7,145	829	6,000	346	558
	Maximum	15,000	16	18,998	1,060	7,000	600	1,005

4.4 Emergency Rescue Vessels

Standby emergency rescue vessels are designed to respond quickly to events even in severe weather conditions and can also assist in rescue towing operations. These vessels range in size from 6 to 65 meters, with the smaller vessels being associated with a larger vessel that coordinates services with shore-based helicopters.

Emergency rescue ships are equipped with diesel or diesel/electric engines rated up to 7,800 kWs. The size, speed, and power rating of these vessels make them very maneuverable.[39] Table 4-4 summarizes some of the vessel characteristics for emergency rescue vessels. They can anchor to the seabed or may also attach to a WTIV.

Table 4-4. Summary of Select Emergency Rescue Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
3	Minimum	2,000	12	1,987	1,987	0	496	584
	Average	3,284	14	4,718	4,487	0	557	584
	Maximum	4,568	16	7,755	7,061	0	618	584

38 Offshore Fleet Diving Support Vessel (accessed 7/12/2022) http://offshore-fleet.com/data/dsv.htm

39 John Snyder Emergency Search and Rescue Vessels: Offshore's Swiss Army Knife. (22 Feb 2019) https://www.rivieramm.com/opinion/opinion/emergency-search-and-rescue-vessels-offshores-swiss-army-knife-21692

4.5 Self-Elevating Barges

Barges are typically used to provide cargo and equipment to offshore operations. Problems have been encountered connecting stationary jack-ups with floating barges, especially in severe weather conditions. Self-elevating barges (sometimes referred to as jack-up barges) are equipped with legs that can be attached to the seabed, lifting the barge platform up to the height of the WTIV addressing the problem of moving cargo and equipment from a moving vessel to a stationary vessel; when legs are attached to the seabed, both the WTIV and the attached barge are stationary.[40] Larger self-elevating barges can also act as WTIVs on their own, able to operate in waters up to 120 meters deep.

Table 4-5 summarizes some of the vessel characteristics for self-elevating barge vessels; these barges can be towed or may be self-propelled, able to get to the site under their own power without need of a tow boat.

Table 4-5. Summary of Select Self-Elevating Barge Vessel Characteristics

Count	Statistic	Dead weight Tonnage	Speed (knots)	Total (kW)				
				Engine Derived Mechanical Electricity	Engine Derived Mechanical Propulsion	Engine Derived Electrical Propulsion	Auxiliary Engine Derived Electricity	Auxiliary Engine Derived Mechanical Power
34	Minimum	608	3	285	285	1,100	190	540
	Average	4,532	8	7,138	3,512	5,625	1,363	2,821
	Maximum	20,000	14	15,275	10,752	14,200	3,964	4,228

40 Ronald Schukking, Jack-Up Barge Presents New Installation Method (March 17, 2014) https://www.offshorewind.biz/2014/03/17/jack-up-barge-presents-new-installation-method/

Appendix A-1. Clarksons Data Dictionary

Database Field	Description
Z01_CURRENT_NAME	Current name of the ship.
L95_STATUS_DISPLAY	Alternative version of the ship status decode.
P36_VESSEL_TYPE	Ship type according to CRSL definitions
ZY1_DESCRIPTION	Top level ship type according to Clarksons Research
ZGH3_RENEWABLES_TYPE	Alternative vessel type for renewable vessels
A04_DWT_tonnes	Deadweight tonnes or Summer deadweight.
A11_TEU_TOTAL_CAP	Total number of TEU (Twenty foot equivalent units) containers the vessel is designed to carry.
Z04_GT_ESTIMATED	Estimated Gross Tonnage unless actual Gross Tonnage is known.
B47_NT	Net Tonnage.
Z20_SPEC_VALUE	Value related to Z21_SPEC_UNIT
Z21_SPEC_UNIT	Unit of size most relevant to the ship type
A08_DRAFT_m	Maximum summer draft measured in metres.
B50_LDT	Light displacement tonnage
A07_BREADTH_m	Extreme breadth of the vessel measured at it widest point in metres.
A06_LOA_m	Length overall of the vessel measured in metres.
B53_LBP_m	Length between perpendiculars in meters.
EB03_SPEED_knots	Speed in knots
J06_BOLLARD_PULL_tonnes	Bollard pull
Z05_DATE_BUILT	Date of build
E56_KEEL_LAYING_DATE	Date of keel laying
EF01009_ENGINE_FUEL_TYPE	Fuel type of vessel
EF05001_PROPULSOR_DERIVED_PROPULSION_TYPE	Main propulsion type of vessel (e.g. Propeller CPP, Azimuth, Waterjet etc.).
EF09013_ENVIRONMENTAL_SUMMARY	Text summary of environmental equipment on board the vessel
EF01008_ENGINE_DERIVED_POWER_TYPE	Type of Propulsion System
EF01005_ENGINE_DERIVED_TOTAL_MECHANICAL_GENERATED_KW	Sum of mechanical power generated by all engines on board the vessel. Expressed in KW
EF01001_ENGINE_DERIVED_TOTAL_ENGINE_NUMBER	Total number of main engines
EF01003_ENGINE_DERIVED_TOTAL_MECHANICAL_PROPULSION_KW	Sum of power generated by the main engine(s) and transferred mechanically to the main propulsor(s). Power can be transferred via shaft either directly or with the use of reduction gears (gearbox). Expressed in mechanical KW (mKW). Not applicable to electrically-driven vessels.
EF01006_ENGINE_DERIVED_TOTAL_ELECTRICAL_PROPULSION_KW	That part of the electrical power generated by the main engine generator(s) transferred to the electric motors that drive the main propulsor(s). Expressed in electrical KW (eKw). Only applicable to electrically-driven vessels.
EF02001_AUXILIARY_DERIVED_TOTAL_ENGINE_NUMBER	Total number of auxiliary engines

Database Field	Description
EF02007_AUXILIARY_DERIVED_TOTAL_ELECTRICAL_ GENERATED_KW	Sum of electrical power generated by all auxiliary engines/generators on board the vessel. Expressed in electrical KW (eKw).
EF02005_AUXILIARY_DERIVED_TOTAL_MECHANICAL_ GENERATED_KW	Sum of mechanical power generated by all auxiliary engines on board the vessel. Expressed in KW
B32_PASSENGERS_TOTAL_NO	Passenger capacity of the vessel
B33_PASSENGER_CABINS	Number of passenger cabins on board
LAST_REPORTED_CONTRACT_END_DATE	End date for last reported vessel fixture (data are not comprehensive)
FLAG	Flag state of the vessel
ED01002_ENGINE_NUMBER	Number of engines related to ED01012_ENGINE_MODEL
ED01021_ENGINE_BORE	Engine bore in mm
ED01022_ENGINE_STROKE	Engine stroke in mm
ED01020_ENGINE_CYLINDER	Number of cylinders
ED01019_ENGINE_CYCLE	2 or 4 stroke
EF01105_ENGINE_1_DESIGNER	Engine designer
ED01012_ENGINE_MODEL	Engine model
ED01016_ENGINE_RPM	RPM of engine
ED01001_ENGINE_FUEL_TYPE	Fuel Type of engine

A-2. Summary of WTIVs and self-elevating barges that have contact with the seabed.

ERGID	Lift Height (m)	Leg Height (m)	Lift Capacity (tons)	Gross Tonnes (GT)	Net Tonnes (NT)	Deadweight Tonnes (DWT)	GT Bin	IMO Tier	Engine Derived Total Mechanical Generated (kW)	Engine Derived Total Mechanical Propulsion (kW)	Engine Derived Total Electrical Propulsion (kW)	Auxiliary Derived Total Electrical Generated (kW)	Auxiliary Derived Total Mechanical Generated (kW)	Category	FLAG
399			32	29,896	8,968	7,890	> 27500 to 30000	III						Unknown	China P.R.
214	25	105	1,200	24,586	7,376	13,174	> 22500 to 25000	II	25,763		13,600			C2	Denmark
213	31	105	1,200	24,586	7,376	13,105	> 22500 to 25000	II	25,763		13,600			C2	Denmark
296		105	1,500	23,641	7,092	5,000	> 22500 to 25000	II	22,097		10,500			C3	Panama
216	32	89	1,500	22,313		11,166	> 20000 to 22500	I	29,762		14,000	1,468	1,530	C3	Germany
502				20,722	6,216	8,161	> 20000 to 22500	III				3,000		Unknown	China P.R.
491				20,000			> 20000 to 22500	III						Unknown	Belize
211	25	106	1,200	19,697	5,909	21,000	> 17500 to 20000	II	18,616		6,000	1,840	1,900	Unknown	Malta
159	25	72	1,000	19,533	5,860	20,739	> 17500 to 20000	I	16,480		4,500			C2	Netherlands
158	25	72	1,000	19,533	5,860	20,739	> 17500 to 20000	I	16,480		4,500			C2	China P.R.
239	22	90	1,500	18,886	5,665	8,265	> 17500 to 20000	II	25,232		10,400			C3	Luxembourg
436		90	1,200	18,167	5,450		> 17500 to 20000	III			11,400			Unknown	China P.R.
445		90		17,714	5,314	25,927	> 17500 to 20000	III	21,000					C3	China P.R.
218	14	84	1,600	16,700	5,011	6,500	> 15000 to 17500	II	19,232		5,000			C3	Netherlands
210	24	83	900	15,966	4,790	5,000	> 15000 to 17500	II	18,512		11,400			C2	Danish Int'l
258		83	632	15,934	4,781	15,771	> 15000 to 17500	II	18,512		11,400			C2	Danish Int'l
402				15,591	4,677	10,227	> 15000 to 17500	II						Unknown	China P.R.
196		92	1,600	15,328	4,599	9,033	> 15000 to 17500	II	18,500		11,400			Unknown	Malta
195	26	92	800	15,328	4,599	9,033	> 15000 to 17500	I	18,500		11,400			Unknown	Malta

ERGID	Lift Height (m)	Leg Height (m)	Lift Capacity (tons)	Gross Tonnes (GT)	Net Tonnes (NT)	Deadweight Tonnes (DWT)	GT Bin	IMO Tier	Engine Derived Total Mechanical Generated (kW)	Engine Derived Total Mechanical Propulsion (kW)	Engine Derived Total Electrical Propulsion (kW)	Auxiliary Derived Total Electrical Generated (kW)	Auxiliary Derived Total Mechanical Generated (kW)	Category	FLAG
326		167	75	15,262	4,578	4,897	> 15000 to 17500	II	16,157			10,320	15,150	Unknown	China P.R.
73	25	72	600	14,310	4,226	10,968	> 12500 to 15000	I	9,854		6,000	2,200	2,280	C1	Netherlands
480		92		13,867	4,162	4,304	> 12500 to 15000	III			5,400			Unknown	China P.R.
438		85	1,433	13,368	4,010	4,965	> 12500 to 15000	III						Unknown	China P.R.
406		85	2,205	12,131	3,639		> 10000 to 12500	III			6,000			Unknown	China P.R.
423		90		12,027	3,608		> 10000 to 12500	III						Unknown	China P.R.
198	25	78	1,000	11,730	3,519	6,314	> 10000 to 12500	II	11,200					Unknown	Denmark
217	25	78	1,000	11,730	3,519	6,313	> 10000 to 12500	II	11,200					Unknown	China P.R.
370		85	1,102	11,671	3,501	2,800	> 10000 to 12500	II	7,040					C1	China P.R.
371		85	1,102	11,653	3,495	2,800	> 10000 to 12500	III	7,040					C1	China P.R.
450		90	1,323	11,056	3,316	15,872	> 10000 to 12500	III						Unknown	China P.R.
376		92	1,323	10,551	3,165	4,781	> 10000 to 12500	III	11,692		6,400			C1	China P.R.
443			1,102	10,349	3,104	4,729	> 10000 to 12500	III						Unknown	China P.R.
434		85		10,000			> 10000 to 12500	III						Unknown	China P.R.
428				9,752	2,925	10,384	> 7500 to 10000	III	7,040					C2	Tuvalu
252			400	9,722	2,916		> 7500 to 10000	II			2,200			Unknown	China P.R.
407		73	1,323	9,717	2,915	3,991	> 7500 to 10000	III				9,600		Unknown	China P.R.
212	24	85	800	9,704	2,911	3,000	> 7500 to 10000	I	9,916		4,500	2,400	2,514	C1	Japan
323				9,564	2,869	4,044	> 7500 to 10000	II	9,009			7,670	8,015	Unknown	China P.R.

ERGID	Lift Height (m)	Leg Height (m)	Lift Capacity (tons)	Gross Tonnes (GT)	Net Tonnes (NT)	Deadweight Tonnes (DWT)	GT Bin	IMO Tier	Engine Derived Total Mechanical Generated (kW)	Engine Derived Total Mechanical Propulsion (kW)	Engine Derived Total Electrical Propulsion (kW)	Auxiliary Derived Total Electrical Generated (kW)	Auxiliary Derived Total Mechanical Generated (kW)	Category	FLAG
403		75		9,337	2,801		> 7500 to 10000	III				3,200		Unknown	China P.R.
492		91		9,326	2,797	3,883	> 7500 to 10000	III						Unknown	China P.R.
375		80	882	9,157	2,747	3,783	> 7500 to 10000	II	4,928					C1	China P.R.
287		60		9,103	2,730		> 7500 to 10000	II	5,334			4,650	5,334	Unknown	China P.R.
460		90	1,200	9,000			> 7500 to 10000	III						Unknown	China P.R.
468	140		600	8,391	2,517		> 7500 to 10000	III						Unknown	China P.R.
345		80	1,102	8,331	2,499		> 7500 to 10000	II	8,490		4,540			Unknown	China P.R.
484				8,256	2,476	2,809	> 7500 to 10000	III			3,800			Unknown	China P.R.
477		90		8,154			> 7500 to 10000	III			4,000			Unknown	China P.R.
452		85		8,029	2,408		> 7500 to 10000	III						Unknown	China P.R.
467	140		600	8,000			> 7500 to 10000	III						Unknown	China P.R.
451		85	600	7,992	2,397		> 7500 to 10000	III						Unknown	China P.R.
127	31	71	500	7,962		2,623	> 7500 to 10000	I	6,660		4,400			C2	Germany
453		95	600	7,805	2,341		> 7500 to 10000	III						Unknown	China P.R.
257				7,726	2,317	2,673	> 7500 to 10000	I	8,497			7,650	7,907	Unknown	China P.R.
427		72	600	7,665	2,299		> 7500 to 10000	III			3,000			Unknown	China P.R.
425		85		7,648	2,294		> 7500 to 10000	III						Unknown	China P.R.
426		85		7,648	2,294		> 7500 to 10000	III						Unknown	China P.R.
230			2,500	7,500		800	> 7500 to 10000	I	2,463				2,463	Unknown	China P.R.

ERGID	Lift Height (m)	Leg Height (m)	Lift Capacity (tons)	Gross Tonnes (GT)	Net Tonnes (NT)	Deadweight Tonnes (DWT)	GT Bin	IMO Tier	Engine Derived Total Mechanical Generated (kW)	Engine Derived Total Mechanical Propulsion (kW)	Engine Derived Total Electrical Propulsion (kW)	Auxiliary Derived Total Electrical Generated (kW)	Auxiliary Derived Total Mechanical Generated (kW)	Category	FLAG
488				7,495	2,248		> 5000 to 7500	III	3,200					Unknown	China P.R.
270		95		7,466	2,239	2,311	> 5000 to 7500	I	8,130					C1	China P.R.
394		66	882	7,456	2,236	3,624	> 5000 to 7500	III	10,153					C1	Japan
272		85		7,000	1,555	1,683	> 5000 to 7500	II	664		6,000			Unknown	Panama
373		90		6,920	2,076	1,694	> 5000 to 7500	II	6,268	3,520		2,250	2,460	C2	China P.R.
292		67	882	6,879	2,063		> 5000 to 7500	I	3,284			2,860	3,284	Unknown	China P.R.
240	22	90	1,000	6,873	2,062	2,100	> 5000 to 7500	II				3,392		Unknown	China P.R.
192	15	82	500	6,831	2,049	1,681	> 5000 to 7500	I	5,120					C1	Madeira
273		56		6,567	1,971	1,500	> 5000 to 7500	II	8,999		5,500			C1	Denmark
131	19	85	400	5,186	1,555	1,683	> 5000 to 7500	I	6,311		6,000			Unknown	Panama
130	16	85	300	5,186	1,555	1,683	> 5000 to 7500	I	6,311		6,000			Unknown	Panama
222	26	80	600	5,125	1,537	2,000	> 5000 to 7500	II	8,712	6,712		1,888	2,000	C1	Luxembourg
189	18	94	230	5,087	1,526	1,526	> 5000 to 7500	I	6,560		4,800			C2	Panama
237	30	75	350	4,873	1,461		> 2500 to 5000	I	2,084			1,740	2,084	Unknown	China P.R.
342		42	250	4,765	1,429		> 2500 to 5000	II	2,084			1,740	2,084	Unknown	China P.R.
483		75		3,516	1,054	1,419	> 2500 to 5000	III				1,328		Unknown	China P.R.
482		75		3,516	1,054	1,427	> 2500 to 5000	III				1,328		Unknown	China P.R.
309		43		2,400	710	1,838	> 0 to 2500	I	927				747	Unknown	Danish Int'l

A-3. Summary of U.S. flagged vessels included in Clarksons.

ERGID	Standardized Vessel Type	Gross Tonnes (GT)	Net Tonnes (NT)	Deadweight Tonnes (DWT)	Category	US Tier	Engine Derived Total Mechanical Generated (kW)	Engine Derived Total Mechanical Propulsion (kW)	Engine Derived Total Electrical Propulsion (kW)	Auxiliary Derived Total Electrical Generated (kW)	Auxiliary Derived Total Mechanical Generated (kW)
1061	Crew Boat	160			C1	4	2,354	2,354		43	
1043	Crew Boat	89	71	18	C1	4	2,402	2,352		48	50
858	Crew Boat	55			C1	3	2,059	2,059		17	
274	Self Elevating Install. Barge	3,908	1,172	1,526	C1	2	6,858		3,627		
543	Self Elevating Install. Barge	168	134		C1	0	794	794		190	
232	Supply	3,378	1,387	4,466	C1	2	7,600		5,000		
233	Supply	3,378	1,387	4,466	C1	2	7,600		5,000		
234	Supply	3,200	1,387	4,500	C1	2	7,600		5,000		
197	Supply	2,918	1,310	3,580	C1	2	8,044		4,000	550	600
71	Supply	2,045	797	2,929	C1	0	4,730		3,132		
38	Supply	1,891	820	2,669	C1	0	2,516	2,516		900	
283	Support	5,700		4,500	C1	2	1,232		5,200		
161	Support	5,289		3,200	C1	2	9,000		5,000		
572	Support	503	193	488	C1	1	1,250	1,250		572	
91	Support	498	163	750	C1	1	1,103	1,103		198	
90	Support	498	163	625	C1	1	1,103	1,103		198	
607	Support	495	185	592	C1	2	1,250	1,250		572	
562	Support	493	147	750	C1	0	1,250	1,250			
579	Support	447	134	576	C1	2	2,238	2,238		300	
575	Survey	874	262		C1	1	1,471	1,471		500	
548	Survey	806	241		C1	0	1,545	1,545		500	
549	Survey	401			C1	0	2,648	2,648			