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M.Sc. IN SHIPPING MANAGEMENT

How can a vessel's hull affect fuel consumption

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To my family

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Abstract

The main purpose of this thesis is to examine the relationship between the hull of the vessel in regard with the fuel consumption. The structure of the hull , the material that the hull is built , the time that took the designer to design the hull . How can a hull be perfect for each voyage ? how important is the place where a vessel is trading in relationship with the hull type? The reduction of the ships fuel consumption and and how can a vessel achieve it. Fuel consumption is very crucial in the economic part of the vessel during its short term or long term life and each knot plays a role. Ship owners can pay for better paints in their hulls that wont allow micro organisms to appear and reside on the vessels hull and propeller . They can also ask from companies to clean the hull of their vessels with new technologies or divers , which is called underwater hull cleaning. Does this helps them economically and with the vessels speed and consumption? The speed of the vessel is also affected by the emissions and how much the vessel is harming the environment with CO2.
Kamsarmax bulkers , new type of bulkers that are being ordered massively and are trading and preferred by the ship owners because of their specification. We are going to see real data from a Kamsarmax vessel about its speed , its consumption and the engine hours before and after the underwater hull cleaning.
Aframax tankers ,also known as “Dirty Tankers” the answer to the traffic due to the VLCC’s and blocking the routes . How they are used in the Mediterranean and Africa. We are also going to analyze data regarding its speed , its consumption and the engine hours before and after the underwater hull cleaning.

Keywords: Hull, hull cleaning , speed optimization, fuel consumption, Kamsarmax, Aframax , data analysis , antifouling

Περίληψη

Ο κύριος σκοπός αυτής της Διπλωματικής εργασίας είναι να εξετάσει την σχέση της γάστρας ενός καραβιού και που επηρεάζει την κατανάλωση του καυσίμου. Η δομή της γάστρας , τα υλικά από τα οποία κατασκευάστηκε η γάστρα , ο χρόνος που χρειάστηκε για να σχεδιαστεί. Ποτέ θεωρείται μια γάστρα τέλεια για ένα ταξίδι , πόσο σημαντικό είναι το μέρος οπού εκτελεί δρομολόγια το εκάστοτε καράβι σε σχέση με την τον τύπο της γάστρας , η μείωση της κατανάλωσης του καυσίμου και πως μπορεί να το πετύχει το καράβι το επιθυμητό αποτέλεσμα.

Η κατανάλωση καυσίμου είναι πολύ σημαντική στο οικονομικό κομμάτι στη μακροχρόνια ή βραχυχρόνια ζωή του καραβιού και κάθε κόμβος που πιάνει το καράβι παίζει το δικό του ρόλο. Οι Πλοιοκτήτες μπορούν να πληρώσουν ακριβότερες προστατευτικές μπογιές που δεν θα επιτρέψουν σε μικροοργανισμούς να εμφανιστούν και να κολλήσουν στην γάστρα και την προπέλα του πλοίου. Μπορούν επίσης να πληρώσουν για να καθαρίσουν τη γάστρα τους όσο ακόμα βρίσκεται στο νερό καράβι . Ο καθαρισμός αυτός μπορεί να γίνει με την βοήθεια δυτών αλλά και με μη επανδρωμένα μηχανήματα. Βοηθάει στο οικονομικό κομμάτι και στην καλύτερη απόδοση του καραβιού όσον αφορά την ταχύτητα και την κατανάλωση καυσίμου ;

Η ταχύτητα του καραβιού παίζει ρόλο στην εκπομπή παραπάνω καυσαερίων και κατά πόσο επηρεάζει το περιβάλλον με τους ρύπους του και την εκπομπή διοξειδίου του άνθρακα;

Τα φορτηγά πλοία τύπου Kamsarmax , είναι ένας νέος τύπος φορτηγού πλοίου τα οποία γνωρίζουν μεγάλη άνοδο όσον αφορά τις παραγγελιές για νεότευκτα καράβια από τους πλοιοκτήτες , και ο λόγος είναι τα χαρακτηριστικά κατασκευής τους. Θα εξετάσουμε πραγματικά στοιχεία ενός Kamsarmax , όπως είναι η ταχύτητα του , η κατανάλωση καυσίμου και οι ώρες που δούλευε η κύρια μηχανή πριν και μετά από έναν υποβρύχιο

καθαρισμό .
Δεξαμενόπλοια που μεταφέρουν αδιύλιστο πετρέλαιο που ονομάζονται Aframax . Έχουν το προσωνύμιο «Dirty Tankers” και είναι απάντηση στην συμφόρηση που γίνεται σε κάποια λιμάνια λόγω της φορτοεκφόρτωσης από μεγαλύτερα δεξαμενόπλοια όπως VLCC που μπλοκάρουν τις διόδους. Πως τα χρησιμοποιούν οι πλοιοκτήτες σε περιοχές όπως η Μεσόγειος και η Αφρική. Θα δούμε επίσης στοιχεία όπως είναι η ταχύτητα του , η κατανάλωση καυσίμου και οι ώρες που δούλευε η κύρια μηχανή πριν και μετά από έναν υποβρύχιο καθαρισμό .

Λέξεις Κλειδιά : γάστρα , Kamsarmax , Aframax ,υποβρύχιος καθαρισμός , κατανάλωση καυσίμου ,

Table of contents

Introduction

A ship is a vessel that can sail by its own power. It is consisted of a lot of different structures brought together. The most notable entity of these structures is the hull which is the watertight body or enclosure of the ship . It is the most notable since it protects , the machinery , the cargo and the accommodation from weather and flooding damages. Apart from the other crucial features that the selection of a correct hull for our ship (course keeping at sea , superstructure etc) affect is the performance of the ship at sea.

By performance of the ship we refer to the speed and consumption . In order to calculate the routes and the operations expenses of the vessel we need to know the consumption for the referred speed .

Uprising fuel costs have driven shipping companies to discover various ways to reduce ship fuel consumption. To reduce fuel consumption, major shipping companies are using technological and operational approaches such as new power and propulsion systems, ship hull design optimization, voyage optimization by speed reduction, and use of renewable energy.

In this dissertation we are going to focus on how the design of the hull affects the speed.Moreover the cost of fouling operation and if it is more optimum to use antifouling methods or let the vessel undergo hull cleaning when the vessel is drydocked.

A ship has a three-dimensional hull form that can be represented by a series of curves which are the intersections of the hull with three sets of mutually orthogonal planes. Along the other costs which we are going to refer below and eplain thoroughly we will discuss the hull and the consumption along the Building cost.

1. Building Cost

Building cost is the total cost the shipowner pays the shipyard for building his ship. This is a part of life cycle cost and occupies a big amount. The building cost occupies about 2/3 of the life cycle cost and the other 1/3 is occupied by the maintenance.

Here is a table showing a small breakdown of the building costs.

Items		Ratio(100%)
Material	Steel	20
	ME	10
	Others	30
	Total	60
Fabrication		30
Design		5
charge		5
Total		100

1.1 Material Cost

Material cost occupies roughly a 50-60% of the total building cost which is a big amount. In the material costs the the cost of steel occupies the 35%. Nowadays that all vessels are equipped with double hull which is thousands of tons of steel which are also higher tensile strength steel. The cost of the main engine occupies about 15 % while the rest outfitting occupy about 50%.

1.2 Fabrication Cost

The fabrication cost occupies more than 32 % among them the hull structural part occupies about 50 % and the outfitting is about 15 % , mostly depending on the nature of the vessel , the type , the extra features etc.

1.3 Design Cost

The design part is divided in two stages , the basic design and the detailed one which both the designs take up to 10-12 months . Mostly the design cost takes up to 5 % . Design costs vary in accordance the ship type and features.

1.3.1 Basic design

After the building contract is signed the basic characteristics of the ships are decided by basic design to satisfy the specifications attached to the contracts. Basic design consists of total design, hull structural design, outfitting design(hull part and machinery part) and electric design. The basic design cost is less than 10% of the total design cost. However by this basic design, 90 % of the total building costs of a ship is decided, so it is the most important division.

1.4 Maintenance cost

The maintenance costs are mostly influenced by the shipowner and the management policies he follows. Consequently the ship ages vary from 10 and several years to more than 20 years. Here age of 20 years is taken as standard life length.

1.5 Inspection By IMO

Rules every ship classification society makes close up survey. In order to make this easier the inspection stages are installed in the double hull of VLCC, as shown in Figure 2. Using these stages close up survey is made in every part of structures.

The hull form is largely determined by the required speed – a finer hull for higher Froude numbers. (Froude number (Fr) is a dimensionless number defined as the ratio of the flow inertia to the external field). The initial form will be chosen from historical data – a methodical model series, computer-generated forms or a type ship. It will be adjusted to enable it to carry its cargo more efficiently and to obtain the desired hydrodynamic characteristics. The influence of form changes on those characteristics has been discussed in the relevant chapters.

Having high speed vessel is regarded as a better way to get more charters during a year, but it is costly in power and fuel and the speed is really high it leads us to an uneconomic vessel. Faster ships can make more journeys in a given time period. Passengers like short passage times and are often prepared to pay a premium to get them as in the case of high-speed catamaran ferries. Some goods require to be moved relatively quickly. They may be perishable and a balance must be struck between refrigeration and a fast transit. For other products speed may be of little consequence. For instance, as long as enough oil is arriving in port each day, it does not matter to the customer how long it has been on passage. It is important to the ship owner who needs to balance speed, size, number of ships and capital locked up in ships and goods in transit to achieve the desired flow rate economically.

2. Designing The Perfect Hull

The beginning of designing a ships hull is designing its form and shape. The form of the hull is created through many coefficients.

The Block Coefficient (C_b) :

$$\mathrm{Cb} = \frac{Volume\ Displacement\ of\ the\ Ship}{Lbp * MaxBeam * Draft}$$

The ratio of the underwater volume to the imaginary rectangle enclosure volume of the underwater portion of the hull. Block coefficient is a number lower to 1 , the closer to 1 this the block coefficient is the fuller its hull form is.

The Midship Coefficient (C_m) :

$$Cm = \frac{Submerged\ Midship\ Area}{Beam\ at\ midship\ x\ Draft}$$

The ratio of the submerged area of the midship section to the enclosing rectangle.

Wake Friction Values

Ship Type	**Typical C_b Fully Loaded**	**Approximate W_t**
Supertankers	*0.825*	*0.363*
Oil Tankers	*0.800*	*0.350*
Large Bulk Crriers	*0.825*	*0.363*

2.1 Lines plan and three views

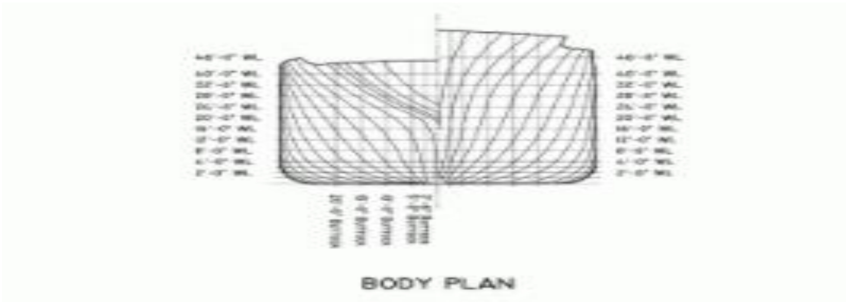
These two Coefficient along with other coefficients such as the Prismatic and the Volumetric coefficient etc are the parameters in order to make the statistical studies and develop the Lines Plan.

The lines plan comprises in three views :

The Profile View

Half Breadth Plan

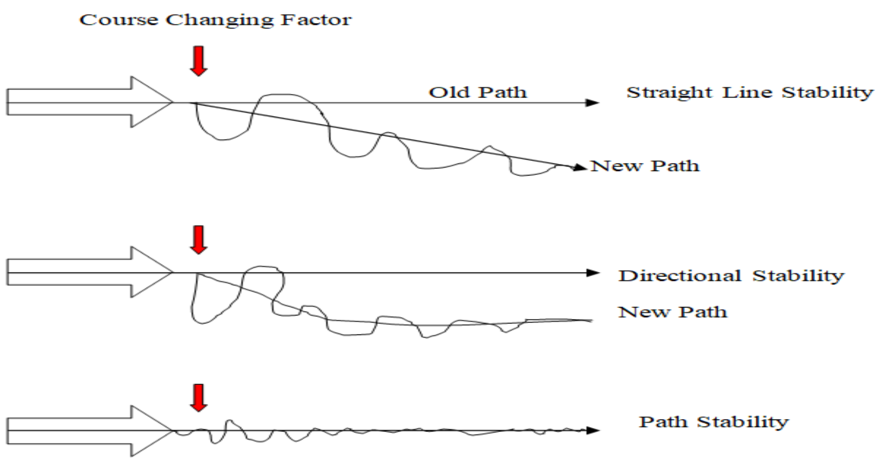
The Body Plan



Almost the 70% of the total design of a ship is taken from the hull design. Another important aspect of the hull design is the ships manoeuvrability or else the course-keeping performance at sea.

2.2 Stability

While developing the ships hull we need to understand that the main goal is to have a straight line stability. Straight line course cost less money to the vessel since we know that “The straight line is the fastest route”. The coefficients to which we referred before are the characteristic properties of giving to our vessel the course keeping abilities , and if the results



we get while testing the hull are not the results we want the hull shape or geometry should change.

- Straight Line Stability: The vessels course is subjected to a course changing factor , even though this factor is changing the direction the vessel continuous to move in a straight line without the help of the rudder.
- Directional Stability: The vessel course is a straight line and a course changing factor appears but it continues to move along the same path which is parallel to the initial direction. Directional stability is not possible without the aid of a control surface (e.g. rudder), but having straight-line stability makes it easy to attain directional stability.
- Path Stability: If a ship moving in a straight line is disturbed externally, and it continues to move along the same path (after a few oscillations), it is said to have path stability. Path stability, like directional stability, can only be attained if straight-line stability is achieved.

The major role in designing a ship's hull is the performance of the ship at sea.Hull hydrodynamic performance is an important aspect of ship design because it determines their economic viability.

3.Bulk Carriers and Tankers designs

3.1 Bulk Carriers

A Bulk carrier is designed to carry un-packaged bulk cargoes.The first bylk carriers were built back in 1852. From that time up to 2020 these vessels are developing rapidly reaching now about 22 % of the global market. The reason to have such a percentage is their efficiency , the way they adapt and the vast amount of goods they can carry. Out of this 22% , over 52% belong to Greek Shipowners with more than 20 % registered in Panama. Bulk carriers are also called trump , resulting the phrase “Trump Shipping” when we refer to this kind of sector.

Bulk Carriers are primarily designed to store cargo efficiently. Some bulk Carriers are smaller than 100 m but also large vessels with a capacity of greater than 250.000 m^3 are under development. Although bulbous bow allows a ship to move more easily through the water, lately designers lean toward the simple vertical bows on the large bulkers. We will discuss the bulbous bow more extensively later in the dissertation.

Bulkers are slow moving vessels (a Kamsarmax’s sailing speed is abou 12 knots) because thy have full hulls , large bloc coefficients (C_b) Full hulls and are traveling universal lines.However the fact that they are slow is a plus to their efficiency.One measure of this efficiency is found in the ratio of the empty ship’s weight to its deadweight tonnage.

A handymax ship has a ratio of empty ship’s weight to deadweight of a 20 % while a larger Dwt vessel such a capesize has at least 18-20 %.

As already referred nowadays the bulk carriers are single screw type vessels with high Block Coefficient. Thus attention need be paid to the fore design i.e the bow design which will result in a good related power performance and low overall resistance which will create a better flow towards the propeller and rudder.

Large differences between design (loaded) draught and ballast draught have to be taken into account. The combination of single screw type of ship, high propeller loading, and rather pronounced wake field requires carefully checking of the risk for cavitation erosion and vibrations .

3.2 Tankers

Tankers are vessels that carry the supplies of liquefied freight . They are responsible of supplying mass quantities that type of freight in the global market. In the term liquefied freight are included rock oil excavated from underwater reservoirs or oil rigs , juices , alcoholic beverages , hydrogen compounds and gas substances. These type of vessels , thath carry , crude oil , LNG , petroleum etc in bulk are termed as **TANKERS**.

Through the years and with the advancement of technology , the transportation of liquefied freights is being handled by a large amount of tankers. Modern technology and a lot of different types as well as small barges . All types of tankers are about a 30 % of the total merchant ships in the world

An oil tanker has a weight based design , the dimensions of the tanker are governed by the weight of cargo that can be carried , there is also another type of design which is volume based where the dimensions are calculated by the volume of the cargo. Tanker operators want the weight of the oil they carry in each voyage to be maximized , it is preferable to have maximum speed for oil tankers. As ships the oil tankers are running on very low speed , so based on the above mentioned factors the form and shape of the hull of the tanker is determined. Buoyancy coefficient of tankers is higher than containerships for example.

While bulkers also have a double hull , we call them Double Skin. The outer skin known as the hull of the ship can be of a single layer or of double-layer, i.e. there are two hulls of the ship known as double hull. The double hull is most commonly found in oil tanker ships.

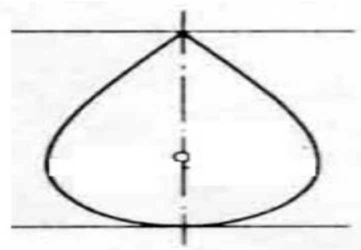
All newly built oil tankers of 5000 deadweight tonnage of above are obliged to have double hulls according to The IMO which introduced the 13 F of Annex 1 of Marpol. This annex was was created after the Exxon Valdez oil spill thus the U.S Government to make double hulls compulsory for all new tanker ships coming to the U.S.

All tankers are equipped with bulbous bow in order to increase the power efficiency of the ship. The bulbous bow reduces the wave resistance considerably , even the these big volume vessels are operating with slow speed.

3.3Bulbous Bow:

Bulbous bow is one of the most common characteristics of the modern merchant ships

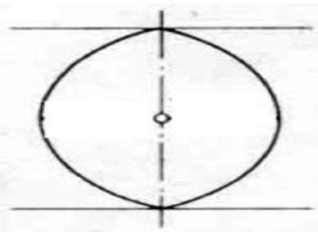
The main reason of the to install a bulbous bow is the reduction of the wave resistance while operating in calm waters. Namely an important resultant force of the whole resistance for vessels.



Delta Type

In the below figures we can see the three basic shapes of a bulbous bow when looked from fore to aft of the ship.

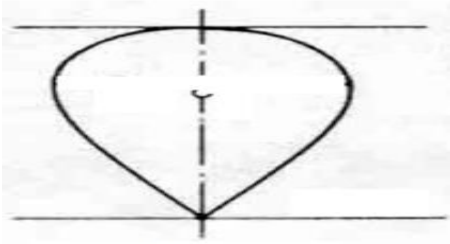
Delta type bulb : Volume concentrated at the lower half , which gives the advantage to be used in ships which alter their waterline.The more concentration of bulb volume at the lower portion ensures the bulb immersion for larger waterline conditions.



O - Type

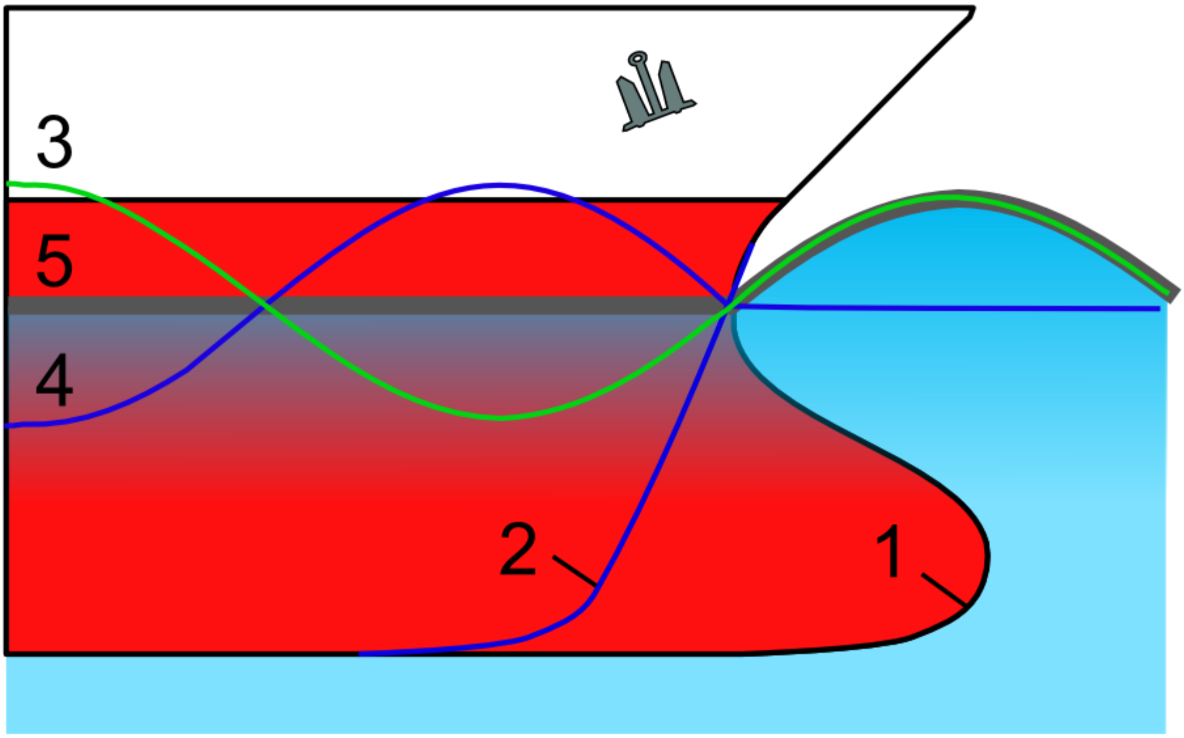
O-Type : Maximum volume concentrated at the center. This is mostly used by Bulkers who require a cylindrical bow shape.

Nabla Type : Bulb is shaped like a tear-drop , and the most volume is concentrated on the top , this type of bulb is equipped on ships that have exceptional sea keeping abilities.



Nabla Type

The bulb due to its forward motion is pushing the water sideways and up , creating a crest ahead of the ship , with the trough occurring aft of hull entry, which necessarily means reducing the pressure on the hull, resulting in lower wave resistance. The higher the speed within that Froude number range , the more is the effect of the bulb . The bulbous bow was first designed for the SS Bremen owned by Nordeytscher Lloyd line back in the 1920.The bulbous bow is the most common asset on a bulk carriers hull .



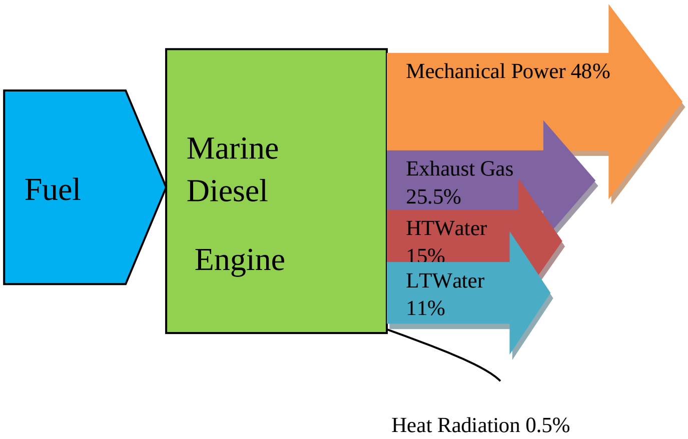
4.Marine Engines and Fuel Consumption and Distribution

The first internal combustion engines we beginning to develop back in the early 19's from Diesel and Otto . Their names were Nikolaus Otto and Rudolph Diesel and they designed a whole new meaning of initiating combustion of the fuel.

Diesel continued to compress the fuel until it ignited , with this way the head was produced would by the higher compression while Otto was compressing fuel to a particular volume and then applied the ignition through a spark. When we are talking about the same pressure the Otto Engines are more efficient because they consume less fuel , in practice though the diesel engines use higher pressure thus making them more efficient and less costly since they don't consume as much fuel.

Until 1934 all marine diesels were four-stroke and were running with distillate , not with residual fuels that they are running now. In our times ships are equipped with big two-stroke main engines with way better power to weight ratio. Medium speed with high propulsion and power generator sets in a diesel system are used by other type of ships and lastly the high-speed diesel electric system are rarely encountered and mostly used by tug boats or fast ferries.

Marine engines play catalytic role in the energy utilization of a vessel and that's why the engines need to operate efficiently leading to a big overall energy efficiency. All ship types and capacities have a different type of marine engine installed , however when we are talking about energy flow distribution within a vessel we can break down how the energy is being distributed and with which flow.



Energy Distribitution of a typical Marine Engine.

The highest thermal efficiency is being achieved by diesel engines which have a regular combustion engine since the compress in high rates . In numbers less than 50% fuel energy can be converted into mechanical work . The other 50 % of the energy is also called heat waste energy and is taken by the gas exhaustion , the high temperature cooling water (HT) , the low temperature cooling water (LT) and emitted to the air and sea eventually. A small amount will be scattered to the engine room with the form of heat. Taking into consideration that a vast amount of bunker fuel is burned every day , even a small portion of recovery can result in great energy savings,

4.1 Power generation On board

Power to the shipboard is generated by prime a mover and an alternator , working together. This generator is working when the magnetic field is close to the conductor , a current is created near the conductor , thus this alternator is used on board.

The generator consists of a stationary set of conductors wound in coils on an iron core. This is known as the stator. A rotating magnet called the rotor turns inside this stator producing magnetic field. This field cuts across the conductor, generating an induced EMF or electro-magnetic force as the mechanical input causes the rotor to turn.

The generated magnetic field is being energized through a DC current through rings and brushes. A brushless alternator is generating through induction the magnetic field. The AC is working with 3 phase power which is preferred over DC since it offer more power and has the same size. A 3 phase generator is preferred over single phase since it draws more power and even if you one phase fails , you still got the other 2.

4.2 How is the power distributed.

Power distribution throughout the vessel needs to be supplied efficiently , that’s why every ship has a power distribution system. More thoroughly this system is consists of different compontets.These components are :

1. The ships generator with its prime mover ant the alternator.It is a device that converts motive power (mechanical energy) into electrical power for use in an external circuit.The main on board switch used the power from the diesel generator and supplies it to the machinery.

2. Busbars which is a copper plate/bar which is used in ship’s main and emergency switchboards to conduct electricity from generators or from one electrical terminal to another.

3. Transformers generally have one of two types of cores: Core Type and Shell Type. These two types are distinguished from each other by the manner in which the primary and secondary coils are place around the steel core. Core type - With this type, the windings surround the laminated core. The pace of the voltage is being set through them.

4. A normal voltage for distribution system is roughly 440v but it might different in several types of ships , since some very large installation might exceed 6000v.

5. One of the important safety devices used for ship's generator is Air Circuit Breaker (ACB).They also assist for the power to be supplied to the auxiliary engine. If our vessel has a smaller supply fuse there are also smaller circuit breaker to be used.

6. Insulated systems are most used and preferred than the earthed ones because if a defect occurs in essential machinery then they might be lost.

4.3 Emergency Power

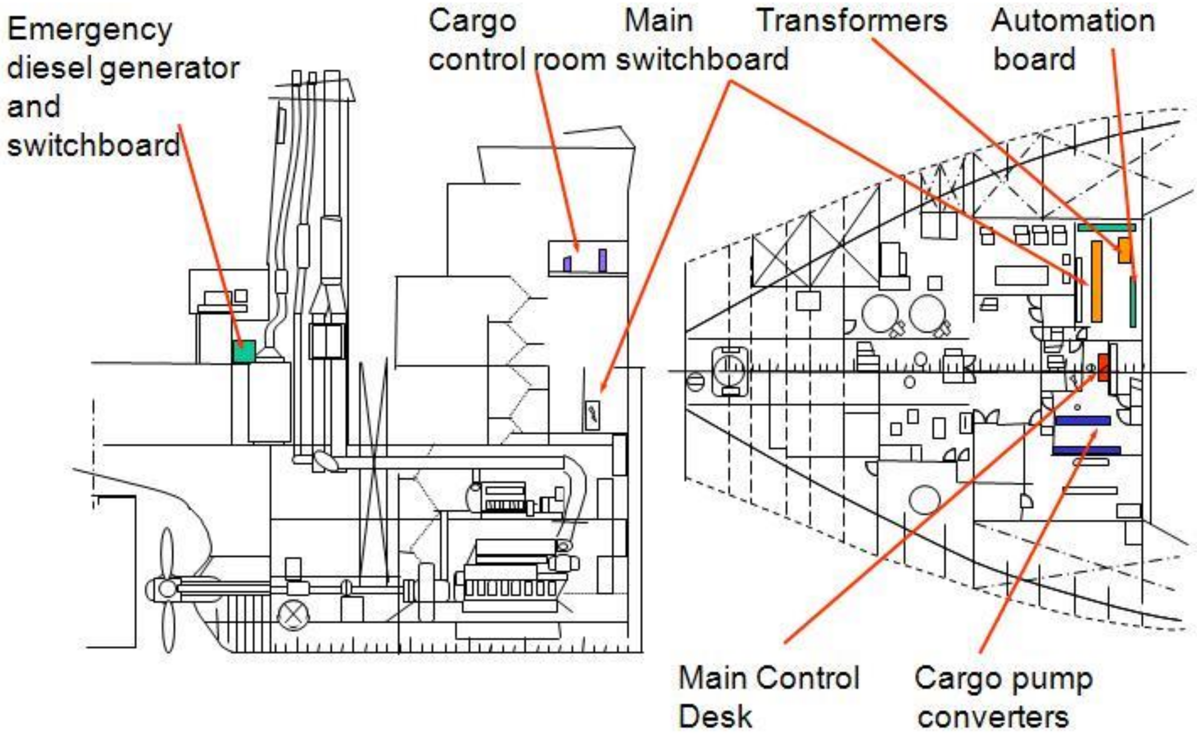
A source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power, (SOLAS). The emergency source of electrical power may be either a diesel-driven generator or an accumulator battery of sufficient capacity to provide essential circuits such as steering, navigation lights and communications when the main power supply fails. (Emergency Source of Electrical power according to Wärtsilä).

The emergency power supply ensures that the essential machinery and system continues to operate the ship.The emergency power can be supplied with an emergency generator or with batteries or with a combination of both depending on the type of the vessel.

Asd referred above the emergency supply should provide aid to the essential systems of the vessel :

- Watertight doors.
- Steering gear system (the device used for controlling the direction of a ship)
- Fire fighting system.
- Emergency pumps.
- Communication systems , Vhf , AIS ,emergency lights etc.

In order to avoid situation where you cannot enter the engine room for some reasons , such as fire , smoke etc the emergency generator is located outside of the machinery space of the ships and the switch board in order to switch to the emergency generator room power supplies to different essential machinery.



Images Courtesy: Wartsila (2008) – Pentti Hakkinen Ship Auxiliaries 11.1

4.4 Who is responsible for recordkeeping and fuel oil consumption calculation on board?

Chief engineer should ensure that all the **ship's** machinery and equipment are working in an efficient manner in order to support safe navigation of the **ship**. He is responsible for the calculating the ships fuel consumption and keep track of the records which are two of the most crucial tasks.

.

When fuel is provided to our vessel , either from ship to ship or from shore , even if it is provided by the charterers of the owned company the Chief Engineer has to report them every day during the reports which we are going to analyze . He also has to make a book keeping of the Rob bunkers (Remaining on-board) and plan the requirements for the next voyage.

4.4.1Measuring and Reporting Fuel Oil Consumption

In order to determine the fuel consumption , a flow meter is put on every pipeline supplying fuel to an emission source (main engine , auxiliary etc..). By checking the fuel temperature and the flow meter every day at 12 : 00 noon hours (it is called noon time) and also the Arrivals and Departures (both written in the Arrival Report and Departure Report) and then placed on an excel and calculate with the help of formulas.

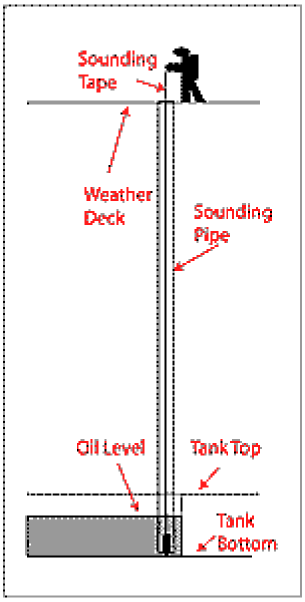
The formula we are using is

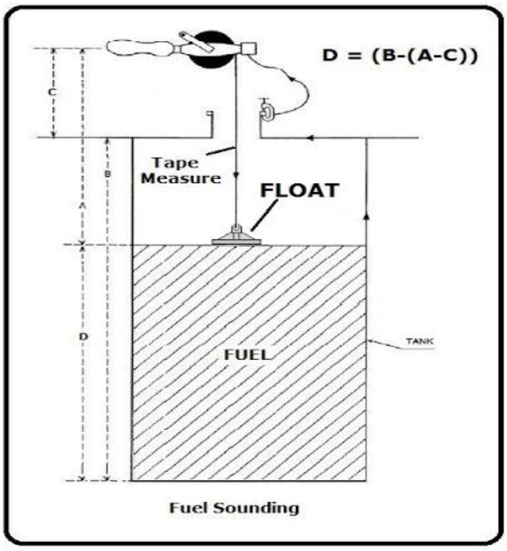
$$\boldsymbol{Corrected\ Density} = Density\ at\ 150C\ \times \{1 - [(Fueltemp\ (C) - 150C) X\ 0.00065)]\}$$

In order to calculate the correct density. On every noon and arrival and departure of the vessel we should also be aware of the End of the sea passage , Commencement of sea passage and when a fuel change operation is sompleted. Through the fuel oil drain tank the fuel is transferred and also written in the reports (Noon , Position , Arrival) and the amount will be substructed from the voyage fuel consumption.

4.4.2 Sounding process

Even though the flow meter can track the emissions they may have a malfunction and not be operative , ships need to have an alternate monitoring system on board. The most common system for readings is the sounding by which the the tank reading are noted in the engine room sounding log.





Furthermore the above measures to track down emissions and energy efficiency the fuel quantities should be checked periodically with a standard schedule.

1) Every time a vessel arrives in a port and enters the Berth and at the time the vessel departs from the berth.

2) Once per week or once per 10 days.

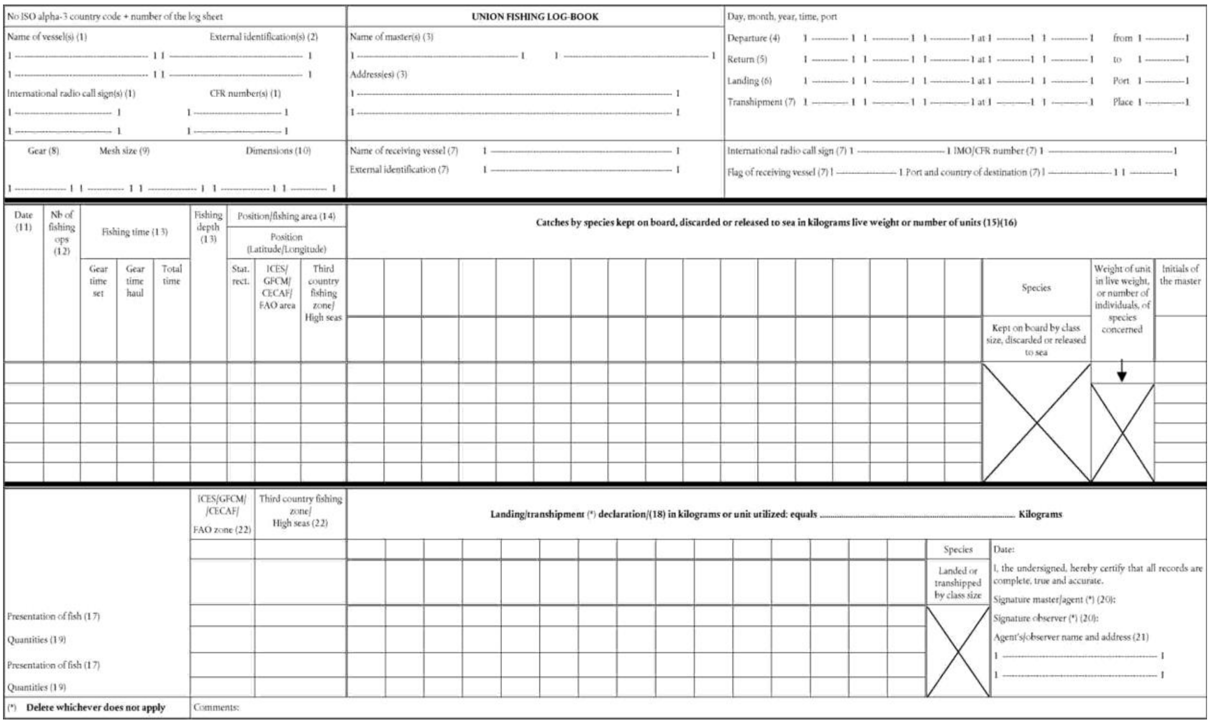
3) Before the vessel is going to do bunkering or debunker .

4) Right after the bunkering and debunkering procedure.

These are some standards formats , this format varies between companies since every company has a different policy.

4.5 Three Types of reports

Between position reports there should be gap but not more than 24 hours , as referred before the position report is submitted every day at 12 : 00 (Noon report) , no matter if the vessel is sailing or is at a berth in a port. The above reports are a key to the the company means of tracking the fuel consumption , transport work and other essential voyage data.



UNION FISHING LOG-BOOK

No ISO alpha-3 country code + number of the log sheet

Name of vessel(s) (1) | External identification(s) (2)

International radio call sign(s) (1) | CFR number(s) (1)

Name of master(s) (3)

Address(es) (3)

Day, month, year, time, port

Departure (4) ... at ... from

Return (5) ... at ... to

Landing (6) ... at ... Port

Transhipment (7) ... at ... Place

Gear (8) | Mesh size (9) | Dimensions (10)

Name of receiving vessel (7)

External identification (7)

International radio call sign (7) | IMO/CFR number (7)

Flag of receiving vessel (7) | Port and country of destination (7)

Date (11) | Nb of fishing ops (12) | Fishing time (13): Gear time set, Gear time haul, Total time | Fishing depth (13) | Position/fishing area (14): Position (Latitude/Longitude), Stat. rect., ICES/GFCM/CECAF/FAO area, Third country fishing zone/High seas

Catches by species kept on board, discarded or released to sea in kilograms live weight or number of units (15)(16)

Species | Kept on board by class size, discarded or released to sea | Weight of unit in live weight, or number of individuals, of species concerned | Initials of the master

ICES/GFCM/CECAF/FAO zone (22) | Third country fishing zone/High seas (22)

Landing/transhipment (*) declaration/(18) in kilograms or unit utilized: equals ... Kilograms

Species | Landed or transhipped by class size

Presentation of fish (17)

Quantities (19)

Presentation of fish (17)

Quantities (19)

Date:

I, the undersigned, hereby certify that all records are complete, true and accurate.

Signature master/agent (*) (20):

Signature observer (*) (20):

Agent's/observer name and address (21)

(*) Delete whichever does not apply

Comments:

When a vessel arrives for the first time at a port there should be conducted the Arrival report for this specific location that the vessel is at that time and it should be submitted as "First Arrival In port" . This should mean either anchored , outside port limits , fasted to a lighter vessel such as a tug boat etc. Every arrival report for a specific port , port limits or a named location must be followed by a departure report from the same location , port. A departure report must be submitted as the "Final Departure from port " which might be referred to a departure from last wharf , anchorage , outside port limits , lines cast on a tug boat etc.

4.5.1 How do we determine the fuel bunkered and the fuel in tanks?

Whenever our ship is doing bunkering there should be a delivery note known as Bunker Delivery Note by which the fuel tanks are checked on board after the completion of the bunker and after the appropriate correction factor to density temperature in order not to have the well known cappuccino effect.

Written records showing the Soundings before and after of all fuel tanks and details of the calculations showing ship's figure in Metric Tonnes of quantity Bunkered are to be retained on board.

The temperature of the fuel tank is obtained from the temperature gauges or by portable temperature devices .The density of the bunkers will be measured through the Bunker Delivery Note.

The density is calculated through a formula :

$$\text{Corrected Density} = \text{Density (air)150 C} \times \{1 - [(\text{TOC} - 150\text{C}) \times 0.00065]\}$$

T stands for the temperature of the fuel in Celsius

Before entering **ECA** , a fuel change to low sulphur oil must be started . The correct time is decided by the volume of fuel in the system , calculations should apply on how much time would be needed for a complete changeover into low sulphur fuel. Additionally there should be made logbook entries , at the times and dates the changeover takes place and they have to be written in the correct format.

Emission Control Areas (ECAs), or Sulfur Emission Control Areas (SECAs), are sea areas in which stricter controls were established to minimize airborne emissions from by Annex VI[1] of the 1997 MARPOL Protocol.

4.6 Measure and Report the Distance Traveled

Distance that is travelled from the vessel is measured over the ground , between the Departure point and the arrival point which are written in the position and arrivals reports. Those reports derive their datas from the vessels GPS or the Electronic Chart Display. (ECDIS is a navigational system which assists the seafarers to pinpoint locations and navigate the vessel easier.) Other distances such as the shifting between terminals within the same port would be extracted from the Deck log Book.

4.6.1How to measure hours underway

The hours underway are measured from the berth at the port of departure until the first port of arrival and the arrival times and dates in GMT are reported in Departure and Arrival reports.

'Hours underway' from the last berth at the port of departure to the first berth at the port of arrival is calculated from the departure and arrival times (GMT) and dates (GMT) recorded in Departure and Arrival reports.

4.6.2 Emission Factor

The CF is a non dimensional conversion factor between consumptions and the emitted co2 which was generated in 2014 where the Energy Efficiency Design index was introduced.

CF is a non-dimensional conversion factor between fuel oil consumption and CO_2 emission in the 2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships. The annual total amount of CO_2 is calculated by multiplying annual fuel oil consumption and CF for the type of fuel.

Fuel oil Type	C_F (t-CO_2 / t-Fuel)
Diesel/Gas oil (e.g. ISO 8217 grades DMX through DMB)	3.206
Light fuel oil (LFO) (e.g. ISO 8217 grades RMA through RMD)	3.151
Heavy fuel oil (HFO) (e.g. ISO 8217 grades RME through RMK)	3.114
Liquefied petroleum gas (LPG) (Propane)	3.000
Liquefied petroleum gas (LPG) (Butane)	3.030
Liquefied natural gas (LNG)	2.750
Methanol	1.375
Ethanol	1.913
Other (.........)	

4.6.3 What do ships submit to the IMO Ship Fuel Oil Consumption?

Since 2019 , every vessel that is above 5000 GT has to submit the collected information about the vessels fuel to the IMO. This includes

- Ship particulars (Loa , Breadth , dwt , gt etc..)
- Which period of the wear (through the calendar) were the specific data collected.
- What type of fuel is the vessel burning.
- What kind of method did the vessel used to collect the fuel oil consumption data.
- What distance did the vessel travel.
- How many hours underway have been recoded.

By submitting the above mentioned data a research will be done to find out ways to reduce emissions and pollution.

5. Fuel Costs

A ship has a lot of costs when it comes down to own one , such as capital costs , operating costs , voyage costs etc . Here we are going to analyze the fuel costs which is a category of voyage costs .

The cost of fuel represent a 50-60% of total ship voyage costs , depending on the type of the ship. In this dissertation we are going to refer to Kamsarmaxes and Aframaxes. Ships need to somehow recover from these costs in order to maintain their standards of service and be competitive in the shipping market. This percentage sometimes reaches the 70% of the operating costs due to oil increasing prices.

Heavy fuel oil (HFO) is a residual fuel incurred during the distillation of crude oil. It is used to generate motion and/or heat that have a particularly high viscosity and density. Heavy fuel oil is mainly used as a marine fuel.
The quality of the residual fuel depends on the quality of the crude oil. To achieve various specifications and quality levels, these residual fuels are blended with lighter fuels such as marine gasoil or marine diesel oil. The resulting blends are also referred to as intermediate fuel oils (IFO) or marine diesel oil. They are classified and named according to their viscosity, IFO 180 and IFO 380, with viscosities of 180 mm²/s and 380 mm²/s, respectively/

The distinction between the two grades is the distillate content, Grade 180 has 7–15% distillate content, while Grade 380 has a lower distillate content of 2–5% . As far as distillate content is concerned the higher it is the more energy the fuel has. In order to be more accurate we have to refer to the percentage of each type of fuel that is used.

A 10 % goes with MDO (Marine Diesel Oil) , considering of smaller vessels in deadweight tones , small tugs , or special types such as utility vessles. A 60 % of the world volume in bunkers is IFO 380 (Intermediate Fuel Oil) used by all types of commercial and cargo vessels while the rest 30% is IFO 180 and other grades. The IFO380 used in modern ships reflects the technological advances in the design and efficiency of the engines.The higher the distillate content, the more energy the fuel has.The numbers 380 and 180 declare the maximum viscosity of the fuel and in centistokes (cSt).

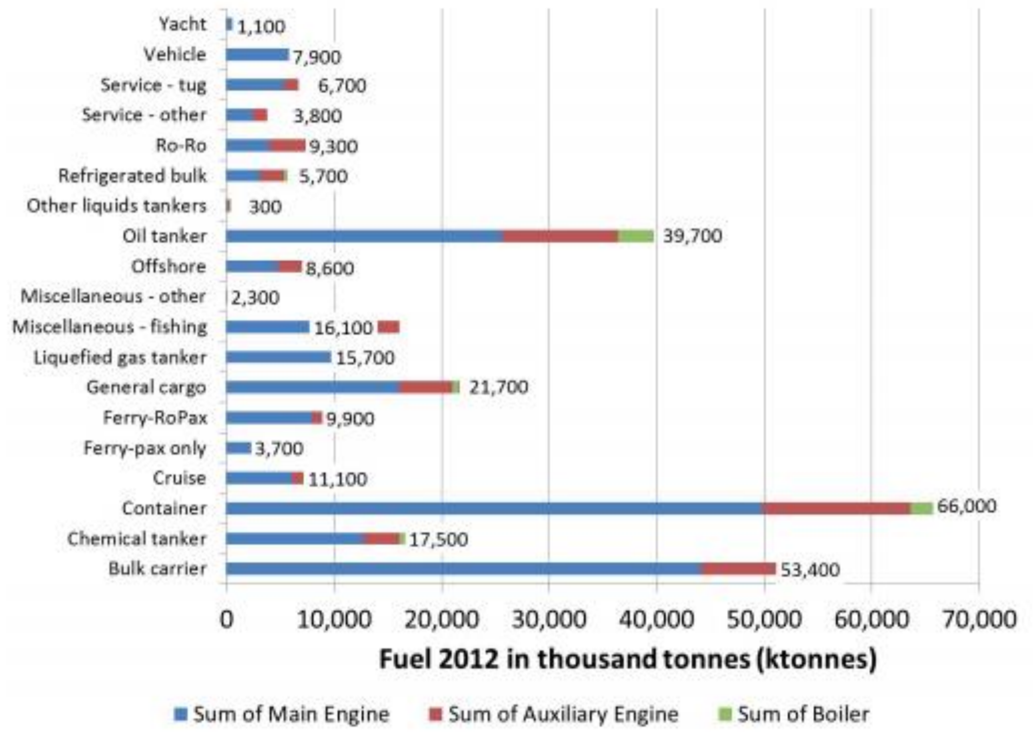
IFO 380 Throughout 2020

IFO180 Throughought 2020 **(Intermodal Report 2020)**

5.1 Emissions

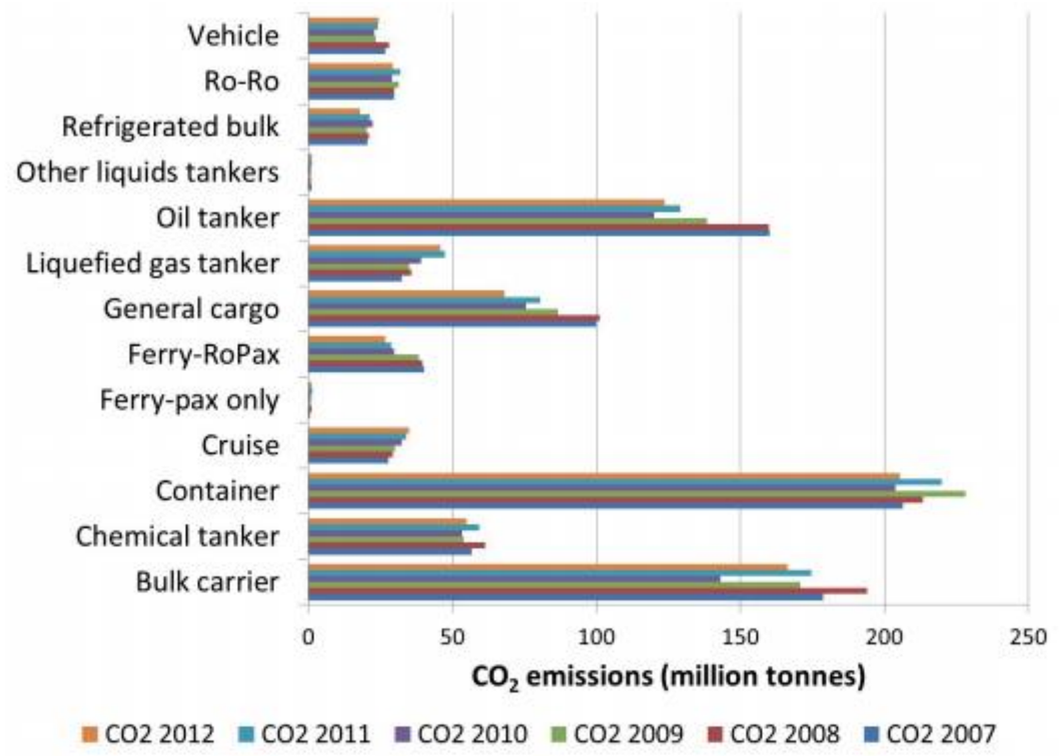
The worldwide seaborne transportation volume according in 2015 is about 10 billion tons in volume. The most fuel-efficient and economic way to transfer your goods is by shipping goods through waterway transportation.

An IMO study showed that more than 900 million tons of CO_2 is emitted by maritime which is accounted as a 2.6% of the total emissions at the Third IMO GHG Study 2014 .These emissions would increase at least twice by 2050.



Speed is a key factor in the maritime transportation equation. Long-distance trips may typically last a couple of months, a higher speed is significant but they entail an added economic value of faster deliveries and thus lowering the cost of inventory while increasing the trade. Shipping industry has created the need for higher speeds because the world trade and development was growing , eventually through the technological overgrowth . The hull designs , the hydrodynamic performance and engine efficiency contributed to reach this goal.

However depressed markets , a lot of environmental issues from air emissions to the hull cleaning as a vector of species in other sea regions have brought a new optimization on how a vessels speed should be regarded. Thus for a sum of reasons sailing at high speed may not necessarily be the best choice , and nowadays is given increased emphasis in optimizing the ship speed.



In the last years the biggest factor in that is making a difference is the environmental one , since the emissions of the ship should be environmental friendly. High speed ships don't have a linear relationship between speed and consumption and the conclusion that the slower speeds result in in less emissions.

Below is a table of the Classified Gases emitted from ships , grouped in several categories.

Green House Gases (GHGs)		
Carbon Dioxide (CO2)	Methane (CH4)	Nitrous Oxide (N20)

Non-Green House Gases	
Sulphur Oxides (Sox)	Nitrogen Oxides (NOx)

Various other pollutants, such as particulate matter (PM), volatile organic compounds (VOC), black carbon, and others, are also emitted. The effects of all of the above gases on global climate are diverse and most are considered negative if not kept under control. Among other effects, GHGs contribute to global warming, SOx cause acid rain and deforestation, and NOx cause undesirable health effects.

5.2 Speed And Pollution

Diminishing outflows from maritime vessels as they sail close to populated regions is a broadly perceived objective, and vessel speed decrease guidelines is one of a few methodologies that is being received by controllers and port specialists. Slowing the speed of cargo ships close to coastlines could significantly cut boats' air contamination.

The emissions benefits related with greenhouse gas substance and standards contaminations when vessels are operating in a slower speed.

The emissions were estimated from one Panamax and one post-Panamax as their vessel speed was decreased from 14 to 12 knots. The outcomes demonstrated that:

- Vessels' speed reduced to 12 knots we have emissions of (CO_2) and nitrogen oxides (NO_x) outflows decreased both measured in kg/nmi of roughly 61% and 56%, separately, when contrasted with vessel voyage speed.
- The emission rate measured in (kg/nmi) of PM2.5 was decreased by 69% with vessels' speed decreased to 12 . This percentage was increased up to 97% when combined with the utilization of the marine gas oil (MGO) with 0.00065% sulfur content.

Moreover, emissions information from vessels while operating in trading condition are rarely seen and estimations from this research exhibited that tidal current is a huge factor influencing emission factors at lower engine loads.

Emissions factors at ≤20% loads determined by procedure embraced by agencies were found to underestimate a particular issue (PM2.5) which is found in the air and NOx by 72% and 51%, individually, when contrasted with emiossion factors estimated.The total pollution created from the in the Emission Control Area (ECA) determined during the examination and the discharge benefits were assessed as the vessels' speed decrease zone was expanded from 24 to 200 nmi. Total pollution emitted (TPE) CO_2 and particulate issue (PM2.5) assessed for huge compartment vessels indicated benefits for CO_2 (2–26%) and PM2.5 (4–57%) on decreasing speed from 14 to 12 knots, though TPECO2 and TPEPM2.5 for little and medium holder vessels were comparative at 14 and 12 knots.
The study conducted by the Bourns College of Engineering, University of California .

The shipping industry responsible for about 3 % of the world's carbon dioxide emissions (CO_2), as indicated by the International Maritime Organization. Shipping emissions will grow 2 to 3 percent in the next decades as shipping is developing rapidly according to the IMO.

Year	Global CO_2[1]	Third IMO GHG Study 2014 CO_2 Total shipping	% of global	International shipping	% of global
2007	31,409	1,100	3.5%	885	2.8%
2008	32,204	1,135	3.5%	921	2.9%
2009	32,047	978	3.1%	855	2.7%
2010	33,612	915	2.7%	771	2.3%
2011	34,723	1,022	2.9%	850	2.4%
2012	35,640	938	2.6%	796	2.2%
Average	**33,273**	**1,015**	**3.1%**	**846**	**2.6%**

Year	Global CO_2e[2]	Third IMO GHG Study 2014 CO_2e Total shipping	%of global	International shipping	%of global
2007	34,881	1,121	3.2%	903	2.6%
2008	35,677	1,157	3.2%	940	2.6%
2009	35,519	998	2.8%	873	2.5%
2010	37,085	935	2.5%	790	2.1%
2011	38,196	1,045	2.7%	871	2.3%
2012	39,113	961	2.5%	816	2.1%
Average	**36,745**	**1,036**	**2.8%**	**866**	**2.4%**

Shipping CO2 emissions compared with global CO2 (values in million tonnes CO2); and b) Shipping GHGs (in CO2e) compared with global GHGs (values in million tonnes CO2e).

5.3 Speed and Consumption

The length and span of voyages has affected significantly and the weather conditions during these voyages , which impacts the drag forces and vessels speed, which vary through different routes and segments.. Nonetheless, the main engine (ME) in ships' power plants (principally low-speed marine diesels with direct-driven propellers) are customarily run constant set motor speed ¼ idem. This speed is kept up by utilizing programmed fire rev/min governors at the rate pointed toward keeping ships service speed and ME day fuel oil consumption at the mean estimations of these qualities vc and Bc, which are commonly stated in the charter parties.

Kamsarmax has a service speed of 12 knots and burns rougly 23 tons per day. Out of those 23 tons of fuel 21.5 tons are for the main engine (ME) and the rest 1.5 is for the electric motors.

Not including speed as a decision variable may in some cases remove flexibility in the overall decision making process and render fixed-speed solutions subobtimal. For instance, a ship sailing at a prescribed speed to a certain port, only to have to wait there because the port is congested, may be a higher cost solution than one in which the ship is allowed to sail at a lower speed so as to arrive when the port is not congested any more. Overall emissions would be higher in that case as well. There are several models in the literature that include port capacity constraints, berth occupancy constraints, time window constraints or other constraints that preclude the simultaneous service of more than a given number of vessels .

6. Fouling

Hull fouling is situation where marine plants (goose barnacle etc) and animals grow on the submerged part of a ship affecting ships trading in warm waters. It often appears as Macrofouling which contains plants and animals or Microfouling which includes biofilm formation and bacterial adhesion ,most commonly called slime.

The fouling of ships results in a reduction of speed, an increased cost in fuel, and losses in time and money in applying the necessary -remedial measures. The immediate effect is due to an increase in the resistance to movement of the hull through the water-a' phenomenon known as frictional resistance.

In order to protect the vessel and as a precaution measure to delay the development of fouling the Bureau of ships has come up with the improvement of protective coatings which allows the vessel stay out of drydock as long as fifteen to eighteen months. Also lowers the demand for fuel up to 10 % more than a normal paint.

Choosing the correct paint for your ship is depending on many factors :
1) Where the vessel is trading . The type of water differs from place to place , the vessel might be trading in a river or in a warm environment. Warm environments help the microorganisms produce , thus the vessels hull will need an underwater hull cleaning muchfaster than in cold waters . Same situation applies to a vessel that is trading in salty water and a vessel that is trading in river water.
2)When the vessel is prepared for a voyage or time charter contract , the owning company has to make calculations on many things. During the five year gap between each Drydocking procedure they have to estimate the amount of sailing days the vessel will have and the average speed .

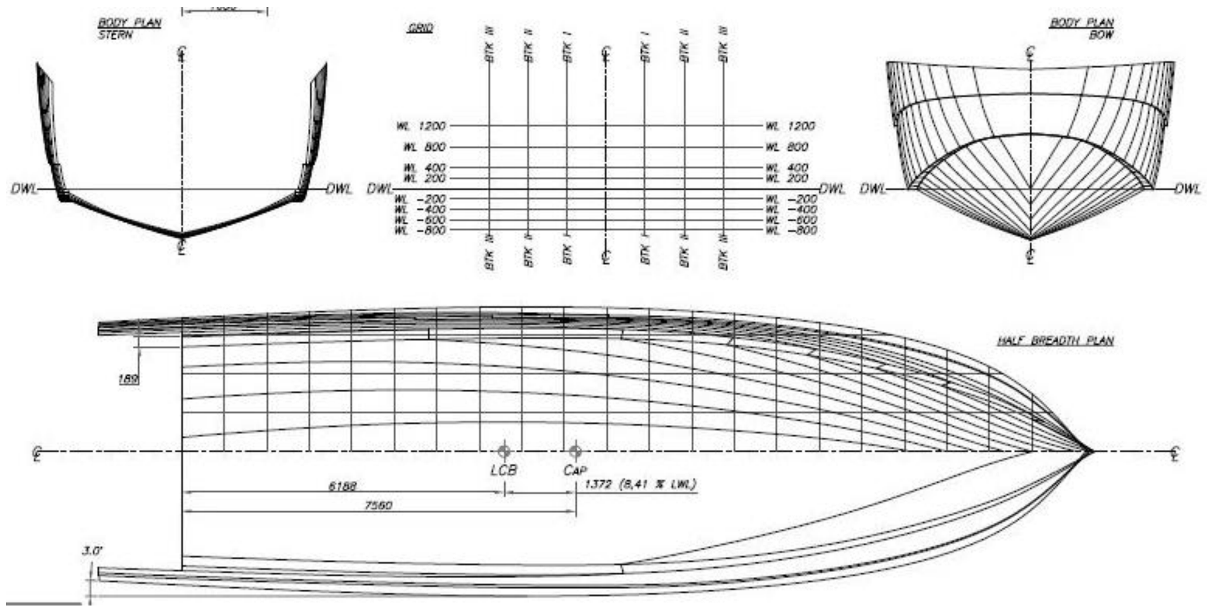
Lets say that vessel is sailing 250 days per year , means that it will stay in warm lay up condition for 115 days . Lay up condition means that the vessel is not sailing , it is steady somewhere close to the port limits . The more a vessel stays in this condition the easier it is for fouling to occur. These factors help you decide how thick the layer of the paint will be and how many liters you are going to use.

The thicker the layer of the paint the safer the vessel is , but how much does this premium costs in numbers?

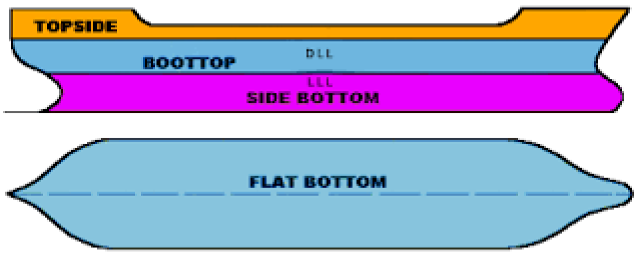
Every port and everyshipyard has its own modus operandi when it comes down to payment for the paint .It is extremely complicated to estimate accurately the quantity of paint required

for a particular job since the theoretical spreading rate does not take into account the various losses" involved during application.

As referred before the antifouling paint costs vary between shipyards , an average price is 20 dollars per liter.



First thing you need to do is calculate the surface area using the **flat bottom** and **vertical side** from the ship plans.

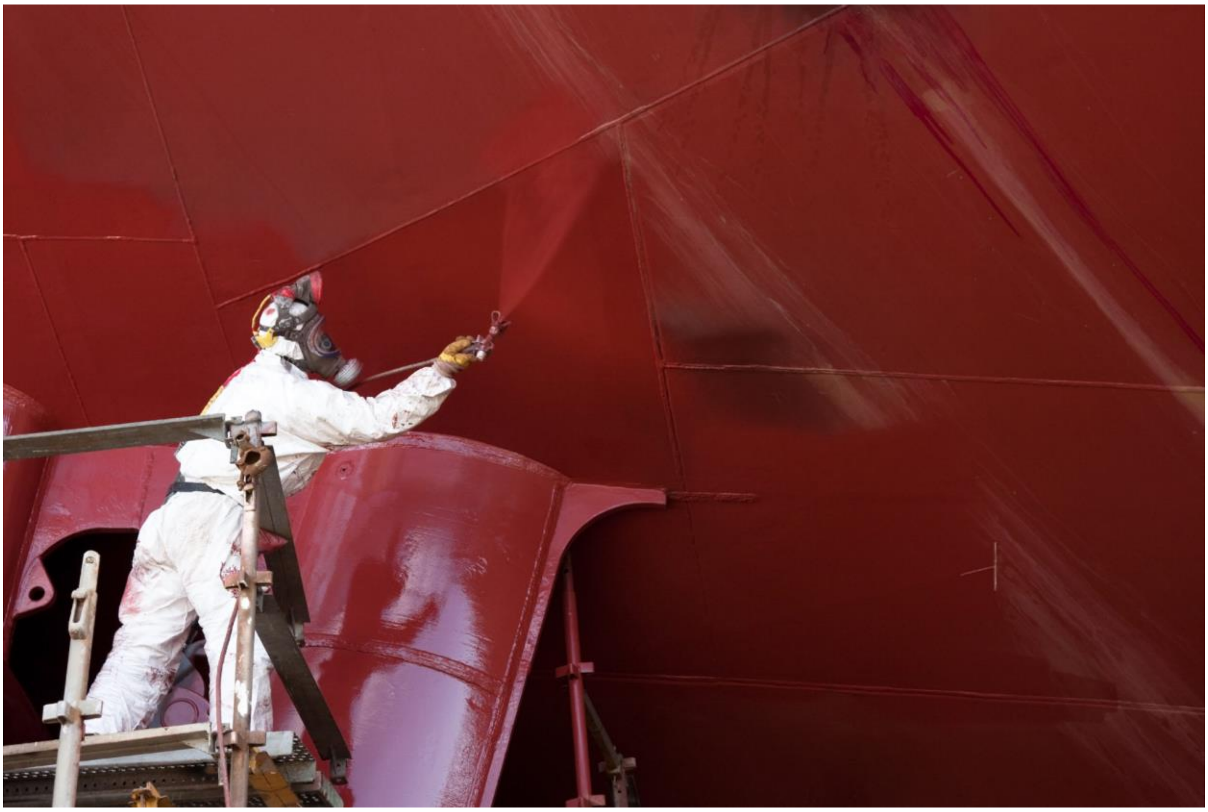


6.1 Apparent Loss

The extent of paint "loss" is proportional to the surface roughness produced by blasting .In a coarse open blasting when you are blasting 100 to 150 microns you might have a loss of 60 while in an old steel where you will reblast with 150 to 300 microns you might have a loss of 120 microns.(is an SI derived unit of length equaling 1×10−6 meter)

Another factor we are taking into account is the Dry film thickness or DFT. Dry film thickness (DFT) is the thickness of a coating as measured above the substrate. This can consist of a single layer or multiple layers.

There is also a loss in paint distribution resulting from attempting to achieve the minimum specified paint thickness with reasonable certainty. This loss is depending on the type of structure if it is simple or complex and how many coats will be applied (double or triple).



Two coats of two pack paint to be applied by spray in a confined space to a blasted surface which yield a DFT of 100 microns per coat.

The theoretical spreading rate is 6.0 Sq.Mtr/Ltr. What is the practical spreading rate?

<u>For the first Coat</u>

We require DFT   100 microns

+ Surface rough   10 microns
+Distribution loss 40 microns
----
150 microns

Now we take into consideration :

a small loss due to the application methods 3-5% which is 4.5 microns.

Loss due to wastage 7-10% which is :**154.5 * 0.07 = 10.815** microns

Total of **165.315-100= 65.315** which equals to roughly 65% extra paint only for the first coat.

<u>Second Coat</u>

We need DFT 100 microns
No loss due to surface roughness only due to distribution

Loss due to distribution 35-40% i.e 35 microns

135 microns up to now in total

Application losses 3% i.e 4.05 microns , totaling the amount of 139.05 microns

Extra paint used 39.05 i.e which is rougly 39 % more than the initial calculation.

Total loss for two coats =65,315+39,05 / 200 = 52,1%

In other words, for the two coat system, 52,1% more paint is required than would be calculated from the theoretical spreading rate.

For each liter we can paint approximately 6-10 sqm. In practice though and considering the above example when we need 1.52 liters of paint to paint a surface of 6 sqm.

Therefore, the practical spreading rate is 6 / 1.52 =3.9Sq.Mtr/Ltr

The loss factor is usually expressed as the difference between the theoretical and practical spreading rates expressed as a percentage of the theoretical spreading rate. In the above the actual loss is 2.1 sqm/ltr which is translated as 35% loss in general

This calculation are based on the fact that the antifouling paint will last 36-60 months.

For one kamsarmax the cost of antifouling paint is 70.000-80000 $ depending in all the above factors.

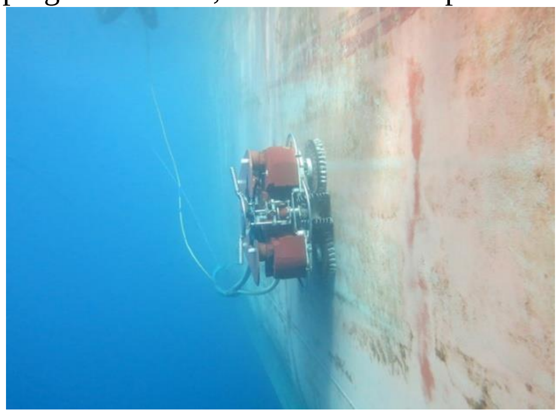
7. Underwater Hull Cleaning

Another well known measure against hull fouling is the underwater hull cleaning , most companies nowadays are doing both , they buy protective coatings and hire divers for underwater hull cleaning.

Underwater cleaning is the procedure which all traces of fouling are removed from the hull of the vessel while the vessel is still in water.
There are several types of underwater hull cleaning available in order to restore the ships performance. We can divide the hull cleanings into three types depending on what we are going to clean.

1) Full Cleaning, fouling is removed from the entire underwater hull, propellers, shafts and rudders, and all openings.
2) Interim Cleaning refers to removal of fouling from propellers, shafts, struts and rudders.
3) Partial Cleaning covers removal of fouling from particular sections of the ship hull (only one part , such as propeller , only the rudder , etc) and can be performed in combination with an Interim Cleaning.

This procedure is performed either by a diver with brushers or by a remotely operated vehicle (ROV) controlled from land.
Alternatively, preventive maintenance approaches have also been suggested, such as hull grooming, consisting in frequent and gentle wiping of the hull, and continuous prevention methods, such as aeration or ultrasound transducers .



Using hull cleaning as a measure to reduce emissions and improve the energy efficiency of the world fleet is very important. It is a measure under which the owner has a great degree of control. Specifically, while the rate of marine growth on the hull (i.e. the ‘fouling’) is largely exogenous, the frequency and quality of periodic maintenance on the underwater hull is decided by the ship owner. This can only take place when the vessel is at port limits and the weather conditions allow the hull cleaning to take place . Large vessels typically have several layers of coatings, up to 6 millimeters thick, and generally operate 4 to 6 months between hull cleanings.

Another type of hull cleaning occurs when when the vessel is in dry-dock for a special survey, every five years. The total cost of drydocking is substantial, ranging from USD 1.2 to 1.6 million for tankers, depending on vessel size. The special survey is a mandatory requirement imposed by the vessel's classification society and flag state administration in order to renew the vessel's safety and environmental certificates.

Since the effects of fouling on performance vary among ships (as referred above the place where the ship operates) , and the degree of fouling differs with type of hull coating, operational profile and area of operations of the vessel we cannot add to the ships calendar a specific interval for hull cleaning.
The need for hull cleaning can also be indicated through performance indicator including a reduction in the vessels speed and a proportional increase in vessel consumption. For example a lower speed by 1 knot and an increase in fuel use of 5% to maintain a particular speed.

Periodic hull cleaning can significantly improve the energy efficiency of the vessel ,if we accurately calculate its impact , it is quite challenging since there are numerous other drivers for the vessels fuel consumption such as speed , weather conditions , rudder in use etc.

7.1 Fuel consumption according to Telfer

The theoretical foundation of ship fuel consumption was introduced by Telfer in 1926 and the term resistance modelling came after Todd in 1967 , which aims more at estimating rather than calculating the total resistance of the ship as an equation of speed and external factors such as weather conditions.

$$FC = \frac{P_S + P_W + P_A}{\eta}$$

Ps : Speed

PA : Impact of Wind

η : Propulsion Efficiency

Pw : Impact of waves

FC : Fuel Consumption

Hull fouling results in excess fuel usage at a maintained speed or speed loss at a maintained engine power .Hull fouling can also damage the structural integrity of the ship due to corrosion induced by the fouling. Regular hull cleaning and propeller polishing can assist in negating these effects. Even with routine maintenance, surface roughness can occur as a result of erosion, corrosion, or from tubeworm Atracings , barnacles etc. This situation alone can increase fuel consumption up to 10 %.

A new Kamsarmax bulker uses approximately 23 tons of bunker fuel per day and 168 barrels of fuel per 24-hour period. The cost per day for fuel alone would be approximately $8,500 with an additional $5,000 for operating expenses per day. On an average 10,000-mile cruise, the Kamsarmax would make the cruise in about 32 days with a clean hull. If the ship's hull is fouled with marine growth not exceeding 0.5 inch the difference in speed would be 2 knots which equates to 4 days, the same trip would take 36 days.

The ship would run with 10 knots , if we convert the knots to miles there would approximately 11.5 mph , which is 276 per day. For a 10,000 miles cruise there would be 36 days which concludes in 4 more days .

The difference is the loss in speed of over 2 knots, which equates to 4 days. Those additional four days cost $34,000 in fuel consumption alone. The propeller is particularly vulnerable to marine fouling since it is an unpainted surface that must remain clean and shiny for proper operation.

The cost of underwater hull cleaning including propeller polishing varies between 15.000 $ to 20.000 $ depending on the port , the draft and the hull condition.
Depending on the port is something that goes without saying , but why depending on the draft?

When the vessel is laden there is more surface area to clean in m^2 while when the vessel is in ballast we got less.

7.2 What is ballast speed and laden speed ?

If a cargo vessel (such as a tanker, bulk carrier or container ship) wishes to travel empty or partially empty to collect a cargo, it must travel in ballast , the speed that the vessel achieves in this situation is called “Ballast speed “. This keeps the vessel in trim, and keeps the propeller and rudder submerged. Typically, being "in ballast" will mean flooding the ballast tanks with sea water. Ballast or ballast water is sea water carried by a vessel in its ballast tanks to ensure its trim, stability and structural integrity. ... In ancient times, ships used to carry solid ballast for stability as the cargo was minimal or there was no cargo to be carried.If a cargo vessel is loaded with cargo and sailing , reaches a speed which is called the “**laden Speed**”

Vessel in Laden condition

Vessel in Ballast condition

An underwater hull cleaning has a duration of eight to twelve hours . Those hours are considered non profitable for the vessel , since you will have a delay the charter for half a sailing day.

8. Kamsarmax

Kamsarmax was named because it meets the 229-meter limit on length overall at the port of Kamsar. The port of Kamsar is a major bauxite shipping port which belongs to the Republic of Guinea on the west coast of Africa. The model of a Kamsarmax vessel was developed with great improvements in its stability , fuel efficiency , propulsion and maneuverability in addition with an increased deadweight.

Length over all×Breadth×Depth	less than 229m×32.26m×20m	Draft	14.4m
DW	81,600MT	Gross Tonnage	43,400
Cargo Capacity	97,000m³	Service speed	14.5knots

A Kamsarmax Bulker is designed to barely fit through the Panama Canal and to be accommodated at the loading pier at the Port of Kamsar as stated before. The Guinea region is one of the worlds largest deposits of bauxite which is shipped through the Port of Kamsar , to where it is carried from India and china for the production of the well aluminum. Since the pier of the Port cannot accommodate a a ship with a length greater than 229 meters therefore the Kamsarmax was invented , which is something lika a Panamax bulk carrier with length of 229 meter , which is severa meter longer than an average Panamax. In fully laden condition a Kamsarmax has an economic advantage over a Panamax since it is bigger. There are some Kamsarmax vessels that never carry bauxite on the contrary with the majority of Kamsarmaxes , they are carrying grain , soybeans and other agricultural products. Eventually a most Kamsarmax vessels are carrying a variety of cargoes throughout their multiyear career such as , coal , cement , steel pellets , grains , fertilizers , coal , bauxite etc.

A sale and purchase report showing how much a kamsarmax vessel is being paid :

North Pacific rounds ranged at the usd 13,000/14,000 pd.
A number of Indonesian and Australian trips into China were reported fixed in the usd 11,000/13,000 pd range.
A number of Indonesian and Australian trips into India were reported at the level of usd 13,000 pd. China trips via US Gulf into China were fixed around usd 11,000/12,000 pd.
South African trips into China via US Gulf were reported at the level of usd 13,750 pd plus ballast bonus at the usd 375K.
South African trips into India were fixed around usd 12,900 pd plus ballast bonus at the usd 290K. South African iron ore trips into Continent were reported at the level of usd 13,000 pd.
West African trips into Continent with coal were fixed around usd 13,500 pd.
InterContinental trips via Baltic were reported at the level of usd 15,000/16,000 pd.
Mediterranean trips via US East Coast into Continent were fixed around usd 13,000 pd.
Mediterranean trips via US East Coast into India with coal were reported at the level of usd 24,000 pd.

US Gulf trips into China were fixed around usd 16,000 pd plus ballast bonus at the usd 600K.

South American trips into India with sugar were reported at the level of usd 14,000 pd plus ballast bonus at the usd 400K.

South American trips into Continent were fixed around usd 14,900 pd.

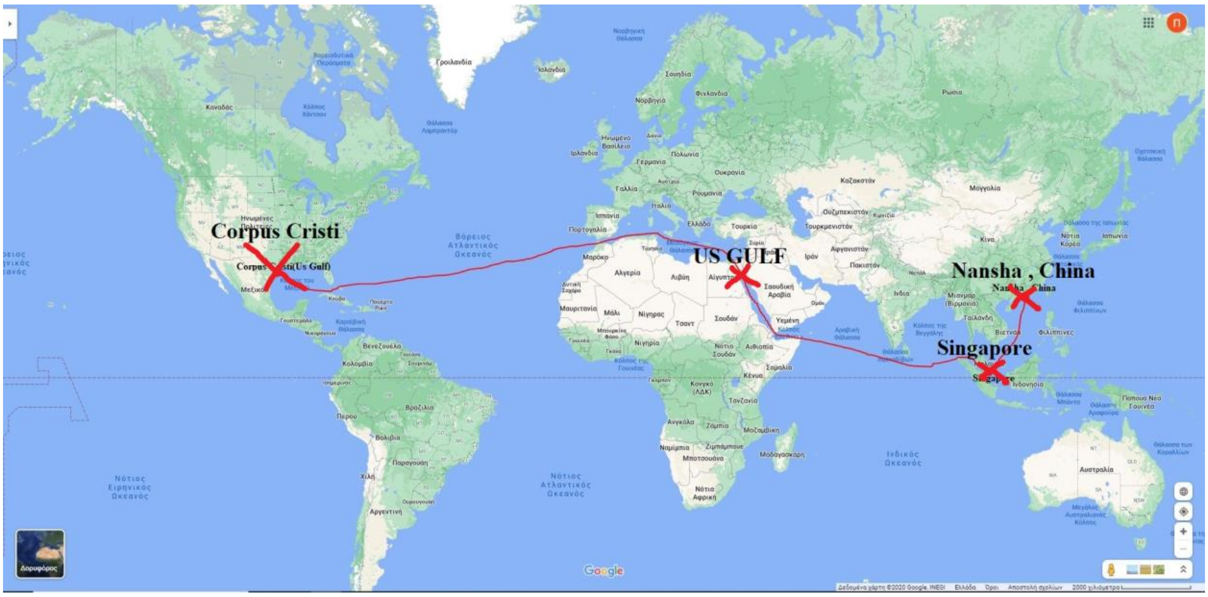
South American trips into China were reported at the level of usd 14,650 pd plus ballast bonus at the usd 465K.

Usd 12,500 pd on a Kamsarmax for 6/9 months employment basis delivery in the Pacific.

Daily T/C Avg	9-Oct	2-Oct	± (%)
Capesize	$ 29.479	$ 33.066	-10,85%
Kamsarmax	$ 12.950	$ 12.355	4,82%
Panamax	$ 11.614	$ 11.019	5,40%
Supramax	$ 10.807	$ 10.900	-0,85%
Handysize 38	$ 10.718	$ 10.672	0,43%

Herebelow we are going to see an example of a kamsarmax vessel sailing and its speed and consumption before and after the underwater hull cleaning. The vessel started from Corpus Cristi , went through the Us Gulf to Singapore and discharged at Nansha in China.

Here we can see the map of the voyage of our vessel



8.1 Speed and Consumption of Kamsarmax in numbers

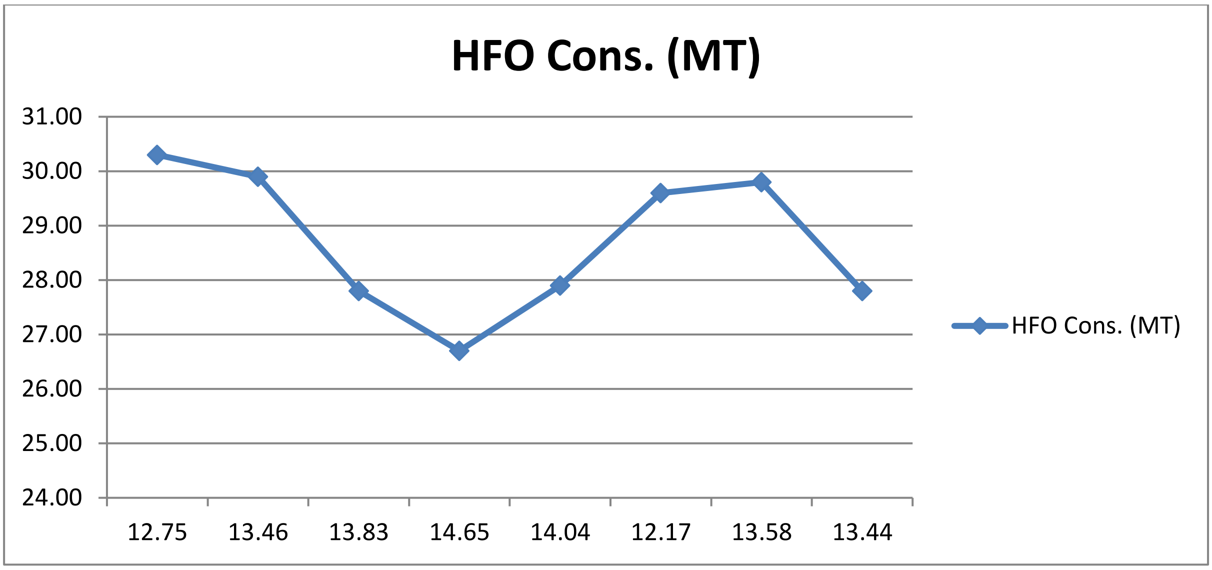
8.1.1Before Underwater Hull cleaning

In the below table we are going to see the ballast speed and consumption of the vessel from January 1 2019 up to January 8 2019 where it loaded.

DATE	LOCATION	(LADEN / BALLAST)	SPEED (Kt)	ME Hrs	HFO ME Cons. (MT)
21-01-19	AT SEA	LADEN	11.88	24	29.30
22-01-19	AT SEA	LADEN	12.21	24	29.50
23-01-19	AT SEA	LADEN	12.83	24	29.60
24-01-19	AT SEA	LADEN	12.64	25	30.70
25-01-19	AT SEA	LADEN	10.88	25	29.60
26-01-19	AT SEA	LADEN	11.38	24	29.50
27-01-19	AT SEA	LADEN	11.44	25	30.90
28-01-19	AT SEA	LADEN	9.42	24	31.40

DATE	LOCATION	(LADEN / BALLAST)	SPEED (Kt)	ME Hrs	HFO ME Cons. (MT)
01-01-19	AT SEA	BALLAST	12.75	24	30.30
02-01-19	AT SEA	BALLAST	13.46	24	29.90
03-01-19	AT SEA	BALLAST	13.83	24	27.80
04-01-19	AT SEA	BALLAST	14.65	23	26.70
05-01-19	AT SEA	BALLAST	14.04	24	27.90
06-01-19	AT SEA	BALLAST	12.17	24	29.60
07-01-19	AT SEA	BALLAST	13.58	24	29.80
08-01-19	AT SEA	BALLAST	13.44	22.7	27.80

As we can see from the above table the vessel consumed in those 8 days a sum of 229.80 Mt while in ballast condition.



While here in laden condition in the next 8 days after the vessel was loaded it consumed in total 209.10 Mt in total.

Difference between Ballast and Laden = 209.10-229.8 = 20.70 Mt.

Considering the price of HFO roughly 360$/mt we spent 7.866 $ on fuel while in ballast condition. The above numbers are only for 8 days lets take this example from January 1st 2019 to December 29th 2019 one day before the hull cleaning.

In a sum of eighty eight days trading with laden speed our vessel consumed 2664.76 Mt of fuel. While at the same days in ballast speed our vessel consumed 2408.96 Mt of fuel.

2664.76-2408.96=255.80 Mt

With 360$/Mt is equal to 92088 $ in fuel consumption while our vessel is in laden condition.

In order to determine the before and after the underwater hull cleaning speed and consumption we are going to add up all the consumptions and have an average speed for ballast and laden condition.

Average Laden Speed : 11.87 kn Average Ballast Speed : 12.79 kn

The Average speed , concluding laden and ballast speed is : **11.99 kn**

The fuel consumed from our vessel both in laden and ballast condition is :

Burned HFO in ballast condition : 882.10 Mt
Burned HFO in laden condition : 1394.10 Mt
Which amounts a total : **2276.20 Mt**

1394.10+ 882.10 =2276.20Mt

This fuel was consumed in a sum of 74 days . With a price of 380$/Mt :

2276,20 Mt * 380$/Mt = **864.956 $**

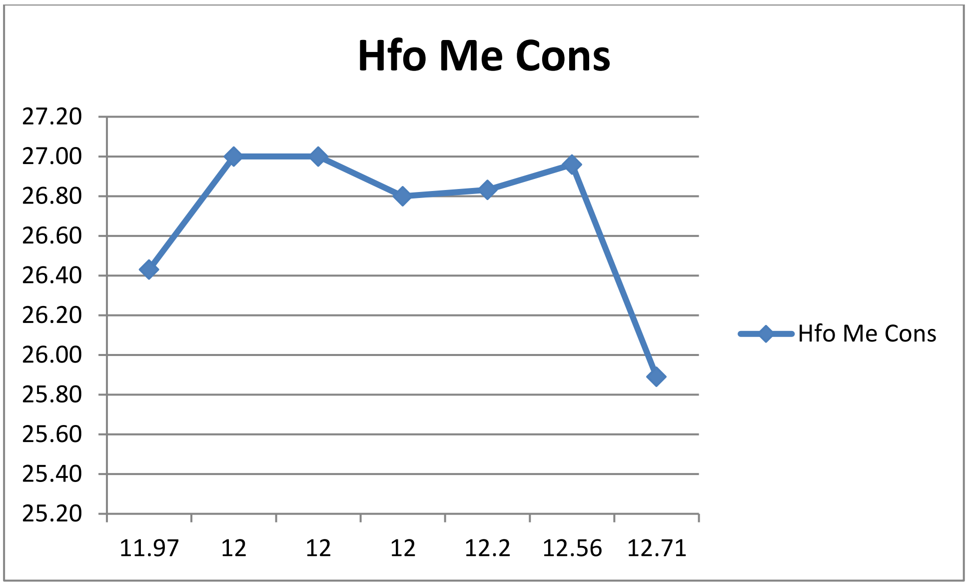
8.1.2 After The underwater Hull Cleaning

Our vessel has undergone an underwater hull cleaning at the Port of Singapore which cost us 18.000 $. The speed and consumption in ballast after the cleaning :

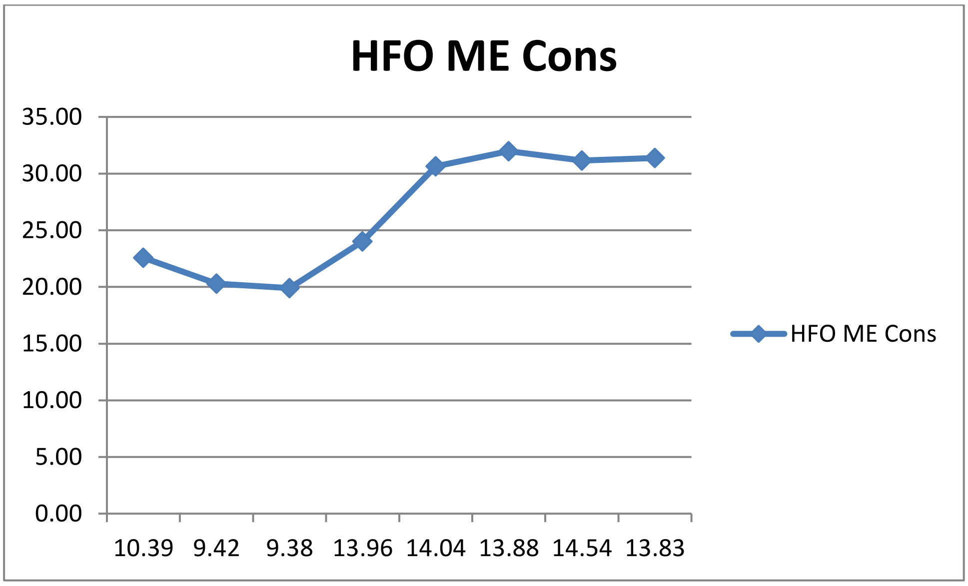
DATE	LOCATION	(LADEN / BALLAST)	SPEED (Kt)	ME Hrs	HFO ME Cons. (MT)
01-03-20	AT SEA	LADEN	11.97	24	26.43
02-03-20	AT SEA	LADEN	12	24	27.00
03-03-20	AT SEA	LADEN	12	24	27.00
04-03-20	AT SEA	LADEN	12	24	26.80
06-03-20	AT SEA	LADEN	12.2	25	26.83
07-03-20	AT SEA	LADEN	12.56	25	26.96
08-03-20	AT SEA	LADEN	12.71	24	25.89
09-03-2020	AT SEA	LADEN	12.5	24	25.91

The first eight days after the underwater hull cleaning we have in laden condition :

Average Laden Speed : 12.24 kn and fuel consumption : 212.82 Mt.



DATE	LOCATION	(LADEN / BALLAST)	SPEED (Kt)	ME Hrs	HFO ME Cons. (MT)
20-03-20	AT SEA	BALLAST	10.39	25.5	22.57
21-03-20	AT SEA	BALLAST	9.42	24	20.30
22-03-20	AT SEA	BALLAST	9.38	24	19.90
27-03-20	AT SEA	BALLAST	13.96	24	24.00
28-03-20	AT SEA	BALLAST	14.04	24	30.65
29-03-20	AT SEA	BALLAST	13.88	25	31.98
30-03-20	AT SEA	BALLAST	14.54	24	31.16
31-03-20	AT SEA	BALLAST	13.83	24	31.37



The first eight days after the underwater hull cleaning we have in ballast condition :

Average Ballast Speed : 12.43 Kn and fuel consumption : 211.93 Mt

This fuel was consumed in a sum of 74 days after undergoing underwater hull cleaning in Singapore:

Burned HFO in ballast condition : 793,12 Mt
Burned HFO in laden condition : 1327,43 Mt
Which amounts a total : **2120,55 Mt**

With the price of 380 $ per Mt we have 2120,55 Mt x 380 $/Mt = **805.810 $**

8.1.3 Kamsarmax Underwater Hull Cleaning Conclusion

Average Laden Speed : 11.57 Kn and fuel consumption : 209.10 Mt	Average Ballast Speed : 12.01 Kn and fuel consumption : 208.5Mt

After Underwater Hull cleaning

Average Laden Speed : 12.24 kn fuel consumption : 212.82 Mt.	Average Ballast Speed : 12.43 Kn fuel consumption : 211.93 Mt

In a total of 74 days before the hull cleaning and after our vessel have spent in fuel **864.956 $** .

In a sum of 74 days after the underwater hull cleaning , our vessel has spent in fuel **805.810$** and **18.000 $** for the underwater hull cleaning which lasted for 8 hours. This sums up an amount of **823.810 $** .

$$\mathbf{864.956}\ \$ - \mathbf{823.810}\ \$ = \mathbf{41.146}\ \$$$

Our profit is 41.146$.

9. Aframax

The Aframax name on the contrary to the Kamsarmax as a name is connection of abbreviation which means Average Freight Rate Assessment System or AFRA system. At a time when large oil tankers were entering to sea routes that were highly prone to traffic the aframax tankers were utilized.

Specifications

The aframax tanker weighs around 120.000 dead weight tones and they generally trade in the European waters of the Black sea in addition to that Aframaxes are also found as cargo containers in the Northe sea , Caribbean and in the most busiest and most important sea rout , the Mediterranean Sea.

Aframax are smaller than Very Large Crude Carriers and the Ulta Larfe Crude Carriers , also known as VLCC and ULCC respectively , the tanker has a carrying capacity between 65,000 Mt and 100,000 Mt while in barrels the average cargo capacity of the aframax is about 750,000 barrels.

Because of the way the Aframax tankers are designed they can operate and be accommodated in most port in the world. The Aframax tankers are serving regions with offshore oil terminals and rigs and very large ports in order to facilitate VLCC's and ULCC's. The

Aframax tankers are the best way to fit into short up to medium haul of crude oil transportation.

The main areas of operation of Aframax tankers include , US Gulf region through the Caribbean , American oil cargo exports , North African Expos to Southern Europe since they use Mediterranean , they also export from Russia and former Soveiet union to northern Europe , to the Black and North Sea. They are highly operated and used in areas of lower crude oil prodiction (for example in Non-OPEC countries) which lack the large harbors where a VLCC and a ULCC can operate. Non-OPEC oil producers refers to crude oil producing nations outside of the OPEC group and those producing shale oil. Interestingly, some of the top oil-producing countries are non-OPEC nations. This includes the United States of America, which is the number one producer, Canada, and China. Since they are operating mainly by transporting crude opil they are also called as "dirty tankers". Even though there are countries who are major oil exporting nations in the world , it is the same countries who export oil on a lesser level that the Middle Eastern countries who need Aframax tankers for their exports. Since the demand and the level of oil exported from the Middle Eastern countries is high , they use , VLCC's and ULCC's the routes are blocked and only smaller and easier to maneuver tankers such the Aframax tankers are useful , thus proving them a great asset.

Smaller size of tankers such as the Panamax and the Aframax are the only feasible solution the growing problem of blocked sea routes due to traffic

Here we can see a report from week 41 regarding the crude carriers.

Crude Oil Carriers - The marginal correction for the crude oil tanker market continued for yet another week, with the benchmark BDTI index experiencing losses of 4.0%.

In the VLs, the scene was mostly stagnant, with few changes in terms of sentiment both for Middle East and West Africa rates. In the Suezmaxes, the situation was rather similar. The Black Sea/Med trade was under slight pressure, with sentiment across the main trades finishing on a negative tone. In the Aframaxes, the general negative pressure was more intense, given the relatively attuned correction across most of the benchmark routes. For the time being, the Baltic—UKC trade seems more problematic, though this should reverse soon. Oil Products - On the DPP front, it was another negative week, given the continuing bearish mood across most of the main trades. With the exception of Med rates that remained stable, all other trades witnessed some small losses. On the CPP front, there were some mixed messages, with most routes though, finishing on the negative side. However, the MEG-Japan showed some slight potential.

AFRAMAX							
NSEA-CONT	WS	67.81	73.13	-7.3%	108.50	117.06
	$/day	-$ 3,142	$ 969	-424.3%	$ 23,640	$ 23,410
MEG-SPORE	WS	57.89	60.17	-3.8%	108.39	127.42
	$/day	$ 3,899	$ 4,926	-20.8%	$ 21,472	$ 19,343
CARIBS-USG	WS	45.63	52.19	-12.6%	129.92	127.91
	$/day	-$ 3,186	-$ 469	-579.3%	$ 27,526	$ 19,566
BALTIC-UKC	WS	35.94	41.56	-13.5%	84.23	95.59
	$/day	-$ 2,229	$ 1,869	-219.3%	$ 24,792	$ 25,348

Here in this example we are going to use the data of an Aframax Tanker which went from San Francisco to Balboa , Panama for underwater hull cleaning at 08.08.2019 and then proceeded to Esmeraldas , Equador.

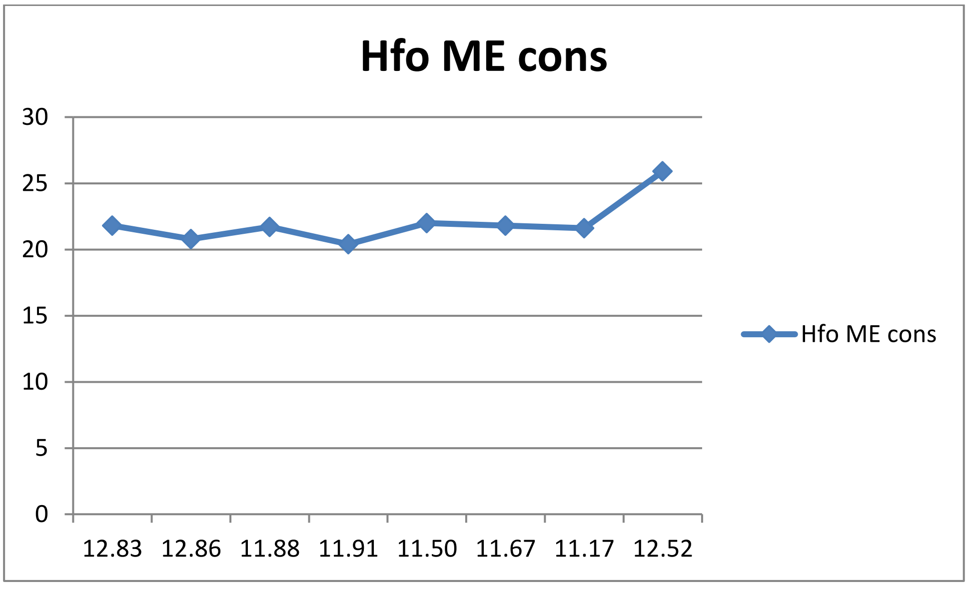
9.1.2 Speed and Consumption of Aframax vessel in numbers.

In the below table we are going to see the ballast speed and consumption of our Aframax Tanker from January 1st 2019 until January 8th 2019.

9.1.3 Before the Underwater Hull cleaning

DATE	LOCATION	(LADEN / BALLAST)	ME Hrs	HFO ME Cons. (MT)	Speed Knots
01-01-19	AT SEA	BALLAST	24	21.8	12.83
02-01-19	AT SEA	BALLAST	23	20.8	12.86
03-01-19	AT SEA	BALLAST	24	21.7	11.88
04-01-19	AT SEA	BALLAST	23	20.4	11.91
05-01-19	AT SEA	BALLAST	24	22	11.50
06-01-19	AT SEA	BALLAST	24	21.8	11.67
07-01-19	AT SEA	BALLAST	24	21.6	11.17
08-01-19	AT SEA	BALLAST	23	25.9	12.52

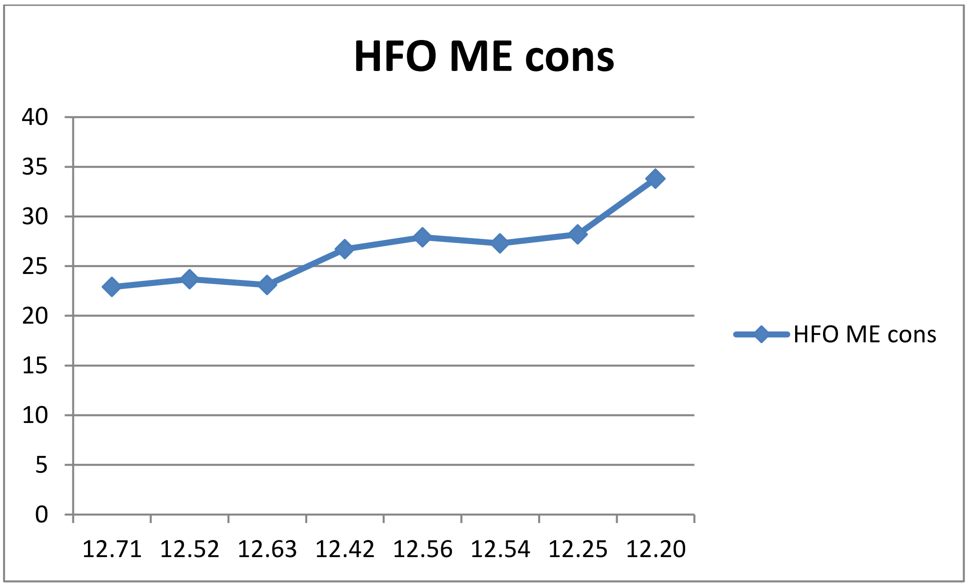
The average speed for 8 days in ballast condition is 12.04 Knots and the consumption is 176 Mt HFO.



In the below table we are going to see the speed and consumption of our Kamsarmax in Laden condition.

DATE	LOCATION	(LADEN / BALLAST)	ME Hrs	HFO ME Cons. (MT)	Speed Knots
30-01-19	AT SEA	LADEN	24	22.9	12.71
31-01-19	AT SEA	LADEN	25	23.7	12.52
01-02-19	AT SEA	LADEN	24	23.1	12.63
02-02-19	AT SEA	LADEN	24	26.7	12.42
03-02-19	AT SEA	LADEN	25	27.9	12.56
04-02-19	AT SEA	LADEN	24	27.3	12.54
05-02-19	AT SEA	LADEN	24	28.2	12.25
06-02-19	AT SEA	LADEN	25	33.8	12.20

The average speed for 8 days in Laden condition is 12.48 Knots and the consumption is 213 Mt HFO.



The difference between Laden and Ballast consumption :

Laden consumption – Ballast Consumption = $213 - 176 = 37$Mt

So we burn an amount of 37 Mt of fuel while in laden , which goes without saying since the vessel is loaded with cargo.

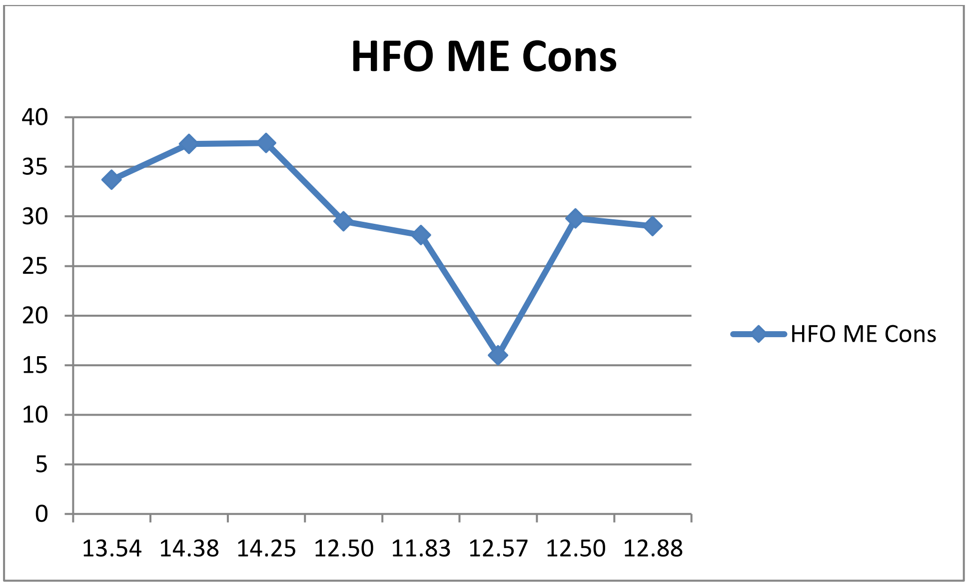
9.1.4 After the Underwater Hull Cleaning

On August 08 2019 our Aframax Tanker has undergone underwater hull cleaning at Balboa Panama which cost us 20.000 $.

The speed and consumption in Ballast condition after the hull cleaning :

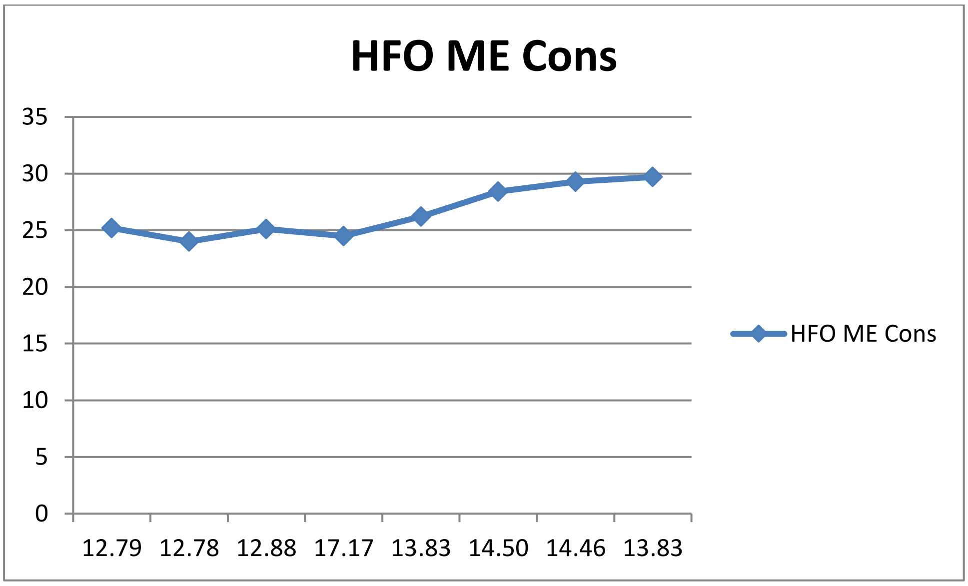
DATE	LOCATION	(LADEN / BALLAST)	ME Hrs	HFO ME Cons. (MT)	SPEED (Kt)
21-08-19	AT SEA	LADEN	24	33.7	13.54
22-08-19	AT SEA	LADEN	24	37.3	14.38
23-08-19	AT SEA	LADEN	24	37.4	14.25
24-08-19	AT SEA	LADEN	24	29.5	12.50
25-08-19	AT SEA	LADEN	24	28.1	11.83
18-09-19	AT SEA	LADEN	22	16	12.57
19-09-19	AT SEA	LADEN	24	29.8	12.50
24-09-19	AT SEA	LADEN	21.5	29	12.88

At the first eight days in Laden condition our Aframax Tanker burned a total of 240.8 Mt of fuel with an average speed of 25.95 knots.



DATE	LOCATION	(LADEN / BALLAST)	ME Hrs	HFO ME Cons. (MT)	SPEED (Kt)
01-09-19	AT SEA	BALLAST	24	25.2	12.79
02-09-19	AT SEA	BALLAST	23	24	12.78
03-09-19	AT SEA	BALLAST	24	25.1	12.88
04-09-19	AT SEA	BALLAST	23	24.5	17.17
16-11-19	AT SEA	BALLAST	24	26.2	13.83
17-11-19	AT SEA	BALLAST	24	28.4	14.50
18-11-19	AT SEA	BALLAST	24	29.3	14.46
22-11-19	AT SEA	BALLAST	24	29.7	13.83

At the first 8 days after the hull cleaning and in Ballast condition our Aframax Tanker burned 212.4 Mt with an average speed of 28.06 knots.



The difference between Laden and Ballast consumption :

Laden consumption – Ballast Consumption = $240{,}8 - 212{,}4 = 28{,}4$Mt

So we burn an amount of 28,4 Mt of fuel while in laden , which goes without saying since the vessel is loaded with cargo.

$$28{,}4Mt \times 380\$/Mt = 10.792\$$$

In the below table we can see a sum of the original table in a total of 108 days , what was the average speed and the consumption of our Aframax tanker before the underwater hull cleaning.

Ballast days				Laden Days		
	Avg Ballast Speed	**Hfo**	**Days**	**Hfo**	**Days**	**Avg Laden Speed**
	13.50	858.6	24	279.7	10	12.26
	13.54	366.7	10	288.3	9	10.76
	12.33	151.8	6	292.1	8	10.70
	12.65	401.9	11	1122.4	30	12.75
Sum	13.00	1779	51	1982.5	57	11.61
				HFO SUM	Days Sum	Avg Speed
				3761.5	108	12.31

We can see that in 51 days of ballast voyages and with average Speed of 13.00 knots while burning a total of 1779 Mt Hfo.
Burning 1779 Mt Hfo with 380 $ per ton equals with 676.020 $ in **ballast** condition.

While in 57 days of laden voyages with an average speed of 11.61 knots our vessel burned a total of 1982,5 Mt.

Burning 1982,5 Mt with 380$ per ton equals 753.350 $ in **laden** condition.

Which sums the amount of 676.020$ + 753.350 = **1.429.370$**

After the Underwater hull cleaning in Balboa we can see the average speed and consumption of our Aframax Tanker after 108 days.

Ballast days				Laden Days		
	Avg Ballast Speed	**Hfo**	**Days**	**Hfo**	**Days**	**Avg Laden Speed**
	14.98	98.8	3	166	4	12.69
	13.83	317.8	10	403.3	14	11.77
	12.26	104.9	3	49.3	2	11.87
	12.40	226.4	9	219.3	6	12.29
	12.51	243.2	9	277.1	8	12.87
	13.65	477.9	17	433.5	23	13.08
Sum	13.27	1469	51	1548.5	57	12.43
				HFO SUM	Days Sum	Avg Speed
				3017.5	108	12.85

We already mentioned that we paid 20.000 $ dollars for the underwater hull cleaning in Balboa.

We can see that in 51 days of ballast voyages and with average Speed of 13.27 knots while burning a total of 1469 Mt Hfo.
Burning 1469 Mt Hfo with 380 $ per ton equals with 558.220 $ in **ballast** condition.

While in 57 days of laden voyages with an average speed of 12.43 knots our vessel burned a total of 1548.5 Mt.

Burning 1548.5 Mt with 380$ per ton equals 588.240 $ in **laden** condition.

Which sums the amount of 558.220$ + 588.240 + 20.000 = **1.166.460$**

9.1.5 Aframax Underwater Hull Cleaning Conclusion

Average Laden Speed : 11.61 Kn	Average Ballast Speed : 13.00 Kn

fuel consumption : 1982.5 Mt	fuel consumption : 1779 Mt

After Underwater Hull cleaning

Average Laden Speed : 12.43 kn fuel consumption : 1548 Mt.	Average Ballast Speed : 13.27 Kn fuel consumption : 1469 Mt

In a total of 108 days before the hull cleaning and after our vessel have spent in fuel **1.429.370$** .

In a sum of 108 days after the underwater hull cleaning , our vessel has spent in fuel 1.146.460$ and 20.000 $ for the underwater hull cleaning which lasted for 8 hours. This sums up an amount of **1.166.460 $** .

$$\mathbf{1.429.370}\ \$ - \mathbf{1.166.460}\ \$ = \mathbf{282.910}\$$$

Our profit is 282.910 $.

Conclusion

Our aim on this dissertation was to identify and explain the relation of the hull of a vessel with speed and consumption of fuel. In order to do so we proceeded by explaining how the fuel is being distributed throughout the vessel. We also explained the types of the hulls that are used and made an extensive breakdown of the bulbous bow.

The design of the hull differs and varies depending on the vessel and the kind of trading it will do. We also find out that the place , the waves or the calmness of the waters are also a big factor that affects the hull and as a result the performance of the vessel. Concluding that the type of the hull plays an important role in the course stability of the vessel and that having a path stability affects the performance in a positive way. A part of the hull is also the bow of the vessel , the bulbous bow is an essential invention for all vessel trading with low speed and plays an important role in the smooth breaking of the waves in order to reduce the amount of forces that are influencing the speed of the vessel. Shipping industry has created the need for higher speeds because the world trade and development was growing , eventually through the technological overgrowth . The hull designs , the hydrodynamic performance and engine efficiency contributed to reach this goal, speed and consumption.

Regarding the engines and the speed consumption we discussed and also made a historic retrospective in the diesel engines . We made clear how the fuel is distributed in the Main Engine and how it is transmuted and in which percentage in mechanical power , exhaust gas , Ht Water , LT water and heat radiation. All the steps that power is distributed and the emergency power.

The chief engineer is responsible for the measurement of the rob bunkers and the fuel consumption records through which the ship owner is informed about the ship owner. The measurement is done by the sounding process , we measured the density of the fuel and analyzed the 3 types of reports.

If we take a look in this study "Bunker fuel cost and freight revenue optimization for a single liner shipping service" by

Sainan Wanga,b , Suixiang Gaoa,b , Tunzi Tana,b , Wenguo Yanga,b, (https://www.sciencedirect.com/science/article/abs/pii/S0305054819301637) where they emphasize more on the hull fouling method they conlcude that in the medium to long term, the costs incurred may be viewed as positive investments.

The importance of the CF which is a non-dimensional conversion factor between fuel oil consumption and CO2 emission in the 2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) , the fuels and hfo and prices.In regards with the emissions and referring to the IMO GHG study of 2014 we showed that the emissions of ships is about 2.6 % of the total emissions of the and that they would increase.

According to "Estimating fuel consumption in maritime transport" (https://www.journals.elsevier.com/journal-of-cleaner-production) study the speed of ship along with the frequency of rotation of the ship's engines are the most notable input factors when estimating the HSIFO consumption per mile. While also they have given more emphasis in the fact that GHG emissions and the environment as whole , the protection of the environment and the weather as well.

The cost of fuel represent a 50-60% of total ship voyage costs , depending on the type of the ship. Ships need to somehow recover from these costs in order to maintain their standards of service and be competitive in the shipping market. This percentage sometimes reaches the 70% of the operating costs due to oil increasing prices.

Regarding the hull fouling we analyzed the need for a vessel to use protective coatings which allows the vessel stay out of drydock as long as fifteen to eighteen months. Also lowers the demand for fuel up to 10 % more than a normal paint. We also made an example of how the paint is being distributed giving an emphasis to the clean film and loss factor while painting the vessel . The price of antifouling paint varies between shipyards , an average price is 20 dollars per liter.

In regard with the underwater hull cleaning apart from the examples with the kamsarmax we concluded that Using hull cleaning as a measure to reduce emissions and improve the energy efficiency of the world fleet is very important. It is a measure under which the owner has a great degree of control and along with the protective coating the vessel has an increased performance.

Based on the kamsarmax bulker model and by using the data extracted from the annex table vessel 1 and table vessel 2 we observed that the speed was decreasing and the consumption was increased when the vessel was reaching the time for the underwater hull cleaning . Right after the underwater hull cleaning we saw that the vessel was performing clearly better and that our vessel had a profit of 59145,9 $. Same way but with more profit we observed on the aframax tanker which had a profit of 282.910 $. These numbers of 24% fo the fuel expenses are extremely optimistic in regard of just one underwater hull cleaning . Concluding we used as our main data source the noon reports which we have discussed encyclopaedically on chapter 4.5 , we also utilised the engine hours , speed and consumption mostly and the results of our study are in parallel with those reported in the literature. However the numbers which we included in the tables are accurate since we extracted them from actual voyages of the vessels thus the results are more specific.

The difference in this dissertation is that the result was provided by using actual recorded data. Although as we refered before the results can be described correct it is not possible to be 100% accurate since there are other variations and outputs that might occcur.

Also we can state that the bunker consumption as n expense on hour vessel depends also on the charter type . Here we discussed a voyage charter but in reality in a time charter basis the ship owner wouldn't shoulder the expenses of fuel consumption thus he might not be interested in investing in a better hull as we propose.Other than that in order to get a better price in a second hand sale or to use the vessel after the timecharter finishes it is to his benefit to follow the procedure and invest in protective paints and underwater hull cleaning in order for the vessel to achieve higher performance.

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12.Annex

Here I am going to add the tables that I extracted all the data for the above mentioned vessels. Because the name of a vessel and its voyages are data that must be used discretely I will name them Vessel 1 and Vessel 2.

Vessel 1 : Kamsarmax vessel before the Underwater Hull cleaning

Table Annex 1

DATE	LOCATION	(LADEN / BALLAST)	SPEED (Kt)	ME Hrs	HFO ME Cons. (MT)
01-01-19	AT SEA	BALLAST	12.75	24	30.30
02-01-19	AT SEA	BALLAST	13.46	24	29.90
03-01-19	AT SEA	BALLAST	13.83	24	27.80
04-01-19	AT SEA	BALLAST	14.65	23	26.70
05-01-19	AT SEA	BALLAST	14.04	24	27.90
06-01-19	AT SEA	BALLAST	12.17	24	29.60
07-01-19	AT SEA	BALLAST	13.58	24	29.80
08-01-19	AT SEA	BALLAST	13.44	22.7	27.80
21-01-19	AT SEA	LADEN	11.88	24	29.30
22-01-19	AT SEA	LADEN	12.21	24	29.50
23-01-19	AT SEA	LADEN	12.83	24	29.60
24-01-19	AT SEA	LADEN	12.64	25	30.70
25-01-19	AT SEA	LADEN	10.88	25	29.60
26-01-19	AT SEA	LADEN	11.38	24	29.50

27-01-19	AT SEA	LADEN	11.44	25	30.90
28-01-19	AT SEA	LADEN	9.42	24	31.40
29-01-19	AT SEA	LADEN	12.5	24	29.20
30-01-19	AT SEA	LADEN	12.21	24	29.20
31-01-19	AT SEA	LADEN	12.96	24	29.10
01-02-19	AT SEA	LADEN	11.54	24	29.30
04-02-19	AT SEA	LADEN	12.32	25	30.60
05-02-19	AT SEA	LADEN	12.21	24	29.20
06-02-19	AT SEA	LADEN	12.2	24	30.50
07-02-19	AT SEA	LADEN	12.2	24.5	29.70
08-02-19	AT SEA	LADEN	12.43	24	28.60
15-02-19	AT SEA	BALLAST	12.86	24.5	27.50
16-02-19	AT SEA	BALLAST	12.54	24	26.30
17-02-19	AT SEA	BALLAST	12.68	25	27.20
18-02-19	AT SEA	BALLAST	13.29	24	26.20
19-02-19	AT SEA	BALLAST	13.67	24	26.30
20-02-19	AT SEA	BALLAST	13.17	24	26.30
21-02-19	AT SEA	BALLAST	13.21	24	26.20
22-02-19	AT SEA	BALLAST	13.68	25	27.20
23-02-19	AT SEA	BALLAST	13.46	24	26.30
24-02-19	AT SEA	BALLAST	14.52	25	27.10
25-02-19	AT SEA	BALLAST	13.96	24	26.00
06-03-19	AT SEA	LADEN	11.5	24	28.60
07-03-19	AT SEA	LADEN	10.26	23	28.30
08-03-19	AT SEA	LADEN	10.88	24	29.90
09-03-19	AT SEA	LADEN	10.75	24	29.40
10-03-19	AT SEA	LADEN	12	23	28.30
11-03-19	AT SEA	LADEN	11.79	24	28.70
12-03-19	AT SEA	LADEN	12.38	24	28.60
13-03-19	AT SEA	LADEN	12.17	24	28.70
14-03-19	AT SEA	LADEN	12.3	23	27.70
15-03-19	AT SEA	LADEN	12.79	24	28.80
16-03-19	AT SEA	LADEN	12.13	24	28.70
17-03-19	AT SEA	LADEN	12.88	24	28.70
18-03-19	AT SEA	LADEN	11.74	23.5	28.20
19-03-19	AT SEA	LADEN	11.71	24	28.90
20-03-19	AT SEA	LADEN	12.12	23.8	26.10
30-03-19	AT SEA	BALLAST	13.96	24.5	29.90
31-03-19	AT SEA	BALLAST	13.38	24	29.40
01-04-19	AT SEA	BALLAST	13.58	24	29.60
02-04-19	AT SEA	BALLAST	13.25	24	29.80
03-04-19	AT SEA	BALLAST	12.83	24	30.40

04-04-19	AT SEA	BALLAST	12.8	25	31.30
05-04-19	AT SEA	BALLAST	13.5	24	29.60
06-04-19	AT SEA	BALLAST	13.33	24	29.60
07-04-19	AT SEA	BALLAST	13.71	24	29.50
08-04-19	AT SEA	BALLAST	13.64	25	30.70
09-04-19	AT SEA	BALLAST	14	24	29.40
10-04-19	AT SEA	BALLAST	13.56	25	30.50
17-04-19	AT SEA	LADEN	11	23	27.80
18-04-19	AT SEA	LADEN	11.96	23	28.30
19-04-19	AT SEA	LADEN	11.17	24	29.50
20-04-19	AT SEA	LADEN	10.13	24	29.90
21-04-19	AT SEA	LADEN	9.83	23	28.50
22-04-19	AT SEA	LADEN	11.29	24	29.80
23-04-19	AT SEA	LADEN	11.08	24	29.80
24-04-19	AT SEA	LADEN	11.46	24	29.90
25-04-19	AT SEA	LADEN	11.46	24	30.00
26-04-19	AT SEA	LADEN	11.3	23	28.60
27-04-19	AT SEA	LADEN	12.75	24	28.90
28-04-19	AT SEA	LADEN	12.75	24	28.10
29-04-19	AT SEA	LADEN	12.54	24	28.80
30-04-19	AT SEA	LADEN	11.53	23.5	27.90
03-05-19	AT SEA	LADEN	11.71	24	27.00
04-05-19	AT SEA	LADEN	10.96	24	27.80
13-06-19	AT SEA	BALLAST	11.25	24	26.50
14-06-19	AT SEA	BALLAST	11.88	24	27.57
15-06-19	AT SEA	BALLAST	12.04	24.5	29.25
16-06-19	AT SEA	BALLAST	10.54	24	26.65
17-06-19	AT SEA	BALLAST	12.13	24	25.93
18-06-19	AT SEA	BALLAST	12.42	24	25.52
19-06-19	AT SEA	BALLAST	12.79	24	24.10
20-06-19	AT SEA	BALLAST	12.64	25	25.45
21-06-19	AT SEA	BALLAST	12.29	24	25.10
22-06-19	AT SEA	BALLAST	11.83	24	25.60
23-06-19	AT SEA	BALLAST	12.54	24	25.10
24-06-19	AT SEA	BALLAST	12.76	25	25.75
25-06-19	AT SEA	BALLAST	13.38	24	24.75
26-06-19	AT SEA	BALLAST	13.29	24	24.67
27-06-19	AT SEA	BALLAST	11.88	25	26.09
28-06-19	AT SEA	BALLAST	12.17	24	25.19
29-06-19	AT SEA	BALLAST	11.79	24	25.96
30-06-19	AT SEA	BALLAST	11.24	25	27.00
01-07-19	AT SEA	BALLAST	11.71	24	25.90
02-07-19	AT SEA	BALLAST	9.28	25	28.30

03-07-19	AT SEA	BALLAST	9.68	24	26.66
04-07-19	AT SEA	BALLAST	10.21	24	26.37
05-07-19	AT SEA	BALLAST	11.25	24	24.97
06-07-19	AT SEA	BALLAST	11.52	25	26.66
07-07-19	AT SEA	BALLAST	9.63	24	26.72
08-07-19	AT SEA	BALLAST	10.12	25	27.62
09-07-19	AT SEA	BALLAST	8.29	24	26.57
10-07-19	AT SEA	BALLAST	10.08	24	25.49
11-07-19	AT SEA	BALLAST	11.63	24	25.45
12-07-19	AT SEA	BALLAST	12.84	25	25.80
13-07-19	AT SEA	BALLAST	12.21	24	25.55
14-07-19	AT SEA	BALLAST	11.75	24	24.60
23-07-19	AT SEA	LADEN	12.42	24	29.95
26-07-19	AT SEA	LADEN	11.78	24	27.20
27-07-19	AT SEA	LADEN	11.78	24	28.70
28-07-19	AT SEA	LADEN	10.3	23	27.52
29-07-19	AT SEA	LADEN	10.08	24	28.25
30-07-19	AT SEA	LADEN	10.42	24	28.21
31-07-19	AT SEA	LADEN	12.35	23	27.10
01-08-19	AT SEA	LADEN	11.79	24	28.25
02-08-19	AT SEA	LADEN	11.75	24	28.27
03-08-19	AT SEA	LADEN	12	24	28.73
04-08-19	AT SEA	LADEN	12.35	23	27.10
05-08-19	AT SEA	LADEN	11.92	24	28.11
06-08-19	AT SEA	LADEN	12.17	23	26.95
07-08-19	AT SEA	LADEN	11.58	24	28.20
08-08-19	AT SEA	LADEN	11.54	24	28.15
09-08-19	AT SEA	LADEN	11.35	23	26.98
10-08-19	AT SEA	LADEN	10.79	24	28.11
11-08-19	AT SEA	LADEN	10.21	24	28.19
12-08-19	AT SEA	LADEN	11.74	23	26.96
13-08-19	AT SEA	LADEN	12.5	24	28.19
14-08-19	AT SEA	LADEN	11.79	24	28.30
15-08-19	AT SEA	LADEN	11.57	23	27.50
16-08-19	AT SEA	LADEN	11.79	24	28.27
17-08-19	AT SEA	LADEN	11.92	24	28.30
18-08-19	AT SEA	LADEN	11.87	23	27.06
19-08-19	AT SEA	LADEN	11.92	24	28.13
20-08-19	AT SEA	LADEN	11.58	24	28.08
21-08-19	AT SEA	LADEN	11.22	23	26.85
22-08-19	AT SEA	LADEN	11.83	24	28.09
23-08-19	AT SEA	LADEN	11.58	24	28.04
24-08-19	AT SEA	LADEN	11.91	23	26.88

25-08-19	AT SEA	LADEN	12.5	24	29.03
26-08-19	AT SEA	LADEN	12.25	24	29.43
27-08-19	AT SEA	LADEN	12.65	23	27.70
28-08-19	AT SEA	LADEN	12.5	24	26.90
31-08-19	AT SEA	LADEN	12.92	24	28.40
01-09-19	AT SEA	LADEN	13.5	24	27.83
02-09-19	AT SEA	LADEN	12.46	24	28.30
10-09-19	AT SEA	BALLAST	12.08	24	24.41
11-09-19	AT SEA	BALLAST	11.38	24	24.56
12-09-19	AT SEA	BALLAST	12.08	24	24.13
13-09-19	AT SEA	BALLAST	12.58	24	24.40
15-09-19	AT SEA	BALLAST	13.15	20	20.93
16-09-19	AT SEA	BALLAST	13.2	25	25.50
17-09-19	AT SEA	BALLAST	11.58	24	24.00
18-09-19	AT SEA	BALLAST	12	24	23.50
19-09-19	AT SEA	BALLAST	13.44	25	25.10
20-09-19	AT SEA	BALLAST	13.38	24	23.30
21-09-19	AT SEA	BALLAST	13.13	24	23.90
22-09-19	AT SEA	BALLAST	12.68	25	24.95
23-09-19	AT SEA	BALLAST	12.5	24	23.20
24-09-19	AT SEA	BALLAST	11.76	25	24.85
25-09-19	AT SEA	BALLAST	12.63	24	23.50
26-09-19	AT SEA	BALLAST	13.08	24	23.80
27-09-19	AT SEA	BALLAST	12.24	25	24.70
28-09-19	AT SEA	BALLAST	13.08	24	23.65
29-09-19	AT SEA	BALLAST	12	24	23.55
30-09-19	AT SEA	BALLAST	12.72	25	24.65
01-10-19	AT SEA	BALLAST	11	24	23.71
02-10-19	AT SEA	BALLAST	13	24	23.80
03-10-19	AT SEA	BALLAST	12.04	24	23.60
04-10-19	AT SEA	BALLAST	11.08	25	25.48
05-10-19	AT SEA	BALLAST	9.58	24	23.65
06-10-19	AT SEA	BALLAST	10.44	25	24.30
07-10-19	AT SEA	BALLAST	9.13	24	23.84
08-10-19	AT SEA	BALLAST	9.83	24	23.60
09-10-19	AT SEA	BALLAST	10.52	25	24.80
10-10-19	AT SEA	BALLAST	12	24	24.20
11-10-19	AT SEA	BALLAST	11.63	24	23.45
12-10-19	AT SEA	BALLAST	10.32	25	25.50
13-10-19	AT SEA	BALLAST	10.92	24	24.10
14-10-19	AT SEA	BALLAST	10.8	25	25.40
15-10-19	AT SEA	BALLAST	9.58	24	23.50

16-10-19	AT SEA	BALLAST	12.29	24	22.71
18-11-19	AT SEA	LADEN	12.34	24	30.34
25-11-19	AT SEA	LADEN	10.54	24	30.10
26-11-19	AT SEA	LADEN	10.21	24	30.13
27-11-19	AT SEA	LADEN	10.96	23	28.87
28-11-19	AT SEA	LADEN	11.75	24	30.07
29-11-19	AT SEA	LADEN	12	24	30.04
30-11-19	AT SEA	LADEN	11.91	23	28.90
01-12-19	AT SEA	LADEN	11.46	24	0.00
02-12-19	AT SEA	LADEN	11.57	23	0.00
03-12-19	AT SEA	LADEN	12.42	24	0.00
04-12-19	AT SEA	LADEN	12	24	0.00
05-12-19	AT SEA	LADEN	12.26	23	0.00
06-12-19	AT SEA	LADEN	12.33	24	0.00
07-12-19	AT SEA	LADEN	12.29	24	0.00
08-12-19	AT SEA	LADEN	11.52	23	0.00
09-12-19	AT SEA	LADEN	10.46	24	0.00
10-12-19	AT SEA	LADEN	10	24	0.00
11-12-19	AT SEA	LADEN	10.87	23	0.00
12-12-19	AT SEA	LADEN	10.88	24	0.00
13-12-19	AT SEA	LADEN	7.29	24	0.00
14-12-19	AT SEA	LADEN	6.7	23	0.00
15-12-19	AT SEA	LADEN	8.54	24	0.00
16-12-19	AT SEA	LADEN	10.71	24	0.00
17-12-19	AT SEA	LADEN	11.96	23	0.00
18-12-19	AT SEA	LADEN	11.88	24	0.00
19-12-19	AT SEA	LADEN	11.63	24	0.00
20-12-19	AT SEA	LADEN	10.88	24	0.00
21-12-19	AT SEA	LADEN	11.91	23	0.00
22-12-19	AT SEA	LADEN	11.25	24	0.00
23-12-19	AT SEA	LADEN	11.17	24	0.00
24-12-19	AT SEA	LADEN	11.3	23	0.00
25-12-19	AT SEA	LADEN	12.67	24	0.00
26-12-19	AT SEA	LADEN	11.75	24	0.00
27-12-19	AT SEA	LADEN	11.83	24	0.00
28-12-19	AT SEA	LADEN	11.3	23	0.00
29-12-19	AT SEA	LADEN	12.29	24	0.00

Vessel 1 : Kamsarmax vessel after the underwater hull cleaning.

DATE	LOCATION	(LADEN / BALLAST)	SPEED (Kt)	ME Hrs	HFO ME Cons. (MT)
14-02-20	AT SEA	BALLAST	12.17	24	22.36
15-02-20	AT SEA	BALLAST	12.25	24	22.43
16-02-20	AT SEA	BALLAST	12.71	24	22.28
01-03-20	AT SEA	LADEN	11.97	24	26.43
02-03-20	AT SEA	LADEN	12	24	27.00
03-03-20	AT SEA	LADEN	12	24	27.00
04-03-20	AT SEA	LADEN	12	24	26.80
06-03-20	AT SEA	LADEN	12.2	25	26.83
07-03-20	AT SEA	LADEN	12.56	25	26.96
08-03-20	AT SEA	LADEN	12.71	24	25.89
09-03-20	AT SEA	LADEN	12.5	24	25.91
10-03-20	AT SEA	LADEN	12.2	24.5	26.04
11-03-20	AT SEA	LADEN	11.54	24	27.37
14-03-20	AT SEA	LADEN	11.29	24	26.95
20-03-20	AT SEA	BALLAST	10.39	25.5	22.57
21-03-20	AT SEA	BALLAST	9.42	24	20.30
22-03-20	AT SEA	BALLAST	9.38	24	19.90
27-03-20	AT SEA	BALLAST	13.96	24	24.00
28-03-20	AT SEA	BALLAST	14.04	24	30.65
29-03-20	AT SEA	BALLAST	13.88	25	31.98
30-03-20	AT SEA	BALLAST	14.54	24	31.16
31-03-20	AT SEA	BALLAST	13.83	24	31.37
01-04-20	AT SEA	BALLAST	13.95	25	30.82
02-04-20	AT SEA	BALLAST	13.63	24	31.29
05-04-20	AT SEA	BALLAST	13.24	20	22.75
23-04-20	AT SEA	BALLAST	13.17	24	15.79
24-04-20	AT SEA	BALLAST	11.29	24	27.60
25-04-20	AT SEA	BALLAST	13.38	24	28.28
26-04-20	AT SEA	BALLAST	14.18	24	9.43
07-05-20	AT SEA	LADEN	12.33	24	22.85
08-05-20	AT SEA	LADEN	12.29	24	27.85
09-05-20	AT SEA	LADEN	13	24	29.28
10-05-20	AT SEA	LADEN	12.5	24	29.47
11-05-20	AT SEA	LADEN	11.42	24	28.60
12-05-20	AT SEA	LADEN	11.57	23	27.52
13-05-20	AT SEA	LADEN	10	24	27.93

14-05-20	AT SEA	LADEN	12.17	24	28.59
15-05-20	AT SEA	LADEN	11.7	23	28.53
16-05-20	AT SEA	LADEN	11.38	24	30.08
17-05-20	AT SEA	LADEN	11.79	24	30.00
18-05-20	AT SEA	LADEN	11.75	24	29.92
19-05-20	AT SEA	LADEN	12.74	23	28.76
20-05-20	AT SEA	LADEN	12.5	24	30.15
21-05-20	AT SEA	LADEN	11.88	24	30.43
22-05-20	AT SEA	LADEN	11.79	24	30.02
23-05-20	AT SEA	LADEN	11.65	23	29.19
24-05-20	AT SEA	LADEN	11.46	24	30.07
25-05-20	AT SEA	LADEN	11.75	24	29.98
26-05-20	AT SEA	LADEN	11.75	24	29.84
27-05-20	AT SEA	LADEN	11.48	23	28.41
28-05-20	AT SEA	LADEN	11.42	24	29.93
29-05-20	AT SEA	LADEN	11.75	24	30.02
30-05-20	AT SEA	LADEN	11.96	24	30.04
31-05-20	AT SEA	LADEN	12.09	23	29.20
01-06-20	AT SEA	LADEN	12.5	24	30.08
02-06-20	AT SEA	LADEN	12.13	24	30.08
03-06-20	AT SEA	LADEN	11.78	23	28.52
04-06-20	AT SEA	LADEN	11.42	24	29.88
05-06-20	AT SEA	LADEN	12.25	24	29.91
06-06-20	AT SEA	LADEN	11.61	23	28.66
07-06-20	AT SEA	LADEN	11.17	24	30.70
08-06-20	AT SEA	LADEN	11.21	24	30.59
09-06-20	AT SEA	LADEN	12.22	23	29.46
10-06-20	AT SEA	LADEN	11.58	24	30.28
11-06-20	AT SEA	LADEN	11.04	24	30.81
12-06-20	AT SEA	LADEN	10.96	24	30.89
13-06-20	AT SEA	LADEN	11.04	23	29.51
14-06-20	AT SEA	LADEN	10.71	24	30.83
15-06-20	AT SEA	LADEN	11.25	24	29.63
16-06-20	AT SEA	LADEN	12.38	24	29.59
17-06-20	AT SEA	LADEN	12.96	23	27.87
18-06-20	AT SEA	LADEN	12.54	24	30.02
19-06-20	AT SEA	LADEN	12.29	24	29.72
20-06-20	AT SEA	LADEN	12.26	23	28.30
21-06-20	AT SEA	LADEN	12.17	24	30.32
22-06-20	AT SEA	LADEN	12.63	23	29.62
23-06-20	AT SEA	LADEN	12.91	23	28.30
24-06-20	AT SEA	LADEN	13.04	24	31.01

25-06-20	AT SEA	LADEN	13.13	24	30.79
26-06-20	AT SEA	LADEN	13.21	24	30.86
04-07-20	AT SEA	BALLAST	11.67	24	23.51
05-07-20	AT SEA	BALLAST	11.88	24	22.80
06-07-20	AT SEA	BALLAST	12.25	24	22.97
07-07-20	AT SEA	BALLAST	12	24	22.86
08-07-20	AT SEA	BALLAST	10.94	21	20.14
10-07-20	AT SEA	BALLAST	14.44	25	34.18
11-07-20	AT SEA	BALLAST	13.88	24	31.68
12-07-20	AT SEA	BALLAST	12.72	25	31.10
13-07-20	AT SEA	BALLAST	12.5	24	27.81
14-07-20	AT SEA	BALLAST	11.8	25	28.64
15-07-20	AT SEA	BALLAST	12.08	24	27.48
16-07-20	AT SEA	BALLAST	12.79	24	27.17
17-07-20	AT SEA	BALLAST	12.64	25	27.82
18-07-20	AT SEA	BALLAST	12.75	24	26.28
19-07-20	AT SEA	BALLAST	12.38	24	26.94
20-07-20	AT SEA	BALLAST	11.88	24	27.19
21-07-20	AT SEA	BALLAST	12.12	25	27.77
22-07-20	AT SEA	BALLAST	13.63	24	26.75
23-07-20	AT SEA	BALLAST	12.63	24	26.62
24-07-20	AT SEA	BALLAST	13.72	25	28.21
25-07-20	AT SEA	BALLAST	13.58	24	27.79
26-07-20	AT SEA	BALLAST	11.72	25	30.42
27-07-20	AT SEA	BALLAST	12.67	24	27.91
28-07-20	AT SEA	BALLAST	12.5	24	27.16
29-07-20	AT SEA	BALLAST	12.72	25	27.97
30-07-20	AT SEA	BALLAST	12.83	24	27.04
31-07-20	AT SEA	BALLAST	12.83	24	27.24
01-08-20	AT SEA	BALLAST	13.04	25	28.34
02-08-20	AT SEA	BALLAST	13.33	24	27.04
03-08-20	AT SEA	BALLAST	13.13	24	26.63
04-08-20	AT SEA	BALLAST	13.04	25	28.41
05-08-20	AT SEA	BALLAST	13.5	24	27.04
06-08-20	AT SEA	BALLAST	13.42	24	26.66
07-08-20	AT SEA	BALLAST	14.76	25	27.01
08-08-20	AT SEA	BALLAST	14.88	24	22.76
25-08-20	AT SEA	LADEN	11.65	23	27.35
26-08-20	AT SEA	LADEN	13.5	24	30.10
27-08-20	AT SEA	LADEN	13.65	23	29.26
28-08-20	AT SEA	LADEN	12.67	24	30.44
29-08-20	AT SEA	LADEN	12.7	23	29.62

30-08-20	AT SEA	LADEN	12.58	24	31.55
31-08-20	AT SEA	LADEN	12.09	23	29.44
01-09-20	AT SEA	LADEN	12.75	24	31.12
03-09-20	AT SEA	LADEN	12.29	24	30.17
04-09-20	AT SEA	LADEN	12.65	23	30.57
05-09-20	AT SEA	LADEN	12.8	23	26.31
06-09-20	AT SEA	LADEN	12.79	24	30.14

Vessel 2 : The Aframax tanker before the underwater hull cleaning

DATE	LOCATION	(LADEN / BALLAST)	ME Hrs	HFO ME Cons. (MT)	SPEED (Kt)
21-08-19	AT SEA	LADEN	24	33.7	13.54
22-08-19	AT SEA	LADEN	24	37.3	14.38
23-08-19	AT SEA	LADEN	24	37.4	14.25
24-08-19	AT SEA	LADEN	24	29.5	12.50
25-08-19	AT SEA	LADEN	24	28.1	11.83
01-09-19	AT SEA	BALLAST	24	25.2	12.79
02-09-19	AT SEA	BALLAST	23	24	12.78
03-09-19	AT SEA	BALLAST	24	25.1	12.88
04-09-19	AT SEA	BALLAST	23	24.5	17.17
18-09-19	AT SEA	LADEN	22	16	12.57
19-09-19	AT SEA	LADEN	24	29.8	12.50
24-09-19	AT SEA	LADEN	21.5	29	12.88
25-09-19	AT SEA	LADEN	23	29.1	12.35
26-09-19	AT SEA	LADEN	24	29.8	12.17
27-09-19	AT SEA	LADEN	24	30	11.71
28-09-19	AT SEA	LADEN	24	28.5	11.25
29-09-19	AT SEA	LADEN	47	25.4	11.79
30-09-19	AT SEA	LADEN	23	25.2	11.52
01-10-19	AT SEA	LADEN	24	26.5	11.04
02-10-19	AT SEA	LADEN	23	25.9	11.70
03-10-19	AT SEA	LADEN	24	29.6	10.67
04-10-19	AT SEA	LADEN	23	26.5	10.52

05-10-19	AT SEA	LADEN	23	26.6	10.65
06-10-19	AT SEA	LADEN	23	25.4	10.96
16-11-19	AT SEA	BALLAST	24	26.2	13.83
17-11-19	AT SEA	BALLAST	24	28.4	14.50
18-11-19	AT SEA	BALLAST	24	29.3	14.46
22-11-19	AT SEA	BALLAST	24	29.7	13.83
23-11-19	AT SEA	BALLAST	24	28.9	14.10
24-11-19	AT SEA	BALLAST	24	29.2	13.79
25-11-19	AT SEA	BALLAST	24	28.1	13.71
26-11-19	AT SEA	BALLAST	23	27.9	13.43
27-11-19	AT SEA	BALLAST	24	29.8	13.71
28-11-19	AT SEA	BALLAST	23	30.2	14.43
29-11-19	AT SEA	BALLAST	24	30.1	13.83
02-12-19	AT SEA	LADEN	23.8	29.5	12.57
09-01-20	AT SEA	LADEN	24	19.8	11.17
14-01-20	AT SEA	BALLAST	21.3	31.3	11.92
15-01-20	AT SEA	BALLAST	24	36.4	12.58
16-01-20	AT SEA	BALLAST	25	37.2	12.60
17-01-20	AT SEA	LADEN	24	36.1	12.58
18-01-20	AT SEA	LADEN	24	37.2	12.50
19-01-20	AT SEA	LADEN	25	35.1	12.48
20-01-20	AT SEA	LADEN	25	34.7	12.52
21-01-20	AT SEA	LADEN	24	27.8	12.54
22-01-20	AT SEA	LADEN	24	26.4	12.46
23-01-20	AT SEA	LADEN	24	22	12.00
10-02-20	AT SEA	BALLAST	24	29.2	14.41
11-02-20	AT SEA	BALLAST	24	29.6	15.33
12-02-20	AT SEA	BALLAST	24	29.1	15.48
13-02-20	AT SEA	BALLAST	24	29	15.08
14-02-20	AT SEA	BALLAST	23	15.8	11.65
15-02-20	AT SEA	BALLAST	24	18.1	10.50
16-02-20	AT SEA	BALLAST	24	26.9	11.58
17-02-20	AT SEA	BALLAST	24	26.1	12.67
18-02-20	AT SEA	BALLAST	23	22.6	10.39
23-02-20	AT SEA	LADEN	24	31.6	13.08
24-02-20	AT SEA	LADEN	25	30.9	12.95
25-02-20	AT SEA	LADEN	24	21.1	12.95
26-02-20	AT SEA	LADEN	24	29.7	12.92
27-02-20	AT SEA	LADEN	25	32.8	12.64
28-02-20	AT SEA	LADEN	24	35.2	13.04
29-02-20	AT SEA	LADEN	24	34.9	13.29
01-03-20	AT SEA	LADEN	25	34.4	12.92

08-03-20	AT SEA	LADEN	25	26.5	12.65
12-03-20	AT SEA	BALLAST	24	26.4	13.10
13-03-20	AT SEA	BALLAST	24	20.6	12.90
14-03-20	AT SEA	BALLAST	24	25.9	13.13
15-03-20	AT SEA	BALLAST	24	25.1	13.25
16-03-20	AT SEA	BALLAST	24	25.3	13.33
17-03-20	AT SEA	BALLAST	24	24.8	13.29
18-03-20	AT SEA	BALLAST	23	26.2	12.96
19-03-20	AT SEA	BALLAST	24	23.8	12.63
20-03-20	AT SEA	BALLAST	24	22.6	12.54
21-03-20	AT SEA	BALLAST	23	22.5	11.91
27-03-20	AT SEA	LADEN	23.3	29.8	12.96
28-03-20	AT SEA	LADEN	24	30.1	12.92
29-03-20	AT SEA	LADEN	25	29.2	13.04
30-03-20	AT SEA	LADEN	24	28.1	12.50
31-03-20	AT SEA	LADEN	24	26.2	12.21
01-04-20	AT SEA	LADEN	25	22.7	10.64
02-04-20	AT SEA	LADEN	24	21.8	10.46
03-04-20	AT SEA	LADEN	24	21.8	10.50
04-04-20	AT SEA	LADEN	24	22.2	10.13
05-04-20	AT SEA	LADEN	24	22.3	10.63
06-04-20	AT SEA	LADEN	24	12.4	9.67
19-04-20	AT SEA	LADEN	24	20.6	11.75
18-05-20	AT SEA	LADEN	25	22	12.52
19-05-20	AT SEA	LADEN	24	25.9	12.42
20-05-20	AT SEA	LADEN	25	25.9	11.28
21-05-20	AT SEA	LADEN	24	26.3	10.92
22-05-20	AT SEA	LADEN	24	22.4	9.75
23-05-20	AT SEA	LADEN	25	23.8	8.92
24-05-20	AT SEA	LADEN	24	25.4	11.25
26-05-20	AT SEA	LADEN	25	28.6	13.00
27-05-20	AT SEA	LADEN	24	27.2	12.29
28-05-20	AT SEA	LADEN	25	27.1	11.48
29-05-20	AT SEA	LADEN	24	27.1	12.45
30-05-20	AT SEA	LADEN	25	29.7	13.20
31-05-20	AT SEA	LADEN	24	28.2	13.04
01-06-20	AT SEA	LADEN	25	27.9	12.80
02-06-20	AT SEA	LADEN	24	28.8	12.42
03-06-20	AT SEA	LADEN	25	29.6	12.80
04-06-20	AT SEA	LADEN	24	29.9	13.04
05-06-20	AT SEA	LADEN	24	28.9	12.83
06-06-20	AT SEA	LADEN	24	29.8	13.08

07-06-20	AT SEA	LADEN	25	32.1	13.08
08-06-20	AT SEA	LADEN	24	30.7	13.04
09-06-20	AT SEA	LADEN	24	29.5	13.08
10-06-20	AT SEA	LADEN	24	28.6	12.88
24-06-20	AT SEA	LADEN	24	28.2	12.50
25-06-20	AT SEA	LADEN	24	28.2	12.54
26-06-20	AT SEA	LADEN	24	28.4	12.58
27-06-20	AT SEA	LADEN	24	28.9	12.54
28-06-20	AT SEA	LADEN	24	28.6	12.50
29-06-20	AT SEA	LADEN	24	29.2	12.33
30-06-20	AT SEA	LADEN	24	28.9	11.50
01-07-20	AT SEA	LADEN	24	22.3	11.08
14-07-20	AT SEA	BALLAST	24	21.4	13.08
15-07-20	AT SEA	BALLAST	24	27.2	13.04
16-07-20	AT SEA	BALLAST	24	26.3	12.96
17-07-20	AT SEA	BALLAST	23	23.8	12.87
18-07-20	AT SEA	BALLAST	24	22.3	12.46
19-07-20	AT SEA	BALLAST	23	22.1	12.22
20-07-20	AT SEA	BALLAST	24	23.8	12.83
21-07-20	AT SEA	BALLAST	23	21.7	12.26
22-07-20	AT SEA	BALLAST	24	22.9	11.50
23-07-20	AT SEA	BALLAST	47	31	13.38
24-07-20	AT SEA	BALLAST	24	29.8	14.42
25-07-20	AT SEA	BALLAST	23	29.3	14.34
26-07-20	AT SEA	BALLAST	24	29.5	14.54
27-07-20	AT SEA	BALLAST	23	30.1	14.52
28-07-20	AT SEA	BALLAST	24	30.2	14.54
29-07-20	AT SEA	BALLAST	23	29.2	14.52
30-07-20	AT SEA	BALLAST	24	28.1	13.42
31-07-20	AT SEA	BALLAST	23	29.2	14.22
01-08-20	AT SEA	BALLAST	24	30.6	14.88
02-08-20	AT SEA	BALLAST	23	29.8	14.66
03-08-20	AT SEA	BALLAST	24	30.5	14.50
04-08-20	AT SEA	BALLAST	23	29.6	14.39
05-08-20	AT SEA	BALLAST	23	29.1	13.30
06-08-20	AT SEA	BALLAST	24	29.2	12.83
07-08-20	AT SEA	BALLAST	24	30.3	14.13
08-08-20	AT SEA	BALLAST	24	32.5	14.38
09-08-20	AT SEA	BALLAST	24	32.6	14.54
15-08-20	AT SEA	LADEN	24	33.8	12.21
16-08-20	AT SEA	LADEN	25	34.5	11.52
17-08-20	AT SEA	LADEN	24	34.1	12.54

18-08-20	AT SEA	LADEN	24	33.7	12.08
19-08-20	AT SEA	LADEN	25	30.6	12.36
20-08-20	AT SEA	LADEN	24	30.1	12.17
21-08-20	AT SEA	LADEN	24	31.8	12.67
22-08-20	AT SEA	LADEN	24	30.1	12.50
23-08-20	AT SEA	LADEN	24	31.1	12.54
31-08-20	AT SEA	LADEN	24	21.4	12.58
01-09-20	AT SEA	LADEN	24	20.8	12.17
02-09-20	AT SEA	LADEN	24	20.3	11.96
03-09-20	AT SEA	LADEN	24	20.2	12.25
04-09-20	AT SEA	LADEN	24	20.2	12.67
05-09-20	AT SEA	LADEN	23	19.3	11.22
06-09-20	AT SEA	LADEN	24	21.2	12.25

Vessel 2 : The Aframax tanker after the underwater hull cleaning.

DATE	LOCATION	(LADEN / BALLAST)	ME Hrs	HFO ME Cons. (MT)	SPEED (Kt)
21-08-19	AT SEA	LADEN	24	33.7	13.54
22-08-19	AT SEA	LADEN	24	37.3	14.38
23-08-19	AT SEA	LADEN	24	37.4	14.25
24-08-19	AT SEA	LADEN	24	29.5	12.50
25-08-19	AT SEA	LADEN	24	28.1	11.83
01-09-19	AT SEA	BALLAST	24	25.2	12.79
02-09-19	AT SEA	BALLAST	23	24	12.78
03-09-19	AT SEA	BALLAST	24	25.1	12.88
04-09-19	AT SEA	BALLAST	23	24.5	17.17
18-09-19	AT SEA	LADEN	22	16	12.57
19-09-19	AT SEA	LADEN	24	29.8	12.50
24-09-19	AT SEA	LADEN	21.5	29	12.88
25-09-19	AT SEA	LADEN	23	29.1	12.35
26-09-19	AT SEA	LADEN	24	29.8	12.17
27-09-19	AT SEA	LADEN	24	30	11.71
28-09-19	AT SEA	LADEN	24	28.5	11.25
29-09-19	AT SEA	LADEN	47	25.4	11.79
30-09-19	AT SEA	LADEN	23	25.2	11.52
01-10-19	AT SEA	LADEN	24	26.5	11.04

02-10-19	AT SEA	LADEN	23	25.9	11.70
03-10-19	AT SEA	LADEN	24	29.6	10.67
04-10-19	AT SEA	LADEN	23	26.5	10.52
05-10-19	AT SEA	LADEN	23	26.6	10.65
06-10-19	AT SEA	LADEN	23	25.4	10.96
16-11-19	AT SEA	BALLAST	24	26.2	13.83
17-11-19	AT SEA	BALLAST	24	28.4	14.50
18-11-19	AT SEA	BALLAST	24	29.3	14.46
22-11-19	AT SEA	BALLAST	24	29.7	13.83
23-11-19	AT SEA	BALLAST	24	28.9	14.10
24-11-19	AT SEA	BALLAST	24	29.2	13.79
25-11-19	AT SEA	BALLAST	24	28.1	13.71
26-11-19	AT SEA	BALLAST	23	27.9	13.43
27-11-19	AT SEA	BALLAST	24	29.8	13.71
28-11-19	AT SEA	BALLAST	23	30.2	14.43
29-11-19	AT SEA	BALLAST	24	30.1	13.83
02-12-19	AT SEA	LADEN	23.8	29.5	12.57
09-01-20	AT SEA	LADEN	24	19.8	11.17
14-01-20	AT SEA	BALLAST	21.3	31.3	11.92
15-01-20	AT SEA	BALLAST	24	36.4	12.58
16-01-20	AT SEA	BALLAST	25	37.2	12.60
17-01-20	AT SEA	LADEN	24	36.1	12.58
18-01-20	AT SEA	LADEN	24	37.2	12.50
19-01-20	AT SEA	LADEN	25	35.1	12.48
20-01-20	AT SEA	LADEN	25	34.7	12.52
21-01-20	AT SEA	LADEN	24	27.8	12.54
22-01-20	AT SEA	LADEN	24	26.4	12.46
23-01-20	AT SEA	LADEN	24	22	12.00
10-02-20	AT SEA	BALLAST	24	29.2	14.41
11-02-20	AT SEA	BALLAST	24	29.6	15.33
12-02-20	AT SEA	BALLAST	24	29.1	15.48
13-02-20	AT SEA	BALLAST	24	29	15.08
14-02-20	AT SEA	BALLAST	23	15.8	11.65
15-02-20	AT SEA	BALLAST	24	18.1	10.50
16-02-20	AT SEA	BALLAST	24	26.9	11.58
17-02-20	AT SEA	BALLAST	24	26.1	12.67
18-02-20	AT SEA	BALLAST	23	22.6	10.39
23-02-20	AT SEA	LADEN	24	31.6	13.08
24-02-20	AT SEA	LADEN	25	30.9	12.95
25-02-20	AT SEA	LADEN	24	21.1	12.95
26-02-20	AT SEA	LADEN	24	29.7	12.92
27-02-20	AT SEA	LADEN	25	32.8	12.64

28-02-20	AT SEA	LADEN	24	35.2	13.04
29-02-20	AT SEA	LADEN	24	34.9	13.29
01-03-20	AT SEA	LADEN	25	34.4	12.92
08-03-20	AT SEA	LADEN	25	26.5	12.65
12-03-20	AT SEA	BALLAST	24	26.4	13.10
13-03-20	AT SEA	BALLAST	24	20.6	12.90
14-03-20	AT SEA	BALLAST	24	25.9	13.13
15-03-20	AT SEA	BALLAST	24	25.1	13.25
16-03-20	AT SEA	BALLAST	24	25.3	13.33
17-03-20	AT SEA	BALLAST	24	24.8	13.29
18-03-20	AT SEA	BALLAST	23	26.2	12.96
19-03-20	AT SEA	BALLAST	24	23.8	12.63
20-03-20	AT SEA	BALLAST	24	22.6	12.54
21-03-20	AT SEA	BALLAST	23	22.5	11.91
27-03-20	AT SEA	LADEN	23.3	29.8	12.96
28-03-20	AT SEA	LADEN	24	30.1	12.92
29-03-20	AT SEA	LADEN	25	29.2	13.04
30-03-20	AT SEA	LADEN	24	28.1	12.50
31-03-20	AT SEA	LADEN	24	26.2	12.21
01-04-20	AT SEA	LADEN	25	22.7	10.64
02-04-20	AT SEA	LADEN	24	21.8	10.46
03-04-20	AT SEA	LADEN	24	21.8	10.50
04-04-20	AT SEA	LADEN	24	22.2	10.13
05-04-20	AT SEA	LADEN	24	22.3	10.63
06-04-20	AT SEA	LADEN	24	12.4	9.67
19-04-20	AT SEA	LADEN	24	20.6	11.75
18-05-20	AT SEA	LADEN	25	22	12.52
19-05-20	AT SEA	LADEN	24	25.9	12.42
20-05-20	AT SEA	LADEN	25	25.9	11.28
21-05-20	AT SEA	LADEN	24	26.3	10.92
22-05-20	AT SEA	LADEN	24	22.4	9.75
23-05-20	AT SEA	LADEN	25	23.8	8.92
24-05-20	AT SEA	LADEN	24	25.4	11.25
26-05-20	AT SEA	LADEN	25	28.6	13.00
27-05-20	AT SEA	LADEN	24	27.2	12.29
28-05-20	AT SEA	LADEN	25	27.1	11.48
29-05-20	AT SEA	LADEN	24	27.1	12.45
30-05-20	AT SEA	LADEN	25	29.7	13.20
31-05-20	AT SEA	LADEN	24	28.2	13.04
01-06-20	AT SEA	LADEN	25	27.9	12.80
02-06-20	AT SEA	LADEN	24	28.8	12.42
03-06-20	AT SEA	LADEN	25	29.6	12.80

04-06-20	AT SEA	LADEN	24	29.9	13.04
05-06-20	AT SEA	LADEN	24	28.9	12.83
06-06-20	AT SEA	LADEN	24	29.8	13.08
07-06-20	AT SEA	LADEN	25	32.1	13.08
08-06-20	AT SEA	LADEN	24	30.7	13.04
09-06-20	AT SEA	LADEN	24	29.5	13.08
10-06-20	AT SEA	LADEN	24	28.6	12.88
24-06-20	AT SEA	LADEN	24	28.2	12.50
25-06-20	AT SEA	LADEN	24	28.2	12.54
26-06-20	AT SEA	LADEN	24	28.4	12.58
27-06-20	AT SEA	LADEN	24	28.9	12.54
28-06-20	AT SEA	LADEN	24	28.6	12.50
29-06-20	AT SEA	LADEN	24	29.2	12.33
30-06-20	AT SEA	LADEN	24	28.9	11.50
01-07-20	AT SEA	LADEN	24	22.3	11.08
14-07-20	AT SEA	BALLAST	24	21.4	13.08
15-07-20	AT SEA	BALLAST	24	27.2	13.04
16-07-20	AT SEA	BALLAST	24	26.3	12.96
17-07-20	AT SEA	BALLAST	23	23.8	12.87
18-07-20	AT SEA	BALLAST	24	22.3	12.46
19-07-20	AT SEA	BALLAST	23	22.1	12.22
20-07-20	AT SEA	BALLAST	24	23.8	12.83
21-07-20	AT SEA	BALLAST	23	21.7	12.26
22-07-20	AT SEA	BALLAST	24	22.9	11.50
23-07-20	AT SEA	BALLAST	47	31	13.38
24-07-20	AT SEA	BALLAST	24	29.8	14.42
25-07-20	AT SEA	BALLAST	23	29.3	14.34
26-07-20	AT SEA	BALLAST	24	29.5	14.54
27-07-20	AT SEA	BALLAST	23	30.1	14.52
28-07-20	AT SEA	BALLAST	24	30.2	14.54
29-07-20	AT SEA	BALLAST	23	29.2	14.52
30-07-20	AT SEA	BALLAST	24	28.1	13.42
31-07-20	AT SEA	BALLAST	23	29.2	14.22
01-08-20	AT SEA	BALLAST	24	30.6	14.88
02-08-20	AT SEA	BALLAST	23	29.8	14.66
03-08-20	AT SEA	BALLAST	24	30.5	14.50
04-08-20	AT SEA	BALLAST	23	29.6	14.39
05-08-20	AT SEA	BALLAST	23	29.1	13.30
06-08-20	AT SEA	BALLAST	24	29.2	12.83
07-08-20	AT SEA	BALLAST	24	30.3	14.13
08-08-20	AT SEA	BALLAST	24	32.5	14.38
09-08-20	AT SEA	BALLAST	24	32.6	14.54

15-08-20	AT SEA	LADEN	24	33.8	12.21
16-08-20	AT SEA	LADEN	25	34.5	11.52
17-08-20	AT SEA	LADEN	24	34.1	12.54
18-08-20	AT SEA	LADEN	24	33.7	12.08
19-08-20	AT SEA	LADEN	25	30.6	12.36
20-08-20	AT SEA	LADEN	24	30.1	12.17
21-08-20	AT SEA	LADEN	24	31.8	12.67
22-08-20	AT SEA	LADEN	24	30.1	12.50
23-08-20	AT SEA	LADEN	24	31.1	12.54
31-08-20	AT SEA	LADEN	24	21.4	12.58
01-09-20	AT SEA	LADEN	24	20.8	12.17
02-09-20	AT SEA	LADEN	24	20.3	11.96
03-09-20	AT SEA	LADEN	24	20.2	12.25
04-09-20	AT SEA	LADEN	24	20.2	12.67
05-09-20	AT SEA	LADEN	23	19.3	11.22
06-09-20	AT SEA	LADEN	24	21.2	12.25