NTNU
Norwegian University of Science and Technology
Department of Marine Technology

Vegard Stølen Bjørnerem

Low Greenhouse Gas Emission Ship

Master Thesis

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Preface

In this report I will assess the effect of slow steaming as a measure for reductions of greenhouse gas emissions in seaborne shipping. I have collaborated with Inge Norstad from Marintek and I have had correspondence with Geir Olafsen from Inge Steensland AS. Maurice White from NTNU, department of marine technology has also helped me out.

I want to thank the persons mentioned above in addition to my guidance Bjørn Egil Asbjørnslett for support in my master thesis.

Vegard Stølen Bjørnerem Trondheim, June 11th 2010

Abstract

The fleet consists of 6 LNG carriers where 3 have a loading capacity of 44 000 tons while the remaining 3 ships can lift 33 00 tons of LPG. Since the ships are set to operate at speeds between 14 and 20 knots it is necessary to upgrade the prime movers as the service speeds range from 14.5 to 16.7 knots. BW Clipper will prove to be far more effective in terms of fuel consumption compared to the other ships due to higher initial service speed and a relatively efficient engine.

The fleet will operate within tramp shipping fulfilling 18 contracted orders and serving the spot market in between ordered shipments. The duration and the profitability of the orders influenced the net income. It is favorable to be committed to profitable contracted orders in recession while it is unfavorable to be bound to low rate contracted orders in prosperity. The ships were assigned to two to four contracted orders each.

The fuel prices are changing rapidly and the magnitude of the variations can be vast. This impacts the shipping companies as the fuel costs are a large item of expenditure in the shipping industry. For the period between second half of 2006 and end 2007 I estimated the IFO 180 price to be 353 USD/ton, while it was 383 USD/ton in a defined prosperity level and 138 USD/ton in a defined recession level.

The freight rates for the actual level, the prosperity level and the recession level were estimated to 36.5 USD/ton, 63 USD/ton and 25.7 USD respectively. The spot market potential was fully utilized at the prosperity level, 88% in the actual level while only 57.5% was utilized in the recession level.

	Optimized speed	Increased total net income at optimized speed		CATCH at optimized speed
ACTUAL LEVEL				
BW Clipper	17 knots	1 367 500 $	8.4 %	12.6 $/ton CO_2 averted
BW Saga	15 knots	4 246 100 $	40.2 %	-5.0 $/ton CO_2 averted
Gas Beauty I	15 knots	4 506 200 $	50.9 %	-6.3 $/ton CO_2 averted
Maharshi Vamadeva	14 knots	5 698 100 $	145.3 %	-18.8 $/ton CO_2 averted
BW Helios	14 knots	6 369 500 $	172.1 %	-19.6 $/ton CO_2 averted
BW Havfrost	14 knots	6 521 300 $	174.3 %	-19.2 $/ton CO_2 averted
		28 708 700 $	61.0 %	
PROSPERITY LEVEL				
BW Clipper	20 knots	-	-	-
BW Saga	18 knots	863 300 $	2.3 %	16.6 $/ton CO_2 averted
Gas Beauty I	18 knots	940 500 $	2.6 %	15.6 $/ton CO_2 averted
Maharshi Vamadeva	17 knots	2 704 000 $	11.7 %	-5.5 $/ton CO_2 averted
BW Helios	17 knots	3 020 500 $	12.4 %	-6.1 $/ton CO_2 averted
BW Havfrost	17 knots	3 086 800 $	13.4 %	-5.9 $/ton CO_2 averted
		10 615 100 $	5.7 %	
RECESSION LEVEL				
BW Clipper	19 knots	11 200 $	0.1 %	23.1 $/ton CO_2 averted
BW Saga	17 knots	414 400 $	5.3 %	13.9 $/ton CO_2 averted
Gas Beauty I	17 knots	489 700 $	7.5 %	12.4 $/ton CO_2 averted
Maharshi Vamadeva	16 knots	823 400 $	19.3 %	8.1 $/ton CO_2 averted
BW Helios	16 knots	955 000 $	21.9 %	7.1 $/ton CO_2 averted
BW Havfrost	16 knots	1 063 900 $	20.9 %	6.4 $/ton CO_2 averted
		3 757 600 $	9.9 %	

Table 1 Benefit and CATCH for speed reduction

The calculations in table 1 and 2 are based on the improvements at reduced speed compared to a baseline at 20 knots speed.

	Optimized speed	Increased total net income at optimized speed		CATCH at optimized speed
ACTUAL LEVEL				
BW Clipper	16 knots	3 211 500 $	24.9 %	23.6 $/ton CO_2 averted
BW Saga	14 knots	7 559 200 $	133.5 %	5.4 $/ton CO_2 averted
Gas Beauty I	14 knots	7 946 300 $	210.9 %	3.8 $/ton CO_2 averted
Maharshi Vamadeva	14 knots	8 919 600 $	2102.2 %	-18.8 $/ton CO_2 averted
BW Helios	14 knots	9 945 000 $	883.2 %	-19.6 $/ton CO_2 averted
BW Havfrost	14 knots	10 118 500 $	895.3 %	-19.2 $/ton CO_2 averted
		47 700 100 $	242.6 %	
PROSPERITY LEVEL				
BW Clipper	19 knots	270 400 $	0.6 %	56.8 $/ton CO_2 averted
BW Saga	17 knots	3 056 800 $	9.5 %	27.5 $/ton CO_2 averted
Gas Beauty I	17 knots	3 233 100 $	10.8 %	26.5 $/ton CO_2 averted
Maharshi Vamadeva	16 knots	5 534 000 $	30.6 %	4.1 $/ton CO_2 averted
BW Helios	16 knots	6 162 700 $	32.7 %	3.4 $/ton CO_2 averted
BW Havfrost	15 knots	6 251 500 $	35.7 %	14.7 $/ton CO_2 averted
		24 508 500 $	15.6 %	
RECESSION LEVEL				
BW Clipper	16 knots	920 600 $	12.2 %	13.7 $/ton CO_2 averted
BW Saga	15 knots	2 407 800 $	55.7 %	-4.3 $/ton CO_2 averted
Gas Beauty I	15 knots	2 625 300 $	91.1 %	-6.2 $/ton CO_2 averted
Maharshi Vamadeva	14 knots	2 824 400 $	204.8 %	-10.3 $/ton CO_2 averted
BW Helios	14 knots	3 220 100 $	290.9 %	-11.6 $/ton CO_2 averted
BW Havfrost	14 knots	3 452 300 $	204.0 %	-12.4 $/ton CO_2 averted
		11 123 400 $	58.8 %	

Table 2 Benefit and CATCH for speed reductions with environmental fuel taxation

Table of contents

List of figures

List of tables

Introduction

In this report I will present a case involving a given fleet of 6 LPG carriers of different sizes and loading capacities which will deliver 18 contracted shipments and additional spot market deliveries of liquefied petroleum gas, LPG. The overall objective of my master thesis will be to highlight the mechanism of speed reductions in terms of an economical and environmental point of view. I will also present a recommended measure for IMO which will promote reduced greenhouse gas emissions in seaborne shipping. With reference to my previous project assignment I will only focus on slow steaming since it proved to be a cost-effective measure. Slow steaming is sustainable for the maritime industry since vast savings can be made and in fact finance abatement technologies of other emissions such as NOx and SOx.

In my opinion most shipping companies are only interested in making money without paying much attention to environmental issues. To approach the industry one must therefore award low emission shipping. There are different ways to do this but it has to prevail in every location and apply for every fleet worldwide. Due to the large varieties in vessel types and vessel sizes abatement technologies for prevention of GHG-emissions cannot be feasible for every ship.

I have utilized the decision-support program TURBOROUTER in my master thesis. Inge Norstad implemented the 18 contracted orders into TURBOROUTER with data about the origins and the destinations for every order. Time windows for loading and discharging were also included.

I estimated the fuel consumption per mile as a function of speed. The operating speeds were set to 14-20 knots, which resulted in severe upgrades of the prime movers since the maximum speeds were below 20 knots initially. The range of an average voyage and Suez passage frequency in spot market was estimated based on data for the 18 fixed shipments.

Details about the financial and environmental mechanisms by speed reductions will be elaborated for the contracted orders and the spot market shipping separately initially and the total outcome later on. Cost of Averting a Ton of CO_2-eq Heating (CATCH) was introduced in my project thesis and it will be utilized in my master thesis as well, but slightly different. The change is the benefit which was considered as the fuel costs savings last time, but will now include the net income increase. The lost income caused be lower capacity at reduced speed will be taken into account. Notice that CATCH includes the cost of replacing lost capacity, which might not be necessary in the spot market when maximizing the net income at reduced speed.

BW Clipper (former Berge Clipper)

Figure 1 BW Clipper - Courtesy Shipping Publications AS

Ship segment	LPG carrier
Built	1992
Deadweight	56 864 tons
Length overall	224 meters
Length between perpendiculars	213 meters
Breadth moulded	36 meters
Draught	12.4 meters
Depth	21.8 meters
Displacement	75 723 tons
Load capacity	44 000 tons
Volume capacity	78 530 m^3
Engine	Sulzer 7RTA62
Total power, initially	13 086 kW @ 101 RPM
Service power, initially	11 760 kW
Service speed, initially	16.7 knots

Table 3 Specifications for BW Clipper

The data above is collected from Sea-web (Lloyd's Register, 2010). MAN B&W Diesel defines the relationship between engine power and ship speed as:

$$P = cV^4$$

for a medium-sized, medium-speed ship where c is a constant (MAN B&W Diesel, 2005). I use this formula to estimate the power demand at 20 knots speed which is the required top speed. The speed window for the fleet is ranging from 14 to 20 knots. Since the function is defined I get a value for the constant c by implementing the service power and service speed into the function. The engine power demand at max speed 20 knots is the new total engine power maximum continuous rating. The value for the constant c is 0.1512. The power-speed function for BW Clipper Is illustrated in Figure 2. At 20 knots 24 200 kW is needed, which is about twice as much as the power demand at the original service speed 16.7 knots.

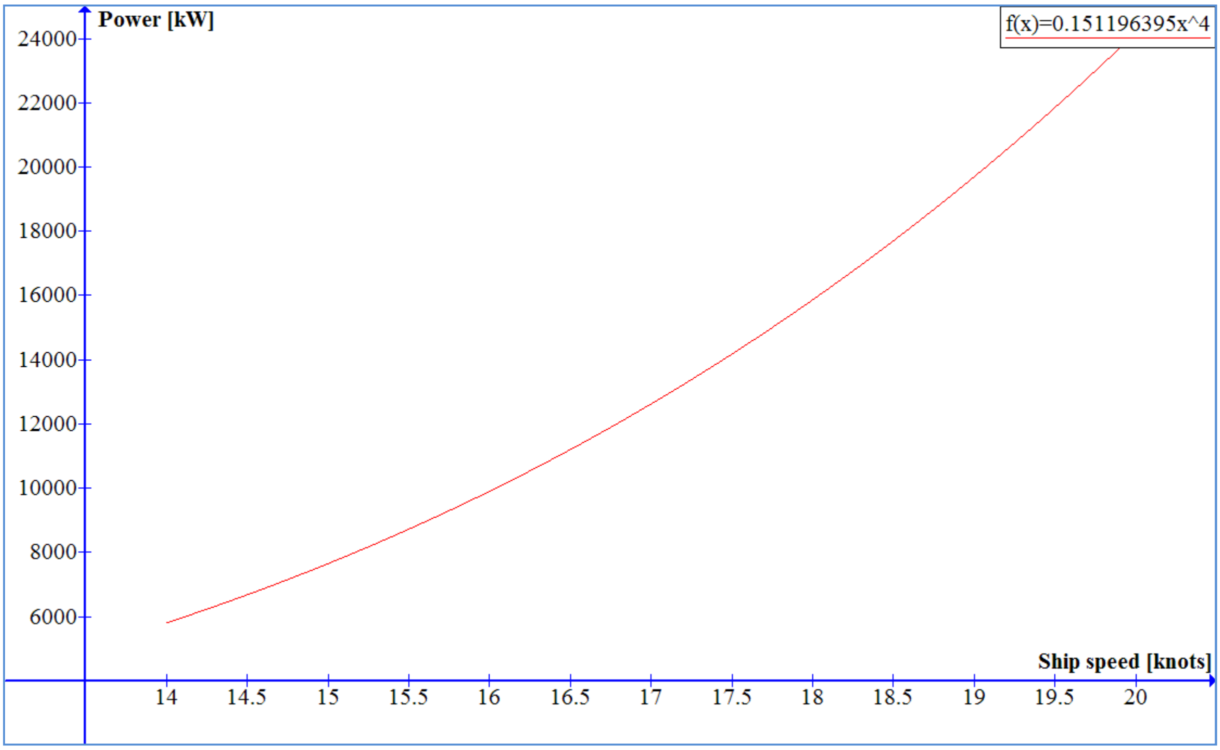


Figure 2 Power speed diagram for BW Clipper

Since the function is in the power of 4 relatively small speed increases yield significant power increases. The power demand at 20 knots is about fourfold as large as the power demand at 14 knots.

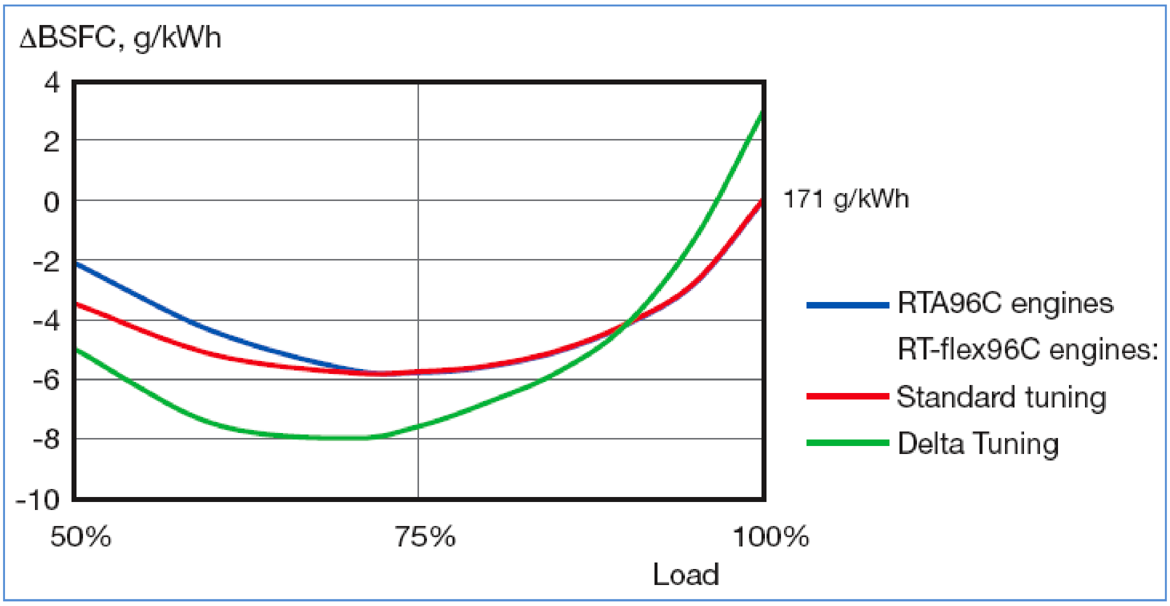


Figure 3 Specific fuel oil consumption for Sulzer RTA96C engines – Courtesy Wärtsilä

Figure 3 illustrates the SFOC for Sulzer RTA96C engines which has larger bore area than our RTA62. However I assume the SFOCs is similar by advice from Professor Maurice White (White, 2010). The blue line is used for further calculations in this report which is identical with the red line between 75% load and 100% load. Since this diagram only applies for loads between 50% and 100% I perform a regression for the load range between 0% and 50%. The function is a biquadration with 99,24% accuracy. This is illustrated in Figure 4.

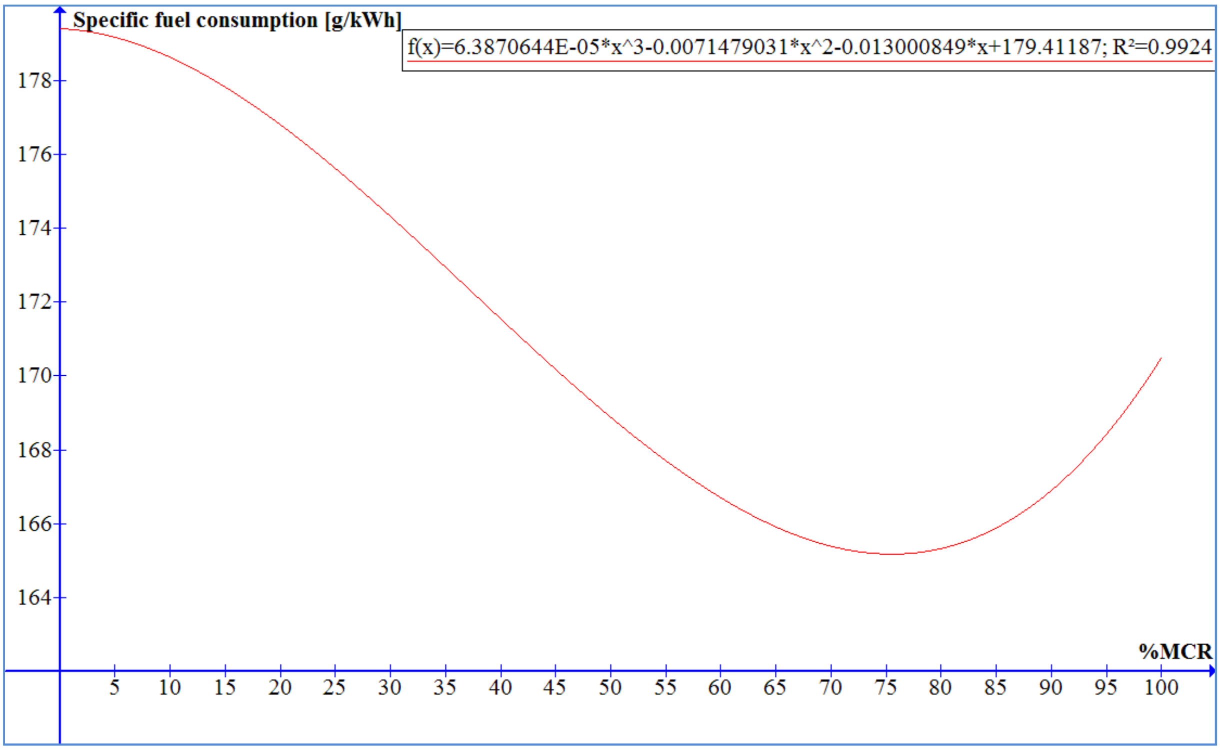


Figure 4 Specific fuel oil consumption RTA96C regression

The fuel consumption can be found by multiplying the SFOC with the power demand and the inverse speed. I performed this procedure in Excel with a 0.5 knot interval for speeds between 14 and 20 knots. A regression by the power of 4 is done and the results are illustrated in Figure 5 with 99.86% accuracy. BW Clipper consumes 2.7 times more fuel at 20 knots as she consumes at 14 knots.

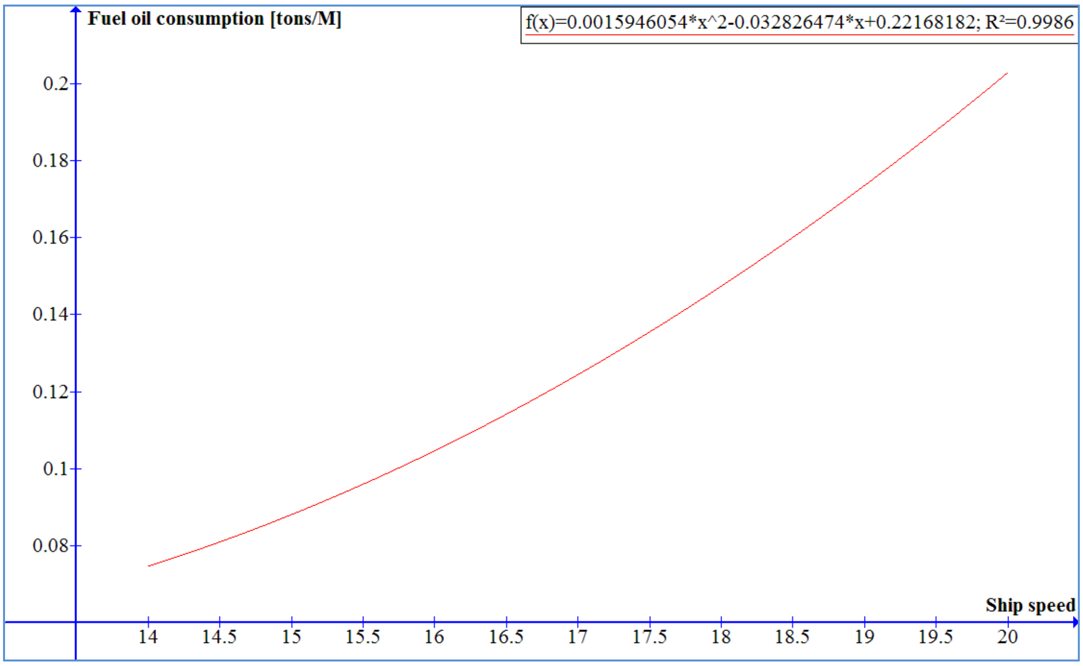


Figure 5 Fuel consumption for BW Clipper

BW Saga (former Berge Saga)

Figure 6 BW Saga - Courtesy Vesseltracker

Ship segment	LPG carrier	
Built	1979	
Deadweight	55 303 tons	
Length overall	225 meters	
Length between perpendiculars	216 meters	
Breadth moulded	34.2 meters	
Draught	10.8 meters	
Depth	21.6 meters	
Displacement	75 603 tons	
Load capacity	44 000 tons	
Volume capacity	78 530 m^3	
Engine	Sulzer 7RND90M	
Total power, initially	17 247 kW @ 122 RPM	
Service power, initially	14 660 kW	*assume 85% MCR
Service speed, initially	16.7 knots	

Table 4 Specifications for BW Saga

The same assumptions and calculations are done on BW Saga as for BW Clipper. The service power is not given for BW Saga, however I assume the service power is 85% of the maximum continuous rating since this relation applies for BW Clipper. BW Saga is the oldest ship in the fleet and it has a prime mover which is on average 15% less fuel efficient compared to the prime mover installed in BW Clipper (Schmid & Weisser, 2005). To reach 20 knots speed the engine needs to deliver 30 200 kW. The data presented in Table 4 is cited from Sea-web (Lloyd's Register, 2010).

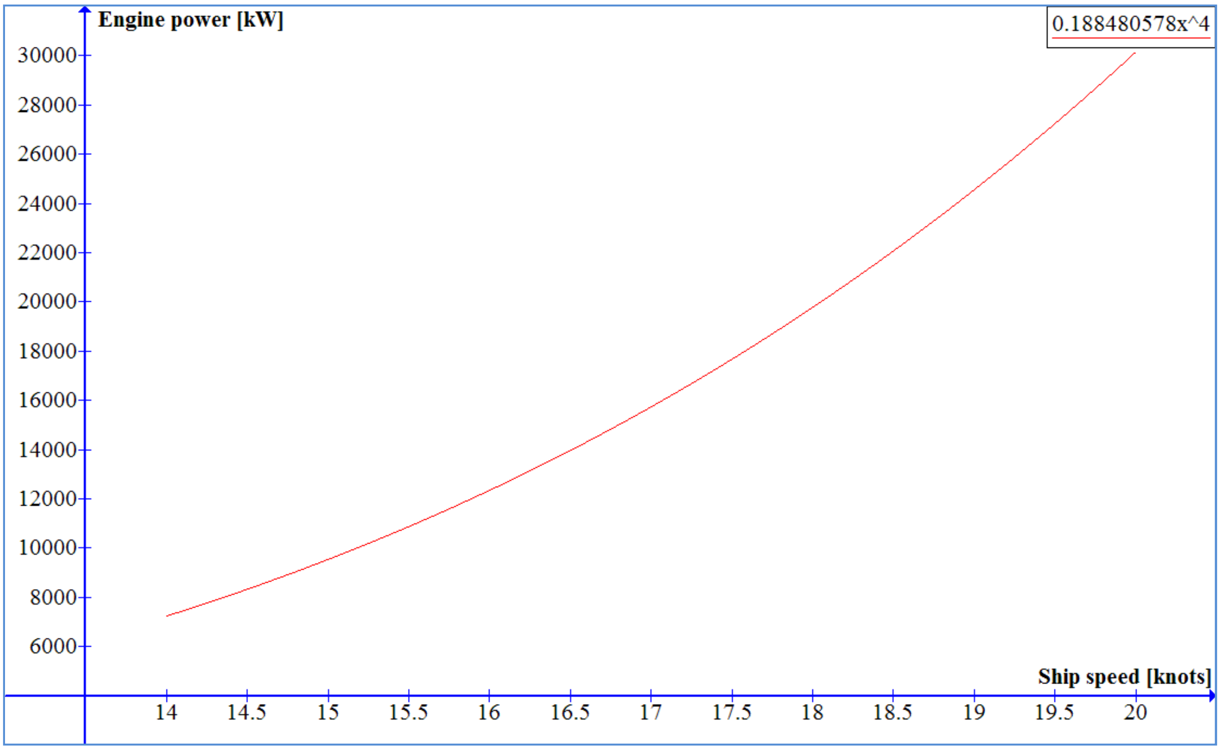


Figure 7 Power speed diagram for BW Saga & Gas Beauty I

Since the service power and service speed for BW Saga and Gas Beauty I is identical the vessels have an identical power-speed curve as presented in Figure 7.

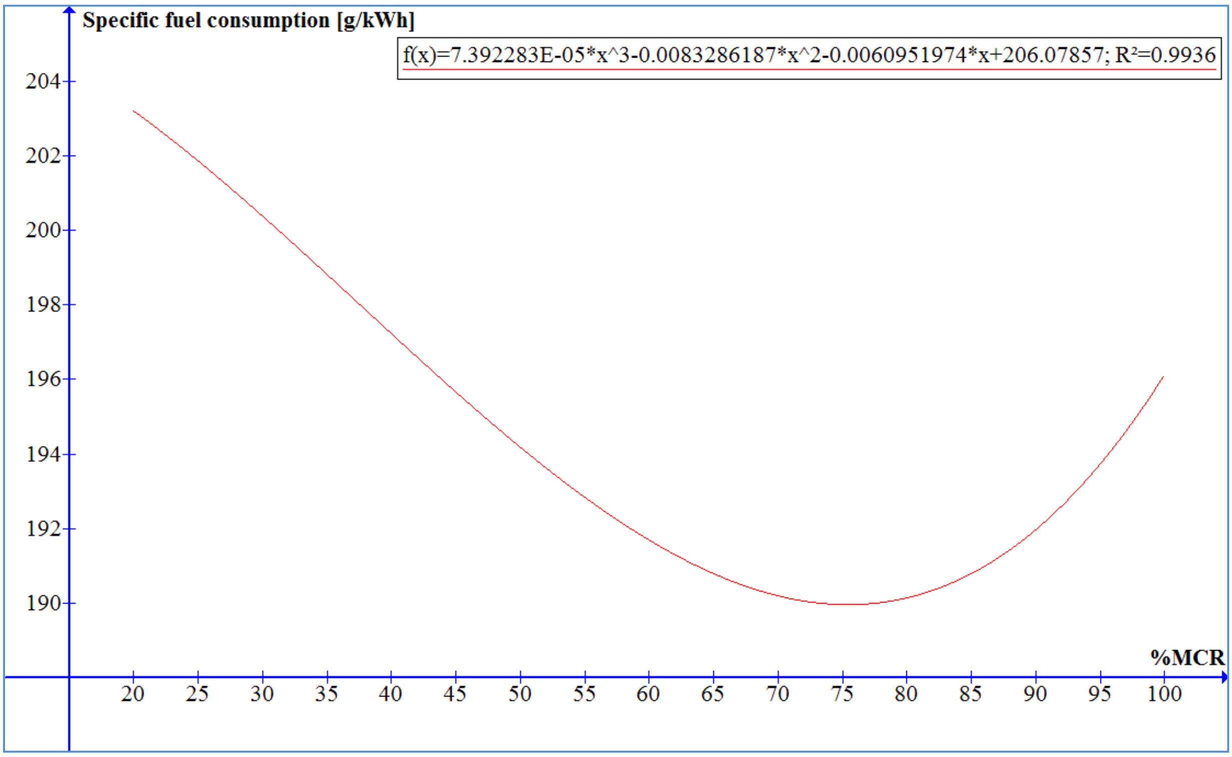


Figure 8 Specific fuel oil consumption for Sulzer RND90M engines

The optimum operating point in terms of SFOC is found approximately at 75% MCR.

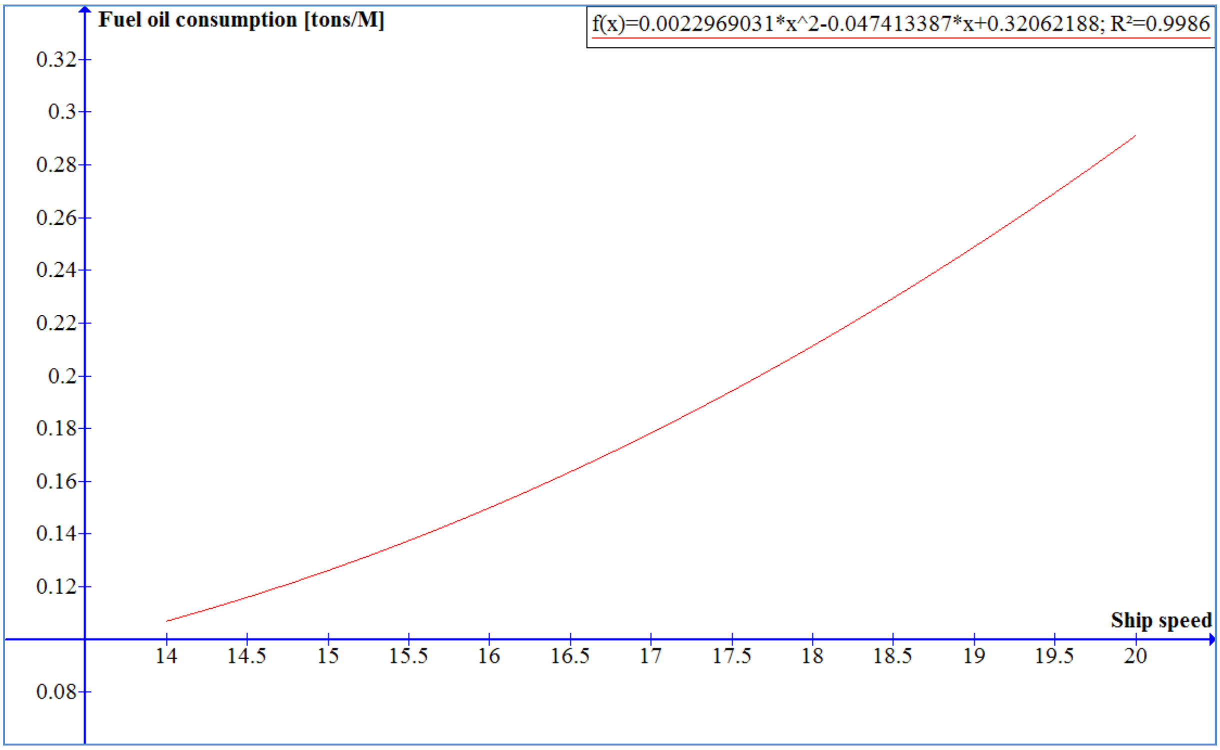


Figure 9 Fuel consumption for BW Saga & Gas Beauty I

BW Saga and Gas Beauty I consume 0.107 tons fuel per mile at 14 knots speed and 0.291 tons at 20 knots speed. As for BW Clipper the relationship between the fuel consumption at 20 knots and 14 knots is the same, however BW Saga and Gas Beauty I consume 43% more fuel on average. BW Clipper is a younger ship which is more efficient as it needs 3 000 kW less to sail at the initial service speed of 16.7 knots. This difference will prove to be essential in the later calculations.

Gas Beauty I (former Berge Strand)

Figure 10 Gas Beauty 1 – Courtesy Vesseltracker

Ship segment	LPG carrier
Built	1982
Deadweight	55 361 tons
Length overall	225 meters
Length between perpendiculars	216 meters
Breadth moulded	34.2 meters
Draught	10.8 meters
Depth	21.6 meters
Displacement	75 661 tons
Load capacity	44 000 tons
Volume capacity	78 530 m^3
Engine	Sulzer 7RND90M
Total power, initially	17 247 kW @ 122 RPM
Service power, initially	14 660 kW
Service speed, initially	16.7 knots

Table 5 Specifications for Gas Beauty I

Gas Beauty I has the same preferences as BW Saga in terms of fuel consumption, initial service speed and prime mover figures. If the ship is to reach 20 knots speed under the prevailing ship design her output power must be more than twofold as large. The figures in Table 5 are cited from Sea-web (Lloyd's Register, 2010).

Maharshi Vamadeva (former Helice)

Figure 11 Maharshi Vamadeva – Courtesy Vesseltracker

Ship segment	LPG carrier
Built	1991
Deadweight	44 995 tons
Length overall	205 meters
Length between perpendiculars	194 meters
Breadth moulded	32.2 meters
Draught	12.2 meters
Depth	20.0 meters
Displacement	61 089 tons
Load capacity	33 000 tons
Volume capacity	57 160 m^3
Engine	Sulzer 6RTA62
Total power	11 393 kW @ 106 RPM
Max speed	16 knots
Service power	9 690 kW
Service speed	14.5 knots

Table 6 Specifications for Maharshi Vamadeva

The following ships Maharshi Vamadeva, BW Helios and BW Havfrost have similar performances, sizes and loading capacities. The same calculations as for the previous ships are done for these ships. The loading capacity for the latter ships are lower counting 33 000 tons versus 44 000 tons for the former ships. The service speed is also lower with 14.5 knots. These vessels are equipped with the RTA62 engine which is more efficient than the RND90 engine, but since the service speed is relatively low the prime mover needs to deliver three times as much power as for the initial situation. The data presented in Table 6 are cited from Sea-web (Lloyd's Register, 2010).

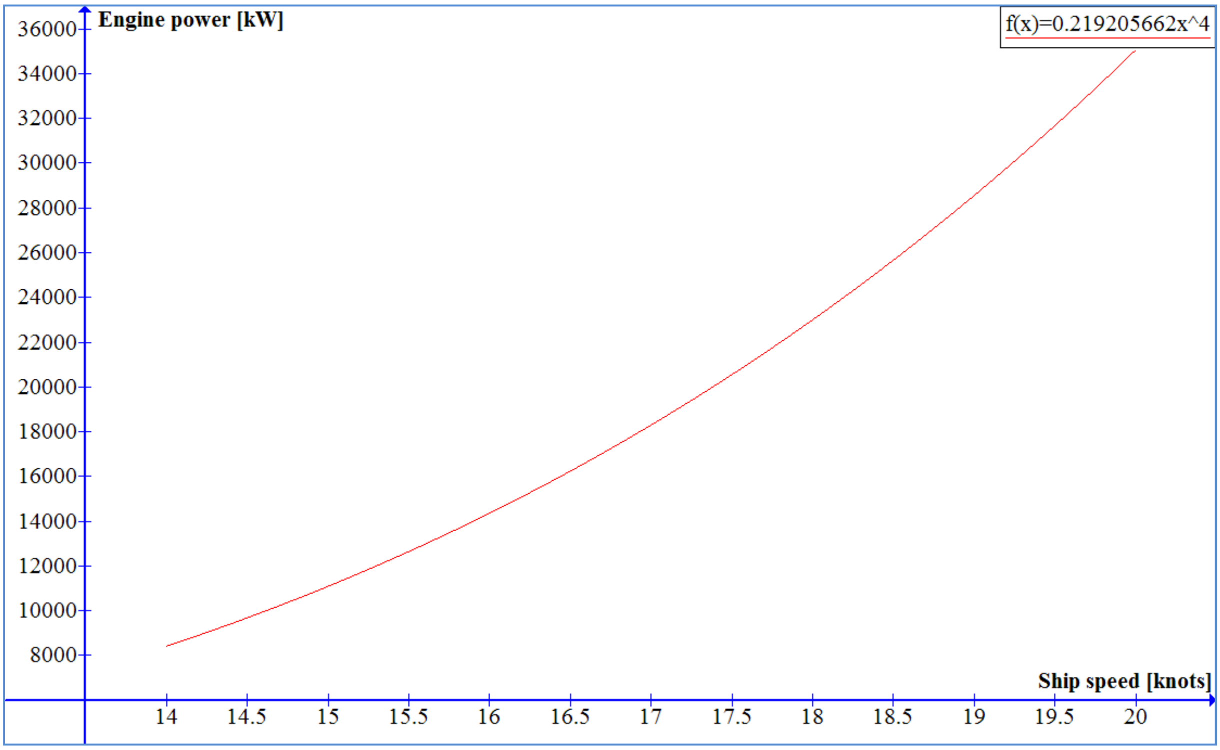


Figure 12 Power speed diagram for Maharshi Vamadeva, BW Helios & BW Havfrost

The SFOC for Maharshi Vamadeva, BW Helios and BW Havfrost is identical to BW Clipper's figures as the prime mover is similar. A regression of the fuel consumption for the prevailing ships is illustrated in Figure 13 and its accuracy is 99.86%. At 14 knots the fuel consumption per mile is 0.11 tons while it is 0.29 tons at 20 knots.

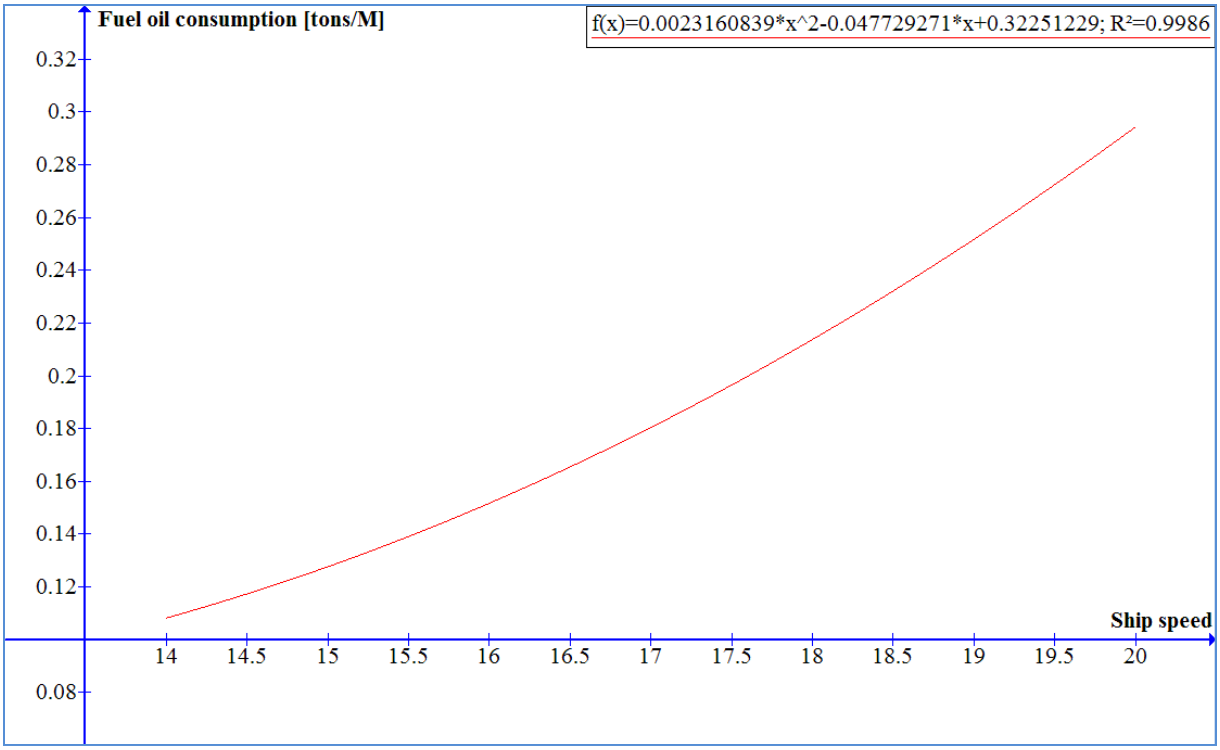


Figure 13 Fuel consumption for Maharshi Vamadeva, BW Helios & BW Havfrost

BW Helios (former Helios)

Figure 14 BW Helios – Courtesy Shipping Publications AS

Ship segment	LPG carrier
Built	1992
Deadweight	44 995 tons
Length overall	205 meters
Length between perpendiculars	194 meters
Breadth moulded	32.2 meters
Draught	12.2 meters
Depth	20.0 meters
Displacement	61 089 tons
Load capacity	33 000 tons
Volume capacity	57 160 m^3
Engine	Sulzer 6RTA62
Total power	11 393 kW @ 106 RPM
Max speed	16 knots
Service power	9 690 kW
Service speed	14.5 knots

Table 7 Specifications for BW Helios

BW Helios is similar to Maharshi Vamadeva with regards to performances, laoding capacity and size. I will therefore refer to the section above for the fuel consumption calculations. The data in Table 7 are collected from Sea-web (Lloyd's Register, 2010).

BW Havfrost (former Havfrost)

Figure 15 BW Havfrost – Courtesy Shipping Publications AS

Ship segment	LPG carrier
Built	1991
Deadweight	44 995 tons
Length overall	205 meters
Length between perpendiculars	194 meters
Breadth moulded	32.2 meters
Draught	12.2 meters
Depth	20.0 meters
Displacement	61 089 tons
Load capacity	33 000 tons
Volume capacity	57 160 m^3
Engine	Sulzer 6RTA62
Total power	11 393 kW @ 106 RPM
Max speed	16 knots
Service power	9 690 kW
Service speed	14.5 knots

Table 8 Specifications for BW Havfrost

BW Havfrost is similar to the latter two ships and the fuel consumption is therefore identical as well. The data in Table 8 are collected from Sea-web (Lloyd's Register, 2010).

Fuel consumption for the fleet

In Figure 16 I compare the fuel consumptions for the vessels in the fleet. BW Clipper has a far better fuel efficiency compared to the other ships in the fleet mainly because she is equipped with the RTA62 engine and she is designed for higher speeds than the latter three vessels. BW Saga and Gas Beauty I do not differ much in hull shape and dimensions compared to BW Clipper but have outdated prime movers with relatively low efficiency. Maharshi Vamadeva, BW Helios and BW Havfrost must increase their max speed by 4 knots and this significant increase demands vast amounts of power and hence large amounts of fuel. The fuel demand for BW Clipper at 14 knots is halved compared to the rest of the fleet.

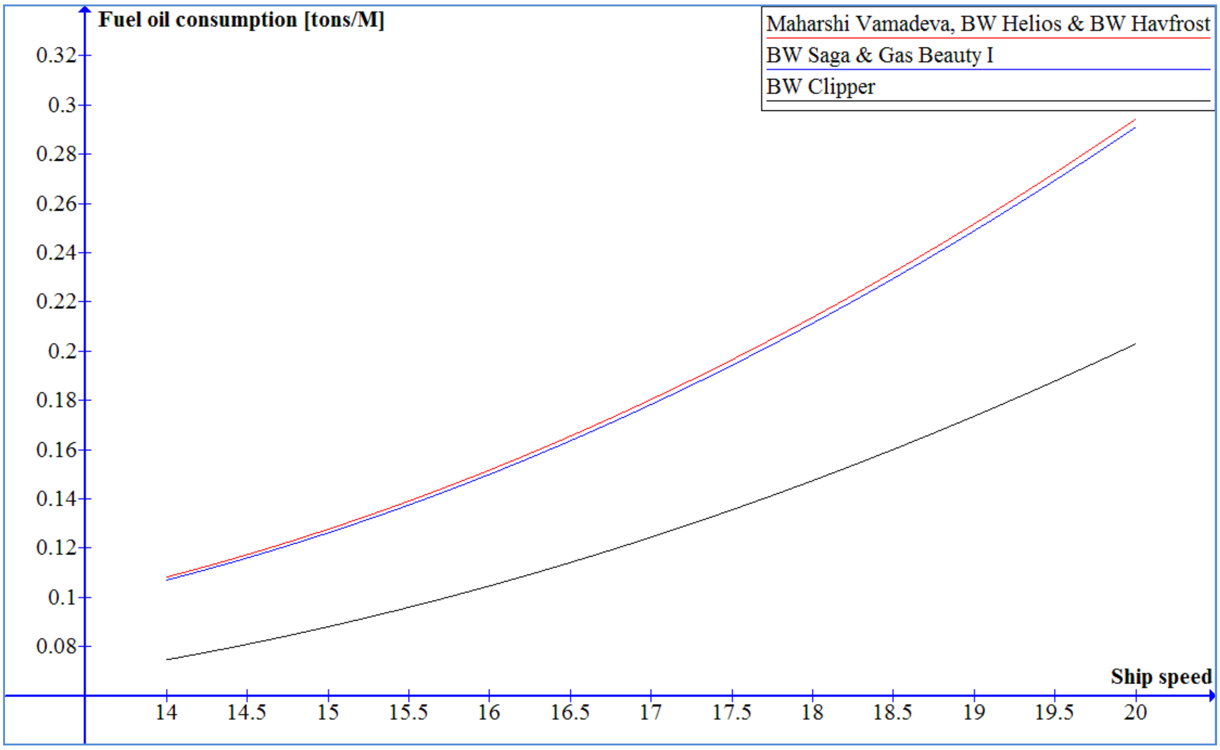


Figure 16 Fuel consumption for fleet

Orders

In this case there are 18 orders defined between various international harbors. The orders have time windows for loading and discharging operations confirming when the transportation can be carried out. The orders will be contracted by the shipping company in charge of the presented fleet. The agreement will be stated in contracts of affreightment, COA. The shipping company will execute tramp shipping serving customers on COAs and spot market.

Details for the orders are attached in the appendices. The essence of the orders is listed in Table 9. The time windows for discharging are significantly larger than the time windows for loading. The difference in transit times for average speeds of 14 and 20 knots is listed. One has to decide whether a ship should arrive early or late and take into account the benefits and the costs by the strategy chosen. This will be discussed later in the report.

Order	Load window	Load start	Discharge window	Discharge start	Transit time 14 knots [days:hours]	Transit time 20 knots [days:hours]
1	3 days	11.10.2007	60 days	21.09.2007	11:09	07:23
2	3 days	10.11.2007	60 days 23 hrs	21.10.2007	11:09	07:23
3	3 days	11.12.2007	423 days	21.11.2006	11:09	07:23
4	6 days	21.09.2007	59 days 23 hrs	21.09.2007	07:18	05:10
5	6 days	21.10.2007	60 days 23 hrs	21.10.2007	07:18	05:10
6	3 days	01.10.2007	59 days 23 hrs	21.09.2007	15:02	10:13
7	3 days	21.10.2007	60 days 23 hrs	21.10.2007	15:02	10:13
8	3 days	17.11.2007	61 days	17.11.2007	15:02	10:13
9	11 days	06.12.2007	55 days	06.12.2007	19:02	13:09
10	3 days	17.10.2007	64 days 23 hrs	17.10.2007	04:18	03:08
11	368 days	10.11.2007	41 days	10.11.2007	04:18	03:08
12	6 days	31.10.2007	70 days	31.10.2007	04:18	03:08
13	2 days	15.10.2007	49 days 23 hrs	15.10.2007	06:02	04:06
14	6 days 23 hrs	23.10.2007	49 days 23 hrs	23.10.2007	06:02	04.06
15	3 days	15.12.2007	56 days 23 hrs	15.12.2007	06:02	04:06
16	11 days	21.11.2007	57 days	21.11.2007	24:22	17:10
17	11 days 23 hrs	26.10.2007	66 days 23 hrs	26.10.2007	24:22	17:10
18	5 days 23 hrs	23.10.2007	60 days 23 hrs	23.10.2007	06:02	04:06

Table 9 Time schedule for orders

Table 10 is an outline of the cargo weight, volume and value. Vast differences in cargo values are prevailing. The orders and the cargo values are set by Inge Norstad (Norstad, 2010) and implemented into TURBOROUTER (MARINTEK, 2010).

Order	Cargo weight	Cargo volume	Cargo value
1	44 000 tons	73 333 m^3	1 804 000 USD
2	44 000 tons	73 333 m^3	1 804 000 USD
3	44 000 tons	73 333 m^3	1 804 000 USD
4	33 000 tons	55 000 m^3	1 072 500 USD
5	33 000 tons	55 000 m^3	1 072 500 USD
6	44 000 tons	73 333 m^3	880 000 USD
7	44 000 tons	73 333 m^3	880 000 USD
8	44 000 tons	73 333 m^3	880 000 USD
9	44 000 tons	73 333 m^3	930 000 USD
10	33 000 tons	55 000 m^3	594 000 USD
11	33 000 tons	55 000 m^3	825 000 USD
12	33 000 tons	55 000 m^3	825 000 USD
13	31 200 tons	52 000 m^3	624 000 USD
14	31 200 tons	52 000 m^3	312 000 USD
15	31 200 tons	52 000 m^3	624 000 USD
16	33 000 tons	55 000 m^3	1 171 500 USD
17	44 000 tons	73 333 m^3	1 430 000 USD
18	44 000 tons	73 333 m^3	1 540 000 USD

Table 10 Cargo measurements

Ship deployment

There are 3 ships which are able to carry 44 000 tons of LPG and 3 ships able to transport 33 000 tons of LPG in the fleet. The orders range from 31 200 tons to 44 000 of LPG. It is adequate to handle each order with only one shipment hence the 3 largest ships handle the largest loads. The ship deployment is done by utilization of TURBOROUTER (MARINTEK, 2010).

Order / Ship	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BW Clipper						X					X						X	X
BW Saga	X		X					X										
Gas Beauty I		X					X		X									
M. Vamadeva										X		X						
BW Helios													X	X	X			
BW Havfrost				X	X											X		

Table 11 Ship deployment

Fuel prices

The fuel costs are important in shipping and the oil prices fluctuate. The variations in oil price for Brent spot from 1987 to 2009 is shown in Figure 17 (Energy Information Administration and Bureau of Labor Statistics, 2010). These variations are a result of the global economies and the demand and supply of oil. These variations do occur as do the freight rates for LPG on spot. These parameters can of course not be controlled by shipping companies, however the ship speed strategy can be optimized for a maximal profit.

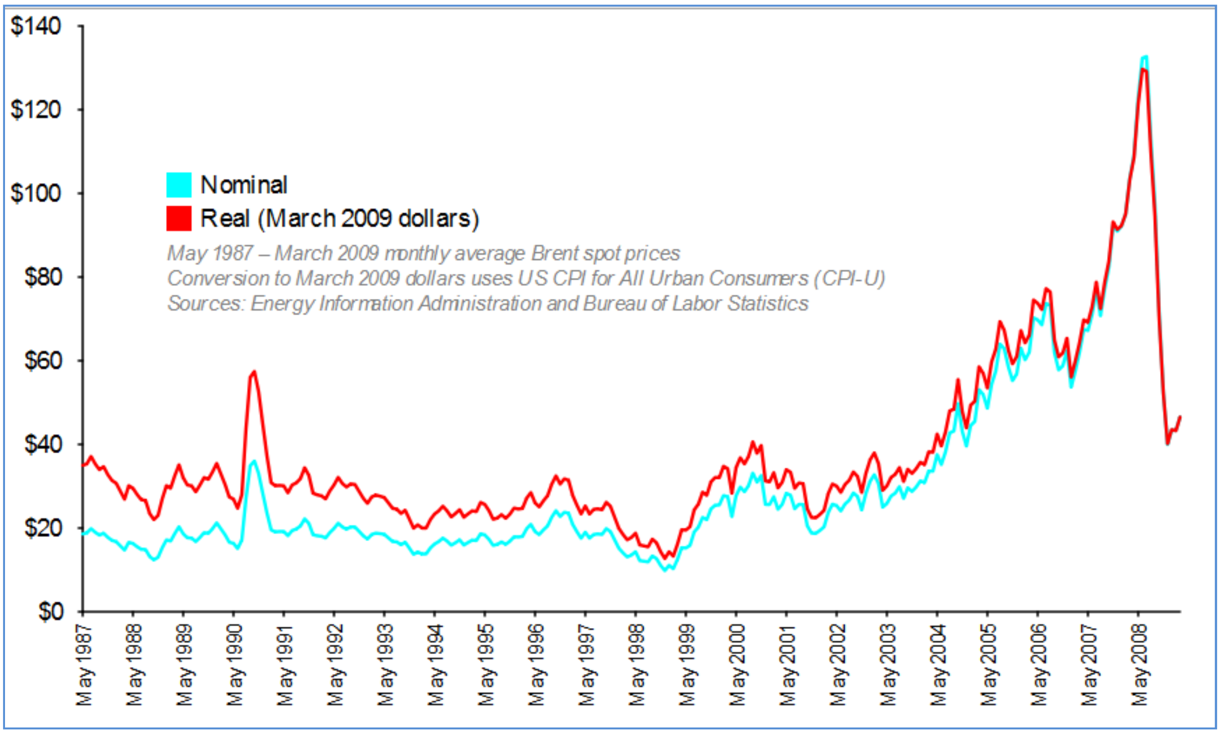
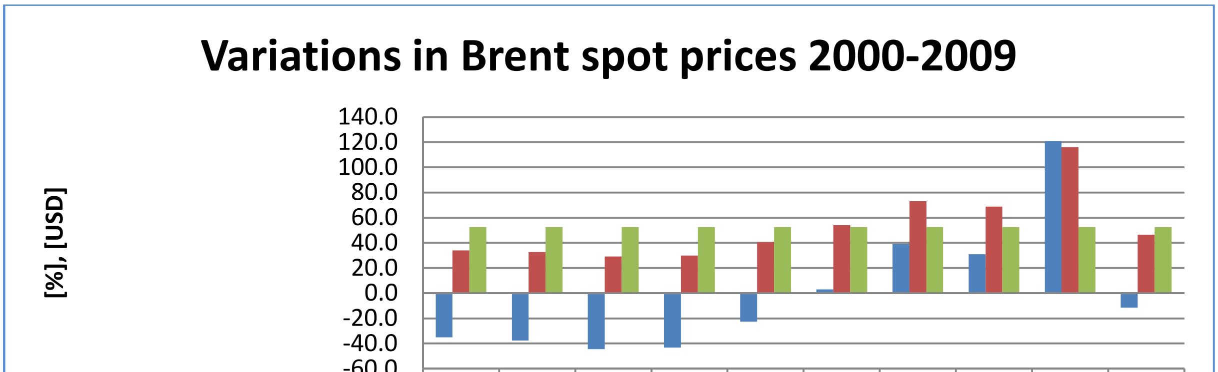


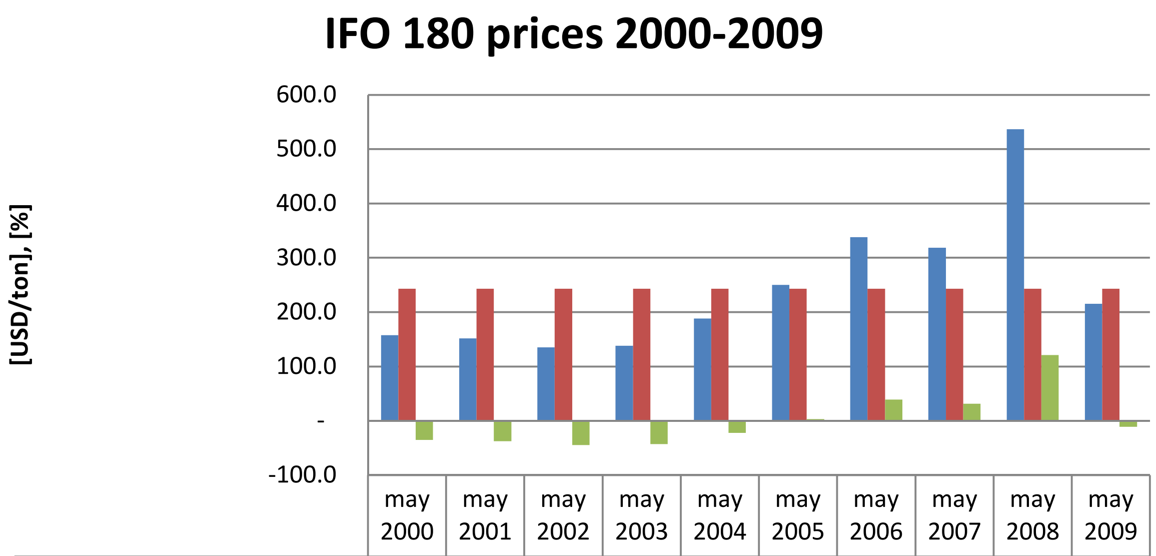
Figure 17 Brent spot prices [USD/ton] – Courtesy to EIABLS



	may 2000	may 2001	may 2002	may 2003	may 2004	may 2005	may 2006	may 2007	may 2008	may 2009
Variaton in Brent spot price vs average [%]	-35.1	-37.6	-44.4	-43.2	-22.6	3.0	39.2	31.1	121.0	-11.4
Brent spot prices [USD]	34.1	32.8	29.2	29.8	40.7	54.1	73.1	68.9	116.1	46.6
Average Brent spot price [USD]	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5

Figure 18 Variations in Brent spot prices

Brent spot is crude oil from the North Sea. The vessels in the fleet consume IFO 180, intermediate fuel oil with maximum viscosity of 180 Centistokes (Shipping Publications AS, 2010). In Figure 18 I have calculated the average Brent spot price between 2000 and 2009 and listed the variations of each year's price level compared to the average level. The average IFO 180 price from 2000 to 2008 was 243 USD/ton in Amsterdam (Eide, Endresen, Skjong, Longva, & Alvik, 2009). I let this be the average price and let the IFO 180 have the same annual variations as Brent spot. This is presented in Figure 19.



	may 2000	may 2001	may 2002	may 2003	may 2004	may 2005	may 2006	may 2007	may 2008	may 2009
IFO 180 [USD/ton]	157.8	151.7	135.0	138.0	188.1	250.3	338.3	318.5	537.0	215.4
Average IFO 180 price [USD]	243	243	243	243	243	243	243	243	243	243
Variation in IFO 180 price [%]	-35.1	-37.6	-44.4	-43.2	-22.6	3.0	39.2	31.1	121.0	-11.4

Figure 19 Estimated IFO 180 prices

The COAs will be executed between August 2006 and December 2007. By a linear approach I find the IFO 180 priced to 328.4 USD/ton in December 2006 and 427.8 USD/ton in December 2007. The average value for the prevailing period is therefore 353.3 USD/ton.

BW Clipper – COA

BW Clipper is assigned to deliver 4 contracted orders. The operations will run smoothly with only one major period in standby mode if delays don't occur. The wait period is 400 days which can be used in the spot market trade. The data presented in the schedule tables, the port cost and the commissioning costs for the ships was implemented into TURBOROUTER by Inge Norstad (Norstad, 2010).

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Ras Tanura		27.08.2006	00:00	1 day	400 days 1 hr	02.10.2007	01:00
Suez canal	11 hrs	08.10.2007	23:24	11 hrs		09.10.2007	10:24
Algeciras		13.10.2007	12:15	1 day		14.10.2007	12:15
Suez canal	11 hrs	19.10.2007	01:06	11 hrs		19.10.2007	12:06
Ras Tanura		25.10.2007	23:31	1 day		26.10.2007	23:31
Tuticorin		31.10.2007	05:39	1 day		01.11.2007	05:39
Jabung		04.11.2007	22:30	1 day		05.11.2007	22:30
Suez canal	11 hrs	16.11.2007	22:19	11 hrs		17.11.2007	09:19
Rotterdam		24.11.2007	06:48	1 day		25.11.2007	06:48
Arzew		28.11.2007	14:54	1 day		29.11.2007	14:54
Rotterdam		02.12.2007	23:00	1 day		03:12.2007	23:00

Table 12 Schedule for BW Clipper at 20 knots

The fuel consumption will be proportional to the sailed distance when the speed is kept steady. The port costs and the commissioning costs will vary with time and location.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Ras Tanura		20			100 000	
Suez canal	3108	20	631			
Algeciras	1957	20	398		80 000	17 600
Suez canal	1957	20	398			
Ras Tanura	3108	20	631		100 000	
Tuticorin	2043	20	415		75 000	30 800
Jabung	1777	20	361		80 000	
Suez canal	5057	20	1 026			
Rotterdam	3310	20	672		100 000	28 600
Arzew	1602	20	325		65 000	
Rotterdam	1602	20	325		90 000	16 500
TOTAL	**25 520**		**5 182**	**1 829 200**	**690 000**	**93 500**

Table 13 Costs for BW Clipper at 20 knots

The Suez transit charges are significant since the Suez Canal is passed 3 times. A detailed calculation of the Suez transit charges is attached in the appendices. The calculation is done by implementing BW Clipper's ship dimensions into the online tariff calculator from Leth Agencies (Leth Agencies, 2010).

Location	Voyage	Order –operation	Suez transit charges [USD]	Gross freight [USD]
Ras Tanura	1	6-load		
Suez canal	1-northbound		364 800	
Algeciras	1	6-unload		880 000
Suez canal	2-southbound		313 600	
Ras Tanura	2	18-load		
Tuticorin	2	18-unload		1 540 000
Jabung	3	17-load		
Suez canal	3-northbound		364 800	
Rotterdam	3	17-unload		1 430 000
Arzew	4	11-load		
Rotterdam	4	11-unload		825 000
TOTAL			**1 043 200**	**4 675 000**

Table 14 COA details for BW Clipper

I have investigated the effects of speed reductions in this report with focus upon the economical and the environmental aspects. The extremities of the feasible speeds are evaluated in this section. Table 15 shows the schedule for 14 knots transit.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Ras Tanura		27.08.2006	00:00	1 day	400 days 1 hr	02.10.2007	01:00
Suez canal	11 hrs	11.10.2007	18:01	11 hrs		12.10.2007	05:01
Algeciras		18.10.2007	00:48	1 day		19.10.2007	00:48
Suez canal	11 hrs	25.10.2007	07:35	11 hrs		25.10.2007	18:35
Ras Tanura		04.11.2007	00:36	1 day		05.11.2007	00:36
Tuticorin		11.11.2007	02:30	1 day		12.11.2007	02:30
Jabung		17.11.2007	09:26	1 day		18.11.2007	09:26
Suez canal	11 hrs	03.12.2007	21:37	11 hrs		04.12.2007	08:37
Rotterdam		14.12.2007	05:00	1 day		15.11.2007	05:00
Arzew		19.12.2007	23:26	1 day		20.12.2007	23:26
Rotterdam		25.12.2007	17:52	1 day		26:12.2007	17:52

Table 15 Schedule for BW Clipper at 14 knots

At 14 knots speed large fuel savings are made while the other costs are kept constant. Since the shipments will be delivered within the time windows it is reasonable to sail at 14 knots if the shipping company operates merely on contracts of affreightment. A speed reduction from 20 to 14 knots will decrease the fuel consumption and hence the greenhouse gas emissions by 63%. Although the calculations are based on rough estimates it is evident that the potential for GHG reductions by speed reductions is large.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Ras Tanura		14			100 000	
Suez canal	3108	14	232			
Algeciras	1957	14	146		80 000	17 600
Suez canal	1957	14	146			
Ras Tanura	3108	14	232		100 000	
Tuticorin	2043	14	152		75 000	30 800
Jabung	1777	14	133		80 000	
Suez canal	5057	14	377			
Rotterdam	3310	14	247		100 000	28 600
Arzew	1602	14	120		65 000	
Rotterdam	1602	14	120		90 000	16 500
TOTAL	**25 520**		**1 905**	**672 500**	**690 000**	**93 500**

Table 16 Costs for BW Clipper at optimized speed

The overall costs for BW Clipper's fixed routes are illustrated in Figure 20. The fuel costs increase with increasing speed. The fixed costs are independent to speed variations if all routes are covered. The fixed costs consist of port costs (690 000 USD), commissioning costs (93 500 USD) and Suez transit costs (1 043 200 USD). The sum of the costs is therefore increasing with increased speed.

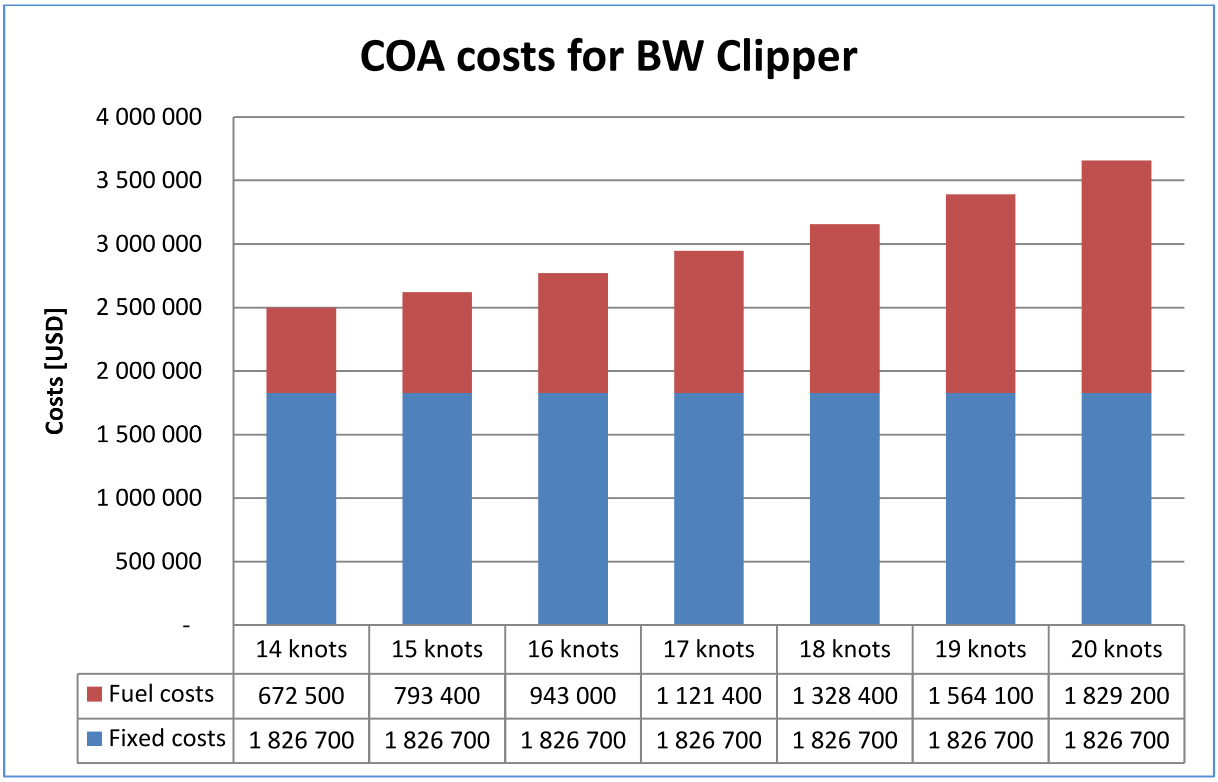
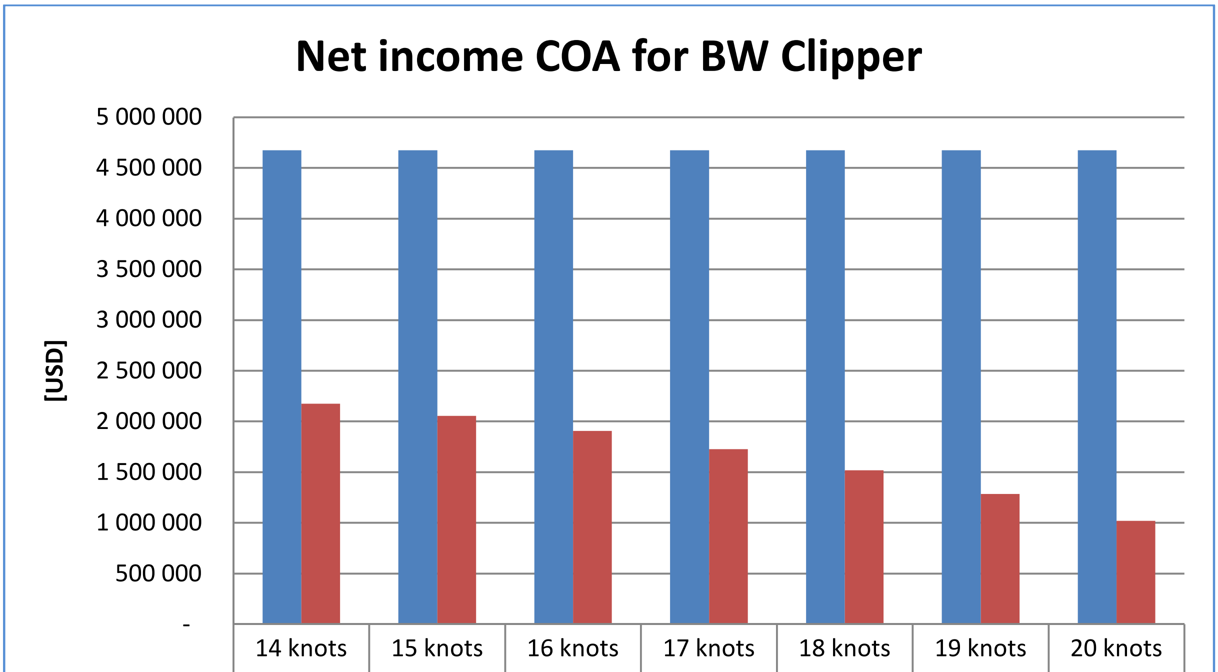


Figure 20 COA cost for BW Clipper

The gross freight of the pay load is decided before the shipment takes place and speed variations will due to this not affect the freight rates. The only parameter that changes with speed is fuel expenses and this will cause a variation in net income as well. Figure 21 describes the benefit of slow steaming when only taking the fixed routes into account for BW Clipper. The advantage of BW Clipper is her low fuel consumption and high payload capacity.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	4 675 000	4 675 000	4 675 000	4 675 000	4 675 000	4 675 000	4 675 000
Net income	2 175 800	2 054 900	1 905 300	1 726 900	1 519 900	1 284 200	1 019 100

Figure 21 Net income COA for BW Clipper

BW Saga - COA

BW Saga is assigned to 3 orders mainly supplying customers north of Suez with Saudi-Arabic and Indonesian LPG. The idle time for BW Saga is approximately 420 days if she sails at 20 knots fixed speed constantly.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Algeciras						27.08.2006	00:00
Suez canal	11 hrs	31.08.2006	12:50	11 hrs		31.08.2006	23:50
Yanbu		02.09.2006	01:08	1 day	404 days	12.10.2007	01:00
Suez canal	11 hrs	13.10.2007	13:17	11 hrs		14.10.2007	00:17
Rotterdam		20.10.2007	21:46	1 day		21.10.2007	21:46
Suez canal	11 hrs	29.10.2007	06:14	11 hrs		29.10.2007	17:14
Ras Tanura		05.11.2007	04:39	1 day	11 days 19 hrs	18.11.2007	00:00
Suez canal	11 hrs	24.11.2007	22:24	11 hrs		25.11.2007	09:24
Algeciras		29.11.2007	11:15	1 day		30.11.2007	11:15
Suez canal	11 hrs	05.12.2007	00:06	11 hrs		05.12.2007	11:06
Yanbu		06.12.2007	12:24	1 day	4 days 12 hrs	12.12.2007	00:00
Suez canal	11 hrs	13.12.2007	12:17	11 hrs		13.12.2007	23:17
Rotterdam		20.12.2007	20:46	1 day		21.12.2007	20:46

Table 17 Schedule for BW Saga at 20 knots

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Algeciras		20				
Suez canal	1957	20	570			
Yanbu	506	20	147		80 000	36 100
Suez canal	506	20	147			
Rotterdam	3310	20	963		100 000	
Suez canal	3310	20	963			
Ras Tanura	3108	20	905		100 000	
Suez canal	3108	20	905			
Algeciras	1957	20	570		80 000	17 600
Suez canal	1957	20	570			
Yanbu	506	20	147		80 000	
Suez canal	506	20	147			
Rotterdam	3310	20	963		100 000	36 100
TOTAL	**24 040**		**6 999**	**2 470 600**	**540 000**	**89 800**

Table 18 Costs for BW Saga at 20 knots

As for BW Clipper the fuel costs is dominating at 20 knots, however since BW Saga frequently passes the Suez Canal her Suez transit expenses are significant at a level which is nearly 80% of the fuel cost.

Location	Voyage	Order -operation	Suez transit charges[USD]	Gross freight [USD]
Algeciras	1			
Suez canal	1-southbound		310 200	
Yanbu	1	1-load		
Suez canal	1-northbound		348 500	
Rotterdam	1	1-unload		1 804 000
Suez canal	2-southbound		310 200	
Ras Tanura	2	8-load		
Suez canal	2-northbound		348 500	
Algeciras	2	8-unload		880 000
Suez canal	3-southbound		310 200	
Yanbu	3	3-load		
Suez canal	3-northbound		348 500	
Rotterdam	3	3-unload		1 804 000
TOTAL			**1 976 100**	**4 488 000**

Table 19 COA details for BW Saga

Luckily the gross freights are high giving approximately 1.5 million USD per shipment. The effects of speed reductions will prove to be important for this case as high incomes are to some degree counteracted for by severe costs.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Algeciras						27.08.2006	00:00
Suez canal	11 hrs	02.09.2006	06:46	11 hrs		02.09.2006	17:46
Yanbu		04.09.2006	05:55	1 day	401 days 19 hrs	12.10.2007	01:00
Suez canal	11 hrs	14.10.2007	00:08	11 hrs		14.10.2007	11:08
Rotterdam		24.10.2007	07:31	1 day		25.10.2007	07:31
Suez canal	11 hrs	04.11.2007	14:55	11 hrs		05.11.2007	01:55
Ras Tanura		14.11.2007	07:56	1 day	2 days 16 hrs	18.11.2007	00:00
Suez canal	11 hrs	27.11.2007	17:01	11 hrs		28.11.2007	04:01
Algeciras		03.12.2007	23:48	1 day		04.12.2007	23:48
Suez canal	11 hrs	11.12.2007	06:35	11 hrs		11.12.2007	17:35
Yanbu		13.12.2007	05:43	1 day		14.12.2007	05:43
Suez canal	11 hrs	16.12.2007	04:52	11 hrs		16.12.2007	15.52
Rotterdam		26.12.2007	12.15	1 day		27.12.2007	12:15

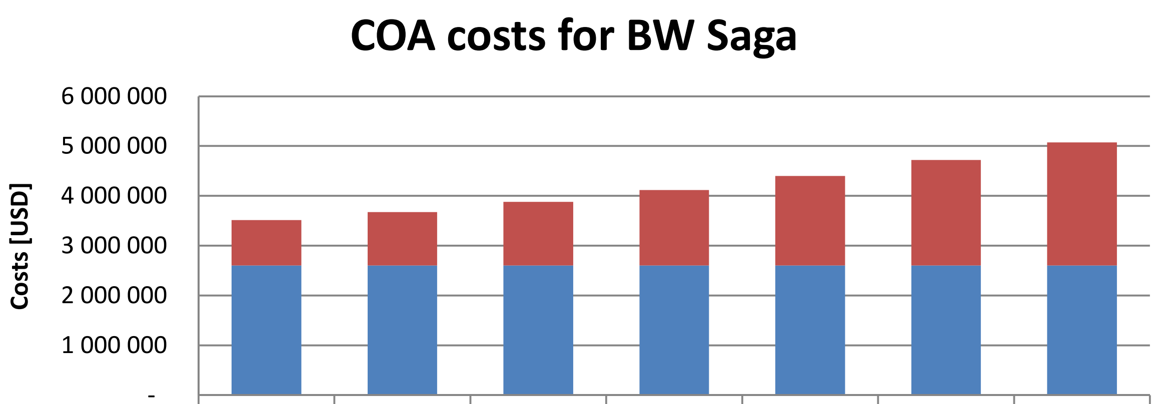
Table 20 Schedule for BW Saga at optimized speed

By reducing the speed from 20 to 14 knots for BW Saga additional 15 days will be spent in transit.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Algeciras		14				
Suez canal	1957	14	209			
Yanbu	506	14	54		80 000	36 100
Suez canal	506	14	54			
Rotterdam	3310	14	354		100 000	
Suez canal	3310	14	354			
Ras Tanura	3108	14	333		100 000	
Suez canal	3108	14	333			
Algeciras	1957	14	209		80 000	17 600
Suez canal	1957	14	209			
Yanbu	506	14	54		80 000	
Suez canal	506	14	54			
Rotterdam	3310	14	354		100 000	36 100
TOTAL	**24 040**		**2 573**	**908 300**	**540 000**	**89 800**

Table 21 Cost for BW Saga at optimized speed

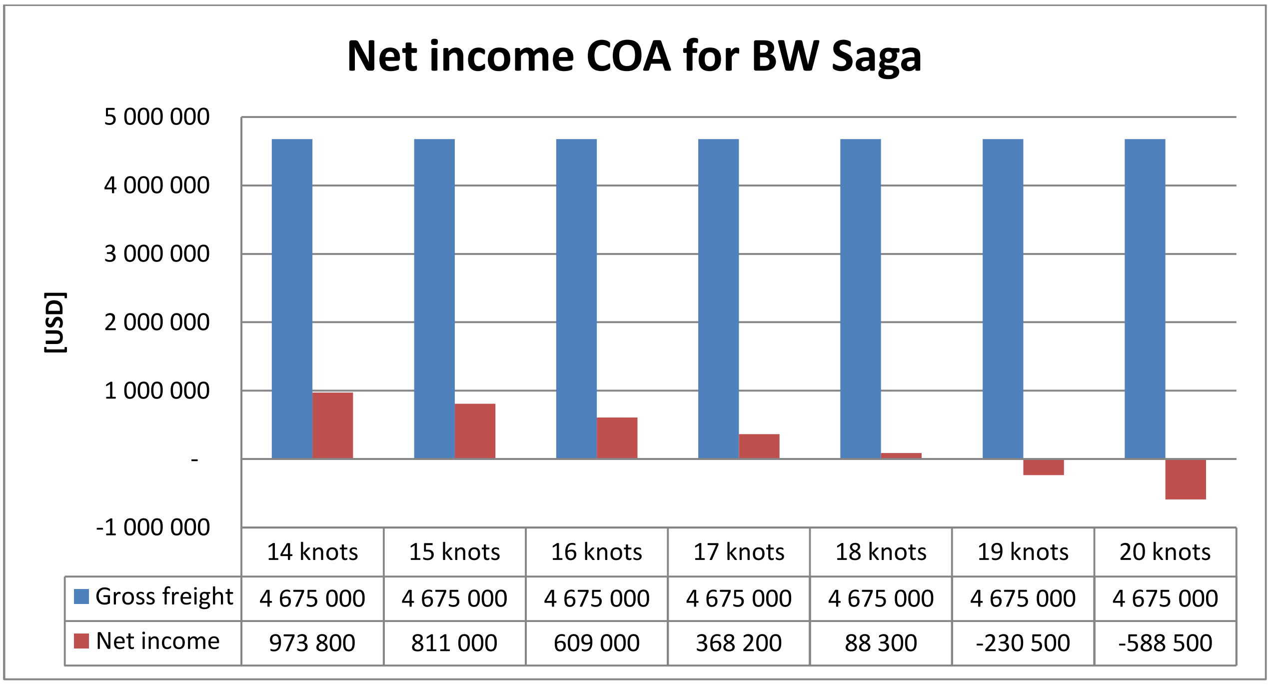
As for BW Clipper the fuel consumption is reduced by 63% when shifting the speed from 20 to 14 knots. At 20 knots speed the fuel costs and the fixed costs are almost equal, while the fuel costs only are 38% of the fixed costs at 14 knots.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Fuel costs	908 300	1 071 100	1 273 100	1 513 900	1 793 800	2 112 600	2 470 600
Fixed costs	2 605 900	2 605 900	2 605 900	2 605 900	2 605 900	2 605 900	2 605 900

Figure 22 COA costs for BW Saga

Frequent Suez Canal passages cause high Suez transit charges and this can result in negative net income. BW Saga sailed through Suez two times for each voyage, in total six times and despite large incomes from high valued gross freight it will only be sustainable at low speed as illustrated in Figure 23.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	4 675 000	4 675 000	4 675 000	4 675 000	4 675 000	4 675 000	4 675 000
Net income	973 800	811 000	609 000	368 200	88 300	-230 500	-588 500

Figure 23 Net income COA for BW Saga

Gas Beauty I - COA

Gas Beauty I will transport three shipments between harbors north and south of Suez. The idle time for the ship when sailing at 20 knots speed on average is approximately 407 days.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Rotterdam						27.08.2006	00:00
Suez canal	11 hrs	03.09.2006	08:28	11 hrs		03.09.2006	19:28
Ras Tanura		10.09.2006	06:53	1 day	405 days 18 hrs	22.10.2007	01:00
Suez canal	11 hrs	28.10.2007	23:24	11 hrs		29.10.2007	10:24
Algeciras		02.11.2007	12:15	1 day		03.11.2007	12:15
Suez canal	11 hrs	08.11.2007	01:06	11 hrs		08.11.2007	12:06
Yanbu		09.11.2007	13:24	1 day	10 hrs 35 min	11.11.2007	00:00
Suez canal	11 hrs	12.11.2007	12:17	11 hrs		12.11.2007	23:17
Rotterdam		19.11.2007	20:46	1 day		20.11.2007	20:46
Suez canal	11 hrs	28.11.2007	05:14	11 hrs		28.11.2007	16:14
Ras Tanura		05.12.2007	03:39	1 day	20 hrs 20 min	07.12.2007	00:00
Suez canal	11 hrs	13.12.2007	22.24	11 hrs		14.12.2007	09:24
Rotterdam		21.12.2007	06:53	1 day		22.12.2007	06:53

Table 22 Schedule for Gas Beauty I at 20 knots

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Rotterdam		20				
Suez canal	3310	20	963			
Ras Tanura	3108	20	905		80 000	36 100
Suez canal	3108	20	905			
Algeciras	1957	20	570		100 000	
Suez canal	1957	20	570			
Yanbu	506	20	147		100 000	
Suez canal	506	20	147			
Rotterdam	3310	20	963		80 000	17 600
Suez canal	3310	20	963			
Ras Tanura	3108	20	905		80 000	
Suez canal	3108	20	905			
Rotterdam	3310	20	963		100 000	36 100
TOTAL	**30 600**		**8 907**	**3 144 200**	**540 000**	**89 800**

Table 23 Costs for Gas Beauty I at 20 knots

Gas Beauty I will pass the Suez Canal frequently and her gross freight value will be lower than for BW Saga. As BW Saga barely made a profit it is evident that Gas Beauty I will have difficulties as the Suez transit charges are large and her gross freight value is relatively low. Savings can be made by slow steaming as usual.

Location	Voyage	Order -operation	Suez transit charges [USD]	Gross freight [USD]
Rotterdam	1			
Suez canal	1-southbound		310 200	
Ras Tanura	1	1-load		
Suez canal	1-northbound		360 700	
Algeciras	1	1-unload		880 000
Suez canal	2-southbound		310 200	
Yanbu	2	8-load		
Suez canal	2-northbound		360 700	
Rotterdam	2	8-unload		1 804 000
Suez canal	3-southbound		310 200	
Ras Tanura	3	3-load		
Suez canal	3-northbound		360 700	
Rotterdam	3	3-unload		930 000
TOTAL			**2 012 700**	**3 614 000**

Table 24 COA details for Gas Beauty I

The effects of slow steaming will be better utilization of the vessel as depicted in Table 25 where the waiting time is reduced by 7 days which only appears in Ras Tanura.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Rotterdam						27.08.2006	00:00
Suez canal	11 hrs	06.09.2006	07:23	11 hrs		06.09.2006	18:23
Ras Tanura		16.09.2006	00:24	1 day	400 days 1 hr	22.10.2007	01:00
Suez canal	11 hrs	31.10.2007	03:13	11 hrs		31.10.2007	14:13
Algeciras		06.11.2007	00:41	1 day		07.11.2007	00:41
Suez canal	11 hrs	12.11.2007	22:08	11 hrs		13.11.2007	09:08
Yanbu		14.11.2007	18:52	1 day		15.11.2007	18:52
Suez canal	11 hrs	17.11.2007	18:01	11 hrs		18.11.2007	05:01
Rotterdam		28.11.2007	01:24	1 day		29.11.2007	01:24
Suez canal	11 hrs	09.12.2007	08:48	11 hrs		09.12.2007	19:48
Ras Tanura		19.12.2007	01:49	1 day		20.12.2007	01:49
Suez canal	11 hrs	29.12.2007	18:50	11 hrs		30.12.2007	05:50
Rotterdam		09.01.2008	02:13	1 day		10.01.2008	02:13

Table 25 Schedule for Gas Beauty I at optimized speed

In order to fulfill her commitments Gas Beauty I cannot sail at 14 knots speed for every transit in order to reach the time windows. See the appendices for details.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Rotterdam		14				
Suez canal	3310	14	354			
Ras Tanura	3108	14	333		80 000	36 100
Suez canal	3108	15	392			
Algeciras	1957	15	247		100 000	
Suez canal	1957	15	247			
Yanbu	506	15	64		100 000	
Suez canal	506	14	54			
Rotterdam	3310	14	354		80 000	17 600
Suez canal	3310	14	354			
Ras Tanura	3108	14	333		80 000	
Suez canal	3108	14	333			
Rotterdam	3310	14	354		100 000	36 100
TOTAL	**30 600**		**3 419**	**1 206 900**	**540 000**	**89 800**

Table 26 Costs for Gas Beauty I at optimized speed

The label "optimized speed" from Figure 24 takes into account that speed must be raised from 14 knots to 15 knots on some voyages to make the deliveries with reference to Table 26.

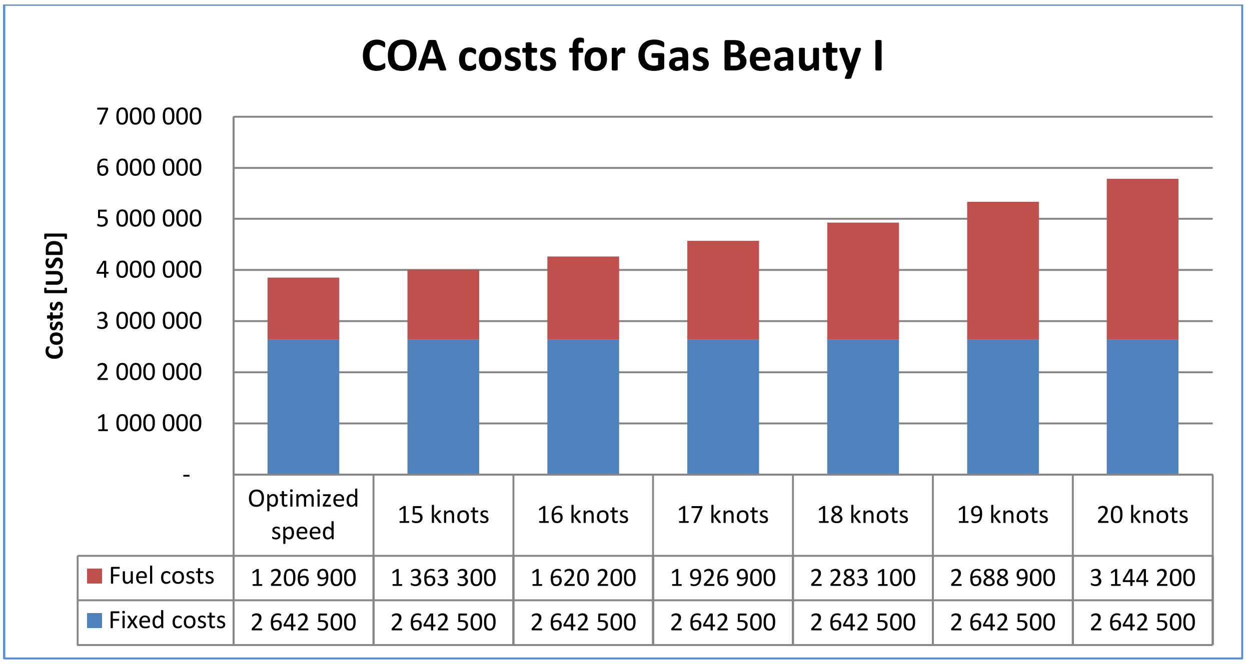
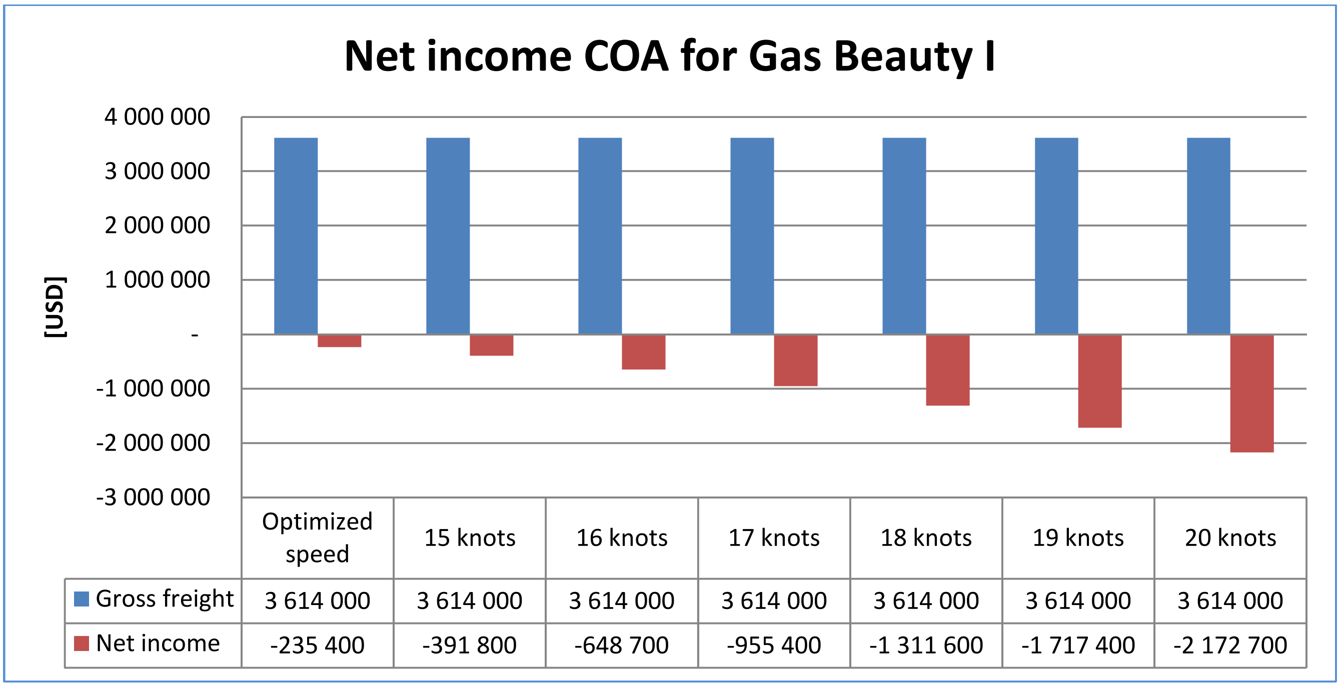


Figure 24 COA costs for Gas Beauty I

As mentioned above the net income for Gas Beauty I will be negative at the prevailing conditions described. A thorough contract evaluation will be necessary to decline some of the orders. Anyhow, the effect of speed reductions is tremendous for Gas Beauty I as the losses are reduced by over 2 million USD between 20 knots and optimized speed.



	Optimized speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	3 614 000	3 614 000	3 614 000	3 614 000	3 614 000	3 614 000	3 614 000
Net income	-235 400	-391 800	-648 700	-955 400	-1 311 600	-1 717 400	-2 172 700

Figure 25 Net income COA for Gas Beauty I

Maharshi Vamadeva - COA

Maharshi Vamadeva is the first out of three ships in the fleet with a loading capacity of 33 000 tons and she is only assigned to carry two shipments. When Maharshi Vamadeva follows a 20 knots speed strategy she will be idle for 421 days in the period.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Arzew		27.08.2006	00:00	1 day	416 days 1 hr	18.10.2007	01:00
Rotterdam		21.10.2007	09:06	1 day		22.10.2007	09:06
Arzew		25.10.2007	17:12	1 day	5 days 7 hrs	01.11.2007	00:00
Rotterdam		04.11.2007	08:06	1 day		05.11.2007	08:06

Table 27 Schedule for Maharshi Vamadeva at 20 knots

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Arzew		20			65 000	
Rotterdam	1 602	20	472		90 000	11 800
Arzew	1 602	20	472		65 000	
Rotterdam	1 602	20	472		90 000	16 500
TOTAL	4 810		1 416	338 300	310 000	28 300

Table 28 Costs for Maharshi Vamadeva at 20 knots

The distance between Arzew and Rotterdam is far shorter than the other legs and due to this the fuel consumption will be low. Since the Suez Canal is not part of the route savings will be made. The port costs are almost as high as the fuel costs.

Location	Voyage	Order -operation	Suez transit fee [USD]	Gross freight [USD]
Arzew	1	10-load		
Rotterdam	1	10-unload		594 000
Arzew	2	12-load		
Rotterdam	2	12-unload		825 000
TOTAL				1 419 000

Table 29 COA details for Gas Beauty I

By sailing at 14 knots speed constantly additional 3 days will be needed in transit.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Arzew		27.08.2006	00:00	1 day	416 days 1 hr	18.10.2007	01:00
Rotterdam		22.10.2007	19:25	1 day		23.10.2007	19:25
Arzew		28.10.2007	13:51	1 day	2 days 10 hrs	01.11.2007	00:00
Rotterdam		05.11.2007	18:25	1 day		06.11.2007	18:25

Table 30 Schedule for Maharshi Vamadeva at optimized speed

The fuel cost-port cost ratio will decrease substantially from 1.09 to 0.59 at 14 knots. The fuel consumption will be reduced by 63% by slow steaming at 14 knots.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Arzew		14			65 000	
Rotterdam	1 602	14	173		90 000	11 800
Arzew	1 602	14	173		65 000	
Rotterdam	1 602	14	173		90 000	16 500
TOTAL	**4 810**		**519**	**183 600**	**310 000**	**28 300**

Table 31 Costs for Maharshi Vamadeva at optimized speed

The fuel expenses are 2.7-fold larger at 20 knots compared to the situation at 14 knots. About 92% of the fixed costs is port costs.

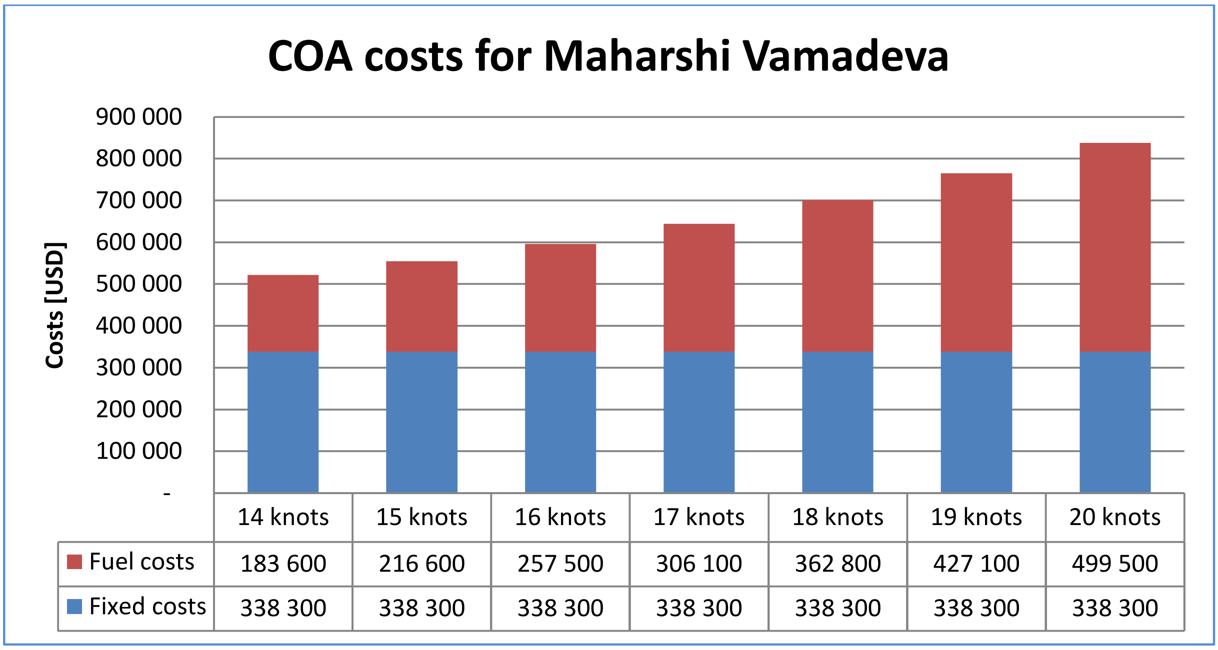
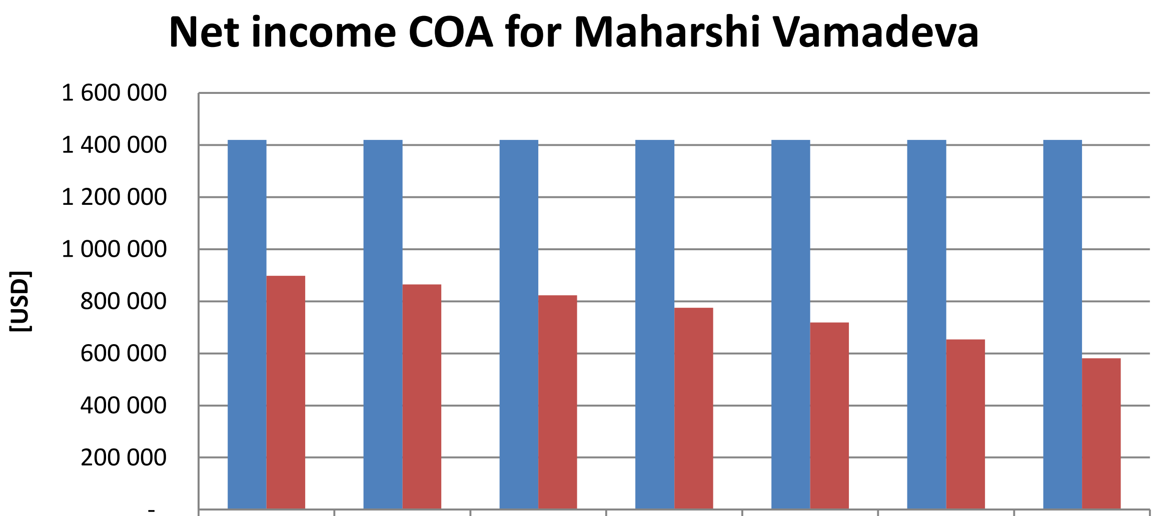


Figure 26 COA costs for Maharshi Vamadeva

Since Maharshi Vamadeva can carry less freight compared to the former ships she will not be utilized as much since her loading capacity is lower than some of the shipments. Since Maharshi Vamadevas activity is at a low level for the fixed market her gross freight values are low as well. However, since her total costs are low she will deliver solid net income.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	1 419 000	1 419 000	1 419 000	1 419 000	1 419 000	1 419 000	1 419 000
Net income	897 100	864 100	823 200	774 600	717 900	653 600	581 200

Figure 27 Net income COA for Maharshi Vamadeva

BW Helios - COA

BW Helios will operate between Saudi-Arabia, India and Indonesia and since there will be no transits through Suez no Suez transit charges will be made. BW Helios is assigned to deliver 3 orders and with a speed of 20 knots she will have 455 idle days for the period.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Ras Tanura		27.08.2006	00:00	1 day	414 days 1 hr	16.10.2007	01:00
Tuticorin		20.10.2007	07:07	1 day		21.10.2007	07:07
Jabung		24.10.2007	23:58	1 day		25.10.2007	23:58
Tuticorin		29.10.2007	16:50	1 day		30.10.2007	16:50
Ras Tanura		03.11.2007	22:57	1 day	41 days 1 hr	16.12.2007	00:00
Tuticorin		20.12.2007	06:07	1 day		21.12.2007	06:07

Table 32 Schedule for BW Helios at 20 knots

BW Helios is nearly identical to Maharshi Vamadeva in terms of size and propulsion parameters, but she will cover larger distances and an additional order and this will give larger fuel consumption. For Maharshi Vamadeva the fuel costs were about the same as the port costs, but the situation for BW Helios is different since she will cover larger distances with lower port call frequency.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Ras Tanura		20			90 000	
Tuticorin	2 043	20	601		60 000	12 500
Jabung	1 777	20	523		70 000	
Tuticorin	1 777	20	523		60 000	6 200
Ras Tanura	2 043	20	601		90 000	
Tuticorin	2 043	20	601		60 000	12 500
TOTAL	**9 680**		**2 850**	**1 006 100**	**430 000**	**31 200**

Table 33 Costs for BW Helios at 20 knots

The gross freight value is essentially lower for BW Helios compared to the values for the first 3 ships.

Location	Voyage	Order -operation	Suez transit charges[USD]	Gross freight [USD]
Ras Tanura	1	13-load		
Tuticorin	1	13-unload		624 000
Jabung	2	14-load		
Tuticorin	2	14-unload		312 000
Ras Tanura	3	15-load		
Tuticorin	3	15-unload		624 000
TOTAL				**1 560 000**

Table 34 COA details for BW Helios

By reducing the average speed to 14 knots additional 7 days will be spent in transit.

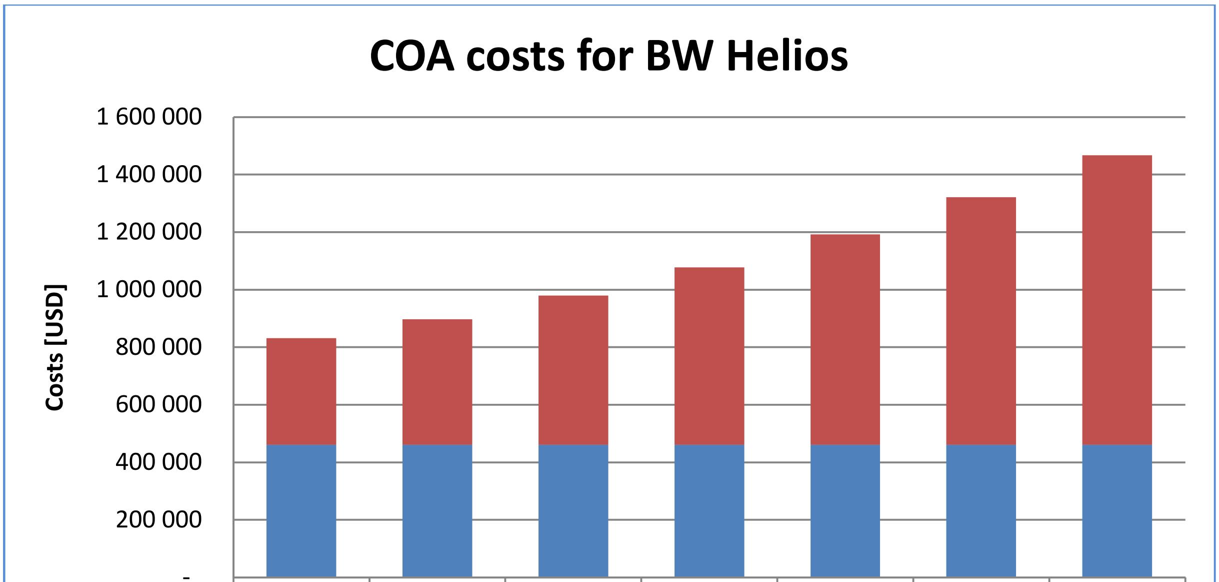
Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Ras Tanura		27.08.2006	00:00	1 day	414 days 1 hr	16.10.2007	01:00
Tuticorin		22.10.2007	02:53	1 day		23.10.2007	02:53
Jabung		28.10.2007	09:49	1 day		29.10.2007	09:49
Tuticorin		03.11.2007	16:45	1 day		04.11.2007	16:45
Ras Tanura		10.11.2007	18:39	1 day	34 days 5 hrs	16.12.2007	00:00
Tuticorin		22.12.2007	01:53	1 day		23.12.2007	01:53

Table 35 Schedule for BW Helios at optimized speed

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Ras Tanura		14			90 000	
Tuticorin	2 043	14	221		60 000	12 500
Jabung	1 777	14	192		70 000	
Tuticorin	1 777	14	192		60 000	6 200
Ras Tanura	2 043	14	221		90 000	
Tuticorin	2 043	14	221		60 000	12 500
TOTAL	**9 680**		**1 048**	**369 900**	**430 000**	**31 200**

Table 36 Costs for BW Helios at optimized speed

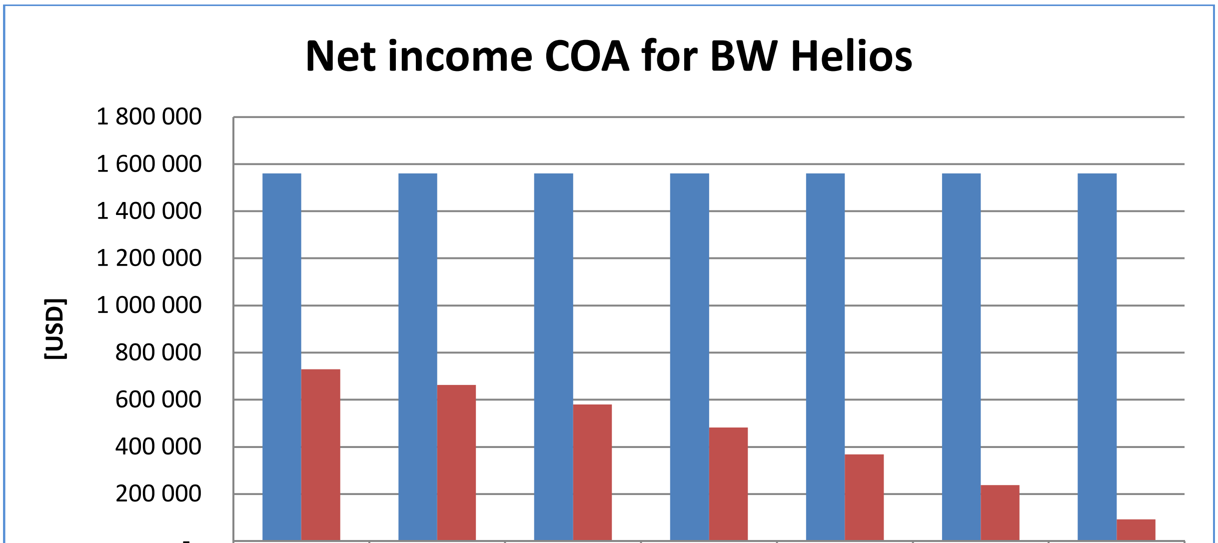
At the baseline of 20 knots speed the fuel costs exceed one million USD and at 14 knots it is down to 369 900 USD, a 63% reduction as for the other ships. The reduction measured in percentages is on the same level due the similarity within the fuel consumption curves.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Fuel costs	369 900	436 400	518 700	616 700	730 700	860 400	1 006 100
Fixed costs	461 200	461 200	461 200	461 200	461 200	461 200	461 200

Figure 28 COA costs for BW Helios

The effect of speed reduction will be conspicuous for BW Helios because the net income is close to 100 000 USD at 20 knots while it is over 7-fold as large at 14 knots speed.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	1 560 000	1 560 000	1 560 000	1 560 000	1 560 000	1 560 000	1 560 000
Net income	728 900	662 400	580 100	482 100	368 100	238 400	92 700

Figure 29 Net income COA for BW Helios

BW Havfrost - COA

BW Havfrost is Maharshi Vamadevas sister ship and it is assigned to 3 orders. It will be necessary to pass the Suez Canal once. The idle time for her contracted orders is 421 days.

Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Tuticorin						27.08.2006	00:00
Jabung		30.08.2006	16:51	1 day	386 days 8 hrs	22.09.2007	01:00
Weihai		27.09.2007	11:10	1 day		28.09.2007	11:10
Jabung		03.10.2007	21:21	1 day	17 days 4 hrs	22.10.2007	01:00
Weihai		27.10.2007	11:10	1 day		28.10.2007	11:10
Jabung		02.11.2007	21:21	1 day	18 days 3 hrs	22.11.2007	00:00
Suez canal	11 hrs	02.12.2007	23:49	11 hrs		03.12.2007	10:49
Rotterdam		10.12.2007	08:18	1 day		11.12.2007	08:18

Table 37 Schedule for BW Havfrost at 20 knots

Since BW Havfrost will cover large distances when transporting the contracted orders the fuel consumption will be proportionally larger as well with a fuel consumption of 6 051 tons at 20 knots.

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Tuticorin		20				
Jabung	1 777	20	523		70 000	
Weihai	2 604	20	766		70 000	21 500
Jabung	2 604	20	766		70 000	
Weihai	2 604	20	766		70 000	21 500
Jabung	2 604	20	766		70 000	
Suez canal	5 057	20	1 488			
Rotterdam	3 310	20	974		90 000	23 400
TOTAL	**20 560**		**6 051**	**2 136 000**	**440 000**	**66 400**

Table 38 Costs for BW Havfrost at 20 knots

The gross freight for BW Havfrost is more than two times larger than for the two former ships.

Location	Voyage	Order -operation	Suez transit charges [USD]	Gross freight [USD]
Tuticorin	1			
Jabung	1	4-load		
Weihai	1	4-unload		1 072 500
Jabung	2	5-load		
Weihai	2	5-unload		1 072 500
Jabung	3	16-load		
Suez canal	3-northbound		322 500	
Rotterdam	3	16-unload		1 171 500
TOTAL			**322 500**	**3 316 500**

Table 39 COA details for BW Havfrost

The speed reduction to 14 knots from a baseline of 20 knots will result in an increase in transit time of approximately 9 days overall.

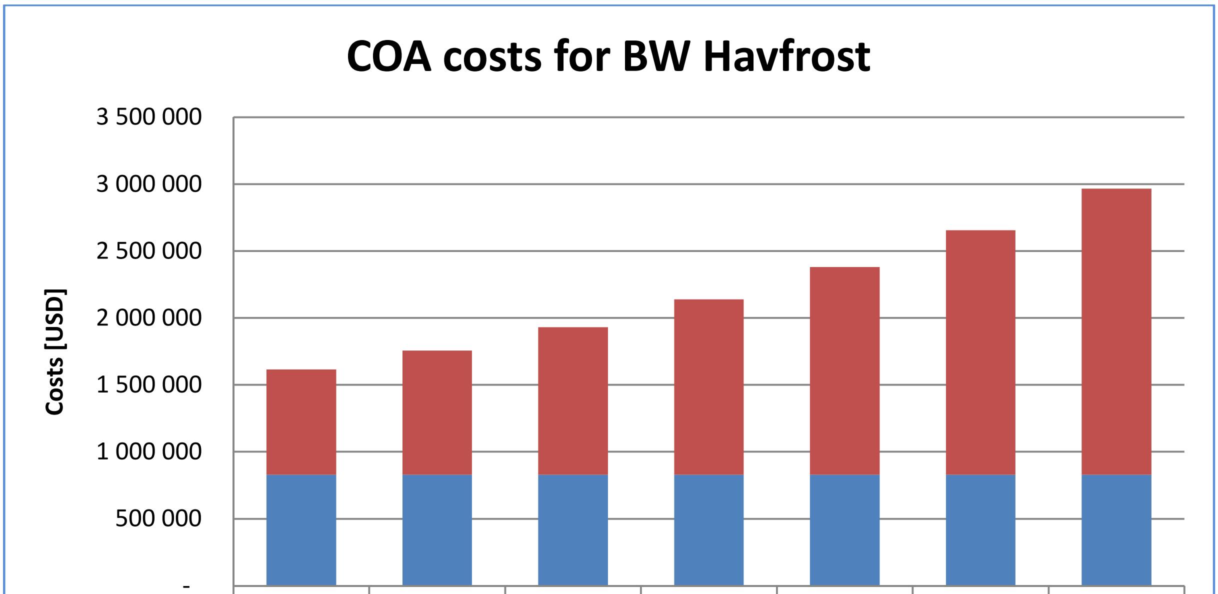
Location	Docking	Arrival day	Arrival time	Service	Wait	Departure day	Departure time
Tuticorin						27.08.2006	00:00
Jabung		01.09.2006	06:56	1 day	384 days 18 hrs	22.09.2007	01:00
Weihai		29.09.2007	18:58	1 day		30.09.2007	18:58
Jabung		08.10.2007	12:56	1 day	12 days 12 hrs	22.10.2007	01:00
Weihai		29.10.2007	18:58	1 day		30.10.2007	18:58
Jabung		07.11.2007	12-56	1 day	13 days 11 hrs	22.11.2007	00:00
Suez canal	11 hrs	07.12.2007	12:10	11 hrs		07.12.2007	23:10
Rotterdam		17.12.2007	19:34	1 day		18.12.2007	19:34

Table 40 Schedule for BW Havfrost at optimized speed

Location	Milage [M]	Speed [knots]	Fuel consumption [tons]	Fuel cost [USD] 353 USD/ton	Port cost [USD]	Comm. cost [USD]
Tuticorin		14				
Jabung	1 777	14	192		70 000	
Weihai	2 604	14	282		70 000	21 500
Jabung	2 604	14	282		70 000	
Weihai	2 604	14	282		70 000	21 500
Jabung	2 604	14	282		70 000	
Suez canal	5 057	14	547			
Rotterdam	3 310	14	358		90 000	23 400
TOTAL	**20 560**		**2 225**	**785 400**	**440 000**	**66 400**

Table 41 Costs for BW Havfrost at optimized speed

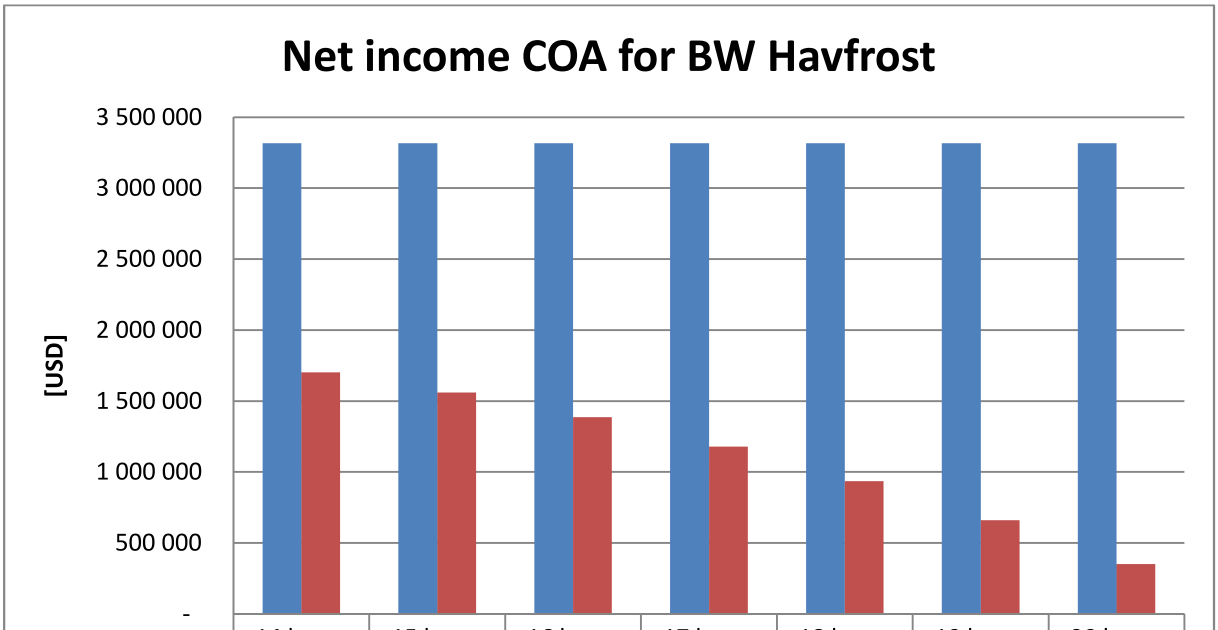
The fixed costs are larger for BW Havfrost than for the former 2 ships since she has to cross the Suez Canal. The fuel costs are reduced by 63% as usual for the speed reduction from 20 knots to 14 knots.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Fuel costs	785 400	926 600	1 101 300	1 309 600	1 551 500	1 827 000	2 136 000
Fixed costs	828 900	828 900	828 900	828 900	828 900	828 900	828 900

Figure 30 COA costs for BW Havfrost

By decreasing the speed from 20 to 14 knots it is possible to increase the net income by 1.35 million USD or 384%.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	3 316 500	3 316 500	3 316 500	3 316 500	3 316 500	3 316 500	3 316 500
Net income	1 702 200	1 561 000	1 386 300	1 178 000	936 100	660 600	351 600

Figure 31 Net income COA for BW Havfrost

The global LPG market

The main share of LPG is transported waterborne contained in LPG carriers. The freight rates are fluctuating rapidly and the variations can be large. Figure 32 is a graph listing monthly freight rates on a 10 year contract from 1998 to 2008 between Ras Tanura, Saudi-Arabia and Chiba, Japan for a 75000 m^3 LPG carrier. The freight rates in 2008 is interesting as large fluctuations happened during that year as it started off at 27 USD/ton peaked to 82 USD/ton in the summer and descended to 17.5 USD/ton in December. The pink line marks the average value for the period.

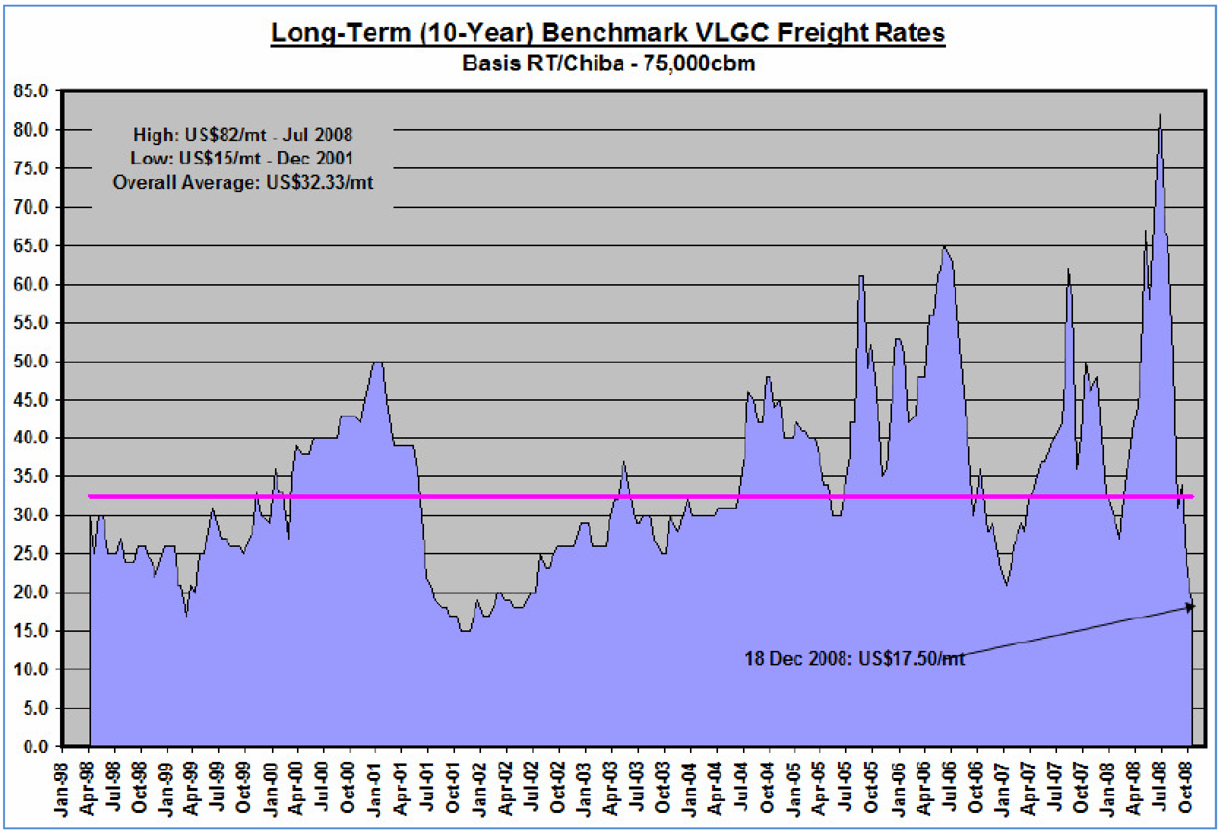


Figure 32 LPG freight rates, courtesy Waterborne Energy

For the coming calculations I will define three scenarios; actual level, prosperity level and recession level. The aim of the further analysis is to support the contracts of affreightments by additional spot market shipping. This type of shipping is called tramp shipping where the object is to maximize profit. The objective of the further analysis is to investigate the correlation between environmental shipping and market conditions such as freight rates, global LPG demand and fuel prices. I define environmental shipping as shipping with significant CO_2 reductions. I will assess the cost of speed reductions for the different scenarios.

The prosperity level is selected as the peak of global lifted tons of LPG in Figure 33 which occurred in July 2006.Approximately 5 378 400 tons of LPG was lifted in that month globally. At prosperity level I assume 100% of the idle time from the fixed orders will be utilized for spot market purposes. Based on my assumptions in Figure 19 the fuel price for IFO 180 will be 383.3 USD/ton in May 2006 and I assume this is the same in July 2006. The freight rate in July 2006 was 63.0 USD/ton.

The recession level is selected as the bottom of global lifted LPG in Figure 33 which occurred in February 2003 when 3 094 600 tons of LPG was lifted globally. This is 57.5% of the transported LPG in the defined prosperity level. Therefore I assume 57.5% of the available time for spot marketing will be used. The freight rate in February 2003 was 25.7 USD/ton. The fuel price for IFO 180 is estimated to 138 USD/ton.

The actual level is the level at the current time between September 2006 and December 2007 (the time line for the contracted orders). I calculate an average freight rate of 36.5 USD/ton for the period. The average monthly transported LPG in this period was 4 730 600 tons which is 88.0% of the peak in the defined prosperity level. The spot market utilization is therefore 88.0% of its potential. The fuel price for IFO 180 is estimated to 353 USD/ton for the period.

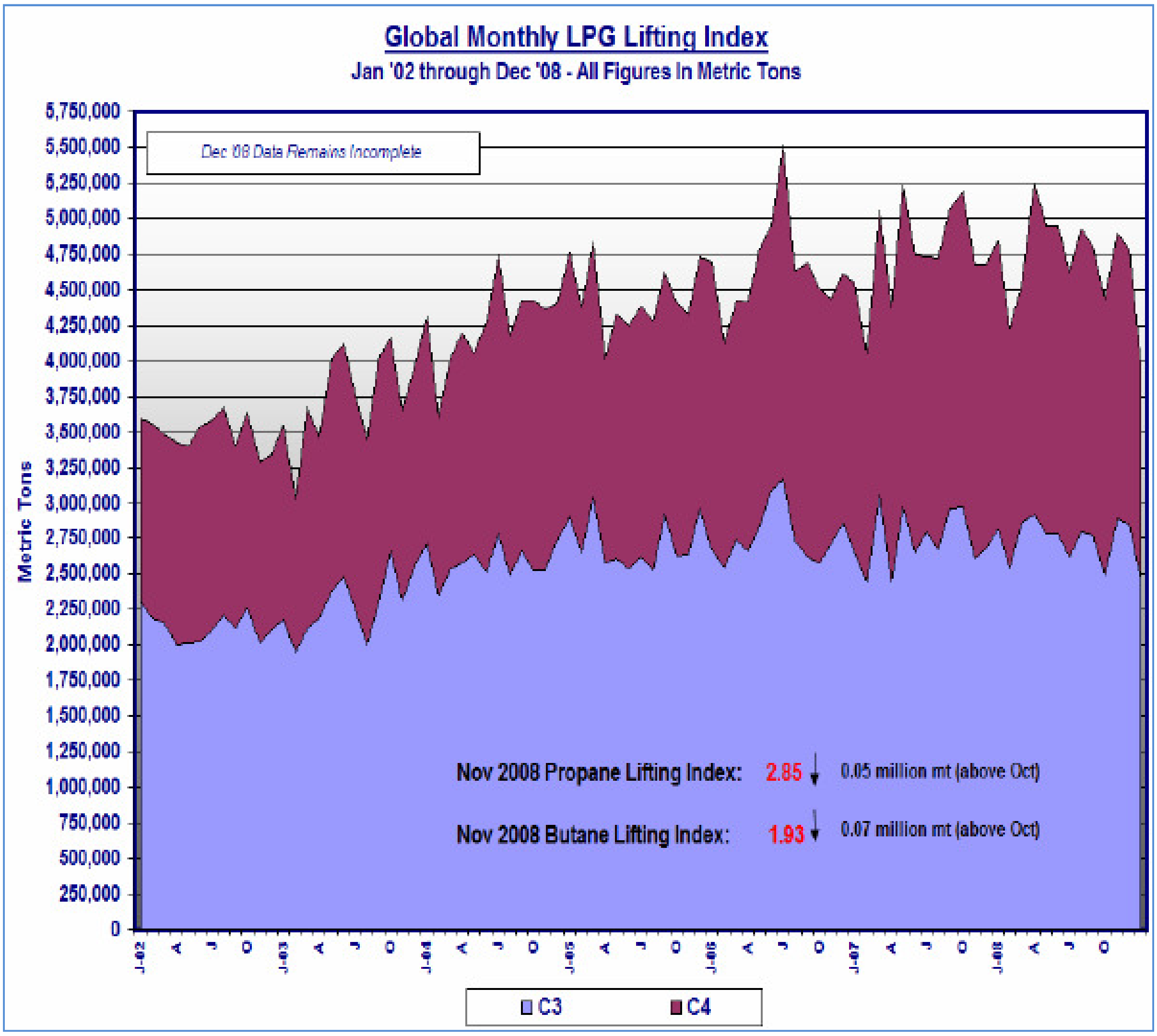


Figure 33 Global monthly waterborne LPG lifting, courtesy Waterborne Energy

The abbreviations C3 and C4 in Figure 33 describe propane (C_3H_8) and butane (C_4H_{10}) respectively. The LPG lifted in total is the sum of the weight of these to hydrocarbons in liquid state.

BW Clipper – Spot market

I assume 40 000 dwt tons are carried on average per voyage by BW Clipper. When the vessel is assigned to a voyage I assume 20% of the time is spent in port while 80% is spent in transit mode. For the contracted orders (COA) a total sailing distance of 115 203 nautical miles is expected with 18 voyages. The average distance for each voyage is therefore 6400 nautical miles and this figure will help predict the amount of LPG carried for each ship.

Figure 34 depicts the potential for spot market purposes for BW Clipper after adjusting for the current market demand (88.0% of prosperity level).

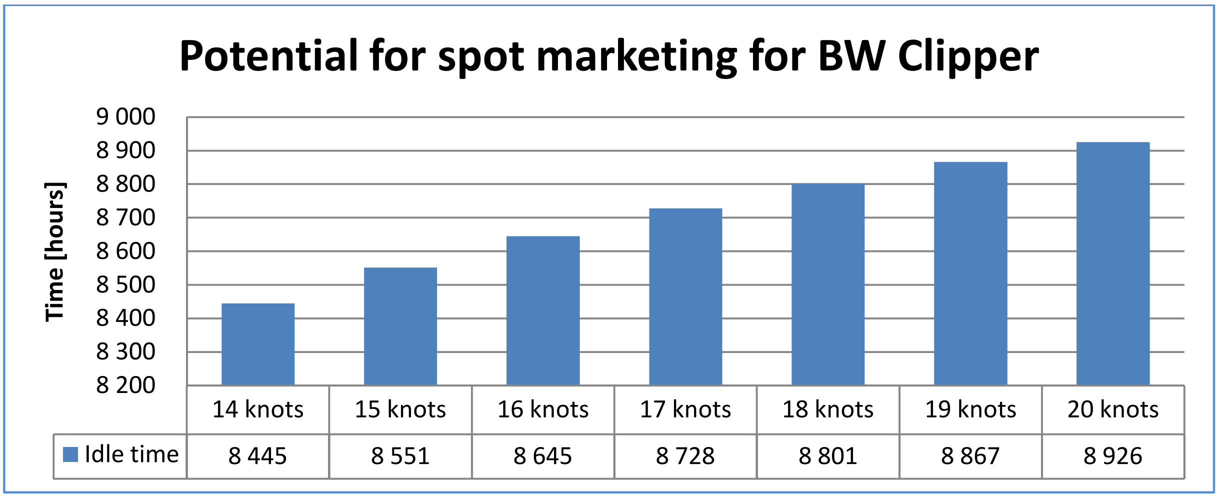
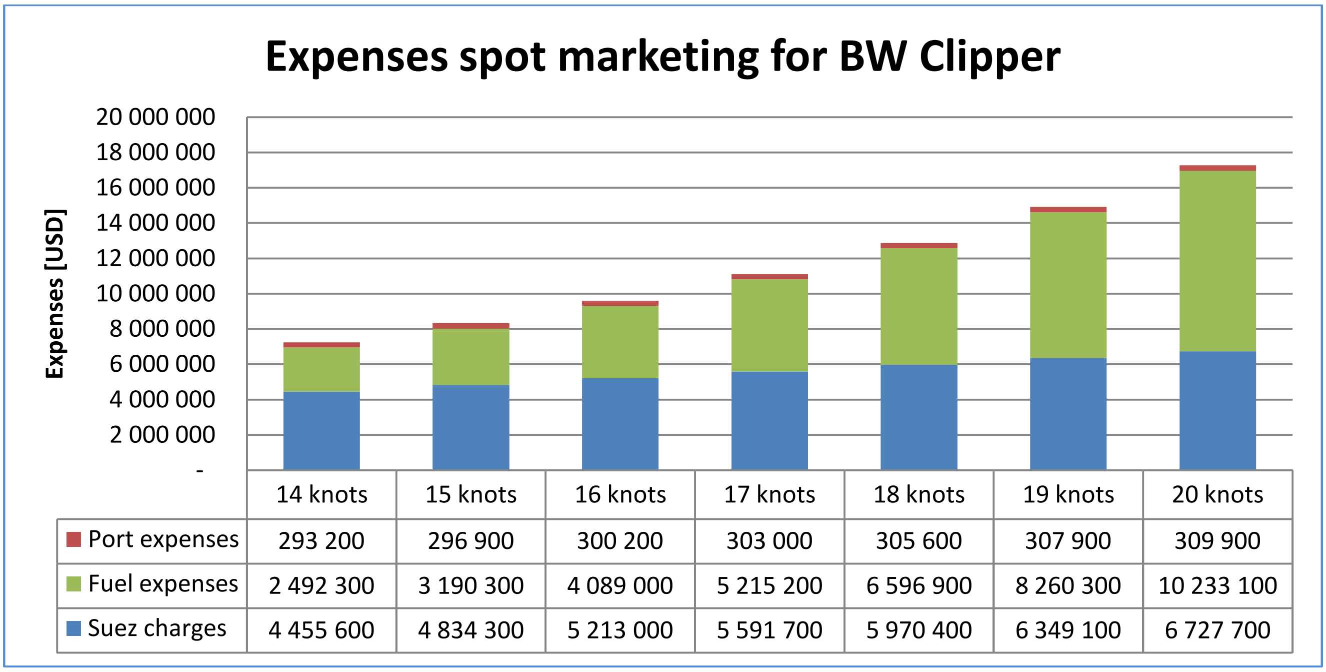


Figure 34 Potential for spot marketing - BW Clipper

Since I assume 80% of the voyage is spent in transit, the transit range can easily be calculated. When the transit range is found one can estimate how many voyages the ship can execute and thereby the amount of LPG carried in the spot market and the following gross freight income. This will increase with increased speed as a larger transit range can be covered with greater speed and more voyages can be made.

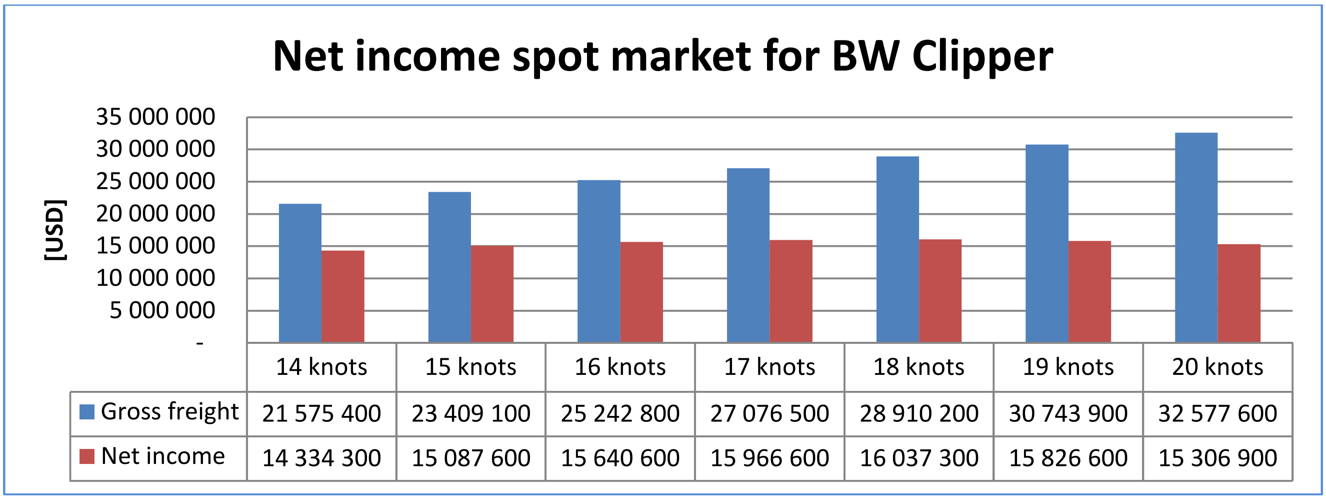
For every 7200 nautical miles a ship passes the Suez Canal for the contracted orders and I will base my calculations in this figure for the spot market as well. This indicates that not only the gross freight income will increase with increased speed but also the Suez Canal transit charges in addition to increased fuel expenses. Daily docking costs for LPG carriers is approximately 830 USD (Olafsen, 2010) and the docking costs will increase as more voyages are made possible with increased speed. The costs for BW Clipper in spot market are described in Figure 35.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Port expenses	293 200	296 900	300 200	303 000	305 600	307 900	309 900
Fuel expenses	2 492 300	3 190 300	4 089 000	5 215 200	6 596 900	8 260 300	10 233 100
Suez charges	4 455 600	4 834 300	5 213 000	5 591 700	5 970 400	6 349 100	6 727 700

Figure 35 Expenses spot marketing - BW Clipper

The gross freight is derived from the number of voyages multiplied with the loading capacity (set to 40 000 tons/voyage) multiplied with the prevailing freight rate (36.5 USD/ton). The net income is as usual the difference between the gross freight and the total costs. The peak income is reached at 18 knots and the bottom occurs at 14 knots, however all results are positive and solid.

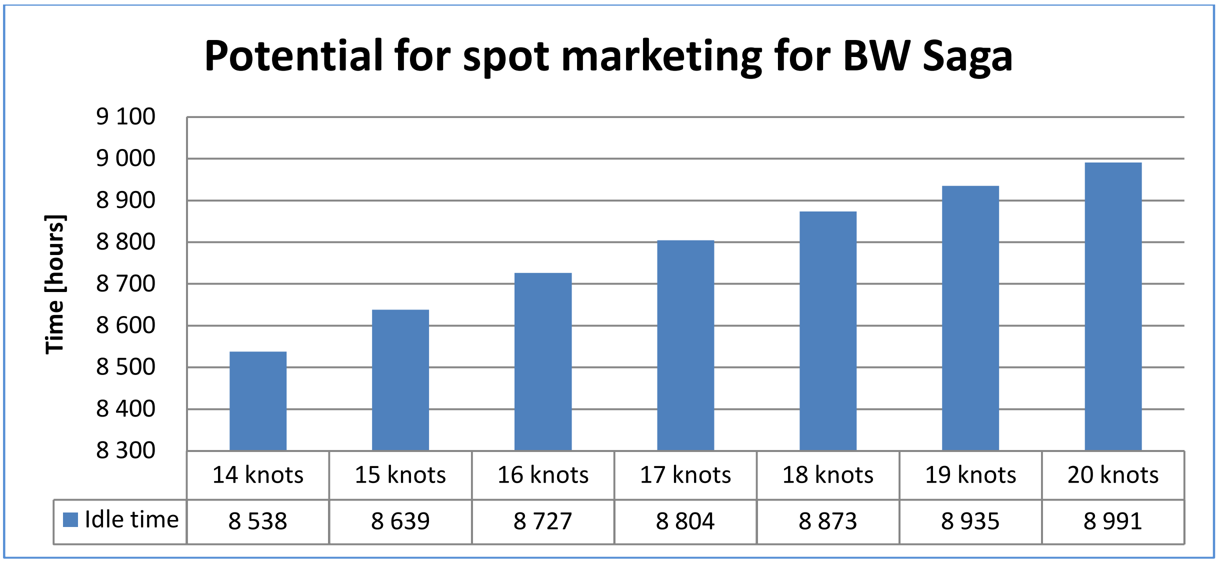


	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	21 575 400	23 409 100	25 242 800	27 076 500	28 910 200	30 743 900	32 577 600
Net income	14 334 300	15 087 600	15 640 600	15 966 600	16 037 300	15 826 600	15 306 900

Figure 36 Net income spot market - BW Clipper

BW Saga –Spot market

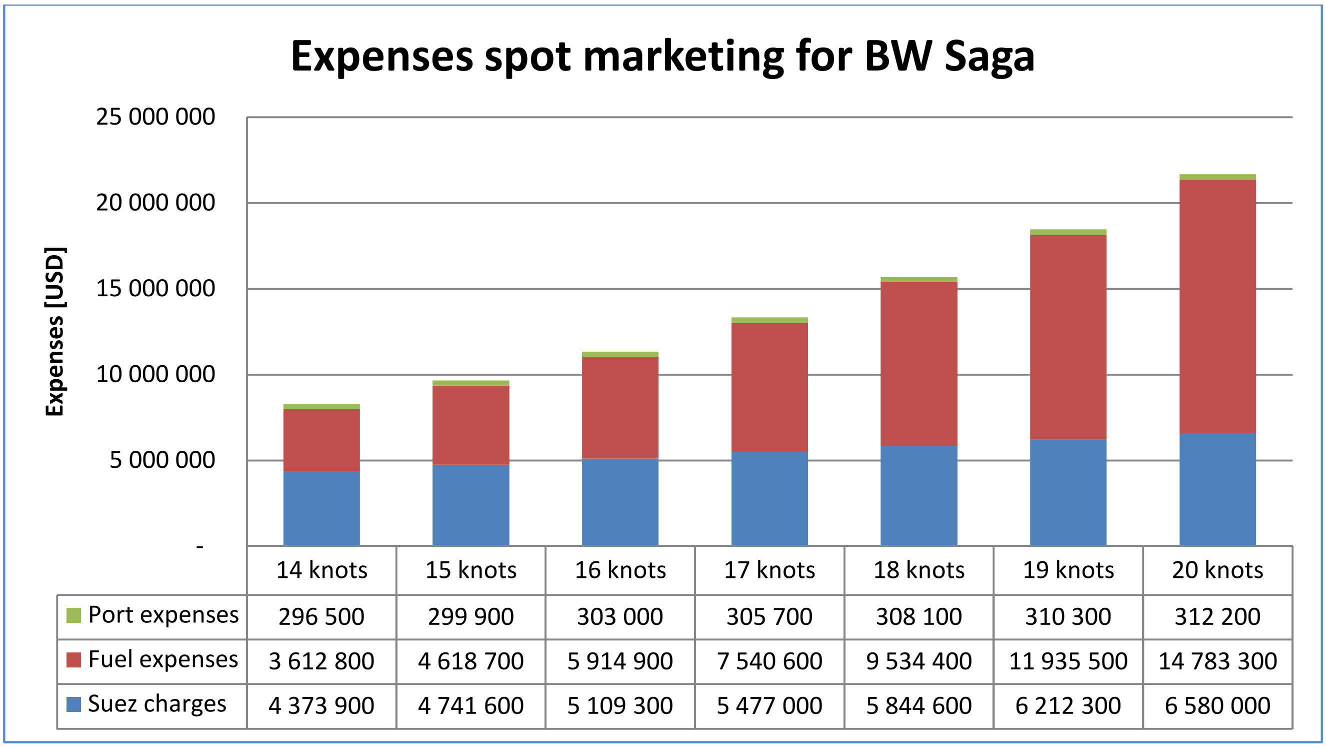
For BW Saga I base my calculations on the same assumptions as for BW Clipper. The potential for spot marketing is slightly different among the two ships due to different duration of the fixed orders (COAs). A speed reduction from 20 to 14 knots will reduce the spot market potential by nearly 19 days for BW Saga.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Idle time	8 538	8 639	8 727	8 804	8 873	8 935	8 991

Figure 37 Potential for spot marketing - BW Saga

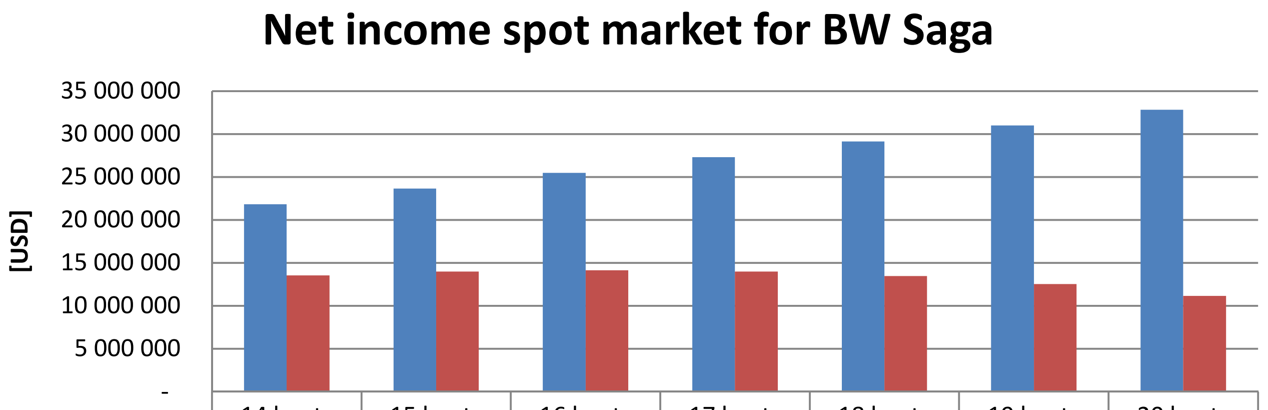
An increase is visible for all categories of expenses in Figure 38, but only the increase in fuel expenses is significant. The fuel cost saving potential for a speed reduction from 20 to 14 knots is over 11 million USD for BW Saga in the spot market.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Port expenses	296 500	299 900	303 000	305 700	308 100	310 300	312 200
Fuel expenses	3 612 800	4 618 700	5 914 900	7 540 600	9 534 400	11 935 500	14 783 300
Suez charges	4 373 900	4 741 600	5 109 300	5 477 000	5 844 600	6 212 300	6 580 000

Figure 38 Expenses spot marketing- BW Saga

The net income for BW Saga in spot market is reduced compared to BW Clipper and the peak in net income occurs at 16 knots. The relationship between gross freight and ship speed is nearly linear while the relationship between net income and ship speed is parabolic.

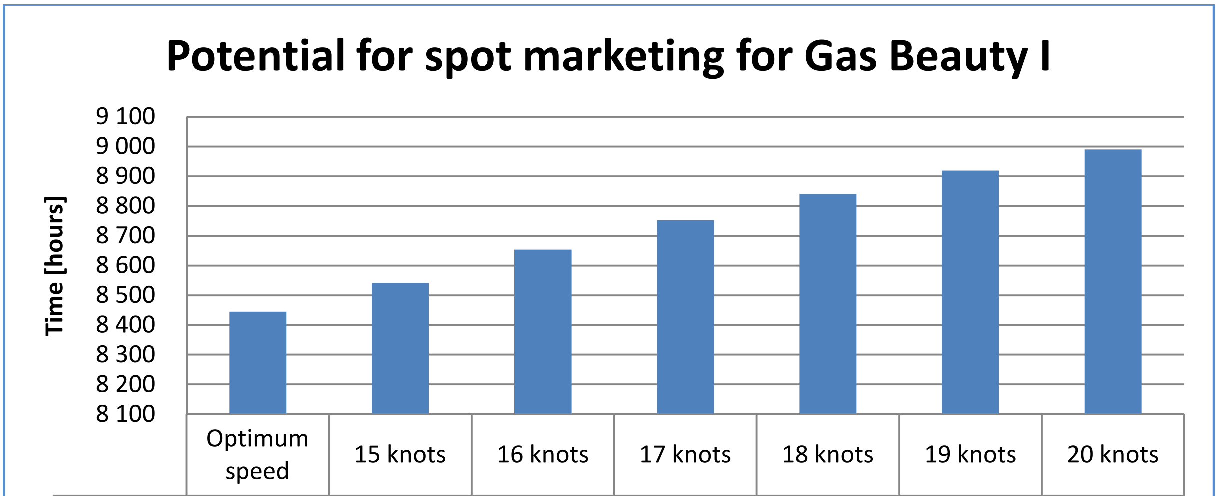


	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	21 813 600	23 647 400	25 481 100	27 314 800	29 148 600	30 982 300	32 816 100
Net income	13 530 400	13 987 200	14 153 900	13 991 500	13 461 500	12 524 200	11 140 600

Figure 39 Net income spot market - BW Saga

Gas Beauty I – Spot market

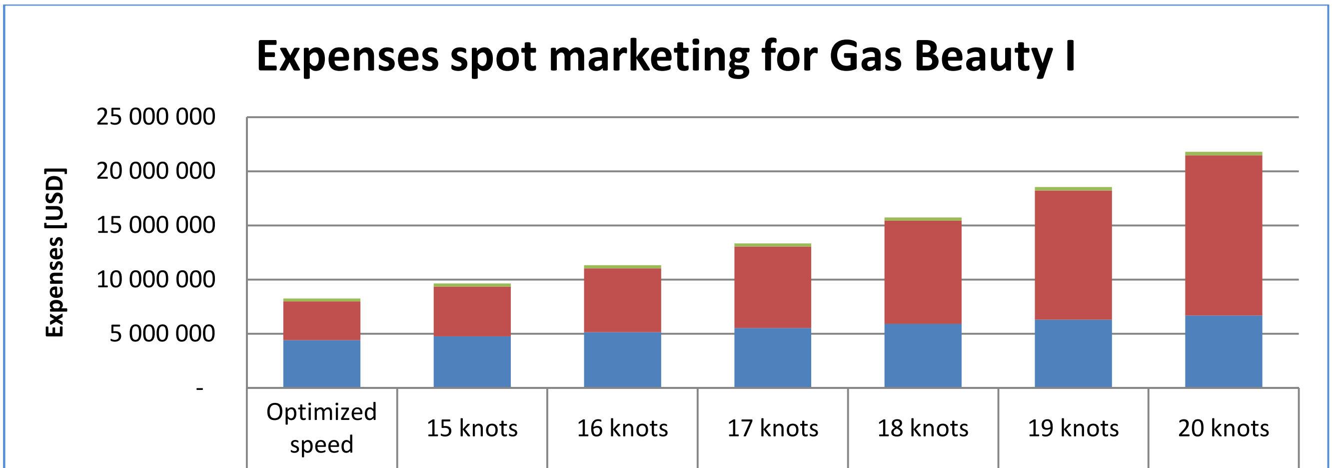
The estimated time used in spot market is illustrated in Figure 40. It is similar to BW Clipper's potential. The idle time is calculated from sailing at the respective speeds in the contracted orders and corrected for the prevailing market demand, which is estimated to 88.0% from September 2006 to December 2007. Since Gas Beauty I cannot operate at 14 knots for all COA voyages the "14 knots" label is changed to "optimized speed".



	Optimum speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Ilde time	8 445	8 541	8 653	8 752	8 840	8 919	8 990

Figure 40 Potential for spot marketing - Gas Beauty I

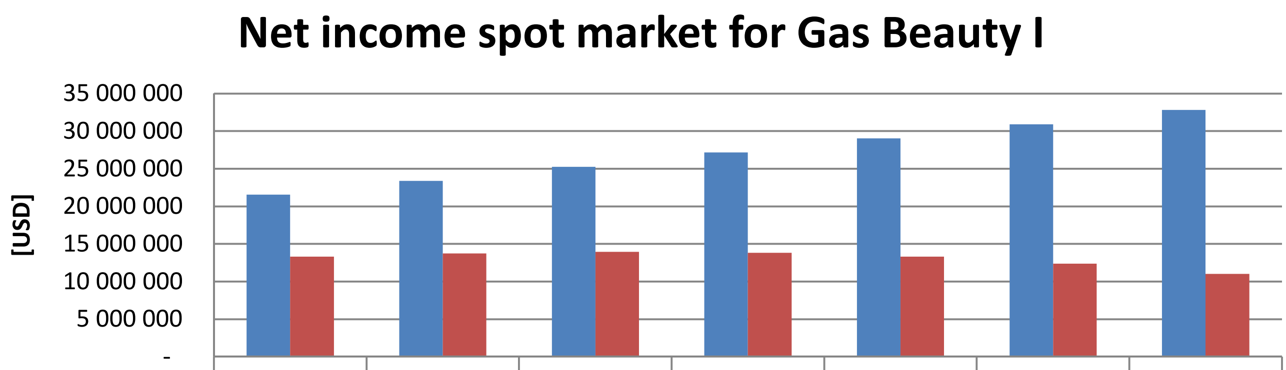
Speed reductions result in less activity hence less fuel consumption, less Suez passages and fewer port calls. The decrease in fuel costs are most significant counting 11.2 million USD, although the Suez transit costs are reduced by 2.3 million USD while the port expenses only encounter small changes.



	Optimized speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Port expenses	293 200	296 600	300 500	303 900	307 000	309 700	312 100
Fuel expenses	3 573 400	4 566 700	5 865 300	7 496 000	9 498 700	11 913 600	14 781 400
Suez charges	4 405 900	4 774 600	5 159 800	5 544 900	5 930 100	6 315 300	6 700 500

Figure 41 Expenses spot marketing - Gas Beauty I

As for the former ships Gas Beauty I will meet maximum net income in between the maximum speed and the minimum speed. For Gas Beauty I the maximum net income will occur at 16 knots.

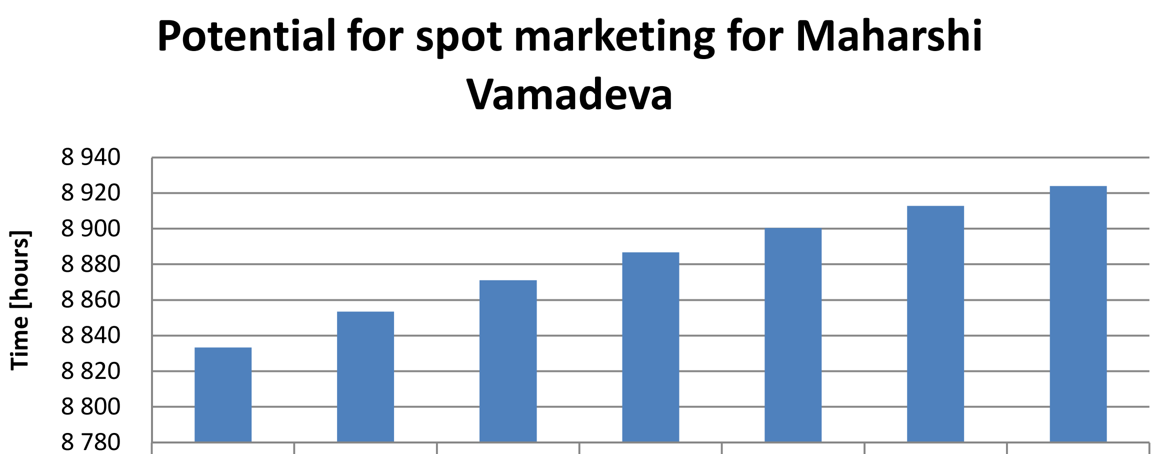


	Optimized speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	21 575 400	23 381 000	25 267 200	27 153 300	29 039 500	30 925 600	32 811 800
Net income	13 302 900	13 743 100	13 941 600	13 808 500	13 303 700	12 387 000	11 017 800

Figure 42 Net income spot market - Gas Beauty I

Maharshi Vamadeva – Spot market

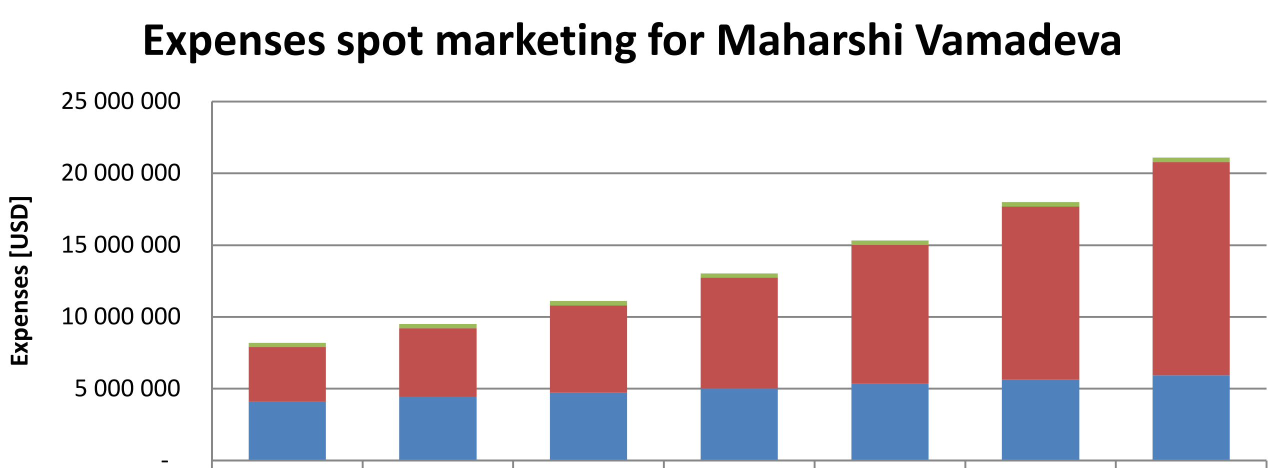
Maharshi Vamadeva is only assigned to two orders and this will have an impact on the idle time she will have available. The potential for spot market is large, but the effect of speed reductions in terms of more time available for spot market purposes is limited compared to the former ships.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Idle time	8 833	8 853	8 871	8 887	8 900	8 913	8 924

Figure 43 Potential for spot marketing - Maharshi Vamadeva

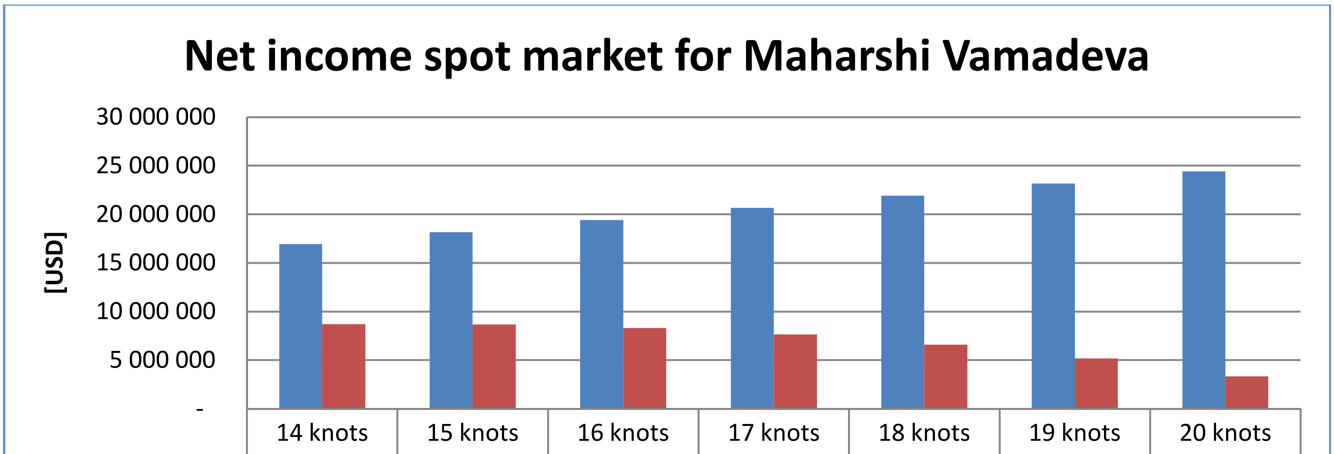
The port expenses for Maharshi Vamadeva will hardly change at decreased speeds. By reducing speeds from 20 to 14 knots it is possible to save 11 million USD. The savings in Suez transit charges for the same speed reduction are 1.8 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Port expenses	306 700	307 400	308 000	308 600	309 000	309 500	309 900
Fuel expenses	3 780 500	4 788 800	6 083 000	7 699 000	9 672 900	12 039 800	14 836 500
Suez charges	4 118 100	4 422 300	4 726 500	5 030 700	5 334 900	5 639 100	5 943 300

Figure 44 Expenses spot marketing - Maharshi Vamadeva

Maharshi Vamadeva is the first out of three ships with a loading capacity of 33 000 tons. In this analysis I assume only 30 000 tons is loaded on average for each voyage. For each voyage 25% less LPG will be transported compared to the three former ships. The net income will be severely reduced to 3.3 million USD at 20 knots. At 14 knots a 5.4 million USD increase in net income occurs compared to the situation at 20 knots. The maximum net income is present at 14 knots and this fact differs from the earlier ships.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	16 926 500	18 176 900	19 427 200	20 677 600	21 928 000	23 178 300	24 428 700
Net income	8 721 200	8 658 400	8 309 700	7 639 300	6 611 200	5 189 900	3 339 000

Figure 45 Net income spot market - Maharshi Vamadeva

BW Helios – Spot market

BW Helios has the best potential for spot market purposes as she has most idle time available after finishing her contracted orders. As for the other ships is her spot market potential corrected for a 88.0% market demand where 100% is the demand at prosperity. The figures can be artificial as every saving between every journey is assumed to be available for long voyages and it is hard to use the exact time to run the operation smoothly without delays. These issues will be neglected in my analyses.

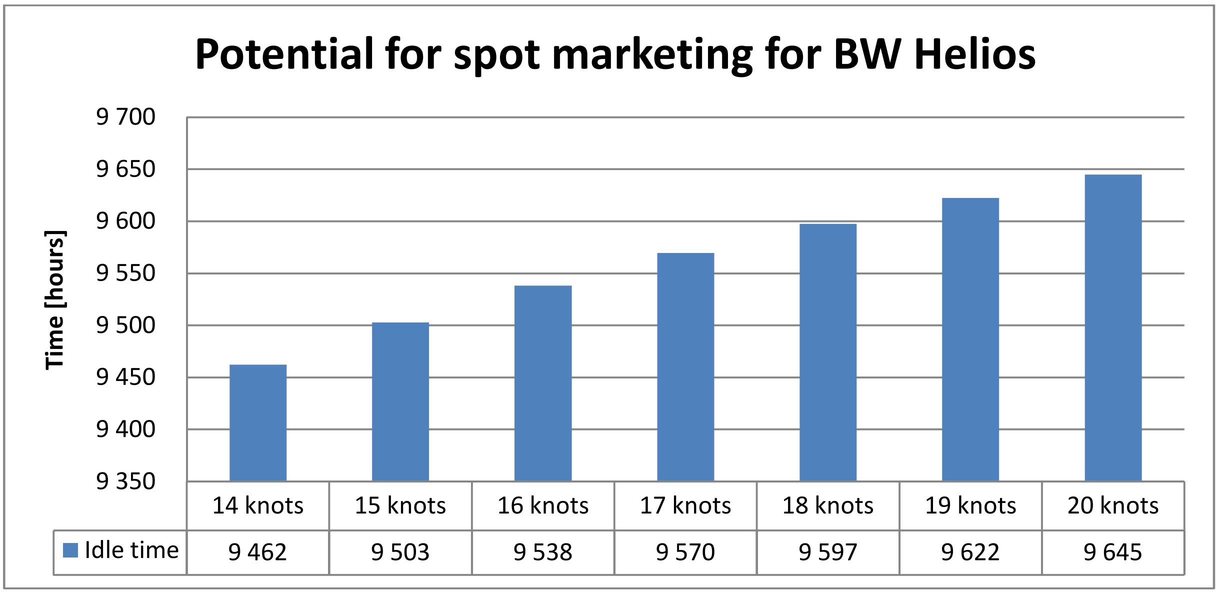


Figure 46 Potential for spot marketing - BW Helios

The port expenses see small changes, the Suez charges can be reduced by 2 million USD and the fuel expenses can be reduced by 12 million USD by a speed reduction from 20 to 14 knots.

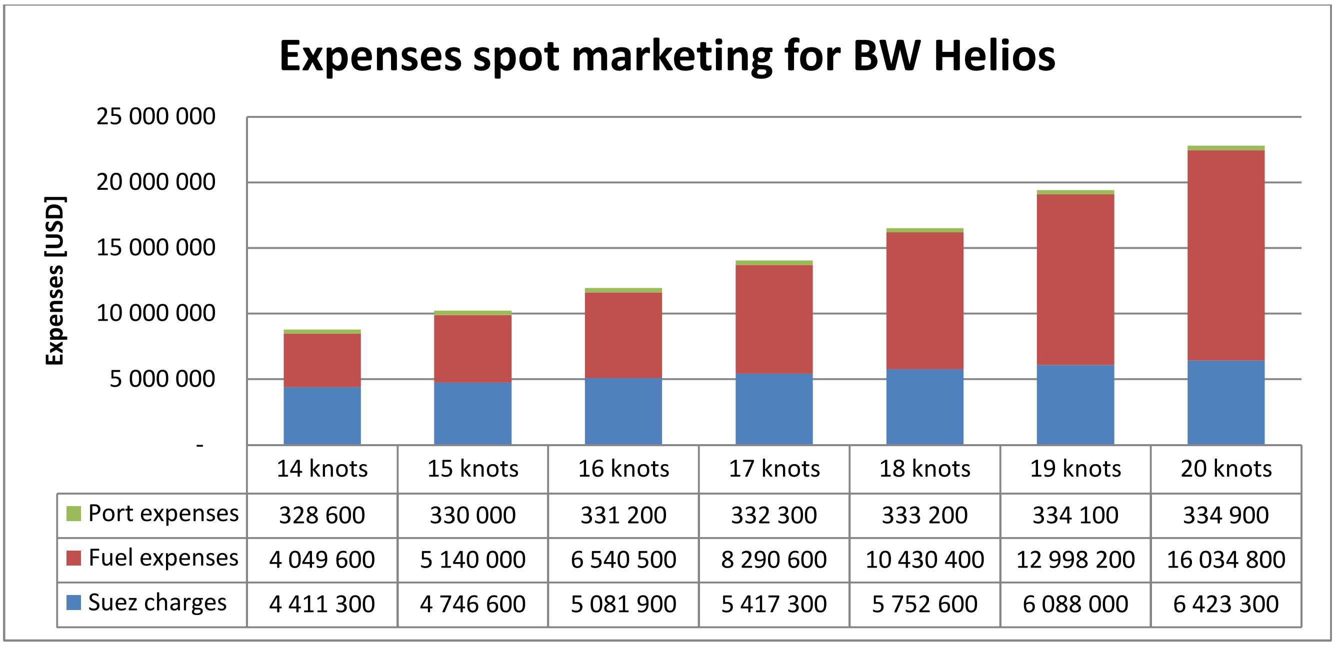
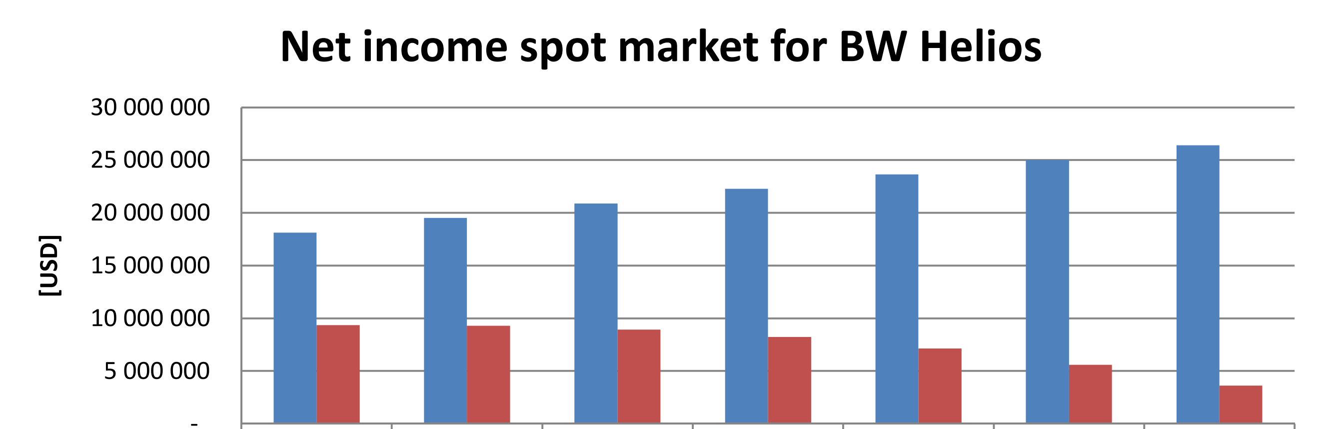


Figure 47 Expenses spot marketing - BW Helios

The net income and gross freight for BW Helios is higher than for Mahrashi Vamadeva, but significantly lower than the net incomes and gross freights for the three first ships. The net income is largest at 14 knots and by reducing the speed from 20 knots to 14 knots it is possible to save 5.7 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	18 131 600	19 509 900	20 888 300	22 266 700	23 645 000	25 023 400	26 401 800
Net income	9 342 100	9 293 300	8 934 700	8 226 500	7 128 800	5 603 100	3 608 800

Figure 48 Net income spot market - BW Helios

BW Havfrost – Spot market

BW Havfrosts potential for spot market purposes are lower than for BW Helios. The level is similar to the potential for the remaining ships. A speed reduction from 20 to 14 knots will result in 387 hours less for spot market purposes.

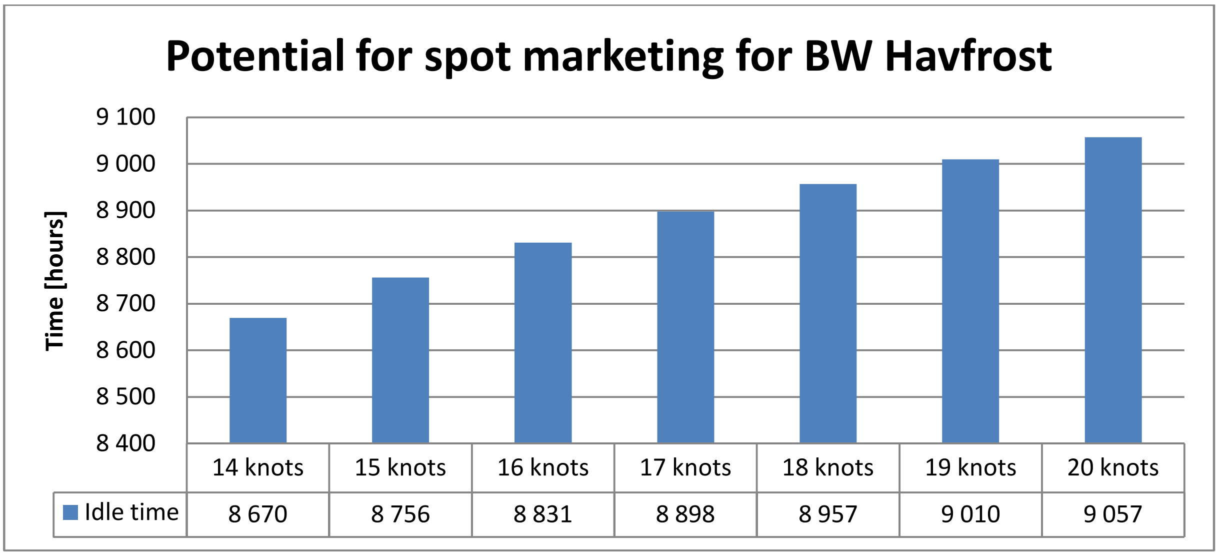


Figure 49 Potential for spot marketing - BW Havfrost

The port expenses do not change much with reduced speed, but significant savings can be made in fuel expenses and Suez Canal charges. By reducing the speed from 20 to 14 knots it is possible to lower the fuel costs by 11.3 million USD and lower the Suez Canal charges by 2 million USD for BW Havfrost.

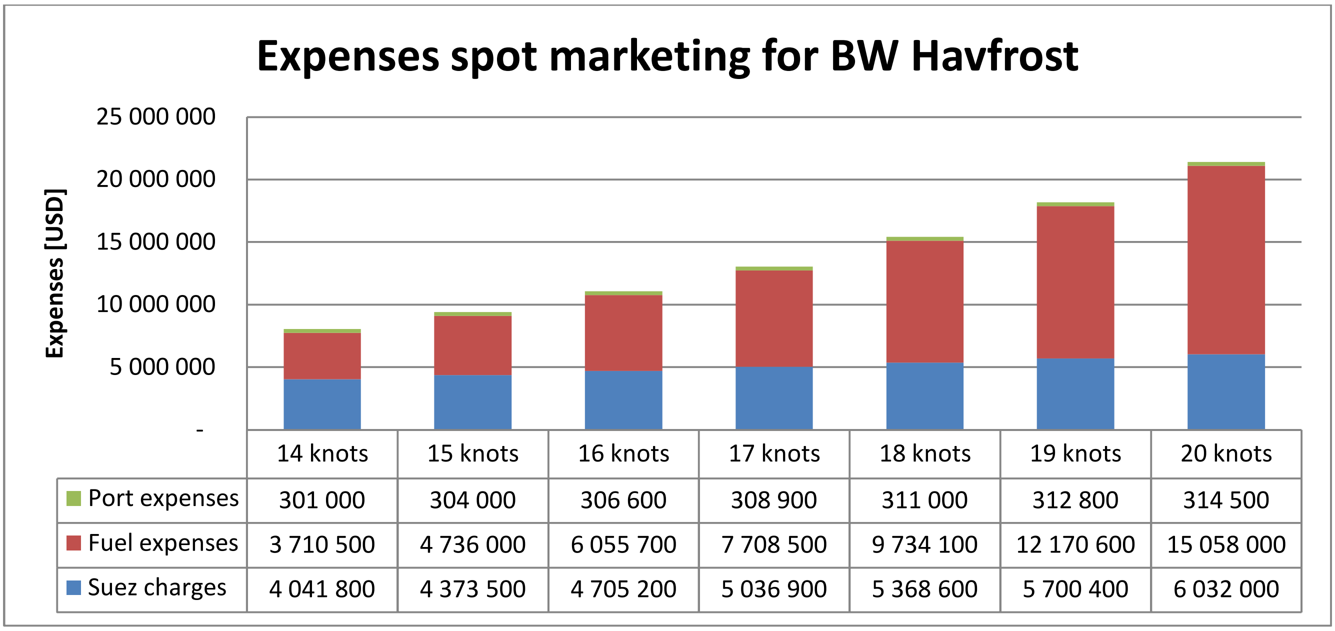
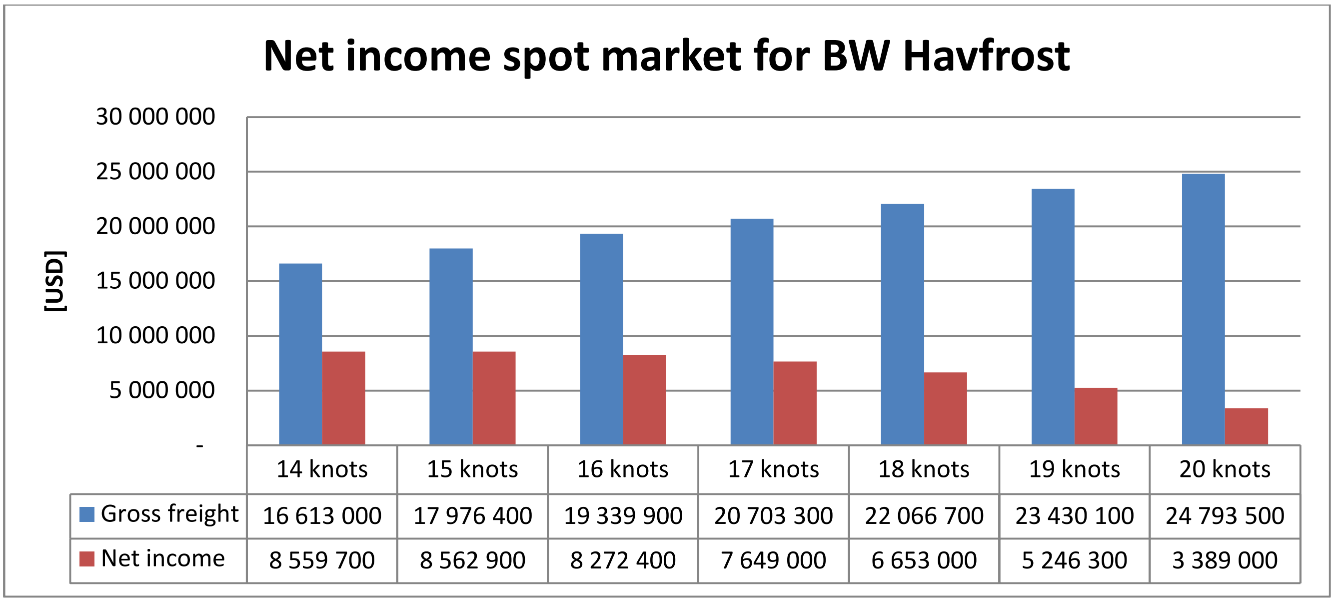


Figure 50 Expenses spot marketing - BW Havfrost

The gross freight increase with increased speed, while the net income decrease with increased speed. The net income peaks at 14 knots with a 5.17 USD improvement compared to the level at 20 knots.



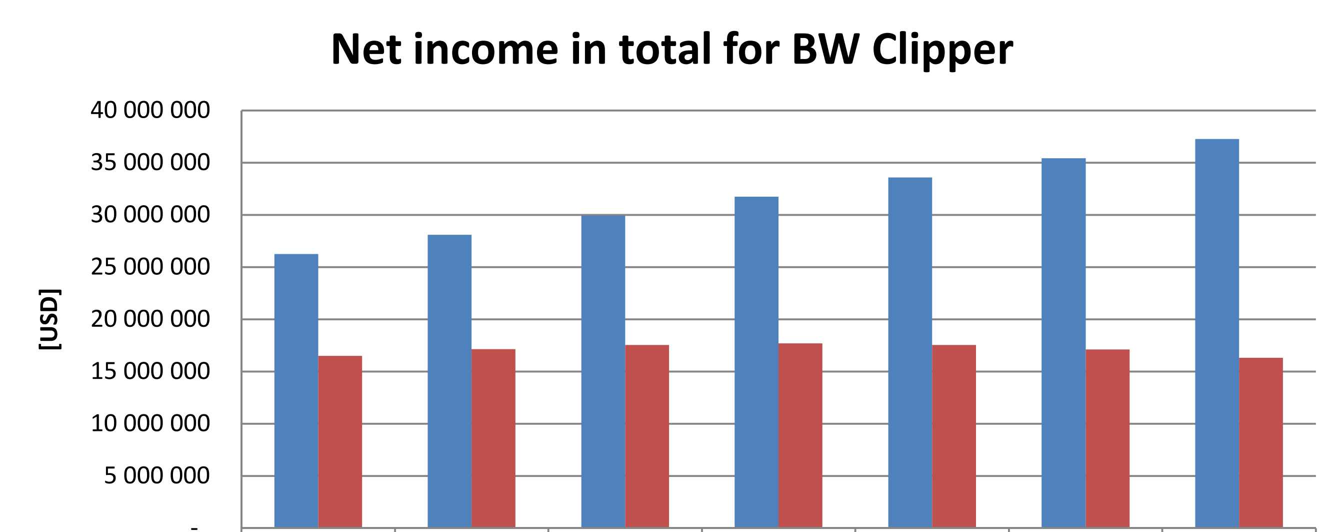
	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	16 613 000	17 976 400	19 339 900	20 703 300	22 066 700	23 430 100	24 793 500
Net income	8 559 700	8 562 900	8 272 400	7 649 000	6 653 000	5 246 300	3 389 000

Figure 51 Net income spot market - BW Havfrost

Total incomes

In this section I have combined the net income for the contracts of affreightment with the net income for spot market as a function of speed. For simplicity I assume the chosen ship speed is kept constant for the contracted orders and for shipping in spot market. In this part of the analysis I will make a recommendation for the ship speed based only on maximized profit.

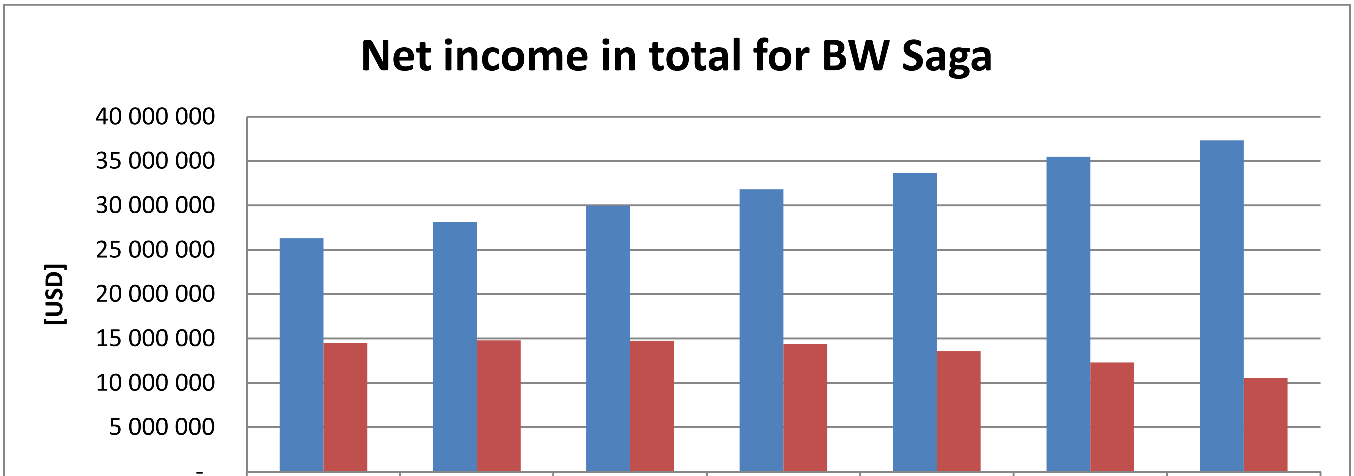
The net income for BW Clipper peaks at 17 knots where it will reach nearly 17.7 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	26 250 400	28 084 100	29 917 800	31 751 500	33 585 200	35 418 900	37 252 600
Net income	16 510 100	17 142 500	17 545 900	17 693 500	17 557 200	17 110 800	16 326 000

Figure 52 Net income in total - BW Clipper

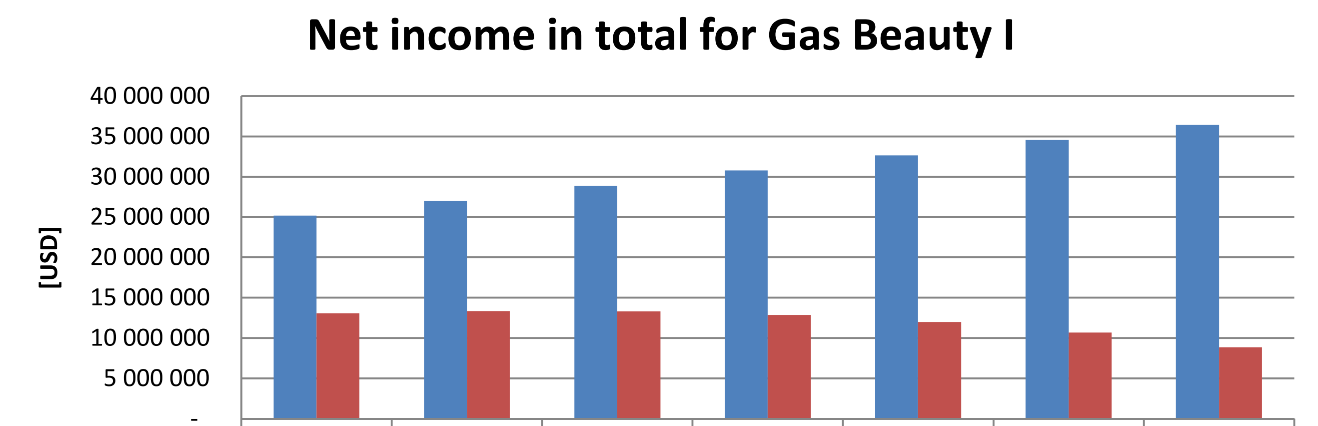
The net income for BW Saga peaks at 15 knots where it will reach nearly 14.8 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	26 301 600	28 135 400	29 969 100	31 802 800	33 636 600	35 470 300	37 304 100
Net income	14 504 200	14 798 200	14 762 900	14 359 700	13 549 800	12 293 700	10 552 100

Figure 53 Net income in total - BW Saga

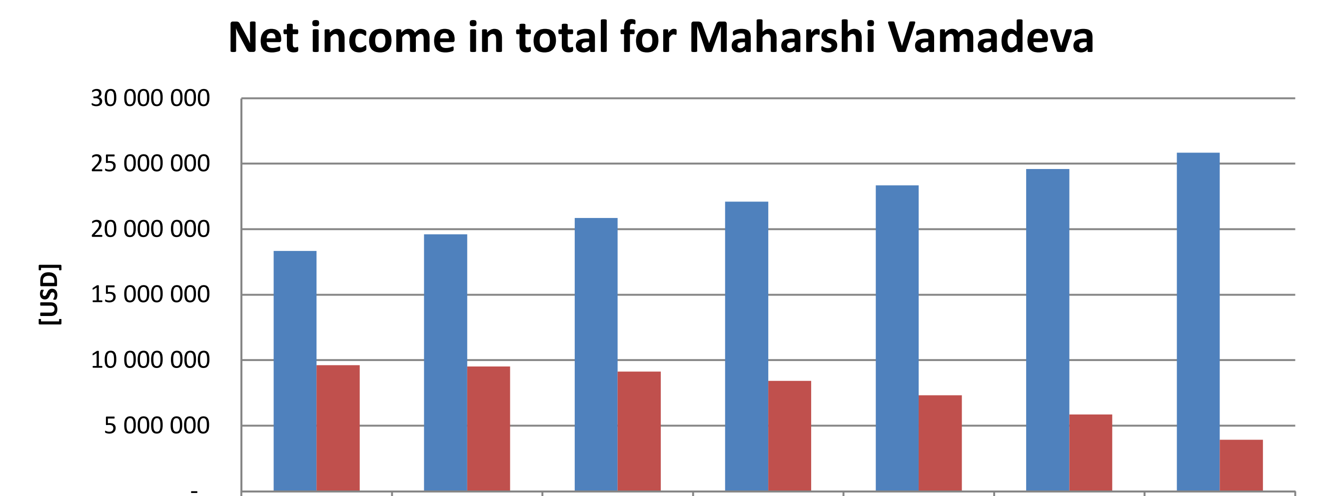
The net income for Gas Beauty I peaks at 15 knots where it will reach 13.35 million USD.



	Optimized speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	25 189 400	26 995 000	28 881 200	30 767 300	32 653 500	34 539 600	36 425 800
Net income	13 067 500	13 351 300	13 292 900	12 853 100	11 992 100	10 669 600	8 845 100

Figure 54 Net income in total - Gas Beauty I

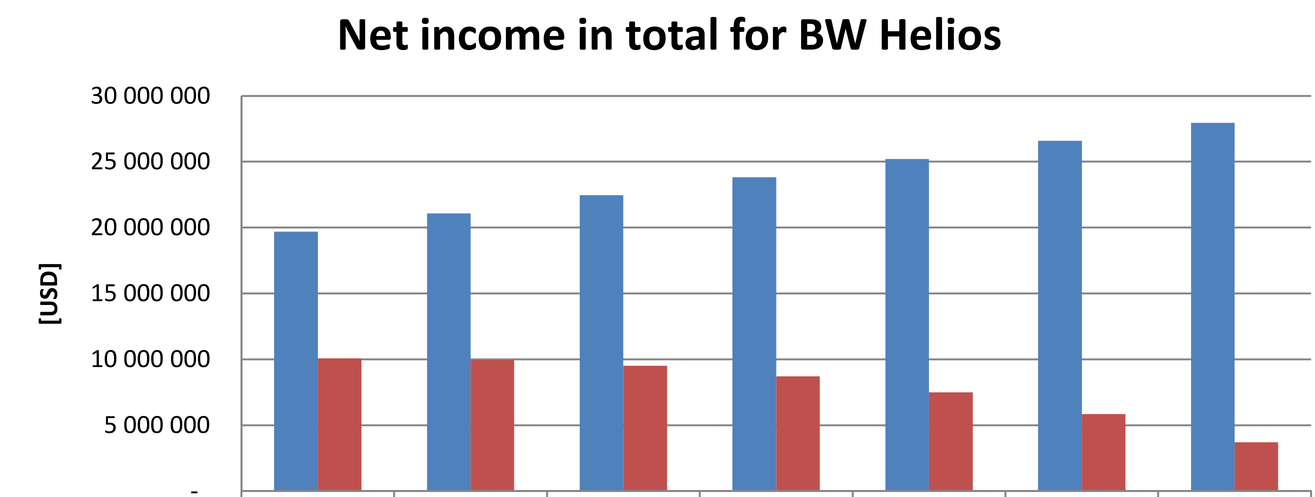
Maharshi Vamadeva has 25% less loading capacity and therefore will the losses in spot market caused by speed reduction not have the same impact as for the latter ships. The net income peaks at 14 knots where it will reach 9.6 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	18 345 500	19 595 900	20 846 200	22 096 600	23 347 000	24 597 300	25 847 700
Net income	9 618 300	9 522 500	9 132 900	8 413 900	7 329 100	5 843 500	3 920 200

Figure 55 Net income in total - Maharshi Vamadeva

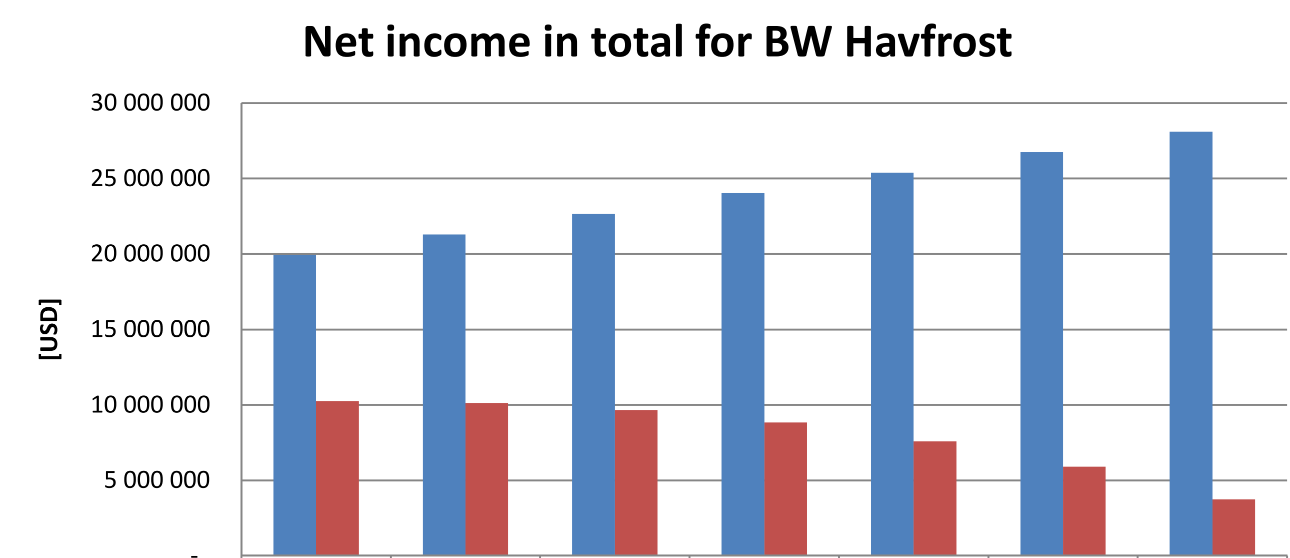
The net income for BW Helios will peak at 14 knots where it will reach 10.1 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	19 691 600	21 069 900	22 448 300	23 826 700	25 205 000	26 583 400	27 961 800
Net income	10 071 000	9 955 700	9 514 800	8 708 600	7 496 900	5 841 500	3 701 500

Figure 56 Net income in total - BW Helios

The net income for BW Havfrost will also peak at 14 knots where it will reach 10.3 million USD.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	19 929 500	21 292 900	22 656 400	24 019 800	25 383 200	26 746 600	28 110 000
Net income	10 261 900	10 123 900	9 658 700	8 827 000	7 589 100	5 906 900	3 740 600

Figure 57 Net income in total - BW Havfrost

The total maximized net income for the fleet will therefore be 75.8 million USD between September 2006 and December 2007.

Cost of Averting a Ton of CO_2-eq Heating, CATCH

Speed reduction is an effective measure to reduce greenhouse gas emissions. By speed reduction the utilization of the vessel decreases hence the incomes are likely to decrease as well. As mentioned earlier it is important to carry out sustainable measures which can be defended in the board room. A cost effective analysis can be a useful tool to prove the effect of a measure. In this report I will use the CATCH-method which was introduced by DNV researchers (Eide, Endresen, Skjong, Longva, & Alvik, 2009).

$$CATCH = \frac{\Delta C - \Delta B}{\Delta E}$$

Delta C is the cost of replacing lost capacity in terms of ton-miles by reduced speed. Delta B is the benefit of the speed reduction measured by the net income variations. The net income depends on the magnitude of LPG carried, the freight rates, fuel expenses, Suez charges and port expenses. At high speeds the gross incomes increase as the capacity increases. At low speeds the expenses decrease due to lower fuel consumptions, less passages through the Suez Canal and port calls are made. A ship owner will strive to find the point where the net income is maximized. The ideal case is if the ship owner can increase his net income and at the same time reduce the greenhouse gas emissions. This will be the aim for my calculations.

When a ship reduces speed her annual lifted volumes will decrease and this can be counteracted by replacing the lost capacity with a new ship. The cost of replacing a ship does not only involve the acquisition but also the operational costs. The fleet contain three vessels with a loading capacity of approximately 78 500 m^3 and three vessels with a loading capacity of 57 000 m^3 LPG. By correspondence with Inge Steensland AS (Olafsen, 2010) I received the cost data presented in Table 42. The abbreviations VLGC and LGC is short for very large gas carriers (+70 000 m^3) and large gas carriers (50 000 – 70 000 m^3).

	VLGC, 78 500 m^3	**LGC, 57 000 m^3**
Newbuilding price	74 000 000 USD	64 000 000 USD
Suprvision of ship building	6 000 000 USD	5 000 000 USD
Delivered cost	80 000 000 USD	69 000 000 USD
Daily capital costs (@7% 10 yrs)	30 500 USD	26 300 USD
Daily insurance and crew costs	10 000 USD	9 200 USD
Daily docking costs	830 USD	830 USD
Total daily fixed costs	**41 330 USD**	**36 330 USD**

Table 42 Daily fixed costs - new LPG vessel. Courtesy Inge Steensland AS

In the analysis I define the benefit, ΔB, as the gain in net income at a respective speed compared to the baseline at 20 knots speed. I also calculate the CO_2 emissions for every speed and find the reductions compared to the baseline at 20 knots speed, ΔE. The results are presented in Table 43.

Speed	Net income [USD]	ΔB [USD]	CO_2 emissions [tons]	ΔE [tons]
20	16 326 000		107 640	
19	17 110 800	784 800	87 670	19 970
18	17 557 200	1 231 200	70 720	36 920
17	17 693 500	1 367 500	56 540	51 100
16	17 545 900	1 219 900	44 900	62 740
15	17 142 500	816 500	35 550	72 090
14	16 510 100	184 100	28 240	79 400

Table 43 Effect of speed reduction for BW Clipper

In the next table I have calculated the daily costs for a new ship replacing the lost lifting capacity due to speed reductions. The daily fuel costs are added for the contracted orders and the spot market shipping and divided by the number of days from the start till the end of the contracted orders. The total Suez costs were also added together and divided by the duration of the period for the contracted orders. The daily fixed cost for the ship is calculated in Table 42. The total daily cost is simply the sum of these categories. Assuming the ship is loaded with 40 000 tons of LPG and sailing 24 hours at the respective speeds I derive the costs per ton-mile. As the ship reduces speed she will have decreased capacity in terms of ton-miles and this lost capacity must be replaced. The cost of replacing lost capacity, ΔC is simply found by multiplying the cost per ton-mile with the decreased capacity expressed in ton-miles. The CATCH formula can now be used in the results are presented in Table 44 where the minus-sign means a gain while positive CATCH values imply a cost for the measure.

Speed [knots]	Daily fuel costs [USD]	Daily Suez costs [USD]	Total daily costs [USD]	Costs per ton-mile [USD]	Decreased capacity [ton-miles]	ΔC [USD]	CATCH [USD]
20	24 820	15 990	82 140	0.00428			
19	20 220	15 210	76 760	0.00421	160 766 700	676 600	-5.4
18	16 310	14 430	72 070	0.00417	321 533 400	1 341 000	3.0
17	13 040	13 650	68 020	0.00417	482 300 100	2 010 200	12.6
16	10 350	12 870	64 550	0.00420	643 066 800	2 702 500	23.6
15	8 200	12 090	61 620	0.00428	803 833 500	3 439 700	36.4
14	6 510	11 310	59 150	0.00440	964 600 200	4 245 200	51.1

Table 44 CATCH for BW Clipper

The same procedure is done for BW Saga as depicted in Table 45 and Table 46. The benefit of speed reductions is clearly larger for BW Saga compared to BW Clipper the CO_2 reductions are significantly larger as well. This can be explained by the differences in the fuel consumption curves with reference to Figure 16.

Speed	Net income [USD]	ΔB [USD]	CO_2 emissions [tons]	ΔE [tons]
20	10 552 100		153 960	
19	12 293 700	1 741 600	125 360	28 600
18	13 549 800	2 997 700	101 090	52 870
17	14 359 700	3 807 600	80 800	73 160
16	14 762 900	4 210 800	64 140	89 820
15	14 798 200	4 246 100	50 770	103 190
14	14 504 200	3 952 100	40 340	113 620

Table 45 Effects of speed reduction for BW Saga

Since the fuel consumption is larger for BW Saga than for BW Clipper the fuel costs will be proportionally larger. The Suez costs will be slightly larger and the fixed daily costs are identical. The cost of replacing lost capacity is therefore highest for BW Saga, but this is counteracted by a high benefit giving favorable CATCH-values.

Speed [knots]	Daily fuel costs [USD]	Daily Suez costs [USD]	Total daily costs [USD]	Costs per ton-mile [USD]	Decreased capacity [ton-miles]	ΔC [USD]	CATCH [USD]
20	35 430	17 570	94 330	0.00491			
19	28 850	16 810	86 990	0.00477	160 770 500	766 700	-34.1
18	23 260	16 060	80 650	0.00467	321 541 000	1 500 700	-28.3
17	18 590	15 300	75 220	0.00461	482 311 500	2 223 000	-21.7
16	14 760	14 550	70 640	0.00460	643 082 100	2 957 500	-14.0
15	11 680	13 790	66 800	0.00464	803 852 600	3 729 000	-5.0
14	9 280	13 040	63 650	0.00474	964 623 100	4 568 300	5.4

Table 46 CATCH for BW Saga

Gas Beauty I will have the best benefit of the latter ships and slightly better CO_2 reduction as well. Her fuel consumption is similar to the figures for BW Saga.

Speed	Net income [USD]	ΔB [USD]	CO_2 emissions [tons]	ΔE [tons]
20	8 845 100		159 960	
19	10 669 600	1 824 500	130 310	29 650
18	11 992 100	3 147 000	105 140	54 820
17	12 853 100	4 008 000	84 090	75 870
16	13 292 900	4 447 800	66 800	93 160
15	13 351 300	4 506 200	52 920	107 040
14	13 067 500	4 222 400	42 660	117 300

Table 47 Effects of speed reduction for Gas Beauty I

The overall costs for Gas Beauty I do not differ much to BW Saga, but since the amount of LPG lifted measured in ton-miles will decrease more with speed for Gas Beauty, the costs of replacing the lost capacity will be larger. This is counteracted for by a larger benefit in terms of higher net incomes at reduced speeds and results in lower CATCH which is desirable.

Speed [knots]	Daily fuel costs [USD]	Daily Suez costs [USD]	Total daily costs [USD]	Costs per ton-mile [USD]	Decreased capacity [ton-miles]	ΔC [USD]	CATCH [USD]
20	35 780	17 390	94 500	0.00492			
19	29 150	16 620	87 100	0.00478	165 365 500	789 700	-34.9
18	23 520	15 850	80 700	0.00467	330 731 000	1 544 600	-29.2
17	18 810	15 090	75 230	0.00461	496 096 600	2 286 800	-22.7
16	14 940	14 320	70 590	0.00460	661 462 100	3 039 900	-15.1
15	11 840	13 550	66 720	0.00463	826 827 600	3 831 000	-6.3
14	9 540	12 810	63 680	0.00474	985 130 100	4 667 600	3.8

Table 48 CATCH for Gas Beauty I

As noted earlier is the net income for the three smallest ships significantly lower than for the ships with largest loading capacities. The benefit by speed reduction for Maharshi Vamadeva is although higher than the latter ships. The reason for this might be that she has less loading capacity and therefore will lose less income when reducing speed.

Speed	Net income [USD]	ΔB [USD]	CO_2 emissions [tons]	ΔE [tons]
20	3 920 200		136 850	
19	5 843 500	1 923 300	111 250	25 600
18	7 329 100	3 408 900	89 550	47 300
17	8 413 900	4 493 700	71 430	65 420
16	9 132 900	5 212 700	56 580	80 270
15	9 522 500	5 602 300	44 670	92 180
14	9 618 300	5 698 100	35 370	101 480

Table 49 Effects of speed reduction for Maharshi Vamadeva

The daily fuel costs are almost identical to Gas Beauty I's while the daily Suez costs are a notch lower. As this is a smaller ship the fixed daily costs will be reduced with reference to Table 42. The total daily costs will therefore be lower and as the decreased capacity is far less the cost of replacing lost capacity due to speed reduction is reduced severely. Speed reductions will for this ship be beneficial as there is no net cost introduced since the CATCH-values are negative for all speeds between 14 to 19 knots.

Speed [knots]	Daily fuel costs [USD]	Daily Suez costs [USD]	Total daily costs [USD]	Costs per ton-mile [USD]	Decreased capacity [ton-miles]	ΔC [USD]	CATCH [USD]
20	35 170	16 890	88 390	0.00614			
19	28 590	16 190	81 110	0.00593	109 623 600	650 000	-49.7
18	23 020	15 490	74 840	0.00577	219 247 200	1 266 100	-45.3
17	18 360	14 790	69 480	0.00568	328 870 800	1 866 800	-40.2
16	14 540	14 100	64 970	0.00564	438 494 400	2 473 000	-34.1
15	11 480	13 400	61 210	0.00567	548 118 000	3 106 500	-27.1
14	9 090	12 700	58 120	0.00577	657 741 600	3 792 400	-18.8

Table 50 CATCH for Maharshi Vamadeva

The benefit for speed reduction is even larger for BW Helios. The CO_2 reductions are on level with the figures for BW Saga.

Speed	Net income [USD]	ΔB [USD]	CO_2 emissions [tons]	ΔE [tons]
20	3 701 500		152 060	
19	5 841 500	2 140 000	123 670	28 390
18	7 496 900	3 795 400	99 600	52 460
17	8 708 600	5 007 100	79 490	72 570
16	9 514 800	5 813 300	63 000	89 060
15	9 955 700	6 254 200	49 760	102 300
14	10 071 000	6 369 500	39 440	112 620

Table 51 Effects of speed reduction for BW Helios

The daily costs do not differ much compared to Maharshi Vamadeva, but the decreased capacity is larger. The reason for this is that BW Helios has a higher potential for spot market purposes. The cost of replacing lost capacity due to speed reduction will be higher than for Maharshi Vamadeva. The CATCH-values are fairly similar.

Speed [knots]	Daily fuel costs [USD]	Daily Suez costs [USD]	Total daily costs [USD]	Costs per ton-mile [USD]	Decreased capacity [ton-miles]	ΔC [USD]	CATCH [USD]
20	35 280	16 530	88 140	0.00612			
19	28 690	15 830	80 850	0.00591	120 846 000	714 200	-50.2
18	23 110	15 140	74 580	0.00575	241 691 900	1 390 800	-45.8
17	18 440	14 450	69 220	0.00566	362 537 900	2 050 200	-40.7
16	14 620	13 750	64 700	0.00562	483 383 900	2 714 800	-34.8
15	11 550	13 060	60 940	0.00564	604 229 900	3 409 400	-27.8
14	9 150	12 360	57 840	0.00574	725 075 800	4 160 600	-19.6

Table 52 CATCH for BW Helios

The benefit and the CO_2 reduction for BW Havfrost and BW Helios do not differ much.

Speed	Net income [USD]	ΔB [USD]	CO_2 emissions [tons]	ΔE [tons]
20	3 740 600		153 430	
19	5 906 900	2 166 300	124 910	28 520
18	7 589 100	3 848 500	100 710	52 720
17	8 827 000	5 086 400	80 470	72 960
16	9 658 700	5 918 100	63 870	89 560
15	10 123 900	6 383 300	50 530	102 900
14	10 261 900	6 521 300	40 120	113 310

Table 53 Effects of speed reduction for BW Havfrost

The daily fuel costs do not change much, but the daily Suez costs will increase since BW Havfrost must pass the Suez Canal once in the COA shipping while the latter two ships don't. The costs per ton-mile have therefore increased. The rate of the decreased capacity is a bit larger for BW Havfrost compared to the latter two ships. The cost of replacing lost loading capacity is larger for BW Havfrost than for BW Helios, but the CATCH-values are about the same.

Speed [knots]	Daily fuel costs [USD]	Daily Suez costs [USD]	Total daily costs [USD]	Costs per ton-mile [USD]	Decreased capacity [ton-miles]	ΔC [USD]	CATCH [USD]
20	35 970	19 560	91 860	0.00638			
19	29 280	18 860	84 470	0.00617	119 535 600	738 100	-50.1
18	23 610	18 170	78 110	0.00603	239 071 200	1 440 900	-45.7
17	18 870	17 480	72 680	0.00594	358 606 800	2 129 400	-40.5
16	14 970	16 780	68 080	0.00591	478 142 500	2 825 700	-34.5
15	11 850	16 090	64 270	0.00595	597 678 100	3 556 700	-27.5
14	9 410	15 390	61 130	0.00606	717 213 700	4 349 500	-19.2

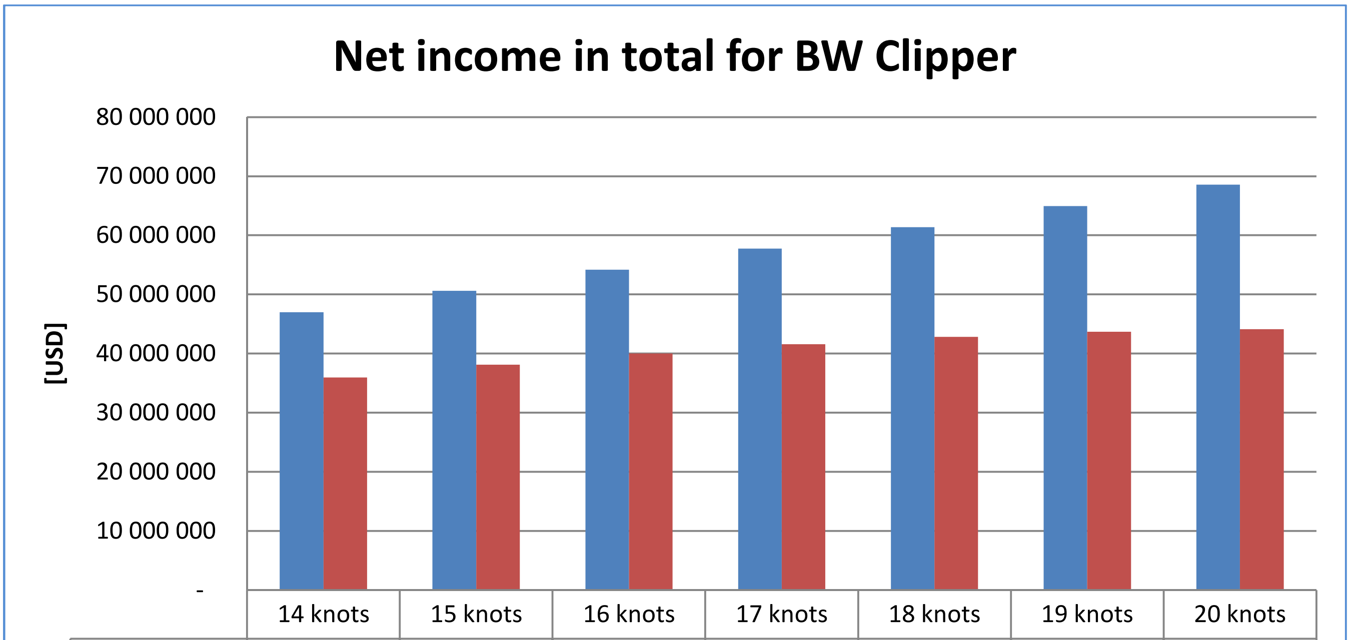
Table 54 CATCH for BW Havfrost

In the next section I will investigate what will happen when the market situation and the fuel prices change. The scenarios “prosperity” and “recession” were presented earlier. Will it be more sustainable to reduce the emissions at different market conditions? This will be assessed based on the following analysis.

Prosperity

As mentioned earlier the freight rate for LPG was calculated to 62.96 USD/ton and the estimated fuel price for IFO 180 was 383.3 USD/ton for the prosperity level. The spot market potential will be fully utilized.

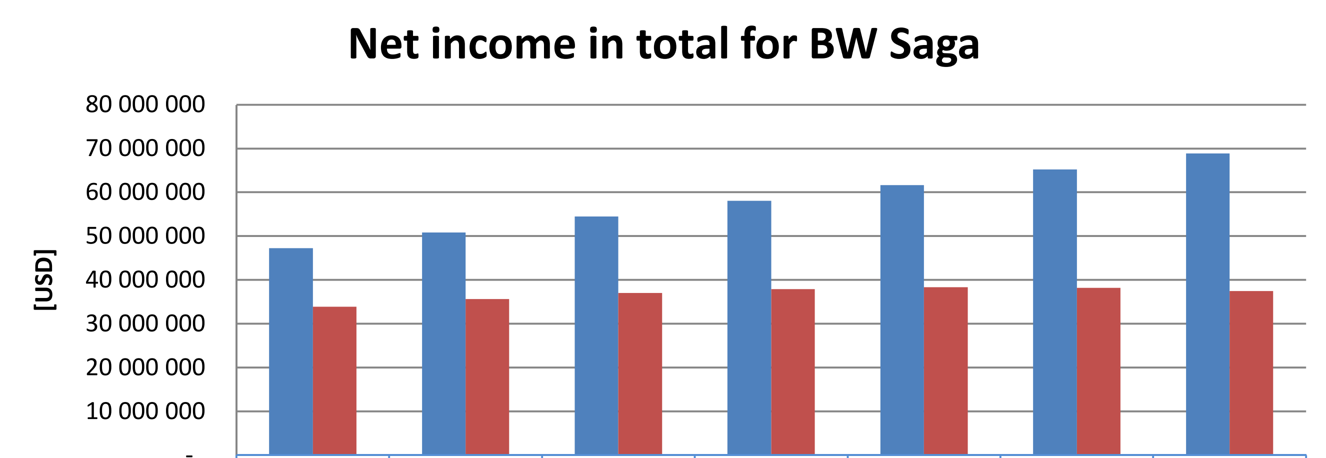
The trend for BW Clipper in prosperity is losses in net income at speed reduction. While the net income for the actual level occurs at 17 knots the profit is maximized at 20 knots speed in prosperity for BW Clipper. The maximum net income at prosperity is 26.4 million USD larger than the peak for the actual level. When sailing at a constant speed of 20 knots in the prosperity level, BW Clipper will emit 120 150 tons of CO_2. Since it is the same speed as for the baseline there will of course not be an improvement with regard to $C0_2$ reductions.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	46 987 400	50 583 600	54 179 700	57 775 900	61 372 000	64 968 200	68 564 400
Net income	35 954 600	38 123 100	40 013 000	41 591 200	42 823 300	43 676 900	44 117 100

Figure 58 Net income in prosperity - BW Clipper

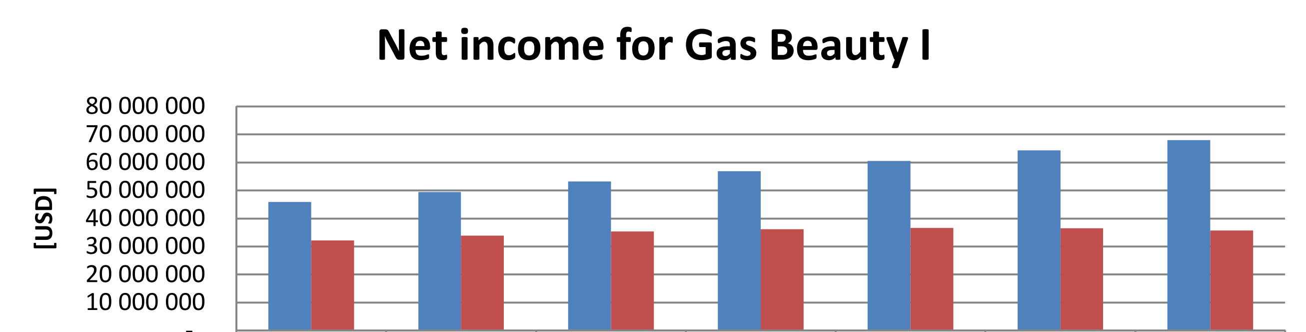
While the net income peaked at 15 knots for the actual level, the top will be shifted to 18 knots speed for BW Saga in prosperity level. The maximum net income in prosperity will be 23.5 million USD larger than the maximum for the actual level. At 18 knots in the prosperity level BW Saga will emit 112 740 tons of CO_2, which is an improvement of 34.5% compared to the emissions at baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	47 267 600	50 863 900	54 460 100	58 056 300	61 652 600	65 248 700	68 845 100
Net income	33 905 300	35 661 200	37 016 300	37 923 000	38 333 300	38 198 400	37 470 000

Figure 59 Net income in prosperity - BW Saga

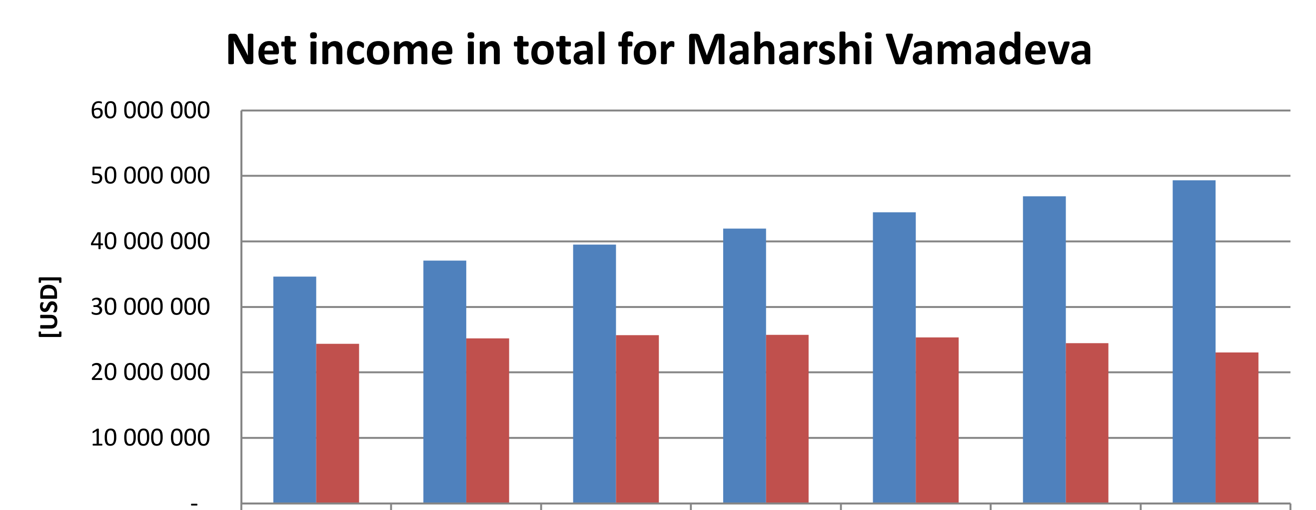
The maximum net income for Gas Beauty I occurred at 15 knots speed while it will be present at 18 knots for the prosperity level. The difference at the two points is 23.3 million USD. At 18 knots Gas Beauty I will emit 116 750 tons of CO_2 which is a reduction of 34.4% compared to the baseline (20 knots).



	Optimized speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	45 926 400	49 467 500	53 166 600	56 865 500	60 564 600	64 263 500	67 962 600
Net income	32 219 300	33 941 400	35 315 800	36 226 900	36 625 500	36 461 500	35 685 000

Figure 60 Net income in prosperity - Gas Beauty I

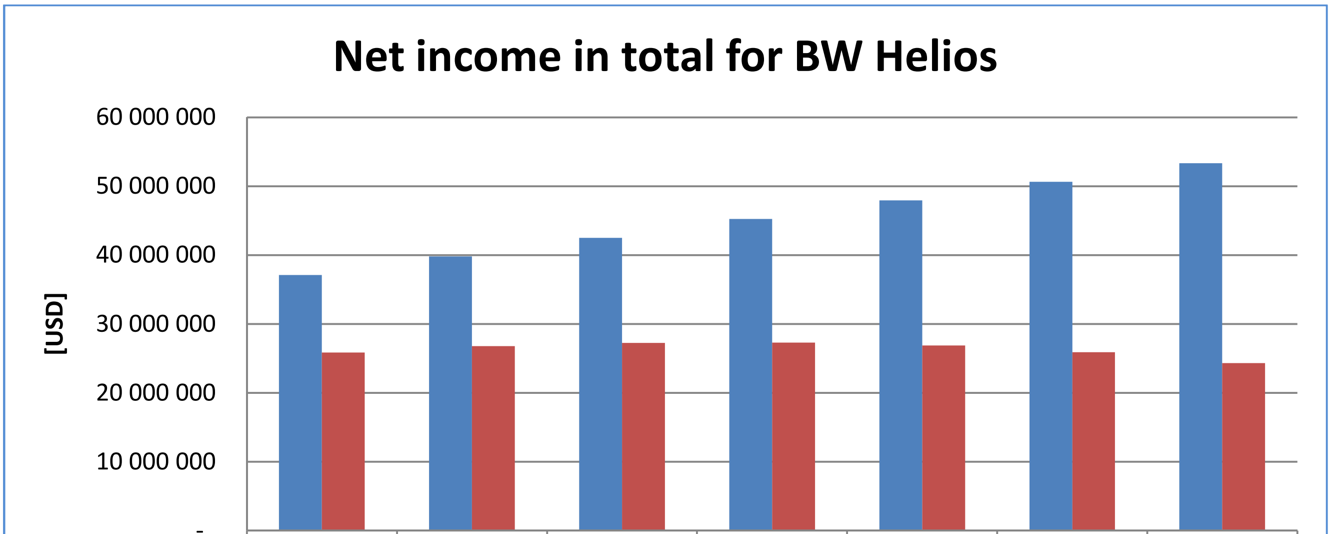
The maximal net income occurred at 14 knots for the actual level and it will peak 17 knots for the prosperity level for Maharshi Vamadeva. The difference for the two points is 16.1 million USD. At 17 knots Maharshi Vamadeva will emit 80 840 tons of CO_2 which is an improvement of 47.8% compared to the baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	34 614 200	37 066 500	39 518 500	41 970 800	44 422 900	46 874 900	49 327 200
Net income	24 378 500	25 203 700	25 667 000	25 724 900	25 332 500	24 446 100	23 020 900

Figure 61 Net income in prosperity - Maharshi Vamadeva

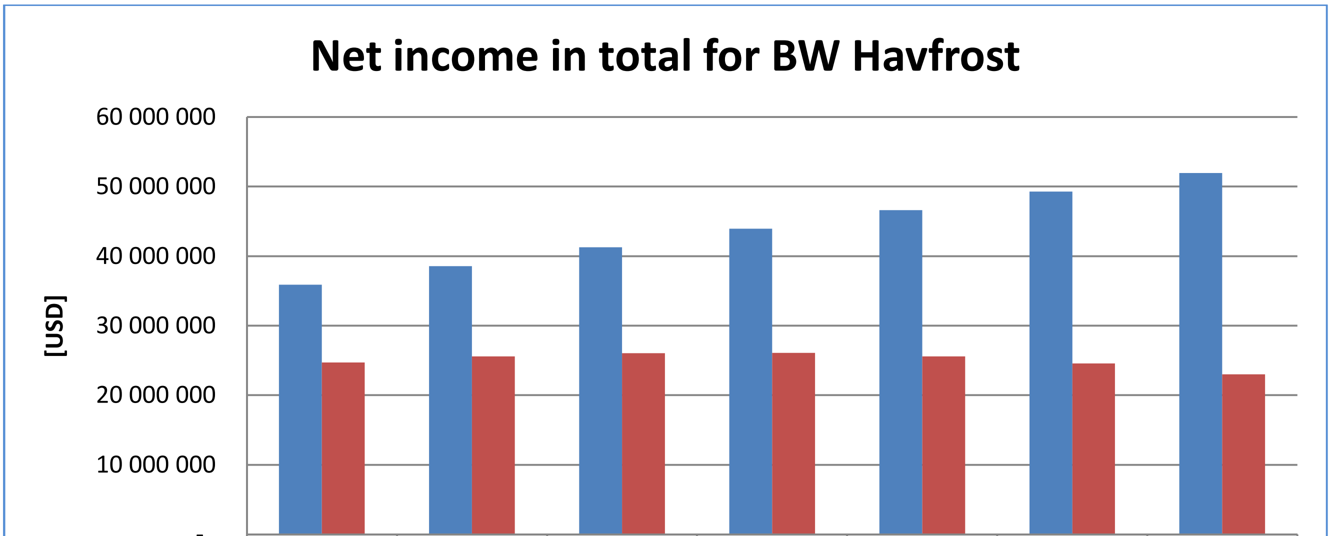
For the actual level the maximum net income was found at 14 knots and for the prosperity level it appears at 17 knots. The difference is 17.3 million USD. At 17 knots 89 620 tons will be emitted by BW Helios which is an improvement of 47.8% compared to the baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	37 118 600	39 821 700	42 525 000	45 228 200	47 931 200	50 634 500	53 337 700
Net income	25 867 400	26 769 400	27 271 800	27 325 400	26 880 700	25 890 900	24 304 900

Figure 62 Net income in prosperity - BW Helios

At the actual level the net income was largest at 14 knots speed while it is maximized at 17 knots for the prosperity level for BW Havfrost. The difference is 15.8 million USD. BW Havfrost will emit 89 890 tons of CO_2 in the prosperity when sailing 17 knots which is an reduction of 47.7% compared to the baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	35 897 000	38 570 800	41 244 800	43 918 600	46 592 500	49 266 300	51 940 100
Net income	24 697 200	25 571 100	26 045 900	26 073 500	25 604 600	24 592 000	22 986 700

Figure 63 Net income in prosperity - BW Havfrost

If the decision is to sail at a speed that will maximize the net income the total CO_2 emissions will be 602 240 tons which is an improvement of 37.8% overall. The speed reductions can easily be defended in the board room.

The CATCH values for BW Clipper ranged from -5.4 to 51.1 USD/ton for the actual level and from 56.8 to 148.5 USD/ton for the prosperity level with reduced speed from 19 to 14 knots respectively.

The CATCH values for BW Saga ranged from -34.1 to 5.4 USD/ton for the actual level and from 6.9 to 70.8 USD/ton for the prosperity level with reduced speed from 19 to 14 knots respectively.

The CATCH values for Gas Beauty I ranged from -34.9 to 3.8 USD/ton for the actual level and from 6.1 to 68.9 USD/ton for the prosperity level with reduced speed from 19 to 14 knots respectively.

The CATCH values for Maharshi Vamadeva ranged from -49.7 to -18.8 USD/ton for the actual level and from -21.0 to 27.9 USD/ton for the prosperity level with reduced speed from 19 to 14 knots respectively.

The CATCH values for BW Helios ranged from -50.2 to -19.6 USD/ton for the actual level and from -21.6 to 27.0 USD/ton for the prosperity level with reduced speed from 19 to 14 knots respectively.

The CATCH values for BW Havfrost ranged from -50.1 to -19.2 USD/ton for the actual level and from -21.5 to 27.4 USD/ton for the prosperity level with reduced speed from 19 to 14 knots respectively.

The CATCH values for the prosperity level are depicted in Figure 64. It is clear that it is easier to reduce the emissions by speed reductions for the actual level compared to the prosperity level. The income losses and the costs of replacing lost capacity is larger in prosperity.

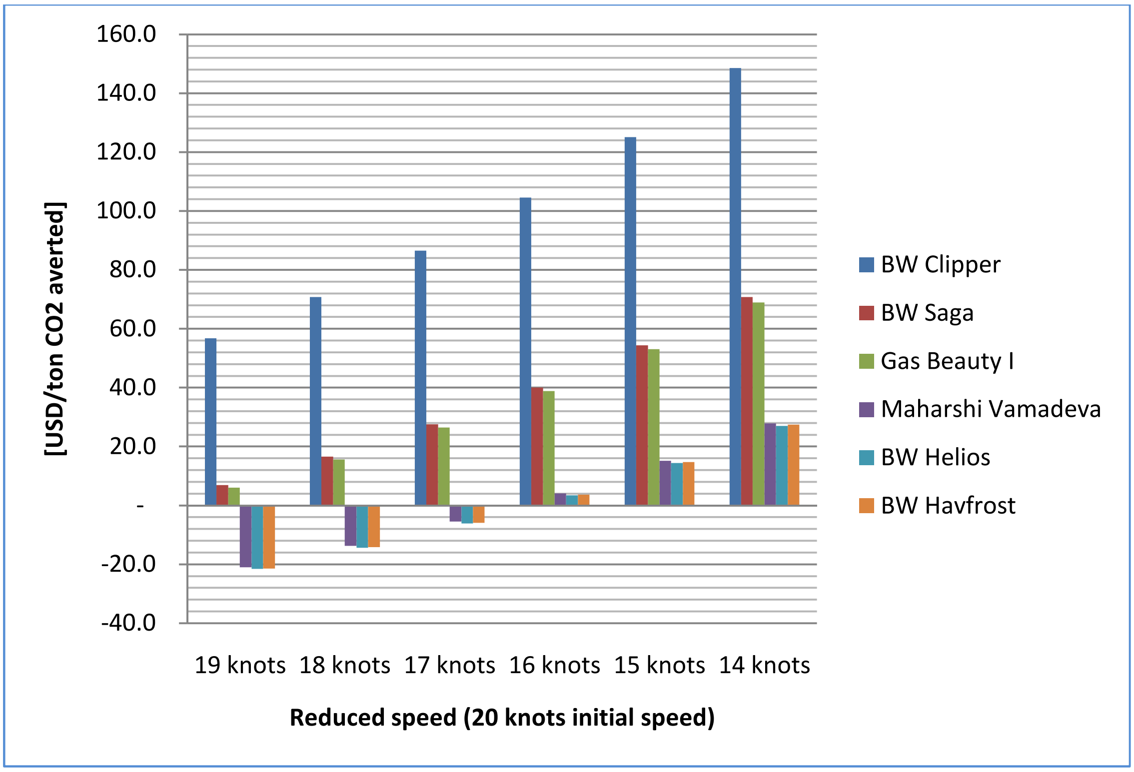
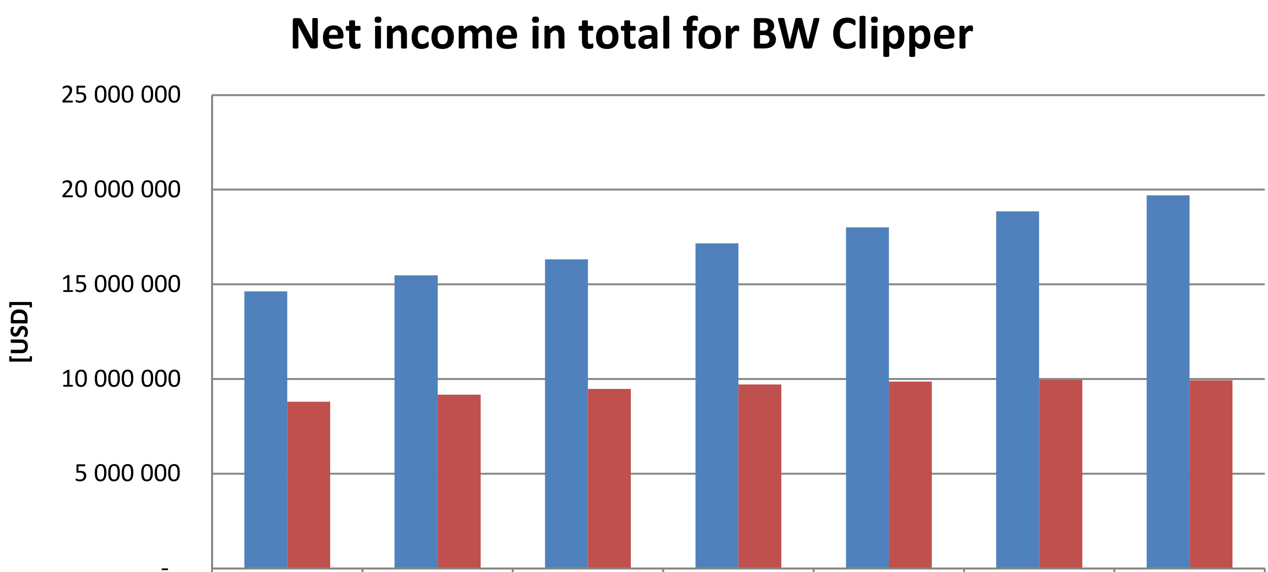


Figure 64 CATCH for prosperity level

Recession

The recession level had a freight rate for LPG of 25.74 USD/ton, the estimated fuel price for IFO 180 was 138 YSD/ton and 57.5% of the spot market potential was utilized.

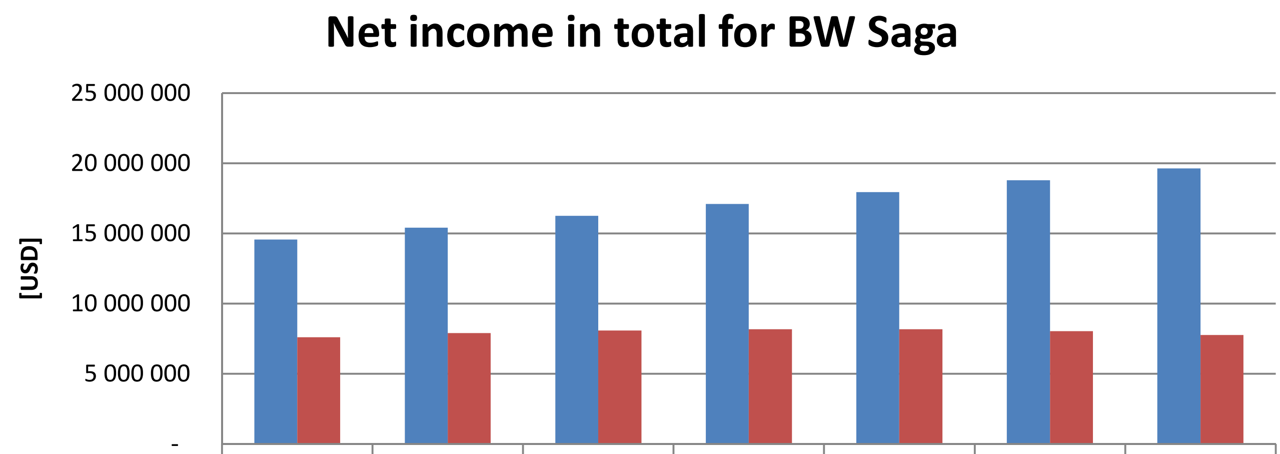
For BW Clipper the maximum net income occurred at 17 knots while it is shifted to 19 knots for the recession level. The maximum net income in the actual level is 7.7 million USD larger than the maximum for the recession level. The CO_2 emissions for the period between late August 2006 to December 2007 at 19 knots in recession is 62 180 tons, which is an improvement of 18.2% compared to the baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	14 628 200	15 474 100	16 320 000	17 166 000	18 011 900	18 857 883	19 703 900
Net income	8 794 700	9 164 700	9 472 400	9 710 900	9 873 100	9 952 583	9 941 400

Figure 65 Net income in recession - BW Clipper

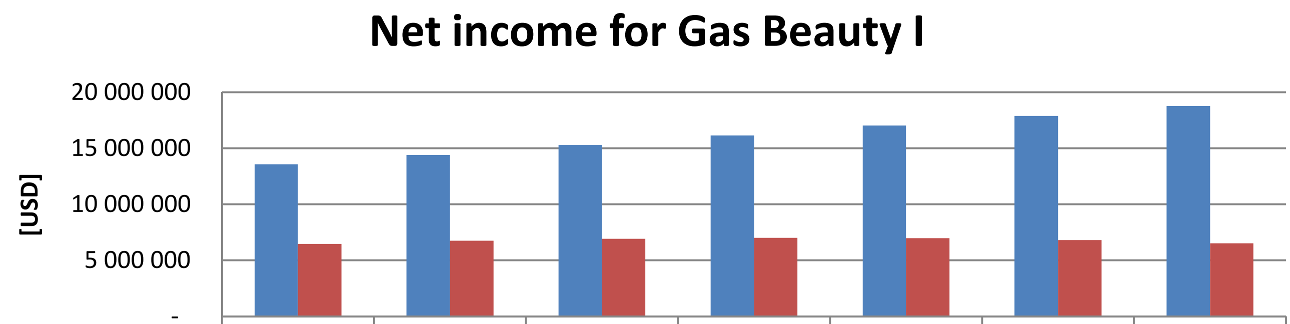
The net income peaked at 15 knots speed for the actual level while it will reach maximum at 17 knots for the recession level. The difference in between the net income for the points is 6.6 million USD. The CO_2 emissions at 17 knots for BW Saga in recession is 57 530 tons, a 46.9% reduction compared to the baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	14 551 100	15 397 100	16 243 100	17 088 900	17 935 000	18 780 800	19 626 900
Net income	7 610 900	7 893 400	8 086 300	8 180 000	8 164 800	8 029 700	7 765 600

Figure 66 Net income in recession - BW Saga

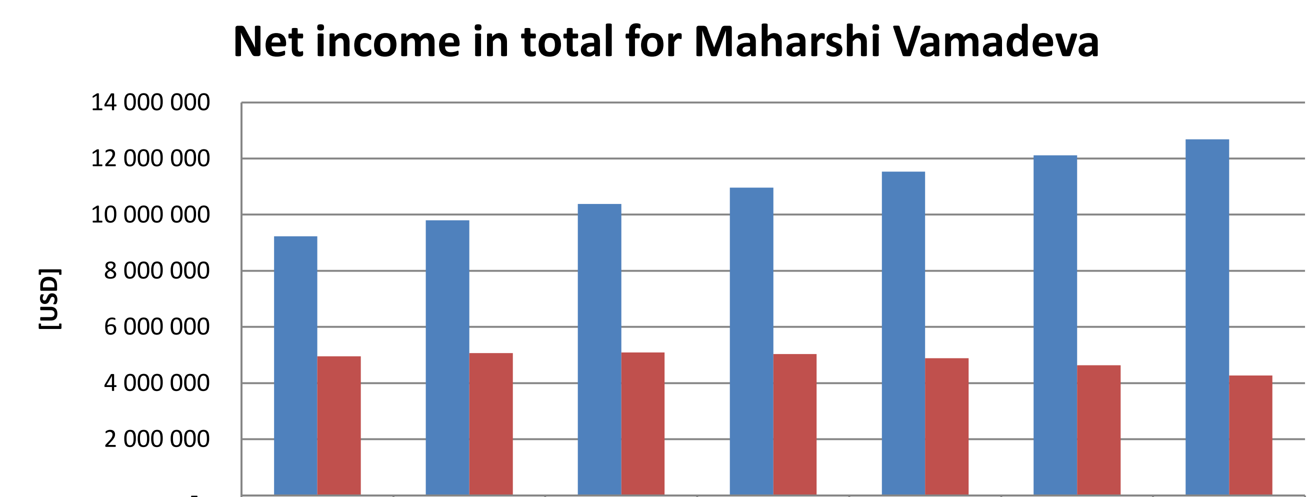
The maximum net income occurred at 15 knots for Gas Beauty I in the actual level while it will peak at 17 knots for the recession. The difference is 6.3 million USD. Gas Beauty I will emit 60 960 tons of CO2 at 17 knots in recession, which is an improvement of 46.7% compared to the baseline (20 knots).



	Optimized speed	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	13 567 200	14 400 300	15 270 400	16 140 400	17 010 600	17 880 700	18 750 900
Net income	6 465 100	6 739 600	6 922 500	7 001 400	6 966 400	6 806 400	6 511 700

Figure 67 Net income in recession - Gas Beauty I

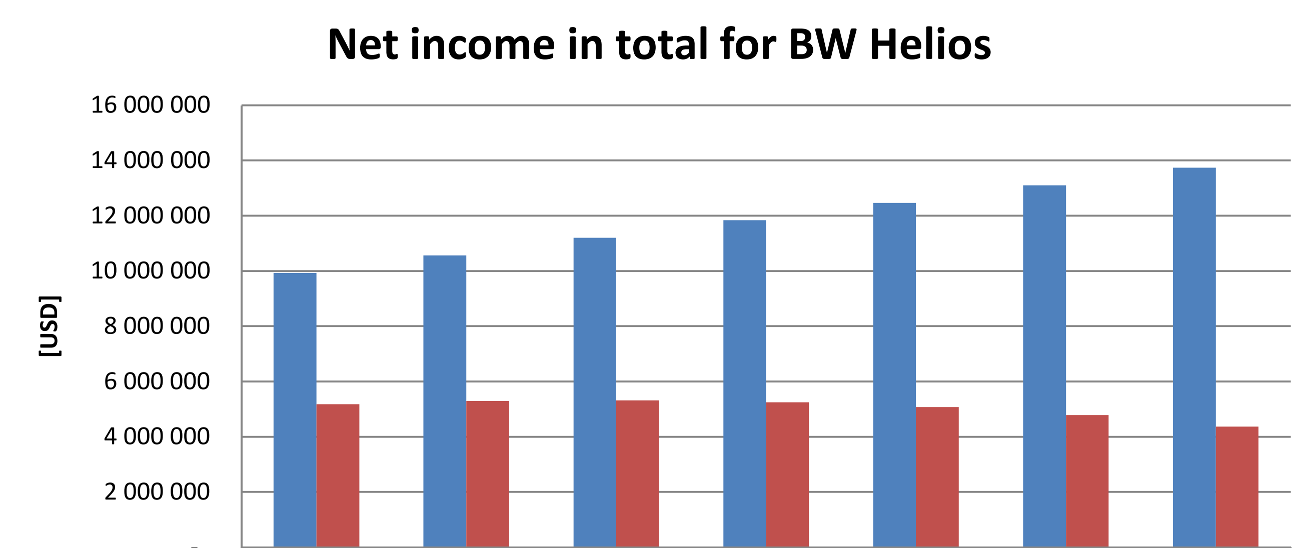
The maximum net income occurred at 14 knots for Maharshi Vamadeva at the actual level while the net income peaks at 16 knots in recession. The difference between the net income at the respective points is 4.5 million USD. At 16 knots Maharshi Vamadeva will emit 37 810 tons of CO_2 which is a 58.5% reduction compared to the baseline (20 knots).



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	9 227 500	9 804 500	10 381 200	10 958 100	11 534 900	12 111 700	12 688 600
Net income	4 956 000	5 063 000	5 093 200	5 038 300	4 889 000	4 636 000	4 269 800

Figure 68 Net income in recession - Maharshi Vamadeva

The net income for BW Helios peaked at 14 knots for the actual level, while it will reach its maximum at 16 knots in recession. The difference will be 4.8 million USD. At 16 knots speed in recession the vessel will emit 37 810 tons CO_2, which is an improvement of 58.5%.



	14 knots	15 knots	16 knots	17 knots	18 knots	19 knots	20 knots
Gross freight	9 924 600	10 560 300	11 196 300	11 832 200	12 468 000	13 103 900	13 739 800
Net income	5 182 400	5 293 100	5 318 600	5 248 400	5 072 600	4 781 200	4 363 600

Figure 69 Net income in recession - BW Helios

The net income for BW Havfrost peaked at 14 knots speed in the actual level while the maximum net income will occur at 16 knots for the recession level. The difference is 4.1 million USD. At 16 knots in recession BW Havfrost will emit 42 810 tons CO2, which is an improvement of 58.3% copared to the baseline (20 knots).

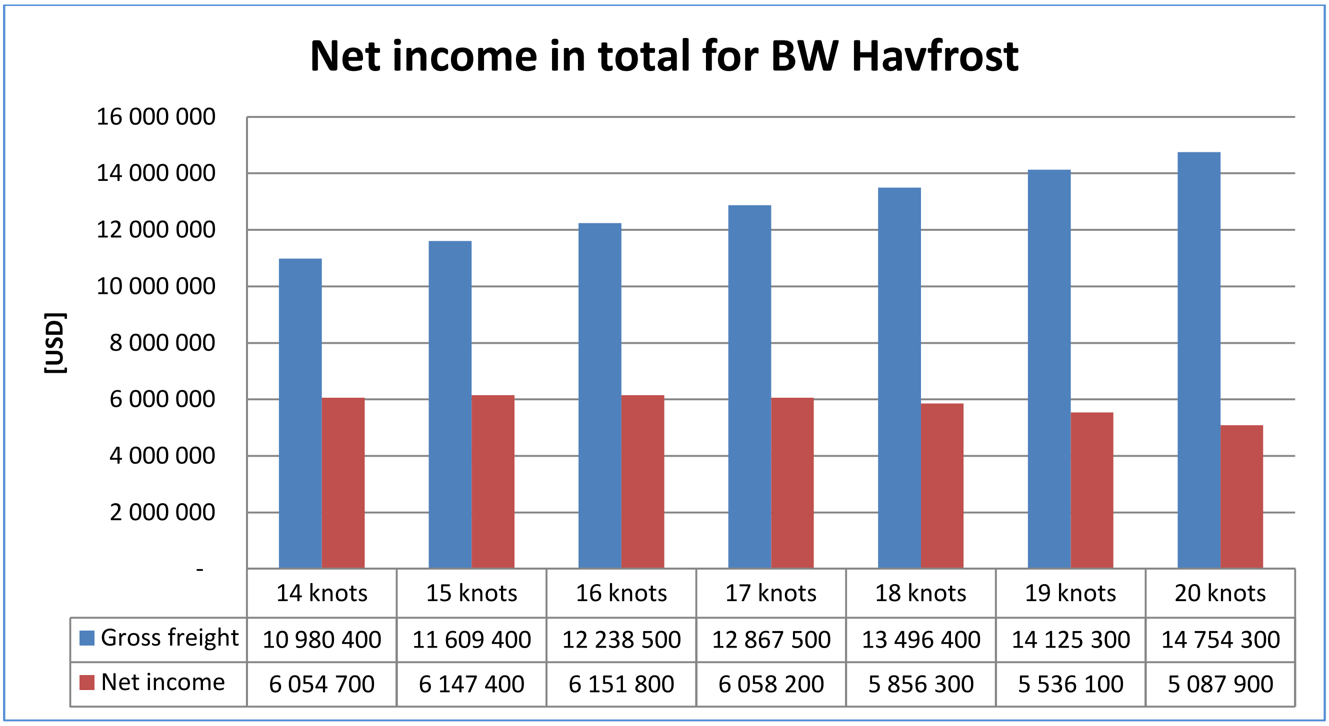


Figure 70 Net income in recession - BW Havfrost

The CATCH values for the entire fleet in recession are depicted in Figure 71 for reduced speeds between 14 and 19 knots.

The CATCH values for BW Clipper range from -5.4 to 51.1 USD/ton in the actual level while the figures for recession range from 23.1 to 64.1 USD/ton at speeds from 19 to 14 knots respectively.

The CATCH values for BW Saga range from -34.1 to 5.4 USD/ton in the actual level while the figures for recession range from 4.6 to 33.9 USD/ton at speeds from 19 to 14 knots respectively.

The CATCH values for Gas Beauty I range from -34.9 to 3.8 USD/ton in the actual level while the figures for recession range from 3.4 to 31.8 USD/ton at speeds from 19 to 14 knots respectively.

The CATCH values for Maharshi Vamadeva range from -49.7 to -18.8 USD/ton in the actual level while the figures for recession range from -4.4 to 20.3 USD/ton at speeds from 19 to 14 knots respectively.

The CATCH values for BW Helios range from -50.2 to -19.6 USD/ton in the actual level while the figures for recession range from -5.1 to 19.0 USD/ton at speeds from 19 to 14 knots respectively.

The CATCH values for BW Helios range from -50.2 to -19.6 USD/ton in the actual level while the figures for recession range from -5.1 to 19.0 USD/ton at speeds from 19 to 14 knots respectively.

The same trend for the recession level appears for the prosperity level; the cost of averting a ton of CO_2 will increase compared to the actual level. The main reason for this is the large income losses which affect ΔB in the CATCH formula.

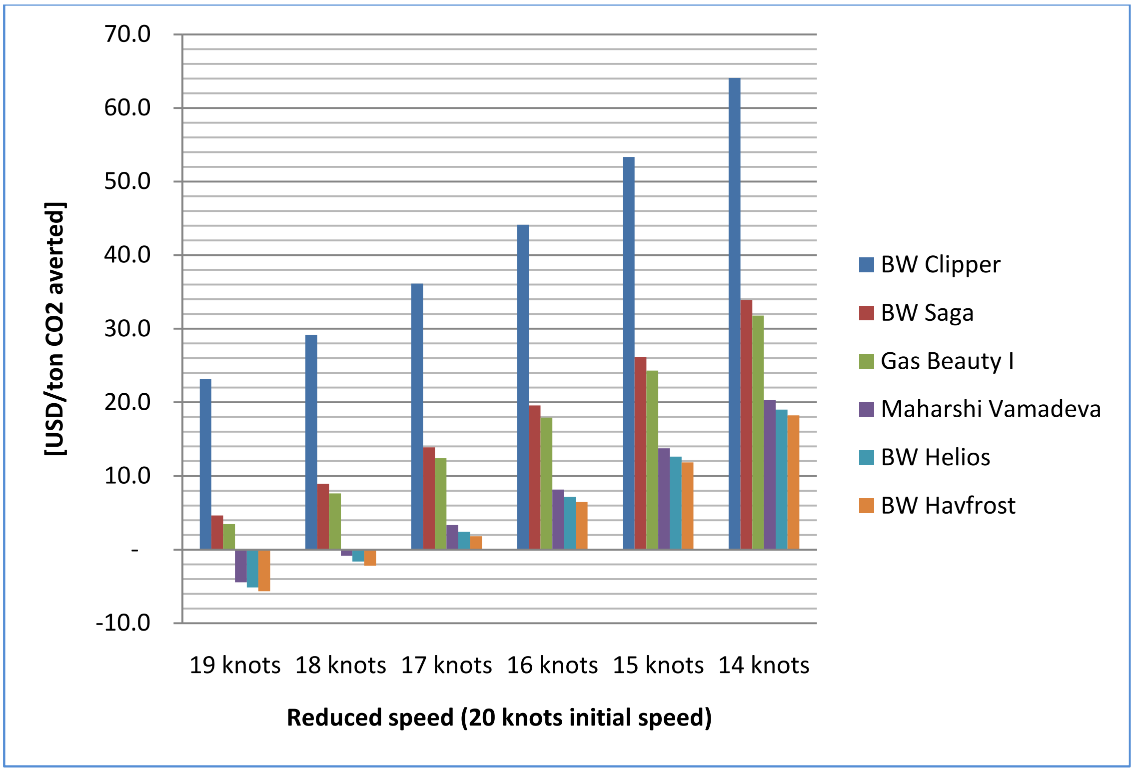


Figure 71 CATCH for recession level

Measures to reduce GHG emissions from IMO

The awareness of the climate changes is growing and the desire to take action and prevent further global warming is increasing. It is expected that the maritime industry will take its share of the burden.

The vast majority of ship owners are in business to make profits and they will deliver green haulage when it is profitable. IMO is in a position to impose environmental sound shipping by introducing legislative measures. These measures must be profit oriented in order to provide a sustainable maritime industry. Environmental taxes on fuel is a measure which might motivate shipping companies to reduce their emissions.

The taxes can be applicable for only the maritime sector or for every purpose of fuel consumption. In this report I will only pay attention to the maritime industry although it only contributes to 3.3% of the global GHG emissions while road transportation is accountable for 21.3% of the GHG emissions (International Maritime Organization, 2009). It is important that the taxes are uniform worldwide and they need to be sustainable but at the same time be large enough to encourage actors to decrease their emissions. The taxes need to be balanced and the tax levels will be discussed in this report. No difference should be given to location, ship segment or ship size. The industry must still be competitive to other modes of transportation and no shipping companies must be given any advantages by the taxation.

By introducing taxes on fuel the global fuel consumption is expected to decrease. The decrease depends on the magnitude of the tax level which impacts the net profit. International shipping is highly dependable upon the global economies; in prosperities high activity levels are present while the activity levels drop in recessions. At high activity levels freight rates are vast while it is low at low activity levels. International shipping is more vulnerable to increased fuel taxes at recessions due to lower incomes and the effect can be cancellations of voyages and improved utilization of cargo capacities. In an environmental point of view this is positive, but shipping companies will probably claim it is not sustainable. The effect of fuel taxes in prosperities is reduced as the incomes are significantly larger, that is if the taxes are kept constant. This problem will be solved if a dynamic fuel tax was introduced and the magnitude of the tax should be decided by a committee within IMO taking the factors mentioned above into account. In 2006 the average CO_2 taxes for inland and coastal shipping in Norway was 190 NOK (approximately 32 USD) per ton of CO_2 emitted (Bruvoll & Dalen, 2009). This taxation level will be the starting point for the further analysis.

Even taxes

As mentioned earlier the motivation for most shipping companies is to make money rather than executing green shipping. Green shipping could be interpreted as low emission shipping with significant reductions of emissions. When green shipping is profitable it will be performed by shipping companies worldwide. One way to make green shipping profitable is to levy global uniform fuel taxes on fuel used in seaborne shipping. I believe this measure will encourage to slow steaming and reduced activity at sea. In the following section I will assess how imposed fuel taxes will affect the CATCH in the different scenarios.

Actual level from August 2006 to December 2007

Combustion of one ton of fuel will emit 3.15 tons of CO_2 (Stapersma, 2009). Transformation of Norwegian CO_2 taxes (32 USD/ton CO_2) into fuel taxes will therefore result 100 USD per ton fuel. The new fuel price will be 453 USD/ton. I assume the freight rates and the market demand are kept constant at the same level as before the fuel tax was introduced.

The fuel tax will cause the CATCH to drop by 29.7 USD on average for all the vessels for all reduced speeds compared to the same scenario without fuel taxes. The effect of fuel taxes for reduced emissions can be positive in terms of improved CATCH as depicted in Figure 72. As the majority of CATCH values are negative the fuel taxes should be able to promote green shipping.

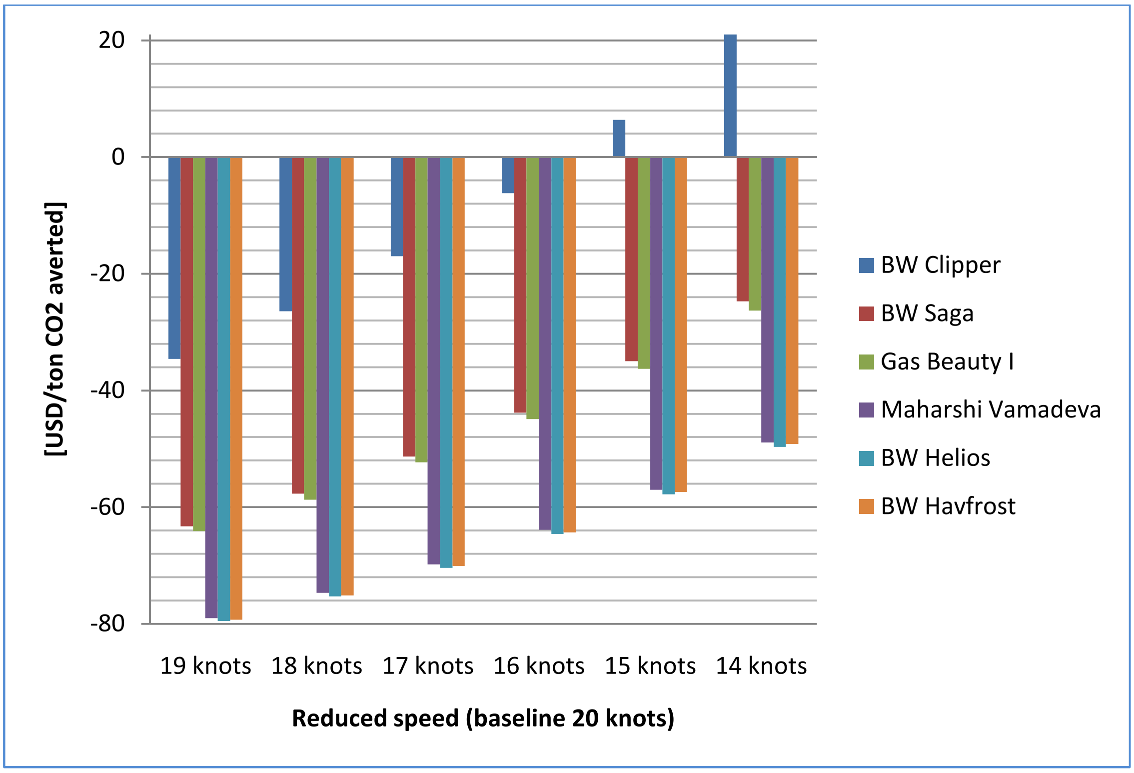


Figure 72 CATCH with environmental tax [100 USD/ton fuel]

The fuel tax will of course result in higher fuel costs and reduced net income. The trend is that the maximum net income is often shifted to lower speeds when fuel taxes are present. This is the case for the fleet defined in this report.

For the actual level BW Clipper will shift her optimum speed to 16 knots which will reduce the net income by 1.57 million USD and the CO_2 emissions will be reduced by additional 20.6%.

BW Saga's optimum speed will occur at 14 knots generating a 1.57 million USD reduction in net income and an additional 20.5% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 15 knots.

Gas Beauty I's optimum speed will occur at 14 knots generating a 1.64 million USD reduction in net income and an additional 19.4% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 15 knots.

Maharshi Vamadeva's optimum speed will occur at 14 knots generating a 1.12 million USD reduction in net income and no additional CO_2 reductions compared to the case without fuel taxes where the optimum speed was identical.

BW Helios' optimum speed will occur at 14 knots generating a 1.25 million USD reduction in net income and no additional CO_2 reductions compared to the case without fuel taxes where the optimum speed was identical.

BW Havfrost's optimum speed will occur at 14 knots generating a 1.27 million USD reduction in net income and no additional CO_2 reductions compared to the case without fuel taxes where the optimum speed was identical.

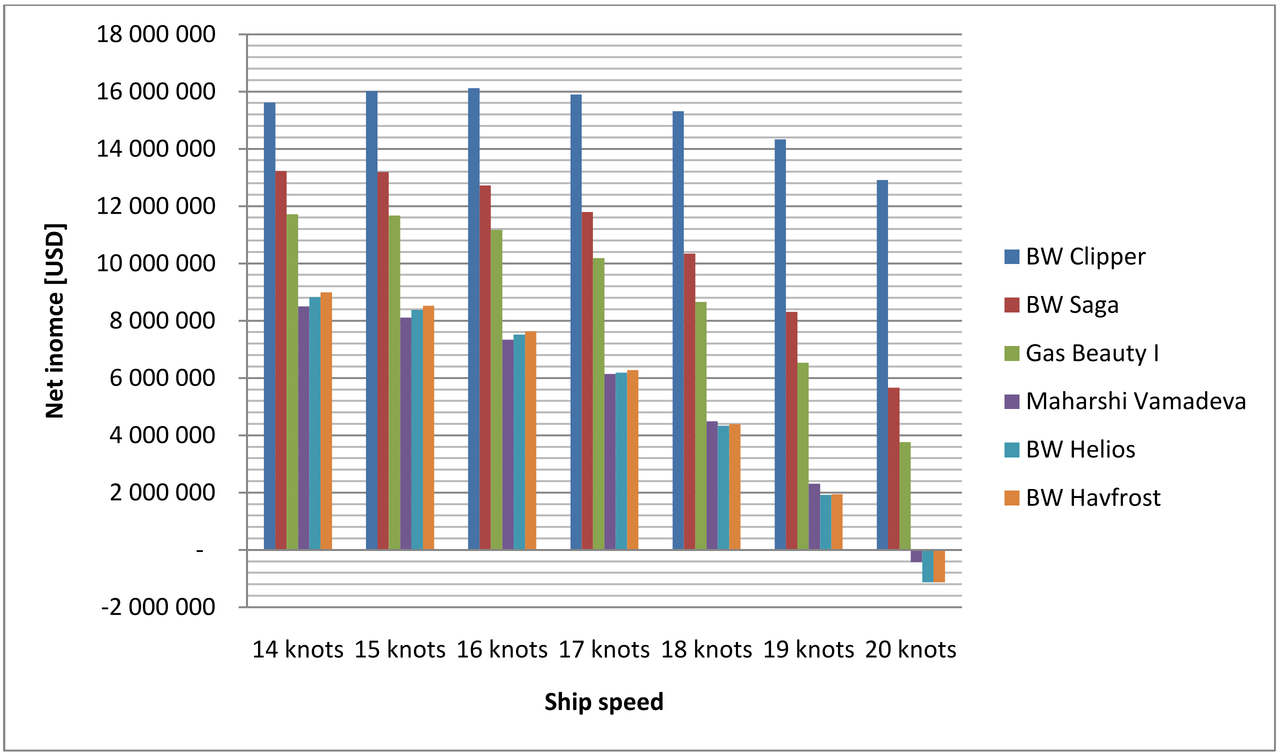


Figure 73 Net income with fuel tax [100 USD/ton] - Actual level

Prosperity level

In prosperity the CATCH values will drop by 29.4 USD/ton after fuel taxation is imposed. The effect of fuel taxation for this scenario is mixed since the last ships will have negative CATCH for every reduced speed between 14 and 19 knots, BW Clipper will have a positive CATCH and the remaining ships will have a negative CATCH from 19 to 17 knots while it is positive from 16 to 14 knots. Since the CATCH values drop by 29.4 on average the measure will encourage to reduced speeds and reduced CO_2 emission from shipping.

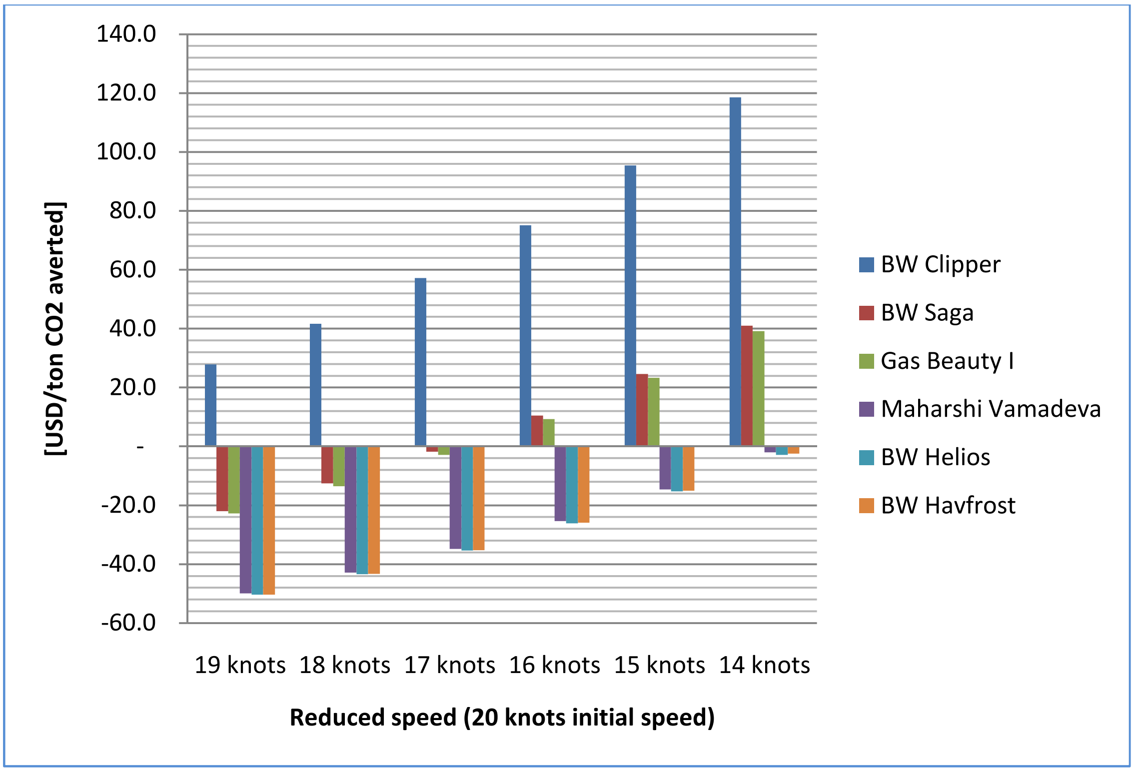


Figure 74 CATCH for prosperity with environmental tax [100 USD/ton fuel]

BW Clipper's optimum speed will occur at 19 knots generating a 3.54 million USD reduction in net income and an additional 18.6% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 20 knots.

BW Saga's optimum speed will occur at 17 knots generating a 3.27 million USD reduction in net income and an additional 20.2% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 18 knots.

Gas Beauty I's optimum speed will occur at 17 knots generating a 3.36 million USD reduction in net income and an additional 20.1% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 18 knots.

Maharshi Vamadeva's optimum speed will occur at 16 knots generating a 2.09 million USD reduction in net income and an additional 20.8% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 17 knots.

BW Helios' optimum speed will occur at 16 knots generating a 2.31 million USD reduction in net income and an additional 20.8% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 17 knots.

BW Havfrost's optimum speed will occur at 15 knots generating a 2.29 million USD reduction in net income and an additional 37.4% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 17 knots.

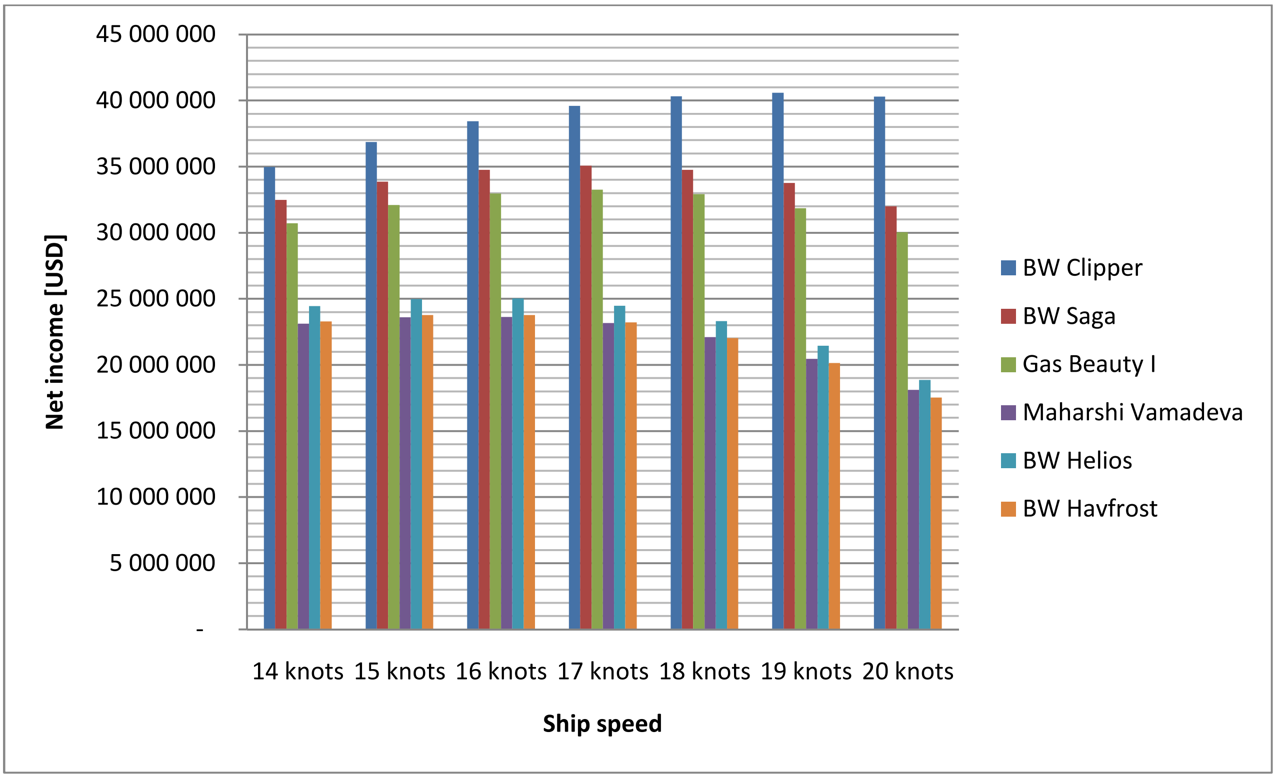


Figure 75 Net income with fuel tax [100 USD/ton] – Prosperity level

Recession level

The fuel tax will cause the CATCH to increase by 30.4 USD/ton on average. Introduction of fuel taxes will therefore not encourage to green shipping in recession. The main reason for this is the low net income present and a fuel tax of 100 USD/ton will nearly double the fuel price in recession. It will not be sustainable for the shipping companies, but if the objective is to reduce the seaborne shipping activity only the measure will be effective. The CATCH is only negative for Maharshi Vamadeva, BW Helios and BW Havfrost at 19 and 18 knots speed.

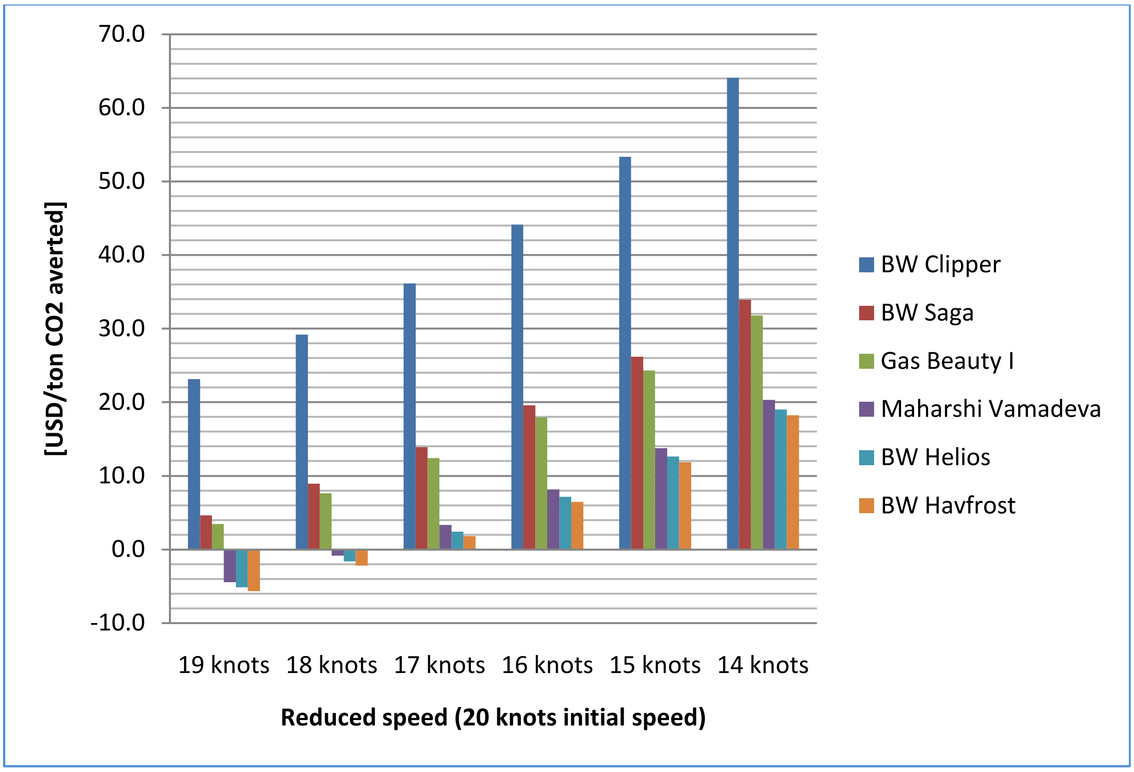


Figure 76 CATCH for recession with environmental tax [100 USD/ton fuel]

BW Clipper's optimum speed will occur at 16 knots generating a 1.51 million USD reduction in net income and an additional 48.1% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 19 knots.

BW Saga's optimum speed will occur at 15 knots generating a 1.45 million USD reduction in net income and an additional 36.5% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 17 knots.

Gas Beauty I's optimum speed will occur at 17 knots generating a 1.49 million USD reduction in net income and an additional 19.6% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 18 knots.

Maharshi Vamadeva's optimum speed will occur at 14 knots generating a 0.89 million USD reduction in net income and an additional 37.3% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 16 knots.

BW Helios' optimum speed will occur at 14 knots generating a 0.99 million USD reduction in net income and an additional 37.0% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 16 knots.

BW Havfrost's optimum speed will occur at 14 knots generating a 1.01 million USD reduction in net income and an additional 36.5% CO_2 reduction compared to the case without fuel taxes where the optimum speed was 16 knots.

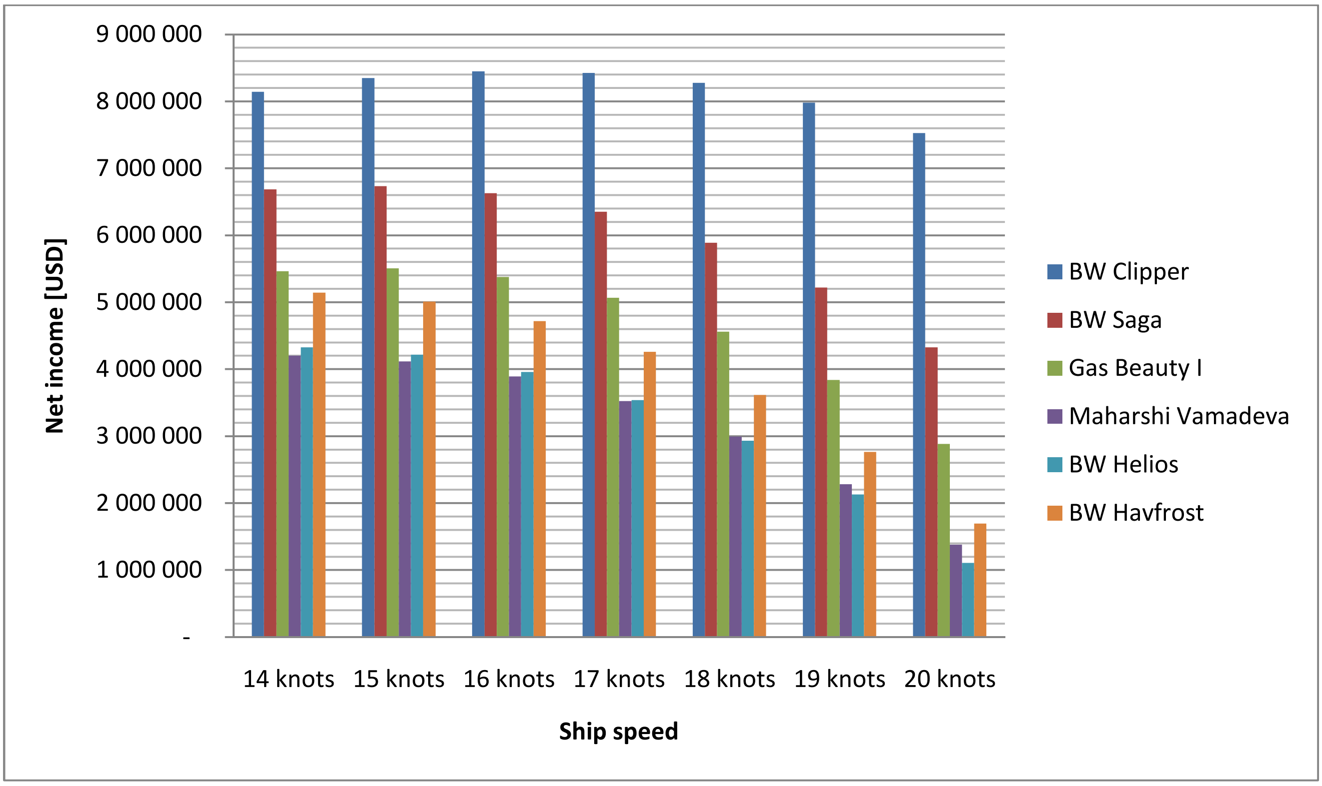


Figure 77 Net income with fuel tax [100 USD/ton] – Recession level

Conclusion

Speed reductions will have potential for large CO_2 reductions and maximized profits. When profits can be made at the same time as fuel costs are reduced, shipping companies will be motivated to perform green shipping.

The speed optimization is listed in table 1 for the different scenarios and it is based upon maximizing the profit. In prosperity a speed reduction will be expensive due to significant losses in income at a peaking spot market and this is why the speeds will be relatively high at “prosperity level”. For the “recession level” the optimized speeds will be reduced a notch compared to the “prosperity level” and the CO_2 emission percentage will therefore be reduced further. In the “actual level” the potential for CO_2 reductions will be largest due to the fact that the net income peaks at lower speeds.

IMO is in a position to levy fuel environmental taxes upon the international maritime society. This measure can be used to encourage ship owners to execute green shipping. It will also prove that the maritime industry will make an effort to reduce greenhouse gas emissions and improve the reputation. It is important that the fuel environmental taxes will be identical at different locations. The tax level can be discussed, but it is crucial that the level is large enough to make an impact on the shipping economy which will promote green shipping. As pointed out earlier it is important to balance the taxes in a way that will promote green shipping at the same time as sustainable shipping is promoted. In this report I have assumed that the freight rates were kept constant after the fuel taxes were introduced. This is not necessarily true as it is likely that the customers will have to take the costs meaning higher freight rates. Shipping companies might be more critical and selective in the negotiations as well and this can reduce the activity at sea. At reduced activity the demand for transportation might exceed the transport capacity the shipping companies are willing to deliver.

From my calculations I find that fuel taxation triggers slow steaming since it will be more profitable. At “actual level” this is evident, while for “prosperity level” the effect is reduced due to a peaking spot market. In prosperity the fuel taxes might be increased to promote slow steaming. This should be executed by a qualified committee within IMO. Increased fuel taxes in recession can be devastating for most shipping companies and it will not promote slow steaming. The best measure in this situation is to be more critical and reduce the activity which is the shipping company’s call. The fuel taxation level at “actual level” is acceptable since the emissions are reduced significantly while the net income is increasing as well.

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Appendices

Appendix I – General arrangement BW Clipper

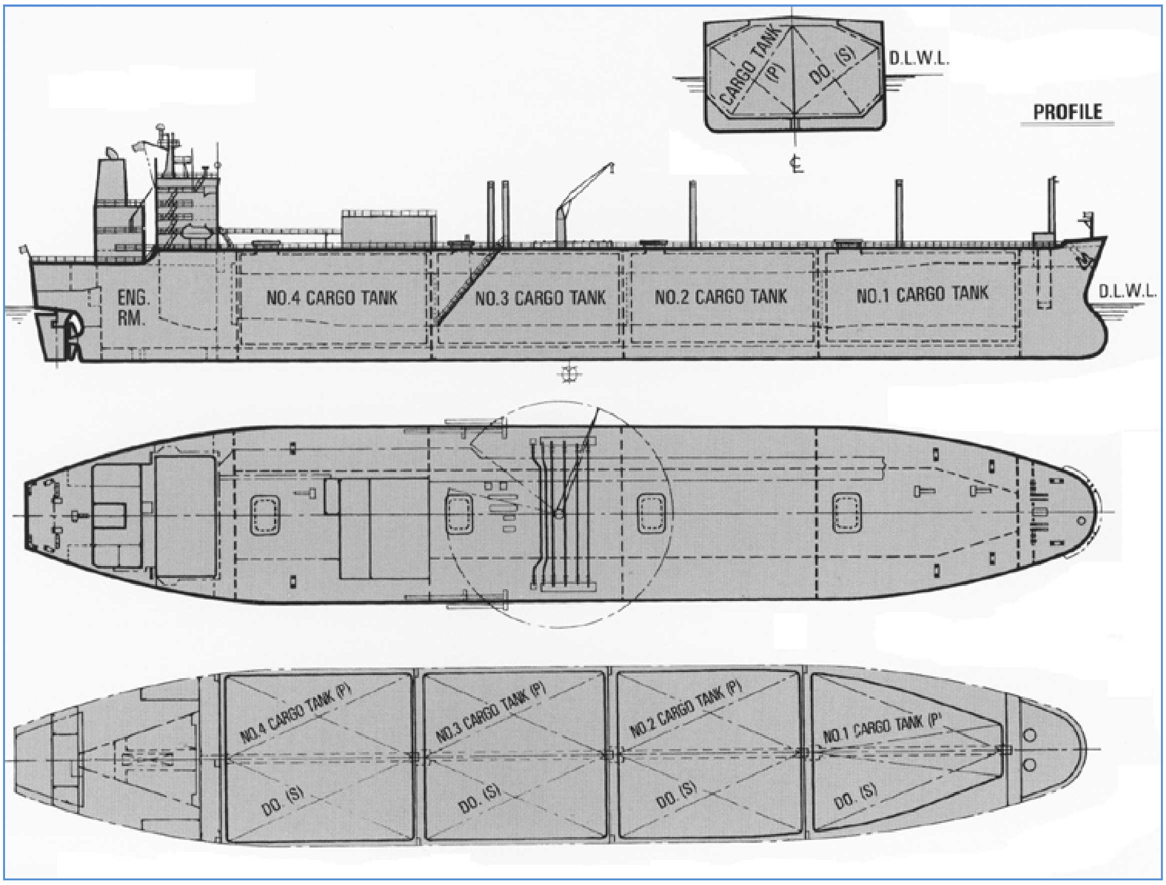

Figure 78 General arrangement BW Clipper - Courtesy Shipping Publications AS

Appendix II – General arrangement Maharshi Vamadeva

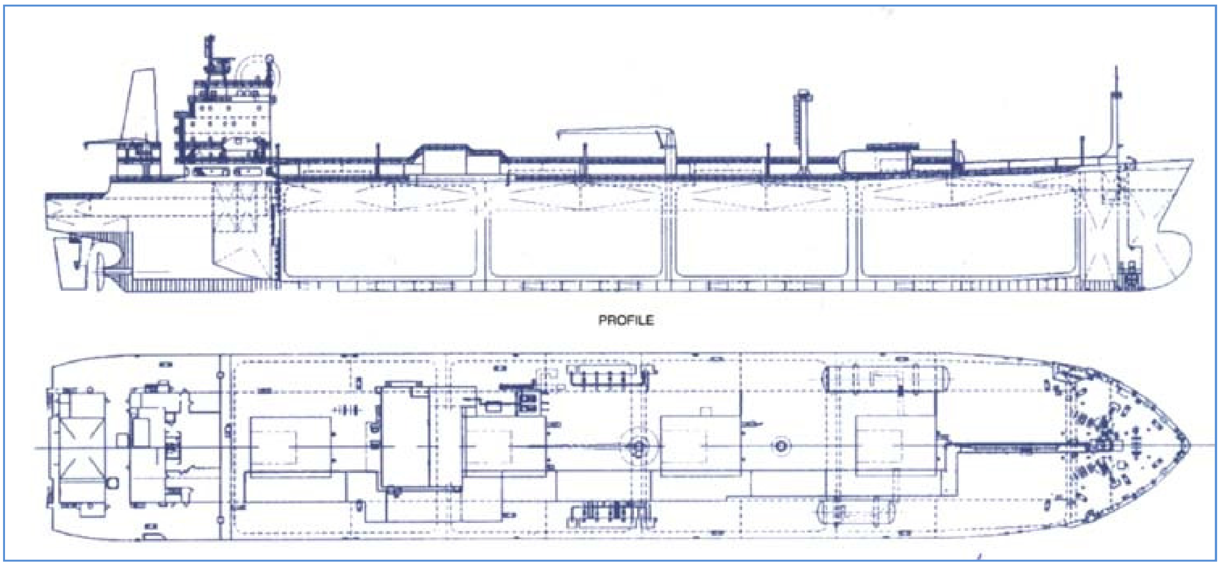

Figure 79 General Arrangement Maharshi Vamadeva – Courtesy Shipping Publications AS

Appendix III – General arrangement BW Havfrost

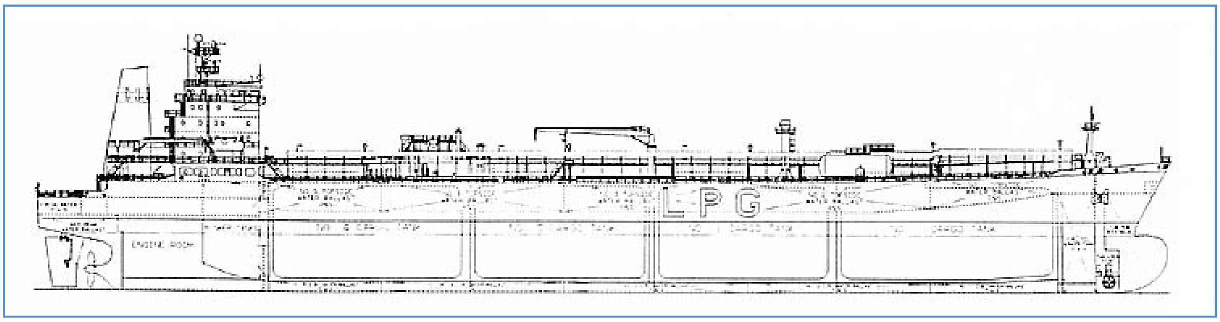

Figure 80 General Arrangement BW Havfrost - Courtesy Shipping Publications AS

Appendix IV – Orders between Yanbu and Rotterdam

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
1	Yanbu, Saudi-Arabia	Rotterdam, Netherlands	11.okt.2007 01:00	14.okt.2007 01:00	21.sep.2007 01:00	20.nov.2007 01:00
2	Yanbu, Saudi-Arabia	Rotterdam, Netherlands	10.nov.2007 00:00	13.nov.2007 00:00	21.okt.2007 01:00	21.des.2007 00:00
3	Yanbu, Saudi-Arabia	Rotterdam, Netherlands	11.des.2007 00:00	14.des.2007 00:00	21.nov 2006 00:00	18.jan.2008 00:00

Table 55 Time windows Yanbu-Rotterdam

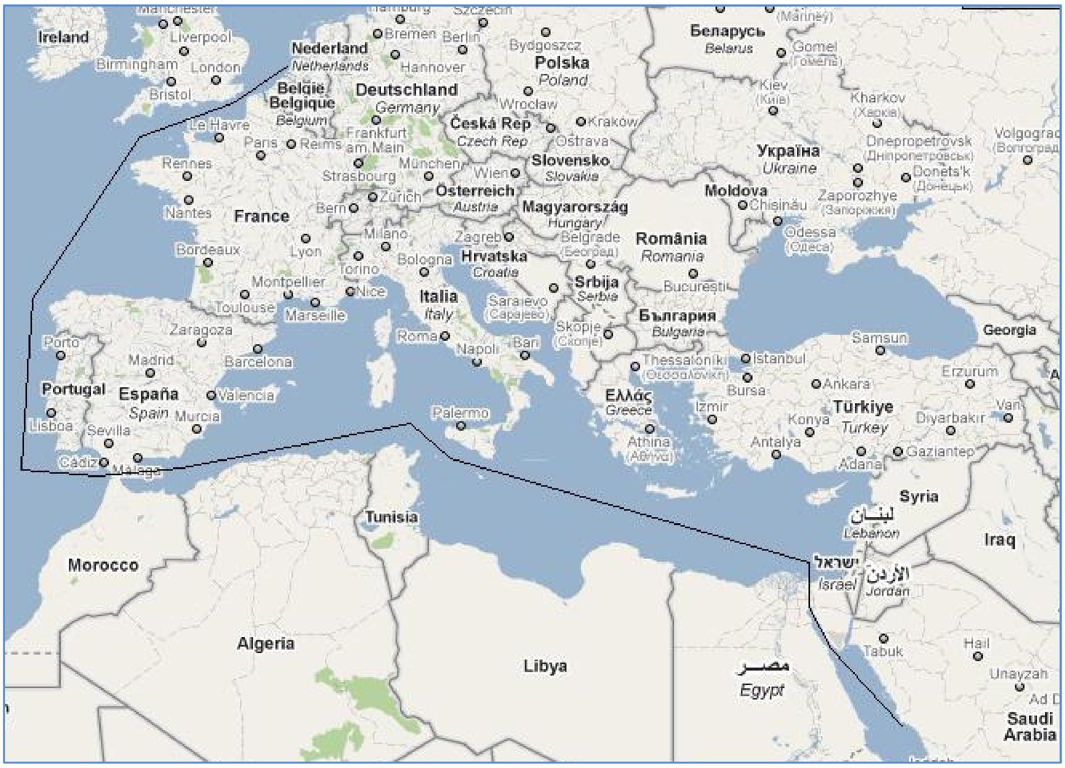

Figure 81 Yanbu-Rotterdam

Appendix V - Orders between Jabung and Weihai

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
4	Jabung, Indonesia	Weihai, China	21.sep.2007 01:00	27.sep.2007 01:00	21.sep.2007 01:00	20.nov.2007 00:00
5	Jabung, Indonesia	Weihai, China	21.okt.2007 01:00	27.okt.2007 01:00	21.okt.2007 01:00	21.des.2007 00:00

Table 56 Time windows Jabung-Weihai

Figure 82 Jabung-Weihai

Appendix VI - Orders between Ras Tanura and Algeciras

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
6	Ras Tanura, Saudi-Arabia	Algeciras, Spain	01.okt.2007 01:00	04.okt.2007 01:00	21.sep.2007 01:00	20.nov.2007 00:00
7	Ras Tanura, Saudi-Arabia	Algeciras, Spain	21.okt.2007 01:00	24.okt.2007 01:00	21.okt.2007 01:00	21.des.2007 00:00
8	Ras Tanura, Saudi-Arabia	Algeciras, Spain	17.nov.2007 00:00	20.nov.2007 00:00	17.nov.2007 00:00	17.jan.2008 00:00

Table 57 Time windows Ras Tanura-Algeciras

Figure 83 Ras Tanura – Algeciras

Appendix VII – Order between Ras Tanura and Rotterdam

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
9	Ras Tanura, Saudi-Arabia	Rotterdam, Netherlands	06.des.2007 00:00	17.des.2007 00:00	06.des.2007 00:00	30.jan.2008 00:00

Table 58 Time windows Ras Tanura-Algeciras

Figure 84 Ras Tanura – Rotterdam

Appendix VIII – Orders between Arzew and Rotterdam

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
10	Arzew, Algerie	Rotterdam, Netherlands	17.okt.2007 01:00	20.okt.2007 01:00	17.okt.2007 01:00	21.des.2007 00:00
11	Arzew, Algerie	Rotterdam, Netherlands	10.nov.2007 00:00	12.nov.2008 00:00	10.nov.2007 00:00	21.des.2007 00:00
12	Arzew, Algerie	Rotterdam, Netherlands	31.okt.2007 00:00	06.nov.2007 00:00	31.okt.2007 00:00	09.jan.2008 00:00

Table 59 Time windows Arzew-Rotterdam

Figure 85 Arzew – Rotterdam

Appendix IX – Orders between Ras Tanura and Tuticorin

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
13	Ras Tanura, Saudi-Arabia	Tuticorin, India	15.okt.2007 01:00	17.okt.2007 01:00	15.okt.2007 01:00	04.des.2007 00:00
15	Ras Tanura, Saudi-Arabia	Tuticorin, India	15.des.2007 00:00	18.des.2007 00:00	15.des.2007 00:00	09.feb.2008 23:00
18	Ras Tanura, Saudi-Arabia	Tuticorin, India	23.okt.2007 01:00	29.okt.2007 00:00	23.okt.2007 01:00	23.des.2007 00:00

Table 60 Time windows Ras Tanura-Tuticorin

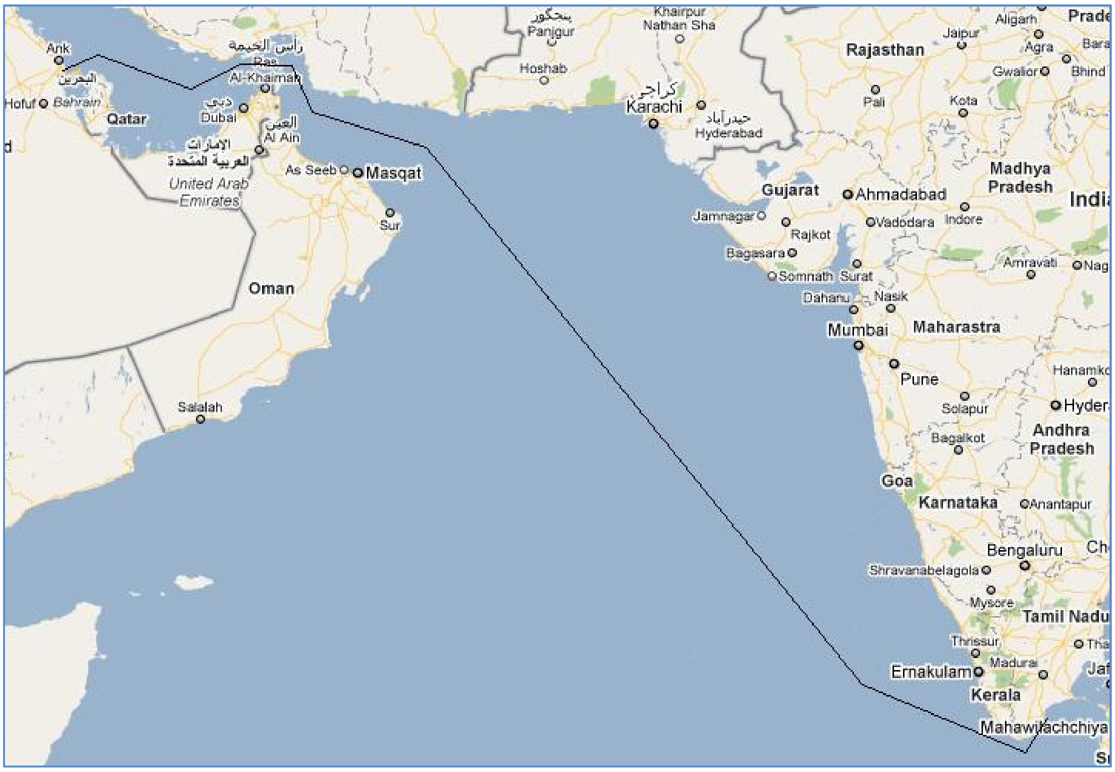

Figure 86 Ras Tanura – Tuticorin

Appendix X – Order between Jabung and Tuticorin

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
14	Jabung, Indonesia	Tuticorin, India	23.okt.2007 01:00	30.okt.2007 00:00	23.okt.2007 01:00	12.des.2007 00:00

Table 61 Time windows Jabung-Tuticorin

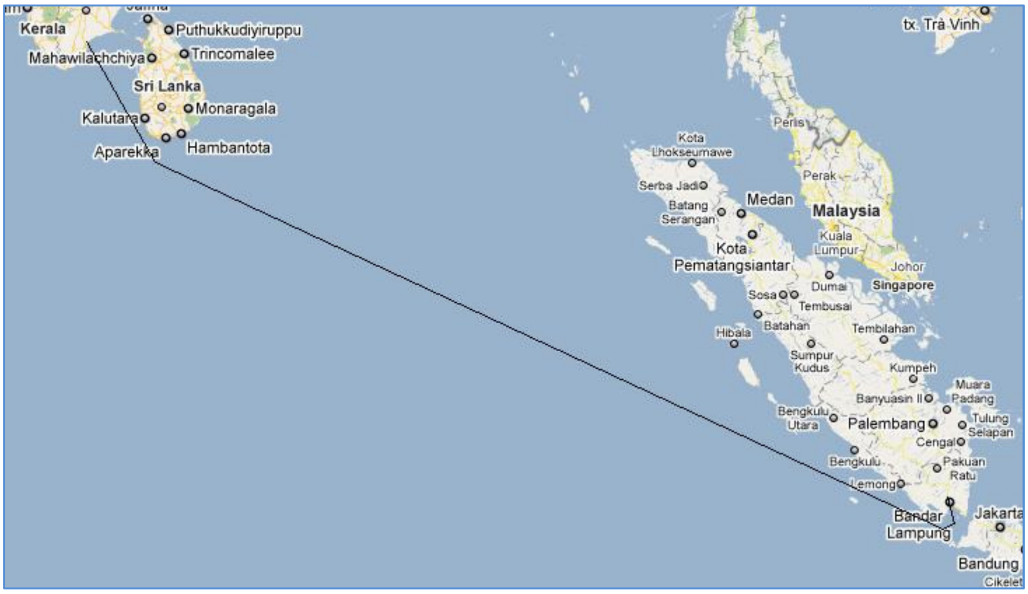

Figure 87 Jabung – Tuticorin

Appendix XI - Orders between Jabung and Rotterdam

Order	Port of departure	Destination	Load start	Load end	Discharge start	Discharge end
16	Jabung, Indonesia	Rotterdam, Netherlands	21.nov.2007 00:00	02.des.2007 00:00	21.nov.2007 00:00	17.jan.2008 00:00
17	Jabung, Indonesia	Rotterdam, Netherlands	26.okt.2007 01:00	07.nov.2007 00:00	26.okt.2007 01:00	01.jan.2008 00:00

Table 62 Time windows Jabung-Rotterdam

Figure 88 Jabung – Rotterdam

Appendix XII – Suez transit fee for BW Clipper

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	65000
GRT :	45032
SDR :	
Draft (if >14.33m) [m] :	12.4
Beam (if >66.45m) [m] :	36
Laden or Ballasted :	Laden
Northbound or Southbound :	Northbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 7,65	38 250,00
Next 5000 : 5000 * 4,9	24 500,00
Next 10000 : 10000 * 3,9	39 000,00
Next 20000 : 20000 * 2,8	56 000,00
Next 30000 : 25000 * 2,6	65 000,00
Next 50000 : 0 * 2,5	0,00
Rest: 0 * 2,5	0,00
Total SDR :	222 750,00
USD/SDR Exchange rate :	1,5179

Canal Tolls :	338 105,54 USD
Tugs (1 tug(s)) :	12 142,96 USD
Mooring / Projector :	2 352,50 USD
Pilotage :	634,63 USD
Disbursements :	11 516,70 USD
TOTAL :	364 752,33 USD

Figure 89 Suez transit fee BW Clipper northbound & laden – Courtesy Leth Agencies

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	65000
GRT :	45032
SDR :	
Draft (if >14.33m) [m] :	12.4
Beam (if >66.45m) [m] :	36
Laden or Ballasted :	Ballasted
Northbound or Southbound :	Southbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 6,5	32 500,00
Next 5000 : 5000 * 4,17	20 850,00
Next 10000 : 10000 * 3,32	33 200,00
Next 20000 : 20000 * 2,38	47 600,00
Next 30000 : 25000 * 2,21	55 250,00
Next 50000 : 0 * 2,13	0,00
Rest: 0 * 2,13	0,00
Total SDR :	189 400,00
USD/SDR Exchange rate :	1,5179

Canal Tolls :	287 484,58 USD
Tugs (1 tug(s)) :	12 142,96 USD
Mooring / Projector :	2 098,75 USD
Pilotage :	395,50 USD
Disbursements :	11 516,70 USD
TOTAL :	313 638,49 USD

Figure 90 Suez transit fee BW Clipper southbound & ballasted – Courtesy Leth Agencies

Appendix XIII – Suez transit fee for BW Saga

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	64000
GRT :	44151
SDR :	
Draft (if >14.33m) [m] :	10.8
Beam (if >66.45m) [m] :	34.2
Laden or Ballasted :	Laden
Northbound or Southbound :	Northbound
Gas Free certificate : (For tankers only)	Yes

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 7,65	38 250,00
Next 5000 : 5000 * 4,9	24 500,00
Next 10000 : 10000 * 3,9	39 000,00
Next 20000 : 20000 * 2,8	56 000,00
Next 30000 : 24000 * 2,6	62 400,00
Next 50000 : 0 * 2,5	0,00
Rest: 0 * 2,5	0,00
Total SDR :	220 150,00
USD/SDR Exchange rate :	1,5179

Canal Tolls :	334 159,08 USD
Tugs (0 tug(s)) :	0,00 USD
Mooring / Projector :	2 352,50 USD
Pilotage :	634,63 USD
Disbursements :	11 385,20 USD
TOTAL :	348 531,41 USD

Figure 91 Suez transit fee BW Saga northbound & laden – Courtesy Leth Agencies

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	64000
GRT :	44151
SDR :	
Draft (if >14.33m) [m] :	10.8
Beam (if >66.45m) [m] :	34.2
Laden or Ballasted :	Ballasted
Northbound or Southbound :	Southbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 6,5	32 500,00
Next 5000 : 5000 * 4,17	20 850,00
Next 10000 : 10000 * 3,32	33 200,00
Next 20000 : 20000 * 2,38	47 600,00
Next 30000 : 24000 * 2,21	53 040,00
Next 50000 : 0 * 2,13	0,00
Rest: 0 * 2,13	0,00
Total SDR :	187 190,00
USD/SDR Exchange rate :	1,5179

Canal Tolls :	284 130,09 USD
Tugs (1 tug(s)) :	12 142,96 USD
Mooring / Projector :	2 098,75 USD
Pilotage :	395,50 USD
Disbursements :	11 385,20 USD
TOTAL :	310 152,50 USD

Figure 92 Suez transit fee BW Saga southbound & ballasted – Courtesy Leth Agencie

Appendix XIV – Suez transit fee for Gas Beauty I

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	64000
GRT :	43849
SDR :	
Draft (if >14.33m) [m] :	13
Beam (if >66.45m) [m] :	34.2
Laden or Ballasted :	Laden
Northbound or Southbound :	Northbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :		
First 5000 : 5000 * 7,65	38 250,00	
Next 5000 : 5000 * 4,9	24 500,00	
Next 10000 : 10000 * 3,9	39 000,00	
Next 20000 : 20000 * 2,8	56 000,00	
Next 30000 : 24000 * 2,6	62 400,00	
Next 50000 : 0 * 2,5	0,00	
Rest: 0 * 2,5	0,00	
Total SDR :	220 150,00	
USD/SDR Exchange rate :	1,5179	
Canal Tolls :		334 159,08 USD
Tugs (1 tug(s)) :		12 142,96 USD
Mooring / Projector :		2 352,50 USD
Pilotage :		634,63 USD
Disbursements :		11 385,20 USD
TOTAL :		360 674,37 USD

Figure 93 Suez transit fee Gas Beauty I northbound & laden – Courtesy Leth Agencies

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	64000
GRT :	43849
SDR :	
Draft (if >14.33m) [m] :	13
Beam (if >66.45m) [m] :	34.2
Laden or Ballasted :	Ballasted
Northbound or Southbound :	Southbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 6,5	32 500,00
Next 5000 : 5000 * 4,17	20 850,00
Next 10000 : 10000 * 3,32	33 200,00
Next 20000 : 20000 * 2,38	47 600,00
Next 30000 : 24000 * 2,21	53 040,00
Next 50000 : 0 * 2,13	0,00
Rest: 0 * 2,13	0,00
Total SDR :	187 190,00
USD/SDR Exchange rate :	1,5179

Canal Tolls :	284 130,09 USD
Tugs (1 tug(s)) :	12 142,96 USD
Mooring / Projector :	2 098,75 USD
Pilotage :	395,50 USD
Disbursements :	11 385,20 USD
TOTAL :	310 152,50 USD

Figure 94 Suez transit fee Gas Beauty I southbound & ballasted – Courtesy Leth Agencies

Appendix XV – Suez transit fee for BW Havfrost

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	55000
GRT :	34946
SDR :	
Draft (if >14.33m) [m] :	12.2
Beam (if >66.45m) [m] :	32.2
Laden or Ballasted :	Laden
Northbound or Southbound :	Northbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 7,65	38 250,00
Next 5000 : 5000 * 4,9	24 500,00
Next 10000 : 10000 * 3,9	39 000,00
Next 20000 : 20000 * 2,8	56 000,00
Next 30000 : 15000 * 2,6	39 000,00
Next 50000 : 0 * 2,5	0,00
Rest: 0 * 2,5	0,00
Total SDR :	196 750,00
USD/SDR Exchange rate :	1,5120

Canal Tolls :	297 491,67 USD
Tugs (1 tug(s)) :	12 096,23 USD
Mooring / Projector :	2 352,50 USD
Pilotage :	543,50 USD
Disbursements :	10 051,70 USD
TOTAL :	322 535,60 USD

Figure 95 Suez transit fee BW Havfrost northbound & laden – Courtesy Leth Agencies

Calculate Cost

Online Toll Calculator for Suez Canal Transit

Vessel Particulars

Tariff :	08-04
SCNT :	55000
GRT :	34946
SDR :	
Draft (if >14.33m) [m] :	12.2
Beam (if >66.45m) [m] :	32.2
Laden or Ballasted :	Ballasted
Northbound or Southbound :	Southbound
Gas Free certificate : (For tankers only)	No

Calculation result

Canal Tolls breakdown :

First 5000 : 5000 * 6,5	32 500,00
Next 5000 : 5000 * 4,17	20 850,00
Next 10000 : 10000 * 3,32	33 200,00
Next 20000 : 20000 * 2,38	47 600,00
Next 30000 : 15000 * 2,21	33 150,00
Next 50000 : 0 * 2,13	0,00
Rest: 0 * 2,13	0,00
Total SDR :	167 300,00
USD/SDR Exchange rate :	1,5082

Canal Tolls :	252 317,43 USD
Tugs (1 tug(s)) :	12 065,39 USD
Mooring / Projector :	2 098,75 USD
Pilotage :	340,50 USD
Disbursements :	10 051,70 USD
TOTAL :	276 873,77 USD

Figure 96 Suez transit fee BW Havfrost southbound & ballasted – Courtesy Leth Agencies