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Effects of gross tonnage and engine power on fishing efforts and economic indicators of trawl vessels operating the Central Black Sea region

Ümüt Yigit[1]*&Ibrahim Erkoyuncu[2]
[1]CanakkaleOnsekiz Mart University, Faculty of Marine Science and Technology, Canakkale/Turkey
[2]Sinop University, Faculty of Fisheries, 57000-Sinop/Turkey
*[E. Mail: umut.yigit@ymail.com]

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Present study was conducted to evaluate the effects of gross tonnage and engine power on economic efficiencies of trawl vessels with different gross tonnages (69, 92, 107, 115), and engine powers (550and 416 HP). Gross revenue, annual operation cost, profits, and profit rate as percent of investment costs were recorded as 236.696, 187.014, and 49.682 US$, and 21% for Vessel-A (69GT-550HP); 316.985, 249.231, and67.753 US$, and 20% for Vessel-B (92GT-550HP); 297.156, 231.031, and 66.125 US$, and 14%for Vessel-C (107GT-416HP);269.395, 200.922, and 68.473 US$, and 28% for Vessel-D (115GT-416 HP), respectively. Profit for the fishing activity could be compensated by increasing engine power from 416 to 550 HP when gross tonnage of the vessel declined around 15%. Further reduction of the vessel's gross tonnage by 35%, decreased the annual profit by 25%, where the increase of engine power from 416 to 500 HP was not sufficient to compensate the annual profit of the vessel.

[**Keywords***:* Engine power, fisheries economy, fishing effort, gross tonnage, trawl vessels]

Introduction

The world fishing industry is facing a serious problem, the so-called overfishing, that occurs when more fish is caught than the replacement of fish population in the ocean by natural reproduction of the species itself[1]. International organizations and national governments show increasing concern over overfishing and excess capacity[2].Overfishing can arise from uncontrolled fishing operations and management, which is one of the main problems to be solved for the future of the oceans. Fish and fishery products are important sources for high quality protein to meet the increasing demand of food for human consumption. The world population that amounts around 7.4 billion today[3], is significantly increasing with a daily births rate of about 15000 and estimated to reach around 9.6 billion in year 2050[4]. The development in technology has also canalized the vessel owners to upgrade their electronic devices used in fish finding and catch. With the increase of the vessel capacity the mechanical capacity is also shifted towards higher power conditions with the intention of improving the efficiency of the vessel that arise an important question of profitability of this move. It is noted that the development in science and technology is influencing fishing capacity especially for active fisheries such as trawling and purse seining, for which the fishing capacity varied with the improvement of fishing vessel and equipment used. With the increase of the industry in terms of vessel production, gross tonnage or engine power of the vessels are leading to an expansion of gear size and the use of more advanced equipment that in terms increase fishing capacity[2]. As a-matter-of-fact, gathering as many fish as possible was the main target of the fishermen, who nowadays seem to understand the consequences of the uncontrolled fishing activities as a result of disproportionate fishing.

The fishing capacity of similar sized vessels is generally expressed with definitions such as gross tonnage or engine power[5]. Nevertheless, the fishing power which outlines the harvesting potential of a fishing vessel is highly dependent on many other factors such as experience and technical knowledge of the staff, or the characteristics of the gears and electronic devices available on board and on-board, as well as the sea kindliness of the vessel itself, or on a combination of these factors[6-8].

The fishing capacity of fishing vessels is mostly characterized by the quantity of capital or yield, which is close related to the variables such as gross tonnage (GT) and the engine power, which is expressed as HP or kW. These two variables are evaluated in the present study for the assessment of

their effects on capital and profit margins of trawl vessels with the aim to contribute towards vessel capacity and power formation for effective management of trawl fishery operations in the Black Sea, that is expected to contribute on economic and social welfare development of fishery communities and the nations around the Black Sea as a whole can be foreseen.

Materials and Methods

The study area was encircled between Yakakent-Çayağzı Cape of Samsun province (41° 42' 41.94" N, 35° 25' 20.61" E) and Ünye-Taşkana Cape of Orduprovince (41° 09' 03.75" N, 37° 18' 44.58" E) (Figure 1). Trawl vessels with similar sizes (23-27 m in length), but with four different gross tonnages of 69, 92, 107, and 116 GT, and two different engine powers of 550 and 416 HP were evaluated. All capture fish species were included in the economic evaluations and calculations for profitability during the 2004-2005 fishing season.

The fishing net used in the present study was a typical polypropylene net, that is commonly used in fishing operations in the Black Sea, with two trawl boards at both end parts of the net in order to hold it open. The wings with float –and sinker lines have a mesh of 100 mm mesh, whereas the holding bag consists of a 40 mm mesh net.

The names of commercial trawl vessels used for the evaluations are not given upon the request of the fleet company. Hence, all vessels here are given in alphabetical order (Vessel A, B, C, and D). The characteristics of trawl vessels, engine power, mechanical and fuel specifications are given in Table 1.

Among the commercial fishing vessels operating in the Black Sea, four trawl vessels were chosen in this study with regards to the special approval by the companies for the continues following their fishing activities during the 2004-2005 fishing season. Monthly survey observations and catch yield records were compared with the accountancy reports of each vessel, which were used in the economic evaluation. Expenditures and revenue elements were outlined and assessed for each of the fishing vessels, by using performance parameters and financial characteristics such as financial costs of the fishing activity (capital, labor, fuel), gross income, net revenue, that is the profit or cash return to the company at final, and the profit margin, which presents the percentage of profit over sales revenue were assessed for each of the fishing vessels.

The operational costs applied in this study were modified using structures given by Matsunaga et al[9], Ünal[10], Kaiser et al[11] and Bezerra et al[12], and consisted of the effective operational costs (EOC), which are related to labor costs; total operational costs (TOC) derived from the EOC and other expenses such as time dependent depreciation of equipment, social charges, general expenses and financial charges. Social charges represented 18% of the staff cost and

Fig. 1 — Location of the study area and the operational path for the trawl fleet

Table 1 — Specifications of trawl vessels used in the study

	Vessel A	**Vessel B**	**Vessel C**	**Vessel D**
Main specifications of trawl vessels				
Length (m)	23.4	24.0	26.1	27.6
Breadth (m)	6.90	6.50	7.90	9.50
Depth (m)	1.70	2.35	1.90	2.32
Construction year	03.01.1979	20.12.1989	15.05.1993	15.05.1991
Gross Tonnage	**69.07**	**92.02**	**107.0**	**115.6**
Mechanical and Fuel specifications of engine on-board of trawl vessel				
Type	Diesel	Diesel	Diesel	Diesel
Rotation/min	1800	1800	2000	2000
Fuel tank (ton)	17	30	30	20
Daily consumption (ton)	1.00	2.00	1.00	0.83
Operation hours	1	3	3	3
Power (HP/Kw)	**550/410**	**550/410**	**416/310**	**416/310**

Table 2 — Annual catch yield (case), sales price and annual gross revenues of trawl vessels

Engine Power	550 HP (410 kW)						416 HP (310 kW)					
Vessel (GT)	Vessel A (69)			Vessel B (92)			Vessel C (107)			Vessel D (115)		
	ACY	SP	AGR	ACY	SP	AGR	ACY	SP	AGR	ACY	SP	AGR
Fish species	(case)	($/case)	($)	(case)	($/case)	($)	(case)	($/case)	($)	(case)	($/case)	($)
Anchovy	3,985	9.60	38,256.0	4,252	9.60	40,819.2	4,009	9.60	38,486.4	3,950	9.60	37,920.0
Anchovy-box	14	6.40	89,6	28	6.40	179.20	18	6.40	115.20	10	6.40	64.00
Atlantic bonito	8	3.95	31.60	32	3.95	126.40	13	3.95	51.35	11	3.95	43.45
Anchovy-bulk	2,300	0.90	2,070.0	1,032	0.90	928.80	2,990	0.90	2,691.0	2,650	0.90	2,385.0
Blue fish (young)	230	54.0	12,420.0	310	54.0	16,740.0	243	54.0	13,122.0	236	54.0	12,744.0
Horse mackerel	3,056	13.0	39,728.0	5,863	13.0	76,219.0	4,944	13.0	64,272.0	4,000	13.0	52,000.0
Red mullet	223	26.0	5,798.0	655	26.0	17,030.0	437	26.0	11,362.0	358	26.0	9,308.0
Govit	8	12.0	96.00	25	12.0	300.00	13	12.0	156.00	11	12.0	132.00
Whiting	1,456	14.0	20,384.0	1,510	14.0	21,140.0	2,045	14.0	28,630.0	1,785	14.0	24,990.0
Whiting-box	247	28.0	6,916.0	270	28.0	7,560.0	520	28.0	14,560.0	342	28.0	9,576.0
Medit. Shad	316	6.90	2,180.4	432	6.90	2,980.8	285	6.90	1,966.5	245	6.90	1,690.5
Seabass	3	18.0	54.00	1	18.0	18.00	3	18.0	54.00	2	18.0	36.00
Picarel	1	9.80	9.80	3	9.80	29.40	3	9.80	29.40	0.00	9.80	0.00
Mix	3	27.8	83.40	4	27.8	111.20	2	27.8	55.60	1	27.8	27.80
Total AGR (US$)			128,116.80			184,182.00			175,551.15			150,916.75

ACY (case): annual catch yield; SP (US$/case): sales price; AGR (US$, annual gross revenue) = ACY (case) x sales price (US$/case)

the general expenses were calculated as 5% of the EOCs. Financial charges represented 8% of the half amount of EOCs. The total production cost (TPC) was obtained by the addition of TOC and the compensation for investment (CFI) that was a value of 10% per annum on fixed investments.The operational costs comprised the expenses for labor, gasoline, food for staff, depreciation and maintenance of the equipment.

Results and Discussion

In the present study, trawl vessels with varying GTs and engine powers were evaluated in terms of fishing performance data and economic indicators such as financial expenses of the fishing activity, gross revenue, profit or the net revenue, and the profit margin of the overall fishing operations in a season. The annual catch yields as “case”, “pieces”, or in “bulk”, sales price and annual gross revenues have been given in Tables 2-4 and the annual gross revenues of trawl vessels in the Black Sea region have been presented in Table 5.

The total and proportional initial investment costs for each of the vessels and depreciation rates and amounts were estimated (Table 6). The operational and financial costs of trawl vessels during a 12-month period, along with compensation for investment and the total production costs are demonstrated in Table 7.

Table 3 — Annual catch yield (pieces), sales price and annual gross revenues

Engine Power	550 HP (410 kW)						416 HP (310 kW)					
Vessel (GT)	Vessel A (69)			Vessel B (92)			Vessel C (107)			Vessel D (115)		
	ACY	SP	AGR	ACY	SP	AGR	ACY	SP	AGR	ACY	SP	AGR
Fish species	(piece)	($/piece)	($)	(piece)	($/piece)	($)	(piece)	($/piece)	($)	(piece)	($/piece)	($)
Turbot	241	28.0	6748.0	257	28.0	7196.0	301	28.0	8428.0	230	28.0	6440.0
Shi-drum	16	20.4	326.40	12	20.4	244.80	15	20.4	306.00	7	20.4	142.80
Stingray	231	1.03	237.93	273	1.03	281.19	225	1.03	231.75	296	1.03	304.88
Catfish	937	1.35	1264.95	1110	1.35	1498.5	1047	1.35	1413.45	985	1.35	1329.75
Red snapper	-	-	-	2	87.5	175.00	-	-	-	-	-	-
Flounder	-	-	-	-	-	-	1	21.0	21.00	2	21.0	42.00
Total AGR (US$)			8,577.28			9,395.49			10,400.00			8,259.43

GT: gross tonnage; ACY (piece): annual catch yield; P (US$/piece): sales price; AGR (US$, annual gross revenue) = ACY (piece) x sales price (US$/piece)

Table 4 — Annual catch yield (bulk), sales price and annual gross revenues

Engine Power	550 HP (410 kW)		416 HP (310 kW)	
Vessel (GT)	Vessel A (69)	Vessel B (92)	Vessel C (107)	Vessel D (115)
ACY (kg)	1,000,025	1,233,929	1,112,050	1,102,196
SalesPrice (US$/kg)	0.10	0.10	0.10	0.10
AGR (US$)	100,002.50	123,392.90	111,205.00	110,219.60

ACY (bulk, kg): annual catch yield; S. Price: sales price
AGR (US$, annual gross revenue) = ACY (kg) x sales price (US$/kg)

Table 5 — Total annual gross revenues of trawl vessels

Engine Power	550 HP (410 kW)		416 HP (310 kW)	
Vessel (GT)	Vessel A (69)	Vessel B (92)	Vessel C (107)	Vessel D (115)
Annual gross revenues (US$)				
Case	128,116.80	184,182.00	175,551.15	150,916.75
Piece	8,577.28	9,395.49	10,400.20	8,259.43
Bulk	100,002.50	123,392.90	111,205.00	110,219.60
Total	236,696.58	316,970.39	297,156.35	269,395.78

The gross revenue, effective expenses and profit margins in cash or percent rates of trawl vessels were evaluated using economic indicators (Table 8).

The gross revenue was highest in Vessel B operating with the biggest engine power (500 HP) regardless the GT of the vessels. The total production and operational costs were also higher for Vessel B with the biggest engine power, the latter most strongly due to the increase fuel consumption and fuel costs that doubled over the other vessels with lower engine power of 416 HP (Vessels C, D), as well as Vessel A with 500 HP but lower GT of 62.The compensation for investment (CFI) in the present study was rated as 10 % of the initial investment cost, which was highest for Vessel C with low engine power (416 HP), but lower GT (107), unequivocally due to the Sonar equipment on board, different than the other vessels, which increased the total investment costs from 40% to 96 % over the other vessels. The significantly higher CFI in Vessel C resulted with the lowest profit based on the estimations of total production costs.

Considering the performance parameters and economic indicators such as financial costs of the fishing activity, gross revenue, the profit or cash return to the fishing company at the end of the season, and the profit margin, that shows the percentage of profit over sales revenue, fishing vessel with higher GT within the same engine power class demonstrated better performance in terms of profit derived from the extraction of the operational costs from the gross revenue. Considering the engine power, however, fishing vessel with lower engine power (416 HP) but higher GTs (107 and 115) showed better profits based on both operational and production costs, except for

Table 6 — Initial investment costs for trawl vessels and depreciation amounts

	Vessel A			Vessel B			Vessel C			Vessel D		
	550 HP (410 kW)			550 HP (410 kW)			416 HP (310 kW)			416 HP (310 kW)		
Item Description*	Value US$	%	Depreciation US$	Value US$	%	Depreciation US$	Value US$	%	Depreciation US$	Value US$	%	Depreciation US$
Vessel	140,000	58.4	4,000	200,000	59.5	5,714	2000,000	42.3	5,555	140,000	56.9	4,000
Eco-sounder	5,000	2.1	333	6,000	1.8	400	6,000	1.3	400	5,000	2.0	300
Surface radar	7,500	3.1	625	6,000	1.8	429	6,000	1.3	500	3,000	1.2	250
Sonar	-	-	-	-	-	-	108,000	22.8	10,800	-	-	-
Sattelite (GPS)	4,500	1.9	450	4,500	1.3	450	8,000	1.7	800	5,800	2.4	580
VHF Marine	1,000	0.4	67	1,000	0.3	67	1,000	0.2	67	1,100	0.5	73
Telephone	700	0.3	47	700	0.2	47	800	0.2	57	700	0.3	47
Windlass	14,300	6.0	715	15,000	4.5	750	12,500	2.7	625	14,500	5.9	725
Main engine	40,000	16.6	2,000	50,000	14.9	2,500	81,000	17.1	4,050	40,000	16.3	2,000
Trawl net	16,400	6.8	4,100	27,000	8.0	6,750	27,000	5.7	9,000	15,600	6.4	5,200
Boards	450	0.2	113	450	0.1	113	450	0.1	113	450	0.2	113
Ice machine	-	-	-	3,500	1.0	292	3,500	0.7	269	3,000	1.2	250
Cold room	-	-	-	10,000	3.0	714	5,000	1.1	417	5,500	2.2	423
Rigging & others	10,000	4.2	1,667	12,000	3.6	2,400	13,000	2.8	2,167	11,000	4.5	2,200
Total investment	239,850	100	14,117	336,150	100	20,626	472,250	100	34,820	245,650	100	16,194

Depreciation; Economic life (years) for vessel: 30, eco-sounder: 15, surface radar: 12, sonar: 10, sattelite (GPS): 10, VHF marine: 15, telephone: 15, windlass: 20, main engine: 20, trawl net: 4, boards: 4, ice machine: 12, cold room: 13, rigging and others costs: 5.

*Number of equipments on board of each vessel: Vessels A to D; On-board radar, Eco-sounder, VHF Marine, Telephone, GPS, Windlass, Cold storage: 1. Vessels A to D; Boards, Generator: 2. Vessels A and D; Fishing Nets: 5. Vessels B and C; Fishing Nets: 6. Vessels A and B; Sattelite: 1. Vessels C and D; Sattelite: 2. Vessels A and D; Ice machine: 1. Vessel C; Ice machine: 2. Vessel C; Sonar: 2.

Table 7 — Operational and financial costs of trawl vessels for a period of 12 month

	Vessel A		Vessel B		Vessel C		Vessel D	
	550 HP (410 kW)		550 HP (410 kW)		416 HP (310 kW)		416 HP (310 kW)	
Item Description*	US$	%	US$	%	US$	%	US$	%
Staff*	67,800	44.48	64,500	31.54	78,900	45.49	77,700	47.60
Fuel	36,030	23.64	80,210	39.22	37,576	21.66	30,530	18.70
Boat maintenance	3,800	2.49	2,500	1.22	1,800	1.04	2,000	1.23
Mechanical and Electronical maintenance	1,500	0.98	1,350	0.66	2,400	1.38	1,800	1.10
Ice, transport, case and commission	35,504	23.29	47,546	23.25	44,573	25.70	40,409	27.75
Food for staff	7,800	5012	8,400	4.11	8,200	4.73	10,800	6.62
Effective operational cost (EOC)	152,434	100	204,506	100	173,449	100	163,239	100
Depreciation (DP)**	14,783		20,626		34,820		16,194	
Social charges (SC)	6,780		6,450		7,890		7,770	
Generalexpenses (GE)	7,231.7		9,844.2		8,262.5		7,621.9	
Financial charges (FC)	5,785.4		7,844.2		6,609.9		6,097.6	
Total operational cost (TOC)	187,014.1		249,231.5		231,031.4		200,922.5	
Compensation for investment (CFI)	23,985.0		33,615.0		47,225.0		24,565.0	
Total production cost (TPC)	211,002.1		282,846.5		278,256.4		225,487.5	

*Number and duty of staff on board: Vessel A; Skipper: 2, Seaman: 1, Deckhand: 1, Crew: 3. Vessel B; Skipper: 1, Master: 1, Seaman: 1, Deckhand: 1, Crew: 3. Vessel C; Skipper: 1, Seaman: 1, Crew: 4, Cook: 1. Vessel D; Skipper: 2, Mechanic: 1, Seaman: 1, Crew: 5.
**Estimated from item values and economic life data given in Table 7.
Social charges (SC) = (staff cost x 18) / 100
General expenses (GE)= (effective operational cost x 5) / 100
Financial charges (FC) = [((effective operational cost x 50) / 100) x 8] / 100
Compensation for investment (CFI) = (fixed investments x 10) / 100
Total operational cost (TOC) = Σ (effective operational cost + depreciation + social charges + general expenses + financial charges)
Total production cost (TPC) = Σ (total operational cost + compensation for investment)

Table 8 — Gross revenue, effective expenses and profit of trawl vessels

Engine Power	550 HP (410 kW)		416 HP (310 kW)	
Vessel Gross Tonnage	69 GT	92 GT	107 GT	115 GT
Economic indicators (US$)				
Gross revenue (GR)	236,696.58	316,985.39	297,156.65	269,395.78
Compensation for investment (CFI)	23,985.00	33,615.00	47,225.00	24,565.00
Total operational cost (TOC)	187,014.10	249,231.50	231,031.40	200,922.50
Total production cost (TPC)	211,002.10	282,846.50	278,256.40	225,487.50
Profit (P, TOC based)	49,682.48	67,753.89	66,125.25	68,473.28
Profit (P, TPC based)	25,694.48	34,138.89	18,900.25	43,908.28
Total investment (TI)*	239,850.00	336,150.00	472,250.00	245,650.00
Net profit rate (NPR %TI, TOC based)	20.71	20.16	14.00	27.87
Net profit rate (NPR % TI, TPC based)	10.71	10.16	4.00	17.87
Profit margin (PM % GR, TOC based)	20.99	21.37	22.25	25.42
Profit margin (PM % GR, TPC based)	10.86	10.77	6.36	16.30

*refers to Table 6.
GR (US$/season) = annual catch yield (kg) x sales price (US$/kg)
CFI (US$) = (fixed investment cost x 10) / 100
TOC (US$) = Σ (effective operational cost + depreciation + social charges + general expenses + financial charges)
TPC (US$) = Σ (total operational cost + compensation for investment)
P (US$, TOC based = gross revenue – total operational cost
P (US$, TPC based = gross revenue – total production cost
NPR, % of investment costs (TOC based) = (profit $_{TOC}$ / total investment cost) x 100
NPR, % of investment costs (TPC based) = (profit $_{TPC}$ / total investment cost) x 100
PM, % of gross revenue (TOC based) = (profit $_{TOC}$ / gross revenue) x 100
PM, % of gross revenue (TPC based) = (profit $_{TPC}$ / gross revenue) x 100

Vessel C, which used Sonar equipment different than the other vessels that increased the initial investment cost and so the compensation for investment.

The profit margin, that presents the percentage of profit over sales revenue were higher for the vessels with lower engine power but higher GTs (Vessel C and D), compared to the high engine power and lower GT vessels (Vessel A and B).

Within the same engine power group of 500 HP, the total annual gross revenue increased 34 % from 236,696.58 US$ to 316,985.39 US$ when GT increased by 33% from 69 to 92. However, this was not observed for the vessels in the lower engine power group of 416 HP, where the annual gross revenue remained similar for both GTs (Table 5).

The profit margin, that presents the percentage of profit over sales revenue were higher for the vessels with lower engine power (416 HP) but higher GTs (Vessel C and D), compared to the high engine power (500 HP) and lower GT vessels (Vessel A and B).

In both engine power groups of 500 HP and 416 HP, increasing GTs by 33 % and 7.5% improved the profit around 36.4 % and 3.6%, respectively. The highest profit margin was recorded in Vessel D with low engine power (416 HP), but high GT (115), while the lowest rate of profit margin was recorded in Vessel A with the high engine power (500 HP) but low GT (69).

Decreasing the GT around 15% from 107 to 92 GT, the engine power seems to have an effect on keeping the profit over the operational costs at similar levels with the low engine but high GT vessels. However, when decreasing the GT by 35% from 107 to 69 GT, the increase of engine power from 416 to 500 HP did not compensate the profit, which decreased by 25%.

The fishing capacity and effort have been evaluated using different methodologies applied by previous researchers[13-16].Fishing effort was measured using data such as vessel length, gross tonnage and engine power by Gulland[13]. Bevert on and Holt[14] however, used gross tonnage only, for the assessment of fishing effort, while Placentietal[15] applied a more complex formulation using “vessel tonnage x vessel engine power x fishing hours” in their bio-economic model. Sabatella and Piccinetti[16] used a more simple method, using data from the fishing yield of vessel tonnage and days of fishing applied. Due, the fishing effort seems to have different definitions and there is no single methodology for the measurement, since there are various methods of measurements proposed for

the assessment of fishing effort in earlier studies. From the results in the present study, it can be concluded that not only the GT but also the engine power affected the profit and profit margin in trawl vessels. In overall, the trawl vessel with low engine power of 416 HP and high GT of 115 performed best under the conditions evaluated in the present study.

Conclusions

The present study was conducted based on the assumption that fishing capacity and effort is dependent on the gross tonnage and the engine power. With an around 15 % reduction of gross tonnage of the vessel, the economic profit margin of the fishing activity could be compensated by increasing the engine power to 550 HP without any loss of profit. However, a further decline in the vessel's gross tonnage by 35%, the increase of engine power from 416 to 500 HP may not sufficiently enough to compensate the profit of the fishing vessel. Hence, for the estimation of fishing efforts and annual capital returns, both the vessel's tonnage and engine power are suggested to be considered for the contribution of capacity and power formation towards effective management of trawl fishery operations, which in a long term might contribute to global economic and social welfare development of fishery communities.

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