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Economic performance and productivity of the small pelagic fleet in southern Angola

–A comparative study between the fleets in Benguela and Namibe fishing towns

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ABSTRACT

The study on Economic performance and productivity of representative Angolan purse seine fishing fleets contains operational and economic information regarding the small pelagic fishery in the fishing towns of Benguela and Namibe for the year 2014. The 28 distinct purse-seiners represent 48% of the small pelagic fleet population and contribute with about 54% of landings. Most vessels vary with respect to physical and operational characteristics, how these variations may have affected the vessels performance and productivity is the subject matter of this paper. For analysis and comparison purpose, the fleet was stratified by fishing towns (Namibe and Benguela), and engine groups ($100<HP\leq400$; $400<HP\leq700$; and $HP>700$).

To assess the economic performance, the following indicators were measured: EBITDA= (revenue - operating costs); EBT= (revenue - (operating costs + capital costs)); OCFM =(EBITDA/revenue); OM =(EBT/revenue) and ROC= (EBT/invested capital). To assess productivity, the following indicators were considered: CPUE; cost per unit of effort; revenue per unit of effort, and liters of fuel used to land 1 ton of fish. Another closely related indicator (environmental) was the carbon footprint, expressed in kg of CO_2 emitted per liters of fuel burned in fishing operations. Differences in operating costs structures (labor, running and vessel costs) are also presented. In addition, the study presents the effects of harvest tax and fuel subsidies on the fleets profitability. These indicators were compared between the two fleets and among vessel groups.

Results indicate that 93% of the vessels in Benguela, in contrast to 100% in Namibe fully recovered their operating costs, (positive EBITDA). When also considering capital costs, 71% of vessels in Benguela, showed positive EBT and ROC. In contrast, to 70% in Namibe. EPI also varied among vessel groups such that $400<HP\leq700$ and $HP>700$ groups had higher performance in Benguela and Namibe fleets, respectively. However, these differences are not statistically significant ($p>0.05$). Vessels in Namibe operated with better cost efficiency than those in Benguela, particularly those in the group $HP>700$. Vessels in Benguela fleet operated with higher labour cost than those in Namibe ($p=0.01$), this cost was the highest in $HP>700$ group. The fleet in Namibe was more efficient in terms of fuel consumption per ton of fish landed than that of Benguela ($p<0.05$). Vessel group $HP>700$, in Benguela was the least fuel and eco-efficient. Harvest tax was found to account for proportions 19 and 35% of EBT in Benguela and Namibe fleets, respectively. While fuel subsidies accounted for 3 and 1.4% of EBT in the two fleets.

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ACRONYMS AND ABBREVIATIONS

ABF	Angola Benguela Front (Oceanographic boundary)
BCC	Benguela Current Commission
AC	Average Costs
AR	Average Revenue
BCLME	Benguela Current Large Marine Ecosystem
FUI	Fuel Use Intensity
CPUE	Catch Per Unit Effort
DNPPRP	Direcção Nacional de Pesca e Protecção do Recursos (Angolan Fisheries Directorate)
EPI	Economic Performance Indicator
EBITDA	Earnings before Interest Tax and Depreciation
EBT	Earnings before Tax
FAO	Food and Agriculture Organization
FMP	Fisheries Management Plan
GDP	Gross Domestic Product
GRT	Gross Registered Tonnage
GPS	Global Positioning System
GR	Gross Revenue
HP	Horse Power
IVQ	Individual Vessel Quota
LME	Large Marine Ecosystem
LOA	Length Over All
INE	Instituto Nacional de Estatisticas (The Angolan Statistics Institute)
INIP	Instituto Nacional de Investigacao Pesqueiro (Fisheries Research Institute)
MC	Marginal Cost
MR	Marginal Revenue
MCS	Monitoring Control and Surveillance
MEY	Maximum Economic Yield
MSY	Maximum Sustainable Yield
OCFM	Operating Cash Flow Margin
OM	Operating Margin
OMP	Operational Management Procedure
ROC	Return on Capital
SPF	Small Pelagic Fishery
SST	Sea surface temperature
TAC	Total Allowable Catch
VMS	Vessel Monitoring System

CHAPTER ONE: INTRODUCTION

1.1 General information

The Republic of Angola is located along the South West coast of Africa and is home to about 25 million people (INE, 2014). With a coastline of 1 650 km long and, an EEZ of 200 NM, the country's economy is mainly driven by marine resource base, particularly oil and gas (see table 2). Favourable oceanographic conditions along the SW coast of Africa make the Angolan coast rich in fisheries resources including small pelagic, demersal finfish, and crustaceans that support a large fishing industry and numerous fishery-dependent communities. Fishing takes place from small-scale level, operated by smaller coastal vessels; to large-scale level, operated by Industrial Ocean going vessels.

With an annual landing quantity of 350 thousand tons, and value estimated at USD 950, million, the fishing sector contributes to the GDP with a very small proportion (around 3%). However, it plays a vital role on the socio-economic aspect. The small pelagic fleet comprises of 90 licensed purse-seiners that land about 180 thousand tons annually, with an estimated landing value of 216 million USD. This fleet segment employs approximately 1,500 fishermen as crewmembers and several people in related services. Despite their low fish grade, small pelagic species like sardinellas constitute a regular component of the diet of approximately one quarter of the population, particularly coastal people.

The coastal provinces of Benguela and Namibe in southern Angola are the most important fishing towns and harbour 65% of the small pelagic purse seine fleet. The two towns have nearly the same fleet capacity in terms of number and size of fishing vessels. However, differences in the natural and social systems between the two geographical zones are factors that may lead to differences in productivity and economic performance of the fleets i.e. labour cost may be affected by the town's social-economic structures (Flaaten, 2016). Furthermore, individual vessels with different dimensions may perform differently. This study can therefore be important towards understanding and monitoring performance of different fishing vessels. Further, it can contribute in understanding differences in energy and, environmental efficiency of the fishery, information that is indispensable for fisheries management.

1.2 Geographical location

The map below shows the geographical location of Angola, along the SE Atlantic. In particular, the fishing towns of Benguela and Namibe, in the south where data was collected.

Figure 1. Map of Angola showing the study area, namely Benguela and Namibe province, along the SE coast of the Atlantic Ocean in southern Africa. Source: https://www.google.no/url.mapas.com. Edited by author.

Benguela province (fishing town) Namibe province (fishing town)

The coastal provinces of Benguela and Namibe are the most important fishing centres in the country due to ecological reasons explained in section 2.1. In order to perform a cost and earning analysis of their respective fleets, it is therefore important to look at the socioeconomic factors that may influence the economic performance and productivity of the fishing industry. For example, the population density along the coast may have influence on the labour market of the fishery (Flatten, 2016).

1.3 Research problem

Many fisheries in developing countries, integrate few key economic performance-related indicators, of different fishing fleets into management (FAO, 2005b). Whatever economic information exists is normally communicated piecewise and in a summarized format, often orally, by the operators to the public administration.

In 2013, the Angolan Fisheries Ministry, proposed new development goals for the small pelagic fishery, summarized in two points: (1) to ensure sustainable fisheries, while maintaining the marine ecosystem functions; (2) to enhance income, create new jobs and improve the living standards of fishing dependent communities. Therefore, in order to evaluate the achievement of these goals, monitoring and reporting annual performance indicators is needed. This implies, the Angolan policy-makers necessitate not only reliable stock assessment data of small pelagic resources, but also an understanding of the economic realities of this fishery. At government level, fisheries managers may use this information to correct, design and implement policy instruments. At the industry level, operators may use this information to determine their real fishing effort for improving their productivity and economic efficiency.

On his analysis, Sainsbury (1996), pointed out that, the design and operation of a fishing vessel may affect its productivity and economy. Then, productivity and economic efficiency are expected to vary between fishing zones and vessel size. Results obtained from this analysis can be used to determine what fleet/vessels were more efficient from a productivity point of view (CPUE; energy efficiency), more economically efficient (profitability and ROC) and more environmentally efficient (litres of fuel burnt per ton of catch). This is important and neutral information that can be incorporated into management advice (FAO, 2009). It may also contribute towards providing fleet managers with an understanding of investment decisions in this fishery (Sarker, 2012). There is a perception that larger purse-seiners with higher capital investment are more efficient in terms of CPUE and cost per unit effort, thus, there is a need to test this hypothesis for the Angolan SPF.

Increasing operating costs particularly fuel and maintenance costs, and low market price of the target species, particularly sardinellas, are major concerns to fishing operators, therefore, there is a need to understand as to what extent vessel's average costs and revenues are affected by these factors.

In one way or another, the behavior of a fish-harvesting firm is affected by the existence of any government's action or inaction (Flaaten, 2016). Operators in this fishery argued that they are facing financial constraints, so they need government support. The usual method of determining the effect of government actions i.e. harvest taxes and fuel subsidies is to analyze as to what extent, profit margins may be altered as a result of such measures.

On his research, Gulbrandsen (2012) stated that fuel use intensity in fishing vessels varies with regard to vessel dimension, region of fishing, technologies used, skipper behaviour, and other factors. Responding to climate change by reducing both the amount of waste generated, and the amount of toxic substances released into the environment is a smart choice for the fishing industry (SEAFISH, 2009). The research by Tan and Culaba (n.d) supports that, fisheries that consume relatively less fuel not only have a lower carbon footprint, up to the point of landing, but are also in a favourable position to meet future fuel and emissions regulations. This is important information if fisheries management is to better align with policies to address climate change regarding GHG emissions.

1.4 Research questions

Based on the above considerations, the study on economic performance and productivity of the small pelagic fleets in Benguela and Namibe fishing towns, will attempt to answer the following questions:

1) Do the economic performance indicators differ between the fleets in the two fishing towns (Benguela and Namibe), and among vessel groups (engine HP)?
2) What fleet (in terms of fishing towns), and what vessel groups (in terms of engine HP) were more and/or less cost-efficient?
3) Do the operating cost structures differ between the fleets in the fishing towns, and among vessels?
4) What fleet (in terms of fishing towns), and what vessel groups (in terms engine HP) were more and/or less fuel-efficient, and eco-efficient?

In addition to the above questions, the author will look at how government actions like, harvest taxes (quota tax) and fuel cost support (subsidies) may have affected annual operating costs and profit margins of the fleets.

To address these problems, the author will be supported and guided by a list of study materials, including: operational aspects of purse seiners (i.e. Sainsbury, 1996; FAO 2009); Fisheries economics theories and concepts (i.e. Flaaten, 2016; Long et al, 2015); Statistical analysis and graphical displays (i.e. Berk and Kery, 2007; Cumming, 2007).

1.5 Research objectives

The broad objective of this thesis is to present and compare the cost and earnings findings, as well as productivity of the small pelagic fleet, based on data collected through a representative survey of 28 purse seiners in southern Angola, for the fishing year 2014. The economic performance and productivity indicators shall be compared between the fleets in the fishing towns of Benguela and Namibe, and among vessel groups (based on engine size). Four main objectives will be addressed.

The first objective is to determine a set of output economic performance indicators (EPI), and compare these indicators between fishing towns and among vessel groups. The output EPI include EBITDA (earnings before interest tax and depreciation), EBT (earnings before opportunity cost on owner's capital), OM (operating margin), and ROC (return on invested capital).

The second objective is to find out what fleet and vessel group are more and/or cost-efficiency. Cost efficiency will be expressed as cost revenue ratio, computed by the relationship between cost per unit effort and revenue per unit effort of each vessel.

The third objective is to compute and compare the cost structure of the fleets and vessel groups. The operating cost structure includes labour, running and vessel costs; while the capital cost includes depreciation and interest on invested capital. Quantification of the main operating costs will allow the author to examine their effects on the profitability of the vessels.

The fourth objective is to compare the fuel efficiency and eco-efficiency between the fleets and among vessel groups. Fuel efficiency is compared in terms of litres of fuel consumed per ton of fish landed, while eco-efficiency in this study is based on the concept of landing more fish while using less quantity of fuel, hence less carbon footprint.

The last objective is to understand how government policies on harvest quotas and fuel cost support might have affected the vessels operating costs and profitability. In other words, what proportion of operating costs and profits (EBT) are represented by harvest tax and fuel cost supports.

CHAPTER TWO: BACKGROUND INFORMATION – THE SMALL PELAGIC FISHERY

2.1 The Natural System

The natural system in fisheries governability refers to the marine and costal ecosystem, the resources it holds, and the relationships among the various components and natural driving forces of the ecosystem. Jentoft & Chuenpagdee (2011).

2.1.1 The marine ecosystem

The Angolan marine realm is part of the Benguela Current Large Marine Ecosystem (BCLME). This is among the four most productive eastern boundary upwelling systems in the world. The vast ecosystem is found along the SE Atlantic Ocean, extending from the Agulhas Banks in South Africa, through Namibia, to southern Angola (BCC, 2014).

The waters off the continental shelf of Angola consist of tropical warm waters, the Angola Current (AC), and a cold northward current, the Benguela current (BC). The two water masses meet at a point known as the Angola-Benguela Front (ABF). The front is considered as a permanent hydrographic feature, situated between 14°S – 16°S. However, episodic intrusions of warm, saline water southwards, as stated by (Shillington et al. 2006) can displace the front to approximately 23°S, with associated effects on the overall biological productivity of the LME. Shannon et al. (1986) termed these events Benguela Niño, as they are comparable to the El Niño of the eastern tropical Pacific Ocean. Such variations in currents can have substantial impact on the growth and recruitment of fish stocks (Ekau and Verheye 2005). The sea surface temperatures (SST) vary with latitude and season. Usually lower in southern Angola, during winter, around 20 °C, and higher further north during summer, around of 28°C (Gyory et al. 2004). The water masses within the LME contain higher nutrient concentrations because of coastal upwelling in addition to the ultimate water sources. Usually nitrate, phosphate and silicate concentrations of 10-18μM/L, 0.8-1.5μM/L and 6-15μM/L respectively (Chapman and Shannon, 1985). Such a high concentration of nutrients supports large biomass of phytoplankton like diatom and dinoflagelates species and subsequently zooplankton mostly those of the Calanoid species (Ekau and Verheye 2005). These form the base of the marine food chain, sustaining large biomass of pelagic, demersal finfish and crustaceans' species particularly in the southern fishing zone, the area from Lobito in Benguela all the way to Cunene river mouth in Namibe province. (INIP, 2006).

2.1.2 The fishing resources

The small pelagic fishery comprises of several species (Shannon and O'Toole 1998). However, only a few major ones support the fishery: Two species of Trachurus: Cunene horse mackerel (*T. trecae*) and Cape horse mackerel (*T. capensis*); Two species of Sardinellas: The Madeiran or flat sardinella *(S. maderensis)* and the round sardinella (*S. aurita);* The South African sardine (*Sardinops sagax*) and small Scombrids such as jack mackerel Bianchi et. al. (1993). These are all bony fishes that belong to the actinopterygii (ray-finned fishes) class, and, coastal species that form large schools in pelagic waters.

Information from FishBase (2016) indicayes tha *T. capensis* is a subtropical species distributed on the Eastern Atlantic (7°N - 37°S, 4°E -24°E), particularly in the Gulf of Guinea through Angola, to South Africa. It is usually found at depth range of 0-500 m, but highly concentrated in 100-300 m; has a common length of 20 - 33 cm, and can grow as long as 60.0 cm. *T. trecae* on the other hand, is widely distributed, from Morocco through Angola, to Namibia (35°N - 19°S, 26°W - 14°E). It is usually caught between 20 - 100 m, matures at 24 cm, grows as long as 35 cm, and feeds mainly on small crustaceans.

The Sardinella species have a very wide distribution along the SW African coast *(*46°N - 23°S, 17°W - 36°E). Usually caught at around 50 m depth (although found up to 350 m). Its diet comprises mainly of small planktonic invertebrates, fish larvae and phytoplankton. Breeds during the warm season (July-September), and migrates in response to seasonal upwelling. The common length in catch is 25 cm and grow as long as 30-cm.

Sardinops sagax, is more abundant along the Southern African coast and to a lesser extend off the Angolan coast, at depth range of 0 - 200 m. Feed mainly on plankton and zooplankton like copepods. The fish matures when 9 cm long, grows as long as 39.5 cm, and lives as long as 25 years FishBase (2016). Other commercial pelagic species are presented on the table below.

Table 1. Main commercial pelagic species/species group in the natural system

Pelagic Species/Species Groups	
Clupeids	*Sardinella aurita , S. maderensis*
Carangids	*Trachurus trecae, T. trachurus capensis*
Scombrids	Small tuna like species
Clupeidae	*Ethmalosa fimbriata; Sardinas oscellata; S.sagax*
Hairtails	*Trichiurus spp*
Barracudas	*Sphyraena spp*
	Engraulis hepsetus

Source: Own table.

Stock biomass

For many years, several research cruises have been conducted off the Angolan coast with the aim of monitoring the status of the commercial fish stocks and the marine environment at large. (INP, 2014). The annual Sampling Program is conducted twice a year (during summer and winter), by the Angolan Fisheries Research Institute (INP), in cooperation with regional and international institutions such as the Benguela Current Commission and the Norwegian Agency for Development Cooperation (NORAD). Research vessels such as Dr. Fridjof Nansen and RV O Pensador support the sampling program.

Capricorn Fisheries Motoring (2012). Reported that densities and abundance of small pelagic schooling stocks is relatively higher in southern waters particularly along the coast of Namibe and to a lesser extent along the coast of Benguela province.

Results from hydro-acoustic surveys, INIP (2014), show that during the summer season the biomass of the two sardinella species was estimated at 363 468 tons, of which the flat sardinella (*Sardinella maderensis)* accounted for 46%, while the round sardinella (*Sardinella aurita)* accounted for 54%. In winter, the biomass was estimated at 426 591 tons, being 72% flat sardinella (*S. maderensis), and* 28%, round sardinella (*S. aurita).* The highest biomass was reportedly recorded in 2012, when it was estimated at 1.12 million tons during winter season (INIP, 2014). .

The biomass of horse mackerel *(Trachurus. trecae,* and *Trachurus capensis)* is more uncertain, since it highly depends on seasonal variations of water parameters. Nevertheless, its biomass was estimated at 66 757 tons in the summer and 136 646 tons during winter 2014 (INIP, 2014). However, the stock rebuilding target is 430 000 tons, the estimated biomass in 1996 (Cofrepeche, 2013).

INIP (2013) reported that there were substantial recruitment failures in 2002-2003 and again in 2007, 2008. Overfishing, rather than changing climatic or oceanographic conditions, is considered the primary cause of biomass depletion for both species.

The South African sardine, considered to be shared with Namibia, was also estimated to be depleted to critical levels; however, recent results show stock recovery (Capricorn Fisheries Motoring, 2012).

2.2 The Social System

In fisheries management the social system refers to all the stakeholders of the fishery together with their roles and interest as well as their attached cultural aspects, their social relation and interactions, Jentoft & Chuenpagdee (2011). The table below summarizes the characteristics of the social system of the study area.

Table 2. Socioeconomic profiles of Benguela and Namibe provinces.

	Country's information	
Population	25 million people (INE, 2016)	
Surface area	1 252 145 km^2	
Population density	20 people/km^2	
Number of provinces	18 provinces	
Official language	Portuguese	
GDP	121,700 million USD (2013)	
Main exports	Oil, diamonds, wood, fish and coffee	
Coastline extension	1650km (SE Atlantic)	
Annual fish landings	400 MT	
Number of industrial boats	Around 240 (finfish trawlers; coastal and tuna seiners; shrimp trawlers)	
Number of SSF boats	5000	
Fish consumption p/c	18kg/capita	
	Benguela	**Namibe**
Province surface area	39 827 km² (3%)	57 091 km² (4.5%)
Municipalities	10 Municipalities	5 Municipalities
Population	2.4 million People (10%)	471,613 people (1, 9%)
Population density	60 people/km^2	8,3 people/km^2
Coastline extension	350 km (20%)	450 km (27%)
Geographic location	Central coastline (12°S, 13°E)	Southern coastline (15° S, 12°E)
Coastline ecosystem	Temperate coastline (savanna)	Semi-arid coastline (desert land)
Climate	Dry tropical	Temperate
Main economic activities	Trading (port), farming, fishing, Mining and manufacturing.	Trading (port), fishing, mining (granite), farming, and trade.
Education facilities	Primary, secondary and tertiary institutions and training centers.	Primary, secondary and tertiary institutions and training centers.
Transport infrastructures	Commercial port, airport, railway and public roads.	Commercial port, airport, railway and roads.

Source: own table. Data from INE (2016).

2.3 The Managing System

The managing system in the fishery context refers to the legal and institutional framework governing the natural and the social system of the fishery (Jentoft & Chuenpagdee, 2011).

Most small pelagic fisheries, in developing countries are managed in order to secure food supply and protect employment (FAO, 2009), Angola is not an exception, then, its managing system is grounded on a compatible institutional, legal and regulatory framework. The Angolan Fisheries Law (Lei n.° 6-A/04) is the legal instrument that governs the management and conservation policies of all aquatic living resources.

Due to the transboundary nature of horse mackerel in the southern coast, Angola and Namibia, participated in the development of management plans for their horse mackerel fisheries in late 2013 through the ACP program funded by the European Union. However, the FMPs incorporated other small pelagic species that are sometimes caught together with horse mackerel, thus, The Small Pelagic Fisheries Management Plan. The plan emphasizes the sector's role in promoting core national objectives of combatting hunger and poverty and maximizing socio-economic benefits within a framework of sustainable development. In addition, the plan considers the dynamics of the various stocks and possible harmonization and strengthening of management measures. The key management unit is thus the small pelagic stocks and the associated purse seine fleet. (Cofrepeche, 2013).

For the past few decades, the government has been managing all marine commercial fisheries by a Right-based approach in the form of individual vessel quotas (IVQ), disaggregated from a scientifically-based TAC, regulated by a set of measures and enforced by a MCS system. Fishing rights are initially granted by the National Fisheries Directorate in form of concession rights, with a validity of up to 20 years, exclusively for national citizens (DNP, 2013). This is the basis prior registering a fishing vessel and being allocated a harvesting quota.

For the fishing year 2013-2014, the pelagic species TAC was set at 224, 8 thousand tons. One of the main objectives of the fishery is to maintain stocks at the MSY level, and to achieve, the best possible scientific advice is incorporated. The advice includes the use of indices from the commercial sectors exploiting the resource and importantly, the annual scientific acoustic surveys (INIP, 2013). There is a vast industrial fishermen association. They do not have a direct involvement in decision-making but play an advisory role, particularly in the Annual Advisory Council.

All licensed purse seiners in the fleet are eligible for the initial allocation of a share of the TAC. The allocation process requires comprehensive data from the fisheries operators. That includes information on the operational conditions of the vessel and adequate landing infrastructures. IVQ is preferably allocated to operators with inshore facilities (landing and processing/freezing). In addition, allocation criteria also focus on eligibility of ownership, where preference is on national citizens; good fishing records (apply to old fishers). As mentioned in the Fishery Law (Lei n.° 6-A/04), the installation of satellite tracking devices (VMS) in the entire fleet is mandatory to ensure effective surveillance.

Table 3. TAC for the small pelagic fishery in 2014

Species/group of species	TAC (tons)
Horse mackerel (*Trachurus spp*.)	55,000
Sardinellas *(S. maderensis and S. aurita)*	150,000
South African sardine (*S. Sagax*)	10,000
Mackerel (Scombridae species)	8,000
Other species	1,869
Total	224, 869

Source: Angolan Fisheries Directorate (2014).

It is important to point out that the TAC quantities presented on table 3 are the overall quantities for the entire small pelagic fishery that incorporates 90 purse seine vessels. As a result of disaggregation, 33% and 45% of the TAC, as illustrated on table 4 below, were allocated to the Benguela and Namibe fleets, respectively in form of IVQ.

Table 4. Allocated individual vessel quota in Benguela and Namibe SPF.

	Vessels-Benguela (n=31)	Vessels-Namibe (n=27)
Allocated quota (tons)	75,000	102,200
% of TAC	33%	45%

Source: own table, figures from the Angolan Fisheries Directorate (2014).

Drastic management measures have recently been implemented to favor recovery of the overexploited pelagic resources, particularly of horse mackerel (*Trachurus spp*.) to more sustainable levels (Cofrepeche, 2013). Table 5 summarizes the main management measures adopted by the managing system.

Table 5. Management measures for the small pelagic fishery 2014.

	Command and control	Incentive based/indirect measures
Input control and Technical restrictions	• Licensed purse seiners: 90 • 84 vessels with a GRT ≤250 and hold capacity ≤120m^3 • 6 vessels with: 250 < GRT >800 t and • Minimum mesh size: 25-30 mm • Minimum landing size: 18mm (Decree no 109/05) • Restriction on net size • Prohibition of beach seine • Prohibition of pelagic trawl since 2004	i.e. Fuel subsidies
Output control	• TAC set at 224,869 tons • IVQ • Landings should take place at base ports • Prohibition on unauthorized transshipment.	Tax on harvest: harvest quota tax in $ per ton
Time and area restrictions	• Closed seasons: only applies to horse mackerel Species-May-August • Closed areas: Estuaries and bays • Smaller purse seiners should operate beyond 2nm (4nm beyond closed bays and ports) • Larger vessels should operate beyond 4 nm (6 nm beyond closed bays and ports)	

Source: Own table, information from Angolan Fisheries Directorate (2014).

The management approach sees the MCS system as one of the pillars of the IVQ system supported by the inspectors at the landing points and vessel-monitoring systems (VMS) installed in the all fleet. The information collected at the landing sites specifies landings weight, species, and name of the vessel. This brings about great advantage for controlling the individual landings in each terminal, making it possible to undertake an accurate control of vessels' landings. Illegal activities such as misreporting and quota busting are considered serious offences (Article 21, Fishery Law n.° 6-A/04), and serious corrective measures can be taken by the authorities (Article 23, Fishery Law n.° 6-A/04).

2.4 Fishing capacity and effort

Recognizing the existing overcapacity in the fishing fleet, the Angolan Government took action to establish a balance between available resources and fishing capacity through limited entry. The fleet capacity was significantly reduced in recent years due to changes in management measures (see table 5). The small pelagic fleet in 2014 consisted of 90 licensed purse seine vessels with a total GRT of around 7,500 tons and total fleet power of around 31,250 HP. Based on the vessels size (length), the fleet is classified into two segments, namely the semi-industrial and industrial segment. Vessels considered semi-industrial range from 15 to 20 m of LOA, while, industrial are those with at least 21 m LOA. The industrial segment comprises 36 out of 90 purse seiners. These have on average 31 m LOA and 600 HP and usually fitted with brine freezers and their hull material is mainly steel. The semi-industrial on the other hand, comprises of 54 purse seiners, with an average LOA of 18m, and 376 HP; mostly fitted with RSW or no freezing facility at all. Most have wooden or fiberglass hull material.

Nevertheless, for the purpose of this thesis, the focus is on the southern fishing zone, namely Benguela and Namibe provinces that harbors 64% of the purse seine fleet that is 58 out of 90 vessels. On average, a company owns three vessels, and they may be a multi-vessel, or a single vessel company. The two fishing towns have nearly the same fleet capacity, as illustrated in table 6. the fleet in Benguela comprises 31 vessels with a total GRT of 3,406 tons and a total engine capacity of 14,001 HP. Whereas, the Namibe comprises 27 vessels with a total GRT of 3,386 and total engine capacity of 16,432 HP.

Table 6. Average size of the operating fleet in Benguela and Namibe

	Benguela	Namibe
Number of purse seiners	31	27
Average LOA (m)	24	26
Average GRT	137	158
Average HP	596	656
Average crew per vessel (men)	10	17

Source: Own table, information from Angolan Fisheries Directorate (2014).

In principle, fishing takes place all year round (except for horse mackerel, see table 5), unless when the vessels have to stay onshore for repairs and maintenance. However, in general, vessels are actively involved in fishing for about 200 days a year, performing on average 110 fishing trips that are relatively of short duration, usually 12-48 hours. An average purse seiner consumes up to 250 thousand litres of fuel per fishing year.

2.5 Landings and trade

The SPF fleet has a long history dating back to the early 1950s when total catches already exceeded 300 thousand tons. After a decline in 1960, production increased and reached nearly 600 thousand tons in 1972 (Capricorn Fisheries Monitoring. 2012). At present, with the participation of 90 vessels, total annual catches are estimated around 180 thousand tons with a corresponding value estimated at USD 216 million.

By volume the catches of schooling, pelagic species caught by purse seiners would be considered the largest fishery, landings account for about 60% of the total catches in the country (DNP, 2014). The catch composition may consist of several species. However, horse mackerel, sardinellas and jack mackerel are the three most important species for the industry. Sardinellas account for about 2/3 of the total catch; however, the landing value of horse mackerel may be three times higher than that of sardinella.

During fishing operations, catches are recorded in logbooks on board by vessel operators (or onboard inspectors in industrial vessels) and submitted to the local fisheries office. The logbooks contain catch and effort information, e.g. kg or ton per species or group of species, duration of fishing trips and fishing zone. Inspectors are understood to check landings records against catch records. In 2014, the two southern provinces, Benguela and Namibe, accounted for about 27% (51.3 thousand tons) and 32% (58.4 thousand tons) of the overall small pelagic landings, respectively. The annual catch composition and monthly variations for both fishing towns are illustrated on figures 2 and 3 below.

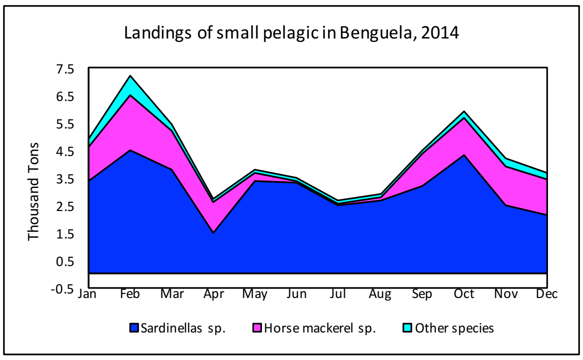


Figure 2. Monthly landings of small pelagic in Benguela. Fishing towns in 2014.The catch composition comprises of sardinellas, horse mackerel and other species, representing an average of around 66%, 27% and 7% respectively. On average, monthly landing was around 4.2 thousand. Lower catches of horse mackerel are primarily due to effort reduction and closing season (May-August). All figures are in thousand tons.

Source: Data collected from (DNP, 2014), figures generated by the author.

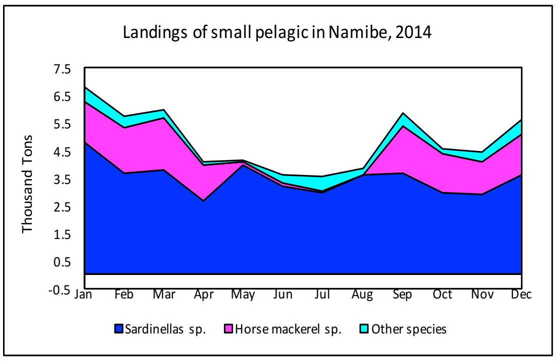


Figure 3. Monthly landings of small pelagic in Namibe fishing town in 2014.The catch composition comprises of sardinellas, horse mackerel and other species, representing an average of around 64%, 28% and 8% respectively. On average, monthly landing was around 4.4 thousand. Lower catches of horse mackerel are primarily due to effort reduction and closing season (May-August). All figures are in thousand tons.

Source: Data collected from (DNP, 2014), figures generated by the author.

Fish trade

Horse mackerel (*Trachurus spp.*) is the most valuable species due to its high demand and price in the local market. This major species is reportedly the one that gives harvesting firms in the small pelagic fishery, economic sustainability. It is among the preferred staple food in Angola, and the market price can vary from 1.60 to 2.60 USD per kilo. This fish is usually sold immediately after or during landings, mostly frozen and boxed into 20-30kg cartoons. It may also be sold fresh but in minor quantities. The total catch within the Angolan waters are not enough to meet the local demand. As a result, the Angolan Fisheries Ministry has established horse mackerel imports quota (up to 90 thousand tons per year) in order to meet the national demand.

Despite higher landing volumes (about 2/3 of the total small pelagic species), sardinella *(S. maderensis and S. aurita)* are considered as low value species, usually consumed by low-income people, and used as raw material in the fishmeal and oil reduction industry. The market price can vary from as low as 0.4 to 1.00 USD per kilo. Other species such as small tunas in the scombridae family may have higher demand and market value. However, they are not caught in larger volumes as the other two stated above.

Upon landing, sardinella catch may be sold as fresh fish, blast frozen, and boxed in cartoons. Fresh fish is usually sold to small retailers, usually women (fishmongers) who sell in the local markets. It may also be sold in bulk to artisanal processors who usually salt and dry then sell big piles to other cities and even neighbouring countries like Congo and Zambia. Larger quantities of landed fresh fish can also be sold to processing plants for reduction purpose (fishmeal and oil). Fishmeal and fish oil exports values in 2014 were USD 16.065.500 and USD 107.156, respectively.

Producers who own freezing facilities onshore may however, sell the catch as either fresh or frozen boxed into 20-25kg cartoons. That is supplied to major institutional clients, usually in large quantities to wholesalers and minor quantities to women traders who sell in the local markets. The ex-vessel price varies as a function of supply and demand of fish. It is usually higher when the catch is sold frozen in cartoons than as fresh fish because of value added.

CHAPTER THREE: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

3.1 Literature review

The aim of this section is to review previous research studies related to the present one. Since this study attempts to analyse and compare the productivity and economic performance of a fleet, it was necessary for the author to consult available literature on similar studies.

Farrell (1957) suggested that productivity or efficiency reflects the firm's ability to obtain maximum output from a given set of inputs. Meanwhile, allocative efficiency reflects the firm's ability to use the inputs in optimal proportions, given their respective prices and the production technology. These two measures are then combined to provide a measure for the total economic efficiency (Coelli at al., 2005). Thus, Economic efficiency as defined by (Henry et al, 1976) refers to the use of resources in such a way that maximizes the production of goods and services at the lowest possible cost. In relative terms, one economic system is more efficient than another if can provide more goods and services for the society without using more resources. Economic efficiency is one way to measure the economic performance. Economic performance, however, is assessed by relating the value of output to the real cost of inputs needed (Coglan and Pascoe, 1997). In practice, assessment of the economic performance of fisheries is derived from economic surveys of the individual fishers participating in the fishery (FAO, 2009). On his research, Hao (2012), argued that regular surveys of economic performance are undertaken in order to assess the requirements of the respective fisheries policy.

Many authors presented economic performance and technical efficiency results through the measurement of technical and economic efficiency of fishing fleets using various methods such as the Stochastic Frontier Production Function and Data Envelopment Analysis methods. In this study the author adapted to a method proposed by Flaaten et al., (1995) and Kim Anh et al., (2006), through which, economic performance indicators are based on the accounting ratios such as profitability, the ratio of net profit to gross revenue, and the ratio of net profit to the capital value.

In the United States, two researchers from the University of Hawaii's Joint Institute for Marine and Atmospheric Research (JIMAR), Marcia Hamilton and Steve Huffman carried out costs and earnings study of Hawaii's small boat pelagic fishery in 1995 and 1996. Data, collected through surveys consisted of information on vessel physical and operational characteristics, investment capital, fixed and variable costs, as well as annual landings quantity and value. Findings showed that, the average annual fixed costs accounted for large proportion in total cost. Fixed costs were higher for pelagic vessels as compared to non-pelagic vessels. Fuel consumption was the most significant variable cost and varied according to vessel size and gear type.

In the UK, under the Centre for the Economics and Management of Aquatic Resources (CEMARE) Coglan and Pascoe (2001), presented the results of an economic and financial performance study of the UK English Channel fleet. Data was collected through economic surveys of the fishery undertaken in 1995-97. The sample size was that of 100 boats and was stratified by port, size and engine power. The key information included financial indicators such as costs, revenue; and operational characteristics such as crew size and vessel age. Results indicate that: for vessel age, engine power and corresponding vessel capacity units, are the major factors that may have affected the average costs and revenues of vessels.

In Bangladesh, Swati (2012), presented the results of an economic study of gillnet marine fishery in coastal areas. The aim of the study was to document the socio-demographic profile of gillnet fishermen and determine costs and returns of the fishery. Data was collected through personal interviews, from 60 SSF boats, randomly selected in Cox´s Bazar coast. Tabular analysis and quantitative data analysis was performed in order to identify and measure the effects of production factors on revenue. The results also show that higher level of efforts resulted in larger catch as well as higher level of net revenue. Panayotou production function analysis shows that all explanatory variables were statistically significant and had positive effect in increasing revenue from the fishery.

In Vietnam, Nguyen Duy (2010), evaluated the economic performance and efficiency of gillnet vessels in Nha Trading. The aim of the research was to find out whether the fleet was profitable and efficient or not. Based on a cost and earning survey, data on 58 vessels was collected and analysed. Empirical results indicate that an average a vessel earns a gross profit margin of 17.3% and a profit margin of 3.8%. The average annual crew income is 74.5% more than the local average income per capita. Efficiency analysis of the vessels based on Salter-diagram application shows that vessels with high relative standardized effort are the most cost efficient and derived intra-marginal rent. On average, government fuel subsidies led to 17.5% increase in gross cash flow, and 36% of profit per vessel.

Still in Vietnam, Nguyen Duy (2010), evaluated the economic performance and efficiency of gillnet vessels in Nha Trading. The aim of the research was to find out whether the offshore fishing fleet was profitable and efficient or not. Based on a costs and earning survey, data on 58 vessels was collected and analysed. The empirical results indicate that an average gillnet vessel earns a gross profit margin of 17.3% and a profit margin of 3.8%. The average annual crew income is 74.5% more than the local average income per capita. Efficiency analysis of the vessels basing on an application of the Salter-diagram shows that vessels with high relative standardized effort are the most cost efficient both in the short- and long-run. Majority of these cost efficient vessel derived intra-marginal rent from the fishery. On average, government fuel subsidies led to 17.5% increase in gross cash flow, and 36% of profit per vessel. The study also demonstrates that engine capacity, fishing gear and fishing day are the factors best reflecting fishing effort of the vessels.

In the European Union, economic performance of selected European fishing fleets was assessed within the EU fisheries: Economic Assessment of European Fisheries (Q5CA-2001-01502-2004). The study was carried out in marine fisheries of 20 countries, of which 86 specific segments of fishing fleets were included. Main characteristics, economic and technical indicators, economic performance of the fishing fleets in 2003 were discussed. The economic indicators were landing value, gross value added, gross cash flow and net profit. For calculating and evaluating capital costs, the replacement value of the vessel was used to calculate depreciation. An imputed interest was computed, reflecting the opportunity cost of the capital invested in the vessel as there was a widely difference in actual interest cost per vessel in different countries.

In Brazil, Almeida et al. (2001), presented the results of an economic analysis of the Santarem commercial fishing fleet in 1997 in lower Amazonian fisheries based on 50 interviews with boat operators whose main gear was gill nets. The fleet was homogeneous in terms of hull design and gear operations, but different in size. Results show that smaller boats had higher economic efficiency in terms of income in relation to expense, but had less in terms of catch per unit effort than larger boats. Greater economic efficiency of small boats was explained in terms of labour, fishing and marketing strategies, whereas the large boats faced small domestic market size. The crew payment was the biggest expenses of the fishing activity, 30% for smallest boats and 63% for the largest.

Flaaten at al. (1995), studied the economic efficiency of Norwegian Purse Seine Fleets. This was processed by comparing the profitability of vessels with no license with the profitability of vessels with license fees. The results show that vessels that purchased licenses have significantly lower profitability than the other vessel group. This is due to the owners who bought licenses along with vessels have higher capital costs. Another report of Flaaten (2008), compared the economic performance indicators of some major fishing vessel groups in Khanh

Hoa of Vietnam in 2004 and 2005. It is proved that the two inshore vessel groups had a contrast in economic performance: a negative profit margin for small-scale trawlers and a positive profit margin for anchovy purse seiners, whereas the offshore gillnetters and offshore longliners had positive net profits in percentage of gross revenue.

U. Tietze and R. Lasch (2002-2003) under the FAO, performed studies on economic performance and fishing efficiency. Results show that all 94 fishing vessels covered had a positive gross cash flow and fully recovered their operating costs, with no losses. When also considering capital costs, i.e. the costs of depreciation and interest, 88 of the 94 types of vessels or 94 percent showed a net profit after deducting the costs of depreciation and interest. To assess the economic and financial performance of fishing vessels, two indicators were used. The NCF, and NCF/total earnings (TE) ratio, as well as NCF/return on investment.

Thean *et al* (2011), under the Department of Agribusiness, performed a study on the technical efficiency of the Penang Trawl Fishery in Malaysia. The research examined the score of technical efficiency and factors causing inefficiency of 69 surveyed trawl vessels in Penang. Technical and operational information such as gross holding capacity, engine power, fuel consumption and landings per trip were collected through a survey. Data Envelopment Analysis (DEA) was applied to examine trawl vessels efficiency. Results showed that the score of technical efficiency among vessels was estimated to be 57%. It was realised that echo sounder was the only factor with positive significant effects on technical efficiency. While, factors related to skipper characteristics such as family background, education and experience of captains however, had negative effects on technical inefficiency of the vessels.

Several broad analyses of fuel consumption in fisheries have been undertaken in recent decades e.g. (Thrane, 2004; Schau et al., 2009). Results of these studies suggest that fuel use intensity (FUI) varies greatly between fisheries targeting different species, employing different gears, and fishing in different regions. Generally, fisheries targeting small pelagic species and employing purse seine gear perform relatively well when compared to higher trophic level species caught with trawl or longline. A recent study in Galicia (Spain) one of Europe's most important fishing regions, identified aquaculture and fishery activities as responsible for approximately 3% of the total GHG emissions of that region in 2008. Robert et al (2014), measured fuel inputs to purse seining vessels targeting primarily skipjack (Katsuwonus pelamis) and yellowfin (Thunnus alba- cores) tuna. Data reported represent that these vessels burned, on average, 368 L of fuel per tonne of wet weight landings. This corresponds to a fuel-related carbon footprint of 1.1 kg CO_2 per landed kg of tuna, lower than that of average marine capture fisheries as well as most forms of land-based animal protein production.

3.2 Theoretical framework

This section provides the key concepts, theories, and models that support and guide this thesis. Therefore, justifications shall be grounded on this section in addition to literature review on the previous section. Section 3.2.3 to 3.3.7 was mainly adapted from Flaaten (2016).

3.2.1 Operation of purse seine gears

Seines and surrounding nets are fishing gears that encircle dense schools of fish on, or near the surface with a large wall of net. The net is then drawn together underneath the fish to make an artificial pond. There are a number of techniques, working from either a single vessel or two craft. Which utilize variations in the rigging and operating procedures (Sainsbury, 1996). This is often a fuel intensive method due to the searching times and distances that may be involved. Modern purse seine can be 1000 m long and 200 m deep, i.e. a fine- meshed wall covering an area of 200.000 m^2 Larsen (2011). They are predominantly used for pelagic, schooling species.

For very fast swimming species like tunas, a two boat operation, including a skiff, is mainly used. In fisheries for slower swimming fish like mackerel, herring, and sardines, it is more common to use a one-boat operation. Modern purse seiners are equipped with mechanical equipment such as triplex power block, net hauler and net winch that help in deploying, maneuvering and hauling the net during operations, as well as fish finding equipment such as Eco sounders and sonars (Sainsbury, 1996). Eco sounders are useful in locating fish, but during the tactics of deploying, the net the sonar is more useful for following the depth, swimming direction and speed of the school (Larsen 2011).

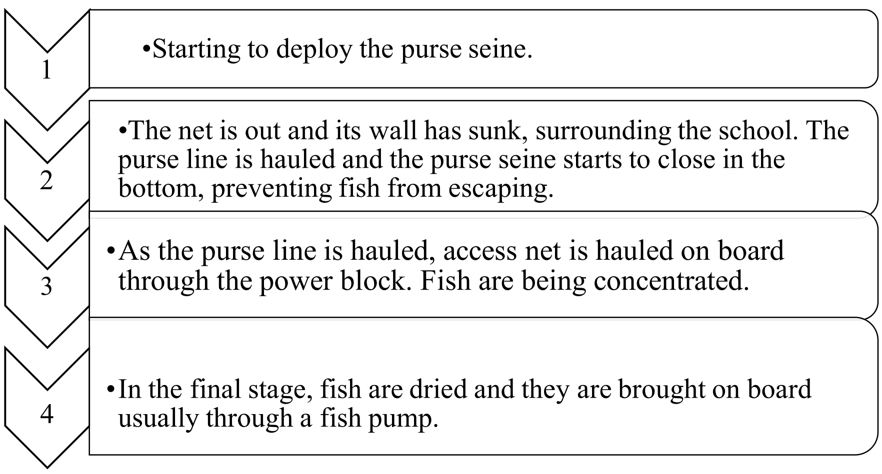


Figure 4. Steps in purse seine operations (Larsen, 2011). Source: own figure.

3.2.2 Cost and earning concepts

The cost and earning definitions used in this study correspond in principle to those used in business economic analysis in general and in previous economic performance studies of fishing vessels. The main economic performance indicators include those related to cost and revenue of fishing operations. The definitions are adapted from Duy N, Flaaten O and Long L (2015).

Table 7. Definitions of the performance indicators

Gross revenue (=Landing value)
-Variable operating costs (i.e. cost of fuel, lubricant, ice, provision and minor repairs)
= Income
- Fixed operating costs (i.e. maintenance costs and insurance)
- Labor costs
= Earnings before interest taxes and depreciation (EBITDA)
- Depreciation
= Operating profit (EBIT)
- Interest payment on loans
= Pretax profit (EBT)
- Calculated interests on the owners capital
= Rent (i.e. IMR or EMR)
Operating cash flow (OCF) margin=EBITDA/Gross revenue
Operating margin=EBT/Gross revenue
Return on capital value (ROC)=(EBT+Interest payment on loans)/Total capital value
Return on equity (ROE)=EBT/Vessel owners capital

Source: Duy et al (2015).

EBITDA mainly reflects the cash a fishing firm has earned from its fishing operation. A positive EBITDA indicates that the gross revenue (GR) exceeds the vessel operational and labour costs, and that there may exist IMR in the short run for the owner.

Meanwhile rent is an EP indicator that measures the efficiency of a producer from society's perspective. Rent (i.e. IMR) is referred to as the economic profit society of employing the owner's capital in fishing activity after subtracting all expenses, including the opportunity cost of this capital.

If the revenue generated by the industry (gross revenue) exceeds the real cost of the factors of production (operating costs), the resultant positive rent implies that the fishery is efficient and profitable for society. If rent is negative while while EBITDA is positive, vessel owners may be commercially viable in the short run, but not operating optimally, based upon a long-term analysis of allocating society resources efficiently.

Costs incurred include the invested capital on the fishing vessel. The hull, mechanical and electronic equipment as well as fishing gears, together with the operational costs. Those costs involved in maintaining the functioning of the fishing vessel are termed as fixed costs. They include maintenance and repairs, insurance, license fees, and administrative costs.

Those costs that are incurred in catching and landing fish are known as variable costs. They are directly related to the number of fishing trips, and includes fuel and lubricants, ice, provisions for the crew, and materials such as twine used in repair of fishing gear at sea. (FAO, 2001). In addition, vessel owners have to take into account the capital costs i.e. the accumulated depreciation and interest on capital loan (. Tietze and Lasch 2003).

A far as share of income is concerned, it is a common practice to manage a vessel as a form of joint enterprise between owner and crew, in such a manner that both share in the success, or lack thereof, of each trip. Under such an arrangement, earnings and expenses are allocated between owner and crew in a prearranged proportion (Duy, 2010). Often the boat or fixed expenses are charged to the boat (owner), while variable expenses are either subtracted directly from gross earnings before making the split, or charged to the crew's share of earnings. Whatever detailed accounting arrangement is used, the split is balanced so that the owner receives a reasonable return on his investment capital, while crew are reward for their work, both parties being encouraged to run and efficient operation and maximize returns.

Productivity is commonly defined as a ratio between the output volume and the volume of inputs (Henry et al, 1976). In this study, it refers to how efficient production inputs, such as fuel, labour and capital, were used to produce a given level of output.

3.2.3 Fishing effort and production

Fisheries management authorities traditionally plays a key role in managing fishing capacity and effort. Capacity may be defined in terms of numbers and size of vessels whereas effort is related to the use of vessels in fishing. Fishing effort is a key concept in bioeconomic models, relative resource assessment, and regulation in marine capture fishery. FAO (2009), defines fishing effort as the combined effect of the inputs used in fishing, including fixed components of vessel and variable components.

The use of the variable inputs and the fixed capital components makes up the overall input base as an aggregate input that is underlying the measure of total fishing effort in order to generate catch (FAO, 2009). Beverton and Holt (1957), related effort to fishing power that is measurement of the potential ability of a vessel to catch fish. Fishers encounter the stock with what is called fishing effort. Frequently relating to a given combination of inputs into the fishing activity. Examples of effort in the purse seine fishery are hours or days hours of fishing. Smith (1996) measured effort of the Dutch cutter fleet from the fishing capacity based on engine power and the number of days at sea, in which the engine power of vessels of different sizes was weighted according to their economic productivity. Flaaten, (2016), expressed effort based in the production function such that

$$(3.1.) \qquad E = \Psi(v_1, \ldots, v_n).$$

Where E is effort and v_1 to v_n are fishing inputs. This is basically a regular production function from the theory of the firm where inputs may have constant returns to scale or variable returns to scale. But, the difference is that E is not the final output like in most firms. Any production firm, uses a set of inputs called factors of production to produce a level of output. With regard to this, a fish harvesting firm uses inputs such as gear, fuel and labour to catch and land fish. Catch is therefore the output in a harvesting firm. However, a fish harvesting firm differs from any other firm for instance a manufacturing firm, in the sense that a harvesting firm can vary the amount of all other inputs, except the size of the stock. Unlike, Factors like fish migration for spawning and feeding and year classes are the basis for the variability of most stocks in certain areas and times- making fish more available for fishers in different areas at different times of the year. Production is therefore as function of E and X.

$H = f(E, X)$. Where H is the harvest, and E and X are effort and stock respectively. This function is described as a short-run production function. It is only valid for a given stock level at any point in time.

3.2.4 Bioeconomic models

The the traditional bioeconomic model in figure 5 below was adapted from Gordon (1954). It comprises of a total revenue *(TR)* function and a total cost *(TC)* function as a function of effort *(E).* The *TR* of a fishery, equals to the quantity harvested multiplied by the price per unit of harvest (*p).* Whereas, the TC is the product of fishing effort and the cost per unit of effort (*a*). *TC* is then dependent on *a*, and the efficiency of each fishing vessel and its crew. It is important to highlight that *p* and *a* in the model below were assumed constant across time and quantity. Based on the sustainable yield curve the *TR* and *TC* can be represented by the following equations:

$$(3.3) \quad TR(E) = p.H(E)$$

$$(3.4) \quad TC(E) = a.E$$

From equation 3.3, the average revenue *(AR)* and the marginal revenue (*MR)* per unit effort functions can be derived. The $AR(E) = TR(E) / E$, and $MR(E) = dTR(E) / dE$. The *AR(E)* shows the revenue generated per unit effort, while, *MR(E)* shows the change in *TR* as a result of a small change in effort. On the same mode, average cost *(AC)* and marginal *MC* marginal cost can be derived from equation 3.4 as: $AC(E)=TC(E)/E$ and $MC(E) = dTC(E) / dE$. *AC(E)* shows the cost per unit effort while*, MC(E)* shows the change in total cost as a result of a small change in effort.

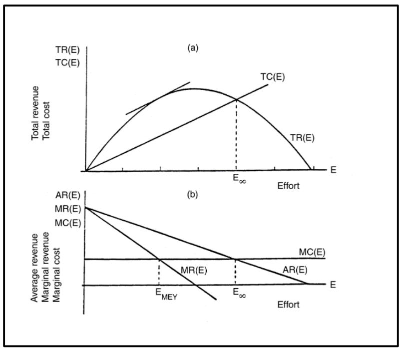


Figure 5. Traditional bioeconomic model (Flaaten, 2016)

Vessels will enter the fishery if: *AR(E) > a*, and exit the fishery if: *AR(E) < a*. However, when: *AR(E) = MC(E),* there will be an economic equilibrium called bionomic equilibrium. At this point there is neither an incentive to leave nor incentive to enter the fishery. The total rent of the fishery is defined as $\pi(E) = TRE(E) - TC(E)$. However, from the optimality rule, resource rent is maximized when *MC(E) = MR(E).* This is the economic reference point at effort level, E_{MEY} (Flaaten, 2016).

3.2.5 Fishing vessels economics

This section deals with application of basic microeconomic theories to the operation of fishing vessels. It includes the economic objectives of fishing activities, differences in cost structure, market prices and opportunity cost of fishing inputs such as labour and capital in heterogeneous vessels.

Suppose, e is the level of effort of an individual fishing vessel. Then, the total cost of effort is:

$$(3.5)\ tc(e) = c(e)+f,$$

where $c(e)$ is the variable cost and f the fixed cost. Similarly, the average cost of effort: $ac(e) = tc(e)/e$, and the marginal cost of effort: $mc(e) = dtc(e)/de$. Example, if effort of a purse-seiner is measured in fishing hours, the average variable cost tells how many $ one hour of fishing on average costs, whereas marginal cost tells by how many $ total cost increases with the addition of one fishing hour.

The fishing effort can be varied by changing the inputs. For instance, the purse seiner operator may decide to vary its speed from the harbour to the fishing ground. If the skipper decides on increasing the sailing speed, that will mean less sailing time and more fishing time. However, fuel consumption increases with increasing speed and that implies increasing marginal costs in response to increasing effort.

At individual vessel level, the harvest (h) in a given period of time is a function of effort (e), stock size (X) and catchability coefficient (q). Thus, adapted from Schaefer linear harvest function: $h(e; X) = qeX$. Then, the operating profit of the vessel is:

$$(3.6)\ \pi(e; X) = pqeX - c(e).$$

Where $c(e)$ is the cost per unit effort. The cost per unit of harvest will depend on both input costs and on the stock level and its catchability.

Like any other firm, a fish harvesting firm may have different strategies for its short-run and its long-run adaptation. In the short run it aims to cover operation cost whereas in the long run the operator will have to cover its fixed cost as well. The marginal and average costs are based on the total cost $tc(e) = c(e) + k$, with $c(e)$ as variable cost and k as fixed cost. Marginal effort cost is $mc(e)$, average variable cost of effort is $avc(e)$ and average total cost of effort is $atc(e)$.

3.2.6 Vessels cost efficiency and intra-marginal rent

Heterogeneous fishing vessels may vary with respect to size, engine power, holding capacity and other technical and economic characteristics, that leads to variations in fishing power, in other words, variation in fishing effort among the vessels (Pascoe and Robinson, 1996).

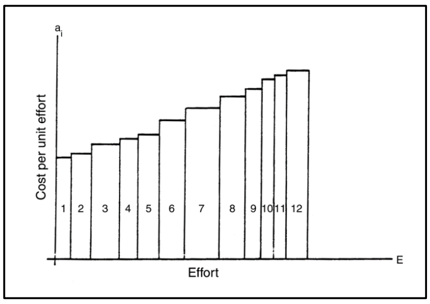


Figure 6. Cost efficiency of heterogeneous vessels in cost per unit of standardized effort. The fishing effort of each vessel is measured by the width of the bar whereas the height of the bar measures cost per unit of effort (Flaaten, 2016).

The vessels in figure 6, are arranged from the left to the right according to their cost efficiency, with vessel no. 1 as the most cost efficient one and vessel no. 12 as the least cost efficient. Vessel no. 9 for example, was chosen as the standard against which the efforts of the others are measured. Since the width of each vessel bar illustrates the standardised effort of each vessel, it was noticed that, for example, vessel no. 3 produces about twice as much effort as the standard vessel, no. 9. This implies that vessel no. 3 would catch twice as much fish per day as vessel no. 9, when effort is measured in hours or days of fishing of the standard vessel. Further, it was noticed that the average cost per unit of standardised effort is lowest for vessel no. 1, even though this vessel no. 1 produces the same effort as the standard vessel no.

In case of heterogeneous fishing effort, the most cost- efficient vessels do make above-normal profit, called intra-marginal rent (IMR). Differences in cost and revenue per unit effort may also result from vessels operating in different geographical areas. For example, fishers living in a small coastal community far away from larger towns and cities usually have few alternative employment possibilities; thus the opportunity cost of labour will be lower in such a community than in larger labour markets. On the other hand, other inputs required for fishing may be costlier in small fishing communities than in towns, due to transportation cost and less competition between distributors. Thus, differences in efficiency of effort, market prices of inputs and opportunity cost of labour may all contribute to the existence of heterogeneous effort in the fish harvesting industry.

3.2.7 Fishing licence and harvest quota

Fishing licenses and harvest quota are examples of input and output controls, respectively. They are also known as effort and catch management instruments. In actual fisheries the initial distribution of the fishing rights, such as vessel licences, and harvest quotas are often heavily debated. A vessel licence is a permission to register and use a vessel for commercial fishing. The licence may or may not specify limits of the vessel characteristics, for example, length (metres), weight (GRT), hold volume (cubic metres) or engine power (HP or kilowatt), and the type of gear (for example, trawl, long-line or purse seine). The focus is on harvest quotas as management tools without discussing explicitly the use of licences. In principle, input controls might also refer to limits placed upon other vital supplies of fishing such as the amount of fuel use in mechanised fisheries. Licensing fishing vessels is therefore a way by which effort management may be stablished. For example, the UN Fish Stocks Agreements (Article 18) require Flag State to control its vessels through licenses, authorisations or permits to fish in the high seas.

Output regulations related to the harvest of fish are called quotas – be it total harvest quotas (TAC) or harvest quotas per enterprise, vessel (IVQ) or fisher (IFQ). Some of the regulatory instruments may be transformed into market instruments, such as tradable quotas (ITQ). For the purpose of this thesis, the focus is on Individual Vessel Harvest Quota (IVQ). That is a non-transferable quota allocated per individual licensed vessel, where direct limits are placed upon the tonnage of fish that may be caught per vessel in a period of time; the system allocates a Maximum Capture Limits per Vessel, and should not in principle, bring any opportunity cost to the quota, as there is no alternative use of it.

The main characteristic of the system is the non-transferability of rights and it comprises complementary mechanisms to counteract eventual social distress due to the rationalization of fishing activities. They are attached to the vessel itself and the fishing license. Should a boat be scrapped, its remaining rights can be accumulated to other boats belonging to the same boat owner. Should a boat not fully utilise its rights in a given season, it cannot accumulate the remaining rights to the following season. According to Aranda (2011), the introduction of the IVQ system in the Peruvian pelagic fishery, responds to the need of rationalising the fishing activity directed to the fishery of anchoveta. The IVQ scheme incorporates mechanisms to assure holders that the management environment will not change throughout the validation period. Example 10-year in Peru. These mechanisms take the form of a Contract of Permanence of the IVQ regime (Aranda, 2011).

3.2.8 Harvest tax and subsidies

Indirect management instruments include taxes, fees and subsidies. Taxes can be used to discourage the expansion of effort and can be regarded as an instrument to reduce effort, while, subsidies would encourage an expansion of effort and can be disregarded as an instrument to reduce effort in the direction of E_{MEY}. Corrective taxes can in theory bring marginal private costs into alignment with marginal social costs. Such instruments are called Pigouvian taxes. In principle, studying the effects of Pigouvian taxes on fishing effort, as well as on resources, is an excellent point of departure for studies in fisheries management.

Therefore, on his work, Flaaten, (2016), looked into the effects of taxes on fish harvest. He pointed out that, the manager's task is to find the tax rate, on harvest, that adjusts effort to optimum points such as E_{MSY} or E_{MEY} levels. This requires an extensive knowledge about the biological and economic characteristics of the fishery, expressed in equations 3.2; 3.3 and 3.4. Suppose, the manager has all necessary information freely available: t_H = tax per unit harvest (for example, $ per kg or tonne of fish caught). With a harvest tax the total private revenue of fishers equals:

$$(3.7)\quad TR_P(E)=(p-t_H)H(E)$$

where *p* and *H* are the price of fish and of harvest, respectively. The subscript *p* on TR is what the private industry receives as net of taxes. The other part, equal to $t_h H(E)$, is the government's tax revenue. Then, total revenue of the fishery, $p_H(E)$, equals the sum of private and government revenues. The tax rate t_h is measured in $ per kg or per tonne.

A fisheries subsidy is a government action that confers an advantage on fish harvesters or consumers in order to supplement their income or lower their cost (FAO, 2009). Fisheries subsidies come in many shapes and forms such as fuel tax rebate; fuel cost support and compensation; provision of landing site facilities; and no resource access fees. For the purpose of this thesis, the focus is on fuel cost support subsidies where costs of fuel for fishing vessels are lowered. In the EU for instance, fuel subsidies for fishers within member states consist mainly of fuel tax exemptions with respect to the excise taxes directed at specific fuels (Council Directive 2003/96/EC). Theoretically, subsidies are expected to increase profit in the short term, but not in the long run. It is acknowledged that some forms of fisheries subsidies can threaten the sustainability of fisheries resources by encouraging overcapacity and excess fishing effort, thus reducing the long-term viability of the fishing industry (2002, WSSD).

CHAPTER FOUR: DATA AND DESCRIPTIVE STATISTICS

4.1 The study area

The study area falls within the Angolan EEZ, in the southern fishing zone, more precisely in the municipalities of Baia Farta (12° S, 13° E) and Tombwa (15° S, 11° E), in Benguela and Namibe provinces, respectively.

Most fish harvesting firms have their landing terminals within the bays illustrated on the images below.

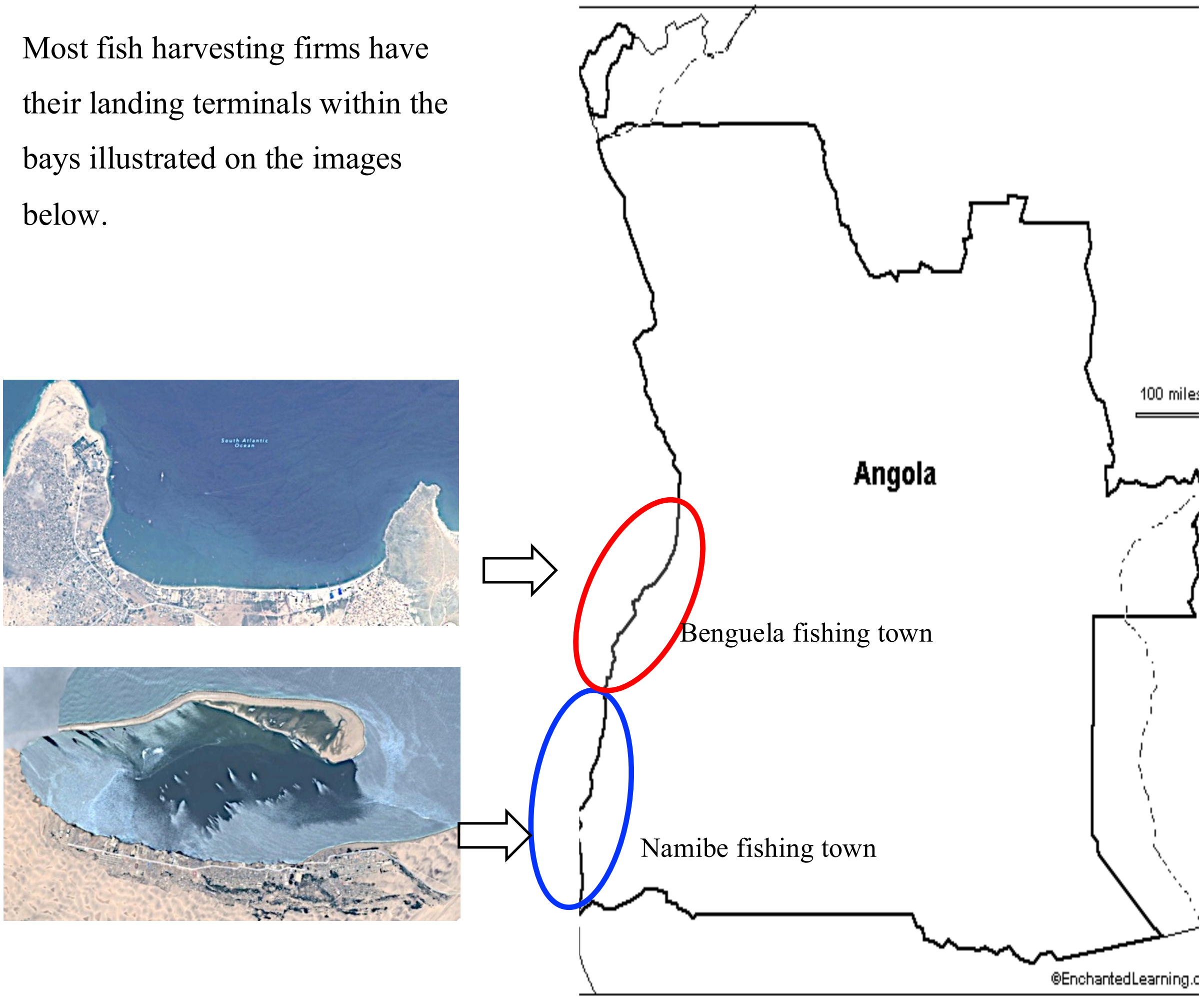


Figure 7. Study area, Benguela and Namibe fishing zones and landing terminals

Source: https://www.google.no/angola_mapa.co.ao . Edited by the author.

The surveyed sites, were five (5) fish harvesting firms in the municipality of Baia Farta-Benguela, and six (6) harvesting firms in the municipality of Tombwa-Namibe, at their respective landing terminals. Namibe and Benguela, represent the first and second largest fishing towns in the country, respectively.

4.2 The data collection method

Data was directly collected by the author through semi-structured personal interviews with key informants among vessel owners, skippers and vessel or harvesting firm's managers at their respective landing terminals.

Two main types of information were collected: (1) description of the vessel's physical and operational characteristics including hull length, engine power, fuel consumption, duration of fishing trip and crew size, and (2) economic and financial data such as invested capital, operating costs, and price per unit of harvest concerning the fishing year 2014.

All data was collected in July and August 2015. In addition, data pertaining the same fleet/vessels was directly collected from the Angolan Fisheries Directorate data base and logbooks. Particularly effort and catch data, and harvest quota quantity and taxes.

4.3 Sample representativeness

28 purse-seiners (14 in each fishing town) in a population of 58 were surveyed. The sample size was limited to 48% of due to availability of information and operational status of certain vessels.

The sample was stratified into fishing town, and engine power (HP). Based fishing towns, the fleet was subdivided into two groups: Benguela and Namibe. While, based on the engine horse-power, it was subdivided into three groups: 100< HP≤400; 400 <HP≤700; and HP>700. This information is summarized on the table below.

Table 8. Distribution of purse-seiners by fishing towns and vessel groups (HP).

Vessel groups	Benguela				Namibe			
	Population		Sample		Population		Sample	
	No.	%	No.	%	No.	%	No	%
100<HP≤400	19	61%	5	26%	6	22%	4	67%
400 <HP≤700	8	26%	5	63%	15	56%	5	33%
HP>700	4	13%	4	100%	6	22%	5	83%
Total	31	100%	14	45%	27	100%	14	52%

Source: own data and table

4.4 Data analysis

With the aid of computer software, (particularly Microsoft Excel) and standard economic formulations, the quantitative observations performed were used in the calculation of output economic performance and productivity indicators per vessel e.g. EBITDA (earnings before interest tax and depreciation), OM (operating margin), ROC (return on capital), CPUE, cost per unit of effort, revenue per unit of effort and fuel consumption per unit of catch. The general calculation approach for the economic performance indicators presented in chapter 5 were adapted from Duy N, Flaaten O, and Long L (2015), defined in table 7, chapter 3.

The fishing effort was the basis for calculating some productivity or efficiency indicators of vessels including cost and revenue per unit effort and CPUE. In this study effort is considered as the product of vessels engine HP and number of fishing trips performed in the year (HP*fishing trips). This approach, according to GFCM (2006), may be appropriate for vessels of different dimensions using the same type of gear, as the case of this study.

Another indicator of productivity is fuel efficiency, in other words the quantity of fuel used to land one ton of fish, as well as the cost of fuel as a proportion of fish sales. This was calculated as the ratio of annual fuel consumption to annual catch, expressed in liters/tons.

Fuel use intensity (FUI) created the basis for calculating the environmental productivity indicator, namely carbon footprint expressed in kg of carbon CO_2 per liter of fuel burned in fishing operations. The burning of a liter of diesel on-board fishing vessels results in the emission of 2.8 kg CO2-e (Seafish, 1996), resulting in a total GHG-to-fuel ratio of approximately 2.8 kg CO2-e per liter consumed.

The indicators were first compared in terms of values and percentage between fishing towns and vessel groups. In order to test for statistically significant differences in the mean values of indicators between fishing towns and vessel groups, T-Test for two independent samples assuming equal variances, and/or unequal variances (depending on F-Test results) was performed. To support the t-test results, 95% Confidence Interval error bars were displayed in order to estimate statistical significance using the overlap rule for 95% CI bars.

4.5 Descriptive statistics of technical and operational characteristics

Table 9 and 10 present a statistical summary of the technical and operational data of the 28 surveyed vessels within the fishing towns and vessel groups. All parameters are per vessels.

Table 9. Descriptive statistics of some technical and operational characteristics of the 28 purse seiners in Benguela and Namibe.

Variables	Vessels -Benguela N=14 vessels				Vessels -Namibe N=14 vessels			
	Min.	Max.	Mean	S.Dev.	Min.	Max.	Mean	S.Dev.
Engine power (HP)	190.	1690	536	415	250	1200	642	345
Length (m)	14.3	37.0	21.9	7.9	17.0	43.0	26.3	9.2
GRT (tons)	25.0	364.0	135.8	127.5	40.0	431.0	139.7	138.2
Age (years)	1.0	24.0	13.1	7.9	6.0	24.0	13.5	7.8
Crew (persons)	10.0	30.0	17.8	5.2	15.0	27.0	18.6	4.2
Diesel fuel (1000 liters)	120.0	720.0	278.9	159.8	80.0	360.0	197.7	107.5
Fishing trips	37.7	135.8	90.1	29.6	59.5	152.5	111.0	24.1
Catch per vessel (ton)	1000.0	3279.0	1524.1	648.4	551.0	8633.0	2718.0	2714.5
Catch per trip (tons)	8.0	60.0	19.1	13.8	5.0	88.0	27.4	29.0

Source: own data and calculations

Table 10. Descriptive statistics of technical and operational characteristics among vessel groups.

Variables	Vessel groups -Benguela						Vessel groups -Namibe					
	100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
HP	268	75	431	19	1135	376	347	67	450	0.0	1070	148
GRT	58	38	70.5	39	315	82	47	6	60	8	294	125
Length (m)	16	2	20.3	2	34	4	22	6	19	0.0	37	4
Age (years)	18	5	11	8	10	10	10	3	7	1	23	4
Fuel (1000 liters)	232	92	236	106	390	247	115	25	133	34	368	99
Crew (persons)	15	2.1	22	8	13	2	19	4	21.8	4	15	0.0
Fishing trips	115	18	93	16	54	15	125	10	123	22	88	16
Catch (Tons)	1193	242	1588	597	1858	965	847	242	1251	590	5681	2528
Tons per trip	11	3	15	4	35	17	7	2	10	3	61	21

Source: own data and calculations

The data in tables 9 and 10 indicate that the representative vessels are heterogeneous in terms of technical and operational characteristics.

The average average horse power of the vessels in Benguela fleet is smaller than that of Namibe, 536 HP and 642 HP, respectively. However, there is a higher standard deviation within the Benguela fleet (SD=415HP in contrast to 345HP). In terms of GRT and LOA, the fleet in Namibe is relatively larger as well. In fact, regression analysis results show that two variables HP, and GRT are strongly correlated (R^2=0.7).

The annual mean fuel consumption on the other hand, was higher in Benguela, 278.9 thousand litres, than in Namibe fleet, 197.7 thousand litres.

In terms of age, the two fleets are nearly the same age, with means of 13.1 and 13.5 years, respectively. It is should be point out that, some vessels are older than the recorded age. Therefore, their age was considered from the acquisition year by the present owner. In fact, such vessels may be older since some may have been bought as second hand. Thus, vessel age here means the years of ownership by the present owner.

On average, other operational characteristics such as number of fishing trips and catch per trip were also relatively higher in Namibe than in Benguela fleet.

Among vessel groups, variables such as hull length, GRT, fuel consumption, and catch per trip increased with increasing engine size. Meaning, vessels in the group 100< HP≤400 are shorter (length), had less tonnage, lower fuel consumption and smaller catch per trip, while vessels in the group HP>700 are longer, had more tonnage, higher fuel consumption and larger catch per trip in both fishing towns.

In contrary, vessels in the group 100< HP≤400, performed more fishing trips than those in the group HP>700. As far as average vessel age is concerned, those in the group 100< HP≤400, were found to be older (17 years) and those in the group HP>700 the younger (10 years) in Benguela.

In Namibe, however, HP>700 were found to be older (23 years) while those in the group 400< HP≤700 were younger (7 years). The number of crewmembers in both fishing towns was found to be higher in 400< HP≤700 vessel group (21 men) and smaller in HP>700 group (13 men in Benguela and 15 in Namibe).

4.6 Descriptive statistics of investment capital structure

Tables 11 and 12 present the summary of investment capital (acquisition value and replacement values) of the fishing vessels re-valued for the year 2014. The capital stock is further presented by different components that make the fishing vessel operational such as hull and mechanical equipment.

Table 11. Invested capital of the vessels in Benguela and Namibe

Variables	**Vessels -Benguela** N=14 vessels				**Vessel -Namibe** N=14 vessels			
	Min.	Max.	Mean	S.Dev.	Min.	Max.	Mean	S.Dev.
Hull	438.2	1565.0	989.3	302.4	313.0	2191.0	1212.9	684.0
Engine	105.0	375.0	237.1	72.4	75.0	525.0	290.6	163.9
Mechanical equipment	76.3	272.5	172.3	52.6	54.5	381.5	211.2	119.1
Electronic equipment	42.0	150.0	94.8	29.0	30.0	210.0	116.3	65.6
Storage equipment	24.5	87.5	55.3	16.9	17.5	122.5	67.8	38.2
Fishing gear	75.0	100.0	90.4	5.7	75.0	300.0	166.1	104.6
Others	14.0	50.0	31.6	9.7	10.0	70.0	38.8	21.9
Total invested capital	**790.0**	**2600.0**	**1670.7**	**484.8**	**575.0**	**3800.0**	**2103.6**	**1183.2**

Unit: Thousand USD per vessel

Table 12. Invested capital among vessel groups

Variables	**Vessel groups -Benguela**						**Vessel groups -Namibe**					
	100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Hull	707.4	187.3	1023.5	197.8	1299.0	186.9	626.0	357.8	954.7	348.4	1940.6	462.1
Engine	169.5	44.9	245.3	47.4	311.3	44.8	150.0	85.7	228.8	83.5	465.0	110.7
Mechanical	123.2	32.6	178.2	34.4	226.2	32.5	109.0	62.3	166.2	60.7	337.9	80.5
Electronic	67.8	17.9	98.1	19.0	124.5	17.9	60.0	34.3	91.5	33.4	186.0	44.3
Storage equip	39.6	10.5	57.2	11.1	72.6	10.5	35.0	20.0	53.4	19.5	108.5	25.8
Fishing gear	90.0	0.0	87.0	6.7	95.0	5.8	75.0	0.0	105.0	14.1	300.0	0.0
Others	22.6	6.0	32.7	6.3	41.5	6.0	20.0	11.4	30.5	11.1	62.0	14.8
Total capital	**1220.0**	**299.2**	**1722.0**	**316.5**	**2170.0**	**300.3**	**1075.0**	**571.5**	**1630.0**	**566.2**	**3400.0**	**738.2**

Unit: Thousand USD per vessel

It is important to highlight that for vessels whose acquisition value was not provided, the replacement value was used.

The total invested capital on the fishing vessels presented on tables 11 and 12 were disaggregated into different components that make up the fishing vessel. Namely the hull, engine, mechanical equipment, electronic equipment, storage equipment, fishing gear and others.

The vessel hull, mainly include the superstructure and deckhouse, that was the major component in terms of invested capital, accounting for about 60% of the total capital. Its material varied from wood in smaller purse seiners to fibreglass and steel in larger purse seiners.

The second component in terms of cost was vessel engine. That accounted for an average of 15% of total capital cost.

Mechanical equipment included the winch, dynamo, lighting system and battery. Altogether, mechanical equipment accounted for an average of 10% of the total invested capital.

Most vessels are equipped with some electronic equipment such as compass, sonars and short and long-distance communication equipment. In addition, a few vessels use radars, particularly the larger ones. On average, electronic equipment accounted for 6% of the invested capital of the vessel.

Not all vessels are equipped with storage equipment. E.g., some smaller vessels that fish closer to the shore do not have preservation facilities at all. However, larger ones are equipped with RSW and brine freezers. These equipment accounts for minor proportions of the invested capital. Around 2%.

The cost of fishing gear varied according to size. Ranging from 70 thousand to 300 thousand USD. That accounted for an average of 6% of the total invested capital.

Comparatively, the fleet in Benguela represent a relatively lower investment capital than that of Namibe. With means of 1.6 million USD and 2.1 million USD respectively. Moreover, the standard deviation of invested capital in Namibe is 1.18 million compared to only 485 thousand USD in Benguela fleet.

The mean fixed capital increased with engine size in both fishing towns. Vessels in the group HP>700 had an invested capital far greater than those in the group 100< HP≤400. For instance, within the Benguela fleet, vessels HP>700 on average invested twice the capital of those 100< HP≤400. The same vessel group (HP>700), in Namibe fleet invested three times more than the 100< HP≤400.

4.7 Descriptive statistics of cost structure

4.7.1 Fixed costs

Fixed cost refers to those that did not change with the number of fishing trips performed in a fishing year 2014. These generally have to be paid regardless of what state the the fishing operations are in. In this study, they are referred to the annual repair and maintenance costs of hull, engine, and other equipment on the vessel, as well as fixed salaries, insurance, and harvest quota tax for the vessels.

Table 13. Fixed cost structure of the 28 vessels in Benguela and Namibe.

Variables	**Vessels -Benguela** N=14 vessels				**Vessel -Namibe** N=14 vessels			
	Min.	Max.	Mean	S.Dev.	Min.	Max.	Mean	S.Dev.
Maintenance	90.0	150.0	122.9	28.4	40.0	200.0	114.3	68.6
Salary (fixed)	66.0	126.0	102.5	23.9	24.0	118.0	69.2	34.5
Harvest quota fee	15.0	88.0	35.6	19.9	12.0	528.0	98.4	147.2
Insurance	1.3	3.8	2.8	0.8	0.9	6.3	3.5	2.0
Others	18.0	30.0	24.6	5.7	8.0	120.0	50.0	51.4
Total fixed costs	**202.7**	**394.8**	**288.3**	**58.5**	**78.9**	**962.3**	**325.8**	**279.3**

Unit: Thousand USD per vessel per year (2014).

Table 14. Fixed costs structure among vessel groups.

Variables	**Vessel groups -Benguela** 100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		**Vessel groups -Namibe** 100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Maintenance	116.0	31.3	108.0	23.9	150.0	0.0	57.5	22.2	74.0	21.9	200.0	0.0
Salary (fixed)	97.4	23.2	99.6	31.1	112.5	17.1	43.5	15.5	44.0	15.	110.2	12.6
Harvest fee	23.7	7.9	32.8	12.5	54.0	27.0	23.8	14.4	27.6	4.9	228.8	192.
Insurance	2.0	0.5	2.9	0.6	3.5	0.2	1.8	1.0	2.7	1.0	5.6	1.3
Others	23.2	6.3	21.6	4.8	30.0	0.0	11.5	4.4	14.8	4.4	116.0	8.9
Total fixed costs	**262.3**	**58.2**	**264.8**	**37.6**	**350**	**36.2**	**128.1**	**41.6**	**157.2**	**40.2**	**652.6**	**206**

Unit: Thousand USD per vessel per year (2014).

From tables 13 and 14 its noted that the mean fixed cost were higher in Namibe fleet, 325.8 thousand compared to 288thousand USD in Benguela fleet, particularly harvest fees in Namibe. However, mean fixed salaries was higher in Benguela fleet, 102 thousand compared to 69 thousand USD per vessel year. Among vessel groups fixed costs, particularly maintenance and salaries increased with engine sizes in both fishing towns.

4.7.2 Variable costs

Variable costs are referred to the expenses for all fishing trips in a year. They are the result of the average vessel variable cost per fishing trip times the number of fishing trips in the year 2014. These costs may increase depending on whether more production is done, and how it is done.

Table 15. Variable costs structure of the vessels in Benguela and Namibe.

Variables	**Vessels -Benguela** N=14 vessels				**Vessel -Namibe** N=14 vessels			
	Min.	Max.	Mean	S.Dev.	Min.	Max.	Mean	S.Dev.
Diesel fuel	87.6	525.6	203.6	116.7	58.4	379.6	154.9	98.3
Lubricants	2.6	15.8	6.1	3.5	1.8	11.4	4.6	2.9
Wage	28.3	187.6	68.3	46.9	14.0	129.5	49.4	36.0
Ice	4.0	30.0	18.7	10.8	0.0	36.0	14.6	14.0
Minor repairs	17.5	105.1	40.7	23.3	1.8	75.9	28.8	21.8
Catering	7.5	30.0	13.3	8.1	3.0	30.0	15.5	11.6
Others	17.5	105.1	45.3	23.2	14.6	94.9	36.9	25.2
Total variable costs	**179.3**	**941**	**395.9**	**202.6**	**107.5**	**535.2**	**286.6**	**166.1**

Unit: Thousand USD per vessel per year (2014).

Table 16. Variable costs structure among vessel groups.

Variables	**Vessel groups -Benguela** 100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		**Vessel groups -Namibe** 100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Diesel fuel	169.9	67.5	172.3	77.5	284.7	180.6	84.6	18.6	97.5	24.7	268.6	72.7
Lubricants	5.1	2.0	5.2	2.3	8.5	5.4	2.5	0.6	2.9	0.7	8.1	2.2
Wage	46.5	14.0	92.3	61.4	65.6	50.1	24.6	8.0	40.5	20.8	85.2	37.9
Ice	16.5	12.5	13.8	9.6	27.5	5.0	6.8	7.9	21.6	19.7	14.0	8.9
Minor repairs	34.0	13.5	34.5	15.5	56.9	36.1	13.2	6.9	16.4	9.5	53.7	14.5
Provisions	8.4	0.8	11.2	4.4	21.9	10.7	7.5	6.5	7.5	1.5	30.0	0.0
Others	38.1	13.6	42.2	20.6	58.0	34.6	19.9	3.6	22.1	4.9	65.4	21.2
Total	**318.5**	**106.7**	**371.4**	**174.**	**523.2**	**299.4**	**153.1**	**36.0**	**198.1**	**69.6**	**481.8**	**92.7**

Unit: Thousand USD per vessel per year (2014).

Average variable costs were higher in Benguela, 395.9 thousand in contrast to 286.6 thousand USD in Namibe fleet. Major differences are in fuel and labour cost (wage), where Benguela fleet had higher costs than Namibe. Variable costs of all components show an increasing trend with increasing engine size.

4.7.3 Operating costs

Operating costs are the cost of resources related to the operation of the fishing vessel including running costs, repair, maintenance and labour costs (Rose et al, 2000). In this study, Labor costs consist of crew wages, fixed salaries and labor charges such as insurance and pension funds. Running costs include the costs of fuel, lubricants, preservation and storage of fish, food and supplies for the crew. Vessel costs are those of vessel insurance, and maintenance and minor repairs expenses.

Table 17. Operating costs structure of the vessels in Benguela and Namibe.

Variables	Vessels -Benguela N=14 vessels				Vessel -Namibe N=14 vessels			
	Min.	Max.	Mean	S.D	Min.	Max.	Mean	S.D
Labor cost (salaries and wage)	105.5	313.6	170.8	63.3	41.4	302.2	122.1	88.8
Running costs (fuel, food, fees)	148.6	784.5	322.5	164.3	104.8	904.4	325.0	268.1
Vessel costs (maintenance, insur.)	109.8	258.9	166.3	43.0	49.9	282.2	146.6	90.8
Total Operating costs	**368.5**	**1305.7**	**659.6**	**246.6**	**216.0**	**1438.4**	**593.7**	**437.1**

Unit: Thousand USD per vessel per year (2014)

Table 18. Operating costs structure of among vessel groups.

Variables	Vessel groups -Benguela						Vessel groups -Namibe					
	100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Labor cost	143.9	33.4	191.9	89.0	178.1	57.2	61.3	20.2	70.7	20.0	222.1	73.8
Running costs	261.8	83.3	277.5	112.7	454.7	240.8	144.9	35.5	179.3	52.7	614.9	256.5
Vessel costs	152.0	42.4	145.3	21.8	210.5	36.2	72.5	27.9	93.1	31.8	259.3	15.6
Total OC	**557.7**	**155.8**	**614.6**	**203.5**	**843.2**	**332.0**	**278.8**	**68.0**	**343.1**	**100.5**	**1096.3**	**337.3**

Unit: thousand USD per vessel per year (2014)

In general, operating costs were higher in Benguela than in Namibe fleet, with means of 659.6 thousand and 593.7 thousand USD, respectively. With the exception of running costs that were nearly the same in both fleets, all other costs were relatively higher in Benguela fleet.

Among vessel groups, the mean operating costs increased with increasing engine size in both fleets. However, labour cost within the Benguela fleet, was higher in vessel group 400< HP≤700 and lowest in 100< HP≤400.

4.7.4 Capital cost

Capital cost include depreciation and interest paid for the fishing vessel (Rose et al, 2000) Some vessels in the sample are fully owned by the operators, others were acquired through government loans and a few operate under joint venture with foreign investors. With a view to eliminating these differences, an imputed interest was calculated. The basis for the calculation was the capital value of the vessel, and an assumed annual interest rate of 6%. As for annual depreciation, a straight-line depreciation method was used to calculate the annual depreciation value:

$$(4.1) Annual\ depreciation = (cost - residual\ value) * rate\ of\ depreciation$$

Where the cost is the invested capital value on the vessel, the residual is the salvage value, estimated at 20% of the investment capital. The depreciation rate varied from 6% for the hull to 12% for engine 7% for mechanical equipment, 9% for electronic equipment, 6% for storage, and 15% for gear and 7% for others.

Table 19. Calculated capital cost for the fishing vessels in Benguela and Namibe

Variables	Vessels -Benguela N=14 vessels				Vessel -Namibe N=14 vessels			
	Min.	Max.	Mean	S.Dev.	Min.	Max.	Mean	S.Dev.
Calculated interest rate	42.0	150.0	94.8	29.0	30.0	210.0	116.3	65.6
Calculated annual depreciation	51.2	156.2	102.0	28.1	37.8	237.9	131.7	74.0
Total capital cost	**93.2**	**306.2**	**196.8**	**57.1**	**67.8**	**447.9**	**247.9**	**139.4**

Unit: Thousand USD per vessel per year (2014).

Table 20. Calculated capital costs among vessel groups

Variables	Vessel groups -Benguela						Vessel groups -Namibe					
	100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Calculated IR	67.8	17.9	98.1	19.0	124.5	17.9	60.0	34.3	91.5	33.4	186.0	44.3
Depreciation	76.0	17.3	104.7	18.3	131.1	17.4	66.7	33.0	100.5	33.3	214.8	42.6
Total C. Cost	143.8	35.2	202.8	37.2	255.6	35.3	126.7	67.3	192.0	66.7	400.8	86.9

Unit: Thousand USD per vessel per year (2014).

CHAPTER FIVE: RESULTS

5.1 Economic performance indicators

The key economic performance indicators of the vessels, adapted from Duy et al (2015), are presented in table 21 and partially summarized in figure 6. These include Gross Revenue (GR), Earnings before Interest Taxes and Depreciation (EBITDA), Earnings before Tax (EBT), Operating Cash Flow Margin (OCFM), Operating Margin (OM) and Return on Capital (ROC). GR refers to the landing value, which is the product of annual catch in tons and price per unit of harvest in USD; EBITDA was obtained after subtracting all operating costs from gross revenue; while, EBT was calculated by subtracting all costs, including capital cost from gross revenue. The OCFM is the ratio of EBITDA to GR, OM is the ratio of EBT to GR and ROC is the ratio of EBT to total invested capital value.

Table 21. Economic performance indicators of the vessels in Benguela and Namibe

Variables	**Vessels -Benguela** N=14 vessels				**Vessel -Namibe** N=14 vessels			
	Min.	Max.	Mean	S.D	Min.	Max.	Mean	S.D
Gross revenue	**700.0**	**2295.3**	**1066.9**	**453.9**	**292.0**	**3021.6**	**1143.7**	**944.4**
-Variable costs	205.7	1029.0	431.5	217.3	139.1	1124.1	415.6	344.0
=Income	**289.4**	**1266.3**	**635.4**	**283.2**	**119.4**	**1897.5**	**728.1**	**611.9**
-Fixed costs	176.3	306.8	252.7	46.8	66.9	434.3	228.1	154.5
=EBITDA	**-13.8**	**959.6**	**382.7**	**278.9**	**27.3**	**1463.2**	**500.0**	**480.5**
-Depreciation	51.2	156.2	102.0	28.1	37.8	237.9	131.7	74.0
= Operating Profit (EBIT)	-129.6	803.4	280.7	262.1	-18.1	1441.4	383.7	450.8
-Calc. interest on loan	42.0	150.0	94.8	29.0	30.0	210.0	116.3	65.6
Pretax Profit (EBT)	**-237.6**	**653.4**	**185.9**	**246.7**	**-58.3**	**1015.3**	**252.0**	**357.3**
Operating CF Margin	*-2%*	*51%*	*34%*	*16%*	*9%*	*60%*	*39%*	*14%*
Operating Margin	*-30%*	*37%*	*14%*	*18%*	*-19%*	*39%*	*13%*	*17%*
Return on Capital	*-13%*	*31%*	*10%*	*12%*	*-8%*	*27%*	*8%*	*11%*

Unit: Thousand USD per vessel per year (2014).

Source: own data and calculations.

The results in table 21 show that 13 out of 14 vessels covered in Benguela, had positive EBITDA and fully recovered their operating costs, with no losses. When also considering capital costs, i.e. the costs of depreciation and interest, 10 out of the 14 vessels or 71% percent showed positive EBT (profit before interest on owner's capital) after deducting the costs of depreciation and interest. Similarly, the same 10 out of 14 vessels showed positive return on invested capital.

In Namibe, on the other hand, all 14 vessels covered, had positive EBITDA and fully recovered their operating costs, with no loss. However, when considering capital costs, 11 out of the 14 vessels or 70% showed a positive EBT (profit before interest on owner's capital); and positive return on invested capital. These values are illustrated on the figure below.

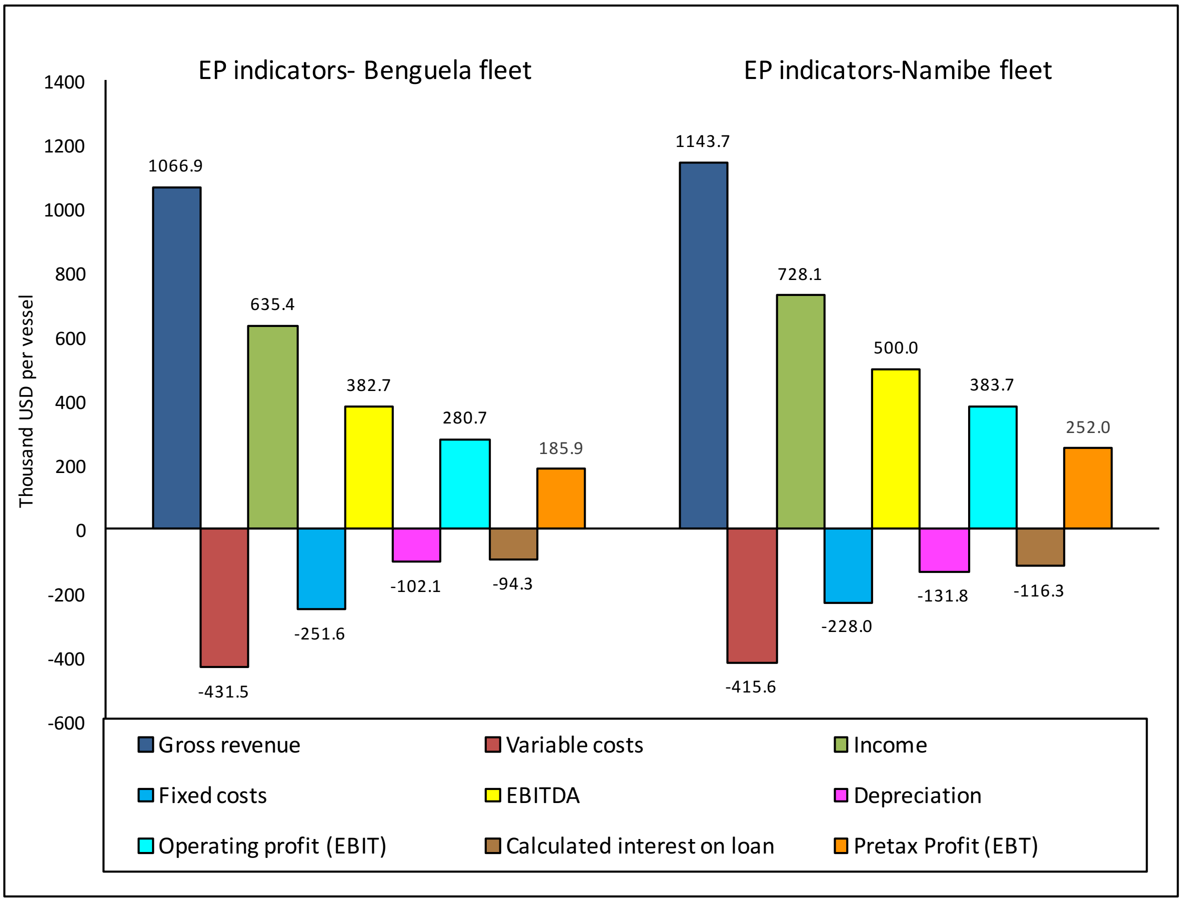


Figure 8. Mean economic performance indicators of vessels in Benguela and Namibe. All figures are in thousand USD per vessel per year (2014). Negative signs indicate the cost items. EBITDA is the earnings before interest tax and depreciation, EBIT stands for earning before tax while EBT is the earning before tax on owner's capital. In addition to this, resource rent would have been calculated as the difference between EBT and interest on owner's capital; however, data on owner's capital was not made available. Therefore, EBT is the final indicator in this study.

Source: own data, and figure generated by paper author.

The mean annual gross revenue of the two fleets as illustrated in figure 6, were nearly the same: 1.06 million and 1.14 million USD of landed value per vessel for Benguela and Namibe fleet, respectively. However, in Benguela GR ranged from 700 thousand to 2.3 million while it ranged from 292 thousand to 3.02 millions USD per vessel year in Namibe.

The second indicator, EBITDA, that represents the operating cash flow margin (OCFM), was found to be higher in Namibe, 39% of gross revenue and, relatively lower in Benguela, 34%. In fact, OCFM in Benguela varied from -2% to 51% as compared to 9% to 60% in Namibe fleet. That implies not all sampled vessels in Benguela were able to cover their operating costs, while all in vessels in Namibe were able to cover their operating costs for the fishing year 2014.

EBT (profit before interest on owner's capital) is considered the remaining value after all costs, (including annual depreciation interest on capital) have been deducted. In general, Benguela fleet had a slightly higher mean EBT representing 14% of gross revenue, in contrast to 13% in Namibe. However, in Benguela EBT ranged from -237 thousand to 653 thousand USD, while it ranged from -58.3 thousand to 1.01 million USD per vessel in Namibe. Four out of 14 vessels in Benguela had a negative EBT, ranging between -237 to -21.3 thousand USD, whereas, three out of 14 vessels in Namibe had a negative EBT ranging from -58.3 to -45.3 thousand USD.

Statistical test results of economic performance indicators

The mean values of the economic performance indicators presented in table 21 and figure 6 are different from an economic point of view. Such difference would support the idea that one fleet or vessel group had a better performance than the other. However, from a statistical point of view, this is not enough to make such a conclusion. The conclusion is therefore grounded on the T-test for two independent sample and the Confidence Interval error bars that indicate statistically significant differences or no significant differences in the mean values of indicators in Benguela and Namibe fleet i.e. EBT, operating cash flow margin (OCFM), operating margin (OM) and return on capital (ROI).

The T test results, as seen on tables 1 to 4 on appendix C, show that there are no statistically significant differences between the mean values of economic performance indicators of Benguela and Namibe fleets. The probability value for the four comparisons are greater than the alpha value (*0.05*): for the EBT $(p=0.52)$; OCFM ($p=0.36$); OM $(p=0.93)$ and ROI $(p=0.40)$.

The hypothesis test is further supported by the 95% confidence interval error bars illustrated in figures 9 below.

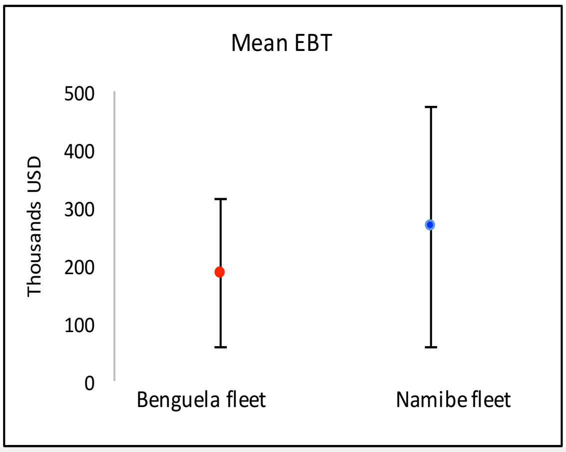


Figure 9a. Comparison of mean EBT (profit before opportunity cost on owner's capital) between the fleets in Benguela and Namibe.

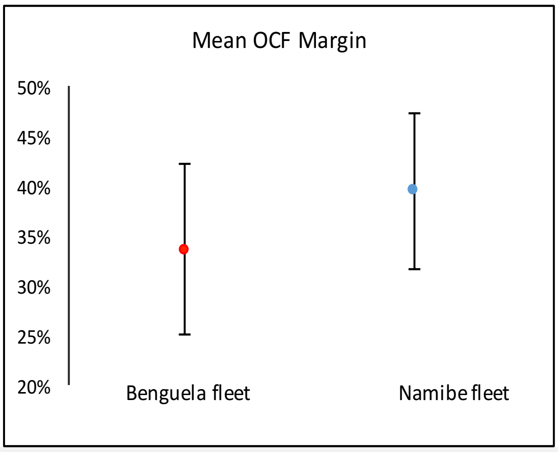


Figure 9b. Comparison of mean operating cash flow margin between the fleets in Benguela and Namibe.

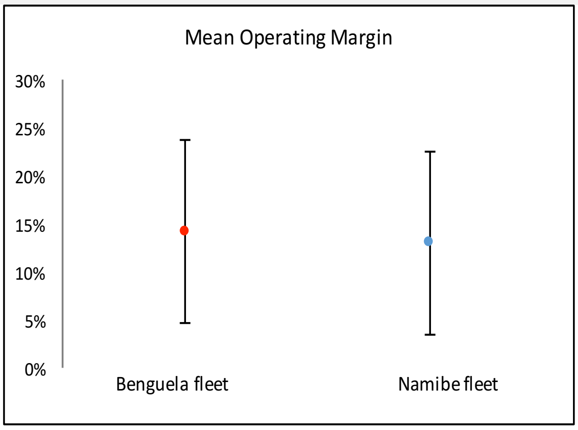


Figure 9c. Comparison of mean OM between the fleets in Benguela and Namibe.

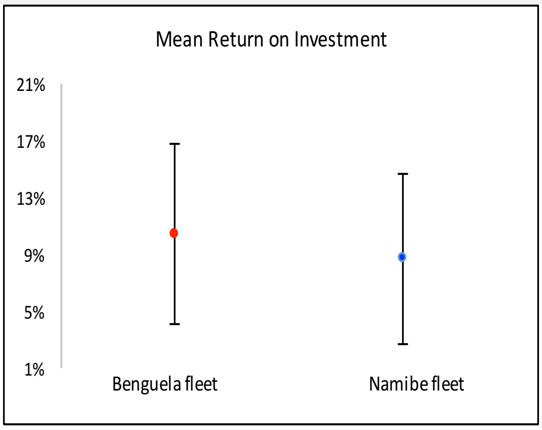


Figure 9d. Comparison of mean return on invested capital between the fleets in Benguela and Namibe.

Figure 9. 95% Confidence Intervals (CI) error bars showing variations in the mean values of the economic performance indicators (EBT, NCFM, OM and ROI).The overlap rule for 95% CI error bars ($n \geq 10$) states that: if error bars overlap by half the average arm length, $p \approx 0.05$. And, if the tips of the error bars just touch, $p \approx 0.01$ (Cumming et al, 2007). The error bars on the figures do overlap, reflecting a p value higher than alpha (0.05), thus no statistically significant difference between the means values of economic performance indicators of Benguela and Namibe fleet.

Table 22. Economic performance indicators among vessel groups in Benguela and Namibe.

Variables	**Vessel groups -Benguela**						**Vessel groups -Namibe**					
	100< HP≤400 (N=5)		400 <HP≤700 (N=5)		HP>700 (N=4)		100< HP≤400 (N=4)		400 <HP≤700 (N=5)		HP>700 (N=5)	
	Mean	S.D	Mean	S.D	Mea n	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Gross revenue	**835.0**	**169.1**	**1111.6**	**417.7**	**1301.**	**675.3**	**448.9**	**128.6**	**663.3**	**313.0**	**2179.8**	**821.6**
Variable costs	342.3	106.3	404.2	182.4	577.2	319.9	182.7	42.4	228.9	69.3	788.6	326.7
Income	492.7	136.5	707.4	263.6	723.8	420.9	266.2	94.4	434.4	256.3	1391.2	523.1
Fixed costs	238.7	56.9	232.1	31.6	296.0	17.0	107.6	37.8	128.9	36.2	423.8	23.2
EBITDA	**254.0**	**145.3**	**475.4**	**254.2**	**427.7**	**422.2**	**158.6**	**90.7**	**305.5**	**232.4**	**967.5**	**503.1**
Depreciation	76.0	17.3	104.7	18.3	131.1	17.4	66.7	33.0	100.5	33.3	214.8	42.6
EBIT	*178.1*	138.2	370.6	238.6	296.7	406.0	92.0	70.4	204.9	209.0	795.9	525.2
Calc. interest	67.8	17.9	98.1	19.0	124.5	17.9	60.0	34.3	91.5	33.4	186.0	44.3
EBT	**110.3**	**132.8**	**272.5**	**223.1**	**172.2**	**389.4**	**32.0**	**62.1**	**113.4**	**189.1**	**566.7**	**424.3**
OCF Margin	*30%*	*16%*	*42%*	*9%*	*28%*	*23%*	*34%*	*13%*	*41%*	*19%*	*41%*	*12%*
OM	*13%*	*16%*	*22%*	*10%*	*6%*	*28%*	*7%*	*15%*	*10%*	*21%*	*21%*	*16%*
ROC	*9%*	*12%*	*15%*	*10%*	*6%*	*17%*	*4%*	*7%*	*5%*	*11%*	*15%*	*11%*

Unit: Thousand USD per vessel per year (2014).

Source: own data and calculations.

Results in table 22 show remarkable differences in the values of economic performance indicators among vessel groups in both fishing towns (fleets).

Within the Benguela fleet, the mean gross revenue increased with increasing engine power such that vessel group 100 <HP≤400 generated the lowest mean revenue whereas, those with HP>700 generated the highest. All other performance indicators such as EBITDA, EBT, OCFM and ROC where higher in 400 <HP≤700 and lower in 100 <HP≤400.

Within the Namibe fleet, all performance indicators including gross revenue increased with increasing engine power. That implies, vessel group 100 <HP≤400 generated the lowest mean revenue whereas, those with HP>700 generated the highest.

Comparisons of economic performance among vessel groups are further illustrated in figures 10 and 11.

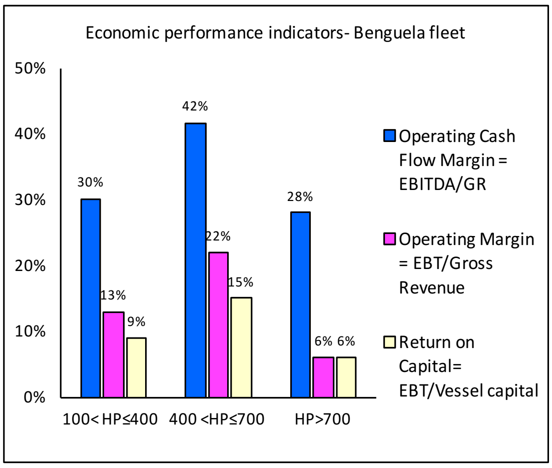


Figure 10. Economic performance indicators among vessel groups within the Benguela fleet. Along the x-axis are the HP vessel. Each bar represents the percentage of an EPI namely OCMF; OM; and ROC

Source: collected data and authors figure.

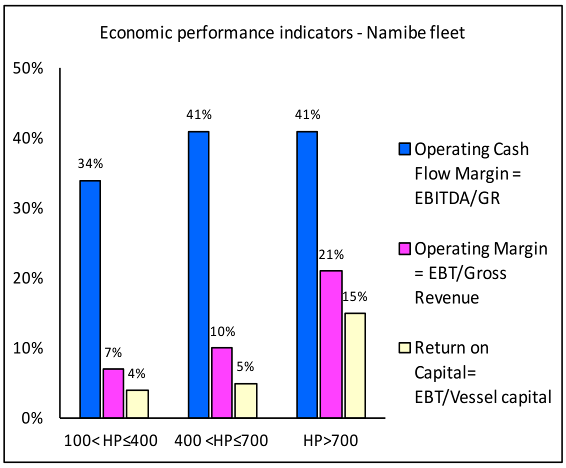


Figure 11. Economic performance indicators among vessel groups within the Namibe fleet. Along the x-axis are the HP vessel. Each bar represents the percentage of an EPI namely OCMF; OM; and ROC

Source: collected data and authors figure.

In Benguela, engine vessel group 400 <HP≤700 achieved the best financial and economic results, with OCFM at 42%, OM at 22% and ROC at 15%; followed by engine vessel group 100<HP≤400, with an OCFM at 30%, OM at 13% and ROC at 9%. Vessel group HP>700, had a relatively lower OCFM, 28%, in fact, this group had the poorest performance, since OM and ROC were found to be 6% each.

In contrary, within the Namibe fleet, engine vessel group HP>700 achieved the best financial and economic results, with OCFM at 41%, OM at 21% and ROC at 15%; followed by vessel group 400<HP≤700 with an OCFM at 41%, OM at 10% and ROC at 5%. Vessel group 100 <HP≤400, had a relatively lower OCFM, 34%, then, this group had the poorest performance, with OM and ROC values at 7% and 4%, respectively.

Statistical tests of the EPI among vessel groups

To support the above conclusions on comparison, 95% CI error bars displaying variation in mean values of indicators (EBT, OM and ROC) are illustrated in figures below.

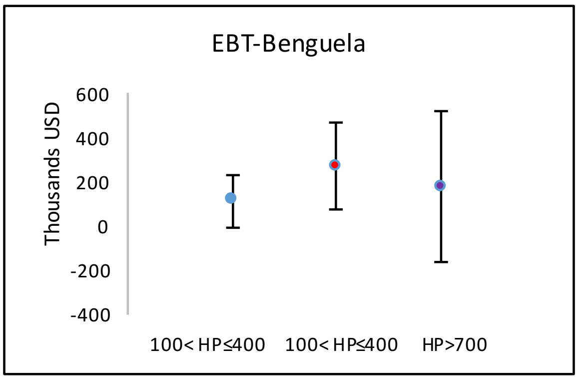


Figure 12a. Earning before tax. Benguela fleet

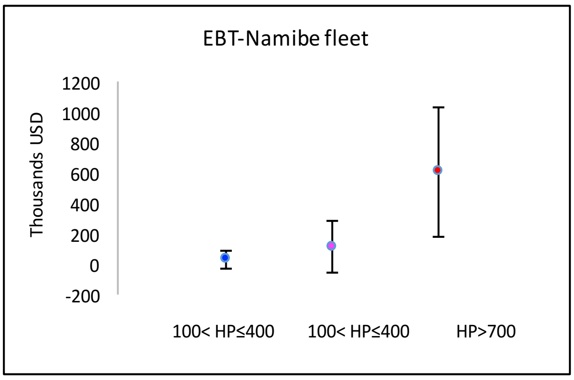


Figure 12b. Earning before tax. Namibe fleet

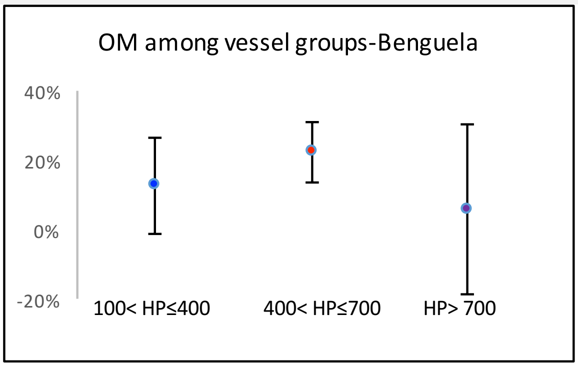


Figure 12c. Operating margin. Benguela fleet

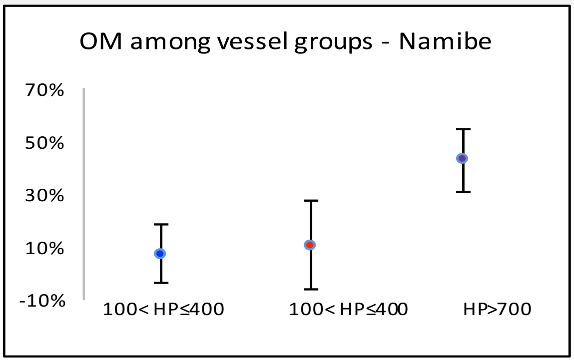


Figure 12d. Operating margin. Namibe fleet

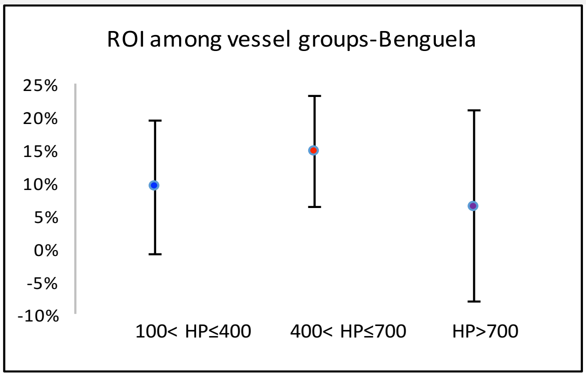


Figure 12e. Return on capital. Benguela fleet

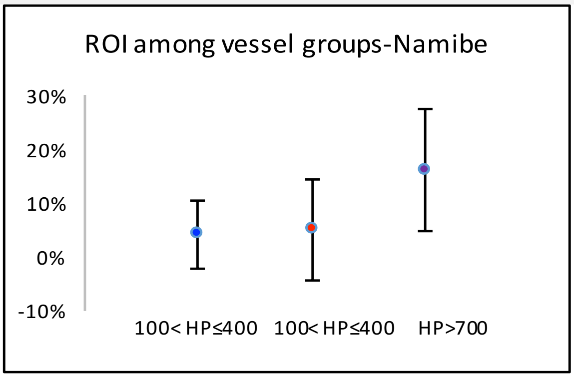


Figure 12f. Return on capital. Namibe fleet

Figure 12. 95% Confidence Intervals (CI) error bars showing variations in the mean values of economic performance indicators (EBT, OM and ROI) among vessel groups in Benguela and Namibe. All error bars within the Benguela fleet overlap, reflecting p values ≥ 0.05, while EBT and OM error bars of some vessel groups within the Namibe fleet do not overlap, reflecting p values ≈ 0.01. Thus there are no statistically significant differences in the mean values of economic performance indicators among vessel groups in Benguela, while the mean values of economic performance indicators for some vessel groups are statistically significant different in the Namibe fleet.

5.2 Cost efficiency of the vessels

The basis for calculating cost efficiency was the cost and revenue per unit of effort. Fishing effort is measured as a product of HP and fishing trip per vessel for the year 2014. Then, the average cost tells how many USD one HP in a fishing trip, on average costs, whereas average revenue tells how many USD is generated per unit of HP in a fishing trip. The efficiency ratio (cost: revenue) therefore measures the firm's ability to turn resources into revenue. It shows essentially how much was spent to generate a dollar of revenue. The lower the ratio, the better the efficiency. These relationships are summarized in figures 13 and 14 below.

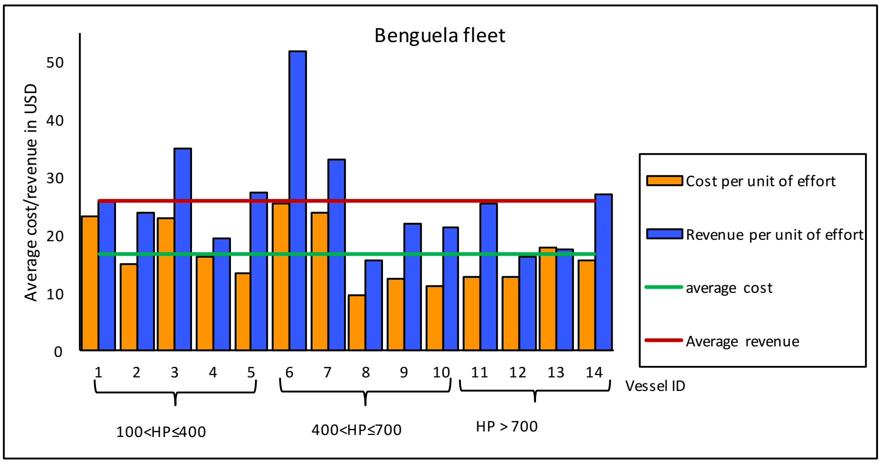


Figure 13. Cost efficiency in terms of cost and revenue per unit effort among for all 14 purse-seiners in Benguela, each bar represents a fishing vesselarranged in horse power groups, from the least to the most powerful group. Along the y-axis is average cost and average revenue in USD. Source: own data and generated figure.

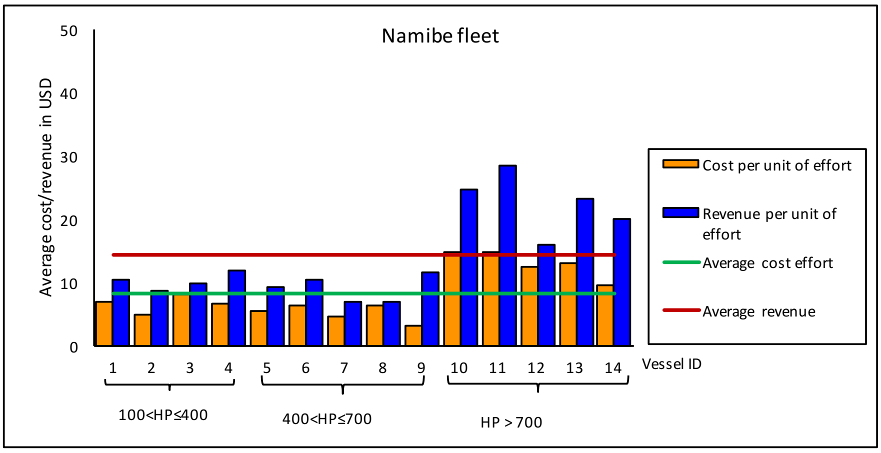


Figure 14. Cost efficiency in terms of cost and revenue per unit effort among for all 14 purse-seiners in Namibe, each bar represents a fishing vessel. On the x-axis are vessels ID no.1 to no. 14, arranged in horse power groups, from the least to the most powerful group. Along the y-axis is average cost and average revenue in USD. Source: own data and generated figure.

On average, vessels in Benguela, as illustrated in figures 13 and 14 operated at higher cost and generated higher revenue per unit effort than those in Namibe. The average cost and average revenue per unit of effort in Benguela fleet was that of 16.5 USD and 25.76 USD, respectively. Whereas, in Namibe fleet, average cost and average revenue per unit effort was 8.43 USD and 14.26 USD respectively. This would imply that, fishing at one horse power per fishing trip, in Namibe would cost 49% less than in Benguela. However, applying the efficiency ratio (cost/revenue), the fleet in Benguela operated with an efficiency of 0.64; and the Namibe operated at 0.59. That means 0.64 USD and 0.59 USD were spent to for every dollar earned in revenue in Benguela and Namibe, respectively. Showing higher cost efficiency in Namibe fleet.

Among vessel groups in Benguela, those with HP>700, operated with the lowest cost per unit effort, an average of 14.72 USD, and generated the lowest revenue per unit effort, an average of 21.51 USD, corresponding to a cost efficiency of 0.68; vessel group 100 <HP≤400, operated at the highest cost per unit effort, an average of 18.05 USD, generating an average of 26.25 USD, corresponding to a cost efficiency of 0.69 ; while, those within 400 <HP≤700, generated the the highest revenue per unit effort, 28.68 USD, with an average cost of 16.46 USD, corresponding to a cost efficiency of 0.57. Thus, vessels within 400 <HP≤700 group were the most cost-efficient (0.57 dollars spent to generate 1.00 of revenue) while those in the group 100 <HP≤400 were the least cost efficient (0.69 dollars spent to generate 1.00 of revenue) in Benguela fleet.

Within the Namibe fleet, results in figure 11 show that vessel group 400<HP≤700, operated at the lowest cost, 5.28 USD and, generated the lowest revenue per unit effort, of 9.19 USD, corresponding to a cost efficiency of 0.57, while those within HP>700 operated at the highest cost: 12.94 USD, and generated the highest revenue, 22.52 USD per unit effort, corresponding to a cost efficiency ratio of 0.57. vessel group within 100 <HP≤400), operated at a cost of 6.74 USD and generated a revenue of 10.28 USD per unit effort, corresponding a cost efficiency ratio of 0.66. Thus, vessels within the group 400<HP≤700 and HP>700 were the most cost efficient with rations of 0.57 each while, 100<HP≤400 vessels were the least cost-efficient (0.66) in Namibe fleet.

Statistical test results of cost efficiency

The mean values of cost efficiency indicators (cost per unit effort, revenue per unit effort and cost revenue ratio) presented in figures 13 and 14 are different from an economic point of view.

Statistical results derived from a T-test, for independent samples, show that there are statistically significant differences between the mean values of cost per unit effort; revenue per unit effort of the two fleets. The probability value for the two comparisons are smaller than 0.05: Cost per unit effort (p=0.00005) while, revenue per unit effort (p=0.001). However, there is no statistically significant difference between the mea cost revenue ratios ($p=0.33$). See tables 5 and 6 on appendix C.

The hypothesis test is further supported by confidence interval error bars illustrated in figures 15 and 16 below.

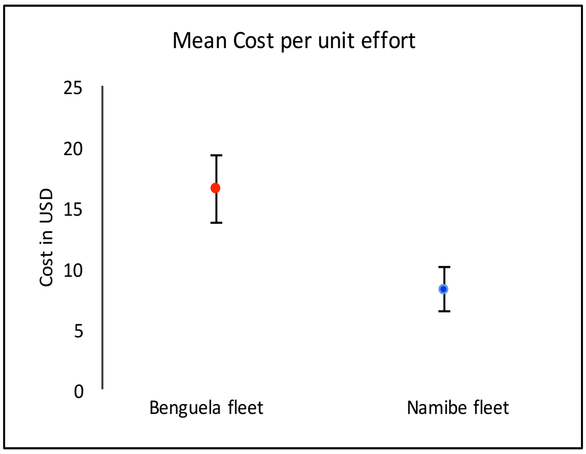


Figure 15. 95% Confidence Intervals (CI) error bars showing variation in the mean values of cost per unit effort. The error bars on the figure do not overlap, reflecting a p value lower than alpha ($p<0.05$). Meaning that there is statistically significant difference between the mean values of cost per unit effort between the fleets in Benguela and Namibe. The cost is in USD, while effort is expressed as the product of HP and fishing trips.

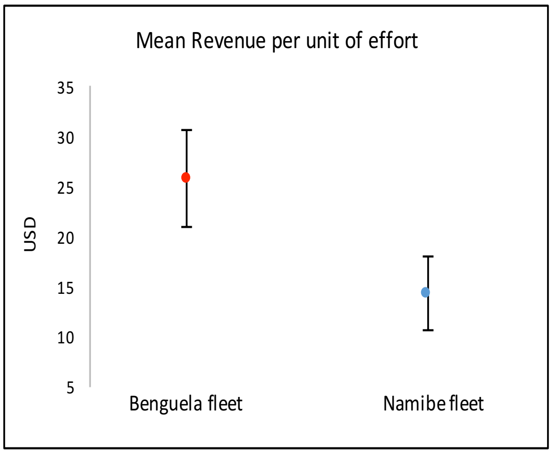


Figure 16. 95% Confidence Intervals (CI) error bars showing variation in the mean values of revenue per unit effort. The error bars on the figure do not overlap, reflecting a p value lower than alpha ($p<0.05$). Meaning that there is statistically significant difference between the mean values of revenue per unit of effort between the fleets in Benguela and Namibe. The revenue is in USD, while effort is expressed as the product of HP and fishing trips.

Statistical differences in cost and revenue per unit effort among vessel groups are also illustrated by CI error bars on the figures below.

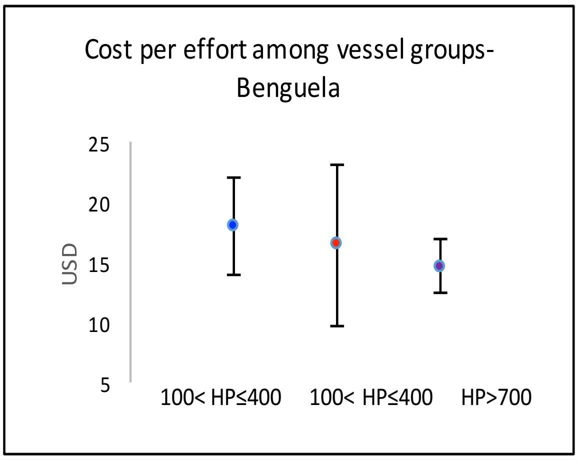


Figure 17a. Comparison of the mean values of cost per unit of effort among the three vessel groups within the Benguela fleet.

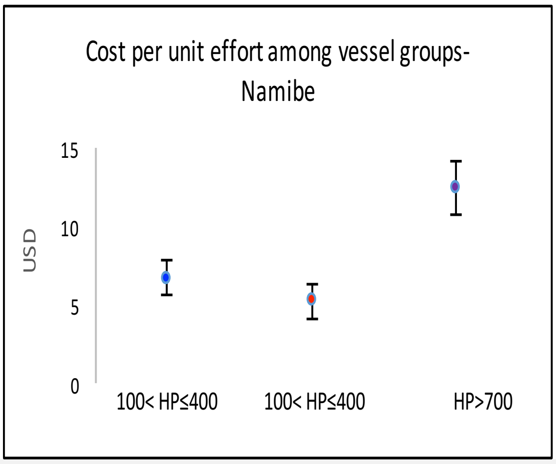


Figure 17b. Comparison of the mean values of cost per unit of effort among the three vessel groups within the Namibe fleet.

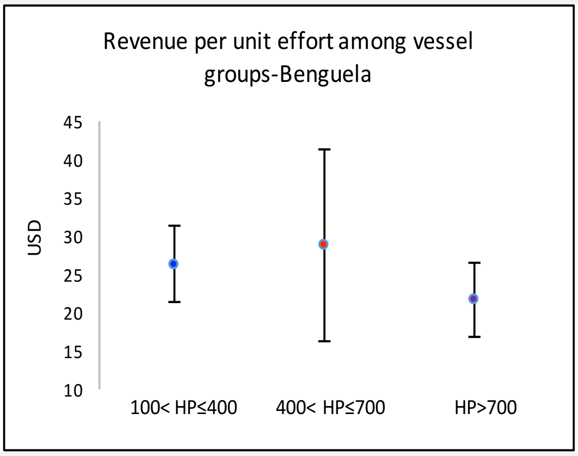


Figure 17c. Comparison of the mean values of revenue per unit of effort among the three vessel groups within the Benguela fleet.

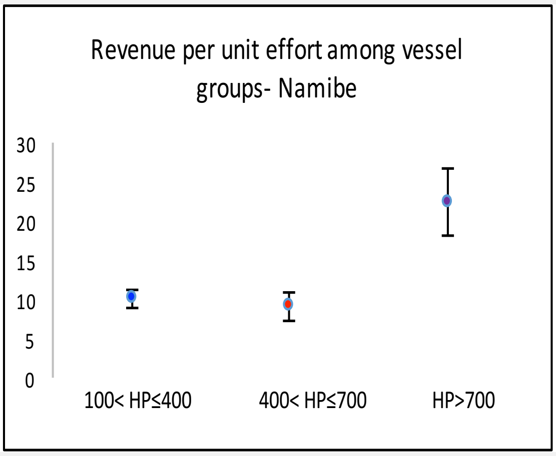


Figure 17d. Comparison of the mean values of revenue per unit of effort among the three vessel groups within the Benguela fleet.

Figure 17. 95% Confidence Intervals error bars showing variations in the mean values of cost and revenue per unit effort among vessel groups within Benguela and Namibe fleet. All CI error bars (figure 17a and 17c) within Benguela fleet overlap, reflecting p values higher than alpha ($p>0.05$), thus no statistically significant differences in the mean values of AC and AR among vessel groups in Benguela. Whereas, not all CI error bars (figures 17c and 17d) in Namibe fleet overlap, reflecting some p values lower than alpha ($p<0.05$), then, there is statistically significant difference in mean values of HP>700 and the other two vessel groups within the Namibe fleet.

5.3 Cost structure of the fishing vessels

Operating cost structure

Figures 18 and 19 present a comparison of the operating cost structure of the vessels between the fishing towns and among vessel groups. For each vessel, the operating costs, divided into labor costs, running costs and vessel costs are presented.

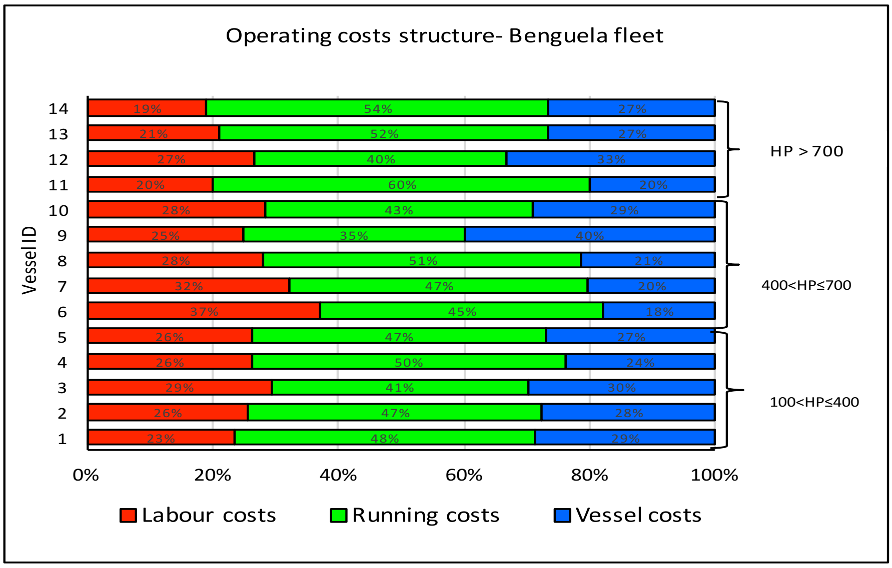


Figure 18. Operating cost structure of the 14 purse-seiners within the Benguela fleet for the fishing year 2014. Each horizontal bar represents the operating cost of an individual fishing vessel Along the x-axis are the proportions of operating cost components, namely labor, running and vessel costs. Along the y-axis (left) are the 14 vessels ID numbers, and the HP group (right) where each vessel belongs. Source: own data and figure.

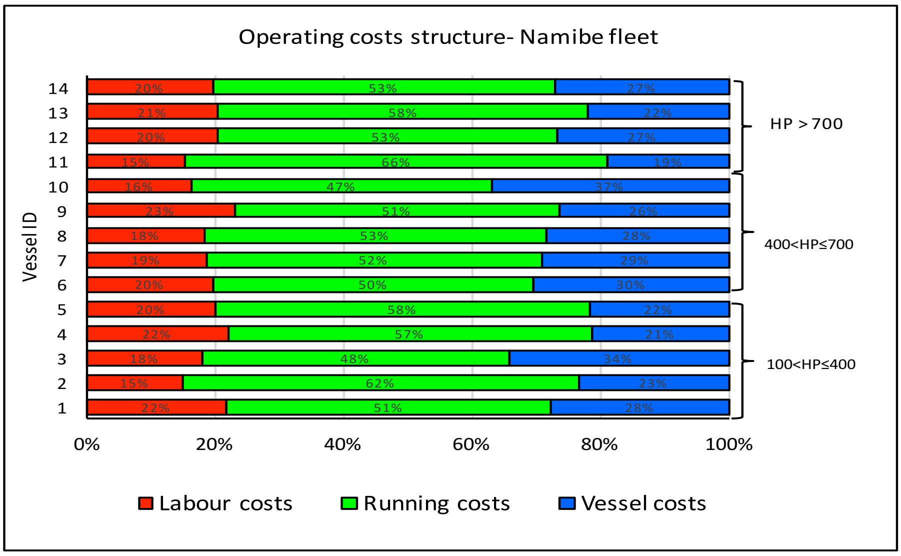


Figure 19. Operating cost structure of the 14 purse-seiners within the Namibe fleet for the fishing year 2014. Each horizontal bar represents the operating cost of an individual fishing vessel Along the x-axis are the proportions of operating cost components, namely labor, running and vessel costs. Along the y-axis (left) are the 14 vessels ID numbers, and the HP group (right) where each vessel belongs. Source: own data and figure.

As illustrated in figure 18 and 19, operating cost structures in both fleets are similar in the sense that, running cost was the most significant component and, labor cost the least component, that applies to all vessel groups. However, there differences in their proportions. In the Benguela fleet, on average, running costs, accounted for 47% of operating costs (ranging from 35 to 60%). Vessel costs, were the second highest component with an average of 27% (ranged from 18 to 40%), followed by labour cost representing an average of 26%. (ranging from 19 to 37%).

Comparatively, in Namibe fleet, running costs accounted for an average of 54% of operating costs, (ranging from 38 to 63%), vessel costs 27%, (with a range of 18 to 40%), and labor costs 19%, (ranging from 16 to 30%). Thus, running costs were 7% higher in Namibe, while, labor cost was equally 7% higher in Benguela. The major component of running costs was fuel, that accounted for an average of 61% in Benguela and 53% in Namibe fleet. Fuel consumption has also been shown to be a major contributor to the overall operating costs of fishing vessels, typically representing around 29% and 28% of total operating costs in Benguela and Namibe fleet, respectively. Within Benguela fleet, the proportions of operating cost components were found to vary among vessel groups, 100<HP≤400; 400 <HP≤700; and HP>700. On average, labor cost, accounted for a proportion of 26%, 30% and 23%, in respective order from least to most powerful engine group; running costs accounted for averages of 46%, 44% and 48%, while the proportion of vessel cost were 27, 26 and 28% for the three vessel groups. Thus, vessel group HP>700 operated at lower labor cost (23%), and higher running and vessel costs (48 and 28%) within the Benguela fleet. Within the Namibe fleet, proportions of operating cost components were found to vary among the three vessel groups, 100<HP≤400T; 400<HP≤700 and HP>700.

On average, labor cost accounted for proportions of 19, 20 and 18%, in respective order (from the least to the most powerful vessel engine), running costs accounted for proportions of 54, 53 and 57%, on average, while vessel cost proportions were 27, 27 and 24% for the three groups. These results indicate that vessel group HP>700 operated with the lowest labor cost (18%), and vessel cost (24%), but with the highest running cost (57%). While 400 <HP≤700 group operated with the highest labor cost and vessel cost (20% and 27%), but with the lowest running cost (53%).

With regard to the definition of the various cost components, the study follows basically the same methodology used by FAO previous three surveys carried out in 1995/1997, 1999/2000.

The mean values of operating cost components (labor, running and vessel cost) presented in figures 18 and 19 are different from an economic point of view. However, from a statistical point of view, this is not the case for all components.

Statistical results derived from T-test, for independent samples (see table 9 to 11 on appendix C) show that there are statistically significant differences between the mean values of labour cost in Benguela and Namibe fleet (*p=0.01*); there are no statistically significant differences in mean values of running costs *(p=0.8),* and there are no statistically significant differences in men values of vessel cost *(p=0.4)*. The hypothesis test is further supported by confidence interval error bars illustrated on the figures below.

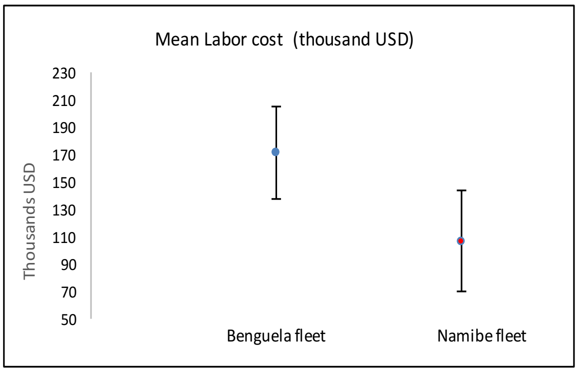


Figure 20a. Comparison of the mean values of labour cost between the fleets in Benguela and Namibe.

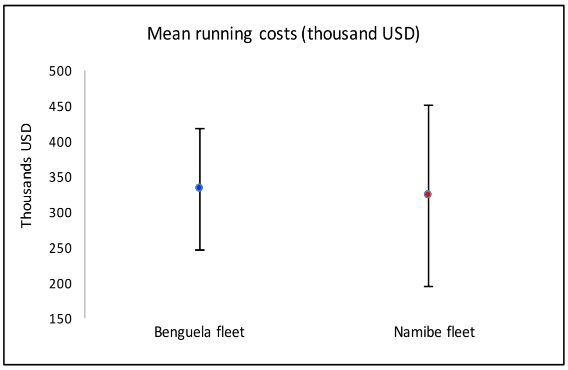


Figure 20b. Comparison of the mean values of running costs between the fleets in Benguela and Namibe.

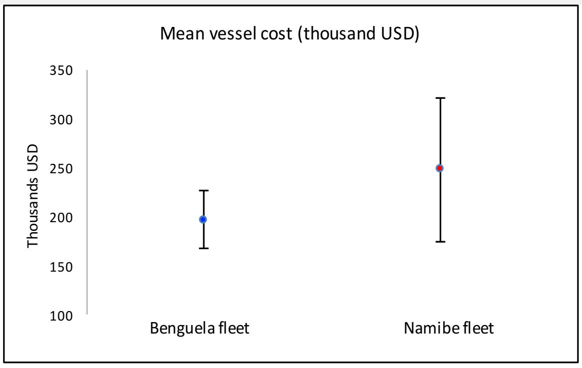


Figure 20c. Comparison of the mean values of vessel cost between the fleets in Benguela and Namibe.

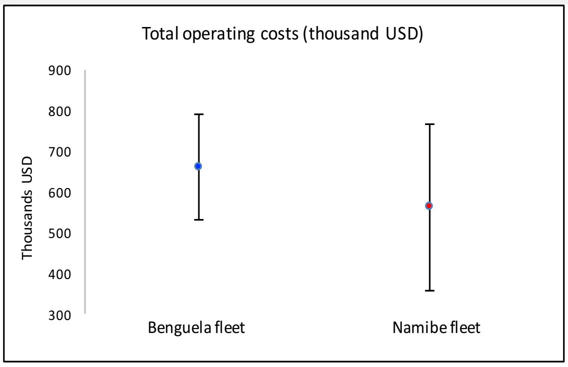
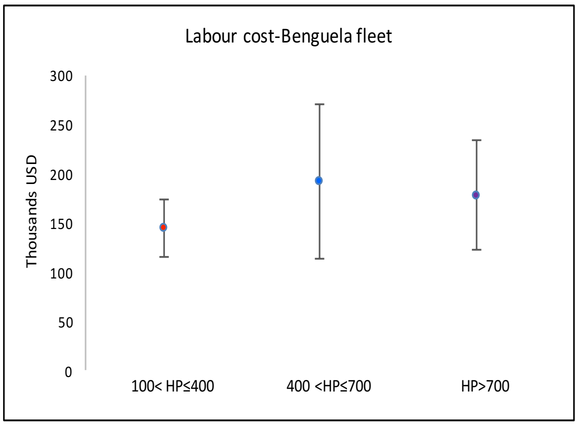


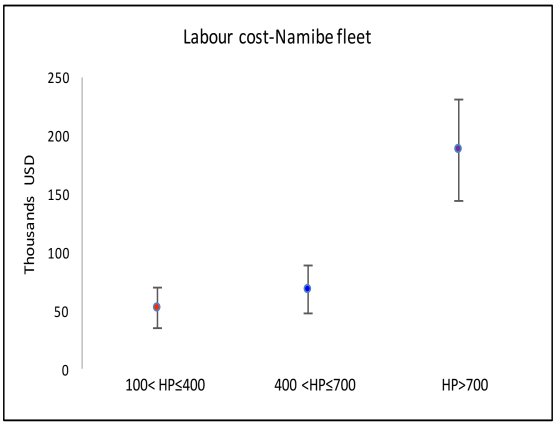
Figure 20d. Comparison of the mean values of total operating costs between the fleets in Benguela and Namibe.

Figure 20. 95% Confidence Intervals (CI) error bars showing variations in the mean values of operating (labor cost, running cost and vessel cost) between Benguela and Namibe fleet. With the exception of labor cost (figure 20a), error bars overlap, reflecting p values higher than alpha ($p>0.05$). Meaning that there is statistically significant difference between the mean values of labor cost (figure 20a), while, there is no statistically significant difference between the mean values of running costs (figure 20b), vessel costs (20c) as well as operating costs in general (20d). The values are in thousand USD per vessel year.

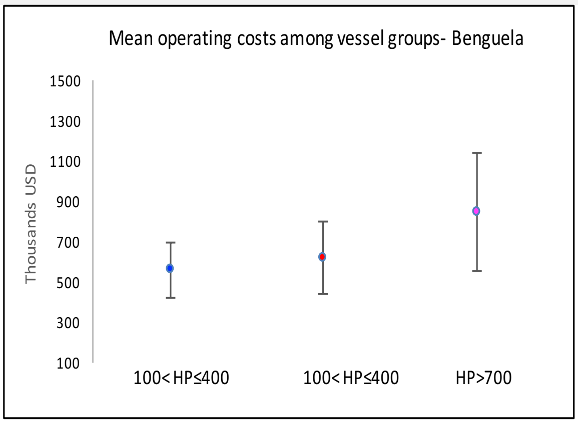
The mean values of operating costs were compared among vessel groups within the two fleets, results are displayed on figures below.



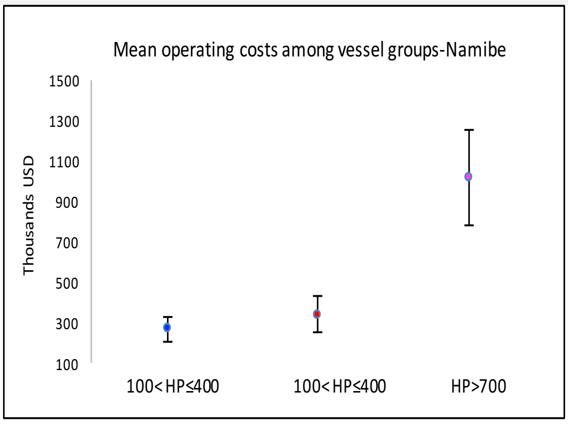
Figures 21a. Comparison of the mean values of labour costs among the three vessel groups within the Benguela fleet. The values are in thousand USD per vessel year.



Figures 21b. Comparison of the mean values of labour costs among the three vessel groups within the Namibe fleet. The values are in thousand USD per vessel year.



Figures 21**c**. Comparison of the mean values of total operating costs among the three vessel groups within the Benguela fleet. The values are in thousand USD per vessel year.



Figures 21d. Comparison of the mean values of total operating costs among the three vessel groups within the Namibe fleet. The values are thousand USD per vessel year.

Figure 21. 95% Confidence Intervals (CI) error bars showing the variation of the mean values of labour costs and total operating cost among vessel groups. All CI error bars within the Benguela fleet (figure 21c) do overlap, reflecting a p value higher than alpha (p>0.05). Then, there is no statistically significant difference in mean values of operating costs among vessel groups in Benguela; On the other hand, not all CI error bars within the Namibe fleet (figure 21d) overlap. Reflecting a p value lower than alpha (p<0.05). Then, there is statistically significant differences in mean values of operating costs among vessel groups HP>700, and those in the two other groups (100<HP≤400 and 400 <HP≤700), within the Namibe.

Total cost structure

Total fishing costs in this study is referred to the sum of operating costs and capital costs. Capital costs is the calculated depreciation and calculated interest on capital value. Usually capital cost accounts for a lower proportion of total cost than operating cost does. This is illustrated on figures 22 and 23 below.

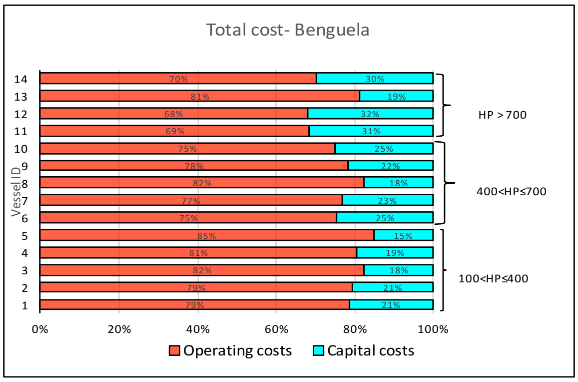


Figure 1. Total cost structure of the 14 purse-seiners within the Benguela fleet in 2014.

Each horizontal bar represents the total cost of an individual fishing vessel. Along the x-axis are the proportions of total cost components, namely operating, and capital costs. Along the y-axis (left) are the 14 vessels ID numbers and the HP group (right where each vessel belongs. Each bar represents a fishing vessel.

Source: collected data and authors figure.

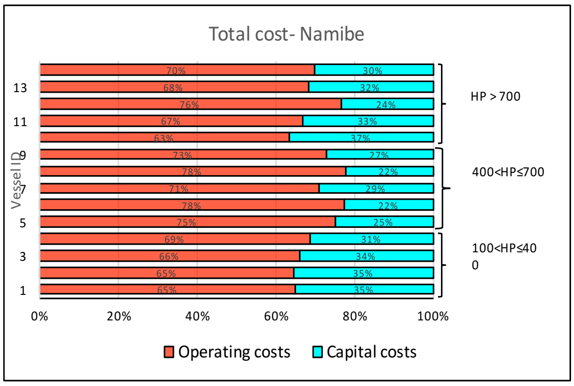


Figure 2. Total cost structure of the 14 purse-seiners within the Namibe fleet in 2014.

Each horizontal bar represents the total cost of an individual fishing vessel. Along the x-axis are the proportions of total cost components, namely operating, and capital costs. Along the y-axis (left) are the 14 vessels ID numbers and the HP group (right where each vessel belongs. Each bar represents a fishing vessel.

Source: collected data and authors figure.

On average, operating costs accounted for 77% while, capital cost accounted for an average, of 23% of total fishing cost within the Benguela fleet. In contrast, within the Namibe fleet, the same components accounted for averages of 70 and 30% respectively. Among vessel groups, it is interesting to note that the highest share of capital cost, 28%, in Benguela was among HP>700), followed by 400 <HP≤700 (23%), and 100 <HP≤400 (19%) vessel groups. In Namibe, in contrary, the highest share of capital costs, 34% was that of smaller engine vessels 100 <HP≤400, followed by larger engine vessels HP>700 (31%) and finally 100 <HP≤400 group (25%).

5.4 Fuel and eco-efficiency

Fuel efficiency, in this study is considered as the amount of diesel fuel required to land one tone of wet weight fish; while eco-efficiency (carbon footprint) is presented as the amount (kg) of CO2-e as a result of burning diesel fuel on-board fishing vessels, in 2014. Results of fuel efficiency in liters of fuel used to land 1 ton of fish are illustrated on the figure 25 below.

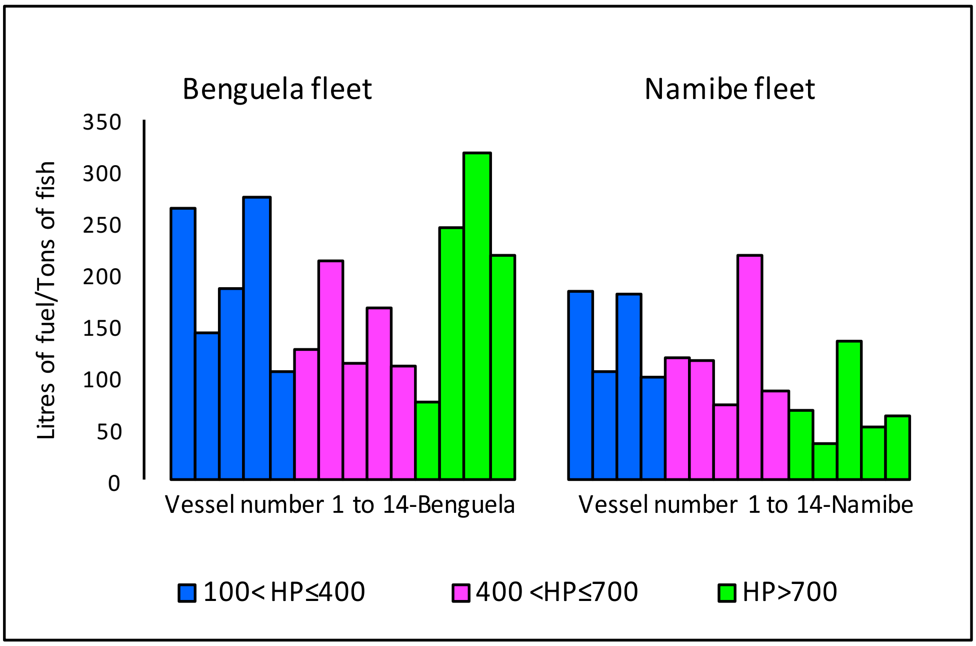


Figure 3. Variation in fuel efficiency-in liters of fuel used to land 1 ton of fish, among vessel groups in Benguela and Namibe fleet. There are remarkable variations in fuel efficiency between the fleets and among vessel groups. Each bar represents a fishing vessel.

Source: Own data and figure generated by author.

On average, fuel efficiency in Benguela fleet was 184 L/ton (range 77 to 318 L/ton), in contrast to 110 L/ton (range 37 to 217 L/ton) in Namibe fleet. (This indicates that Namibe fleet was more fuel efficient in terms of catch than that of Benguela.

Fuel efficiency also varied among vessel groups in both fleets. On a respective order from vessel group 100 <HP≤400; 400 <HP≤700 to HP>700, the average fuel efficiency in Benguela fleet was 195, 146 and 215 L/ton, whereas in Namibe it was 142, 123 and 71 L/ton, respectively. Thus, vessel group HP>700 in Namibe was the most fuel efficient (71 L/ton), and the same group, HP>700 in Benguela was the least efficient (215 L/Ton).

Statistical test results

Statistical test results derived from a T-test, for independent samples (see table 8 in appendix C), show that there are statistically significant differences in mean values of fuel efficiency between the fleets in Benguela and Namibe (*p=0.005)*. Confidence interval error bars illustrated in figures 26 below further tested the hypothesis test.

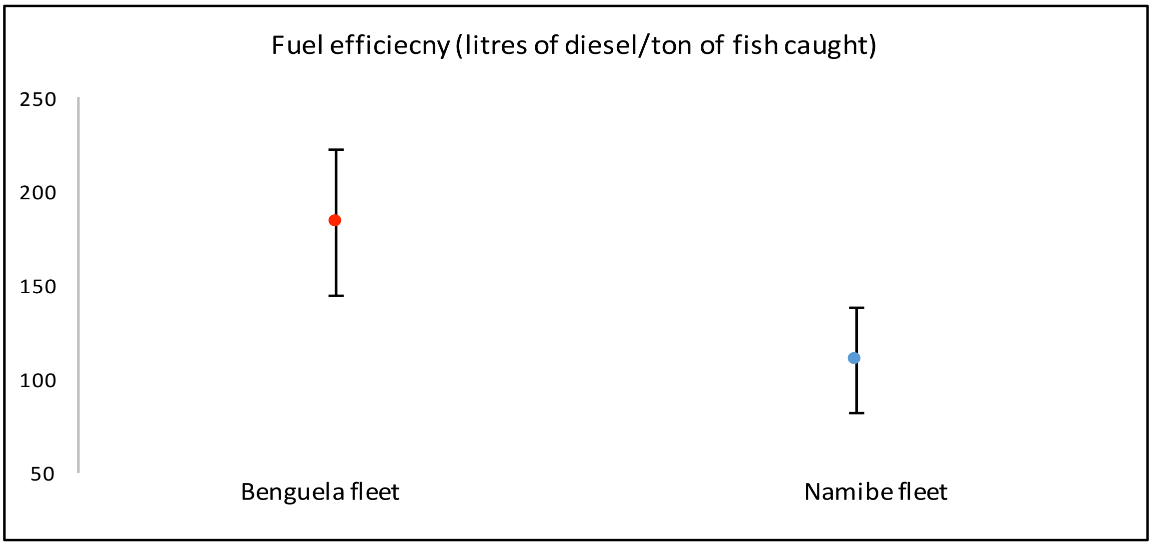


Figure 4. Confidence Intervals (CI) error bars showing difference in the mean fuel efficiency (liters of fuel per tons of fish landed). The error bars on the figures do not overlap, reflecting a p value lower than alpha *(0.05)*. Meaning that there is statistically significant difference between the means.

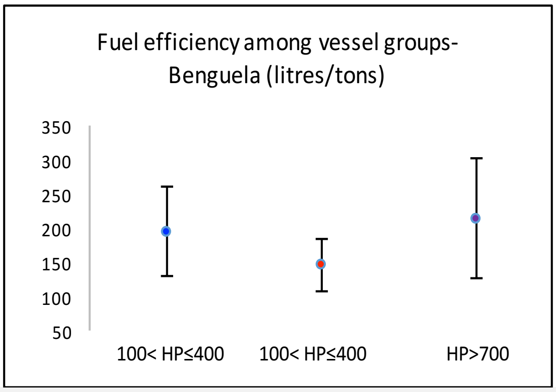


Fig. 26a

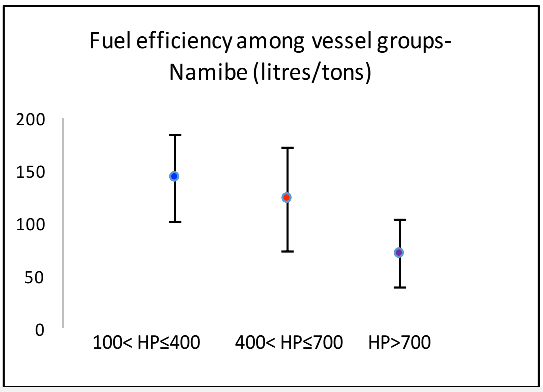


Fig. 26b

Figure 5. 95% Confidence Intervals error bars showing the variation of the mean fuel consumption (L) per ton of fish landed (tons) among vessel groups in Benguela (n=14) and Namibe (n=14). All CI error bars within Benguela fleet overlap, reflecting p values higher than alpha ($p>0.05$). While, not all CI error bars in Namibe fleet overlap, reflecting some p value lower than alpha ($p<0.05$). Then the means are not statistically significant different in Benguela fleet, while, the mean values of vessel group 100 <HP≤400 is statistically significant different from HP>700 in Namibe fleet.

Eco-efficiency

Burning a liter of diesel fuel on-board fishing vessels results in the emission of approximately 2.8 kg CO2-e per liter consumed (GHG-to-fuel ratio) (Seafish, 2009). Relating this to fuel efficiency, figure 25, or liters of fuel consumed per ton of wet landings, results on eco-efficiency in terms of carbon footprint per ton of fish landed is presented below.

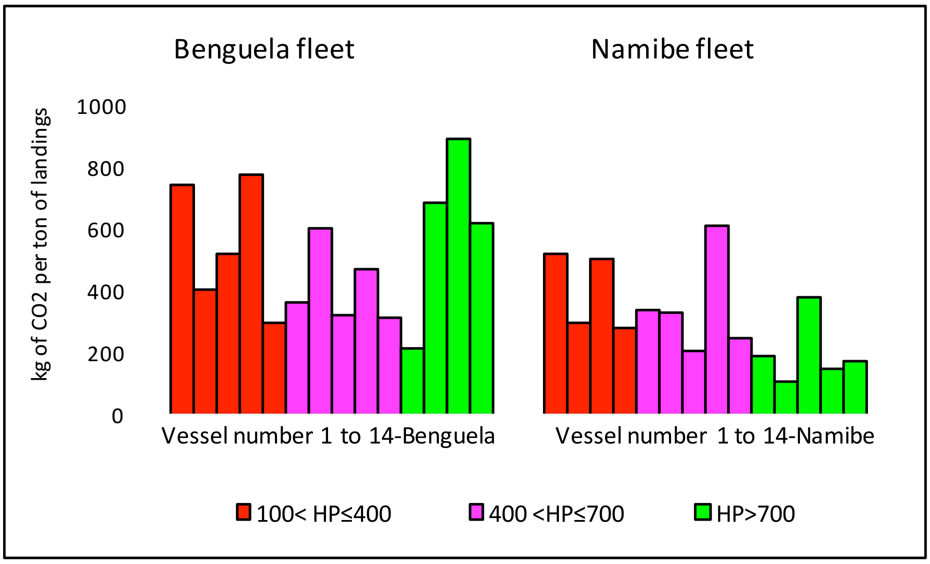


Figure 6. Eco-efficiency-in terms of kg of carbon emitted per ton of fish landings in both fishing towns fleet (Benguela and Namibe) and, among vessel. There are remarkable variations in carbon footprint between fleets and among vessel groups. Each bar represents a fishing vessel, and each color represents a vessel group.

Source: own data and figure generated by author.

In principle, results on figure 27 (eco-efficiency) follow the same trend as that of figure 24 (fuel efficiency). If burning a liter of fuel results in approximately 2.8 kg CO2-emission, then, the carbon footprint per ton of fish landed is the product of fuel efficiency (L/tons) and CO2 emission rate (2.8kg). In other words, the fuel use intensity (FUI), or liters of fuel consumed per ton of wet weight landings (L/t) is the) is a relatively reliable indicator of the carbon footprint of landed, unprocessed fish. When applied to this fleet, these results in an average direct fuel-related GHG value of 514 kg CO2-e per ton of fish landed by Benguela fleet in contrast to 307 kg CO2-e per ton of fish landed by Namibe fleet. This indicates that Namibe fleet was more eco-efficient in terms of CO_2-e released per unit of catch landed than that of Benguela. In other words, an average purse seiner in Benguela released 207 kg CO2 more into the atmosphere than an average purse seiner in Namibe for every ton of fish landed.

Of course, this varied by fishing towns and vessel groups in accordance with variation in fuel use intensity e.g., the average fuel-related GHG emissions per ton of fish landed, among 100 <HP≤400; 400 <HP≤700 and HP>700 groups were, 547 kg, 410 kg, and 602 kg CO_2-e respectively within the Benguela fleet and, 399 kg, 343 kg and 198 kg CO_2-e in Namibe with the same respective order. Therefore, vessel group 400 <HP≤700 was the most eco-efficient (410kg CO_2/ton fish) while HP>700 group was the least efficient (602kg) in Benguela fleet. Within Namibe fleet, HP>700 group was the most eco-efficient (198kg), while 100 <HP≤400 the least eco-efficient (399kg).

Statistical test results derived from a T-test, for independent samples (see table 8 in appendix C), show the same output as fuel efficiency. That is, there are statistically significant differences between the mean values of eco-efficiency in Benguela and Namibe fleet ($p=0.005$).

5.5 Effects of harvest tax and fuel subsidies on profitability

This section simply provides an overview on how government policies on harvest quota tax and fuel support cost (subsidies) may have affected the industry net revenue, of the fleets in Benguela and Namibe fishing towns. The harvest quota tax is usually paid by the industry to the state, in proportion to the allocated quota quantity, in USD per ton (see section 2.3). Fuel cost support (until 2015) was by means of subsidizing the price of diesel fuel in fishing vessels by a few cents per liter (around USD 0.02 per liter of diesel).

Within the Benguela fleet, harvest quota tax varied from 15 thousand to 88 thousand USD, corresponding to a quota quantity of 1000 and 4000 tons, respectively. Therefore, an average harvest tax of 35.6 thousand USD (SD=19.9 thousand) was paid per vessel in the fishing year 2014. Recalling from section 5.1, the mean EBT (profit before opportunity cost on owner's capital) was 185.9 thousand USD (SD=246.7 thousand). Therefore, the harvest tax corresponds to an average of 19% of the EBT. Meaning that on average operators had to pay an equivalent to 19% of their profit to the state as harvest tax, as illustrated in figure 29.

In contrast to Namibe fleet, harvest quota tax varied from 12 thousand to 528 thousand USD, corresponding to a quota quantity of 800 to 24000 tons respectively. Then, on average, a vessel paid a harvest tax of 98.5 thousand (SD=141.8 thousand); In relation to the mean EBT generated by this fleet, 283.4 thousand USD (SD=397.6 thousand), harvest quota tax corresponds to an average of 35% of EBT of the fleet, as illustrated in figure 30 below.

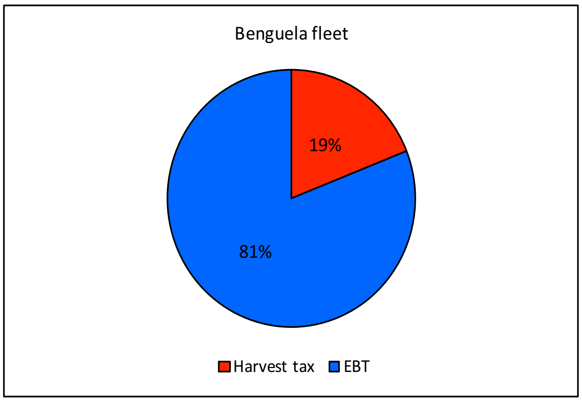


Figure 7. Proportion of mean harvest quota tax to mean EBT (earning before opportunity cost on owner's capital) in the Benguela fleet.

Source: own data and figure.

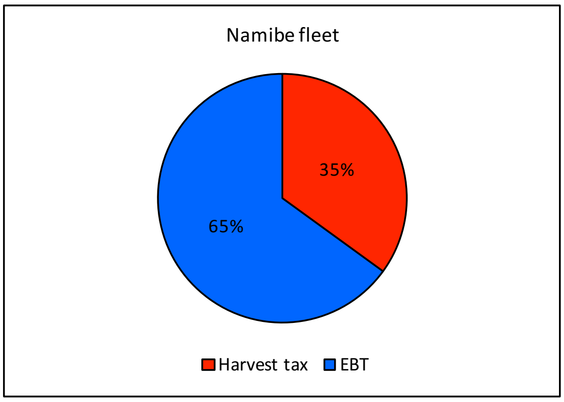


Figure 29. Proportion of mean harvest quota tax to mean EBT (earning before opportunity cost on owner's capital) in the Namibe fleet.

Source: own data and figure.

The annual government support on fuel subsidy ranged from 2.4 thousand to 14.4 thousand per vessel in the Benguela fleet. Then, on average 5.5 thousand USD, equivalent to 2.67% of fuel cost were subsidized per vessel in Benguela. In relation to the mean profit (EBT) per vessel, 185.9 thousand USD, fuel subsidy accounted for 3%, (figure 31).

In contrast, within the Namibe fleet fuel subsidy ranged from 1.6 thousand to 7.2 thousand USD. Thus, an average of 3.9 thousand USD per vessel, equivalent to 2.67% of fuel cost were subsidized per vessel in Namibe. In relation to the mean, profit (EBT (per vessel, 283, 4 thousand USD, fuel subsidy accounted for 1.4% as illustrated in figure 32. In relation to total operating costs, it covered on average 0.8% (range=0.4 to 1.1%) of the vessels operating costs in Benguela and 0.7% (range=0.5 to 1.4%) in Namibe.

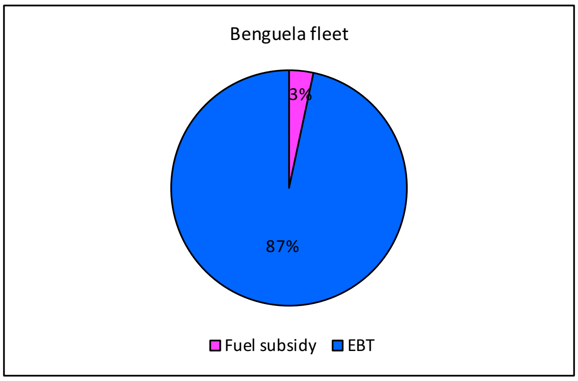


Figure 8. Proportion of mean fuel subsidy to mean EBT (earnings before opportunity cost on owner's capital) in the Benguela fleet.

Source: own data and figure.

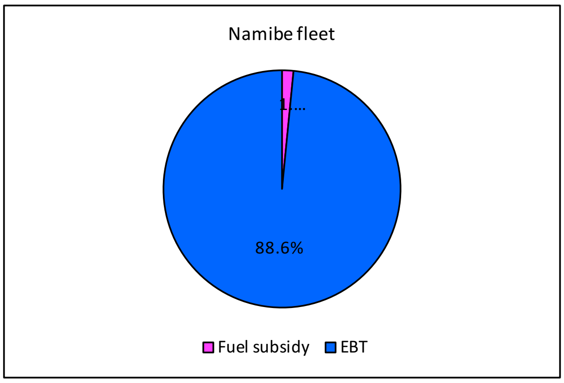


Figure 9. Proportion of mean fuel subsidy to mean EBT (earnings before opportunity on owner's capital) in the Namibe fleet.

Source: own data and figure.

CHAPTER SIX: DISCUSSION

6.1 Economic performance indicators

This section discusses the output indicators presented in section 5.1, namely EBITDA (earnings before interest tax and depreciation), EBT (profit before opportunity cost on owner's capital), OM (operating margins) and ROC (return on capital). The input indicators, i.e. operating costs are discussed in section 6.2 and 6.3.

On average, all vessels in both fleets had positive output indicators. The gross annual vessel revenue was slightly different between the two fishing towns fleet. In Benguela, the mean was 1066.09 thousand (*SD*=453.9 thousand), while in the Namibe fleet the mean gross revenue was that of 1143.7 thousand USD (*SD*=944.4 thousand) USD per vessel year. Differences in gross revenue are due to differences in landing volumes and the market price per kilo of fish, recalling equation 2 in chapter 3: $TR(E)=H*p$, where TR(E) is the gross revenue as a function of effort, H is the harvest and p the price per unit of catch. Table 9 and 10 show differences in the mean wet weight landings between the fleets and HP groups. The Benguela fleet landed an average of 1524 tons per vessel (SD=648 tons), in contrast to 2718 tons per vessel (SD=2714 tons) landed by the Namibe fleet. However, vessel operators in Benguela sold their catch at a relatively higher price per kilo than those in Namibe. Differences in price per kilo of fish may be explained by the supply demand relationships, and differences between the socioeconomic structures of the fishing towns. On his work, Flaaten (2016), stated that vessel earnings arise from the sale of fish brought to port, the price for which may be fixed under contract or vary subject to the laws of supply and demand. Earnings are greatly dependent on both quantity and individual value of the fish unloaded, differing widely from fishery to fishery. Moreover, that the price of fish from a particular stock is hardly affected by quantity fished if the fish is sold in a competitive market with many sellers and buyers and in competition with similar types of fish from other stocks. From table 2, we notice that Benguela is more densely populated, and has a wider economic structure than Namibe. Then, the demand and price of fish tend to be higher in Benguela.

Landing values (GR) as indicated in table 22 under results, show an increasing trend with increasing engine size in both fleets, in other words, $100 < HP \leq 400$ had lower landing values than $HP > 700$ group. This can be explained by the fact that smaller engine vessels have lower fishing power and less holding capacity than larger engine vessels.

It is important to highlight that most capital costs in this study are imputed which can depress the apparent operating and pre-tax profit in certain cases. Therefore, an important indicator to consider in this analysis is the EBITDA*,* referred to as a good short-term indicator in fisheries (Flaaten, 2016). Positive EBITDA means that the vessel owners are able to pay for all their operating costs and meeting at least part of their obligations to creditors (Duy et al, 2015). Further, Duy et al, (2015), argued that, EBITDA mainly reflects the cash a fishing firm has earned from its fishing operations, and that positive EBITDA indicates that the gross revenue exceeds the vessel owner's operational and labour costs and that there may exist IMR in the short term for the owners.

A reasonable hypothesis here is that most vessel owners in both fishing fleets had positive EBITDA, with annual means of 328.7 thousand (SD=278 thousand) and 500 thousand USD (SD=480 thousand) in Benguela and Namibe fleet respectively. In contrary to gross revenue, EBITDA was notably higher within the Namibe fleet, this was mainly due to lower operating costs, particularly labour and fuel cost as compared to Benguela fleet, taking into account the fact that EBITDA is obtained by subtracting operating costs from gross revenue. Variations in EBITDA found among vessel groups table 22, reflects the influence of technical and operational characteristics on vessel earning, in other words, input-output relationship (CEMARE, 2003), such that larger engine vessels, with higher capital inputs and higher fishing effort, incur higher operating costs than smaller vessels, however, vessels with higher capital input tend to have higher fishing efficiency (Lim *et al*, 2012). Table 21 indicates that not all vessels within Benguela fleet were not able to cover their operating costs (EBITDA value is -13.8 thousand USD). Surprisingly it is the youngest vessel in the fleet (acquired in 2013). This economic inefficiency may be explained by the vessels smaller landing quantity for the fishing year that was reportedly below average (1130 tons). In fact, it is a vessel within the HP>700 engine group whose operating and capital costs were very high.

Upon deducting imputed capital from EBITDA, the resultant mean positive profit (EBT, profit before the opportunity cost of owner’s capital) in both fleets implies that, on average both fleets were economically efficient and profitable. However, 28% of the vessels in Benguela, and 21% in Namibe fleet had negative profit, in other words operated at a loss. Operators argued that these losses are attributed to a variety of factors, of which the low market price of sardinellas (the major species in terms of volume), and increasing operating costs, particularly fuel and vessel maintenance are the main factors. If this loss persists in the following fishing years, such vessels may eventually be forced out of the fishery (Flaaten, 2016).

The OCFM (ratio of EBITDA to gross revenue), and the OM (ratio of EBT to gross revenue), are two important indicators in this study. The former expresses what is left as compensation to capital in relation to gross revenue and, the latter expresses the percentage of earnings left after all costs. The average OCFM was 34 and 39% for Benguela and Namibe while the average OM was 14 and 13%, respectively. This implies, all vessels in both fleets managed their operating costs and capital costs quiet well. In effect, operating margin measures how much out of every dollar of sales a company actually keeps in earnings. A 14% OM, then, means that vessels in Benguela had an average net income of USD 0.14 for each dollar, while those in Namibe fleet had a net income of USD 0.13 for each dollar of total revenue earned. The mean rates of return on invested capital of 10% and 8% for vessels in Benguela and Namibe, respectively, show that invested capital was more effectively used by vessels in Benguela than in Namibe fleet. Partly because of higher invested capital value in Namibe than Benguela and because of differences in cost structure between the vessels as discussed in section 6.3. On an economic performance study, FAO (2001) stated that a profit margin and ROC above 10% is considered ok. Based on this, we can conclude on average vessels in both fleets covered their opportunity cost of capital. However, ROC on the Namibe fleet was relatively of poor performance (8%).

Overall, vessels with engine 400 <HP≤700 had better economic performance indicators than the other groups in Benguela, while in Namibe those within HP>700 had the best performance. In case of low performance in large engine vessels, one may partly consider overinvestment on the particular vessel (Coglan and Pascoe, 1997). That may be the case of vessel no 13 within the Benguela fleet (see table 1B in appendix). Higher performance of large engine vessels (HP>700), on the other hand, can be explained by the fact that they often generate higher revenue than smaller ones due to high fishing power and efficiency (Lim et al, 2012). On their research, Long et al, (2008), stated that in most fisheries larger engine vessels are able to search for large schools of fish and catch with less effort than smaller ones. For instance, larger vessels (HP>700) in Namibe operate with bigger purse seine nets, up to 400 meters long and 45 m deep, and are well equipped with fish finding equipment, so, may fish at lower cost per unit effort. In contrary, smaller vessels (100 <HP≤400) are restricted to go further offshore (article 12, Fisheries Law), and cannot stay longer at sea. Furthermore, this may also be potentially explained by differences in vessel management, e.g., some skippers may have been more experiment than others may, as well as differences in crew skills (although data on this was not available).

As presented on the previous chapter, some vessels earned negative economic profits after subtracting capital costs, but the average vessel's economic profit is positive. Differences in profitability (EBT) among vessels can be explained by fisheries economic theory under the concept of intra-marginal rent, which exists due to the different cost structure of heterogeneous vessels (Flaaten, 2016). Vessels making economic losses after capital costs, may, however, operate in the short term if their marginal revenue of effort is more than the minimum average variable cost of effort but, in the long term, they will be forced to exit the fishery. This is further discussed on section 6.2.

It should be noted that there are other costs e.g. administrative costs that were not included in this analysis. Meaning that for some vessels, the final economic performance output (EBT) should be lower than the calculated. And that there is an assumption that all catch is sold within a given period. However, in reality the market for low graded fish (e.g. sardinella) is not stable. Often, operators have additional costs for preserving unsold fish in freezers.

6.2 Cost efficiency

This section discusses results from section 5.2. The cost efficiency of the vessels in relation to cost of harvest and potential revenue.

Overall, cost efficiency, expressed as a ratio of cost per unit and effort, and revenue per unit effort was higher in Benguela (USD 0.64) than Namibe fleet (USD 0.59). In this context, the lower the efficiency ratio, the better the performance. That means, 0.64 and 0.59 USD were spent for every dollar earned in revenue. Higher operating costs in Benguela, fleet was mainly driven by the higher fuel consumption per unit of catch and, higher labor costs, in addition to lower landing volumes of horse mackerel. Such higher costs have been offset to some extent by increasing fish prices, however some vessel owners still have to consider tying up for part of the year. Better cost efficiency in Namibe fleet, may have been as a result of lower labor costs and easier access to fishing grounds. Another possible explanation is the difference in catch per trip indicated on table 9. The mean catch per trip by vessels in Benguela was 20 tons (SD=15), in contrast to 27 tons (SD=29) in Namibe fleet.

The greatest apparent cost efficient vessel group in terms of cost revenue ratio is that of 400 <HP≤700, that operated at a cost of 0.57 USD to generate a dollar of revenue, in Benguela. The same trend was observed within Namibe fleet, such that vessel group 400 <HP≤700 operated with the best cost efficiency of 0.57 USD, while those in the group 100

<HP≤400 were the least cost efficient. The absolute differences in mean cost and revenue per unit effort is attributed to a variety of factors. Smaller purse seiners (usually 100 <HP≤400) fish closer to the shore (beyond 2nm), while bigger seiners fish beyond 4nm. That reflects different distances from the harbours to the fishing grounds, hence, differences in time spent sailing and fishing. It is noted in table 10 that larger vessels performed less fishing trips than smaller ones. On his work, Flaaten (2016) stated that if a skipper decides on increasing the sailing speed that will mean less sailing time and more fishing time. However, fuel consumption increases with increasing speed and that implies increasing marginal costs in response to increasing effort.

In fact, large engine vessels (HP>700) had higher operating costs due to higher absolute amounts inputs than smaller ones. Fishing trips were actually longer, nets are larger nets, thus higher fuel consumption. Additionally, larger vessels incur high depreciation and interest payment on loans due to higher investments. Fuel costs are usually based on the engine size of the vessels. It implies that bigger vessels are technically expected to have higher fuel costs (Lim et al, 2012). Furthermore, majority of lager vessels have modern equipment that enable them to fish with high efficiency.

In general, for a particular fishery, vessel type and base of operation, a particular size range of craft will offer maximum returns, Boncoeur *et al* (2000). However, as size increases above the optimum, both capital and operating costs tend to increase ever more rapidly than catches (earnings), so that too large a vessel will lose money (Flaaten, 2016). Variations in cost efficiency among vessels is additionally explained by variations in technical and operational characteristics illustrated on table 9 and 10 in chapter 4. On their study, Thanh et al, (2008), pointed out that homogenous vessels on the other hand, are from a cost point of view, equally equipped and crewed and the marginal and the average cost of effort are the same for all vessels. This relates to a few vessels within the groups 400 <HP≤700 in Namibe fleet, that are of the same size and equally equipped. However, average revenue; hence cost efficiency varied within these homogeneous vessels due to differences in operational aspects.

The most cost- efficient vessels such as those in the groups 400 <HP≤700 and HP>700 in Benguela and Namibe respectively, might have made above-normal profit, called intra-marginal rent. This according to Flaaten, (2016), may have some implications for management. For instance, if the fishery manager wants to reduce effort to E_{MEY}, some vessels may lose their part of the intra-marginal rent. This may result in objections to change of management objective. However, as demonstrated in section 3.2. The total rent is highest for the E_{MEY}

effort level, and some of this could be used to compensate those vessels that may be in danger of losing their previous intra-marginal rent.

6.3 Cost structure

This section mainly discusses differences in operating cost structure (labour, running and vessel costs), and to a smaller extend, capital cost structure presented on section 5.3.

In general, operating costs vary widely depending on fishing method and gears used, the distance to the fishing grounds, the general cost structure of a particular country or region and many other factors (FAO, 2005). The mean labor costs differ statistically between the two fleets, with 26% (SD=5%) of total operating cost in Benguela and 19% (SD=2%) in Namibe *($p=0.01$).* This difference is partly because Benguela is, from a socioeconomic point of view a larger city than Namibe (see table 2 in chapter 2). The city of Benguela is among the countries most developed province, it harbors the second largest commercial port that employs about 3000 people; it has potential agricultural resources in contrast to Namibe that is a smaller town with fewer job opportunities. All these factors, in fact contribute to higher opportunity cost of labor in Benguela than in Namibe. For instance, according to Flaaten (2016), fishers living in a small coastal community far away from larger towns and cities usually have few alternative employment possibilities; thus, the opportunity cost of labour will be lower in such a community than in larger labour markets. On the other hand, other inputs required for fishing may be costlier in small fishing communities than in towns, due to transportation cost and less competition between distributors Thus, differences in efficiency of effort, market prices of inputs and opportunity cost of labour may all contribute to the existence of heterogeneous effort in the fish harvesting industry.

Within the Benguela fleet, vessel group 400 <HP≤700 operated with highest labor cost while 100 <HP≤400 group operated with lowest cost. Thus, as indicated on table 9 this is directly related to the crew number, in other words, vessel group with the higher number of crew had the highest labour cost in Benguela fleet. This can be supported by the fact that larger vessels are more capital rather than labour intensive. The trend was different within Namibe fleet where labour cost increased with engine size group such that larger vessels (HP>700) operated with a labour cost almost three times higher than those of smaller ones (100 <HP≤400). The major component of labor cost in larger vessels was fixed salaries to operators (captain and well-qualified technical staff) rather than crew wage. These are large purse seiners

mainly operated by foreign investors in joint venture with national fish harvesting firms. Concerning crew wage in most firms, (particularly smaller vessels) there is a common practice to manage a vessel as a form of joint enterprise between owner and crew, in such a manner that both share in the success, or lack thereof, of each trip. Under such an arrangement expenses are allocated to the owner, while earnings are allocated between owner and crew in a prearranged proportion, usually one to two US$ per fishermen per ton of landings, in most cases. On his research, Hao (2012), stated that whatever detailed accounting arrangement used between the owner and crew, the share is balanced so that the owner receives a reasonable return on his investment capital, while crew are reward for their work, so that both parties are encouraged to run the operations efficiently and maximize returns.

Concerning running costs, the means of the two fleets, namely Benguela and Namibe were not statistically significant different *(p=0.8),* although they varied in terms of percentage of operating cost: 47% (SD=6%) and 54% (SD=5%) in Benguela and Namibe fleets respectively. Such differences are mainly due to fuel costs that accounted for 61 and 53% respectively. Characteristically smaller vessels tend to fish near the shore with smaller gears compared with large vessels that fish further from the shore and use larger gears (Lim, 2012). Hence, it would be expected that boats operating far from the shore (e.g. HP>700) would have higher running costs than those operating near the shore (e.g.100 <HP≤400). There was an apparent increase in mean total running cost from small (100 <HP≤400) to large engine vessels (HP>700) both in Benguela and Namibe fleet, in fact, all running costs components including fuel and lubricant, food and ice follow the same trend.

Vessel cost as the second major component of operating cost (accounting for 27%), as illustrated in figure 20, the means of the two fleets are not statistically significant different *(p=0.4).* The mean values for Benguela and Namibe fleets were 146 thousand US$ (SD=90) and, 166 thousand (SD=43 thousand) respectively. Vessel cost mainly comprised of annual maintenance (approximately 70%) and to a smaller extend minor repairs and insurance costs). Higher vessel costs, particularly maintenance in Namibe fleet is primarily because of larger vessels in Namibe (table 10); further, Long (2008), stated that vessels with higher fishing intensity or effort during a fishing year are expected to have more break downs and worn out equipment, requiring higher costs of repairs and maintenance.

The greatest apparent mean vessel costs were experience by vessel group HP>700 in both fleets. In fact, larger engine vessels would be expected to have higher maintenance, repair and insurance costs than smaller ones.

The mean capital costs differ between the two fleets, with 23% of total cost in

Benguela and 30% in Namibe. This difference is partly due to the fact that Namibe fleet is relatively larger, with a total GRT of 3,386 tons and total engine capacity of 16,432 HP, in contrast to 3,406 tons and a total engine capacity of 14,001 HP in Benguela. Vessels in Namibe have therefore a higher mean book value and annual depreciation. The share of capital costs in total fishing costs seem to be directly associated with the investment capital. Table 11, shows that there was higher investment capital in the Namibe than Benguela fleet, particularly in large engine group.

6.4 Fuel use and eco-efficiency

Fuel used in fishing vessels operations is the main energy use in fisheries (FAO, 2012). However, the price of fuel is still a major issue for the industry.

Several factors are known to influence the fuel intensity of commercial fisheries. These include the abundance and characteristics of the target species, vessel and engine size, fleet size and the degree of its overcapitalization, trip length and distance travelled to fishing grounds, and the gear used SEAFISH (2009). Based on some of this factors, there was a significant difference in fuel efficiency between the fleets in Benguela and Namibe ($p=0.005$). The mean fuel consumption per ton of landings in Benguela fleet was that of 184 L/ton (SD=74.28), in contrast to 110 L/ton (SD=53.7) in Namibe fleet. Recalling from chapter 3, stock density of schooling species is relatively higher off the Namibe than Benguela coast; tables 1B and 1C in appendix indicate that Namibe fleet had a higher CPUE, and that trips were relatively shorter (table 9). That may have contributed to better fuel efficiency in Namibe fleet. FAO (2012), reported that, vessels using seines to target near shore stocks of schooling small pelagic species may use well under 100 litres of diesel per metric ton landed, while trawlers and longliners targeting high value species have been documented to burn over 2000 litres per metric ton. Moreover, it was reported by FAO (2004), that purse seiners targeting herring in the NE Atlantic have a fuel efficiency of 100 liters per ton of fish landed. Thus, results indicate that Namibe fleet had a fuel efficiency close to that of NE Atlantic herring fleet. Several broad analyses of fuel consumption in fisheries have been undertaken in recent decades for instance (Tyedmers, 2004; Driscoll and Tyedmers, 2008). Results of these studies suggest that fuel use intensity varies greatly between fisheries targeting different species, employing different gears, and fishing in different regions. Generally, fisheries targeting small pelagic species and employing purse seine gear perform relatively well when compared to higher trophic level species caught with trawl or longline.

Variations in fuel efficiency among vessel groups as illustrated in figure 24 can also be explained by variations in technical and operational characteristics such as steaming speed to and from fishing grounds, time spent searching for fish; the quality and availability of fish-finding equipment e.g. sonars and echosounders. Vessel engine group 400 $<$HP$\leq$700 appear to be the most fuel efficient in Benguela (mean=146 L/ton) while those in the group HP$>$700 were the most efficient in Namibe (71L/ton). Recalling from section 5.2 these were the most cost efficient groups.

According to FAO, (2012), in order to minimize fuel costs fishers examine closely the costs and benefits of various factors and this influences their decision-making. For example, when deciding whether to go fishing, a fisherman would consider the following factors: weather conditions, distance to the fishing grounds, duration of fishing trips, quota, quality of fish, and supply of fish to the market and the potential of landing to a hungry market. The cost of fuel in trip with bad weather will inevitably be more than in good weather. However, this can be offset by a good market price upon landing.

Eco-efficiency

Commercial fisheries are heavily dependent upon the combustion of fossil fuels and as such contribute to increased atmospheric concentrations of greenhouse gases that has huge impact on the world's climate (SEAFISH, 2009). Using the fishery-related fuel use intensity effects on greenhouse gas emissions, specifically, comparing the direct effect of the annual burning of diesel fuel by purse seiners in Benguela and Namibe fishing towns, the mean carbon footprint, measured in kilos of CO_2 per liter of fuel burned during fishing operations was found to differ significantly *($p=0.005$)* such that vessels in Benguela produced a mean annual of 514 kg co_2-e per ton of fish landed in contrast to 307 kg co_2-e in Namibe fleet. In fishing operations, according to Tan and Culaba (n.d.), emissions are influenced by a link between stocks and fishing effort e.g. fishing gears and technology used the abundance of fish (stocks) and the steaming distance to fishing grounds. Burning fuel in engine (s) plays a large part in overall emissions. Steaming distance is important but additional CO_2 emissions may be generated during fishing operations (i.e. whilst towing the gear through the water) or by using a generator or hydraulics on the vessel. An important guide to the carbon footprint of a vessel is the amount of fuel burnt in the engines. Thus a vessel or fleet's GHG emission (GHG emissions associated with a fishery per unit of catch landed), as stated by OECD (2010), is strongly related to its fuel intensity (the fuel used per unit of catch landed).

Figure 27 also illustrates that eco-efficiency varied among vessel engine groups in both fleets such that, CO_2 emission per ton of landed fish was lower in 400 $<HP\leq700$ group (410kg) in Benguela fleet in contrast to 198kg in vessel group HP>700 within the Namibe fleet. As a matter of fact, this variation mirrored those of fuel use efficiency discussed earlier on this section, whose explanations is again attributed to some biological and technical factors within the fishery e.g. stock density, distance to fishing ground, time spent searching for schools of fish and the fishing technology used. Measuring and improving the energy use and associated GHG emissions from fisheries according to Weidema et al., (2008) and OECD (2010), can decrease operational costs to fishing vessels, help vessels reach current and future marine emission standards, and effectively communicate to consumers the relative environmental costs and benefits of choosing certain products over others.

6.5 Effects of harvest tax and fuel cost support on profitability

Fisheries management measures such as harvest tax and subsidies are aimed to regulate effort and create fishing incentives, respectively (Flaaten, 2016).

From fisheries economic theory it is well known that, in a quota managed fishery, the application of harvest tax as a government regulation, leads to a controlled number of participant and is a way of regulating effort at the same time generating revenue. On the other hand, it rises fishing costs and lowers revenue of the industry. When comparing to the total operating costs, harvest tax accounted for minor proportions of the industry cost, 5% and 12% in Benguela and Namibe fleets respectively.

However, in relation to the profit before opportunity cost on owner's capital (EBT), harvest tax, as presented in section 5.5 represent higher proportions of, 19 and 35% of EBT. According to Flaaten (2016), this is a usual method of determining the effect of government actions/ (regulatory policy) on the industry, or fishing firms, it allows fisheries management authorities to determine whether, and to what extent, the profits are altered by such policies. Hao, (2012), pointed out that it is an important step on the way to evaluate such government policies (harvest quota tax and fuel subsidies) such that, the reaction of the industry can be determined. The tax authority, traditionally the central government, collects the resource rent generated. This tax revenue may be used to reduce other taxes or to augment the government's expenditures. From a policy point of view, resource rent can be re-distributed, for example, to fishing communities or regions, without any efficiency loss (Flatten 2016).

The great variations in harvest quota quantity, hence harvest tax within the Namibe fleet is partly explained by variation in vessel size (table 9 in chapter 4). In fact, larger vessels (HP>700) firms secure higher quota quantity because they own fishmeal and oil processing plants onshore. Regardless of the market price of fish, they tend to catch and land larger quantities for reduction purpose. In Benguela, the situation is not that different, however, reduction takes place at a larger scale in Namibe. With regard to harvest quota quantity on average, vessels in Benguela were more efficient because they fished out 81% of the allocated quota compared to those in Namibe that only fished out 57% of their allocated quota. If costs are to be minimized, operators need to improve their catch efficiency. Usually, fishery manager determines the quota price as harvest tax of *m* $ per tonne. In addition, the fish harvesters can buy any amount of harvest quota at this price, so he has to pay for its quota in proportion to its harvest. Assuming a liner marginal cost of effort curve, a downward sloping demand curve for harvest quota can be derived (Flaaten, 2016).

As presented in section 5.3, fuel costs accounted for larger proportions of the vessels total operating costs. The annual government support on fuel subsidy represent about 0.8% of total operating costs. This percentage may look insignificant. However, it represents about 2% of the mean net revenue of a fishing vessel. In fact, fisheries subsidies that encourage expansion of effort are disregarded and not recommended in most cases, because one of the aims of fisheries management at a global scale is to reduce fishing capacity and effort (FAO, 2012).

CHAPTER SEVEN: CONCLUSION

In general, both fishing fleets had fairly good economic performance results, since most vessels gross revenue exceeded the real cost of the factors of production, the resultant positive EBITDA implies that, vessel owners would be commercially viable in the short term, but not operating optimally upon a long-term analysis. EPI, with the exception of OM and ROC were relatively higher in Namibe than Benguela fleet. This was due to differences in invested capital, CPUE, cost per unit effort and market price of fish. However, there was no statistically significant difference in the mean values of EPI. In general, we could say that low cost fishing operations, as the case of Namibe fleet, had the greatest potential for generating resource rent. However, lower price per unit of catch within the Namibe market, have caused lower profits.

On the other hand, highly cost-fishing operations, as the case of Benguela fleet, may even make it uneconomical to sustain the fishery on a commercial basis. However, relatively higher prices per unit of harvest within the Benguela market, has allowed operators to sustain in the short run. Hence, vessels in Namibe were more efficient in terms of cost than those in Benguela (statistically significant different). This was mainly explained by lower labour costs and lower fuel consumption per unit of fish landed. Supported by the fact that Namibe has a relatively cheaper labour market; and vessels have easier access to fish fishing grounds than those in Benguela. In fact, better fuel efficiency reflects better eco-efficiency, thus vessels in Namibe, in particular large engine ones operated with the best environmental efficiency.

Within the Benguela fleet, vessels group 400<HP≤700 had the best economic performance while, in Namibe were those with HP>700. Such differences were explained by variations in vessels fishing power, efficiency and investment on capital. In terms of cost efficiency, a contrary situation was observed, vessels with HP>700 in Benguela and those with 400<HP≤700 in Namibe fleets operated with the lowest cost per unit of effort. This was explained by lower fuel consumption per ton of fish landed in Namibe. However, when considering cost efficiency in terms of cost revenue ratio, 400<HP≤700 in Benguela, and HP>700 in Namibe performed relatively well; had the least operating costs in terms of cents spent to generate a dollar of revenue. Overall, smaller engine vessels (100<HP≤400), operated with relatively poor cost efficiency. This was explained by technological creep and capital versus labor-intensive methods. Thus, vessel 400<HP≤700 in Benguela and those HP>700 in Namibe had the best performance results in terms of productivity and economic efficiency.

The economic measure aimed to regulate fishing effort, at the same time generate revenue to the state namely, harvest tax has increased the industry operating costs, but in very small proportions when comparing to other costs such as fuel and labor costs. On the other hand, fuel cost support by the state, has lowered the industry costs to about 1%, representing about 3% of the industry net revenue.

The results presented may have some implications for management of the coastal purse seiners in Benguela and Namibe fishing towns, and could be used by the Angolan Fisheries Management Authorities as a basis to restructure the Small Pelagic Fishery particularly following the Small Pelagic FMP and the National Development Plan 2013-2017.

Fishing for resources such as shrimp and tuna, which command a high market price, encourages high fuel consumption (FAO, 2012). However, fishing for resources such as sardinellas and herring, which fetch low prices on the market, incurs low fuel consumption during purse seine operations.

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APPENDICES

Appendix A: Characteristics of the fishing vessels

Table 1A: Characteristics of the sampled fishing vessels in Benguela fishing towns

Vessel ID	LOA	HP	TAB	Crew	Fuel (1000 L/year)
1	18	220	60	17	320
2	22,90	360	56	17	320
3	14.3	190	25	16	300
4	21,75	335	120	15	300
5	15	235	30	12	300
6	19	450	53	18	300
7	25,8	406	139	30	360
8	24,7	425	43.3	15	144
9	23	425	60	30	360
10	19	450	57	15	120
11	30	850	354	13	120
12	43,1	1000	349	12	120
13	24,99	1000	191	10	720
14	37	1690	364	17	120

Table 2A**:** Characteristics of the sampled fishing vessels in Namibe fishing town

Vessel ID	LOA	HP	TAB	Crew	Fuel (1000 L/year)
1	20	250	40	18	156
2	20	360	45	25	156
3	30	400	54	18	156
4	17	380	48	15	140
5	19	450	69	22	240
6	19	450	53	22	360
7	19	450	56	27	360
8	19	450	53	22	320
9	19	450	69	16	360
10	43	850	431	15	80
11	37	1100	250	15	120
12	30.5	1000	108	15	120
13	37	1200	300	15	80
14	38	1200	380	15	120

Appendix B: Input and output of fishing vessels

Table 1B: Effort, cost and revenue of the fishing vessels in Benguela fishing town

Vessel ID no.	Capital value (USD)	Effort (HP* Trips)	Total operating Costs (USD)	Cost per unit effort (USD)	Annual catch (tons)	Gross revenue (USD)	CPUE (tons/E)	Revenue per unit effort (USD)
1	1.000.000	30834	711.410	23.07	1136	795.200	0.037	25.79
2	700.000	29375	435.538	14.83	1000	700.000	0.034	23.83
3	1.250.000	32280	741.665	22.98	1614	1.129.800	0.050	35.00
4	1.200.000	39096	629.485	16.10	1086	760.200	0.028	19.44
5	1.500.000	29068	386.548	13.30	1128	789.600	0.039	27.16
6	1.875.000	57857	711.495	12.30	1800	1.260.000	0.031	21.78
7	2.000.000	33847	862.403	25.48	2501	1.750.700	0.074	51.72
8	1.600.000	31875	758.008	23.78	1500	1.050.000	0.047	32.94
9	1.200.000	47430	453.853	9.57	1054	737.800	0.022	15.56
10	1.500.000	35471	395.486	11.15	1085	759.500	0.031	21.41
11	2.000.000	63826	807.444	12.65	1468	1.027.600	0.023	16.10
12	2.000.000	42692	544.851	12.76	1557	1.089.900	0.036	25.53
13	1.800.000	45200	804.794	17.81	1130	791.000	0.025	17.50
14	2.500.000	85254	1.335.716	15.67	3279	2.295.300	0.038	26.92

Table 2B: Effort, cost and revenue of the fishing vessels in Namibe fishing town

VESSEL ID no.	Capital value (USD)	Effort (HP* Trips)	Total operating Costs (USD)	Cost per unit effort (USD	Annual catch (tons)	Gross revenue (USD)	CPUE (ton/E)	Revenue per unit effort (USD)
1	1.875.000	73800	416.587	5.64	1312	695.360	0.018	9.42
2	1.875.000	67150	426.269	6.35	1343	711.790	0.020	10.60
3	1.875.000	96075	458.781	4.78	2135	1.131.550	0.022	11.78
4	1.000.000	42234	344.950	8.17	778	412.340	0.018	9.76
5	1.800.000	59500	743.551	12.50	1785	946.050	0.030	15.90
6	3.500.000	118320	1.494.774	12.63	6902	2.760.800	0.058	23.33
7	3.500.000	116200	1.082.394	9.31	5810	2.324.000	0.050	20.00
8	3.500.000	105514	1.277.523	12.11	8633	3.021.550	0.082	28.64
9	3.200.000	74743	1.073.844	14.37	5276	1.846.600	0.071	24.71
10	1.400.000	68775	221.558	3.22	917	486.010	0.013	7.07
11	1.800.000	53378	341.830	6.40	1201	636.530	0.023	11.93
12	600.000	41325	252.812	6.12	551	292.030	0.013	7.07
13	700.000	45540	216.725	4.76	759	402.270	0.017	8.83
14	500.000	32500	221.140	6.80	650	344.500	0.020	10.60

Appendix C: Statistical test results

Table 1C: T test results of mean operating cash flow margin

t-Test: Two-Sample Assuming Equal Variances

	Benguela	*Namibe*
Mean	0.3364	0.3949
Variance	0.0270	0.0222
Observations	14.0000	14.0000
Pooled Variance	0.0246	
Hypothesized Mean Difference	0.0000	
df	26.0000	
t Stat	-0.9874	
P(T<=t) one-tail	0.1663	
t Critical one-tail	1.7056	
P(T<=t) two-tail	0.3325	
t Critical two-tail	2.0555	

Table 2C: T test results of mean operating margin

t-Test: Two-Sample Assuming Equal Variances

	Benguela	*Namibe*
Mean	0.142208292	0.136481634
Variance	0.033547523	0.0355933
Observations	14	14
Pooled Variance	0.034529504	
Hypothesized Mean Difference	0	
df	25	
t Stat	0.080012875	
P(T<=t) one-tail	0.468432043	
t Critical one-tail	1.7081407	
P(T<=t) two-tail	0.9368640	
t Critical two-tail	2.059538553	

Table 3C: T test results of mean EBT

t-Test: Two-Sample Assuming Unequal Variances

	Benguela	*Namibe*
Mean	185900.9214	267466.9143
Variance	6087940603 4	1.56366E+11
Observations	14	14
Hypothesized Mean Difference	0	
df	22	
t Stat	0.654783135	
P(T<=t) one-tail	0.259697637	
t Critical one-tail	1.717144374	
P(T<=t) two-tail	0.519395274	
t Critical two-tail	2.073873068	

Table 4C: T test results of mean ROC

t-Test: Two-Sample Assuming Equal Variances

	Benguela	*Namibe*
Mean	0.104446419	0.086462451
Variance	0.014617467	0.013243424
Observations	14	14
Pooled Variance	0.013930446	
Hypothesized Mean Difference	0	
df	26	
t Stat	0.40313643	
P(T<=t) one-tail	0.345071938	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.690143875	
t Critical two-tail	2.055529439	

Table 5C: T test results of mean Cost per unit effort

t-Test: Two-Sample Assuming Equal Variances

	Benguela	Namibe
Mean	16.53112975	8.288067836
Variance	27.49847276	13.21642862
Observations	14	14
Pooled Variance	20.35745069	
Hypothesized Mean Difference	0	
df	26	
t Stat	4.833657635	
P(T<=t) one-tail	2.60657E-05	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.0000521	
t Critical two-tail	2.055529439	

Table 6C: T test results of mean revenue per unit effort

t-Test: Two-Sample Assuming Equal Variances

	Benguela	Namibe
Mean	25.76362754	14.25931456
Variance	89.11636692	49.90201505
Observations	14	14
Pooled Variance	69.50919099	
Hypothesized Mean Difference	0	
df	26	
t Stat	3.65080462	
P(T<=t) one-tail	0.000577085	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.001154169	
t Critical two-tail	2.055529439	

Table 7C: T test results of mean CPUE

t-Test: Two-Sample Assuming Equal Variances

	Benguela	Namibe
Mean	0.036805182	0.032499581
Variance	0.00018187	0.000521644
Observations	14	14
Pooled Variance	0.000351757	
Hypothesized Mean Difference	0	
df	26	
t Stat	0.607381399	
P(T<=t) one-tail	0.274433144	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.548866287	
t Critical two-tail	2.055529439	

Table 8C: T test results of mean fuel efficiency

t-Test: Two-Sample Assuming Equal Variances

	Benguela	Namibe
Mean	183.5321562	109.7794927
Variance	5516.92558	2885.706739
Observations	14	14
Pooled Variance	4201.316159	
Hypothesized Mean Difference	0	
df	26	
t Stat	3.010468218	
P(T<=t) one-tail	0.002868838	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.005737677	
t Critical two-tail	2.055529439	

Table 9C: T test results of mean Labour costs

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	170801.9643	106156
Variance	4003555109	4994056662
Observations	14	14
Pooled Variance	4498805886	
Hypothesized Mean Difference	0	
df	26	
t Stat	2.550018306	
P(T<=t) one-tail	0.008504904	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.017009809	
t Critical two-tail	2.055529	

Table 10C: T test results of mean running costs

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	322489.8286	311695.2286
Variance	26995446217	59144101086
Observations	14	14
Pooled Variance	43069773651	
Hypothesized Mean Difference	0	
df	26	
t Stat	0.137616111	
P(T<=t) one-tail	0.445802017	
t Critical one-tail	1.70561792	
P(T<=t) two-tail	0.891604034	
t Critical two-tail	2.055529439	

Table 11C: T test results of mean vessels costs

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	166329.2143	144487.5
Variance	1851426079	7693154849
Observations	14	14
Hypothesized Mean Difference	0	
df	19	
t Stat	0.836512254	
P(T<=t) one-tail	0.206632206	
t Critical one-tail	1.729132812	
P(T<=t) two-tail	0.413264412	
t Critical two-tail	2.093024054	

Table 12C: T test results of mean capital costs

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	196806.6429	247918.0714
Variance	3254825333	19444182545
Observations	14	14
Hypothesized Mean Difference	0	
df	17	
t Stat	-1.269341852	
P(T<=t) one-tail	0.11071115	
t Critical one-tail	1.739606726	
P(T<=t) two-tail	0.2214223	
t Critical two-tail	2.109815578	

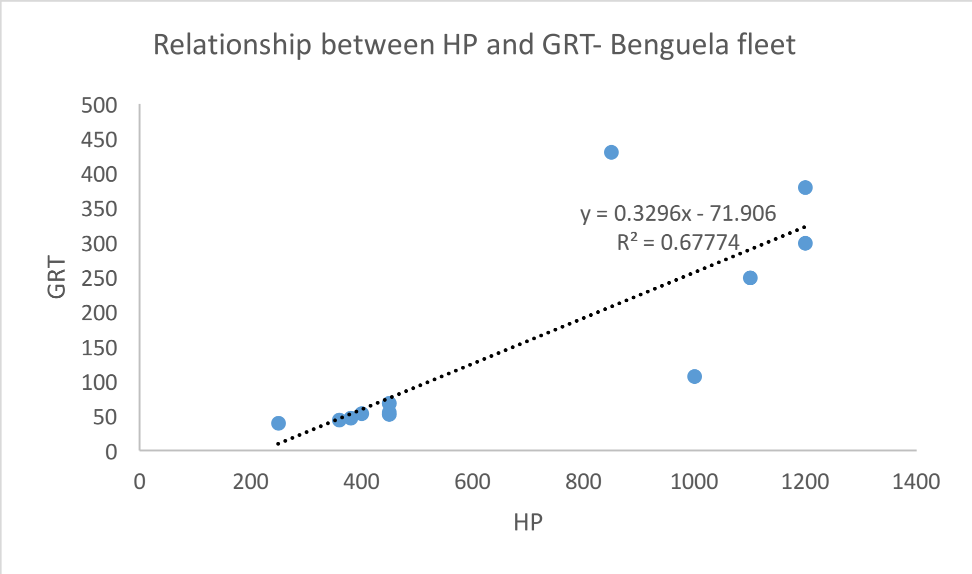

Figure 1C.

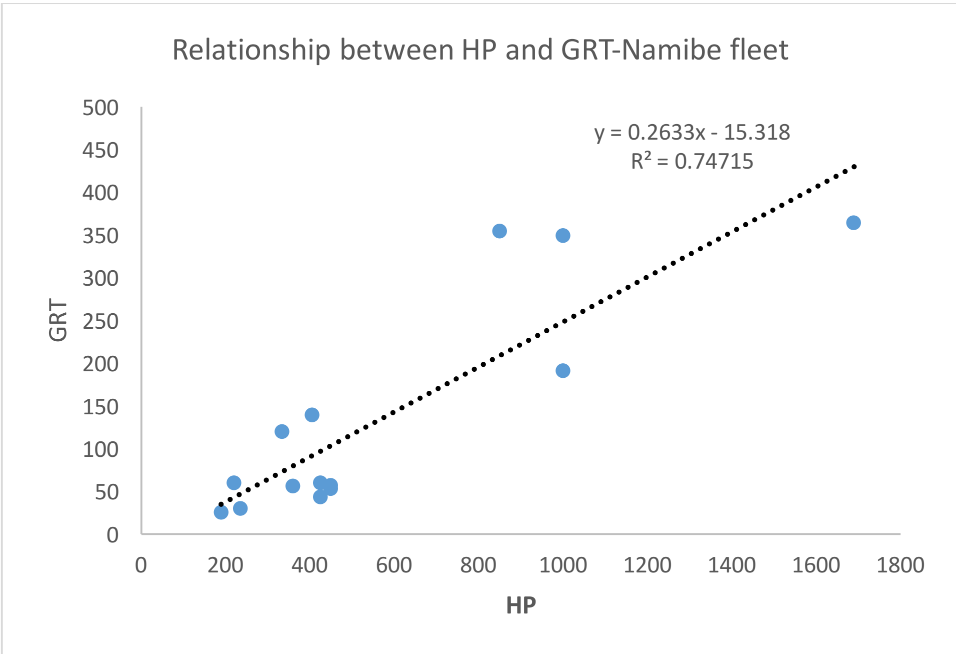

Figure 2C

Appendix D: Images of study area

1. Landing terminal-Benguela

2. Purse seiners in Benguela

3. Fish harvesting firm-Namibe

4. Mending seine nets-Namibe

5. Mending seine-Namibe

6. Landing terminal-Namibe

7. Landing terminal-Namibe

8. Landing terminal-Namibe

Source: Authors images.