Fishing capacity of the southeastern Black Sea anchovy fishery.

Castilla-Espino, D. [a] (corresponding author), García-del-Hoyo, J.J. [a], Metreveli, M. [b], Bilashvili, K.[b]

[a] Quantitative Methods for Business and Economics, Statistics and Operations Research – MEMPES, Universidad de Huelva, Plaza de La Merced, 11, 21071 – Huelva, Spain.

Tl.: +34 959 21 78 68

Fax: +34 959 21 78 66

david.castilla@dehie.uhu.es

[b] Iv.Javakhishvili Tbilisi State University, 1, Chavchavadze Ave., 0128 Tbilisi, Georgia

Abstract

The anchovy fishery of Georgia experienced a considerable decline at the end of the 1980s due to a regime shift in the Black Sea, virtually disappearing during the 1990s. At the beginning of the 2000s, it recovered, encouraging the Georgian state to hire out a significant part of the annual Total Allowable Catch (TAC) to Turkish vessels. This practice resulted in a significant reduction of the anchovy fish stock at the end of this decade due to the overcapacity of the fleet. Since late 2006, the Ministry of Environment Protection and Natural Resources is implementing a new licensing system based on the auction system. According to this management system, 4 winning bidders own the right to fish an annual TAC for 10 years. The bioeconomic sustainability of this fishery and the success of this management framework is subject to controlling the fishing capacity of the fleets that exploits this fishery. This paper is aimed at measuring the fishing capacity and overcapacity of this fleet during four seasons in the period from 2005 to 2009. Fishing capacity, capacity utilization and technical efficiency are estimated using Data Envelopment Analysis (DEA). This paper concludes that fishing capacity has increased since the implementation of the 2006 management framework and that the fleet has reached a significant level of overcapacity in 2008-2009 season suggesting the necessity of international cooperative right based fisheries management to guarantee bio-economic sustainability.

Keywords

Data Envelopment Analysis, fishing capacity, clupeoid fisheries, Management, Georgia, Black Sea.

1 Introduction

Overexploitation of fisheries resources, that is the exploitation of commercial fish stock over safe biological limits, is a big concern in world fisheries. The 32% of the stocks groups of the world monitored by Food and Agricultural Organization of the United Nations (FAO) are overexploited, depleted or recovering from depletion (FAO, 2010).

Overexploitation is mostly caused by overfishing as a consequence of fishermen economic incentives to maximize their capture instead of investing in the conservation of their exploited fish stocks in open access or regulated open access fisheries. The incentives of fishermen produce the capitalization of fishing fleets leading to levels of fishing capacity that are generally significantly higher than sustainable not only since the biological point of view but also the economic resulting in overcapacity and hence in the dissipation of the potential rent that fishermen gain in different extends depending on the regulatory framework (Gordon, 1954; Homans and Willen, 1997).

This paper is aimed at measuring the fishing capacity and overcapacity of the fleet that exploits the southeastern Black Sea anchovy fish stock in the EEZ of Georgia during four seasons in the period from 2005 to 2009. The paper discusses the results attained in context of Georgia anchovy fishery and reaches conclusions regarding the evolution of fishing capacity under the current management framework of this fishery.

The Mediterranean and Black seas main commercial fish stocks are not an exception to overexploitation problem. Namely, hake, red mullet and small pelagic fish stocks are also fully exploited or overexploited in these two seas (FAO, 2010). In particular, the main commercial fish stock of the Black Sea, that is anchovy, has been recently classified as overexploited (STECF, 2011, FAO 2012).

Six countries exploits the goods and services provided by the Black Sea Economic Exclusive Zone (EEZ) of 423,500 km^2: Turkey (South), Bulgaria (West), Romania (West and North-West), Ukraine (North-West and North), Russian Federation (North-East) and Georgia (South-East) (Fig. 1). The Black sea is a nearly enclosed sea only connected to the Mediterranean Sea through the narrow and shallow Bosphorus Strait. Its continental shelf is significantly wider in the Northwestern and Northern coastline, characterized by shallow waters with a depth of up to 200 m, than in the rest of the coastline. The Northwestern basin provides most of the riverine input of the Black Sea mainly coming from Danuve, Dniester and Dnieper rivers. Eukaryotic life is only supported in a surface layer of a depth of up to 100 m. There is an anoxic layer below characterized by high concentrations of hydrogen sulphide and ammonium that only supports anaerobic bacteria life (Oguz et al. 2004).

The recent history of Black Sea fisheries is marked by two discontinuous regime shifts events that took place at the end of the 1970s and 1980s that produced dramatic changes in the Black Sea ecosystem that have a significant impact on small pelagic fish stocks. The aforementioned regime shifts were mainly caused by a combination of anthropogenic effects namely eutrophication, overfishing and outbursts of the alien ctenophore species (*Mnemiopsis leidyi* and *Beroe ovate*); and climate change (Oguz, 2005a, 2005b).

The agricultural revolution in Iron Curtain countries resulted in intense eutrophication of the Black Sea as a consequence of nutrients discharges (inorganic phosphorus and nitrogen), especially in the northwestern basin of the Black Sea, as a consequence of (Kideys, 2002). The subsequent increase of pelagic primary production and the overexploitation of main small pelagic predators resulted in a significant increase small pelagic fish stocks, mainly anchovy (*Engraulis encrasicolus*) in early 1980s; however the combination of overexploitation of small pelagic fish and the accidental introduction of the ctenophore *Mnemiopsis leidyi* that competes ecologically with small pelagics resulted in a sharp decrease of anchovy population at the end of the 1980s (Oguz, 2005a, 2005b).

The economic failure of the communist regimes after the fall of the Iron Curtain during the 1990s and a new international management framework for the management of the Black Sea caused a significant reduction of nutrients river discharges (Mee et al. 2005). The reduction of nutrients inputs together with the introduction of the ctenophore Beroe that predates *Mnemiopsis leidyi* resulted in a slight recovery of anchovy fish stock that reached the current mean stock level with landings of at most 10% of the level of the 1980s, only increasing in Turkey that fishes at levels that are roughly two times over the Maximum Sustainable Yield (Oguz et al. 2012, Oguz and Velikova, 2010).

The aforementioned reduction of landings caused a significant reduction of the revenues coming from fishing in Black Sea coastal communities. This situation was worsened by the adoption of the Law of the Sea since 1982, which obliged a significant part of the fleet that operated offshore to move back to their respective EEZs dissipating even more the rent of fishermen due to the higher number of vessels fishing in territorial waters. This situation is the case in Georgia (in the southeastern corner of the Black Sea), which experienced a significant increase of purse seiners operating on its EEZ (a total of 220) together with a significant reduction of their productivity —the capture decreased from 175 mT in 1989 to 4.7 mT in 1990. Consequently, the profitability of the coastal communities depending on these fishing fleets declined along with the employment they could offer (Van Anrooy et al. 2006).

The fall of the iron countries worsened the aforementioned situation due to the new economic order that implied in the case of fisheries the destruction of traditional commercial relations and therefore the different linkages of market agents along the market chain. At this point, a significant part of the offshore, unprofitable Georgian fishing fleet was sold to Ukraine and almost disappeared during the 1990s despite a small recovery of the Black Sea anchovy fish stock in the mid 1990s.

The sharp reduction of the fleet mentioned above produced a recovery of the Georgian anchovy fish stock at the end of the 1990s; thus, the anchovy fish stock size reached 380 mT in 1999-2000 season (Van Anrooy et al. 2006). However, the operating Georgian fleet at the beginning of the 2000s was not able to fully exploit this stock due to a considerable level of undercapacity, which encouraged the Georgian state to rent to Turkish and Ukrainian companies[1], 90% of the Total Allowable Catch (TAC) set in the 1999-2000 season at 120 mT with no restrictions on vessels size, but on fishing gear (Minister order no. 512). Vessels could not use bottom trawl and the fishing gear mesh size and dimensions were limited. Additionally a control and inspection system was posted in place to guarantee the TAC.

[1] Ukrainian companies were exploiting Georgian EEZ anchovy stocks until 2005 when the new management framework set a limit of 20 vessels to the licenses owners. This encouraged renting vessels of higher capacity, especially Turkish vessels.

Currently, the joint exploitation of anchovy fish stock by Georgian, Turkish and Ukrainian vessels has resulted in a significant increase in the capture of anchovies (Fig. 2), whose fish stock has decreased to less than half its earlier size in 1999-2000 season to 170 mT in the 2003-2004 season, according to fish stock assessment surveys by acoustic methods. The decrease of the anchovy fish stocks again puts this fish specie at risk which is the only one that has registered captures of commercial interest in the last five-year period.

Overfishing of the Georgian-Turkish fleet caused by an inappropriate setting of the TAC seems to be the origin of the aforementioned reduction of the anchovy stock in Georgian fishing grounds. This is worsened by the significant pressure that overcapacity of the fleet exerts over the fishery resource decreasing fisheries profitability. As claimed in Khavtasi et al. in 2010, by means of a rough estimate, the fishing capacity of the hired Turkish fleet might exceed around three times the TAC, set at 60 mT in the 2008-2009 season, although other authors disagree on this number (Öztürk et al. 2011).

Overcapacity should be taken into account by policymakers for the bioeconomic sustainability of Georgia anchovy fishery. A fishing capacity management framework must be implemented to reduce the fishing capacity in case it exceeds TAC limits or the MSY in case it is not set appropriately. In effect, overcapacity is an important fishing problem given that it results in the dissipation of fishermen’s rent and in the overexploitation of fish stocks when the fishing output is not limited or is not set properly. The above situation justifies the need to provide accurate estimates of fishing capacity and overcapacity as recognized in the scientific arena to identify and avoid the structural problem of overcapacity.

This paper uses Data Envelopment Analysis (DEA) in order to measure fishing capacity, which can be defined with a technical-economic output orientation as the “maximum catch a vessel can produce if inputs are fully utilized given the biomass, the fixed inputs, the age structure of the fish stock, and the present state of technology” (Vestergaard et al. 2003: 359). The DEA has been recommended by the Food and Agricultural Organization of the United Nations (FAO) after an extensive review of alternative methods of measuring fishing capacity (FAO, 1998).

The paper is structured as follows: Material and methods section describes the Georgian and Turkish anchovy fleets and their management framework, define fishing capacity and describes the data and methodology used to measure fishing capacity and overcapacity of the fleet that exploits Georgian anchovy fishing grounds; results and discussion section presents the main results attained, showing and discussing the current levels of technical efficiency, fishing capacity, capacity utilization and overcapacity of the aforementioned fishing fleet; and finally, the main conclusions are presented.

2 Material and Methods

2.1 Georgian waters anchovy fleet

The Georgian fisheries are located in the southeastern Black Sea along a coastline of 330 km from Psou (40°01'E, 43°39'N) to Sarpi (41°55'E, 41°52'N) and are exploited by Georgian vessels mainly located in the ports of Poti and Batumi along with Turkish hired vessels supported by catch transport ships. However, the real fishing area is currently less than 180 km because of geo-political conflict with the Autonomous Republic of Abkhazia and the 5 mile closure areas around the Kolkhety National Park and Supsa oil terminal (Fig. 3).

The main target species of these fleets are middle and small-sized pelagic, schooling species, including anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*) and whiting (*Merlangius merlangus*); however, most of the landings registered by the fleet are of anchovies, which is the most abundant and of the most commercial interest; therefore, the fleet's target can be considered to be this single species. The target species come from two different stocks which are transboundary forming schools in the EEZ of Georgia during winter: the Azov anchovy (*Engraulis encrasicolus maeoticus*) that migrates from the Azov Sea along the Caucasus coast to Georgia and the Black Sea anchovy (*Engraulis encrasicolus ponticus*) that is distributed in the northwestern Black Sea in summer and migrates along the coasts of Romania, Bulgaria and Turkey to Georgia, especially the Poti-Batumi region (Fig. 3 - Cashchin, 1996). The latter is the main stock targeted by the fleet that operates in the EEZ of Georgia.

In the 2008-2009 season, the Georgian fleet was composed of 26 seiners and 11 motorized wooden vessels equipped with purse nets locally called "motofelugas" (engine power 14.6 kW, the fishing area mainly cover the territorial waters), while the Turkish fleet operating in Georgia waters consisted of 19 seiners (all rented by Georgian companies and operating in Georgian waters). Among the latter, 14 vessels registered anchovy captures in that season. The main technical characteristics of these fleets are shown in Table 1. It is worth noting that there are important differences in technical characteristics of Georgian and Turkish fleets given that the latter are much bigger than the formers.

There is neither a national fishery policy nor a fishery law in Georgia, but several recent laws and regulations address different issues related to resource conservation for fisheries and the fishing industry. However, a Master Plan for Fishery Sector Development in Georgia (2005-2020) has been prepared with the participation of stakeholders in order to promote the bioeconomic sustainable development of Georgian fisheries (Duzgunes and Erdogan, 2008; Van Anrooy et al. 2006). All fishery affairs were transferred from the Ministry of Agriculture (MOA) to the Ministry of Environment Protection and Natural Resources (MEPNR) in 1994 to benefit from synergies in the management of biodiversity, fisheries, species introductions, pollution, environmental degradation, and other environmental matters that influence fisheries. The MOA took responsibility for the post harvest catch and marketing issues.

The management framework of anchovy fishery in place during 2005-2009 seasons was set in late 2006 and consists of a licensing system for the industrial anchovy fishery granted by the Ministry of Environment and Natural Resources Protection (Fig. 4) [2]. The licensing system was based on an auction system. According it, the winning bidders, four in 2006 auction (currently 6), did a blind offer of a price over a minimum set by the government [1,000,000 GEL (1 USD = 1.6 GEL)] in a public sale to acquire the right to exploit and transfer for 10 years a share of the TAC, that vary from year to year, depending on the availability of fish. The winning bidders do not own vessels and have to rent them to exercise their fishing rights.

[2] Currently, the monitoring and licensing of all natural resources including fisheries resources were transferred to the Agency of Natural Resources (Former Georgian Environment Protection Inspection) under the Ministry of Energy and Natural Resources of Georgia. The Ministry of Environment Protection was left with a function of conservation natural resources setting the TAC based upon The Black Sea Institute scientific advice. The Convention Inspection of the Black Sea Protection has been renamed to Black Sea Agency Regional Office. http://www.menr.gov.ge/en/4448.

Additionally, the winning bidders have to pay two fees: 15 GEL per ton of their fishing right 25 GEL per ton of fish catched.

Among some other responsibilities, like the declaration of their capture, the winning bidders also have the following requirements:

- To transfer the 10% of their share to the Georgian fleet.
- To present a fish stock assessment each season to the government for setting the TAC.
- To process not less than 2/3 of the fish in Georgia.
- To introduce not more than 20 vessels

2.2 Fishing capacity

Fishing capacity can be defined since a technological-economic (primal) or economic (dual) points of view. The former only considers productive aspects of fishing activity while the latter requires defining output as an economic optimum through assumptions on the economic behaviour of fishing boats (vg. profit maximization or cost minimization - kirkley and Squires, 1999). The absent of economic information available on the Georgian waters anchovy fleet obliged this paper to be focused on the technological economic approach despite the unquestionable interest in considering the pure economic perspective.

Fishing capacity is the "maximum catch a vessel/fleet can produce if inputs are fully utilized given the biomass, the fixed inputs, the age structure of the fish stock, and the present state of technology" (Vestergaard et al. 2003: 359)[3], while capacity utilization is the ratio of the actual capture and the fishing capacity of a vessel/fleet. Technical-economic fishing capacity concept implies that all the fleet operate efficiently since the technical point of view that is, the fleet has the ability of catching the maximum possible given the state of the fisheries resource and the actual use of productive inputs (Farrell, 1957)[4].

Fishing effort is closely related to fishing capacity. Fishing effort (E) can be defined as a composed variable of productive inputs representing the activity (τ) or the intensity of fishing and the fishing power (ω) or the potential to fish of a certain boat i or a fleet (Anderson, 1976, 1977, 1978). Therefore, as shown in equation 1, the capture of a certain boat i in season t (y_{it}) can be mathematically represented as a function of its fishing effort and the exploited fish stock size (x). Accordingly, fishing capacity could be estimated using equation 1 expanding the fishing effort to its maximum potential level and assuming that the boat is operating efficiently.

$$y_{it} = f\left[E_{it}\left(\varpi_{it}, \tau_{it}\right), x_t\right] \qquad (1)$$

Overcapacity is as a structural problem of fishing fleets that results form the capitalization processes that take place in open access and regulated open access fisheries described in the Introduction section. Overcapacity of fishing fleets implies that it can catch more fish than a

[3] Note that this is an output-oriented definition of fishing capacity that could also be defined assuming an input orientation in terms of the capital stock of the fleet.

[4] Technical efficiency is part of overall or economic efficiency which also includes allocative efficiency that refers to the ability of a vessel to allocate input so that an economic optimum is reached.

desirable target level of fishing capacity that generally implies sustainability since biological and/or socioeconomic points of view given the exploited fish stock current state according the management objectives of the fishery (Ward at al, 2005). This objective is embodied in the TAC of regulated open access fisheries (Pascoe and Greboval, 2003). According this, overcapacity is the excess over 1 of the ratio of fishing capacity and target capacity.

2.3 Measuring fishing capacity using DEA

DEA is a non-parametric mathematical programming technique initially conceived for the measurement of efficiency and productivity through the comparison of the maximum potential output of a decision making unit (DMU) with its attained actual output (Charnes et al. 1978). The maximum potential output results from a production frontier built by a non-parametric linear combination of efficient DMUs of a certain industry.

DEA is a relatively simple technique that does not need the specification of the production frontier and allows the imposition of lineal restrictions as well as accommodates multi-output technologies easily with few theoretical restrictions. These characteristics make DEA a powerful tool for policymakers in order to inform and evaluate fishery management performance.

This technique has been widely applied to measure and analyze the efficiency of the fishing industry and fishing capacity, since it was recommended by FAO (1998), after being first adapted by Färe et al. (1989) and Färe et al. (1994) in a two-stage procedure to determine output-oriented capacity and capacity utilization of a DMU based upon Johansen (1968) production capacity definition (Reid et al. 2003; Castilla Espino et al. 2005).

The implementation of DEA requires critical assumptions related to the orientation of the efficiency measure: input or output; and the returns to scale of the technology of production. Färe et al.'s (1989) two stages procedure to measure plant capacity was first adapted for the case of fisheries by Kirkley and Squires (1999). This procedure allows, assuming and output orientation, the estimation not only of technological economic output oriented fishing capacity and capacity utilization, but also the technical efficiency scores of each vessel that operates in the fishery.

The DEA linear program 2 is solved in the first step. Linear program 2 assumes constant returns to scale and output orientation[5]. Linear program 1 implies that J vessels (j) of the fleet capture S fish species (y_{js}) using M productive inputs (x_{jm}) where α of these inputs are fixed and α' are variable and fully utilized according restriction 3[6]. The restrictions that a vessel uses unless one input ($x_{jm} > 0$) and one output ($y_{js} > 0$) are also imposed to this linear program.

[5] Variable returns to scale can be easily accommodated in linear programs 1 and 3 adding convexity restriction (Eq. 5).
[6] According the definition of fishing capacity in section 2.2, these productive inputs have to represent the fishing effort of the boat.

$$
\begin{aligned}
&\max_{\lambda,\varphi_1,\gamma} \varphi_1 \\
&\text{s.t.} \quad \varphi_1 y_{js} - \sum_{j=1} \lambda_j y_{js} \leq 0, \; s = 1, 2, ..., S \\
&\qquad \sum_{j=1} \lambda_j x_{jm} - x_{jm} \leq 0, \; m \in \alpha \\
&\qquad \sum_{j=1} \lambda_j x_{jm} - \gamma_{jm} \, x_{jm} = 0, \; m \in \alpha' \\
&\qquad \lambda_{j} \geq 0 \\
&\qquad \gamma_{jm} \geq 0, \; m \in \alpha'
\end{aligned} \tag{2}
$$

The optimal solution for φ_1 in linear program 2 (φ^*_1) is the output radial expansion needed to operate technically efficiently assuming full utilization of the variable inputs so that a vessel operates on this frontier when $\varphi^*_1 = 1$ while it operates under the frontier when $\varphi^*_1 > 1$. Linear program 2 allows determining observed capacity utilization (CU_{obs}) through the inverse of φ^*_1 (Eq. 3), the current utilization of variable inputs through γ_{jm} and fishing capacity (y^*_{js}) through the product of φ^*_1 by the actual output of j vessels (y_{js}). The fishing capacity of the whole fleet can be attained summing up the fishing capacity of each vessel. Overcapacity of a fleet can be estimated by comparing the latter value of fishing capacity and the target capacity for the fleet. This ratio takes values over 1 when there is overcapacity.

$$
CU_{obs} = \frac{y_{js}}{\varphi^*_1 \cdot y_{js}} = \frac{1}{\varphi^*_1} \tag{3}
$$

CU_{obs} takes 0 value when a vessel did not fish or took the decision of staying at port while it takes 1 value when it uses all its potential to fish during the season; however the most common is that this measure takes values between these two extremes depending on the actual use of the fishing capacity[7]. However, the possibility that technical efficiency can be biased downwards if a vessel is operating inefficiently (Färe et al. 1989) and that CU_{obs} can be an unrealistic measure of capacity utilization if technical efficiency vary significantly among vessels and it is persistent over time (Felthoven and Morrison, 2004) obliges solving standard DEA linear program 4 in a second stage to attain an unbiased (efficient) measure of capacity utilization (CU_{eff}) isolated from the negative impact of inefficiency.

$$
\begin{aligned}
&\max_{\lambda,\varphi_2} \varphi_2 \\
&\text{s.t.} \quad \varphi_2 y_{js} - \sum_{j=1}^{J} \lambda_j y_{js} \leq 0, \; s = 1,2,...,S \\
&\qquad \sum_{j=1}^{J} \lambda_j x_{jm} - x_{jm} \leq 0, \; m = 1,2,...,M \\
&\qquad \lambda_j \geq 0, \; j = 1,2,...,J
\end{aligned} \tag{4}
$$

The optimal solution for φ_2 in linear program 3 (φ^*_2) is the output radial expansion needed to

[7] Capacity utilization could eventually takes values higher than 1 what would mean that a certain variable input is overutilized in a certain period.

operate technically efficiently given the actual use of variable inputs so that it provides the technical efficiency score (TE) of a vessel measured conventionally through the inverse so that it takes values between 0 and 1. 0 value means that the vessel is technically inefficient while 1 value means that the vessel is technically efficient. Moreover, linear programs 2 and 4 allow attaining CU_{eff} by means of the ratio 4.

$$CU_{eff} = \frac{\varphi_2^* \cdot y_{js}}{\varphi_1^* \cdot y_{js}} = \frac{\varphi_2^*}{\varphi_1^*} \qquad (4)$$

2.4 Data

A panel data set drawn from a sample of vessels from the Georgian and Turkish fleets has been built in order to estimate the measures described in section 2.3 using DEA along with other relevant measures like technical efficiency, capacity utilization and overcapacity.

The panel data set mentioned above was collected for SESAME IP using all available data sources (including entries of fishermen's logbooks) in close collaboration with stakeholders, fishermen community and NGO-s specialists and consists of vessels licensed to catch anchovy in the EEZ of Georgia on a regular basis.

The panel data include information of the inputs that make up fishing effort[8] and the actual landings of each vessel operating in the fishery for the 4 seasons from 2005 to 2009. Table 2 shows that the representativeness of the sample is approximately 60% during the last three seasons. The data on productive inputs covered in the panel data are the technical characteristics of the vessels; the number of crew members; the number of fishing trips and the fishing days the fishing gears are operating (activity) during each of the four seasons (Table 3).

3 Results and discussion

The methods described in section 2.3 have allowed estimates of fishing capacity, unbiased (efficient) capacity utilization, overcapacity, and the technical efficiency of Georgian and Turkish fleets that exploit the northeastern Black Sea anchovy each season.

The linear program 2 and 4 were solved using the routines described in Walden and Kirkley (2000) for GAMS Minos 2.5 software for the j vessels of the fleet, assuming an output orientation and variable returns to scale (Eq. 6). The output variable of linear programs 2 and 4 was the annual capture per vessel of anchovy (S = 1) measured in kilograms (y_{js}). The fixed productive inputs (α) were the tonnage measured in GT (x_{j1}) and the engine power measured in kw (x_{j2}), while the variable inputs (α') included the activity (x_{j3}) and the crew members (x_{j4}).

$$\sum_{j=1}^{J} \lambda_j = 1 \qquad (6)$$

There were no reliable data available on the anchovy fish stock size, which means that the model is conditional on the stock size for each season so that the linear programs 2 and 4 were

[8] See section 2.2.

solved once each season. Unbiased (efficient) capacity utilization was measured using equation 5 for each vessel of the fleet each season.

The assumption of variable returns to scale by means of the addition of the convexity restriction (Eq. 6) to linear programs 2 and 4 allowed measuring fishing capacity, technical efficiency and unbiased capacity utilization of a vessels related to the segment of the fleet of similar capital structure avoiding the overestimation of fishing capacity of small and big vessels that would result from other returns to scale assumptions like constant returns to scale given that the TAC does not bind the vessels' capture.

Results for all seasons are summarized in Tables 4 and 5. Table 4 shows that in general, capacity is underutilized by the fleets, especially during the last season; this underutilization may be due to a binding annual TAC. Additionally, it also shows a relatively low technical efficiency of the fleet during the last three seasons.

The results of last season (2008-2009) show that the Turkish (TE ≈ 79%) is more technically efficient in mean than the Georgian (TE ≈ 35%) segment of the fleet which also shows smaller mean unbiased capacity utilization ($CU_{eff} \approx 13\%$) and variable inputs capacity utilization ($CU_{effort} \approx 58\%$, $CU_{crew} \approx 26\%$) than Turkish ($CU_{eff} \approx 62\%$, $CU_{effort} \approx 64\%$, $CU_{crew} \approx 100\%$). Regarding fishing capacity, it should be noted that Georgian and Turkish fleet segments show similar levels of fishing capacity that season.

The results also provide relevant information on the different fishing gears that exploit southeastern anchovy fish stock of EEZ of Georgia. It is worthwhile noting that the technical efficiency level of the purse seiners (TE ≈ 75% in 2008-2009 season) is higher than pelagic trawlers (TE ≈ 37% in 2008-2009 season). These make purse seiners preferable than pelagic trawler to catch anchovy more effectively.

Table 5 highlights an increasing trend in the fishing capacity of the fleets. Nonetheless, we should be cautious regarding this data given that it is conditional to the size of the fish stock each season. If we assume that the exploited fish stock has hold stable or even decreased during the period of analysis this could be interpreted as an increase of fishing capacity of the fleet during the four seasons considered in the analysis. A decreasing trend of unbiased capacity utilization support the assumption that the exploited fish stock size is decreasing.

Overcapacity of the whole fleet can be measured in the 2008-2009 season by the ratio of the estimated fishing capacity of the whole fleet (Table 5) and the annual TAC set by the MEPNR at 80 mT for this season according section 2.2. The result of this computation is evidence that there is a considerable level of overcapacity given that the fishing capacity of the fleet exceeds the annual TAC by almost two times. The estimation of overcapacity in the rest of the seasons evidences an quick increasing trend during time horizon considered in this research.

The overcapacity of Georgian waters anchovy fleet could be even higher if the TAC is no appropriately set accounting for sound scientific advice. The implementation of surplus production (Schaefer, 1957) or any other biological models (Hilborn and Walters, 1992) to determine the reference points for the management of the fishery would provide more accurate estimates of overcapacity using the fishing capacity estimates of this paper for the 4 seasons from 2005 to 2009 (Table 5).

The aforementioned increase of fishing capacity requires improving the management framework of the anchovy fishery of Georgia EEZ. The current situation guarantees that the capacity target set by the policy maker by means of the TAC is not exceeded, however the inappropriate setting of the TAC, which is not binding, and the little restrictions on the fishing effort exerted which encourages the race to fish and capital stuffing, results in an overcapitalized fleet that is overexploiting inefficiently anchovy fish stocks assuming a significant capital cost. The current overcapacity level also encourages unregulated, unreported and illegal fishing given the significant pressure that it poses in place.

The current management system based on the auction of the fishing rights to fish in the EEZ of Georgia provides an ideal framework to go further towards the implementation of a quota management system defining lots per vessels. This improving would result in increasing economic efficiency and decreasing the pressure on the fish stocks guaranteeing bioeconomic sustainability. Additionally, the appropriated setting of a minimum bidding price and the taxes on the TAC and capture would represent a Pigouvian incentive to reduce the fishing capacity of the fleet in the current management framework[9].

The last official data of anchovy captures in the EEZ of Georgia shows a peak in 2009-2010 season (≈40 mT. - Gaerke and MothPoulsen, 2011) and a sharp decrease until 2011-2012 season (≈7 mT.). Overcapacity of the fleet that exploits the EEZ of Georgia, as shown in this paper, and overexploitation of the Black Sea anchovy in the EEZ of Turkey (Oguz, et al. 2012) given the transboundary nature of this fish stock, seem to be the causes of this sharp decreasing. As a consequence of this, the Georgian Government reduced the TAC to 60 mT. for 2012-2013 of which 30 mT. in Poti-Batumi region and 30 mT. in Abkhazian, before prohibited, where Azov anchovy is more abundant.

Therefore, a hypothetical new management framework for the anchovy fishery of the EEZ of Georgia should also account for the transboundary nature of anchovy fish stocks. This implies that the actual international institutional arrangement represented by the Black Sea Commission should increase its competences in the management of the two main stocks (Azov and Black Sea anchovy) of the area encouraging the cooperation among the six riparian countries of the Black Sea to guarantee the bioeconomic sustainability of Black Sea anchovy stocks exploitation.

Georgia has a significant potential of increasing the profits of its fishing industry modernizing its fleet and increasing its share of the TAC. The developing of new commercial relations with Europe would allow catching the intermediation margin that is currently in hands of Turkish companies that resale fresh anchovy from Georgia waters in Europe (Mathews, 2007). Additionally, the development of processing industry of anchovy would also contribute to the increasing of profits. The “Generalized Scheme of Tariff Preferences” of the European Union to promote trade with non-EU countries constitutes an opportunity to Georgia to commercialize fresh and processed anchovy in Europe where the largest importer of anchovy (Spain) is located (Eurofish, 2012).

4 Conclusions

The anchovy fishery of Georgia experienced a considerable decline at the end of the 1980s due to a Black Sea regime shift, virtually disappearing during the 1990s. At the beginning of

[9] The Minister order 7 (06.04.2011) of Georgian government has introduced some changes in the management framework that reduced even more fishing effort controls.

the 2000s, it recovered, encouraging the Georgian state to hire out a significant part of the annual Total Allowable Catch (TAC) to Turkish and Ukrainian vessels. This decision resulted in a significant reduction of the anchovy fish stock by the end of the decade due to the overcapacity of the fleet. The availability of reliable and accurate measures of the capacity and overcapacity of the fleet provides the policymaker with a useful tool for managing fishing capacity with the aim of avoiding fishermen's rent dissipation and/or the overexploitation it causes.

Since late 2006, the Ministry of Environment Protection and Natural Resources has implemented a new licensing system based on the auction of rights to fish in the EEZ of Georgia. The success of this management framework, which provides lucrative revenues to the Georgian state, is subject to bioeconomic sustainability of the fishery and therefore, adjustment of the fleets that exploit this fishery to the size of the fish stock. The results presented in this paper suggest that fishing capacity has increased during the first four seasons of this management framework and that the fleet that exploits it register significant levels of overcapacity in the last season.

A couple of DEA linear mathematical programs have been run as described in section 2.3 on the anchovy fishery of the southeastern Black Sea (Georgia) in order to measure fishing capacity, capacity utilization, overcapacity, and technical efficiency. Based on resulting estimates, the fishing capacity of the sample from the anchovy fishery is 99.37 mT, and the capacity for the whole fleet is 142.37 mT for the 2008-2009 season increasing during the considered period. The fleet has reached a considerable level of overcapacity in the 2008-2009 season, given that the estimated fishing capacity exceeds almost 2 times the TAC set by the policymaker.

Capacity utilization shows a considerable decrease during the last season, while during the first three seasons keeps stable around 79%. This observation suggests that there is a considerable level of overexploitation due to an annual TAC that has not limited the capture of any of the seasons. These results imply a considerable level of overcapacity and a reduction of the fish stock in the considered period. It is necessary to reduce the fishing capacity of fleets that operate in the southeastern Black Sea anchovy fishery posting in place an appropriate management framework that adjusts fishermen incentives and accounts for the transboundary nature of the anchovy fish stocks in order to guarantee its bioeconomic sustainability.

The mean technical efficiency of sampled vessels is 58% in all seasons. It is 52% in the last season while the rate of utilization of activity was 60.55% in the 2007-2008 season. This percentage would represent 860 days of activity under full utilization of this input.

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