

Cost and profitability analysis for a seabass production farm in Morocco

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Abstract. Cost production and profitability analysis was performed for a marine fish farm, located in M'diq Bay, in Morocco. Currently, it is the alone farm in operation on Moroccan Mediterranean cost while three others had been ceased their activity. Created in 1998, it has experienced three main periods during its history, start-up period, followed by a crisis period followed by a recovery period on which the present study has been focused on. Production costs analysis has shown financial results yielding a very low profitability (0.24%). Two main constraints were found to be relevant, one environmental related to the weak local annual seawater temperature profile (18°C in average, 14-21°C in range) and the other technical related to feed and fingerlings management. The use of SGR and TGC tools, based on real growing and production data, have allowed to establish suitable start-up date for annual batches. Feed and fingerlings constraints have analysed in order to contribute in production costs improvement. Results showed that total costs could be reduced and profitability improved following pertinent inputs management optimization, marketing strategies improvement and production plan adjustment. Support measures provided by public powers offer suitable opportunity to improve farm's financial results.

1 Introduction

Despite Moroccan marine fisheries has reached a total annual amount of about 1.5 million tons in recent years, marine aquaculture is still facing development constraints and sustainability problem, although suitable sites availability. The lack of substantial support, mainly in terms of incentive measures, represent a major bottleneck affecting aquaculture development. Investors seemed to be fear about domestic marketing risks because aquaculture products still not well perceived by domestic consumers. Unlike some European countries, Moroccan Government did not give any subsidies to aquaculture farms.

Shellfish culture has started in Morocco since the fifties in Oualidia lagoon on Atlantic coast and marine fish culture has begun in the late of eighties in Nador lagoon on Mediterranean coast. The first marine fish farm was growing both gilthead seabream,

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Sparus aurata, and European seabass, *Dicentrarchus labrax*. Afterward, three others marine fish farms have been established on Mediterranean coast, one in early nineties near Moulouya river estuary and the two others in late nineties in M'diq bay and Martil bay. They all have been growing seabream and seabass with same main targeted market, the European one. However, their contribution to national cultured fish production was low and variable. Maximum total production was 1,224 tons achieved in 2005, followed by a sudden great collapse in 2006. The maximum marine aquaculture production amount, recorded for both fish and shellfish, was 1,500 tons.

Seabass and seabream selling prices collapse in European market, occurred since the beginning of 2000s [1], had negative effects on Moroccan fish farms. Three of the four said fish farms have successively ceased their activity. Selling process of seabass and seabass have collapsed and became lower than these three farms' production cost. Moreover, national market for aquaculture products was very weak and attempts to reduce the production cost have been disadvantaged by the dependence from foreign inputs (fingerlings and feeds) and their high import taxes. If they would sell their products in domestic market, they should first pay these inputs taxes; if not, they could import these inputs in a temporary admission way (legal procedure) but, in this case, they should to export their products to foreign market. The exported quantity is legally based on imported feed amount, using a standard feed conversion rate of 2. This was possible when European market was interesting in terms of selling prices.

Nowadays, only one marine fish farm is still in operation; it is located in M'diq Bay, in the West part of Mediterranean coast of Morocco. Since 2006, it sells its farmed seabass in domestic market while reducing, its production cost and optimising its farming process as much as possible. It has tried using local manufactured fish feed (first pressed then extruded) and locally produced seabass fingerlings through INRH's experimental marine fish hatchery. The later could not satisfy its total need of this farm in fingerlings because of its small scale. So, since 2010, and due to domestic market need in farmed fish, it has been forced to restarted importing small fish from foreign hatcheries, paying import fees and taxes.

In this context, the present study was carry out for and with joint cooperation of this seabass farm in M'diq. The purpose consisted in seeking for opportunities allowing to reduce production cost and optimize selling price of its products to avoid losses and ensure even a minimum profitability allowing first its survival while keeping working for its development. As reported by [2], the profitability of fish producers is mainly a result of two factors: sale price and production costs, and according to [3], the better understanding of the relevant elements and their interrelationships inside the entire production process allow to achieve a sustainable and profitable aquaculture operation. So, considering several studies conducted in different countries, dealing with productivity and efficiency analysis and on structural and economics analysis of fish farming, the present study was focused on cost and profitability analysis of M'diq seabass farm. It is crucial for the development and management of M'diq seabass farm to know its production cost structure and evolution and to search where it could be possible to react to reduce its production cost. For this reason, the present study aimed at providing M'diq seabass farm a clear visibility about options of management improvement in terms of production cost and selling price under which it could be able to ensure a profit margin allowing its sustainable exploitation.

2 Materials and methods

2.1 Site characterization of sea bass farm in M'diq

Seabass farm, subject of the present study, is located in M'diq Bay, in Morocco. The distance between the farm site and the local harbour is about 1.6 km. Currently, this bay still represents the only exploited site for Moroccan marine fish culture. It is located in the west part of Moroccan Mediterranean coast, between Sebta Cape ($35^{\circ}54'N$, $5^{\circ}17'10''W$) and Negro Cape ($35^{\circ}40'N$, $5^{\circ}16'40''W$). M'diq bay stretches for 23 km in length with a water surface of about 150 km^2 [4]. It is located close to Gibraltar Strait and oriented North-South between two Caps (Sebta and Negro) and limited by Mediterranean Sea in the East and a mountainous hinterland in the West. Current average speed in fish framing site is 0.12 m/s with a maximum of 0.27 m/s. Tidal currents directions are North-West at rising tide and South-East at ebb tide with a tidal range of 20 to 80 cm. The swell could reach a height of 5.5 m with an associated period of 5 s. The seawater temperature regime ranged between 14°C in February-March and 21°C in August-September. The salinity is about 36.0 ‰ to 36.6 ‰ along the year.

2.2 Production system characterization of sea bass farm

M'diq seabass farm has 14 high density polyethylene (HDPE) floating cages of 12 m in diameter with 10 m useful net depth. It has been set up in the South part of M'diq Bay in 1999 with a total investment of 30 million dirhams (Moroccan money (MAD)). Its nominal production capacity is estimated at about 200 tons. The production cycle is variable from 18 to 22 months. Feed and fingerlings are imported from Europe countries, mainly France. Seabass growing culture system is based on the intensive method using a final fish density of about 20 to 25 kg/m³. Mortality ratio is less than 20%.

Seabass fingerlings have an initial weight of 3 to 8 g. Fish are fed three to twice a day for younger stages and once a day for large stages. Feeding rates are expressed as percentages of fish biomass of each cage, depending on fish monthly average weight and daily seawater temperature. Commercial feed designed for seabass is used, first entirely imported and then partially replaced by locally produced feeds. Fishes are harvested when their mean body weight reached at least 300 g. Commercialsizes are mostly composed of 300/400 g (designed as 3/4), 400/600 (4/6) and 600/800 g (6/8) and also but, sometimes, they include others sizes such as 200/300 g (2/3) and over 800 g. Fishes are sold along the year round, fresh and packaged in 10 kg polystyrene. Their selling prices of seabass are variable, depending on commercial range size and also seasons.

M'diq farm has buildings located inside land area of M'diq fishing port. These buildings comprise a warehouse, cold chamber for harvested fish, room storage for feed, room storage for nets, offices, toilets, changing rooms, handling room, etc. It owns an aquaculture boat and uses loading and unloading dock. The farm staff were educated locally.

2.3 Data source and economic analysis methodology

Data and values used in this study were collected from M'diq seabass farm, covering a period ranged between 2010 and 2016. These data include technical characteristics, zootechnical parameters, production plan, investment budget and costs of different production components. So, cost structure and the financial and economic analysis were made based real seabass production data. This study was performed based on seabass growing batches with starting farming date recorded from 2010 un until 2015, and fish sales data recorded from 2012 until 2016. It covered production cycle of each growing batch, from stocking fingerlings until harvesting commercial fish sizes.

Economic analysis was based on an average production year, calculated from real farm data to determine production cost and estimate profitability in terms net return and benefit/cost ratio. A comparison of production cost and its breakdown components was to provide a better understanding of cost structure and its relative production efficiency. Total production cost structure includes variable and fixed costs which are related to fish farm operations along the year. Variables costs components include feed, fingerlings, taxes related to feed and fingerlings, marketing and others variable costs. Fixed costs components include labour, repair and maintenance, service provision, premises rental, insurances and taxes, depreciation financial expenses and others fixed costs.

Economic analysis was based on farm-gate prices of harvested seabass and current local markets (MAD). Data on operating expenses including information required for variables and fixed costs calculation were provided. Profitability analysis was performed in static economic study framework, considering average values of income and expenses, based on an average production year calculated for a period of 5 years (2012-2016).

Total income was calculated by multiplying total sales (kg) by their average sale price (MAD/kg). Net return (MAD/kg) was assessed by subtracting production costs from average sale price. The Benefit/Cost ratio (profitability) was calculated as net return divided by production cost; it indicates the net gain generated by the farm for each spent monetary unit.

2.4 Bioeconomic model

Bioeconomic model was carried out with the same data as in the previous paragraph. Many strategic and operational decisions in fish farming can be optimized by mathematical modelling, e.g., stocking strategy, feeding rate, harvesting time, and harvested weight [5]. However, the complexity of the aquaculture production process in open sea makes difficult to find universal optimal solution.

To help making optimization decisions at farm level, analysis should involve general characteristics study of the production function describing relationships between inputs and outputs in the production process [6]. The latter is described over a limited period, by fish weight (W), number of fish (N), time (t), production costs (C) and revenues (R) [5]. For each batch, decision variables are stocking time (ti), initial weight of stocked fingerlings (Wi) and final weight of harvested fish (Wf) [5].

Seawater temperature conditions in fish farming is not able to be controlled. It is a constraint that should be considered deterministic. Feeding rates are managed according to feed quality, rearing site temperature and fish size. Stocking time and initial weight of fingerlings and stocking densities are also managed according to farm production strategy and farming site conditions, mainly seawater temperature profile. Number of fish growing batches per year is defined by fish farmer taking in consideration production cycle length, harvesting time and fish harvested weight.

Among pertinent factors influencing fish growth, seawater temperature, initial fish weight and feeding quality and quantity are essential for bioeconomic analysis. However, considering [1, 7] works, respectively for gilthead seabream and sharp snout seabream farming in sea cages in Spanish Mediterranean coast, a growing simulation is made based on initial and final average weight of cultured seabass (5-400 g) and rearing site temperature conditions (14-21°C), recorded in seabass floating cages farm in M'diq bay.

An estimated production plan was prepared based on fish growth performed according to growth model [8] or Thermal Growth Coefficient (TGC) model [9, 10, 11, 12, 13], taking into account the effective temperature or the minimum temperature for growth. The TCG calculation formula is as follows:

$$TGC = \frac{(W_f^{1/3} - W_i^{1/3})}{\sum (Tef)} \quad (1)$$

- W_f : Final Weight;
- W_i : Initial Weight;
- ΣTef : sum of effective temperature = $15 \times (\text{Tef biweekly average} - 12^\circ\text{C})$

Effective temperature of seabass is 12°C [14]. On this basis, a seabass growing model was developed for each month of the year, based on an initial mean juvenile weight of 5 g until a mean marketable fish size of 400 g, to determine the best possible fry stocking periods for better yields as a function of temperature. So, three annual batches should be chosen among the ten monthly possibilities simulated, in which the cycle was relatively shortest and allowing both commercial sizes throughout the year. M'diq farm has introduced fingerlings in each month from December to September since 2010 until 2015, based generally on three, or sometimes two, introductions per year. Introduction date choice varies according to empty cages availability. So, in each year, subsequent three new batches of juveniles should be added to the existing rearing fish stock in the fish farm in the same months that have been selected and which could be obviously taken into account in calculating feed consumption [7].

An average TGC values was calculated from real growth results in M'diq farm, for each of the ten monthly batches (i.e. fingerlings stocking month) and the effective temperatures were calculated from daily temperature data recorded during 2010 until 2016. Starting with 20 batches corresponding to the first and second fortnight of all the ten months of the year (designated as Jan-d1 for the first fortnight in January, Jan-d2 for its second fortnight, and so on the others months), the growth of seabass was estimated by elaborating a summary table of weights in order to choose three among them, so that sales of each batch could last for four months in such a way to cover continuously fish demands throughout the year. For each of selected batches, a production and feeding plan could be elaborated by the fish farm, through determining a series of parameters such as number of fish, biomass, total feed consumption and cost, as well as cages number needed to carry each seabass batch until cultured fish reach 400 g, following [14, 15] methodology.

3 Results and discussion

3.1 Seabass sales evolution of M'diq fish farm

Considering total cage size, the said farm has a total rearing volume of $15,825.60 \text{ m}^3$ which allow a yearly production capacity of about 200 tons. Figure 1 shows annual sales evolution since the starting year (1998) until 2016.

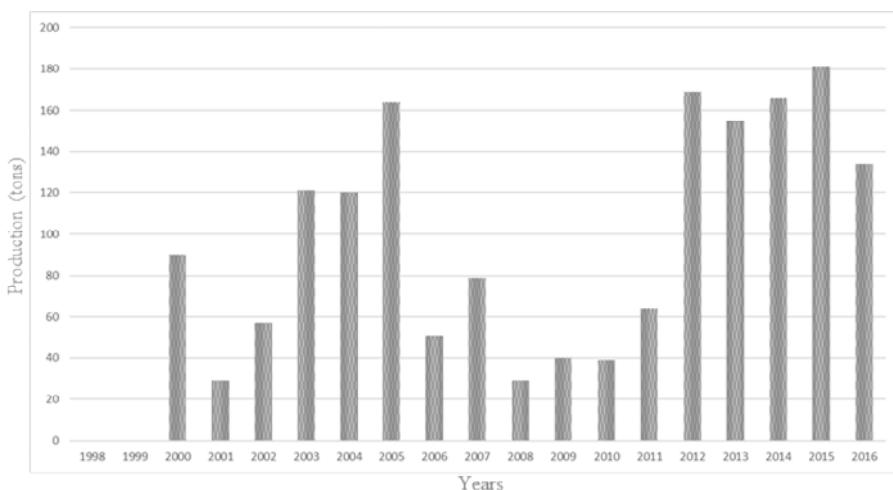


Fig. 1. Annual sales (in tons) evolution of M'diq fish farm (1998-2016).

This figure shows three main periods characterizing the production (considered through sales) evolution of the M'diq farm, including start-up period, followed by a crisis period and then a recovery period. The first one, lasted from starting year until 2005, was generally characterized by a gradual increasing sale totally destined for export, to Spanish market. Then, after the shares held by foreign shareholders were sold and purchased by Moroccan shareholders in 2006, where M'diq farm was forced to change its targeted market by domestic market during the crisis period, lasted from 2006 to 2011. Its production has been reduced less than 80 tons because of limited availability of locally produced seabass fry. Also, sales were mostly intended for a single customer, a supermarket. Furthermore, when recovery period has begun in 2012, after a shareholding of foreign shareholders in 2010, M'diq farm restarted to operate at its full capacity, by importing seabass fingerlings from foreign hatchery and increasing its fish sales, reaching 160 to 180 tons/year. The targeted market remains domestic with diversification of customers, composed both of supermarkets and restaurants through wholesalers.

During its life history, sales of this farm have recorded an average value of 99,3 tons/year, oscillated between a minimum of 29 tons recorded in 2001 and a maximum of 181 tons recorded in 2015. Considering recovery period, mainly from 2012 until 2016, annual average sale was about 161 tons, ranged between a minimum of 134 ton recorded in 2013 and a maximum of 181 tons recorded in 2015. Seabass sales vary also inside each year; monthly sales evolution recorded in this recovery period is shown in Figure 2. Overall monthly average sale was 13,634 kg ranger between a minimum of 211 kg recorded in December 2013 and a maximum of 31,955 kg recorded in November 2016.

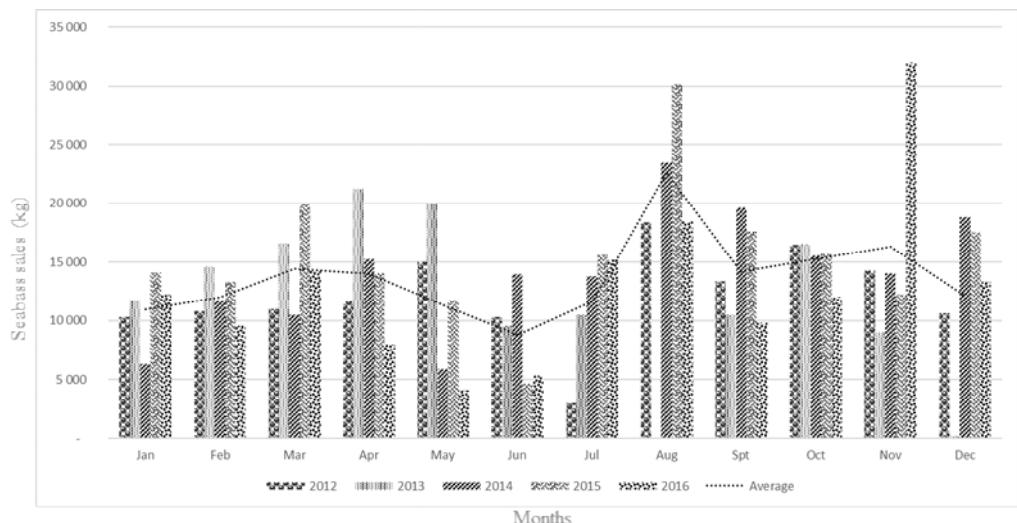


Fig. 2. Monthly sales (in kg) evolution of M'diq fish farm (2012-2016).

Fish sales are performed throughout the year with a monthly variability characterized by a seasonality usually composed of two main periods of high sales, the first in March and April and the second in June, July and September. This monthly sales variability is mostly influenced by fish orders importance, ordered commercial fish sizes availability in fish farming stock and losses level caused by storms and pathologies. Storm losses have been occurred in March 2012 (all fishes (61,559) from one cage after being grown for 21 months), in November 2012 (all farmed fishes (64,288) from one cage and a part of farmed fishes (21,667) from another cage after being both grown for 8 months), in February 2013 (parts of farmed fishes from four cages) and in February 2015 (all farmed fishes (83,983) from one cage after being grown for 10 months). Main pathologies losses were happened in 2012, first in April in two cages containing farmed fishes aged of 17 months and the second in following month (May) on other two cages containing fingerlings introduced in the previous month (April). Also, monthly sales were affected by Ramadan (fasting month) occurrence during which sales of farmed fish are reduced, mainly because of orders lack from restaurants which are closed during Ramadan month. It has been occurred during July and August in 2012 and 2013 and during June and July in 2014, 2015 and 2016. It lasted 29 to 30 days and is advanced 11 days from year to another. Ramadan influence on sales is very important and is well taken in consideration by farm manager in his marketing strategy.

3.2 Analysis of production costs

Although M'diq farm's production has been significantly increased since 2012, profitability remained a critical. It has been facing technical and financial difficulties. Production costs analysis was based on realistic data related to recovery period. However, production costs were calculated based on an average year data calculated from recovery period's real data to serve as a basis for this study purposes. Table 1 shows production costs of this average year.

Table 1. Production costs of seabass average year production in M'diq's farm.

Items	Average operating year		
	MAD/kg (± standard deviation)	% (partial)	% (total)
Feed cost	27.41(± 5.85)	54.52	37.06
Fingerlings cost	9.91(± 2.40)	19.71	13.40
Feed & Fingerlings Taxes cost	5.16(± 0.95)	10.27	6.98
Marketing cost	3.32(± 0.56)	6.60	4.49
Others variable costs	4.47(± 0.56)	8.90	6.05
Total variables costs	50.27(± 3.83)	100.00	67.98
Labour cost	11.74(± 2.18)	49.59	15.88
Repair and maintenance cost	1.58(± 1.14)	6.67	2.14
Service provision	1.54(± 1.11)	6.51	2.08
Premises rental	0.17(± 1.12)	0.72	0.23
Insurances & taxes	1.11(± 0.80)	4.68	1.50
Depreciation cost	1.53(± 1.11)	6.46	2.07
Financial expenses	2.10(± 1.52)	8.86	2.84
Others fixed costs	3.91(± 2.82)	16.52	5.29
Total fixed costs	23.68(± 6.88)	100.00	32.02
Total costs	73.94(± 4.48)		100.00

Economic analysis of M'diq's fish farm production system revealed that seabass cost production is 73.94 MAD/kg for an average year production. Variable costs were a little bit more than the twice of the part shared by fixed costs in the total costs, having respectively 67.98% and 32.02%. These data are similar to those reported by [3] for seabass farms in Turkey, respectively 67.49% and 32.51%.

Variable operating costs are very influenced by two major elements, feed and fingerlings; they both represent 84.50% including their taxes fees. The latter is composed 61.62% of feed taxes and 38.38% of fingerlings taxes. In fact, imported feeds and fingerlings are subjected to customs duties (CD) and value added tax (VAT). They are respectively of 25% (CD) and 20% (VAT) for imported feeds and 20% (CD) and 10% (VAT) for fingerlings. Since 2016, VAT has been reduced to 2.5% for two years in case of imported feeds and cancelled (0%) for imported fingerlings.

So including these taxes, feed showed the highest part in variables costs with 60.85% followed by fingerlings with 23.65%. These values are higher than those reported by [3] in Turkey for sea bass farms with respectively of 47.73% and 10.43%. Therefore, any effort of optimization of these feed and fingerlings costs, allowing even a little reduction level of the hole operating costs, would have a positive effect on the fish farm profitability. Their respective part in total costs are respectively 37.06% and 13.40% without taxes and 41.37% and 16.06% including their taxes, totalling both a common part of 57.45%.

Fixed costs seemed to be greatly influenced by one major element, the labour; it represents almost 50%. On the overall operating costs, it is the third most influencing, after feed and fingerling, with a part of 15.88%. The latter value is lower than the one reported by [3] in Turkey for sea bass farms with 22.59%. In M'diq case, feed, fingerlings and labour both account for about three-quarters of production costs, with 73.32%. These

factors, and particularly feed and fingerlings, influence a lot the farm profitability. The latter is presented in the Table 2.

Table 2. Profitability of sea bass average year production in M'diq's farm.

Items	Values	Standard deviation
Total sales (kg)	160,463.67	17,828.12
Average sales price (MAD/kg)	74.12	0.93
Total income (MAD)	11,893,567.22	128,088.25
Total production (kg)	171,647.78	22,693.08
Production cost (MAD/kg)	73.94	4.48
Net return (MAD/kg)	0.18	0.19
Benefit/Cost ratio (%)	0.24	0.28

The total income of M'diq farm is of about 11.9 million MAD for an average year, with a net return of 0.18 MAD/kg and a benefit/cost ration of 0.24%. According to data reported by [3], Turkish seabass farms have shown values of net return and benefit/cost ratio respectively of 0.48 US\$ and 1.10 (i.e. 10%). Environmental conditions in Turkey sea farming sites are not same than those in Morocco; Turkish conditions, mainly annual temperature profile, allow shorter seabass production run cycle.

Considering its variable contribution margin, which resulted from subtracting variable production costs from revenue. It is important tool because it gives an idea about available margin for the payment of fixed costs and most useful for making incremental pricing decisions in such a way to allow setting prices high enough to cover fixed costs and generate profit. For the M'diq farm, variable contribution margin is of 23.85 MAD/kg (average sales prices (74.12 MAD/kg) - variable costs part (50.27 MAD/kg)). This margin is so small that it just covers fixed costs without generating sufficient profit. This situation is critical and does not give the fish farm enough means to develop its activity and ensure its durability.

The main constraints pointed out by the local fish farm in M'diq which could be considered much affecting negatively the production cost are the lack of capital, the highest price of the local feed, the far-away sea bass fingerlings source, the high charges of taxes and the seasonal disease and the lack of sorting fish stock (high heterogeneous sizes in fish stock in each cage). Among these factors, feed and fingerlings, mainly in terms of price, quality and taxes fess, are considered to be the most important constraints for the local fish farm in M'diq, and even for former three marine fish farms that have ceased their farming activities.

Regarding to M'diq farm current production system, it follows intensive seabass farming technique. According to its recovery period's data, it bought annually an average number of 635,117 seabass fingerlings of 3 to 8 g in individual body weight average. The growing cycle of seabass in M'diq Bay conditions is ranged between 19 and 25 months, depending on the period of fingerlings introduction in rearing fish stock. Total average feed conversion rate is 2.1 (1.9 to 2.6) and harvested densities are about 20 kg/m³. Some factors such as initial stocking densities, the quality and quantity of feed supply, labour qualifications and managements skills are well taken in consideration. The current densities of the farm are however not managed with size to re-establish fish population homogeneity before reaching commercial sizes because of the lack of a suitable fish sorting device.

Sure, even when starting from a homogeneous population of fry, a significant spread in growth and in biomass distribution is usually observed [16, 17]. According to these authors, seabass growth exhibits a slower dynamic below a critical temperature of about 10°C. It is

not the case in M'diq Bay where the minimum seawater temperature is much higher than this value.

Considering marketing characteristics, M'diq farm sold basically its seabass fishes when they reached an individual body average weight of 300 g or more. In spite of the fact that sea bass sold price fluctuates with seasons, average wholesale price is about 74.12 MAD/kg (Table 2). The market price of aquaculture products mainly depends on size and weight, quality, seasonality, supply and demand and competitiveness [18].

To try to improve its economic results, M'diq farm should consider optimization of its production plan, mainly on structural and managerial aspects. For the first one, it is planning to increase its total production volume capacity without significant added investment; and for the second one, it is focused on feed and fingerlings optimization uses.

3.3 Improvement through structural aspect

M'diq farm introduces yearly about 630,000 seabass fingerlings to be stocked in 7 cages of individual volume of 1,130 m³. The decision of these fingerlings introduction depends on the availability of empty cages according to the planned number of batches. It is necessary to have at least 2 empty cages available in order to ensure that the transport costs using a tank truck could be appropriate.

Right now, M'diq farms uses multi-batches production, by stocking fingerlings through three batches a year, over a time period of four to ten months, depending on harvesting time (availability of harvested or empty cages). When fish are actually harvested, space is made available for new fish; this is important, as the availability space in fish farms is limited. Furthermore, the present farm performed partial harvests during two to four or five months, based on a weekly harvest frequency.

The rotation of cages utilization depends upon the fish growing performances which influences, in its turn, the batches cycle and the harvested time [5]. It is useful therefore to find out an optimal rotation time for the batches of seabass in M'diq bay conditions, i.e., the time for harvesting each fish culture batch and stocking the next. The best economic results will basically be obtained by producing the maximum number of batches in appropriate period, regardless to larger fish size.

So, to overcome this constraint, it has been set up additional small cages, of 7 m in diameter in each, which have been used to stock fingerlings for a short period of pre-growing before having empty cages available for growing. In fact, 7 small cages have been set up in the same farming site without any additional investment in supporting and mooring systems. They were suitable for stocking seabass fingerlings of an average weight of 3 to 5 g. They have allowed appropriate fingerlings introduction schedule and commercial sized fishes sales. They have also allowed to avoid seasonal outbreak of some diseases in seabass fingerlings when introduced in farming fish stock which occurred in summer period causing high mortalities and reducing the value of harvested fish.

If this working strategy, M'diq fish farm could then invest in expanding its production capacity. Moreover, once the fixed investment has been made, farm production decision should be based on expected return or income above variable costs. Fixed investment is considered as sunk cost and may not be recovered in short-run period of at least one production cycle.

3.4 Improvement through managerial aspect

This aspect is very pertinent. To improve variable contribution margin and to increase profit of M'diq farm, feed and fingerlings management should be improved according to local conditions. The importation of these two inputs from foreign origins increase variable

operating costs, both through taxes fees and also exchange ratio of MAD to Euros. Local feed has been used since 2005, first as pressed pellet then as extruded pellet while the use of locally produced seabass fingerlings by a small experimental hatchery could not be maintained for reasons of limited production not satisfying farm's needs. The lack of local commercial marine fish hatchery Regardless of farming system, the lack of a local commercial marine fish hatchery has then forced M'diq farm to import again seabass fingerlings from foreign hatcheries.

Marketable seabass sizes are harvested usually after a growing period ranged between the 18th and 23th month, but, in fact, harvested weights are usually given by market conditions and consumer preferences. Fish growth can be influenced by several factors, including fish weight, water temperature, feeding rate, water quality, diet quality, stocking rates and environmental conditions [6]. In M'diq Bay, where the concerned fish farm has its rearing site, the annual temperature profile is estimated a little bit weak to allow good growth performances. It is characterized by an annual average of 17.6°C with a minimum and maximum monthly average values of 14.2°C and 20.7°C respectively.

The analysis of growth performances of all growing batches performed between 2010 and 2015 has allowed to draw average growth curves for every monthly batch among the ten, conducted from December to September (Figure 3).

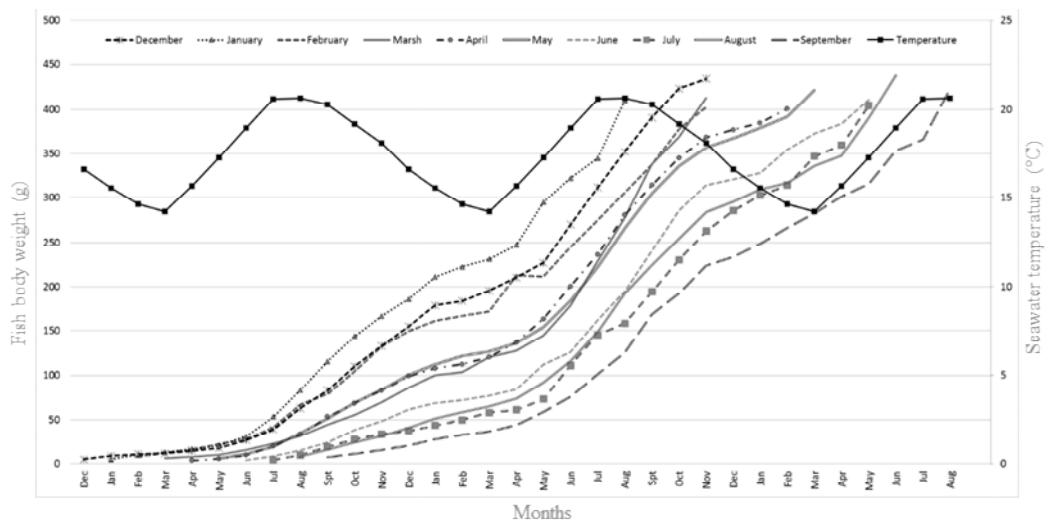


Fig. 3. Average growth curves of the monthly batches conducted by M'diq fish farm during the period of 2010 and 2015.

As showed in Figure 3, temperature influence when fingerlings were first introduced in stock culture is very important. According to these real data, batches started in January showed better results than those introduced in December. The growth during the first months after introduction became a little bit faster as fingerlings date is closer to warm season. The analysis of these growth curves could suggest that three introductions a year, in January, March and May would be important as they would allow harvesting commercial fish sizes (of 400 g in average weight) respectively since July, November and March with sales lasting during four months each.

The analysis based on Specific Growth Rate (SGR) was performed on all monthly batches data, using the following formula [12]:

$$SGR = (\ln W_f - \ln W_i) / days \quad (2)$$

Where (\ln) is natural logarithm, (W_f) is final weight and (W_i) is initial weight.

Table 3 shows results relating to SGR analysis, calculations for each monthly batch of seabass lots grown in M'diq fish farm from real data recorded since 2010 until 2015.

Table 3. SGR average data calculated for monthly batches of growing seabass lots in M'diq's farm (2010-2015).

Batches	SGR				Time (months)
	M6 (%d ⁻¹)	M12 (%d ⁻¹)	M18 (%d ⁻¹)	Bc (%d ⁻¹)	
December	0.69	0.90	0.70	0.64	22
January	1.00	0.99	0.76	0.73	19
February	0.90	0.82	0.65	0.59	21
March	0.91	0.78	0.70	0.66	20
April	1.49	0.97	0.82	0.68	22
May	1.34	0.86	0.74	0.61	22
June	1.36	0.91	0.80	0.64	23
July	1.22	0.91	0.78	0.63	23
August	1.02	0.80	0.67	0.57	22
September	0.84	0.79	0.66	0.56	23

With: M6, M12 and M18 respectively the 6th month, 12th month and 18th month of the growing cycle and BC means batch growing cycle

In this table, SGR are calculated for each growing period of six months' intervals, mainly at the 6th month (M6), the 12th month (M12) and 18th month (M18) during the growing cycle and also for the whole batch growing cycle (Bc). The analysis of these data showed that SGR in M6 are very low in January's batch and very high in April's batch. M6's SGR data showed a decreasing trend from April's batch toward September's batch then it a little bit increased in January's batch with a relative stabilization in February's and March's batches. Moreover, M12 and M18 showed same trend but their SGR values are very low comparatively to those of M6. Except for the December's batch, all the other month's batches showed a proportional decrease of SGR's values with their fishes ages. This evolution is highly marked for batches started in April, May, June, July and August.

Considering these characteristics showed in Table 3, batches started in January, March and May seem to be very interesting for selection as common practice of regulated seabass fingerlings recruits since they showed relatively highest SGR values and also appropriate batches cycles.

To highlight the importance of the effect of seawater temperature when fishes are introduced and also the subsequent evolution of temperature according to the local pattern of its annual profile, it was judged to use growth curves simulation based on thermal growth coefficient (TGC) (Table 4 and Figure 4).

Table 4. Calculation of TGC data based on monthly batches of growing seabass lots in M'diq's farm (2010-2015).

Batches	Wi (g)	Wf (g)	T-av. (°C)	STef (°C)	TGC (g ^{1/3} °C ⁻¹)
December	5.00	423.70	17.60	3,96	0.00146
January	5.00	410.00	17.50	3,30	0.00173
February	8.00	402.50	17.60	3,76	0.00143

March	6.00	413.00	17.80	3,73	0.00150
April	3.50	401.00	18.00	4,36	0.00134
May	6.00	422.00	18.10	3,68	0.00154
June	4.00	411.00	17.80	3,99	0.00146
July	4.00	404.50	17.70	4,14	0.00140
August	8.00	414.00	17.80	4,05	0.00134
September	7.00	424.00	17.40	3,73	0.00150

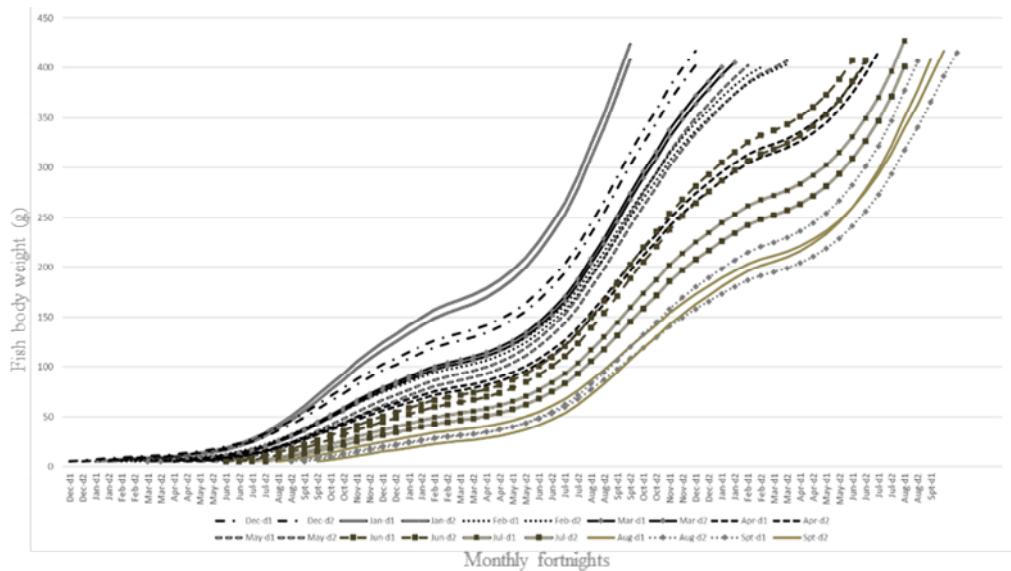


Fig. 4. SGR average data related to growth evolution of monthly batches of seabass growing lots in M'diq farm (with: Jan-d1 for the first fortnight in January, Jan-d2 for its second fortnight, and so on the others months).

In Table 4, the meaning of used terms is initial weight for W_i , final weight for W_f , average temperature of each batch period for T_{-av} , cumulative effective temperature (effective temperature is temperature in degrees' Celsius minus 12) for STef and Thermal Growth Coefficient for TGC.

The comparative analysis of these data showed that preselected monthly batches (January, March and May) have TGC respectively of 0.00173, 0.00150 and 0.00154 (Table 4). Simulated growth curves showed in Figure 4 allowed selecting the three preselected monthly batches as suitable for production planning in seabass farming in M'diq fish farm conditions. This proposal procedure based on small pre-growing cages and introduction plan of seabass fingerlings (may be initial average weight ranged between 5 and 10 g) should allow fish growth improvement and economic results.

Furthermore, Moroccan Government measure related to the exemption of customs duties and value added tax (VAT) came into force since the beginning of 2018 for five years, should allow M'diq farm to improve its economic resultants (Tables 5 et 6). This measure is very important since fishes are sold tax free in Morocco and therefore do not allow aquaculture farms to recover VAT paid for inputs used during the production process. Imported fishes are however subjected to VAT (20%).

Table 5. Production seabass costs in M'diq's farm after exemption of customs duties and VAT since 2018.

Items	MAD/kg	% (partial)	% (total)
Feed cost	27.41	60.76	39.85
Fingerlings cost	9.91	21.96	14.40
Feed & Fingerlings Taxes cost	0.00	0.00	0.00
Marketing cost	0.00	0.00	0.00
Others variable costs	3.32	7.36	4.83
Total variables costs	45.11	100.00	65.58
Labour cost	11.74	49.59	17.07
Repair and maintenance cost	1.58	6.67	2.30
Service provision	1.54	6.51	2.24
Premises rental	0.17	0.72	0.25
Insurances & taxes	1.11	4.68	1.61
Depreciation cost	1.53	6.46	2.23
Financial expenses	2.10	8.86	3.05
Others fixed costs	3.91	16.52	5.69
Total fixed costs	23.68	100.00	34.42
Total costs	68.78		100.00

Table 6. Profitability improvement of seabass in M'diq's farm after exemption of customs duties and VAT since 2018.

Items	Values
Total sales (kg)	160,463.67
Average sales price (MAD/kg)	74.12
Total income (MAD)	11,893,567.22
Total production (kg)	171,647.78
Production cost (MAD/kg)	68.78
Net return (MAD/kg)	5.34
Benefit/Cost ratio (%)	7.76

Exemption of customs duties and VAT, performed since 2018 should then allow reduction of variable costs to reach 45.11 MAD/kg instead of 50.27 MAD/kg, improvement of production cost which could be reduced to 68.78 MAD/kg instead of 73.94 MAD/kg, improvement of variable contribution margin which could reach 29.01 MAD/kg instead of 23.85 MAD/kg, sufficiently higher to cover fixed costs (23.68 MAD/kg) and allowing an increase in net return and benefit/cost ratio, respectively to reach 13.24 MAD/kg instead of 0.18 MAD/kg and 7.6% instead of 0.24%.

With regard to mortality, fish losses contribute also to affect fish farm results. One should distinguish between mortality due to particular pathology and a physiological (or natural) mortality. In M'diq farm, mortality is followed and counted once every two or three days and reported on a monthly basis. The recorded data showed an average of mortality (both natural and pathologic) of 14.66% with 5.6% and 47.0% respectively as minimum and maximum recorded values. There are also lost fishes discovered when comparing final harvested fishes number to initial introduced number of fingerlings from

witch mortality number is subtracted. This kind of loss accounted on average 17.49% with a minimum and maximum values respectively of 6.4% and 39.1%. The total loss of fishes reached on average 32.2%; the overall survival rate is then 67.8% that should be improved to reduce the impact of this farmed fish loss on the economic farm results.

Pathologies occurred generally when introducing fingerlings during summer months and fish's loss by storms occurred mainly in winter season, following rips of old nets. Furthermore, concerning fish's loss, it seems also that there is may be another reason which could be related to fingerlings quality, particularly in terms of sizes heterogeneity level and deformities level. The analysis of the introduced fingerlings batches showed some different values of coefficient of variation (ratio of the standard deviation to the average weight of fingerlings). It is a statistical measure of the dispersion of data points in a data series around the mean. The recorded values are ranged between 15.65% and 20.27%. So, in case of higher values, cannibalism could happen, mainly between biggest and smallest fingerlings and juveniles or when heterogeneity level increase with fish's age. According delivering hatchery, initial fingerlings average weights are ranged between 2.88 g and 5.21 g (sampling data recorded few days before delivery transport). Also, recorded deformities values ranged between 1% and 6%. The major part of fingerlings batches has deformities level more than 3%. No one could know what should happen to these deformed fishes but they are very vulnerable.

Concerning feed performances, for each fish weight class, the feed amount to supply is computed as a function of water temperature and monthly fish average weight using locally appropriate data, established on the basis to feeding tables provided by aqua-feed suppliers and adjusted following local experience. At the end of fish growing batch, a global value of feed conversion ratio ($FCR = \text{Feed supplied} / \text{fish weight gained}$), is computed as a ratio of the provided feed and the harvested fish biomass. There is a common practice of overfeeding when production is undertaken in off-shore cages with the advantages of natural recirculation [6].

The average value recorded for FCR in M'diq farm is equal to 2.1 with a minimum and maximum respectively of 1.9 and 2.6. These values are accounting data, including feed used even for fishes lost or died during growing process. Improvement of quality, in terms of formulation and used ingredients, and quantity by optimizing feeding rationing is a key factor to reduce feed cost and improve growth performances.

Experiences still are conducting to improve local seabass feed, using locally available ingredients and aiming also to reduce as much as possible the used level of fish oil and fish meal.

It is therefore evident that the management benefits depend on the accuracy in the predicted trends for the exogenous variables, especially market and prices. It is also clear that, due to the complex interactions of the many variables affecting the production process, the optimal management strategies cannot be provided by simple rules [16]. Study of the national farmed fishes market and the diagnosis of its regional typology will allow to develop knowledge about on commercial fish sizes' needs of different domestic market branches and to be able to adopt marketing strategic according to the demand evolution. On the average, M'diq fish farm sold different commercial sizes of its farmed seabass (Table 7).

Table 7. Average composition of commercial sizes of farmed seabass sold by M'diq fish farm.

Commercial fish sizes	Average operating year		
	% (in amount)	% (in value)	Average prices (MAD/kg)
200-300	18.90	15.25	60.70

300-400	35.30	34.81	74.21
400-600	39.50	42.07	80.16
600-800	5.80	7.21	93.53
800-1000	0.50	0.66	99.15

As shown in this table 7, the two important commercial fish sizes are 300-400 g and 400-600 g shared both a cumulated part reaching 74.80%, with individual parts of 35.30% and 39.50% respectively. Their average sales prices are respectively 74.21 MAD/kg and 80.16 MAD/kg and are higher than the production cost (73.94 MAD/kg). They both shared 76.88% of the farm income. Large commercial fish sizes (> 800 g) are very interesting in terms of average sales price. The latter is more than 90 MAD/kg. This category of fish size represents 6.30 % in amount and 7.87% in value in the case of M'diq farm. It worth to be developed much but in real proportional trend of domestic market. By the way, several previous studies underwent in others countries have concluded that batches producing larger fish sizes allow to reach higher operating profits due to their higher value in the market [5, 19, 20].

The main fish sales constraint in terms of commercial fish sizes is the part of small harvested fishes (< 300 g). This category is sold on average at 60.70 MAD/kg in the case of M'diq fish farm. This sale price is quite lower than the production cost with lost gap of 13.24 MAD/kg. This category of fish size represents 18.90% in amount and 15.25% in value. To reduce the impact of fish size category lower than 300 g, M'diq farm should to perform fish sorting and include it in its production plan or, if not, increase the average fish weight threshold to begin harvesting and sales from 300 g to more than 350 g. According to [6], the results show that optimal decisions about the ration size approach observed managerial practices. This optimal decision involves a trade-off between biological and economic inputs.

Finally, it is important to explore technical and market feasibility to develop new product alternatives of framed seabass for commercial exploitation. M'diq farm have recently tried it but opportunities of this potential different market is still under investigation taking into account socio-economic aspects and consumer requirements. M'diq farm is very interesting undergoing experimental works aiming at evaluating and improving its farmed seabass market performance through an appropriate supply chain, market-oriented design of diversified or new types of added-value its products for Moroccan consumers. This may contribute to diversify aquaculture products and enhance Moroccan aquaculture farms competitiveness.

4 Conclusion

The present study has examined biotechnical and economic characteristics of a marine fish farm in M'diq Bay, in Morocco. It analysed its seabass production costs and profitability. This farm was created in 1998 and started fish production in 2000. Three main successive periods characterized its history: start-up period, crisis period and recovery period. The present study has been focused on the latter period.

The production system is composed of 14 floating net-cages of 12 m in diameter, placed in open sea in M'diq Bay. Annual farmed seabass sales are ranged between 134 tons and 181 tons. Production costs, calculated over the recovery period (2012-2016), is 73.94 MAD/kg in average among which variable costs are of 50.27 MAD/kg representing a little bit more than the two thirds (67.98%). Seabass are sold along the year round, at an average price of 74.12 MAD/kg.

The net return and the benefit/cost ratio recorded very low values, respectively of 0.18 MAD/kg and 0.24%. The resulted variable contribution margin is just enough to cover fixed costs. These results show very weak profitability and an economic balance just ensuring financial equilibrium of M'diq fish farm. Considering variable costs, feed and fingerlings fees, including their taxes, shared both a major part of 84.50%. Any steadily increase in these two inputs would affect operating and limit development of this farm. So, how could this farm do to ascertain its sustainability and to be timely able to develop its fish farming activity.

To answer this question, fish production batches data were analysed from 2010 to 2015. Fingerlings stocking procedure has been shown based on two to three introductions per year, performed according to the availability of empty cages. In this period, fingerlings introductions have been performed in ten different months, from December to September. So, growth performances were influenced by stocking date. Results showed that batches started in January, March and May could be more interesting for production plan. Farm's aim is to shorten growing cycle to improve its farming results in terms of production cost decrease and sale income increase.

Productivity and economic results are very influenced by seawater temperature. Growing performance is variable during all the year. The annual temperature profile in M'diq Bay is characterized by a range (14-21°C) with an annual average temperature of about 18°C, recorded in floating cages site. These conditions are a little bit weak, not allowing high growth performance for seabass compared to middle and eastern Mediterranean countries. The latter have higher average seawater temperature in their rearing sites (optimal geographical locations of fish farms) allowing higher productivity. So, M'diq farm should take in consideration this environmental constraint to adjust its production strategies and optimize its operational economic performances through suitable technical solutions that could result in reduction of its operating costs. This was highlighted through analysis of Specific Growth Ratio (SGR) evolution with fish age and growth performance simulation using Thermal Coefficient Growth (TCG) based on real data which showed that growing batches started in January, March and May are more interesting in production planning optimization.

In this regards, improvement of farm's profitability could be generated through optimization of fingerlings and feed management, as major variable costs components having high influence on production costs. Their management could be improved in terms of their appropriate introduction date (January, March and May batches), their initial average weight (to be increased to 5 -10 g) with more relatively suitable homogeneity level, their deformities level (less than 3%), etc. Moreover, it was found that batches started in summer months were more exposed to disease outbreaks. Regarding feed management, it is very relevant to master its conversion ratio (FCR) which should be reduced from the current average value of 2.1 to less than 2.0. Lowering feed's FCR through improving feed formulation and feeding practices could help to reduce feed costs and improve farm's profit margin. In fact, researches on feed quality are undergoing based on locally available low-cost ingredients to improve local produced seabass feed.

Moreover, profit level of this farm could also be significantly improved by the Moroccan Government support in terms of exemption of imported feed and fingerlings from customs duties CD and value added tax VAT. Performed since the beginning of 2018 in Morocco, this exemption should contribute to reduce production cost could to 68.78 MAD/kg, generating a variable contribution margin sufficiently larger to cover fixed costs and allow an increase in net return and benefit/cost ratio reaching respectively 13.24 MAD/kg and 7.76%. The decrease in operating cost is one of major means of increasing profit for M'diq seabass farm. The net income of this farm is then affected by its production cost and also by the level of its production and selling prices. So, increase in farm

productivity, reduction in production costs and increase in average farm revenue are major measures to increase net return.

Under the lights of these results, sharing risks by growing others species in terms of cultured species diversification or in multi-trophic model would be economically efficient and may reduce market risks and increasing its profitability. Farmed seabass is still sold in nich market. An economic assessment of seabass production based on the current state of technical and economic knowledge could help overcome its aquaculture development constraints and enhance its social perception.

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