First trial on rearing European seabass *Dicentrarchus labrax* in floating cages in Dakhla bay- SW Morocco, Atlantic Ocean

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Abstract. This study sought to examine the growth performance parameters of European seabass (*Dicentrarchus labrax*) in a newly installed fish farm in Dakhla bay in southern Morocco. The rearing of the *D. labrax* was undertaken on 13 March 2018 through the launching of fingerlings imported from a French hatchery (n=120,000 individuals) of average body weight 1.97±0.23 g fry^{-1} a total initial mean size of 5.3±2.44 cm fry^{-1} and a condition factor of 1.32. These fry were stored in two circular cages HDPE 12 meters in diameter and a volume of 565 m^3. The pilot fish farm consisted of 6 floating cages installed in front of the Boutalha foreshore at a depth of 10-12 m. The anchoring system consisted of 14 anchors of 2.7 tons each, and a buoyancy system composed of 12 buoys of 500 L each. The stored population was fed with a feed imported granule type at a ration rate of 3 to 4 times a day during the pre-on-growing and once a day during the on-growing phase. Sampling was done weekly during the first phase and monthly during the second phase to monitor the stored fish growth performance. After 16 months of breeding, specifically on 09 July 2019, the fry exceeded 430±84.75 g fish^{-1} in average weight and 34.2±1.88 cm fish^{-1} in average length. Thus, there was a weight gain of about 50,196 kg with a consumption of 65,363 kg of feed (FCR=1.31). The daily growth index DGI is about 1.29 g fish^{-1} day^{-1}. The specific growth rate SGR is 1.06% day^{-1} and survival at harvest reaches 97.25%. The hydrological parameters, such as temperature, dissolved oxygen, salinity, turbidity and pH were from 16.5 to 24°C, from 6.25 to 9.17 mg L^{-1}, from 35 to 38 psu, from 1.53 to 6.25 FNU and from 7.3 to 8.41, respectively. The results of this experiment are insightful, indicating that the rearing of *D. labrax* in Dakhla bay can yield significant benefits in terms of faster growth.

Key words: Moroccan aquaculture, fish farm, zoo-technical, growth performance, DGI.

Introduction. Recognizably, capture fisheries have reached their maximum usable point. For this reason, aquaculture is seen as the only way to meet and maintain the human consumption of fish (FAO 2018). Morocco has strong potential and good opportunities for building a productive aquaculture sector, especially in terms of significant natural assets, availability of cheap labor and proximity to the major markets. Moroccan fish farming remains geographically limited in the bay of M'diq with a minimal annual production of around 200 tons year^{-1} of *Dicentrarchus labrax.*

*D. labrax*is is a very significant commercial fish asset and is the target of several farming projects, especially in the Mediterranean region. The thorough knowledge of the biology of these species has promoted scientific research (Bou Ain 1977), geared for optimizing the growth rate as well as the survival in farms. The rearing performance of *D. labrax* was studied in floating cages, in the tropical waters of the Robert bay in Martinique, where commercial size (300 g) was obtained after 12 months of rearing (Barnabe & Le Coz 1987). A related study was conducted in brackish water pond in Egypt (El-Shebly 2009). Regarding the techniques of rearing of these species at sea, a comparative study between the submerged and surface cages showed that submerged cages could be a promoting system for rearing *D. labrax* (Maricchiolo et al 2011).

Recent studies have focused on determining optimal feeding practices and the nutritional requirement for *D. labrax*. According to Eroldoğan et al (2004), the growth rate of *D. labrax* can be improved by feeding them at about 3.0% BW day^{-1}. Likewise, the effect of the biochemical composition and energy value of the feed on the growth of *D. labrax* was evaluated by Boujard (2004), Fontagne et al (2000), Peres & Oliva-Teles (2002) and Skalli & Robin (2004).

The main objective of this study was to investigate the feasibility of commercial livestock scale production of *D. labrax* for the first time in southern Morocco, in particular in Dakhla bay, where farming conditions of these species remain very praiseworthy given the existence of excellent culture site with an exceptional water quality which benefits from a favorable maritime current.

Material and Method

Description of study site. Dakhla bay is located on the Atlantic border of southern Morocco between 23° 35' and 23° 55' latitude North-East oriented NE-SW (Figure 1). It extends over an area that exceeds 400 km^2, with a length of about 37 km and a width ranging between 11 and 12 km. It is separated from the Atlantic Ocean by the peninsula of Dakhla (Hilmi et al 2017). The area chosen for fish farming in Dakhla bay is characterized by an enormous potential for aquaculture. It is worth mentioning that the site is protected from the bad weather with a highly favorable and stable temperature throughout the year. Due to an average depth of 12, the oxygenation of the site is provided by strong currents, and a low turbidity is ensured by the rocky coast.

Figure 1. Location of floating cages in Dakhla bay.

Culture system. The fish farm consists of six circular cages in HD polyethylene (PE), having a circular shape of 12 m in diameter, fixed by 14 anchors 2.7 tons each, and 12 buoys of 500 L each (Figure 2). A cubic cage composed of four small pools was set up for pre-ongrowing phase of rearing fish (Figure 3). These cages are flexible and designed by the manufacturer to withstand 6 m swells. They are installed perpendicular to the direction of prevailing winds NN-East. The buoyancy of circular cages is provided by two HD polyethylene pipes of 200 mm diameter. These tubes are interconnected by PE legs on which are fixed the mesh pockets. These feet are attached by their upper part to a PE pipe of 110 mm in diameter. Each cage has a total volume of 565 m^3 obtained after using a breeding net 5 m deep, and considering that the overall shape of the cage is cylindrical. The *D. labrax* fry were reared in cubic cages within two basins, at a density of 60,000 fingerlings $cage^{-1}$. The splitting was carried out in December 2018. The total biomass was divided into four circular cages (L1, L2, L3, and L4). For the realization of the offshore work (distribution of food, net change, transport equipment and personnel, transfer of fish), a boat of 5.25 m long and 1.80 m wide and featuring a motor 29420 W was used. The hull is wooden, polyester and has a sufficient platform for work onboard.

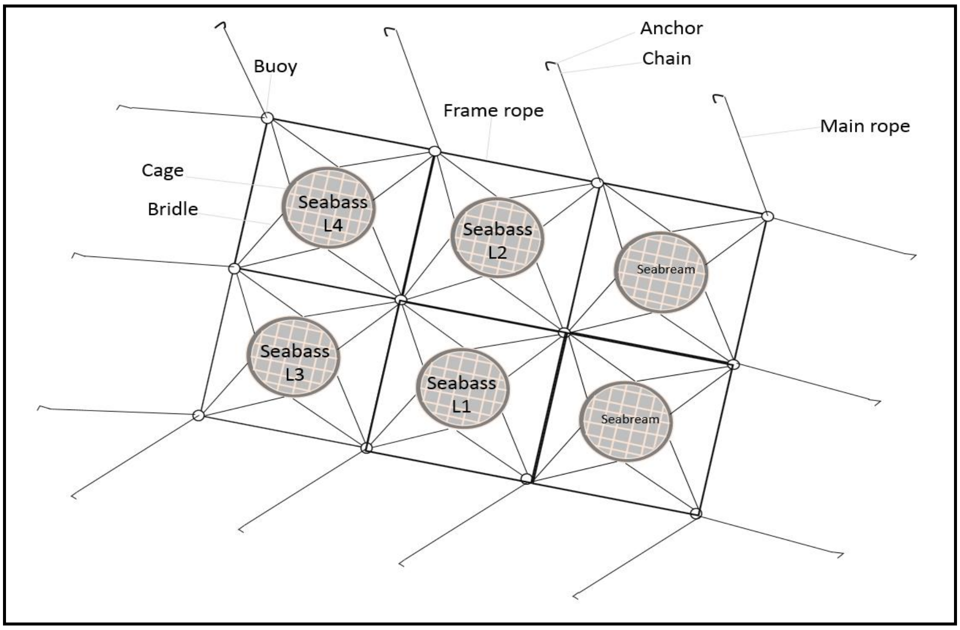


Figure 2. Composition of floating cages.

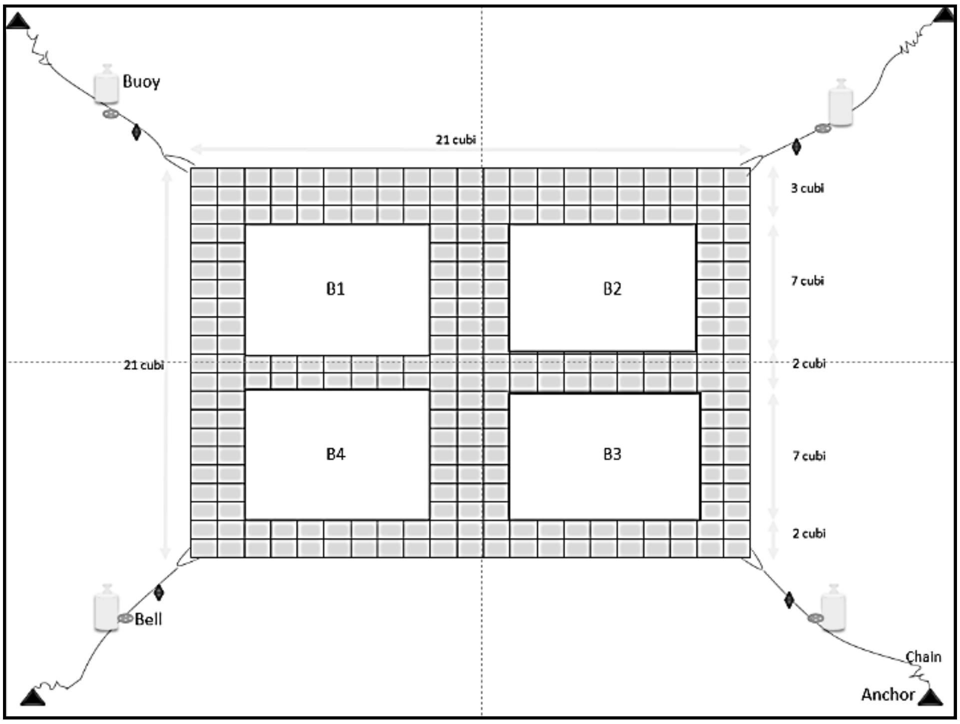


Figure 3. Floating structure built in Cubi floats.

Biological model. There is currently no commercial marine fish hatchery in Morocco. Therefore, the fry placed in rearing are imported from a French Mediterranean hatchery. Transport to Morocco was performed by trucks adapted to this type of merchandise.

During the journey, the fry was placed in tanks (2 m^3 in volume) supplied with oxygen through a bubbler system. The truck also had a reserve of liquid oxygen for supplying the tanks in case the original system was insufficient. The fingerlings were under a lot of stress during transport, and eventually had to adapt to a new environment. At times, it was necessary to enrich their food with vitamin C to help them get through this period. At the arrival to the site, the fingerlings were gradually acclimated to the temperature of the local site by a gradual change of the water parameters in the tanks. Next, they were transferred to small cages built by Cubi floats. The mesh size of the net used in the nursery cages was 5 to 6 mm. Thereafter, the cages were transferred to the fry rearing site, characterized by a depth of 10 to 12 m. Once brought back to the site, the fry spent a pre-ongrowing phase, during which their feed was higher in lipids and proteins, in order to stimulate their growth and to boost their resistance in the new environment, and thereby to limit the mortality rate. During this period, they were fed 3 to 4 times a day for the first two months to keep up the amount of feed digested, and then twice per day by increasing the amount distributed. When the average weight reached 50 g, the feed was reduced to once a day. The daily quantities distributed were determined by following a specific rationing table at *D. labrax* (Table 1). During the first week of rearing, the following observations and tasks were mandatory: monitoring of fry swimming behavior, mortality control and counting, and adaptation of fry to life under local conditions (currents).

Table 1

Rationing calculation parameters for the *Dicentrarchus labrax*

FCR	*Average weight (g)*	*Temperature (°C)*							*Feed size (mm)*	*Net mesh (mm)*
		14	*16*	*18*	*20*	*22*	*24*	*26*		
0.6>0.8	04-07	2.73	3.51	4.29	5.07	6.25	7.42	7.81	1.3	4
0.7>0.9	07-10	2.13	2.74	3.35	3.96	4.87	5.79	6.09	1.5	6
0.8>1	10-15	1.82	2.35	2.87	3.39	4.17	4.95	5.21	2	
0.8>1	15-20	1.42	1.83	2.24	2.64	3.25	3.86	4.07	2	8
1.3>1.5	20-50	1.2	1.54	1.88	2.23	2.74	3.26	3.43	3	12
1.3>1.5	50-100	0.94	1.2	1.47	1.74	2.14	2.54	2.67	3	15
1.4>1.6	100-200	0.74	0.95	1.16	1.37	1.69	2	2.11	4.5	20
1.4>1.6	200-400	0.58	0.74	0.9	1.07	1.32	1.56	1.64	4.5	24
1.5>1.7	400-600	0.45	0.57	0.7	0.83	1.02	1.21	1.27	6	

Feeding regime*.* Distributed manually, the feed was of a different type, grain size and composition. During the pre-ongrowing, the feed was provided up to 4 times a day, but once a day during the ongrowing phase (Table 2). The amount of feed distributed depended on the average weight of individuals and temperature. It was calculated with the following relationship:

$$Q \text{ food / day} = B \times TR = (N \times PM) \times TR$$

Where:
B - the biomass;
N - the number of specimens;
PM - the average weight;
TR - food rationing rate.
In other words, the amount of food distributed per day for the biomass of 100 kg of fish (Table 1). This rate increases with temperature and decreases with weight.

Table 2

Composition of the distributed feed

Type of feed	*Date of administration*	*Fish weight(g)*	*Protein (%)*	*Fat (%)*	*Vitamins*			
					A (IU kg^{-1})	*D3 (IU kg^{-1})*	*E (mg kg^{-1})*	*C (mg kg^{-1})*
F1 F2 AL3G	14.03.2018 to 23.03.2018	2-4	52	17	10000	1750	200	300
1.3	01.04.2018 to 10.05.2018	4-7	56	18	10000	1750	200	300
1.5	11.05.2018 to 12.06.2018	7-15	56	18	10000	1750	200	300
2	13.06.2018 to 04.08.2018	15-50	48	15	10000	1750	200	300
4	05.08.2018 to 01.10.2018	50-100	42	20	10000	1750	200	150
5	02.10.2018 to 20.11.2018	100-150	42	20	10000	1750	200	150
6 and 7	21.11.2018 to 07.09.2019	150-450	41	19	8000	1400	160	90

F1- grain size 0.4 to 0.7 (mm); F2- grain size 0.7 to 1 (mm); AL3G- grain size 0.8 to 1.1 (mm).

***Sampling protocol**.* Sampling involved taking randomly from each cage a set of at least 200 fish samples. The average weight was measured based on sub-samples of 20 individuals per 1 m^3, in a tank filled with seawater. An anesthetic (concentration of 0.3 mL L^{-1}, 2-phenoxyethanol or clove oil) was used to accommodate the individuals to be weighed. The sampling procedure was performed every week during the pre-ongrowing, and once a month during the ongrowing period, in order to track the growth, to readjust the feeding rate, to forecast of transfers and to control the sanitary state of the livestock. Subsequently, the coefficient of variation was calculated for each sample. The equipment used for sampling consisted of a portable balance for weight measurements and a flat millimeter scale for length measurements. It should be noted that before sampling endeavors were launched, the fish must have fasted for 24 hours.

***Water quality parameters**.* The monitoring of the rearing environment consisted of controlling the physicochemical parameters that influence the growth of the species. The rearing environment parameters were transmitted in real-time using a YSI EXO2 continuous mode multi-parameter probe installed into the floating cages implantation area. The measurements were received through a network information sending system. The data provided by this system was water temperature, dissolved oxygen (DO), turbidity, potential hydrogen (pH), chlorophyll, blue-green algae (BGA), conductivity, salinity and total dissolved solids (TDS).

***Zootechnical analysis**.* Calculations of feed conversion ratio (FCR), daily growth index (DGI), specific growth rate (SGR), stocking density, condition factor (K) and survival rate were performed according to the following equations:

- Feed Conversion Ratio (FCR): indicator commonly used in all types of farms, be they aquaculture or not, as well as in the research community. It can give an idea about the food efficiency or food strategy. It is understandably a figure without unity; the lower it is, the more the food related weight gain is important (Sammouth et al 2009).

  FCR = feed consumed (kg) / weight increase (kg)
- Daily Growth Index DGI (g $fish^{-1}$ day^{-1}) = 100 x (Final $BW^{1/3}$ - Initial $BW^{1/3}$) / days of rearing (Boujard 2004).
- Specific Growth Rate SGR (% day^{-1}) = 100 x [ln final weight (g) – ln initial weight (g)] / trial duration (in days) (Jobling & Koskela 1996).
- Stocking density: the stocking density (kg m^{-3}) is the biomass (B) on available volume (V): D = BV^{-1} (Lanari et al 2002).

- Fulton's condition factor (K): Is the ratio of the weight in grams and length of fish in centimeter. This is a good fish performance indicator.

  K= 100 x [total body weight (g) / fork length (cm^3)] (Bolger & Connolly 1989).
- Survival rate (%) = 100 x (Final number of fish / initial number of fish) (Eberhardt & Ricker 1977).

Results

Physicochemical parameters of farming medium. During the rearing period, the average values of the physicochemical parameters influencing the growth of individuals in rearing included temperature 20.18°C, dissolved oxygen 7.68 mg L^{-1}, pH 8.28 and salinity 37.13 PSU. Other parameters, such as turbidity and chlorophyll, had acceptable mean values of around 3.81 FNU and 4.05 μg L^{-1}, respectively (Figure 4).

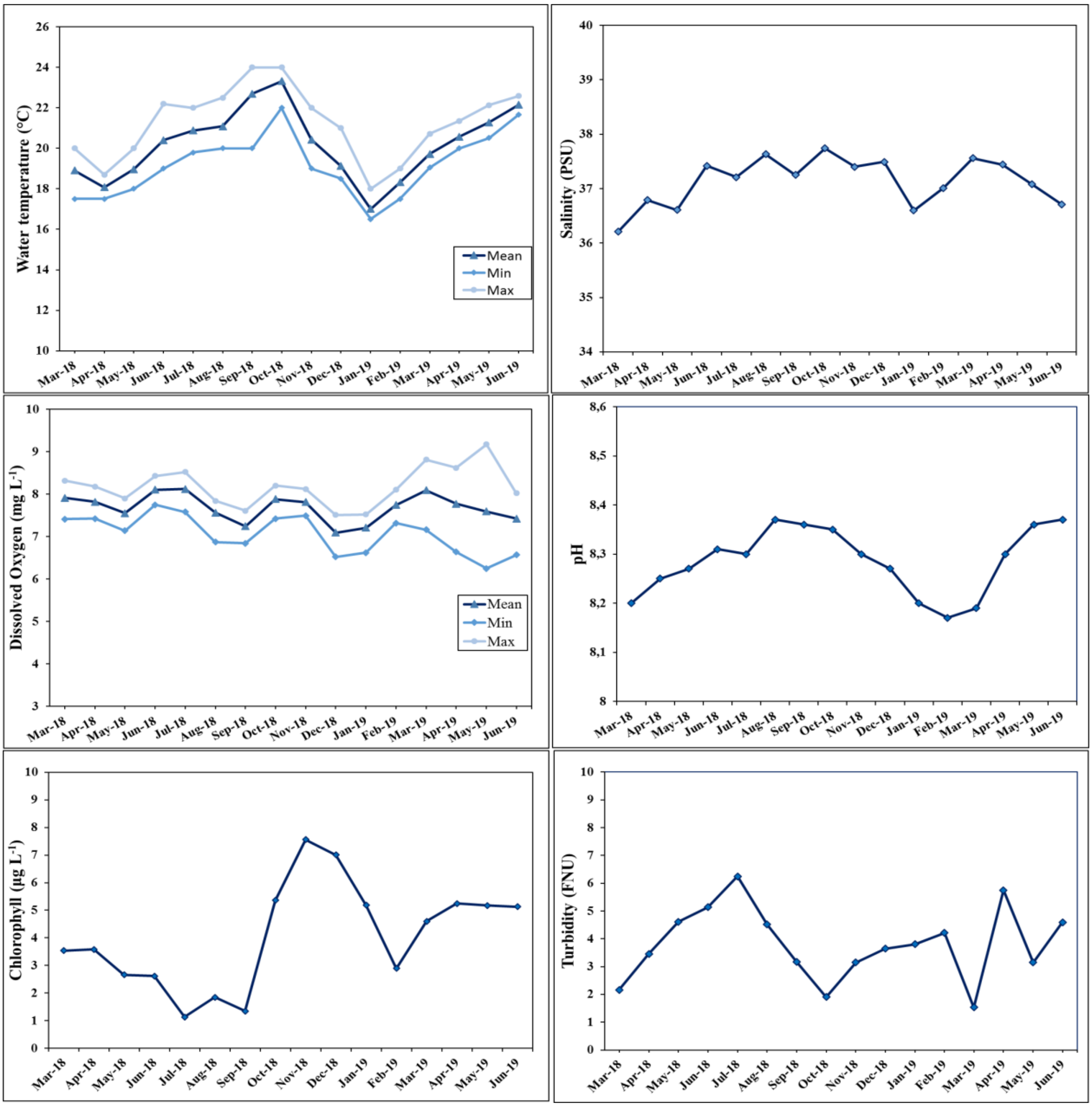


Figure 4. Physicochemical parameters of farming medium.

Evolution of zootechnical indicators. Figure 5 shows that the progress of the average weight of *D. labrax* rearing in four cages followed an exponential logic, whereby the rate of weight gain was accelerating over time. After 16 months of rearing, the average weight of individuals increased from 1.97±0.23 g fish^{-1} to 430±84.75 g fish^{-1}, marking a maximum of 667.5 g and a minimum of 229.5 g. Regarding linear growth, the specimens have changed from an average size of 5.3±2.44 cm fish^{-1} to a length of 34.2±1.88 cm, witnessing a maximum of 36.5 cm and a minimum of 20 cm.

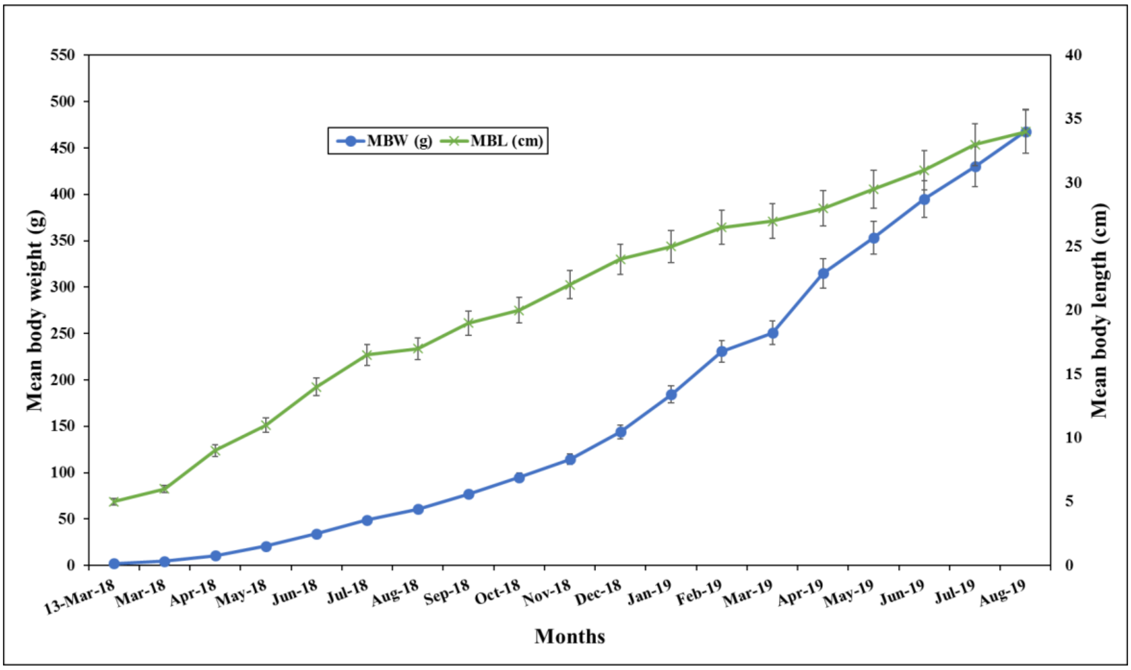


Figure 5. Growth in length and weight of the *Dicentrarchus labrax* in Dakhla Bay.

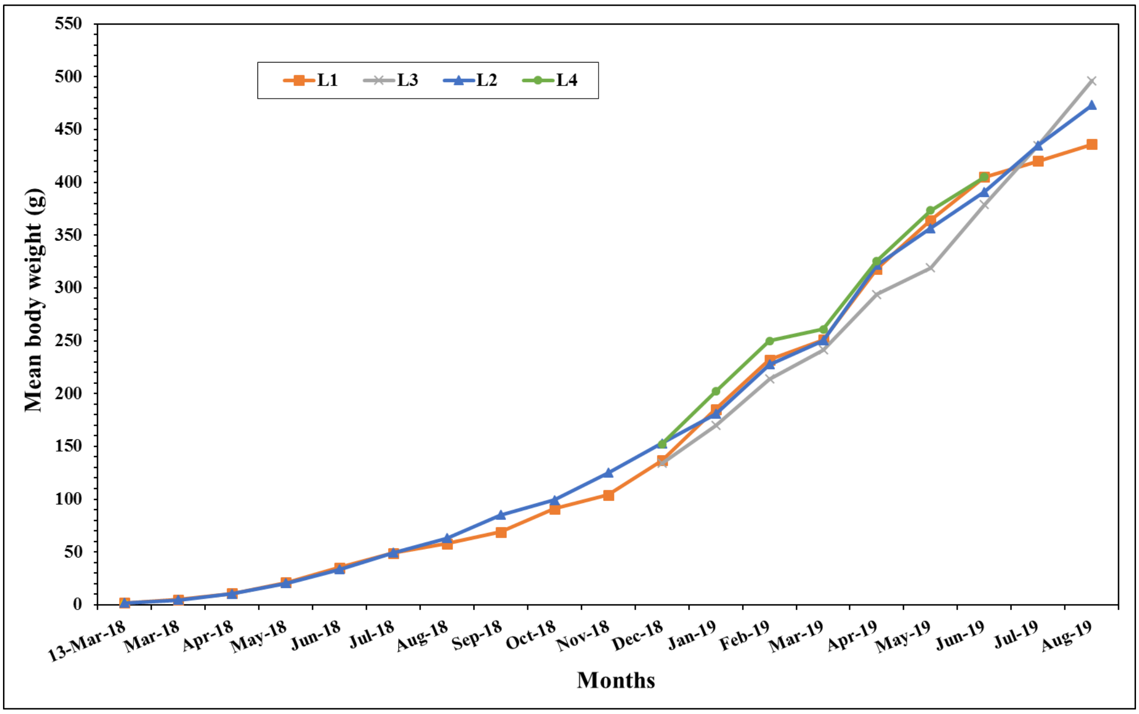


Figure 6. Growth rate of *Dicentrarchus labrax* in the four cages (L1, L2, L3 and L4).

The growth of *D. labrax* in all four cages (L1, L2, L3 and L4) remained similar (Figure 6), which can be attributed to the similarity of the amounts of feed distributed in each cage. It also reflects the similarity of the rearing operations carried out for all cages.

Regarding the feed conversion ratio (FCR), the results are shown below (Table 3), an FCR of 1.31 indicator with a feed efficiency ratio (FER) of 0.76 involving the proper food use. The latter, varied depending on several parameters, such as the food's intrinsic performance, the processing capacity of given fish weight, and the rearing medium temperature determining the animal metabolic activity.

Table 3

Calculation of feed conversion ratio

Rearing period	*Pre-ongrowing phase*	*Ongrowing phase*	*Total cycle*
	13.03.18-25.10.19	*26.10.18-09.07.19*	*13.03.18-09.07.19*
Initial biomass (kg)	236.4	11002.6	236.4
Final biomass (kg)	11239	46069	50196
Biomass gain (kg)	11002.6	35066.4	49959.6
Feed (kg)	9230.5	56132.5	65363
FCR	0.84	1.60	1.31
FER	1.19	0.62	0.76

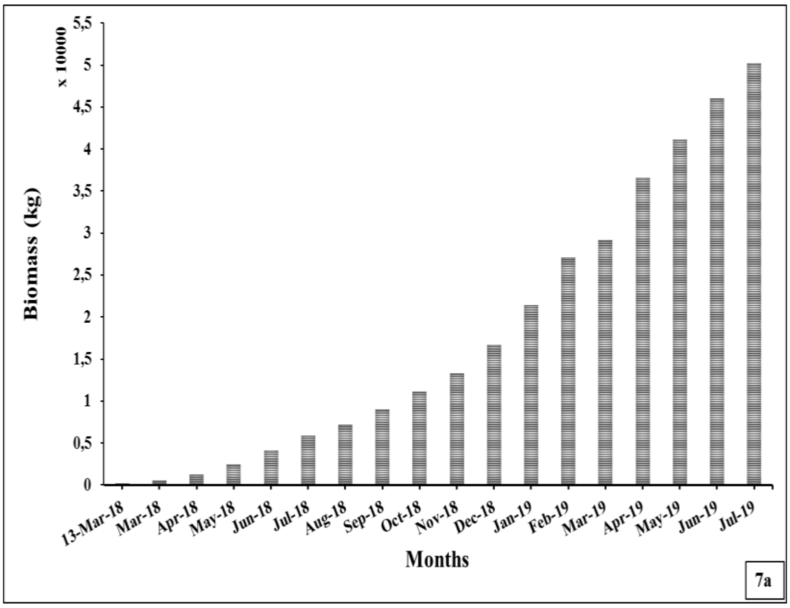
The biomass in the four cages exceeded 50 tons after 16 months of rearing, bearing in mind that the initial biomass was only 236.4 kg. Figure 7 summarizes the evolution of the rearing biomass of *D. labrax*.

The densities recorded during the rearing period as part of this study correspond to the standard stocking densities of this species. The recorded final density was 22.21 kg m^{-3} (Figure 8). Regarding the specific growth rate (SGR) and the daily growth index (DGI), they recorded average values of 1.06% day^{-1} and 1.29 g $fish^{-1}$ day^{-1}, respectively, given that the specific growth rate decreases following the increase of fish weight (Figure 9). The condition factor (k), which gives an overview on the state of growth and quality of the cultured species, recorded a minimum value of 1 and a maximum value of 2.13 with an average of 1.32 (Table 4).

Table 4

DGI, SGR and condition factor

Months	*Mean body weight (g)*	*Mean body length (cm)*	*DGI (g $fish^{-1}$ day^{-1})*	*SGR (% day^{-1})*	*Condition factor (k)*
March-18	5	6	2.41	2.83	2.13
April-18	11	9	1.77	2.77	1.45
May-18	21	11	1.83	2.24	1.55
June-18	34	14	1.68	1.69	1.25
July-18	49	16.5	1.38	1.20	1.09
August-18	61	17	0.88	0.70	1.23
September-18	77	19	1.09	0.80	1.12
October-18	95	20	1.03	0.70	1.19
November-18	115	22	0.97	0.62	1.08
December-18	144	24	1.28	0.76	1.04
January-19	184	25	1.50	0.83	1.18
February-19	231	26.5	1.47	0.75	1.24
March-19	251	27	0.57	0.28	1.27
April-19	315	28	1.65	0.76	1.43
May-19	353	29.5	0.89	0.38	1.38
June-19	395	31	0.89	0.37	1.33
July-19	430	33	0.70	0.28	1.20



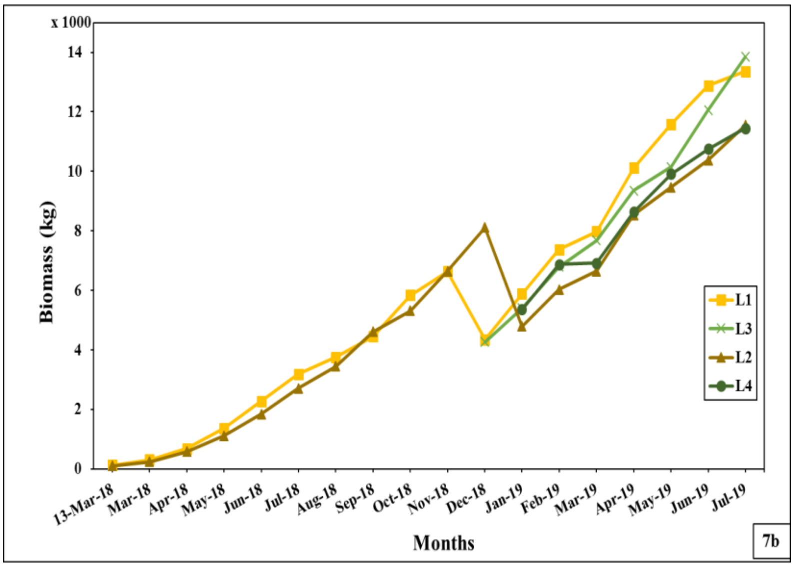


Figure 7. Rearing biomass progress of the *Dicentrarchus labrax* (7a: total biomass, 7b: biomass in 4 cages).

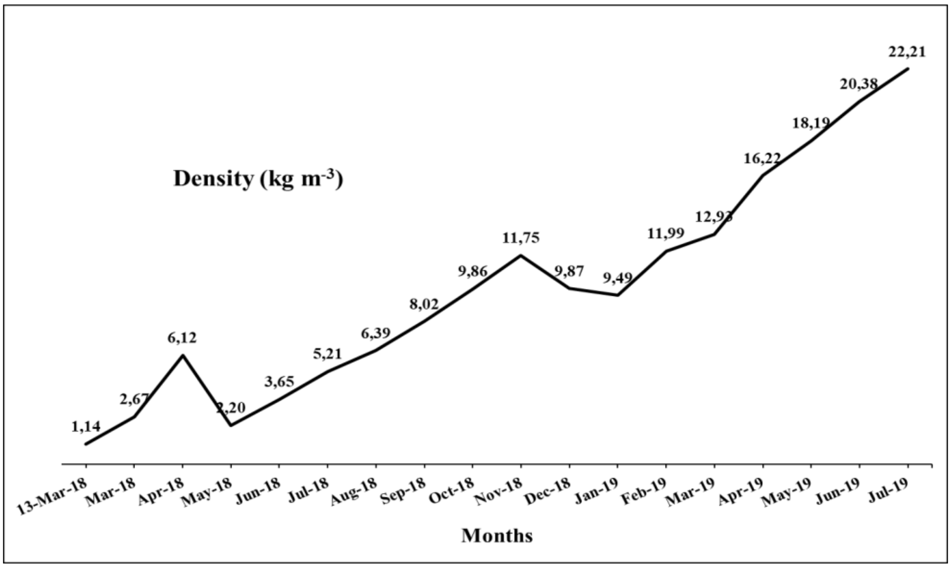


Figure 8. Rearing density evolution of the *Dicentrarchus labrax.*

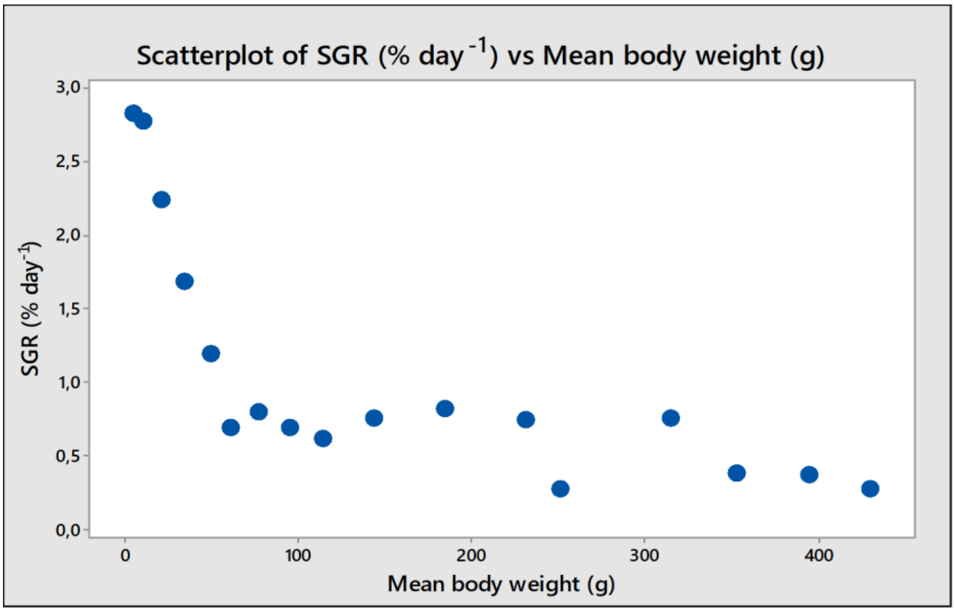


Figure 9. Evolution of SGR against the average weight.

Mortality. The losses recorded during the two rearing phases reached 3,290 fish specimens, meaning a survival rate of about 97.25%. These mortalities, identified during the period from the end of August 2018 to the end of December 2018 (Figure 10), were due to the rearing operations carried out during this period (among which the change of nets, the splitting and the installation of new cages.). Regarding the health of *D. labrax* during the production cycle, the onset of symptoms was recorded about a month after the fry arrival (such as the appearance of small white cysts on the skin; reddish tints to eyes). As a remedy, treatments were carried out using the Florfenicol as antibiotics and/or formalin, in order to prevent Ectoparasites development. The treatment administration was done orally by distributing a mixed feed with antibiotic and edible oil (to obtain an improved powder adhesion to the feed).

The heterogeneity observed in the growth of *D. labrax* as livestock (Figure 11) was generally due to the feeding behavior of this species, and also to the fact that females grew more quickly than the males (Díaz et al 2013).

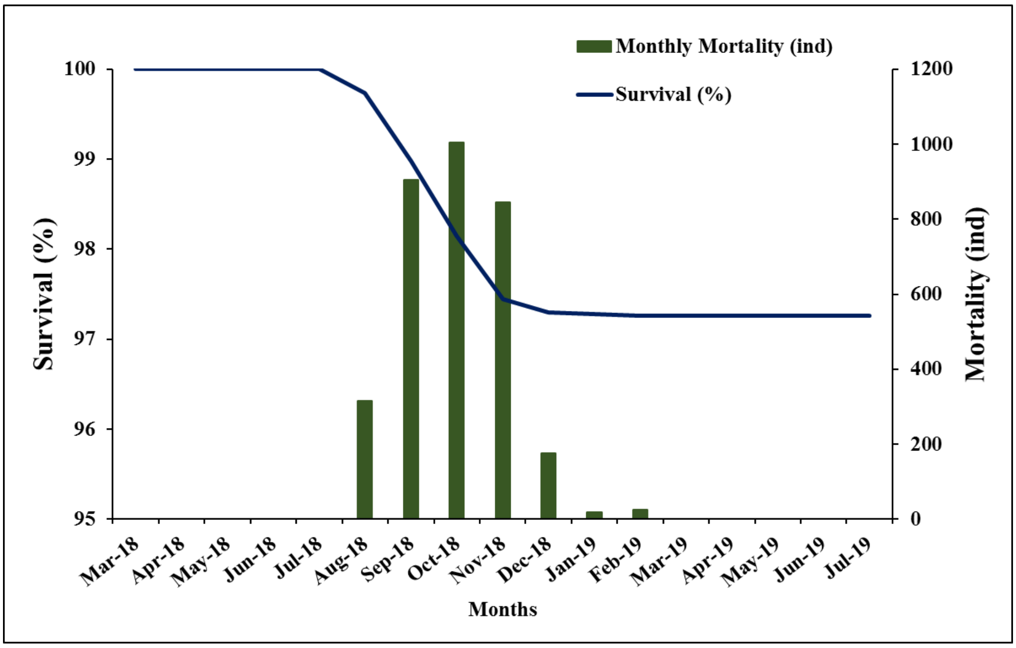


Figure 10. Survival of *Dicentrarchus labrax* reared in Dakhla bay.

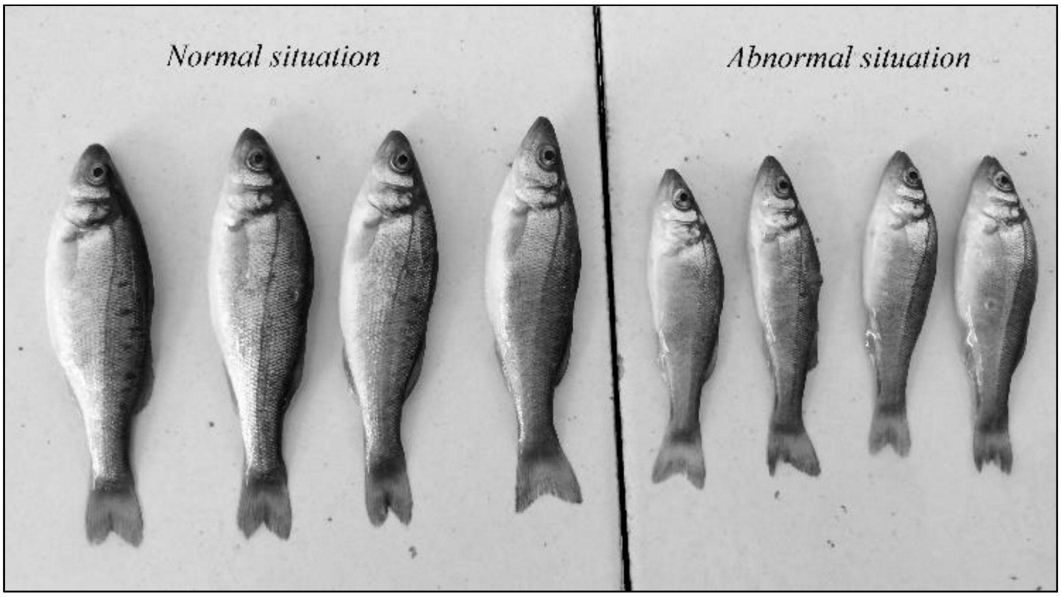


Figure 11. Heterogeneity of *Dicentrarchus labrax.*

Discussion. The objective of this study was to examine the performance of *D. labrax* farming as a new activity in the southern region of Morocco. As in the region there are already hosted several oyster farms, it is necessary to diversify its aquaculture production. The results obtained with the *D. labrax* reared in floating cages in Dakhla bay, in terms of both growth and feed conversion ratio, were significantly better than those achieved in the Mediterranean Sea. Indeed, in 16 months of rearing, the European *D. labrax* reached a weight of 430 g with a feed conversion ratio of 1.31, against a weight of 167.30±31.40 g, starting with an initial weight 28.2±4.3 g, in 12 months in the Mediterranean sea (Maricchiolo et al 2011). In the Atlantic Ocean, particularly in the Caribbean (tropical zone), *D. labrax* reached a weight of 300 g in 12 months of farming, starting with fry of 3.5 g of average weight (Barnabe & Le Coz 1987).

The use of floating (surface) cages as a choice for the rearing technique was the consequence of the results obtained in several studies comparing European *D. labrax* rearing techniques. Undertakings to monitor the growth of *D. labrax* in submerged and surface cage rearing have been carried out in the Mediterranean sea by (Maricchiolo et al 2011). At the end of 12 months of rearing, the *D. labrax* reached a weight of 175.40 g and 167.30 g for submerged and surface cages, respectively, starting with an initial weight of 28.2 g. According to the same study, the comparison between the two techniques used, in terms of specific growth rate and condition factor, is statistically insignificant.

On the other hand, the rearing volume affects the growth performance and stress parameters of the *D. labrax* (Papoutsoglou et al 1998; Samaras 2017). In this study, the maximum density recorded at harvest was of the order of 22.21 kg m^{-3}, indicating that the density influence on the zootechnical performance was minimal. According to (Sammouth et al 2009), *D. labrax* can be tolerated at very high densities.

Furthermore, the profile of water parameters recorded in this study was at the optimal level for the normal growth of *D. labrax*. Considering that this species is a eurythermal fish because it is capable to tolerate large temperature variations ranging from 2 to 32°C, it is also euryhaline because it enjoys the ability to put up with large variations in salinity, ranging from 0.4 to 40‰ (Moretti et al 1999).

Table 5

Zootechnical assessment of farming *Dicentrarchus labrax* in Dakhla bay

Parameter	*Value*
Initial average weight (g fish^{-1})	1.97±0.23
Final average weight (g fish^{-1})	430±84.75
Weight gain (g fish^{-1})	428.03
% weight gain fish^{-1}	21727.4
Rearing period (day)	483
Daily weight gain (g fish^{-1})	0.89
Effective (fish)	120 000
Total initial weight (kg)	236.4
Total final production (kg)	50196
Number of dead fish	3290
Mortality rate (%)	2.75
Total food consumed (kg)	65363
Total net production (kg)	49959.6
Feed conversion ratio	1.31
Initial average size (cm fish^{-1})	5.30±2.44
Final average size (cm fish^{-1})	34.2±1.88
Condition factor (k)	1.31

Conclusions. The promising growth performance achieved in this study was due to the geographical, position-specific potential of Dakhla Bay in the south of Morocco. This area has a climate characterized by a sea water temperature highly favorable to the rearing of the European *D. labrax* and typically adequate hydrodynamic conditions for the development of fish farming. Despite the obtained production yield, the absence of the private sector investment remains the underpinning factor behind the underdevelopment of the rearing *D. labrax* activity in Dakhla bay.

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