RESEARCH ARTICLE **(Open Access)**

Plan of Production and Site Selection from Marine Aquaculture Cages in the Bay of Raguza, Karaburun - Vlora

EDMOND HALA[1*], RIGERS BAKIU[2], ELVIS KAMBERI[3], JERINA KOLITARI[4], ENKELEJDA BUDA[5], EDLIRA SADIKU[6]

[1*] Department of Aquaculture and Fisheries, Agricultural University of Tirana, Tirana, Albania

[2] Department of Aquaculture and Fisheries, Agricultural University of Tirana, Tirana, Albania

[3] Department of Aquaculture and Fisheries, Agricultural University of Tirana, Tirana, Albania

[4] Laboratory of Aquaculture and Fisheries, Department of Aquaculture and Fisheries, Agricultural University of Tirana, Durres, Albania

[5] Laboratory of Aquaculture and Fisheries, Department of Aquaculture and Fisheries, Agricultural University of Tirana, Durres, Albania

[6] Department of Aquaculture and Fisheries, Agricultural University of Tirana, Tirana, Albania

Abstract

The aim of the study is the setting up an aquaculture cage culture plant for rearing European seabass (*Dicentrarchus labrax*) in the bay of Raguza on the Karaburun peninsula, Vlora, Albania. The study deals only with the aquaculture engineering aspects regarding system production and maintenance, without focusing on the investment cost. The diameter of the floating aquaculture cages is 20 m and the height is 10 m. From the calculations, it resulted that the rearing density is 15 kg / m3. The annual production provided by the aquaculture floating cages plant is 568 tons / 12 months if the starting culture of sea bass will be about 10g. The production from a single floating cage is 47,339 tons. Starting from the fourteenth month of culture the investor will harvest this quantity of fish for each month. Considering the normal losses that may occur during the fattening phase, the investor should purchase 184621 juvenile individuals weighing 10 g previously vaccinated against major bacterial diseases (Vibrio and Pasteurella polyvalent vaccine) every month. The mesh size of the culture net should start with 15 mm for individuals from 10 -40 g and 25 mm for individuals over 40 g.

Keywords: floating cages, seabass, biomass, fattening.

1. Introduction

Cage aquaculture is one of the fastest-growing aquaculture sectors in the last 20 years, due to the increasing demand for aquatic products and the increasing population growth (Cardia and Lovatelli 2017). In the Mediterranean countries, cage aquaculture is also the main aquaculture activity. This culture started in the 1980s in Greece and Spain rearing European seabass (*Dicentrarchus labrax*) and the gilthead seabream (*Sparus aurata*) and in a short time, a great number of farms expanded rapidly in the 19 Mediterranean countries. In these countries, approximately 90% of cage aquaculture represents these two species. The freshwater cage aquaculture has marginally developed in countries like Italy and Turkey rearing mostly (Oncorhynchus mykiss), and in Egypt rearing the Nile tilapia (Oreochromis niloticus) and silver carp (Hypophthalmichthys molitrix) (SIPAM, 2006).

In Albania, cage aquaculture is also the most rapidly growing aquaculture sector. This activity started in the mid-1990s, rearing European seabass and the gilthead seabream in the south-west Albanian coast. From that time this activity attracted the interest of investors to extend this business in the different areas of the Albanian coast (FAO).

In the presented study the species under culture is the European Sea Bass (*Dicentrarchus labrax*). This is a predatory fish species found in the area of the Mediterranean and Eastern Atlantic, starting in southern Morocco and the Canary Islands off the coast

*Corresponding author: Edmond Hala; E-mail: hiedmo@ubt.edu.al

Special Issue of the Conference: Agriculture a Life Science with Roots in Applied Biology; 3-4 Dec. 2020. (Accepted for publication 10.01.2020)

***ISSN**: 2218-2020, © Agricultural University of Tirana*

of Norway, including the Bay of Biscay, the Canal. Angles, Baltic Sea, Irish Sea, and the North Sea (Fritch et al. 2007). The development of fishing technologies such as faster vessels, sonar, and nylon nets allow fish to be located and opened more easily. ICES (2004) have reported total reductions in sea bass catches in recent years, which may be due to a combination of persistent fishing pressures and numerous cold winters since 2008, reducing larval and juvenile survival or an increase in the size of the recreational catch.

The first study of the installation of marine aquaculture cages in Albania was presented by Hala, (2012). This is another contribution that will help interested persons to better understand how to install a cage aquaculture system in Albania and not to influence touristic activity.

2. Material and Methods

Installation of a system of floating marine aquaculture cages for rearing European sea bass (*Dicentrarchus labrax*) species in the eastern part of the Karaburun peninsula (bay of Raguza). The required annual yield is 560 tons/year.

2.1. Fish species under cultivation

Sea bass is one of the most well-known fish species by consumers throughout the Mediterranean basin. On the other hand, this is a very studied species and it's biological cycle is well known thus, it gives more confidence in cultivation and avoids the surprises that may be encountered if we try to rear another marine fish species. Also, in comparison to gilthead seabream, sea bass has a higher price in the Albanian retail fish market.

Sea bass juveniles will be exported abroad at the average weight of 10 g. This is because in the Albanian territory does not exist any hatchery of marine fish species. The juveniles can also be imported in smaller sizes (2-5) g, but this would extend the production cycle and will add another operational important task such as vaccination. Juveniles of 10 g should be pre-vaccinated in the pre-fattening plants for diseases such as pasteurellosis and vibrio before be transported and reared in aquaculture cages.

2.2. Methods for design calculations

For the design calculations must consider:

Depth (bathymetry of the area)

Exposure to waves / winds

Renewal of water / oxygen

Depth

Below are presented the obligatory requisites for installation of floating cages (Vergara-Martin 2007)

Low tide: at least, 8m from bottom of the sea to the bottom of the net. Excessive depth less than 50m. Slope of the depth: as minimum as possible. It is essential to obtain at least one of the two options: Navigation Chart and/or Bathymetric map of the selected site.

Exposure to waves / winds

$$Ua = 0.71 \times W^{1.23} \text{ m.sec-1}$$

Ua - stress factor of the wind

W - is the maximum wind speed in the direction of the selected fetch (m/sec).

Maximum wave height

For this calculation we will use the chart of using a chart that relates the wind stress factor to the length of fetch (Landless and Edwards 1976)

Directions of water currents

Important to know: Frequencies, Directions, Speed of currents in the area

Will be estimated velocities and directions of the currents for every possible situation of the tide. For this will be used one of the below current meters a. *Propeller current meters* or b. *Doppler current meters*.

2.3. Methods used for calculation of production/biomass

Calculation of the volume of the cage:

Volume/cage= $\pi r^2 h$ where

$\pi \approx 3.1416$; r = radius of the cage.

h = height of the cage

Time for water renewal

$$T = Vi / Ve \times 100$$

T - transmission factor

Vi - current velocity inside the cage

Ve - velocity outside the cage

Time = Volume of cage/(diameter of cage/Ve)

Calculation of the maximum biomass per cage

$$Q = V (m^3)/\text{time of renewal (sec)}$$

Q = Caudal (l/min)

O_2 input (mg O_2/sec) = Q x O_2 minimal possible (mg O_2/l)

Biomass/cage = O_2 input / Consumption of O_2 (mg O_2/kg/min)

2.4. Material of floating cages

Plastic pipes - High density polyethylene (PVC or ABS) that can be used as flexible pipes providing adequate rigidity. This material is considered low cost (compared to plastic and stainless-steel systems) and of better quality.

The diameter of the cages will is 20 meters. Will be used double-ring cages to increase the lifespan and to manipulate it as easily as possible.

The flexibility of HDPE material is that it allows to be pulled by boats, trawlers, etc., without suffering the cracks or deformation.

Disadvantages:

It is a material that can crack over time under the constant action of ultraviolet radiation.

Net *flexibility:*

Two different of net materials can be used:

1. flexible material (it is light in weight and low cost). The material can be selected from nylon and knotless formation in it (the reason is that in this way it is more difficult to deposit fouling).

2. rigid material (strong material, retains its shape and resistant to abrasion – used mostly for predatory fish that break nets and easily escape). The material that can be chosen for this case can be, polythene 'Netlon', that wears a wire mesh, or copper-nickel material (Chua and Tech 2002).

***Mesh shape*:**

cubic or hexagonal because they are easy to disassemble and fold.

Mesh size:

10-15mm for starting juveniles from 10-30g and changing to 25 mm after they reach the weight of 40 g.

3. Results and Discussion

3.1. Calculations of design

The Ionian coastal area is very favorable for the installation of cage aquaculture plants. It meets all the criteria needed such as immediate depth from the shore, rugged relief, protection from winds, and proximity to the touristic area which requires fresh fish. The proposed area located inside the bay is completely protected from the winds and far enough away from the tourists ’sight.

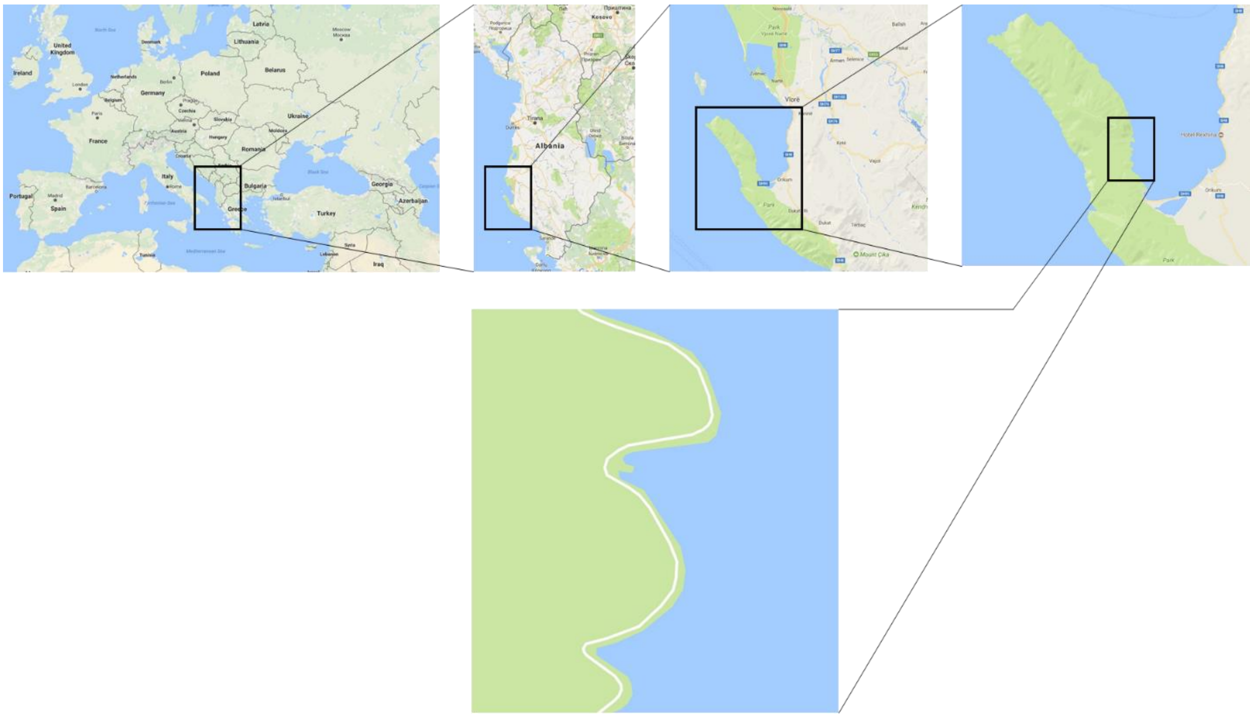

Figure 1. Location of the proposed site (modified from Google maps)

Bathymetry

To design the bathymetry of the area of study are necessary a boat and an apparatus called a transducer, which through a sonic pulse (1.400 cm/sec) leads to a monitor the respective depth of the study area. The result shows a graph according to the degrees of depths determined by the way we do by boat. Then, by joining the points that have the same depth, the isobaths of the area in question are obtained. Also, another information that this map gives us is the indication of sea currents that predominate in the area and how sediments are deposited.

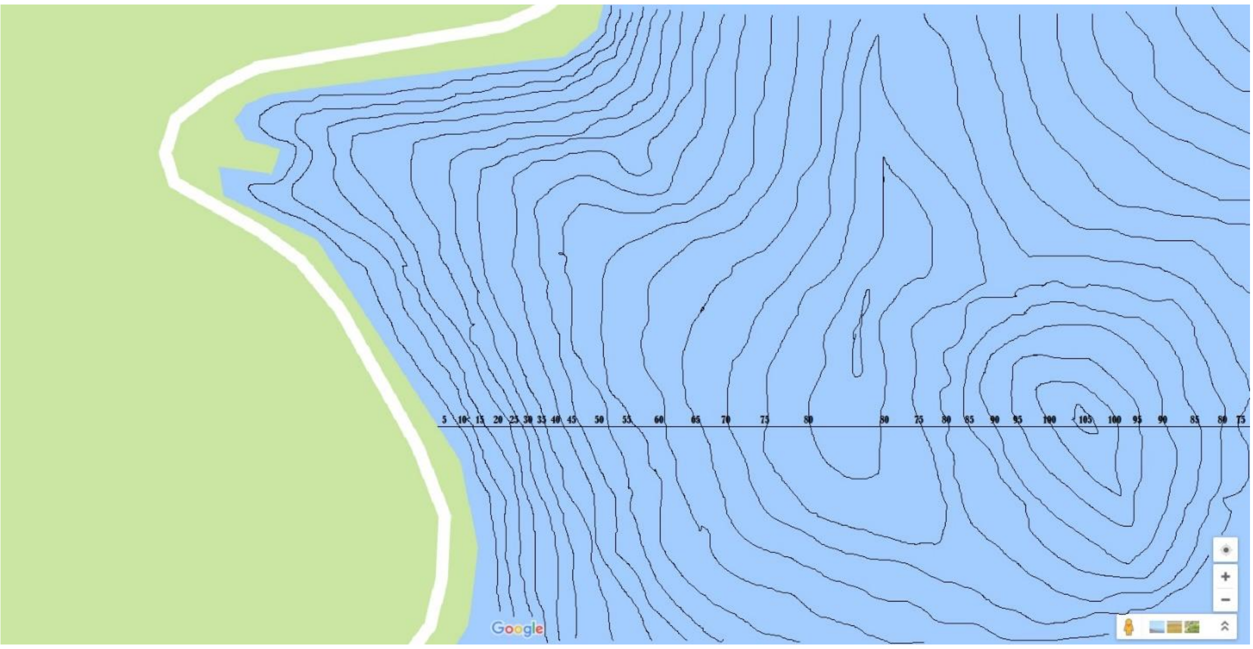

Figure 2. The bathymetric map of the area (modified from google maps).

Exposure to winds and waves

Availability of "wind rose" of the area of the survey.

From the meteorological station of Vlora we get the map of the maximum winds that have blown these last 20 years in the area in question. This can come in many forms, but the simplest is to determine winds based on the length of the imaginary lines.

Figure 3. The wind rose placed on the map of the selected place (modified from google maps).

The longest line which is not affected by the terrestrial relief of the country is the line that interests us. It determines the "fetch" with the highest wavelength. After that, we remove from each side of the line that we have already extended to the nearest shore, four imaginary lines in the interval of 3 degrees.

*Corresponding author: Edmond Hala; E-mail: hiedmo@ubt.edu.al
Special Issue of the Conference: Agriculture a Life Science with Roots in Applied Biology; 3-4 Dec. 2020. (Accepted for publication 10.01.2020)
***ISSN**: 2218-2020, © Agricultural University of Tirana*

Figure 4. Extension of the longest line of the wind map *(modified from Myftiu 2019)*

Determining the maximal wave height.

The figure shows the extension of the longest line of the wind map that does not touch the ground. This line extends until it touches the other shore. On each side are drawing 4 lines at 3 degrees from each other. The distance is the average of the nine lines.

Wind Stress Factor Ua is determined:

$$Ua = 0.71 \text{ x } W1.23 \text{ m.seg-1}$$

$$Ua = 0.71 \text{ x } (7.38 \text{ x } 3.13) \text{ x } 1.23 \text{ m.seg-1}$$

$$Ua = 20$$

Fetch (average) = 31 km

This distance is the average for the nine lines in the direction of the ground of the next shore.

The following graphic table (Landless and Edwards 1976). Shows what the maximum wavelength will be when we have already found the wind stress factor and know the length of the Fetch.

In fact, the table shows the most extreme climatic condition for the area in the study. This means that the cage system must also be selected to withstand a wave force greater than that resulting from the graphic table below.

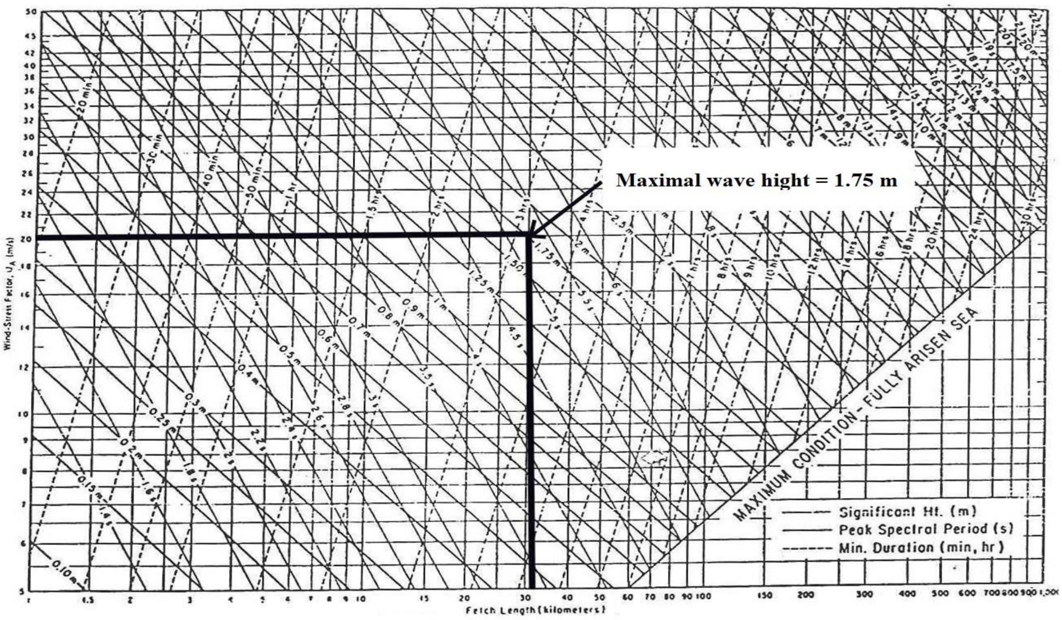

Figure 5. Calculation of the maximum wave height (modified from Landless and Edwards 1976)

Ua = 20
Fetch = 31km
The table shows that the maximum wave height that can reach the area is **1.75 m**
The investor must choose cages that support wave heights higher than 1.75m.

Determination of sea currents
For this purpose, was used current meter model Doppler. The result is shown in the below figure.

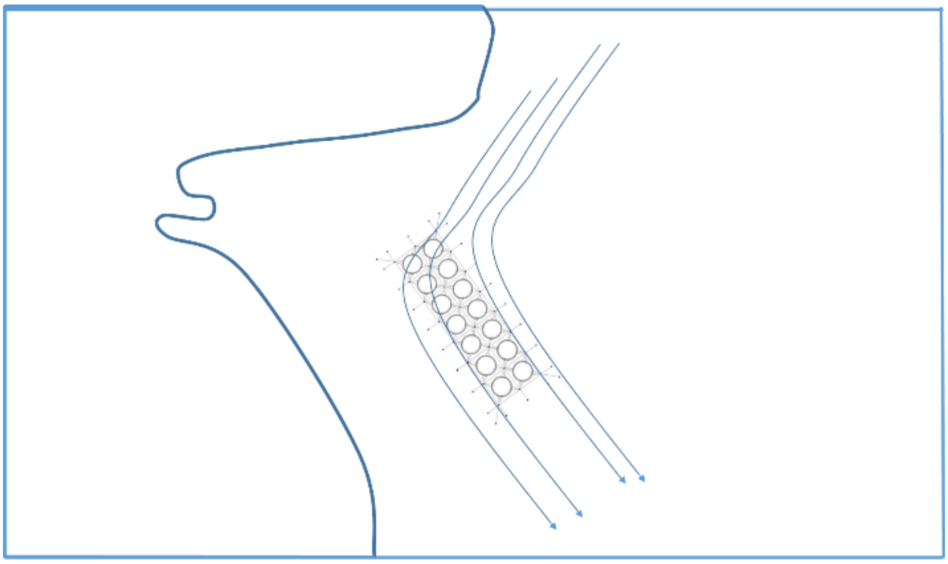

Figure 6. Positioning the cage system on the selected site.

3.2. Plan of production

Cages 14
Diameter 20m
Height 10m
Volume / cage = πr2h = 3.1416 x 102 x 10 = 3142.8 m3 = 3 142 800 liters of water Fouling, (according to the instructions of the company where the product was imported) cleaning / replacing every 6 months.
In fact, the exact level of pollution in the area is not known and for this purpose, we should consider this area with an average level of pollution.

FT max (given by the importing company) = 85%
Ve = 15 cm / sec → FT = Vi / Ve x 100 → Vi = 12.75 cm / sec (best case with a clean net and no fouling)

FT min (given by the importing company) = 75%
Ve = 15 cm / sec → FT = Vi / Ve x 100 → Vi = 11.25 cm / sec (worst case with a net with maximum fouling after 6 months)

We take the second case (the worst case).
O2 min in water = 7.0 mg / liter
O2 min tolerated for fish life = 2.0mg / liter (unconfirmed data)

Cage volume = 3142m3
FT = 75%
Ve = 15 cm / sec (this selected area is close to the Otranto canal where many sea currents circulate and the renewal of the cage is satisfactory)
O2 min available → 7.0 mg / liter - 2.0mg / liter = 5.0mg / liter

Calculations of water renewal time for floating cages for the specific case:

20m = 2000cm / 11.25cm / sec = 177.7sec = 2.96min
3 142800liter / 2.96min = 1061756 liter / min
1061756 liter / min x 5.0mg / liter = 5308783 mg O2 / min
5308783 mg O2 / sec / 112 mgO2 / kg / min = 47339 kg fish / cage
Cultivation density 47339 kg fish / 3142.8 m3 = 15.0 kg fish / m3
Normally the cultivation density for Sea Bass in this type of fattening for the Mediterranean Sea area is 10-15 kg / m3. (Merinero, S., Martínez, S., Tomás, A., Jover, M. AquaTIC Magazine, No. 23, pp. 1-19).
47339 kg fish / 0.3 kg (preferred commercial weight in our country) = 157796 fish in total can grow until

they reach the commercial weight inside a floating cage.

The owner of the subject will buy the case in a pre-fattening plant abroad at an average weight of 10g.

The time to rear Sea Bass from the weight of 10 g to the commercial 300g will take 14 months (table).

The owner of the entity that undertakes the installation of the unit seeks to supply the market with a continuous year-round product and not less than 47 tons/month ≈ 560 tons/year

Production will start only after 14 months.

After 14 months and in the following months the production is expected to easily exceed the investor's objectives with about 47339 kg * 12 months ≈ 568 t Total

Diameter 20m

Height 10m

Volume / cage = πr2h = 3.1416 x 102 x 10 = 3142.8 m3 = 3 142 800 liters of water

Fouling, (according to the instructions of the company where the product was imported) cleaning every 6 months.

In fact, this time limit should be taken with a reserve because the exact level of pollution in the area is not known and for this purpose, we should take an area with an average level of pollution.

Production will start only after 14 months.

After 14 months and in the following months the production is expected to easily exceed the investor's objectives with about 47339 kg * 12 months = 568.0 t

	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul	1-Aug	1-Sep	1-Oct	1-Nov	1-Dec	1-Jan	1-Feb	1-Mar
Months	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Weight	10.45	11.93	13.4	16.35	21.07	33.76	57.36	95.12	150.43	204.7	245.76	266.52	276.9	283.04	295.31
Survival	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
Biomass (no)	184621.3	184621.3	184621.3	184621.3	184621.3	184621.3	184621.3	184621.3	171997.6	170419.7	168841.7	167263.8	165685.8	164107.8	157796.0
Biomass (no)	1929.3	2202.5	2473.9	3018.6	3890.0	6232.8	10589.9	17561.2	25873.6	34884.9	41494.5	44579.1	45878.4	46449.1	47339.0
Density (kg)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Water Volume	128.6	146.8	164.9	201.2	259.3	415.5	706.0	1170.7	1724.9	2325.7	2766.3	2971.9	3058.6	3096.6	3155.9
Cage Volume	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8	3142.8
Cages	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Figure 7. Plan of annual production from the floating cage, starting with juvenile sea bass of approx. 10g

4. Conclusions

The Raguza bay is a very suitable site to install the system of aquaculture cages for rearing European sea bass. The area has a very good water exchange and protected by atmospheric agents. This is a convenient position and not interferes with the tourist exclusive area.

The suggested material for cages was the HDPE. Compared to other materials, it has a much longer life and lower cost. Also, such cages are easier to find in the market and their servicing is easier.

The annual production provided by the installed cages is 568 tons / 12 months if the starting juveniles of sea bass will weigh approximately 10g. This level of production meets the requirements of the investor. The capacity of the cages to be installed, for the suggested area, reaches the maximum production potential. This is because the water exchange in the cage and the oxygen level are optimal.

Production from a single cage is 47,339 tons, and this quantity the investor will obtain after 14 months. While the cage is emptied, after the cleaning operations are performed, it is ready for the introduction of 10 g juveniles which the investor will provide abroad. Considering the normal losses that may occur during the fattening phase, the investor must purchase 184621 juvenile individuals weighing 10 g previously vaccinated against the main bacterial diseases (vibrio and pasteurellosis).

Based on the calculations, the maximum wave height that can be reached in the suggested area is 1.75 m. This wave height reduces the routine services that can be done to the cages. The investor will select cages with double rings for any unexpected weather conditions.

6. References

1. Cardia F, Lovatelli A 2017. **Aquaculture operations in floating HDPE cages.** FAO publications. 10.
2. Chua TE. Tech, E: **Introduction and history of cage culture**. In Disease and disorders of finfish in cages culture Woo, P. T. K. Bruno, D. W. and Lim, L.H.S. CAB International. 2002:40

3. FAO. FAO UNJP/ALB/013/UNJ project titled “Harmonization with the EU Legislation of Technical Measures for the Albanian Marine Fishery and Aquaculture Development Potential in Albania”.http://www.fao.org/fishery/countrysector/naso_albania/en
4. Fritsch, M., Y. Morizur, E. Lambert, F. Bonhommeb and B. Guinand. 2007. **Assessment of sea bass (Dicentrarchus labrax L.) stock delimitation in the Bay of Biscay and the English Channel based on mark-recapture and genetic data**. Fish. Res. 83: 123–132. In:. Biology of European Sea Bass. Sánchez Vázquez, F. J. and Muñoz-Cueto, M.A. 2015 by Taylor & Francis Group, LLC
5. Hala, E. 2012. **Plan of production and site selection for farming sea bream (*sparus aurata*) in cage culture systems on the albanian coast**. Albanian j. agric. sci., 2012, Nr. 2/Vol. 11.
6. ICES. 2004. **Report of the Study Group on Bass,** August 2003. ICES Document CM 2004/ ACFM: 04. 73 pp In: In:. Biology of European Sea Bass. Sánchez Vázquez, F. J. and Muñoz-Cueto, M.A. 2015 by Taylor & Francis Group, LLC
7. Landless PJ, Edwards A: **Economical ways of assessing hydrography for fish farms.** Aquaculture; 1976; (8):29-43.
8. Myftiu, G. 2019. **Vlerësimi i statusit ekologjik dhe vlerësimi fillestar paraprak i PHD-së në zonën e gjirit të Vlorës (Shqipëri)**, në kuadër të projektit pilot të PHD-së me mbështetjen e Ministrisë Italiane të Mjedisit, Tokës dhe Detit (IMELS) dhe në përputhje me marrëveshjen e bashkëpunimit me UNEP/MAP. p 20
9. SIPAM. 2006. **Information System for the Promotion of Aquaculture in the Mediterranean.** FAO. Production statistics available at www.faosipam.org.
10. Vergara Martin JM: **Selección de sitios para jaulas flotantes**. Aquaculture engineering block. V International Master of Aquaculture; 2007:1-25