Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print), 2222-3045 (Online)
http://www.innspub.net
Vol. 6, No. 1, p. 249-259, 2015

RESEARCH PAPER | OPEN ACCESS

Mortality of red mullet *Mullus barbatus barbatus* (Linnaeus., 1758) in Western Algerian coasts

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Article published on January 12, 2015

Key words: Demersal, Mortality, *Mullus barbatus barbatus*, Oran's coast, Stock.

Abstract

Red mullet *Mullus barbatus barbatus* (Linnaeus, 1758) is a demersal species. It is an important commercial fish in Mediterranean coasts of Algeria, as a target of trawl fishery. Annual landings of this species are approximately 17.3% of the total landings of demersal fishes species (**DPRH**, **2010**). Of a total of 1679 specimens, 1150 females and 529 males were captured in 2009; The range of the length is between 83 to 277 mm. Fishing of red mullet occurs at depth of 0-50 m on sandy bottoms. The catch is comprised on 5 cohorts, but the average sizes of our fish sample, that are the most exploited, are aged between 0-5 years. The parameters of the Von Bertalanffy growth equation obtained for both sex were L∞= 28.88cm, k = 0.59 cm / year, and to = 0 years. The size of the first capture is 11.2 cm. Total, natural and fishing Mortalities were respectively 1.34; 0.76 and 0.58 year-1; while exploitation rate is about 0.43. It would be a preserved stock.

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Introduction

The growth represents the positive aspect of the fish stock dynamic; the study of growth is focused primarily on the determination of length function of age. When we use growth parameters to describe mortality rate they are called “mortality rates” and reflect the number of disappearances per time unit. The easiest way to describe changes in number of fish in the analyzed stock is to determine no of “larve eclozate” in the same period of time in the same cohort. It is considered that mortality in a cohort, Z value, it is composed of mortality due to fishing (“F” fishing mortality) and that having natural causes (“M” natural mortality).

Fishing is a major link, intimately related the man overboard, based on impressions of a cultural dimension, emotional satisfaction and strict food requirements relations. It is a fundamental contribution to a food security and animal protein intake, employment and countries’ welfare in maritime domain. Fishing is an activity that contributes significantly to the welfare and prosperity of mankind. In addition, fishery products are part of the staple foods most traded in the world (FAO, 2012). Fish is the main source of protein (over 70%) for African populations (Vanga, 2011). Thus, many countries have experienced economic wealth through fishing as Mauritania, Morocco and Senegal (Boushaba, 2008).

In Algeria, fishing has not been the focus of interest but now is currently the subject of considerable attention, increasingly important to overall development strategy. In 2009, the maritime Algerian population, had realized a net increase of over 15% compared to 2008, wish has created of 8800 new direct and indirect jobs (MPRH, 2009).

The total landing of demersal fish has clearly evolved over time. In fact, it is noted that the production of these fish species, recorded a weight of 5855 tonnes in 1999; 7632,5 tonnes in 2006 and 5115 tonnes in 2007 (DPRH, 2010). This species is caught by trawlers and a various other small scale fishing vessels with a range of gears practically in all Mediterranean areas. The fishery begins on age group 0, in many areas the small individuals (caught in summer and early autumn) reach higher prices. The catch is composed mainly of two species; *Mullus surmuletus* and *Mullus barbatus*.

The demersal species with high economical values are mainly caught and landed by the bottom trawl fishing fleet (Dimech and *al.*, 2008).

The Mullidae, an economic resource of the Mediterranean coasts, where they are heavily exploited (Bauchot, 1987) and characterized by the presence of two barbs in the lower jaws for foraging (Aguirre, 2000). They don't have a swim bladder (Fischer and *al.*, 1987).

Mullus barbatus barbatus (L., 1758) is a Mullidae, demersal species widely distributed along the coasts of Europe, Africa and Mediterranean Sea. It is the target of artisanal and trawls fisheries. This fish gregarious nature frequenting sandy bottoms, rocky and gravelly (Lombarte and Aguirre, 1997) is one of the favorite species for evaluation studies in the Mediterranean Coasts (CGPM, 2002).

Red mullet is the oldest known and appreciated fish. Despite the high commercial value (Suquet and Person-Le Ruyet, 2001; Gharbi and *al.*, 2004), biology and stock assessment of these of Mullidae species, are poorly known in Algeria, in general and in Oran’s coast in particular.

In the Algerian coast, only two studies have been conducted on the biology (including growth) of this species (Lalami, 1979; Djabali and *al.*, 1990) and one study on the identification and ecology of crustacean ectoparasites of fish Teleost in the eastern coast of Algeria (Ramdane, 2010). Despite no studies have been performed on mortality and exploitation of this species. The main aims purpose of the present work, is to provide the first information on the deaths: Total, natural and fishing *Mullus barbatus barbatus* and to give the state of the stock in the western coast of Algeria (Oran's coast).The data of this study will contribute to the management of this demersal species and serve as a reference for other studies.

Materials and methods

Area Sampling

The selected biological material collected from the trawler auction landings of Oran's port (Fig. 1). Oran (North Western of Algeria) is located at the bottom of an open north and west dominated directly by the mountain of Aïdour (Murdjajo), with a height of 375 m, and by the tea Moulay Abdelkader al-Jilani (Moul el Meida). The town is spread out on either side of the ravine of the river Rhi now covered.

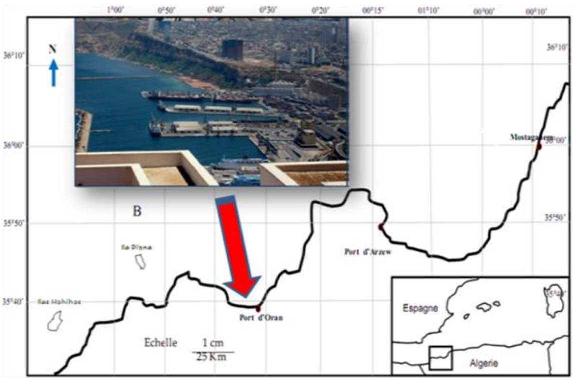


Fig. 1. Geographical Position of Oran's Coast (Hebbar and *al.*, 2012).

The geographical position of the port of Oran (longitude west 2°58′53″- North Latitude 35°42′58″) is located midway between the limits of Morocco and the province of Algiers. It is a combo port established between the beaches between the Lamoune tip to the west and the White Cap to the east. This port's dock is 6km longer with drafts ranging from 7 to 12m. It is an important fishing freight-transit port (PDAU, 1995).

Sampling and Collection of Data

A total of 1679 individuals of both sexes were collected monthly at the port fishing of Oran from January to December 2009. The fish individuals measured between 83 and 277 mm, divided into 20 length classes with a 10 mm. The total length selected (Lt) was measured to the nearest mm (the only one recognized by fishermen and legislation). The total weight (Wt) varying between 6.43 g and 206.21 g randomly. The total body weight (Wt) and eviscerated body weight were measured at 0.01 g. Sex was identified macroscopically.

In the dynamics of a stock, the growing is the positive aspect, while the disappearance process is the negative one. In order to maintain the fish stock at the desired level, the mortality control through fishing is needed. The growing was described with the help of a model and some parameters, the same data being used for mortality.

The mortality of these species is the result of the combined action of natural mortality (disease, predation, old age ...) and fishing mortality. Thus, total mortality rate is $Z = F + M$.

There are some methods for estimating mortality, and these are:

1-Total Mortality (Z)

Total mortality is the total number of missing persons in a given time interval that may be one day, month, or year. To evaluate this mortality, there exist several methods based on following parameters:

- Abundance of one or several age classes
- Marking
- Analysis CPUE-effort relations
- Analysis size frequency of the catch. It is enjoyed by our data available on the red mullet of Oran's coast.

Total mortality was determined by these following three methods:

-Powell-Wetherall Method which, from size frequency, estimates a value of asymptomatic length $L\infty$ and Z, expressed by the equation: $Z / K = b / (1-b)$.

-Beverton and Holt Method, expressed by the equation $Z = K (L\infty - Lm) / (Lm - Lc)$

Where :

K and L ∞: Parameters of the Von Bertalanffy equation;

Lm: Mean length of the sample;

Lc: Size at first capture and the smallest size that is well-represented in the sample or the smallest limit classes (Cadima, 2002).

-Method of curve linearized capture.

2 - Natural Mortality (M)

Natural mortality includes all factors of death from natural origin, such as old age, illness, stress and lack of food. Pauly (1980) shows that mortality differs according to the size of fish. Those small have a higher than those of large natural mortality.

The estimate of natural mortality (M) is obtained by three equations:

-Method Taylor (1959) given by: M = 2.996 K / (2.996 + Kto)

-Method Pauly (1980) given by the following form: log M = -0.0066-0.279Log (L∞) + 0.6543 log (K) + 0.4634 log (T°)

-And the method Djabali and *al.* (1993) expressed by Log10M = -0.0278 - 0.1172 + 0.5092 Log10L∞ log10 K

3 - Fishing Mortality

It is derived from the relationship Z = M + F, where F = Z-M.

4 - Rate of Exploitation

What is the ratio of dead individuals fishing on the number of dead individuals from various causes? The stock is in equilibrium when E is close to 0.5.

Pauly (1985) defines the usage rate (E) as: E = F / (F + M) = F / Z.

In 1989, Barry and Tegner enunciated the general rules:

If Z / K 1: Population has a tendency to mortality;

If Z / K≈ 2: Population slightly used;

If Z / K >2: Population overexploited.

Results and discussion

Age Analysis by Bhattacharya Method

The application of the method of Bhattacharya (1967) by FISAT II (Gayanilo and *al.*, 2005) allowed us to get five cohorts gather around lengths of 11.84; 15.47;19.92; 20.85 and 26.25 cm. The most important mode of catch is situated between16 and 20 cm. The modes and less than 10 cm beyond 26 cm are very negligible (Fig.2).

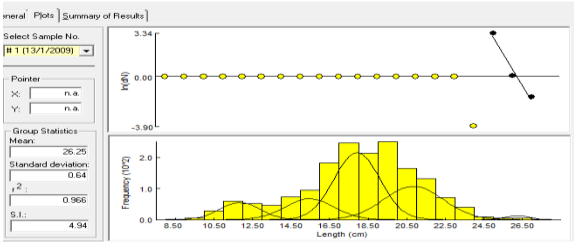


Fig. 2. Decomposition of Frequency Distribution of Sizes of *Mullus barbatus* in cohorts by Bhattacharya Method (Gayanilo and *al.*, 2005).

For both sexes, age 2 (46.84%) is dominant, followed by age 3 (27.89%) and age 1 (23.09%). Ages 4 (1.96%) and 5 (0.23%) adults are poorly represented in the catch.

Probability of Capture

The logistic curves (Fig. 3) are characterized by three distinctive points L_{25}, L_{50} and L_{75}.

L_{25}: total length (9.60 cm) at which 25% of the fish will be vulnerable to the fishing gear;

L_{50}: total length (10.73 cm) at which 50% of the fish will be vulnerable to the fishing gear;

L_{75}: total length (11.85 cm) at which 75% of the fish will be vulnerable to the fishing gear.

These results of capture depending on the lengths are generally bad for the studied species which are caught at sizes too small that have not reached sexual maturity. According Hebbar and *al.* (2012), the size at first maturity is 14.5 cm for females and 13.6 cm for male's sex of Oran's coast.

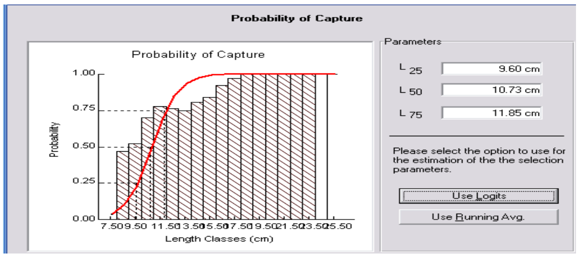
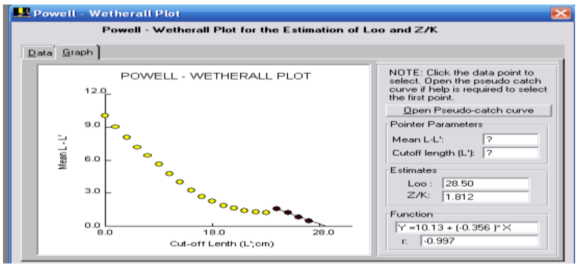


Fig. 3. Probability of Capture Of *Mullus barbatus* (Gayanilo and *al.*, 2005).

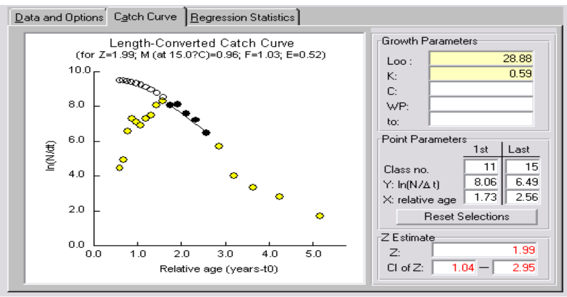
Analysis of Mortalities

Using the FISAT II software (Gayanilo and *al.*, 2005), the values of total mortality (Z) are respectively estimated from the linearized catch curve and the Powell Wetherall (Fig. 4 and 5). Furthermore, using the approximate method of Beverton and Holt (1957) (K = 0.59 yr-1, L∞ = 28.88 cm, Lm =17.91 cm, Lc = 11.20 cm), the instantaneous coefficient of total mortality (Z) was estimated at 0.965 year -1.



• : Points included in the calculation of the regression
○: Points not included

Fig. 4. Determination of Z from the Powell-Wetherall Method.



• : Points included in the calculation of the regression
○ : Points not included

Fig. 5. Determination of Z by Curve Linearized Capture.

The relationship Z/K = 1.812 (both sex) ratio is less than 2; confirming that the stock of *M. barbatus* of Oran coastline is preserved.

Altogether, the values of the instantaneous coefficient of total mortality (Z), for any sex confused, obtained by the different methods are averagely close. The average value is esteemed to be 1.34 year-1. The obtained average value of Z depends on the method used, the points included in the calculation of the regression (Hemida, 2005) and mainly on the quality of the sample.

From the growth parameters defined above and an average temperature of 15°C, the value M estimated by the equation of Pauly (1980) is 0.96 year-1. Method of Taylor (1959) gives a coefficient of natural mortality of 0.59 year-1. Method Djabali and *al.* (1993) gives a coefficient of natural mortality of 0.73 year-1. The average value of natural mortality is estimated to be 0.76 yr-1; it seems to be in standards as specified (Copace, FAO, 1994) as the lower limit conventional of natural mortality (M) is 0.5 and the superior limit is 1.

The coefficient of fishing mortality (F) is estimated at 0.58 year-1 from the values of Z and M, calculated above; it is generally less than that of natural mortality (Table. 1). The reduction in fishing mortality can only lead to increased spawning biomass, which is recommended. The biomass of the spawning stock is the capital of the entire population, one that will produce qualified interests of future generations. Booth (2000) shows that fishing mortality is significantly and spatially correlated with fishing effort.

In general, more K is great, more natural mortality (M) is high.

Natural mortality is also linked to the size and weight asymptotics (L∞, W∞) (Roff, 1984).

Other studies suggest that natural mortality (M) is correlated with reproduction. Fish species arriving early maturity have high mortality (Rikhter and Efanov, 1976). It's the same idea that Gunderson and Dygert (1968) connect natural mortality (M) at the gonadosomatic index (GSI).

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Table 1. Summary of Results of Instantaneous Mortality Rates of *M. barbatus*.

Mullus barbatus	**Both Sex**	
Total mortality Z (year -1)	Powell-Wetherall	1.07
	Linearized catch curve	1.99
	Beverton & Holt	0.96
	Z average used	**1.34**
Natural mortality M (year-1)	Taylor (1959)	0.59
	Djabali and *al.*, (1993)	0.73
	Pauly (1980)	0.96
	M average used	**0.76**
Mortality by fishing F (year -1)	**0.58**	
Rate of Exploitation E	**0.43**	

In contrast, older stages (4 and 5 years) show a low sensitivity to changes in natural mortality (M). This could be because older fish undergo fishing mortality (F) higher than natural mortality (Hilborn and Walter, 1992).

Estimates of various instantaneous coefficients of total, natural and fishing mortalities differ from an author in the other one and from a region to another. These differences may be due to the divergence of the methods used for their determination; the high values of K and L∞ that can also influence directly the natural and total mortalities by increasing them; and temperature of the water where caught demersal species was.

The method of Taylor (1959) and Pauly (1980) assume that more a species has rapid growth, more its rate natural mortality is high.

The same species can present different rates from natural mortality in various areas depending on the density of predators and/or competitors whose abundance is moreover influenced by fishing activities (Sparre and Venema, 1996).

Results of earlier studies concerning mortality rates of *Mullus barbatus* in different localities are represented in Table 2. In this study, the average exploitation rate (E =0.48) indicated that red Mullet in Oran's coasts is under exploited.

Table 2. Various Mortality Coefficients in Different Zones.

Autors (year)	**Zone**	**Sex**	**Z**	**M**	**F**	**E**
Arneri and Jukic (1986)	Adriatic Sea	Confused	1.64			
Papaconstantinou and *al.*(1986)	Golf Patraikos		0.709			
	Golf Korinthiakos	Confused	0.662			
	Ionian Sea		0.694			
Livadas (1988)	Chypre	Confused	1.278			
Vrantzas and *al.* (1992)	Saronikos Golf	Confused	1.88			
Slimani and Hamdi (2002)	Moroccan Mediterranean Sea	Confused		0.482		
Gharbi and *al.* (2004)	North and South of Tunisia	Confused		0.54		
Layachi and *al.* (2007)	Mediterranean coast of Nador	Confused	0.848			
Joksimović and *al.* (2008)	Adriatic Sea (tray of Montenegro)	Confused	0.749	0.342		
Aissat (2010)	Coast center of Algeria	Confused	1.29	0.46	0.83	0.64
Present Study	Oran's coast	Confused	1.34	0.76	0.58	0.43

The instantaneous coefficient of total mortality estimate is higher than that obtained in the Mediterranean coast of Nador (Morocco) and the tray Montenegro (Layachi, 2007; Joksimović and *al.*, 2008). In fact, it is much closer to that reported by

Livadas (1988) in Cyprus and Aissat (2010) of Algerian coastal centers (Table. 2).

The discrepancies between the mortality rates from different localities can probably be attributed to various factors such as different ecological conditions and intensive fishing activities between the localities and unequal precision of employed various methods (Joksimović and *al.*, 2009).

Fishing Mortality Analysis (F) by Virtual Population Analysis (VPA)

Fishing mortality (Fig. 6) is almost zero for sizes from 8 to 10 cm but remains low in all sizes between 11 and 15.5 cm and never exceeds the value of 0.359 yr-1. However, this is of course linked to low harvest pressure by weight. Then, very large F values recorded are observed with two high and two peaks of 2.121 and 2 yr-1, corresponding to size classes of 21.5 and 23.5 cm. The value of the average fishing mortality $\overline{F}$, estimated at 0.905 yr-1, is still much higher than the total value of fishing mortality (Fg), which is 0.555 yr-1. This is due to the fact that Fg links the total annual catch to the average number of individuals in the population.

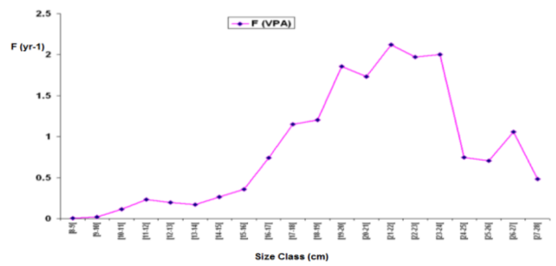

Fig. 6. Fishing Mortality (VPA) according to the size of *Mullus barbatus* Stock in Oran's Coasts.

The most vulnerable fish for fishing gear have sizes ranging from 16 to 24.9 cm. The majority of fish are caught in sizes between 15 and 28 cm if we refer to the curve of the fishing mortality (Fig. 6).

Considering that fishing mortality should be maintained below safety thresholds to ensure high long-term returns, while limiting the risk of stock collapse and ensuring stability and increased sustainability of fisheries. Whereas preventive actions are required to address and control the levels of excessive fishing mortality while waiting for the development and the adoption of multiannual management plans for stocks and the fisheries involving.

Exploitation Rates

Exploitation rate E = 0.48 so close to 0.5, suggests that the stock of red mullet would be good. The relatively small value of E indicates underfishing of this stock during that period. However, these results are approximate in the absence of reliable statistics over several years (fishing effort, catch, ...) to directly calculate different rates. Gulland (1971) stated that suitable yield is optimized when F= M (i.e., when E is more than 0.5), the stock is generally considered to be overfished. More recently, Pauly (1987) proposed a lower optimum F that equals 0.4 M.

Very high exploitation rates have been recorded in Italian waters (CGPM, 1995; Baino and *al.*, 1985; Abella and *al.*, 1999) except for Sardinia and other areas of the Tyrrhenian Sea; the species is overexploited, as in the Adriatic (Ungaro and *al.*, 1994) or Western Mediterranean (Martin and *al.*, 1999). The red mullet is fully exploited in southern Tunisian waters and in the Ionian Sea (Tursi and *al.*, 1995).

Conclusion

In 2009, landings of red mullet at the port of Oran are fluctuating, with a maximum in September and a minimum during the summer season. This maximum would be due, on one hand to new recruits (juveniles join the parental stock and therefore represent of this fact a large part of the catch), and on the other hand, to the turbidity ruling on funds and supports increased taken. By cons, declining catches in the summer is due to the withdrawal of the parents and the closure of the fishery during the biological period rest.

The estimated fishing mortality rates and exploitation rates were very average in the study area. Possible causes of the differences in life-history parameters between these results to those of previous studies could be attributed to differences in environmental conditions and/or sampling strategy.

Estimation the growth rhythm constitutes in a basic parameter that comes to answer and to argument the recommendation to protect the stocks and to limit the length of the standard fishes at first catch. Analyzing the influence result of this restriction, doubled by the Y/R (production / recruitment) rule, we can obtain, in general lines, information over the dimensions of the stock and its exploitation level.

The present work has shown that the stock of red mullet : *M. barbatus* of Oran coastline is preserved (underexploited) and to test our estimates and assumptions made during this first works. It is necessary and will be interesting to pursue and to spread this study over several annual cycles.

Oran's coast can be at present considered as a refuge for *Mullus barbatus* and (probably) for other demersal species from which it is suggested a partial transfer of the fishing offshore (beyond 3 nautical miles). This measure will allow certainly an increase of the biomass, and improvement of recruitment levels and a growth of the productivity of the resource. This stock is considered within its safety limits.

The Scientists begin to measure the scale of the rarefaction of large-sized fish. Researchers whether biologists, oceanographers, ecologists and economists, lean on fishery resources. To listen and read to them allows understanding better phenomena with which the fishermen are confronted.

Finally, three actors of the fisheries to know the administration, scientists and professionals, must imperatively work, cooperate together their policies and strategies for a sustainable development methods and fishing gear, in order to preserve and manage fishery resources to be able to meet the needs present and future generations.

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