Structure of the ichthyological stands in the Gulf of Annaba, Algerian east coast

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Abstract. The city of Annaba is located in the eastern part of the Algerian coast, its basin extends on a continental shelf from Cap de Garde in the west to Cap Rosa in the east occupying 2,337 km^2. The Gulf of Annaba is characterized by an alternation of soft bottoms (muddy, sandy and detrital) and hard substrates (rocky, tuff and gravel). In 2016, we focused on the description and spatial distribution of the biodiversity of this ecosystem through daily landings by a trawler (Zin Elabidine registered 731/AN). Fishing operations are carried out with 2 types of trawls: bottom trawlers with a large vertical opening (GOV) and pelagic trawlers drawn on depths ranging from -25 to -280 m at 3 and 4 knots. We inventoried a total of 42 species belonging to 31 families of fish with 97.2%, crustaceans with 0.5% and cephalopods 2.3%. The sardine *Sardina pilchardus* (Walbaum, 1792) as the main species fished, reaching 26.2% of the annual stock. Small pelagics represent 59.2% of landings, while demersal stands are more diversified despite their low abundance. The fishing features show a variability in species richness of 6.20±2.64 species which can be explained by either habitat heterogeneity, inter and intraspecific space-trophic competition or anthropogenic and/or climatic disturbances. Ichthyological stands in the Gulf of Annaba are dominated only by a few species representing numerically and weightingly almost the totality. The exploitation indices obtained and the structure of the ichthyological stand show the existence of a r-type demographic strategy reflecting a disturbed ecological system. It requires particular attention, aimed at protecting the marine environment, or the creation of marine protected areas and the strengthening of fisheries regulations.
Key Words: fishing, ichthyological population, exploitation indices, Gulf of Annaba.

Introduction. The study of ichthyological stands can be considered an important approach for proposing a management model for a marine area (Draud et al 2018). It defines in the short term the conditions for sustainable exploitation of fishery resources, taking into account the balance and functioning of ecosystems (Lévêque & Paugy 2006; Russ & Leahy 2017). This ecosystem approach allows management and protection of the environment based on ecological knowledge of ichthyological stands (Pérez-Domínguez et al 2012; Doyen et al 2017).

This work is part of an extremely broad scientific theme, which addresses national and international biodiversity conservation concerns through the acquisition and synthesis of scientific data by creating a dashboard with indicators of the health status of marine ecosystems (Walker 1995). This integrating framework will be restored to the other sectors of natural environment management and development in the form of a geo-referenced database. This information will allow a better understanding of the spatio-temporal variations in the specific biodiversity of ichthyological stands, using classical indices derived essentially from theoretical ecology (Dallot 1998; Barbault 2008; Legendre & Legendre 2012).

The ichthyological populations in the Mediterranean are represented by a very large number of species, but they are only dominated by a few that represent 75% of ichthyological populations numerically and by weight. In numerical and weight terms, these dominant species use the strategy that characterizes a disturbed ecosystem.

The study of the faunal inventory, specific richness, density and biomass of ichthyological populations frequenting the trawlable waters of the Annaba Gulf in 2016 will make it possible to identify and prioritise the main factors governing the structuring processes of ichthyological populations, as well as the consequences of fishing activities on the marine environment. It has been shown that fishing pressure can lead to new trophic or spatial competition between species and cause profound changes in the organisation and functioning of ecosystems (Graham et al 2005).

Material and Method

Description of the study sites. The Algerian coast is bordered on the greater part of its extent by high cliffs of varied geological formations, it presents indentations more or less widely open towards the north and which form from east to west the following bays and gulfs: Annaba Gulf, Skikda Gulf, Jijel Bay, Béjaïa Gulf, Zemmouri Bay, Algiers Bay, Bou-Ismaïl Bay, Arzew Gulf, Oran Gulf, Beni Saf Bay and Ghazaouet Gulf.

The Gulf of Annaba is bounded by the Cap de Garde to the west (36°58'02''N, 7°47'49''E) and Cap Rosa to the east (36°57'03''N, 8°14'35''E), located about 670 km from Algiers, it forms the eastern wing of the Algerian coast (Figure 1).

The Gulf of Annaba extends over 2,337 km², the continental shelf of the shore at -100 m depth occupies an area of 1,048 km², the upper edge of the continental slope from -100 to -500 m extends over 733 km² and the lower part of the continental slope from -500 to -1,000 m depth represents 556 km² (Refes 2011).

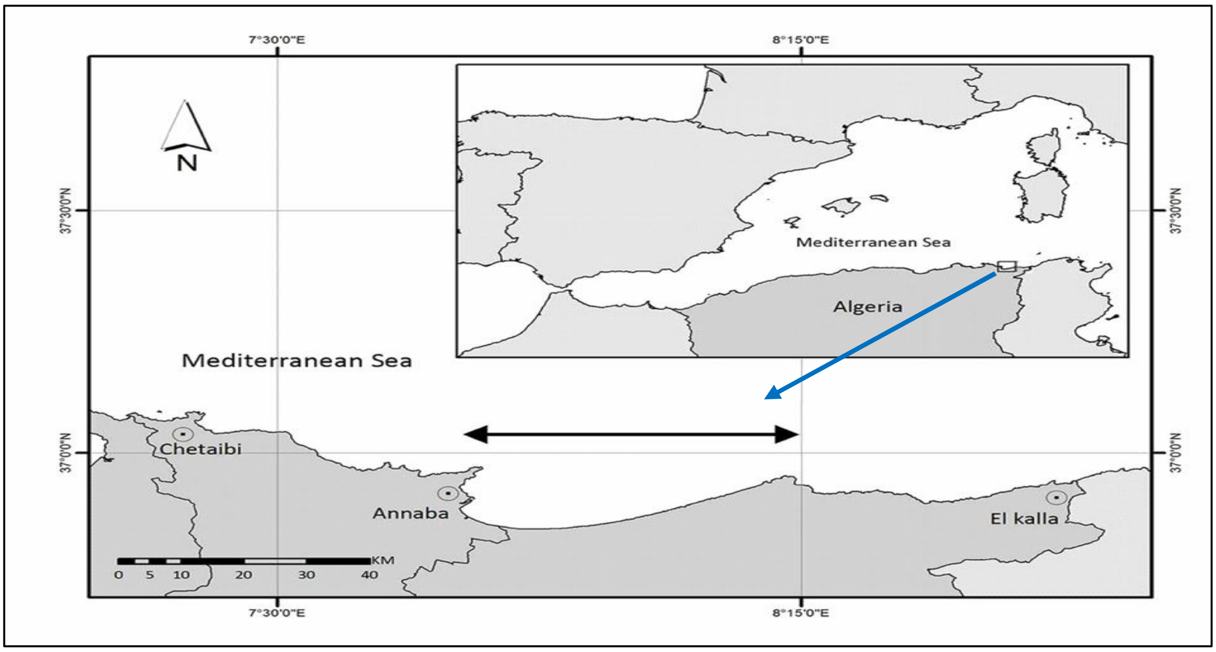

Figure 1. The location of the Gulf of Annaba, Algeria.

Sampling. Ichthyodiversity was studied on the basis of information collected daily from professional fishing in 2016 (except on days of bad weather or equipment maintenance). A total of 101 sea outings on the trawler Zin Elabidine registered 731/AN were carried out. Fishing operations were carried out by a pelagic trawl of 18 m vertical opening for pelagic waters drawn at a speed of 4 knots and by a bottom trawl (GOV) for benthic waters of 0 to 3 m vertical opening dragged at 3 knots between -25 and -280 m depth.

Sample processing. On board the trawler, catches are divided into 3 categories: fish, crustaceans and cephalopods before being classified using the identification keys recommended by Whitehead et al (1986) and Bauchot (1987) or Louisy (2005). After identification, individuals are counted and weighed. During abundant catches, the count is carried out on a sample weighed and subsequently reported to the total individuals sinned.

Data analysis. To analyze the structure of ichthyological populations, we calculated 5 ecological indices as recommended by Frontier (1983):
Species richness: Species richness is the number of species recorded in a sample (S).
Numerical abundance and weight abundance: The numerical abundance (A) of a species in a given sample is the number of individuals of that species in the sample and the weight abundance (W) is the mass of those individuals.
Density: The density of a species (d) is the number of individuals of that species in a given sample relative to a unit area (ind km^{-2}).
Biomass: The biomass (B) of a species is the mass of individuals of that species in a given sample relative to a unit area (kg km^{-2}).
Numerical dominance, weight dominance and mean:

Numerical dominance (Dn): $Dna = \frac{Aa}{Aa + Ab + \cdots .. + An} \times 100$
Dna: numerical dominance of species (a) in the sample (%);
Aa: abundance of species a;
Aa + Ab + ... + An: abundance of the species contained in the sample.

Weight dominance (Dp): $Dpa = \frac{Ba}{Ba + Bb + \cdots .. + Bn} \times 100$
Dpa: dominance by weight of species (a) in sampling (%);
Ba: biomass of species a;
Ba + Bb + ... + Bn: biomass of the species contained in the sample.
Mean dominance (Dm) is the ratio of the sum of the numerical or weight dominances of the species (a) to the total number of samples taken.

Results. To study the structure of the ichthyological population fished by the trawler Zin Elabidine in the coastal waters of Annaba, we established its overall faunal composition, structure and spatial and bathymetric distributions.

Global faunistic composition populating the Gulf of Annaba. The wildlife inventory based on the daily fisheries of 2016: the specific diversity is 42: 34 fish, 5 crustaceans and 3 molluscs (Table 1).

Concerning fish. The inventoried fish belong to 2 class: Chondrichthyes and Actinopterygii, 10 orders, 23 families and 34 species (Table 1).

The Chondrichthyes class (Huxley, 1880) belongs to the Elasmobranchii subclass in the Chordata phylum and the Actinopterygii class (Klein, 1885) to the Osteichthyes superclass in the Teleostei subclass and the Gnathostomata phylum.

The Chondrichthyes inventoried belong to 2 orders: Myliobatiformes (Compagno, 1973) and Carcharhiniformes (Compagno, 1977) with only 1 family and only 1 species each, while Actinopterygii are represented by 8 orders: Clupeiformes, Lophiiformes, Gadiformes, Scorpaeniformes, Perciformes, Pleuronectiformes, Tetraodontiformes and Zeiformes represented by a set of 21 families and 32 species (Table 1).

Concerning crustaceans. The Malacostraca class (Latreille, 1802) belongs to the Crustacea subphylum in the Euarthropoda Clade. Malacostraca crustaceans are related to one single order, Decapoda, with 5 different families: Artisteidae, Nephropidae, Palinuridae, Penaeidae, and Scyllaridae each represented by a single species (Table 1).

Concerning molluscs. The class of Cephalopoda (Cuvier, 1797) belongs to the super phylum of the Lophozoa in the infra-regnum of the Protostomia and the sub-regnum Bilaeria of the Animalia. Cephalopod molluscs are represented by 3 orders: Myopsida, Octopoda and Sepiida with 1 family and 1 species each (Table 1).

Table 1

List of fish, crustaceans and molluscs inventoried from the daily fisheries of the trawler Zin Elabidine in 2016 (classification according to Eschmeyer et al (2018)

Class	*Order*	*Family*	*Genera and species*
Chondrichthyes	Myliobatiformes	Dasyatidae	*Dasyatis pastinaca* (Linnaeus, 1758)
	Carcharhiniformes	Scyliorhinidae	*Scyliorhinus canicula* (Linnaeus, 1758)
Actinopterygii	Clupeiformes	Clupeidae	*Sardina pilchardus* (Walbaum, 1792)
			Sardinella aurita Valenciennes, 1847
		Engraulidae	*Engraulis encrasicholus* (Linnaeus, 1758)
	Lophiiformes	Lophiidae	*Lophius piscatorius* Linnaeus, 1758
	Gadiformes	Gadidae	*Phycis blennoïdes* (Brünnich, 1768)
		Merlucciidae	*Merluccius merluccius* (Linnaeus, 1758)
	Scorpaeniformes	Triglidae	*Trigla lyra* Linnaeus, 1758
	Perciformes	Gobiidae	*Gobius niger* Linnaeus, 1758
		Serranidae	*Epinephelus marginatus* (Lowe, 1834)
		Carangidae	*Seriola dumerili* (Risso, 1810)
			Trachurus trachurus (Linnaeus, 1758)
		Sparidae	*Boops boops* (Linnaeus, 1758)
			Dentex gibbosus (Rafinesque, 1810)
			Lithognathus mormyrus (Linnaeus, 1758)
			Pagellus acarne (Risso, 1827)
			Pagellus bogaraveo (Brünnich, 1768)
			Pagellus erythrinus (Linnaeus, 1758)
			Pagrus pagrus (Linnaeus, 1758)
			Sparus aurata Linnaeus, 1758
		Sciaenidae	*Argyrosomus regius* (Asso, 1810)
		Mullidae	*Mullus barbatus* Linnaeus, 1758
			Mullus surmuletus Linnaeus, 1758
		Trachinidae	*Trachinus draco* Linnaeus, 1758
		Scombridae	*Sarda sarda* (Bloch, 1793),
			Scomber scombrus Linnaeus, 1758
		Sphyraenidae	*Sphyraena sphyraena* (Linnaeus, 1758)
		Uranoscopidae	*Uranoscopus scaber* Linnaeus, 1758
		Xiphiidae	*Xiphias gladius* Linnaeus, 1758
	Pleuronectiformes	Soleidae	*Solea solea* (Linnaeus, 1758)
		Scophthalmidae	*Scophthalmus maximus* (Linnaeus, 1758)
	Tetraodontiformes	Balistidae	*Balistes capriscus* Gmelin, 1789
	Zeiformes	Zeidae	*Zeus faber* Linnaeus, 1758
Malacostraca	Decapoda	Artisteidae	*Aristeus antennatus* (Risso, 1816)
		Nephropidae	*Nephrops norvegicus* (Linnaeus, 1758)
		Palinuridae	*Palinurus elephas* (Fabricius, 1787)
		Penaeidae	*Melicertus kerathurus* (Forskål, 1775)
		Scyllaridae	*Scyllarus arctus* (Linnaeus, 1758)
Cephalopoda	Myopsida	Loliginidae	*Loligo vulgaris* Lamarck, 1798
	Octopoda	Eledonidae	*Eledone cirrhosa* (Lamarck, 1798)
	Sepiida	Sepiidae	*Sepia officinalis* Linnaeus, 1758

***Zone, sector and fishery characteristics**.* The Gulf of Annaba is characterized by 3 types of bottoms : sandy, muddy or covered with gravel which change according to the depth (Tables 2, 3, 4). Thus, we divided it into 3 zones, the 1st has 4 fishing sectors, the 2nd 11 and the 3rd 3 (Figure 2).

The restricted fishing areas are 2 nautical miles (3704 m) around the port of Annaba and the 2 Caps de garde to the west and rosa to the east (Figure 2 yellow, red and green circles). It is the same for the 2 crossed red lines, basic lines delimiting the zone excluded from fishing all year round. The first line goes from the Cap de Garde to Oued Mafrag and the 2nd from the Basilica of Saint Augustine to Cap Roux at the Tunisian border via Cap rosa to El kala (Figure 2). The areas closed between 1 May and 31 August, the breeding period, are represented by the 2 black lines in Figure 2 separated from the red lines by 3 nautical miles.

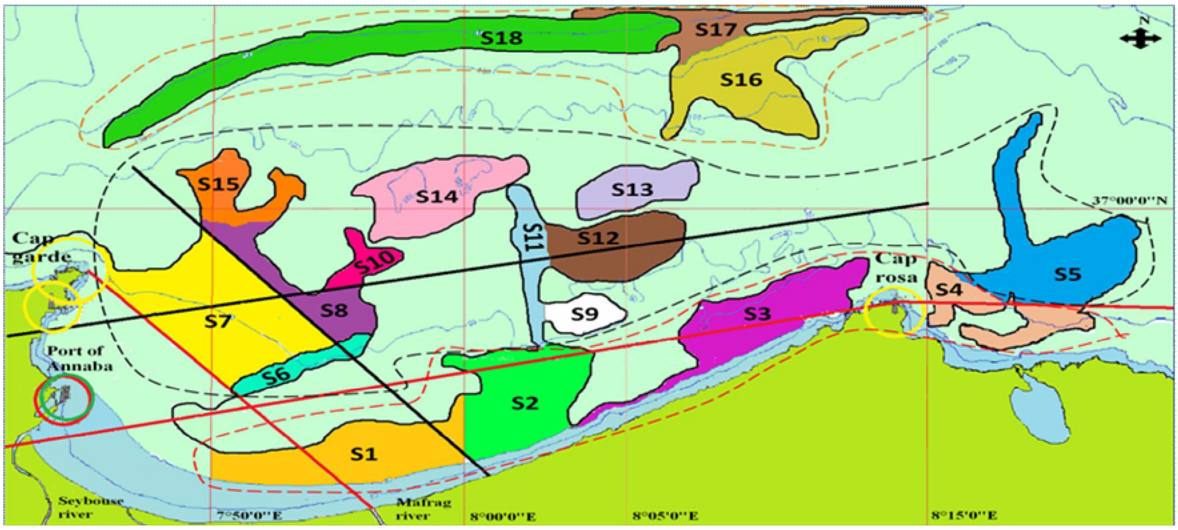

Figure 2. Geographical situation of the 3 zones and 18 fishing sectors. Yellow, red, green circles and red lines: areas not permitted for fishing. Black lines: areas temporarily closed to fishing.

In 2016, we conducted a total of 245 boat landings samples from the 18 sectors in the 3 fishing zones. Total fishing effort is estimated at 394 hours, 141 hours devoted to pelagic fishing and 253 hours to demersal fishing, for an annual fishery production of 43 tonnes.

Concerning fishing zone 1. Fishing zone 1 has 4 sectors that lie between -25 m (S1, S3, S4) and -52 m (S3) deep, it is an alternation of sandy, gravel and sometimes muddy bottoms (Table 2). On an annual total of 93 landings and a fishing effort of 161 h, the highest yield is achieved in fishing sector 2 (S2) with 162 Kg h^{-1} and the lowest yields in S1 and S3 around 91 Kg h^{-1} (Table 2). *M. surmuletus, T. trachurus* and *E. encrasicolus* are the dominant species fished in the 4 sectors (Table 2).

Table 2

Bathymetric characteristics, number, effort, yield and main species fished in the 4 sectors of fishing area 1 of Gulf of Annaba

Sectors	*Depth (m)*	*Nature of the bottom*	*Number of landings*	*Fishing effort (h)*	*Fishing yield (Kg h^{-1})*	*Dominant species*
S1	25-46	Sand	53	100	92	*M. surmuletus* *S. pilchardus* *T. trachurus* *B. boops*
S2	30-45	Sand	12	13	162	*T. trachurus* *B. boops* *M. surmuletus* *S. pilchardus*
S3	25-52	Sand, gravel	21	34	91	*M. surmuletus* *T. trachurus* *S. pilchardus* *P. erythrinus*
S4	25-50	Sand, gravel, mud	7	14	116	*E. encrasicolus* *S. pilchardus* *S. aurita*

Concerning fishing zone 2. Fishing zone 2 has 11 sectors distributed between -30 m (S6) and -101 m (S14) of depth, it is an arrow of sand, mud, soft mud, tuff and gravel bottom (Table 3). Out of an annual total of 138 landings and a fishing effort of 208 hours, the highest yield is achieved in fishing sector 10 (S10) with 202 Kg h^{-1} and the lowest yields in S9 with 52 Kg h^{-1} (Table 3). *M. merluccius, S. pilchardus, M. barbatus, P. erythrinus* and *S. aurita* are the dominant species fished in these 11 areas (Table 3).

Table 3

Bathymetric characteristics, number, effort, yield and main species fished in the 11 sectors of fishing area 2 of the Gulf of Annaba

Sectors	*Depth (m)*	*Nature of the bottom*	*Number of landings*	*Fishing effort (h)*	*Fishing yield (Kg h^{-1})*	*Dominant species*
S5	50-90	Sand, mud	3	6	161	*M. merluccius* *S. aurita* *M. surmuletus*
S6	30-72	Sand, mud, soft mud	40	63	116	*S. pilchardus* *E. encrasicolus* *T. trachurus* *M. surmuletus*
S7	32-55	Mud	8	11	122	*S. pilchardus* *T. trachurus* *E. encrasicolus* *M. barbatus*
S8	52-90	Mud, soft mud	9	22	95	*M. merluccius* *M. surmuletus* *T. trachurus* *T. lyra*
S9	47-60	Mud	4	3	52	*M. barbatus* *T. trachurus* *B. boops*
S10	42-60	Sand, tuff	2	2	202	*P. erythrinus* *T. lyra*
S11	56-80	Gravel	9	12	105	*S. pilchardus* *T. trachurus* *M. surmuletus*
S12	44-74	Sand, gravel, mud	26	35	76	*S. pilchardus* *T. trachurus* *M. surmuletus* *S. aurita* *M. merluccius*
S13	66-90	Gravel, mud	9	8	66	*M. merluccius* *S. aurita* *T. trachurus*
S14	60-101	Sand, gravel, mud	24	38	126	*S. pilchardus* *M. merluccius* *M. surmuletus* *T. trachurus*
S15	44-100	Sand	4	8	112	*S. aurita* *S. pilchardus*

Concerning fishing zone 3. Fishing zone 3 has 3 sectors shared between -55 m (S17) and -208 m (S18) depth, varying between sand, mud and tuff bottoms (Table 4). On an annual total of 14 harvests and a fishing effort of 27 hours, the highest yield is achieved in fishing sector 18 (S18) with 237 Kg h^{-1} and the lowest yields in S16 with 91 Kg h^{-1} (Table 4). The species *M. merluccius* and *T. trachurus* are the dominant species fished in the 3 sectors of this 3rd zone (Table 4).

Table 4
Bathymetric characteristics, number, effort, yield and main species fished in the 3 sectors of fishing zone 3 of the Gulf of Annaba

Sectors	*Depth (m)*	*Nature of the bottom*	*Number of landings*	*Fishing effort (h)*	*Fishing yield (Kg h⁻¹)*	*Dominant species*
S16	85-180	Mud	3	6	91	*M. merluccius* *T. lyra*
S17	55-250	Mud	4	7	144	*M. merluccius* *M. surmuletus* *T. trachurus* *A. antennatus*
S18	155-280	Sand, tuff, mud	7	14	237	*T. trachurus* *E. encrasicolus* *B ; boops* *S. pilchardus* *M. merluccius* *A. antennatus*

Ichthyological species richness. The mean species richness of trawlable ichthyological stands is 6.2±2.6 species in all samples. The sector S8 of zone 2 has an average species richness of 8.11 species, it is the largest in the Gulf of Annaba (Figure 3), the lowest species richness are found in the sector S4 of zone 1 and sector S15 of zone 2 with 2.1 and 1.5 species respectively (Figure 3).

The species richness is a function of bathymetry, it increases from coast to offshore in the 3 fishing zones, the highest values are on the continental shelf (Table 5).

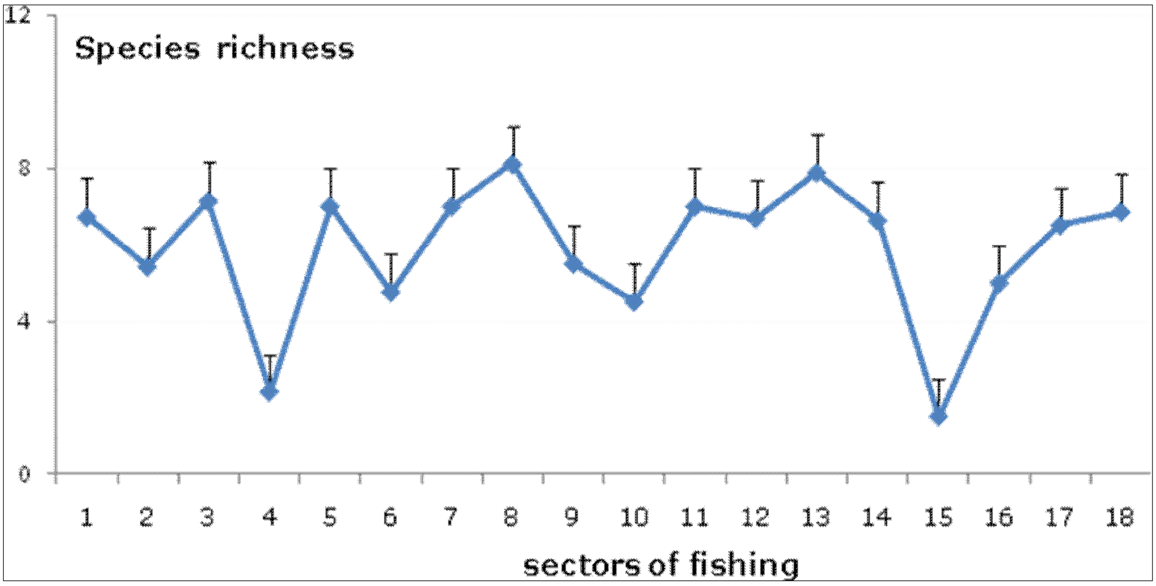

Figure 3. Mean values of species richness ichthyological stands in the 18 sectors of the 3 fishing zones of the Gulf of Annaba in 2016.

Ichthyological density. The mean density of trawlable ichthyological stands is 455.2±213.6 ind km-² in all samples. The fishing sector S4 of zone 1 has the highest average density of the Gulf of Annaba it reaches 1646.05 ind km-², the lowest is found in the fishing sector S16 of zone 3 the average density being 49.86 ind km-² (Figure 4).

The general evolution of densities as a function of depth shows a regressive trend in density from the coast towards the open sea with the highest values on the coast at depths from 0 to -50 m (Table 5). The dominant species on the mainland coast of the Gulf are S. pilchardus with 51%, *E. encrasicolus* with 14%, *M. surmuletus* and *T. trachurus* with 11% for both, *S. aurita* with 6%, *M. barbatus* with 3%, *B. boops* with 2% and finally *M. merluccius* 1%.

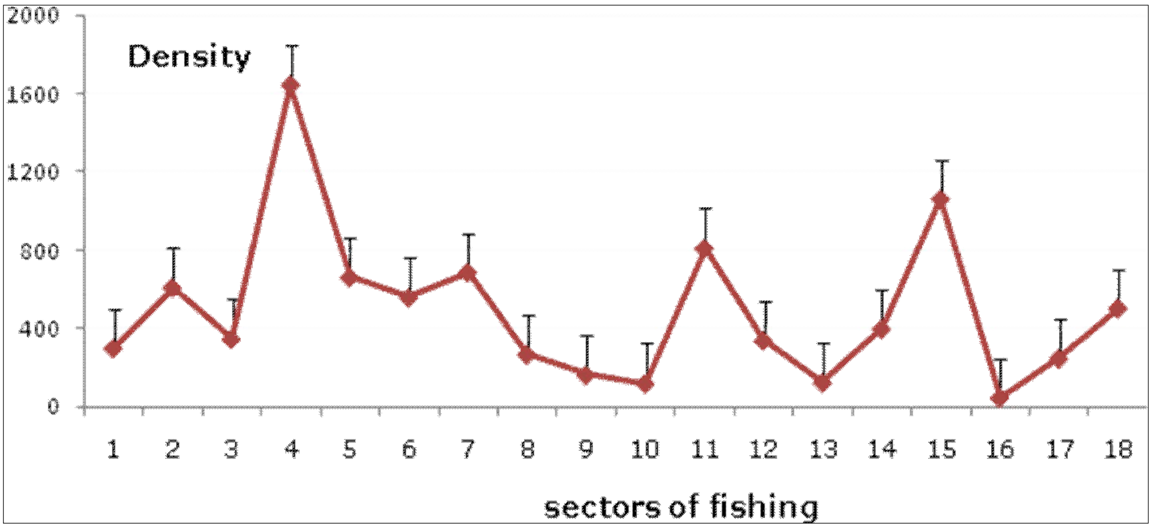

Figure 4. Mean density values (ind km-^{2}) of ichthyological populations in the 18 sectors of the 3 fishing zones of the Gulf of Annaba in 2016.

Ichthyological biomass. The mean biomass of trawlable ichthyological populations is 14.8±3.0 kg km-^{2} in all samples. The highest average biomass is in zone 1 sector S4 with 38.99 kg km-^{2} and the lowest in zone 2 sector S9 with 7.11 kg km-^{2} (Figure 5).

Changes in mean biomasses as a function of bathymetry show that the values tend to decrease from the coast towards the open sea (Table 5). On the continental coast, the dominant species by weight are: *S. pilchardus* and *T. trachurus* main dominant species with 26.2 and 14.4% followed by *M. surmuletus* with 14.3%, *M. merluccius* with 9.3%, *E. encrasicolus* with 8.2%, *S. aurita* with 5.2%, *P. erythrinus* with 4.3% and finally *B. boops* with 4%.

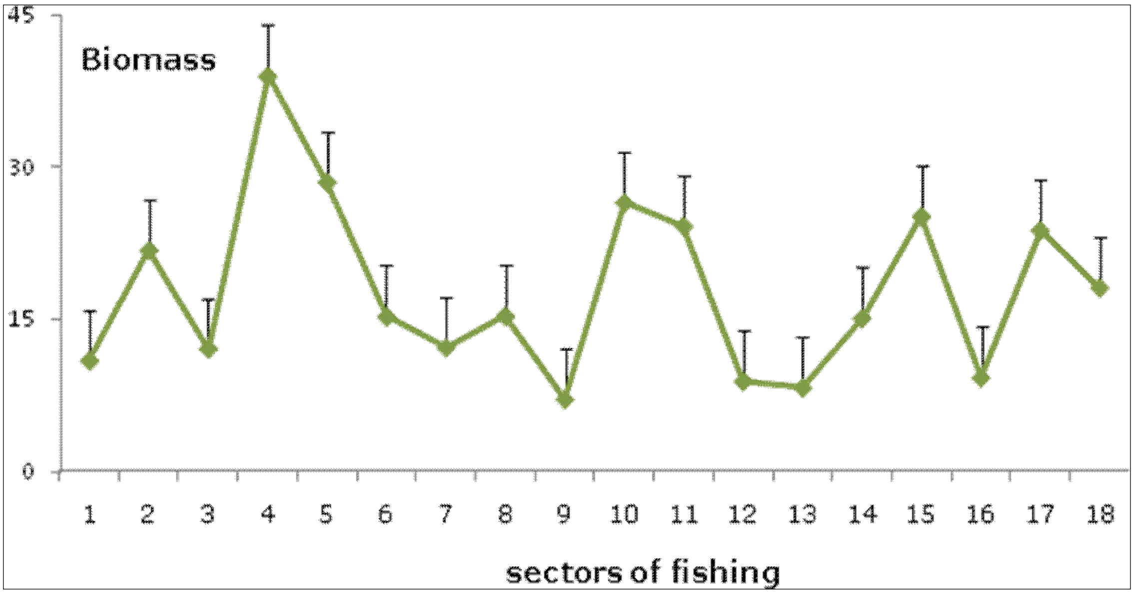

Figure 5. Mean biomass values (kg km-^{2}) of ichthyological populations in the 18 sectors of the 3 fishing zones of the Gulf of Annaba in 2016.

Table 5

Bathymetric distribution of species richness, density (ind km^{-2}) and biomass (kg km^{-2}) of ichthyological populations in the 3 zones of the Gulf of Annaba

Storey (m)	*Species richness*	*Density*	*Biomass*
Zone 1 (0-50)	5.9±2.5	477.2±260.2	65.9±22.6
Zone 2 (50-100)	6.6±2.8	427.1±176.1	14.6±2.2
Zone 3 (100-200)	6.5±2.7	365.8±114.4	17.4±8.0
Means	6.2±2.6	455.2±213.6	14.8±3.0

Discussion. The mean species richness of ichthyofauna is 6.20±2.64 species. The means obtained during the various fishing campaigns from ISTPM (1982); from Djabali & Refes (1990); from Massuti et al (2003, 2004a) and from Refes (2011) are higher than those obtained in the present study (Table 6).

This difference is related to the sampling effort carried out, the trawl areas are much larger and the fishing sorting times are 2 to 4 hours.

Moreover, the species richness obtained concerns only the continental shelf of the Gulf of Annaba at a maximum depth of -280 m, the fisheries in the depths of the slope were not counted.

Table 6

Mean species richness obtained during the various fishing campaigns in the Gulf of Annaba

	ISTPM (1982)	*Djabali & Refes (1990)*	*Massuti et al (2003)*	*Massuti et al (2004a)*	*Refes (2011)*	*Present study*
Gulf of Annaba	20.1	18.8	20.9	21.0	30.8	6.2

The sampling effort is proportional to the number of species and the chances of capturing rare groups are increased. Blondel (1995) shows a close relationship between specific wealth and sample size. This finding is reported by many authors (Whittaker 1972; Hubalek 2000; Magurran 2013). On the other hand, Leathwick et al (2006) correlate species richness with trawl speed and trawl distance; they also indicate, on the basis of statistical models applied to fishing campaigns, a close link between species richness and residual temperature, surface temperature, residual salinity, chlorophyll and tidal currents.

The analysis of the evolution of species richness, from the coast towards the open sea in the Gulf of Annaba, is parabolic with maximum diversity at intermediate depths. This evolution is similar to those encountered by Djabali & Refes (1990); Massuti et al (2003, 2004a); Refes (2011) and during the work of the ISTPM (1982) (Table 7).

Table 7

Mean species richness per bathymetric stage obtained during the various fishing campaigns carried out in the waters of the Gulf of Annaba in 2016

Storey (m)	*ISTPM (1982)*	*Djabali & Refes (1990)*	*Massuti et al (2003)*	*Massuti et al (2004a)*	*Refes (2011)*	*Present study*
0-50	17.3±2.7	22.5±2.9	-	-	32.4±5.4	5.9±2.5
50-100	19.3±1.8	19.2±3.1	-	20.8±2.0	37.7±5.3	6.6±2.8
100-200	20.8±3.7	20.6±6.0	-	19.0±4.0	34.8±3.2	6.5±2.6
200-500	20.1±2.5	-	21.3±1.7	23.4±2.9	30.3±4.0	-
500-800	13.7±1.9	-	20.6±3.5	19.6±2.1	21.8±3.9	-
Means	18.9±1.1	20.3±2.8	21.1±1.7	20.9±1.4	32.4±2.5	6.2±2.6

Allain (1999) explains that this phenomenon is linked to spatiotrophic competition, predation and growth rates of different ichthyological populations, which leads to maximum species richness at a given depth, allowing the ichthyological populations of the different bathymetric stages to reach or not a balance.

According to Hall-Spencer & Moore (2002), high stand species richness is characterized by high stand sensitivity to anthropogenic impacts. Ordines & Massutí (2009) explain that this high species richness of ichthyological stands is closely linked to a high species richness of benthic stands, which is linked to complex ecosystems such as the Maerl or Posidonia bottoms.

In the long term, competition due to exploitation by fishing could lead to a change in diversity through a change in the faunal composition of stands. The latter involve replacing species with long life, late maturity, low growth and mortality rates (k strategy species) with more reactive and less sensitive species that can rapidly colonize disturbed areas due to short life span, early sexual maturity, high fertility (r strategy species) and high growth and mortality rates as reported by Blanchard (2000).

The densities and biomasses of ichthyological populations in the Gulf of Annaba show strong fluctuations with values of 455.2±213.6 ind km^{-2} and 14.8±3.0 kg km^{-2} respectively (Table 8). A comparison of the numerical and weight means with the means of the previous campaigns shows a significant decrease in the mean densities and biomasses (Table 8) which pass respectively from 33784.5 ind km^{-2} and 1832.4 kg km^{-2} in 1982 to 455.2 ind km^{-2} to 14.8 kg km^{-2} in 2016.

These observations can be directly linked to the pressure of fishing, exerted on all resources and the general decrease in abundance that results and more particularly on the ichthyological populations directly targeted by exploitation.

Table 8

Average densities (ind km^{-2}) and biomass (kg km^{-2}) obtained during the various fishing campaigns in the Gulf of Annaba

	ISTPM (1982)	*Djabali & Refes (1990)*	*Massuti et al (2003)*	*Massuti et al (2004a)*	*Refes (2011)*	*Present study*
Density	33784.5	5301.9	7020.4	7216	4416.9	455.2
Biomass	1832.4	498.6	385	250.5	467.1	14.8

The lowest abundance indices (densities and mean biomasses) are recorded above -100 m depth, the Mediterranean bottoms of the continental shelf and the slope down to -500 m are subject, as Caddy (1993) reports, to strong pressure from trawlers, particularly the bathymetric stratum between 100-200 m. This result is not in line with that of the ISTPM (1982), which finds the highest abundance indices in bottoms of -100 m (Tables 9 and 10). This difference is explained by a greater fishing pressure since 1982 when trawlers, because of their low motive power, exerted their activity on the coastal strip on the -100 m bottom.

Table 9

Mean densities (ind km^{-2}) per bathymetric stage obtained during the various fishing campaigns in the Gulf of Annaba, Eastern Algeria

Storey (m)	*ISTPM (1982)*	*Djabali & Refes (1990)*	*Massuti et al (2003)*	*Massuti et al (2004a)*	*Refes (2011)*	*Present study*
0-50	19103±11149	5506±2793	-	-	6149±2150	477±260
50-100	30547±16216	6149±690	-	42426±32590	5482±1794	427±176
100-200	74228±89227	4591±1279	-	17383±16560	2012±753	366±114
200-500	1757±11631	-	13482±9646	3301±1730	1932±290	-
500-800	1791±280	-	4742±1482	5576±6004	1531±446	-
Means	35697±25848	5393±785	9433±3887	15720±7677	3696±830	455±214

Table 10
Mean biomasses (kg km-²) per bathymetric stage obtained during the various fishing campaigns in the Gulf of Annaba, Eastern Algeria

Storey (m)	*ISTPM (1982)*	*Djabali & Refes (1990)*	*Massuti et al (2003)*	*Massuti et al (2004a)*	*Refes (2011)*	*Present study*
0-50	1165±563	565±80	-	-	469±212	66±23
50-100	1313±551	580±84	-	765±320	445±127	15±2
100-200	1724±517	1017±840	-	439±223	325±136	17±8
200-500	1080±1032	-	510±341	296±180	359±73	-
500-800	912±260	-	762±328	241±111	288±62	-
Means	1324±293	759±353	616±241	491±151	386±62	15±3

Currently, these boats are equipped with a strong driving power and practice fishing on depths above -100 m despite the existence of national regulations prohibiting the practice of trawling (decree of 24 April 2004 setting limitations on the use of pelagic, semi-pelagic and bottom trawls in time and space) on depths less than -50 m. Graham et al (2005) show that fishing pressure combined with non-selectivity in fishing practices can indeed lead to new competition between species for space and resources and induce profound changes in communities and their structures.

A comparison of abundance indices recorded by Massuti et al (2004b) in the north-east Atlantic (Table 11), in the western Mediterranean Sea in the Balearic Islands and in the Algerian basin (Table 12) shows that the Gulf of Annaba of the Algerian coast shows low abundance indices, signs of over-exploitation (Table 13).

Table 11
Representation of means and extreme values of densities (ind km-²) and biomasses (kg km-²) in the North-East Atlantic: Rock Trough and Porcupine Seabight (Massuti et al 2004b)

	North-East Atlantic					
	Porcupine			*Rock Trough*		
	Minimum	*Means*	*Maximum*	*Minimum*	*Means*	*Maximum*
Densities	702±113	1015±110	1692±252	1291±334	2497±293	1822±461
Biomasses	102±13	123±11	193±142	334±81	436±51	416±134

Table 12
Representation of means and extreme values of densities (ind km-²) and biomasses (kg km-²) in the western Mediterranean Sea: Balearic Islands and Algerian Basin (Massuti et al 2004b)

	Western Mediterranean Sea					
	Balearic Islands			*Algerian Basin*		
	Minimum	*Means*	*Maximum*	*Minimum*	*Means*	*Maximum*
Densities	344±35	352±32	653±42	374±42	348±22	374±73
Biomasses	12±1	42±5	16±1	44±6	81±5	15±3

Table 13
Mean and extreme values of densities (ind km-²) and biomasses (kg km-²) in the Gulf of Annaba in 2016 (present study)

	Algerian Basin - Gulf of Annaba		
	Minimum	*Means*	*Maximum*
Densities	50±10	455±214	1646±1267
Biomasses	7±3	15±3	39±24

A comparison with the results of Refes (2011) for the Gulf of Annaba shows a decrease of fish stocks from 2006 to 2016 (Table 14). This decrease is explained by fishing pressure on fishery resources, where biomass has increased from 1009 tonnes in 2006 to 43 tonnes in 2016 for a total area of the Gulf of 2,337 km².

Table 14

Estimation of total biomass of the fishery resources (tonnes) in the Gulf of Annaba: results of 2006 (Refes 2011) and 2016 (present study)

Storey (m)	*Refes (2011)*	*Present study*
0-50	16.5	23.7±7.9
50-100	896.5	14.9±7.5
100-200	96.4	4.5±1.2
Total	1009.4	43.0±11.0

The trawlable ichthyological stands of the Gulf of Annaba are numerically and weightingly dominated by a small number of species: *B. boops*, *E. encrasicolus, M. merluccius, M. barbatus, M. surmuletus, P. erythrinus, S. pilchardus, S. aurita, T. trachurus, T. lyra.* The majority of these species are characterized by a catch frequency > 50% and by a generally very diversified diet reflecting, according to Sorbe (1979) or Fanelli (2007), their ability to adapt to available trophic resources.

In the Gulf of Annaba, the main dominant species are found at the different bathymetric levels as follows: between 0 and -50 m, we have: *S. pilchardus, E. encrasicolus* and *M. surmuletus* which represent numerically 80% of the stand. In terms of weight, *S. pilchardus, M. surmuletus* and *T. trachurus* dominate the stand with 63%.

Between -50 and -100 m, *S. pilchardus, E. encrasicolus* and *M. surmuletus* represent 73% and *S. pilchardus, M. merluccius* and *M. surmuletus* are the main species with 52% of the total stand weight.

Between -100 and -200 m, *T. trachurus, E. encrasicolus* and *B. boops* account for 71% of the stand in numerically terms. *T. trachurus, M. merluccius* and *E. encrasicolus* contribute 57% of the stand by weight.

It appears that ichthyological stands in the Mediterranean are represented by a very large number of species, but they are dominated only by a few that represent almost all ichthyological stands numerically and by weight.

This trend is also observed in the north-east Atlantic, where Sánchez & Serrano (2003), in the southern Bay of Biscay, highlights the presence of 130 fish species dominated by only a few of them.

In this study 75% of the dominant species, both numerically and by weight, are species with strategy r. These include *B. boops, E. encrasicolus, T. trachurus, S. pilchardus* and *S. aurita* compared to k-strategic species such as *M. merluccius, M. barbatus, M. surmuletus, P. erythrinus* and *T. lyra*, which account for 25% of relative dominance.

According to the principles stated by Frontier et al (2008), the k or r strategy of dominant species allows an interpretation of stand structure without having to measure factors such as productivity or disturbance. These authors define disturbances as anthropogenic (pollution or overexploitation) and hydroclimatic (winds, storms or thermal anomalies). In 2016, the dominant species in the Gulf of Annaba have a strategy r, which corresponds to a disturbed system.

Conclusions. The analysis of the structure of the ichthyological stands in the Gulf of Annaba has enabled us to contribute to the knowledge of the state of fish, crustacean and mollusc and the ecological status of the environment. It appears that the species richness did not allow us to provide detailed and precise information on the state of ichthyological stands in 2016. On the other hand, densities and biomasses give a good indication of the state of these stands. They can be said to be good indicators of the effect of fishing effort on exploited stands. In terms of conservation, the ecosystems of the coastal and marine zone of the Gulf of Annaba are the subject of particular attention, whether in the framework of international conventions aimed at protecting the marine environment or at the national level through the creation of marine protected areas and the strengthening of fisheries regulations.

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