Thesis for the Degree of Master of Fisheries Science

A Comparative Study on the Ecosystem-based Fisheries Risk Analysis of Algerian Coastal Fisheries

by

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KOICA-PKNU International Graduate Program of Fisheries Science

Graduate School of Global Fisheries

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알제리 연안 어업의 생태계 기반 어업 위험도 분석 비교연구

Advisor: Prof. Chang Ik Zhang

by

Mohamed El Amine Bouhadja

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Ecosystem-based Fisheries Risk status Comparison in Algerian Coastal Ecosystem

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Abstract

There is a growing need to evaluate how fishing activities is being affecting the ecosystem. The thesis seeks to frame the assessment of risk status of three main fisheries operating in the Algerian coastal ecosystem, which are trawl, purse seine, and small-scale fisheries. The ecosystem-based fisheries assessment was developed by (Zhang, et al., 2009) have been suggested to conduct the present study. Tier 2 process analysis has been used, since the qualitative data was not rich. Across the nested risk design, the trawl, purse seine, and small-scale fisheries risk indices were projected in the yellow zone. The highest FRI were observed in trawl fishery (1.363), followed by the small-scale fishery (1.309), than the lowest value were found in the purse seine fisheries (1.114). The purse seine fishery risk index differed significantly from both of trawl and small-scale fisheries risk indices, whereas there was no significant difference between trawl fishery risk index and small-scale fishery risk index. A proper management measures were to improve the fisheries risk situations.

1. Introduction

1.1 Background of the study

The fishing activity in the Mediterranean Sea is characterized by the multi-specificity; moreover, the Mediterranean Sea is one of most important biodiversity hotspots of the world. Furthermore, human pressure is increasing on this environment, that's mean habitat and species destruction are increasing.

Algerian coastline is on the Mediterranean Sea, it has a long coastline (about 1300 km) and small continental shelf, the biodiversity is higher in the coastal areas and decreases with depth. The Algerian coastal zone encountered numerous problems such as urban, industrial and agriculture pollution, overexploitation of resources and coastal erosion.

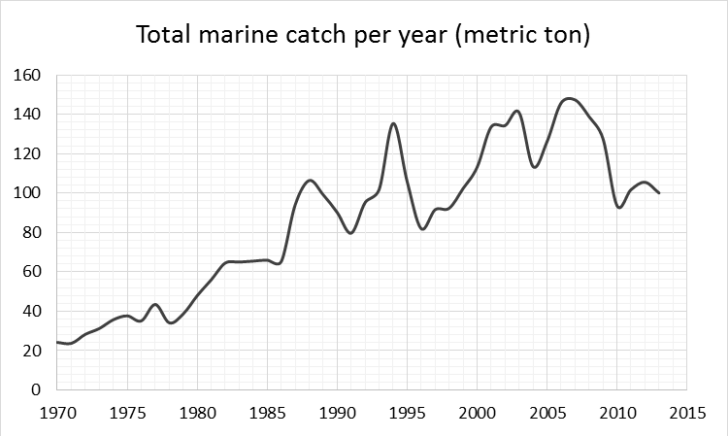
To balance between ensuring sustainability, habitat and socio-economical requires became an issue for policy-makers. However, including all of previous dimensions allows interpreting the system's complexity and integrating them into fisheries assessment process.

1.2 History of the study

In Algeria, the fishing activities are generally coastal, which target mainly the small pelagic. The landing composition of small pelagic represented about 78% (Maouel, 2003).

A main issue for pelagic fisheries is their seasonal nature and their linkage to climatic conditions, which might create a high fluctuation in the market. The bottom trawling fleet targets the high value species such as red shrimp (Belhabib D. , 2007). The small-scale coastal fishing fleet represents nearly 61% of the total of the Algerian national fleet (Chakour & Guedri, 2014). The Algerian government grants in recent years the fishing sector, which might increase the pressure on fish stocks. The small-scale or artisanal fisheries do not have a single international accepted definition since their characteristics are different among the countries (Garcia-Florez, et al., 2014). In Algeria the small-scale fishery differs from purse seine and trawl by the overall length of vessels (<12m) and the wide variety of fishing gears, basically passive fishing gears such as drift net, gillnet, trammel net, surface and bottom longline. Thus, GFCM implemented a new measure in the Mediterranean Sea, which is "segmentation" of the fleet, and that aims to split the fleet into vessel groups. The main vessel group of small-scale fishery in Algeria was "polyvalent Small-scale vessels with engine", which use different gear during the year without a clear predominance of one of them.

The total marine catch showed a gradual increasing in catch over the years until 2007 with some fluctuation. The trend decreased from 2007 (Figure 1).



Source: FishStatJ

Figure 1. Trend of total marine catch from 1970 to 2013

According to (Babouri, Pennino, & Bellido, 2014), there is an overexploitation situation on Algerian coast of small pelagic species, for which catch are constantly falling, and that due to the sector development policy from 1999 onwards. A declining in ratio P/D (pelagic/demersal) reflected the overexploitation of the small pelagic and the increasing in demersal fisheries with near 70% rise in the number of purse seine fleet and 70% increased number of trawler from 1999 to 2009 (Babouri, Pennino, & Bellido, 2014). In Algeria, the origin of control device is: (i) national law such as 01-11 July 03, 2001, relating to fisheries and aquaculture. (ii) Regional obligation such as GFCM (General Fisheries Commission for the Mediterranean) and ACCOBAMS (Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area). (iii) International obligation: such as United Nations Convention on the Law of the Sea (UNCLOS) and International Commission for the Conservation of Atlantic Tunas (ICCAT).

To date, Algerian government applied the technical measures, which include the minimum mesh size limit and gear restriction and minimum size limit for fish. Closed areas and seasons which is known as the biological rest, this last device is addressed to trawling activity and recently the swordfish fishing activity was included in this measure. In addition, the input control, which is the mechanism, that regulates the fishing effort going into the fishery, was employed as a management control. The output control is not involved in management measures except for tuna and tuna-like species, because of the wide variety of species. In Algeria, stock enhancement is based on the establishment of a marine nature reserve, note the Habibas Island with a total surface of 27.4 km^2. Two policies have been applied in term of Co-management, which are participatory and proximity approaches

1.3 Rationale for the study

The traditional quantitative fish stock assessments are problematic whenever data are not enough or are inaccurate (Pazhayamadom, Kelly, & Codling, 2013); furthermore, Single-species stock assessment and sampling high-value can be an issue to cover all exploited species.

Three main fisheries are operating in Algerian coastal ecosystem, which are trawl, purse seine, and small-scale. Their average contributions in landing were estimated during the last ten years at 25.07%, 68.66%, and 6.18% respectively. National tuna and recreational fisheries represented less than 0.05% in landing for each. The total catch per fisheries was illustrated in table 1. The fishing activities are coastal and operated on the continental shelf. This last one is narrow for a major part of the Algerian coast.

Table 1 Total catch by fishery in Algeria from 2005 to 2014

Year	Trawl fishery		small-scale fishery		Recreational fishery		Purse seine fishery		Algerian Tuna fishery		Total	
2005	38006	27.73%	9803	7.15%	63	0.05%	89195	65.07%	0	0.00%	**137067**	**100%**
2006	37684	24.14%	9984	6.40%	204	0.13%	108207	69.33%	0	0.00%	**156079**	**100%**
2007	39773	27.58%	9075	6.29%	247	0.17%	95106	65.95%	0	0.00%	**144201**	**100%**
2008	30378	23.61%	9751	7.58%	0	0.00%	88543	68.80%	18	0.01%	**128689**	**100%**
2009	25153	21.28%	7898	6.68%	0	0.00%	84995	71.91%	153	0.13%	**118199**	**100%**
2010	21747	25.87%	4652	5.53%	0	0.00%	57654	68.59%	0	0.00%	**84054**	**100%**
2011	20628	22.32%	5049	5.46%	0	0.00%	66673	72.15%	58	0.06%	**92408**	**100%**
2012	22732	24.53%	4599	4.96%	0	0.00%	65309	70.46%	43	0.05%	**92683**	**100%**
2013	24472	28.25%	4131	4.77%	0	0.00%	57874	66.80%	158	0.18%	**86635**	**100%**
2014	21021	25.26%	4487	5.39%	0	0.00%	57676	69.30%	37	0.05%	**83220**	**100%**
Average	**28159**	**25.07%**	**6943**	**6.18%**	**51**	**0.05%**	**77123**	**68.66%**	**47**	**0.04%**	**112324**	**100%**

Across the issues mentioned above, there is growing concerns over what is the risk condition of three main fisheries with taking into account the multi-species concept.

1.4 Objective of the study

Within the ecosystem-based approach, there is an increasing requirement for measuring the impact of fishing on ecosystem. The Algerian coastal ecosystem is under pressure of fishing activities. Trawl, purse seine, and small-scale fisheries might share a limited fishing grounds delimited by the narrow continental shelf, and target in many cases the same species, which is one of the main shortcomings in Mediterranean fisheries assessment.

In this perspective, the Tier 2 approach was suggested as an alternative analysis to assess the risk scores for indicators, objective, species, fisheries, and ecosystem.

The aim of this study is: (i) to investigate the Algerian main fisheries risk, (ii) to compare the status of the main Algerian fisheries with target species overlaps concept, (iii) to suggest a proper management strategies and tactics to reduce high-risk indices and provide an effective policy.

1.5 EBFM

The ecosystem approach for fisheries management is widely accepted concept, and various international instruments require its application. Under the name of ecosystem approach, a wide range of measures have been advocated such as reduction of incidental catch of non-target species, protection of ecosystems, multi-species management is also regarded (Morishita, 2008)

Numerous international instruments for the past around 40 years refer to ecosystem approach

1: The UN Law of the Sea Convention of 1982. UNCLOS has provisions for sustainable living resources. The United nations Fish Stock Agreement (UNFSA) notes the terms «ecosystem» and «biodiversity» (Morishita, 2008)

2. The UN Conference on Environment and Development that produced the Rio Declaration, which deals with protecting the marine environment.

3. FAO is one the UN specialized agencies that deals with the main production sectors such as fisheries field. In the 1990s the fisheries management paradigm was expanded to include the ecosystem considerations which reflected in the Code of Conduct for responsible

fisheries of 1995. These were developed during the Expert Consultation-based Fisheries Management at the Reykjavik on 2002 (FAO, 2003)

The definition of EAF follows. *An Ecosystem Approach to Fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries*. (FAO, 2003)

The ecosystem-based fisheries management (EBFM), or alternatively the ecosystem approach to fisheries (Garcia, et al, 2003; Pikitch, et al., 2004). The approach is required since the concern is growing over how ecosystems are being affected by fishing. Furthermore, the approach is necessary to holistically assess and manage fisheries resources and their associated habitats by considering ecological interactions of target species with predators, competitors, and prey species, interaction between fishes and their habitats, and the effects of fishing on these processes (Zhang, et al., 2009).

1.6 Coastal ecosystem

Coastal ecosystem usually means the phytal system where the photosynthetic organisms are present, which bounded through the distance from the coast. By definition, the deep sea is the opposite of the coastal areas. According to some authors and organizations, the deep ecosystems are the areas lying outside the continental shelf (RAC/SPA, 2010). The present study focuses the ecosystem laying inside the continental shelf. The coastal strip harbors a large variety of communities decreasing with the depth (Dauvin, Grimes, & Bakalem,

2013). The most typical communities giving the Mediterranean its touch of originality such as Lithophyllum byssoides (e.g. L. Lichenoides) rims in the medio-littoral stage, *Posidonia oceanica* meadows and Fucal forests (biocenoses with Cystoseira) in the infra-littoral stage and the coralligenous in the circa-littoral stage (Boudouresque, 2004). Added to these habitats are the Vermetid platforms and *the Neogoniolithon brassica-florida* concretion (Boudouresque, 2004)

Algerian coast is one of the best-developed vermetid platform; typically, it consists of a horizontal platform extending near sea level and covered by shallow pools, a few centimeters deep. (Laborel, 1987) in (Boudouresque, 2004) considers some particularity remarkable vermetid platform in Tipasa (central coast of Algeria) as a natural monument and is worth protecting.

The meadows are composed by seagrass *Posidonia oceanica* (L). Which represent the most important ecological assemblages of Mediterranean coastal systems (Chahrour, et al., 2013; Boudouresque, 2004), because of their high benthic primary production, ensure a spawning ground, nursery and shelter for numerous animal species (Pergent, et al., 1993). It acts as a barrier, attenuating the force of currents and waves and thus preventing coastal erosion, it dampens the waves through the layer of dead leaves deposited on the beaches, which protects against erosion; especially during winter storms. The *Posidonia oceanica* meadows are present along the Algerian coast (Chahrour, Boumaza, Semroud, & Boutiba, 2013). It is the key ecosystem, the most productive and the most symbolic of the national marine area (CNRDB, s.d.).

2. Materials and Methods

2.1 Material

2.1.1 Study area and data source

The study examined three fisheries (trawl, purse seine, small-scale fisheries) operate on the coastal ecosystem; the fishing effort is distributed among 14 coastal districts. The present study covered a variety of species, including 05 small pelagic, 04 demersal fish, 01 large pelagic and 02 cephalopods (table 2).

Table 2 Target assessed species by type of fishery in Algerian coastal ecosystem

Trawl	**Purse seine**	**Small-scale**
Sardine *Sardina pilchardus*	Sardine *Sardina pilchardus*	Surmulet *Mullus barbatus*
Mackerel *Trachurus spp*	Mackerel *Trachurus spp*	Axillary seabream *Pagellus acarne*
Bogue *Boops boops*	Bogue *Boops boops*	Blackspot seabream *Pagellus bogaraveo*
Surmulet *Mullus barbatus*	Anchovy *Engraulis encrasicolus*	Common Pandora *Pagellus erythrinus*
Axillary seabream *Pagellus acarne*	Sardinella *Sardinella aurita*	Cuttlefish *Sepia officinalis*
Blackspot seabream *Pagellus bogaraveo*		Common Octopus *Octopus vulgaris*
Common Pandora *Pagellus erythrinus*		Swordfish *Xiphias gladius*
Cuttlefish *Sepia officinalis*		
Common Octopus *Octopus vulgaris*		

The species were chosen depending on their availabilities in the coastal ecosystem, their representativeness in total production and the overlaps among the fishing gear (multi-gears concept). The annual catch by species for the three main fisheries were summarized in Table 3, 4, and 5.

Table 3 Annual catch by species for trawl (ton)

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pagellus acarne	1532	1097	962	966	750	646	737	661	613	513
Boops boops	3513	2630	2249	3009	2662	2538	2410	2369	2040	1159
Trachurus spp	5135	8786	14590	9699	6738	4633	3451	4425	6309	3121
Pagellus bogaraveo	286	219	209	191	71	33	48	40	53	47
Pagellus erythrinus	1181	1039	831	714	446	424	549	488	292	267
Octopus vulgaris	1233	629	721	799	672	614	897	899	755	735
Mullus barbatus	1191	1521	1512	627	358	436	414	397	369	355
Sardina pilchardus	10468	10926	10928	5259	4937	3726	2736	3035	4812	5774
Sepia officinalis	424	248	272	342	238	212	215	201	176	206
Total assessed species	**24964**	**27095**	**32273**	**21607**	**16870**	**13260**	**11456**	**12516**	**15417**	**12178**
Total catch	**38006**	**37684**	**39773**	**30378**	**25153**	**21747**	**20628**	**22732**	**24472**	**21021**

Table 4 Annual catch by species for purse seine (ton)

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sardinella aurita	18551	20221	15237	21448	14279	10103	12327	15492	11605	10688
Engraulis encrasicolus	2306	1009	948	1571	2807	1664	2046	1865	754	1785
Boops boops	2728	3135	2386	4149	3687	3867	4665	3908	2862	2733
Trachurus spp	5011	9494	12358	21336	11179	6301	7478	7249	5474	4897
Sardina pilchardus	58089	70691	60962	33838	48825	26936	30205	27897	30382	29001
Total assessed species	**86685**	**104550**	**91891**	**82343**	**80778**	**48871**	**56720**	**56411**	**51077**	**49105**
Total catch	**89195**	**108207**	**95106**	**88543**	**84995**	**57654**	**66673**	**65309**	**57874**	**57676**

Table 5 Annual catch by species for small-scale (ton)

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pagellus acarne	1691	1276	1178	1120	885	695	807	728	687	593
Mullus barbatus	1455	1795	1855	748	383	446	426	411	382	370
Pagellus bogaraveo	422	347	341	358	141	52	81	72	73	71
Sepia officinalis	516	344	453	449	322	291	259	268	240	270
Octopus vulgaris	692	605	601	802	468	459	216	388	521	557
Pagellus erythrinus	1316	750	824	895	740	672	971	977	854	844
Xiphias gladius	1427	1206	972	951	591	488	595	537	347	337
Total assessed species	**7518**	**6324**	**6224**	**5323**	**3529**	**3103**	**3355**	**3381**	**3105**	**3042**
Total catch	**9803**	**9984**	**9075**	**9751**	**7898**	**4652**	**5049**	**4599**	**4131**	**4487**

The fisheries data and the annual catch were collected from Fisheries and Marine Resource directorate. The qualitative data involved sampling and analysing of 03 fisheries and total of 12 species, using questionnaires and interviews to fishers and fishing inspectors from some fishing ports along the Algerian coast. The Algerian government has established a new device of fisheries inspectors in 2008, in order to organize and monitor the fishery sector by respecting the allowed fishing gears and the commercial size of landed species to preserve the resources from depletion, furthermore, to control and inspect the healthiness and hygiene of the seafood products.

The current investigation examined 58 questionnaires collected from 09 ports which are located in 08 districts 46 questionnaires were filled out by fisherman and 12 questionnaires were filled out by fisheries inspectors. Eight districts were surveyed. The basic issue was sampling size by port on account of the availability of the investigators.

2.2 Method

Six questionnaires were prepared to conduct the Tier 02 approach, three of them were addressed to fishermen and 03 were addressed to inspectors, each questionnaire (table 6) deals with one of the fishery and the defined target species. The questionnaires were translated into the French language, in order to be understandable by the surveyed population (appendix 27).

Table 6 questionnaire for risk analysis

Port	……..	Vessel name	……..	Fisherman's name	….. Phone#….
District	……..	Horse power	……	Vessel Tonnage	…….

Production

1-1.Do you have recent catch per unit of effort (CPUE) data?

Yes ☐ No ☐

If yes, how many years of data do you have? ……..Years.

What is the trend of current CPUE compared with average of recent X years?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

1-2.What is the trend of catch during the recent 05 years?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Fishing intensity

2-1.What is the trend of fishing effort during recent 05 years?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

2-2.Has there been any activity of fisheries management (such us the closed fishing season or closed fishing ground) or self-regulation around your fishing ground?

Yes ☐ No ☐

If yes, what is the activity?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Size of fish

3-1.What is the body lengths of target species caught?

Species	Body length (cm)	Mature length (cm)
Species 01	……cm	……cm
Species 02	……cm	……cm
Species 03	……cm	……cm
Species n	……cm	……cm

3-2.Do you have a regulation for the limited body length of target species from fishing?

Yes ☐ No ☐

If yes, what is the magnitude?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Rate of mature fish

4-1.When is the main fishing and spawning period for major species and what are the proportions of them?

Species	Fishing month	% of annual catch	Spawning month
Species 01	.....	.....%	.....
Species 02	.....	.....%	.....
Species 03	.....	.....%	.....
Species n	.....	.....%	.....

4-2.Are there matured target species in your catch?

Yes ☐ No ☐

If yes, what is the magnitude?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

4-3.Do you have a closed season during the spawning period?

Yes ☐ No ☐

If yes, what is the magnitude?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Genetic structure

5-1.Has there been release activity?

Yes ☐ No ☒

If yes, how much amount of eggs, fries and juveniles are released?

A few ☐ small ☐ considerable ☐

If yes, how many times eggs, fries and juveniles are released during recent five years?

Once☐ twice☐ three times☐ more than four time☐ continuously☐

Population resiliency (reproduction habitat)

6-2.Has there been any changes in the ratio of sea grass coverage in your fishing area?

Yes ☐ No ☐

If yes, what is the magnitude?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Community structure

7-1.What is the ratio of herbivorous to carnivorous in catch?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Discards

9-1.What is the percentage of discards in your harvest?

More than 95% ☐ 80~90% ☐ 60~80% ☐ 40~60% ☐ 20~40% ☐ 5~20% ☐ Less than 5% ☐

Diversity index

10-1.Has there been a change in dominant species in your fishing ground?

Yes ☐ No ☐

If yes, what is the magnitude?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Fishing gear and habitat damage

11-1.How many fishing gear do you have?

(1)Fishing gear:……..Quantity:…….……..width/number.

(2)Fishing gear:……..Quantity:……..……..width/number.

(3)Fishing gear:……..Quantity:……..……..width/number.

11-2.How many fishing gears do you use per unit fishing operation? …….. (Width/number)

11-3.How long (hours) does it take for fishing? ……..... (Hours/day).

11-4.How many days do you conduct your fishing in a month? …… (Day/month).

11-5.What is the loss likelihood of your fishing gear per unit fishing operation?

High degree of uncertainty ☐ Highly unlikely ☐ unlikely ☐ Ambiguous ☐ Likely☐ Highly likely ☒ High degree of certainty Evident☐

Discard wastes and pollution

12-1.Recently, has there been any oil spill accident in your fishing ground?

Yes ☐ No ☐ Do not know☐

If yes, when did it occur? What is the magnitude?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

12-2.How do you handle wastes (cigarette butts, waste fishing gear, etc.) during fishing operation?

Dumping in the Sea ☐ Bring to land ☐ Both ☐

If dumping in the sea, what is the amount of wastes dumped in the Sea?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

12-3.Are there any spawning or nursery ground around your fishing ground?

Yes ☐ No ☐ Do not know☐

If yes, how do you conduct your fishing operation?

No difference ☐ Carful fishing operation to avoid destruction and/or pollution ☐

Income

13-2.What is the trend of your income during the recent 05 years?

Increase ☐ Stable ☐ Decrease ☐

13-3.What is the income this year comparing with minimum living cost?

Extremely small ☐ Small ☐ Moderately small ☐ Average ☐ Moderately large ☐ Large ☐ Extremely large ☐

Ratio of profit to sales (RPS)

14-1.What is the profit during this year comparing with sale?

Extremely small □ Small □ Moderately small □ Average □ Moderately large □ Large □ Extremely large □

Employment

15-1.What is the index of employment (fisherman x fishing vessel) during recent 05 years?

Extremely small□ Small□ Moderately small □ stable□ Moderately large □ Large□ Extremely large □

15-2.What is the trend of employment rate during the recent 05 years?

Increase □ Stable □ Decrease □

Job satisfaction

16-1.What is the condition of the job satisfaction?

Extremely small □ Small □ Moderately small □ Average □ Moderately large □ Large □ Extremely large □

Cultural consideration

17-2.What is the level of spiritual (religious) satisfaction on fisheries?

Extremely small □ Small □ Moderately small □ Average □ Moderately large □ Large □ Extremely large □

IUU

18-1.Has IUU occurred in your fishing ground recently? Yes □ No □

If yes, please describe specifically on the IUU fishing? .....

2.2.1 Assessment for Algerian coastal ecosystem fishery by the Tier 02 analysis.

To assess the Algerian coastal fisheries and the status of management, a pragmatic ecosystem-based fisheries assessment developed by (Zhang, et al., 2009) and MOMAF, 2007, which integrates Four management objectives: sustainability, biodiversity, habitat quality, and socio-economic. The approach has two tiers of assessment namely Tier 01 and Tier 02; the first one is used in the situations wherever the data are rich and available, while Tier 02 were used to assess the Algerian coastal fisheries system. Tier 02 is designed for a semi-quantitative or/and qualitative analysis of the data-poor situation. The present study carried out a Tier 02 process assessment for a total of 18 indicators developed by (ParkH.W, ZhangC.I, KwonY.J, SeoY.I, 2013) Specific to this study was using all indicators except 'Bycatch rate B-1' due to the particularity of Algerian fisheries which characterized by Multi-species (Table 7).

Table 7 Objectives, full indicators, selected indicators and factors weight to assess Algerian coastal ecosystem by Tier 02 approach

	Full indicators		**Indicators for Algerian costal ecosystem**				
Objectives	**Attribute**	**Indicators**	**Indicators**	**surveyed population**	**Rationale**	**Alternative**	**Weight**
Sustainability	abundance	Catch or CPUE S-1	+	-Inspectors fisheries Survey -fishers survey			3
	Fishing intensity	Catch or fishing mortality (F) S-2	+	-fishers survey			2
	Optimum age (or size) at first capture	Age (or length) at first capture S-3	+	- Inspectors fisheries Survey			3
	Stock structure	Rate of mature fish S-4	+	-fishers survey			2

	Genetic structure	Ratio of (released stock abundance)/(wild stock abundance) in catch S-5	+			1
	Population resiliency	Reproduction habitat S-6	+	-fishers survey		1
	Community structure	Mean trophic level of catch (TLc) S-7	+	- Inspectors fisheries Survey		1
Biodiversity	Bycatch rate	Bycatch rate B-1	-	Fisheries in Algerian coast is multi-species	Focusing the minimal size of fish length and discards rate	-
	Discards	Discards rate B-2	+	-fishers survey		3
	Diversity	Diversity index (DI) B-3	+	- Inspectors fisheries Survey -fishers survey		1
Habitat quality	Habitat damage	Critical habitat damage rate H-1	+	- fishers survey		2
		Lost fishing gear H-2	+	- fishers survey		1
		Pollution of spawning and nursery areas	+	- fishers survey		1

		H-3			
	Discarded wastes	Discarded wastes from fishing vessels H-4	+	- fishers survey	1
Socio-economic	Economic considerations	Income per person employed (IPPE) E-1	+	- fishers survey	2
		Ratio of profit to sales (RPS) E-2	+	- fishers survey	2
	Social considerations	Employment rate E-3	+	- fishers survey	1
		Job satisfaction E-4	+	- fishers survey	1
		Cultural considerations E-5	+	- fishers survey	1

- +: indicator used for Algerian coastal ecosystem;
- -: indicator does not used for Algerian coastal ecosystem.

Target and limit corresponding to desirable and undesirable respectively, are reference points were defined for each indicator to assess the status of objectives, species, and fisheries for each fishing segment.

The relative weights for each indicator were ranging from 01 to 03 (table3), and they are although in essence similar as in (Zhang, et al., 2009), except slight modifications for the sake of assessing the Algerian coastal ecosystem particularity situation.

A nested design were developed by (MOMAF, 2007; Zhang et al., 2009, 2010) (Figure2), thus an objective risk index (ORI), species risk index (SRI), and fishery risk index (FRI), Ecosystem Risk Index (ERI) were estimated to assess the fishery and ecosystem status risk indices,

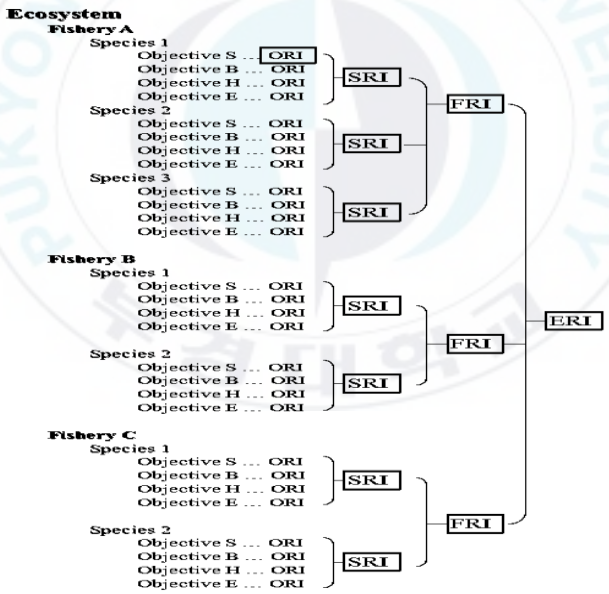


Figure 2 Nested structure of risk indices used in the ecosystem-based fisheries assessment approach. ORI denotes objectives risk index, SRI, species risk index, FRI, fishery risk index, ERI, ecosystem risk index (Zhang et al., 2009).

The ORI is defined through the following formula:

$$\mathbf{ORI} = \frac{\sum_{i=0}^{n} \mathbf{RS}_i \boldsymbol{W}_i}{\sum_{i=1}^{n} \boldsymbol{W}_i}$$

Where "$\mathbf{RS}_i$" is the risk score for indicator "i", "$\mathbf{W}_i$" is the weighting factor (1, 2 or 3) for indicator "i" and "n" is the number of indicators.

The species risk index is calculated for each species as mathematical weighted sum of the objectives risk indices

$SRIi = \lambda_S ORI_S + \lambda_B ORI_B + \lambda_H ORI_H + \lambda_E ORI_E$

Where: λ_S, λ_B, λ_H and λ_E : Weighting value for objectives, the condition is $\sum \lambda = 1.0$

$\mathbf{ORI_S}$: Sustainability risk index,, $\mathbf{ORI_B}$: Biodiversity risk index, $\mathbf{ORI_H}$: Habitat risk index, $\mathbf{ORI_E}$: Socio-economic risk index.

The objectives factors were weighted equally, assuming that $\lambda S = \lambda B = \lambda H = \lambda E = 0.25$.

As mentioned earlier, the main objective of the present study is to investigate the main fisheries risk status in Algerian coastal ecosystem. The fishery risk index FRI is the weighted average risk index for exploited species in a fishery,

$$\boldsymbol{FRI} = \frac{\sum \boldsymbol{Bi}\, \boldsymbol{SRIi}}{\sum \boldsymbol{Bi}}$$

Where $\mathbf{B}_i$ is the biomass or relative biomass such as catch per unit effort for species $\boldsymbol{i}$. Where this last one was used in the present study, as an alternative of biomass. Five years

of catch per unit effort CPUE average were considered as an appropriate time period, furthermore, the CPUE were separated over fisheries

One-way ANOVA procedure was performed to examine statistically the difference of risk indices means of the three fisheries. fisheries risk indices of trawl, purse seine, and small-scale fishery were FRIs tested group with unbalanced observations. Then post hoc analysis using Tukey-Kramer test to figure out which groups of FRIs are making the difference in means, Tukey-Kramer test is recommended in the unbalance design situation.

The ecosystem risk index ERI is reported as the weighted average of the fishery risk indices in an ecosystem,

$$ERI = \frac{\sum Ci\ FRIi}{\sum Ci}$$

Where Ci is the catch of i fishery.

2.2.2 Target and limit reference points to conduct the risk assessment

Across the four management objectives namely sustainability, biodiversity, habitat quality, and socio-economic, these objectives are associated with their attribute including, abundance, fishing intensity, stock structure, genetic structure, population resiliency, community structure, discards, diversity, habitat damage, discarded wastes, economic considerations and social considerations

The target reference point corresponds to a state of each indicator that considered desirable, while the limit reference point is defined as the limit beyond which the state of each indicator is considered undesirable. The risk score was evaluated for each indicator,

producing possible risk value between 00 and 03. The risk assessment outcomes were separated into 03 risk zones figure; better than target corresponding to the risk value less than ‘1.0’, between target and limit when the risk indices are located between ‘1.0’ and ‘2.0’, and beyond limit when the risk value exceed ‘2.0’.

The questionnaires (table2). were matched to the indicators belonging the four objectives, the target and limit reference points for Tier 02 approach were listed in appendices 1 to 4.

2.2.3 Target and limit reference point for indicators of sustainability

Appendix 1 shows the target and limit reference points of indicators and sub-indicators belonging sustainability in the Tier 2 EBFA. The assessment is divided into seven ordinal categories as following: ‘Better than target’, two reference points (‘0’ and ‘0.5’), then ‘Between target and limit’, three reference points (‘1.0’, ‘1.5’ and ‘2’), for ‘Beyond limit’, two reference points (‘2.5’ and ‘3.0’).

A total of 07 indicators belonging sustainability were defined and assessed by Tier 2 process as shown in table 8.

Table 8 Relevant categories of the questionnaire for assessing indicators of sustainability of the Tier 2 approach

Objective	Indicators		Questionnaires	Weight
Sustainability	S-1	Catch per unit effort (CPUE)	1-1, 1-2	3
	S-2	Fishing mortality (Catch)	2-1, 2-2, 18-1	2
	S-3	Length at first capture	3-1, 3-2	3
	S-4	Rate of mature fish	4-1, 4-2, 4-3	2
	S-5	Genetic structure	5-1	1
	S-6	Reproduction habitat	6-2	1
	S-7	Mean trophic level	7-1	1

2.2.4 Target and limit reference points for indicators of biodiversity

This study estimated target and limit reference points for two indicators for biodiversity. Appendix 2 shows the target and limit reference points of indicators and sub-indicators belonging biodiversity in the Tier 2 EBFA. The selected indicators under biodiversity objective and the relevant categories of the questionnaire are summarized in table 9.

Table 9 Relevant categories of the questionnaire for assessing indicators of biodiversity of the Tier 2 approach

Objective	Indicators		Questionnaires	Weight
Biodiversity	B-2	Discard rate	9-1	3
	B-3	Diversity index	10-1	1

2.2.5 Target and limit reference points for indicators of habitat quality

Habitat quality objective includes; 'Critical habitat damage rate', which was assessed, based on characteristics of fishing gear and operation fishing period on the habitat. 'Pollution rate of spawning and nursery ground' is assessed based on factors of information on the pollution (oil spillage) by the target fishery and pollution level on the spawning and nursery grounds. 'Lost fishing gears' is assessed based on likelihood to lose the fishing gear. 'Discarded wastes' is assessed based on factors of discard amount of wastes. The selected indicators under habitat quality objective and the relevant categories of the questionnaire are summarized in table 10. Appendix 3 shows the target and limit reference points of indicators and sub-indicators belonging habitat quality in the Tier 2 EBFA.

Table 10 Relevant categories of the questionnaire for assessing indicators of habitat quality of the Tier 2 approach

Objective		Indicators	Questionnaires	Weight
Habitat quality	H-1	Critical habitat damage	11-1, 11-2, 11-3, 11-4	2
	H-2	Lost fishing gear	11-5	1
	H-3	Pollution rate of spawning and nursery ground	12-1, 12-2	1
	H-4	Discarded wastes	12-3	1

2.2.6 Target and limit reference points for indicators of socio-economic benefits

Indicators belonging socio-economy were divided into seven categories in the same manner as sustainability, biodiversity, and habitat quality objectives. The selected indicators for socio-economy objectives include; 'Income per fisherman' is assessed based on the difference of income to minimum living cost. 'Ratio of profit to sale'. 'Employment rate' were assessed based on factors of change tendency of number of fishermen. 'Job satisfaction' and 'cultural consideration'. The selected indicators under socio-economic benefits objective and the relevant categories of the questionnaire are summarized in table 11. Appendix 4 shows the target and limit reference points of indicators and sub-indicators belonging socio-economic benefits in the Tier 2 EBFA

Table 11 Relevant categories of the questionnaire for assessing indicators of socio-economic benefits of the Tier 2 approach

Objective		Indicators	Questionnaires	Weight
Socio-economic benefits	E-1	Income per person employed (IPPE)	13-1, 13-2, 13-3	2
	E-2	Ratio of profit to sales (RPS)	14-1	2
	E-3	Employment rate	15-1, 15-2	1
	E-4	Job satisfaction	16-1	1
	E-5	Cultural consideration	'17-2	1

3. Results

3.1 Assessment of risk scores to each indicator of Algerian coastal ecosystem

Twelve species were selected in coastal Algerian ecosystem, and assessed in three main fisheries by Tier 2 analysis process. The specificity to this research is taking into account the overlaps of target species among the fisheries.

The first constituent of EBFA's Tier 02 nested design is indicator risk scores (RSs) where the assessment is based on. The RSs were calculated as an arithmetic mean for each target species and for each questionnaire, Indicators risk zones for Algerian coastal ecosystem were classified into for objective for 21 species as assessed (table12)

Sustainability had 14.3% of indicators in the desirable green zone, while 70.7% of indicators were in the yellow zone and 15% in the red zone (Table12)

Biodiversity had 71.4% of indicators in the green zone, the yellow zone had 28.6%, and otherwise no indicator belonging biodiversity were assessed in the red zone (table12).

Habitat quality had only 6% of indicators in the desirable green zone, though 75% of indicators were in the yellow zone and 19% were behind limit (table12).

Table 12 Risk zone by number of indicators, by four objectives in Algerian coastal ecosystem

Objective	**Number of indicators in the green zone**	**Number of indicators in the yellow zone**	**Number of indicators in the red zone**
Sustainability	21 (14.3%)	104 (70.4%)	22 (15.0%)
Biodiversity	30 (71.4%)	12 (28.6%)	00 (0.0%)
Habitat quality	5 (6.0%)	63 (75.0%)	16 (19.0%)
Socio-economic benefits	5 (4.8%)	88 (83.8%)	12 (11.4%)
Total	**61 (16.1%)**	**267 (70.6%)**	**50 (13.2%)**

Only 4.8% of indicators belonging the socio-economic objective were in the desirable green zone, whereas 83.8% of the indicators were in the yellow zone, and 11.4% of indicator were in the red zone (table8).

The overall of the Algerian coastal ecosystem had 16.1% of the indicator in the green zone, 70.6% in the yellow zone and 13.2% in the red zone (table9).

3.2 Assessment of objectives risks indices ORIs by Tier 2 approach

The assessment of objective risk indices is one of the most important steps in the process; ORIs can be examined to determine the effectiveness in promoting sustainability, biodiversity, habitat quality (Zhang, et al., 2009) and socio-economic benefits. The ORIs were calculated for target species. The objective risk assessment diagram was created to

express graphically the relative positions of the objective risk indices for the assessed species.

Once scores were assigned to all of the indicators for each species and each fishery, objectives risk indices (ORIs) were calculated for each of the objectives.

3.2.1 Objective risk indices (ORI's) assessment by Tier 02 approach for 09 assessed species caught by trawl

The calculated ORIs in trawl fishery showed that all nine species assessed, were ranged from 0.59 to 1.78 (table 13). Only the ORI biodiversity was in the desirable zone at 0.59 (table 13 and figure 3). Although sustainability, habitat quality, and socio-economic benefits objectives risk indices fell in the yellow zone (Figure 3), where the highest value of ORI was estimated at 1.78 for habitat quality objective (table 13 and figure 3).

Trawl fishery had nine species namely; sardine *Sardina pilchardus*, mackerel *Trachurus spp*, bogue *Boops boops*, surmulet *Mullus barbatus*, axillary seabream *Pagellus acarne*, blackspot seabream *Pagellus bogaraveo*, common pandora *Pagellus erythrinus*, cuttlefish *Sepia officinalis*, and common octopus *Octopus vulgaris*. Sustainability risk indices were 1.40, 1.45, 1.46, 1.43, 1.44, 1.49, 1.44, 1.57 and 1.37 respectively.

The highest ORI of sustainability were estimated for the cephalopod cuttlefish at 1.57, while the lowest were for cephalopod Common Octopus 1.37 (table 13).

Table 13 Objectives risk average to each species caught by trawl

Species	Objective	ORI
Sardina pilchardus	Sustainability	1.40
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Trachurus spp	Sustainability	1.45
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Boops boops	Sustainability	1.46
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Mullus barbatus	Sustainability	1.43
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Pagellus acarne	Sustainability	1.44
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Pagellus bogaraveo	Sustainability	1.49
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Pagellus erythrinus	Sustainability	1.44
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Sepia officinalis	Sustainability	1.57
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66
Octopus vulgaris	Sustainability	1.37
	Biodiversity	0.59
	Habitat quality	1.78
	Socio-economic benefits	1.66

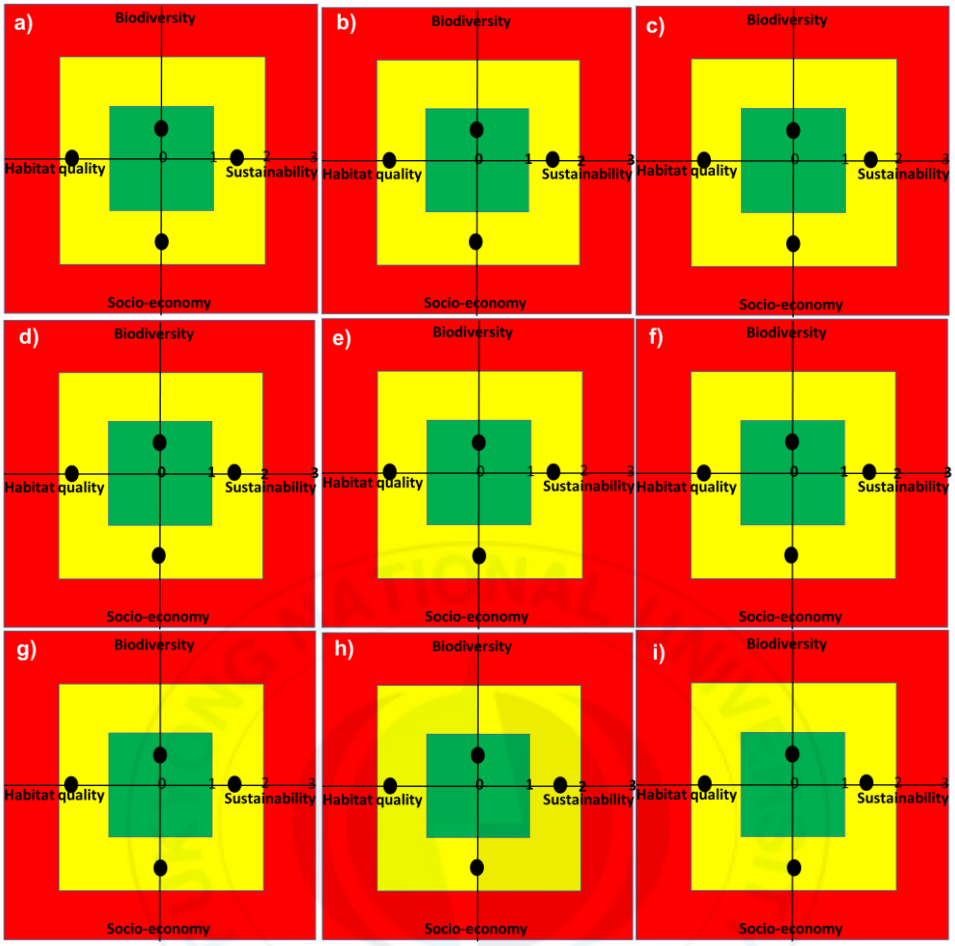


Figure 3. Relative positions of objective risk indices (ORI), for the nine species in the trawl fishery from the ecosystem-based Tier 2 fishery assessment approach. (a) Sardine *Sardina pilchardus*, (b) Mackerel *Trachurus spp*, (c) bogue *Boops boops*, (d) Surmulet *Mullus barbatus*, (e) Axillary seabream *Pagellus acarne*, (f) Blackspot seabream *Pagellus bogaraveo*, (g) Common Pandora *Pagellus erythrinus*, (h) Cuttlefish *Sepia officinalis*, and (i) Common Octopus. *Octopus vulgaris*.

3.2.2 Objective risk indices (ORI's) assessment by Tier 02 approach for 05 assessed species caught by purse seine

Sardine *Sardina pilchardus*, mackerel *Trachurus spp*, anchovy *Engraulis encrasicolus*, round sardinella *Sardinella aurita*, and bogue *Boops boops*, are 05 species assessed by Tier 02 approach in purse seine fishery. The objective risk indices (ORIs) for biodiversity and habitat quality were estimated at the green zone, 0.31 and 0.85 respectively (table14. Figure4). Although the ORI for sustainability and socio-economic were projected in the yellow zone for the fives assessed species in purse seine fishery with 1.61 for socio-economic benefits, and ORI sustainability varied from 1.66 to 1.70 depending on the assessed species (table 14 and figure 4). Sardine *Sardina pilchardus*, Anchovy *Engraulis encrasicolus*, and Round sardinella *Sardinella aurita* had ORIs for sustainability 1.68, 1.66, and 1.67 respectively. Anchovy *Engraulis encrasicolus* and bogue *Boops boops* had sustainability ORI estimated at 1.70 (table 14).

Table 14 Objectives average to each species caught by purse seine

Species	Objective	ORI
Sardina pilchardus	Sustainability	1.68
	Biodiversity	0.31
	Habitat quality	0.85
	Socio-economic benefits	1.61
Trachurus spp	Sustainability	1.70
	Biodiversity	0.31
	Habitat quality	0.85
	Socio-economic benefits	1.61
Engraulis encrasicolus	Sustainability	1.66
	Biodiversity	0.31
	Habitat quality	0.85
	Socio-economic benefits	1.61
Sardinella aurita	Sustainability	1.67
	Biodiversity	0.31
	Habitat quality	0.85
	Socio-economic benefits	1.61
Boops boops	Sustainability	1.70
	Biodiversity	0.31
	Habitat quality	0.85
	Socio-economic benefits	1.61

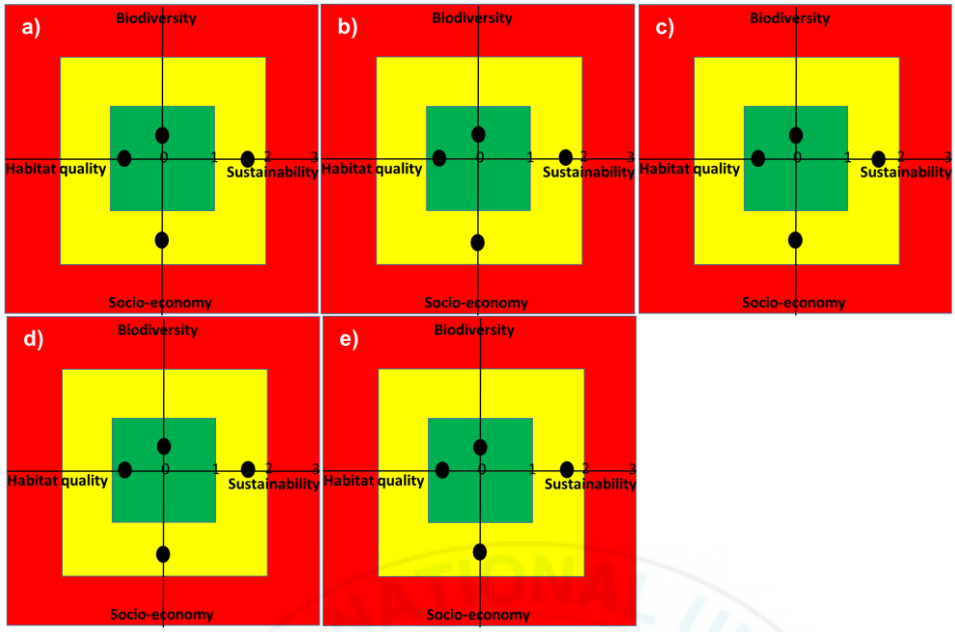


Figure 4 Relative positions of objective risk indices (ORI) for the five species in the purse seine fishery from the ecosystem-based Tier 2 fishery assessment approach, (a) Sardine *Sardina pilchardus*, (b) Mackerel *Trachurus spp*, (c) Anchovy *Engraulis encrasicolus*, (d) Round sardinella *Sardinella aurita*, (e) Bogue *Boops boops*.

3.2.3 Objective risk indices (ORI's) assessment by Tier 02 approach for seven assessed species caught by small scale-fisheries

The small-scale fishery had 07 species namely; surmulet *Mullus barbatus*, axillary seabream *Pagellus acarne*, blackspot seabream *Pagellus bogaraveo*, common pandora *Pagellus erythrinus*, cuttlefish *Sepia officinalis*, common octopus *Octopus vulgaris* and, swordfish *Xiphias gladius*. Table 15, surmulet had risk indices 1.59, 0.39, 1.52, and 1.77 for sustainability, biodiversity, habitat quality and socio-economy, respectively. Axillary

seabream had risk scores 1.63, 0.36, 1.53, 1.53, and 1.79 for sustainability, biodiversity, habitat quality, and socio-economy, respectively. Blackspot seabream had risk indices 1.67, 0.39, 1.52, and 1.77 for sustainability, biodiversity, habitat quality, and socio-economy, respectively. Common Pandora had risk scores 1.56, 0.39, 1.52, and 1.77 for sustainability, biodiversity, habitat quality, and socio-economy, respectively. The two cephalopods cuttlefish *Sepia officinalis*, common Octopus *Octopus vulgaris* assessed in small-scale fishery had respectively 1.65, 1.50 for sustainability, 0.33, 0.38 for biodiversity, 1.58, 1.53 for habitat quality, and 1.80 for both of cephalopods in socio-economic benefits.

Table 15 Objectives average to each species in small-scale fishery

Species	Objective	ORI
Mullus barbatus	Sustainability	1.59
	Biodiversity	0.39
	Habitat quality	1.52
	Socio-economic benefits	1.77
Pagellus acarne	Sustainability	1.63
	Biodiversity	0.36
	Habitat quality	1.53
	Socio-economic benefits	1.79
Pagellus bogaraveo	Sustainability	1.67
	Biodiversity	0.39
	Habitat quality	1.52
	Socio-economic benefits	1.77
Pagellus erythrinus	Sustainability	1.56
	Biodiversity	0.39
	Habitat quality	1.52
	Socio-economic benefits	1.77
Sepia officinalis	Sustainability	1.65
	Biodiversity	0.33
	Habitat quality	1.58
	Socio-economic benefits	1.80
Octopus vulgaris	Sustainability	1.50
	Biodiversity	0.38
	Habitat quality	1.53
	Socio-economic benefits	1.80
Xiphias gladius	Sustainability	1.49
	Biodiversity	0.34
	Habitat quality	1.47
	Socio-economic benefits	1.76

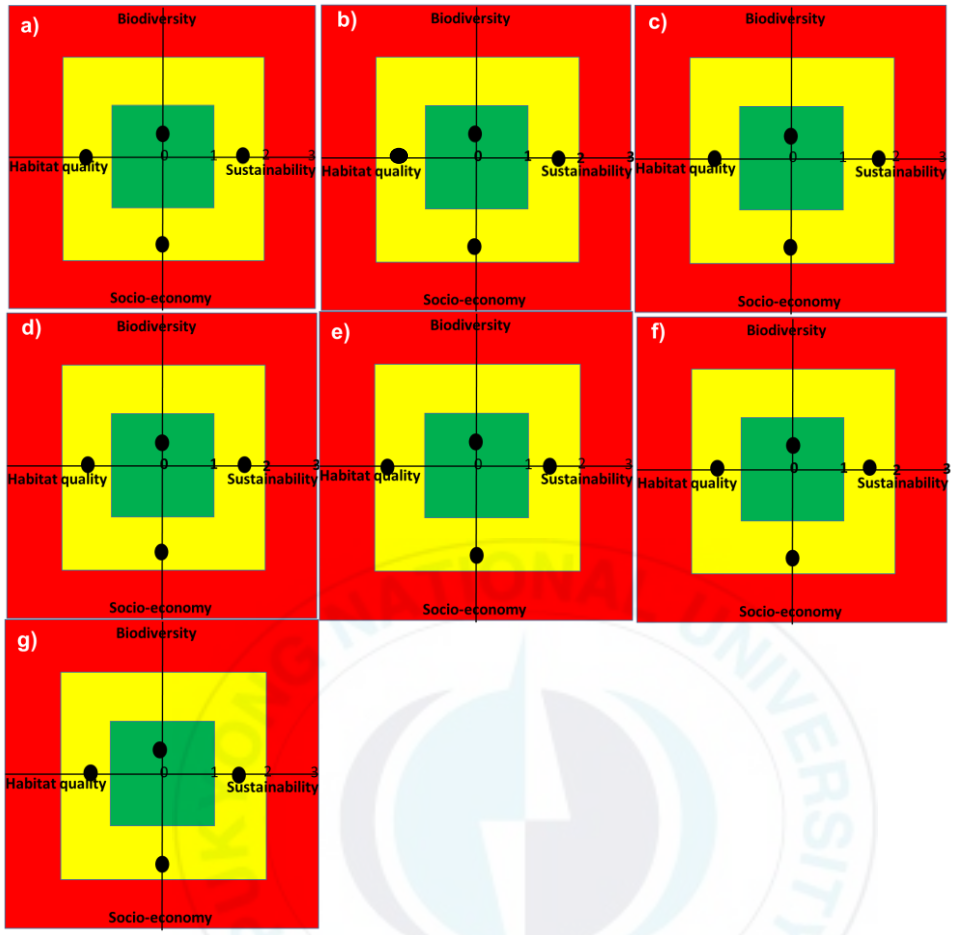


Figure 5 Relative positions of objective risk indices (ORI) for the seven species in the small-scale fishery from the ecosystem-based Tier 2 fishery assessment approach, (a) Surmulet *Mullus barbatus*, (b) Axillary seabream *Pagellus acarne*, (c) Blackspot seabream *Pagellus bogaraveo*, (d) Common Pandora *Pagellus erythrinus*, (e) Cuttlefish *Sepia officinalis*, (f) Common Octopus. *Octopus vulgaris* and, (g) Swordfish *Xiphias gladius*.

3.2.4 Number of species by risk zones for four objectives

Objectives risk indices for 21 species assessed by Tier 2 process analysis in Algerian coastal ecosystem as shown table 16. All species were in the yellow zone in sustainability,

while for biodiversity all species were in the desirable zone. Habitat quality had 5 species in the green zone and 14 species in the yellow zone. Twenty-one species were in the yellow zone for the socioeconomic benefit.

Table 16 Number of species by risk zones for four objectives in the Algerian coastal ecosystem

Objective	Number of species in the green zone	Number of species in the green zone	Number of species in the green zone
Sustainability	0	21	0
Biodiversity	21	0	0
Habitat quality	5	14	0
Socio-economic benefits	0	21	0

3.3 Assessment of species risks indices (SRIs) of each fishery assessed by Tier 2 approach

The assessment of SRIs is an important information, useful in the process to characterize the system's status. The SRIs were calculated for each questionnaire; the issue in this study is that the assessed species are targeted by different fisheries at the same time. To solve this issue, the fisheries markers (t), (p), and (s) were added to each species in order to indicate which fishery the species belong to. Where (t), (p), (s) were allocated to trawl, purse seine,

and, small-scale fishery respectively, (i.e., *Sardina pilchardus* (p), *Sardina pilchardus* (t), *Xiphias gladius* (s)) (Figure 6).

The obtained SRIs values were ranged from 1.11 to 1.40, the lowest risk values were observed in species caught in purse seine fishery table17. All assessed species had risk indices that fell in the yellow zone.

3.3.1 Species risk indices (SRI's) assessment by Tier 02 approach for nine assessed species caught by trawl

Trawl fishery had nine species namely: Sardine *Sardina pilchardus*, mackerel *Trachurus spp*, bogue *Boops boops*, Surmulet *Mullus barbatus*, axillary seabream *Pagellus acarne*, blackspot seabream *Pagellus bogaraveo*, common pandora *Pagellus erythrinus*, Cuttlefish *Sepia officinalis*, and Common Octopus. *Octopus vulgaris*. The estimated species risk indices (SRIs) for the assessed species caught by trawling varied from 1.35 to 1.40 (table17). The highest SRI value was corresponding to the cuttlefish *Sepia officinalis* at the risk of 1.40 (table17).

3.3.2 Species risk indices (SRI's) assessment by Tier 02 approach for five assessed species caught by purse seine

Sardine *Sardina pilchardus*, Mackerel *Trachurus spp*, Anchovy *Engraulis encrasicolus*, round sardinella *Sardinella aurita*, and bogue *Boops boops*, are 05 species assessed by Tier 02 approach in purse seine fishery. As shown in table 17, the species risk indices SRIs in purse seine fishery had 02 values that were almost equal each other 1.11 and 1.12. The

Mackerel and bogue risk indices were evaluated at 1.12, while anchovy, round sardinella and sardine risk indices were 1.11.

3.3.3 Species risk indices (ORI's) assessment by Tier 02 approach for seven assessed species caught by small scale-fisheries

The small-scale fishery had 07 species namely; surmulet *Mullus barbatus*, axillary seabream *Pagellus acarne*, Blackspot seabream *Pagellus bogaraveo*, common Pandora *Pagellus erythrinus*, cuttlefish *Sepia officinalis*, Common Octopus *Octopus vulgaris* and, Swordfish Xiphias gladius. The species risk indices SRSs were estimated at 1.34 for Cuttlefish *Sepia officinalis* and Blackspot seabream *Pagellus bogaraveo*, respectively (table17). The Common Octopus, common Pandora, and Surmulet had species risk indices 1.3, 1.31, 1.32 and 1.33, respectively. Swordfish *Xiphias gladius* had the lowest value of SRI 1.26 (table17).

Table 17 Species risk index (SRI), standard deviation of SRI, Fishery risk index (FRI), and ecosystem risk index (ERI) for the Algerian coastal ecosystem using ecosystem-based assessment Tier02 approach

Fishery	**Species**	**SRI mean**	**SD**	**FRI**	**ERI**
Trawl	*Boops boops(t)*	1.37	0.22	1.363	**1.245**
	Mullus barbatus(t)	1.36	0.24		
	Octopus vulgaris(t)	1.35	0.23		
	Pagellus acarne(t)	1.37	0.24		
	Pagellus bogaraveo(t)	1.38	0.23		
	Pagellus erythrinus(t)	1.37	0.23		
	Sardina pilchardus(t)	1.36	0.22		
	Sepia officinalis(t)	1.4	0.23		
	Trachurus spp(t)	1.37	0.23		
Purse seine	*Boops boops(p)*	1.12	0.14	1.114	
	Engraulis encrasicolus(p)	1.11	0.14		
	Sardina pilchardus(p)	1.11	0.14		
	Sardinella aurita(p)	1.11	0.14		
	Trachurus spp(p)	1.12	0.14		
Small-scale	*Mullus barbatus(s)*	1.32	0.18	1.309	
	Octopus vulgaris(s)	1.3	0.15		
	Pagellus acarne(s)	1.33	0.15		
	Pagellus bogaraveo(s)	1.34	0.16		
	Pagellus erythrinus(s)	1.31	0.15		
	Sepia officinalis(s)	1.34	0.15		
	Xiphias gladius(s)	1.26	0.15		

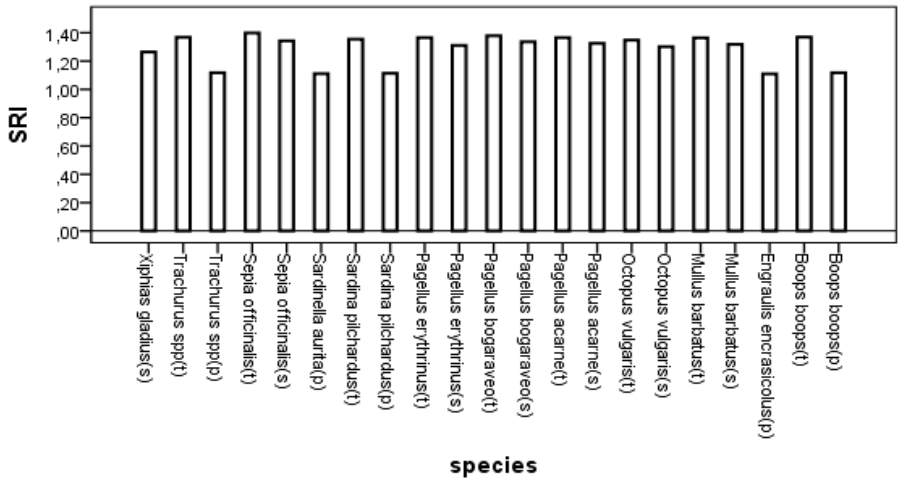


Figure 6 Mean SRIs by assessed species. (t): trawl fishery, (p): purse seine fishery, and (s): small-scale fishery

3.4 Evaluation of Algerian coastal fisheries and ecosystem indices based on estimated fisheries risk indices and ecosystem risk index

Estimation and comparison of fisheries risk indices FRIs, which are one of the most important indices in this research to interpret the fisheries risk conditions when many species are targeted by different fisheries.

To this end, the fisheries risk indices FRIs were calculated from the following formula: $\text{FRI} = \frac{\sum \boldsymbol{Bi\ SRIi}}{\sum \boldsymbol{Bi}}$, Where $\mathbf{B}_{\boldsymbol{i}}$ is the biomass or relative biomass such as catch per unit effort for species $\boldsymbol{i}$. Where this last one were used in the present study as an alternative of biomass.

Five years of catch per unit effort CPUE average were considered as an appropriate time period, furthermore, the CPUE were separated over fisheries.

The Algerian coastal ecosystem index ERI was estimated, since the FRIs for all main fisheries, trawl, purse seine, and small-scale operating inside the coastal ecosystem were evaluated. The ecosystem risk index ERI is reported as the weighted average of the fishery risk indices in an ecosystem,

$\boldsymbol{ERI} = \frac{\sum \boldsymbol{Ci\ FRIi}}{\sum \boldsymbol{Ci}}$, Where Ci is the catch of i fishery. The catch used in this study was the average during the last 05 years.

To estimate fishery risk indices for trawl, purse seine, and small-scale fisheries as indicated in table13, Tier 2 process analysis was applied to 21 species by considering the overlapping of species among the three assessed fisheries.

Table 18 Fishery risk index (FRI), and ecosystem risk index (ERI) for the Algerian coastal ecosystem using ecosystem-based assessment Tier02 approach

Fishery	**FRI**	**ERI**
Trawl	1.363	1.245
purse seine	1.114	
Small-scale	1.309	

From Table 18, it can be seen that trawl, purse seine, and small-scale fisheries risk indices fell in the yellow zone. The lowest FRI value was observed in purse seine fishery at '1.114', while FRIs of small-scale and trawl fisheries were estimated at '1.309', '1.363' respectively.

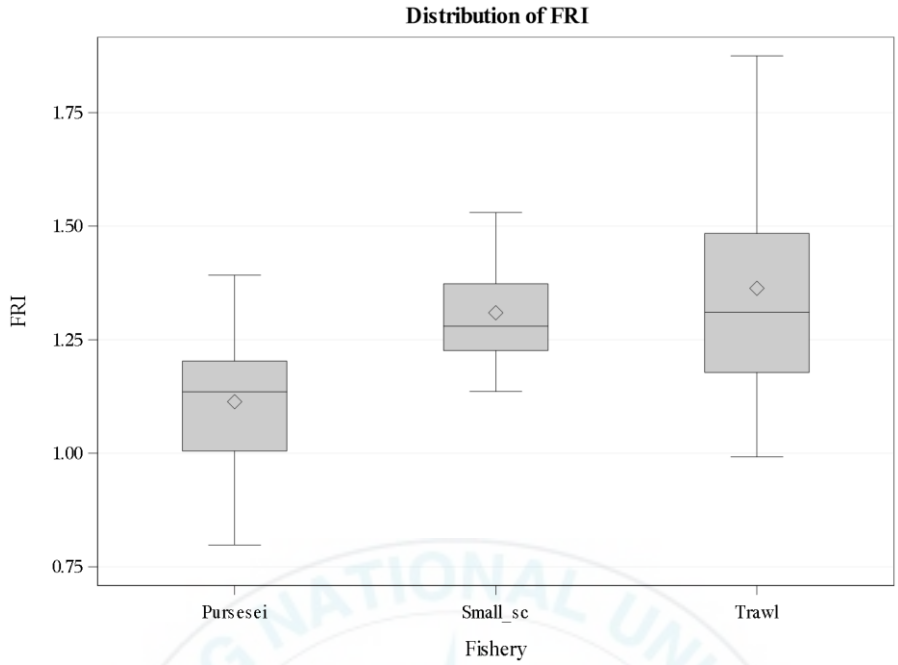


Figure 7. Box plot of FRI by trawl, purse seine, and small-scale fisheries.

Box plots further illustrating the differences in Figure 7. An analysis of variance was conducted and the difference of FRIs means was significant *P<0.05*. Post hoc analysis using Tukey-Kramer test multiple comparisons which is a recommended test for the unbalanced design case, the procedure revealed that the mean FRI for purse seine was significantly different than the FRIs for small-scale and trawl fisheries *P<0.05*. However, the FRI of trawl fishery did not significantly differ from small-scale FRI mean.

Across the three assessed fisheries in the Algerian coastal ecosystem, the risk status of the assessed ecosystem was estimated at '1.245', which was projected in the yellow zone, results are given in table18.

4. Discussion

Evaluating fishing impact on ecosystem is critically necessary for implementing, correcting, and/or maintaining a proper management mechanism at the national, regional, and international level. There is a growing consensus about the need to assess and manage holistically fisheries resources. In the other hand, the measurability of indicators, the weakness of data, and the complexity of the system, became issues for scientists and deciders maker.

Although trawl, purse seine, and small-scale fisheries are the main fishing pressure on the Algerian coastal ecosystem and target in different cases the same species.

Including the previous issues and the need to assess the fisheries risk situation, those dimensions drive the present study to adopt an ecosystem-based fisheries assessment approach based on Tier 2 analysis process developed by (Zhang, et al., 2009).

In 2008, the Algerian government has established a new device of fisheries inspectors, in order to organize and monitor the fishery sector by respecting the allowed fishing gears and the commercial landed size of species, and by controlling and inspecting the healthiness of the sea products. Thus, the current investigation examined both of the opinions of

fishermen and inspectors, since they are the main compartment who have a detailed image about the Algerian fisheries situations.

The nested risk design was used to evaluate the risk conditions at different level; the first constituent of the nested design are the indicators where the assessment was based on. Seven indicators related to sustainability were assessed for each fishery; the ecosystem-based fisheries assessment (EBFA) identifies the catch per unit effort (CPUE) as one of the most critical indicators of sustainability. The results showed that the risk score related to CPUE for all assessed species for the three assessed fisheries were beyond limit (appendix from 5 to 25). The others risk scores for indicators belonging sustainability were in the yellow zone for all species by fishery, except the indicator "rate of mature fish" for cuttlefish in small-scale fishery, which the risk exceeded the limit reference point. The biodiversity objective in this study lists two indicators namely 'discard rate' and 'diversity index', those indicators are based on the amount of discarded fish and the change of dominant species. Four indicators were defined under the habitat quality objective. The socio-economic benefits included five indicators, most of their risk scores for all fisheries fell into yellow zone.

The assessment of objective risk indices ORIs for nine exploited species by trawl showed that only the ORI biodiversity was in the desirable zone. Although sustainability, habitat quality, and socio-economic benefits objectives risk indices fell in the yellow zone, where the highest value of ORI was estimated at 1.78 for habitat quality objective, the evidence suggests that trawl-fishing gears have a high negative impact on the habitat. The ORI for

sustainability and socio-economic were projected in the yellow zone for the fives assessed species in purse seine fishery, while ORIs for biodiversity and habitat quality were estimated at the green zone. It appears that the purse seine fishing gear has a low impact on habitat quality comparing to trawling. In small-scale fishery, only biodiversity fell into the green zone, while other objectives were in the yellow zone.

The present study suggests a useful alternative tool to evaluate the risk situation for the main fisheries operating on the Algerian continental shelf through EBFA Tier2 approach based on the overlaps target species among the fisheries. Trawl, purse seine, and small-scale fisheries risk indices were projected in the yellow zone. The importance of the fisheries risk indices in interpreting the fishing system status led to compare carefully the obtained indices among fisheries. The highest FRI were observed in trawl fishery (1.363), followed by the small-scale fishery (1.309), then the lowest value were found in the purse seine fisheries (1.114). The purse seine fishery risk index differed significantly from both of trawl and small-scale fisheries risk indices, whereas there was no significant difference between trawl fishery risk index and small-scale fishery risk index.

According to (Zhang, et al., 2009), an ecosystem-based management strategy for marine fisheries is one that reduces potential fishing impact, furthermore, the same author reported that objective risks could examine the effeteness of management in promoting sustainability, biodiversity, habitat quality, and socioeconomic benefits. It is crucial to effectively manage the fisheries by defining the management strategies which could be translated into management tactics and actions. To reduce the impact of fishing by reducing

the fisheries risk conditions as much as possible until changing the status to the desirable green zone. The nested assessment system might retrace back to frame a proper management for each fishery. It can be seen clearly that the trawl fishery has a heavy negative impact on habitat.to prevent a habitat damage we suggest an update on the technical measures, such as improving the selectivity. The sustainability must be enhanced for all fisheries, as a strategy for sustainability is to increase biomass and protect juveniles. This strategy could be translated by modifying fishing closed season and area. Once this process is accomplished, it is necessary to implement carefully the corrective measures into reality in order to avoid all kind of socioeconomic conflicts in the fisheries sector. In addition, the involvement of stakeholders is recommended to achieve the consensus (Zhang, et al., 2009).

The results could be a benchmarks for evaluating the fisheries risk situations and the management effectiveness. The future work should, therefore, shift to Tier1 approach analysis, either progressively by incorporating the available data for some selected indicators. In addition, the next assessment should be oriented to include other activities taking place in and around the ecosystem, particularly when the assessed ecosystem is defined as an inshore area.

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Appendix 1. Target and limit reference points for indicators of sustainability in the Tier 2 EBFA.

Attributes	Indicators	Indicator status						
		Better than target		Between target and limit			Beyond limit	
		0	0.5	1.0	1.5	2.0	2.5	3.0
Abundance	Biomass (B) or Catch per unit effort (CPUE)	More than X years of CPUE data are standardized	More than X years of CPUE data are standardized	More than X years of CPUE data are available but not standardized	Less than X years of CPUE data are standardized	Less than X years of CPUE data are available but not standardized	CPUE data are not available, catch trend is unchanged	CPUE data are not available, catch trend is declining
	[S-1]	Current CPUE are extremely large compared with average of CPUE during X years	Current CPUE are large compared with average of CPUE during X years	Current CPUE are moderately large compared with average of CPUE during X years	CPUE is Unchanged	Current CPUE is moderately small compared with average of CPUE during X years		
				or	or	or	or	or
				Less than X years of CPUE data are available	Less than X years of CPUE data are available but not standardized	CPUE data are not available, catch trend is increasing	CPUE data are available, current CPUE are small compared with average of CPUE during X years	CPUE data are available, current CPUE are extremely small compared with average of CPUE during X years
				Current CPUE are moderately large compared with average of CPUE during X years	Current CPUE is similar to average of CPUE during X years			

Fishing intensity	Catch or fishing mortality (F) [S-2]	Effort is extremely small compared with average of effort during X years Fishery management and active self-regulation exist	Effort is small compared with average of effort during X years Fishery management or self-regulation exist	Effort is moderately small compared with average of effort during X years Fishery management or self-regulation exist partly	Effort is similar to average of effort during X years Fishery management or self-regulation exist partly	Effort is moderately large compared with average of effort during X years Fishery management or self-regulation exist partly	Number of license or fishing gear is unchanged or Effort is in an increasing state or IUU fishery exist partly	Number of license or fishing gear is excessive or Effort is rapidly increasing or IUU fishery exist largely
Optimum age (or size) at first capture	Age (or length) at first capture [S-3]	Average length of catch is extremely large compared with mature length or Regulation for	Average length of catch is large compared with mature length or Regulation for	Average length of catch is moderately large compared with mature length or Regulation for	Average length of catch is similar to mature length or Regulation for	Average length of catch is moderately small compared with mature length or Regulation for	Average length of catch is small compared with mature length or Regulation for	Average length of catch is extremely small compared with mature length or Regulation for

		body length exists actively or Length at first capture is extremely large compared with mature length	body length exists actively or Length at first capture is large compared with mature length	body length partly exists or Length at first capture is moderately large compared with mature length	body length partly exists or Length at first capture is similar to mature length	body length does not exist or Length at first capture is moderately small compared with mature length	body length does not exist or Length at first capture is small compared with mature length	body length does not exist or Length at first capture is extremely small compared with mature length
Stock structure	Rate of mature fish [S-4]	Fishing never occurs during the spawning season or Prohibition season (prohibition fishing ground) is set up and conduct to conserve mature fish	No more than a minor amount of the catch is taken during the spawning season	No more than a moderate amount of the catch is allowed to be harvested during the spawning season	No more than a moderate to a considerable amount of fish is allowed to be taken during the spawning season	A significant amount of catch is allowed to be taken during the spawning season	A significant amount of catch is taken as most of fisheries are taking place during the spawning season	Fishing activities are free to operate whenever during the spawning season
Genetic structure	Ratio of(released stock abundance) /(wild stock abundance) in catch [S-5]	Never release fish in the area (There is no entrance from external area)	A few release fish in the area	Release conducted once and small amount in recent X year on the area	Release conducted twice in recent X year on the area	Release conducted three times and considerable amount in recent X year on the area	Release conducted more than four times and considerable amount in recent X year on the area	Release conducted continuously and considerable amount in the most recent past

Population Resiliency	Reproduction habitat [S-6]	Coral coverage of fishing area is extremely large	Coral coverage of fishing area is large	Coral coverage of fishing area is moderately large	Coral coverage of fishing area is average	Coral coverage of fishing area is moderately small	Coral coverage of fishing area is small	Coral coverage of fishing area is extremely small
		Seagrass coverage of fishing area is extremely large	Seagrass coverage of fishing area is large	Seagrass coverage of fishing area is moderately large	Seagrass coverage of fishing area is average	Seagrass coverage of fishing area is moderately small	Seagrass coverage of fishing area is small	Seagrass coverage of fishing area is extremely small
		Mangrove coverage of fishing area is extremely large	Mangrove coverage of fishing area is large	Mangrove coverage of fishing area is moderately large	Mangrove coverage of fishing area is average	Mangrove coverage of fishing area moderately small	Mangrove coverage of fishing area is small	Mangrove coverage of fishing area is extremely small
Community structure	Mean trophic level of catch (TL_C) [S-7]	Ratio of herbivorous to carnivorous in catch is extremely small	Ratio of herbivorous to carnivorous in catch is small	Ratio of herbivorous to carnivorous in catch is moderately small	Ratio of herbivorous to carnivorous in catch is average	Ratio of herbivorous to carnivorous in catch is moderately large	Ratio of herbivorous to carnivorous in catch is large	Ratio of herbivorous to carnivorous in catch is extremely large

Appendix 2. Target and limit reference points for indicators of biodiversity in the Tier 2 EBFA.

Attributes	Indicators	Indicator status						
		Better than target		Between target and limit			Beyond limit	
		0	0.5	1.0	1.5	2.0	2.5	3.0
Bycatch	Bycatch rate **[B-1]**	Catch of non-target species is extremely small	Catch of non-target species is small	Catch of non-target species is moderately small	Catch of non-target species is average	Catch of non-target species is moderately large	Catch of non-target species is large	Catch of non-target species is extremely large
Discards	Discard rate **[B-2]**	Amount of discarded fish is extremely small	Amount of discarded fish is small	Amount of discarded fish is moderately small	Amount of discarded fish is average	Amount of discarded fish is moderately large	Amount of discarded fish is large	Amount of discarded fish is extremely large
Diversity	Diversity index (DI) **[B-3]**	Dominant species is unchanged or Number of species is unchanged	Dominant species is changed (small) or Number of species is unchanged	Dominant species is changed (moderately small) or Number of species is unchanged	Dormant species is partly changed (average) or Number of species is part decreased	Dominant species is some changed (moderately large) or Number of species is some decreased	Dominant species is considerably Changed (large) or Number of species is considerably decreased	Dominant species is most changed (extremely large) or Number of species is most decreased

Appendix 3. Target and limit reference points for indicators of habitat quality in the Tier 2 EBFA

Attributes	Indicators	Indicator status						
		Better than target		Between target and limit			Beyond limit	
		0	0.5	1.0	1.5	2.0	2.5	3.0
Habitat damage	Critical habitat damage rate **[H-1]**	Fishing gear that has extremely small impact on the habitat (Purse seine, Midwater trawl etc.) or Fishing gear that has small impact on the habitat (Surface gillnet, anchovy tow net, boat seine, jigging, pole and line, lift net etc.) Operating period of fishing gear is short	Fishing gear that has small impact on the habitat (Surface gillnet, anchovy tow net, boat seine, jigging, pole and line, lift net etc.) Operating period of fishing gear is very long or Fishing gear that has moderately small impact on the habitat (Stow net, swing net on stakes, long bag set net, setnet etc.) Operating period of fishing gear is long	Fishing gear that has moderately small impact on the habitat (Stow net, swing net on stakes, long bag set net, setnet etc.) Operating period of fishing gear is very long or Fishing gear that has average impact on the habitat (bottom longline, bottom drift gill net etc.) Operating period of fishing gear is long	Fishing gear that has average impact on the habitat (bottom longline, bottom drift gill net) Operating period of fishing gear is very long or Fishing gear that has moderately large impact on the habitat (Trap, bottom gill net etc.) Operating period of fishing gear is long	Fishing gear that has moderately large impact on the habitat (Trap, bottom gill net etc.) Operating period of fishing gear is very long or Fishing gear that has large impact on the habitat (Beam-trawl, Danish seine, haul net etc.) Operating period of fishing gear is long	Fishing gear that has large impact on the habitat (Beam-trawl, Danish seine, haul net etc.) Operating period of fishing gear is very long or Fishing gear that has extremely large impact on the habitat (Bottom trawl, dredge, spray fishing gear etc.) Operating period of fishing gear is long	Fishing gear that has extremely large impact on the habitat (Bottom trawl, dredge, spray fishing gear etc.) Operating period of fishing gear is very long
	Lost fishing gear **[H-2]**	Possibility for potential loss of fishing gear	Possibility for potential loss of fishing gear is	Possibility for potential loss of fishing gear is	Possibility for potential loss of fishing gear	Possibility for potential loss of fishing gear is	Possibility for potential loss of fishing gear is	Possibility for potential loss of fishing gear is

		is high degree of uncertain	highly unlikely	unlikely	is ambiguous	likely	highly likely	high degree of certainty
	Pollution of spawning and nursery area **[H-3]**	The target fishery on the spawning and nursery areas No pollution by the target fishery on the spawning and nursery areas No oil spillage accident	The target fishery on the spawning and nursery areas A few pollution by target fishery on the spawning and nursery areas	The target fishery on the spawning and nursery areas Some pollution by the target fishery on the spawning and nursery areas	The target fishery on the spawning and nursery areas Considerable pollution by the target fishery on the spawning and nursery areas	The target fishery on the spawning and nursery areas Much pollution by the target fishery on the spawning and nursery areas	The target fishery on the spawning and nursery areas Existence of oil spillage accident within recent 3-5 years	The target fishery on the spawning and nursery areas Existence of oil spillage accident within recent 3years
Discarded wastes	Discarded wastes from fishing vessels **[H-4]**	Quantity of discarded wastes is extremely small	Quantity of discarded wastes is small	Quantity of discarded wastes is moderately small	Quantity of discarded wastes is average	Quantity of discarded wastes is moderately large	Quantity of discarded wastes is large	Quantity of discarded wastes is extremely large or Fatal fishing wastes are being discarded

Appendix 4. Target and limit reference points for indicators of socio-economic benefits in the Tier 2 EBFA.

Attributes	Indicators	Indicator status						
		Better than target		**Between target and limit**			**Beyond limit**	
		0	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
Economic considerations	Income per person employed (IPPE) **[E-1]**	Income for recent X years is extremely larger than the minimum living cost Income is Increasing or stable	Income for recent X years is larger than the minimum living cost Income is increasing or stable	Income for recent X years is moderately larger than the minimum living cost Income is increasing or stable	Income for recent X years is similar to the minimum living cost Income is stable	Income for recent X years is moderately smaller than minimum living cost Income is stable	Income for recent X years is smaller than the minimum living cost Income is stable or decreasing	Income for recent X years is extremely smaller than the minimum living cost Income is decreasing
	Ratio of profit to sales (RPS) **[E-2]**	Profit/sale by the fishery is extremely high	Profit/sale by the fishery is high	Profit/sale by the fishery is moderately high	Profit/sale by the fishery is average	Profit/sale by the fishery is moderately low	Profit/sale by the fishery is low	Profit/sale by the fishery is extremely low
Social considerations	Employment rate **[E-3]**	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is extremely large or average Employment rate is Increasing for recent X years	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is small Employment rate is increasing for recent X years	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is large Employment rate is stable for recent X years	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is average Employment rate is stable for recent X years	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is small Employment rate is stable for recent X years	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is large Employment rate is decreasing for recent X years	Index of fishery employment (number of fishermen X actual fishing days) for recent X years is average or small Employment rate is decreasing for recent X years
	Job satisfaction **[E-4]**	Job satisfaction of the fishery is optimal	Job satisfaction of the fishery is negligible	Job satisfaction of the fishery is minor	Job satisfaction of the fishery is moderate	Job satisfaction of the fishery is major	Job satisfaction of the fishery is severe	Job satisfaction of the fishery is catastrophic

Cultural considerations **[E-5]**	Traditional womens participation satisfaction of the fishery is optimal	Traditional womens participation satisfaction of the fishery is negligible	Traditional womens participation satisfaction of the fishery is minor	Traditional womens participation satisfaction of the fishery is moderate	Traditional womens participation satisfaction of the fishery is major	Traditional womens participation satisfaction of the fishery is severe	Traditional womens participation satisfaction of the fishery is catastrophic
	Traditional spiritual satisfaction of the fishery is optimal	Traditional spiritual satisfaction of the fishery is negligible	Traditional spiritual satisfaction of the fishery is minor	Traditional spiritual satisfaction of the fishery is moderate	Traditional spiritual satisfaction of the fishery is major	Traditional spiritual satisfaction of the fishery is severe	Traditional spiritual satisfaction of the fishery is catastrophic
	Traditional Religious (discipline) satisfaction of the fishery is optimal	Traditional spiritual satisfaction of the fishery is negligible	Traditional spiritual satisfaction of the fishery is minor	Traditional spiritual satisfaction of the fishery is moderate	Traditional spiritual satisfaction of the fishery is major	Traditional spiritual satisfaction of the fishery is severe	Traditional spiritual satisfaction of the fishery is catastrophic

Appendix 5: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of bogue *Boops boops*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.44	0.62	3
	Rate of mature fish	1.24	0.48	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.46			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat_quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix6: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators *of Mullus barbatus*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.40	0.67	3
	Rate of mature fish	1.15	0.46	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.43			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix 7: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Octopus vulgaris*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.18	0.63	3
	Rate of mature fish	1.06	0.47	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.37			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix8: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Pagellus acarne.* Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.44	0.55	3
	Rate of mature fish	1.14	0.48	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.44			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix9: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Pagellus bogaraveo*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.63	0.53	3
	Rate of mature fish	1.17	0.44	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.49			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix10: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Pagellus erythrinus*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.43	0.51	3
	Rate of mature fish	1.14	0.43	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.44			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix11: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Sardina pilchardus*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.18	0.35	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.25	0.59	3
	Rate of mature fish	1.13	0.57	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.40			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix12: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Sepia officinalis*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.49	0.72	3
	Rate of mature fish	1.93	0.41	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.57			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix13: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Trachurus spp*. Of trawl fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.17	0.33	3
	Fishing mortality (Catch)	1.61	0.55	2
	Length at first capture	1.45	0.61	3
	Rate of mature fish	1.16	0.49	2
	Genetic structure	0.02	0.11	1
	Reproduction habitat	1.05	0.81	1
	Mean trophic level	1.33	0.53	1
ORI s	1.45			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.62	0.51	3
	Diversity index	0.50	0.62	1
ORI B	0.59			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	2.58	0.23	2
	Lost fishing gear	1.45	0.84	1
	Pollution rate of spawning and nursery ground	1.08	0.73	1
	Discarded wastes	1.19	1.10	1
ORI h	1.78			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix14: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Sardina pilchardus*. Of purse seine fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.28	0.26	3
	Fishing mortality (Catch)	1.89	0.63	2
	Length at first capture	1.55	0.63	3
	Rate of mature fish	1.64	0.32	2
	Genetic structure	0.15	0.45	1
	Reproduction habitat	1.61	1.10	1
	Mean trophic level	1.59	0.69	1
ORI s	1.68			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.08	0.18	3
	Diversity index	1	1.01	1
ORI B	0.31			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	0.00	0.00	2
	Lost fishing gear	1.47	0.83	1
	Pollution rate of spawning and nursery ground	1.11	0.46	1
	Discarded wastes	1.65	0.88	1
ORI h	0.85			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.03	0.49	2
	Ratio of profit to sales (RPS)	1.71	0.48	2
	Employment rate	1.06	0.76	1
	Job satisfaction	1.97	0.87	1
	Cultural consideration	0.79	0.75	1
ORI E	1.61			

Appendix15: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Sardinella aurita*. Of purse seine fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.28	0.26	3
	Fishing mortality (Catch)	1.89	0.63	2
	Length at first capture	1.37	0.57	3
	Rate of mature fish	1.81	0.34	2
	Genetic structure	0.15	0.45	1
	Reproduction habitat	1.61	1.10	1
	Mean trophic level	1.59	0.69	1
ORI s	1.67			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.08	0.18	3
	Diversity index	1	1.01	1
ORI B	0.31			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	0.00	0.00	2
	Lost fishing gear	1.47	0.83	1
	Pollution rate of spawning and nursery ground	1.11	0.46	1
	Discarded wastes	1.65	0.88	1
ORI h	0.85			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix16: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Trachurus spp*. Of purse seine fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.28	0.26	3
	Fishing mortality (Catch)	1.89	0.63	2
	Length at first capture	1.50	0.72	3
	Rate of mature fish	1.80	0.37	2
	Genetic structure	0.15	0.45	1
	Reproduction habitat	1.61	1.10	1
	Mean trophic level	1.59	0.69	1
ORI s	1.70			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.08	0.18	3
	Diversity index	1	1.01	1
ORI B	0.31			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	0.00	0.00	2
	Lost fishing gear	1.47	0.83	1
	Pollution rate of spawning and nursery ground	1.11	0.46	1
	Discarded wastes	1.65	0.88	1
ORI h	0.85			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix17: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Boops boops*. Of purse seine fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.28	0.26	3
	Fishing mortality (Catch)	1.89	0.63	2
	Length at first capture	1.53	0.61	3
	Rate of mature fish	1.78	0.35	2
	Genetic structure	0.15	0.45	1
	Reproduction habitat	1.61	1.10	1
	Mean trophic level	1.59	0.69	1
ORI s	1.70			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.08	0.18	3
	Diversity index	1	1.01	1
ORI B	0.31			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	0.00	0.00	2
	Lost fishing gear	1.47	0.83	1
	Pollution rate of spawning and nursery ground	1.11	0.46	1
	Discarded wastes	1.65	0.88	1
ORI h	0.85			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix18: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Engraulis encrasicolus*. Of purse seine fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.28	0.26	3
	Fishing mortality (Catch)	1.89	0.63	2
	Length at first capture	1.34	0.72	3
	Rate of mature fish	1.84	0.34	2
	Genetic structure	0.15	0.45	1
	Reproduction habitat	1.61	1.10	1
	Mean trophic level	1.59	0.69	1
ORI s	1.66			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.08	0.18	3
	Diversity index	1	1.01	1
ORI B	0.31			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	0.00	0.00	2
	Lost fishing gear	1.47	0.83	1
	Pollution rate of spawning and nursery ground	1.11	0.46	1
	Discarded wastes	1.65	0.88	1
ORI h	0.85			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	1.85	0.68	2
	Ratio of profit to sales (RPS)	1.79	0.61	2
	Employment rate	1.48	0.69	1
	Job satisfaction	1.74	0.81	1
	Cultural consideration	1.13	0.77	1
ORI E	1.66			

Appendix19: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Mullus barbatus*. Of small-scale fishery by Tier 02 approach

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.33	0.2	3
	Fishing mortality (Catch)	1.52	0.5	2
	Length at first capture	1.61	0.7	3
	Rate of mature fish	1.64	0.3	2
	Genetic structure	0.00	0.0	1
	Reproduction habitat	1.86	1.0	1
	Mean trophic level	1.29	0.7	1
ORI s	1.64			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.54	1.05	1
ORI B	0.39			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	1.63	0.30	2
	Lost fishing gear	2.17	0.37	1
	Pollution rate of spawning and nursery ground	1.06	0.86	1
	Discarded wastes	1.13	1.08	1
ORI h	1.52			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.06	0.58	2
	Ratio of profit to sales (RPS)	1.75	0.60	2
	Employment rate	1.71	0.87	1
	Job satisfaction	1.75	0.75	1
	Cultural consideration	1.33	0.75	1
ORI E	1.77			

Appendix20: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Octopus vulgaris*. Of small-scale fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.33	0.2	3
	Fishing mortality (Catch)	1.45	0.6	2
	Length at first capture	1.10	0.7	3
	Rate of mature fish	1.60	0.2	2
	Genetic structure	0.00	0.0	1
	Reproduction habitat	1.87	0.9	1
	Mean trophic level	1.27	0.7	1
ORI s	1.50			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.50	1.02	1
ORI B	0.38			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	1.62	0.29	2
	Lost fishing gear	2.15	0.36	1
	Pollution rate of spawning and nursery ground	1.08	0.83	1
	Discarded wastes	1.19	1.07	1
ORI h	1.53			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.12	0.59	2
	Ratio of profit to sales (RPS)	1.81	0.61	2
	Employment rate	1.69	0.83	1
	Job satisfaction	1.81	0.75	1
	Cultural consideration	1.23	0.80	1
ORI E	1.80			

Appendix21: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Pagellus acarne*. Of small-scale fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.35	0.2	3
	Fishing mortality (Catch)	1.54	0.5	2
	Length at first capture	1.42	0.7	3
	Rate of mature fish	1.70	0.2	2
	Genetic structure	0.08	0.3	1
	Reproduction habitat	1.95	1.0	1
	Mean trophic level	1.35	0.7	1
ORI s	1.63			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.42	1.09	1
ORI B	0.36			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat_quality	Critical habitat damage	1.65	0.30	2
	Lost fishing gear	2.08	0.47	1
	Pollution rate of spawning and nursery ground	1.10	0.84	1
	Discarded wastes	1.19	1.07	1
ORI h	1.53			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.10	0.57	2
	Ratio of profit to sales (RPS)	1.77	0.58	2
	Employment rate	1.81	0.90	1
	Job satisfaction	1.73	0.72	1
	Cultural consideration	1.23	0.80	1
ORI E	1.79			

Appendix22: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Pagellus bogaraveo*. Of small-scale fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.33	0.2	3
	Fishing mortality (Catch)	1.52	0.5	2
	Length at first capture	1.71	0.5	3
	Rate of mature fish	1.67	0.2	2
	Genetic structure	0.00	0.0	1
	Reproduction habitat	1.86	1.0	1
	Mean trophic level	1.29	0.7	1
ORI s	1.67			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.54	1.05	1
ORI B	0.39			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	1.63	0.30	2
	Lost fishing gear	2.17	0.37	1
	Pollution rate of spawning and nursery ground	1.06	0.86	1
	Discarded wastes	1.13	1.08	1
ORI h	1.52			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.06	0.58	2
	Ratio of profit to sales (RPS)	1.75	0.60	2
	Employment rate	1.71	0.87	1
	Job satisfaction	1.75	0.75	1
	Cultural consideration	1.33	0.75	1
ORI E	1.77			

Appendix23: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Pagellus erythrinus*. Of small-scale fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.33	0.2	3
	Fishing mortality (Catch)	1.52	0.5	2
	Length at first capture	1.22	0.7	3
	Rate of mature fish	1.73	0.3	2
	Genetic structure	0.00	0.0	1
	Reproduction habitat	1.86	1.0	1
	Mean trophic level	1.29	0.7	1
ORI s	1.56			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.54	1.05	1
ORI B	0.39			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	1.63	0.30	2
	Lost fishing gear	2.17	0.37	1
	Pollution rate of spawning and nursery ground	1.06	0.86	1
	Discarded wastes	1.13	1.08	1
ORI h	1.52			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.06	0.58	2
	Ratio of profit to sales (RPS)	1.75	0.60	2
	Employment rate	1.71	0.87	1
	Job satisfaction	1.75	0.75	1
	Cultural consideration	1.33	0.75	1
ORI E	1.77			

Appendix24: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Sepia officinalis*. Of small-scale fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.37	0.21	3
	Fishing mortality (Catch)	1.41	0.51	2
	Length at first capture	1.29	0.78	3
	Rate of mature fish	2.23	0.22	2
	Genetic structure	0.08	0.27	1
	Reproduction habitat	1.87	0.92	1
	Mean trophic level	1.31	0.72	1
ORI s	1.65			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.31	1.05	1
ORI B	0.33			

Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat_quality	Critical habitat damage	1.69	0.24	2
	Lost fishing gear	2.04	0.46	1
	Pollution rate of spawning and nursery ground	1.15	0.82	1
	Discarded wastes	1.35	1.03	1
ORI h	1.58			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.13	0.59	2
	Ratio of profit to sales (RPS)	1.85	0.60	2
	Employment rate	1.75	0.89	1
	Job satisfaction	1.81	0.75	1
	Cultural consideration	1.12	0.86	1
ORI E	1.80			

Appendix25: Risk scores for sustainability, biodiversity, habitat quality, and socioeconomic indicators of *Xiphias gladius*. Of small-scale fishery by Tier 02 approach.

Objective	Indicators	Risk score		Weight
		mean	SD	
Sustainability	Catch per unit effort (CPUE)	2.28	0.23	3
	Fishing mortality (Catch)	1.29	0.62	2
	Length at first capture	1.59	0.65	3
	Rate of mature fish	1.12	0.36	2
	Genetic structure	0.00	0.00	1
	Reproduction habitat	1.77	0.97	1
	Mean trophic level	1.19	0.68	1
ORI s	1.49			

Objective	Indicators	Risk score		Weight
		mean	SD	
Biodiversity	Discard rate	0.00	0.00	3
	Diversity index	1.34	1.06	1
ORI B	0.34			

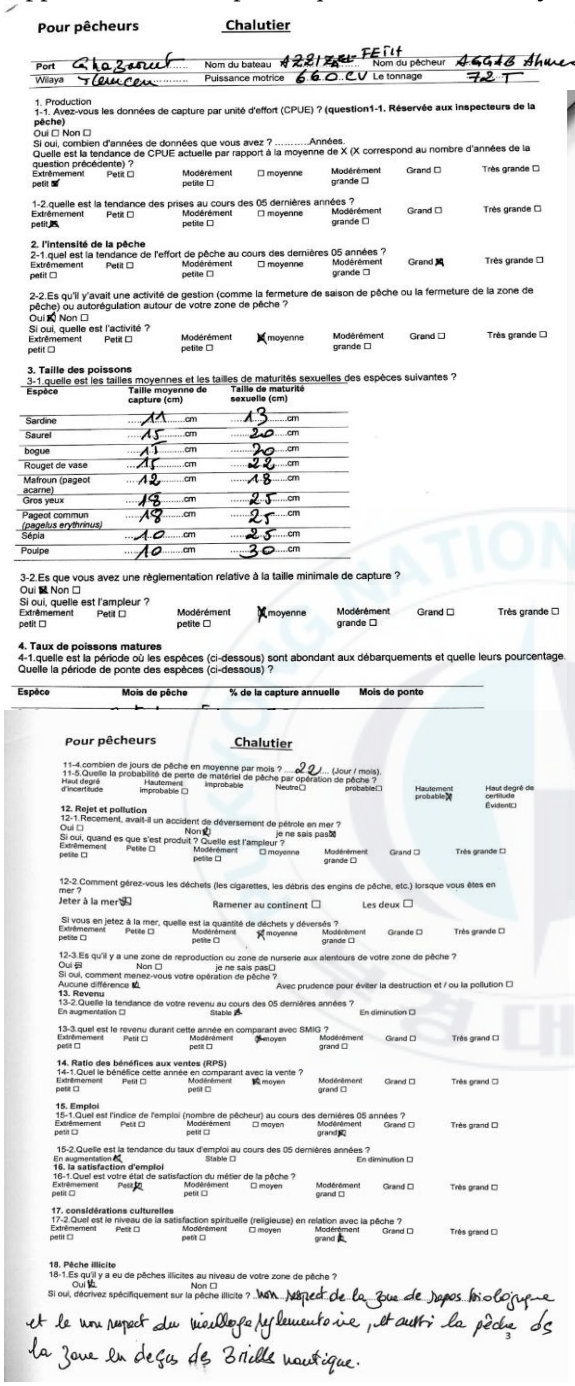
Objective	Indicators	Risk score		Weight
		mean	SD	
Habitat quality	Critical habitat damage	1.50	0.40	2
	Lost fishing gear	2.13	0.33	1
	Pollution rate of spawning and nursery ground	1.02	0.77	1
	Discarded wastes	1.22	1.05	1
ORI h	1.47			

Objective	Indicators	Risk score		Weight
		mean	SD	
Socio-economic benefits	Income per person employed (IPPE)	2.08	0.55	2
	Ratio of profit to sales (RPS)	1.75	0.59	2
	Employment rate	1.45	0.90	1
	Job satisfaction	1.91	0.75	1
	Cultural consideration	1.28	0.73	1
ORI E	1.76			

Appendix 26 number of vessels by fishery from 2005 to 2014

fishery	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
trawl	403	435	476	487	494	502	512	521	526	542
small-scale	2731	2825	2972	2898	1077	2561	2646	2665	2796	2964
purse seine	836	906	972	1038	2935	1102	1143	1202	1231	1255

Appendix27: Example of questionnaire survey form



Pour pêcheurs — Chalutier

Port Ghazaouet — Nom du bateau 4221 FEit — Nom du pêcheur AGGAB Ahmed
Wilaya Tlemcen — Puissance motrice 660 CV — Le tonnage 72 T

1. Production
1-1. Avez-vous les données de capture par unité d'effort (CPE) ? **(question1-1. Réservée aux inspecteurs de la pêche)**
Oui ☐ Non ☐
Si oui, combien d'années de données que vous avez ? .....Années.
Quelle est la tendance de CPUE actuelle par rapport à la moyenne de X (X correspond au nombre d'années de la question précédente) ?
Extrêmement petit ☑ — Petit ☐ — Modérément petite ☐ — ☐ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

1-2.quelle est la tendance des prises au cours des 05 dernières années ?
Extrêmement petit ☒ — Petit ☐ — Modérément petite ☐ — ☐ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

2. l'intensité de la pêche
2-1 quel est la tendance de l'effort de pêche au cours des dernières 05 années ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☐ — ☐ moyenne — Modérément grande ☐ — Grand ☒ — Très grande ☐

2-2.Es qu'il y'avait une activité de gestion (comme la fermeture de saison de pêche ou la fermeture de la zone de pêche) ou autorégulation autour de votre zone de pêche ?
Oui ☒ Non ☐
Si oui, quelle est l'activité ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☐ — ☒ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

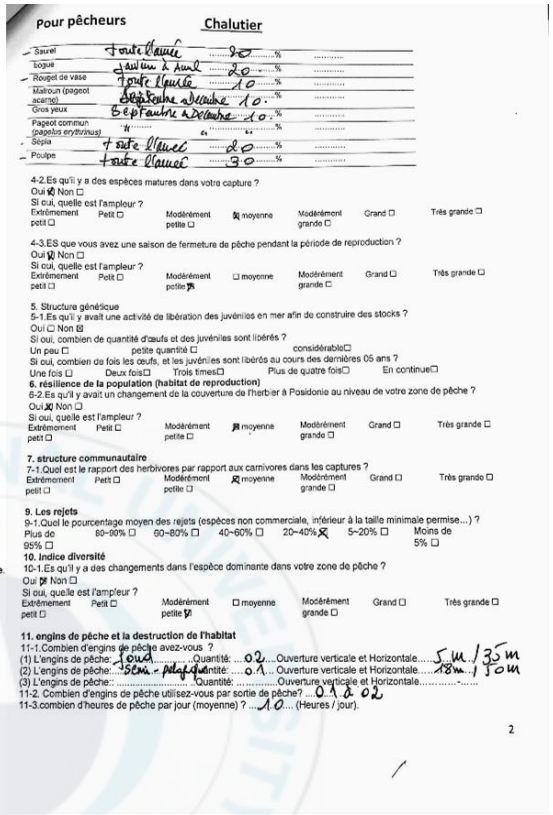
3. Taille des poissons
3-1.quelle est les tailles moyennes et les tailles de maturités sexuelles des espèces suivantes ?

Espèce	Taille moyenne de capture (cm)	Taille de maturité sexuelle (cm)
Sardine	11 cm	13 cm
Saurel	15 cm	20 cm
bogue	15 cm	20 cm
Rouget de vase	15 cm	22 cm
Mafroun (pageot acarne)	12 cm	18 cm
Gros yeux	18 cm	25 cm
Pageot commun *(pagelus erythrinus)*	18 cm	25 cm
Sépia	10 cm	25 cm
Poulpe	10 cm	30 cm

3-2.Es que vous avez une règlementation relative à la taille minimale de capture ?
Oui ☒ Non ☐
Si oui, quelle est l'ampleur ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☐ — ☒ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

4. Taux de poissons matures
4-1.quelle est la période où les espèces (ci-dessous) sont abondant aux débarquements et quelle leurs pourcentage.
Quelle la période de ponte des espèces (ci-dessous) ?

Espèce	Mois de pêche	% de la capture annuelle	Mois de ponte



Pour pêcheurs — Chalutier

Saurel	Toute l'année	20 %
Bogue	Janvier à Juin	20 %
Rouget de vase	Toute l'année	10 %
Mafroun (pageot acarne)	Septembre à Octobre	10 %
Gros yeux	Septembre à Octobre	10 %
Pageot commun *(pagelus erythrinus)*	"	%
Sépia	Toute l'année	20 %
Poulpe	Toute l'année	30 %

4-2.Es qu'il y a des espèces matures dans votre capture ?
Oui ☒ Non ☐
Si oui, quelle est l'ampleur ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☐ — ☒ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

4-3.ES que vous avez une saison de fermeture de pêche pendant la période de reproduction ?
Oui ☒ Non ☐
Si oui, quelle est l'ampleur ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☒ — ☐ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

5. Structure générique
5-1.Es qu'il y avait une activité de libération des juvéniles en mer afin de construire des stocks ?
Oui ☐ Non ☒
Si oui, combien de quantité d'œufs et des juvéniles sont libérés ?
Un peu ☐ — petite quantité ☐ — considérable ☐
Si oui, combien de fois les œufs, et les juvéniles sont libérés au cours des dernières 05 ans ?
Une fois ☐ — Deux fois ☐ — Trois fimes ☐ — Plus de quatre fois ☐ — En continue ☐

6. résilience de la population (habitat de reproduction)
6-2.Es qu'il y avait un changement de la couverture de l'herbier à Posidonie au niveau de votre zone de pêche ?
Oui ☒ Non ☐
Si oui, quelle est l'ampleur ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☐ — ☒ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

7. structure communautaire
7-1.Quel est le rapport des herbivores par rapport aux carnivores dans les captures ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☐ — ☒ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

9. Les rejets
9-1.Quel le pourcentage moyen des rejets (espèces non commerciale, inférieur à la taille minimale permise...) ?
Plus de 95% ☐ — 80~90% ☐ — 60~80% ☐ — 40~60% ☐ — 20~40% ☒ — 5~20% ☐ — Moins de 5% ☐

10. Indice diversité
10-1.Es qu'il y a des changements dans l'espèce dominante dans votre zone de pêche ?
Oui ☒ Non ☐
Si oui, quelle est l'ampleur ?
Extrêmement petit ☐ — Petit ☐ — Modérément petite ☒ — ☐ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

11. engins de pêche et la destruction de l'habitat
11-1.Combien d'engins de pêche avez-vous ?
(1) L'engins de pêche: Tonna ..... Quantité: ....02.... Ouverture verticale et Horizontale..... 5 m / 35 m
(2) L'engins de pêche: Senne - Mafaq Quantité: ....01.... Ouverture verticale et Horizontale..... 18 m / 150 m
(3) L'engins de pêche: ..... Quantité: ..... Ouverture verticale et Horizontale.....
11-2. Combien d'engins de pêche utilisez-vous par sortie de pêche? ....01 à 02
11-3.combien d'heures de pêche par jour (moyenne) ? ....10.... (Heures / jour).

2

Pour pêcheurs — Chalutier

11-4.combien de jours de pêche en moyenne par mois ? ....22.... (Jour / mois).
11-5.Quelle la probabilité de perte de matériel de pêche par opération de pêche ?
Haut degré d'incertitude — Hautement improbable ☐ — Improbable — Neutre ☐ — probable ☐ — Hautement probable ☒ — Haut degré de certitude Évident ☐

12. Rejet et pollution
12-1.Recement, avait-il un accident de déversement de pétrole en mer ?
Oui ☐ — Non ☒ — je ne sais pas ☒
Si oui, quand es que s'est produit ? Quelle est l'ampleur ?
Extrêmement petite ☐ — Petite ☐ — Modérément petite ☐ — ☐ moyenne — Modérément grande ☐ — Grand ☐ — Très grande ☐

12-2.Comment gérez-vous les déchets (les cigarettes, les débris des engins de pêche, etc.) lorsque vous êtes en mer ?
Jeter à la mer ☒ — Ramener au continent ☐ — Les deux ☐

Si vous en jetez à la mer, quelle est la quantité de déchets y déversés ?
Extrêmement petite ☐ — Petite ☐ — Modérément petite ☐ — ☒ moyenne — Modérément grande ☐ — Grande ☐ — Très grande ☐

12-3.Es qu'il y a une zone de reproduction ou zone de nurserie aux alentours de votre zone de pêche ?
Oui ☒ — Non ☐ — je ne sais pas ☐
Si oui, comment menez-vous votre opération de pêche ?
Aucune différence ☒ — Avec prudence pour éviter la destruction et / ou la pollution ☐

13. Revenu
13-2.Quelle la tendance de votre revenu au cours des 05 dernières années ?
En augmentation ☐ — Stable ☒ — En diminution ☐

13-3.quel est le revenu durant cette année en comparant avec SMIG ?
Extrêmement petit ☐ — Petit ☐ — Modérément petit ☐ — ☒ moyen — Modérément grand ☐ — Grand ☐ — Très grand ☐

14. Ratio des bénéfices aux ventes (RPS)
14-1.Quel le bénéfice cette année en comparant avec la vente ?
Extrêmement petit ☐ — Petit ☐ — Modérément petit ☐ — ☒ moyen — Modérément grand ☐ — Grand ☐ — Très grand ☐

15. Emploi
15-1.Quel est l'indice de l'emploi (nombre de pêcheur) au cours des dernières 05 années ?
Extrêmement petit ☐ — Petit ☐ — Modérément petit ☐ — ☐ moyen — Modérément grand ☒ — Grand ☐ — Très grand ☐

15-2.Quelle est la tendance du taux d'emploi au cours des 05 dernières années ?
En augmentation ☒ — Stable ☐ — En diminution ☐

16. la satisfaction d'emploi
16-1.Quel est votre état de satisfaction du métier de la pêche ?
Extrêmement petit ☐ — Petit ☒ — Modérément petit ☐ — ☐ moyen — Modérément grand ☐ — Grand ☐ — Très grand ☐

17. considérations culturelles
17-2.Quel est le niveau de la satisfaction spirituelle (religieuse) en relation avec la pêche ?
Extrêmement petit ☐ — Petit ☐ — Modérément petit ☐ — ☐ moyen — Modérément grand ☒ — Grand ☐ — Très grand ☐

18. Pêche illicite
18-1.Es qu'il y a eu de pêches illicites au niveau de votre zone de pêche ?
Oui ☒ — Non ☐
Si oui, décrivez spécifiquement sur la pêche illicite ? Non respect de la zone de repos biologique et le non respect du vieillissement réglementaire, et autri la pêche de la zone en deçus de 3 Mille marétique.

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