

## Assessment of the potential vulnerability of small-scale fisheries to the effects of climate change

**“Provision of two socio-economic and statistical studies on small-scale fisheries (WP3) for the project called 'Adri.Smartfish' within the framework of the Programme Interreg V-A Italy-Croatia 2014/2020”. CUP H41C19000000007 - CIG: Z9C2C0DF51**

### WP3 Evaluation of the Small-Scale Fishery sector D3.3 Assessment of the vulnerability of SSF to Climate Change

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## 1. Introduction

Fishing is an activity strongly influenced by climate change. The 2017 National Plan for Adaptation to Climate Change (PNACC) states: "In the Italian seas and throughout the Mediterranean most of the fish stocks of commercial interest are overfished, and in many cases it is difficult to distinguish the effects of overfishing from those caused by climate change. Already in 2008, FAO pointed out that the impacts of climate change will have significant effects on fisheries and aquaculture, with serious consequences on coastal environments and communities. The PNACC also points out that "Climate change also has effects on the composition of communities, because non-indigenous and thermophilic species, of subtropical origin, tend to settle in Italian seas, while some native species, which need lower water temperatures, become less and less abundant. However, since there are relatively few species appreciated by the market, these variations tend to have negative effects on fishing. Recent studies state that in this context the western coast of the upper Adriatic "can be considered an extremely vulnerable area". If this is in a very summary the international and national scenario, studies evaluating the effects of climate change on fishing in regional contexts and specifically in Emilia-Romagna are only at the beginning. This difficulty is first linked to the multiplicity of environmental variables, closely related to fishing activity.

Below some preliminary cognitive elements are collected, useful to evaluate the potential vulnerability of small-scale artisanal fishing, also in relation with other economic activities that insist on the same area. Finally, data concerning the environmental impact in terms of emissions and climate change balance are compared.

## 2. Assessment of the potential vulnerability of small-scale fisheries to the effects of climate change, taking into account adaptation to the composition of the species fished, adaptation of the fleet structure and fishing strategies

### *Climate change in the Adriatic Sea, Emilia-Romagna coast*

Numerous studies show a significant climate change in the region under study. By way of example, with reference only to marine waters, the following is a very brief excerpt from the "National Plan for Adaptation to Climate Change PNACC" of 2017. "The anomalies of the surface temperature of the sea indicate an increase of about 1.2 °C on an annual basis for the Mediterranean basin [...] In particular, the greatest increase in winter and spring temperatures is for the Adriatic basin, with values between 1.5 °C and 2.0 °C [...] In the summer period there are the highest and most widespread anomalies in the Tyrrhenian Sea (about 1.5°C), in the upper Adriatic and in the Ionian Sea".

In the Gulf of Trieste, the OGS (National Institute of Oceanography and Experimental Geophysics) reports in recent decades "an increase in water temperatures, which has favored the accentuation of thermohaline stratification in the summer period, with a consequent limitation of oxygen exchange with the deep layers of the water column". In the period 1985-2020 "it is possible to estimate a maximum increase of 0.4 °C/decade, in good agreement with the estimates from satellite data" reported in the bibliography for Mediterranean surface waters.

As far as the oceanographic parameters are concerned, there are also changes in salinity and pH. These factors considerably influence the currents and consequently the planktonic populations both in qualitative and quantitative terms. In the same Plan it is pointed out that climate change will also have "effects on the composition of communities, because non-indigenous and thermophilic species, of subtropical origin, tend to settle in Italian seas, while some native species, which need lower water temperatures, become less and less abundant. However, since relatively few species are appreciated by the market, these variations tend to have negative effects on fishing. In addition to fish stocks, climate change will have local impacts, even remarkably diverse ones, with effects on both

resource productivity and fishing operations. In addition to this, fishermen will have to adapt fishing tactics more frequently, which will necessarily have to differ, at least in part, from those of the past and, therefore, knowledge handed down or learned from experience will become less useful. Finally, it is to be considered the scarcity of economic resources dedicated to mitigating the impacts of climate change or adapting to them, also due to the now chronic low profitability of national sea fishing, linked to competition from aquaculture products or from fishing in non-Mediterranean areas".



Figure 1 - Artisanal small-scale fishing vessel in Marina di Ravenna.

By limiting attention to small-scale artisanal fishing, the impact of two alien species is highlighted: the swimming crab or blue crab and the sea walnut.

The swimming crab or blue crab (*Callinectes sapidus*) is a naturalized allochthonous species, introduced into the Mediterranean from the North Atlantic through ballast waters. Along the Atlantic coast it is the object of professional fishing, while in the upper Adriatic it was reported in the late 1940s. In recent years it has become very frequent in coastal waters and especially in lagoon waters. Exemplary is the situation of the Sacca di Goro, where in the last five years there has been a real propagation. As well as numerous newspaper articles and a few scientific articles, the observations of the fishermen are testimonies to this phenomenon. Inequivocal are the marketing data of the Goro Fish Market, where it has gone from 7 kg sold in 2017 to 5.451 kg in 2019.



Figure 2 - Blue crabs sold in the Goro fish market

The sea walnut (*Mnemiopsis leidyi*) is native to the Atlantic coast of America and has arrived in the Mediterranean probably through the ballast waters of ships. It has a hyaline body like jellyfish, but it is a ctenophore, it is not urticant for man. It is a voracious predator of zooplankton, from eggs to larvae to adult forms, in competition with other organisms,

including small pelagics. It is included in the list of the 100 most harmful invasive species in the world and since summer 2016 it has formed huge swarms (*blooms*) even in the North Adriatic, creating serious problems for the fishing industry in the lagoons and at sea. Usually the sea walnut occupies the surface area of the water column, with shoals that in recent years have reached hundreds of thousands of individuals. This can partly influence the fishing strategies of vessels using fixed nets. In fact, the ctenophores can end trapped in large numbers in the net, making it work poorly and complicating the handling operations, due to their weight. As a result, the use of trammel nets is further reduced and gillnets are rigged to remain lower and closer to the seabed.



Figure 3 Sea walnut (*Mnemiopsis leidy*) (fonte ARPA - FVG)

#### *Adaptation to the composition of the species fished, fleet structure and fishing strategies*

Small-scale artisanal fishing is by its very nature an activity strongly dependent on seasonal cyclicity and equally significant annual variability. While on the former the fishing cycles have been structured over the years and remain substantially unchanged in recent decades, also in relation to technological adjustments, a multi-annual analysis is more complex. There are activities such as fishing for cuttlefish (*Sepia officinalis*) and marine snails (*Nassarius mutabilis*) that have been consolidated in recent decades,

maintaining more or less the same seasonality, despite the changes and better techniques adopted in the boat's gear and equipment.

The same is true for gillnets, although in this case the methods and timing have been more affected by the technological improvement of vessel and engines. The use of trammel nets, on the other hand, is greatly reduced, primarily due to an increased need for labor. On the contrary, it is only in the last few years that the fishing with the mantis shrimp (*Squilla mantis*) has spread in the northern central area of the region with good results in economic terms. All these activities have been described in detail in Study 3.2, carried out for the same project.

Regarding the changes that have occurred in recent decades, one can take for example the sardine fishing (*Sardina pilchardus*) made with gillnets in Cattolica in the first half of the 20th century, an activity that had already disappeared at the end of the 1960s. In the immediate post-war period, there were about forty vessel that dedicated themselves to this fishing in the summer months. Hundreds of quintals were landed every day, most of which were processed in local canning factories. Fishing with fixed gear, carried out by vessel attributable to small-scale artisanal fishing, was replaced in a few years by fishing with lights, in turn overtaken by pelagic pair trawling fishing.

Below is a list of the main species of commercial interest that could be negatively affected by the rising temperatures in the Adriatic Sea:

- Norway lobster (*Nephrops norvegicus*)
- European hake (*Merluccius merluccius*)
- European sprat (*Sprattus sprattus*)
- European flounder (*Platichthys flesus*)

If these are psychrophilous species, which need "cold water" to complete their biological cycle, an even more complex and articulated discourse concerns all the other species. For example, all the small pelagics, which are a fundamental link in the trophic chains, are more generally subject to climate change that "would influence the influx into the basin of masses of water with a salinity different from other parts of the Mediterranean and from this could result in similar oscillations in the landings of the species examined."

However, all these organisms are not target species of small-scale artisanal fishing.

We should also mention some of the most frequent thermophilic species of commercial interest, in addition to the already mentioned swimming crab, which at the moment are only by-catches for small-scale fishing:

- Leerfish (*Lichia amia*)
- Bluefish (*Pomatomus saltatrix*)
- Common dolphinfish (*Coryphaena hippurus*)
- Greater amberjack (*Seriola dumerili*)
- Yellowmouth barracuda (*Sphyraena viridensis*)
- Atlantic bonito (*Sarda sarda*)

Since 2007, two of these species have been present on the Chioggia fish market, one of the most important in Italy. "It is interesting the appearance in the landed fish market of Chioggia of two other thermophilic species, such as bluefish (*Pomatomus saltatrix*) reported since June 2007 and common dolphinfish (*Coryphaena hyppurus*) since October 2008". From the data collected, the presence of leerfish (*Lichia amia*) in the wholesale fish markets of Cattolica and Goro in 2018 and 2019 should be noted. Table 1 shows the data of the marketed quantities, from which the autumnal presence of the species is shown, even if very variable in the two years considered. Regarding bluefish, on the other hand, the quantities marketed are lower but it is present in almost all months of the year (Table 2). Common dolphinfish and yellowmouth barracuda were not marketed in the same years in both wholesale markets, at least as single species, because occasional catches sold in very small quantities with the "mixed fish". Only a few individuals of amberjack and atlantic bonito transited to Cattolica, as a single entry.



Table 1 – Leerfish (*Lichia amia*) marketed in Cattolica and Goro wholesale fish markets, 2018-2019

Months	Cattolica		Goro	
	2018	2019	2018	2019
01	0.0	0.0	0.0	28.4
02	0.0	0.0	5.8	0.0
03	0.0	0.0	0.0	0.0
04	0.0	0.0	0.0	0.0
05	0.0	0.0	0.0	0.0
06	0.0	0.0	15.5	42.4
07	0.0	190.0	3.1	0.0
08	0.0	0.0	307.3	0.0
09	0.0	3.6	971.7	89.2
10	0.0	19.4	625.0	57.8
11	0.0	0.0	47.3	3.9
12	0.0	0.0	49.5	0.0
Total	0.0	213.0	2.025.2	221.7

Table 2 – Bluefish (*Pomatomus saltatrix*) marketed in Cattolica and Goro wholesale fish markets, 2018-2019

Months	Cattolica		Goro	
	2018	2019	2018	2019
01	8.3	0.0	58.2	9.7
02	0.0	7.5	30.9	14.0
03	3.3	0.6	0.0	6.6
04	0.0	0.0	0.8	2.2
05	0.0	0.0	85.9	12.6
06	1.4	0.0	132.7	188.2
07	4.3	2.5	117.7	75.8
08	5.0	10.4	61.0	11.7
09	14.0	5.9	65.4	88.8
10	0.0	1.9	184.9	69.2
11	15.9	34.8	4.7	41.8
12	9.4	2.2	2.1	0.0
Total	61.6	65.8	744.3	520.6

Finally, we provide a brief comment on the "Red List of Italian Marine Bony Fish", made in 2017 by the Ministry of the Environment (Table 3).

Among these, the only two species of interest for small-scale artisanal fishing are the turbot (*Scophthalmus maximus*) and brown meagre (*Sciaena umbra*). Mackerel (*Scomber scombrus*) is added as a by-catch.

The report, however, shows that "most species of bony marine fish are not subject to any significant threat". With regard to the decline of some species. in addition to overfishing. "the urban development of coastal areas and the increase in pollution of coastal waters

that it entails follow, in order of importance. Another significant threat is represented by changes in habitats and environmental dynamics in general, due to climate change which has favoured the invasion of historically warmer sea species in the Mediterranean". The case of the two mackerel species is emblematic. In fact, the decrease in *Scomber scombrus* seems to correspond to a considerable increase in the thermophilic species *Scomber japonicus* (Pacific chub mackerel). Equally important is the case of *Sardinella aurita*, a thermophilus species for which a significant extension of the distribution area in the Mediterranean area has been recorded".

In relation to what has been written. for small-scale fishing, there are currently no major changes in the structure of the fleet and fishing strategies with the exception of the ones previously described to reduce the sea walnut impact on the set gillnets.

Table 3 – Marine bony fish red list, Italy – 2017 (source: "Lista Rossa dei Pesci Ossei Marini Italiani")

Ordine	Famiglia	Nome scientifico	Nome comune	Categoria Lista Rossa
Perciformes	Sciaenidae	<i>Argyrosomus regius</i>	Ombriina bocca d'oro	CR
Perciformes	Serranidae	<i>Epinephelus marginatus</i>	Cernia bruna	EN
Pleuronectiformes	Scophthalmidae	<i>Scophthalmus maximus</i>	Rombo chiodato	EN
Perciformes	Serranidae	<i>Epinephelus aeneus</i>	Cernia bianca	VU
Perciformes	Serranidae	<i>Epinephelus costae</i>	Cernia dorata	VU
Perciformes	Polyprionidae	<i>Polyprion americanus</i>	Cernia di fondale	VU
Perciformes	Sciaenidae	<i>Sciaena umbra</i>	Corvina	VU
Perciformes	Scombridae	<i>Scomber scombrus</i>	Sgombro	VU

Note: CR: critical danger, EN: in danger, VU: vulnerable.

### 3. Identification of main fishing areas and conflicts or synergies with other uses of marine space

In order to respond to the need to identify the main areas in which small-scale artisanal fishing operates, and conflicts and/or synergies with other activities, a Geographical Information System has been developed. drawing on geo-referenced databases created in other projects by the writer and/or other public or private bodies that have made the data available.

Additional information was then integrated and geo-referenced on these, collected specifically, such as:

- areas of presence of the clam (hydraulic dredge fishing)
- maritime traffic routes

An archive of geo-referenced spatial data has therefore been created to facilitate spatial analysis and to be able to calculate surfaces to compare the remaining spaces and those in which small-scale fishing has to share spaces with other uses. These data have been organized in different thematic maps together with information on the fishing fleet and fishing grounds. To enable this, the open source software QGIS version 10.2 "A Coruña" was used and lines, perimeters and areas in use or according to the current maritime regulations were drawn. With the maps created, a series of tables were produced for an organic representation of the work.

Below is a list of the geo-referenced data entered:

1. Emilia-Romagna nautical chart with
  - 200-metre limit (precluded to all forms of professional fishing. art.105 DPR 2/10/1968), obtained from OpenStreetMap coast line.
  - 500-metre limit (closed to all forms of professional fishing. during the summer period - RER Bathing Ordinance no. 1/2019), obtained from OpenStreetMap coastline line.
  - Area within 0.3 nautical miles (hydraulic dredges - EC Reg. 1967/2006). obtained from OpenStreetMap coastline.

- Area within 3 nautical miles (forbidden to trawling - EC Reg. 1967/2006), obtained from OpenStreetMap coastline.
- Area within 6 nautical miles (closed to trawling for vessel over 15 m in the period August-September-October 2019 - DM n.173 of 30 April 2019), obtained from OpenStreetMap coastline.
- Area within 12 nautical miles ( small-scale artisanal fishing area of competence- Ministerial Decree of 7 December 2016).

2. Location of the ZTB (Zona di Tutela Biologica) (Biological Protection Area) Outside Ravenna; precluded to professional fishing with towed gear (Ministerial Decree 21 July 1995; Official Gazette no. 203 of 31/08/95 - Annex G - DGR/2012/893)
3. Location of the SCI-ZPS (Site of Community Interest - Special Protection Area) IT4070026 - Wreck of the Paguro platform; closed to professional and sport/recreational fishing (Emilia Romagna - Annex G - DGR/2012/893)
4. Localization of Ravenna Area di Tiro (Foce Reno - Ravenna Area Ordinance No. 22/2018)
5. Off-shore platforms; prohibition of navigation and fishing for a radius of 500 metres (Safety zones - art. 28 DPR 24 May 1979 - n.886)
6. Underwater pipelines (sealines). prohibition to anchor and fish. in the 250-metre band (or more as indicated on charts) along both sides (Safety zones - art. 28 DPR 24 May 1979 - n.886), obtained as distance from the pipelines taken from WebGIS of the Ministry of Economic Development (WebGIS DGS-UNMIG)
7. Areas for aquaculture; all vessels in navigation. with the exception of those intended for the service of fishing facilities, must be kept at a distance of not less than 200 metres from the external perimeter of the entire plant area (Subdivisional Ordinances).
8. Artificial barriers; some fall within areas under concession for aquaculture. others are of regional competence and have compartmental ordinances prohibiting anchoring and fishing within half a mile from the centre of the water area concerned.
9. Total fleet by port and small-scale small-scale fishing fleet, broken down by port (from Fleet register UE. 2020 and census conducted. 2018)

This work has made it possible to visualize and quantify some areas of small-scale artisanal fishing (Table 4), also useful to clarify conflicts and/or synergies with other fishing

activities or uses. A detailed Geographical Information System also makes it possible to plan interventions and harmonize management. Through the GIS some thematic maps have been realized. attached to this one. and the following areas have been calculated:

1. Exclusive fishing area (between 200 metres and 0.3 nautical miles), non summer period
2. Exclusive fishing area (between 500 metres and 0.3 nautical miles), summer period
3. Fishing area shared with theoretical hydraulic dredges (between 0. 3 and 3.0 nautical miles)
4. Effectively shared fishing area with hydraulic dredges (between the maximum limit of presence of the shoals and 3.0 nautical miles)
5. Shared fishing area with trawl (3-6 nautical miles)
6. Total area of small-scale artisanal fisheries from 200 meters to 12 nautical miles.

For each of these areas an index of fishing area per boat (small-scale fishing - SSF) has also been calculated, referring to the 212 vessel surveyed, registered in the Ravenna and Rimini compartments. This is a very first spatial elaboration, which has no comparative bibliographic data, but could prove very useful in the future.

It should be noted that, according to current regulations, the reference surfaces have been removed:

- the concessions for the breeding of molluscs with 200 m of respect (72.13 squared km)
- artificial barriers with 200 m or 900 m of respect (8.90 squared km)
- submarine pipelines with 250 m of respect on both sides and methane extraction platforms with 500 m of respect (534.41 squared km)
- the area of the ECHO 346 firing range (of which 130.21 square kilometres are permanently closed to fishing)

Areas periodically banned and a source of conflict:

- the area of the ECHO 346 firing range (of which 213.59 square kilometres are periodically closed to fishing)
- dumping sites (70.46 sq. km periodically closed to fishing)

Table 4 -Fishing areas and areas/boat indexes. in the Emilia-Romagna sea

Description	Surface (Kmq)	SSF vessel (n)	Index (Kmq/SSF boat)
SSF exclusive fishing area (from 200m to 0.3 nautical miles). winter*	37.84	212	0.18
SSF exclusive fishing area (from 500m to 0.3 nautical miles). summer*	6.11	212	0.03
SSF/hydraulic dredges shared fishing area (until 3 nautical miles) *	490.83	212	2.27
SSF/hydraulic dredges effectively shared fishing area (until 3 nautical miles)*	129.79	212	0.61
SSF/hydraulic dredges shared fishing area (from 0.3 to 3 nautical miles). not effectively used by dredges*	361.04	212	1.70
SSF/trawlers shared surface (3-6 nautical miles). from November to July)	208.25	212	2.22
SSF exclusive surface August-September 2019 (from 3 to 4 nautical miles)	71.08	212	0.33
Overall SSF fishing grounds from 200 meters to 12 nautical miles	1427.93	212	6.73

As already written, 7 thematic maps are attached to this document:

1. ATTACHMENT 1 - Thematic map on small-scale artisanal fishing and other uses in Ravenna Maritime Compartment (North Area)
2. ATTACHMENT 2 - Thematic map on small-scale artisanal fishing and other uses in Ravenna Maritime Compartment (South Area)
3. ATTACHMENT 3 - Thematic map on small-scale artisanal fishing and other uses in Rimini Maritime Compartment (North Area)
4. ATTACHMENT 4 - Thematic map on small-scale artisanal fishing and other uses in Rimini Maritime Compartment (South Area)
5. ATTACHMENT 5 - Emilia Romagna ports with reference to the official artisanal small-scale fishing fleet (Fleet Register 2020)

6. ATTACHMENT 6 - Emilia Romagna ports with reference to the active artisanal small-scale fishing fleet (Census 2018)
7. ATTACHMENT 7 - Cargo marine traffic in the Emilia-Romagna regional waters (EMODNET 2019)

These tables and the indexes developed make it possible to visualise and evaluate conflicts and synergies with other activities. The main conflicts concern the overlapping of fishing areas with other gear.

Attachment 7 instead presents a thematic map dedicated to cargo traffic routes, obtained by EMODNET (European Marine Observation and Data Network). The map, with reference to the three areas of the PPA, within 3, 6 and 12 nautical miles from the coast, is intended to display the areas of greatest density of passage or stationing of cargo ships, excluding all values below 2 hours of presence per square kilometre per month during the 2019 annuality. It can be seen that with the exception of entry and exit routes from the port of Ravenna, the routes are outside the 12 miles, so they do not overlap with the PPA areas. Within the 12 nautical miles there is also passenger traffic (motorboats for summer tourist transport), that of other work activities (dredgers, pontoons, platform service vessels, etc.) and that of pleasure boats. Despite a few isolated incidents, there were no conflicts with the PPA.

*Conflicts.* First conflict concerns hydraulic dredges operating below the coast, within the 3 nautical miles precluded from trawling, by way of derogation from point 1 of Article 13 of Regulation (EC) No 1967/2006. But since the area of presence of the clam shoals is narrower, the real overlapping indices of the two activities have been calculated, which amount to about 130 square kilometres of the 490 square kilometres of the coastal strip, therefore reduced compared to the entire coastal strip but nevertheless using in all cases the part closest to the coast and occupying it constantly during the fishing periods.

A second conflict concerns bottom trawling which must operate beyond 3 nautical miles. In addition to this, there is a further temporary ban on trawling between 3 and 6 miles for vessel over 15 metres in length, which follows technical grounding for 60 days. The Ministerial Decree n.173 of 30 April 2019 reads as follows:

- (art. 2 paragraph 1) from Trieste to Ancona, the mandatory temporary interruption of fishing activities for 30 consecutive days from 29 July to 27 August of the current year.
- (Art. 6 paragraph 4) from 29 July 2019 until 31 October 2019, it is forbidden, in the waters of the maritime compartments of the Adriatic Sea, with the exception of those of Monfalcone and Trieste, and of the Ionian Sea, to fish with the trawl and/or pelagic system - including the following gears: otter trawls, rapid beam trawls, twin otter trawls, pelagic otter trawls, pelagic pair trawls - within a distance from the coast of less than 6 miles or with a water depth of less than 60 metres.
- (art. 6 paragraph 5) from 29 July 2019 until 31 October 2019, by way of derogation from the prohibition referred to in paragraph 4 above, units in category IV authorised to fish within six miles from the coast and units with an overall length of up to 15 metres are authorised to fish beyond 4 miles from the coast.

Therefore the small-scale artisanal fishing has found itself operating in a further exclusive area. between 3 and 4 miles, for three months (from August to October) on an area of approximately 71 square kilometres.

A further conflict is with sport/recreational cuttlefish fishing with pots. In fact, in the regional maritime compartments (Capitaneria di Rimini Ord.102/2019; Capitaneria di Ravenna Ord.167/2009) fishing with two pots is authorised. Professional fishermen complain that neither the number of pots dropped nor the maximum daily quantity (5 kg) is respected. In addition to this. there is the problem of the conflict "in the strip of sea between 500 (five hundred) and 1.000 (one thousand) metres from the coast", where sportsmen can set their gear ("without prejudice to the further limitations set out in the current Bathing Safety Ordinance and in specific Ordinances regulating other maritime activities incompatible with the exercise of this type of fishing").

*Synergies.* The relationship between small-scale artisanal fishing and shellfish farming has been controversial over the last thirty years. but beyond local conflicts, mussel farming facilities, as well as all facilities that prevent trawling and encourage increased biodiversity. have helped to increase biodiversity and available biomass. In Emilia-Romagna. overall



the areas given in concession for marine aquaculture. occupied only partially by facilities, amount to 72.13 square kilometers, including the 200 m of respect area around the farming areas.

To these are added those occupied by artificial barriers, 8.9 square kilometers, methane extraction plants and submarine pipelines, 534.41 square kilometres within the 12 nautical mile boundary.

Equally positive was the establishment of the Biology Protection Zone Outside Ravenna (DM) which occupies an area of 179.31 square kilometres.

In this Z.T.B. trawling and flying fishing is forbidden. while the DM 22nd January 2009 specifies that:

- Professional fishing: the use of traps. gillnets and longlines is allowed.
- Sport fishing: fishing with a maximum of 5 hooks per fisherman is allowed. Fishing with collective vessels is also allowed.

It is also worth mentioning the SIC IT4070026 "Paguro" platform wreck in front of Ravenna. which has an extension of 0.66 square kilometres. Any form of professional and sport/recreational fishing is forbidden in this area.

Once we have summed up all the restrictions. we can estimate that from 0.3 to 12 nautical miles, areas pertaining to small-scale artisanal fishing, remain available in a non-exclusive way and not always in positions reachable by vessel of these types about 1.427 square kilometers, excluding 665 square kilometers of areas permanently closed to fishing and including other 284 square kilometers that can be temporarily closed or whose occasional use by others makes it temporarily impossible to use for small-scale fishing (e.g. dumping sites).

## 4. Environmental impact of the sector in terms of emissions and climate change balance

The environmental impact of small-scale artisanal fishing in terms of emissions is not easy to assess and there are no works in the literature concerning the area covered by this study. Therefore, a first approach has been implemented to collect quantitative data related to fuel consumption, comparing them to other fishing activities, in order to provide a first generic comparative picture.

Therefore, data have been collected from some vessel engaged in annual fishing activities with: small-scale artisanal fishing (SSF), trawlers and hydraulic dredge.

Even for trawling an estimate of average consumption and expenditure is not easy, because there is a considerable diversity depending on the size of the boat, the type of gear used, the season and other variables. The situation of hydraulic dredges, on the other hand, is different, as they usually have very similar fishing days.

As far as small-scale artisanal fishing is concerned, above all, the evaluation of average consumption is complex because first of all different gears are used, which have different target species and consequently different fishing areas and periods. To make it simple, much depends on the distance from the port of the fishing areas. Consumption doubles, for example, with the use of gillnets, since they have to be lowered at sunset and set sail the next dawn.

In general, however, the use of towed gear, unlike the fixed gear used by small-scale artisanal fishing, has a greater impact also in terms of energy consumption. In Table 5 the data collected for the three types of fishing are first of all compared, concerning the number of annual fishing days and consumption. Small-scale fishing vessels are on average engaged for 175 days a year, compared to 150 days of trawling and 130 days of hydraulic dredging. In comparison with the annual consumption, for the small coastal fishing vessel it has been estimated that about 70 litres/day, 85 litres/day for the hydraulic dredger that in the last few years has been able to fish the daily quota in only 3/4 hours, 500 litres/day for the trawl. For the latter type, a considerable variability has been estimated, depending on the distance from the port where they operate, the number of

hours at sea and the type of net used. Daily costs are also estimated. considering an average price of 0.60 €/l

Table 6 instead correlates consumption with the estimate of the average quantities landed, Here the relative values are to the detriment of small-scale artisanal fishing, which has higher consumption per kg landed (1.14 l/kg) than the hydraulic dredger (0.22 l/kg). The values for trawling remain higher (1.67 l/kg). In the same table the costs are also estimated. considering an average diesel price of 0.60 €/l.

The estimated cost of diesel fuel per kilogram of species caught. with the four main gears used, is also interesting (Table 7; Table 8). It can be seen that although gillnet fishing requires higher energy consumption costs, given the estimated quantities landed and the price. the percentage value is in line with the other gears, in the order of 8-12%. These percentage values are in line with estimates for small-scale fisheries in other European areas (Figure 4).

Table 5 - Estimated fishing days and diesel fuel consumption by type of fishing. annual; 2019

Fishing system	Fishing days/year (n)	Fuel consumption/year (l)	Fuel consumption/day (l)	Fuel consumption/day (€)
Small-scale artisanal fishing	175	12.000	69	41.14
Trawlers	150	75.000	500	300.00
Hydraulic dredges	130	11.000	85	50.77

Table 6 - Estimated consumption of diesel fuel by type of fishing. in relation to the landings

Fishing system	Daily product landed (kg)	Fuel consumption /day (l)	Fuel consumption/day (€)	Fuel consumption/landed (l/kg)	Fuel consumption/landed (€/kg)
Small-scale artisanal fishing	60	69	41.14	1.14	0.69
Trawlers	300	500	300.00	1.67	1.00
Hydraulic dredges	390	85	50.77	0.22	0.13

Table 7 - Estimated diesel fuel consumption by type of gear used by small-scale artisanal fishing

Fishing system	Fishing days/year (n)	Fuel consumption/day (l)	Fuel consumption/day (€)
Fyke nets (cuttlefish)	33	50	30
Pots (marine snails)	70	50	30
Pots (mantis shrimp)	150	40	24
Gillnets (mixed product)	170	135	81

Table 8 - Estimated economic value of diesel fuel consumption by type of gear (target species) used by small-scale artisanal fisheries

Gear	Daily product landed (kg)	Average price/kg	Revenue €/day	Fuel consumption/day (€)	Fuel cost per l/kg of landed product (€/Kg)	Economic impact on the overall value (%)
Fyke nets (cuttlefish)	50	8.00	400.00	30	0.60	7.50
Pots (marine snails)	130	3.00	390.00	30	0.23	7.69
Pots (mantis shrimp)	30	12.00	360.00	24	0.80	6.67
Gillnets (mixed product)	60	12.00	720.00	81	1.35	11.25

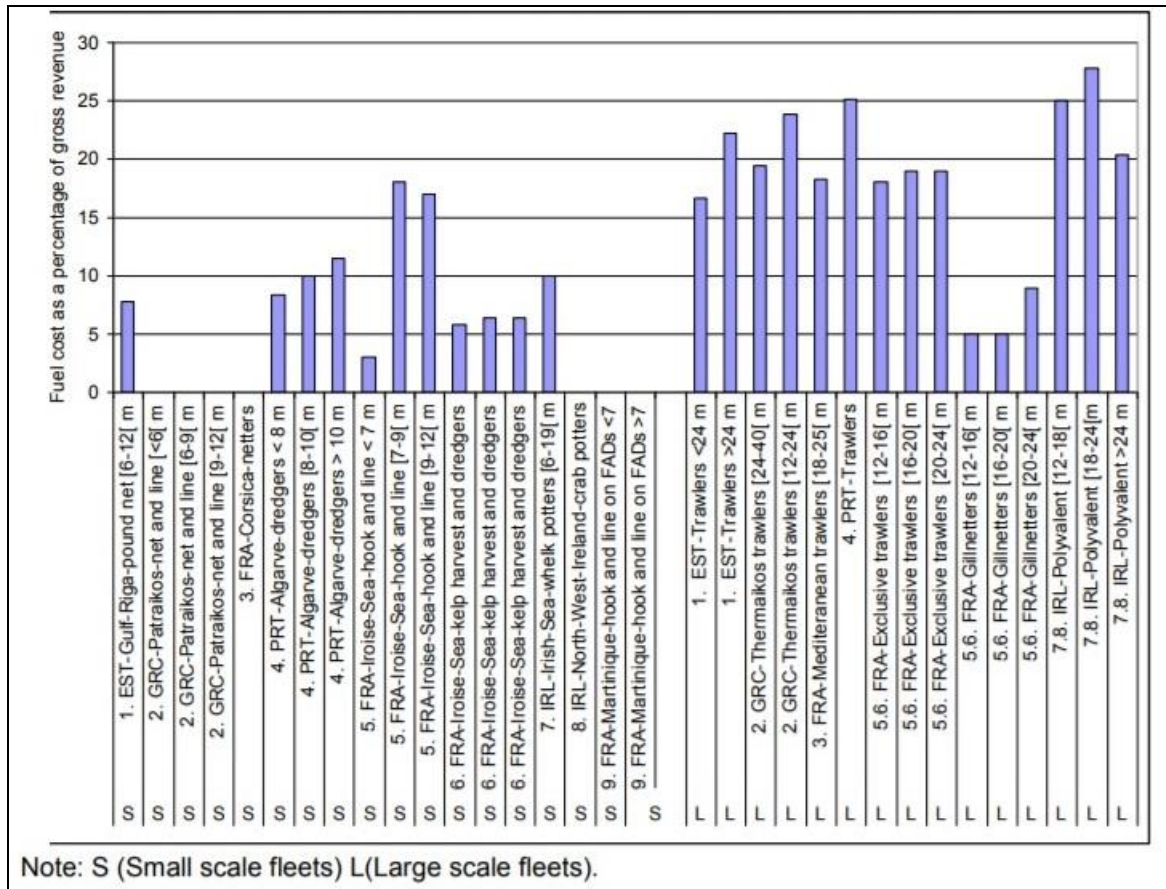


Figure 4 - Fuel costs for gross revenues (source O. Guyadera et al. 2008. Small scale fisheries in Europe: A comparative analysis based on a selection of case studies)