DELIVERABLE D3.2.1

Report on SSF sustainability in GSA17

Project ID	10045781
Project acronym	Adri.SmArtFish
Project full title	Valorisation of SMall-scale ARTisanal FISHery of the Adriatic coasts, in a context of sustainability
WP3	Evaluation of the small-scale fishing sector
Activity 3.1	Evaluation of the ecological sustainability of SSFs
Partner in charge	PP8
Partners involved	PP1
Status	Final
Distribution	Public
Date	31/03/2020

European Regional Development Fund

www.italy-croatia.eu/adrismartfish

D3.2.1

Report on SSF Sustainability in GSA17

The importance of the fishery sector is widely recognised, both in social and economic terms, but also for its criticality. Fishing activities are crucial for human nutrition, and also as a source of employment and income but, at the same time, they contribute to several environmental impacts.

Small scale fishery is recognized as one of the less unsustainable among the renewable resources' exploitation activities at sea, due to the use of low impact fishing gear and their high selectivity. However, many questions remain to be addressed with the context of sustainability improvement. Among them, one of the most relevant is Greenhouse Gases (GHG) emission, mainly related to fuel consumption, and its reduction represent the main issue for facing with the climate changes.

Fisheries, as many other human activities, actively contribute to global GHG emissions depending on many factors, as target species, fishing method, type of gear, distance between harbour and fishing ground, main power of the vessel, and speed (Tyedmers et al., 2005; Driscoll and Tyedmers, 2010; FAO, 2012; Coello et al., 2015).

In the last decades, different approaches have been applied to reduce fuel consumption in the fishery sectors, and therefore to decrease the GHGs emissions, such as speed reduction, steeper cuttings in the wings and bellies or increase of mesh size of the net (Sala, 2002; Fiorentini et al., 2004; Parente et al., 2008; Sala et al., 2008; 2011). Also, the creation of an energy audit system for the fishing vessels has been proposed (Buglioni et al., 2011). However, the implementation on a global scale of these new approaches is still lacking. Within this context, the emissions inventories could be useful for scientific purposes and also for policy makers, in order to monitor the emissions and develop new strategies and policies act to achieve a more sustainable fishery.

The global emissions estimated for the fishery sector amounted at 134 million tonnes of CO_2 in 2000 (Tyedmers et al. 2005; FAO, 2012) and 179 million tonnes of CO_2-equivalent in 2011 (Parker et al., 2018). More recently, Greer et al. (2019) estimated that 207 million tonnes of CO_2 were released into the atmosphere in 2016 by marine fishing vessels (159 million tonnes for the industrial fishery and 48 million tonnes from the small-scale fishery). In Europe, it was estimated that 10 million tonnes of CO_2 were realised in 2008 by the European fleet, responsible for a considerable part of the worldwide GHGs emissions. Different methods were used to estimate the fuel consumption and the relative CO_2 emissions, including fuel-based method, which use fuel data provided by fishing vessel operators, and activity-based method, using geospatial data of fishing vessel (Coello et al., 2015).

In order to prepare a mitigation plan for the small-scale fishery, it should be crucial to create an emission inventory. For this reason, the present deliverable focalised on the assessing of SSF emission at the GSA17 scale.

The basic method Tier 1 (IPCC, 2006; Park et al., 2015; Parker et al., 2018) based on the following equation, was used for the estimation of the CO_2 emissions:

$$CO_2 emissions = FC \cdot Emission\ Factor$$

The fuel consumed (*FC*) and the Emission Factor depends on the type of fuel, of which the marine diesel is generally the most common in the fishing vessels (Greer et al., 2019), with a carbon content of about 86.7% (Klein et al., 2012). Anyway, small vessels (LOA < 7 m) with an outboard engine use gasoline as main fuel. Therefore, two emission factors were considered in the present study: 2.86 kg CO_2 per litre of fuel combusted (Parker et al., 2018) for bigger vessel (7 m < LOA < 12 m) with a diesel inboard engine and 2.324 kg CO_2 per litre of fuel combusted for smaller vessels (LOA < 7 m) with a gasoline outboard engine (ISPRA, 2015).

The fuel consumption (FC) of each fishing vessel was estimated in three different ways, moving from different data obtained from fishermen answering the questionnaires (data from 46 fishermen):

1. directly using the diesel/gasoline litres declared;
2. applying the equation reported by Prado (FAO, 1990):

$$FC = a \cdot P_{max} \cdot S \cdot d \cdot t \cdot 0.001$$

where

a = average coefficient (ranging between 0.5 and 0.8)

P_{max} = maximum engine power (kW)

S = specific fuel consumption expressed in g/kW/h

d = density of fuel (kg/L)

t = hours (h) of navigation declared by fishermen

The average coefficient, corresponding to the percentage of engine power used, was fixed at 0.75, as reported in Prado (1990). The engine power ($P_{(max)}$) has been assessed for each vessel according to the questionnaires. Two different set of parameters were applied, depending on the type of engine: for gasoline engine, the specific fuel consumption was set at 350 g/kW/h and fuel density was considered to be 0.74 kg/L; for diesel engine, the specific fuel consumption was set at 150.4 g/kW/h and fuel density was considered to be 0.86 kg/L for the larger ones.

3. using the above formula but estimating the hours of navigation as the ratio between the travel distances (nm) declared by fishermen in the questionnaires and an average navigation speed of 6 nm/h.

To estimate CO_2 emissions per unit of landing, data from the landings (kg) from 75 fishing trips were used. The estimation of CO_2 (kg) emitted to catch 1 kg of each species in a given fishing trip was calculated as the ratio between the daily CO2 emission (kg) and the total landings (kg), results are reported on a seasonal basis.

Fuel consumptions declared by fishermen for inboard engines are double respect to outboard engines in both countries (Table 1). This could derive from vessels size, bigger for outboard engine, and from longer distances travelled. The second estimate, based on the duration of the fishing trip, shows much higher values of fuel consumption. Most of the fuel consumption occurs during the navigation phase, while in other phases of the fishing trip the main engine is reasonably turned off or idling. Therefore, this estimate can be considered as a precautionary upper level of fuel consumption. The third method show values closer to the litres declared by fishermen, but in most cases slightly lower. Fuel consumption in Croatia is always much lower than in Italy, probably due to a fishing activity closer to the shore.

Table 1. Average (mean ± st. err.) daily fuel consumptions (l) in the whole GSA17 (tot) and separated by country (HR: Croatia, IT: Italy) and engine type. l-declared: fuel consumptions declared by fishermen; h-declared: fuel consumptions estimated by the duration (h) of fishing trip; nm-declared: fuel consumptions estimated by the distance travelled (nm) in a fishing trip.

	l-declared	h-declared	nm-declared
inboard	*36 ± 5*	*61 ± 6*	*18 ± 2*
HR	17 ± 4	20 ± 3	13 ± 4
IT	45 ± 6	71 ± 7	20 ± 2
outboard	*17 ± 1*	*86 ± 8*	*15 ± 2*
HR	8 ± 2	19 ± 2	10 ± 2
IT	22 ± 2	126 ± 10	18 ± 2
total	**24 ± 2**	**77 ± 6**	**16 ± 1**

Of course, the daily CO2 emissions per vessel showed the same pattern (Table 2). The daily estimates for the SSF vessels are much lower respect to the emissions calculated by Russo (2019) for other type of fishing vessels, such as bottom and pelagic trawlers (ranging between 1.07 – 2.59 tons per day per vessel).

Table 2. Average (mean ± st. err.) daily CO_2 emissions (kg) per vessel in the whole GSA17 (tot) and separated by country (HR: Croatia, IT: Italy) and engine type. Emissions has been calculated using three different fuel consumptions estimate: l-declared: fuel consumptions declared by fishermen; h-declared: fuel consumptions estimated by the duration (h) of fishing trip; nm-declared: fuel consumptions estimated by the distance travelled (nm) in a fishing trip.

	l-declared	h-declared	nm-declared
inboard	*102.38 ± 12.87*	*173.28 ± 17.26*	*50.81 ± 6.35*
HR	48.54 ± 11.85	56.51 ± 7.74	37.00 ± 12.85
IT	127.95 ± 16.85	201.76 ± 21.07	57.90 ± 6.91
outboard	*38.96 ± 3.31*	*199.27 ± 17.96*	*34.75 ± 3.50*
HR	19.24 ± 3.54	44.68 ± 5.34	22.54 ± 3.99
IT	51.89 ± 4.30	293.47 ± 22.31	42.76 ± 4.98
Total	**62.35 ± 5.64**	**190.66 ± 13.17**	**40.49 ± 3.24**

The same pattern was found also for the annual CO2 emissions (Table 3), except for estimate based on the duration of fishing trips (h-declared) in Croatia for inboard engine. For other fleet segments, such as bottom and midwater trawler, CO2 emissions calculated by Russo (2019) appears to be at least one order of magnitude greater respect to SSF emissions (ranging between 175-427 tonnes per year per vessels).

Table 3. Average (mean ± st. err.) annual CO_2 emissions (t) per vessel in the whole GSA17 (tot) and separated by country (HR: Croatia, IT: Italy) and engine type. Emissions has been calculated using three different fuel consumptions estimate: l-declared: fuel consumptions declared by fishermen; h-declared: fuel consumptions estimated by the duration (h) of fishing trip; nm-declared: fuel consumptions estimated by the distance travelled (nm) in a fishing trip.

	l-declared	h-declared	nm-declared
inboard	*19.68 ± 5.17*	*26.95 ± 7.82*	*9.18 ± 1.85*
HR	9.07 ± 2.81	2.60 ± 1.07	7.55 ± 2.82
IT	24.50 ± 7.03	38.03 ± 9.69	9.93 ± 2.42
outboard	*7.54 ± 1.37*	*41.82 ± 8.68*	*6.77 ± 1.53*
HR	2.49 ± 0.92	5.59 ± 2.36	3.47 ± 1.62
IT	10.91 ± 1.82	65.97 ± 11.23	8.97 ± 2.19
Total	**11.76 ± 2.15**	**36.65 ± 6.32**	**7.61 ± 1.19**

CO_2 emissions for the entire SSF sector in the central-north Adriatic (Table 4) has been calculated multiplying the average annual emission (separated by engine type and country) for the number of vessels from the AIS database. Outboard engines contribute to most of the CO_2 emissions (6151 vessels out of 7807).

Table 4. Total annual CO_2 emissions (t) for the entire SSF fleet in GSA17 and separated by country (HR: Croatia, IT: Italy) and engine type. Emissions has been calculated using three different fuel consumptions estimate: l-declared: fuel consumptions declared by fishermen; h-declared: fuel consumptions estimated by the duration (h) of fishing trip; nm-declared: fuel consumptions estimated by the distance travelled (nm) in a fishing trip.

	nr of vessels	l-declared	h-declared	nm-declared
inboard	*1656*	*32592*	*44637*	*15209*
HR inboard	1274	11556	3308	9617
IT inboard	382	9360	14526	3792
outboard	*6151*	*46382*	*257244*	*41635*
HR outboard	5275	13119	29496	18320
IT outboard	876	9557	57794	7854
Total	**7807**	**91836**	**286130**	**59403**

Due to the much larger number of vessels in the SSF respect to the other fleet segments, total annual emissions (92000 t/year) are comparable to those of the Large Bottom Otter Trawl (LOTB) and higher than those of other segments. However, by looking at the emissions per vessel, the situation reverses: on average, in one year, an SSF vessel emits 15 to 35 times less CO_2 than the other segments (Table 5).

Table 5. *Annual CO_2 emissions in GSA17: total fleet values (CO_2 emissions) and single vessel emission (CO_2 / vessels), divided by fleet segment (SSF: Small Scale Fishery; SOTB: Small Bottom Otter Trawl; LOTB: Large Bottom Otter Trawl; RAP: Rapido trawl; PTM: Midwater Pair Trawl)*

Fleet segment	nr of vessels	CO_2 emissions (1000 t/y)	CO_2 / vessels (t/y)
SSF	*7807*	*92*	*12*
SOTB	151	25	182
LOTB	296	93	328
RAP	70	29	424
PTM	98	33	334

Analysing the emission intensity for the main SSF target species (table 6, figure 1), highlighted strong seasonal differences. For example, for the two most important target species, cuttlefish (*Sepia officinalis*) and mantis shrimp (*Squilla mantis*), the emission intensity in Winter and Spring is about half the emission intensity in Summer and Autumn. Considering another important target species, common sole (*Solea solea*), the highest emission intensity is observed in Spring, with values more than double respect to Summer and Autumn. Also, the engine type makes quite a difference, with inboard engine showing an emission intensity 2 to 3 times higher than outboard engine.

Table 6. *Seasonal variation of emission intensity (kg CO_2 per kg landing) for the two engine types (inboard and outboard) and for the entire SSF fleet*

	inboard				outboard				all vessels			
Species	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
Chelon auratus	-	-	-	3.35	-	-	-	1.10	-	-	-	1.87
Mustelus mustelus	-	23.22	6.08	5.51	-	8.36	2.20	1.82	-	14.02	3.66	3.08
Mugil cephalus	4.90	-	-	-	2.57	-	-	-	3.45	-	-	-
Gobius niger	-	1.55	1.70	-	-	0.56	0.62	-	-	0.93	1.02	-
Homarus gammarus	-	-	-	3.35	-	-	-	1.10	-	-	-	1.87
Melicertus kerathurus	-	-	8.31	-	-	-	3.01	-	--	-	5.00	-
Scomber scombrus	-	-	-	3.35	-	-	-	1.10	-	-	-	1.87
Squilla mantis	0.77	1.54	4.80	5.01	0.40	0.56	1.74	1.65	0.54	0.93	2.89	2.80
Sepia officinalis	4.90	3.44	9.89	16.45	2.57	1.24	3.58	5.42	3.45	2.08	5.95	9.19
Solea solea	-	23.22	10.56	11.60	-	8.36	3.83	3.82	-	14.02	6.35	6.48
Pegusa lascaris	-	-	7.02	-	-	-	2.54	-	-	-	4.22	-

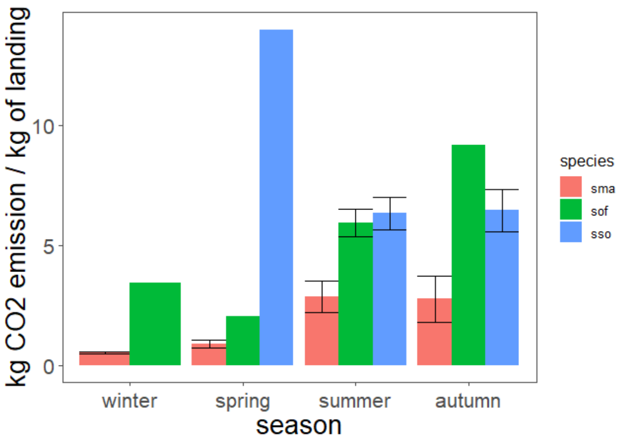

Figure 1. *Seasonal variation of emission intensity (kg CO_2 per kg of landing) for the three main target species of SSF:* Sepia officinalis *(sof),* Squilla mantis *(sma)* and Solea solea *(sso)*

Comparing with the other fleet segments (PTM - Midwater Pair Trawl was excluded due to a different landing composition), SSF average emission intensity is the lowest in all seasons (figure 2): the large bottom otter trawl (LOTB) and the rapido trawl (RAP) segments show values from 2 to 4 times higher. Only in Autumn and, on a lesser extent in Spring, SSF reach values comparable with those of the small bottom otter trawl (SOTB) even if, on a seasonal average, SSF emission intensity are always clearly lower.

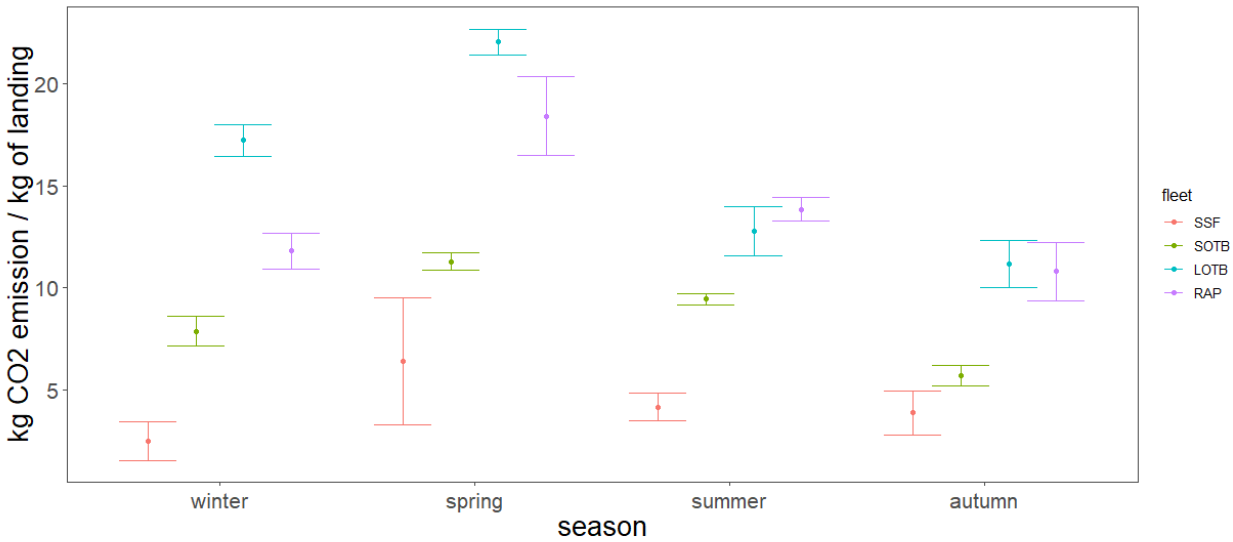

Figure 2. *Seasonal variation of emission intensity (kg CO_2 per kg of landing) for the four fleet segments with comparable landing composition (SSF: Small Scale Fishery; SOTB: Small Bottom Otter Trawl; LOTB: Large Bottom Otter Trawl; RAP: Rapido trawl)*

Considering the emission intensity separated by species in the 4 fishing segments (table 7), it is interesting to observe how seasonal emission trends follow the seasonality of species. The lowest emission intensity values for *S. mantis* and *S. officinalis*, for example, are observed in Winter and Spring, those for *S. solea* in Summer and Autumn. On the other hand, SSF emission intensity is higher, in some cases with values that exceed those of other fishing segments, in the seasons when these species are not the main target.

Table 7. Seasonal variation of emission intensity (kg CO_2 per kg landing) for the for the different fleet segments (SSF: Small Scale Fishery; SOTB: Small Bottom Otter Trawl; LOTB: Large Bottom Otter Trawl; RAP: Rapido trawl)

	SSF				SOTB				LOTB				RAP			
Species	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au	Wi	Sp	Su	Au
Chelon auratus	-	-	-	1.87	-	-	-	-	-	-	9.7	20.1	-	-	-	-
Mustelus mustelus	-	14.02	3.66	3.08	5.9	12.3	8.9	6.6	17	23.3	15.9	10.9	10	16.8	15.4	10.1
Mugil cephalus	3.45	-	-	-	-	8.1	-	2	-	17.4	5.7	5.5	-	-	-	-
Gobius niger	-	0.93	1.02	-	6.5	11.8	10.4	6.2	17.1	22.5	17.6	11	13.2	14.4	15.8	19.7
Homarus gammarus	-	-	-	1.87	12.6	11.2	10.3	6.4	12.4	23.5	15.5	9.2	11.3	26.6	15.4	8.9
Melicertus kerathurus	-	-	5.00	-	7.2	12	9.6	6.4	18.7	21.2	7.9	10.3	13.5	20	11.9	10.7
Scomber scombrus	-	-	-	1.87	8.5	11.1	9.5	5.7	16.3	21.7	13.5	10.3	-	-	-	-
Squilla mantis	0.54	0.93	2.89	2.80	7.2	10.8	7.8	4.9	19.4	22.6	14.8	11.3	15	20.1	13.7	10.4
Sepia officinalis	3.45	2.08	5.95	9.19	7.4	11.9	9.1	7.2	18.9	23.4	13.1	11.5	11.9	17.9	13.1	10.4
Solea solea	-	14.02	6.35	6.48	7.6	12.4	9.9	5.9	18	22.9	14.3	11.6	12.7	23.2	13.9	10.8
Pegusa lascaris	-	-	4.22	-	-	-	-	-	-	-	-	-	6.8	8.4	11.6	5.4

In this deliverable, for the first time the inventory emission by SSF in the GSA17 has been assessed. Obtained results confirmed the lower emission factor by vessel of this feet segment. On a global scale, however, given the higher number of boats involved, the emissions resulted comparable with the large trawlers (> 15 m LOA) segment. Taking into consideration the emissions per kg of landing, the SFF still confirmed the lowest values, with a strong seasonality.

All this could be a solid base for working on a mitigation plan; for instance, analysing possible strategies for fuel consumption optimization (reduction of travel distance or turning off the engine during some fishing phases) or better focalizing the fishing activities, on a seasonal basis, on the most important target species. All these measures have to be discussed with all the fishermen involved in the project for a real co-creating process and would be part of the management plan for the new transboundary SSF association.

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