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Common Baseline Draft for the Document on guidelines to implement SSF resilience to Climate Change in the Sustainability Protocol & in Management

Introduction

The importance of the fishery sector, both in social and economic terms, as well as its criticality, is widely recognised. Indeed, if on one side fishing activities are crucial for human nutrition, as well as source of employment and income, on the other side they contribute to several environmental impacts. Among them, Greenhouse Gases (GHG) emissions, mainly related to fuel consumption, which in turn depends on many factors (*e.g.*, target species, fishing method, type of gear, distance between harbour and fishing ground, main power of the vessel, speed, etc…) represent one of the main issues related to this sector (Tyedmers et al., 2001; Driscoll and Tyedmers, 2010; FAO, 2012; Coello et al., 2015). Since the industrial revolution, GHG emissions are responsible of the global warming, and nowadays their reduction is one of the most important global challenge in order to keep the temperature rise well below 2°C, as established in the Paris Agreement adopted by the United Nations Climate Change Conference (COP21). To date, 185 parties of 197 have ratified the agreement, which entered in force on 4th November 2016, with the intent to "*combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future*". In the fishery sector, some efforts have been made to move forward a fuel consumption reduction, and therefore to decrease the GHGs emissions, such as the installation of a new magnetic device (Sala and Notti, 2014), the suggestion to change the fishing behaviour (*e.g.*, speed reduction, steeper cuttings in the wings and bellies, increase of mesh size of the net; Sala, 2002; Fiorentini et al., 2004; Parente et al., 2008; Sala et al., 2008; 2011) and the creation of an energy audit system for the fishing vessels (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 monitoring 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).

The aim of this work was to estimate CO_2 emissions for the SSF sector in the Northern and Central Adriatic (GSA 17). Indeed, even if the GSA 17 has been recognised as intensively exploited (Barausse et al., 2009; Pranovi et al., 2015; Fortibuoni et al., 2017) and characterized by intensive marine traffic (Ferraro et al., 2007; Spagnolo et al., 2017; Rak et al., 2018), to date no emissions inventory related to the fishing activities were produced in this basin.

Materials and methods

The fuel consumption (FC) of each fishing vessel was estimated applying the equation reported by Prado (FAO, 1990):

$$FC = a * P_{(max)} * Sd * t * 0.001$$

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 (0.86 kg/l)

t = hours (h) of fishing or navigation

The average coefficient, corresponding to the percentage of engine power used, was fixed at 0.75, as reported in Prado (1990). The specific fuel consumption was set at 188 g/kW/h for fishing and 150.4 g/kW/h for navigation phase (Lee et al., 2018), and the engine power ($P_{(max)}$) has been assessed for each vessel according to the database. In order to test the formula (Eq.1), values of fuel estimated consumption will be compared with consumption declared by fishermen.

The basic method Tier 1 (IPCC, 2006; Park et al., 2015; Parker et al., 2018) based on the following equation (Equation 3.2), was used for the estimation of the CO_2 emissions:

$$CO_2\ Emissions = \Sigma(Fuel\ Consumed * Emission\ Factor)$$

The fuel consumed 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). An emission factor that can be used in the present study is 3.179 kg CO_2 per kg of fuel (Cooper and Gustafsson, 2004; Greer et al., 2019), corresponding to 2.86 kg CO_2 per litre of fuel combusted (Parker et al., 2018), but we are still working on this aspect, trying to improve the analysis. In order to estimate CO_2 emissions per unit of landing, data from questionnaires filled by SSF operators were used.

As a first step, the CO_2 emissions and the relative catches quantity (kg) from four fishermen were used. Since the landings were multispecies, to avoid an over-estimation of the CO_2 emissions, the incidence (expressed in %) of each specie caught by a specific vessel in a specific day, was calculated. Therefore, the CO_2 emitted by each fishing vessel in that day was then multiplied for the incidence of the species, and the result was divided per the catches quantity, obtaining the estimation of kg of CO_2 emitted to catch 1 kg of that species in a given fishing trip. Finally, the ratio between the emissions (kg of CO_2) and the landing quantity (kg), was calculated.

Results

Table 1. Dataset with baseline fishing statistics used to estimate CO2 emissions

Season	Vessel	Fishing days	Engine power (kW)	Average fishing trip (h)	Average fishing distance (km)	Average fuel consumption (L)
winter	Alessia V	36	100	4	15	30
	Cico	36	63	6.5	37	90
	Dario	30	40	8	11	6
	Manuel B	36	51	7	28	30
	Moby Dick	36	130	4	25	20
	Moira	60	40	6	10	10
	Papà Alberto	36	100	5	28	50
	Pensa per te I	36	75	8	9	--
	Pirata	36	150	4	8	17
	Re Simba	72	132	6	15	60
	S. Dorotea	36	75	5	10	22.5
	Scampo	36	234	6.5	19	45
	Vedetta	36	130	5	16	20

spring	Alessia V	48	100	3.5	15	20
	Cico	36	63	8	37	70
	Dario	36	40	7	28	30
	Manuel B	36	51	6.5	37	90
	Moby Dick	120	130	2	8	20
	Moira	30	40	6	14	10
	Pensa per te I	36	75	5	7	25
	Pirata	36	150	4	8	17
	Re Simba	72	132	6.5	15	80
	S. Dorotea	36	75	5	10	22.5
	Santo	60	40	6	12	12
	Scampo	50	234	8	33	50
	Vedetta	36	130	5	16	20
	Zio Lino	90	130	4	7.5	30
summer	Alessia V	60	100	5.5	25	40
	Cico	36	63	8	56	100
	Dario	36	40	7	28	30
	Manuel B	36	51	6.5	37	90
	Moby Dick	36	130	6	--	--
	Moira	30	40	7.5	17	15
	Papà Alberto	36	100	8	9	--
	Pensa per te I	36	75	6.5	19	45
	Pirata	36	150	4	8	17
	Re Simba	72	132	4	15	60
	S. Dorotea	36	75	5	10	22.5
	Santo	75	40	7	12	12.5
	Scampo	60	234	10	37	60
	Vedetta	36	130	5	16	20
	Zio Lino	72	130	6	--	80
autumn	Alessia V	36	100	3	10	20
	Cico	36	63	6	28	50
	Dario	36	40	7	28	30
	Manuel B	36	51	6.5	37	90

	Moira	30	40	6	22	10
	Papà Alberto	36	100	8	9	--
	Pensa per te I	36	75	6.5	19	45
	Pirata	36	150	4	8	17
	Re Simba	72	132	8	20	80
	S. Dorotea	36	75	5	10	22.5
	Santo	60	40	6	10	12
	Scampo	40	234	8	6	10
	Vedetta	36	130	5	16	20
	Zio Lino	90	130	7.5	20	200

Table 2. Estimated annual CO2 emission on the basis of the daily fuel consumption estimated and declared by fishermen

Season	**Vessel**	**Daily CO_2 emission (kg) Estimated Fuel Consumption**	**Daily CO_2 emission (kg) Declared Fuel Consumption**
winter	Alessia V	150	86
	Cico	154	257
	Dario	120	17
	Manuel B	134	86
	Moby Dick	195	57
	Moira	90	29
	Papà Alberto	188	143
	Pensa per te I	225	--
	Pirata	225	49
	Re Simba	297	172
	S. Dorotea	141	64
	Scampo	571	129
	Vedetta	244	57
spring	Alessia V	131	57
	Cico	189	200
	Dario	105	86
	Manuel B	124	257

	Moby Dick	98	57
	Moira	90	29
	Pensa per te I	141	72
	Pirata	225	49
	Re Simba	322	229
	S. Dorotea	141	64
	Santo	90	34
	Scampo	702	143
	Vedetta	244	57
	Zio Lino	195	86
summer	Alessia V	206	114
	Cico	189	286
	Dario	105	86
	Manuel B	124	257
	Moby Dick	293	--
	Moira	113	43
	Papà Alberto	300	--
	Pensa per te I	183	129
	Pirata	225	49
	Re Simba	198	172
	S. Dorotea	141	64
	Santo	105	36
	Scampo	878	172
	Vedetta	244	57
	Zio Lino	293	229
autumn	Alessia V	113	57
	Cico	142	143
	Dario	105	86
	Manuel B	124	257
	Moira	90	29
	Papà Alberto	300	--
	Pensa per te I	183	129
	Pirata	225	49

	Re Simba	396	229
	S. Dorotea	141	64
	Santo	90	34
	Scampo	702	29
	Vedetta	244	57
	Zio Lino	366	572
	Lowest	90	17
	Highest	878	572
	Average	221	115

Table 3. Estimated annual CO2 emission on the basis of the daily fuel consumption estimated and declared by fishermen

Vessel	Annual CO_2 emission (t) Estimated Fuel Consumption	Annual CO_2 emission (t) Declared Fuel Consumption
Moira	14	5
Dario	15	10
Manuel B	18	31
Santo	19	7
S. Dorotea	20	9
Cico	24	32
Pensa per te I°	26	12
Alessia V	28	15
Papà Alberto	28	5
Moby Dick	29	9
Pirata	32	7
Vedetta	35	8
Zio Lino	72	76
re Simba	87	58
Scampo	136	23
Lowest	14	5

Highest	136	76
Average	39	20

Table 4. Landings (kg) – separated by species - from four SSF operators used to estimate CO2 specific emissions

Fisherman	Date	*Mustelus mustelus*	*Mugil cephalus*	*Gobius niger*	*Paenaeus kerathurus*	*Squilla mantis*	*Sepia officinalis*	*Solea solea*	*Pegusa lascaris*
FTT	27/6/2019						14.7	0.8	0.6
FTT	24/7/2019					6.9			
FTT	27/8/2019					6.7			
MLC	24/7/2019						18.5	1.6	0.9
MLC	27/8/2019					1.1	0.5	4.7	
MLC	30/9/2019					1.3	0.3	5.3	
MLC	7/11/2019					2.6		2.3	
MLC	11/12/2019							10.4	
TBU	17/5/2019			10		100			
TBU	21/5/2019			25		50			
TBU	22/5/2019			7		87			
TBU	24/5/2019			10		80			
TBU	28/5/2019			8		30			
TBU	7/6/2019			8		80			
TBU	11/6/2019			4.5		110			
TBU	12/6/2019			5		90			
TBU	13/6/2019			5		13.9			
TBU	14/6/2019			5		75			
TBU	16/6/2019					70			
TBU	18/6/2019					80			
TBU	19/6/2019					40			
TBU	20/6/2019					70			
TBU	23/6/2019					60			
TBU	24/6/2019					80			
TBU	25/6/2019			5		70			
TBU	30/6/2019					60			
TBU	1/7/2019					65			
TBU	2/7/2019					60			

TBU	5/7/2019					70			
TBU	7/7/2019					70			
TBU	8/7/2019					75			
TBU	15/7/2019					65			
TBU	16/7/2019					70			
TBU	17/7/2019					90			
TBU	24/10/2019					70			
TBU	6/12/2019					75			
TBU	9/12/2019					55			
TBU	10/12/2019					70			
TBU	12/12/2019					85			
TBU	13/12/2019					30			
TBU	16/12/2019					70			
TBU	17/12/2019					75			
TBU	20/12/2019					70			
TBU	21/12/2019					105			
TBU	22/12/2019					110			
TBU	23/12/2019					95			
TBU	27/12/2019					95			
TBU	28/12/2019					80			
TDB	7/1/2019		10				5		
TDB	31/5/2019	3						1	
TDB	14/6/2019						27		
TDB	22/6/2019						5	1	
TDB	27/6/2019				4		13		
TDB	1/7/2019						15		
TDB	2/7/2019						18		
TDB	5/7/2019				3		11		
TDB	12/7/2019						11		
TDB	13/7/2019						20		
TDB	30/7/2019						40		
TDB	1/8/2019							12	
TDB	5/8/2019							20	
TDB	7/8/2019							12	
TDB	8/8/2019							10	
TDB	9/8/2019							8	

TDB	13/8/2019							6	
TDB	6/9/2019	13						8	
TDB	19/9/2019							10	
TDB	8/10/2019							14	
TDB	9/10/2019							16	
TDB	17/10/2019	15							
TDB	18/10/2019							10	

Table 5. Specific CO2 emissions (CO2 kg per fish kg) estimated on the average CO2 emission calculated from Table 1-3

Fisherman	Date	***Mustelus mustelus***	***Mugil cephalus***	***Gobius niger***	***Paenaeus kerathurus***	***Squilla mantis***	***Sepia officinalis***	***Solea solea***	***Pegusa lascaris***
FTT	27/6/2019						12.6	0.7	0.5
FTT	24/7/2019					32.0			
FTT	27/8/2019					32.9			
MLC	24/7/2019						9.2	0.8	0.4
MLC	27/8/2019					6.0	2.8	25.7	
MLC	30/9/2019					6.0	1.5	23.9	
MLC	7/11/2019					23.6		21.0	
MLC	11/12/2019							21.2	
TBU	17/5/2019			0.2		1.8			
TBU	21/5/2019			1.0		2.0			
TBU	22/5/2019			0.2		2.2			
TBU	24/5/2019			0.3		2.2			
TBU	28/5/2019			1.2		4.6			
TBU	7/6/2019			0.2		2.3			
TBU	11/6/2019			0.1		1.8			
TBU	12/6/2019			0.1		2.2			
TBU	13/6/2019			3.1		8.6			
TBU	14/6/2019			0.2		2.6			
TBU	16/6/2019					3.1			
TBU	18/6/2019					2.8			

TBU	19/6/2019					5.5			
TBU	20/6/2019					3.1			
TBU	23/6/2019					3.7			
TBU	24/6/2019					2.8			
TBU	25/6/2019			0.2		2.7			
TBU	30/6/2019					3.7			
TBU	1/7/2019					3.4			
TBU	2/7/2019					3.7			
TBU	5/7/2019					3.1			
TBU	7/7/2019					3.1			
TBU	8/7/2019					2.9			
TBU	15/7/2019					3.4			
TBU	16/7/2019					3.1			
TBU	17/7/2019					2.4			
TBU	24/10/2019					3.1			
TBU	6/12/2019					2.9			
TBU	9/12/2019					4.0			
TBU	10/12/2019					3.1			
TBU	12/12/2019					2.6			
TBU	13/12/2019					7.3			
TBU	16/12/2019					3.1			
TBU	17/12/2019					2.9			
TBU	20/12/2019					3.1			
TBU	21/12/2019					2.1			
TBU	22/12/2019					2.0			
TBU	23/12/2019					2.3			
TBU	27/12/2019					2.3			
TBU	28/12/2019					2.8			
TDB	7/1/2019		9.8				4.9		
TDB	31/5/2019	41.3						13.8	
TDB	14/6/2019						8.1		
TDB	22/6/2019						30.6	6.1	
TDB	27/6/2019				3.0		9.9		
TDB	1/7/2019						14.7		
TDB	2/7/2019						12.2		
TDB	5/7/2019				3.4		12.3		

TDB	12/7/2019						20.0		
TDB	13/7/2019						11.0		
TDB	30/7/2019						5.5		
TDB	1/8/2019							18.3	
TDB	5/8/2019							11.0	
TDB	7/8/2019							18.3	
TDB	8/8/2019							22.0	
TDB	9/8/2019							27.5	
TDB	13/8/2019							36.7	
TDB	6/9/2019	6.5						4.0	
TDB	19/9/2019							22.0	
TDB	8/10/2019							15.7	
TDB	9/10/2019							13.8	
TDB	17/10/2019	14.7							
TDB	18/10/2019							22.0	
		6.5	9.8	0.1	3.0	1.8	1.5	0.7	0.4
		41.3	9.8	3.1	3.4	32.9	30.6	36.7	0.5
		20.8	9.8	0.6	3.2	5.0	11.1	17.1	0.5