

CleanAtlantic

Tackling marine litter in the Atlantic Area

Economic impact of marine litter on fisheries and shellfisheries

María Loureiro

Maria.loureiro@usc.es



USC tasks

- Literature review of the impact of marine litter:
 - At global level
 - For the Galician fishing sector (fishermen +shellfisher)
- Design and implementation of a survey directed to Galician **fishermen and shellfishers**
 - To understand costs (direct and indirect), concerns...and preferences towards a marine litter program

Marine litter estimated costs

Description	Cost	Data year	Country/region	Source
Cost of marine litter for Shetland boats	9,000 - 45,000 USD per boat per year	2000	UK	UN Environment (2017)
Cost of marine litter for the European fishing sector	61,71 million € per year	2010	Europe	UN Environment (2017)
Cleaning cost	31 million pounds	-	England	Lee, J. (2015)
Cost of micro plastic and marine waste	38-56 million pounds	-	England	Lee, J. (2015)
Losses due to blue crab dead	300,000 USD	2009 - 2011	Virginia (US)	Bilkovic et al. (2014)
Economic impact of marine litter for tourism, fishing and shipping industries	1.265 billion USD per year	2008	APEC	McIlgorm et al. (2011)
Marine litter average cost to Portuguese fleet	2,930 € per year per vessel	-	Portugal	Mouat et al. (2010)

Source: own representation

Marine litter estimated costs

Description	Cost	Data year	Country/ region	Source
Cost of marine litter for United Kingdom harbours	8,034.37 € per harbour per year	2010	UK	Mouat et al. (2010)
Average cost of marine litter for 9 Spanish harbours	61,013.04 € per harbour per year	-	Spain	Mouat et al. (2010)
Average cost to Shetland agriculture sector	500 € per farmer per year	-	Scotland	Mouat et al. (2010)
Average cost to Scottish aquaculture sector	580 € per producer per year	2007	Scotland	Newman et al. (2015)
Cost of rescue of fishing vessels with fouled propellers	830,000 - 2,189,000 € per year	2008	UK	Mouat et al. (2010)
Beach cleaning cost	7,031 - 7,249 per km per year	2001	UK	Mouat et al. (2010)
Marine litter cost to each Scottish fishing vessel	17,219 - 19,165 € per year	2009	Scotland	Mouat et al. (2010)

Source: own representation

Possible solutions

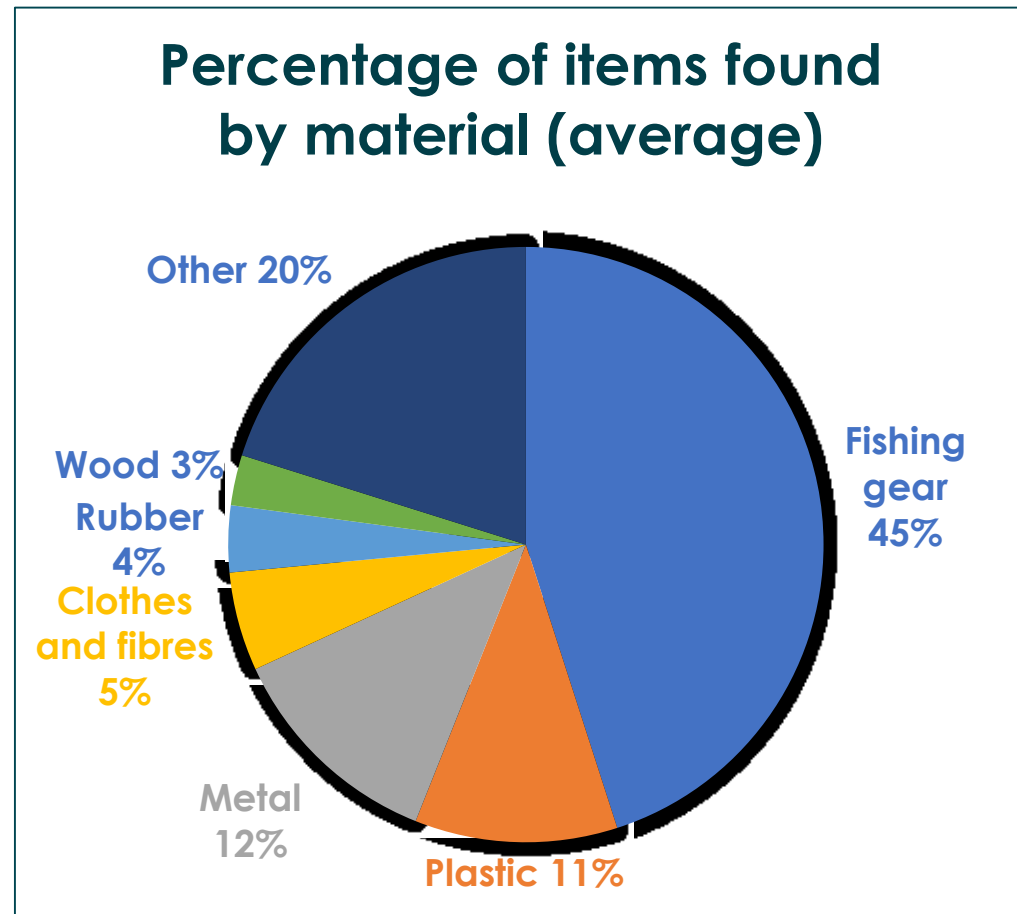
- Fees or taxes
- Deposit-refund schemes
- Eco-design
- Less disposable products
- Cleaning
- **Initiatives with fishermen**

Initiatives with fishermen

- Korea: incentive programme (Cho, 2009):
 - 2003 – 2006: 11,000 tons of marine litter recovered
 - Cost: 9,3 mill. USD
- Ocean Sole: 120,000 kg per year
- Repurpose Schoolbags: 160,000 bags until 2017
- **Upcycling the oceans:** 550 tons in 2018

Initiatives with fishermen

- MARLIMPO (Consellería do Mar, 2016):
 - Main objectives:
 - Raise awareness
 - Improve education
 - Collaboration



Source: based on Consellería do Mar, 2016

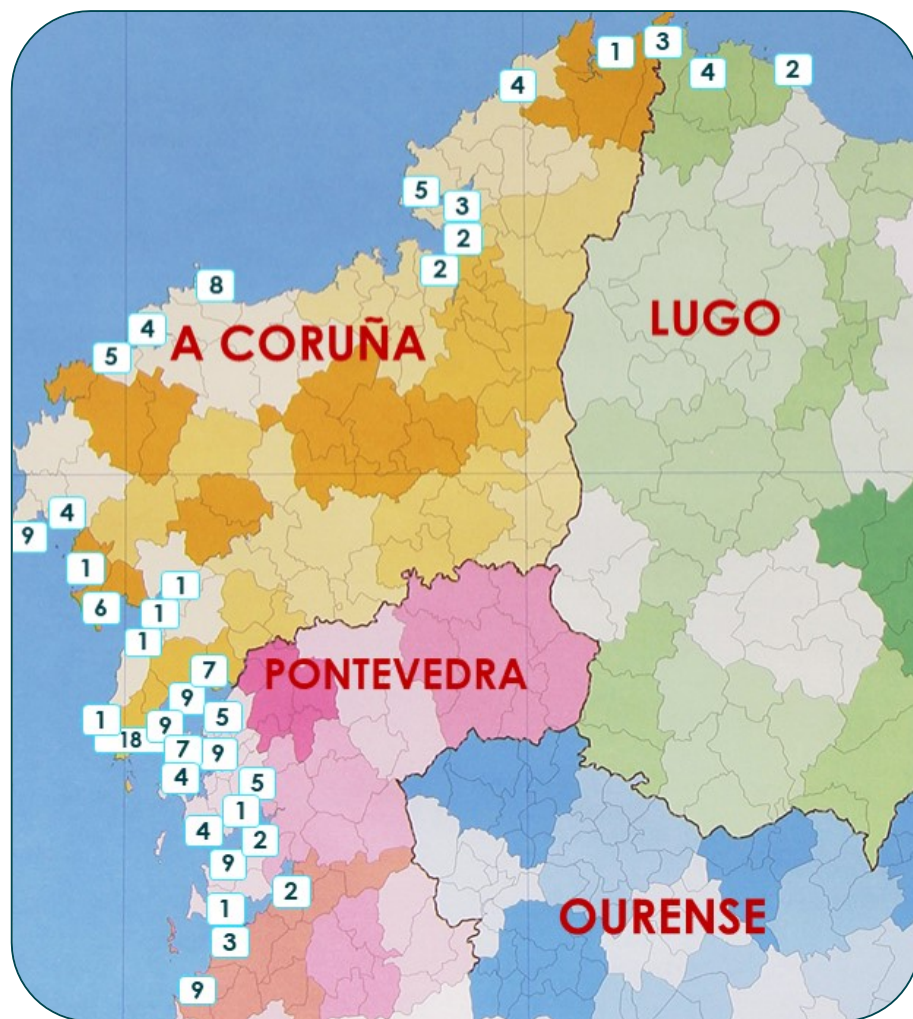
Survey structure

- Part A: General questions
 - A1: Interaction with marine litter
 - A2: Costs of marine litter
 - A3: Awareness and information
 - A4: Actions and measures
- Part B: Behaviour study
- Part C: Preferences for marine litter collection
- Part D: Additional data



Survey

- Total responses: 194
 - Minor arts: 169 (87,11%)
 - Siege: 14 (7,22%)
 - Longline: 6 (3,09%)
 - Trawl: 5 (2,58%)
- Type of survey:
 - Paper: 134 (69,10%)
 - Online: 59 (30,40%)



Source: own elaboration

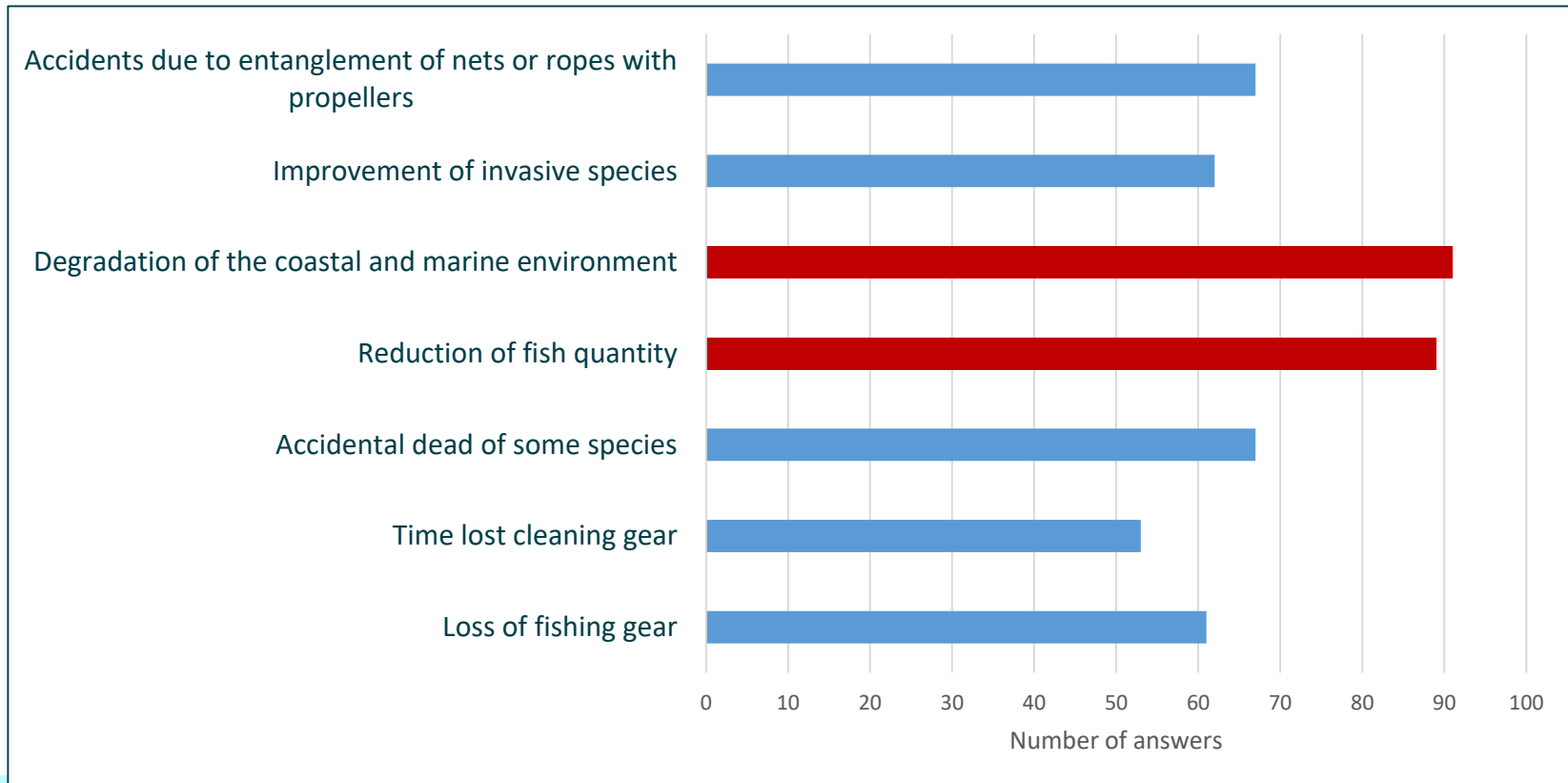
Magnitude of the problem

- **97,89 %** of respondents consider marine litter as a relevant threat to the fishing sector
- Proportion of fish and waste on riggings with calm sea:
 - More fish: 48,94 %
 - Very little waste or none: 35,11 %
 - The **same quantity** of both: **9,04 %**
 - **More waste: 6,91 %**
- **16,76 %** have changed their work zone to avoid marine litter



Magnitude of the problem

- Ranking of the most relevant effects of marine litter:



Source: own elaboration

Magnitude of the problem

	Time lost per day because of marine litter (min)	Cost per lost hour of fishing (€)
Observations	151	124
Mean	56.40397	60.18145
Standard Deviation	59.98079	107.0892
Minimum	0	0
Maximum	240	1,000

Source: own elaboration

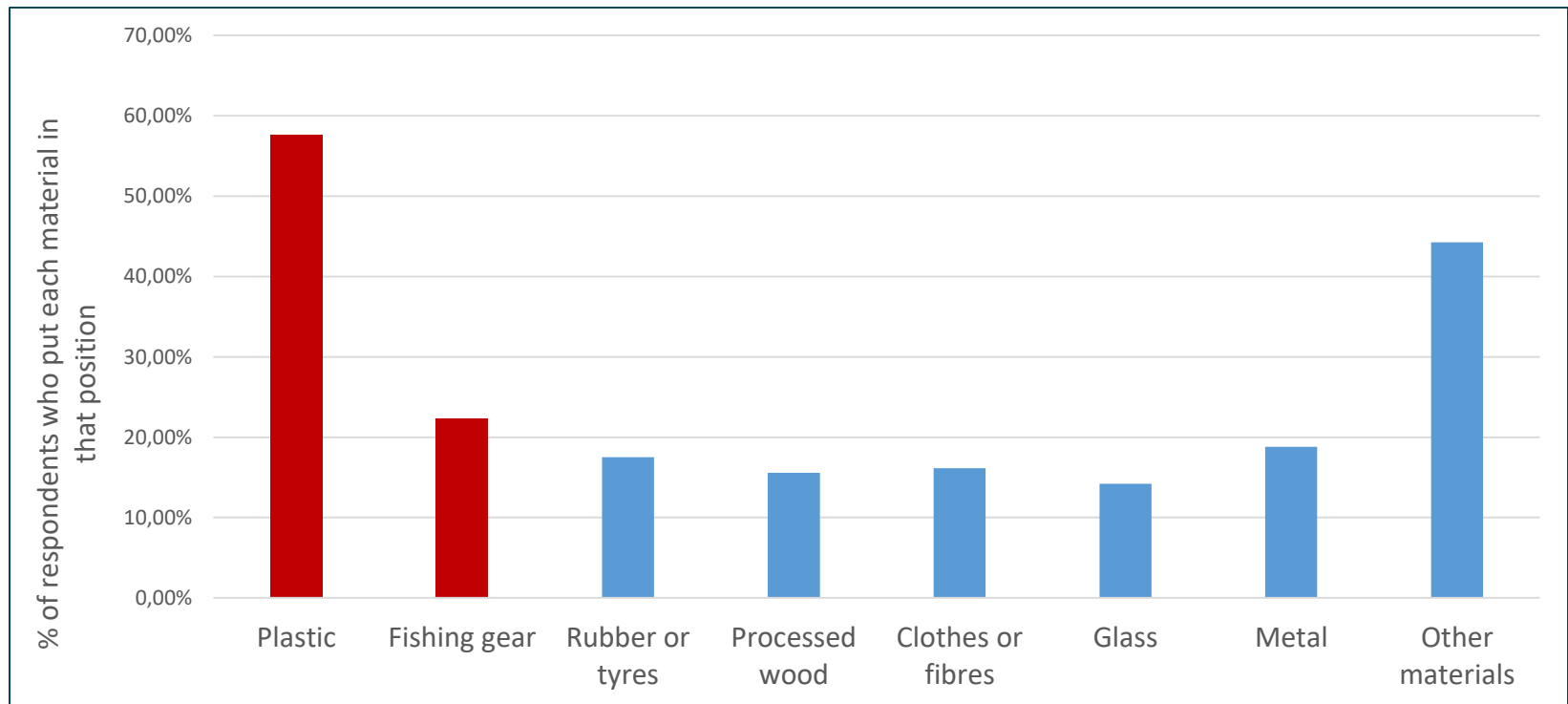
- Average daily cost per fishing vessel: **49,31 - 109,08 €**

(95% confidence interval)

Magnitude of the problem

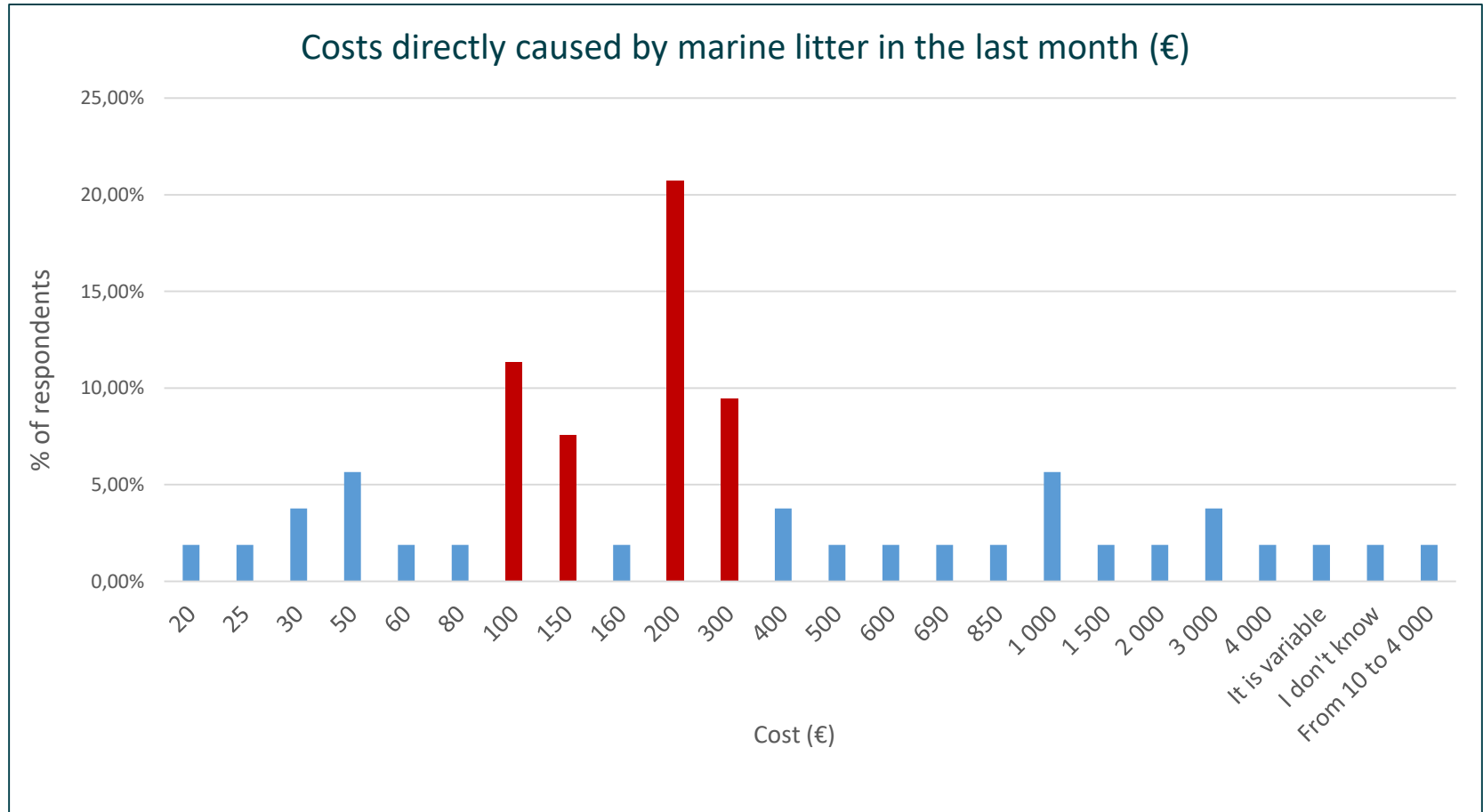


- Ranking of the most common materials found by fishermen



Source: own elaboration

Magnitude of the problem



Source: own elaboration

Magnitude of the problem



Photos taken during data collection in A Illa de Arousa

Measures to reduce marine litter

- The most proposed measures by respondents were:
 - Raising awareness
 - Avoid certain materials like plastic
 - Education
 - More surveillance and fines
 - Avoid litter generated by rafts, it is very polluting
 - More information
 - Enable more free collection points
 - Force fishermen to pick up the waste that comes up on their riggings
 - Deposit-refund scheme for packages taken to the sea

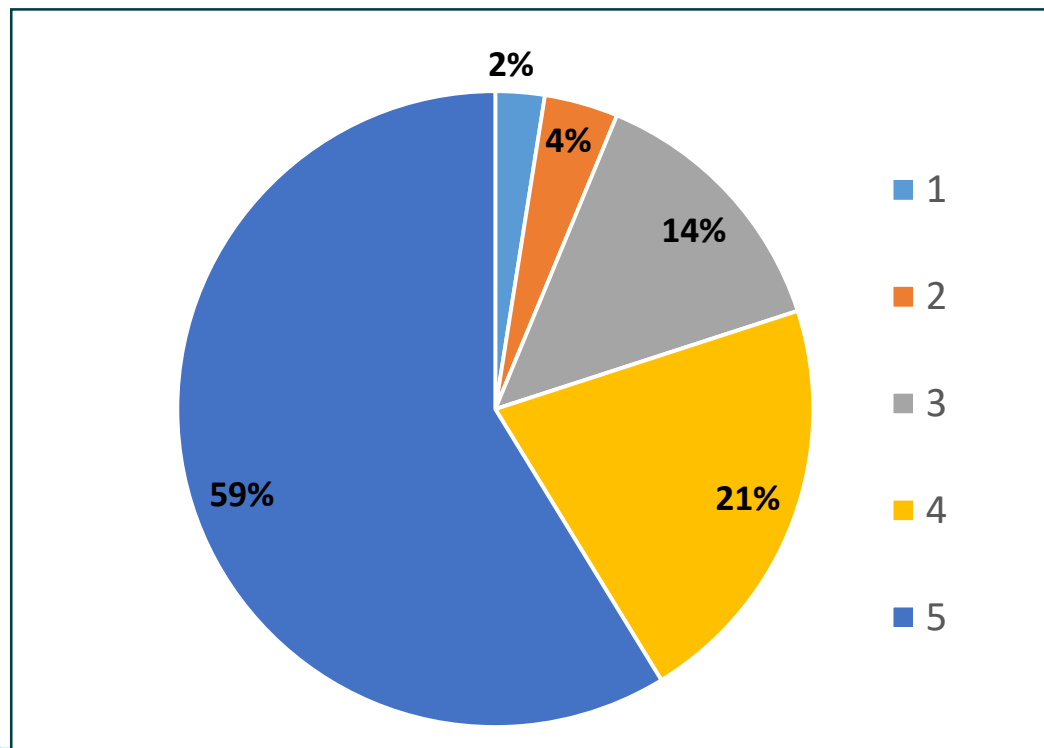


Measures to reduce marine litter

- On average, **97,34 %** of respondents considered these measures useful to reduce marine litter generated by vessels
 - Improve waste collection facilities at port
 - Raise awareness about the consequences of marine litter in order to avoid future littering
 - Toughen legislation relative to waste generation on board
 - Raising vigilance and fees for littering seas/ water ways
 - Give economic incentives for vessels to bring litter to port instead of throwing it overboard

Participation in a fishing for litter programme

- Willingness to get involved in a fishing for litter programme
 - Scale from 1 (nothing willing) to 5 (very willing)



Source: own elaboration

Barriers to join a fishing for litter plan

- Scale from 1 (nothing important) to 5 (very important)

	Observations	Mean	Standard Deviation
Lack of awareness about the problem of marine litter	164	3.27439	1.325435
Lack of recognition for participating	161	2.67702	1.477339
Lack of space on the boat to store the litter collected	159	3.04403	1.494064
Lack of necessary infrastructure in the port	160	3.36875	1.443362
Bad management of litter collect once delivered at port	163	3.53374	1.334639
It supposes an additional cost for me to participate	160	3.54375	1.461656

Source: own elaboration

Barriers to join a fishing for litter plan

- Scale from 1 (nothing important) to 5 (very important)

	Observations	Mean	Standard Deviation
Lack of awareness about the problem of marine litter	164	3.27439	1.325435
Lack of recognition for participating	161	2.67702	1.477339
Lack of space on the boat to store the litter collected	159	3.04403	1.494064
Lack of necessary infrastructure in the port	160	3.36875	1.443362
Bad management of litter collect once delivered at port	163	3.53374	1.334639
That supposes an additional cost for me to participate	160	3.54375	1.461656

Source: own elaboration



Interreg
Atlantic Area
European Regional Development Fund



Attributes in Choice Experiment

Attribute	Levels
Type of fishing	Active
	Passive
Reward	Any
	45€ (270€) by day per worker
	80€ (310€) by day per worker
Work to do	Collect the litter
	Collect and separate the litter
Monitoring of the collected litter	Yes
	No

Source: own elaboration

Choice experiment & follow up valuation questions

Example choice card

	OPTION 1	OPTION 2	OPTION 3
TYPE OF FISHING	Passive	Passive	Active
REWARD	Any	45€ by day per worker	80€ by day per worker
WORK TO DO	Collect the litter	Collect and separate the litter	Collect the litter
MONITORING OF THE COLLECTED LITTER	Yes	Yes	No

Source: own elaboration



Favorite fishing for litter programmes

Type of fishing	Passive	Passive	Passive
Work to do	Collect the litter	Collect the litter	Collect & separate the litter
Monitoring of the collected litter	Yes	No	Yes
% OF RESPONDENTS	46,84 %	22,78 %	16,46 %

- Reward:
 - **No reward: 58,67 %**
 - From 1 to 80 €: 26,67 %
 - 100 € : 10,67 %

Cost-benefit analysis



	Scenario 1	Scenario 2
Estimated litter collected (tons)	323.62	610.16
Estimated cost (€)	9,121.00	355,850.11
Estimated benefit 1 (€)	122,993.98	-223,735.13
Estimated benefit 2 (€)	321,166.44	-25,562.67
Estimated benefit 3 (€)	453,281.41	106,552.31



Comparison of estimated costs

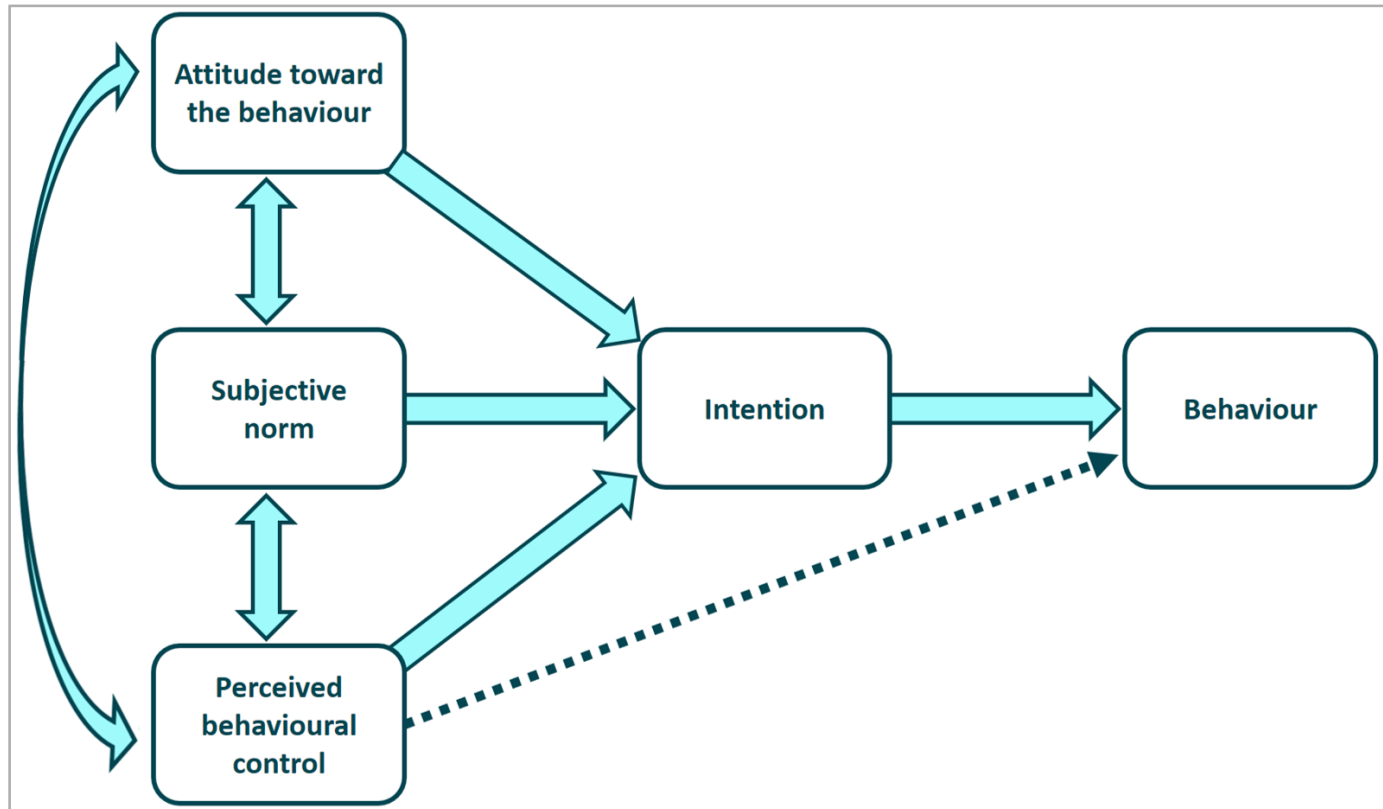
Description	Cost	Data year	Country/ region	Source
Beach cleaning cost	7,031€ - 7,249€ per km per year	2001	UK	Mouat et al. (2010)
Beach cleaning cost in Galicia	941.42 € per coastal km per year	2018	Galicia	Own estimation
Marine litter cost to each Scottish fishing vessel	17,219€ - 19,165 € per year	2009	Scotland	Mouat et al. (2010)
Marine litter cost to each Galician fishing vessel	17,648.71 € per year	2019	Galicia	Own estimation
Cost of marine litter for Shetland boats	9,000 - 45,000 USD per boat per year	2000	UK	UN Environment (2017)
Marine litter average cost to Portuguese fleet	2,930 € per year per vessel	-	Portugal	Mouat et al. (2010)

In summary....

- Marine litter imposes significant costs to the fishing sector in Galicia
- Common understanding that litter should be eliminated or reduced.
- Willingness to collect litter, but not to engage in a fishing for litter program with payment.
- Barriers to collection related to the current lack of infrastructure
- Results call for policy actions!

Theory of planned behavior

Figure 2. Theory of planned behaviour



Source: own elaboration

Characteristics of the population

		Mean	S.D.
Age		47.7	8.19
		N	%
Gender	Male	127	88.19
	Female	17	11.81
Education	No studies	2	1.39
	Primary	65	45.14
	Secondary	40	27.78
	Professional degree	31	21.53
	University degree	4	2.78
	Master/PhD	2	1.39
License	Coastal trawl	5	3.47
	Minor arts	122	84.72
	Siege	13	9.03
	Longline	4	2.78
	Gill	0	0
Income	Less than 1000€	24	16.67
	1001-1800€	79	54.86
	1801-2500€	18	12.50
	2501-3000€	8	5.56
	Menos de 3000€	8	5.56



Theory of Planned Behavior Items

Variable	Item	Item description
Attitudes	ATT_1	Taking to port the litter I find during fishing
	ATT_2	Collecting the litter I find during fishing and taking it to port will make that litter not disturb my job again.
	ATT_3	Not meeting several times with the same litter while fishing
Subjective norm	SN_1	My guild thinks that I should collect the litter I find while fishing and take it to port.
	SN_2	In terms of fishing, it is important to have our oceans clean
	SN_3	My family would prefer that I take the litter I find during fishing to port.
	SN_4	Most of the fishermen like me take to port the litter they find during fishing.
	SN_5	When it comes to taking care of the sea, cleaning litter is important
Perceived Behavioral Control	PBC_1	I think that I can take to port the litter I find during fishing.
	PBC_2	I would be willing to get involved in the Fishing for Litter program.
Intention	INT_1	I have the intention to take to port the litter I find during fishing.
	INT_2	I hope to maintain my willingness to take care of the sea in the coming years.
	INT_3	My willingness to take care of the sea would enable me to take to port the litter I find during fishing.
Behavior	BH_1	In the last month, I took to the port all the marine litter I found during

Item analysis

Item	Mean (SD)	Skew	Kurtosis
ATT_1	4.58 (0.87)	-2.51	6.21
ATT_2	3.56 (1.64)	-.58	-1.38
ATT_3	4.36 (1.36)	-1.85	1.68
SN_1	3.99 (1.39)	-1.11	-.20
SN_2	3.85 (1.34)	-.88	-.51
SN_3	4.46 (1.19)	-2.10	2.95
SN_4	2.77 (1.37)	0.22	-1.19
SN_5	2.98 (1.47)	0.13	-1.43
PBC_1	4.20 (1.29)	-1.43	0.65
PBC_2	4.37(0.94)	-1.54	2.06
INT_1	4.02 (1.48)	-1.14	-.36
INT_2	4.16 (1.54)	-1.42	0.15
INT_3	4.11 (1.40)	-1.43	0.51
BH_1	4.06 (1.26)	-1.16	0.10

- Items ATT_1 and SN_3 exceeded ± 2 kurtosis and ± 7 skewness threshold (Ryu, 2011)., hence were removed from the analysis.
- Kaiser's measure of sampling adequacy at the single-variable level shows that items INT_1, SN_4 and SN_5 presented an $MSA < 0.6$, so they were removed from the dataset
- Finally, p-value for the Barlett test is less than 0.05 and Overall MSA is equal to 0.8, hence our final sample is adequate to estimate a structural equation modeling analysis.

Confirmatory factor analysis

Factor	Reliability	AVE	Item	Factor loadings	Standard error	P-value
Attitude	0.61	0.45				
			ATT_2	0.53	0.07	0.00
			ATT_3	0.83	0.07	0.00
Social Norm	0.77	0.64				
			SN_1	0.89	0.06	0.00
			SN_2	0.69	0.07	0.00
Perceived Behavioral Control	0.69	0.78				
			PBC_1	0.98	0.09	0.00
			PBC_2	0.17	0.11	0.11
Intention	0.70	0.58				
			INT_2	0.97	0.17	0.00
			INT_3	0.40	0.11	0.00
Behavior	-	-				
			BH_1	1.00	0.00	-



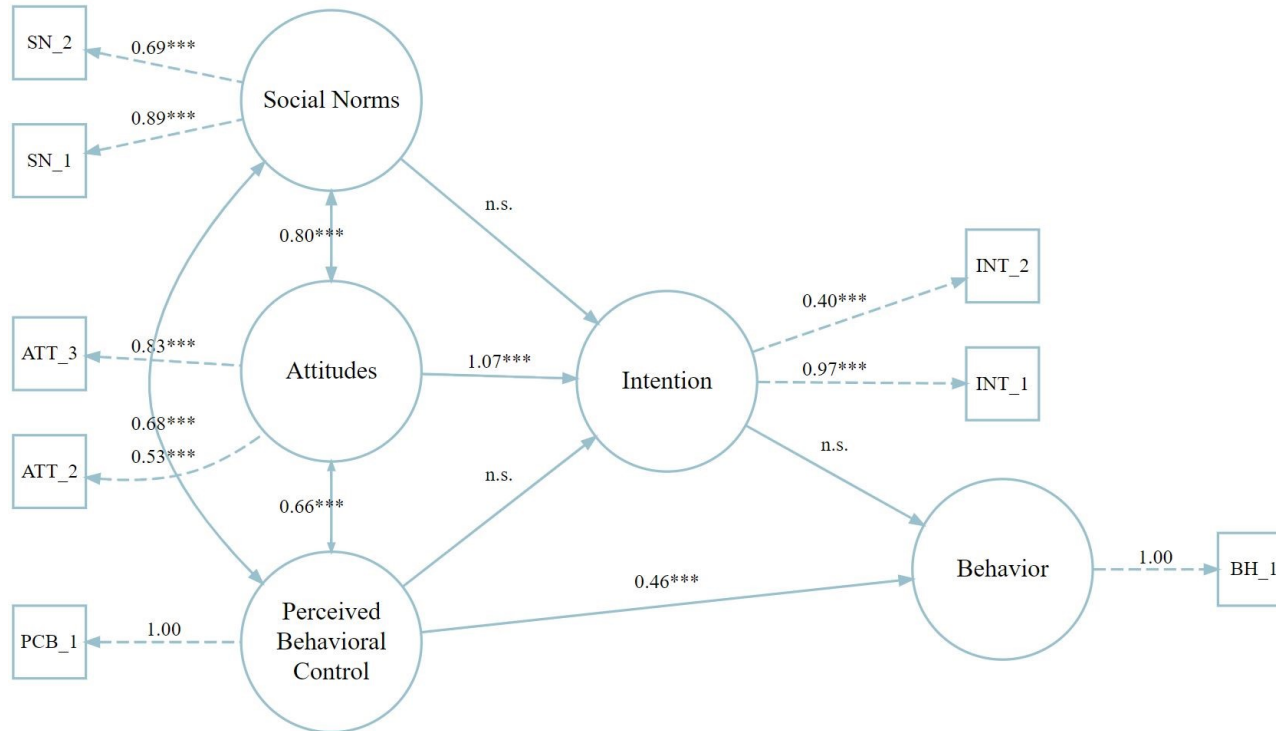
Confirmatory factor analysis

- For the Perceived Behavioral Control, item PBC 2 have a Factor loading less than 0.4, so it should be removed.
- For all factors McDonald's Omega is greater than 0.6, so reliability can be considered acceptable
- Average variance extracted is greater than 0.5 for all factors except attitude.
- Fornell and Larcker (1981) points that a low AVE can be compensated if our reliability is high enough, and the AVE of attitude factor is close to 0.5, so convergent validity will be considered adequate.
- It doesn't seem to be a discriminant validity problem, because all values are less than 0.90.

	SN	ATT	PBC	INT	BH
SN	-	-	-	-	-
ATT	0.80***	-	-	-	-
PBC	0.68***	0.66***	-	-	-
INT	0.47***	0.76***	0.44***	-	-
BH	0.33***	0.33***	0.49***	0.27***	-

Discriminant Validity

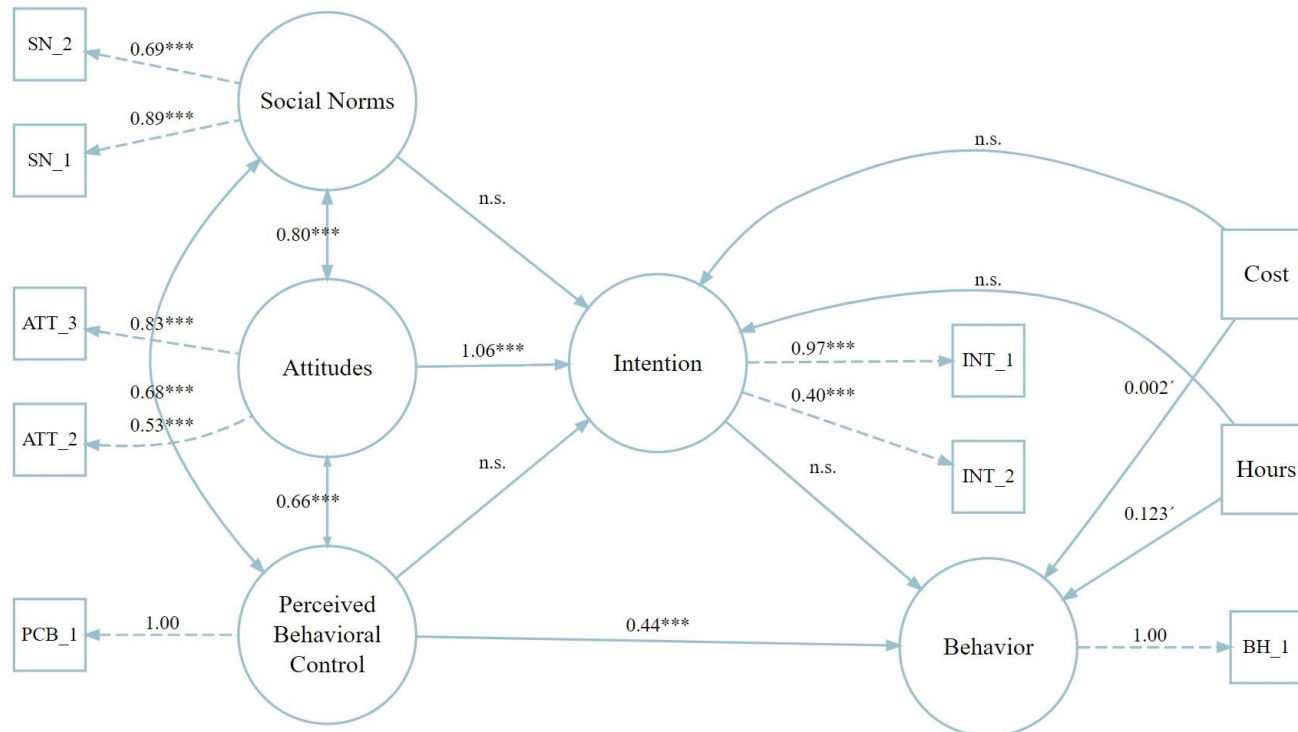
Structural Equation Model of the Theory of Planned Behavior



p-values: n.s. = not significant, ' = (0.05, 0.1], * =(0.01, 0.05], ** =(0.001, 0.01], *** = [0, 0.001]

Relationship between perceived cost and recycling behavior and intentions.

Variable	Mean	S.D.	Min	Max
Hour of cleaning	1.00	0.98	0.00	4.00
Cost of a lost hour	47.09	57.13	0.00	500.00



p-values: n.s. = not significant, ' = (0.05, 0.1], * =(0.01, 0.05], ** =(0.001, 0.01], *** = [0, 0.001]

In sum....

- What do we need for fishermen to be more active on daily bases?
- Appropriate social norms, attitudes, and importance of behaviora control in order to improve intentions to collect marine litter
- However, intentions and behavior are not related.
- Relavant for fishermen to have control over the removal of marine litter
 - Important to have resources and equipment, several green points, and other infraestructura at ports.

References

- Cho, D. O. (2009). The incentive program for fishermen to collect marine debris in Korea. *Marine Pollution Bulletin*, 58(3), 415-417. doi:<http://dx.doi.org/10.1016/j.marpolbul.2008.10.004>
- Consellería do Mar, (s.f.). Plan MARLIMPO. Programa para a protección e recuperación da biodiversidade e dos ecosistemas mariños mediante a recollida de residuos no marco de actividades de pesca sostibles. Xunta de Galicia.
- Mouat, J., López Lozano, R. and Bateson, H. (2010). Economic impacts of marine litter. *Kommunernes International Miljøorganisation (KIMO)*.
- Newman, S., Watkins, E., Farmer, A., ten Brink, P. & Schweitzer, J-P. (2015). The economics of marine litter. En Bergmann, M., Gutow, L. & Klages, M. (Editors), *Marine Anthropogenic Litter* (367-395).
- UN Environment (2017). *Marine Litter Socio Economic Study*, United Nations Environment Programme. Nairobi: Kenia.