6th Mediterranean Conference on Marine Turtles
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Monitoring marine debris ingestion in loggerhead sea turtle, *Caretta caretta*, from East Spain (Western Mediterranean) since 1995 to 2016

Domènech F., Aznar F.J., Raga J.A., Tomás J.

francesc.domenech@uv.es

Marine Zoology Unit, Cavanilles Institute of Biodiversity and Evolutionary Biology, University of Valencia, Valencia, Spain.

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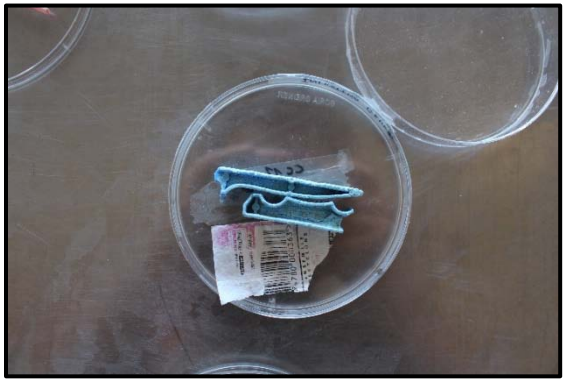
INTRODUCTION

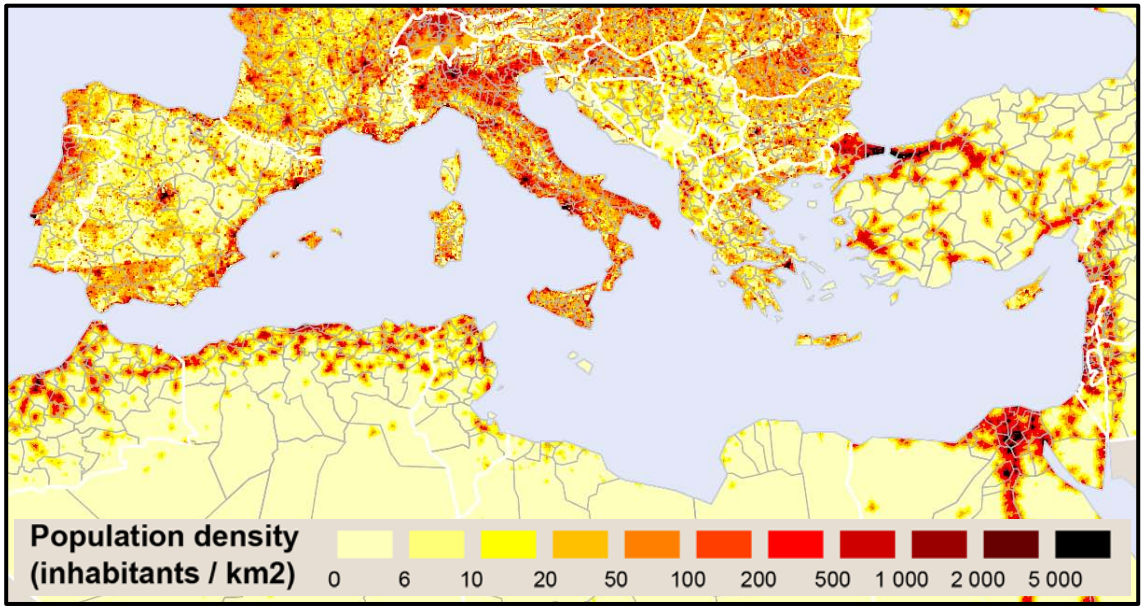
- Anthropogenic marine debris: a threat to marine ecosystems.
- For marine fauna: **debris ingestion.**
- Reports of debris in more than 560 marine species (Kühn et al., 2015).

INTRODUCTION

- Marine turtles may confuse debris with food.
- Debris ingestion reported in all marine turtle species.
- **Detrimental effects**: dietary dilution, assimilation of contaminants and block or tear digestive tracts.

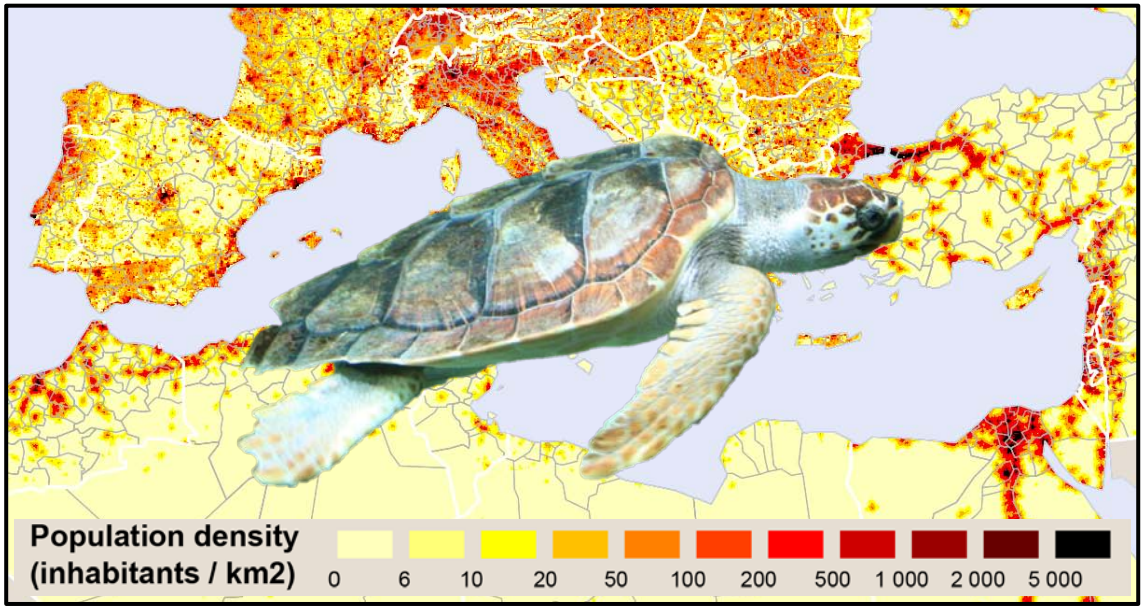


INTRODUCTION



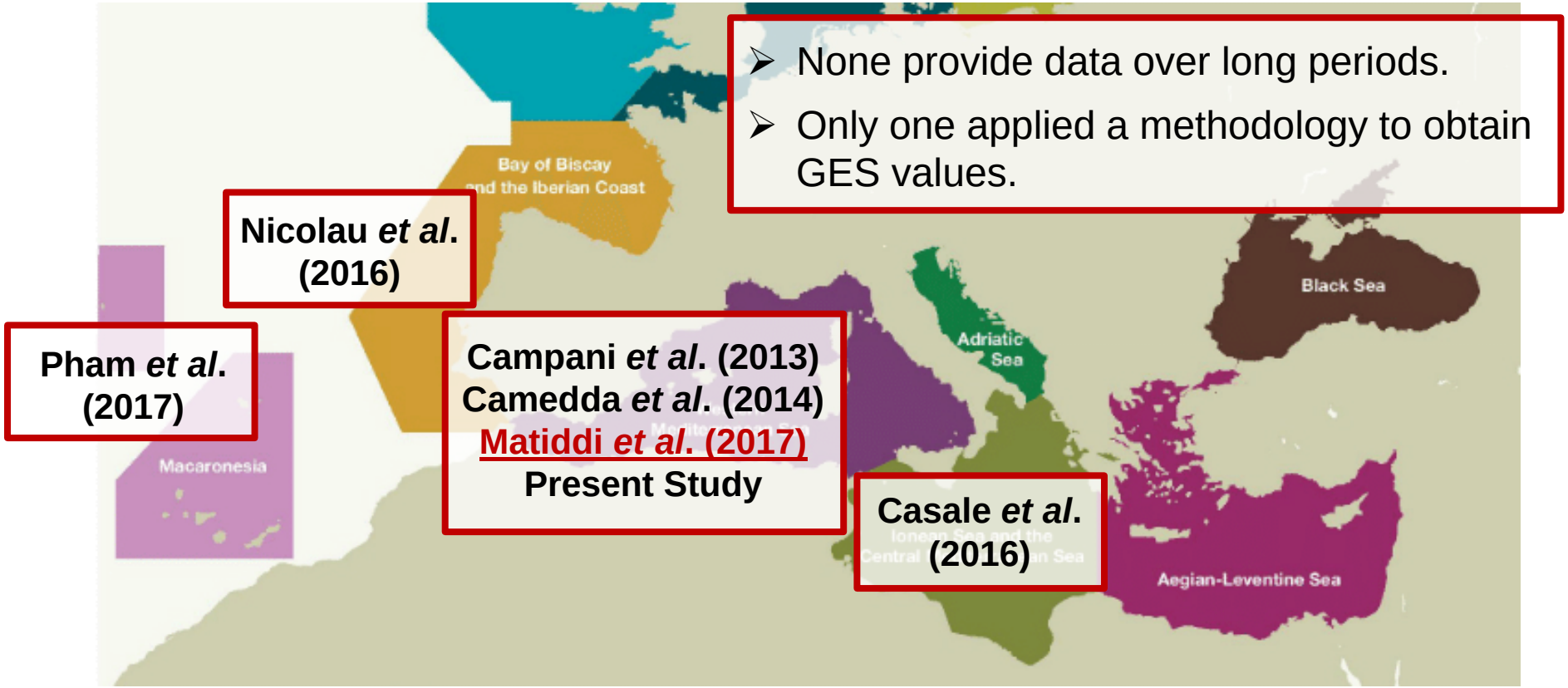
- Mediterranean Sea: a semi-closed basin with high demographic density.
- One of the **most polluted seas of the planet**
- Marine Strategy Framework Directive (MSFD) (European Directive, 2008).

INTRODUCTION



- One of MSFD descriptors: ***trends in the amount and composition of marine debris ingested by marine animals***.
- **Loggerhead sea turtle** as an **indicator species of pollution** in the Mediterranean.

INTRODUCTION



- None provide data over long periods.
- Only one applied a methodology to obtain GES values.

Nicolau *et al*. (2016)

Pham *et al*. (2017)

Campani *et al*. (2013)
Camedda *et al*. (2014)
Matiddi *et al*. (2017)
Present Study

Casale *et al*. (2016)

- Up to date, 6 studies adopted the MSFD methodology.

INTRODUCTION

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Loggerhead sea turtles (*Caretta caretta*): A target species for monitoring litter ingested by marine organisms in the Mediterranean Sea☆

Marco Matiddi [a, *], Sandra Hochsheid [b], Andrea Camedda [c], Matteo Baini [d], Cristiano Cocumelli [e], Fabrizio Serena [f], Paolo Tomassetti [a], Andrea Travaglini [b], Stefano Marra [c], Tommaso Campani [d], Francesco Scholl [e], Cecilia Mancusi [f], Ezio Amato [a], Paolo Briguglio [g], Fulvio Maffucci [b], Maria Cristina Fossi [d], Flegra Bentivegna [c], Giuseppe Andrea de Lucia [c]

- Good Environmental Status (GES): ***the percent turtles having more than average plastic weight per turtle, using samples of 50-100 turtles*.**
- Two GES values: (1) early juvenile turtles (CCL ≤ 40cm) and (2) sub-adults and adults (CCL > 40 cm).

AIMS

- To analyze **data on marine debris consumption** by the loggerhead sea turtle over **two decades** in the Western Mediterranean sub-region, **applying the MSFD methodology**. (First long term study)

- To **provide** and discuss the **GES values** obtained so far to **assess trends on debris ingestion** by loggerhead turtles in the western Mediterranean.

MATERIALS AND METHODS

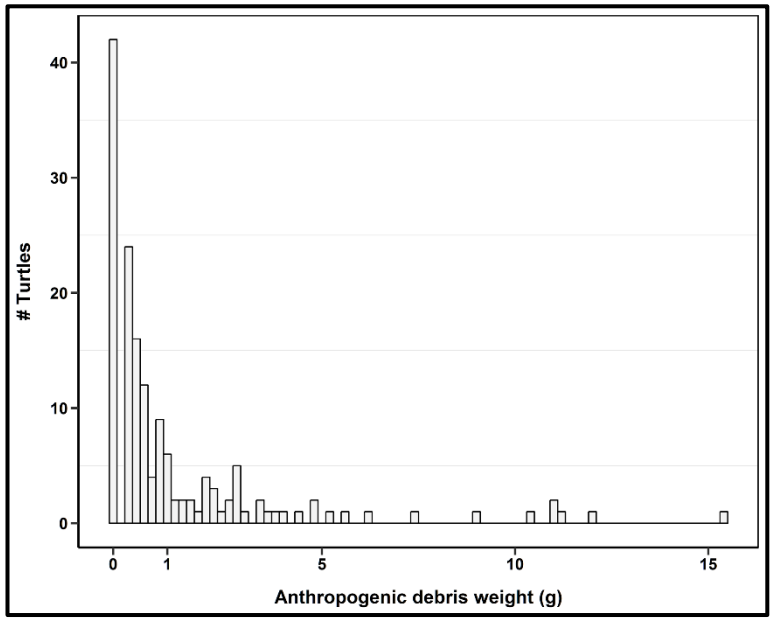
- N = 155 loggerhead turtles for 1995-2016 in Western Mediterranean (East Spain).
- Turtles stranded (n = 68) or bycaught by pelagic long-line, bottom trawl or artisanal fisheries (mainly trammel nets) (n = 87).
- Solid contents analyzed following the MSFD protocol.
- Analysis included particles ≥ 1 mm length

BIOTA categories for contents of digestive tract
(oesophagus, stomach(s), intestine)

PLA	PLASTIC	acronym	all plastic or synthetic items: note number of particles and dry mass for each category
IND	pellets	ind	industrial plastic granules (usually cylindrical but also oval spherical or cubical shapes exist
	probab ind?	pind	suspected industrial, used for the tiny spheres (glassy, milky, ...) occasionally encountered
USE	sheet	she	remains of sheet, eg from bag, cling-foil, agricultural sheets, rubbish bags etc
	thread	thr	threadlike materials, eg pieces of nylon wire, net-fragments, woven clothing; includes 'balls' of compacted such material
	foam	foam	all foamed plastics so polystyrene foam, foamed soft rubber (as in matras filling), PUR used in construction etc
	fragments	frag	fragments, broken pieces of thicker type plastics, can be bit flexible, but not like sheetlike materials
	other	Poth	any other, incl elastics, dense rubber, sigarette-filters, balloon-pieces, softairgun bullets; objects etc. DESCRIBE!!
RUB	OTHER RUBBISH	acronym	any other non synthetic consumer wastess: note number of particles and (in principle) dry mass for each category
RUB	paper	pap	newspaper, packaging, cardboard, includes multilayerd material (eg Tetrapack pieces) and aluminium foil
	kitchenfood	kit	human food remains (galley wastes) like oinion, beans, chickenbones, bacon, seeds of tomatoes,grapes, peppers, melon etc
	other user	rva	other consumber waste, like processed wood, pieces of metal, metal air-gun bulletes; leadshot, painchips. DESCRIBE
	FISHHOOK	hoo	fishing hook remains (NOT FOR HOOKS ON WHICH LONGLINE VICTIMS WERE CAUGHT - THOSE UNDER NOTES)
POL	POLLUTANTS (INDUS/CHEM WASTE)	acronym	other non syathetic indusrial or shipping wastes (number of items and mass per category (wet for paraffin)
POL	slag/coal	sla	industrial oven slags ('looks like non-natural pumice) or coal remains
	oil/tar	tar	lumps of oil or tar (also not n=1 and g=0.0001g if other particles smeared with tar but cannot be sampled separately)
	paraf/chem	che	lumps or mash of unclear paraffin, wax like substances (NOT stomach oil!) if needed subsample and estimate mass
	feather/lump	rva	lump of feathers from excessive preening of fouled feathers (n=1 with drymass) (NOT for few normal own feathers)
FOO	NATURAL FOOD	foo	various categories, depends on the species studied, and aims of study
NFO	NATURAL NON FOOD	nfo	anything natural, but which can not be considered as normal nutritious FOOD for the individual

MATERIALS AND METHODS

- Distribution of debris mass: right-skewed, with 26.2% without debris (Zero values).
- Statistical analyses: Zero-altered gamma (ZAG) models.
- Two parts model: (1) Bernoulli GLM and (2) Gamma GLM.



Variable	Description	Type
Response		
DEBRIS	Weight (g) of anthropogenic debris in each digestive content.	Continuous
Explanatory		
PERIOD	Period of years of turtle death.	Categorical (*2 levels*) 1. *1995-2004* 2. *2005-2016*
CCL	Curved carapace length (cm) of the turtle.	Continuous
LATITUDE	Latitude	Continuous
SEASON	Turtle death season (according to the Northern Hemisphere).	Categorical (*4 levels*) 1. *Dec. 21 – Mar. 20* 2. *Mar. 21 – June 20* 3. *June 21 – Sept. 22* 4. *Sept. 23 – Dec. 20*
ORIGIN	Cause of turtle entry into the stranding network.	Categorical (*2 levels*) 1. *Stranded* 2. *Bycaught*

MATERIALS AND METHODS

- Predictors:

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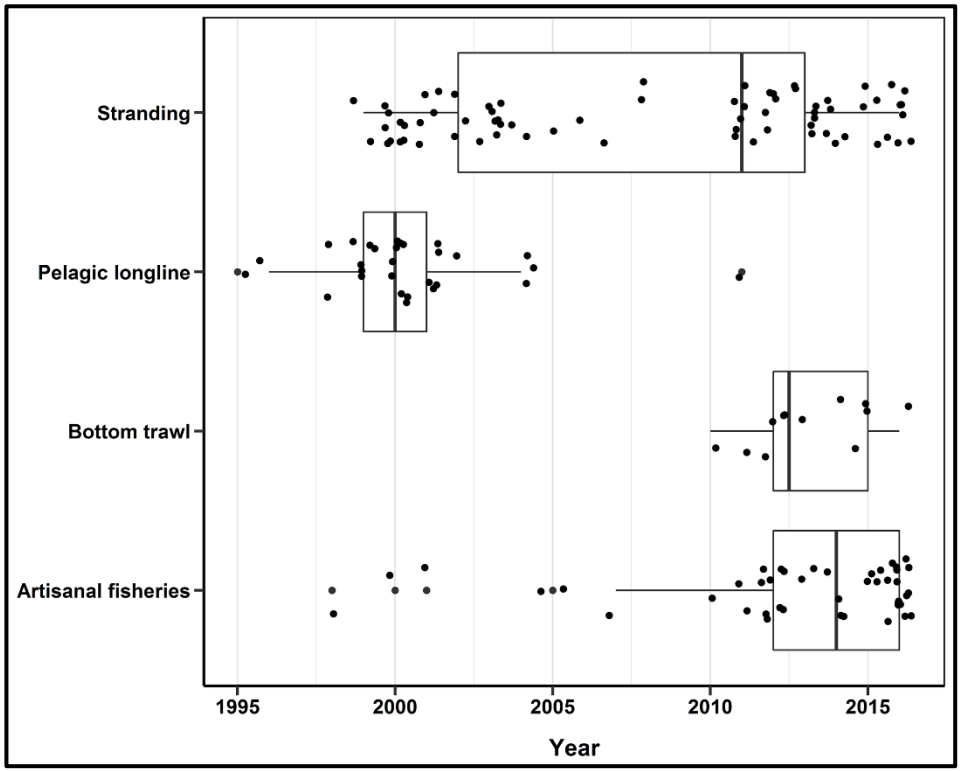

MATERIALS AND METHODS

- Two size groups to calculate GES: early juveniles (CCL ≤ 40cm) and late juveniles (CCL > 40 cm), following Matiddi et al. (2017).

- We calculated *'Past GES'* (1995-2005) and *'Current GES'* (2006-2016) for the two groups.

RESULTS AND DISCUSSION

- Composition of marine debris was similar to that found in other studies from Western Mediterranean.
- FO% [95% CI] = 71.0% [63.2 - 77.8]
- Mean dry weight ± SD = 1.3 ± 2.6 g

Study	Present study	Mattidi *et al.* (2017)	Campani *et al.* (2013)	Camedda *et al.* (2014)	Casale *et al.* (2016)	Nicolau *et al.* (2016)	Pham *et al.* (2017)
Subregion	WM (This study)	WM	WM	WM	CM	IC	Mac
n	155	120	31	121	172	95	24
Mean CCL	51.1 (14.9)	60.6	51.4 (12.2)	51.4 (12.4)	-	49.8 (9.3)	32.4 (20.2)
Mean ADW (± SD)	1.32 (2.63)	1.30 (2.20)	2.01	0.23	0.48	1.35 (4.40)	1.07 (2.01)
Mean ADI (± SD)	10.6 (16.3)	16 (32.8)	16.5 (29.1)	2.8	10.6	9.7 (16.8)	15.8 (29.8)
Frequency (%) [95% CI]	71.0 [63.2 - 77.8]	85.0 -	71.0 -	14.0 -	100.0 -	59.0 -	83.0 -

RESULTS AND DISCUSSION

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Anthropogenic debris categories [frequency (mean weight ± SD)]							
Industrial pellets	0	0	0	0.8 -	1.7 -	12.6 0.06 ± 0.23	- 0.00 ± 0.00
Sheet-like	60.6 0.35 ± 0.92	- 0.55 ± 1.1	- 0.69	12.4 -	82.0 -	45.3 0.29 ± 1.26	-
Thread-like	31.6 0.11 ± 0.44	- 0.15	- 0.02	4.1 -	25.6 -	24.2 0.13 ± 0.65	-
Foamed user	19.4 0.10 ± 0.41	- 0.05	- 0.01	1.7 -	2.3 -	5.3 0.00 ± 0.01	-
Fragments hard	38.7 0.39 ± 1.16	- 0.60 ± 1.1	- 1.06	9.1 -	58.7 -	4.2 0.00 ± 0.02	-
others	15.5 0.16 ± 0.54	- 0.10	- 0.13	0 -	13.4 -	3.2 0.01 ± 0.04	0 -
PLASTICS	69.0 1.11 ± 2.31	-	- 1.92	-	99.4 -	56.8 0.49 ± 1.50	-
RUBBISH	9.7 0.20 ± 1.19	-	- 0.15	0	14.0 -	29.5 0.78 ± 3.51	-
POLLUTANS	5.8 0.01 ± 0.03	-	- 0.01	-	3.5 -	3,2 0.01 ± 0.08	-

RESULTS AND DISCUSSION

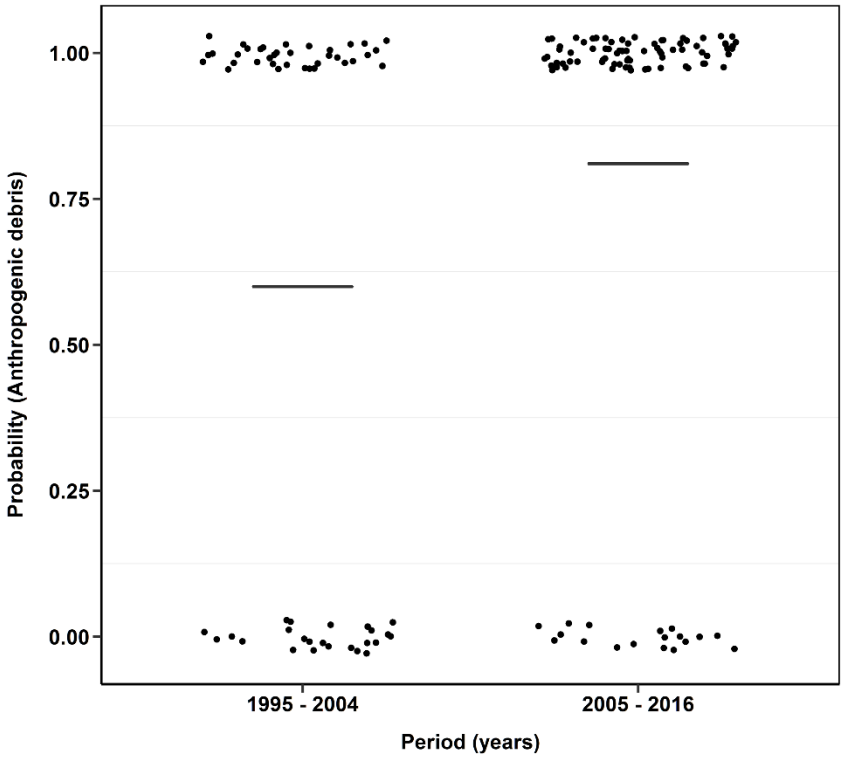
- Best-fitted ZAG models

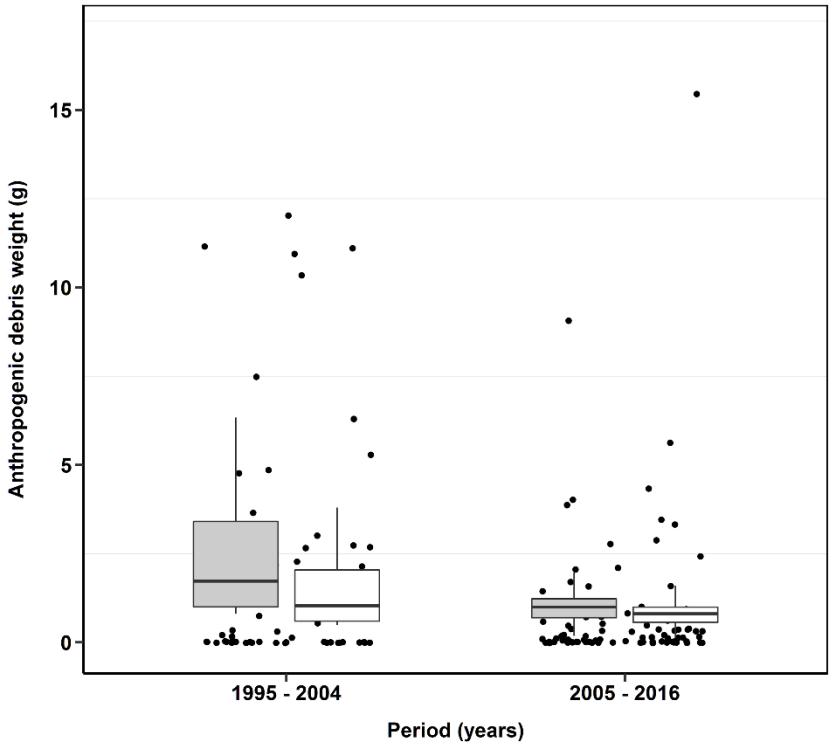
Zero-altered gamma model (ZAG)

Bernoulli part	*Gamma part*	ΔAIC	w_i
PERIOD	**PERIOD + CCL + LATITUDE + ORIGIN**	**0.00**	**0.786**
PERIOD	**PERIOD + CCL + LATITUDE**	**0.27**	**0.687**
PERIOD + LATITUDE	**PERIOD + CCL + LATITUDE + ORIGIN**	**1.39**	**0.393**
PERIOD + LATITUDE	**PERIOD + CCL + LATITUDE**	**1.66**	**0.343**
PERIOD + ORIGIN	**PERIOD + CCL + LATITUDE + ORIGIN**	**1.86**	**0.310**
PERIOD + LATITUDE + ORIGIN	*PERIOD + CCL + LATITUDE + ORIGIN*	*3.07*	*0.170*
PERIOD + LATITUDE + ORIGIN	*PERIOD + CCL + LATITUDE*	*3.34*	*0.148*
PERIOD + CCL + LATITUDE	*PERIOD + CCL + LATITUDE + ORIGIN*	*3.35*	*0.147*
PERIOD + CCL + ORIGIN	*PERIOD + CCL + LATITUDE + ORIGIN*	*3.79*	*0.119*

RESULTS AND DISCUSSION

- **‘Period’**: debris occurred less frequently, but in larger amounts per turtle, in the period 1995-2004 than in the period 2005-2016.

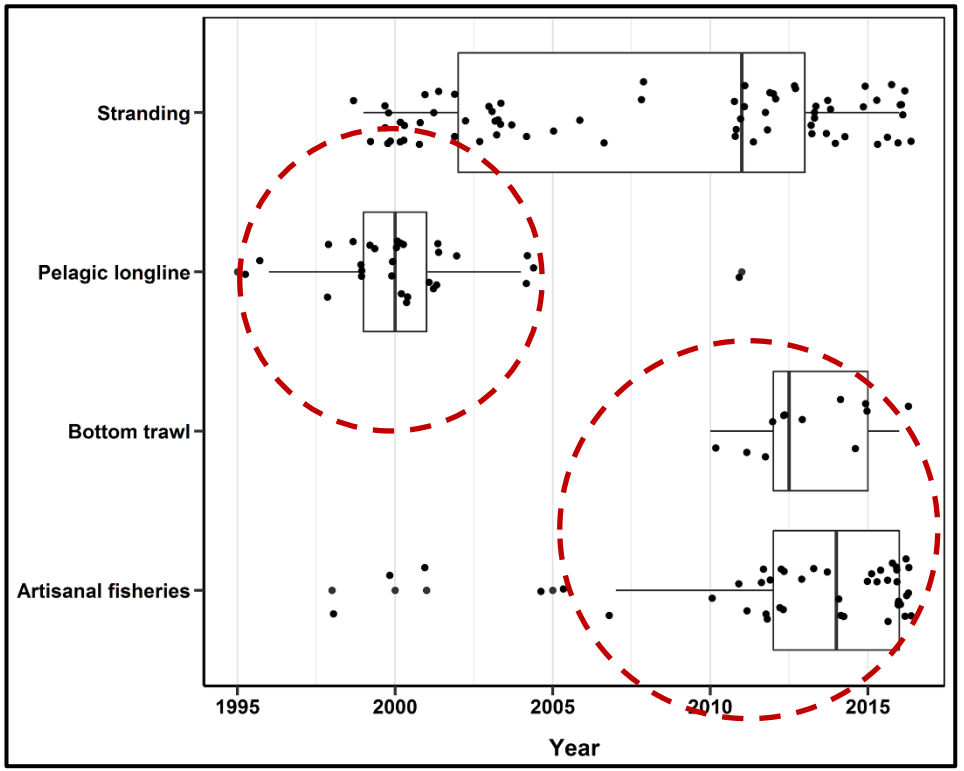




RESULTS AND DISCUSSION

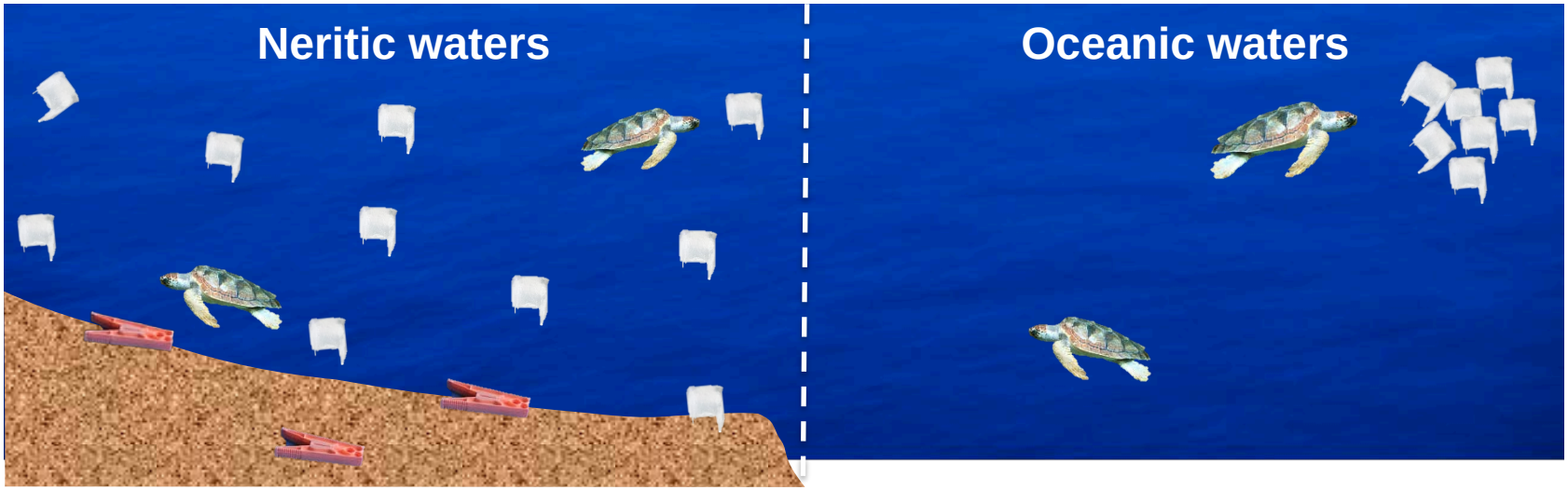
- Only the sample of turtles from the first period contained larger individuals captured in the oceanic realm.

- 1995-2005:
  mean CCL ± SD = **57.4 ± 11.4 cm**
- 2006-2016:
  mean CCL ± SD = **47.0 ± 15.1 cm**
- Pelagic longline:
  mean CCL ± SD = **60.1 ± 11.7 cm**
- Bottom trawling and trammel nets:
  mean CCL ± SD = **46.3 ± 13.6 cm**



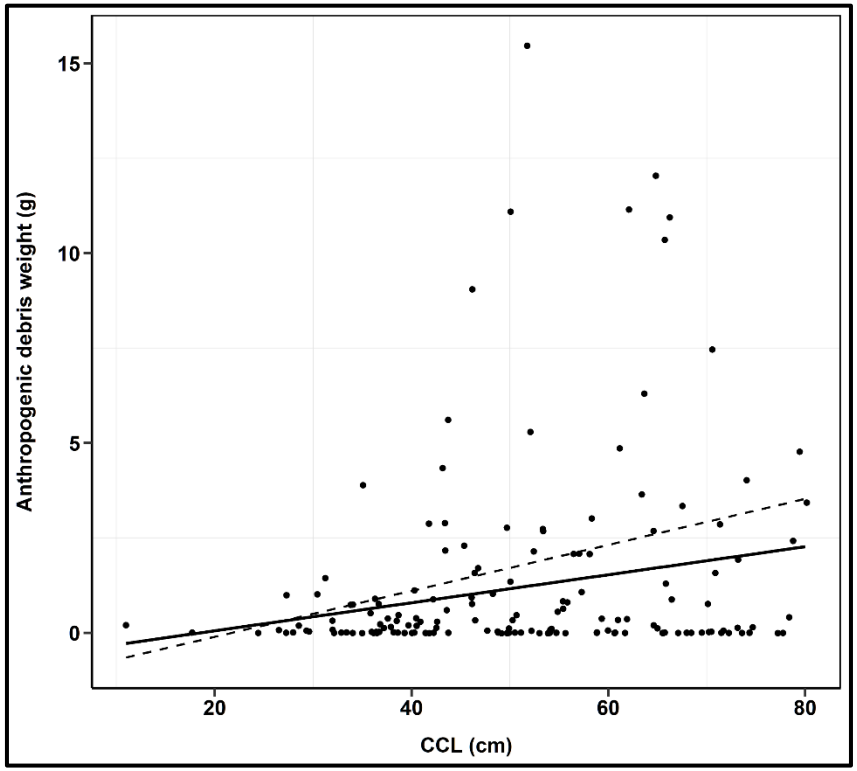
RESULTS AND DISCUSSION

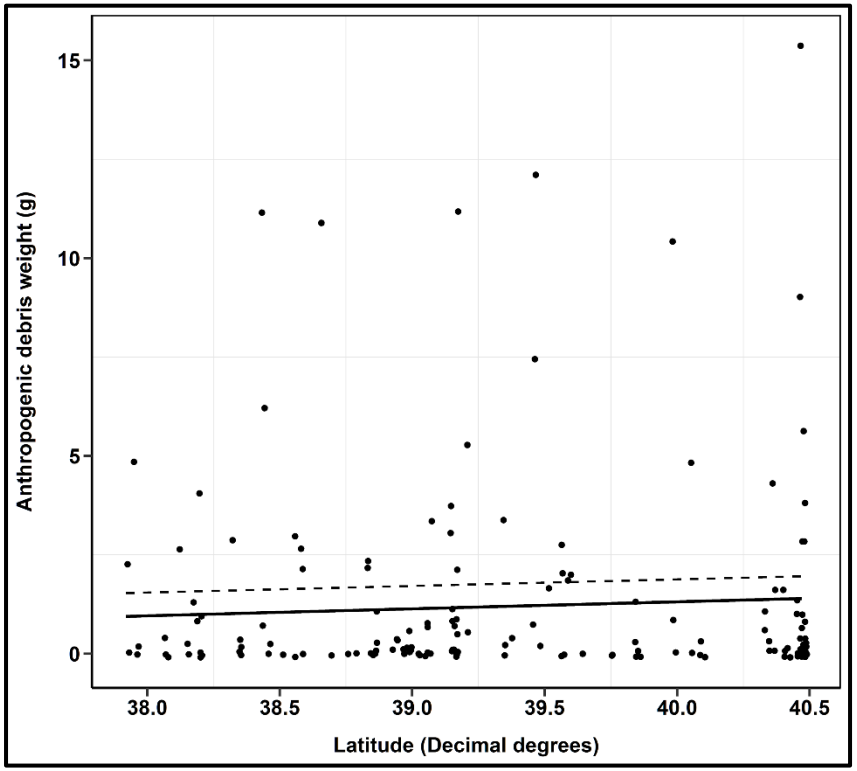
- In neritic areas, the amount of debris could be higher (in densely populated coastal areas), but more dispersed than in oceanic areas.



RESULTS AND DISCUSSION

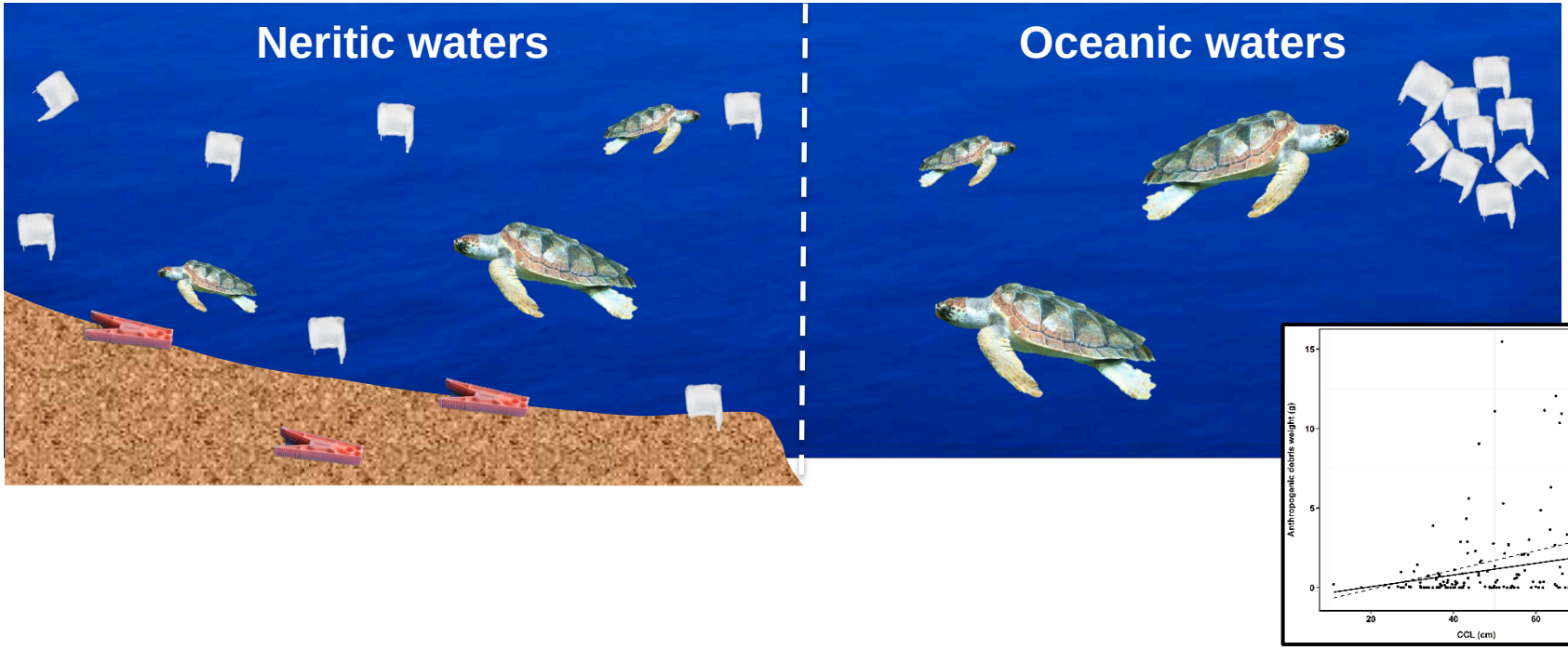
- **Turtle size** (CCL) and **Latitude**: larger turtles at the north of the study area containing significantly more debris.





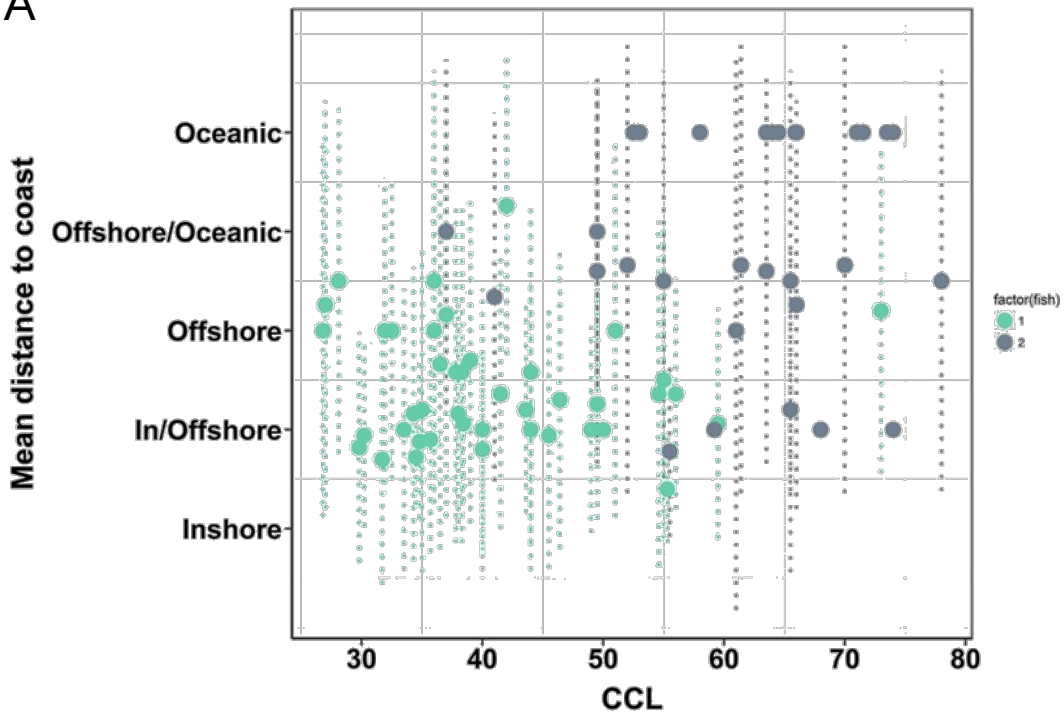
RESULTS AND DISCUSSION

- **Size**: Turtles that inhabit oceanic areas increase the likelihood of ingesting floating marine debris.
- Present study: adults/sub-adults using oceanic areas.



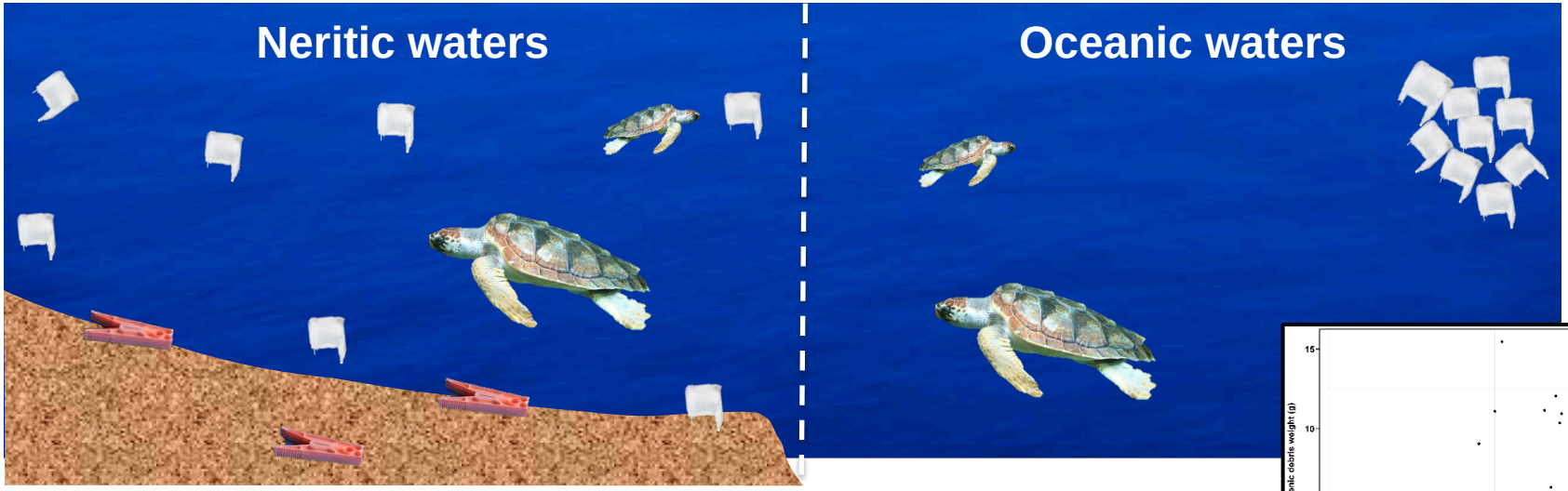
RESULTS AND DISCUSSION

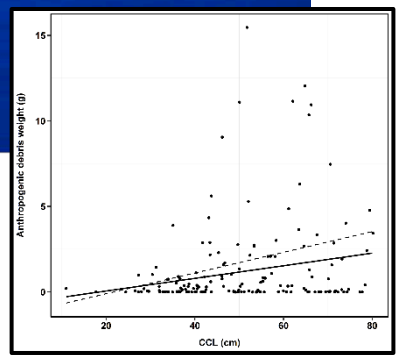
- Poster grafica figura 1 A



RESULTS AND DISCUSSION

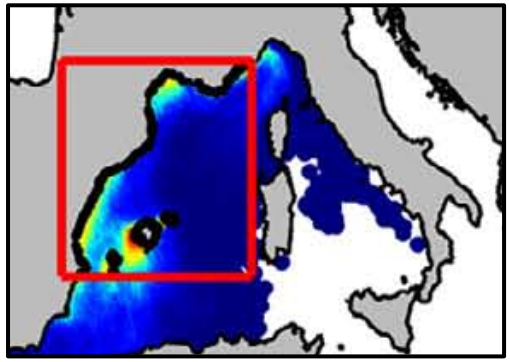
- Opportunistic feeding
- Intake ratio increases with the size of the turtles.
- Larger turtles have lower gape limitation and they have longer intestines.

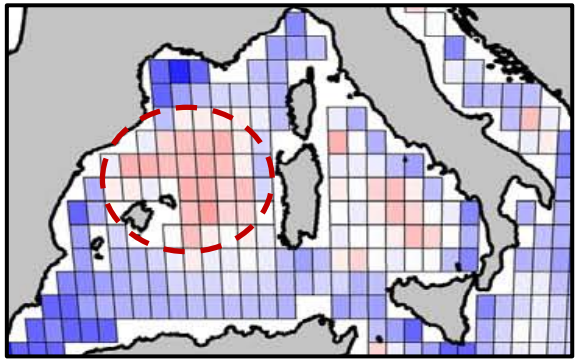




RESULTS AND DISCUSSION

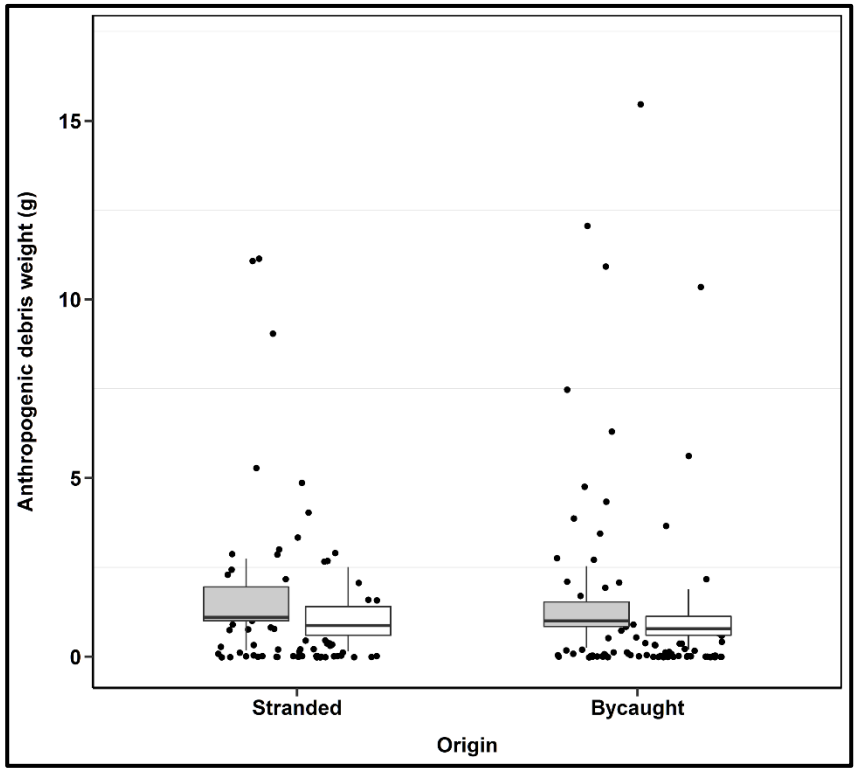
- **<u>Latitude</u>**: Higher availability of anthropogenic debris at higher latitudes.
- North-half of the region:
  - Ebro River flows out into the sea.
  - Population size and marine traffic are larger
  - Debris retention and beaching area





RESULTS AND DISCUSSION

- **Origin** (**Not significant**): stranded turtles had higher mass of debris compared to bycaught turtles.
- Present study only included fresh dead turtles (decomposition state 0, 1 and 2).



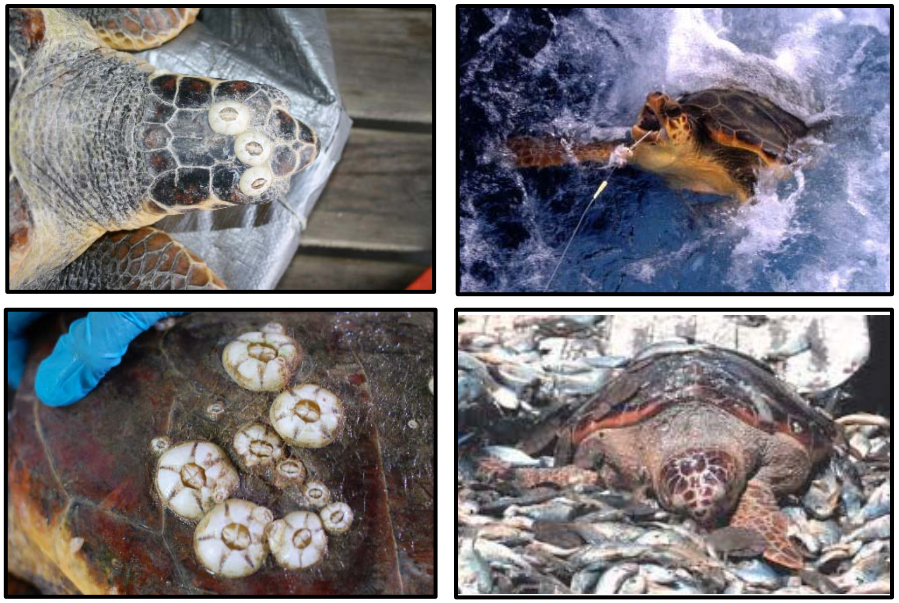
RESULTS AND DISCUSSION

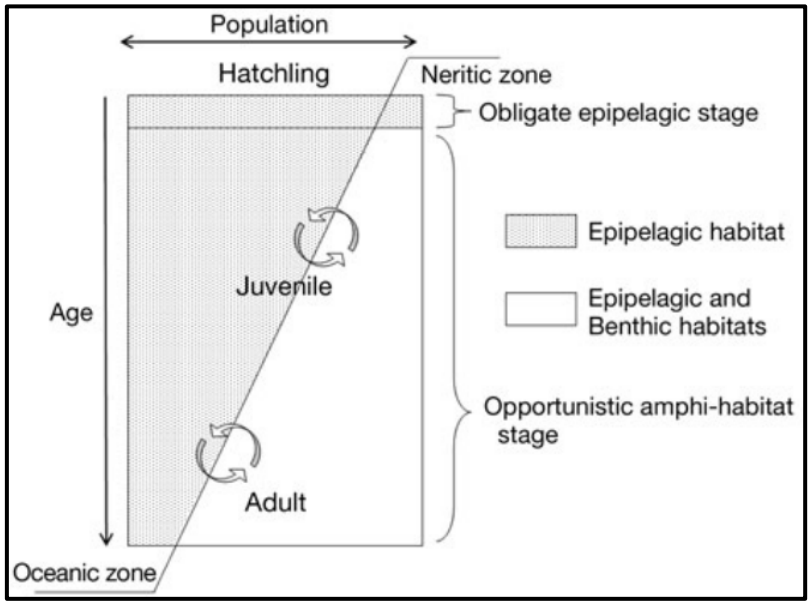
- GES value for late juvenile turtles in present study similar to GES obtained by Matiddi et al. (2017).
- 27.8% of the turtles with more plastics than average (1.3 g).
- GES early-juvenile turtles: 26.3% of turtles with more plastics than average (0.35 g).
- Slight decrease in the amount of plastics ingested by loggerhead turtles in the region.

Ecological group	*Sample size*	*Plastic weight (g)*				
		Frequency (%) (95% CI)	*Mean (± SD)*	*GES (%) (95% CI)*	*Median*	*Range*
Early juveniles 1995 – 2016	41	82.9% (68.5 - 91.8)	**0.345 (± 0.667)**	**26.8% (15.3 - 42.6)**	0.082	0.001 - 3.884
Early juveniles 1995 – 2005	3			-		
Early juveniles 2006 - 2016	38	84.2% (68.6 - 92.9)	**0.348 (± 0.687)**	**26.3% (14.0 - 42.0)**	0.080	0.001 - 3.884
Late juveniles 1995 – 2016	114	64.9% (55.7 - 73.3)	**1.395 (± 2.613)**	**29.8% (21.8 - 39.0)**	0.155	0.001 - 15.177
Late juveniles 1995 - 2005	60	55.0% (42.2 – 67.6)	**1.468 (± 2.664)**	**30.0% (19.6 - 42.9)**	0.115	0.016 - 11.145
Late juveniles 2006 - 2016	54	75.9% (63.0 - 85.7)	**1.313 (± 2.577)**	**27.8% (17.4 - 41.6)**	0.322	0.001 - 15.177

RESULTS AND DISCUSSION

- **CCL** appears to be a **poor predictor of the feeding ecology** of loggerhead turtles in the Western Mediterranean.
- Type of **fishing gear** of bycaught turtles and the **epibiont fauna** detected in turtles: **better indicators of exploitation of neritic or oceanic habitats**.





CONCLUSIONS

- The **amounts of marine debris** ingested by loggerhead turtle are low and **do not apparently pose a significant threat** to the survival of their populations in the region.
- This **species can be a good indicator of pollution in the Mediterranean Sea** through the **standardized protocol** for the collection of marine debris and the **GES values**.

CONCLUSIONS

- But, it is necessary two considerations in future studies:

(1) To check the predictors that may be influencing the occurrence and amount of debris: **the neritic or oceanic habitat and the biases associated with the use of stranded turtles**.

(2) To make a **proper implementation of guidelines** to make full use of data across studies and be able to do viable comparisons among them.

CONCLUSIONS

- More information in:

Domènech F., Aznar F.J., Raga J.A., Tomás J. (*in press*). Two decades of monitoring in marine debris ingestion in loggerhead sea turtle, *Caretta caretta*, from the western Mediterranean. *Environmental Pollution. Accepted 9th October, 2018.*

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Hvala vam puno! // Thank you!

Pitanja? // Questions?

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