OCEANA Protecting the World's Oceans

Using "big data" to evaluate MPA effectiveness - the case of reefs in EU

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Introduction

The study looked into the fishing activity across marine Nature 2000 sites having a focus on variety of protected features protected by the Habitats Directive[1]. Significant incompatible fishing activity was observed inside Marine Protected Areas (MPAs) across all of the European Union (EU), particularly within reef and sandbank habitats types (codes 1170 and 1110). This poster summarizes the methods used and the main results for reefs.

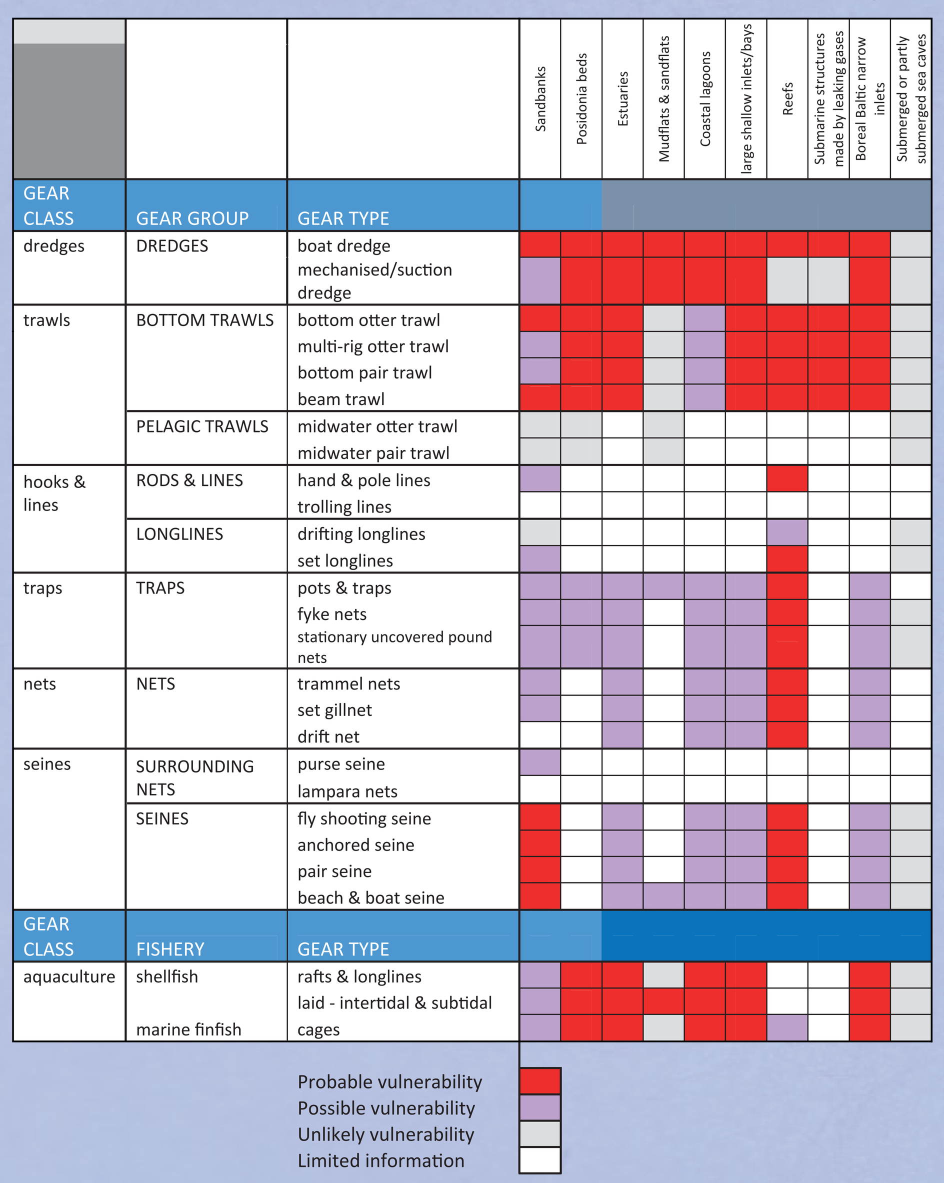
This study breaks new ground by applying a comprehensive data-driven approach, extracting figures that offer insight into an estimate of the actual conservation status of Natura 2000 as a whole through the analysis of bottom-fishing activities. The results demonstrate that substantive conclusions may be reached using algorithmic methods, in such a way as to be useful for lawmakers in deciding how to approach marine protection.

Methods

Fishing activity

Fishing activity across EU waters was identified using machine learning algorithms run on AIS (Automatic Identification System) data from the *Global Fishing Watch* (GFW, globalfishingwatch.org). The study compiled every fishing activity of every vessel within N2000 areas for the entire year of 2017. The fishing data was broken down by the type of fishing gear used by each vessel and mapped across the Natura 2000 sites designated to protect specific habitats and species whose conservation are likely incompatible with those fishing gears. To ensure that the analysis identifies only fishing activity having an impact on listed habitats, only gears with demonstrated potential impact were considered (Figure 1[2]).

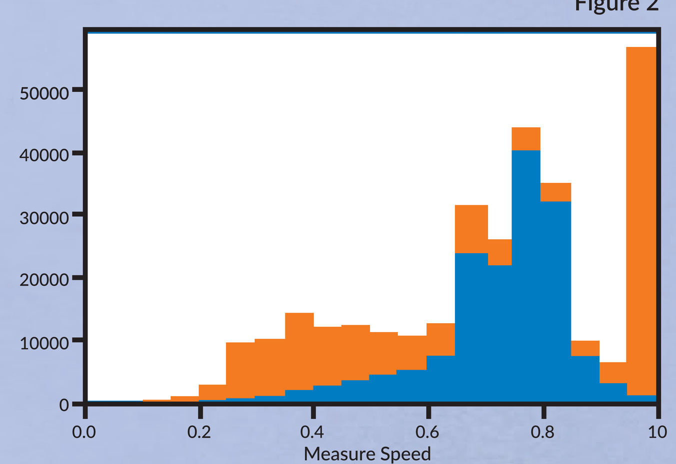
Figure 1



The fishing data was gathered from satellite monitoring of vessels via AIS, matched against fleet register databases, and compiled into tracks that encode each vessel's course. This study used *Google BigQuery* to search GFW's database for fishing events by vessels on the register, fishing in EU waters, in 2017. The key pieces of information extracted were the coordinates and the fishing time, to be summed to determine the total number of hours spent fishing inside the MPAs. There are known limitations to AIS data, however cross-checking with the EU fleet register helps ensure completeness, mitigates false labeling and guarantees that this study cannot over-report the fishing pressure.

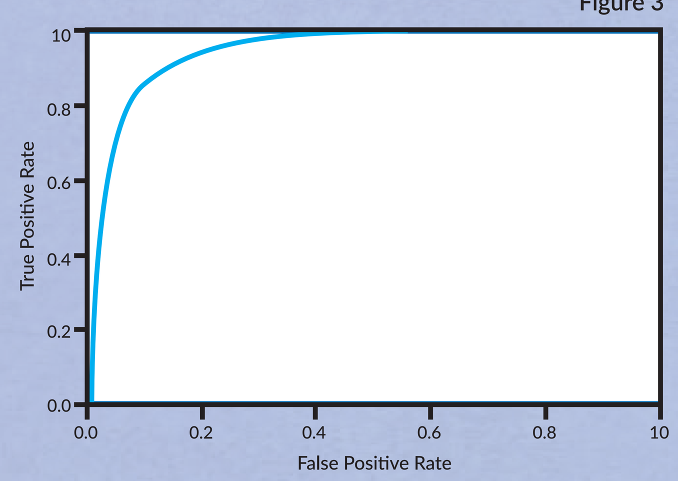
To predict whether a vessel is fishing at any given moment the GFW employs a machine learning algorithm that has been trained on a dataset that was hand-labeled as fishing or non-fishing by the GFW and researchers at Dalhousie University. Figure 2 shows that vessels moving very slowly or very quickly are less likely to be fishing, while a "sweet spot" in the middle is conducive to fishing. Finally a logistic regression was applied using the *Python package sklearn*. Figure 3 demonstrates that the model is robust, accurately and precisely predicting whether a subset of trawlers are fishing. The output of the model is a categorization of all fishing events recorded by the GFW as fishing or not-fishing.

Figure 2



An example feature used to train the machine learning algorithm; the average speed of the vessel over a 6-hour window. Orange represents non-fishing events, blue represents fishing-events. A substantial difference in distribution is observed, making this feature a powerful predictor of fishing activity.

Figure 3



This figure shows the ROC curve for the logistic regression model applied to trawlers. It demonstrates that the model is performing well. A high rate of true positives can be achieved along with a low rate of false positives

Fishing inside Natura 2000

A *Python script* was written to identify every fishing event and check its location. If the coordinates fell inside an MPA, that fishing event was labeled accordingly. Lacking information on the precise geographic location and extent of every habitat, approximations had to be made to estimate the likely activity experienced by a given habitat inside a given MPA. The following parameters were used as meaningful descriptors of fishing pressure:

- **Fishing hours**
- **Cover-weighted fishing hours:** Fishing hours weighted to value MPAs with habitats that are dominant in that MPA.
- **Average fishing density:** Total hours fished inside an MPA divided by the area of the MPA.

Though high values of cover-weighted fishing hours or average fishing density do not conclusively demonstrate that vessels were caught operating on top of the protected habitat, they indicate important patterns of fishing pressure that imply impact on the protected habitat.

1 Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
2 http://ec.europa.eu/environment/nature/natura2000/marine/docs/Fisheries%20interactions.pdf

Results and discussion – case reefs

The study found significant fishing pressure on EU MPAs designated for marine habitat protection, measured as the average density of fishing activity. Table 1 shows the largest fishing countries by fishing hours in 2017. The results showed that many MPAs experience fishing pressure even far exceeding these averages for unprotected waters. The challenge in interpreting these results lies in understanding how much fishing activity is "acceptable" for a given habitat. In this study only gear-habitat pairs with probable vulnerability were considered and this study aims to only report impactful fishing activity.

Table 1. Average fishing densities: largest fishing countries by fishing hours, 2017

	Country	Area of EEZ (km^2)	*fh*	ρ_{fh}	Dredge *fh*	Dredge ρ_{fh}	Trawl *fh*	Trawl ρ_{fh}
1.	Italy	538216	1851822	3.44	6322	0.01	1546731	2.87
2.	France	3122241	1507521	4.83	124220	0.40	961363	3.08
3.	Spain	1020769	1386884	1.36	0	0.00	689597	0.68
4.	UK	768286	1157984	1.51	84266	0.11	589668	0.77
5.	Portugal	1721751	527728	0.31	151	0.00	156676	0.09
6.	Netherlands	61869	412454	6.67	49564	0.80	315315	5.10
7.	Denmark	102693	351904	3.43	2676	0.03	265676	2.59
8.	Ireland	409929	256793	0.63	21216	0.05	129530	0.32
9.	Greece	493708	191331	0.39	258	0.00	160142	0.32
10.	Croatia	55961	184504	3.30	2222	0.04	97583	1.74
	TOTAL (all EU):	6007939	8474896	1.41	299436	0.05	5385045	0.90

Tables 2 and 3 show the MPAs experiencing the greatest fishing pressure, by weighted fishing hours and fishing density respectively. These two measures capture two different types of MPA being affected by fishing pressure: large MPAs with significant reef complexes and small MPAs protecting isolated individual reefs. The fact that one MPA, Roches de Penmarch (FR5302008), appears in both lists, should serve to make that site stand out as particularly pressured.

Table 2. Reefs: Top MPAs, Fishing Hours, 2017

	MPA Code	MPA Name	Area (km^2)	Cover (km^2)	*fh*	ρ_{fh}	*fhcw*
1.	FR5400469	Pertuis Charentais	4560	586	56854	12.5	7311
2.	BEMNZ0001	Vlaamse Banken	1099	506	12477	11.3	5742
3.	FR5302008	Roches de Penmarch	457	174	9249	20.2	3515
4.	DK00VA259	Gule Rev	471	250	5443	11.6	2891
5.	PTCON0062	Banco Gorringe	22928	22673	2287	0.1	2261
6.	FR5300031	Ile de Groix	283	153	3925	13.9	2123
7.	UK0030385	Pobie Bank Reef	966	820	1938	2.0	1646
8.	UK0030375	Lands End and Cape Bank	302	250	1699	5.6	1404
9.	SE0520170	Kosterfjorden-Väderöfjorden	540	229	2916	5.4	1235
10.	FR5300023	Archipel des Gl´enan	586	127	4900	8.4	1065

Table 3. Reefs: Top MPAs, Fishing Density, 2017

	MPA Code	MPA Name	Area (km^2)	Cover (km^2)	*fh*	ρ_{fh}	*fhcw*
1.	IT3250047	Tegn`ue di Chioggia	27	1	1360	51.2	71
2.	HR3000100	Otok Jabuka - podmorje	1	0.3	46	40.5	14
3.	FR3102004	Ridens et dunes hydrauliques du d´etroit du Pas-de-Calais	682	7	16106	23.6	161
4.	DK00VA250	Store Middelgrund	21	4	499	23.4	82
5.	FR5302008	Roches de Penmarch	457	174	9249	20.2	3515

Key findings of this study for the reefs include:

– Reefs are the most at-risk habitat across the EU. The incompatible fishing pressure on EU reefs is pervasive and intense. There are 1101 MPAs containing reef habitats in the Natura 2000 network. In 2017, incompatible fishing occurred within 242 of these, corresponding to 22% of N2000 designated for reef protection. Of these, 113 experienced more than 10 hours of fishing expected over reef habitats, 47 experienced more than 100 hours, and 10 experienced more than 1000 hours.

– Total of 2920 vessels employing incompatible gears engaged in fishing over MPAs protected for reef habitats. Of these, 846 fished for more than 100 hours and 97 fished for more than 1000 hours. Over 6% of all time spent fishing with bottom contacting gears in the EU waters takes place inside MPAs designated for reef protection.

– Both large MPAs with significant reef complexes and small MPAs protecting isolated individual reefs experienced notable fishing pressure.

– Although Bay of Biscay (Figure 4) and the Adriatic Sea (Figure 5) experienced especially high incompatible fishing activity, significant pressure was found throughout the N2000 network.

– It can be difficult to evaluate exactly how much fishing pressure is required to result in habitat damage, but the intensity and consistency of the activity over MPAs designated for reef protection is extreme and serves as highly credible testimony that this habitat is in serious danger. These results are a call to action for proper environmental protection of vulnerable reef habitats in EU. The expansion of marine protected areas is nothing without proper enforcement.

Figure 4

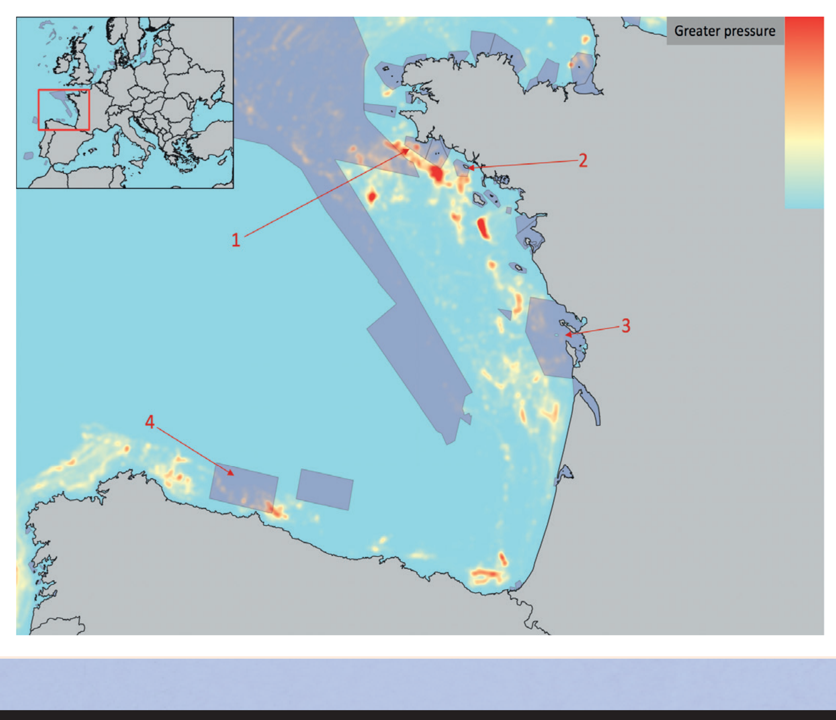
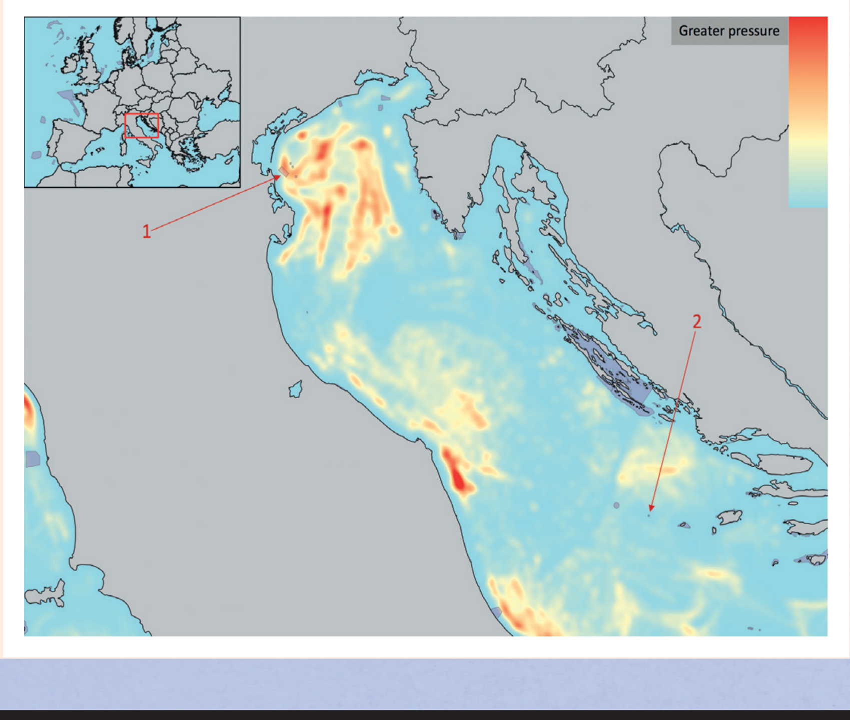


Figure 5



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