MODELIZACIÓN ESTADÍSTICA DE LA ACTIVIDAD DE LOS PESCDORES DE PERDEBE DE LA COSTA ASTURIANA, ESPAÑA

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CERTIFICA:

Que el trabajo titulado: " Modelización estadística de la actividad de los pescadores de percebe de la costa asturiana, España" presentado por D/Dña JOSE ROJAS CONTRERAS, ha sido realizado bajo mi dirección y, considerando que reúne las condiciones necesarias, autorizo su presentación.

En Oviedo, FECHA (16 de Junio/Julio de 2012)

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ABSTRACT

The fishing behaviour of Cudillero fishermen were studied using logistic regression models for linking their fishing activities with oceanographic data. A general pattern of explicative variables was observed across all fishermen. Wave height and tide width were the selected variables that may explain better the catch behaviour of the fishermen. A differential response to this variables was also detected, while some fishermen were less susceptive to tide with and wave height than other. A seasonal pattern of variation in the response variables was also observed. Three groups of fishermen were detected. Some fishermen changed their susceptibility to this variables during the analyzed period, taking a more “risky” approach during the October-December period, but then changing it behaviour to a more “conservative” one for the January-April period. The second group presented a more stable behaviour during the whole analyzed period. The third group was characterized for going to fish only during the October-December period.

INTRODUCCION

Goose neck barnacles *Pollicipes pollicipes* is a pedunculated Cirripedia that can be found along the Atlantic coast of Europe and North Africa inhabiting the lower intertidal zone (Barnes 1996). The fishery of this species dates from S II B.C (Ferré et al 1996), but Vazquez & Rodriguez (1999) suggest that there could be registry as old as the Neolithic. The main consumer of this product is the Spanish market, were the price could be as high as €80 k (Lopez et al 2010)

In the asturian coast, the exploitation of barnacle is carried by cofradias, guilds of fishermen supervised by the local fishery government. Under this model, cofradias are assigned fix location along the coast to harvest. Each cofradia has assigned a "Guarda", person who in charge of the surveillance of the zone, as well as the gathering of the daily catch information. The extraction periods extent only from October to April, period in which it is expected to have finished the reproductive season (De la Hoz & Garcia 1993). The recollection process is very simple, but risky, fisherman approach to the lower intertidal, preferably in low tide, and remove the animals from the rock surface with and scraper (Morales & Freire 2003). The maximum amount of barnacles that a fisherman is allowed to extract is 6 kg a day. 4 years ago the extraction maximum was 8 kg, but has to be reduce due to overexploitation.

Under this management scenario, mostly of the responsibility regarding the dictation of policies and general management of the fishery is under control of the authorities, which in this specific case, dictate the maximum allowed capture, determine the closure and rotation of the extraction localities and supervise the general activities of the fisherman.

Little is known about the fishing behavior of the fisherman of Asturias. Mostly of the information concerns primarily the biology of the barnacle itself (De la Hoz & Garcia 1993, Cardoso et al 1995, Quinteiro et al 2007, Campo et al 2009). Brown (2001) mention that one of the factors for an adequate performance of community management is recognition of the motives of the involved parties. The organization of the people directly involved in the fishery is another requisite. This two factors requires a direct knowledge of the people and how they interact not only with the fishery species-objective, but also with the variables the whole environment

In recent years several authors have pointed the importance of incorporate fisherman behaviour into the management model (Christensen & Raakjær 2002, Hilborn 1985, Curtis & McConnel 2004, Hyun & Ditton 2006) due mainly to the significative results obtained when this variable are incorporated in the management models. The behaviour of the fisherman related not only with when to go fishing but also where and how often could account for an spatial heterogeneity that so far have been consider relatively constant in the traditional management models (Wilen at al 2002).

The present work has the objective to model the habits of the fishermen of the asturian coast, regarding its relation with the environmental variables that may condition the fishery trip to catch barnacles.

METHODOLOGY

Data concerning the fishery habits of the fisherman from the cofradia of Cudillero, Asturias, Spain, were collected, in order to model its relation with certain environmental variables that may explain their fishery behaviour. It is important to highlight that the fishery season extends from October to April. After April, all fishermen abandon the barnacle fishery until the next season. Because of this, the capture data available only extends through this period of time for each campaign; implying that the whole period of time studied (4 campaigns in total) was treated as it would be continuous.

Study Area:

In order to try to establish the behaviour of the fisherman of gooseneck barnacle in the asturian coast, the catch of the Cudillero cofradía where studied. The cofradía port is located in the central area of the asturian coast, approximately 30 km west of cape Peñas, figure 1; the port is the main location from which the fisherman departures to collect the barnacle.

According with the management plan for the gooseneck barnacle in Asturias, each fisherman cofradía is assigned certain groups of rocks to harvest. Figure 1 presents the area assigned to the cofradia of Cudillero-Oviñana for the studied period, as well as the main rocks harvested in the area. The fishery area extends for approximately 32 km of the Asturian coast and includes 59 different localities.

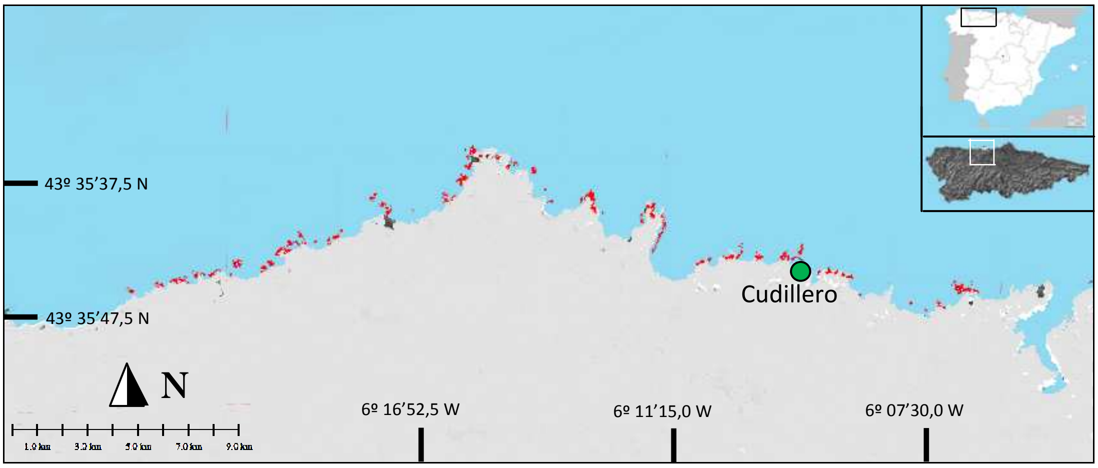

Figure 1: Location of the Cudillero cofradia in the cantabrian coast. The red dots indicate the main localities (rocks) from which the barnacle is extracted.

Fishery Data

Monthly fishery data regarding each fisherman where collected from the CEP (Centro de Experimentación Pesquera) archive, at Gijon, Asturias. The data included not only the extraction of barnacle on a daily base, but also the rock from which it was extracted. This detailed data allows to follow the behaviour of each fisherman in the area, on an individual base level.

The total period of time studied extend from October of 2007 until April 2011, having in mind that each fishery campaign extends only from October until April of the next year. A total 4 fishery campaigns were studied.

Oceanographic Data

The oceanographic data where obtained from the oceanographic buoy of Cabo Peñas. The data included parameters related with the characterization of the wave direction (medium wave direction), wave scalar measures (significant spectral height, average spectral period, peak period, maximum wave period and maximum wave height), general oceanographic data (Tº, Salinity, average current velocity) and meteorological data (atmospheric pressure, wind average velocity and direction). The wave data was collected at interval of 10 minutes, while the oceanographic and meteorological data was collected at interval of 26 min, at 3m above the sea free level in the case of meteorological data and at 3m depth for the oceanographic data. The buoy reports the data on an hourly base, so the data was pooled to obtain a single value for each variable, for each day of campaign.

The tidal information regarding the studied area was collected from the tide table of the Gijon port for the years 2007 – 2011, corrected for the local hour and for the locality of Cudillero.

Data Analysis

Logistic binomial models were fitted using the fishery data as the dependent variable and the oceanographic data as the independent variables, for each fishermen. Maximum likelihood criteria was used to estimate the main parameters in the regression models. The backward/forward methodology was used to estimate which variables/interactions should be included in the regression model. The Wald score was used to estimate the odd ratio of each parameter. Goodness of fit analysis were constructed to test the estimated parameters of the regression. R© software (version 2.15.1), associated with the Rcmd package (version 1.8-4) were used to fit all the regression models.

In order to test for possible associations of the regression coefficients among fishermen, classifications analyses were generated using PRIMER 6 software. Similarity matrices were constructed using the regression coefficients estimated previously and the euclidean distance index. Classification analyses were constructed including the SIMPROF routine (Clarke et al 2008) to test for significance among the conglomerates generated by the analysis.

RESULTS

Fisherman Selection:

Fishery data from a total 35 fisherman were collected from the Centro de Experimentación Pesquera for the studied period. Figure 2 present a comparison of the registered fishing days for each fisherman through the 4 campaigns. From the figure it is clear that there is a great variability in the annual activity among fisherman of this particular fishery. Some registered a very low frequency, only a couple of days a year, while other registered a high and relatively constant activity through each campaign.

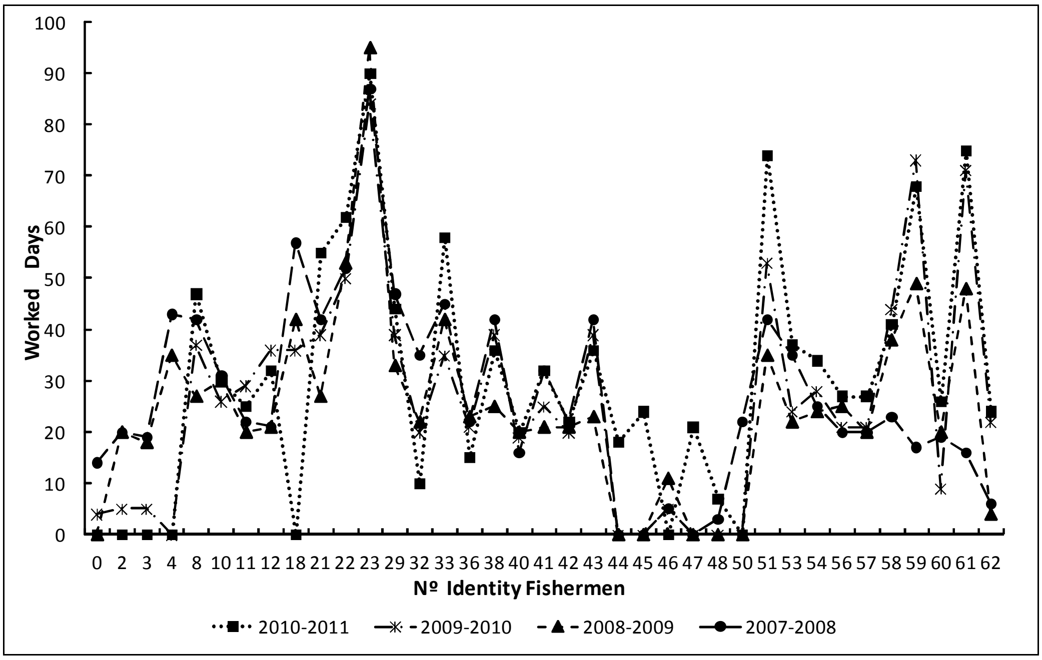

Figure 2: Fishery activity for each registered fishermen. Data collected from October 2007 to April 2011. Each campaign plotted separately, in order to appreciate the variation among fisherman, for each campaign.

Having in mind that for the estimation of the regression coefficients only the days with fishing activity are considered, and the fact that in order to obtain a good level of confidence for the regression coefficients it is needed a certain amount of data; a reduction in the amount of fisherman considered for the analysis was conducted.

The selection criteria consisted in discard those fishermen that were below the level of 80% of activity days for each campaign; considering as the 100% the fishermen with the highest activity for that campaign. In order to be considered for the analysis, a fisherman had to fulfil the criteria for at least 3 campaigns. A total of 20 fishermen were selected. Table 1 present the results of the reduction process.

Table 1: Reduction of fishermen based on the criterion of excluding those who were below the level of 80% of activity days for each campaign. The fishermen that didn't fit the requirements for all campaigns are marked in bold.

2010 - 2011			2009 - 2010			2008 - 2009			2007 - 2008		
Nº Fishermen	**Fished Days**	**Campaign Catch (kg)**	**Nº Fishermen**	**Fished Days**	**Campaign Catch (kg)**	**Nº Fishermen**	**Fished Days**	**Campaign Catch (kg)**	**Nº Fishermen**	**Fished Days**	**Seasonal Catch (kg)**
10	30	169	10	26	135	**4**	**35**	**187,5**	**4**	**43**	**228,5**
11	25	131	11	29	155,3	10	30	133,5	10	31	164,5
12	**32**	**202**	**12**	**36**	**206,5**	11	20	59	11	22	112
21	55	299,5	18	36	239	18	42	234,2	18	57	305,5
22	62	393,5	21	39	223,5	21	27	139,5	21	42	225
23	90	522	22	50	327,5	22	53	317	22	52	316,5
29	44	255,5	23	84	534,5	23	95	559	23	87	549,5
33	58	183,5	29	39	231,5	29	33	168	29	47	222
38	36	223	33	35	202,5	**32**	**22**	**107**	**32**	**35**	**188,5**
41	**32**	**175**	38	39	226	33	42	196,5	33	45	233
43	36	223	**41**	**25**	**159,5**	**36**	**23**	**103**	**36**	**22**	**121,5**
51	74	430	43	39	226	38	25	128,5	38	42	224,5
53	37	228,5	51	53	305,5	43	23	128,5	**41**	**32**	**181**
54	34	220	53	24	146	51	35	165,5	42	22	106,5
56	27	96,5	54	28	140	53	22	140,5	43	42	224,5
57	**27**	**123,5**	58	44	221,5	54	24	124,5	**50**	**22**	**108,5**
58	41	241	59	73	451,5	56	25	67	51	42	229
59	68	426,5	60	9	52	58	38	109	53	35	210
60	26	179	61	71	413	60	20	109,5	54	25	115,5
61	75	445,5	**62**	**22**	**124**	59	49	282	58	23	110,5
						61	48	238,5	60	19	128

For comparative purposes, it was decided to include fishermen 11 and 60, even when they fell slightly below the excluding criterion, since their inclusion could throw some light on the behaviour of that particular segment of fisherman. After the reduction, 20 fishermen were selected to continue the analisis. Fishermen 41 had to be excluded, even when he meets the selection criterion, due to inconsistence in their fishery registry.

Another issue to consider is the big gaps observed in the oceanographic data. There is no complete registry for any campaign, since there were always gaps in the data (big or small). The main consequence of this situation was the elimination of the complete data set, including the fishing data, for all the days in which a lack of continuity was detected. The extent to which this situation could affect the estimation couldn't be assed. The only certainty is the elimination of fishery days, consequently reducing the number of positive cases analyzed for each fisherman.

Logistic Regression:

Table 2 presents the results of the logistic regression coefficients and odds ratio for each selected variable and for each fisherman.

Table 2: Main logistic regression estimations of the B values, for each studied fisherman, from the forward/backward selection criteria. In parentheses the standard error for each estimated parameter. The significance of the estimations is presented with an asterisk key.

Fisherman Identification	Intercept	Max. Wave Height (m)	Tide Width (m)	Med. Curretn Velocity (cm/s)	Tide Coeficient	Med. Current Direction (º)
10	-0,5003 * (0,64)	-0,7048 (0,13)	0,4927 (0,18)			
11	4,0929 ** (1,5689)	-0,8787 ** (0,27)	1,6481 ** (0,57)	-0,1067 * (0,04)	-3,4125 . (1,9823)	
18	-0,0180 (0,58)	-0,6374 * (0,11)	0,3756 * (0,16)			
21	1,5231 * (0,39)	-0,7702 *** (0,1239)	0,1610 * (0,18)			
22	0,2369 (0,51)	-0,8109 *** (0,11)	0,5054 *** (0,14)			
29	-1,089 * (0,49)	-0,3324 * (0,08)	0,3375 *** (0,14)			
33	-0,2476 (0,57)	-0,6989 *** (0,11)	0,4464 ** (0,16)		-2,5362 . (1,44)	
38	1,7131 ** (80,65)	-0,8360 *** (0,13)	0,2075 (0,19)			
40	-0,5282 (0,87)	-0,9321 *** (0,19)	0,7182 ** (0,25)			
42	-0,5112 (0,87)	-1,122 *** (0,21)	0,8806 *** (0,26)			
43	0,9716 (0,68)	-0,6871 *** (0,12)	0,8127 * (0,36)		-2,5362 . (1,44)	
51	-0,3021 (0,59)	-0,4876 *** (0,09)	0,3761* (0,16)	-0,0278 . (0,02)		0,0016 . (0,0001)
53	-1,4806 ** (0,56)	-0,1951 * (0,16)	0,2698 (0,083)			
54	-2,0067 ** (0,67)	-0,2986 ** (0,19)	0,4555 * (0,11)			
56	0,9126 (0,88)	-0,8661 *** (0,19)	0,5490 * (0,23)			-0,0031 * (0,001)
58	-1,9067 ** (0,69)	-0,6884 *** (0,14)	0,8720 *** (0,2)			
59	0,9261 ** (0,008)	-0,4634 *** (0,09)	-0,0150 (0,05)			
60	-1,2958 (0,84)	-0,5562 *** (0,15)	0,58 ** (0,22)	0,0407 (0,03)		
61	0,4576 (0,58)	-0,3854 *** (0,09)	0,24 (0,16)	-0,0332 . (0,01)		

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The table shows that for the majority of the fisherman studied, only 2 variables were selected. In five fisherman 3 variables were selected and only in two cases, 4 variables were selected.

Maximum wave height and tide width were the most frequently selected variables, being selected for all the studied fisherman with very high significant levels and relatively low standard error values.

Median current velocity, tide coefficient and median current direction also were selected for some of the cases, never the less, this variables presented very low regression coefficients, as in the case of median current direction, theirs standard error were very high or the significance level were very low. This poor results for this variables suggest than they may be eliminated from the general model without losing much resolution.

For comparison porpoises, a new regression model was run for each fishermen superimposing the parameters maximum wave height and tidal width as the regression explicative variables. Table 2 presents the results. Figure 2 present a comparison between the estimated B values, for each fisherman.

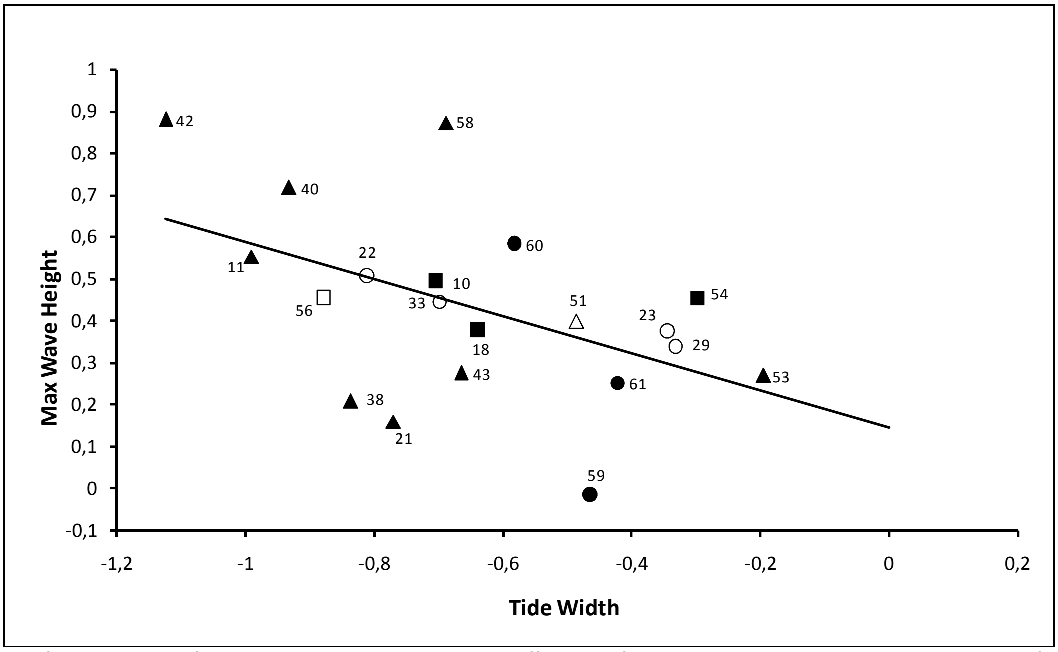

Figure 3: Comparison of the estimated regression coefficient of max. wave height and tidal width. Information regarding the annual frequency of catch (only during part of the season in triangles, all the season in circles and variations campaign to campaign in squares) and the means of collection (by boat in full figures or by foot in empty figures) are added to the graphic. Regression coefficient of b= -0.4031(F: -3.636, p: 0.001%) and m= -0.5583 (F: -2.427, p: 0.01%), residual ST=0,22, 18 df. Variable

Table 3: Estimation of the regression coeficients using maximum wave height and tide width as regressors. In parenthesis standard error (for estimation of B parameters) and 95% confident interval (for odds ratio.). The significance of the estimations is exhibited an asterisk key.

	ESTIMATION B COEFICIENT			ODDS RATIO		
Fishsermen	**Intercept**	**Max. Wave Height**	**Tide Width**	**Intercept**	**Max. Wave Height**	**Tide Width**
33	-0,2476 (-0,57)	-0,6989 *** (0,1199)	0,4464 ** (0,1603)	0,7806 (0,22 - 2,38)	0,4971 (0,39 - 062)	1,5626 (1,14 - 2,13)
38	1,7131 ** (0,6526)	-0,836 *** (0,1328)	0,2075 (0,1901)	5,5459 (1,54 - 19,92)	0,4334 (0,33 - 0,56)	1,2305 (0,84 - 1,78)
10	-0,5003 (0,661)	-0,7048 *** (0,1348)	0,4927 ** (0,1896)	0,6063 (0,17 - 2,15)	0,4942 (0,37 - 0,64)	1,6366 (1,28 - 2,37)
21	0,6232 * (0,1239)	-0,7702 *** (1239)	0,161 (0,1822)	4,5865 (1,35 - 15,55)	0,4629 (0,36 - 0,59)	1,1747 (0,82 - 1,67)
22	0,2369 (0,5162)	-0,8109 *** (0,1154)	0,5054 *** (0,1482)	1,2672 (0,46 - 3,48)	0,4444 (1,23 - 2,21)	1,6576 (0,35 - 0,55)
29	-1,0829 * (0,4993)	-0,3324 *** (0,0861)	0,3375 * (0,1466)	0,3385 (0,12 - 0,89)	0,7171 (0,60 - 0,84)	1,4015 (1,05 - 1,87)
43	0,5973 (0,6496)	-0,6652 *** (0,1270)	0,2761 (0,1932)	0,8172 (0,50 - 6,49)	0,5141 (0,40 - 0,65)	1,3179 (0,90 - 1,92)
51	-0,3368 (0,5225)	-0,4856 *** (0,0984)	0,3986 ** (0,1545)	0,714 (0,25 - 1,98)	0,6152 (0,51 - 0,74)	1,4897 (1,10 - 2,01)
53	-1,4806 ** (0,5633)	-0,1951 (0,0838)	0,2698 (0,1635)	0,2274 (0,07 - 0,68)	0,8226 (0,69 - 0,96)	1,3097 (00,94 - 1,81)
54	-2,0097 ** (0,6743)	-0,2986 ** (0,1123)	0,4555 * (0,1926)	0,1344 (0,03 - 0,50)	0,7418 (0,59 - 0,92)	1,577 (1,08 - 2,30)
58	-1,9067 ** (0,6934)	-0,6884 *** (0,1415)	0,872 *** (0,2002)	0,1485 (0,03 - 0,57)	0,5023 (038 - 0,66)	2,3916 (1,61 - 3,54)
18	-0,0180 (0,5820)	-0,6374 *** (0,1166)	0,3775 * (0,1691)	0,9721 (0,31 - 3,07)	0,5286 (0,42 0,66)	1,4559 (1,04 - 2,02)
56	-0,0599 (0,7880)	-0,8797 *** (0,1837)	0,4533 * (0,2268)	0,9417 (0,20 - 4,34)	0,4148 (0,28 - 0,59)	1,5736 (1,00 - 2,45)
42	-0,5112 (0,8689)	-1,1236 *** (0,2149)	0,8806 **** (0,2624)	0,5997 (0,10 - 3,29)	0,3251 (0,21 - 0,49)	2,5124 (1,44 - 4,03)
40	-0,5282 (0,8731)	-0,9321 *** (0,1961)	0,7182 ** (0,2586)	0,5896 (0,10 - 3,26)	0,3937 (0,26- 0,57)	2,0507 (1,23 - 3,40)
11	0,0635 (0,9676)	-0,9911 *** (0,2393)	0,5530 . (0,2877)	1,0656 (0,15 - 7,09)	0,3711 (0,23 - 0,59)	1,7385 (0,98 - 3,05)
59	0,9261 ** (0,3500)	-0,4634 *** (0,0965)	-0,015 (0,0531)	2,5248 (1,27 - 5,01)	0,6291 (0,52 - 0,76)	0,9851 (0,88 - 1,09)
60	-1,6863 * (0,7925)	-0,5832 *** (0,1562)	0,5827 ** (0,2199)	0,1851 (0,03 - 0,87)	0,5581 (0,41 - 0,75)	1,7909 (1,16 - 2,75)
61	0,1133 (0,5537)	-0,4227 *** (0,0952)	0,2529 (0,1661)	1,2007 (0,37 - 3,31)	0,6552 (0,54 - 0,78)	1,2878 (0,92 - 1,78)
23	-0,0157 (0,4118)	-0,3435 *** (0,0662)	0,3737 ** (0,1252)	0,9843 (0,43 - 2,20)	0,7092 (0,62 - 0,80)	1,4546 (1,13 - 1,85)

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Table 4: Clasification table for the estimated models

			Expected		
			No_Fish	Fish	Correct Percentage
			0	1	
10	Observed	No_Fish	377	7	98,2%
		Fish	89	5	5,3%
11	Observed	No_Fish	207	1	99,5%
		Fish	46	3	6,1%
18	Observed	No_Fish	222	10	95,7%
		Fish	72	9	11,1%
21	Observed	No_Fish	212	48	81,5%
		Fish	78	59	43,1%
22	Observed	No_Fish	372	43	89,6%
		Fish	126	50	28,4%
23	Observed	No_Fish	460	3	97,5%
		Fish	175	6	3,0%
29	Observed	No_Fish	477	0	100,0%
		Fish	132	0	0,0%
33	Observed	No_Fish	343	26	93,0%
		Fish	102	27	20,9%
38	Observed	No_Fish	176	54	76,5%
		Fish	66	70	51,5%
40	Observed	No_Fish	245	4	98,4%
		Fish	52	4	7,1%
42	Observed	No_Fish	256	0	100,0%
		Fish	63	0	0,0%
43	Observed	No_Fish	188	40	82,5%
		Fish	78	36	31,6%
51	Observed	No_Fish	344	43	88,9%
		Fish	140	40	22,2%
53	Observed	No_Fish	268	0	100,0%
		Fish	68	0	0,0%
54	Observed	No_Fish	377	3	99,2%
		Fish	82	1	1,2%
56	Observed	No_Fish	300	1	99,7%
		Fish	66	0	0,0%
58	Observed	No_Fish	267	2	99,3%
		Fish	68	0	0,0%
59	Observed	No_Fish	275	47	86,4%
		Fish	121	46	27,5%
60	Observed	No_Fish	239	1	99,6%
		Fish	33	0	0,0%
61	Observed	No_Fish	253	42	86,8%
		Fish	236	37	22,7%

Table 2 shows that again, the maximum wave height and the tidal width presented good significant level for the regression coefficients, associated with relatively low standard errors. The odds ratio shows that for tidal width, the coefficient is higher than one, for all fishermen, indicating a positive relation of this parameter with the expected event (the higher the tidal width value, the probability of fishery is higher). For fisherman 59, the odds ratio for this coefficient was 0.9851, never the less, the significant level of estimation was very low.

On the other hand, the maximum wave height presented a negative relation with expected response variable, given its lower than 1 odds ratio values, indicating that the higher the value of the wave height there are less probability for a fisherman to go fishing. It is important to highlight that this is a pattern that can be observer in all the fishermen analysed.

Figures 3 present the relation of the estimated B coefficients for max. wave height and tidal width. The figure suggests an inverse linear relation between the estimated regression coefficients among the fishermen. No clear pattern of fishery means could be observer from the figure.

The existence of a linear relation between the coefficients would imply that there is a gradient in the conduct of the fishermen, being influenced differentially by the same variable. On the other hand, the figure also suggests that not all the fishermen behave the same under the same variables, and that may be some seasonal differential behaviour, given the slight grouping patterns suggested in figure 2.

Figure 4 present the evaluated models for some example fisherman. Figures show a slight difference between fisherman, wiyh those close to the upper left of the regression line from figure 3, presenting probability lines above 0.5 closer en between than the one of the fishermen located at the other extreme of the regression line. This particular patter of distribution of the probability could be indicating that those fishermen are more susceptible to the tide width and wave height, requiring more extreme values in order to obtain a positive response (to go to fishing); compared with the fishermen of the extreme right of figure 3.

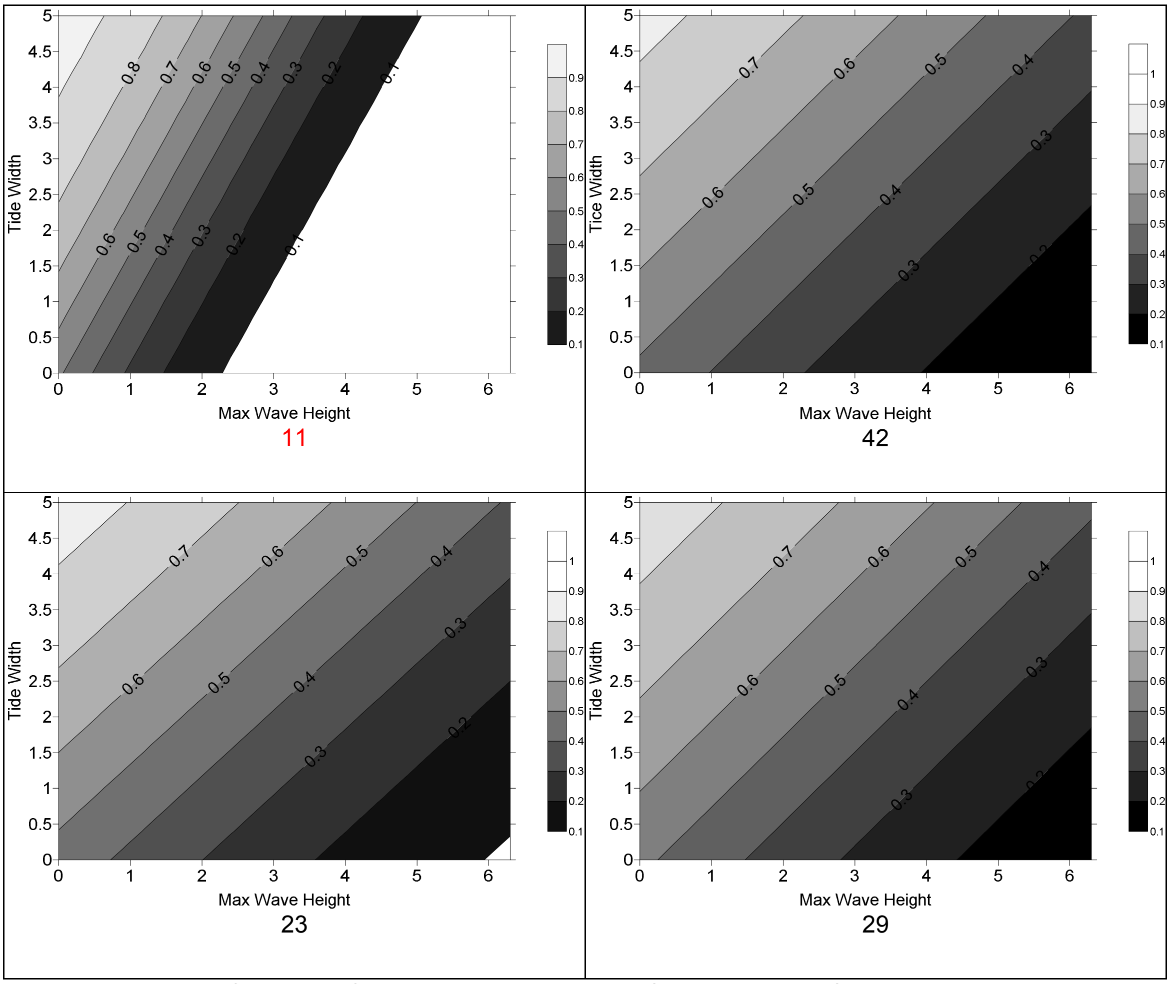

Figure 4: Isolines of probility for the evaluated models of some example fishermen. The probability lines are spaced every 0.1 points.

Seasonal Logistic Regression:

In order to try to elucidate if there is a seasonal catch pattern, each campaign was divided in two periods: from October to December (expected higher extraction rates) and January to April (expected lower extraction rates). New models were constructed for each fisherman and for each period of the campaign. Table 5 present the results for the October to December period and table 6 present the result for the January to April period. Figure 5 present a graphical comparison of the estimated regression coefficients for max. wave height and tidal width.

Table 5: Estimations of the B parameters for maximum wave height and tide width, October-December campaigns. In parenthesis the standard error for the B parameter estimation and the confidence interval (95%) for the odds ratio.

	Estimation of B parameter			Odds Ratio		
Fisherman nº	Intercept	Max. Wave Height (m)	Tide Width (m)	Intercept	Max. Wave Height (m)	Tide Width (m)
10O-D	0,3232 (,7651)	-0,8632 *** (-0,1623)	0,4943 * (-0,2282)	1,3815 (0,30 - 6,18)	0,4217 (0,30 - 0,57)	1,6393 (1,04 - 2,56)
11O-D	0,4125 (1,0281)	-1,0617 *** (0,2631)	0,509 (0,2989)	1,5106 (0,20 - 11,33)	0,3458 (0,92 - 0,57)	1,6635 (0,92 - 2,98)
18O-D	-0,0169 (0,7683)	-0,7086 *** (0,1339)	0,7003 ** (0,2446)	0,9832 (0,21 - 4,43)	0,4923 (0,37 - 0,64)	2,0143 (1,24 - 3,25)
21O-D	1,7323 * (0,6930)	-0,8402 (0,1365)	0,2551 (0,2077)	5,6534 *** (1,45 - 21,98)	0,4315 (0,33 - 0,56)	1,2906 (0,85 - 1,93)
22O-D	1,3956 * (0,7104)	-0,917 *** (0,1472)	0,4168 . (0,2135)	4,0374 (1,00 - 16,24)	0,3997 (0,29 - 0,53)	1,5171 (0,99 - 2,30)
23O-D	-0,3512 (0,5790)	-0,3131 *** (0,0809)	0,5992 ** (0,1974)	0,7038 (0,22 - 2,18)	0,7311 (0,62 - 0,85)	1,8087 (1,22 - 2,66)
29O-D	0,1579 (0,6707)	-0,5547 *** (0,1191)	0,3443 . (0,2079)	1,171 (0,31 - 4,36)	0,5742 (0,45 - 0,72)	1,411 (0,93 - 2,12)
33O-D	0,5350 (0,7251)	-0,8726 *** (0,1511)	0,575 ** (0,2201)	1,7073 (0,41 - 7,07)	0,4178 (0,31 -0,56)	1,7771 (1,15 - 2,73)
38O-D	1,8038 ** (0,7001)	-0,8807 *** (0,1401)	0,2829 (0,2093)	6,0729 (1,53 - 23,95)	0,4144 (0,31 - 0,54)	1,3270 (0,88 - 1,99)
40O-D	-1,0012 (1,0036)	-1,0034 *** (0,214)	1,0411 *** (0,3071)	0,3674 (0,05 - 2,62)	0,3666 (0,24 - 0,57)	2,8323 (1,55 - 5,17)
42O-D	-0,7250 (0,8951)	-1,0693 *** (0,2156)	0,9356 *** (0,2692)	0,4843 (0,08 - 2,79)	0,3432 (0,22 - 0,52)	2,5489 (1,50 - 4,32)
43O-D	0,5878 (0,6886)	-0,6821 *** (0,131)	0,3412 (0,21)	1,7997 (0,46 - 6,94)	0,5055 (0,39 - 0,65)	1,4067 (0,93 - 2,12)
51O-D	0,4192 (0,6476)	-0,6049 *** (0,1145)	0,454 * (0,2045)	1,5207 (0,42 - 5,41)	0,5461 (0,43 - 0,68)	1,5746 (1,05 - 2,35)
53O-D	-0,7845 (0,7175)	-0,4788 *** (0,123)	0,4651 * (0,2225)	0,4563 (0,11 - 1,86)	0,6195 (0,48 - 0,78)	1,5922 (1,02 - 2,46)
54O-D	-1,1998 (0,7670)	-0,439 *** (0,1292)	0,4708 * (0,2366)	0,3012 (0,06 - 1,35)	0,6446 (0,50 - 0,83)	1,6012 (1,007 - 2,54)
56O-D	0,7676 (0,9437)	-1,2328 *** (0,2472)	0,4552 . (0,2689)	2,1544 (0,33 - 13,69)	0,2914 (0,17 - 0,47)	1,5764 (0,93 - 2,67)
58O-D	-1,6025 . (0,8677)	-0,8481 *** (0,1779)	1,1092 *** (0,2717)	0,2013 (0,03 - 1,10)	0,4282 (0,30 - 0,60)	3,0322 (1,78 - 5,16)
59O-D	0,1758 (0,8008)	-0,4448 *** (0,1209)	0,4087 (0,2582)	1,1922 (0,24 - 5,72)	0,6409 (0,50 - 0,81)	1,5049 (0,90 - 2,49)
60O-D	0,2574 (1,4274)	-1,0212 *** (0,2917)	0,4729 (0,3812)	1,2935 (0,07 - 21,22)	0,3601 (0,20 - 0,63)	1,6045 (0,76 - 3,38)
61O-D	-1,1239 (0,9388)	-0,4826 (0,1281)	1,0218 (0,3373)	0,3250 (0,05 - 2,04)	0,6171 (0,48 - 0,79)	2,7782 (1,43 - 5,38)

Table 6: Estimations of the B parameters for maximum wave height and tide width, January-April campaigns. In parenthesis the standard error for the B parameter estimation and the confidence interval (95%) for the odds ratio.

	Estimation of B parameter			Odds Ratio		
Fisherman nº	Intercept	Max. Wave Height (m)	Tide Width (m)	Intercept	Max. Wave Height (m)	Tide Width (m)
10J-A	-4,9685 (1,9112)	-0,4801 (0,347)	1,3296 * (0,5351)	0,006 (0,0001 - 0,29)	0,6187 (0,31 - 1,22)	3,7794 (1,32 - 10,78)
11J-A	-3,8097 (3,6880)	-0,6623 (0,6862)	1,361 (1,2682)	0,0221 (0,000 - 30,52)	0,5156 (0,13 - 1,97)	3,9000 (0,32 - 46,83)
18J-A	-1,3617 . (0,7007)	-0,4913 *** (0,1347)	0,2000 (0,2295)	0,2562 (0,06 - 1,011)	0,6118 (0,46 - 0,79)	1,2214 (0,77 - 1,91)
21J-A	-1,9350 (2,2595)	-0,3716 * (0,3926)	0,3084 . (0,6019)	0,1444 (0,001 - 12,10)	0,6895 (0,31 - 1,48)	1,3612 (0,41 - 4,42)
22J-A	-0421 * (0,9240)	-0,9247 *** (0,2343)	1,0647 *** (0,2723)	0,1297 (0,021 - 0,79)	0,3966 (0,25 - 0,62)	2,8999 (1,70 - 4,94)
23J-A	0,3370 (0,6235)	-0,4951 *** (0,123)	0,2707 (0,1721)	1,4006 (0,41 - 4,75)	0,6095 (0,47 - 0,77)	1,3108 (0,93 - 1,83)
29J-A	-4,1381 *** (1,0158)	0,01359 ** (0,1392)	0,69709 (0,265)	0,00159 (0,0021 - 0,11)	1,0136 (0,77 - 1,33)	2,0079 (1,19 - 3,75)
33J-A	-3,2635 * (1,3021)	-0,6346 * (0,2802)	0,9675 ** (0,3478)	0,0382 (0,002 - 0,49)	0,5301 (0,30 - 0,91)	2,6312 (1,33 - 5,20)
38J-A	-0,9281 (2,9097)	-0,4281 (0,6458)	-0,0202 (0,746)	0,3952 (0,0013 - 118,49)	0,6517 (0,18 - 2,31)	0,9800 (0,22 - 4,22)
40J-A	-0,7543 (2,4963)	-0,3997 (0,4463)	-0,1489 (0,7337)	0,4703 (0,003 - 62,70)	0,6704 (0,27 - 1,60)	0,8615 (0,20 - 3,62)
42J-A	1,468 (5,775)	-3,964 (3,896)	1,889 (3,2557)	4,3407 (0,000 - 35763,3)	0,00189 (0,000 - 39,33)	6,6118 (0,001 - 3915,2)
43J-A	-1,0205 (2,9322)	-0,4476 (0,66)	0,0343 (0,7428)	0,3604 (0,001 - 112,9)	0,6391 (0,17 - 2,33)	1,0348 (0,24 - 4,43)
51J-A	-3,4149 ** (1,3099)	-0,6124 * (0,2690)	1,0900 ** (0,3673)	0,0328 (0,002 - 0,42)	0,5406 (0,31 - 0,91)	2,9741 (1,44 - 6,10)
53J-A	-4,3342 *** (1,2723)	0,2648 * (0,1277)	0,409 (0,329)	0,0131 (0,001 - 0,15)	1,3032 (1,01 - 1,67)	1,5053 (0,79 - 2,86)
54J-A	-2,5089 * (1,0350)	-0,3789 . (0,2119)	0,5224 . (0,2815)	0,0813 (0,01 - 0,61)	0,6845 (0,45 - 1,03)	1,6861 (0,97 - 2,92)
56J-A	-1,9070 (1,6411)	-0,2177 (0,2211)	0,4257 (0,4347)	0,1641 (0,006 - 4,09)	0,8043 (0,52 - 1,24)	1,5306 (0,65 - 3,58)
58J-A	-4,1102 ** (1,4738)	-0,5292 . (0,2841)	1,1232 ** (0,3934)	0,0164 (0,0009 - 0,29)	0,5890 (0,33 - 1,02)	3,0747 (1,42 - 6,64)
59J-A	1,4286 * (0,5632)	-0,7846 *** (0,1983)	-0,04 (0,0562)	4,1731 (1,38 - 12,58)	0,4562 (0,30 - 0,67)	0,9607 (0,86 - 1,07)
60J-A	-2,8296 ** (1,0303)	-0,344 . (0,1907)	0,6513 * (0,2815)	0,0590 (0,007 - 0,44)	0,7089 (0,48 - 1,03)	1,9179 (1,10 - 3,32)
61J-A	0,8105 (0,7610)	-0,6473 *** (0,1795)	0,06926 (0,2129)	2,2492 (0,50 - 9,99)	0,5234 (0,36 - 0,74)	1,0717 (0,70 - 1,62)

Table 5 shows that the tidal width and max. wave height still have very high significance values for most of the fishermen for the October–December period. The standard error also presented very good values for the estimated coefficients. In general, the values of the coefficients were similar to those observed for the correlation considering both periods.

Table 6 shows that only 12 fishermen got a good significance level for the period of January –Abril for max wave height, as for tide width, only 8. Standard errors are also higher, especially for those fishermen with non significance estimation.

Figure 5 present a comparison of the estimated coefficients for both periods, for each fishermen.

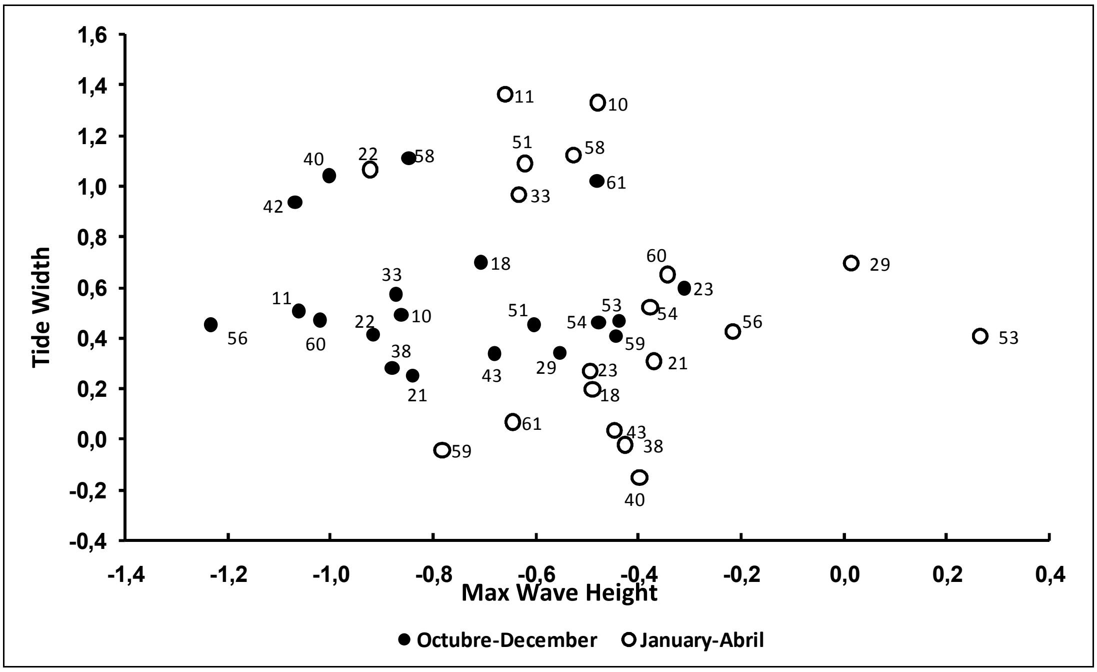

Figure 5: Comparison of the estimated regression coefficients for maximum wave height and tide width, for the period of October-December and January-April, for each fishermen.

The figure shows that mostly of the October-December coefficients are grouped in the lower left part of the graphic while most of the January-April coefficients are grouped in the upper and right zone of the figures.

This results may suggest a seasonal pattern of fishery, which is different for each fisherman, since for some of them, the level of significance of the coefficients of Oct-Dic are much better than those of Jan-Apr, while for other, significance doesn't seams to change much from period to period.

To further elucidate the intra-campaign pattern of catch of each fishermen, a cluster analysis was conducted. The dendrogram was constructed using a similarity matrix calculated using the euclidean distance and the respective regression coefficients. Given the high level of standard error of the Jan-Apr regression coefficients estimations of some fishermen, it was decided to not include these results in the analysis. To balance the model, the estimations for the Oct-Dec for those fishermen also were removed. The excluded fishermen were numbers 11, 30, 40, 42, 43 and 56, which registered the highest standard errors and no significant level for the coefficient estimations of the January-April period.

Figure 3 present the results of the classification analysis.

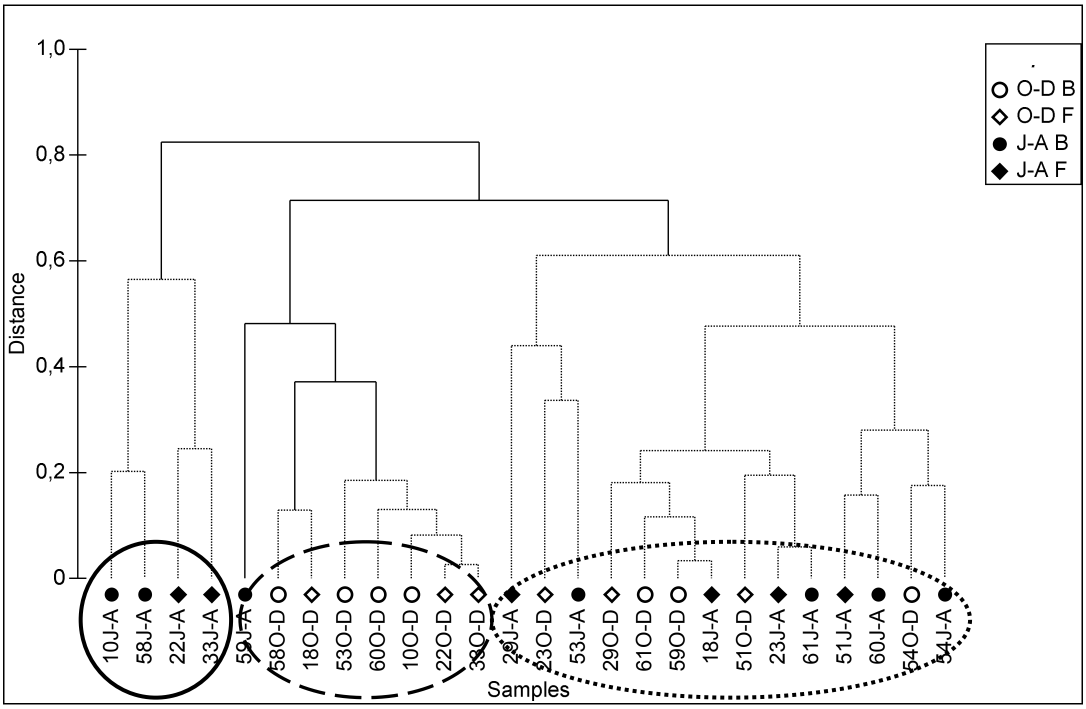

Figure 6: Dendrogram of the association of the regression coefficient values of maximum wave height and tide width for the selected fishermen. Information regarding the movement means of the fishermen (B for boat in circles, F for foot in diamond) and the seasonal variation (in empty figures for October-December and full figures for January-April) are included. Dotted lines indicate non-significant clusters, while full line indicates clusters with 10% significance.

From figure 6 it is possible to observe the formation of at least 3 significant clusters. The first cluster, located at the extreme left of the figure (full line circle), is formed exclusively of estimation from the January-April regression group. Next to it, there is another cluster (second cluster in spaced line circle), formed exclusively of estimation from the October-December period. It is important to highlight that this 2 clusters are complementary among them, since the all fishermen positioned in the first cluster (January-April) are also present in the second cluster (October-December). The later cluster also contains some fishermen from the third and last cluster formed (in dotted line circle). This third cluster contains data bellowing to the period of October-December and January-April but from the same fisherman, implying that this fishermen registered similar regression coefficients for both periods.

Fisherman 59 registered a particular behaviour for the January-April period that shows more similarity with the second cluster, never the less, their October-December behaviour registered more similarity with the third cluster. The inverse behaviour can be observed for the fishermen 18, where it October-December period presented more similarity with the second cluster, but its January-April period was grouped with the third cluster.

No clear distinction of the means of transport used by the fishermen was observed, since it is possible to detect foot-fishermen and boat-fishermen in all the registered clusters.

For fisherman 23, that belongs to the third cluster, almost no change can be observed in the probability lines of the figure. For fisherman 22, which its October-December data belong to the first and second cluster, it can be observe a clear change in the probability lines that shows a greater influence in the values of wave height and tide width during the period of January-April that in the period of October-December, where this fisherman can tolerate higher values of wave height and lower values of tide width.

The ordination analysis shows that there is possible to distinguish 3 types of fisherman, based on the level of their regression coefficients: those that don’t registered a mayor change in the response along the whole campaign (first group), those that behave differentially during October-December and during January-April (second group) and those that just have one period of fishing, that should be October-December (third group).

The first group don't respond very much to the oceanographic variables tested in the analysis. The analysis shows that it is expected that this group of fisherman goes to fishing with median values of tide width, and relatively moderate to high values of wave height. This behaviour doesn't present a considerable change along the campaign. During October to December they could exhibit a behaviour a little more "risky", since they are expected to go to fishing with higher wave heights and lower tide width. That could imply that for this particular group if fisherman, there are another factors that may be more important than the oceanographic characteristics alone at the moment to deciding when to go to fish.

The second group of fisherman presented a differential behaviour during the studied period. From October to December, they are expected to go fishing with more elevated levels of waves and slightly lower levels of tide width, similar to the behaviour of the first group. Never the less, their behaviour change during the January-April period, since they become more susceptible especially to wave height. The cause to this sequential behaviour can't be explained by the change in the oceanographic conditions alone, since there is a whole group of fishermen that still keep on fishing at the same levels, during all the campaign; so it is expected that the factors that determine the fishing trips for this group during the second period could be related with socio-economic variables.

The third group of fishermen wasn't directly detected by the analysis, but it is the group that presented very good estimation of the regression parameters for the October-December, but registered very poor significance level for the period January-April. It is assumed that this group of fishermen only goes to fishing during the first period of October-December, and during the second period reduces their fishing trip to almost cero. They also registered very high standards errors for the January-April period, that may be attributed to the lack of fishing days.

Figures 7 present an evaluative curve for some representative fishermen from each of the detected clusters. From the figure it is possible to observe difference in the levels curves from one type of fishermen to other, and the seasonal change in the regression parameters, that is reflected in the level curves.

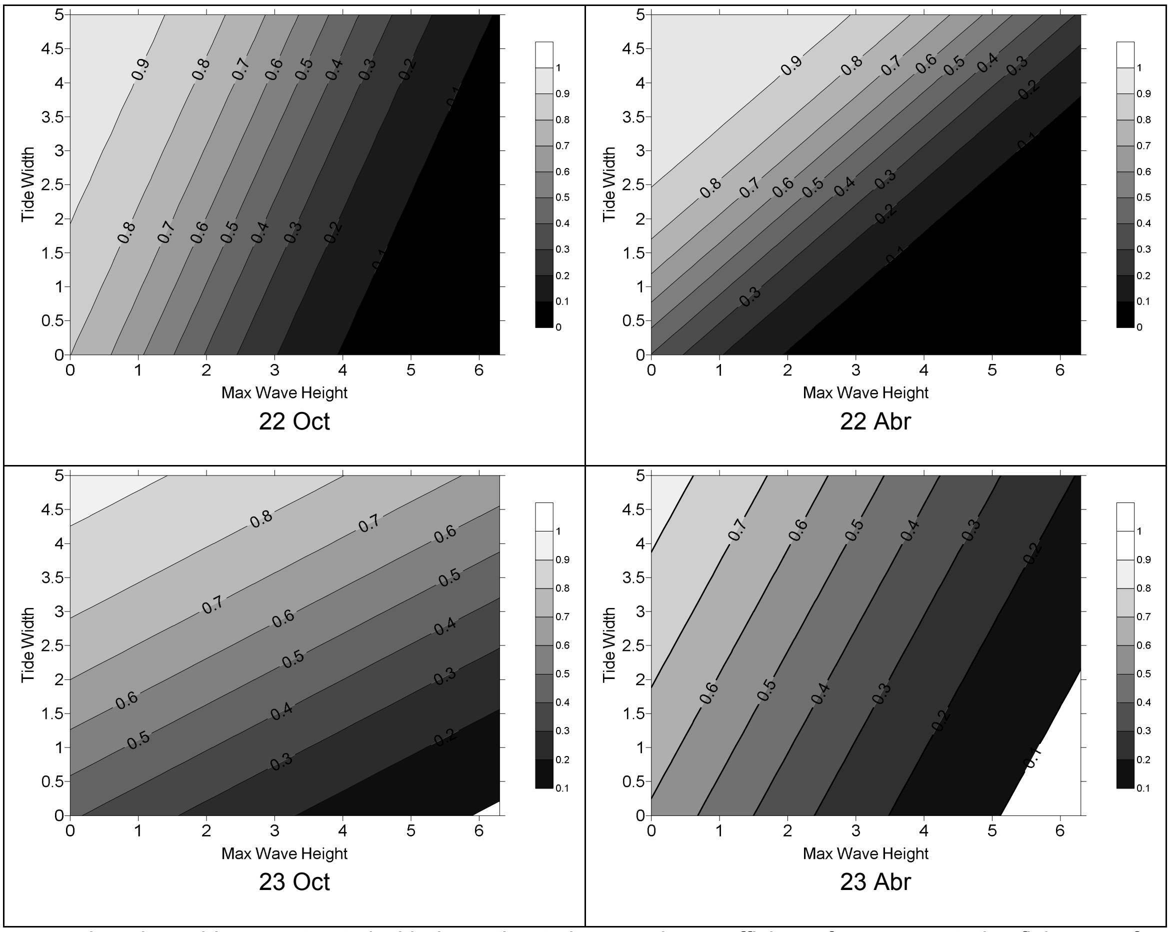

Figure 7: Level graphics constructed with the estimated regression coefficients for representative fishermen from each of the three detected clusters. Figure 22_J-A from cluster 1 (fisherman 22), figure 22 O-D from cluster 2 (Fisherman 22) and figure 23 O-D and 23 J-A from cluster 3 (fisherman 23). Level lines at 0.1 probabilities.

DISCUSSION

Even when the models don’t registered optimal values of prediction, there is a tendency that can be observed across all the fishermen analyzed, and also across all the regression models generated: the maximum wave height and the tidal width are the 2 variables that were selected, for mostly of the fishermen as the one that could better explain the data set. Given the nature of the habitat of the gooseneck barnacle (De la Hoz & Garcia) and the fishing gear used for its extraction (Molare & Freire 2010) it would be expected that this particular variables would determinate better the decision of going fishing or not.

The lack of prediction of the generated models could be explained due to the high variability of the collected data. This variability could be the natural consequence of the variability of the fishermen. It is expected that each fisherman has its own idiosyncrasy that could be unique, or could be share with other fisherman depending on sociological and personal factors. This situation also could suggest the influence of other factors that are not evaluated in the present study. It is important to have in mind that the fishery activities have an intrinsic economic nature, since fishermen go to fish because there is an economic reward.

It is possible to gather information regarding the market price of the barnacle at the Lonja , but the actual behaviour of the fisherman and the technological means that now are at his disposal complicate the correct assessment. It is uncertain of the barnacle sell at any given day really was captured that day, since the cudillero cofradia has a frigorific chamber in which the products can be stored. This situation leaves the door open to the eventuality that one given fisherman goes to fishing one day, with some oceanographic characteristics, but finally sells the products 2 or 3 days later.

Another uncertainty comes from the actual fishery forms collected by the CEP in Gijon. This forms a filled by the fisherman itself and there is no way to actually determine if the form was filled the day that the fisherman went to fish, or when he finally sells its product at the Lonja.

These issues are directly related with the nature of the gooseneck barnacle fishery and should need to be considered in order to accomplish a better assessment of the fisherman behaviour.

Other source of uncertainty comes from the data set used to generate the models. The data gaps of the oceanographic buoy could have introduced a source of error that is complicate to evaluate, mainly by the elimination of effective fished days, because of the lack of the correspondent oceanographic data. Considering that the accuracy of any logistic regression comes mainly from the amount of data collected (Hosmer & Lemeshow 1989, Kleinbaum & Klein 2010), meaning that the response variable adjusted has to have an adequate amount of positive cases to compare among the negative ones. If by any reason the amount of positive cases is reduced, it is also expected a reduction in the confidence of the analysis, to an extend that also depends in the amount of positive cases; meaning that if there are enough positive cases, the deletion of some wouldn't affect much the estimation. If on the other hand, there is not enough positive cases or this are scarce after the deletion, as in the seasonal fisherman may occur, the consequences of deleting some data could be meaningful for the estimation. This particular situation could be the cause of the low significance levels observed in some of the regression models generated for January-April data sets, implicating that some fisherman may have a marked seasonal behaviour.

In any of the above mentioned cases, the best solution is to increase the amount of data collected, in order increase the confidence level of the estimation and compensate for the observed variability. A more accurate collection of fishery data, an increase in this historical data and a better historical oceanographic data could increase the level at which the estimator of the fisherman behaviour are carried.

Never the less, and considering all the above implications, a general pattern of the variables that condition the fishery response in the fisherman of Cudillero could be observed from the carried analysis: tide width and wave height are important in determining whether a fisherman goes to fishing or not.

On the other hand, not all the fishermen are expected to respond the same way to the same oceanographic variables. Figures 3 suggest an inverse linear relation in the estimated coefficients for max. wave height and tide width, implicating a differential behaviour, in the sense that some fishermen would require less tide width to obtain a positive response, while other require wider amplitudes to obtain a positive response.

A similar situation can be observed for the wave height, the estimated coefficients suggest a differential behaviour for some fishermen that may go for fishing at higher values. It is important to highlight that fishermen less sensitive to wave height were also less sensitive to tide width.

The linear relation presented in figure 3 not only presents a gradient in the response to oceanographic variables, but could also being suggesting to some extent a social behaviour towards this variables, some fishermen could afford to go fishing with lower tides or higher waves and take some more risk, maybe because they know better the fishery grounds or maybe because their socio-economical stimuli is greater (family fisherman vs single one). The variation in the valuation that different fisherman does to the socio-economical environment has been point before for Chistensen and Raakjær (2006).

The fishery statistics suggest a marked seasonal change in the quantity of the extracted gooseneck in the asturian coast between December and the rest of the season, due not only to the greater amount of barnacle extracted in this period, but also to the greater number of fishermen activity. The analysis shows that this change in the catches also comes with changes in the relative response to the oceanographic variables analyzed. Some fishermen does not seems to be greatly affected by the oceanographic conditions long the year, while others seems to change their susceptibility based along the campaign.

The decision to where and when to go fishing is complex (Andersen & Chistensen 2005) and may not have an entirely economic base, as it has pointed by Béné & Tewfik (2001) and North (1995). Never the less, in this particular case, the higher catches from the October-December period, as well as the less susceptibility to the analyzed oceanographic variables points to the direction that this particular fishermen may have an economic base stimuli.

On the other hand, it is very valuable the option to actually analyze first hand data regarding the catches for a fisherman on an individual base. Freire & Garcia-Aluut (2000) point the importance of collection of catch statistics directly from the fishermen, that has the advantage not only to save economical and time resources needed for direct assessment, but also has the advantage of direct real time stock information.

The present study indicates that the fisherman of barnacle from the Cudillero cofradia present an heterogeneous behaviour regarding the activity that is not only related with the variations in the catches itself, but also suggest a differential valuation of the oceanographic conditions along the year. This results imply that the behaviour of the fishermen should be taken in account in the tailor of the management measures

CONCLUSION

- The main variables affecting the fishery behaviour of the Cudillero fisherman were the maximum wave height and the tide width
- This variables were highly significative for all the fishermen studied, under all the models constructed
- The studied fishermen registered a differential response to this variables
- In general, the wave height presented a negative influence in the fishing behaviour, in contrast, the tide width presented a positive influence in the fishing behaviour of the fishermen
- The behaviour of the fishermen presented a seasonal influence, also related with response to the wave height and the tide width.
- Some fishermen presented the same response to this variables along all the campaign
- Some fishermen presented a more “risky” behaviour during October-December, while during January-April registered a more “conservative” behaviour

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And finally, but not last, I like to dedicate this work to my family, for their support and patience during all this process. Without you I still could be here, but I wouldn’t be the person that I`m now, for sure. My ray of light, thanks you for being “here”, you sure know what I mean.

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