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Analysis of coastal impact in Basque Country

Gaztelumendi S.[1,2], Egaña J.[1,2], Liria P.[3], González M.[3], Aranda J.A.[1,4]

1- Basque Meteorology Agency (Euskalmet).
2- Meteorology Area, Energy and Environment Division, Tecnalia R&I.
3- Marine Research, AZTI-Tecnalia.
4- Emergencies and Meteorology Directorate, Security Department, Basque Government.

Abstract

Severe weather phenomena impact the European society and economy in many ways, from disruption in various sectors and substantial damages in infrastructure to human and economic losses. Basque Country is recurrently affected by swell episodes and high waves as a consequence of high fetch situations generated by remote deep lows and NW gales configurations. Coincidence of those situations with spring tides usually promotes some degree of littoral impact and economic losses in the area.

In this work we focus on coastal damages that are produced when ocean-meteorological conditions causes some degree of energetic sea waves intrusions over land areas. We present an analysis of economic impact in Basque coastal areas. For this purpose we study "battering of coastal waters" damage data provided by the **Spanish Insurance Compensation Consortium (CCS).** Those data are analyzed considering different aspects as location, date, damage type, etc. in order to extract some conclusions. The final objective is to contribute in reducing the knowledge gaps at the interface between available ocean-meteo prediction/analysis systems and impact observed in Basque Country littoral areas.

Introduction

As a consequence of severe episodes that affects Basque Country coastal areas during the winter of 2013-2014, with million euros damages produced (Egaña et al 2014, Gaztelumendi et al 2014), different studies (internal developments and security department funded project) are done by Euskalmet, Tecnalia R&I and AZTI-Tecnalia in order to a better local characterization of these phenomenon. Most relevant conclusion was the redefinition of the maritime coastal hazards and associated warnings and particularly the splitting of "high wave" warning case introducing the "coastal impact" concept and the overtopping indexes (I, Imax) as key factor to consider. (Liria et al 2014, Gaztelumendi et al 2014, 2016, Stockdon et al., 2006)

In this context, a damages analysis is essential when moving from the different ocean-meteorological variables (causes) to impact (consequence). Here we continue with previous works (Egaña et al.2014, Gaztelumendi et al 2014) and extent to twenty years the analysis of damages .

The data analyzed correspond to compensation of authorized claims for sea battering damages during the period **1996-2015** by the CCS. An amount **of** 53.366 thousands of euros (K€) corresponding to **1639** accepted claims (**#**) during **115** different **days (D)** with some degree of damage impact, affecting **29** different coastal **municipalities (M)**. ***(see Fig 1, Fig 2)***.

Methodology

Original data consist on a excel file from CCS with accepted claims corresponding to "battering waters" for Basque Country during period 1996-2015. Information is structured in date, municipality, town, zip code, risk type and economic amount. Original data present gaps (void cells), different type of inhomogeneities (different names for same place or municipality, language, etc.), inconsistencies (in between zip code, location and municipalities) and errors (e.g. claims far away from littoral areas). A derived data file is prepared after manual depuration of raw data solving most part of detected problems.

Data analysis is performed applying different techniques after segmentation of data in various categories considering type of affected property. Counting and statistics values are calculated focusing on #, €, D and M. Different R (R core Team 2013) and excel tools are used for depuration, data analysis, and reporting, including PivotTables and thematic maps.

Fig 1. Basque coastal municipalities used in this study.

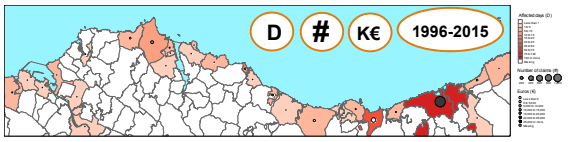

Fig 2. Number of days (D), claims (#) and thousand euros (K€) during period 1996-2015.

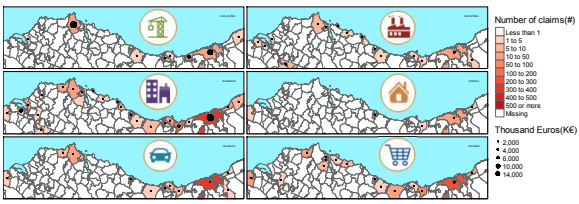

Fig 3. Number of claims (#) and thousand euros (K€) by damage type during period 1996-2015.

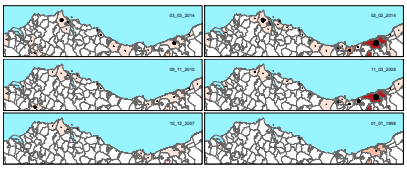

Fig 4. Number of claims (#)and thousand euros (K€) for days with more than 40# (03/03/2014 02/02/2014 09/11/2010 11/03/2008 10/12/2007 01/01/1998)

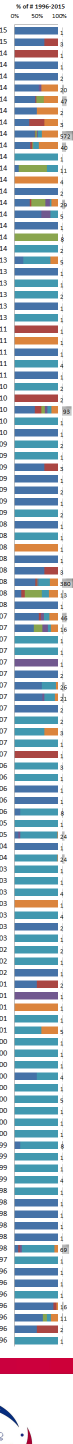

Fig 5. Number of claims (#) and type for all affected days(115D)

Results and Discussion

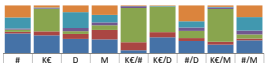

Fig 6. Damages type summary

	#	K€	D	M	K€/#	K€/D	#/D	K€/M	#/M
HOUSING	407	2.171	27	16	5	19	15	136	25
CARS	378	823	64	13	2	27	6	63	29
OFFICES	41	662	13	5	16	9	3	132	8
CIVIL WORK	75	25.191	11	8	336	1.399	7	3.149	9
INDUSTRIAL	56	4.455	20	16	80	278	3	278	4
BUSINESS	682	20.065	58	24	29	872	12	836	28

Type of damages. **Business (shops, stores, warehouses and others risks)** account for 42% of accepted claims (#) with 38% of economic losses (K€) during 50% of days (D) affecting .83% municipalities (M). **Industrial** category account for 3% of # with 8% of € during17% D in 55% of M. **Civil works (mainly harbors)** 5% #, 47% € , 10% D in 28% M. **Offices** 3% #, 1% € , 11% D in 17% M. **Motor vehicles (mainly particular cars)** 23% #, 2% €, 56% D in 45% M. **Housing (homes and proprietary communities)** 25% #,4% €,23% D in 55% M. On average each # represents 33K€, 29K€ for **business**, 80 K€ for **industrial**, 336K€ for **civil works**, 16K€ for **offices**, 2K€ for **vehicles** and 5K€ for **housing**. ***(see Fig 3, Fig 6)***

Civil works (harbor damages) correspond to bigger K€ affecting few M during just more harmful events. Cars are affected during most days in many municipalities, with the higher ratio #/M but lower K€/#.

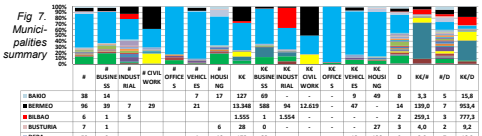

Fig 7. Municipalities summary

	#	# BUSINESS	# INDUSTRIAL	# CIVIL WORK	# OFFICES	# VEHICLES	# HOUSING	K€	K€ BUSINESS	K€ INDUSTRIAL	K€ CIVIL WORK	K€ OFFICES	K€ VEHICLES	K€ HOUSING	D	K€/#	#/D	K€/D
BAKIO	38	14				7	17	127	69	-	-	-	9	49	8	3,3	5	15,8
BERMEO	96	39	7	29		21		13.348	588	94	12.619	-	47	-	14	139,0	7	953,4
BILBAO	6	1	5					1.555	1	1.554	-	-	-	-	2	259,1	3	777,3
BUSTURIA	7	1					6	28	0	-	-	-	-	27	3	4,0	2	9,2
DEBA	59	9				4	46	170	32	-	-	-	12	126	9	2,9	7	18,9
DONOSTIA	937	366	20	24	34	309	204	24.907	12.250	1.652	8.078	637	619	1.672	82	26,6	12	303,7
EA	12	3	1				8	18	13	1	-	-	-	4	5	1,5	2	3,6
ELANTXOBE	7	2	5					67	6	61	-	-	-	-	6	9,6	1	11,2
ERANDIO	4	1					3	35	1	-	-	-	-	34	3	8,8	1	11,8
ERMENTERIA	3		1			1		10	-	6	-	-	5	-	2	5,1	1	5,1
GETARIA	24	10	2	3		8	1	522	328	44	111	-	36	4	9	21,8	3	58,0
GETXO	14	11	2	1				144	97	7	40	-	-	-	6	10,3	2	23,9
HONDARRIBIA	9	7		2				124	108	-	16	-	-	-	6	13,8	2	20,7
IBAIBANGELU	3						3	8	-	-	-	-	8	2	4	2,8	2	4,2
LEKEITIO	42	39	2			1		405	370	34	-	-	0	-	19	9,6	2	21,3
MENDEXA	6	5	1					111	110	0	-	-	-	-	4	18,5	2	27,7
MUNDAKA	22	5	2			1	14	135	38	51	-	-	0	46	6	6,2	4	22,6
MUSKIZ	17	4			1	1	11	21	5	-	-	-	1	15	5	1,2	3	4,2
MUTRIKU	6	1	1	2			2	133	5	43	61	-	-	24	4	22,2	2	33,3
ONDARROA	32	11	4		1	15	1	82	29	23	-	3	25	1	5	2,5	6	16,3
ORIO	17	4		13				4.167	23	-	4.144	-	-	-	5	245,1	3	833,4
PASAIA	34	17			2	4	11	85	57	-	-	6	5	17	9	2,5	4	9,5
PLENTZIA	1	1						6	6	-	-	-	-	-	1	5,8	1	5,8
SANTIOERREKA	1						1	1	-	-	-	-	-	1	1	0,9	1	0,9
SANTURCE	2	1	1					3.673	3.409	264	-	-	-	-	2	1836,7	1	1836,7
SUKARRIETA	3						3	4	-	-	-	-	-	4	2	1,5	2	2,2
ZARAUTZ	214	129	1		3	5	76	3.116	2.516	384	-	16	63	138	34	14,6	6	91,7
ZIERBENA	1		1					238	-	238	-	-	-	-	1	238,1	1	238,1
ZUMAIA	3	1		1		1		125	2	-	122	-	1	-	3	41,7	1	41,7

Spatial distribution of damages. Donostia has 58% of # for 47% of € in 32% of D. Zarautz 13% of # corresponding to 6% € during 30%. Bermeo 6% # for 25% € in 12% D. Orio only 1% # correspond to 8% of € during 4% D. In **business** related claims (#) highlight Donostia, Zarautz, Bermeo and Lekeitio with 54%, 19%,6% and 6% of the total #, respectively. In **Industrial** claims stand out Donostia (36%), Bermeo (13%), Elantxobe (9%), Bilbao (9%) and Ondarroa (7%). In **civil works** the port of Bermeo (39%), Donostia (32%) and Orio (17%). Regarding with **offices**, Donostia (83%), Zarautz(7%) and Pasaia (5%). In **motor vehicles** case, Donostia (82%), Bermeo (6%) and Ondarroa (4%). Regarding **housing**, Donostia (50%), Zarautz(19%) and Deba (11%). . ***(see Fig 2, Fig 7)***

Although # are present throughout the Basque coast, note that most part of # are produced in **Donostia** and **Zarauz** (70%), due to different factors as higher number of affected days, its particular orientation and exposure to NW energetics events and mainly due to the anthropic occupation and urban use of affected areas. The offset observed in between few # and relatively high € is explained by the economic impact of civil works in harbors.

During 73% of days (84 D) just one M is affected, during this days just 153 # for an amount of 1303K€ is produced (but note that 990K€ for two particular industrial and civil works claims in Zierbena and Bermeo respectively). The claim distribution in this cases is; Donostia (115#, 56D), Zarautz (16#,13D), Lekeitio (4#,4D), Bermeo (9#, 2 D) Deba (2#,2D) and other 7 M with just 1# and 1D. Note that Donostia and Zarauz respond to 82% of total single M cases. For 12 days (10%D) just 2 M are affected for a total amount of 164K€ with 43#, in 75% cases Donostia and/or Zarautz are affected. For 19 days (17%D) more than 2M are affected for 1443# with 51.899K€, nearly 50% corresponding to Donostia.

19 Municipalities with 131# industrial or civil works (8% total #) respond to 29.646K€ (55% total €). Donostia represent 56% of total nor industrial/civil works # with 913 # corresponding to 15.177 K€. (28% total €). Remark also Zarautz with 213 # (13%) and 2.732K€ (5% total €).

Temporal distribution of damages. Although # corresponds to 115 different days (D), during 61 D (53% total days) just one # is produced for a total amount of 394 K€ (0,7% total). 17 D with 2 # for 85 K€.. During 4 D more than 50# are produced; . **02/02/2014** ,**11/03/2008** , 09/11/2010 and 03/03/2004 with 69, 93, 380 and 572 # corresponding to 771, 2979, 12940 and 15711 K€. Two days (**02/02/2014** ,**11/03/2008**) account for 58%/54% total #/€ (64%/68% **business** #/€, 38%/41% **industrial** #/€, 35%/42% **civil works** #/€, 44%/61% **offices** #/€, 40%/46% **cars** #/€, 73%/79% **houses** #)/€, 380# Four days account for 75% of # and 79% of total €. ***(see Fig 4, Fig 5)***

Damages in **business** are produced during 58 days (50%D), in **industries** in 20 days (17%), in **harbors** in 11 days (10%), in **offices** in 13 days (11%), in **cars** during 64 days (56%), and in **houses** during 27 days (23%).

In relation to the type of damage and date when is produced, regarding **business** 38%# and 54%€ are produced during 02/02/2014 and 28%# 35%€ in 11/03/2008 days. In **industrial** case 25%# 42%€, 20%# 24%€ and 18%# 17%€ during 09/11/2010, 02/02/2014 and 11/03/2008. For **civil works** highlighting 02/02/2014 day with 25% # 27% €. In **offices** case 02/02/2014 account for 27%# 24%€ In **vehicles** claims, 26%# 33%€ in 11/03/2008 , 14%# 13%€ in 02/02/2014 and 13%# 12%€ in 01/01/1998. In **housing** 02/02/2014 stand out for 54%# 34%€ and 11/03/2008 for 19%# 44%€ .

Oceanographic data

In order to a better understanding of damages behavior in relation with oceanographic registered variables, we present in table 1 different oceanographic parameters and values of # and € for 7 worst events during XXI century. Remark that those events, corresponding to 89% # and 99% €, are produced with mean values of 9,2m Hs, 18,8s Tp, 314º Dir, 4,65m SL, 7,1 I and 8,0 Imax. Correlations between I, Imax and log# are around 0,78 (0,72 with log€). In the case of 13 worst events with # >4, correlations in between I and log# are 0,87 (0,84 for log€) and around 0,78 for # (0,79 for €).

7 events	Hs	Tp	Dirp	SL	I	Imax	#	K€
25/01-03/02 2014	8,6	19,9	318	4,93	7,8	8,7	631	17.840
10-15/03/2008	9,6	19,9	309	4,51	7,5	8,4	398	14.917
08-10/11/2010	9,1	16,6	312	4,38	6,6	7,3	96	2.983
02-04/03/2014	9,1	16,2	312	4,98	6,8	7,4	69	7.163
09-10/12/2007	11,6	19,9	315	3,98	7,1	8,1	62	3.125
18-21/03/2007	7,3	16,6	332	5,02	7,2	7,8	51	1.039
01-03/01/1998	6,5	20	295	4,5	7	7,7	70	772

Hs: significant wave.
Tp: peak period.
Dir: wave direction.
SL: sea level tide
I, Imax: overtopping Indexes

Conclussions & Remarks

Insurance claims data from CCS for ""Pounding of the sea" (prior "battering waters") during the period 1996-2015 are analyzed for the Basque Coast, in order to a better understanding of the nature of impact.

During twenty years we have 115 days with accepted claims (#) but just 7 large events. Most # are produced in Donostia and Zarautz.

In order to extract full conclusions about impact ,due to battering of the waves, using insurance claims data, many factors must be considered. Not only physical (coastline configuration, orientation of seawalls and harbors, direct exposure to the incident wave field, configuration of beaches, etc,) and socioeconomic (distribution of human population and goods, characteristics and amount of the insured assets, etc,) ones but preventive measures applied or previous damages or even chance.

We must consider that the CCS data represent just a portion of the total economic impact. Mostly due to the different degree of penetration on insurance (density of the insurance and the economic value of the property is not the same in every area) and to different considerations inherent to the "extraordinary risk" compensation system (not all type of policy entitles to compensation and not all goods ,type of damages or causes are covered).

Compensation is given by CCS on the condition of holding a policy (with a insurance company) in the field of damages to goods, or life and/or accidents. When giving the economic compensation, the CCS will take into account the same conditions (first loss, compensation limits, etc.) established in this insurance policy. Usually different rates are applied depending on type of property insurance (e.g. Housing 0.09 per thousand, non-recreational harbors 1.95 per thousand).

In any case, the use of number of accepted claims (#) economic quantity (€), and affected municipalities (M) as an indicator of damages extension, seems to be useful particularly in the context of very severe events. Relations in between overtopping indexes (that includes waves characteristics, tides, coastal configuration and slope) with # or € are found. In moderate and less harmful episodes those relations are not so obvious.

Although the raw claim data contain location information (zip code, municipality and city name), often presents inconsistencies . It would be useful to have georeferenced claims with exact location of damage (UTM, lon/lat).

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GOBIERNO VASCO
DEPARTAMENTO DE SEGURIDAD
Dirección de Atención de Emergencias y Meteorología

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Contact info:
santiago.gaztelumendi@tecnalia.com

TECNALIA
Parque Tecnológico de Bizkaia
C/ Geldo Edificio 700
E-48160 DERIO (Bizkaia) Spain
www.tecnalia.com

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