Integrated COastal Alert SysTem

iCOAST

Date: January 2016

Deliverable Number: 3
Due date for deliverable: 30/01/16
Actual submission date: 30/06/16
Leader: Vicente Gracia

Document Dissemination Level: RE

PU	Public
PP	Restricted to other programme participants (including the Commission Services)
RE	**Restricted to a group specified by the consortium (including the Commission Services)**
CO	Confidential, only for members of the consortium (including the Commission Services)

Co-ordinator: Centre Int. d'Inv. dels Recursos Costaners (CIIRC)
Project Contract No: ECHO/SUB/2013/661009
Project website: http://www.icoast.eu

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2.1 Comparative analysis

The Tasks of the project were designed to be interconnected. This aspect enriched the outcomes of the project but forced to follow a strict plan. One of the key elements of the project was its technical starting point, the Task C, which was planned to have duration of 8 months. However, the magnitude of the associated work did not exactly correspond with the original planning and finally it took almost 15 months to be ended.

This delay in task C did not stop the following tasks for the following reasons: (i) the coordinator and most of the beneficiary institutions were experts and had a high knowledge of the region and (ii) an extra (not originally planned) effort was done to obtain results more complex than stated in the proposal. As a drawback the writing of the associated deliverable was delayed. This delay forced the groups to work very closely maintaining a fluent communication and cooperation in order to avoid misunderstandings. As a result of this intense work it has to be said that Task C has provided the first coastal hazard database in the area and it is planned to be public in the incoming years. The document itself (the deliverable) has an extension of 137 pages (after merging the results with other deliverables of the Task).

The rest of the activities did not suffer significant time delays.

The complexity of the numerical models involved in iCoast, and the amount of temporal data generated during the test and implementation task required an extra computing power not initially planned but assumed by CIIRC (3 PC). Besides, SMC also temporally provide part of its computing facilities during the development of Task F.

The outcomes and deliverables of the project have been the originally planned. The planned deliverables have been written and the outcomes match with what was originally proposed. It has to be said that a coastal early warning system prototype has been build. The nature of the models and the complexity of the interconnections between them require a high degree of expertise. That is, iCoast is a tailor-made suite of programs that require a group of expert users in order to run and interpret the runs from the models.

3 EVALUATION OF PROJECT MANAGEMENT IMPLEMENTATION PROCESS

The project management implementation allowed for a greater networking that lets also learning in detail aspects of the project which do not correspond to the expertise of the coordinator. As an example, working together with CECAT paved the way for translating the technical (very detailed) aspects of the project into the real field that is, the operationality and the definition of the interventions typologies needed for satisfying the emergency demands.

It has also served for solving short time managerial problems (such as the change of the acronym of one of the beneficiaries) subdividing the problems and delegating tasks and actions. As it can be imagined, this was possible because the good atmosphere generated within the group. The organization of the scheduled workshop at the different countries involved also served to strengthen the cooperation between beneficiaries, thus bringing a better work atmosphere.

The use of email and Skype conferences has eased the workflow avoiding unnecessary stops. The teleconference has borne fruit especially when few interlocutors were involved. These communication mechanisms forced to be permanently online, then diminishing the response time among possible hindrances.

The construction of a Drive unit permitted the data sharing, being an excellent way of exchanging information. However, it required a short training of the group, understanding the structure, philosophy and instructions that had to be used.

The webpage has served to show the results of the project to the community although has not been used for the management of the project.

The communication with the commission has been very fluent highlighting the possible bottlenecks during the development of the project. This communication has also served to detect the key elements/actions that should not be delayed in order to achieve the goals of the tasks. The flexibility from the DG-ECHO for adapting some points that were slightly modified from the original proposal (i.e. merging the deliverables C1_C2_C4 and D1_D2) has eased the reporting task and then benefiting the project results.

The good atmosphere generated in the project has permitted to be adaptable, which has been an extremely important issue for implementing the iCoast prototype. The September 2015 event that hit the coast was included in the outcomes of the project despite it was not included in the proposal for obvious reasons.

Additional meetings not initially planned had to be scheduled among groups, especially during the second year. These internal meetings, without formal presentations, permitted to achieve more easily the initial goals. It would be strongly recommended to promote the interaction among partners at least monthly.

4 ACTIVITIES

This section has been organized following the tasks of the project (see Table 1). A summary of the actions and timetable associated to each task is presented in Table 4.

Table 4. *Actions associated to tasks and timetable.*

Task	Start Date (month)	End Date (month)	Action
Management and reporting to the Commission	1	24	A.1. Administrative and financial coordination of the project
			A.2. Technical coordination of the project.
			A.3. Organization of the Project Kick-off-meeting, Steering Committee meetings and Final meeting.
Publicity	1	24	B.1. Corporate image and web page
			B.2. Meetings and Workshops
			B.3. Networking
			B.4. Dissemination
Coastal hazards & risk Mapping	1	6	C.1. Inventory of contemporary costal disasters related to storms
			C.2. Drivers characterization
			C.3. Mapping
			C.4. Beach targets
Intervention guidelines	6	18	D.1. Literature Review and Practitioner Survey
			D.2. Best Practice and Lessons Learned
			D.3. Definition of QD/AM and related thresholds of activation
Data assimilation and Modelling	5	14	E.1. Meteorological module
			E.2. Hydrodynamic module
			E.3. Morphodynamic module
			E.4. Coastal state indicator module
***iCoast* architecture & testing**	14	24	F.1. System strategy
			F.2. Scenario definition
			F.3. Tool implementation and tests
			F.4. Evaluation of the results and manual
Emergency Communication protocols	15	24	G.1. Emergency communication protocols at the regional level and national level
			G.2. Emergency communication protocols at the International level

4.1 Management and reporting to the Commission

The activities associated to this task have been achieved on time. No major problems neither deviations from the original plan can be reported. The technical coordination consisted in easing the communication among groups (actions or tasks), scheduling internal meetings under demand and the promoting internal technical discussions that reached technical consensus.

4.2 Publicity

The task took place during the whole period of the project. The associated actions were done on time. The logo of the project was designed and distributed among beneficiaries, the kick-off meeting was held in Barcelona in December 2013, a progress meeting took place in July 2014 in Torino, a second progress meeting was done in Cork in April 2015 and a final meeting in November 2015 was held in Barcelona. The scheduled actions can be shown in detail in Table 5

***Table 5**. Actions associated to tasks B and timetable.*

Event	Type	Date	Place
Kick-off Meeting	Partnership meetings	December 2013	Barcelona
Progress Meetings		July 2014	Torino
		March 2015	Cork
Final Project Meeting		November 2015	Barcelona
Workshop -Starting Project	Public - Stakeholders	February 2014	Barcelona
Workshop -Project Results		November 2015	Barcelona
International Conference on Coastal Engineering (ICCE 2014)	Conference	June 2014	Seoul
European Geoscience Union (EGU)		April 2015	Vienna

As it can be seen from the table there was a small delay in the celebration of the partnership meeting at Cork mainly due to the agenda problems (Easter holidays)

In November 2014 a workshop addressed to the Catalan stakeholders and public in general was organised in the Centre de Coordinació Operativa de Catalunya (CECAT) in which the ICGC, the CECAT, the SMC and the CIIRC institutions presented the iCoast project joint activities. Strong focus was given to the webpage in which coastal damages and incidences should be reported (task C3). A demonstration on the reporting of future wave storms developed within the project was done. It was impossible to involve the technicians of all coastal municipalities and only those who had experienced the hit of a severe storm attended the meeting. Because of that, it was decided to maintain personal interviews with some of the coastal municipality responsible for the second project workshop (November - December of 2015). Because of these interviews, one of the proposed QD/AM (Deliverable D3) has been tested beyond the end of the project (see section 8).

The update of the webpage (http://icoast.eu/) has been done regularly although it has to be said that this action was done from a passive point of view. That is, the events were reported after happening and more pro-active announcing related activities would have improved the project visibility.

Regarding to the networking an important effort has been done to make visible and establish links with other EU projects. In this sense, the project was presented in other FP7 forums, such as Dancers (http://www.dancers-fp7.eu/) or RISES-AM (http://www.risesam.eu/). Results of the project were also presented at the workshop "Costa i Clima. Aprendre del Passat per encarar el futur" (in Catalan) that took place in Vilanova i la Geltrú (Barcelona) the 14 of February of 2014 where the vice-president of CIIRC did a dissertation entitled "Contribució a la sostenibilitat costanera: XX anys del CIIRC" showing the iCoast project to the audience. A non planed activity was carried out by the SMC, SIMO and CIIRC by presenting the results of the project to the Meteorological Service of Morocco in April 2015 at Casablanca.

Other dissemination activities addressed to experts have been: (*i*) two oral presentations entitled: "A new generation of early warning system for coastal risk. The iCoast project", "Reliability of beaches as defence against storm impacts under a climate change scenario" and "Sediment transport and dispersal in the nearshore of flash-flood rivers" at the International Conference on Coastal Engineering of 2014 (ICCE2014) held in Seoul in June 2014, (*ii*) an oral communication at the conference ECOPLAYAS 2014 held in Bilbao in November 2014 entitled "Estrategias de gestión frente a temporales. Los proyectos iCoast y RISES-AM", (*iii*) the 7th EuroGoos Coneference, Operational Oceanography for Sustainable Blue Growth in October 2014 held in Lisbon, with the presentation of a poster entitled "High resolution ocean modelling forecast for coastal early warning system in the Catalan Coast", (*iv*) the EGU Conference in April 2015 with a poster communication entitled "Wave ensemble forecast in the Western Mediterranean Sea Application to an early warning system" (EGU General Assembly 2015 had 4,870 oral, 8,489 poster and 705 PICO presentations and 11,837 scientists from 108 countries participated), (*v*) the conference Coastal Sediments'15 held in San Diego (USA) in May 2015 with two oral presentations ("Evaluation of transient defense measures against storms" and "Natural accretion mechanisms. The role in future coastal sustainability") and (*vi*) the Jornadas de Geomorfología Litoral held in Marbella (Spain) in June 2015 with an oral communication entitled "Metodología para la delimitación de la zona de inundación del oleaje en el Mapa para la Prevención de Riesgos Geológicos de Cataluña".

The scientific dissemination also include the publication of a book chapter entitled "sustainability of artificial coasts: The Barcelona coast case", published in "Coastal Zones: Solutions for the 21st Century" editorial Elsevier.

The results of the project have been also disseminated through mass media (from local TV to internet press) and public. The second activity consisted in the participation of the fair "La Festa del Mar" held in Badalona the 21th of June 2015. The event was organized by the city of Badalona (an iCoast beach target) to promote contact between citizens and Badalona beach and all related issues. Rollers explaining the iCoast project were generated for this event. A summary of these activities can be found in the folder "Task A. Management and reporting to the commission/ Deliverables/Task B/ Public "or following the link:

https://drive.google.com/open?id=0B7bAtniS1yZOV2xZaUNuaXd1ZlE

4.3 Coastal hazards and risk mapping

The actions associated to this task have a direct translation in deliverables. Table 4 shows the activities done in the task.

Action C1 consist in a review of recent coastal disasters associated to storms reported in the literature. This action has been more time consuming than originally expected. Due to the nature of the news (subjective or reflecting a journalist opinion) it was difficult to introduce objectiveness requiring an additional crosschecking of the information. Besides, in some cases there was also difficult to precisely localize the reported damage. Although most of the important contemporary extreme events were known, it was necessary to make a deep search to found less popular events and consequently the end of the task required more time than planned.

Action C2, the forcing drivers characterization, has been in charge of describe the events in terms of physical variables such as, wave height, period and direction and also the mean water level oscillation. To do this we had take advantage of the high degree of knowledge and expertise of the iCoast team. Different datasets have been used (local and national meteo-oceanographic networks, numerical hindcast and forecast meteo-oceanographic databases).

Action C3, mapping, has established the bases for a future GIS-based platform with the results obtained in the previous tasks with emphasis in the Catalan coast. The map service has integrated all the cartographic information of the project: coastal disasters reported in the literature, reference beaches and location of early warning and alert devices. An example of the web map server is shown in Figure 1.

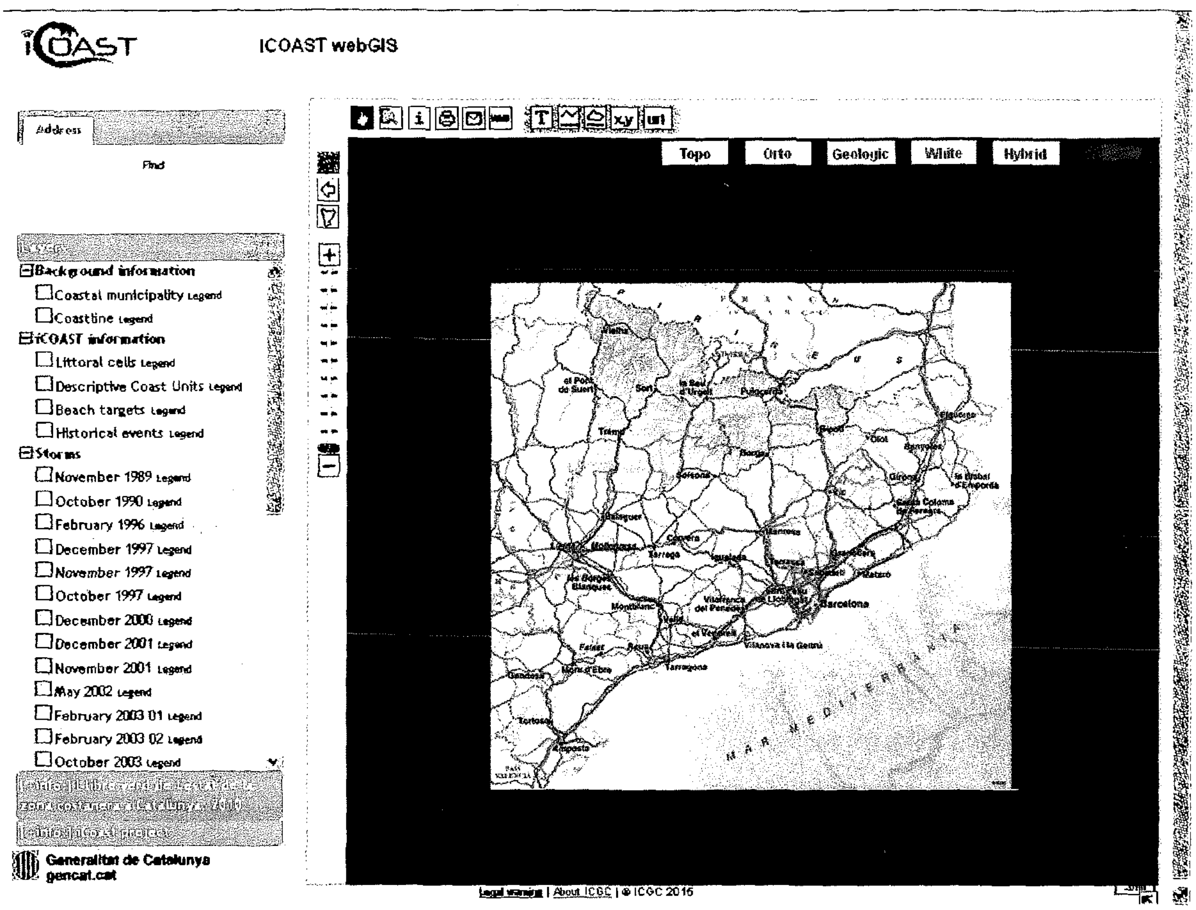

Figure 1. Screen capture of the web map server developed within iCoast (http://siurana.icgc.cat/visorIGC/icoast.jsp)

The initial proposed scales for the maps had to be modified. It was decided to be flexible in the map scaling in order to properly show the desired details due to the uncertainty in the localisation of the damages.

Action C4 was devoted to the definition of the beach targets. The initial plan was to identify two sets of reference beaches: (*i*) urban sandy beaches which have experienced severe damages and (*ii*) coastal areas mainly configured with structures (revetments, groins and breakwaters). This main categorization was maintained although it was necessary to split the first group into different sub-categories. Finally, the Catalan coast was divided into 561 Descriptive Coastal Units (DCU) based on the cartography of the area. A DCU is a section of the coast which limits are based on geomorphological and administrative criteria. DCU were classified in three types: sandy beaches, rocky coast (including the steep coast and intensely urbanized coast), and harbors. Each DCU belongs to a single municipality, which allows a better exploitation of the database: it is the local and basic reference where damages and the physical phenomena are reported.

4.4 Intervention guidelines

The actions associated to this task have a direct translation in deliverables. Table 4 shows the activities done in the task.

Action D1, Literature Review and Practitioner Survey, comprised the collation and review of relevant literature as well as identifying points of contact from relevant projects/ organisations who could contribute to objectives of iCoast. More than 50 references were checked and documented.

This action was closely related to Action D2. Best Practice and Lessons Learned were a critical review of the reviewed information was done. A SWOT analysis was done to identify the key elements for defining actions to be taken within 24 hours or less, prior to the forecasted storm episode. These interventions aim to reduce the storm risk and the related thresholds of activation (QD/AM).

Action D3, Definition of QD/AM and related thresholds of activation, was in charge of testing the feasibility of the QD/AM. Such numerical tests range a set of wave return periods and high sea levels. The analysis was performed for sandy beaches where the measures exhibit effectiveness. The activity was focused on analyzing the general setup of the QD/AM, the basic geometric dimensions and their location at the beach. The tests were used to determine the threshold of functionality of such measures. This activity required an important amount of computing calculation due to the type of models used and grid resolutions. The first tests reveal the need for increasing the computing power. To solve the problem an array of three CPU (8 cores each) were mounted as a small cluster.

4.5 Data assimilation and modelling

The actions associated to this task have a direct translation in deliverables. Table 4 shows the activities done in the task. The activities developed gone in parallel with the activities of Task F, iCoast architecture and testing.

Action E1, Meteorological module, consists in the setup of the first model of the chain. It was needed to define the appropriate downscaling and grid nesting of the forcings. Four main domains were defined from regional to very local. This initial strategy allowed the use of different meteorological models. The modelling exercise consisted in a trial and error approach, changing parameters and detecting key process governing the atmospheric environment. The numerical runs were focused on two main extreme events that represented different data quality conditions. Hence, the December 2008 event (defined in activities C1, C2, and C4) represented the best quality data situation in which the meteorological forcings were obtained after a reanalysis. This is not a realistic forecasting case but was used to check possible deviations in the forecasting tests. The second event, March 2013 (defined in activities C1, C2, and C4), represents a forecasting exercise, that is no re-analysis is done in the initial forcing conditions. No major deviations were detected in this activity.

Action E2, Hydrodynamic module, consists in the setup of the second model of iCoast chain. It has an analogy to the previous activity. The activity runs in parallel with E1. Despite belonging to different institutions the group worked closely. The forcings provided by the activity E1 were used to test a sequence of hydrodynamic models with new grids. The same trial an error approach was used to obtain the correct hydrodynamic parameters into the models. The December 2008 and March 2013 events were used as test cases. No major deviations were detected in this activity.

Action E3, Morphodynamic module. The purpose of this action is to define the most suitable models that will be used within iCoast to accurately reproduce the impacts of extreme wave events. In the activity, the models for the already defined beach targets were set up. Following the results of activities C1, C2, C3 and C4 two different modelling approaches were implemented: for sandy beaches and for armoured coasts. A total of five very detailed coastal targets were used which required more computational requirements than initially planned. The event of December 2008 was used for the calibration of the models. The event of March 2013 was used for validation in activity F2.1. No major deviations were detected in this activity.

Action E.4, Coastal state indicator module. The main objective was the threshold definition taking into account the results of activities C1, C2 and C4. Different end-user profiles were defined after discussing the approach with CECAT and stakeholders meetings. The aggregated schema was also defined to integrate the complex models outputs and emergency requirements. This activity demanded a special effort of the different bodies involved. One of the major constraints that the stakeholders stated was a request for official communication protocols, in order to test the feasibility of the proposed coastal state indicators.

4.6 iCoast architecture and testing

Table 4 shows the activities done in the task. In that case there is not a direct correspondence with deliverables.

Action F.1 System strategy. The timing and model interconnections are defined in this activity. The result is crucial because influences the forecasts and the way the information is transmitted to ground actions. Internal meetings involving most of the group of the project were needed to arrive to a consensus of the iCoast flow chart. The details of the functioning of such activity can be found in the deliverable F1. The activity was completed timely.

Action F2. Scenario definition characterises the conditions for validating the morphodynamic module. The March 2013 event was used as a forecast test and a climate change scenario was defined according to the outcomes of the ongoing FP7 project RISES-AM. The implemented scenarios share commonalities with the IPCC AR5. Apart from the above scenarios, the occurrence of a relative intense storm in September 2015, with two casualties, gave the possibility to test the whole framework. Because of this, this new scenario was also included. The results of this activity were included in deliverables F2.1 and F2.2.

Action F.3. Tool implementation and tests. The activity was split in two layers, the physical and the emergency domains. The implementation for the physical environment was done through the forecast of the events of March 2013 and September 2015 plus climate change scenarios. The activities were mainly dedicated to reproduce the morphodynamic behaviour of the coast at different target beaches. The emergency domain included the analysis of the whole calibration process, the validation tests plus the defined climate change scenarios. This second activity was the last in the chain of iCoast and because of this it experienced a small delay. Additional meetings and short stays were required (teamwork) to successfully complete the activity.

Action F.4, Evaluation of the results and manual. This activity was devoted to analyse the results of previous actions and runs in parallel with task E and G. The results of the analysis were included in deliverables E1, E2, E3 E4, F2.1, F2.2. The technical details about the implementation, installation and data formats requirements for running the iCoast prototype can be found at deliverable F3.

4.7 Emergency communication protocols

The actions associated to this task have a direct translation in deliverables. Table 4 shows the activities done in the task.

Action G1, Emergency communication protocols at the regional level and national level. A review of existing communication protocols at the regional and national levels was done in order to accommodate the specificities of iCoast. Several meetings with the INT (The Emergency Centre of

Catalonia, CECAT) were held to show the iCoast results and distil from such events valuable feedback. Two different languages had to be merged, one providing detailed physical description of the storm parameters defined in Task C and D and another requiring a YES/NO activation of an alert and consequently the definition of ground actions. More effort than expected had to be put in this action to arrive to a consensus.

Action G2, Emergency communication protocols at the International level reviews existing international recommendations in the field of emergency communication protocols for coastal areas. This state of the art analysis had no constraints.

5 PRESENTATION OF THE TECHNICAL RESULTS AND DELIVERABLES

This section report is structured following the tasks of the project (Table 3). The deliverables are summarized in Table 2.

5.1 Management and reporting to the Commission

This task involved all the management aspects of the project, in particular the coordination of the work and the control of the project development and quality, checking the achievement of milestones, the production of deliverables and the budget evolution.

The associated deliverables have: (*i*) the Firsts progress report, (*ii*) the Second progress report and (*iii*) the Final report. All deliverables and outcomes (including this document) can be found at the Drive of the project in the directory "Task A. Management and reporting to the commission", subdirectory Deliverables. Moreover, additional information has been also uploaded to better explain the actions taken. The Drive link to the folders is:

https://drive.google.com/folderview?id=0B7bAtniS1yZOfjNNWUVZcTJjM3A4THVrM1dCckFuUWg3WWVwNHYwXy1uaGlWbmF4U0cyc0k&usp=sharing

The progress reports show the status of the project for different periods giving also detailed information on specific actions.

5.2 *Publicity*

The objective of this action was to establish an international transfer board of the iCoast results by creating a website of the project and disseminating the results through workshops address to different end-users, leaflets and a Layman's report. The iCoast dissemination activities were focused on ensuring the visibility and awareness of the project in the whole Catalan coast community (NW Spanish Mediterranean coast) by presentations and demonstrations at conferences, workshops, publications, web and press. Figure 2 shows the structure of the folder "Publicity" at Drive.

The metrics of the webpage of the project throughout its lifetime is shown in Figure 3. The "bounce rate", i.e. the percentage of visitors who just enter the site rather than continuing, is high. That indicates that the homepage provides a good overview of the project, the updates and progress done. Table 6 shows the top 10 list of countries that have visited the webpage. As can be seen the USA tops the list. China is appearing at the third position reflecting the efforts done translating the leaflets to Chinese plus the dissemination work done at the ICCE'14 conference held at Seoul (South Korea).

Regarding with the scientific publications (all the production done in the project has been uploaded at the corresponding subfolder) it has to be mention that there are still two papers in the review process at the submitted peer-review journals: (i) "A multivariate model of NW Mediterranean extreme events: hydrodynamics, energy and duration" (submitted to Coastal Engineering) and (ii) "Effects of Ultra-Porous 3D Printed Reefs on Wave Kinematics" (submitted to Journal of Coastal Research). During this month we have received the acceptance of the paper entitled "Managing coastal environments under climate change: pathways to adaptation" (to be published at the journal Science of the Total Environment).

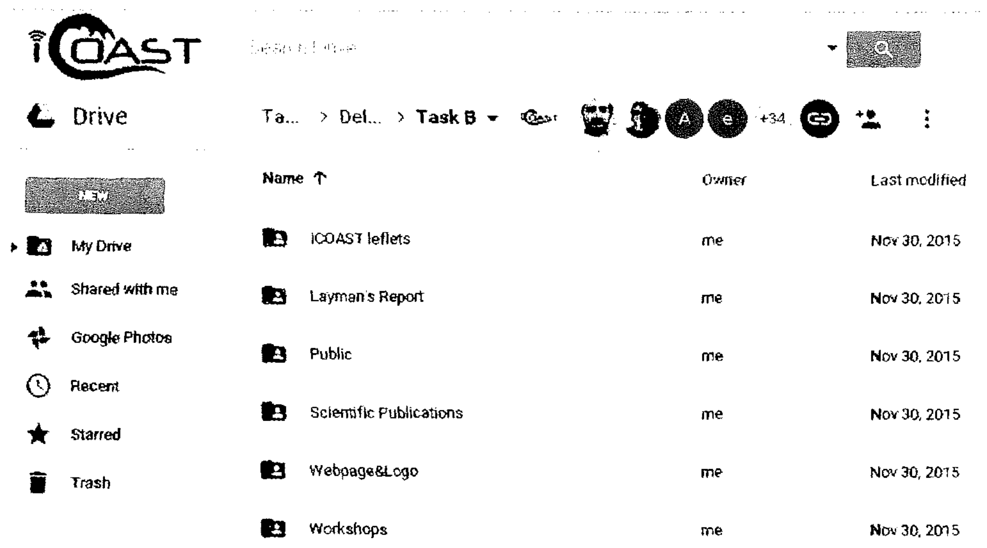

Figure 2. Screen capture of the folder "Task B" showing the associated subfolders with the related information.

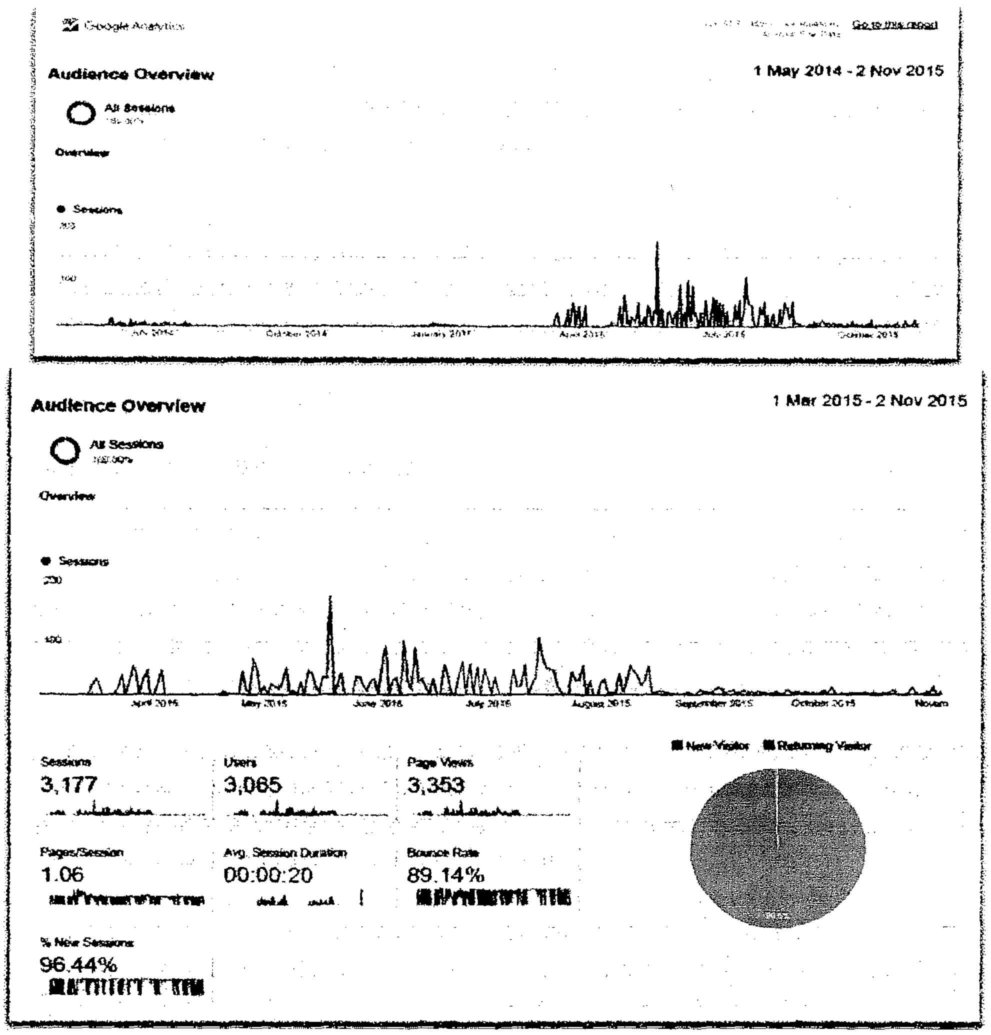

Figure 3. Basic web metrics of the iCoast website.

***Table 6**. Basic web metrics by countries*

	Country	Acquisition: Sessions	Acquisition: % New Sessions	Acquisition: New Users	Behaviour: Bounce Rate	Behaviour: Pages/Session	Behaviour: Avg. Session Duration
		3,177 % of Total: 100.00% (3,177)	99.46% Avg for View: 96.44% (3.13%)	3,160 % of Total: 103.13% (3,064)	89.14% Avg for View: 89.14% (0.00%)	1.06 Avg for View: 1.06 (0.00%)	00:00:20 Avg for View: 00:00:20 (0.00%)
1.	United States	1,148 (36.13%)	99.83%	1,146 (36.27%)	87.02%	1.09	00:00:25
2.	(not set)	768 (24.17%)	100.00%	768 (24.30%)	91.54%	1.07	00:00:18
3.	China	165 (5.19%)	99.39%	164 (5.19%)	83.03%	1.02	00:00:32
4.	Japan	103 (3.24%)	100.00%	103 (3.26%)	83.50%	1.01	00:00:22
5.	Germany	88 (2.77%)	100.00%	88 (2.78%)	93.18%	1.05	00:00:10
6.	United Kingdom	85 (2.68%)	100.00%	85 (2.69%)	94.12%	1.04	00:00:17
7.	South Korea	69 (2.17%)	100.00%	69 (2.18%)	89.86%	0.93	00:00:06
8.	Netherlands	59 (1.86%)	100.00%	59 (1.87%)	98.31%	0.98	00:00:00
9.	Russia	55 (1.73%)	76.36%	42 (1.33%)	87.27%	1.15	00:00:12
10.	France	54 (1.70%)	100.00%	54 (1.71%)	90.74%	1.02	00:00:20

The project outcomes have been shown at three stakeholders meeting that were taken at February 2014, November 2014 and November 2015. The November 2014 also included a half day training session about how to fill the coastal inventory form (action C3), that can be found at the ICGC website.

The workshop showing the project results with the stakeholders scheduled for November 2015 was made through personal interviews with Catalan coastal responsible of the Spanish government and also with technicians of different Catalan municipalities. As a result of these interviews, an implementation test of the Quick defence measures (action D3) proposed in the project has been performed at Gavà *(see section 8 for details).*

5.3 Coastal hazards and risk mapping

The main objective of this action was to obtain the coastal hazard landscape of the NW Mediterranean taking as example the Catalan coast. The characterization and mapping of the most relevant coastal hazards and risks (disasters) along the Catalan Coast will serve to identify possible geographic hot spots for urban beaches and coasts backed by infrastructures susceptible to be at risk and finally determine a set of reference beaches to be forecasted by the iCoast system.

The associated deliverables within this task are: *(C1)* "Inventory of disasters", *(C2)* "Synthetic Charts of the wave and mean water level climate of the reported disasters", *(C3)* "Database and Map of the reported disasters and Proposal for its implementation within a GIS-based system" and *(C4)* "Methodology and results for beach target selection".

All deliverables have been finished and can be found at the DRIVE of the project. For a matter of simplicity deliverables *(C1)*, *(C2)* and *(C4)* have been merged in a unique report clearly identified as "iCoast_Deliverable_C1_C2_C4_final_version". A screen capture with the deliverables is shown in Figure 4.

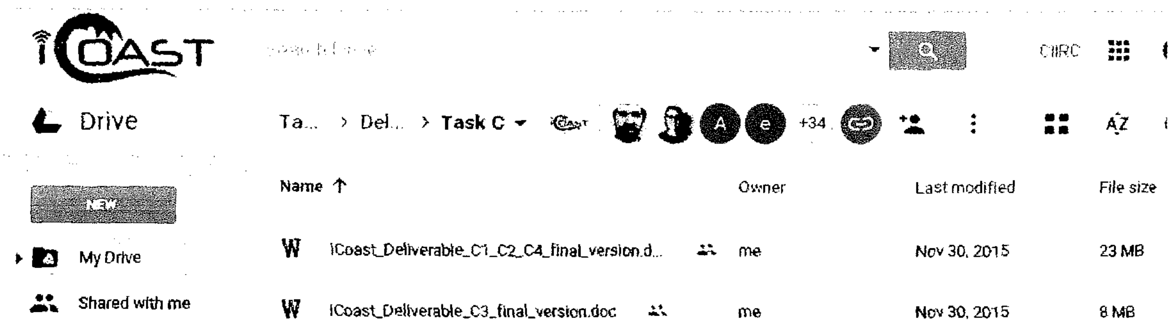

***Figure 4**. Screen capture of the folder "Task C" showing the related deliverables.*

5.3.1 Deliverable C1-C2-C4

This deliverable merges the proposed deliverables C1 "Inventory of disasters", C2 "Synthetic charts with a description of the wave and mean water level climate of the reported disasters" and C4 "Methodology and results for beach target selection". The aim of the document is to provide a compiled inventory of coastal disasters that have happened during the last decades at the Catalan Coast (action C1). In addition to the damage identification, the hydrodynamic loads are also included via measurements (when available) and hindcast databases (aim of task C2). This set of events constituted the input data for the methodology which defines the coastal hotspots (aim of task C4) that have been analysed at the other tasks.

The results from this deliverable were beyond the original proposal devoting special hindsight for obtaining a clear hazard landscape of the pilot area. This definition allows a vision that will be extended beyond the project life and can be complemented with future changes in the marine hydrodynamics due to climate change. However, as a drawback, more time than the scheduled was necessary. The main bottlenecks were the data gathering and the analysis of the information in order to find consistent parameters that are not only suitable for the project area at the current time, but also directly applicable to other European areas and in a time window beyond the iCoast project.

The analysis method is simple to build and maintain, reproducible, and does not explicitly need continuous records. An important part of the damages relied on newspapers that can be easily found at other zones. However, it must be keep in mind the bias induced by the reporters. Hence, quantitative objective data that complements such individual episodes are desirable.

5.3.2 Deliverable C3

The C3 Deliverable "Data base and map of the reported disasters and a proposal for its implementation within a GIS-based system" presented the prototype of a GIS-based system that displays the records from the storm database (deliverable C1-C2-C4). The GIS system is also complemented with an on-line form that enhances the storm database update. Stakeholders and end-users can upload and check local information in a straightforward fashion.

The outcomes were timely delivered and they coincide with the project proposal. It has to be added that a half-day training session for stakeholders was held in November 2014 in which the storm database filling form was presented. Despite it was not originally planned, the iCoast partners agreed that this event will ease the data exchange among the iCoast team and the end-users.

5.4 Intervention guidelines

The main objective of this task was to undertake a comprehensive literature review of best practices, state-of-the-art approaches, and implementation of policies associated with disaster prevention in the context of urban coastal environments. To distil from this review, the best management practices and lessons learned from the body of literature were held. To define Quick Defense or Accommodation Measures (QD/AM) the main aim was to diminish or act against a specific forecasted storm.

The associated deliverables within this task are: (*D1*) "Guidelines. Report of lessons learned from observations established in similar coasts", (*D2*) "Best practices. Report of Quick defence or adaptation strategies" and, (*D3*) "Report with the definition of the QDM or QAM options".

All deliverables have been finished and can be found at the DRIVE of the project (Figure 5). For a matter of easing the readability, the deliverables *(D1)* and *(D2)* have been merged in a unique report clearly identified as "iCoast_Deliverable_D1_D2_final_version".

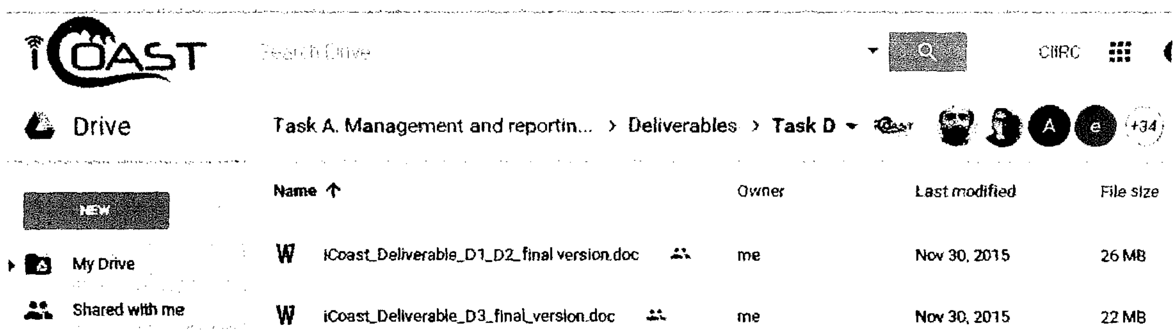

***Figure 5**. Screen capture of the folder "Task D" showing the related deliverables.*

5.4.1 Deliverable D1-D2

The deliverable D1-D2 merges the originally proposed deliverable D1 "Guidelines. Report of lessons learned from observations established on similar coasts" and deliverable D2 "Best practices. Report of quick defense or adaptation strategies". The first part (D1) deals with an exhaustive literature review of best practices for coastal protection. More than 50 references have been checked and cross-checked to provide examples of similar practices. The second part (D2) distils the best management and state-of-the-art practices, thus highlighting the most suitable options for defining Quick Defence and Adaptation Measures. A SWOT analysis of the major current practiced coastal rapid response/risk limitation is included. This analysis also synthesizes all the literature reviewed.

The deliverable is identified as "iCoast_Deliverable_D1_D2_final version". The outcomes coincide with the original proposal. This body of knowledge provides an opportunity for integrating the current typologies of coastal interventions, their range of applicability and the key factors that must be considered for implementing a coastal intervention. In that sense, the SWOT analysis paved the way for discriminating a limited subset of parameters (lifetime, construction time, resilience and "working with nature" symbiotic combination) to focus on the Deliverable D3.

5.4.2 Deliverable D3

The deliverable D3 "Report with the definition of the QDM or QAM options" can be found at the DRIVE of the project "iCoast_Deliverable_D3_final_version". This report aims to define the QDM

/QAM given the results from Deliv. D1-D2. The defence strategies include the physical intervention of the beach by constructing small dunes and trenches. However, it has also been included (not originally stated in the proposal) the design and quantification of QDM via the modeling framework present in Task E, at two pilot sites. The performance of such TDM has been numerically assessed by several combinations of waves and high sea levels. This synergic contribution strengthens collaboration among the involved partners and provides a common standpoint for sharing ideas that enriched the final result. Part of the results was shown at the Coastal Sediments Conference (see Publicity activities).

5.5 Data assimilation and modelling

The purpose of this task was to setup and couple meteo-oceanographic models to build the main core of the coastal early warning system, iCoast. Simulations of the extreme events were defined in task C whose characteristics were chosen for accurately calibrating the meteorological, hydrodynamic and morphodynamic models. Besides, a coastal state indicator module was developed which aggregates the results of the previous mentioned coupled models to finally define the level of alarm of a specific storm event. Table 2 indicates the reports associated to this task.

All the deliverables have been finished and can be found at the DRIVE of the project (Figure 6).

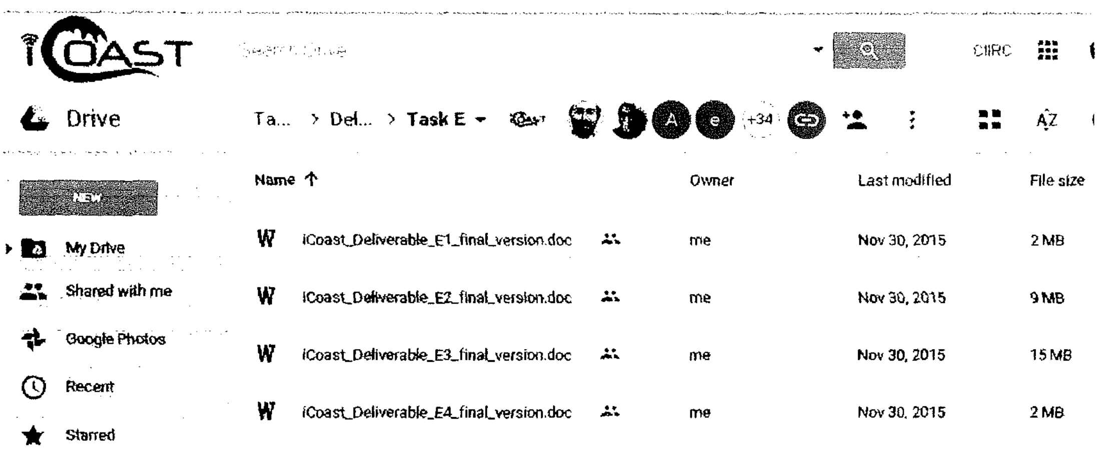

Figure 6*. Screen capture of the folder "Task E" showing the related deliverables.*

5.5.1 Deliverable E1

The meteorological report, deliverable E1, provides a description of the simulations already defined and the associated meteorological models used. The deliverable was finished on time and can be downloaded from the DRIVE of the project.

5.5.2 Deliverable E2

The hydrodynamic report, deliverable E2, provides a description of the hydrodynamic components of the early-warning system. The document is structured in three main sections. In the first section the models used, the nesting strategy and input data are described. In the second section the results of two test periods are presented for both wave model and oceanic model. Finally, a discussion of the results obtained is elaborated. The deliverable was finished on time and can be downloaded from the DRIVE of the project.

5.5.3 Deliverable E3

The morphodynamic report, deliverable E3, comprises the description of the models that use the hydrodynamic module forecasts as the basis. For open sandy beaches, the wave-averaged model XBEACH (Roelvink et al. 2009) is used, whereas for harbours, revetments and pocket beaches iCoast takes advantage of the transient model SWASH (Zijlema et al. 2011). The latter model is chosen because its ability to handle phenomena which requires a wave-by-wave computation (e.g. wave diffraction). Part of the results can be found at Sánchez-Arcilla et al. (2014) (see Publicity activities and scientific dissemination). The deliverable was finished on time and can be downloaded from the DRIVE of the project.

5.5.4 Deliverable E4

Deliverable E4 deals with the Coastal State Indicator module as part of the Data Assimilation and Modelling task. The document is structured in three main sections. In the first section the indicators used, their related thresholds and a variety of target users whose needs are used to generate tailored alerts, are described. In the second section, the results of two test periods and the validation of the module according to the historical inventory are presented. Finally, a discussion of the results obtained is elaborated.

The deliverable needed more time than expected, because it was necessary to select the adequate thresholds for avoiding false alarms. In that sense, the outcomes from Task C (deliverable C1-C2-C4) are tightly coupled with this module. The report can be downloaded from the DRIVE of the project.

5.6 iCoast architecture and testing

This task had as a main objective the construction of the prototype iCoast and how the early warning system modules were to be linked in an operational mode. Different tests of the whole system were performed for the episodes defined in Task C. The associated deliverables within this task are: (*F1*) "Report on system strategy", (*F2*) "Report on the analysis of the implementation test" and, (*F3*) "iCoast manual".

Computational resources requirements, operational time (from the Global Meteorological forecast availability to the local forecast at a pilot site), model queuing and data exchange were considered. The proposed procedure can be found at the deliverable F1.

The report on the analysis of the test implementation (F2) has been divided in two parts: (F2.1) the physical domain and (F2.2) the emergency domain. The physical domain part shows the results of physical forecasted variables defined in the project (see deliverables E1, E2, E3 and E4) and is uploaded as "iCoast_Deliverable_F2.1_final_version" whereas the emergency domain deals with the definition and classification of the alert and can be identified in Drive as "iCoast_Deliverable_F2.2_final_version".

The technical procedures of the forecasting modules and their implementation can be found at deliverable F3.

All the deliverables have been finished and can be found at the DRIVE of the project (Figure 7).

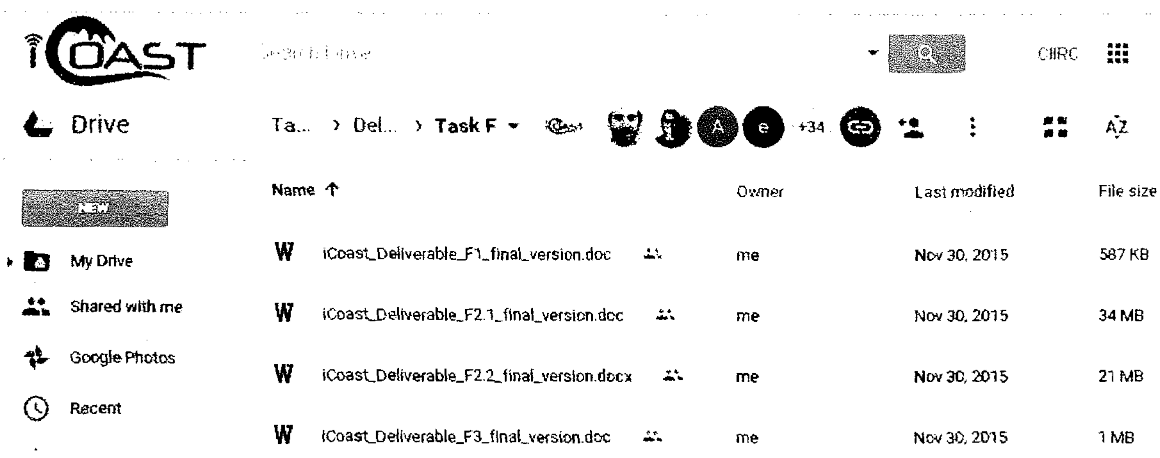

***Figure** 7. Screen capture of the folder "Task F" showing the related deliverables.*

5.6.1 Deliverable F1

Deliverable F1, Report on system strategy, presents a description of the system strategy as part of the early warning system. The document is structured in five main sections. In the first section the iCoast framework is briefly presented. In the second section, the system strategy is described from a conceptual point of view. In the third part, a description of iCoast architecture and its particular implementation are provided. The computation requirements for the iCoast prototype are summarised in the fourth section, and, finally, some remarks are made in the last section regarding the implementation of the system on a real time basis. The deliverable was finished timely and can be downloaded from the DRIVE of the project.

5.6.2 Deliverable F2.1

This deliverable shows the physical domain variables for the test implementation cases. Two real storms were tested at the coastal targets (task C4): March 2013 and September 2015. In addition, a set of climate change scenarios were applied. In particular the RCP 4.5, RCP 8.5 and a High-End scenario for the sea level rise variable were tested. These scenarios are in agreement with the recent report IPCC-AR5 (Stocker et al. 2013). The sea level rise scenarios were obtained within the framework of the FP7 RISES-AM project. The original deliverable F2 was divided into two parts in order to ease readability.

The joint work show in F2.1 and F2.2 highlights the work done for improving forecasts and giving tailor-made information for different end users. The deliverable was finished timely and can be downloaded from the DRIVE of the project.

5.6.3 Deliverable F2.2

This deliverable describes the emergency domain variables for the test implementation cases. The tests are analogous with the ones from Deliverable F2.1. Two real storms were tested at the coastal targets (task C4): March 2013 and September 2015. In addition, the same climatic change scenarios from Deliverable F2.2 were applied. One of the aims of this deliverable was to propose a set of thresholds that define the different alarm levels. In addition to the alarm level, the forecasting framework relies on a threshold that activates the high resolution morphodynamic module. Both switches and threshold values varies upon the zone where the iCoast tool is deployed. Henceforth, it has been found that tailor-made alarms demands "a priori" study of aggregated parameters damage/hydrodynamic loads (such as the one performed in task C). This mandatory detailed level of definition couples the physical and emergency domains.

The joint work show in F2.1 and F2.2 highlights the work done for improving forecasts and giving tailor-made information for different end users. The deliverable was finished timely and can be downloaded from the DRIVE of the project.

5.6.4 Deliverable F3

The deliverable F3 "iCoast manual" describes the technical procedures of the forecasting modules (task E) and their implementation in the prototype version. Hardware and software requeriments, queuing and bottlenecks are addressed in Deliverable F1; whereas F3 focus on model parameters and data exchange protocols/formats among models. It represents a clear technical roadmap for implementing iCoast at other European areas. The results from this deliverable coincide with the ones present in the proposal. The deliverable was finished timely and can be downloaded from the DRIVE of the project.

5.7 Emergency communication protocols

The main aim of this task is to define the emergency communication protocols to be established within iCoast at the regional, national and international level. These protocols take advantage of iCoast results, the outcomes from the stakeholder's workshops and local features.

Deliverable G1 describes the involved bodies, the operational framework and the communication protocols given an alert. The analysis ranges from generic to hazard-specific. Results are summarized in a set of recommendations clearly identified in the document in boxes.

Deliverable G2 provides a common standpoint of different EU country alert levels.

All the deliverables have been finished and can be found at the DRIVE of the project (Figure 8).

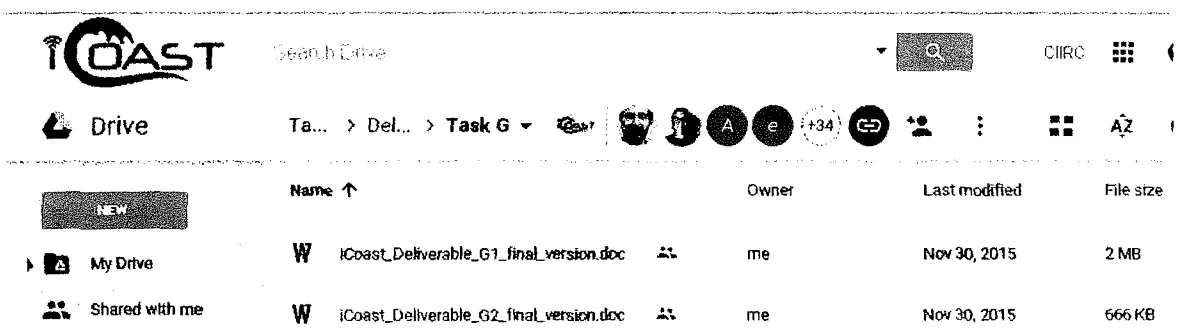

***Figure 8**. Screen capture of the folder "Task G" showing the related deliverables.*

5.7.1 Deliverable G1

Deliverable G1 "Report with the communication protocols recommended at the regional scale" describes the involved bodies, the operational framework and the communication protocols given an alert at the regional scale. The Catalan region was set as a case study due to the expertise of CECAT in this area. The analysis plus recommendations ranges from generic to hazard-specific, with strong focus on water related hazards. The different levels of communication protocols for the different end-users distil possible bottlenecks. Bottlenecks can be avoided by being as precise as possible, plus not relying on a single communication channel. The results are summarized in a set of recommendations that can be found in the deliverable via boxes. An important part of these actions can be applied at several European countries where security policies share commonalities. The veracity of these statements can be concluded with the Deliverable G2 which deals with communication protocols at other countries.

The deliverable was finished timely and can be downloaded from the DRIVE of the project.

5.7.2 Deliverable G2

Deliverable G2 "Report with the communication protocols recommended at the international scale" describes the involved bodies, the operational framework, the alert levels and communication protocols given an alert at the national scale. Two countries were analysed (Italy and France). Commonalities with the regional level exposed at deliverable G1 were highlighted. Strong focus was given on water related hazards. Despite the policies and recommendations show commonalities, differences among the different alert levels were denoted. These differences come from social perception of risk plus the climatic differences. In order to ensure proper alert levels, knowledge of the area is mandatory; reinforcing the concept that disaster inventory and risk mapping (action C) is a stepping stone for defining an effective coastal early warning system.

The deliverable was finished timely and can be downloaded from the DRIVE of the project.

6 EVALUATION OF THE TECHNICAL RESULTS AND DELIVERABLES

The aim of the iCoast project was:

1. To deliver a map of the most relevant coastal hazards and associated risks over the Western Mediterranean coast (task C).

2. The risk landscape stated above, should serve for defining a set of guidelines and best practices of intervention (task D).

3. The outcomes described above aimed to develop a prototype of a coastal early warning system (CEWS), which includes the protocols of interventions and alert information (tasks E, F and G).

These three blocks constitutes the main results from the iCoast project. All three core outputs were strongly related. The underlying relationships were appropriately addressed at the proposal, but throughout the project, slight deviations and unexpected constraints were found. The main lessons learned from the project are summarised below:

1. The importance of a proper risk landscape and its interaction with the system strategy (Deliverable F1) conditioned the operational structure. In order to avoid false alarms, in cases when there is strong confidence that a given alarm threshold will not be surpassed, the high resolution modules that constitutes the main bottleneck at the operational time won't be run.

2. The definition of the alarm threshold must follow two types of constraints: a) coastal damage induced by hydrodynamic loads; and b) end-user groups. The coastal damages depend on the assets present at the hinterland, the present coastal state and the hydrodynamic loads (waves and sea level). On the other hand, each end-user group has a different risk perception plus it varies among regions (Deliverable G2). Due to the differences in acceptable risk levels and the tailor-made nature that the iCoast tool has, the implementation of the tool in other areas requires: a) a previous coastal risk landscape definition and b) a clear definition of end-users.

3. Current state-of-the art numerical models provide skill enough three days ahead for having a degree of certainty that an extreme event may happen. These three days are the main constraint for the intervention protocols and guidelines highlighted in Task D. One of the strengths of the project is to test the feasibility of interventions with the same set of tools used for forecasting, paving the way for a generator of "what-if" scenarios. These interventions, denoted as Quick Defence Measures / Quick Adaptation Measures (QDM/QAM) also need to address their lifetime, the resilience, "working with nature" natural processes and construction cost. The weights among the different factors will vary upon the countries: a developed country will have technology that will reduce the construction time, but the costs can be higher than in developing areas. Construction proceedings, raw material availability, energy costs and social perception are also points that need to be considered.

4. The regional nature of the iCoast project shed light on considering several pilot sites for a same region: the impact of the event varied upon the pilot site, especially due to notably differences among the drivers. The high spatiotemporal resolution shows that in a matter of

few tenths of kilometres the impact can vary substantially. Other European initiatives span a wider area (the whole Europe), but each region has solely a pilot site. The iCoast project has shown the difficulties for extrapolating results even at the same region. Local features such as the coastal state, the coastline orientation and the resilience capacity play a key role in the forecast. Then, the higher computational demands at this scale are justified when there exists enough certainty of a forecasted storm (see point above).

5. Mean water level has revealed to be a fundamental parameter even in microtidal environments. This highlights the need of implementation of models that can reproduce storm surges accurately.

6. Bathymetry and topography introduced uncertainty in the process that should be taken into consideration for the forecasting chain. Uncertainties can be bounded by introducing an ensemble approach in the system, then providing a probability of risk occurrence. An analogous schema for hydrodynamic forcings will also enrich the ending result.

Despite the stakeholders were engaged with the project and the outcomes during the workshops, they proposed that will ease the workflow the set-up of official channels for communication and intervention protocols.

7 FOLLOW-UP

The continuation after the project end is guaranteed through four main actions: (*i*) the maintenance of the Storm Database, (*ii*) Meteo-oceanographic network data assimilation, (*iii*) the constitution of an active committee involving other institutions apart from the project team and (*iv*) by incorporating modelling updates.

At present the ICGC has as part of its tasks the maintenance of the database, although there has not been any extreme event since the end of the project. The questionnaire developed in the project to document a wave storm is operative and available at ICGC webpage. The following link leaves the reader to the mentioned questionnaire (in Catalan): http://www.igc.cat/web/ca/icoast_form_icgc.html

The initially planned link with the existing local meteo-oceanographic network (XIOM) will not be available due to budget restrictions. In order to solve this problem a contact with the Spanish network (Puertos del Estado) is planned.

The Active Committee has been constituted involving public bodies and stakeholders to ensure the follow-up. The project outcomes has arisen the importance of the proper characterization of storm patterns from the generation area to the arrival of the storm to the coast. As a result of this, new collaborative initiatives have been submitted to a Spanish call, the ST-MAP project, at present under the review process.

The cooperation with the "Demarcación de Costas" of the Spanish Ministry of Environment led to the building of one of the measures proposed and modelled in Task D. From the workshops made during the project with the stakeholders arose the need and possibility to test a Quick Defence Measure (QDM) at the municipality of Gavà, one of the pilot sites of iCoast used to probe the capabilities of the developed framework. The Gavà beach poses a suitable candidate for becoming a pilot site: the joint action of the longshore drift and the sediment budget cut by the Barcelona harbour has misbalanced its coastal resilience. The lack of beach width in some areas can exacerbate coastal flooding.

The proposed QDM consisted in the recycling part of the emerged sand from a neighbouring beach and the construction of a small dune to withstand extreme wave storms. These proposed actions, a dune and a trench will serve to evaluate the following aspects: (*i*) the manpower and machinery needs, (*ii*) the construction time requirements, (*iii*) the economic costs, (*iv*) possible hindrances and bottlenecks, (*v*) social acceptance and in case of occurrence of an extreme storm (*vi*) the feasibility of the proposed QDM. The works started on December 2015. The cost of the intervention has been paid by the "Demarcación de Costas" of the Spanish Ministry of Environment with the collaboration of the municipality of Gavà. Figure 9 shows the construction process.

The risk levels may change significantly in the near future, especially due to sea level rise (climate change). Throughout the project, special focus was given on testing both the forecasting system (deliverable F2.1.) and the QDM design (deliverable D3) under such future conditions. The results have lead to develop a set of adaptation measures against climate change that will be further explored within the FP7 RISES-AM- project. In that sense, the maintenance of the modelling framework and possible updates (new physical parameterizations, increases in spatial resolution, knitting better the end-user with the modelling layer) will be done from such collaborative relationship.

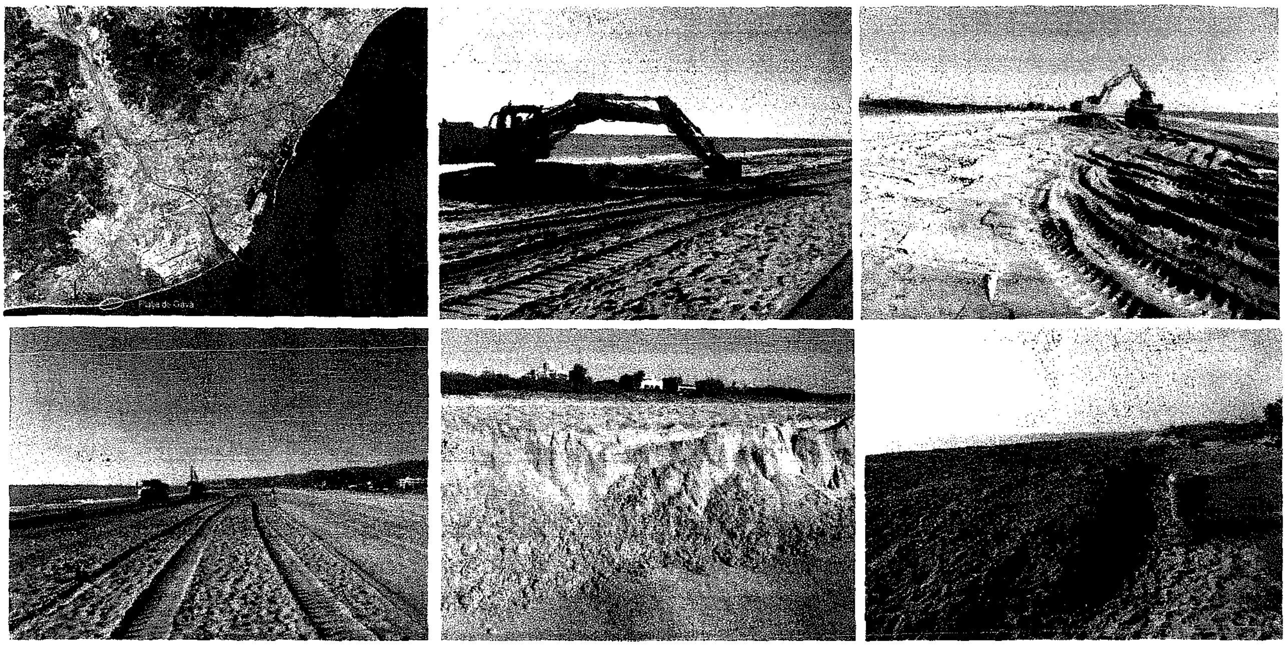

***Figure 9**. QDM construction process at Gava during December 2015*

Despite the implementation area has been the Catalan coast; the Committee is currently implementing an analogous system at the Danube Delta. The upcoming work will show the general applicability of the iCoast prototype and how can be extended to other areas. This ongoing work started within the framework of the FP7 DANCERS project.

8 CONSOLIDATED COST STATEMENT

The summary of the consolidated cost statements is shown in Table. In the following pages the details of the cost statements is shown.

***Table** 7. Consolidated cost statement*

FR02 - Consolidated Cost Statement

Consolidated Cost Statement for the Action

ATTENTION! to be completed only if the project involves one or more associated beneficiaries

Part A: Eligible cost categories	Rate %	€	Part B: Financing Plan	€	% of eligible costs
A: Personnel		590.441,98	EC contribution*	475.714,62	70,34%
B: Travel and subsistence		31.200,30	Contribution of the coordinating beneficiary	56.193,55	8,31%
C: Equipment			Contribution of the associated beneficiary/ies	144.380,35	21,35%
D: Sub-contracting		4.748,67	Other sources of funding		0,00%
E: Other direct costs		5.654,64	Direct revenues		0,00%
Indirect costs / overheads	7,00%	44.242,94			
TOTAL ELIGIBLE COSTS		676.288,53			
			TOTAL	676.288,53	

* eligible costs x EC-funding rate OR maximum EC-contribution, whatever is lower

For information only	
Estimation of "in kind" contributions / costs not	

CIIRC
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Date and signature

9/4/2016