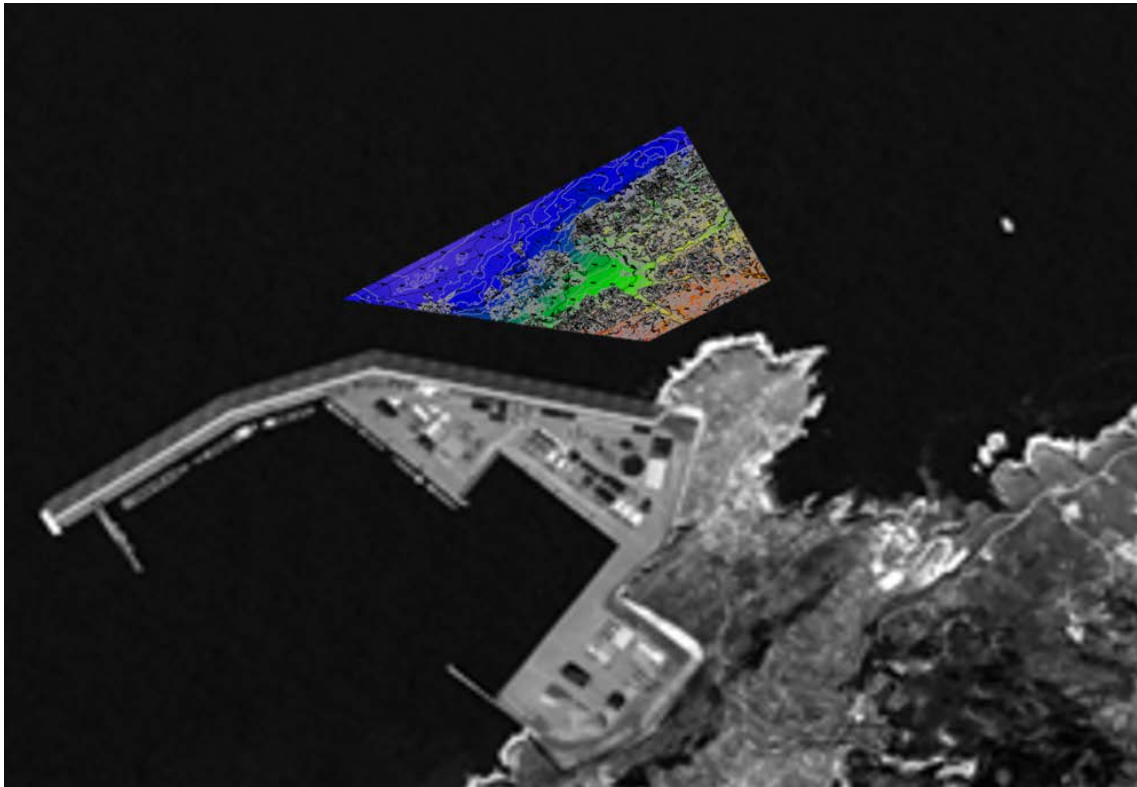


EXECUTIVE REVIEW

Analysis of environmental and socio-economic
framework related with marine energy's
experimental area construction



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1. INTRODUCTION

Galicia's government, through Industry and Economic Department and, in particular, through Galician Energy Institute (INEGA) has developed, since November of 2012, European EnergyMare project (Atlantic Area Programme 2007-2013). Project's aim is to study marine energy current situation and to determine exploitation possibilities of European Atlantic coast energy resources. Besides, experimental areas' creation, where pilot or pre-commercial devices could be tested, is included in the project.

INEGA, in collaboration With Meteogalicia, has developed a complete geospatial analysis of Galician's coast to determine possible experimental areas according to possible, pro or unfavourable, constraints (technical, environmental, socioeconomic and regulatory).

As a result, A Coruña-Malpica area stands out as ideal localization. Specifically, as show in Figure 1, an area located near outer harbour of A Coruña has been chosen as more favourable area.

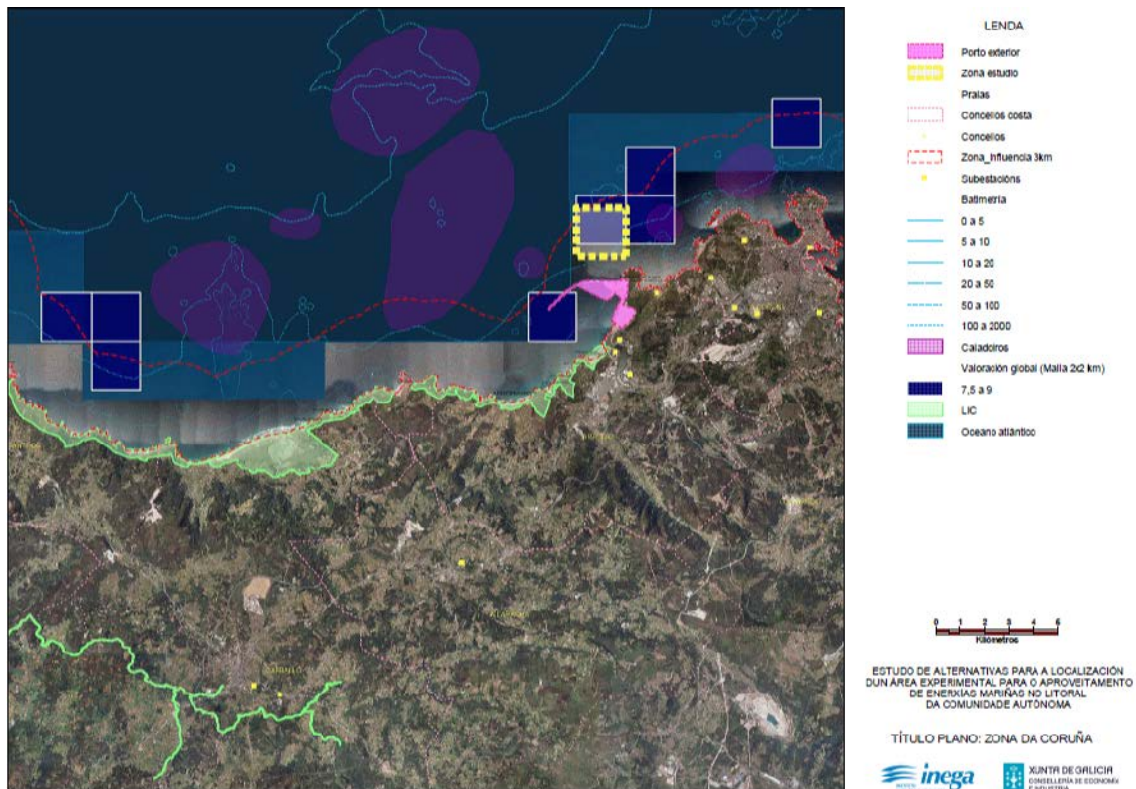


Figure 1: Source: "Locations for the creation of an experimental area for the use of marine energy on the coast of the autonomous community of Galicia" Internal report. INEGA/Xunta de Galicia, EnergyMare Project.

Once most favourable area has been identified, INEGA decided to ask for a detailed environmental and socio-economic framework analysis. The objective of this study is to establish a reference starting point in regards to a possible installation and operation phase in this experimental area

2. SCOPE OF THE REPORT

Present report presents an executive review of the environmental inventory based on the experimental area's available information. Thus, report's objective is identification (by specialist requests and bibliography revision) and available information analysis but also recognize which parameters need a future in-situ monitoring

In next lines, aspects taken into account for the environmental inventory are detailed. The selected environmental parameters (physical environment, biotic environment and socioeconomic) are just ones which could be significantly impacted (negative or positive) by marine energy devices installation (J. Bald et al, 2009¹; Solaun et al. 2003²).

- **Physical environment:** Climatology (temperature range, rainfall average, wind, solar irradiation...), currents, sea level, swell, bathymetry (geomorphology and sedimentary dynamic), hydrography, acoustic quality and landscape information of experimental area were collected
- **Biotic environment:** Benthos communities, fish population, marine mammals, seabirds and ecological interactions data of experimental area were presented
- **Socioeconomic aspects:** Fishing resources, archaeological resources and socioeconomic aspect about experimental area were studied.

¹Bald, J., A. del Campo, J. Franco, I. Galparsoro, M. González, P. Liria, I. Muxica, A. Rubio, O. Solaun, A. Uriarte, M. Comesaña, R. Fernández, A. Cacabelos, G. Méndez, D. Prada y L. Zubiate, 2009. Protocolo para la realización de los estudios de impacto ambiental de los captadores de energía del oleaje Proyecto singular y estratégico en energía marina (PSE MAR). Subproyecto 5. Impacto de las energías marinas. Memoria Técnica 2009. Informe para Ministerio de Ciencia e Innovación. 259 pp.

²[Protocolo para la realización de los estudios de impacto ambiental en el medio marino](#)

3. PHYSICAL ENVIRONMENT

Analysis of physical environment must take place from a double point of view: Study of possible impact of the facilities in the environment (environmental standpoint) and also environment's potential impacts on facilities (security point of view).

In present section information of marine energy experimental site influence area about climatic data (temperature, average rain, wind, solar radiation...), waves, currents, tides, hydrologic parameters, hydromorphology (bathymetry, sediment dynamics...), acoustic quality, landscape, protected or interest areas is presented.

3.1. Available meteorological and climatic data

Classical climatic and meteorological parameters to take in account for an Environmental Impact Study are average wind direction and intensity, average thermal regime, direction and intensity of the maximum gust, precipitation and radiation. All of these information is available for the experimental site area of influence; sources of information are summarized in table 1

Source	Organization	Data	Availability
Meteogalicia	Meteogalicia	-Climatic -Meteorological	www.meteogalicia.es
Plan Camgal	INTECMAR	-Wind direction -Wind intensity -Air temperature	http://ww3.intecmar.org/plancamgal/ GIS shape download: http://xeocatalogo.intecmar.org/geonetwork/srv/spa/catalog.search#/home
Atlas de viento Galicia	Meteogalicia	- Wind annual average speed - WindPower density - Wind energy annual average production	http://www.meteogalicia.es/modelos/atlas/atlasVento.action
Puertos del Estado	MAGRAMA	-Wind direction -Wind speed -Atm. pressure -Air Temperature	www.puertos.es

Table1: Abstract of available meteorological and climatic information for experimental site area of influence

Thus, it will be easily possible to consult state and daily weather forecast for the area, which will allow to schedule and to choose best possible location for marine power use devices installation.

At same time and based on Meteogalicia's wind atlas, interested companies could previously estimate wind energy production in the experimental site.

3.2. Available wave, currents and sea level information

Large information of wave, currents and sea level for experimental site area of influence is available from different sources (table 2)

Source	Organization	Data	Availability
Meteogalicia	Meteogalicia	<ul style="list-style-type: none"> -Significant average height -Average period -Peak period -Max. wave height -Max. wave height average -Max/Min significant average height -Max./Min. peak average period -Max/Min. Peak period 	www.meteogalicia.es
Plan Camgal	Intecmar	<ul style="list-style-type: none"> -Current direction -Current intensity 	http://ww3.intecmar.org/plancamgal/ GIS shape download: http://xeocatalogo.intecmar.org/geonetwork/srv/spa/catalog.search#/home
Atlas de oleaje Galicia	Meteogalicia	<ul style="list-style-type: none"> -Average wave regime -Extreme regime -Wave average power -Annual wave average energy 	http://www.meteogalicia.es/modelos/atlas/atlasOndas.action;jsessionid=D19F664E6549015D48256C40BF8473A8.EUM
Puertos del Estado	MAGRAMA	<ul style="list-style-type: none"> -Current direction -Current speed -Significant average height -Average period -Peak period -Wave max. height -Wave max. weight average -Max./Min. average significant height -Max./Min. average period -Max./Min. peak period 	www.puertos.es

Table 2: Abstract of available information of wave, tides and sea level for experimental site area of influence

Available information for waves, tides and sea level have enough resolution to characterize experimental site area of influence, both physical environment (current and wave direction and intensity and sea level) or area's energy potential. Besides, once marine energy use devices are installed, will be possible to request wave, currents and sea level conditions and download data to posterior analysis either.

In future Environmental Impact Study a high resolution wave propagation analysis could be interesting. This study must be focused on experimental site with the aim of generate knowledge of wave conditions at microscale. Thus, this level of resolution allows to evaluate reflexion effects on experimental site caused by dike and Langosteira formation.

3.3. Available hydrological parameters information

Compiled information about hydrological parameters in experimental site influence area is presented in table 3.

Source	Organization	Data	Availability
EIS. exterior port	A Coruña P.A.	-Temperature -Salinity -Conductivity, -Dissolved oxygen -Dissolved oxygen saturation - pH -Redox potential -Turbidity	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
InstitutoEspañol de Oceanografía	IEO	- Oceanographic data - A Coruña estuary data	Available by previous request
Puertos del Estado	MAGRAMA	- Water temperature - Salinity	www.puertos.es

Table 3: Abstract of available information of hydrological parameters for experimental site area of influence

Available information for hydrological parameters in experimental site influence area do not have resolution enough. In this way, A Coruña's exterior Port EIS could provide data with more interest but this work is only available by previous request.

In conclusion, facing marine energy use devices future installation and if access to A Coruña's exterior port EIS is not possible, area's hydrological characterization would be necessary. This characterization of experimental site water column could be done by CTD measuring or by multiparametric buoy installation. On the other hand, during devices installation or removing it is recommended hydrological characterization which allows to monitor parameters (mainly turbidity) affected by mooring and dis-mooring tasks.

3.4. Available hydromorphology information

Available information for hydromorphology parameters for experimental site area of influence is summarized in table 4

Source	Organization	Data	Availability
Hydromorphology study	INEGA	- 3D Bathymetry - Geomorphology profile	Available by previous request
Atlas de oleaje Galicia	Meteogalicia	- Bathymetry	http://www.meteogalicia.es/modelos/atlas/atlasOndas.action
EIS exterior port	A Coruña P.A.	- Sediments dynamic	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf

Table 4: Abstract of available information of hydromorphology parameters for experimental site area of influence

To carry out an Environmental Impact Study of marine energy use areas is required a bathymetric survey with appropriate resolution, both in area of occupancy of the facility as the shadow area. Thus, the work commissioned by INEGA for bathymetric and geomorphological characterization of the experimental site allows adequate knowledge of the target sea bottom. This works show a mainly rocky bottom that presents the maximum depth in the sandy areas, factors that hinder the future mooring and wiring of energy use systems.

The sediment dynamic information of the experimental site is other key factor for devices mooring and wiring. Environmental Impact Declaration document summarizes the study of sediment dynamic carried out in Langosteira during de A Coruña's EIS. However, it is recommendable to realize sediment dynamic studies focused in the experimental site with the aim of know "zero point" and future behavior of this parameter at local level.

3.5. Available acoustic quality information

Available information for acoustic quality for experimental site area of influence (table 5) is poor and with low representability

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	- Day and nighttime acoustic quality measures	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
National Oceanic and Atmospheric Administration	NOAA	- Underwater noise model maps Atlantic level	cet sound.noaa.gov/sound_data
Evaluation of underwater noise	UVIGO	- Punctual measures at exterior port	http://www.researchgate.net/publication/257207260_Evaluation_of_underwater_dredging_noise

Table 5: Abstract of available information of acoustic quality parameters for experimental site area of influence

A classic methodology for characterizing sonic environment is proposed by Nedwell et al³. This methodology is consist in the installation three buoys equipped with high (500ks/s) and low frequency (192ks/s) hydrophones as well as amplifiers and recording systems at least 4 channels in the study area. The use of three buoys allows to determine noise directionality and origin.

Underwater noise measurement devices should be moored before the installation of energy use equipment and make day and night time measures. Thus, it is possible to set up a noise control patter which work as reference to characterize underwater noise during installation and operation of marine energy use devices.

³<http://www.subacoustech.com/wp-content/uploads/534R1231.pdf>

3.6. Available information of landscape and protected or interest areas.

Landscape and protected or interest areas for experimental site area of influence (table 6) describes coast and terrestrial line in Langosteira's area.

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	-Langosteira's area description	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
Red Natura model document	Red Natura	- Langosteira's area description	http://www.magrama.gob.es/es/biodiversidad/temas/espacios-prottegidos/ES0000176_tcm7-154964.pdf
Plan Camgal	ITECMAR	- GIS shapes ZEPA areas - GIS shapes LIC	http://ww3.intecmar.org/plancamgal/ GIS shape files download: http://xeocatalogo.intecmar.org/geonetwork/srv/spa/catalog.search#/home

Tabla6: Abstract of available information of landscape and protected or interest areas parameters for experimental site area of influence

To complete future energy use devices EIS must be necessary to study the landscape's marine component. Therefore, navigation charts, aerial photography and/ or urban planning, should be consulted. Besides, intertidal areas and meteorological information have to be included.

It is important to highlight that experimental marine energy site should be installed in sea sheet and big infrastructures are not necessary. In addition, energy use devices do not have big dimensions and his installation should be temporal. Thus, a less significant visual quality impact is expected for marine site area of influence.

4. BIOTIC ENVIRONMENT

Biotic environment analysis pay especial attention to communities, species and areas of high environmental value which could be protected by national or European regulations. In the case of marine energies use equipment installations should pay attention to noise and electromagnetic impacts may have on communities of seabirds, cetaceans and fish fauna. Benthic communities and fish fauna could be also affected by moorings and wiring associated impacts.

In this section benthic communities, fish population, marine mammals and marine seabird information for experimental site area of influence is presented.

4.1. Available benthic communities information

Information about benthic communities for experimental site area of influence could be found in three principal points, A Coruña's exterior port Environmental Impact Study, the Coruña's University (UDC) research "Comunidades de peces de los arrecifes rocosos costeros de Galicia: ecología e impactos humanos" and the Instituto Español de Oceanografía (IEO) "Spatial and temporal changes in benthic communities of the Galician continental shelf after the Prestige oil spill". These information is summarized in table 7:

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	-Visual and photographic transects	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
Comunidades de peces de los arrecifes rocosos costeros de Galicia: ecología e impactos humanos	UDC	-Visual underwater census data	http://ruc.udc.es/dspace/handle/2183/9951
Spatial and temporal changes in benthic communities of the Galician continental shelf after the Prestige oil spill	IEO	-Trawl nets, box corer and suprabenthic sled	Spatial and temporal changes in benthic communities of the Galician continental shelf after the Prestige oil spill

Table 7: Abstract of available information of benthic community for experimental site area of influence

A Coruña's exterior port EIS is the work which more information could contribute to experimental site benthic community characterization. However, A Coruña's exterior port EIS is only available by previous request.

Data from UDC and EOI researches could be a base line foreexperimental site's benthic community knowledge, now these researches do not have resolution enough. In this way, UDC research describes and analyzes different underwater communities study methods (underwater visual census, underwater remote cameras and remote vehicles) which, facing an experimental site's benthic community study, is an interesting information. Similarly, these information is also applicable to nektonic community study.

4.2. Available fish fauna information

Available fish fauna information for experimental site area of influence is summarized in table 8.

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	-Visual and photographic transects	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
Comunidades de peces de los arrecifes rocosos costeros de Galicia: ecología e impactos humanos	UDC	-Visual underwater census data	http://ruc.udc.es/dspace/handle/2183/9951
Spatial distribution patterns of demersal and epibenthic communities on the Galician continental shelf (NW Spain)	IEO	-Transects samples	Spatial distribution patterns of demersal and epibenthic communities on the Galician continental shelf (NW Spain)

Table 8: Abstract of available information of fish community for experimental site area of influence

A Coruña's exterior port EIS is the work which could contribute more and better information about fish community of experimental site. Abstract of material and methods employed likewise results could be consulted in the Environmental Impact Statement while complete EIS is only available by previous request.

Similarly to benthonic fauna case, UDC and IEO researches data have low resolution for experimental site and could be used as started line information. As discussed in the previous section, the analysis and comparison of different.

At least, during future utilization of marine use experimental site a study of impacts (positives or negatives) caused by electromagnetic fields over fish populations, should be done.

4.3. Available sea mammals information

Sea mammals have a great movement capacity, so, it increases the possibility of sea mammal presence, both punctual as continuous, in experimental area. This point is very important for porpoise (*Phocoenaphocoena*) and bottlenose dolphins (*Tursiops truncatus*), considered priority species for conservation.

Available information about sea mammals for experimental site area of influence is mainly presented in two research presented in table 9.

Source	Organization	Data	Availability
Cetacean Offshore Distribution and Abundance in the European Atlantic	IEO	-Transects samples	Avistamiento de cetáceos en el Atlántico Norte
Trends in cetacean sightings along the Galician coast, north-west Spain, 2003–2007, and differences about cetacean habitat preferences	CEMMA	- Costal visual census	Trends in cetacean sightings along the Galician coast, north-west Spain, 2003–2007, and differences about cetacean habitat preferences

Table 9: Abstract of available marine mammal information for experimental site area of influence

In the same way that fish populations, marine mammals could be affected by electromagnetic fields and/or underwater noise caused by marine energy use devices. Therefore these impacts and the necessary corrective steps should be studied.

4.4. Available seabird population information

Langosteira formation, and for extension the experimental site, is located in the middle of "Costa da morte" ZEPA area. Thus, the marine energy use devices will be installed in an important area for seabird nesting and migratory routes. Among the present species in the area could highlight the presence of species considerate "Critically Endangered" such as balearic shearwater (*Puffinus mauretanicus*) or nesting colonies of black-legged kittiwake (*Rissa tridactyla*), common shag (*Phalacrocorax aristoteles*) or common murre (*Uria aalge*) which represents nearly all populations at Spanish level for these species.

Principal point of available information for seabird in experimental site area of influence is summarized in table 10.

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	-Visual and photographic transects	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
Estudio de Impacto Ambiental del acceso al puerto exterior	A Coruña P. A.	- Birdscensuslist	http://www.artex.org/informacion/norma/estudioinformativo/doc01/03anexos/anexo02.pdf
Red Natura model document	Red Natura	-Seabirdcensuslist	http://www.magrama.gob.es/es/biodiversidad/temas/espacios-protegidos/ES0000176_tcm7-154964.pdf

Table 10: Abstract of available seabird information for experimental site area of influence

A Coruña's exterior port EIS joint with A Coruña's exterior port access EIS have information enough about seabird population nearly experimental site. However, A Coruña's exterior port EIS is only available by previous request.

The presence of "Critically Endangered" species in the experimental site area of influence obliged to assess and study the impacts associated with the installation of energy use on seabirds in the area, as well as establish preventive, protective, corrective and compensatory steps for detected negative impacts.

5. SOCIOECONOMIC ASPECTS

In this section, economic and sociologic parameters description is presents. These parameters give information about life quality of nearly experimental site population and their dependence of resources affected by the marine use devices installed.

Following information about fishing resources, archaeological resources and socioeconomic aspects is presented.

5.1. Available information of fisheries resources.

Table 11 summarized available information about fishing resources in experimental site area of influence.

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	-Area socioeconomic analysis	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
SecretaríaXeral do Mar	Xunta de Galicia	-GIS shapes	Personal communication
Comunidades de peces de los arrecifes rocosos costeros de Galicia: ecología e impactos humanos	UDC	-Type of fishing gears -Main catches -Fishinggrounds	http://ruc.udc.es/dspace/handle/2183/9951 GIS shapes on request
El puerto exterior de A Coruña. Efectos económicos de la destrucción de zonas de pesca y marisqueo	USC	-Type of fishing gears -Main catches -Fishinggrounds	http://www.researchgate.net/publication/267392790_El_Puerto_Exterior_de_A_Corua_Efectos_economicos_de_la_destruccion_de_zonas_de_pesca_y_marisqueo

Table11: Abstract of available fishing resources information for experimental site area of influence

Information for fisheries resources is well described in Langosteira area both at local level (USC research and Xunta de Galicia information) as Artabro's gulf level (UDC research).

Regarding the impact on fish stocks,experimental site installation onLangosteiradoes not involved loss of new fishing grounds, since it is located in areas already affected by the installation of the exterior port of A Coruña (Mar do North ground). But it is of interest to study the impact, positive or negative , on fish stocks that can generate magnetic fields and/or underwater noise associated with installed devices and wires.

5.2. Available information of archaeological resources

Information recompiled (table 12) for experimental site area of influence only mark archaeological resources in terrestrial space. Therefore, based on the absence of underwater archaeological resources this parameter is not applicable in the marine energy use experimental area.

Source	Organization	Data	Availability
EIS. Exterior Port	A Coruña P. A.	-List of archaeological resources	Available by previous request Abstract results: https://www.boe.es/boe/dias/2001/03/14/pdfs/A09591-09597.pdf
Estudio de Impacto Ambiental del acceso al puerto exterior	A Coruña P. A.	-List of archaeological resources - Localization maps	http://www.artexo.org/informacion/norma/estudiointeractivo/doc01/03anexos/anexo02.pdf

Table 12: Abstract of available archaeological resources information for experimental site area of influence

5.3. Available economic aspects information

Future Environmental Impact Study (EIS) for the marine energy use experimental site should study the economic impact of this experimental site installation. In this way, works such "Comunidades de peces de los arrecifes rocosos costeros de Galicia: ecología e impactos humanos", "Characterization of fisheries dependence in Galicia (Spain)", "El puerto exterior de A Coruña Efectos económicos de la destrucción de zonas de pesca y marisqueo" (summarize on table 13) gives information which will allow to estimate the economic impact over fisheries and population of Artabro's gulf. For a complete EIS the estimated economic impact should be compared with economic effect over local industry.

Source	Organization	Data	Availability
Comunidades de peces de los arrecifes rocosos costeros de Galicia: ecología e impactos humanos	UDC	- Gross value per ground	http://ruc.udc.es/dspace/handle/2183/9951 GIS shapes on request
Characterization of fisheries dependence in Galicia (Spain)	UVIGO / CETMAR	-Gross production -Gross income -Dependent employment	Characterization of fisheries dependence in Galicia (Spain)
El puerto exterior de A Coruña. Efectos económicos de la destrucción de zonas de pesca y marisqueo	USC	- Estimation losses per ground	http://www.researchgate.net/publication/267392790_El_Puerto_Exterior_de_A_Corua_Efectos_economicos_de_la_destruccion_de_zonas_de_pesca_y_marisqueo

Table 13: Abstract of available economic aspects information for experimental site area of influence

6. GENERAL CONCLUSIONS

In general we can conclude that the chosen marine energy use experimental areas are well characterized and there is enough base information for physical, biological and socio-economic parameters.

Main expected impacts associated with marine energy use devices installation are the following:

- Negatives:
 - Geology-Soil-Morphology: Sea bottom alteration by mooring effect
 - Benthos and sea bottom: Habitat and species removal by mooring effect
 - Water: Sea water quality alteration
 - Risks and marine security: Increase of marine traffic
- Positive:
 - Economy: Effect over other sectors and economic activities
- Studies to develop
 - Research of electromagnetic fields, caused by marine energy use devices effects over environment and present species.
 - Research of underwater noise, caused by marine energy use devices effects over environment and present species.
 - Study of wave reflection effect caused by Langosteira formation and exterior port dike over the experimental area.
 - Impact of marine energy use experimental area over landscape marine component.

To minimize negative impacts identified during the installation phase, preventive, protective, corrective and compensatory measures should be promoted.