Echo-character of the NW Iberian continental margin and the adjacent abyssal plains

Adolfo Maestro a,b, Gloria Jané a, Fernando Fernández-Sáez a, Estefania Llave a, Fernando Bohoyo a, Javier Navas a, Sandra Minka, Maria Gómez-Ballesteros b, José Martín-Dávila c and Manuel Catalán c

aInstituto Geológico y Minero de España, Madrid, Spain; bInstituto Español de Oceanografía, Madrid, Spain; cReal Instituto y Observatorio de la Armada, Cádiz, Spain

ABSTRACT
The acoustic facies analyses have provided an important basis for sedimentary processes in the deep-sea environments. The echo-character mapping, through the interpretation and correlation of very high-resolution seismic profiles, is a very useful tool for the characterization of the recent sedimentary processes and their distribution. This work presents the first echo-character map at 1:800,000 scale of the Galicia Continental Margin and the adjacent abyssal plains elaborated by the Geological Survey of Spain. The map was carried out on the basis of the analysis and interpretation of the bathymetry and reflectivity data from the SIMRAD EM12, EM120 and EM1002 echosounders, and the high-resolution seismic profiles from the SIMRAD TOPAS PS18 parametric echosounder. On the basis of the seafloor morphology, surface bedforms, backscatter and sub-bottom acoustic echo-characters, 26 echo-types were identified in the uppermost sedimentary sequence. These echo-types have been grouped into four main echoes: Distinct, Irregular, Hyperbolic and Undulated, according to their main acoustic characteristics. This information has been acquired in the framework of the ‘Scientific Research Program of the Economic Exclusive Zone of Spain’, which is coordinated and led by the Defense Ministry of Spain, during the oceanographic cruises carried out on board of the R/V Hesperides in 2001–2003 and 2006–2009.

1. Introduction
Acoustic facies analysis using seismic records collected via a 3.5-kHz sub-bottom profiler, pinger, 12 kHz, Panason or TOPAS (TOPographic PARametric Sonar) constitutes a relevant tool for studying marine geology and sediment types, as well as to evaluate near-surface and seafloor sedimentation processes (e.g. depositional, erosive and gravitational). Although B.C. Heezen was the first marine geologist to undertake sedimentary studies in the 1950s, using seafloor reflectivity as recorded by high-resolution precision depth recorders (Heezen, Tharp, & Ewing, 1959; Holllister & Heezen, 1972), it was J.E. Damuth who proposed the first classifications of acoustic response in deep waters, divulging his methodology to the marine research community (Damuth, 1975, 1978, 1980; Damuth & Hayes, 1977; Damuth et al., 1983). Since then, many studies have shown its utility as an indirect method for underwater marine research (e.g. Blondel, 2003; Bouye, 1983; Frappa & Duprat, 1982; Trabant, 1984). These studies have been mainly executed for the characterization of regional deep-sea environments in the Atlantic Ocean (Alves, Gawthorpe, Hunt, & Monteiro, 2003; Damuth, Flood, Kowsmann, Belderson, & Gorini, 1988; Driscoll & Laine, 1996; Jacobi & Hayes, 1984, 1992; Klaus & Ledbetter, 1988; McClennen, 1989; Milliman, 1988), Norwegian-Greenland Sea (Damuth, 1978; Taylor, Dowdeswell, & Siegert, 2002), Mediterranean Sea (Droz, Kergoat, Cochonat, & Berné, 2001), Pacific Ocean (Chough et al., 2002; Damuth, 1980; Damuth et al., 1983; Lee, Chough, Back, & Kim, 2002; Orpin, 2004), Indian Ocean (Damuth, 1980; Kenyon, Amir, & Cramp, 1995; Kottke et al., 2003) and Antarctica (Beaman & Harris, 2003; Ercilla, Baraza, Alonso, & Canals, 1998; Kuhn & Weber, 1993; Pudsey & Howe, 1998, 2002). Nearby the study area, Hernández-Molina et al. (2008) and Iglesias (2009) carried out a characterization of the most recent sedimentary processes occurring in the southwestern Galicia Bank and Cantabrian continental margin, respectively.

Acoustic analysis based both on the acoustic response (or acoustic facies) of the sediment and detailed sea bottom morphology has been defined as echo-character analysis (Damuth, 1980). The analysis of high-resolution seismic and acoustic facies data enables us to identify different echo-types and classes related to sediment distribution on the seafloor and its near-surface. Seismic facies analysis and detailed sea bottom morphology characterization are important tools for understanding recent and present-day sedimentary processes (Damuth, 1980), particularly for
the identification of mass-movement processes including slides, debris/mud flows and turbidity flows (Alves et al., 2003; Taylor et al., 2002).

The characterization of recent sedimentary processes using echo-character analysis has been traditionally carried out with 3.5-kHz sub-bottom profiler systems and sidescan sonar (i.e. GLORIA sidescan sonar), which could be complemented by using deeper penetration seismic-reflection methods. However, over the last decade, substantial technological advances in marine geology and geophysical methods have made it possible to develop full water depth, ultrahigh-resolution seismic methods, such as the Chirp. Parasound and TOPAS systems, which offer much higher resolution and penetration levels than conventional 3.5-kHz sub-bottom profiler systems. The use of these new systems has become generalized (Blondel, 2003; Hailwood & Kidd, 1990; Jones, 1999; Masson, 2003). In addition to the characterization of recent sedimentary processes in deep water, echo-character analysis has also been executed in shallow water using both high-resolution seismic-reflection systems and sediment samples obtained either by dredging or coring. These studies have confirmed the effectiveness of echo-character as an indirect method for sedimentary processes identification (e.g. Chough et al., 2002; García-García, García-Gil, & Vilas, 2004; Hernández-Molina, 1993; Lobo, 1995; Lobo, Hernández-Molina, Gutiérrez-Mas, & Rodero, 1994; Von Rad & Tahir, 1997; Walter, Lambert, & Young, 2002).

This work shows the first echo-character map at 1:800,000 scale of the Galicia Continental Margin and the adjacent abyssal plains elaborated by the Geological Survey of Spain. The map was carried out based on the analysis and interpretation of the bathymetry and reflectivity data from the SIMRAD EM12, EM120 and EM1002 echosounders, and the high-resolution seismic profiles from the SIMRAD TOPAS PS18 parametric echosounder (Main Map). This information has been acquired in the framework of the ‘Scientific Research Program of the Economic Exclusive Zone of Spain’ coordinate and leaded by the Defense Ministry of Spain, during seven 1 month the oceanographic cruises carried out on board of the R/V Hesperides in the periods 2001–2003 and 2006–2009.

2. Geologic and oceanographic settings

Acoustic facies analysis has provided an important basis for sedimentary processes in the deep-sea environment. The distribution of sediments along the NW Iberian Continental Margin and adjacent abyssal plains are mainly controlled by the geologic processes and the deep water masses interaction with the seafloor.

2.1. Geologic setting

The Galicia Continental Margin can be defined as a starved, non-volcanic passive margin (Montadert, Charpel, Roberts, Guennoc, & Sibuet, 1979), meaning that sediments are scarce and the basement palaeotopography has not been covered by sediments; therefore, the observable morphological features on their surfaces are primarily due to tectonic and erosive processes. This area is mainly characterized by a complex structure comprising horsts and grabens bounded by NW–SE and NE–SW strike-slip faults, N–S normal faults and E–W reverse faults (Figure 1(A)). These faults are related to the geological evolution of this sector during the Variscan Orogeny, the north Atlantic rifting in the Jurassic and Lower Cretaceous, and the convergence between Eurasian and Iberian plates in the Cenozoic, where a tectonic inversion for the previous structures and the subduction of the northern Cantabrian margin took place (Álvarez-Marrón, Rubio, & Torné, 1997; Boillot, Girardeau, & Kornprobst, 1988; Mauffret & Montadert, 1987). Stratigraphic and sedimentological studies (Alonso et al., 2008; Boillot, Malod, Dupeuble, & Cybere Group, 1987; Comas & Maldonado, 1988; Ercilla et al., 2008; Vanney, Auxietre, & Dunand, 1979) show that the Cretaceous to Quaternary sedimentary record of the Galicia Bank region reflects depositional responses to the tectonic evolution. Cenozoic sedimentary deposits include turbidites, (hemi) pelagites, contournites and debrites. Contourites and debrites occurred mostly during the Late Miocene and turbidites, debrites, contournites and (hemi) pelagites have dominated the Plio-Quaternary sequences.

2.2. Oceanographic setting

There are four main water masses flowing northwards along the west Iberian margin at distinct depths (Figure 1(B)). (a) The Portugal Current (PC), or Iberian Current (IC) (e.g. Pérez, Castro, Álvarez-Salgado, & Ríos, 2001; Varela, Roson, Herrera, Torres-Lopez, & Fernandez-Romero, 2005), is the main wide and shallow current (100–120 m water depth). Its surface flow is generally southwards (Ambar & Fiuza, 1994). (b) The Eastern North Atlantic Central Water (ENACW) extends down to water depths of 600 m and flowing south-westwards (Ambar & Fiuza, 1994; Fiuza, 1984; González-Pola, 2006; McCartney & Talley, 1982; Pollard & Pu, 1985; Pérez et al., 2001). (c) The Mediterranean Outflow Water (MOW) flows along the middle slope of the Portuguese margin towards the Galician margin and the Bay of Biscay, with two distinct cores centered at water depths of 800 m and nearly 1200 m: one branch flows west of the Galicia Bank plateau and the other continues northwards while the other flows eastwards along the Cantabrian margin slope (Ambar & Howe, 1979; González-Pola, 2006). (d) The deep water masses (below a 1500 m water depth) consist of the southwards-flowing North Atlantic Deep Water (NADW) and northwards-flowing Lower Deep Water (LDW) (Van Aken, 2000). The
NADW (between 1500 and 3000 m water depth) includes a core of Labrador Sea Water (González-Pola, 2006; McCave et al., 2001; Van Aken, 2000). The LDW appears to result primarily from the mixing of the deep Antarctic Bottom Water and the Labrador Deep Water, and it is characterized by a northwards near-bottom flow on the Galicia Margin (Le Floch, 1969; McCave et al., 2001; Van Aken, 2000).

3. Data set and methods

3.1. Processing and interpretation data

Acoustic data, collected during seven cruises on board the RV Hespérides, derived from multibeam echosounder and TOPAS (TOpographic PArameter Sonar). Data positioning was determined via a Differential Global Positioning System (DGPS). The data acquired with TOPAS and multibeam echosounder consisted of 452 profiles with a total length of about 32,400 km that cover a surface of 271,500 km² (Figure 2).

Swath bathymetry was acquired by SIMRAD EM12 and EM120 deep water multibeam echosounders and EM1002 shallow water multibeam echosounder. These multibeam sonars produce a large number of conventional single-beam echo sounders with their beams set in a fan perpendicular to the ship’s track. The coverage area on the seafloor depends on the beams opening angle. The SIMRAD EM12 (2001–2003) and EM120 (2006–2009) echosounders offer a maximum coverage of 120°–150° beams opening angle, respectively, providing a maximum range of 3.5–5.5 times the water depth, respectively. The working central frequency was 13 kHz, and vertical

Figure 1. (A) Geological and tectonic setting of the northwestern Iberian continental margin and adjacent abyssal domains modified from Rodríguez-Fernández et al. (2014). Tectonic structures: 1. Thrust; 2. Normal fault; 3. Strike-slip fault and 4. Peridotite ridge. (B) Superficial, intermediate and deep water masses compilation around of the Galicia Continental Margin and adjacent abyssal plains (modified from Hernández-Molina et al., 2011). Water masses: PC: Portugal Current; IC: Iberian Current; ENACW: Eastern North Atlantic Central Water; MOW: Mediterranean Outflow Water; NADW: North Atlantic Deep Water; and LDW: Lower Deep Water.
precision was approximately 0.25% the total depth (60 cm). On the other hand, the SIMRAD EM1002 echosounder offers a maximum coverage of 150°, providing a range of 5.5–7 times the water depth. The working central frequency was 95 kHz. Caraíbes software was used for data processing. The water column sound velocity spreading corrections for depth calculations were performed with the SIPPICAN MK12 acquisition system, including Expendable Bathythermograph (XBT), Expendable Sound Velocity (XSV), and Expendable Conductivity, Temperature and Depth (XCTD) profilers.

Ultrahigh- to middle-resolution seismic data were acquired by SIMRAD TOPAS PS18. This system uses the interference between two transmitters with primary frequencies of 15 and 18 kHz, to obtain a wave with a variable secondary frequency between 0.5 and 5 kHz (Parametric effect; Westervelt, 1963). This allows higher resolution (tens of cm) and better penetration (90–100 ms TWTT) below the seafloor than Chirp and 3.5-kHz sub-bottom profiler systems.

Data analysis included two phases: (1) classification and cartography of the acoustic facies based on the ultrahigh-resolution seismic records and, as a detailed bathymetry was essential to accurately define echotype distribution during mapping, (2) correlation between the superficial acoustic facies and the bathymetry and backscatter/reflectivity obtained from multibeam echosounders. Nomenclature for the echo-character analysis was based on classic guidelines established by Damuth (1975, 1978, 1980), Damuth and Hayes (1977), McClennen (1989) and Pratson and Laine (1989), adapted to the acoustic response of the study area.

3.2. Echo-character map elaboration processes

Two cartographic products have been developed based on the echo-character study of the region. The main one is the echo-character map of the Galicia Continental Margin at 1:800,000 scale shows the location and distribution the different acoustic facies identified on a shaded digital elevation model of the seabed. The purpose of this map is that it can be used to characterize the bathymetry and to infer the sedimentary distribution, especially to interpret marine sedimentary processes (depositional, erosional or mass-transport deposits). Additionally, this cartographic dataset has also been made for 3D visualization, so that the user can perceive in an easy and intuitive manner the distribution of the echo-characters on the seafloor.

3.2.1. Elaboration of the echo-character map in Mercator projection

The geographical coordinate system used in the layout of the echo-character map of the Galicia Continental Margin is Transverse Mercator projection. A shaded relief model is rendered in combination with the studied data in order to display in a simpler way the relationship between the distribution of different
Echo-types and the seafloor morphology. For this reason, it has been necessary to treat bathymetry and bottom and sub-bottom acoustic character data separately and overlay them later.

The Digital Terrain Model was computed from an XYZ point file in ASCII format containing the bathymetry data of the mapped area. The number of points exceeds 60 million. The processing was performed with the FME 2016 software to generate a DTM with a resolution of 50 m on X and Y axes. The output was stored in WGS84 datum and in a projected GCS, UTM-WGS84 zone 29. For a better fitting of the data to the printed layout, Transverse Mercator projection was chosen. The final shading model is a combination of four individual shading patterns generated at different azimuth angles (225°, 270°, 315°, 360°) and a zenith angle of 30°. The combination of shading models with different azimuths improves the highlight of morphological features that could otherwise remain in shaded or direct light areas. Finally, the overall look was smoothed and the noise was reduced using a low pass filter which calculates the average value (mean) of a 3 × 3 neighborhood for each cell, so that high and low values within each neighborhood will be averaged out, reducing the extreme values in the data. The mapping of polygons and corrections on the topology to ensure the absence of overlaps and holes were performed in ArcGIS v.10.1. To enhance the final layout, the labeling of the depth information was generated following the direction of the contour bathymetry. Moreover, the relief and singular entities identification tags were added in both, the submerged and emerged areas. Finally, the color palette and an adequate transparency were chosen to allow a correct shading visualization of the seabed and to obtain a clear and visually esthetic map. All files obtained in the information processing were stored in ArcGIS Geo-database format (Figure 3 and see Map ‘Echo-character Map of the Galicia Continental Margin, scale 1:800.000’).

3.2.2. Explanation of the echo-character map in PDF3D format

The 3D visualization format of the echo-character map of the Galicia Continental Margin drapes on the Digital Terrain Model is a powerful display tool that offers many advantages for transmitting and interpreting the information and it is an easy tool to handle for the end-user. The visualization of a reality analogue representation facilitates the transmission and comprehension of space concepts (Figure 4).

This format has the advantage that it does not require specialized GIS software to visualize the map, just a free PDF reader is necessary (e.g. Adobe Acrobat Reader). In addition, the 3D functionality allows to add a toolbar in the PDF document to perform the following operations rotate, pan, zoom, get pictures, measure, add comments, view the model tree, hide items, select and save views, change the display/rendering type, sectioning 3D view by an arbitrary plane defined by the user, and change the lighting and background.

The 3D map is composed of the Galicia Margin bathymetry and echo-character layers. The Digital Terrain Model of the area was generated from a bathymetry data file in ASCII format containing approximately 60 million points. Echo-character information has been extracted from ArcGIS project, constituted by shapefile format files of polygons, lines and points that included the legend and toponymy.

In the processing of bathymetric data, some applications with ETL (Extract, Transform, Load) tools were used to obtain the necessary files for elaborating the seafloor relief model:

- PDF3D file that includes the submerged and emerged surface, with shading and color using a color palette (blue–brown–white) for the topographic gradation
- 3D points shapefile with the same resolution as the original data
- GEOTIFF file of three bands (48 bits RGB) and 96 dpi with the georeferenced and colored image according to the same color pallet as in the PDF3D
- GEOTIFF file of one band (real 32-bit) and 96 dpi with the georeferenced image
- Similarly to the process applied to bathymetry data, an application was developed to integrate the following files into the PDF3D (Figure 4 and see supplementary file ‘Echo-character 3D Map Galicia Continental Margin’)
- The bathymetric contour lines every 500 m
- The echo-character surfaces colored and adapted to the sea bottom relief
- The echo-character identification labels tilted 45° with respect to the X axis to improve visibility
- The reliefs and singular entities identification labels tilted 45° with respect to the X axis to improve visibility
- The echo-character information description and distribution attributes. These values can be viewed/displayed in the PDF by clicking on the echo-character labels.

4. Echo-characters: classification, characterization and distribution

In this study, the echofacies have been classified according to Damuth (1975, 1978, 1980), Damuth and Hayes (1977) and Pratson and Laine (1989). A total of 26 echo-subtypes are identified and classified into four main echo-types, from 1 to 4 (Distinct, Irregular, Hyperbolic and Undulated, respectively), according to their main acoustic characteristics (Figure 5).
4.1. Type 1: distinct echoes

This echo-type is characterized by distinct and uniform bottom echoes. It occupies a surface about 147,000 km². Into this echo-type, 14 echo-subtypes have been differentiated in the study area, on the basis of sub-bottom acoustic facies, from A to N.

4.1.1. Subtype 1A

This subtype is characterized by the absence of sub-bottom reflectors underneath a distinct continuous
4.1.2. Subtype 1B
This subtype is characterized by parallel and stratified sub-bottom reflectors underneath a distinct continuous bottom echo. This subtype shows the largest extension of the study area, with a surface of about 75,470 km².

4.1.3. Subtype 1C
This subtype is characterized by truncate sub-bottom reflectors underneath a distinct continuous bottom echo. This subtype shows an extension of about 7740 km².

4.1.4. Subtype 1D
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom acoustic blanking with stratified reflectors in the base. This subtype shows an extension of about 17,730 km².

4.1.5. Subtype 1E
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom prograding reflectors. This subtype shows an extension of about 8350 km².

4.1.6. Subtype 1F
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom acoustic blanking with a distinct reflector in the base. This subtype shows an extension of about 2380 km².

4.1.7. Subtype 1G
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom stratified reflectors with acoustic blanking in the base. This subtype covers an area of approximately 120 km².

4.1.8. Subtype 1H
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom alternation of high

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Figure 5. Echo-character types and subtypes classification established for the Galicia Continental Margin and adjacent abyssal plains map.
reflective parallel reflectors to bottom and acoustic blanking levels. It has an extension of about 6670 km².

4.1.9. **Subtype 1I**
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom alternation of prograding and continuous reflectors and acoustic blanking levels. It occupies a total area of approximately 2500 km².

4.1.10. **Subtype 1J**
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom acoustic blanking with alternation of high reflective reflectors and acoustic blanking levels in the base. It has an extension of about 7775 km².

4.1.11. **Subtype 1K**
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom oblique reflectors. This echo covers a surface of 215 km².

4.1.12. **Subtype 1L**
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom high reflective undulate, disrupted reflectors, parallel to each other but not to the bottom, with vertical transparent zones. This echo covers an area of 260 km².

4.1.13. **Subtype 1M**
This subtype is characterized by a distinct and uniform bottom echo and sub-bottom high reflective undulate, truncate and parallel reflectors. It has an extension of about 4820 km².

4.1.14. **Subtype 1N**
This subtype is characterized by a weak bottom echo and sub-bottom parallel and truncate reflectors. This echo occupies an area of approximately 5640 km².

4.2. **Type 2: irregular echoes**
This echo-type comprises distinct and irregular bottom echoes. It is related to areas where erosive processes predominate and to steep morphologies of the seafloor. Into this echo-type, three echo-subtypes have been differentiated in the study area from A to C, occupying a surface of about 3550 km².

4.2.1. **Subtype 2A**
This subtype is characterized by a distinct and irregular bottom echo and sub-bottom high reflective and prolonged reflectors in the base. It covers an area of about 590 km².

4.2.2. **Subtype 2B**
This subtype is characterized by a distinct and irregular bottom echo and sub-bottom without reflectors. It presents an extension within the mapped area of about 1910 km².

4.2.3. **Subtype 2C**
This subtype is characterized by a distinct and irregular bottom echo and sub-bottom acoustic blanking with high reflective and sub-parallel to the bottom reflectors in the base. It has an area of about 1050 km².

4.3. **Type 3: hyperbolic echoes**
This echo-type comprises prolonged and hyperbolic bottom echoes. It occupies a surface of about 83,100 km². Into this echo-type, six echo-subtypes have been differentiated in the study area from A to F, depending on the relationship between the hyperbolas vertex with respect to the seafloor or the sub-bottom reflectors.

4.3.1. **Subtype 3A**
This subtype is characterized by a bottom echo with irregular hyperbolas overlapping in a single hyperbola with variable elevations of the vertex with respect to the bottom. The hyperbolas wavelength can oscillate between 70 m and 400 m and the amplitude does not exceed 25 m. This echo covers an area of about 64,800 km².

4.3.2. **Subtype 3B**
This subtype is characterized by a bottom echo with regular hyperbolas with variable elevations of the vertex with respect to the bottom and sub-bottom and with reflectors. The hyperbolas' average wavelength is about 350 m and the amplitude is approximately 7.5 m. This echo occupies an area of about 2290 km².

4.3.3. **Subtype 3C**
This subtype is characterized by a bottom echo with small and regular hyperbolas overlapping with tangent vertex to the bottom. The hyperbolas' wavelength is about 6 m and the mean amplitude is about 50 m. This echo presents a surface of about 2580 km².

4.3.4. **Subtype 3D**
This subtype is characterized by a bottom echo with irregular hyperbolas with variable elevations of the vertex with respect to the bottom and sub-bottom and without reflectors. The hyperbolas' wavelength varies between 0.5 m and 1 m, and the amplitude is approximately 10 m. It has an extension of about 7100 km².

4.3.5. **Subtype 3E**
This subtype is characterized by a bottom echo with irregular overlapping hyperbolas and sub-bottom with concordant reflectors. The hyperbolas' wavelength varies between 1 km and 2.5 km, and the
amplitude is about 9 m. It has an extension of about 4600 km².

4.3.6. Subtype 3F
This subtype is characterized by a bottom echo formed by regular overlapping hyperbolas with the vertex tangent to the bottom. The hyperbolas’ wavelength is about 0.9 m and the amplitude not exceeding 3 m. It has an extension of approximately 1730 km².

4.4. Type 4: undulated echoes
This echo-type comprises irregular bottom echoes that appear to be almost hyperbolic echoes. It shows a wide variety of shapes and sizes. This type of echo covers an area of approximately 36,690 km² in the mapped area. Into this echo-type, three echo-subtypes have been differentiated from A to C.

4.4.1. Subtype 4A
This subtype is characterized by an undulated bottom echo and sub-bottom alternation of high reflective reflectors and acoustic blanking levels parallel to the bottom. This echo occupies an area of about 37,780 km².

4.4.2. Subtype 4B
This subtype is characterized by an undulated bottom echo and sub-bottom parallel to each other but not to the bottom reflectors. This echo covers a surface of approximately 2000 km².

4.4.3. Subtype 4C
This subtype is characterized by undulated bottom echo and sub-bottom acoustic blanking with a distinct reflector in the base. This echo occupies an extension of about 7 km².

5. Conclusion
The 1:800,000-scale echo-character map of Galicia Continental Margin and adjacent abyssal plains presented here has been made through the interpretation and correlation of bathymetry and reflectivity data from the SIMRAD EM12, EM120 and EM1002 multibeam echosounders, and the high-resolution seismic profiles from the SIMRAD TOPAS PS18 parametric echosounder. This data was acquired on seven oceanographic cruises carried out on board of the R/V Hesperides in the periods 2001–2003 and 2006–2009. It has been elaborated by the Geological Survey of Spain, in the framework of the ‘Scientific Research Program of Economic Exclusive Zone of Spain’, which is coordinated and leaded by the Defense Ministry of Spain.

The map shows the location and distribution of different acoustic facies identified on a shaded digital terrain model of the seabed. On the basis of seafloor morphology, surface bedforms, backscatter and sub-bottom acoustic echo-characters, 26 echo-types were identified in the uppermost sedimentary sequence. These echo-types have been grouped into four main echoes: Distinct, Irregular, Hyperbolic and Undulated. The purpose of this map is that it can be used to characterize the bathymetry and to infer the sedimentary distribution, especially to interpret the recent sedimentary processes that have been active on the region: depositional, erosional or gravitational. Moreover, this map has also been made for 3D visualization in a PDF3D file, so that the user can perceive in an easy and intuitive manner the distribution of the echo-characters on the seafloor.

The echo-character maps are useful tools that can be used as basis for the interpretation of depositional and erosional processes, since the echo-types are mainly controlled by surface topography, subsurface geometry and sedimentary texture of the superficial and sub-superficial sediments and rocks.

Software
The echo-character map of the Galicia Continental Margin at 1:800,000 scale shows the location and distribution of the different acoustic facies identified on a shaded digital elevation model of the seabed. Caraibes (ifremer) software was used for multibeam bathymetry data processing. Digital Terrain Model (DTM) was performed with the FME 2016 software. The correlation between the superficial acoustic facies based on the ultrahigh-resolution TOPAS seismic records, bathymetry, acoustic backscatter from multibeam SIMRAD EM12, EM120 and EM1002 echosounders, the mapping of polygons and edition of topology was performed in ArcGIS v.10.1. This information was later imported into the Adobe Illustrator CS3 software, where the final design and layout work was done.

The generation of the PDF3D map has been carried out using applications developed with the Workbench module of the FME 2016 software. These applications use the shading surface modeling and contouring functions as well as the 3D editing tools for the labels creation processing. Input data were echo-character polygons, bathymetry and auxiliary vector data. The result is a PDF file with 3D objects organized in layers, including the identification and description attributes, from the original vector files.

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**Disclosure statement**

No potential conflict of interest was reported by the authors.

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**ORCID**

Adolfo Maestro [http://orcid.org/0000-0002-7474-725X](http://orcid.org/0000-0002-7474-725X)
Fernando Bohoyo [http://orcid.org/0000-0002-1044-8816](http://orcid.org/0000-0002-1044-8816)
Maria Gómez-Ballesteros [http://orcid.org/0000-0002-0772-9211](http://orcid.org/0000-0002-0772-9211)
Manuel Catalán [http://orcid.org/0000-0001-9691-7101](http://orcid.org/0000-0001-9691-7101)

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