Benthic habitats modelling and mapping of Galicia Bank (NE Atlantic)

Habitats Directive (92/43/EEC): Galicia Bank has been proposed as Site of Community Importance (SCIs), into the Natura 2000 network because of the presence of habitats included in the Annex I, specifically the habitat type 1170 (Reefs), and for the well conserved populations of DW sharks.
Galicia Bank: deepest SCI in Spanish N2000 proposal

Singularity of GB:
- A “coastal” seamount with a deep summit: water depth at the seamount’s summit is a key factor that controls the occurrence and abundance of benthos (Clark et al., 2011; Tempera et al., 2012)
- Hydrographical links (water masses, currents) with other seamounts and other biogeographical regions (common fauna with NW Atlantic (Flemish Cap), NE Atlantic, Macaronesia, SE Atlantic (Africa) and Mediterranean.
Methodology: Sampling effort


**OTTER TRAWL**
Megaepibenthic and demersal fauna
19 samples

**BEAM TRAWL**
Mega- and macroepibenthic fauna
29 samples

**ROCK DREDGE**
Rocky habitats
31 samples

**MEGABOXCORER**
Sediment analysis
Otter and beam trawl faunal data is quantitative and expressed in biomass (wet weight) whereas rock dredge faunal data was standardized as biomass percentage of each sample.

Trawl and dredge matrices were reduced, considering only structural species, defined as sessile, three-dimensional, large-bodied (mainly cnidarians and sponges), or those accompanying megafauna which appear in large numbers, with a limited motility.

Assemble first, predict later approach. First, the structural species assemblages were identified using clustering analysis. The second step, distribution of the assemblages in the GB was predicted using binominal Generalized Additive models (GAM) in a DM framework.

**PRESENCE-ABSENCE vs. PRESENCE-ONLY MODELS**
- A presence-absence model has been used to predict assemblage presence: GAM
- According to the results of several recent studies (Brotons et al., 2004; Bedia et al., 2011; González-Irusta et al, 2014), the use of absences obtained from sampling (presence–absence data) provides better results that using randomly generated absences or background data.
- Presence-only models (ENFA, MAXENT): Only when absence data are not available or are clearly unreliable, presence-only models are a suitable option (restricted, patchy, or biased records of species’ occurrence, as is often the case in museum, herbaria, etc.: Phillips et al., 2006; Elith et al., 2011).
RESULTS
1- Assemble first...
Sedimentary habitats assemblages

SS
Summit medium sands (750-800 m)
- Ophiomyces grandis, Ophiacanta sp, Flabellum chuni, Deltocyathus moseley
- Limopsis minuta

SSrf
Summit medium sands with CW corals (800-1000 m)
- Lophelia pertusa, Madrepora oculata, Desmophyllum cristagalli, Acanthogorgia armata, Parantipathes sp

BBS
Bank break medium sands (1000-1200 m)
- Thenea muricata
- Cidaris cidaris
- Peltaster placenta
- Colus spp

FS
Bank flanks fine and very fine sands (1400-1800 m)
- Benthogone rosea
- Umbellula sp
- Colossendeis colossea
- Neolithodes grimaldii
- Fissidentailium capillosum
Rocky habitats assemblages

**SPR** (Summit plain rock)
- Black corals, gorgonians

**BBR1** (bank break North & East)
- Bamboo & black corals, gorgonians

**BBR2**
- Bamboo & black corals, gorgonians, Large sponges

**BBRS**
- Bank break- south & Rucabado
- Colonial, bamboo & black corals, large sponges

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**Graph**
- **SPR**
- **SPBR**
- **BBR1**
- **BBR2**
- **BBRS**

- **COLONIAL SCLERACTINIA**
- **ANTIPATHARIA**
- **ALCYONACEA (GORGONIANS)**
- **ALCYONACEA ISIDIDAE**
- **DEMOSPONGIA**
- **HEXACTINELLIDA**
<table>
<thead>
<tr>
<th>GB geohabitat</th>
<th>EUNIS 3</th>
<th>GB habitats</th>
<th>EUNIS 4-6</th>
<th>OSPAR list</th>
<th>HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain rock (summit)</td>
<td>A6.1 Deep-sea rock</td>
<td>Summit plain rock with gorgonians and black corals</td>
<td>A6.11 Deep sea bedrock</td>
<td>Coral garden</td>
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<td></td>
<td>A6.2 Deep-sea mixed substrata</td>
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<td>A6.13 Deep-sea manganese nodules</td>
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<td>A6.6 Deep-sea bioherms</td>
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<td>A6.722 Summit communities of seamount within the mesopelagic zone</td>
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<td>A6.62 Deep-sea sponge aggregations</td>
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<td>A6.621 Facies with Pheronema grayi</td>
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<td>A6.75 Carbonate mounds</td>
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<tr>
<td>Steep rock (bank break and slope)</td>
<td>A6.1 Deep-sea rock</td>
<td>Bank break rock with black &amp; bamboo corals, gorgonians and large sponges</td>
<td>A6.11 Deep sea bedrock</td>
<td>Coral garden</td>
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<td>A6.7 Raised features of the deep-sea bed</td>
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<td>A6.14 Boulders on the deep-sea bed</td>
<td>Deep-sea sponge aggregations</td>
<td>1170</td>
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<td>A6.62 Deep-sea sponge aggregations</td>
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<td>A6.14 Boulders on the deep-sea bed</td>
<td></td>
<td></td>
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<tr>
<td>Medium sands (summit)</td>
<td>A6.3 Deep sea sand</td>
<td>Summit medium sands with Ophiacantidae and <em>Flabellum chunii</em></td>
<td>A6.722 Summit communities of seamount within the mesopelagic zone</td>
<td>Coral garden</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A6.2 Deep-sea mixed substrata</td>
<td></td>
<td>A6.61 Communities of deep sea corals</td>
<td>Lophelia reefs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A6.3 Deep sea sand</td>
<td></td>
<td>A6.611 Deep-sea Lophelia pertusa reefs</td>
<td>Coral garden</td>
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<td>A6.14 Boulders on the deep-sea bed</td>
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<td>Medium sands (summit)</td>
<td>A6.3 Deep sea sand</td>
<td>Summit medium sands with white corals reef patches</td>
<td>A6.722 Summit communities of seamount within the mesopelagic zone</td>
<td>Lophelia reefs</td>
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<td>A6.6 Deep sea bioherms</td>
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<td>A6.75 Carbonate mounds</td>
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<td></td>
</tr>
<tr>
<td>Fine and very fine sands (flanks)</td>
<td>A6.3 Deep sea sand</td>
<td>Bank flanks fine sands with elasipodid holothurians (<em>B. rosea</em>)</td>
<td>A6.724 Flanks of seamount or bank</td>
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<td></td>
<td>A6.4 Deep sea muddy sand</td>
<td></td>
<td>A6.724 Flanks of seamount or bank</td>
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</tbody>
</table>
RESULTS
2- ...predict later
Modelling assemblages

Environmental layers. a) Processed bathymetry, b) northness, c) eastness, d) slope, e) fine Bathymetric Position Index (BPI), f) substrate facies, g) backscatter
Modelling assemblages

Model performance was good in all cases with high values of explained deviance, AUC and kappa values

<table>
<thead>
<tr>
<th>Assemblage</th>
<th>GAM Formula</th>
<th>Explained deviance</th>
<th>AUC</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS</td>
<td>$P_p = \beta_1 + s(\text{depth}) + \text{sediment} + \epsilon_1$</td>
<td>65.2%</td>
<td>0.95±0.02</td>
<td>0.84±0.08</td>
</tr>
<tr>
<td>SSrf</td>
<td>$P_p = \beta_2 + s(\text{depth}) + s(\text{eastness}) + \text{sediment} + \epsilon_2$</td>
<td>54.4%</td>
<td>0.86±0.04</td>
<td>0.64±0.05</td>
</tr>
<tr>
<td>BS</td>
<td>$P_p = \beta_3 + s(\text{depth}) + \text{sediment} + \epsilon_3$</td>
<td>99.8%</td>
<td>0.99±0.01</td>
<td>0.94±0.08</td>
</tr>
<tr>
<td>FS</td>
<td>$P_p = \beta_4 + s(\text{depth}) + \epsilon_4$</td>
<td>100%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SPR</td>
<td>$P_p = \beta_5 + s(\text{depth}) + s(\text{slope}) + \text{sediment} + \epsilon_5$</td>
<td>64.3%</td>
<td>0.97±0.03</td>
<td>0.87±0.13</td>
</tr>
<tr>
<td>BBR</td>
<td>$P_p = \beta_6 + s(\text{eastness}) + s(\text{slope}) + \text{sediment} + \epsilon_6$</td>
<td>69.6%</td>
<td>0.94±0.06</td>
<td>0.37±0.15</td>
</tr>
<tr>
<td>BBRS</td>
<td>$P_p = \beta_7 + s(\text{northness}) + s(\text{depth}) + \text{sediment} + \epsilon_7$</td>
<td>57.8%</td>
<td>0.71±0.09</td>
<td>0.76±0.16</td>
</tr>
</tbody>
</table>
Modelling assemblages

- Model maps per habitat were merged in a unique map selecting for each pixel the habitat with the highest probability of presence.
Some considerations on habitat distribution
**Environmental boundaries: bathymetry / water masses**

<table>
<thead>
<tr>
<th>SEDIMENTARY EPIBENTHOS</th>
<th>DW FISHES</th>
<th>CRUSTACEANS</th>
<th>ENDOBENTHOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study</td>
<td>Punzón et al, 2010</td>
<td>Cartes et al, 2014</td>
<td>Lourido et al</td>
</tr>
</tbody>
</table>

- **SS- Ophiuroids**
  - SSrf DW corals
- **BBS**
  - Cidaris, Thenea
- **FS**
  - Holothurians
- **SUMMIT**
  - Hoplostethus
- **BANK BREAK**
  - Ampharetids
- **FLANKS**
  - Alepocephalidae
- **SUMMIT**
  - Plesionika, Cancer, Sergia, Systellaspis
- **FLANKS**
  - Neolithodes, Glyphocrangon
- **SUMMIT**
  - Syllidae
- **FLANKS**
  - Spionidae, Glyceridae

**Punzón et al (2010).**
Environmental heterogeneity preference of deep-water fishes in a deep seamount (Galicia Bank). Póster ISOBAY

**Lourido et al (submitted).**
Bathyal endobenthic communities in a deep seamount (Galicia bank)
Environmental boundaries: bathymetry / water masses

Bottom trapping hypothesis (Genin and Dower, 2007)

- On the GB we found the highest near-bottom zooplankton biomass (4.3 g/1000 m³), ca. 5 times > than the average on the rest of the bank (Papiol et al., 2014), in a haul performed in parallel to a vertical wall (at 42º27.36' N- 11º53.84' W: S of Bank).
- Zooplankton is the main compartment supporting trophic webs over seamounts (Genin and Dower, 2007; Preciado et al, in press).
- Key role of aspect (orientation) in SSrf (CW corals) distribution model

- Enrichment by northern water masses (LSW) arriving to GB and possible zooplankton biomass increase at vertical-steep walls by “bottom trapping” can explain the higher diversity of habitat providing filter-feeders at slope rocky breaks.
• Nine habitats have been described in the Galicia Bank, 5 in hard substrates and 4 in sedimentary ones.

• Habitat distribution of these habitats has been predicted using a habitat suitability model.

• Depth, substrate type and water masses (all of them depth-related variables) were key factors in sedimentary habitats whereas rocky habitats were also determined by slope and slope orientation.

• Seamount topography can control communities via trophic effects (zooplankton).