Estimating the effects of MPA management on Le Danois Bank ecosystem (El Cachucho) using trophodynamic modelization

ECOMARG Project

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THE STUDY AREA

Le Danois Bank (Le Danois, 1948), locally known by fishermen as 'El Cachucho' (the local name of *Beryx decadactylus*) fishing ground, is a marginal shelf located in the Cantabrian Sea at 5ºW longitude and 44ºN latitude. The Bank is convex southward with a length of about 72 km in an east-west direction and about 15 km wide from north to south; it has an almost flat surface with a minimum depth of 424 m and is separated 25 km from the Cantabrian Sea continental shelf by a deeper inner basin and the Lastres canyon head. It is an area with high values of diversity including typical species of deep seamount ecosystems together with species of continental shelf. The ECOMARG project (www.ecomarg.net) studies this area since 2003.
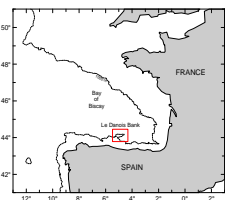
THE IMPORTANCE AS MPA

Threatened and/or Declining Habitats (OSPAR list):
• Deep-sea sponge aggregations (*Pheronema, Asconema,..*)
• *Lophelia pertusa* reefs
• Seamounts communities
• Sea-pen and burrowing megafauna communities

Threatened and/or Declining Species (OSPAR list):
• Common Skate (*Dipturus batis*)
• Orange roughy (*Hoplostethus atlanticus*)
• Basking shark (*Cetorhinus maximus*)
• Bluefin tuna (*Thunnus thynnus*)

Essential Fish Habitat (EFH):
• Forkbeard (*Phycis blennoides*) - spawners
• Anglerfish (*Lophius piscatorius*) - spawners
• Thornyhead fish (*Trachyscorpia christulata*) – spawners
• Bluemouth (*Helicolenus dactylopterus*) - spawners

THE ECOPATH MODEL

The links between species is based on their feeding habits. Quantitative diet estimation was obtained for the main FISH and CRUSTACEA DECAPODA species present in the area. Stomach content analyses were based on the volume occupied by each prey (wet volume, 0.1 cc precision), trying to achieve the lowest taxonomic level possible. In the study of the diet of decapods crustaceans, the stomach content weight was obtained in the laboratory (wet weight, 0.00001 g precision), and this weight was later allocated between preys applying the dot method. A total of 1309 stomach of 45 species of fish (Preciado et al, accepted) and 228 of eleven species of crustaceans (Cartes et al, 2007) were analysed. This information is used to generate the feeding matrix of each functional group for the ECOPATH trophodynamic mass-balance model (Pauly et al., 2000). The model include 35 functional groups, 3 detritus groups (marine snow, deposit detritus and fishery discards) and 5 ground fisheries (gillnet, demersal longline, sharks longline, otter trawl and traps).
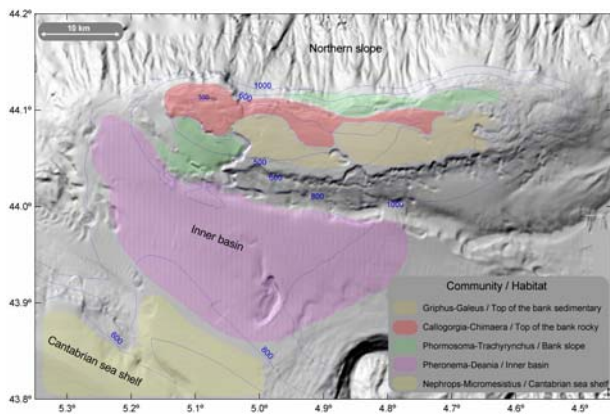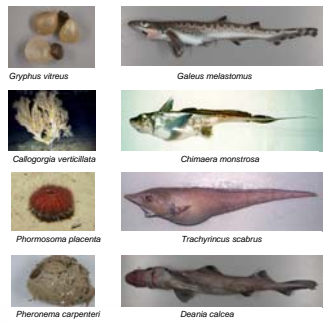
Functional groups:

| Group	Species
Anglerfish	*Lophius piscatorius*
Lg Demersal Fish	*Mora moro, Aphanopus carbo, Conger conger, Molva ...*
Megrim	*Lepidorhombus boscii*
Forkbeard	*Phicis blennoides*
Deepwater elasmobranch	*Deania calcea, Dalatias licha, Etmopterus ....*
Catshark	*Geleus melastomus*
Thornyhead fish	*Trachiscopia christulata echinata*
Benthos-feeders fishes	*Chimaera monstrosa, Trachyrhynchus scabrus, Lepidion ...*
Necton-feeders fishes	*Coryphaenoides, Hoplostethus, Synaphobranchus, ...*
Blue whiting	*Micromesistius poutassou*
Myctophids	*Mictophids*
Plankton-feeders fishes	*Alepocephalus, Xenodenichthys, Chlorophthalmus, ...*
Squids	*Todarodes sagittatus, Illex coindetii, Todaropsis, ...*
Benthic cephalopods	*Opistoteuthis, Bathypolipus, Rossia, Histioteuthis, ...*
Gastropods	*Colus gracilis, Galeodea rugosa*
King crab	*Chaceon affinis*
Detritus-feeders decapods	*Pagurus, Munida, Parapagurus, Anapagurus, ...*
Benthos-feeder decapods	*Pontophilus, Geryon, Aristeus, ...*
Zooplank-feeders shrimps	*Acanthephyra, Sergia, Pasiphaea, Gnathphausia, ...*
Carnivorous zooplankton	*Chaetognaths, Cnidarians, Ctenofors, Hyperidean, ...*
Euphausiids	*Euphausiids*
Copepods	*Copepods, Ostracods*
Carnivorous suprabenthos	*Isopods, Cumaceans, Amphipods, Mysids*
Susp-feeders suprabenthos	*Mysids, Euphausiacs*
Deposit-feeders suprabenthos	*Amphipods, Isopods, Cumaceans, Tanaidaceans*
Jellyfish	*Thaliaceans, Cymbula peroni, Pteropods, Pyrosomids*
Corals & gorgonians	*Callogorgia verticillata, Lophelia pertusa, ...*
Sponges	*Pheronema carpenteri, Asconema setubalense, Geodia...*
Carnivorous echinoderms	*Anseropoda placenta, Phormosoma placenta*
Deposit-feeders echinoderms	*Stichopus tremula*
Carnivorous worms	*Nemertina*
Deposit-feeders worms	*Polychaets, Sipunculids*
Other suspensivore	*Limopsis aurita, Gryphus vitreus*
Meiofauna	*Meiofauna*
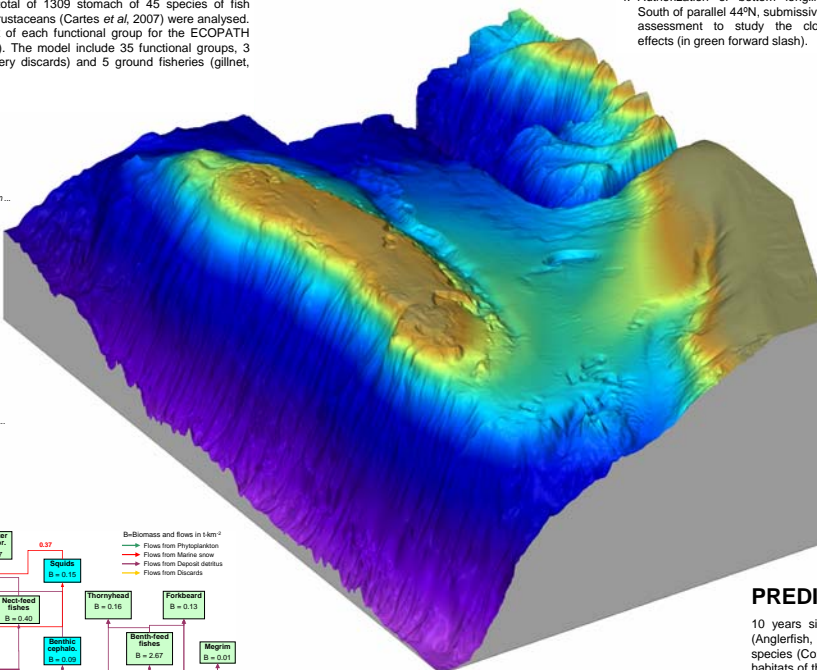
THE BENTHIC COMMUNITIES AND THEIR HABITAT

The *Gryphus-Galeus* community (EUNIS habitat type A6.31) was found mainly on the southern area of the top of the Bank. The *Callogorgia-Chimaera* community lives mainly in the northern area of the top of the Bank, where the sediment coverage is lower, probably due to the strong shelf break current, and there is a high presence of rocky outcrops (Sánchez et al., 2007). The *Phormosoma-Trachyrincus* community lives on the sedimentary terraces that characterize the Bank break, both in the northern and in the southern area. The faunal assemblage with the largest distribution area is the *Pheronema-Deania* community (EUNIS habitat type A6.621), which occupies all the deeper and muddy flat sedimentary grounds of the inner basin. In the truncated slope of the near Cantabrian Sea shelf dwells the heavily-fished community where the commercial species blue whiting, hake and Norway lobster live.

Gryphus vitreus — *Galeus melastomus*
Callogorgia verticillata — *Chimaera monstrosa*
Phormosoma placenta — *Trachyrincus scabrus*
Pheronema carpenteri — *Deania calcea*

Community / Habitat
- Griphus-Galeus / Top of the bank sedimentary
- Callogorgia-Chimaera / Top of the bank rocky
- Phormosoma-Trachyrynchus / Bank slope
- Pheronema-Deania / Inner basin
- Nephrops-Micromesistus / Cantabrian sea shelf

MPA MANAGEMENT proposal measures:

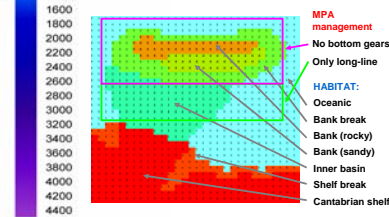The management measures proposed, for a zone of 2330 km², are the following:

1. Prohibition of prospection and hydrocarbon extraction.
2. Prohibition of military maneuvers.
3. Prohibition of the bottom fisheries (trawl, gillnet and longline) by a period of 3 years, except for the fishing of Norway lobster with traps (in red diagonal cross).
4. Authorization of bottom longline to the South of parallel 44ºN, submissive scientific assessment to study the closed area effects (in green forward slash).
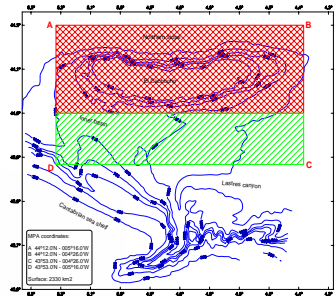

THE ECOSPACE scenario

ECOSPACE routines (Walters et al., 1998) are used as an exploratory tool for the analysis of trophic relationships in time/space and for the evaluation of the effect of MPA management. We have defined a base-map (2x2 km grid cells) with seven habitats corresponding with the main communities. We have also defined the habitat preferences of functional groups and fishery activities, and the movement rates and vulnerability in bad habitats of the living groups. Also we have located the two areas with their specific fisheries regulations. To predict the effects of management measures we use a 10-years simulation.

MPA management
- No bottom gears
- Only long-line

HABITAT:
- Oceanic
- Bank break
- Bank (rocky)
- Bank (sandy)
- Inner basin
- Shelf break
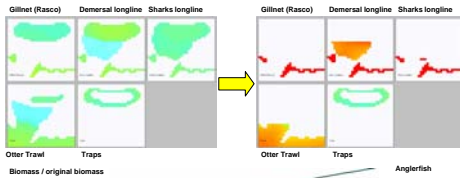- Cantabrian shelf

Meters depth

PREDICTIONS: Biomass spatial distribution

10 years simulation shows an important increase of biomass (in orange) of fish (Anglerfish, Deepwater elasmobranchs, Catshark, Thornyhead, etc.) and vulnerable species (Corals & Gorgonians, Sponges, Gastropods) is observed on the appropriate habitats of the MPA. The spillover effect increases the biomass of commercial species (Anglerfish, Megrim, Squids) on the near continental shelf of Cantabrian Sea.
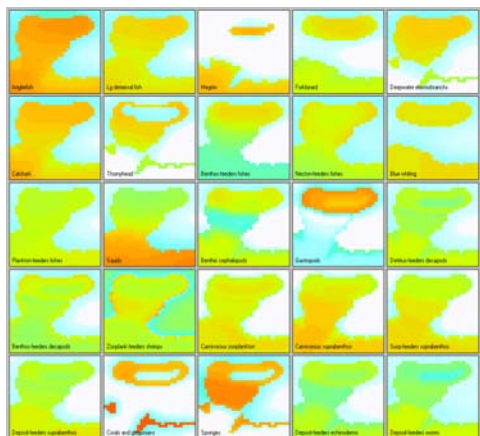
PREDICTIONS: Fisheries effort reallocation

One of the main effect of the proposed management measures is the new distribution of fishing effort. Thus the low levels of the effort inside MPA would be transferred to the adjacent continental shelf. However it should be taken into account that the model only consider the area close to the MPA. The MPA would be more efficient if it was created in combination with a proportional effort reduction. Nevertheless, the increase of spawners in the MPA may compensate these effects since a higher available biomass for the continental shelf fisheries is expected (spillover and larval export effects).

Gillnet (Rasco) | Demersal longline | Sharks longline
Otter Trawl | Traps

Biomass / original biomass

ECOPATH food web diagram

B=Biomass and flows in t·km⁻²
Flows from Phytoplankton
Flows from Marine snow
Flows from Deposit detritus
Flows from Discards

References

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