Implementing a GIS platform for the compilation and analysis of some demersal specie's biomass indices off Catalan coast, NW Mediterranean Sea.

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Abstract

This present implementation compile information on hake, blue whiting and forkbeard biomass distribution around NW Mediterranean Sea obtained by kriging method. Data was then merged with trawl fleet range within the area in order to give indices by Port and by overall fishable area. Results point out blue whiting as the most abundant species followed by hake, who show a noticeable change in its spatial distribution pattern. Forkbeard revealed to be the most stable distribution of all studied resources, even if it is not a target species of the demersal fleet.

Keywords : Abundance, GIS, Kriging, *Merluccius merluccius*, *Micromesistius poutassou,* Modeling, NW Mediterranean Sea, *Phycis blennoides*.

Introduction

GIS frameworks concerning mapping estimates of marine biomass is becoming a generalized tool for proper monitoring and correct management of exploited populations. Scattered georeferenced data that was once gathered for particular purposes, can be easily assembled into a major data-base and be plotted into one map. Besides being of use in the actual plotting of biomass distribution, GIS functionality can be applied to various statistical and resource modeling situations (Meaden, 1996).

Information can be modeled with sophisticated techniques in order to get a clearer picture of what was the past situation and can explain, or give a clue, on a current context. Studies like Simard et al., (1992), Crawford and Fox, (1992); combine GIS functionality to various statistical and resource modeling. Pierce et al., (1998); offer the prospect of developing tools for forecasting the distribution and abundance of commercially important cephalopods populations. As a rule, only careful space–time analysis modeling can give clear answers to important fisheries issues that threaten to do irreparable damage to highly exploited stocks. It is a GIS developers and fisheries scientist's challenge to accomplish such a task. It is important for the purpose of stock conservation and profit optimization, to map and accurately forecast the location and the spatial characteristics of any resources (Conan, 1985). Conan and Wade (1989), Conan et al., (1992), have introduced techniques derived from the geostatistical methodology, initially developed in Mining Geology (Matheron, 1963; Journel and Huijbregts, 1978) which are at present, routinely employed for the assessment of decapod species in the Gulf of St. Lawrence, Canada. These are gaining interest in other species and areas (Petigas, 1993; Fariñas et al., 1994; Maynou , 1998; Maynou et al., 1998)

In this present work we have implemented a GIS platform incorporating, on the one hand, trawl haul data from cruises off the Catalan coastal waters, Northwestern Mediterranean Sea (see Figure 1). A compilation of trawl fleet data has been set into a database establishing a standard protocol from trawl surveys in the area. Basically two of the most important demersal species (Martin, 1991) and a third one as a by-catch of bottom trawl fishing (Massutí et al., 1996), have been thoroughly processed in order to see their biomass distribution along the shelf and slope. The species are: hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*) and forkbeard (*Phycis blennoides*). On the other hand, a map with trawl fleet area influence by individual harbor along the coast was plotted and a buffer zone was created depending on a mean vessel range. An overall fishing area was depicted from the individual Port areas, overlapped into a single map. A final merging step was operated with species biomass and fishing area files in order to have a biomass mean index value by Port and by total fishable area.

Materials and Methodology

During 1981, fifty-seven trawl hauls were taken, eighty-three in 1982, and forty-five during 1983; from commercial fleet on the Catalan sea shelf at depths ranging from 40 to 800 meters (Abello et al., 1988). For the present study, samples where rearranged into two main seasons from mid 1981 to mid 1982 with one-hundred-and-four hauls, and mid 1982 to mid 1983 with seventy-nine hauls. Fish samples were taken from trawlers using bottom nets of 9 mm cod-end mesh-size. Tows of 1 to 2 hrs were made, depending on the characteristics of the area along the shelf and slope. Individuals captured in each haul were sorted to species, weighted and counted. The georeferenced data of each species was expressed as number of individuals per hour of trawling in order to give a recruitment index per species.

The flowchart appearing in Figure 2 represents the scrutinized protocol established for data processing. On the one hand, within a Raster format and following the methodology explained in Maynou et al., (1998), the experimental semiovariogram was employed as a descriptor of the spatial structure of each species biomass indices. The semiovariogram is a form of computing the variance of a population taking into account the spatial positions of all the samples. The variogram is used to determine the local neighborhood of observations used while interpolating, and how the weights are applied to the observations during the calculation. The VARIOWIN software package (Pannatier, 1994) was used to generate variograms and helped to choose a variogram model, as it allows to select the model that best fits the experimental variogram computed from raw data.

For the purpose of mapping each resource, we employed the spatial estimation technique known as point kriging within boundaries defined by the presence of samples. In fact, this procedure constitutes a second stage in the geostatistical modeling. In order to implement the kriging technique, the experimental semiovariograms parameters where seeded into the gridding process using SURFER package (Golden Software, Inc).

On the other hand, the trawl fleet range areas by port were drawn, taking into account vessel's HP and fishermen self established fishing grounds on the area. Based on the action radius for each port, buffers were build around them. The landward side of the buffers was erased using the coastline polygon. Next, a region coverage was created from the resulted seaward buffer polygons for the geographic definition of the area of fishing activity for each port. The creation of region topology was necessary because the buffer polygons overlapped. The ARC/INFO Software (Esri, Inc) was used for this step. An overall fishable area was also plotted as a result of individual buffer zones overlapping into one.

In order to merge information, both raster and vectorial, species data were first organized in ARC VIEW (A/V) grids and geographic area were organized in an A/V shapefile. Species grids were imported into ARC/INFO (A/I) as A/I grids and the shapefiles, as vector coverages. Both grids and coverage were projected into UTM (Universal Transverse Mercator), units meters. After data georeferenced was completed, data manipulation and integration could be performed. The total species biomass for each port's buffer was calculated by map overlay between each grid and the region coverage and by setting the buffer-region for each port as the analysis window. Each calculation was inserted as item in the vector coverage polygon attribute table (PAT). Finally, a table was created showing the amount of species biomass index for each port's fishing activity area and total fishable area. These calculations are useful as recruitment indices for VPA tuning purposes.

Results and Discussion

Maps 1, 2, and 3, show species distributions during 1981-82 and 1982-83 seasons, along the studied area. Table 1 expresses values of trawl fishing range by Ports and Total area. Table 2 gives specie's biomass indices by season on each area.

Hake distribution between season shows both qualitative and quantitative significant changes. During 1981-82 season indices are low and relative high values are located towards the southern and northern edges of the total area. 1982-83 season has conspicuous higher value and show local peaks all along the area. Values from Table 2 show a strong interannual variability yielding a four-fold value during last season. Aldebert and Recasens (1996) have reported these high variations before in the Gulf of Lions region.

Blue whiting appears as the most abundant species with the highest recruitment values. Overall interannual variability is not significant compare with other studied species but, from a spatial point of view, there is a southbound displacement of biomass peaks during the second season.

Forkbeard distributions show a more constant spatial pattern in which most of the recruits are located over the upper continental slope, in contrast to hake and blue whiting recruits who are basically located over the shelf (Recasens et al., 1998). In accordance with Massuti et al (1996) immature juveniles are present in depths shallower than 800 m. Quantitatively values yield a three-fold increase during 1982-83 season with respect to the first season.

This present GIS development of demersal fisheries in the Catalan Sea allows to compile historical and new data integration into a centralized database. It also facilitates its analysis, modeling and visualization of spatial and temporal trends in distribution and abundance of important fisheries resources that need to be proper managed.

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Figure Legends

Figure 1. Map of the studied area in NW Mediterranean Sea.

Figure 2. Methodological flowchart for the analysis of demersal data.

Figure 3. Trawl fleet ranges by Port within the Catalan coastal waters.

Map 1. Abundance distribution of European hake (*Merluccius merluccius*). Magnitudes are expressed in number of individuals by trawl hour.

Map 2. Abundance distribution of blue whiting (*Micromesistius poutassou*). Magnitudes are expressed in number of individuals by trawl hour.

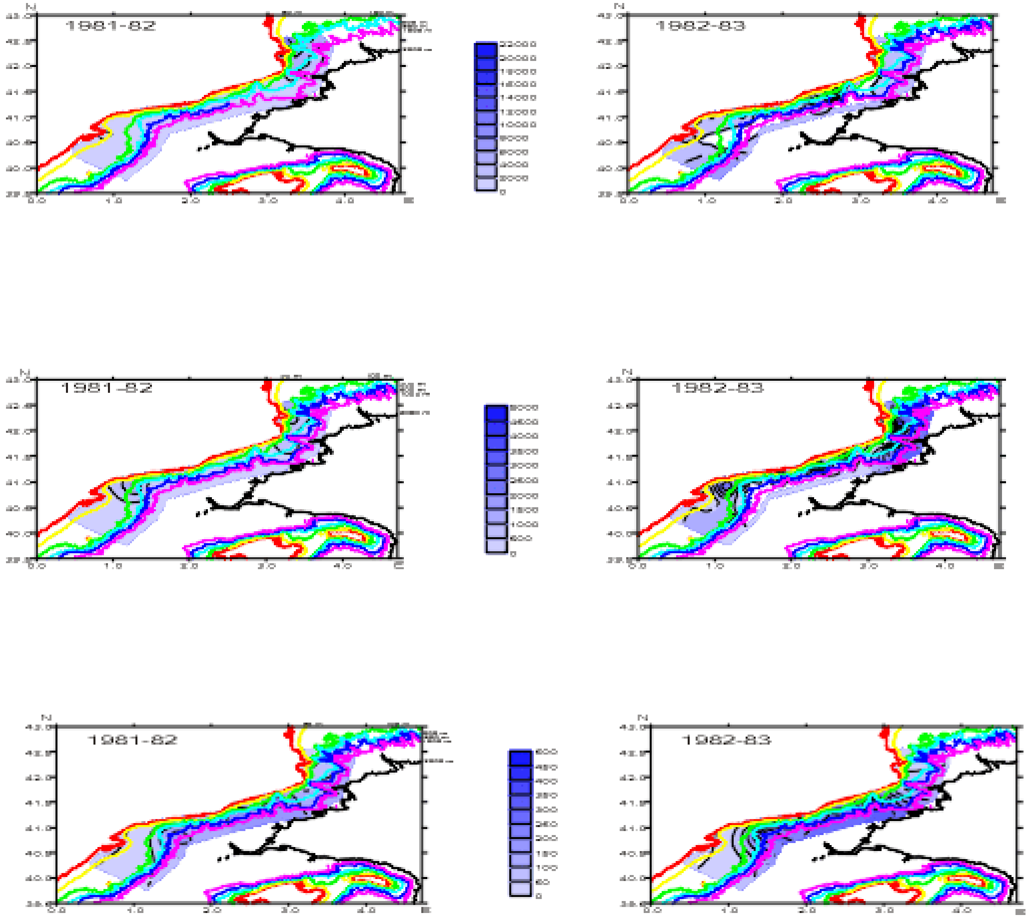
Map 3. Abundance distribution of forkbeard (*Phycis blennoides*). Magnitudes are expressed in number of individuals by trawl hour.

Table 1. Buffer areas characteristics for studied areas

Port Name	Buffer (miles)	Fishing Area (km^2)
Port de la Selva	60	20 523
Roses	60	21 265
Palamos	25	4 025
Blanes	35	6 798
Calella	15	1 104
Arenys	35	6 148
Badalona	20	1 811
Barcelona	30	5 021
Vilanova i Geltru	20	960
Torredembarra	15	1 055
Tarragona	40	7 066
Cambrils	40	6 483
L 'Ametlla	40	6 690
L 'Ampolla	40	6 660
St. Carles Rapita	50	12 057
Cases d' Alcanar	15	772
Total fishable area	---	38 558

Table 2. Biomass index (number of individuals per trawl hour) results by Ports and overall area.

Port Name	Hake 81/82	Hake 82/83	Blue whiting 81/82	Blue whiting 82/83	Forkbeard 81/82	Forkbeard 82/83
Port de la Selva	496 366	1 816 832	3 902 516	991 542	24 500	64 815
Roses	499 601	1 875 416	3 924 725	1 151 854	24 677	69 538
Palamos	235 284	933 002	1 513 305	470 761	22 667	53 209
Blanes	196 981	1 005 178	1 062 501	1 451 322	23 181	71 064
Calella	36 004	113 458	61 858	751 962	16 542	38 985
Arenys de Mar	129 597	604 415	515 990	1 284 262	22 076	66 528
Badalona	39 260	293 851	271 192	780 018	14071	25 018
Barcelona	49 312	431 072	361 824	1 204 801	16 061	45 505
Vilanova i Geltru	26 192	94 555	65 359	47 226	4 305	14 636
Torredembarra	131 202	116 926	180 426	137 826	8 301	25 314
Tarragona	375 372	534 397	437 916	182 577	14 540	44 381
Cambrils	375 549	551 262	428 831	175 783	14 540	44 382
L' Ametlla	371 363	534 241	435 160	444 316	14 253	43 188
L'Ampolla	368 096	541 851	412 346	554 447	12 904	41 129
St. Carles Rapita	370 095	572 602	542 646	1 891 516	14 387	44 295
Cases d' Alcanar	8 429	42 835	13 697	37 782	15	10
Total area	659 621	2 468 484	4 402 529	3 147 588	25 087	72 622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