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Definition of fleet components in the Spanish artisanal fishery of the Gulf of Cádiz (SW Spain ICES division IXa)

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Abstract

The Spanish artisanal fishery in the Gulf of Cádiz is of a notably multi-gear and multi-species nature, with target species occurring seasonally, where a fleet composed of about 1000 vessels captures more than 50 commercial species. From this complexity arises the need for defining *fleet components* (FCs) (i.e., groups of vessels developing the same fishing pattern through the year), which allow the design of simpler and more efficient sampling schemes on the basis of understanding the behaviour of such components.

To define the artisanal FCs, the daily landings by species and vessel during 1996 were considered. In a preliminary analysis, a total of 53 *fishing trip types* were objectively characterised from the species composition of these landings using hierarchical Cluster Analysis (CA) techniques. A non-hierarchical *K*-means CA was applied later to re-classify the 1996 data and to classify 1997 landings data by trip type. The red seabream (*Pagellus bogaraveo*), red-banded seabream (*Pagrus auriga*), octopus (*Octopus vulgaris*) and striped venus (*Chamaela gallina*) types stood out according to their importance in landed weight.

In a second stage, only those vessels with more than 50 daily landings regularly distributed through the year were selected. A matrix with as many rows (cases) as selected vessels and 53 trip types × 12 months = 636 columns (variables) was designed. A new CA was applied to group vessels which show similar fishing annual patterns. Eleven FCs were defined from these results. Two basic features of these components may be emphasised: they are highly related to the landing (home) ports and the fishing gears used, and they show definite seasonal fluctuations according to the main fishing trip types developed.

Keywords: Gulf of Cádiz; Hierarchical cluster; *K*-means cluster; Fishing trip types; Fleet components

1. Introduction

Artisanal fisheries in Spanish waters of the Gulf of Cádiz show a clear multi-species and multi-gear pattern. More than 50 species (Table 1) are landed. Catches are made with a large number of diverse fishing gears including trammelnets (‘‘trasmallos’’) and gillnets (‘‘parguera’’, ‘‘volanta’’, etc.), hand-jigs (‘‘chivos’’, ‘‘pulperas’’, etc.) and longlines (‘‘palangres’’, ‘‘voracera’’, etc.), traps (‘‘nasas’’, ‘‘alcatruces’’, etc.) among others.

In the whole demersal fishery of this area, the artisanal fleet catches during the period 1984–1992 amounted to 23.22% of the total, approximately 3500 tonnes, compared with 76.78% from bottom trawl fleet catches. This catch ratio shows an increasing trend in last years (Sobrino et al., 1994). In spite of

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Table 1
Main landed species from the Gulf of Cádiz artisanal fleet (1996–1997)

Spanish common name (Scientific name)	English common name	Landings 96 (Kg)	Landings 97 (Kg)
Acedia (*Dicologoglosa cuneata*)	Wedge sole	124070	214247
Almejas (*Tapes* spp.)	Carpet shell	6336	49
Atún (*Thunnus thynus*)	Atlantic bluefin tuna	68000	85245
Besugo (*Pagellus acarne*)	Auxiliary seabream	63003	29494
Bocinegro (*Pagrus pagrus*)	Black seabream	45682	53904
Boga (*Boops boops*)	Bogue	5715	7245
Bogavante (*Homarus gamamrus*)	European lobster	501	514
Borriquete (*Plectorhinchus mediterraneus*)	Rubberlip grunt	82240	100081
Breca (*Pagellus erytrinus*, *P. bellotii*)	Red and common pandora	78421	101445
Brotola (*Physis* spp.)	Greater fork-beard	4484	10417
Caballa (*Scomber* spp.)	Chub and Atlantic mackerel	3170	17326
Caella (*Prionace glauca*)	Blue saark	6630	3953
Calamar (*Loligo vulgaris*)	European squid	1896	2986
Cazón (*Galeorhinus galeus*)	Tope shark	48328	44487
Centolla (*Maja squinado*)	Spinous spider crab	10447	6044
Chirlas (*Chamaela gallina*)	Striped venus	196302	89495
Choco (*Sepia officinalis*)	Common cuttlefish	57323	74134
Chopa (*Spondyliosoma cantharus*)	Black seabream	27036	12416
Chova (*Pomatomus saltator*)	Bluefish	9522	27861
Congrio (*Conger conger*)	Conger eel	27169	62144
Corvina (*Argyrosomus regius*)	Meagre	37908	72726
Dorada (*Sparus aurata*)	Gilt head seabream	37037	20674
Escualos (*Squalus* spp.)	Dogfish shaks	47448	17387
Ferrón (*Squalus* spp.)	Spurdog	17266	21069
Herrera (*Lithognatus mormyrus*)	Striped seabream	52901	86917
Japonesa (*Lepidorhombus* spp.)	Megrin	421	133
Japuta (*Brama brama*)	Atlantic pomfret	23300	55600
Jurel (*Caranx rhonchus*, *Trachurus* spp.)	False scad/Horse mackerel	23189	38019
Langosta (*Palinurus* spp.)	Spiny lobster	167	298
Langostino (*Penaeus kerathurus*)	Caramote prawn	37972	82699
Lenguado (*Solea* spp.)	Sole	38971	38720
Liza (*Liza* spp.)	Golden, thinlip and leaping grey mullet	7997	9346
Lubina (*Dicentrarchus labrax*)	European seabass	20938	29208
Merluza (*Merluccius merluccius*)	Hake	31933	45802
Mero (*Epinephelus guaza*)	Dusky grouper	7209	11260
Morena (*Muraena helena*)	Mediterranean moray	10505	13862
Pajel (*Diplodus vulgaris*)	Common two-banded seabream	30421	9732
Palometa (*Trachynotus ovatus*)	Derbio, Pompano	631	586
Pargo (*Dentex gibbosus*)	Pink dentex	36547	65058
Pez Cochino (*Ballister ballister*)	Grey triggerfish	16267	6225
Pez Limón (*Sriola dumerili*)	Greater amberjack	3518	7322
Pulpo (*O. vulgaris*)	Common octopus	218922	59161
Raya (*Raja* spp.)	Skate	10197	20242
Roncaor (*Pomadasys incisus*)	Bastard grunt	14212	32670
Salmonete (*Mullus* spp.)	Striped red and red mullet	7980	21346
Sama (*Dentex dentex*)	Common dentex	10219	11176
Sargo (*Diplodus* spp.)	Whit, annulary and Senegal seabream	60825	62617
Urta (*P. auriga*)	Red-banded seabream	138898	40483
Vieja (*Dentex canariensis*)	Canary dentex	6795	6880
Voraz (*P. bogaraveo*)	Red seabream	281000	275320

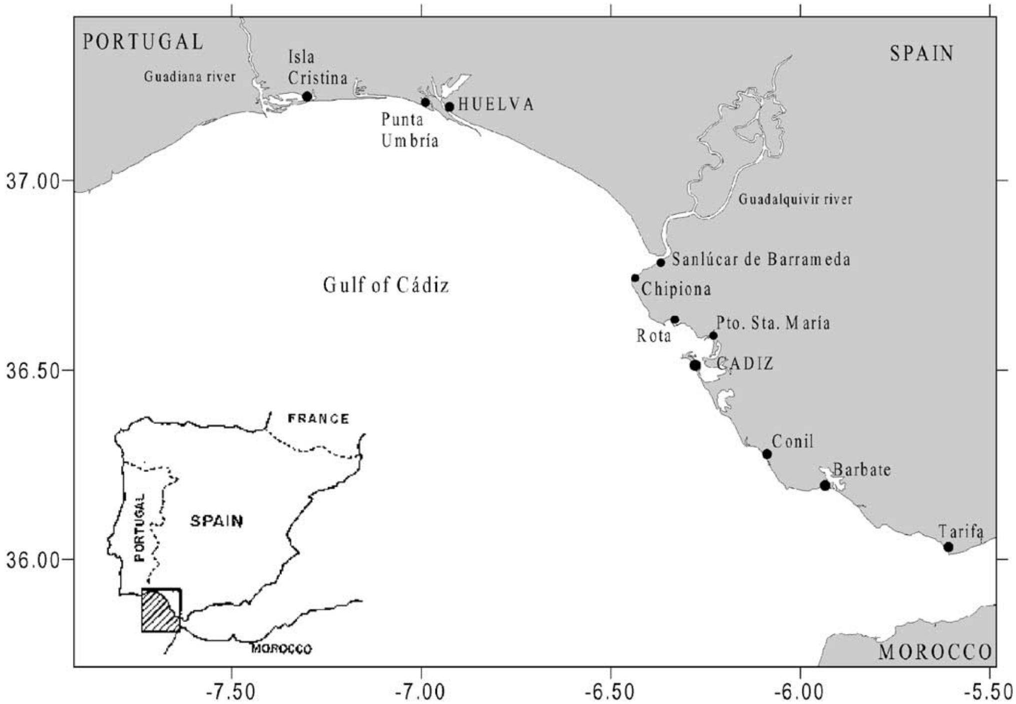

Fig. 1. Gulf of Cádiz (ICES IXa, SW Spain). Main landing ports of the artisanal fleet.

this difference, the artisanal fishery has a great socio-economic importance due to the people involved in the sector and the high prices reached by a great number of species in their first sale. At most of the ports artisanal fishing is important, and at some, the fleet is totally artisanal e.g. Tarifa, Conil and Chipiona in the Cádiz County (Fig. 1).

The artisanal fleet is composed of about a 1000 of vessels representing the 76% of the whole demersal fleet, but the individual vessels are small, with averages of 7.7 m length, 5 gross ton register and 58 hp. They comprise 36 and 38% of demersal fleet total gross ton register and horsepower, respectively (Sobrino et al., 1994). These characteristics limit the autonomy of the fleet although they make a great number of daily fishing trip types throughout the year. Also it is appropriate to highlight the great versatility of these small vessels which use complementary gears during the same fishing trip to improve the catches.

Given all this complexity there is a need to define fleet component (FC). FCs are defined as those groups of vessels that have the same exploitation pattern throughout the year. It is expected that the consideration of the FC concept will allow simpler, more effective and profitable sampling strategies to be defined for the artisanal fishery based on the improved knowledge of its exploitation pattern. Also, the following methodology is shown to be a useful tool, not only for monitoring the artisanal fishing activity, but also for assessing its socioeconomic impacts.

2. Material and methods

2.1. Fishing trip type

The daily landings of the artisanal fishery during 1996 in the nine main ports of the Spanish South Atlantic region (Fig. 1) were used for the definition of fishing trip types. This information, coming from the daily sale sheets per vessel, was collected from the Spanish Fishing Associations either through in the IEO reporter–sampler network or gathered directly from the computerised sale information of these Fishing Associations. A matrix was built on from this database file whose rows (cases) were the daily landings and the columns (variables) were the captured species, resulting a total of 25 394 fishing trips and 53 species.

Fishing trip types were characterised by the application of multivariate analysis techniques on the basis of the mean specific composition of the catches, similar to that reported by Murawski et al. (1983), in NE coast USA trawl fisheries. Hierarchical Cluster Analysis (CA) was carried out using the Euclidean distance (ED) as similarity index and the unweighted paired-group mean average (UPGMA) as clustering algorithm. Previous to the CA, the original matrix expressed in Kg was transformed to catch per unit of effort matrix (CPUEs, in our case the effort unit was the number of fishing days per fishing trip) and then to a percentage CPUEs matrix to standardise these values. In this way, the cases were standardised in relation not only to the effort applied but to the different catchability observed by each vessel, since the aim was to group landings showing a similar relative species composition. After matrix standardisation, CA per month was carried out for all landings without including the mono-species landings (100% of a single species), because these landings are self-defined. CAs were carried out on a monthly basis due to the computer limitations.

The monthly number of clusters was defined by Mojena methods (Mojena, 1977; Mojena and Wishart, 1980) according to the values of the fusion coefficients. This consists in selecting the number of groups corresponding to the first classification step which satisfies the inequality

$$\alpha_{j+1} > \bar{\alpha} + kS_{\alpha}$$

where j is the jth fusion step, $\alpha_0, \alpha_1, \ldots, \alpha_{n-1}$ are the fusion steps correspondent to $n, n-1, \ldots, 1$ groups respectively, S_{α} the standard deviation from the values of the fusion coefficients and k is a constant which may assume values in the range 2.75–3.5 (Mojena, 1977 in Everit, 1993). However, Milligan and Cooper (1985) in Everit (1993) suggest that k should be 1.25. Fundamentally, k quantifies the dispersion to be added to the mean on the decision of determining the optimal number of groups. In the present work, the Milligan and Cooper's approach is used.

Later, an Iterative Partitioning Method (K-means CA) was applied to the percentage CPUEs matrix to classify the landings. In the K-means CA the data are divided into K partitions or groups. In the present study, the number of groups or clusters was previously determinated from the hierarchical CA.

The method is based on the closest centroid output, i.e. the one in which each case is assigned to a cluster based on the criteria that the distance to its centre should be minimum. To calculate the centre of each trip type, the variables were previously standardised, obtaining the z-variables (variable − mean/standard *deviation*), and later calculating for each group the mean of each standardised variable. These variables are the centres of each group. Once the table of centres is estimated (centroids matrix), a K-means CA with known centres was applied to the matrix of % CPUEs to classify the landings, using as variables the z-variables, on the basis of the least ED to the centres of the groups (Norusis, 1997; Visauta, 1998). Moreover, by applying K-means cluster from the above centroids matrix, the landings in future years may be classified while no important changes occur in the current artisanal fishing strategies.

Definitions of fishing trip types were based on the mean values of the species composition of landings by cluster (expressed as percentages of the CPUE).

2.2. Fleet components

First, a frequency analysis was carried out to determine the monthly number of fishing trips types per vessel throughout the year. Only the vessels with at least 50 fishing trips regularly distributed over 12 months were chosen. Second, a data matrix was built with as many variables as fishing trip types done by each vessel in every month (fishing trip types × 12 months).The cases were the selected vessels with the criteria described above. In this way, the number of fishing trips by vessel, N_i ($i = 1, \ldots, n$), is defined as follows:

$$N_i = \sum_{j=1}^{53}\sum_{k=1}^{12}(nijk)$$

where $j = 1, \ldots, 53$ and $k = 1, \ldots, 12$ and n the number of fishing trips within the fishing trip type j in the month. Following the above methodology a hierarchical CA was applied to this matrix for grouping vessels with the same exploitation pattern. FCs were defined starting from these results and from the frequencies analyses per month and landing port.

The same methodology to assess the 1996 FCs was applied to the 1997 artisanal fleet landings. Once obtained the 1997 FCs those vessels which carried out more than 50 fishing trips in both years were selected to analyse and compare if the same vessels belong to the same FC in both years.

3. Results

A total of 53 fishing trip types was defined. The results obtained after the landing re-classification through the *K*-means procedure were very similar to those obtained from the hierarchical CA. The specific composition of the three main species from the fishing trips that integrate each fishing trip type, expressed in % CPUE, as well as the importance (in weight and number) of these landings are shown in Table 2. VORZ-M, URT and PUL-M fishing trip types account jointly for almost a third of the total number of landings of the whole artisanal fleet. Their respective main species are the red seabream (*Pagellus bogaraveo*), red-banded seabream (*Pagrus auriga*) and the octopus (*Octopus vulgaris*). Such species account for 97.7, 64.8 and 99.8% of the total CPUE of each fishing trip type. The importance order changes if the fishing trip types are sorted by landed weight. Thus, BIV fishing trip type passes from the sixth place in terms of number of landings to the second place in terms of landed weight. However the VORZ-M fishing trip type was the most important in terms of number of landings and landed weight too.

Table 2 shows that 85% of the fishing trip types have a main target species with a CPUE higher than 50% of the fishing trip type total CPUE. A total of 219 vessels was selected to obtain the FCs. Eleven FCs were identified after the CA and later frequencies analyses of the resulting groups per port and month. Table 3 shows the relative importance of the fishing trip types for each FC. Landing ports of the vessels which form each component and the fishing trip type seasonality are shown in Tables 4 and 5, respectively.

With the exception of Huelva, all the analysed ports have shown some FC, their number oscillated between only one FC in Tarifa and El Puerto de Sta. María and the four ones found in Barbate and Conil.

The FC 1 and FC 2 account for 61% of analysed vessels and 60.5% of the total landings. The FC 11, exclusive from the Tarifa port, ranked third in importance, comprising the 23% of the analysed vessels. This FC developed a fishing pattern based almost exclusively on the red seabream fishing (fishing trip types VORZ and VORZ-M). The FC 10 and FC 4 are also constituted by vessels dedicated almost exclusively to the capture of a single species, namely the striped venus and common octopus, respectively. FC 10 and FC 4 carry out only a single fishing trip type throughout the year (BIV and PUL-M, respectively).

The exploitation pattern of those FCs developing several fishing trip types is defined by the annual seasonality of these fishing trip types. Likewise, the seasonal changes in the fishing activity experienced by these fishing trip types are delated with the fluctuations in abundance of their respective target species. The shaded percentages in Table 5 for each fishing trip type highlights the seasonality of the FC.

Concerning the 1997 FCs, the results were similar to those obtained in 1996. To test the FCs of both years, 140 vessels were selected that carried out 50 fishing trips in both years. Table 6 shows the number of vessels that belong to the same FC during the 2 years in study. Similarity between the two results sets was estimated between 88 and 100%.

4. Discussion

As a whole, fisheries in the Spanish South Atlantic region (Gulf of Cádiz), as well as in areas close to the study area (Mediterranean sea) are characterised by their multi-species and multi-gear nature (Camiñas, 1990; Sobrino et al., 1994). However, many of the fishing gears composing this fishery are highly selective and species-specific, targeting either on a single or on determinate group of species. These characteristics are clearly reflected in the results. First, the high number of landed species and fishing trip types reflects the multi-species nature of this fishery and a maximum use of the catches, i.e., low discard rate. Second, most of the fishing trip types (85%) show a single species with mean CPUE higher than 50%, which suggests a clear targeting of these trip types. Concerning the fishing trip types, it is noted that many of them are exclusive to certain ports, showing a specialisation

Table 2
Fishing trip types[a]

1996 fishing trip type	Species in percentual decreasing importance of the total of the fishing trip type						Weight of the catch	% of the total annual catch	No. of landings	% of landings
	1st species	2nd species	3rd species	% (1st)	% (2nd)	% (3rd)				
VORZ-M	Red seabream	Rockfish	Wreckfish	97.7	1.5	0.5	260309	12.55	4412	17.37
URT	Red-banded seabream	Common seabream	Gilt head seabream	64.8	12.7	8.4	121056	5.84	2260	8.90
PUL-M	*O. vulgaris*	Cuttlefish	Common seabream	99.8	0.1	0.1	168860	8.14	1811	7.13
LANG-M	Caramote prawn	Wedge sole	Cuttlefish	98.4	0.6	0.4	22039	1.06	1447	5.70
BOR	Common and red pandora	Seabreams	Common and red pandora	53.9	8.8	5.1	88082	4.25	1059	4.17
URT-M	Red-banded seabream	Common seabream	*O. vulgaris*	90.9	3.4	1.7	45418	2.19	970	3.82
BIV	Striped venus	Carpet shell		97.4	2.6		196302	9.46	806	3.17
ACE-M	Wedge sole	European hake	Caramote prawn	98.6	0.4	0.3	94337	4.55	753	2.97
BOC	Common seabream	Red banden seabream	Seabreams	49.5	12	7.0	25913	1.25	670	2.64
LANG	Caramote prawn	Cuttlefish	Wedge sole	45.4	13.7	9.9	39245	1.89	576	2.27
CH	Cuttlefish	Soles	*O. vulgaris*	54.9	13.4	8.6	38694	1.87	553	2.18
SARG	Seabreams	Rubberlip grunt	Gilt head seabream	60.6	4.1	3.9	36018	1.74	535	2.11
CONG	European conger	Common seabream	Rubberlip grunt	45.0	13.6	6.7	38107	1.84	471	1.85
DOR	Gilt head seabream	Red banden seabream	Seabreams	60.5	10.8	7.3	24438	1.18	451	1.78
LENG	Soles	Cuttlefish	Caramote prawn	57.9	14.5	5.6	21217	1.02	445	1.75
HER	Striped seabream	Meagre	Common and red pandora	54.1	5.2	5.2	36684	1.77	436	1.72
CAZ	Tope shark	Rubberlip grunt	Red banden seabream	62.3	7.8	5.8	53229	2.57	387	1.52
BRE	Common and red pandora	Rubberlip grunt	Auxiliary seabream	53.9	9.6	6.6	31466	1.52	362	1.43
CORV	Meagre	Seabreams	Rubberlip grunt	51.5	7.2	6.0	21501	1.04	344	1.35
PCH	Grey triggerfish	Red-banded seabream	Soles	49.9	13.6	5.5	16725	0.81	317	1.25
LUB	Seabass	Rubberlip grunt	Seabrams	70.7	6.3	6.3	21568	1.04	307	1.21
MER	Horse mackerels	European hake	Common and red pandora	31.3	31.1	5.3	49805	2.40	300	1.18
CH-M	Cuttlefish	Soles	*O. vulgaris*	92.7	3.6	0.6	15918	0.77	295	1.16
PAR	Pargo breams	Common seabream	Red-banded seabream	64.7	8.2	3.7	29446	1.42	279	1.10
LENG-M	Soles	Caramote prawn	Cuttlefish	96.7	0.7	0.5	8093	0.39	274	1.08
ATUN-M	Atlantic bluefin tuna	Red sebream	Atlantic pomfret	98.8	1.1	0.1	65364	3.15	270	1.06
PAJ	Two-bandad seabream	Seabreams	Rubberlip grunt	52.1	11.9	6.3	41364	1.99	258	1.02
ACE	Wedge sole	European hake	Caramote prawn	66.0	12.9	8.7	24574	1.18	237	0.93
RONC-BRE	Bastard grunt	Common and red pandora	Rubberlip grunt	410.	16.7	9.7	23935	1.115	237	0.93
VORZ	Red seabream	Atlantic pomfret	Wreckfish	54.3	40.5	4.4	17540	0.85	234	0.92
SAM	Common dentex	Common seabream	Red-banded seabream	37.2	19.7	11.3	7912	0.38	234	0.92
BRE-M	Common and red pandora	Soles	Rubberlip grunt	93.6	1.2	0.7	20516	0.99	228	0.90
CORV-M	Meagre	Rubberlip grunt	Seabreams	93.9	0.6	0.6	12144	0.59	224	0.88
SALMT	Surmullets	Rubberlip grunt	Common and red pandora	59.2	9.7	7.0	6761	0.33	220	0.87
CEN	Spinous spider crab	Rubberlip grunt	Soles	51.9	11.6	7.6	10779	0.52	219	0.86
MER-M	European hake	Common and red pandora	Caramote prawn	91.2	1.9	1.7	11761	0.57	218	0.86
BES	Auxiliary seabream	Common and red pandora	Black seabream	59.9	9.0	3.9	60009	2.89	217	0.85
RAY	Skates	Rubberlip grunt	Common seabream	45.0	6.1	5.7	11306	0.55	193	0.76

FER	Spurdog	Rubberlip grunt	European conger	64.6	5.2	4.7	21140	1.02	189	0.74
PUL2	*O. vulgaris*	Cuttlefish	Red-banded seabream	58.2	6.5	5.9	15332	0.74	185	0.73
HER-M	Striped seabream	Common and red pandora	Meagre	92.8	1.3	0.9	12300	0.59	182	0.72
BRE-HER	Common and red pandora	Striped seabream	Horse mackerels	52.4	20.7	11.1	23888	1.15	178	0.70
PUL1	*O. vulgaris*	Cuttlefish	Striped seabream	28.5	20.1	8.5	21599	1.04	164	0.65
MOR	Moray	Common seabream	European conger	45.1	9.4	6.6	6575	0.32	153	0.60
LIZ	Golden, thinlip and leaping grey mullet	Seabreams	Seabass	73.7	5.0	3.5	7621	0.37	151	0.59
CHP	Black seabream	Auxiliary seabream	Two-banded seabream	44.8	14.7	14.1	36182	1.74	126	0.50
ES-CAE	Dogfish sharks	Blue shark	Pompano	70.7	21.3	1.4	51581	2.49	122	0.48
CHV	Bluefish	Meagre	Common and red pandora	67.1	7.1	1.3	8086	0.39	111	0.44
MERO	Dusky grouper	Common seabream	Seabreams	38.4	7.5	6.4	7032	0.34	81	0.32
PUL3	*O. vulgaris*	Auxiliary seabream	Seabreams	30.2	20.2	11.1	25078	1.21	79	0.31
JAP	Atlantic pomfret	Red seabream	Rockfish	85.0	15.0	0.1	10813	0.52	76	0.30
PLIM	Greater amberjack	Pargo breams	Common seabream	48.7	22.1	4.8	4639	0.22	69	0.27
ATUN	Atlantic bluefin tuna	Red sebream	Atlantic pomfret	76.1	20.4	1.9	3804	0.18	19	0.07
Total							2074105	100	25394	100

[a] Specific composition of the most important species (% CPUE) and their importance in weight and in number of landings.

Table 3
Relative importance (%) of the trip types in each FC (1996) (italic values = highest values)

Trip type	FCs										
	1	2	3	4	5	6	7	8	9	10	11
ACE	0.0	*1.7*	0.0	0.0	0.0	*2.2*	0.0	0.0	*4.8*	0.0	0.0
ACE-M	0.0	*6.4*	0.0	0.2	0.0	*10.7*	0.0	0.0	*8.8*	0.0	0.0
ATUN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*5.1*
ATUN-M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
BES	0.0	1.3	1.0	0.0	*16.7*	0.0	1.7	*10.8*	0.0	0.0	0.0
BIV	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*100.0*	0.0
BOC	*8.1*	0.9	0.0	0.0	0.0	0.0	0.0	*6.5*	0.0	0.0	0.0
BOR	*5.7*	*7.5*	3.0	0.0	1.1	2.1	*12.8*	0.5	0.0	0.0	0.0
BRE	0.6	*3.4*	*7.8*	0.0	0.2	1.4	*2.6*	0.0	0.8	0.0	0.0
BRE_BER	0.0	0.4	1.0	0.0	0.0	*14.3*	0.0	0.0	0.2	0.0	0.0
BRE-M	0.1	1.8	0.8	0.0	0.0	*4.7*	0.0	0.0	0.0	0.0	0.0
CAZ	*3.8*	1.3	0.0	0.0	0.0	0.2	1.7	*11.8*	0.0	0.0	0.0
CEN	0.8	2.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
CH	0.8	*5.1*	0.0	0.0	0.0	1.0	*4.3*	0.0	1.4	0.0	0.0
CH-M	0.2	*2.9*	0.0	0.0	0.0	0.7	0.9	0.0	0.8	0.0	0.0
CHP	0.0	0.2	0.0	0.0	*24.7*	0.0	0.0	0.0	0.0	0.0	0.0
CHV	0.0	0.6	0.0	0.0	0.0	*4.4*	0.0	0.0	0.0	0.0	0.0
CONG	*5.2*	0.8	2.0	0.2	0.0	0.1	0.0	1.6	0.0	0.0	0.0
CORV	0.3	*3.0*	*8.3*	0.0	0.0	*5.9*	0.9	0.0	0.5	0.0	0.0
CORV-M	0.1	1.7	1.0	0.0	0.0	*7.4*	0.0	0.0	0.0	0.0	0.0
DOR	*3.7*	1.5	0.5	0.0	0.2	1.9	0.0	1.1	*5.2*	0.0	0.0
ES-CAE	0.0	0.2	0.5	0.0	0.2	1.0	0.0	0.0	0.0	0.0	0.0
FER	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HER	0.0	2.3	*29.1*	0.4	0.0	*5.4*	0.0	0.0	*7.7*	0.0	0.0
HER-M	0.0	1.1	*8.0*	0.0	0.0	3.0	0.0	0.0	1.1	0.0	0.0
JAP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*1.6*
LANG	0.4	*7.2*	0.0	0.2	0.0	1.3	0.0	0.0	*26.7*	0.0	0.0
LANG-M	0.0	*17.3*	0.0	0.2	0.0	*3.4*	0.0	0.0	*5.2*	0.0	0.0
LENG	0.4	*2.9*	0.0	0.0	0.0	0.3	0.0	0.0	*12.6*	0.0	0.0
LENG-M	0.2	*2.4*	0.0	0.0	0.0	0.1	0.0	0.0	*5.0*	0.0	0.0
LIZ	0.0	1.3	0.0	0.0	0.0	2.8	0.0	0.0	1.9	0.0	0.0
LUB	1.3	1.8	0.3	0.0	0.0	0.7	*7.7*	0.0	4.3	0.0	0.0
MER	0.0	1.3	1.8	0.2	0.6	*10.7*	0.0	0.0	1.3	0.0	0.0
MER-M	0.0	*1.8*	0.3	0.0	0.0	*8.2*	0.0	0.0	0.2	0.0	0.0
MERO	0.4	0.2	0.0	0.0	1.3	0.0	0.0	*7.5*	0.0	0.0	0.0
MOR	1.4	0.2	3.5	0.0	0.0	0.0	0.0	*3.8*	0.0	0.0	0.0
PAJ	0.0	0.4	0.0	0.0	*44.6*	0.0	0.0	0.0	0.0	0.0	0.0
PAR	*2.4*	1.0	0.5	0.0	0.2	0.4	0.0	1.6	0.0	0.0	0.0
PCH	2.2	1.7	0.0	0.0	0.9	0.9	0.0	*2.7*	0.8	0.0	0.0
PLIM	0.9	0.1	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0
PUL1	0.0	1.2	0.3	0.0	0.2	0.0	2.6	0.0	0.1	0.0	0.0
PUL2	1.1	1.0	0.8	0.4	1.1	0.0	0.9	*5.4*	0.0	0.0	0.0
PUL3	0.0	0.4	0.0	0.0	*3.7*	0.0	0.0	*17.2*	0.0	0.0	0.0
PUL-M	*10.0*	*2.0*	0.5	*98.0*	0.4	0.0	*6.8*	*5.4*	0.0	0.0	0.0
RAY	0.9	1.1	0.0	0.0	0.0	1.3	0.0	1.1	0.0	0.0	0.0
RONC-BRE	0.2	1.3	*27.4*	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0
SALMT	0.7	1.1	0.0	0.0	0.0	0.0	*54.7*	0.0	0.7	0.0	0.0
SAM	*3.0*	0.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0
SARG	0.9	*3.6*	1.3	0.0	*3.9*	2.9	0.0	*17.2*	*9.3*	0.0	0.0
URT	*31.2*	0.8	0.0	0.0	0.0	0.0	0.0	2.7	0.1	0.0	0.0
URT-M	*13.1*	0.3	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0
VORZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*5.0*
VORZ-M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*88.0*

Table 4
Distribution by ports of the vessels that compose the 11 FCs, in number and percentages (FC = fleet component)

Landing ports	FC 1		FC 2		FC 3		FC 4		FC 5		FC 6		FC 7		FC 8		FC 9		FC 10		FC 11	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Barbate	1	1.6	9	12.9	0	0	0	0	5	100	0	0	0	0	0	0	0	0	1	10	0	0
Chipiona	0	0	34	48.6	0	0	0	0	0	0	6	100	0	0	0	0	0	0	0	0	0	0
Conil	60	96.8	20	28.6	0	0	0	0	0	0	0	0	1	100	1	100	0	0	0	0	0	0
Isla Cristina	0	0	4	5.7	3	100	6	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Puerto de Sta. María	0	0	1	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Punta Umbría	1	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	90	0	0
Sanlúcar de Bda	0	0	2	2.9	0	0	0	0	0	0	0	0	0	0	0	0	3	100	0	0	0	0
Tarifa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	100
Total	62		72		3		6		5		6		1		1		3		10		50	

Table 5
Monthly relative importance of the trip types throughout 1996 for each FC (expressed in %) (italic values = highest values)

	January	February	March	April	May	June	July	August	September	October	November	December
Trips (FC 1)												
BOC	2.1	1.0	1.1	6.6	4.7	0.4	1.0	*6.4*	*13.4*	*22.3*	*19.6*	*9.4*
BOR	*42.1*	*9.5*	0.0	8.2	3.8	0.2	1.1	1.7	1.6	4.3	*8.2*	*10.5*
CAZ	*10.2*	*5.6*	0.0	4.8	3.6	2.2	2.8	3.1	2.5	4.3	3.5	*4.5*
CONG	*11.6*	*5.6*	0.0	1.3	1.3	0.0	0.4	4.6	*8.6*	*11.6*	*7.0*	*14.7*
DOR	0.7	0.3	0.0	2.8	2.5	1.4	1.7	2.3	*4.0*	*9.6*	*11.0*	2.3
LUB	9.1	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4
PAR	0.4	0.0	0.0	0.3	2.5	0.9	0.8	1.1	2.5	*8.3*	*5.6*	*3.8*
PUL-M	*7.4*	*53.8*	*88.3*	*26.6*	*4.5*	2.0	0.0	0.1	0.0	1.3	2.6	*14.7*
SAM	0.4	0.3	0.0	2.0	1.1	0.5	1.0	4.1	*7.3*	*5.4*	*5.9*	2.6
URT	3.5	4.6	3.2	*25.9*	*56.6*	*51.0*	*51.6*	*45.0*	*41.7*	9.5	12.1	13.5
URT-M	0.7	1.1	1.1	5.6	*12.3*	*34.9*	*32.5*	*23.0*	8.1	1.2	1.7	1.9
Trips (FC 2)												
ACE	*2.6*	*1.3*	*5.8*	0.3	0.7	0.3	0.3	1.0	0.7	1.7	*6.2*	*3.1*
ACE-M	*41.7*	*18.3*	*15.7*	1.3	0.8	1.4	0.3	1.2	0.8	1.6	2.4	*25.6*
BOR	*11.8*	*8.0*	*3.2*	*5.4*	*6.7*	*3.0*	*5.6*	*10.0*	*5.6*	*8.9*	*12.1*	*16.0*
BRE	1.8	*4.1*	1.3	1.7	*4.6*	*2.2*	*3.5*	*3.2*	*4.6*	*4.6*	*5.6*	*2.3*
BRE-M	*4.1*	*2.2*	1.7	1.0	*2.1*	*1.9*	2.0	0.7	0.8	1.1	*4.0*	1.5
CH	2.0	*4.1*	*9.2*	*16.7*	*11.1*	*3.7*	4.2	2.2	2.7	1.4	0.4	1.5
CH-M	0.8	3.2	*8.6*	*11.8*	*6.1*	1.2	1.1	0.6	0.7	0.1	0.2	0.0
CORV	1.3	1.5	1.5	1.0	*3.6*	*1.9*	*2.4*	*7.1*	*5.3*	2.4	1.6	4.2
CORV-M	0.3	0.4	1.3	0.6	*2.9*	*1.6*	*1.8*	*3.6*	*2.2*	1.7	0.6	1.1
DOR	0.3	0.4	0.2	0.5	2.1	0.2	1.0	2.4	2.7	3.2	2.6	2.7
HER	0.0	1.9	2.1	1.9	1.1	1.2	4.1	3.1	3.1	3.1	2.6	1.5
LANG	4.9	1.9	*6.9*	*8.3*	*12.0*	*13.6*	*8.7*	*5.9*	*4.2*	*4.6*	*5.8*	4.6
LANG-M	0.0	0.0	3.4	*20.8*	*19.6*	*31.5*	*23.9*	9.5	*15.5*	*27.7*	*29.2*	2.7
LENG	1.0	1.3	*3.0*	1.4	2.5	*10.1*	*4.1*	*2.3*	1.8	2.1	0.6	1.5
LENG-M	1.0	1.3	1.3	2.1	1.7	*5.1*	*2.9*	*2.4*	*4.7*	*3.1*	0.6	0.0
LUB	*4.9*	*8.6*	*2.8*	0.5	0.7	0.3	1.0	0.7	2.7	1.4	0.4	*2.7*
MER-M	*3.6*	*3.4*	*9.7*	3.3	0.6	0.0	0.0	0.0	0.0	0.0	2.0	*6.9*
PUL-M	*1.3*	*14.8*	*3.6*	3.2	0.7	0.8	0.4	0.7	1.7	0.3	0.0	0.4
SARG	1.8	3.0	2.6	0.3	2.2	0.7	2.5	*8.7*	*8.8*	*5.1*	*3.0*	*3.1*

Table 5 (*Continued*)

	January	February	March	April	May	June	July	August	September	October	November	December
Trips (FC 3)												
BOR	*26.7*	*5.4*	*2.9*	*4.7*	0.0	0.0	0.0	0.0	3.0	1.8	0.0	*4.8*
BRE	*33.3*	*16.2*	*2.9*	*11.6*	*11.1*	*7.7*	*4.3*	*5.0*	*6.1*	*1.8*	0.0	0.0
CORV	*6.7*	*16.2*	*5.9*	0.0	0.0	*3.8*	*14.9*	*10.0*	*18.2*	*7.0*	0.0	*9.5*
HER	0.0	*29.7*	*44.1*	*25.6*	*22.2*	*26.9*	*34.0*	*30.0*	*24.2*	*33.3*	0.0	*33.3*
HER-M	0.0	*2.7*	*14.7*	*11.6*	*13.3*	0.0	*2.1*	*12.5*	*3.0*	*12.3*	0.0	*4.8*
MER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	14.3
RONC-BR	0.0	*8.1*	*11.8*	*39.5*	*33.3*	*34.6*	*29.8*	*32.5*	*36.4*	*35.1*	0.0	*9.5*
Trips (FC 4)												
PUL-M	*94.4*	*100.0*	*100.0*	*98.7*	*100.0*	*100.0*	*100.0*	*97.5*	*100.0*	*100.0*	*100.0*	*42.9*
Trips (FC 5)												
BES	*33.3*	0.0	*10.7*	*39.3*	*27.1*	*9.1*	*4.4*	*16.7*	*5.5*	*9.5*	*27.3*	*7.1*
CHP	*50.0*	*100.0*	*35.7*	*29.5*	*37.5*	0.0	*4.4*	*9.7*	*20.0*	*21.4*	*33.3*	*78.6*
PAJ	*16.7*	0.0	*10.7*	*24.6*	*33.3*	*81.8*	*66.7*	*65.3*	*60.0*	*47.6*	*15.2*	0.0
PUL3	0.0	0.0	*28.6*	*4.9*	0.0	2.3	0.0	2.8	0.0	7.1	0.0	0.0
SARG	0.0	0.0	*10.7*	*1.6*	*2.1*	*4.5*	*2.2*	*4.2*	*9.1*	*4.8*	0.0	0.0
Trips (FC 6)												
ACE	*3.9*	*11.1*	*13.2*	*5.0*	0.0	0.0	0.0	0.0	0.0	0.0	1.1	*1.9*
ACE-M	*70.6*	*41.7*	*30.9*	*6.7*	0.0	2.0	0.0	0.0	0.0	0.0	*4.6*	*27.8*
BRE-HER	0.0	2.8	1.5	1.7	2.9	*39.8*	*45.5*	*20.8*	0.0	1.2	16.1	0.0
BRE-M	7.8	8.3	4.4	3.3	1.5	*8.2*	*10.0*	*6.3*	1.1	0.0	3.4	0.0
CHV	0.0	0.0	0.0	1.7	*7.4*	*8.2*	*5.5*	*10.4*	1.1	2.4	6.9	1.9
CORV	0.0	0.0	0.0	0.0	*16.2*	*5.1*	0.9	*6.3*	*20.5*	*11.9*	2.3	0.0
CORV-M	0.0	0.0	*11.8*	*26.7*	*26.5*	*5.1*	*4.5*	*4.2*	*10.2*	2.4	0.0	0.0
HER	0.0	0.0	0.0	1.7	0.0	1.0	*9.1*	*13.5*	*13.6*	*10.7*	1.1	3.7
HER-M	0.0	0.0	0.0	0.0	0.0	0.0	0.9	8.3	10.2	9.5	0.0	1.9
LANG	0.0	0.0	1.5	*10.0*	*2.9*	1.0	0.0	0.0	*2.3*	0.0	0.0	0.0
LANG-M	0.0	0.0	1.5	*10.0*	*8.8*	*8.2*	2.7	2.1	*4.5*	1.2	0.0	0.0
MER	*5.9*	0.0	2.9	3.3	1.5	7.1	10.0	7.3	1.1	*7.1*	*44.8*	*33.3*
MER-M	*7.8*	*19.4*	*22.1*	*5.0*	0.0	0.0	0.0	2.1	0.0	*21.4*	*13.8*	*24.1*
Trips (FC 7)												
BOR	*33.3*	*12.5*	0.0	*40.0*	*22.2*	0.0	0.0	*9.5*	*14.3*	*11.1*	*10.0*	0.0
BRE	0.0	0.0	0.0	0.0	0.0	*12.5*	*8.3*	*4.8*	0.0	0.0	0.0	0.0
CH	0.0	0.0	0.0	*20.0*	*22.2*	0.0	8.3	0.0	0.0	0.0	0.0	0.0
LUB	*66.7*	*87.5*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUL-M	0.0	0.0	0.0	*20.0*	0.0	*62.5*	*8.3*	0.0	0.0	0.0	0.0	0.0
SALMT	0.0	0.0	0.0	*10.0*	*22.2*	*25.0*	*50.0*	*76.2*	*85.7*	*83.3*	*60.0*	*100.0*
Trips (FC 8)												
BES	0.0	0.0	0.0	*15.0*	*20.0*	*26.7*	*45.5*	0.0	0.0	0.0	0.0	0.0
BOC	*37.5*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*23.8*	*23.5*	0.0
CAZ	*37.5*	*33.3*	0.0	0.0	0.0	0.0	00	4.0	5.6	*14.3*	*35.3*	*42.9*
MERO	0.0	0.0	0.0	0.0	0.0	0.0	*4.5*	*12.0*	*22.2*	*28.6*	0.0	0.0
MOR	12.5	0.0	0.0	0.0	0.0	6.7	0.0	4.0	0.0	*9.5*	*5.9*	*14.3*
PCH	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	*4.8*	*11.8*	*14.3*
PUL2	0.0	0.0	0.0	*30.0*	*20.0*	*6.7*	0.0	0.0	0.0	0.0	0.0	0.0
PUL3	0.0	0.0	0.0	*55.0*	*53.3*	*40.0*	*27.3*	*4.0*	0.0	0.0	0.0	0.0
PUL-M	0.0	*46.7*	*100.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SARG	0.0	0.0	0.0	0.0	0.0	0.0	*9.1*	*76.0*	*50.0*	9.5	0.0	0.0
Trips (FC 9)												
ACE	0.0	0.0	*25.0*	*2.2*	*1.8*	0.8	0.0	0.0	1.0	0.0	*11.6*	*10.4*
ACE-M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	*14.7*	*64.6*

Table 5 (*Continued*)

	January	February	March	April	May	June	July	August	September	October	November	December
CH	0.0	0.0	*1.7*	*5.6*	0.9	0.8	0.0	1.0	1.9	0.0	1.1	0.0
DOR	0.0	0.0	*3.3*	*1.1*	*5.5*	*1.7*	*5.7*	*9.7*	*14.4*	0.0	2.1	2.1
HER	0.0	0.0	*5.0*	*6.7*	*4.6*	*4.2*	*17.1*	*18.4*	*4.8*	0.0	6.3	1.0
LANG	0.0	0.0	*36.7*	*40.0*	*30.3*	*39.0*	*31.4*	*19.4*	*26.9*	0.0	12.6	5.2
LANG-M	0.0	0.0	0.0	*3.3*	*15.6*	*4.2*	*7.6*	*3.9*	*5.8*	0.0	1.1	2.1
LENG	0.0	0.0	*11.7*	*21.1*	*14.7*	*21.2*	*12.4*	*9.7*	*10.6*	0.0	7.4	3.1
LENG-M	0.0	0.0	*3.3*	*3.3*	*2.8*	*16.1*	*9.5*	0.0	*2.9*	0.0	4.2	0.0
LUB	0.0	0.0	0.0	1.1	6.4	0.8	1.0	3.9	*5.8*	0.0	*13.7*	*5.2*
SARG	0.0	0.0	*5.0*	*6.7*	*3.7*	*3.4*	*5.7*	*21.4*	*19.2*	*0.0*	*15.8*	*2.1*
Trips (FC 10)												
BIV	0.0	0.0	*100.0*	0.0	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Trips (FC 11)												
ATUN	0.0	0.0	0.0	0.0	0.0	0.4	*2.3*	0.0	0.0	0.0	0.0	0.0
ATUN-M	0.0	0.0	0.0	0.0	0.0	*8.9*	*24.1*	*5.0*	*2.1*	0.0	0.0	0.0
JAP	0.0	0.0	0.6	*2.1*	0.0	0.4	*8.3*	*2.0*	0.0	0.6	0.0	0.0
VORZ	0.0	0.0	*7.7*	*10.7*	0.5	*2.3*	*10.4*	*8.1*	*3.9*	*8.7*	1.2	0.4
VORZ-HM	0.0	0.0	*91.7*	*87.2*	*99.5*	*88.0*	*54.9*	*84.9*	*94.0*	*90.7*	*98.8*	*99.6*

toward the resource greatly influenced by the bottom features which affect to the distribution of the species. This is the case for the eastern area (Cádiz coast) where rocky bottoms favour sparid fishing. On the other hand, in the ports of the western area (Huelva coast) where the bottoms are of sand, mud and gravel, the most fishing trips captured species like prawns and wedge sole, among others (Ramos et al., 1996). Moreover the nature of these bottoms and also oceanographic conditions are factors in choosing the gear type to fish species distributes all over the coast. A clear example is the octopus artisanal fishery (Silva et al., 1998). Hand-jig fishing (chivos and pulperas) is carried out on rocky bottoms in the eastern area. In this fishery, hand-jigs are drifted taking advantage of the strong sea currents occurring in this area. Use of clay pots (alcatruces) in this area is prevented since the strong currents would crash them against the rocks. However, clay pots are very extended in the western area where they offer shelter to octopus in the less rocky bottoms of the western coast.

Combination of these factors condition the appearance of several fishing trip types dedicated to a single target species. In this way, we find four fishing trip

Table 6
Number of vessels belonging to the same FC for the years 1996 and 1997, expressed in percentage respect to the components of year 1996

FC 1996	FC 1997										
	1	2	3	4	5	6	7	8	9	10	11
1	95.2	4.7	0	0	0	0	0	100	0	0	0
2	4.8	88.4	0	50	0	0	0	0	0	0	0
3	0	0	100	0	0	0	0	0	0	0	0
4	0	0	0	50	0	0	0	0	0	0	0
5	0	0	0	0	100	0	0	0	0	0	0
6	0	0	0	0	0	100	0	0	0	0	0
7	0	0	0	0	0	0	100	0	0	0	0
8	0	2.3	0	0	0	0	0	0	0	0	0
9	0	4.7	0	0	0	0	0	0	100	0	0
10	0	0	0	0	0	0	0	0	0	100	
11	0	0	0	0	0	0	0	0	0	0	100
Total (%)	100	100	100	100	100	100	100	100	100	100	100

types with the octopus as target species (PUL-M, PUL1, PUL2 and PUL3). After checking the accompanying species, their CPUE values and the landing ports we deduce that the octopus was captured by several gear types in some of these fishing trips.

In the later analysis of the fleet composition of the 11 FCs by port (year 1996), we find that all, with the exception of FC 2, belong to vessels from a single port. Within the same port, as is the case of the ports of Conil and Isla Cristina, the determination of the FCs is based on the use of certain types of fishing gears, during different seasons. In consequence, an exploitation pattern based on the seasonal sequence of particular types of fishing trips could be defined.

Therefore, the specialisation of the fishery and the use of the fishing gear targeting different species, at different seasons in many cases, and, moreover, influenced by certain environmental factors (hydrography), determines the different FCs. From the FCs comparison of both years, based on the vessels which carried out more than 50 fishing trips per each year, it is observed that a high percentage of vessels which belong to an FC determined in 1996 continue belonging to the same FC in 1997 (Table 6). This indicates that most of these vessels carry out the same exploitation pattern during the whole period analysed, strengthening the defined FCs. In some cases (like FC 1 and FC 8) when vessels change their exploitation pattern, and consequently are included in other FC in 1997, it is observed that these new components are similar as to the gear type and the landing port. In other cases (like FC 4) some of the vessels dedicated to octopus fishing in 1996 left this fishery. These vessels used another fishing gear type (nets) during 1997. The cause of changing fishing activity from one year to the next, could be the sharp fall of the resource because of heavy rain in 1996 (Sobrino et al., 2002).

Therefore this work suggests a high relationship among the FCs, landing ports and the fishing gears with a slightly marked seasonality in function of each component target trip types. These results will be taken into account in the design of an efficient and simple sampling scheme for the artisanal fishery collection of data (biological, economic and social) under the FC concept. Thus, FCs analysis can be a useful tool for sampling design in artisanal fisheries from the basis of monitoring certain vessels which belong to the estimated FCs. Sampling could embrace biological and fishery aspects (i.e., catches, effort, etc.) and socioeconomic fishery aspects (i.e., first sale prizes, staff involved, etc.). In addition, it provides an important benefit in term of a lower effort requirements for carried out the artisanal fishery study.

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