ICES Journal of Marine Science,62: 727–739 (2005)
doi:10.1016/j.icesjms.2005.01.022



# The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management

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Morales-Nin, B., Moranta, J., García, C., Tugores, M. P., Grau, A. M., Riera, F., and Cerdà, M. 2005. The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management. – ICES Journal of Marine Science, 62: 727–739.

The sociology and habits of recreational anglers on the Island of Majorca (western Mediterranean) were evaluated using telephone and on-site surveys, as well as fishing logbooks and recreational fishing competitions. The recreational fishery is one of the island's main leisure activities, 5.14% of the population (37 265 people) participating. Enthusiasts tend to be mainly middle class (most anglers own boats moored at marinas), middle-aged males (90% male, mean age 46 $\pm$ 2 years). The most popular fishing method is from a boat (62.9%), followed by fishing from shore (32.4%), and spearfishing (3.6%). The mean time spent fishing is 3.86 $\pm$ 0.03 h $d^{-1}$, and more than one type of gear (mean 1.27 $\pm$ 0.21) is used simultaneously by a single angler. The frequency of fishing is 4–6 times per month, mainly on holidays and weekends, increasing in summer. The activity has a sizeable impact on the coastal fauna, with diverse catches of at least 1209.25 t $year^{-1}$ (about 615 000 fishing outings $year^{-1}$). Thus, the amount of carbon extracted annually is at least 137.34 kg C $km^{-2}$ $year^{-1}$, and the recreational fishery removes about 31% of production at trophic level 4. Although these are gross estimates and more detailed study of the effect on trophic level and local production is needed, the values do highlight the pressure the recreational fishery exerts on coastal fish communities. Assuming that this level of exploitation is common to north-shore Mediterranean countries, there may be cause for concern about sustainable exploitation in the recreational fishery, and the effectiveness of current protection measures is discussed. Despite the limitations of the study, recreational fisheries clearly should be taken into account when considering measures for fisheries management. Moreover, fishing has considerable social import, and the benefits must be taken into account when investments to protect exploited resources are being contemplated.



Keywords: coastal zone, fish exploitation, Majorca Island, recreational fishing, western Mediterranean.

Received 4 August 2004; accepted 16 January 2005.

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## Introduction

The transformations undergone by Mediterranean countries in the last century have dramatically altered their coastal regions, especially the sea's northern shore (Morey *et al.*, 1992; Özhan, 1996; Van der Meulen and Salman, 1996; García and Servera, 2003). For instance, the Balearic Islands (western Mediterranean) have shifted their primary economy from one based on agriculture and cattle to a tertiary economy based on tourism (Rullan-Salamanca, 1998). Development has increased shoreline use, and the population increases considerably in summer, when the pressure of tourism is highest. Further, aquatic leisure activities like scuba-diving, water-skiing, sailing, and fishing have flourished, and their added impact on coastal and maritime ecosystems has grown.

Recreational fishing is one of the most frequent leisure activities in coastal zones, and it involves large numbers of people and consequently high levels of fishing effort, which may be higher than in the commercial fishery (Pollock,

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1980; Dunn *et al.*, 1989). Commercial and recreational fishing have similar demographic and ecological effects on fished populations, and they can have equally serious ecological and economic consequences (Coleman *et al.*, 2004). Recreational fishing has economic, social, and cultural roles in the Mediterranean, where commercial fishing is largely the domain of small-scale concerns operating in coastal areas. Over the past 20 years, catches of several key commercial stocks have been in sharp decline despite increased fishing effort, symptomatic of overexploitation. Recreational fishing is particularly important in the Mediterranean, representing more than 10% of total fisheries production in the area (EU, 2004). In the Balearic Islands recreational fishing is one of the principal leisure activities, as indicated by the number of fishing licences issued. The deep-sea sport fishery for tuna and marlin occupies relatively few (around 100) boats in the islands (unpublished data of DG Pesca, Govern de les Illes Balears: Department of Fisheries, Balearic Islands Government), and is a relatively minor activity.

Recreational fisheries have been poorly studied in the Mediterranean, although this has not prevented implementation of some management measures. For instance, a fishing licence is needed in the Balearic Islands, and current legislation limits both fishing effort (number of gears) and daily bag, and stipulates minimum lengths and closed seasons for certain species. In addition, several marine reserves have specific restrictions on fishing. While the number of licences provides a certain measure of the fishing effort expended, inspectors have detected a significant number of recreational anglers who are not official licence-holders, so the actual number of people involved and the yields remain unknown.

Although direct confirmation is unavailable, the response of certain species to protection measures suggests that the coastal fish populations around Majorca Island are probably overexploited. For instance, a shallower distribution and increased biomass for grouper (*Epinephelus marginatus*) followed closure of recreational fisheries in a protected area (Coll *et al.*, 1999). The larger mean size of razor fish (*Xyrichthys novacula*) in the same protected area compared with exploited areas is another example (Riera and Linde, 2001).

Fishing regulations designed to protect recreational fisheries from overexploitation can fail (Post *et al.*, 2003), an outcome all the more likely when basic data are lacking, as in the Balearic Islands. Therefore, the object of this study is to contribute to knowledge of current exploitation of coastal fish resources by the recreational fishery, and in the process to provide essential management data (Kearney *et al.*, 1996; Gartside *et al.*, 1999; Sutinen and Johnston, 2003; Coleman *et al.*, 2004). The results for Majorca could be illustrative of exploitation of coastal resources in other areas of the Mediterranean's north shore, thereby addressing an important yet poorly understood and poorly managed component of the ecosystem.

## Material and methods

### Study area

Majorca Island, the main island in the Balearic Archipelago, is located in the western Mediterranean Sea (Figure 1), has an area of 3620 km$^2$ and about 623 km of coastline, and had 725 000 inhabitants in December 2001 (data furnished by the Conselleria d'Economia, Comerç i Indústria: Department of the Economy, Trade, and Industry). There were 39 harbours, with a total of 14 196 moorings in October 1998. The number of fishing licences has increased since 1998, to 22 000 in 2002 (Figure 2).

The fishing regulations enforced are a bag limit (5 kg angler-day$^{-1}$, or 25 kg d$^{-1}$ in boats with more than 5 anglers on board), closed seasons for some species, and protected areas along the littoral.

### Data collection

Initial information for the study was gleaned from the fishing licences, but a multiple approach based on

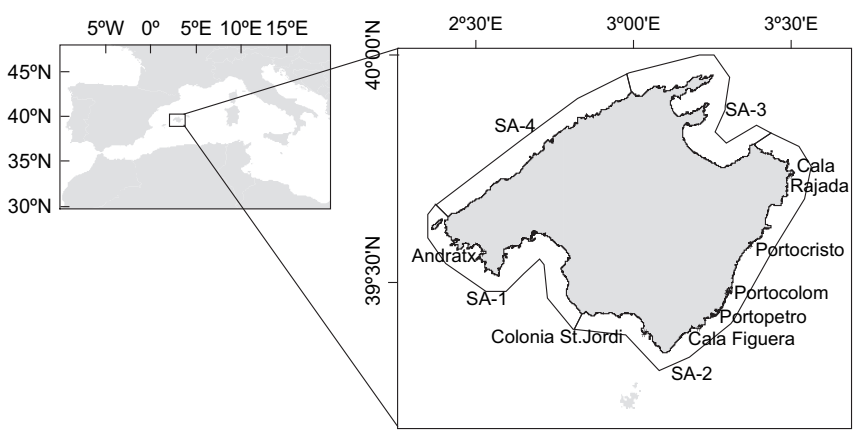


Figure 1. Location of Majorca Island.

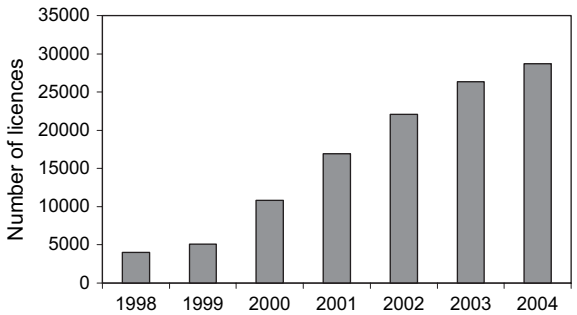


Figure 2. Number of fishing licences for the three major fishing methods on the Island of Majorca. Source DG Pesca, Govern de les Illes Balears (Department of Fisheries, Balearic Islands Government).

a telephone survey, on-site personal interviews, voluntary logbooks, and records from recreational fishing competitions was used for more reliable assessments of the actual numbers of recreational anglers and their habits and of fishing effort and yields (Tables 1 and 2). The telephone survey was based on the Dillman total design method (Dillman, 1978), and was carried out between July and November 2002. Sample size was 2585 Majorcan households chosen randomly from the directory of the most important telephone company on the island, although the number of households selected by town was proportional to population. Questions were the number of members making up the household, participation in recreational fishing by household members, and if members did fish, a series of questions to ascertain catches and fishing habits (i.e. method, time of year, time of day, frequency, number of gears used, etc.). In addition, the anglers' gender and age were requested. Whenever possible the questions were addressed to the active angler, even where this required a follow-up telephone call.

From February to December 2002, interviewers personally surveyed people observed fishing or returning from a day of fishing at harbours or along the shore, according to a stratified spatiotemporal design. The coast was divided into four study areas (Figure 1) of different size. Study area 1 (SA-1) consisted of Palma Bay and the region around Andratx off the southwestern part of the island (184.71 km of coastline), SA-2 was the southern and eastern shorelines (198.02 km of coastline), SA-3 comprised Alcudia and Pollença bays (147.75 km of coastline), and SA-4 the northwestern shoreline (92.52 km of coastline). SA-1 and SA-3 have less steep slopes than SA-2 and SA-4, and more harbours and moorings. In fact, about 64% of the island's harbours and 74% of the moorings are located in SA-1 and SA-3, primarily in SA-1.

Locations were selected randomly in each study area and visited on both weekdays and on either of the two days of the weekend, also selected randomly, but care was taken to visit each location on at least two weekends monthly. Interviews were held at the most active times of day, early morning and midday at harbours, and marinas and mid-morning along the shore. The questions were basically the same as in the telephone survey.

Daily catch composition and weight were estimated on the basis of the information provided by the anglers themselves, because the anglers interviewed tended to be reluctant to allow interviewers to weigh the total catch and to take the weight of each species in the bag. If the interview was held before the end of the fishing outing, the effective time spent fishing at the time the interview took place was taken into account in calculating the total daily catch.

In addition, volunteer recreational anglers kept fishing logbooks from February 2002 to March 2003. The fishing logbooks consisted of two parts. The first part was the same as the telephone surveys and the personal interviews, and was filled out by the volunteer once only. The second part was a record of catches on a single day, and was completed by the volunteer every time he or she went fishing. The data from this second part of the logbooks was used to evaluate daily catches but not fishing frequency, because many anglers forgot to complete the form on every outing.

Another source of information came from monitoring recreational fishing competitions. From 1998 to 2003, the DG Pesca monitored the recreational fishing competitions held on Majorca Island, recording the duration, number of

Table 1. Number of responses for each type of information source used in the present study.

| Information source | Socio-demographic data | Information on general aspects and the most common catches | Census of daily catches |
|---|---|---|---|
| Telephone household survey | 1 271 | 75 | — |
| On-site interviews | — | 672 | 774 |
| Volunteer logbooks | — | 66 | 658 |
| Total | 1 271 | 813 | 1 432 |

Table 2. Summary of data collected from recreational fishing competitions monitored, by fishing method: survey period, total number of competitions, total number of anglers, total number of fish caught, and total yield by fishing method.

| Method | Period | Number of competitions | Number of anglers | Number of fish | Yield (kg) |
|---|---|---|---|---|---|
| Boat-fishing | 2000–2003 | 13 | 414 | 19 345 | 1 035.77 |
| Shore-fishing | 2000–2003 | 29 | 503 | 11 481 | 1 034.54 |
| Spearfishing | 1998–2003 | 14 | 552 | 2 207 | 1 155.22 |

participants, and catch by number and weight for each species, along with the size (total length, TL) of all fish caught or of a representative sample of the catch (Table 2). Where the total catch in weight for each participant could not be obtained, it was calculated using weight−length relationship information culled from the literature (Morey *et al.*, 2003). This unit contributed data from 54 boats and shore-based angling competitions from 2000 to 2003, and from 14 spearfishing competitions from 1998 to 2003. The information was used to evaluate individual bags and effort under controlled conditions (time and gear), and overall to contrast the values obtained with those from the other information sources.

### Data processing

All data collected were entered in a database, using Access. Each interview with a member of a household (in the telephone survey) or with a single angler (in the general survey) was treated as a separate record (or entry), and each response to each question was considered a separate field in the database. Data from recreational fishing competitions were entered in another Access database and processed separately.

The information was extrapolated to the total population of the island using Excel to yield estimates of seasonal and annual fishing activity by fishing method, and graphically represented using Sigmaplot version 8.0. The estimates were analysed separately to calculate effort in days fished and daily yield, which were extrapolated to produce annual values. The proportion of anglers taking part in more than one type of fishing activity was taken into account to avoid duplication when calculating the total estimates.

## Results

### Participants in the recreational fishery

In all, there were 1271 responses to the telephone survey (Table 1), each representing a separate household with 3632 family members in all. By proportion, 5.14% of the respondents acknowledged being recreational anglers. As the population of Majorca in 2001 was 725 000 inhabitants, on this basis we estimated that there were 37 265 recreational anglers in Majorca. This number was considerably higher than the number of issued fishing licences in Majorca in 2002, signifying that only 59% of recreational anglers fulfil this legal requirement (Figure 2).

Recreational fishing is an overwhelmingly male activity (91% of the total), and the few women fishing usually accompanied a male relative. The mean age of recreational anglers in Majorca was 46 ± 2 years. Although anglers between 40 and 50 years old made up the largest segment (29.65% of the total), the percentage of recreational anglers older than 60 was also high (20.40%). These middle-aged men usually go fishing alone (43.7%) or in pairs (39.2%). The percentage of recreational anglers that went fishing in a group was rather low (12.5% in threesomes, 3.1% in foursomes, and only 1.5% in groups of more than four).

Recreational water craft in use are relatively small, and have medium-size engines, the traditional "llaüt" being the most popular (Table 3). Most boats were based at a harbour (81.5%), only few (18.5%) being towed to the coast. Spearfishers commonly used a towed boat (64.71%) as opposed to one moored at a harbour (35.29%). Fishing depth and distance from shore depended on boat type, but most activity takes place at a relatively close distance (mean 3.21 ± 1.23 km), at a depth of around 30 m (Table 3).

### Fishing activity

The recreational fishing method most often employed in Majorca was from a boat (62.9%), followed by fishing from shore (33.4%), with spearfishing (3.6%) being the least common (Table 4).

Nearly all recreational anglers always used the same fishing method. The proportion of anglers who always fished from shore was 92.76%, while for boat-anglers the percentage was lower, only 72%. This flexibility can most likely be attributed to the fact that most boat-anglers (90%) are themselves boat-owners, affording them more options when it comes to choosing a fishing method.

Analysis of daily activity showed that recreational anglers mostly went out in the morning (83.8%), followed by the evening (13.8%), with night-time last (2.4%). The yearly distribution of fishing activity (Figure 3) displayed pronounced seasonality and followed the same pattern for all fishing methods employed, with a maximum in summer (34.88%) and a minimum in winter (16.95%). Most recreational anglers fished on weekends (68%) or any time during the week (26%). Only a few (6%) fished only on weekdays. The percentage fishing on weekdays was directly proportional to monthly activity.

The mean frequency of fishing was 5.5 ± 0.11 times per month. Overall, 46.7% of recreational anglers usually fish

Table 3. Characteristics of the recreational fishing fleet and distance of the fishing grounds from shore by boat type. Values are the mean ± s.e. Distance is the mean distance from the coast to the customary fishing ground.

| Type | Share (%) | Size (m) | Engine horsepower | Fishing depth (m) | Distance (km) |
|---|---|---|---|---|---|
| Llaüt | 55.3 | 6.32 (±0.51) | 33.69 (±1.29) | 30.7 (±2.5) | 3.33 (±0.19) |
| Motorboat | 34.9 | 6.19 (±0.64) | 48.51 (±1.05) | 144.5 (±35.6) | 4.26 (±0.37) |
| Inflatable | 8.5 | 5.69 (±0.39) | 43.24 (±1.91) | 20.3 (±5.2) | 1.85 (±0.37) |
| Sailboat | 1.3 | 7.56 (±0.82) | 21.56 (±3.60) | 42.0 (±8.7) | 6.48 (±1.85) |

Table 4. Share of recreational anglers, and summary of fishing effort and yield by fishing method. Effort is expressed as total number of fishing outings per year (Effort 1), mean number of gears used concurrently by a single angler (Effort 2), and mean number of hours fished per day (Effort 3). s.e. in parenthesis.

| Method | Share (%) | Effort 1 (outings year$^{-1}$) | Effort 2 (gears angler$^{-1}$) | Effort 3 (h d$^{-1}$) | Yield (kg bag$^{-1}$) |
|---|---|---|---|---|---|
| Boat-fishing | 62.9 | 387 001 | 1.24 (0.25) | 4.05 (0.03) | 4.16 (0.24) |
| Shore-fishing | 33.4 | 205 552 | 1.31 (0.25) | 3.42 (0.06) | 4.03 (0.39) |
| Spearfishing | 3.6 | 22 320 | 1.49 (0.30) | 4.18 (0.15) | 4.48 (0.78) |

4−6 times a month, 27% 6−10 times a month, 7.6% between 10 and 15 times a month, and only 1.46% more than 15 times a month (Figure 4). Just 17.2% fish fewer than four times a month. The number of days given over to recreational fishing increased during vacations and bank holidays.

Effort for each fishing method (Table 4) was calculated from the information on the estimated number of recreational anglers (37 265), the seasonal distribution of fishing activity (Figure 3), and the mean number of fishing outings per month per angler (5.5). Total effort in the recreational fishery was 614 873 fishing outings year$^{-1}$. The most popular fishing method, from boats, accounted for most of the effort expended, factoring time spent fishing into the calculation.

The mean number of fishing gears used simultaneously by a single recreational angler was 1.27 ± 0.21, with some differences between fishing methods (Table 4). The mean time spent fishing by recreational anglers was 3.86 ± 0.03 h d$^{-1}$, though somewhat longer for spearfishing (Table 4).

## Catch composition and abundance

Based on the on-site censuses of catches (1432 bags, 5.8% with no catch) and on the personal interviews (Table 1), 60 fish and cephalopod species belonging to 28 families were identified (Table 5). The catches made from boats constituted the largest number of species (54), followed by fishing from shore (43), with spearfishing (29) being the most selective method. Despite the high diversity, effort was concentrated on 32 species, depending on the different fishing methods (Figure 5). *Serranus cabrilla*, *Serranus scriba*, *Coris julis*, *Symphodus tinca*, *Diplodus annularis*, *Diplodus vulgaris*, *Diplodus sargus*, and *Octopus vulgaris* were the most abundant species in the catches. The two species with closed seasons, *Xyrichthys novacula* and *Seriola dumerili*, were also among the most frequently caught.

Bag size was calculated by different methods, with differing results. In the telephone survey, 28% of the recreational anglers interviewed said that they usually caught between 25 and 50 fish per fishing outing. According to the telephone survey responses, the mean catch on a single outing (number of fish per bag) was highest for boat-fishing (29.27 ± 0.89) and lowest for spearfishing (12.28 ± 2.77), with shore-fishing producing a mean of 19.78 ± 1.06 per outing. According to the results of the on-site interviews by surveyors, however, the mean catch per outing was an order of magnitude lower for shore-fishing (9.55 ± 0.82) and spearfishing (7.24 ± 0.63) than for boat-fishing (29.08 ± 3.64). The maximum bags recorded for each fishing method were 98 fish for boat-fishing, 35 fish for shore-fishing, and 11 fish for spearfishing.

## Yield per outing

The data sources likewise furnished two different estimates of mean yield per fishing outing. The catch estimates by the

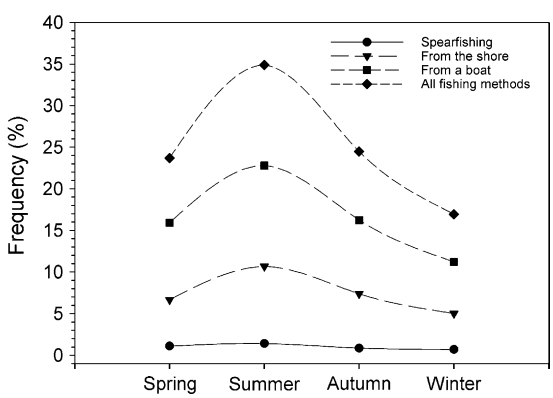


Figure 3. Seasonal distribution of fishing activity by fishing method on the Island of Majorca.

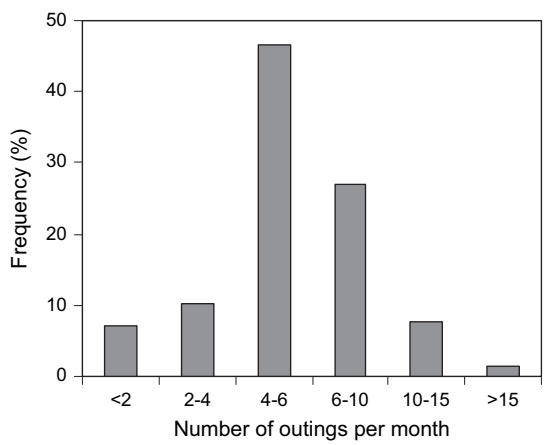


Figure 4. Relative frequency of fishing activity.

Table 5. Taxa caught by recreational fishing off Majorca. Frequency of appearance is qualitative (X = seldom, XX = regularly, XXX = very often). Asterisks indicate species also exploited by the commercial fishery.

| Taxon | Boat | Shore | Spear |
|---|---|---|---|
| Apogonidae | | | |
| *Apogon imberbis* | X | X | |
| Balistidae | | | |
| *Balistes carolinensis** | XX | | X |
| Belonidae | | | |
| *Belone belone* | XX | | |
| Blenniidae | | | |
| *Blennius* spp. | X | X | |
| Bothidae | | | |
| *Bothus podas* | XXX | X | |
| Carangidae | | | |
| *Lichia amia* | X | XX | X |
| *Seriola dumerili** | XXX | X | XXX |
| *Trachurus* spp.* | XX | | |
| Congridae | | | |
| *Ariosoma balearicum* | | XX | |
| *Conger conger** | | XX | XX |
| Coryphaenidae | | | |
| *Coryphaena hippurus** | XXX | | |
| Dactylopteridae | | | |
| *Dactylopterus volitans* | XX | X | X |
| Labridae | | | |
| *Coris julis* | XXX | XXX | |
| *Labrus viridis** | X | XX | XXX |
| *Symphodus ocellatus* | X | XX | |
| *Symphodus tinca** | XX | XX | XX |
| *Thalassoma pavo* | X | XX | |
| *Xyrichthys novacula** | XXX | | |
| Loliginidae | | | |
| *Loligo* spp.* | XX | X | |
| Moronidae | | | |
| *Dicentrarchus labrax** | X | XX | XXX |
| Mugilidae | | XXX | XXX |
| Mullidae | | | |
| *Mullus surmuletus** | X | XX | XX |
| Muraenidae | | | |
| *Muraena helena** | X | XX | XXX |
| Octopodidae | | | |
| *Octopus vulgaris** | XX | XX | XXX |
| Pomacentridae | | | |
| *Chromis chromis* | X | X | |
| Rajidae | | | |
| *Raja* spp.* | X | X | X |
| Sciaenidae | | | |
| *Sciaena umbra** | X | X | XXX |
| *Umbrina cirrosa* | | XX | XX |
| Scombridae | | | |
| *Auxis rochei** | XXX | | |
| *Sarda sarda** | XX | | |
| *Scomber japonicus** | XX | | |
| *Thunnus alalunga** | XXX | | |
| *Thunnus thynnus** | XXX | | |
| Scorpaenidae | | | |
| *Helicolenus dactylopterus** | XX | | |
| *Scorpaena porcus** | X | X | XX |
| *Scorpaena scrofa** | XX | X | XX |
| Scyliorhinidae | | | |
| *Scyliorhinus canicula** | X | | |
| Sepiidae | | | |
| *Sepia officinalis** | XX | XX | XX |
| Serranidae | | | |
| *Epinephelus marginatus** | X | XX | XXX |
| *Serranus cabrilla** | XXX | XXX | |
| *Serranus scriba** | XXX | XXX | |
| Synodontidae | | | |
| *Synodus saurus* | XXX | X | |
| Sparidae | | | |
| *Boops boops** | XX | XX | |
| *Dentex dentex** | XX | X | XX |
| *Diplodus annularis** | XXX | XXX | |
| *Diplodus puntazzo** | X | XX | XX |
| *Diplodus sargus** | XX | XXX | XXX |
| *Diplodus vulgaris** | XXX | XXX | XX |
| *Lithognathus mormyrus** | XX | XXX | XX |
| *Oblada melanura** | XX | XXX | X |
| *Pagellus acarne** | XX | X | |
| *Pagellus bogareveo** | XX | X | |
| *Pagellus erythrinus** | XX | X | |
| *Pagrus pagrus** | XX | X | |
| *Sarpa salpa* | X | XXX | XX |
| *Sparus aurata** | X | XXX | XX |
| *Spondyliosoma cantharus** | XX | X | X |
| Sphyraenidae | | | |
| *Sphyraena* spp.* | XXX | | X |
| Trachinidae | | | |
| *Trachinus* spp.* | XXX | X | X |

anglers themselves were compiled from 813 general information interviews, affording 766 responses with data on yield per outing (Table 1). According to these respondents, the most frequent yield for boat- and shore-fishing was between 1 and 3 kg, while yields for spearfishing were between 3 and 5 kg (Figure 6a). The percentage of anglers taking more than 10 kg per outing was low, 7.7% for boat-fishing and 5.0% for shore-fishing.

According to the survey responses, estimates of mean yield per outing (kg bag$^{-1}$) for all three fishing methods (Table 4) were similar. Biomass removal took place mainly in summer (Figure 6b), in accord with the temporal distribution of fishing activity (Figure 3). In contrast, the estimates obtained from logbooks (658 records) and on-site interviews (774 records) resulted in lower values for boat-fishing ($2.39 \pm 0.08$) and for shore-fishing ($1.09 \pm 0.07$), but a higher value for spearfishing ($2.70 \pm 0.53$).

## Recreational fishing competitions

During the competitions considered, recreational anglers spent $4.1 \pm 0.3$ h fishing from a boat and $4.2 \pm 0.1$ h

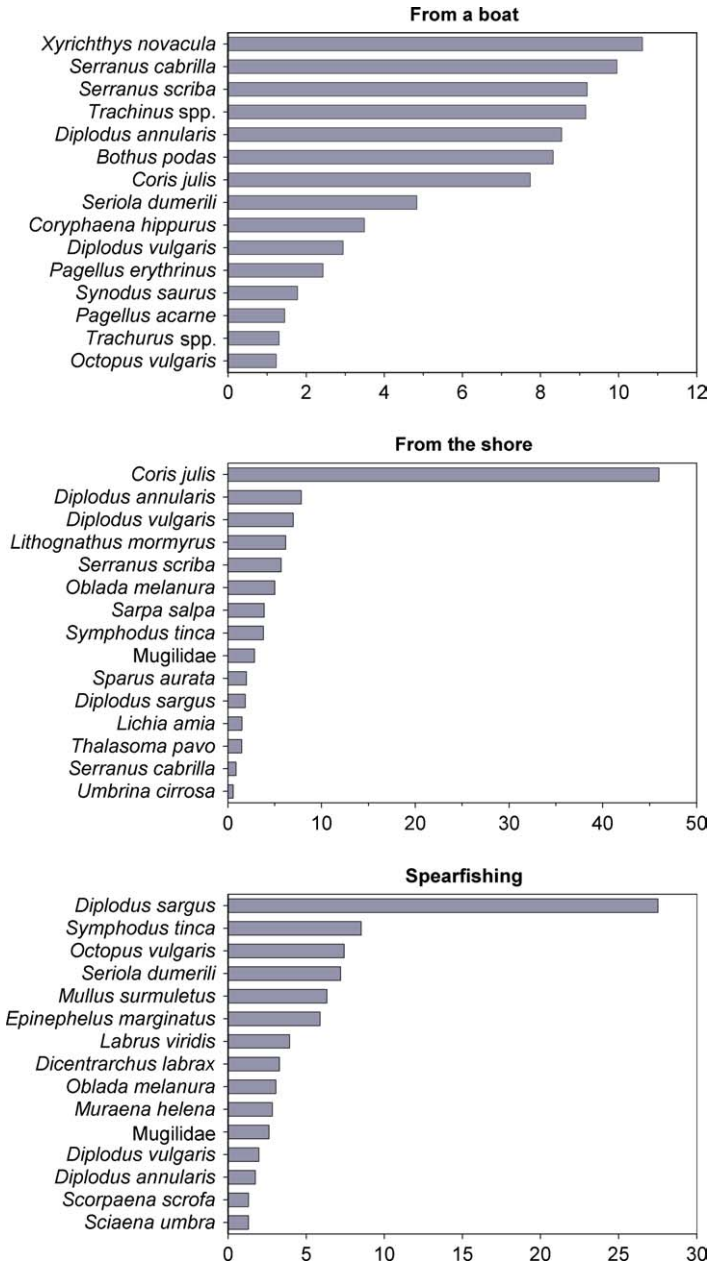


Figure 5. Percentage species abundance in recreational fishing catches by fishing method. Note that the scale of the x-axis differs for each plot.

fishing from shore. Mean catches (number of fish per bag) were much higher for boat-fishing ($45.79 \pm 4.27$) and for shore-fishing ($26.03 \pm 3.45$) than for spearfishing ($4.39 \pm 0.32$).

Estimated mean yield (kg bag$^{-1}$) was lowest for shore-fishing ($1.50 \pm 0.28$), while the highest values were for boat-fishing ($2.45 \pm 0.21$), closely followed by spearfishing ($2.36 \pm 0.24$). Table 6 gives the yields for the species most frequently caught during fishing competitions.

Size of the species caught most frequently was between 10 and 20 cm. *Seriola dumerili* was the only exception to this general pattern, ranging from 29 to 36 cm long (Figure 7). *Coris julis* and *Diplodus annularis* were consistently in the size range 10−15 cm, with a sharp peak at 13 cm. Similarly, *Symphodus tinca* and *Serranus cabrilla* had a modal size at 13 cm, though each also exhibited peaks, the main peak for the former at 18 cm and for the latter at 21 cm. *Diplodus vulgaris* was a little larger, with

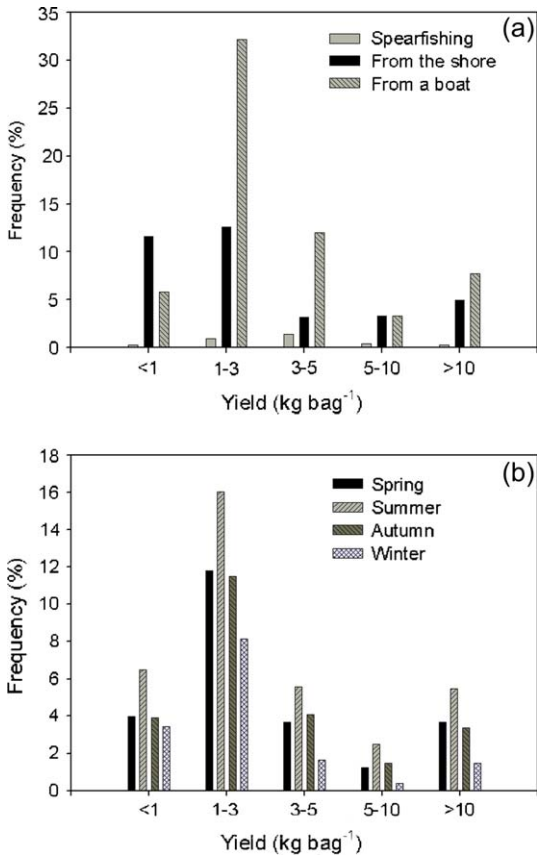


Figure 6. Daily estimated yields (a) by fishing method, and (b) by season (values expressed as percentage catch by biomass range).

a modal size at 16 cm and a main peak at 20 cm. The modal size for *Diplodus sargus* was 17 cm.

## Discussion

Data reliability was tested by cross-checking the data collected from the different sources of information available. Although admittedly subject to some shortcomings (see below), the present study reveals that with 37 265 people (5.14% of the population of Majorca Island in 2001) involved, recreational fishing is one of the main leisure activities and is undoubtedly important to the coastal marine ecosystem as well as being socio-economically important. Actual numbers of recreational anglers are probably higher, because people may well not have told the truth during the telephone survey of households, either because they fish without a licence or because they have other, personal reasons of their own. A veracity check carried out on 100 households having a family member who was a member of a recreational anglers' association showed that 5% denied having any family member actively fishing (Morales-Nin *et al.*, submitted). Therefore, the results presented here could underestimate actual levels of fishing activity, though to achieve better estimates a more extensive veracity test would be needed. Moreover, the sharp rise in the number of fishing licences issued (Figure 2) is probably related to a major drive to enforce fishing regulations, and itself points to a very active fishery.

The recreational fishery on Majorca Island is a predominantly middle class (most anglers are boat-owners who keep boats at marinas), middle-aged male activity that is carried out mainly from boats. The activity is concentrated on weekends and holidays in the coastal strip to a distance of 3 km offshore.

Our inability to weigh the daily bags (except during recreational fishing competitions) precludes accurate estimation of yields in the recreational fishery. For this reason, three approaches to estimating yield were employed, namely, what anglers say they catch (both in interviews and logbooks), on-site estimates by interviewers, and the bag weights in recreational fishing competitions. The first of these three approaches resulted in the highest estimates. The other two approaches produced quite similar results, with the values based on the competition data being slightly higher. There are several different sources of error in the yield estimates. In the telephone survey, error may arise from the anglers' own perception; i.e. selective memory, exaggeration, or perhaps failing to include zero bags in their daily bag assessments. In the on-site interviews, the main source of error is the greater likelihood of interviewing the most active, and hence the best, anglers. This also applies to the fishing competitions. Assessing this source of bias is difficult, because individual fishing success varies widely even among experienced anglers. This has been highlighted by a recent study of fishing competitions in the Balearic Islands spanning 27 years, which revealed considerable variability in individual bags among participants (Coll *et al.*, 2004). In any case, the similar estimates based on the information compiled by the interviewers and the fishing competition data lend support to the results obtained.

It follows, then, that the recreational fishery is landing a minimum of 1209.25 t year$^{-1}$ (based on the on-site interviews and logbook data) and a maximum of 2678.81 t year$^{-1}$ (based on the anglers' own data; Table 7). Assuming that the lower value is probably more accurate, this amounts to approximately 27.44% of the commercial catch of fish and cephalopods in 2002 (unpublished data from the DG Pesca, Govern de les Illes Balears). Moreover, in many cases the commercial and the recreational fisheries exploit the same species (Table 5). In terms of the numbers of people taking part, involvement is two orders of magnitude higher in the recreational fishery (37 265 recreational anglers) than in the commercial fishery (769 professionals in 2001, according to data from the DG Pesca, Govern de les Illes Balears).

The recreational fishery in the Balearic Islands is highly seasonal, mainly the consequence of seasonal variability in abundance of the key target species and variations in the

Table 6. Total catch (number of fish), total weight, abundance in the catches (number of fish per bag), yield, and total length range of the species most frequently taken during recreational fishing competitions by the different fishing methods used (s.e. in parenthesis; n.a., not available).

| Method | Species | Catch | Weight (g) | Abundance | Yield (g bag$^{-1}$) | TL (cm) range |
|---|---|---|---|---|---|---|
| Boat-fishing | *B. boops* | 226 | 7 586 | 2.10 (0.28) | 72.3 (7.6) | 11.2−22 |
| | *C. julis* | 2 215 | 47 826 | 7.39 (0.84) | 167.4 (25.4) | 8.7−20.1 |
| | *D. annularis* | 4 487 | 167 548 | 13.54 (1.95) | 492.8 (70.3) | 7.6−17.7 |
| | *D. vulgaris* | 472 | 30 712 | 1.56 (0.23) | 96.3 (10.1) | 11.5−2.1 |
| | *P. acarne* | 1 119 | 49 045 | 22.84 (4.90) | 945.4 (136.3) | 14.2−5.6 |
| | *P. erythrinus* | 106 | 22 064 | 1.09 (0.15) | 244.5 (52.9) | 14.6−31.5 |
| | *S. cabrilla* | 4 651 | 370 722 | 12.24 (2.58) | 949.5 (254.6) | 7.9−25.1 |
| | *S. scriba* | 4 564 | 187 338 | 13.73 (2.03) | 574.5 (7.7) | 9.3−21.1 |
| | *S. cantharus* | 222 | 23 722 | 1.60 (0.31) | 197.0 (36.8) | 13.2−26.1 |
| | *S. tinca* | 326 | 14 085 | 2.23 (0.28) | 97.2 (14.0) | 10.4−24 |
| Shore-fishing | *C. julis* | 1 247 | 21 716 | 9.65 (1.23) | 169.0 (19.2) | 9−19.9 |
| | *D. annularis* | 1 004 | 47 920 | 4.94 (1.19) | 221.4 (53.6) | 9.2−22.1 |
| | *D. sargus* | 1 297 | 31 329 | 2.14 (0.86) | 401.8 (202.3) | 12−33 |
| | *D. vulgaris* | 298 | 31 329 | 1.31 (0.36) | 116.2 (37.9) | 8.9−25.2 |
| | *L. mormyrus* | 2 122 | 121 643 | 14.27 (3.43) | 784 (156.8) | 8.5−30.9 |
| | *S. salpa* | 1 440 | 243 059 | 4.28 (1.28) | 660 (226.9) | 10.5−35.2 |
| | *S. scriba* | 867 | 37 019 | 5.79 (1.28) | 244.1 (47.6) | 9.2−22.3 |
| | *S. tinca* | 702 | 55 076 | 3.27 (0.66) | 187.0 (31.3) | 6.3−28 |
| | *T. pavo* | 595 | 12 620 | 4.10 (0.79) | 83.5 (16.0) | 7.4−18.1 |
| | *U. cirrosa* | 263 | 22 205 | 2.20 (0.65) | 197.7 (39.7) | 12−37.4 |
| Spearfishing | Mugilidae | 254 | 122 171 | 0.50 (0.06) | 245.1 (31.7) | n.a. |
| | *D. volitans* | 159 | 64 358 | 0.42 (0.05) | 176 (18.9) | n.a. |
| | *D. sargus* | 909 | 369 350 | 182.00 (0.17) | 748.7 (70.6) | n.a. |
| | *L. merula* | 62 | 24 504 | 0.16 (0.30) | 64.4 (11.6) | n.a. |
| | *L. viridis* | 97 | 43 838 | 0.26 (0.05) | 116.7 (21.0) | n.a. |
| | *M. helena* | 132 | 287 025 | 0.33 (0.07) | 721.2 (146.3) | n.a. |
| | *S. salpa* | 245 | 83 212 | 0.49 (0.05) | 167.3 (19.6) | n.a. |
| | *S. umbra* | 179 | 90 666 | 0.38 (0.06) | 159.4 (38.7) | n.a. |
| | *S. scrofa* | 117 | 58 341 | 0.26 (0.09) | 125.0 (22.6) | n.a. |
| | *S. tinca* | 68 | 20 094 | 0.16 (0.02) | 45.0 (5.8) | n.a. |

fishing methods used depending on weather conditions. The target and incidental species varied not only with season but also with fishing method, bottom substratum type, and fishing depth. Accordingly, the main species caught from shore are: on hard bottoms, *Symphodus* spp., *Coris julis*, *Diplodus annularis*, and *Serranus cabrilla* if bottom fishing, and *Oblada melanura* and *Sarpa salpa* if fishing nearer the surface; and on soft, sandy bottoms *Lithognathus mormyrus*, *Umbrina cirrosa*, *Sparus aurata*, *Diplodus* spp., and *Ariosoma balearicum*. The main species caught from boats near the bottom are: on *Posidonia oceanica* beds, *Serranus scriba*, *D. annularis*, and *Coris julis*; on sandy bottoms *Bothus podas*, *Trachinus* spp., *Synodus saurus*, and *Xyrichthys novacula*, the last taken only in summer and autumn; and on hard bottoms *Serranus cabrilla*, *Pagellus* spp., *Pagrus pagrus*, *Diplodus vulgaris*, and *Spondyliosoma cantharus*. Boat-fishing also harvests other species that are markedly pelagic, such as *Trachurus* spp. and young of the year *Coryphaena hippurus* and *Seriola dumerili*, taken mainly by trolling near the surface. Finally, the main species caught by spearfishers are *Epinephelus marginatus*, *Sciaena umbra*, *Diplodus sargus*, and *Octopus vulgaris*. The results for species share in the catches obtained in this study may be biased by the more-intensive sampling in summer. For this reason, the importance of *Xyrichthys novacula* in the boat-fishing catches may well have been overestimated. On the other hand, fishing activity targeting *Xyrichthys novacula* has increased in recent years, i.e. since the closed season was established.

The degree of exploitation of these target species is suggested by the length composition of the landings (Figure 7). Table 8 gives the available information on length at maturity and maximum length for some of the species, showing that there are differing degrees of exploitation, but that in any case the lengths in general tend to be short. This may well be due to the size

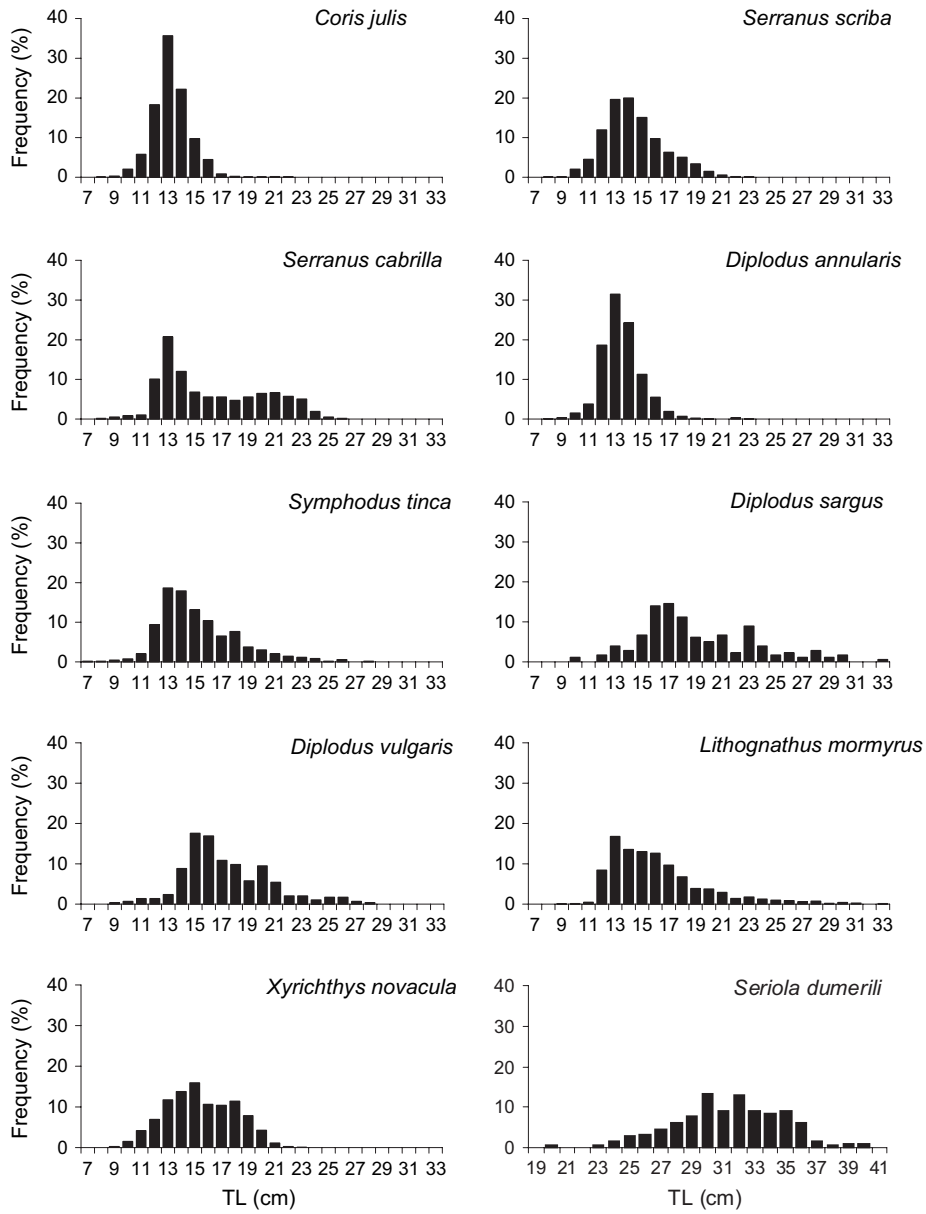


Figure 7. Size distribution of the 10 most abundant species in the catches taken during fishing competitions. Note that the scale of the x-axis differs for *S. dumerili*.

distribution of the species with depth (fishing activity is concentrated between 0 and 30 m) and to the non-regulation of hook size.

There have been few studies on exploitation of the coastal marine fauna in the Mediterranean, but available information seems to indicate that species are heavily exploited (Tserpes and Tsimenides, 2001; Voulgaridou and Stergiou, 2003; Coll *et al.*, 2004). Because of the size of these coastal resources and the relative absence of direct economic value to recreational anglers, ordinarily there is a tendency to overlook recreational fisheries as input for proper management, and to disregard the need for scientific research. Although the lack of earlier data and the study's own limitations preclude evaluating the available biomass and the degree of overexploitation, it is clear that recreational fishing must be taken into account for management purposes. Moreover, regulations such as those in place in Majorca might not be enough to keep fishing mortality at rates that are sustainable at sufficiently high levels of effort (Post *et al.*, 2003). Compliance with regulations in Majorca is low. Depending on the information source, from 25% (number of infractions

Table 7. Estimates of annual yield (t) based on the mean yield per fishing outing by fishing method, monthly fishing outing frequency, and seasonality in fishing activity.

| Season and method | Annual yield (t) | | |
|---|---|---|---|
| | Telephone survey | Logbook | Competition |
| Spring | 633.25 | 289.07 | 311.52 |
| Summer | 935.08 | 419.80 | 455.42 |
| Autumn | 656.59 | 295.30 | 320.30 |
| Winter | 453.89 | 205.07 | 221.93 |
| Total | 2 678.81 | 1 209.25 | 1 309.15 |
| Boat-fishing | 1 733.76 | 924.93 | 948.15 |
| Shore-fishing | 855.10 | 224.05 | 308.33 |
| Spearfishing | 89.95 | 60.26 | 52.67 |
| Total | 2 678.81 | 1 209.25 | 1 309.15 |

reported by fishing inspectors, DG Pesca, Govern de les Illes Balears, unpublished data) to 59% (data from our interviews) of anglers do not have a fishing licence. In practice, therefore, the recreational fishery is an open resource. Typical regulations like the bag limits and closed seasons used in the Mediterranean are not rigorous enough to affect total exploitation levels in open-access sport fisheries (Cox *et al.*, 2002). Therefore, management of recreational fishing requires stronger enforcement of regulatory measures and/or additional regulations such as the restricted and closed areas that are being enforced around Majorca.

The considerable diversity of species caught, with some differences between fishing methods, reflects highly varied exploitation of the littoral fauna. Most effort is concentrated in water shallower than 30 m, from the shore to $3.21 \pm 1.23$ km offshore. Besides the biomass extracted (1209.25 t year$^{-1}$), the disturbance caused by 614 872.5 fishing outings annually (nearly 2.5 million h fished) must be far from negligible given the small size of the island. In fact, relating the biomass removed to the 3663.76 km$^2$ of estimated shelf area exploited by recreational fishing (the

Table 8. Length at which 50% of the population is mature, and maximum length for some of the target species in the recreational fishery (FL, fork length; SL, standard length; TL, total length). Data from different areas (denoted by /) and sources.

| Species | TL 50% maturity (cm) | TL max (cm) | Reference |
|---|---|---|---|
| *Coris julis* | | 18 | Gordoa *et al.* (2000) |
| *Diplodus annularis* | Females, 13.4 Portugal/ Males, 10.3; Females, 12.8 Canary Islands | 24/11.2/20 | Gordoa and Molí (1997), Santos *et al.* (1998), Pajuelo and Lorenzo (2001), Deudero *et al.* (2004) |
| *Diplodus vulgaris* | Males, 17.27; Females, 17.65 | 28.2/28 | Gordoa and Molí (1997), Gonçalves *et al.* (2003), Deudero *et al.* (2004) |
| *Serranus cabrilla* | 15.2 SL | | Garcia Diaz *et al.* (1997) |
| *Serranus scriba* | | 24.8 | Deudero *et al.* (2004) |
| *Symphodus tinca* | Males: 13.1; Females: 13 | 44 | Gordoa *et al.* (2000), Ghorbel *et al.* (2002) |
| *Diplodus sargus* | 21.1* | 42.1/39/39 | Man-Wai and Quignard (1984), Gordoa and Molí (1997), Mann and Buxton (1998), Deudero *et al.* (2004) |
| *Lithognathus mormyrus* | 13 | 55 | Fishbase |
| *Thalassoma pavo* | | 20 | Guidetti *et al.* (2002) |
| *Labrus merula* | | 36.3/42 | Deudero *et al.* (2004)/Gordoa *et al.* (2000) |
| *Labrus viridis* | | 42 | Deudero *et al.* (2004) |
| *Sciaena umbra* | | 44.5 | Deudero *et al.* (2004) |
| *Scorpaena scrofa* | | 38.3 | Deudero *et al.* (2004) |
| *Xyrichthys novacula* | 10 | Females, 15; Males, 20 | Candi *et al.* (2004) |
| *Seriola dumerili* | 60 | 190/134.67 (SL) | Tachihara *et al.* (1993), Marino *et al.* (1995) |

**D. sargus capensis*.

surface area from the coastline to the 100-m isobath) results in direct removal of 330.06 kg km$^{-2}$ year$^{-1}$. Putting the carbon content of fish at 41.61% (Sterner and George, 2000; Cabral *et al.*, 2002), the amount extracted comes to 137.34 kg C km$^{-2}$ year$^{-1}$. Littoral Majorcan fish occupy a high trophic level (TL) of between 3 and 4 (Jennings *et al.*, 1997; Deudero *et al.*, 2004), although they do exhibit a certain degree of omnivory and undergo changes in diet with ontogeny. Mediterranean waters are oligotrophic (Estrada *et al.*, 1985), and littoral Mediterranean *Posidonia oceanica* meadows are important net organic carbon burial sites (García *et al.*, 2002). It follows, then, that shallow-water Mediterranean foodwebs should be benthic-based rather than plankton-based. Primary production of *Posidonia oceanica* meadows has been estimated at 445 883 kg C km$^{-2}$ year$^{-1}$ (Gazeau *et al.*, 2004). Taking this value as an indicator of production in the littoral zone and 10% as the transfer between trophic levels, production by fish ranges between 446 (TL 4) and 4458 kg C km$^{-2}$ year$^{-1}$ (TL 3). Accordingly, the recreational fishery is removing 31% of production at TL 4. Although these are gross estimates, the values do point to the pressure exerted by recreational fishing on coastal fish communities. Our estimates are consistent with the reported overexploitation of fishing resources (Pauly and Christensen, 1995).

Recreational and competitive spearfishing has a sizeable impact on serial depletion of large rocky-bottom littoral fish, and contributes to the non-profitability of some gears used by the small-scale fleet (Coll *et al.*, 2004), and commercial and recreational fishing have similar demographic and ecological effects on exploited populations (Coleman *et al.*, 2004). If the goal of fisheries management is to sustain viable populations and ecosystems, recreational and commercial fishing require effective regulation.

Existing management programmes in the Mediterranean are based on effort regulation, but this does not include recreational fishing. Considering that both the effort expended and the biomass extracted by this leisure activity are quite high, planning and implementing a comprehensive coastal management strategy must include recreational fishing. Additionally, recreational fishing activity has major social repercussions, and the benefits of the activity need to be weighed against investments in resource protection.

The historical sequence of human disturbances that affect coastal ecosystems shows that temporally fishing is always first and is thus essential in any coastal management strategy (Jackson *et al.*, 2001). In the Mediterranean exploitation started early, with evidence of systematic exploitation of fish stocks in southern Spain in the upper Pleistocene (19000 BC; Pellicer and Morales, 1995). This exploitation dating back to ancient times and the recent symptoms of overexploitation, together with economic development and increased use of coastal resources in the past 100 years, make improving the management of fishery resources an urgent priority, and management programmes will have to take recreational fisheries into account.

## Acknowledgements

We thank Jaume Bibiloni for his help in designing the questionnaire and calculating the proportion of required responses, and the interviewers, samplers, volunteer recreational anglers, and respondents for their support. The work was supported by a DG Pesca, Govern de les Illes Balears grant and co-funded by EU Project IFOP ES.R.BAL.5.1.3. Russell Sacks is thanked for his review of the English text, and Colin Attwood and an anonymous reviewer for their valued comments on the submitted draft.

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