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The nationwide assessment of marine recreational fishing: A French example

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ABSTRACT

In 2006, IFREMER, with the help of the polling institute BVA, implemented a national pilot study of recreational fishing. Taking into account all the different fishing methods, from shellfish gathering to offshore angling, including spear-fishing, this study was designed to provide estimates of (i) the number of recreational fishers in France, (ii) recreational fishing effort; (iii) catches and landings; (iv) the economic impacts of recreational fishing, and to develop a classification of recreational fishers. A two-part method was adopted: a random-digit-dialing (RDD) survey combined with an on-site survey. The data collected from telephone and on-site surveys were compared and then used in combination to provide a reliable estimate of this growing activity in France. Recreational fishers are estimated at around 2.5 million, with the total catch estimated at 24,000 t of fish and 3100 t of shellfish. Fishing expenditure was estimated at between 1200 and 2000 million euros.

1. Introduction

Interest in marine recreational fishing has grown in the last three decades, as studies have shown that recreational fishing can be an important source of income for national economies (Haab et al., 2001). Its potential impact on marine biodiversity is increasingly being recognized, where a large proportion of the catch results in the mortality of the fish caught (Coleman et al., 2004; Lewin et al., 2006). Further, conflicts have developed between recreational and commercial fisheries over the allocation of access to fishing areas and fish stocks (Arlinghaus et al., 2005; Cooke and Cowx, 2004; Kerbiriou et al., 2008). Policies aimed at controlling these impacts and reducing these conflicts require a sound information base, which is lacking for recreational activities in most countries around the world (Lee and Chang, 2008). Recreational fishing is difficult to monitor due to the diversity of fishing practices involved, and to the fact that the population concerned is often highly mobile (Pollock et al., 1994), on international, national, regional, and local levels. Large-scale information systems for recreational fishing have been developed in several countries, notably the USA (NOAA, 2006; Steinback and Gentner, 2004), Australia (Henry and Lyle, 2003; Gray, 2008), New Zealand (Wheeler and Damania, 2001), South Africa (Pradervand and Hiseman, 2006), and Canada (Analyses économiques et statistiques Secteur des politiques, 2005). In Europe, the UK, Ireland, and Norway (Toivonen et al., 2004) have also been conducting surveys for several years. However, it has recently been recognized that there is still a widespread lack of national data on this activity (International Council for the Exploration of the Sea, 2009). The number of recreational fishers, their total catch, and their total expenditure are known only approximately, if at all, in most European countries. There does not even seem to be an agreed definition of "recreational fishing" at this stage (Pawson et al., 2008). The definition adopted here is the European Commission definition: "all fishing activities not conducted for commercial fishing purposes" (CEC, 2001, p. 1799; cited by Pawson et al. (2008), p. 340). To date, most studies have focused on particular species and areas, and on one type of fishing (Dintheer et al., 2007; Dubreuil, 2005; Laspougeas, 2007; Lloret et al., 2008; Maggi et al., 1998; Morales-Nin et al., 2005; Peronnet et al., 2003; Pitcher and Hollingworth, 2002; Pradervand and Hiseman, 2006; Rangel and Erzini, 2007; Véron and Appéré, 2004). However, there has been increasing social and political interest in this question (Arlinghaus et al., 2007; Drouot et al., 2003), and the need for more comprehensive monitoring systems on the national level has increasingly been recognized (Roth et al., 2001). Recently, the European Commission encouraged its Member Countries to develop the monitoring of recreational fishing of a limited number of species in the Data Collection Framework (DCF) (International Council for the Exploration of the Sea, 2010, 2011).

In France, recreational fishing is subject to only limited regulation; there is no licensing system or registry of marine recreational

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fishers, and the activity has never been assessed on a national level until the present study. Under the supervision of a national committee, a pilot study was carried out between 2006 and 2009, with the aim of producing a first comprehensive assessment of marine recreational fishing on a national level in France (not including overseas territories) (Berthou et al., 2008; Levrel et al., 2009; Herfaut et al., 2010). The approach drew on methods used in the USA, which combine telephone and on-site surveys (Essig and Holliday, 1991; Gentner and Lowther, 2002), with some adaptations. In particular, the French survey deliberately addressed the entire spectrum of fishing activities, from shore-based shellfish gathering to boat-based angling, spear-fishing, and the use of nets and traps. The aim of the survey was to provide a first estimate of the number of recreational fishers in France, the number of fishing trips and size of catch, and the economic impact of recreational fishing, and to establish a typology of recreational fishing activities. This article presents and discusses the methods used in this pilot survey and the main results obtained.

2. Materials and methods

The survey was designed and carried out under the supervision of a national steering committee involving the national administration in charge of fisheries policy (DPMA), scientists, and a statistical institute in charge of data collection (BVA), as well as representatives of the main recreational fishing associations and of the National commercial fishing organization. A dual survey was adopted: a random digit dialing (RDD) telephone survey (phase 1) and an on-site survey (phase 2) (Ditton and Hunt, 2001; NOAA, 2006; Pollock et al., 1994). A similar method had already been used in the USA (Gentner and Lowther, 2002), focusing on anglers. The approach was used here for all categories of recreational fishing, including shore-based fish and shellfish gathering. Data collection was carried out over a two-year period. The first phase of the survey was designed to produce an initial estimate of the population of marine recreational fishers at the national level and a basis for the sampling plan of the second phase, using direct interviews, which sought to obtain more precise trip-level data on catch and expenditure. The study was conducted with French residents aged over 15, as this is the population for which census-based socio-demographic indicators were available. A representative random sample for the RDD survey was selected, which produced an initial estimate of the population of recreational fishers and description of the diversity of their fishing practices. The information collected via telephone surveys also provided a rough estimate of the number of trips, size of catch, and expenditure by fishers, with fairly large levels of uncertainty, as answers were based on recollections of past behavior in relatively short interviews. The on-site surveys were then set up to capture the diversity of fishing practices described in the responses to the telephone survey, with the aim of getting more precise numbers for size of catch and expenditures.

2.1. Data collection

2.1.1. First stage of data collection: telephone survey of recreational fishers

A total of 15,000 French households were contacted during the year 2006. The interviews were carried out with the computer-assisted telephone interviewing system (CATI) used by BVA. The interviews were conducted in five waves, in April 2006, June 2006, September 2006, November 2006, and January 2007 (Table 1).

The questionnaire was in five sections (with a maximum of 89 questions), covering (1) marine fishing activity over the previous three months (2006), (2) information about the most recent fishing trip (2006), (3) overall fishing activity during the previous year (2005), (4) information on boats owned (2005), and (5) fishers' perceptions of their activities and how these have changed over time, and their attitudes and opinions about new regulations. It took between 10 and 20 min to go through the questionnaire, depending on how many sections were completed by the respondent.

Table 1
Distribution of the five waves of the telephone survey in France (overseas territories excluded).

	Survey date	Number of households interviewed	Period of reference for Part A
Test stage			
Wave 1	April 2006	2061	January, February, and March 2006
Study stage			
Wave 2	June 2006	3003	April and May 2006
Wave 3	September 2006	5012	June, July, and August 2006
Wave 4	November 2006	3003	September and October 2006
Wave 5	January 2007	2006	November and December 2006
Total		15,085	1 year = 2006

The sampling plan was constructed taking into account the location and socio-demographic characteristics of the households to which the respondents belonged, based on census data for the French metropolitan population aged 15+. The coastal zones were over-sampled based on knowledge derived from previous studies, which showed a greater proportion of recreational fishers in coastal resident populations, with higher numbers of fishing trip and catch levels than those of fishers from inland regions (Morizur, 2004). This made it possible to improve the cost-effectiveness of the survey while keeping the sample representative. The selection bias introduced by this over-sampling was adjusted for in the analysis of the information collected, by applying weighting correction factors to the data relating to coastal residents (see below).

2.1.2. Telephone survey data corrections and adjustments

To ensure the sample was representative of the French population, taking into account the over-sampling of coastal residents as well as deviations observed between the socio-demographic characteristics of the sample and the overall population, a set of weighting factors was applied to the sample data. The individual weights were calculated by iterative proportional fitting. This "was done using" a procedure implemented by the French National Institute of Statistics and Economic Studies (INSEE), the "Generalized Calibration Procedure" (Macro CALMAR) (Le Guennec and Sautory, 2002). The weights were based on the observed characteristics of the household in terms of gender by residence zone (coastal or inland), age by residence zone (coastal or inland), socio-professional group by residence zone (coastal or inland), size of household (coastal or inland), region[1] and number of interviews carried out during each of the five waves.

The range of final weights applied to individual observations varied between 0.25 and 2.94. The sample was considered representative, as seen by comparing the characteristics of the head of household in our sample (after adjustment) with those of heads of household in the French population as a whole (Table 2).

2.1.3. Second data collection stage: on-site survey of fishing trips

The second stage was an intercept survey of recreational fishers at fishing access sites. While the aim of the telephone survey was to estimate the size of the population involved in different types of recreational fishing and to make a preliminary assessment of totals

[1] As defined by the National Institute of Statistics and Economic Studies.

Table 2
Characteristics of the heads of household in our sample after adjustment compared to those of heads of household in the French population as a whole.

Head of household characteristics	INSEE French household data	Interviewed households (15,085)
Sex		
Men	74%	74%
Women	26%	27%
Region		
North	6%	6%
East Paris basin	8%	8%
West Paris basin	9%	10%
West	13%	13%
Southwest	11%	11%
Mediterranean region	13%	12%
	12%	12%
Central East	9%	8%
East Paris region	19%	19%
Age		
15–24 years old	4%	4%
25–34 years old	16%	17%
35–49 years old	30%	30%
50–64 years old	23%	23%
65 and over	27%	26%
Occupation		
Farmer	12%	12%
Artisan, shopkeeper, professional	15%	15%
Profession and intermediate occupations	14%	14%
Employee	12%	12%
Laborer	19%	20%
Retired or otherwise inactive	39%	38%

of trip numbers, catch, and landing by recreational fishers in France, it was anticipated that these metrics might be strongly affected by the usual problems of recollection error and response bias described for telephone surveys (NOAA, 2006). The on-site survey was thus used as a complement to the telephone survey, to obtain more precise estimates of the key variables relating to catch and expenditure (Drouot et al., 2003; Pollock et al., 1994). The sampling plan for the on-site surveys was developed based on the information collected via the telephone survey about the location of interviewees' most recent fishing trip, taking into account the different types of fishing identified in the first phase of the study.

The fishing sites where the surveys were to be conducted were identified by combining different sources of information obtained through the local and national maritime administration, fishing clubs, previous studies (Maggi et al., 1998; Drouot et al., 2003), and experts from IFREMER research laboratories on the coast of France. 150 coastal sites were identified, each representing a specific type of fishing (Fig. 1). The statistical unit for this part of the survey was the fishing trip. Three criteria were used to stratify the sample: the maritime region (Atlantic coast, English Channel, and Mediterranean Sea), the season, and the type of fishing. This led to the identification of 44 strata, of which only 28 were considered for sampling, since fishing activity in the 16 others was considered too limited to be accessible to the survey. For instance, although spear-fishing can be carried out in the three maritime regions of France all year round, spear-fishers in the Mediterranean were only interviewed during spring and summer, which corresponded to the highest frequency of trips for this type of fishing, according to the telephone survey.

The allocation of sampling effort across strata was based on the distribution of fishing trips per type of fishing across regions and times of the year, as observed in the telephone survey. Some

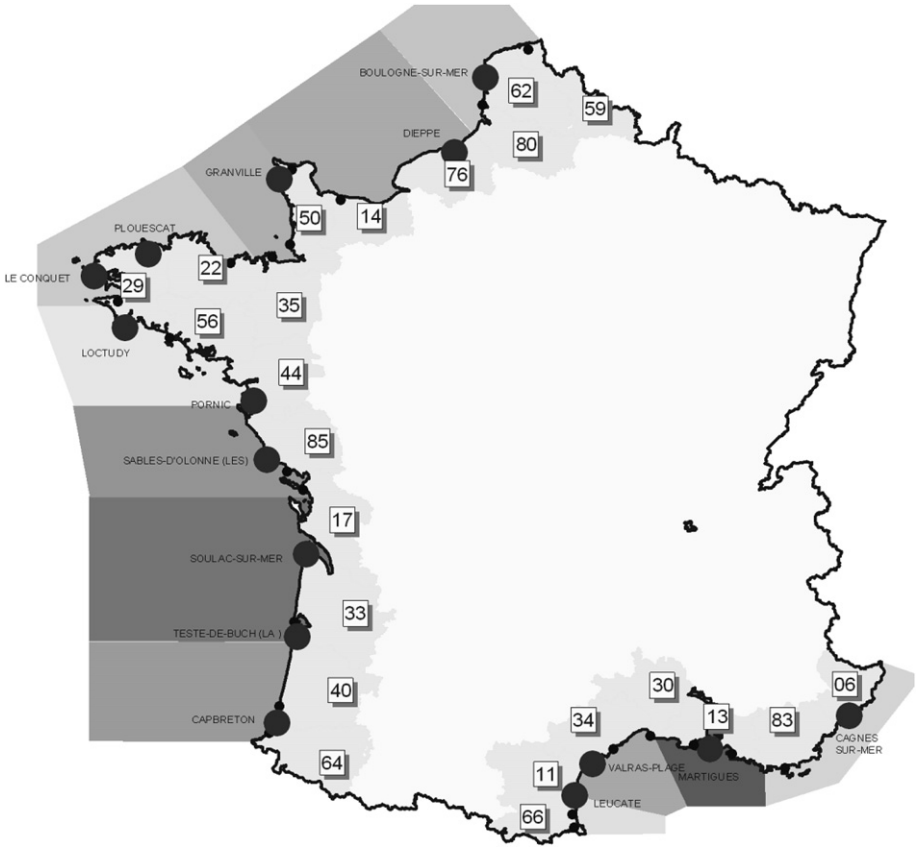

Fig. 1. The 12 coastal areas in which the 150 interview sites were identified.

over-sampling was applied to boat fishing and to the winter strata to ensure that a sufficient number of observations would be collected for these categories of trip. By contrast, under-sampling of shellfish gathering was applied, as this was a strongly represented type of fishing for which it was easier to obtain a relatively large sample. As in the telephone survey, these selection biases were accounted for in the analysis of the data collected by applying weighting factors. Angling competitions were excluded from the sampling frame, as they were deemed to introduce bias that would be difficult to measure and correct.

The sample plan of the on-site survey was not randomized, as no sampling frame was available at the scale of fishing trips. Rather, it was developed as a quota-based approach, using the information collected via the telephone survey to determine the number of observations of fishing trips required per type of fishing (Table 3). This included the description of the most recent fishing trip, which included the type of fishing and the maritime region in which the trip had taken place, and also the number of fishing trips during the previous year along with their distribution across the seasons.

Interviewers received initial training in administering the survey and the questionnaire, and were given advice as to the sites to visit and the time of the day at which to visit them. Different types of fishing called for different approaches. When possible, interviews took place on Friday or Saturday (though some took place during the week, for instance at high spring tide dates or school holidays). For the shellfish gathering interviews, interviewers had to go at low tide. For boat fishing, they visited harbors in late morning and late afternoon, when most of the boats came back. For shore angling, interviewers went to sites known to have a high concentration of fishers (surf-casting beaches, dikes and jetties, etc.). Full questionnaires were administered to fishers only if they had been fishing for at least an hour for shore angling, or 30 min for shellfish gathering.

A total of 1775 interviews were carried out between July 2007 and July 2008 (Table 3). Species were identified by the interviewers, who were given training in species identification, but due to logistical constraints and to avoid suspicion on the part of fishers, fish were not directly measured or photographed. Interviewers had to estimate the weight and length of fish caught by visual observation. The questionnaire for the on-site survey was based on the design used in the telephone survey, and consisted of a maximum of 81 questions, focusing mainly on the current fishing trip of the fishers interviewed.

Lastly, the data from the telephone survey were also sorted by fishing trip (Robson and Jones, 1989). Each fisher received a weight proportional to the annual number of fishing trips taken.

Table 3
Sampling plan of the on-site survey.

	Number of interviews	Quotas	Result
English Channel			
Shellfish gathering	177	150	118%
Offshore by boat	169	180	94%
Onshore angling	183	190	96%
Total English Channel	529	520	102%
Atlantic			
Shellfish gathering	304	180	168%
Offshore by boat	245	220	111%
Onshore angling	252	180	140%
Total Atlantic	801	580	138%
Mediterranean Sea			
Shellfish gathering	20	20	100%
Offshore by boat	140	140	100%
Onshore angling	197	200	98%
Spear-fishing from shore	45	30	150%
Spear-fishing by boat	63	30	210%
Total Mediterranean Sea	445	400	111%
Total	1775	1500	118%

2.2. Extrapolation methods

2.2.1. Appraisal of the number of recreational fishers

To estimate the number of recreational fishers in France, four steps were required. The calculation can be summarized in this formula:

(Number of recreational fishers in 2005 in our sample/Number of people over 15 in our sample) × French population over 15 = Estimate of the number of recreational fishers.

2.2.2. Calculation of size of catch

The two surveys were combined to obtain a first estimate of total catch per species and per group of species. The telephone survey data were considered as equivalent to 3130 fishing trips, weighted to give a representative sample of the total number of fishing trips for the year 2005. Extrapolation from the number of fishing trips and the number of fish landed per trip was used to extrapolate the total catch per species and per type of fishing. The calculations are detailed below.

$$N + N' = T$$

N = Weighted number of fishing trips in the telephone survey (after data adjustment)
N′ = Weighted number of fishing trips in the on-site survey (after data adjustment)
T = Total weighted number of fishing trips

$$\sum_{E,M} n_{E,M} + \sum_{E,M} n'_{E,M} = SP \quad \text{and} \quad TP = \frac{SP}{T}$$

$n_{E,M}$ = number of fishing trips with catch for the species E and the type of fishing M in the telephone survey
$n'_{E,M}$ = number of fishing trips with catch for the species E and the type of fishing M in the on-site survey
SP = total number of fishing trips with catch
TP = catch ratio per fishing trip

For the fishing trips with catch we calculated (with the information from both surveys):

$$PU_i = \frac{KG_i}{PR_i}$$

PR_i = number of fish per fishing trip i
KG_i = total weight of catch per fishing trip i
PU_i = average weight per fish per fishing trip i
w_i = weighting factor for the fishing trip i

$$PU = \frac{\sum_i PU_i}{SP} \quad \text{and} \quad PR = \frac{\sum_i PR_i}{SP} \quad \text{and} \quad PT = PU \times PR$$

PU = average weight per fish
PR = average number of fish per fishing trip with catch
PT = total weight per fishing trip with catch

The previous calculations were also done by species and by type of fishing, and were notated as PR_E, PR_M, $PR_{E,M}$… These detailed calculations were done for each type of fishing, but only for species for which the number of observations was sufficiently high.

We wanted to calculate the extrapolated number of fishing trips in 2005. This extrapolation was made from telephone survey data

only, with the same extrapolation method as for the calculation of the number of recreational fishers in 2005.

$$\text{TOTAL}_{M \text{ with } C} = \text{TOTAL}_M \times TP$$

TOTAL_M = Extrapolated number of fishing trips of type of fishing M = Estimate of the total number of fishing trips for 2005
$\text{TOTAL}_{M \text{ with } C}$ = Estimate of the total number of fishing trips with catch for 2005

Finally, the total catch was estimated by type of fishing and/or by species:

$$W_M = \text{TOTAL}_{M \text{ with } C} \times PT$$

W_M = estimation of the total catch for the type of fishing M in 2005

Aggregation across the telephone and on-site survey data was based on the confidence interval, regarding each group of species: The higher the standard error of the estimate derived from the telephone survey by comparison with the estimate derived from the on-site survey, the lower the weight of the estimate derived from the telephone survey in the final estimate.

2.2.3. Calculation of expenditure

The calculation of costs was based on responses to three groups of questions:

- the description of the most recent fishing trip, regarding both time budgets (preparation, travel, fishing time) and expenses specific to each trip (travel costs, food costs, fees, gasoline for boat trips, etc.), defined as operating costs
- the costs of equipment and clothing for the activity, defined as investment costs
- the costs related to depreciation and maintenance of boats, defined as costs for boats.

Extrapolations based on the sample data were carried out as follows:

- First, we estimated the total number of fishers and calculated total investment costs.
- Second, we estimated the total number of vessel owners and calculated the total costs for boats, which were then weighted by the rate of use of boats for fishing that were declared by respondents (fishing trips as a percentage of total trips made with the boat).
- Third, we estimated the average number of fishing trips per fisher and calculated the overall budget-related operating costs.

Data from both telephone and on-site surveys were used: 67% from phone and 33% from on-site surveys.

The economic results are obtained from a series of calculations based on five variables: number of fishers (X_1), number of trips per fisher (X_2), total expense per trip (X_3), number of boats (X_4), average expenditure per boat (X_5).

The total amount of expenditure is expressed as $D = X_1X_2X_3 + X_4X_5$ and the variance of D is $V(D) = V(X_1X_2X_3) + V(X_4X_5)$.[2]

[2] We assume the independence of these five variables. This simplifying assumption is not too restrictive, since these estimates are based on entirely different calculation methods. Taking into account correlations between variables increases the calculations considerably; we can then show that these effects are second-order, using the same reasoning as in the formula above.

3. Results

In this section, we present the key results obtained for France.

3.1. Recreational fisher population

In 2005, the penetration rate (the number of fishers in the sample) was 11.1% in the coastal zone and 5.4% in the inland zone, representing 6.7% of the total interviewed households for 2005 (Table 4). The number of recreational fishers aged 15+ in the sample was 1016 (1.57 fishers per household).

The total number of recreational fishers aged 15+ in France was estimated at 2.45 million (± 0.15 million) in 2005, corresponding to 5.1% of the population (Table 4).

Statistically significant differences in the socio-demographic profile were observed between recreational fishers and the average characteristics of the French population. There was a greater proportion of males (82%) and of individuals aged between 35 and 49. As expected, recreational fishing was represented twice as much in coastal area households as in the rest of the country (Table 5).

3.2. Recreational fishing effort

The average number of trips per year per fisher was 13 in 2005. Half of them occurred during summer (Fig. 2), the period of better weather conditions and the school summer vacation, which is associated with a large influx of visitors to the coastal areas of France.

In 2005, the average number of types of fishing was 1.4 per fisher. Recreational fishers mainly practiced shellfish gathering (71%); 25% practiced angling from boats (Fig. 3). Spear-fishing represented only a very small proportion of marine recreational fishing. 14% of the interviewed fishers owned a boat used for this activity. The total was estimated at 335,000 boats.

Two-thirds of the fishers interviewed caught at least one shellfish during the year, 55% at least one fish, 51% at least one crustacean, and 12% at least one cephalopod. The main species caught were sea bass, mackerel, pollack, black seabream, and sargo bream (Fig. 4).

We detail total fish catch by type of fishing and by species, highlighting the confidence intervals (Table 6).

Estimated average catch of fish per fisher was 10 kg per year^{-1} (Table 7). The most sought-after species were sea bass (19% of fishers), mackerel (12%), and pollack (12%). The proportion of the three main species in total catch decreased from 67% to 43% when the two surveys were combined, as the on-site survey provided details of catch for species that had not been identified in the telephone survey. Rarer and less targeted species were observed and counted on-site, whereas they were often forgotten by fishers in the RDD declarations (Fig. 4). This led to a final estimate of total catch of fish (Table 7) that was higher in the combined survey results than in the telephone survey only. Conversely, for other species groups (crustaceans, cephalopods, and shellfish), estimates of total catch were lower in the combined survey results, as it appears that fishers over-estimated their catch in weight of these species in

Table 4
Number of recreational fishers in 2005, results of the extrapolation.

Number of recreational fishers over 15 interviewed circa 2005	1016
Mean number of fishers by household	1.57
Total number of recreational fishers represented in our sample	1599
Number of people over 15 in our sample	31 377
Penetration rate based on individuals over 15 (1599/31377)	5.1%

Table 5
Comparison between the characteristics of the French population over 15 and the characteristics of the recreational fishers in the sample, after adjustment.

	French population over 15	Recreational fishers (after adjustment)
Sex		
Men	48%	82%[a]
Women	52%	18%[a]
Age		
15–24	16%	4%[a]
25–34	17%	21%[a]
35–49	27%	38%[a]
50–64	20%	25%[a]
65 and over	20%	12%[a]
Profession		
Farmer	2%	1%
Craft worker, Shopkeeper	17%	18%[a]
Executive	14%	21%[a]
Employee	10%	13%[a]
Laborer	23%	21%[a]
Retired or otherwise inactive	34%	26%[a]

[a] = significant difference at 5% (chi-square test).

the telephone survey. The differences between the two estimates showed the advantage of combining the two survey approaches to get more accurate results (Weithman and Haverland, 1991).

Final results estimated the fish catch at about 24,500 T, shellfish about 3150 T, crustaceans about 1600 T, and cephalopods about 495 T (Table 8). Fish catch was split into two categories. The first included the five main species cited as target species, and represented approximately 15,500 T in total. For these species, estimates obtained from the telephone survey and estimates obtained from combining the telephone and on-site surveys were remarkably similar. It thus appears that for these species at least, the information obtained via telephone surveys was fairly reliable. The second category included all other fish species caught, for which the evaluation was less accurate and the confidence interval too high to make sense at the species level.

3.3. Estimates of expenditure

Estimates of total expenditure were made for the three categories of costs identified in the survey:

a) Operating costs including the costs of transport, food and lodging specific to each trip (Fig. 5a)

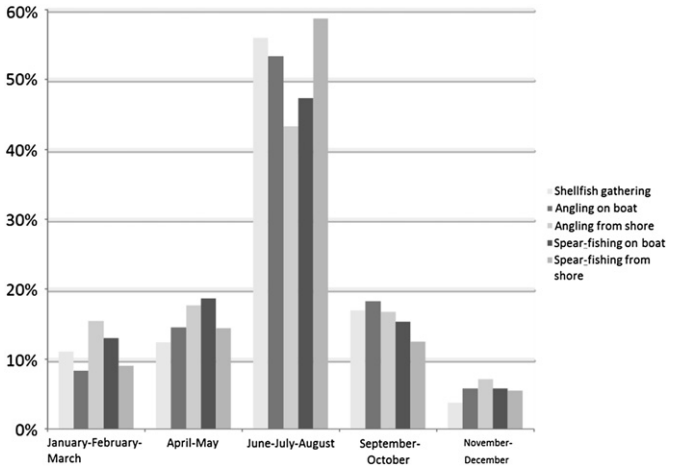

Fig. 2. Distribution of fishing trips during 2005 (telephone survey data).

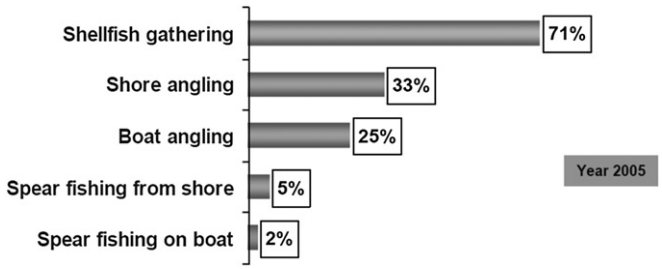

Fig. 3. Distribution of types of fishing for fishers with at least one fishing trip in 2005 (telephone survey data).

- The average car transport cost was 3.20 € per trip per person.
- The average boat transport cost was 1.64 € per trip per person.
- The average food cost was about 23 € per trip with expenses, which represented 42.2% of fishing trips. The average food cost was 9.72 € per trip per person.
- The average accommodation cost was about 339.74 € per stay. Dividing this by the number of fishing trips made during the stay, the accommodation cost per trip per person is estimated at 28.74 €. This expense concerned 7.6% of fishing trips. The average accommodation cost was 2.19 € per trip per person.

b) Investment costs include the cost of practicing recreational fishing (bait, material, equipment, clothes, magazines, etc.) (Fig. 5a):
- Small equipment and bait cost was on average 23.12 € per trip with expenses which represented 44% of fishing trips. The average cost was 10.22 € for the total number of trips.
- Fishing equipment (rods, reels, nets, etc.) and clothing costs were estimated at 4.39 € per trip with expenses, representing 79% of trips. The average cost was 3.48 € for the total number of trips.
- Expenses for specialized magazines were estimated at 0.30 € and concerned 74% of the trips. The average magazine cost was 0.22 € for the total number of trips.

c) Costs relative to the boat include the depreciation and use of boats (maintenance, insurance, etc.) (Fig. 5):

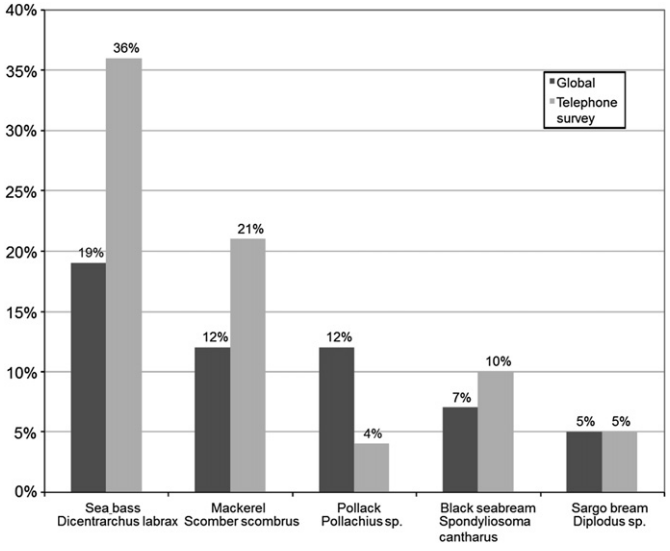

Fig. 4. Proportion of the main species: global estimate (telephone + on-site survey) and telephone survey estimate.

Table 6
Weight of species catch in tonnes and by type of fishing (highlighted species are those for which the confidence interval is lower than the estimate and the estimate can thus be considered sound).

Species name (common)	Spear-fishing from shore	Spear-fishing from boat	Angling from shore	Shellfish gathering	Angling from boat	Total weight	Confidence interval
Abalone	–	–	–	18	–	18	86
Anchovy	–	–	20	–	0	20	57
Atlantic horse mackerel	–	–	1	–	22	23	54
Black seabream	86	0	588	118	1273	2065	962
Bogue	–	–	8	–	2	10	38
Bonito	–	–	7	–	75	81	261
Brown comber	–	–	17	–	51	68	171
Brown trout	–	–	–	30	–	30	302
Carp	–	–	104	21	–	125	410
Clam	–	–	50	564	1	614	368
Cockle	0	–	7	480	–	486	333
Cod	–	–	71	–	308	379	574
Common dab	–	–	0	–	138	139	309
Common prawn	–	–	61	71	0	132	120
Common seabream	–	–	–	–	31	31	154
Conger	–	6	296	17	454	773	806
Crab (edible + spider)	–	42	66	1002	197	1207	972
Cuttlefish	–	7	1	1	99	107	4
Derbio	–	–	2	–	–	2	12
Donax	–	–	–	16	–	16	345
Eel	–	–	969	13	–	981	1075
Flounder	–	–	1	17	0	18	171
Garfish	–	–	25	–	153	177	246
Gilthead	–	–	23	41	73	137	184
Goby	–	–	7	1	55	63	140
Gray triggerfish	–	–	0	–	7	7	26
Great Atlantic scallop	19	27	–	8	–	54	174
Greater sand eel	–	–	–	1	0	1	3
Grey mullet	5	5	125	48	44	227	264
Grouper	–	–	814	–	–	814	1036
Hake	–	–	–	–	97	97	250
Hermit crab	–	–	–	1	–	1	2
Lesser grey mullet	75	1	17	–	95	188	448
Limpet	–	–	–	28	–	28	47
Lobster	10	–	–	–	1	11	51
Mackerel	0	165	193	103	3174	3635	1575
Meagre	–	–	2	16	576	594	860
Moray	–	–	26	–	0	26	76
Mussel	3	–	33	419	–	455	308
Norway lobster	–	–	–	2	–	2	17
Oblade	–	–	35	–	8	43	79
Octopus	5	0	1	74	10	160	991
Oyster	–	–	–	1201	0	1201	1052
Plaice	–	62	48	42	71	223	483
Pollack	–	2	366	0	3161	3529	2515
Pout	–	–	85	–	99	184	–
Queen scallop	–	–	–	3	–	3	14
Rainbow wrasse	26	–	29	0	55	110	178
Ray	–	–	1	–	19	19	138
Red gurnard	–	–	–	–	17	17	74
Red mullet	–	–	–	1	1	1	54
Sand steenbras	–	–	0	–	37	37	75
Sardine	–	–	169	–	2	170	1
Saupe	3	–	30	–	0	33	624
Scorpion fish	19	–	47	–	56	122	55
Sea bass	115	24	1775	690	3009	5612	1964
Sea urchin	0	0	0	116	–	116	183
Sebaste	–	–	–	–	1	1	50
Sergeant major	9	–	–	–	4	13	31
Shark	–	–	14	0	33	48	199
Smelt	–	–	26	2	0	29	45
Sole	0	70	150	1	236	457	138
Solen	–	–	5	49	–	54	76
Sprat	–	–	25	–	–	25	610
Squid	–	0	43	–	185	228	482
Surmullet	0	1	7	–	12	19	91
Tuna	–	–	–	5	53	57	45
Turbot	–	–	–	–	22	22	94
Velvet crab	–	–	82	139	9	230	281
Whelk	–	1	–	50	–	51	73
Winkle	–	–	15	76	–	91	74

(*continued on next page*)

Table 6 (*continued*)

Species name (common)	Spear-fishing from shore	Spear-fishing from boat	Angling from shore	Shellfish gathering	Angling from boat	Total weight	Confidence interval
Whiting	–	–	10	–	57	67	189
White bream	30	53	401	–	256	840	168
Warty venus	–	–	–	77	1	77	261
Worm	–	–	–	11	0	11	80
Weever	–	–	0	0	342	342	69

- The average boat purchase price was 24,931 €. 81% of the fishers had bought a boat. The calculation of depreciation (basis over 30 years) gave an average of 545 € per year^{-1}.
- The average annual cost for the use of boats was divided into several categories: average equipment expenditure = 521 €; maintenance = 194 €; harbor dues = 381 €; insurance = 150 €; registration rights tax = 10 €. The total cost for the use of each boat was estimated at 1256 €, with 61% of the trips made in the boat being related to recreational fishing. The average cost for the use of a boat for recreational fishing was thus estimated at 766 € per year^{-1}.

d) Total costs were calculated using the five variables listed in the methods section (Table 9).

The extrapolation of annual expenditures generated by recreational fishing, based on a combination of the data collected by telephone and the on-site surveys, was 1.256 billion euros, divided among operating expenditures (524 M€), investment expenditures (435 M€), and expenditures on boats (308 M€) (Fig. 6). The standard deviation of expenditure is 221,359,471 €, representing a coefficient of variation of 17.5% (222 M€/1267 M€). The total expenditure is estimated with a relative error of 2*17.5% = 35%.

As in the case of catch figures, this estimate of expenditures was compared to an estimate based on telephone survey data alone. After the two surveys were combined, the final estimate of expenditures represented 61% of the estimate derived from the telephone survey database alone.

Table 7
Catch estimates: comparison of the results from the telephone survey and the results from the combination of the two surveys. The confidence intervals for the estimates are indicated in parentheses.

	Initial estimate	Final estimate
	Telephone data	Telephone + on-site data
Fish		
Overall catch (tonnes)	14,500 T (±5000)	24,500 T (±4600)
Average weight per year per fisher (>15 years old)	6.1 kg ±2.1	10.0 kg ±1.9
Sea bass (*Dicentrarchus labrax*)	5000 T (±1200)	5600 T (±1600)
Mackerel (*Scomber scombrus*)	3300 T (±100)	3600 T (±1600)
Gilthead (*Spratus aurata*)	1600 T (±500)	2000 T (±960)
Pollack (*Pollachius pollachius*)	nc*	3500 T (±2500)
Shellfish		
Overall catch (tonnes)	13,500 T (±2500)	3150 T (±1200)
Average weight per year per fisher (>15 years old)	3.5 kg ±1.3	1.3 kg ±0.5
Mussels (Mytilidae)	4300 T (±1200)	460 T (±300)
Oysters (Ostreidae)	3000 T (±900)	1200 T (±1000)
Common cockles (Cardiidae)	2500 T (±800)	490 T (±300)
Carpet shells (Veneridae)	2300 T (±700)	600 T (±400)
Crustaceans		
Overall catch (tonnes)	6700 T (±2600)	1600 T (±900)
Average weight per year per fisher (>15 years old)	2.8 kg ±1.1	0.7 kg ±0.4
Cephalopods		
Overall catch (tonnes)	1600 T (±500)	495 T (±600)
Average weight per year per fisher (>15 years old)	0.7 kg ± 0.2	0.2 kg ±0.3

nc* = not enough data to calculate the total catch.

4. Discussion

Our results provide a benchmark from which it will be possible to monitor social, economic, and ecological trends in recreational fishing in France in subsequent years. In particular, we have developed a set of statistics that should make for more constructive discussion between commercial and recreational fishers, and help to mediate conflicts over shared resources. Indeed, as emphasized by Arlinghaus (2005) and Cooke and Cowx (2006), it is crucial to share the same indicators and framework for discussing issues to do with recreational fishing if the level of negotiations is to be improved and conflicts successfully mediated. It is also crucial to be able to identify potential sources of conflict and possibly to manage and control them; without data and indicators, conflicts will increase.

The size of the recreational fishing catch is around 2% of the commercial catch in France and 11% of the commercial fresh (not frozen) landings. Even if the total catch of recreational fishing is low compared to commercial fishing, the catch of some targeted species can be considered high, especially sea bass (around 100% of that of commercial landing), mackerel (19%), gilthead and black seabream (44%), and pollack (92%). In addition, mackerel and pollack are subject to the European Commission TAC (Total Allowable Catch) limits: mackerel catch from recreational fishing represents one-third of the permitted French quota for this species. For the moment catch by recreational fishers is not counted against this quota.

Table 8
Final catch estimates (telephone + on-site data) per type of fishing.

	Angling from shore	Angling from boat	Shellfish gathering	Spear-fishing from boat	Spear-fishing from shore	Total
Fish						
Tonnes	7460	14,453	1386	406	621	24,325
ME[a]	±2481	±3653	±800	±646	±667	±4583
CV[b]	0.33	0.25	0.58	1.59	1.07	0.19
Shellfish						
Tonnes	109	2	2990	28	22	3152
ME	±143	±19	±1216	±91	±141	±1235
CV	1.31	9.01	0.41	3.20	6.37	0.39
Crustaceans						
Tonnes	209	206	1146	42	10	1613
ME	±335	±280	±686	±232	±50	±847
CV	1.60	1.36	0.60	5.53	4.87	0.53
Cephalopods						
Tonnes	44	294	74	7	75	495
ME[a]	±197	±473	±199	±27	±162	±574
CV[b]	4.42	1.61	2.69	3.79	2.16	1.16
Invertebrates						
Tonnes		0	11			11
ME		±3	±69			±69
CV		30.72	6.28			6.23
Sea urchins						
Tonnes	0		116	0	0	116
ME	±1		±182	±2	±16	±183
CV	33.36		1.58	41.86	44.16	1.58
Total						
Tonnes	7824	14,956	5723	483	728	29,714
ME	± 2515	±3694	±1633	±693	±703	±4859
CV	0.32	0.25	0.29	1.43	0.97	0.16

[a] ME = Margin of error and.
[b] CV = Coefficient of variation.

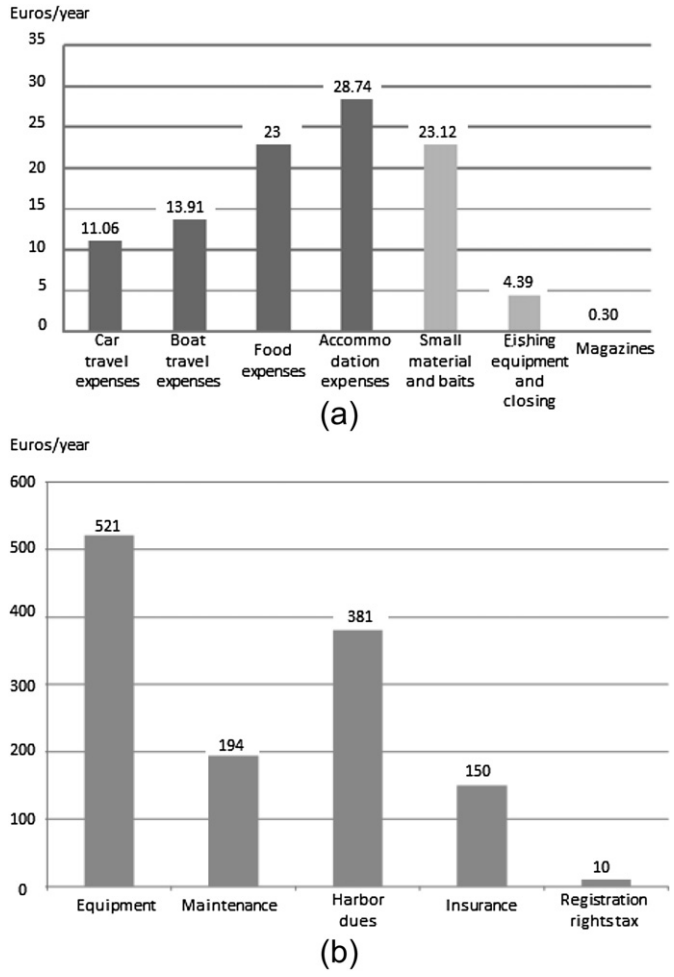

Fig. 5. Average costs: (a) operating and investment costs per fishing trip with expenses and (b) costs related to ownership and use of boat for recreational fishing per year.

However, these figures must be used with caution. In particular, this concerns estimates of economic expenditure.

The estimate of transport expenses (by boat or car) appears to be robust (using mileage and number of liters consumed). The investment and boat costs are also accurately measured, but display high variability in correlation with variability in types of boat. This diversity leads to less precision and greater standard error. The food and lodging expenditures are more difficult to estimate. The variability of the data is very great, and it is sometimes difficult to identify the part of these expenditures actually imputable to recreational fishing (especially when it is included in a vacation). The estimates of total expenditure must thus be viewed with caution. A methodological improvement might be to ask recreational fishers what are their additional costs for food and lodging on these trips.

Table 9
Variable assessment for the calculation of total expenditure.

Code	Variable	Mean	CV[a]
*X*1	Number of fishers	2,450,000	3.1%
*X*2	Number of trips per fisher	12.77	9.6%
*X*3	Total expense per trip (mean of operating cost per trip + mean of investment cost per trip)	30.67	9.3%
*X*4	Number of boats	234,954	1.0%
*X*5	Average expenditure per boat	1311	34.3%

[a] Coefficient of variation.

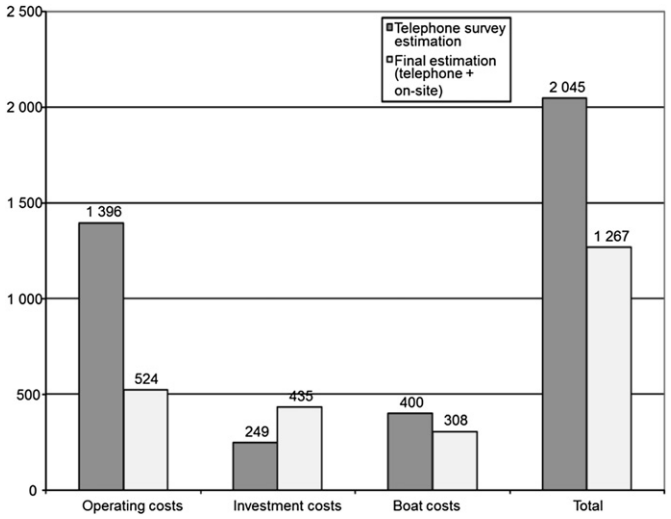

Fig. 6. Total expenditure estimates for 2005, comparison of telephone survey estimates and overall estimates.

The study has made it possible to define reference lists that we will need for systematic follow-up of recreational fishing. This has three dimensions:

- Species: this was developed using the data from the telephone survey, complemented by the on-site survey. It can be improved further, and is linked with the French national Fisheries Information System (website: www.ifremer.fr/sih).
- Types of fishing: this already seems quite complete, as nearly all recreational fishing practices are indexed. It would be useful to connect this information with the "métier classification" used for commercial fishers in France (Daurès et al., 2009).
- Recreational fishing sites: this was developed using several data sets in combination drawn from other studies, administration, local knowledge, and so on. The next step will be to build a more precise site-period matrix on each seaboard, in order to establish a reference state from which the sample plan can be further developed.

The RDD survey seems to be a cost-effective method that gives a good estimate of the proportion of the French population who practice recreational fishing as well as information about recreational fisher profiles. This result is consistent with those of other publications (Gentner and Lowther, 2002; NOAA, 2006). The off-site survey also provides good coverage of night and private-access fishing that is typically difficult to assess using on-site surveys. However, data about catch and expenditure are not precise enough, due to what is known as recall bias (Essig and Holliday, 1991; NOAA, 2006; ICES, 2010, 2011). It was hard for recreational fishers to recall the total weight of their catch during 2005. A year later than the events is certainly too long a delay, and the unreliable memory of respondents introduces bias, as noted in other studies. This is why on-site surveys were conducted, as they were considered to be more reliable for estimating catch (especially in the case of shellfish and crustaceans) as well as expenditures. However, on-site surveys are very expensive, and cross-referencing the RDD and on-site data is far from easy.

The sharp differences between the results of the telephone survey and the combination of surveys are essentially due to errors on declared weights by individuals interviewed by telephone. This bias has already been noted in the literature and seems to pose a major challenge when two different sources of data collected using

different methods are to be compared (Tarrant et al., 1993; NOAA, 2006; ICES, 2010, 2011). This is especially true for shellfish and crustacean species: those interviewed seemed to be unable to assess the weight of their catch precisely (usually overestimating it). In France, it is normal to measure shellfish catch in liters, but in the telephone survey respondents were asked to use kilograms.

The difference between the reported weights of fish is due to the fact that the diversity of fish species is lower in the phone responses than in the on-site survey. Reports of non-targeted fish species were absent. By telephone, anglers only reported the most common species and larger fish actually caught and not discarded. This bias has also been reported in previous publications (Essig and Holliday, 1991).

However, by cross-referencing the data from both surveys, we get a much better estimate of the total catch for the main species. One limitation of this method is that the data from both surveys are not numerous enough to provide a precise estimate of the catch of the less targeted species. The number of observations of those rare species is too low to allow for extrapolation.

Additional biases in both telephone and on-site surveys can be noted:

The telephone survey reached occasional fishers more easily than the on-site survey, because they come to fish less frequently. In this population, probably less used to assessing the volume and weight of their catch, we observe a substantial difference between phone responses and observation by on-site survey.

The telephone survey also samples households, hence individuals, whereas the on-site survey samples fishing trips. In order to combine the two databases we have used one statistical unit, the individual trip.

Another bias of the telephone survey that is difficult to correct is that a (low) percentage of households has no home telephone. These may represent special categories (those with only a cell phone, those who move a lot, those without access to a telephone, etc.) that are undercounted.

But the on-site survey also displays bias: both the avid fishers and the very occasional fishers are undercounted. This bias is now acknowledged and calls for collecting more specific information regarding non-response bias (Dauk and Schwarz, 2001; ICES, 2010, 2011). The first group prefers sites that are not accessible or not known to other fishers or interviewers. The second group is not often present, so their proportion in the on-site sample is lower.

5. Conclusion

This study provides a first comprehensive view of recreational fishing in France, covering all types of fishing. The most common type encountered is shellfish gathering. However, the volume involved is small, as most fishers make only one or two fishing trips a year. Shellfish gathering is an occasional and low-intensity activity; by contrast, angling on shore and from boats accounts for an estimated 24,500 tonnes of fish caught annually.

This new information has substantial importance for improving the governance of marine social-ecological systems. It is increasingly mandatory to produce national statistics on recreational fishing, due to the increase in this activity and its presumed impact. Gathering national statistics on recreational fishing is increasingly becoming mandatory, prompted by the increase of this activity and its potential impact. However, as with all leisure and tourism activities, it is very hard to monitor recreational fishing because the population of recreational fishers is mobile and highly heterogeneous. It is thus necessary to test and improve new methodologies step by step, with a learning-by-doing approach. This French pilot study was interesting to test, and identify the strengths and limits of a dual methodology using telephone and on-site surveys. This is a genuinely new research topic, and it is thus necessary to test and improve new methodologies step by step, using a learning-by-doing approach. This pilot study in France was interesting to test, and has identified the strengths and limits of a methodology using both telephone and on-site surveys. We have noted that on-site surveys have some drawbacks. They are difficult to implement and very expensive, and do not eliminate all the biases of telephone surveys. Also, combining the telephone and on-site data is far from easy; it is thus important to go on to test alternative monitoring systems, such as the use of a voluntary recreational fisher logbook.

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