Ital. J. Zool., *65, Suppl.*: 539-543 (1998)

# Assessment of a brown trout *Salmo trutta* population in the River Gallo (central Spain): angling effects and management implications (Salmonidae)

ANA ALMODÓVAR
GRACIELA G. NICOLA
Department of Ecology, Agricultural Research Service, Community of Madrid, El Encín, P.O. Box 127, E-28800 Alcalá de Henares, Madrid (Spain)

ABSTRACT

The brown trout population of the River Gallo (central Spain) was monitored every two months during 1996 to determine the current impact of angling. To evaluate the influence of additional parameters, physical habitat and food availability were also studied. To assess fishing pressure, trout harvest and angling exploitation, a partial creel census was conducted during the 1996 fishing season. Differences were found in densities and biomass between exploited (1182.4 fish $ha^{-1}$, 68.3 kg $ha^{-1}$) and unexploited areas, the latter being markedly higher (3135.1 fish $ha^{-1}$, 208.2 kg $ha^{-1}$). Production was quite superior in the unexploited area and decreased (from 144.5 kg $ha^{-1}$ $yr^{-1}$ to 37.2 kg $ha^{-1}$ $yr^{-1}$) as fishing pressure increased. However, no consistent differences were observed in growth, condition factor, age diversity, mortality, recruitment age and turnover ratio. Sport fishing seems to be the main negative factor influencing the balance within population of brown trout in the River Gallo and therefore management should be focused on more restrictive angling measures.

KEY WORDS: Angling - Benthos - *Salmo trutta* - Population dynamics - Creel survey - Habitat - Management - Spain.

ACKNOWLEDGEMENTS

This work was funded by the project SC-95/005 of the Spanish INIA. We are grateful to J. Cubo and F.J. Vázquez for their assistance in the field and to Dr B. Elvira for his helpful advice and comments on the manuscript.

*(Received 28 August 1997 - Accepted 29 January 1998)*

## INTRODUCTION

Angling of brown trout *Salmo trutta* L. is considered the most important and popular recreational fishery in Spanish rivers. However, owing to stream habitat degradation caused by water regulation and pollution, local brown trout stocks are not always sufficient to support the increasing demand of sport fishery. Mortality produced by excessive angling can reduce the spawning stock density to such a low level that natural recruitment becomes insufficient to maintain the fishery (Avery & Hunt, 1981). Magnuson (1991) and Kitchell & Carpenter (1993) identified sport fishing as a potent ecological force, which produces strong direct and indirect effects on aquatic ecosystems. Magnuson (1991) also stated that sport fisheries are dynamic and complex systems notoriously variable due to their unpredictable recruitment. In addition, a disturbance in population structure induced by angling can also affects patterns of habitat use, growth rate and fecundity (Healey, 1978, 1980; Fraser *et al.*, 1987; Donald & Alger, 1989).

The relationship between angling and wildlife conservation is complex and often ambiguous. Maitland (1995) pointed out that many anglers consider themselves naturalists and stewards of water quality and freshwater habitats. On the other hand, some people believe that angling involves substantial cruelty to fish and causes considerable damage to aquatic ecosystems. Likewise, Johnson & Carpenter (1994) noted that a poor understanding of fish-angler interactions can hinder both our understanding of how fishing affects ecosystem function and our ability to manage fisheries effectively. Thus, analysis of catch records can provide a valuable indication of changes in abundance associated with the recovery or decline of a fishery (Jenkins & Morais, 1971; Aggus *et al.*, 1980; Gee & Milner, 1980; Swales & Fish, 1986).

Several papers deal with the population dynamics and production of brown trout in Spanish rivers (Lobón-Cerviá & Penczak, 1984; Lobón-Cerviá *et al.*, 1986; Montañés & Lobón-Cerviá, 1986; Lobón-Cerviá, 1996; García de Jalón *et al.*, 1986; García de Jalón, 1992), but only Braña *et al.* (1992) and Almodóvar & Burgaleta (1993) evaluated the effect of angling on fish stocks.

As Elliott (1994) suggested, salmonid populations comprise important fisheries and knowledge concerning their population dynamics, growth and production is essential for the conservation and effective management of their stocks. Thus, the objective of this study was to analyse the population dynamics, stream habitat and angling catch of brown trout in the river Gallo, one of the rivers most disturbed by angling pressure in central Spain, in order to provide basic biological data as a basis for management of the fishery.

## MATERIALS AND METHODS

### *Study area*

This study was conducted on the low sections of the River Gallo, a first-order tributary to the River Tagus. The River Gallo has a basin area of 1312 km$^2$ and its altitude averages 930 m. The river flows over a limestone watershed with a total length of 106 km. The water chemistry shows evidence of pollution (phosphate 0.44 mg·l$^{-1}$, nitrite 12.17 mg·l$^{-1}$ and ammonia 0.65 mg·l$^{-1}$) most probably as a result of agricultural activities. The ionic balance exhibits a dominance of $HCO_3^-$ (392 mg·l$^{-1}$, 971 µS cm$^{-1}$ conductivity) and $Ca^{2+}$ (61 mg·l$^{-1}$). The water temperature is from a low of 5° C in winter to a high of 18° C in summer, with a pH of 7.9.

The bank vegetation at the site is dominated by some riparian deciduous vegetation (*Populus* sp., *Salix fragilis*, *S. purpurea*) and pine (*Pinus pinaster*). The aquatic vegetation consists primarily of *Phragmites australis*, *Nasturtium officinale*, *Typha latifolia*, *Sparganium erectum*, *Iris pseudacorus* and the submerged *Potamogeton pectinatus*, *Myriophyllum verticillatum*, *M. spicatum*, *Groenlandia densa*, and *Cladphora* sp. The fish community of the River Gallo is comprised of five native species, *Salmo trutta* L., *Barbus bocagei* Steindachner, *Chondrostoma polylepis* Steindachner, *Leuciscus pyrenaicus* Günther and *L. alburnoides* Steindachner and one introduced species, *Gobio gobio* (L.). Brown trout *S. trutta* is the prevailing species throughout the study area and constitutes the principal sport fish in this river.

Three sites were sampled (see Fig. 1) with enough distance between them to avoid any migration and to cover the different angling regulations in this river. The sampling sites were between 80 and 100 m long and included two exploited sections and one unexploited section, each with different limitations concerning daily bag limit, number of anglers per day and type of baits:

(1) Regulated section (4000 m): daily bag size of five trout, four anglers·day, only artificial baits.

(2) Free section (12600 m): daily bag size of six trout, no limitation in number of anglers·day, all baits.

(3) Catch and release section (2000 m): no harvest, no limitation in number of anglers·day, only fly fishing.

### *Habitat*

Physical habitat variables were estimated at each site where fish were sampled following Platts *et al.* (1983). Transects were spaced 10 m apart and point measurements were made along the transects at 1 m intervals (Simonson *et al.*, 1994). At each point, the water column depth (cm) and mean water velocity (m·s$^{-1}$) were measured. Also, the percentage of each of six substrate categories (Platts *et al.*, 1983), cover and shading were visually estimated to the nearest 5%. Cover was defined as any submerged structure beneath which fish could hide from an overhead view as well as undercut banks and overhanging vegetation less than 50 cm above the water surface (Heggenes *et al.*, 1990). The pool/riffle ratio was also estimated at each sampling site.

Differences in habitat characteristics between sites were tested utilizing a multivariate analysis of variance (MANOVA). Group means were later compared with the Tukey test. Data were transformed using natural logarithms for linear measurements and arcsine of square-roots for substrate proportions prior to analysis.

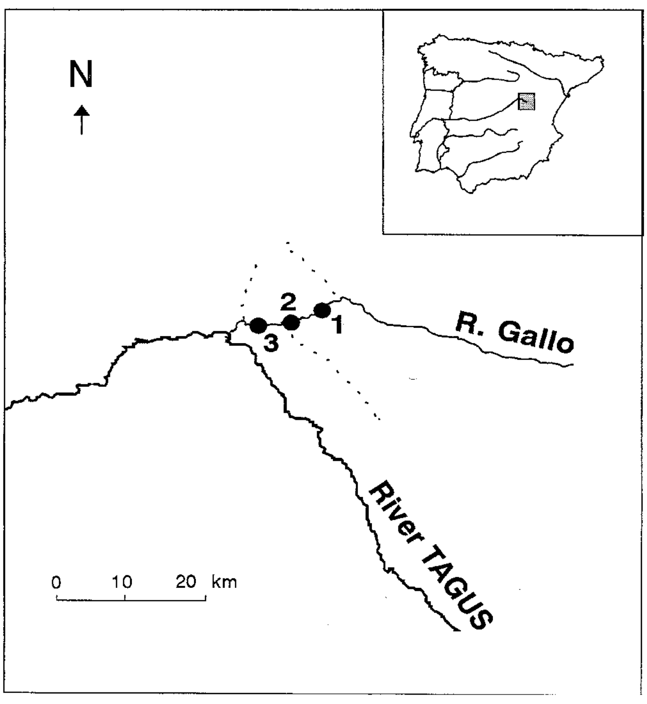


Fig. 1- Map of the study area showing sampling sites (1, regulated; 2, free and 3, catch & release).

### *Benthic macroinvertebrates*

Benthic macroinvertebrates were sampled in riffles every two months during 1996. Three replicate samples per site, taken progressively upstream of each other, were collected on each sampling date by means of a Neil cylinder with a 250 µm mesh net. Invertebrate samples were preserved in 10% formalin for later laboratory identification, sorting and counting. Specimens were dried in an oven at 60° C for 24 hours and density and biomass (dry weight) were determined. An analysis of variance (ANOVA) and multiple comparison tests (Tukey test) were employed to estimate differences between sampling sites in total biomass of macroinvertebrates.

### *Sport fishery*

Anglers impact was determined through a creel survey conducted in the study area from March to August 1996 (fishing season). Data collected from individual anglers included section fished (angling regulation), hours fished, angling method and the number and fork length of trout kept or released. Retained trout were measured to the nearest millimeter and a sample of scales was taken for age determination. Angling effort was estimated by calculating the mean number of hours fished per hectare in each section in a day. Catch rate was calculated per section as the number of trout captured (kept and released) per hectare in a given day. Also, the fishing mortality or harvest rate was estimated per section as the number of trout kept per hectare per day. Exploitation rate was determined by taking into account the biomass of legal size trout and the total harvest in the fishing season at each site. The Kruskal-Wallis analysis of variance was applied to compare these parameters between sections. Multiple comparisons were then carried out using Dunn's procedure (Zar, 1984).

### *Brown trout*

Fish were sampled every two months during 1996 at each site by electrofishing using a 220 VDC generator. Once caught, fish were anesthetized with tricaine methane-sulphonate (MS-222 SANDOZ) and their fork lengths (to within 1 mm) and weights (to within 1 g) were measured. Scales were taken for age determination. After this, fish were placed in holding boxes to recover and then returned to the stream. Trout density was estimated by applying the three- catch removal method (Zippin, 1956). Standing crop was calculated following the formula proposed by Mahon *et al.* (1979). Population estimates were determined separately for each year class. Age structure complexity was assessed for each sampling site by means of Pielou's (1969) diversity index $D = 1 - \Sigma p_i^2$ where $p_i$ is the proportion of fish belonging to the ith age class.

The condition coefficient (K) of the trout was determined by means of Fulton's formula $K = 100\ W / FL^3$ where W designates the body weight in grams and FL the fork length measured in cm. The daily instantaneous or specific growth rate (G, % day$^{-1}$) was derived from the formula $G = 100\ (\ln W_2 - \ln W_1)/(t_2 - t_1)$ where $W_1$ and $W_2$ (in g) were the mean weights of each year class of fish at times $t_1$ and $t_2$ (in days). Growth was also examined by assessing the mean length of each age class in Autumn, since growth in trout populations virtually ceases by this time of the year. The parameters of the von Bertalanffy's growth equation were also estimated using the Ford-Walford plot (Ricker, 1975). Annual production and turnover ratio were estimated according to Ricker (1975).

The daily instantaneous mortality rate (Z) was calculated from the equation $Z = -(\ln N_1 - \ln N_0 / (t_1 - t_0)$ where $N_0$ and $N_1$ are numbers of fish present at time $t_0$ and $t_1$ (in days) respectively.

Density, biomass, age diversity, condition factor and length-for-age were analysed by applying ANOVA and multiple comparison tests (Tukey's method). Logarithmic transformations were used to normalize density, biomass and length data.

## RESULTS

Physical habitat characteristics did not differ significantly between sampling sites (MANOVA, $F_{18,2} = 7.41$, $P > 0.05$; Tukey test, $P > 0.05$ in all cases). The river averaged 8.12 m wide and 0.5 m deep and had a mean water velocity of 0.65 m·s$^{-1}$. The streambed material was composed chiefly of gravel and the availability of cover for fish was mainly due to submerged vegetation. With regard to food availability, the total biomass of macroinvertebrates did not exhibit significant changes (ANOVA, $F_{2,8} = 0.39$, $P > 0.05$; Tukey test, $P > 0.05$) throughout the study area, having an average value of 4.94 g m$^{-2}$.

The analysis of sport fishing parameters showed that fishing pressure was significantly higher in the exploited sections (Kruskal-Wallis, $H = 11.92$, $P < 0.01$; Dunn, $P < 0.01$), especially within the regulated area (Table I). However, fishing mortality was not significantly different (Kruskal-Wallis, $H = 1.03$, $P > 0.05$) within exploited sections, constituting 20% of the total mortality and 50% of the mortality of legal fish size classes. In contrast, considerable differences were found in the exploitation rate. The mean recruitment age or the age at which attain the minimum size limit (22 cm TL) was estimated to be around three years.

In relation to trout populations, total density varied from 3135.08 to 1163.48 ind ha$^{-1}$ and biomass ranged between 208.22 and 67.26 kg ha$^{-1}$ (Table II). Abundance parameters differed significantly (ANOVA, density: $F_{2,8} = 42.26$, $P < 0.001$; biomass: $F_{2,8} = 22.02$, $P < 0.001$) between exploited and unexploited sections, the latter being markedly higher (Tukey tests, $P < 0.001$). In addition, production was considerably lower in exploited areas (Table II). On the contrary, no differences were found between the turnover ratios of the sections studied.

TABLE I - *Estimated means of the sport fishery parameters at the sampling sites during the fishing season.*

| | Regulated | Free | Catch & Release |
|---|---|---|---|
| Fishing pressure (h · ha$^{-1}$) | 1.23 | 0.62 | 0.23 |
| Catch rate (ind · ha$^{-1}$) | 1.59 | 2.06 | 1.59 |
| Fishing mortality (ind · ha$^{-1}$) | 0.34 | 0.14 | - |
| Exploitation rate (%) | 98.8 | 52.3 | - |
| Harvest length (cm) | 25.8 | 25.6 | - |
| Recruitment age (yr) | 3.34 | 3.07 | 3.27 |

TABLE II - *Main population parameters for brown trout stock in the different sections studied in the River Gallo.*

| | Regulated | Free | Catch & Release |
|---|---|---|---|
| Density (ind · ha$^{-1}$) | 1201.36 | 1163.48 | 3135.08 |
| Biomass (kg · ha$^{-1}$) | 67.26 | 69.45 | 208.22 |
| Production (kg · ha$^{-1}$ yr$^{-1}$) | 41.77 | 37.20 | 144.52 |
| Turnover ratio (yr$^{-1}$) | 0.62 | 0.53 | 0.69 |
| Age structure diversity | 0.63 | 0.57 | 0.70 |
| Density (ind · ha$^{-1}$) > 22 cm | 14.65 | 113.71 | 428.31 |
| Biomass (kg · ha$^{-1}$) > 22 cm | 3.46 | 32.97 | 53.20 |
| Daily instantaneous mortality rate (ind · day$^{-1}$) | 0.0168 | 0.0172 | 0.0094 |

The legal size trout comprised 13.7% in the catch and release section, but varied from 1.2 to 9.8% in the exploited areas. Furthermore, both density and biomass of trout above the legal fishing size from total exploited sections were significantly lower (ANOVA, density: $F_{2,8} = 20.85$, $P < 0.001$; biomass: $F_{2,8} = 22.30$, $P < 0.001$; Tukey tests, $P < 0.001$ for exploited-unexploited interactions) than in the catch and release zone (Table II). Notwithstanding, the results of the age structure complexity were similar between sampling sites (ANOVA, $F_{2,8} = 0.86$, $P > 0.05$).

The condition coefficients did not vary significantly (ANOVA, $F_{2,8} = 1.07$, $P > 0.05$; Tukey test, $P > 0.05$) with angling regulations (Table III). The observed means of length-for-age classes demonstrated no significant differences between sampling sites at ages 0+, 1+ and 2+ years (see Table III). The spawning took place within the River Gallo during late November and December. The fry emerged from the stream bed the following April. Maximum growth rates were recorded from April to June. Throughout the winter growth continued although from late November to early March the growth rate was found to be slightly negative or close to zero. No evident variation was found in the daily instantaneous growth rate for all year classes between sites. Nevertheless, the highest rate was obtained in the unexploited area (Table IV). In addition, a clear decrease in growth rate was observed with increasing age.

The parameters of the von Bertalanffy growth equation are given in Table IV. The growth coefficient, K, was similar between sampling locations. Plots of these equations, together with the observed mean length for age of this population are shown in Figure 2. The exploited areas presented a slightly higher daily instantaneous mortality rate than the catch and release location.

## DISCUSSION

The results did not reflect any dissimilarity in both habitat structure and food availability between the areas

TABLE III - *Mean fork length (cm) for age classes in the different sections. F values corresponding to analysis of variance for sections within age classes, and results of Tukey multiple comparison test are also shown.*

| Section | Age 0+ | | Age 1+ | | Age 2+ | |
|---|---|---|---|---|---|---|
| | Mean length (± 1 sd) | *n* | Mean length (± 1 sd) | *n* | Mean length (± 1 sd) | *n* |
| Regulated | 8.7 ± 1.41 | 7 | 14.9 ± 1.33 | 12 | 19.1 ± 1.33 | 22 |
| Free | 10.8 ± 0.25 | 3 | 15.6 ± 1.67 | 9 | 19.8 ± 1.86 | 7 |
| Catch & Release | 9.8 ± 1.67 | 15 | 15.1 ± 1.20 | 31 | 19.7 ± 1.58 | 83 |
| F | 2.14, P > 0.05 | | 0.78, P > 0.05 | | 0.44, P > 0.05 | |
| Tukey | P > 0.05 | | P > 0.05 | | P > 0.05 | |

studied. Thus, it seemed that angling was the factor most likely to exert the greatest influence on the trout population of the River Gallo. Moreover, creel surveys indicated that angling pressure was unequal throughout the river. So, the exploited sectors, especially the regulated one, were subjected to a high fishing pressure and an overexploitation. These effects of harvest were clearly manifested in density, biomass and production of the exploited and the unexploited areas. Thereby, an important decrease in abundance parameters was found in the exploited stocks. Similar results have been found by Anderson & Nehring (1984) in a Colorado river, who noted that a catch and release regulation exceptionally impoverished the densities and biomass of brown trout during four years of monitoring. In contrast, the exploited sectors studied as a control maintained their abundance parameters but at a lower level. These results differed from those obtained by Braña *et al.* (1992) in several mountain streams of northern Spain where no apparent changes in total densities were detected between fished and unfished sections. On the contrary, the main effects of angling upon those populations involved a pronounced decrease in the age structure complexity and life span, which did not agree with our results. While growth is usually favoured by harvest (Healey, 1980; Donald & Alger, 1989; Braña *et al.*, 1992), this was not the case in this study where no consistent differences were observed in growth parameters.

Healey (1978) suggested that fecundity may increase with exploitation, a fact which would compensate the higher fish mortality. This latter involves that there is sufficient remaining mature stock, or that an enough number of individuals can reach reproductive size rapidly. It would seem that this proposal takes place in the River Gallo, characterized by a fast growing and early maturity of the population.

The decline in the abundance parameters observed in exploited areas of the River Gallo is consistent with that expected after overfishing. If angling pressure continues depleting the mature stock, sufficient reproductive capacity to sustain the population may decrease. Moreover, fish extraction can also act in a disadvantageous way on maturity age (Werner *et al.*, 1983; Fraser *et al.*, 1987; Huntingford *et al.*, 1988). Therefore, the survival of some mature individuals would be necessary to allow the development of population interactions and to maintain a quality fishery.

TABLE IV - *Coefficients of the von Bertalanffy equation, daily instanteneous growth rate and condition factor obtained for sampling sites.*

| | Regulated | Free | Catch & Release |
|---|---|---|---|
| Condition factor (g $cm^{-1}$) | 1.20 | 1.20 | 1.15 |
| Growth rate (% g $day^{-1}$) | 1.62 | 1.46 | 1.80 |
| Growth coefficient, K | 0.250 | 0.108 | 0.193 |
| $t_0$ | 0.622 | 1.247 | 0.865 |

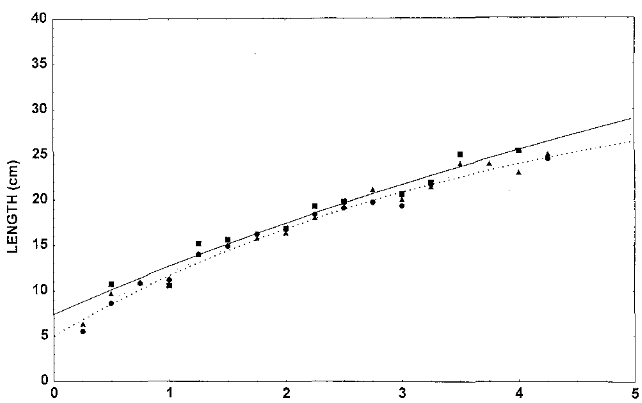


Fig. 2 - Von Bertalanffy growth model (lines) and observed (points) mean lengths for age classes in the three section studied (• Regulated, ■ Free, ▲ Catch & Release).

In summary, if sport fishing pressure continues in this way, there could be a considerable change in both fish community and population dynamic.

## CONCLUSIONS AND MANAGEMENT IMPLICATIONS

First: creel-survey data have proved an essential tool to use in this kind of studies. Unfortunately, their application in Spanish rivers is still scarce. We consider it necessary to connect research results with resource use data in order to adjust the regulatory measures in a way that are not detrimental to the fishery.

Second: more protective regulations are strongly recommended, since the use of catch and release angling is apparently effective in maintaining an abundance of large trout within the fishery. Catch and release appears to be the most suitable fishing regulation to sustain a quality recreational fishery subjected to high fishing pressure. Such regulations also avoid supplemental stocking with allocthonous specimens. However, the eventual success of this kind of regulation depends upon angler attitudes.

Finally: since the main effects of angling on the River Gallo are changes in numerical composition and as for the moment apparent regulatory mechanisms within the population to mitigate this disturbance have not been found, such as an increase in growth and recruitment, a more restrictive harvest would be an appropriate measure to adopt in order to protect the fishery from depletion.

## REFERENCES


Aggus L. R., Clugston J. P., Houser A., Jenkins R. M., Vogele L. E., Walburg C. H., 1980 - Monitoring of fish in reservoirs. *In*: Hocutt C. H. & J. R. Stauffer (eds), Biological monitoring of fish. Lexington Books, Lexington, pp. 149-177.

Almodóvar A., Burgaleta A., 1993 - Productions of brown trout (*Salmo trutta* L.) in five rivers of central Spain under different angling impact. Ecological Basis for River Management Symposium, Leicester (Abstracts).

Anderson R. M., Nehring R. B., 1984 - Effects of a catch and release regulation on a wild trout population in Colorado and its acceptance by anglers. North Am. J. Fish. Manage., *4*: 257-265.

Avery E. L., Hunt R. L., 1981 - Population dynamics of wild brown trout and associated sport fisheries in four Central Wisconsin streams. Wisconsin Department of Natural resources, Technical Bulletin, n. 121, 26 pp.

Braña F., Nicieza A. G., Toledo M. M., 1992 - Effects of angling on population structure of brown trout, *Salmo trutta* L., in mountain streams of Northern Spain. Hydrobiologia, *237*: 61-66.

Donald D. B., Alger D. J., 1989 - Evaluation of exploitation as a means of improving growth in a stunted population of brook trout. North Am. J. Fish. Manage., *9*: 177-183.

Elliott J. M., 1994 - Quantitative ecology and the brown trout. Oxford Series in Ecology and Evolution, Oxford University Press, 286 pp.

Fraser D. F., DiMattia D. A., Duncan J. D., 1987 - Living among predators: the response of a stream minnow to the hazard of predation. *In*: W. J. Matthews & J. D. Heins (eds), Community and evolutionary ecology of North American stream fishes. Oklahoma University Press, Norman & London, pp. 121-127.

García de Jalón D., 1992 - Dinámica de las poblaciones piscícolas en los ríos de montaña ibéricos. Ecología, *6*: 281-296.

García de Jalón D., Tolosana Esteban E., Rodríguez Alcalde F., 1986 - Estimación de algunos parámetros poblacionales de la trucha común (*Salmo trutta fario*) en los ríos pirenáicos. Bol. Estación central Ecol., *15*: 51-58.

Gee A. S., Milner N. J., 1980 - Analysis of 70 year catch statistics for Atlantic salmon (*Salmo salar*) in the River Wye and implications for management of stocks. J. appl. Ecol., *17*: 41-58.

Healey M. C., 1978 - Fecundity changes in exploited populations of lake whitefish (*Coregonus clupeaformis*) and lake trout (*Salvelinus namaycush*). J. Fish. Res. Board. Can., *35*: 945-950.

Healey M. C., 1980 - Growth and recruitment in experimentally exploited lake whitefish (*Coregonus clupeaformis*) populations. Can. J. Fish. aquat. Sci., *37*: 255-267.

Heggenes J., Brabrand A., Saltveit S. J., 1990 - Comparison of three methods for studies of stream habitat use by young brown trout and Atlantic salmon. Trans. Am. Fish. Soc., *119*: 101-111.

Huntingford F. A., Metcalfe N. B., Thorpe J. E., 1988 - Feeding motivation and response to predation risk in Atlantic salmon parr adopting different life history strategies. J. Fish Biol., *32*: 777-782.

Jenkins R. M., Morais D. I., 1971 - Reservoir sport fishing effort and harvest in relation to environmental variables. *In*: G. E. Hall (ed.), Reservoir fisheries and limnology. American Fisheries Society Special Publication, 8.

Johnson B. M., Carpenter S. R., 1994 - Functional and numerical responses: a framework for fish-angler interactions? Ecol. Applications, *4*: 808-821.

Kitchell J. F., Carpenter S. R., 1993 - Variability in lake ecosystems: complex responses by the apical predator. *In*: M. J. McDonnell & S. T. A. Pickett (eds), Humans as components of ecosystems. Springer-Verlag, New York.

Lobón Cerviá J., 1996 - Response of a stream fish assemblage to a severe spate in northern Spain. Trans. Am. Fish. Soc., *125*: 913-919.

Lobón-Cerviá J., Penczak T., 1984 - Fish production in Jarama River, central Spain. Holartic Ecol., *7*: 128-137.

Lobón-Cerviá J., Montañés C., de Sostoa A., 1986 - Reproductive ecology and growth of a population of brown trout (*Salmo trutta* L.) in an aquifer-fed stream of Old Castile. Hydrobiologia, *135*: 81-94.

Magnuson J. J., 1991 - Fish and fisheries ecology. Ecol. Applications, *1*: 13-26.

Mahon R., Balon E. K., Noakes D. L. G., 1979 - Distribution, community structure and production of fishes in the upper Speed river, Ontario: a preimpoundment study. Environ. Biol. Fish., *4*: 219-244.

Maitland P. S., 1995 - Ecological impact of angling. *In*: D. M. Harper & A. J. D. Ferguson (eds), The ecological basis for river management. John Wiley & Sons Ltd.

Montañés C., Lobón-Cerviá J., 1986 - feeding ecology of a population of brown trout (*Salmo trutta* L.) in an aquifer-fed stream of Old Castile, Spain. Ekol. Polska, *34*: 203-213.

Pielou E. C., 1969 - An introduction to mathematical ecology. Wiley, New York.

Platts W. S., Megahan W. F., Minshall G. W., 1983 - Methods for evaluating stream, riparian, and biotic conditions. General Technical Report 138, U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Ricker W. E., 1975 - Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board. Can., Rep. No. 191, 382 pp.

Simonson T. D., Lyons J., Kanehl, P. D., 1994 - Guidelines for evaluating fish habitat in Wisconsin streams. United States Department of Agriculture. North Central Forest Experiment Station. General Technical Report NC-164.

Swales S., Fish J. B., 1986 - Angling catch returns as indicators of the status of upland trout lakes. Aquacult. Fish. Manage., *17*: 75-93.

Werner E. E., Gilliam J. F., Hall D. J., Mittelbach G. G., 1983 - An experimental test of the effects of predation risk on habitat use in fish. Ecology, *64*: 1540-1548.

Zar J. H., 1984 - Biostatistical analysis. Englewood Cliffs, NJ, Prentice Hall.

Zippin C., 1956 - An evaluation of the removal method of estimating animal population. Biometrics, *12*: 163-189.