

Evaluation of fish density in some Spanish reservoirs

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Introduction

The evaluation of the density of fish populations by means of echosounding techniques has been used thoroughly in the marine environment, but seldom in freshwater ecosystems (rivers, lakes and reservoirs). A few results have been published from Spain (GRANADO-LORENCIO & GARCÍA-NOVO 1984, GRANADO-LORENCIO et al. 1998), and elsewhere (KUBECKA et al. 1992, CADIC et al. 1998, LYONS 1998). In all of these, a relationship can be deduced between the trophic state of the reservoir and the density of fish populations. During a significant drought in 1995, an evaluation of fish populations was conducted in 15 reservoirs of the Júcar Basin Water Authority during June and July, in order to study the minimum water level necessary to maintain the fish populations. One of them, the Alarcón Reservoir, was fished extensively during the summer with the purpose of reducing the density of the fish and then re-evaluating the populations in September.

Material and methods

During the summer of 1995, evaluations of the population density of fish coincided with the taking of samples for other limnological studies in the reservoirs (Fig. 1). In each reservoir, 10–20 transects were made from the dam to the tail, with the total length sampled from 2200 to 6500 m. The depth was >2 m at all of the sites. An echosounder was placed vertically, with a beam cone of 46° in the reservoirs of smaller fish densities, and of 28° in those with greater density. The recount of registered echoes was computed starting from the echograms, following the methodology proposed by MORENO-AMICH (1990).

Recent studies in the field of the evaluation of fish density by echosounding show that the results are generally little affected by the seasons, although the presence of the anoxic hypolimnion in summer does exert some effect (CADIC et al. 2002). When the fish move to oxygenated superficial layers, it is more difficult to evaluate them with the vertical beam; the

horizontal beam should be used in that case.

Results and discussion

In the Tibi Reservoir no echo was obtained from the presence of fish over 10 samplings. In the 14 studied reservoirs, the fish population densities varied between 0.01 and 65.86 fish/dam³. Table 1 presents the results from the studied reservoirs, grouped according to their trophic state (DASÍ et al. 1998). The low density of fish populations in the Tous Reservoir can be linked to its construction just the previous year; it was in operation for only 14 months. Also, water inflows from another reservoir located in its tail, through a hydroelectric power station, impede fish migration. The Arquillo Reservoir had a large population density even though it is an oligotrophic reservoir. Its low volume of water resulted in a concentration of the fish in a small pond.

Correlation with trophic state indicators

All of the reservoirs showed a high correlation of fish densities with the trophic state of the system, evaluated from the concentrations of total phosphorus and chlorophyll *a* (DASÍ et al. 1998). The correlation values with total phosphorus were $r = 0.716$ ($P < 0.01$) and with chlorophyll *a* were $r = 0.821$ ($P < 0.001$). With regard to other variables considered in the study, such as the stored percentage of water or the renewal time, the results did not correlate well, with values of $r = 0.516$ ($P < 0.05$) and $r = 0.208$ (not significant), respectively, being obtained.

Comparison with other reservoirs

The present results were compared with those obtained in studies carried out in other Spanish

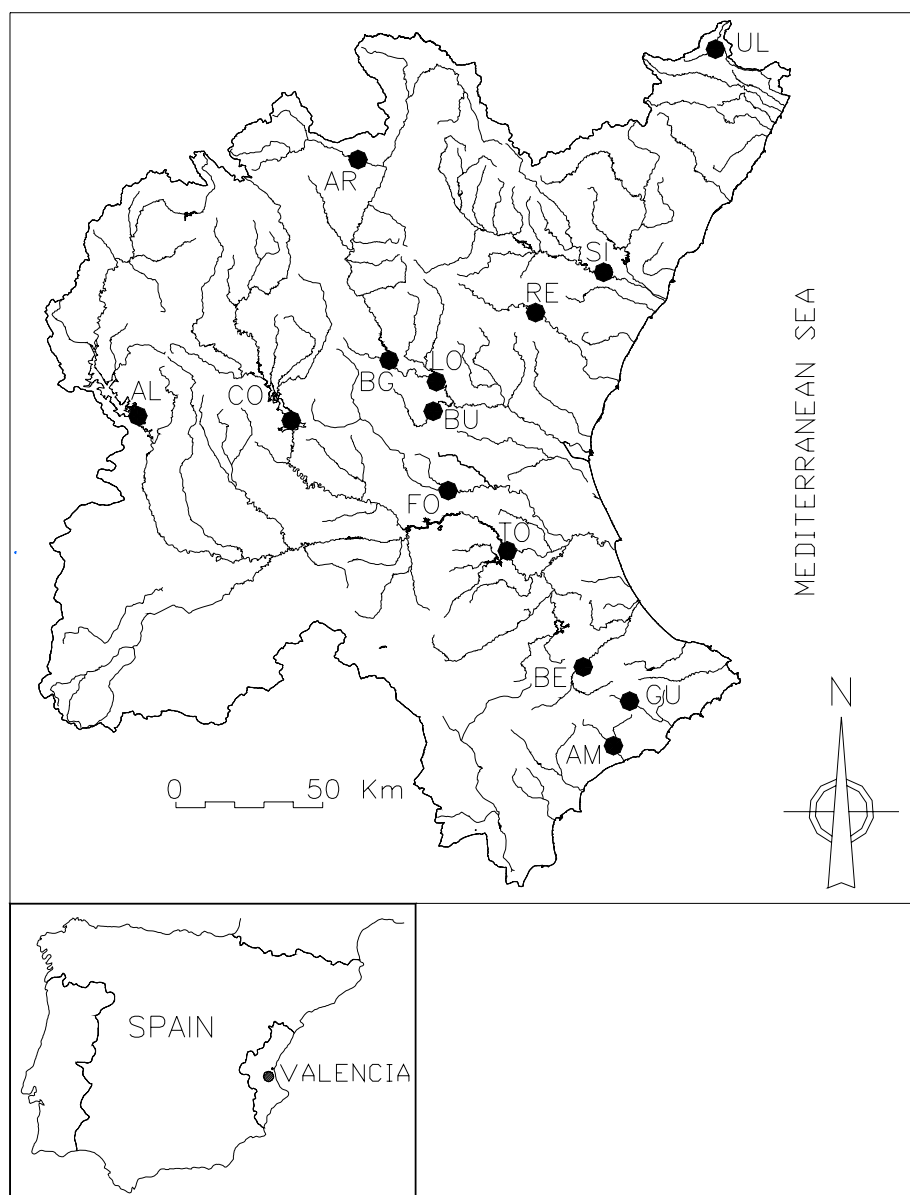


Fig. 1. Map from the Júcar Basin Water Authority indicating the location of the reservoirs in the Iberian Peninsula. Each reservoir is located on its river, identified by the first two letters of its name.

reservoirs. The Barasona Reservoir belongs to the basin of the Ebro River. Densities of between 2.50 and 4.73 fish/dam³ were obtained from the four samplings performed during 1994 and 1995. The trophic state of the reser-

voir in those years was classified as oligomesotrophic (GRANADO et al. 1998). In the eutrophic Arrocampo Reservoir, in the basin of the Tagus River, densities obtained in the year 1981 oscillated between 20.4 and 36.8

Table 1. Reservoirs studied grouped by their trophic state. The volume of stored water refers to the time of the sampling, whereas the percentage refers to its maximum capacity. The percentage of sampled volume is the stored volume that same day. The fish density is expressed in fish/dam³ (1 dam³ = 1000 m³).

| Reservoir | Date | Stored volume | | Sampled volume (%) | Fish density (fish/dam ³) | Confidence interval (95%) | Renewal time (days) |
|--------------------------------|----------|--------------------|------|--------------------|---------------------------------------|---------------------------|---------------------|
| | | (Hm ³) | (%) | | | | |
| Oligotrophic reservoirs | | | | | | | |
| Arquillo | 07/07/95 | 0.86 | 4.1 | 2.27 | 13.52 | 4.28 | >1000 |
| Contreras | 14/07/95 | 20.87 | 2.5 | 1.76 | 0.07 | 0.09 | 359 |
| Guadalest | 11/07/95 | 4.04 | 31.1 | 4.68 | 3.09 | 1.67 | 69 |
| Tous | 5/07/95 | 35.21 | 9.5 | 1.16 | 0.01 | 0.01 | 28 |
| Mesotrophic reservoirs | | | | | | | |
| Amadorio | 11/07/95 | 2.61 | 16.5 | 4.54 | 1.02 | 1.21 | >1000 |
| Benageber | 03/07/95 | 28.67 | 13.0 | 1.12 | 3.54 | 1.95 | 172 |
| Loriguilla | 13/07/95 | 8.86 | 12.1 | 1.40 | 6.48 | 2.87 | 39 |
| Sichar | 30/06/95 | 8.21 | 16.7 | 1.04 | 10.39 | 7.35 | 278 |
| Ulldecona | 25/07/95 | 4.34 | 39.2 | 4.86 | 0.28 | 0.52 | >1000 |
| Eutrophic reservoirs | | | | | | | |
| Alarcon | 14/06/95 | 60.31 | 5.4 | 0.22 | 20.15 | 6.34 | 64 |
| Alarcon | 18/09/95 | 31.84 | 2.9 | 0.43 | 17.27 | 4.34 | 312 |
| Beniarres | 21/06/95 | 13.61 | 50.4 | 0.85 | 65.86 | 45.46 | 1417 |
| Buseo | 06/07/95 | 1.95 | 25.9 | 0.45 | 23.41 | 7.79 | 590 |
| Forata | 04/07/95 | 5.71 | 15.4 | 2.42 | 8.69 | 6.21 | >1000 |
| Regajo | 10/07/95 | 3.37 | 55.6 | 1.51 | 10.67 | 3.12 | 233 |

fish/dam³ (GRANADO & GARCÍA-NOVO 1984). These reservoirs had similar values to those obtained in the present study for reservoirs of similar trophic state.

Conclusions

The densities of fish populations in the reservoirs of the Júcar Basin appear highly correlated with their trophic state, despite some differences due to other factors such as very low water levels or the recent construction of the dams. The vertical echosounder, although limited in shallow-water reservoirs, operates easily and rapidly. In shallow-water reservoirs new acoustic devices are required that will allow scanning of the total water column, including the surface layer, e.g. the multibeam sonar or elliptical transducer used horizontally.

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