FROM THE PROVINCE-BASED FISH MANAGEMENT PLAN TO THE FIRST STEPS OF A CATCHMENT-BASED FISH MANAGEMENT PLAN IN SICILY: THE RAGUSA EXPERIENCE.

DALLA CARTA ITTICA PROVINCIALE AI PRIMI PASSI DI UNA CARTA ITTICA DI BACINO IN SICILIA: L'ESPERIENZA DI RAGUSA.

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Parole chiave: Tellesimo, Irminio, monitoraggio, conservazione, fauna ittica, impatti ambientali

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Abstract

In Italy, the Fish Management Plan (FMP) is considered the fundamental document for the conservation and management of inland fish fauna and fisheries, as well as for the planning of the territory in which aquatic environments are located. There are two phases of the Fish Management Plan: the regional or provincial FMP and the Catchment-based FMP. In Sicily, no Catchment-based FMP had yet been activated. The first steps towards this have recently been taken in the province of Ragusa, in 2001-2024. Two river basins considered to be of particular interest have been monitored: Irminio and Tellesimo (a tributary of the Tellaro), where quantitative fish sampling and specific environmental monitoring have been carried out. This has made it possible to identify breeding areas for wild trout and to implement alternative sampling methods, such as snorkeling, which have already been introduced in the province of Ragusa. The persistence of previously reported sources of environmental impact has been monitored and new sources have been identified, such as the discharge of livestock manure, including at some river sites not previously monitored. A monitoring campaign on river litter was launched, both in the Irminio river basin and in the Tellesimo river sub-basin. The dry areas of watercourses were also monitored; for the first time, the digitisation and processing of fishing data was launched; environmental educational initiatives were carried out. The investigations led to the discovery of new sites where *Sarmarutilus rubilio* is present in the Irminio River. The first outcome of the activities carried out is a project aimed at surveying the transverse barriers along the Irminio River, in collaboration with the Italian Center of River Restoration (CIRF) and supported by Open Rivers Programme.

Riassunto

La Carta Ittica rappresenta un documento fondamentale per la conservazione e gestione della fauna ittica e della pesca, nonché della pianificazione del territorio in cui gli ambienti acquatici sono inscritti. Esistono due fasi della Carta Ittica: la Carta Ittica regionale o provinciale e la Carta Ittica di Bacino. In Sicilia non era stata ancora attivata alcuna Carta Ittica di Bacino. I primi passi di essa sono stati effettuati recentemente in provincia di Ragusa. Sono stati al momento monitorati due bacini fluviali ritenuti di particolare interesse: l'Irminio ed il Tellesimo (affluente del Tellaro), in cui sono stati eseguiti campionamenti ittici quantitativi, nonché monitoraggi ambientali specifici. E' stato in tal modo possibile evidenziare aree di riproduzione per la trota selvatica ovvero implementare metodiche di campionamento alternative, come lo snorkeling, già avviate in provincia di Ragusa. Si è monitorata l'eventuale persistenza di fonti d'impatto ambientale già segnalate e sono state inoltre individuate nuove fonti, quali l'immissione di liquami zootecnici, anche in alcuni siti non precedentemente monitorati. E' stata avviata una campagna di monitoraggio sul River litter, sia nel bacino del F. Irminio che nel sottobacino del T. Tellesimo. Si sono inoltre monitorate le zone in secca di alcuni tratti di corso d'acqua; si è avviata, per la prima volta, la digitalizzazione e la elaborazione dei dati dei tesserini di

pesca; si sono realizzate iniziative di Educazione ambientale. Le indagini, tra l'altro, hanno portato al riscontro di nuovi siti di presenza di *Sarmarutilus rubilio* nel F. Irminio. Le attività svolte hanno avuto come prima ricaduta un progetto finalizzato al censimento delle barriere trasversali lungo l'Irminio, con la collaborazione del CIRF, sostenuto da Open Rivers Programme.

Introduction

The Fish Management Plan (the so called "Carta Ittica") is a fundamental document for the conservation and management of fish fauna and fishing in inland waters in Italy, as well as for land-u se planning in areas where aquatic environments are located (Vittori, 1996). Indeed, starting from the Trento Management Plan (Vittori, 1983), this knowledge-and-planning tool has spread across various Italian contexts, both regional and provincial (Pastorino et al., 2016). As highlighted by Forneris and Alessio (1985), Fish Management Plans can be produced at different territorial scales (region, province, basin). According to the scope of each scale, those authors indicate which biotic and abiotic parameters should be recorded, also taking management implications into account. In connection with this, a document was published that outlines guidelines for drafting Fish Management Plans (AIIAD, 1993). That document emphasizes the need to carry out surveys at two levels: a first, broader level (regional or provincial) and a second, more detailed and territorially limited level (river basin). In both cases, the parameters to be measured are specified, providing differentiated guidance for the management and conservation of fish and catchments, according to spatial scale. According to the document, the Fish Management Plan must consider, beyond the obvious ichthyological aspects, also morphological, physicochemical, and biological aspects (i.e., environmental monitoring through biological indicators).
The territory of Ragusa, the smallest province in Sicily, has stood out in the region for having long initiated a series of actions aimed at studying, conserving, and managing the fish fauna of inland waters, beginning with the island's native salmonid (Duchi, 1988, 1991, 2020a). This pathway led to the activation of the Provincial Fish Management Plan. It was produced in 2000–2001 (fish fauna) and 2005 (environmental quality); its first results were communicated to the public in 2004 (Battiato, 2006; Duchi, 2006a) and later partially published in a specialist journal in 2006 (Duchi, 2006b, 2006c). The document was then published in full as a volume (Duchi, 2008).

Main Features of the Provincial Fish Management Plan of Ragusa

- 84 sampling sites in total (fish-related and/or environmental)

Data collected:

- Ichthyological (presence and distribution of fish fauna)
- Geographic (3 variables)
- Morphological (24 variables)
- Physicochemical and microbiological (12 variables)

This allowed the calculation of two synthetic indices: IBE (Extended Biotic Index) and LIM (a chemical-microbiological index)
There was also close collaboration among the ichthyologist (sampling, specimen collection, data processing, report drafting), the provincial authority (coordination, funding), ARPA Sicilia – DAP Ragusa (physicochemical analyses), and the public-health laboratory AUSL 7 Ragusa (microbiological analyses). In addition, the activities were carried out with the participation of the provincial sport-fishing associations (FIPSAS, Enalpesca, Liberapesca, Italpesca).

Main Results and Outcomes

- Identification of the presence and distribution of fish fauna (25 species; Duchi, 2006a; 2008)
- Provincial-level assessment of the ecological quality of river waters through the calculation of IBE and LIM (Figure 1). Although the two biological indices and the two sampling seasons showed some differences, a significant proportion of stations exhibited signs of river-water quality degradation.
- Evaluation of the condition of river corridors using the Anthropisation Index (AI) (Turin et al., 1995), ranging from 0 (no impact) to 5 (complete channelizazion of the river corridor; Figure 2). Only less than one-third of the investigated sites (29 %) showed no signs of corridor alteration, while nearly 40 % displayed serious alterations (AI = 3-4-5).
- First set of proposals—both species-specific and basin-wide—for management, conservation, and restoration interventions targeting fish populations, aquatic habitats, and the hydrological basins in which they occur. To this end, a series of concise fact-sheets was prepared for each watercourse, outlining the suggested interventions and possible partner organisations (an example for the main stem of Irminio River is shown in Table 1).
- Implementation of a new regulation governing inland-water fishing in the Province of Ragusa, which later served as a model for other Sicilian provinces.

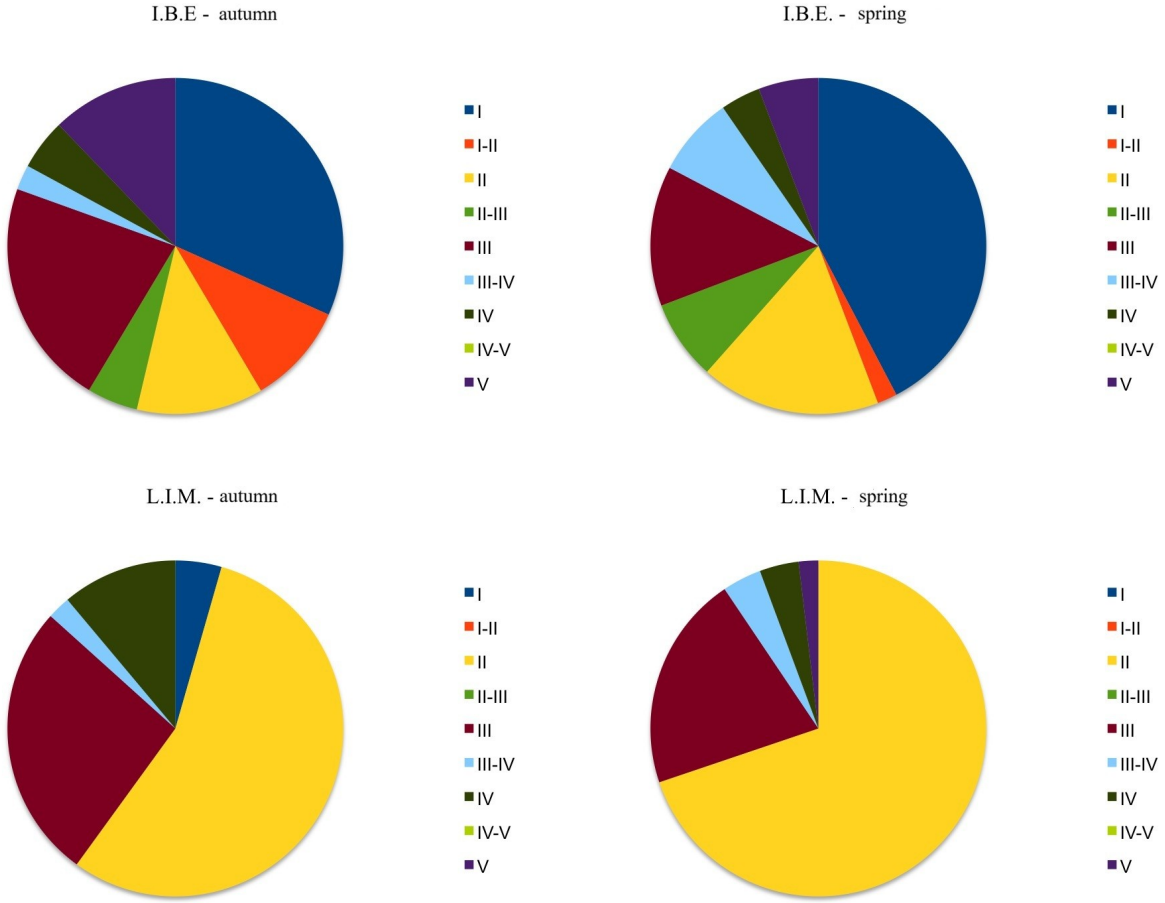

Figure 1. Biological water-quality classes identified in the Provincial Fish Management Plan of Ragusa (from I: the best to V: the worst).

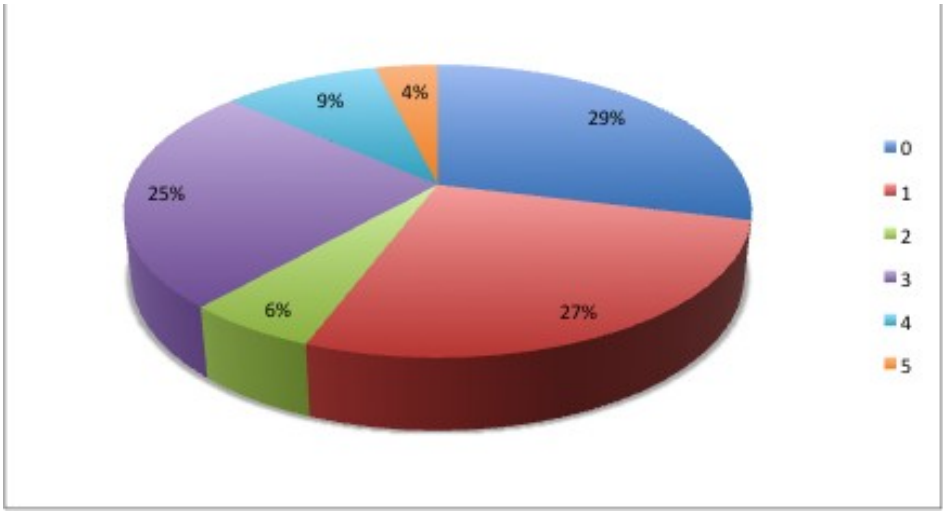

Figure 2. Anthropisation Index values observed in the Provincial Fish Management Plan of Ragusa (no impact = 0; maximum impact = 5).

Table 1. Proposed interventions for the main stem of the Irminio river and its basin within the scope of the provincial Fish management Plan (from: Duchi, 2008).

Watercourse	Irminio
Intervention	River corridor restoration
Brief description	Re-meandering; widening of the riverbed; re-qualification of the riparian vegetation; re-qualification of the substrate
Partner	Civil Engineering Department Department-Municipalities of Giarratana, Ragusa, Modica, Scicli-Reclamation Consortium-Forestry Administration-Agricultural Associations
Intervention	Passability of river barriers
Brief description	Make barriers passable by redesigning/remodelling them using naturalistic engineering techniques or by adding fish ladders.
Partner	Civil Engineering Department Department-Municipality of Ragusa-Reclamation Consortium-Forestry Administration
Intervention	Improving the efficiency of the Giarratana and Ragusa Waste-water Treatment Plants – Use of Treated Water for Irrigation
Brief description	Increase the efficiency of the treatment plants that discharge into the basin and reuse the treated water for irrigation, thereby minimizing extractions and/or increasing releases into the river channel from the S. Rosalia reservoir and from the Castelluccio water diversion
Partner	Civil Engineering Department-Municipalities of Giarratana and Ragusa-Reclamation Consortium-Water Authority -Agriculture Administration-Ragoleto Reservoir Management Entity
Intervention	Efficiency of Civil and Agricultural Water Consumption
Brief description	Raise water-use efficiency for both civil and agricultural purposes through: • Technical improvements to distribution infrastructure • Promotion of water-saving systems • Promotion of crop varieties/species with lower water needs • Education and information for citizens and agricultural operators
Partner	Civil Engineering Department-Municipalities of Giarratana, Ragusa, Modica, Scicli-Reclamation Consortium-Water Authority -Agriculture

	Administration-Environmental Education Laboratory-Agricultural Associations
Intervention	Increasing Forested Area in the catchment
Brief description	Reforestation actions, at least on marginal zones (e.g., slopes), using native species to boost the watercourse's resistance / resilience to environmental disturbances
Partner	Civil Engineering Department-Municipalities of Giarratana, Ragusa, Modica, Scicli-Forestry Administration-Superintendency of cultural and environmental heritage
Intervention	Habitat Diversification in Agricultural landscape
Brief description	Incentives to diversify habitats in agricultural areas to increase naturalness of cultivated lands: planting hedgerows, promoting traditional tree crops, restoring and spreading traditional dry-stone walls…
Partner	Municipalities of Giarratana, Ragusa, Modica, Scicli-Reclamation Consortium-Agriculture Administration-Environmental Education Laboratory-Agricultural Associations
Intervention	Fish-ladder for the S. Rosalia Reservoir
Brief description	Design and installation of a fish-ladder to allow fish (especially trout and eels) to bypass the dam, enabling natural colonization of the reservoir and the upstream river stretch
Partner	Civil Engineering Department-Reclamation Consortium-Sicilian Regional Administration-Agricultural Development Agency
Intervention	Release of Minimum Viable Flow from the S. Rosalia Reservoir
Brief description	Monitoring and control of releases from the S. Rosalia reservoir. Release a flow sufficient to maintain water presence throughout the downstream river stretch, possibly simulating seasonal variations. *Zero-cost intervention.*
Partner	Municipality of Ragusa-Reclamation Consortium-Agricultural Development Agency
Intervention	Re-assessment of Reclamation Consortium Water Withdrawals
Brief description	Evaluation of the Reclamation Consortium's water intake from river tributaries, springs and sub-river sections (Castelluccio water diversion, river-mouth pumping…) to align them with the river's actual flow; improve efficiency of the consortium's distribution system; reshape the Castelluccio water diversion system to allow viable downstream outflow
Partner	Municipality of Scicli-Reclamation Consortium-Civil Engineering Department
Intervention	Limiting Soil Sealing
Brief description	Restrict urban expansion and services (roads…) as well as greenhouses agriculture, to limit soil sealing and support the natural water cycle
Partner	Municipalities of Giarratana, Ragusa, Modica, Scicli-Agricultural Associations
Intervention	Elimination of Illegal Dump Sites
Brief description	Monitoring and removal of illegal dump sites (agricultural waste, plastic, bulky items…) in the basin and along the river stretch
Partner	Municipalities of Giarratana, Ragusa, Modica, Scicli-Agricultural Associations-Environmental Authority

Towards a Basin-Scale Fish Management Plan

In Sicily, no basin-scale Fish Management Plan had been implemented yet. Although there are investigations at the basin or sub-basin level, they have either focused on single species (e.g., Duchi, 1991) or lacked quantitative assessments of fish populations (e.g., Ferrito and Tigano, 1995). The first steps toward creating a basin-scale Fish Management Plan have recently been taken in the Province of Ragusa in 2021-2024.

Two river basins/sub-basins have so far been identified as particularly noteworthy (Figure 3): the Irminio River basin—because it lies entirely within the Province of Ragusa—and the Tellesimo Stream (a right-hand tributary of the Tellaro River), which is of special natural interest overall and ichthyological interest in particular (Duchi, 1988, 1991, 2018, 2020a, 2024a; Sanz et al., 2023).

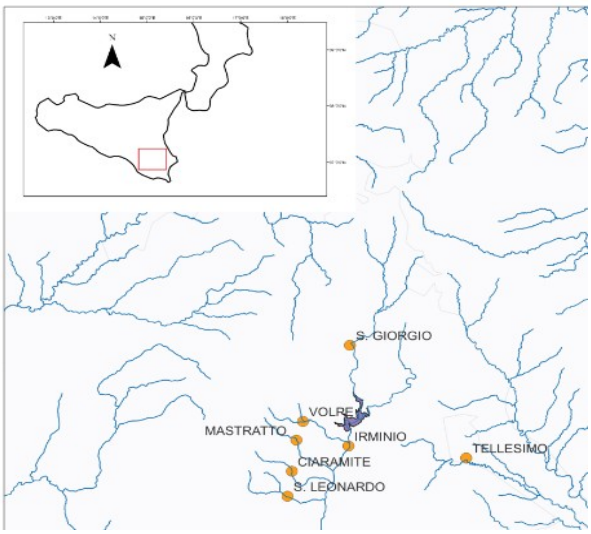

Figure 3. Study area

Activities Conducted

- Quantitative fish samplings were carried out using two-three passes bachpack electrofishing. This work was performed in the Irminio River basin, focusing mainly on a few right-bank tributaries (S. Leonardo, Ciaramite, Volpe) because had fewer existing data.
- A monitoring campaign on river litter was launched in both the Irminio River basin and the sub-basin of the Tellesimo Stream.
- In addition to the first-level Fish Management Plan, some intermittent watercourses in the Tellesimo sub-basin (which normally do not host fish fauna) began to be considered. The aim was to verify whether, during certain periods of the year, these streams could introduce impact factors that have historically received little attention but are increasingly relevant in Mediterranean contexts (Skoulikidis et al., 2017).
- In Tellesimo Stream, experimental monitoring continued using less invasive alternatives to electro-fishing, such as snorkeling (already started earlier: Duchi, 2020b) and a first survey on trout redds was started (Duchi, 2024a).
- Existing impact sources previously reported were monitored, along with any newly emerging sources.
- Dry sections of several river reaches were surveyed.
- For the first time, the digitisation and processing of anglers logbooks data were undertaken.
- Environmental-education initiatives were organised.

Main Results

The sampled tributaries were shown to function as nursery areas for trout (Figure 4).

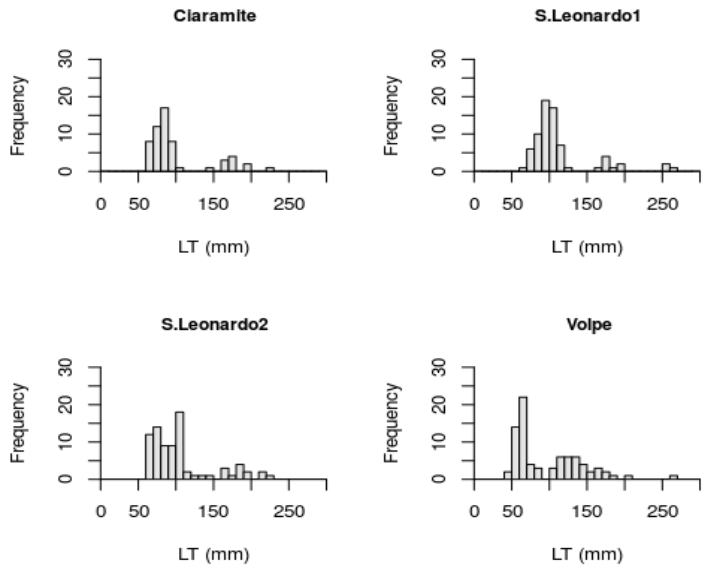

Figure 4. Frequency distribution of wild-trout lengths at the sampling sites of Irminio River tributaries (LT: Total Length).

Unfortunately, environmental-impacts, already highlighted in the provincial Fish Management Plan about twenty years ago, were still present and unresolved, such as the existence of sewage outfalls in the S. Leonardo Stream (Duchi, 2008, p. 100).
Regarding the identification of new impact sources, observations in the "ephemeral/ized" sections of the examined watercourses revealed a novel form of pressure: livestock manure runoff that, during heavy rain events, is discharged into some ephemeral streams and subsequently reaches downstream perennial or intermittent rivers (Figure 5). This problem was especially acute in the Tellesimo sub-basin. Similar impacts had been noted for a few springs in the past (Ruggieri, 2014) but evidently had not received adequate attention from the authorities.

Figure 5. Accumulations of manure and livestock slurry in the watershed of the Tellesimo Stream.

Concerning dry zones, risk situations previously detected were confirmed—for example, in the Tellesimo Stream—but total-dry events were also observed for the first time in stretches which historically never ran dry in the Irminio River downstream of the S. Rosalia Reservoir. This appears linked both to the reduced precipitation of recent years and to groundwater withdrawals combined

with insufficient ecological flow releases from the S. Rosalia Reservoir, which has been prioritized for potable-water and irrigation supply and suffered from intense evaporation.
During fieldwork and site inspections, two new sites of S*armarutilus rubilio* were discovered in the Irminio River basin: the lower reach of Volpe Stream and the upper reach of the Irminio itself (Figure 6). This further indicates the species' expansion on the island (Duchi, 2014, 2022).

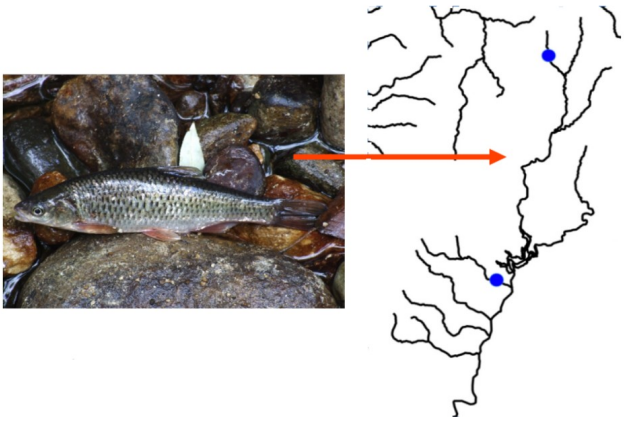

Figure 6. New records of Sarmarutilus rubilio in the Irminio River basin.

Conversely, no specimens of rainbow trout (*Oncorhynchus mykiss*) were captured inS. Leonardo Stream, although this species had been reported there in the provincial Fish Management Plan.
The activities generated interest from several schools in the province, notably the "Galileo Ferraris" Technical Institute in Ragusa. Environmental-education programmes were therefore carried out, consisting of ichthyology labs and river-ecology workshops. These included collecting physico-chemical and biological data from the watercourses, identifying river macroinvertebrates, and using leaf-pack methods as teaching tools.

Discussion and Conclusions

Undoubtedly, the Ragusa area—although the smallest province in Sicily—has been the most proactive over the years in developing a coherent project for research, monitoring, and conservation of freshwater fish fauna and riverine habitats. This commitment materialised in the creation of a high-density monitoring provincial Fish Management Plan and, for the first time in Sicily, the launch of an embryonic basin-scale Fish Management Plan.
The activities carried out, while inherently positive, have not been free of problems and contradictions. The first and most obvious issue is political-bureaucratic. The timing, and choices made have repeatedly delayed progress. Many of the actions could have been completed earlier and within tighter timeframes. Several times the process was interrupted by changes in the provincial administration or by shifts in the composition and cultural orientation of the local angler association that had promoted, since the 1980s, the fishery-environmental-management agenda (Duchi, 2024b). Consequently, the development path has been anything but linear; it resembles a pattern of "punctuated equilibria" (Eldrege & Gould, 1972), alternating between prolonged phases of stagnation and bursts of acceleration.
The second—and perhaps more critical—problem is that much of the study, monitoring, and proposal work has not translated into concrete river-habitat restoration measures. As recent investigations show, the water bodies continue to suffer from widespread issues, now compounded by newer pressures such as livestock-waste management and the growing frequency of droughts. This persists despite the provincial Fish Management Plan having been formally adopted (Provincial Council Resolution No. 48 - 25 February 2008) by the former Regional Province of Ragusa (today called Free

Municipal Consortium;). As a result, most of the intervention proposals remain, unfortunately, still valid.

The principal "product" of the effort undertaken in the early 2000s is the drafting and approval of a new, more detailed fishing regulation for the Province of Ragusa. Developed during a period of intensive activity, the regulation benefited from the positive involvement of the then-working group of FIPSAS-Ragusa fishing-guards. This regulation has also served as a reference for a series of provincial regulations in other Sicilian areas.

Only recently, following the international seminar held in Ragusa at the conclusion of the Basin-scale Fish Management Plan monitoring, was an initiative promoted to remove transverse barriers along rivers, in line with the recommendations of the Fish Management Plan (table I). In fact a project was carried out to catalogue and assess barriers in the Irminio River, thanks to a partnership between the Italian Centre for River Restoration (CIRF) and the local branches of the environmental association Legambiente-Ragusa and the sport-fishing association FIPSAS-Ragusa. Again, Ragusa's activity proved seminal: subsequently, a new project focused on a barrier in the Simeto River (Duchi & De Pietro, 2025). Both initiatives have been supported by the Open Rivers Programme (https://openrivers.eu/).

To ensure continuity of the project, it is also essential to strengthen communication efforts. While some outreach has been performed, it has not been sufficiently effective. Enhanced communication is increasingly important, as it raises awareness among sport-fishing communities and the general public about environmental challenges and, crucially, involves them in finding solutions. This commitment aligns with a growing international emphasis on participatory stewardship and can be supported by newer, updated "toolboxes" (Robinson *et al*., 2024).

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References

A.I.I.A.D. 1993. *Le carte ittiche delle acque correnti superficiali. Strumenti per la gestione dell'ittiofauna e degli ambienti acquatici*. Associazione Italiana Ittiologi Acque Dolci, 1-9.

Battiato, F. 2006. Il primo livello della Carta Ittica della Provincia di Ragusa: il GIS. In: *Convegno: La conservazione ed il recupero della fauna ittica e degli ambienti delle acque interne*, a cura di A. Duchi, Provincia regionale di Ragusa, 97-103.

Duchi, A. 1988. Dati preliminari sulle trote del torrente Tellesimo (RG), Sicilia. *Atti Soc. ital. Sci. Nat. Museo Civ. Stor. Nat. Milano*, 129 (2-3): 167-172.

Duchi, A. 1991. Prime indagini per la conservazione della trota macrostigma, *Salmo trutta macrostigma* Dum., in provincia di Ragusa. *Atti IV Conv. AIIAD – Riva del Garda* (12-13 dic 1991): 423-434.

Duchi, A. 2006a. La prima fase della Carta Ittica della Provincia di Ragusa. In: *Convegno: La conservazione ed il recupero della fauna ittica e degli ambienti delle acque interne*, a cura di A. Duchi, Provincia regionale di Ragusa, 85-96.

Duchi, A. 2006b. Distribuzione della fauna ittica nelle acque interne dell'areale ibleo: la provincia di Ragusa. *Biologia Ambientale* **20**, 291-294.

Duchi, A. 2006c. Osservazioni sui popolamenti di *Aphanius fasciatus* (Valenciennes) e *Gambusia holbrooki* (Girard) in provincia di Ragusa. *Biologia Ambientale* **20** (1): 73-75.

Duchi, A. 2008. *Carta Ittica della Provincia di Ragusa*. Provincia Regionale di Ragusa.

Duchi, A. 2014. Ampliamento dell'areale della rovella *Rutilus rubilio* Bonaparte, 1837 in Sicilia: nuove segnalazioni nell'areale ibleo ed in provincia di Trapani. *Italian Journal of Freshwater Ichthyology* **1**, 221-224.

Duchi, A. 2018. Flank-spot number and its significance for systematics, taxonomy and conservation of the near-threatened Mediterranean trout *Salmo cettii*: evidence from a genetically pure population. *Journal of Fish Biology* **92** (1): 254-260.
Duchi, A. 2020a. Extant because important or important because extant? On the scientific importance and conservation of a genetically pure Sicilian population of the threatened *Salmo cettii* Rafinesque-Schmaltz, 1810. *Cybium* **44**, 41-44.
Duchi, A. 2020b. Prove di censimento di *Salmo cettii* Rafinesque-Schmaltz, 1810, tramite faretto e maschera e boccaglio in Sicilia sud-orientale (Ragusa): attività e risultati preliminari. *Italian Journal of Freshwater Ichthyology* **6** (1): 31-37.
Duchi, A. 2022. Nuove segnalazioni ed aggiornamento della distribuzione di *Rutilus rubilio* Bonaparte, 1837 in Sicilia. *It. J. Fresh. Ichthyol.* **8**, 41-45.
Duchi, A. 2024a. First description of redds of the only non-introgressed population of a critically endangered salmonid in a stream vulnerable to droughts. *Ecology of Freshwater Fish* **e12790**. https://doi.org/10.1111/eff.12790
Duchi, A. 2024b. Il cambiamento del rapporto della popolazione con i fiumi a Ragusa: appunti per analisi e ricerche. In: *Fiumi e città. Un amore a distanza – Vol. III. Corsi d'acqua dell'Italia Meridionale*, a cura di G. Osti, Padova University Press.
Duchi, A., & De Pietro, R. 2025. Modification of the freshwater fish community in the nature reserve "Oasi del Simeto" (Sicily-Italy): preliminary data. *Preprint* (ecoevorxiv.org). https://doi.org/10.32942/X2R04Z
Eldredge, N., & Gould, S. J. 1972. Punctuated equilibria: an alternative to phyletic gradualism. In: T. J. M. Schopf (ed.), *Models in Paleobiology* (pp. 82-115). San Francisco, CA: Freeman Cooper.
Ferrito, V., & Tigano, C. 1995. The distribution of the ichthyofauna in the Simeto basin (Sicily). *Cybium* **19** (2): 187-198.
Forneris, G., & Alessio, G. 1986. Le carte ittiche: estensione territoriale e problemi di rilevamento. *Atti del Primo Convegno Nazionale AIIAD Reggio Emilia, 1985* (Quaderni ETP, Udine) **14**, 117-122.
Pastorino, P., Mordenti, O., & Forneris, G. 2016. Freshwater fish maps for fisheries management in Italy: state of the art. *Italian Journal of Freshwater Ichthyology*, 94-100. (Italian with English abstract).
Robison, V., Jones, M. S., Erickson, B., & Biedenweg, K. 2024. Communication approaches and specialists that can improve fisheries management. *Fisheries* **49** (7): 319-326.
Ruggieri, R. 2014. Tracing the sources of pollution of wells and karst springs supplying water to the city of Ragusa, south-eastern Sicily. *Ambient Science* **1** (2): 26-35. https://doi.org/10.21276/ambi.2014.01.2.ta01
Sanz, N., Araguas, R. M., Giampiccolo, M., & Duchi, A. 2023. Native population structure beyond hatchery introgression in the endemic Sicilian trout. *Diversity* **15** (2): 274. https://doi.org/10.3390/d15020274
Skoulikidis, N. T., Sabater, S., Datry, T., Morais, M. M., Buffagni, A., Dörflinger, G., Zogaris, S., Sánchez-Montoya, M. del Mar, et al. 2017. Non-perennial Mediterranean rivers in Europe: status, pressures, and challenges for research and management. *Science of the Total Environment* **577**, 1-18.
Turin, P., Zanetti, M., Loro, R., & Bilò, M. F. 1995. *Carta Ittica della Provincia di Padova*. Provincia di Padova – Assessorato alla Pesca, 399 p.
Vittori, A. 1983. La carta ittica, documento fondamentale della Provincia autonoma di Trento per una razionale politica di gestione delle acque. *Temi ed.*, Trento, 1-17.
Vittori, A. 1996. Le carte ittiche ieri ed oggi. *Atti del VI Convegno Nazionale AIIAD Varese Ligure*, 405-408.