

# **Aquatic Plant Management in Relation to Irish Recreational Fisheries Development**

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## **ABSTRACT**

Aquatic plant control programs are often conducted in isolation rather than as part of an integrated habitat management strategy. The impact that this policy has on recreational

fisheries in Irish canals is described. The study examined the ecological impact of aquatic weed control procedures employed in the canals and determined fish-holding capacity in relation to a range of aquatic plant species. Fish standing crop estimates were conducted using electrical fishing apparatus in canal habitats which had been subjected to different forms and intensities of weed control. Approximately 200 km of canal was surveyed during the investigation. Canals with

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weed cover values between 20 and 70% generally exhibited fish biomass levels which were between two and four times, respectively, greater than those recorded from densely (>70% cover) or sparsely (<20%) vegetated areas. Submerged plants with broad or complex leaf arrangements or mixed species assemblages had a greater fish harboring capacity than had submerged, strap-leaved or floating-leaved forms. The implications of these findings for aquatic plant management in canal fisheries are discussed.

**Key words:** Canals, weed control, habitat management, angling.

## INTRODUCTION

Irish canals are unique aquatic ecosystems that serve a multitude of recreational pursuits including angling, navigation, canoeing, swimming, walking and nature study. Angling is the largest single recreational activity on these canals and the numbers of participants are increasing annually. Coarse fish, including pike (*Esox lucius* L.), perch (*Perca fluviatilis* L.) and cyprinid species, are the principal angling quarry in the canals.

The canals under study (Figure 1) are man-made and were originally designed specifically for boat traffic. They vary between 13 and 20 m in width, have a shallow (1.6 to 1.8 m) uniform configuration and are relatively unshaded over much of their length. Flow velocities in the canals are low, ranging between 0 and 10  $\text{cm sec}^{-1}$ . Boat traffic intensity is generally low, causing the minimum of in-channel disturbance. Water supply to the canals is provided by feeder rivers, which are largely unpolluted (Caffrey and Cooney 1992). Water quality in the three canal systems under study (Royal, Grand and Barrow) is good, with mean total phosphorus levels rarely exceeding  $35 \mu\text{g l}^{-1}$ . While nutrient levels in the canal water are relatively low, a nutrient-rich sediment throughout the system provides suitable conditions for the proliferation of macrophytes (Caffrey 1991a).

Studies conducted in Ireland and elsewhere demonstrate that waterbodies rich in vegetation generally support productive fisheries (Whitcomb 1968, Northcott 1979, Kelsall 1981, Murphy and Eaton 1981, Wiley *et al.* 1984, Durocher *et al.* 1984, de Nie 1987, Caffrey 1986, 1990a). This reflects the cover, direct and indirect food supply and spawning substrates that macrophyte provide for fish and invertebrate species (Wright *et al.* 1992), although the influence that water fertility has on fish standing crop must also be considered (Hoyer *et al.* 1985; Hoyer and Canfield 1991). The composition or architecture of the vegetation has also been shown to influence fish stock levels, through its affect on macroinvertebrate and periphyton supply (Reynolds and Eaton 1983, den Hartog and van der Velde 1988) and by interfering with the fishes

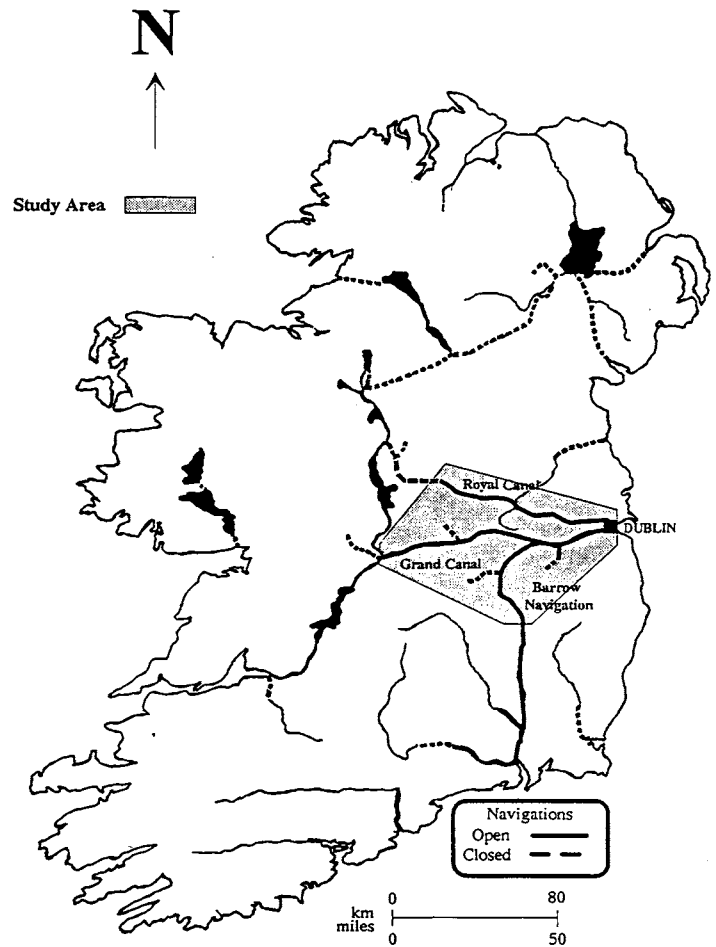


Figure 1. Map of the major inland waterways of Ireland, the study area and the watercourses which are open and closed to navigation.

freedom of movement (Bouquet 1978, Hannon 1992, Canfield and Hoyer 1992).

Prior to the introduction of the Canals Act (1986), canal management procedures focused on maintaining open, relatively weed-free channels where unobstructed boat movement would be facilitated. Since 1986, when the Office of Public Works assumed responsibility for the canals, the primary focus has been on the development and management of these watercourses as multipurpose user resources, with a particular emphasis on optimizing their recreational angling potential.

The objectives of this paper are to demonstrate the role that aquatic plants play in recreational canal fisheries development and to determine weed management practices that will maximize the potential of this valuable resource.

## MATERIALS AND METHODS

Field studies on approximately 200 km of the Royal, Grand and Barrow Canals (Figure 1) were conducted between

1987 and 1991. Fish standing crop estimates, in kilograms per hectare ( $\text{kg ha}^{-1}$ ), were assessed using electrical fishing apparatus in all of the canal habitats studied. Electrical fishing operations were normally conducted between May and October each year. Fifty-seven canal sections, ranging in length between 0.5 and 5 km, were electrofished during this period. Sections were generally contiguous and, during the electrofishing operation, were separated by fine-meshed (5-mm quad) stop nets. The majority of standing crop estimates were obtained using the Zippin (1958) multiple removal technique, although the Seber and Le Cren (1967) mark-and-recapture method was occasionally employed.

At each section details relating to the habitat, and particularly the macrophyte community structure and level of abundance, were recorded. The percentage cover of predominating species and growth forms, defined as the percentage surface area of canal bed covered by the vertical projection of the aquatic plants (Best 1981), was determined by eye, by the author having walked and boated each section. In some sections dry weights ( $\text{g m}^{-2}$ ) of the vegetation were determined, although these are not presented in this paper.

For the purposes of establishing relationships between fish standing crops and abundance of aquatic vegetation, the canal sections investigated were grouped into three broad categories, based on their aquatic plant regimes: densely (>70%), moderately (70 to 20%) and sparsely (<20%) vegetated. The number of sections included in the densely, moderately and sparsely vegetated sections was 17, 24 and 16, respectively.

To investigate the effect that the growth form of the predominating vegetation had on fish standing crop, sections supporting specific growth-form categories (*e.g.* submerged with broad/complex leaves, submerged with strap-shaped/streamlined leaves, floating leaved, mixed categories and filamentous algae) were examined.

## RESULTS

The main fish species collected in the canals were bream (*Abramis brama* L.), roach (*Rutilus rutilus* L.), rudd (*Scardinius erythrophthalmus* L.), cyprinid hybrids, tench (*Tinca tinca* L.), carp (*Cyprinus carpio* L.), pike (*Esox lucius* L.), perch (*Perca fluviatilis* L.) and eels (*Anguilla anguilla* L.). Most prolific among these were bream and roach, although the remaining species did present significant standing crops in certain canal sections.

Standing crop estimates for combined fish species from densely, moderately and sparsely weeded canal sections are presented in Table 1. Mean crop estimates from moderately weeded sections, supporting 20% to 70% plant cover, were approximately 2.5 times higher than those recorded from

densely weeded canals (>70% cover) and four times higher than those recorded from sparsely weeded areas (<20% cover).

TABLE 1. STANDING CROP ESTIMATES ( $\text{kg ha}^{-1}$ ) FOR FISH IN CANALS WHICH SUPPORT DIFFERENT LEVELS OF AQUATIC PLANT GROWTH. DENSE (>70%) PLANT COVER, MODERATE (20 to 70%) PLANT COVER AND SPARSE (<20%) PLANT COVER.

Weed category	Number of sections	Fish crop estimates ( $\text{kg ha}^{-1}$ )		
		Mean $\pm$ S.E.	Minimum	Maximum
Dense	17	123.8 $\pm$ 28	11	390
Moderate	24	327.8 $\pm$ 45	116	825
Sparse	16	82.3 $\pm$ 14	5	644

Most of the 16 sparsely vegetated sections that were electrically fished, totaling approximately 30 km of canal, supported between 30 and 82  $\text{kg ha}^{-1}$  of fish. One section, however, supported a standing crop of 644  $\text{kg ha}^{-1}$ . This atypically high value, comprising mainly bream, was recorded in a section where overhanging deciduous trees cast a heavy shade on the water. As a consequence, little light penetrated to the canal bed and few aquatic plants were present. Adjacent canal sections were unshaded and generally supported abundant and diverse macrophyte communities. It is probable that the school of bream recorded from this sparsely vegetated section were intercepted while moving from one vegetated area to another. Such feeding migrations among bream schools are well documented (Backiel and Zawisza 1968, Goldspink 1978, Whelan 1983, Connolly *et al.* 1991).

Of the 17 densely weeded (>70% plant cover) sections examined, totaling approximately 40 km of canal, only four supported fish crop values in excess of 200  $\text{kg ha}^{-1}$ . In two of these areas, each supporting about 90% plant cover, tench was the dominant fish species. These are relatively sedentary, bottom-loving species that thrive in weeded channels (Kennedy and Fitzmaurice 1970).

The densely weeded canal section that supported the highest fish crop value (390  $\text{kg ha}^{-1}$ ) was dominated with filamentous green algae (mainly *Vaucheria* sp.), stoneworts (*Chara* spp.) and fennel pondweed (*Potamogeton pectinatus* L.). Adult bream, up to 2 kg in weight, dominated the fish community during this early-June sampling occasion. Bream of this size are uncommon in Irish canals and it is probable that these fish had migrated for spawning purposes into this section from the River Barrow, only 0.5 km distant. Local information suggests that large schools of river bream migrate to the canal in May and return, after spawning, in mid to late June each year. The fact that poor angling catches were

reported from this canal section in July and August would support these observations.

Ten of the 17 densely weeded sections examined supported fish standing crops less than 100 kg ha<sup>-1</sup> and represented poor recreational fisheries. Most supported mixed fish communities although pike and perch, both piscivorous species, were well represented.

In moderately vegetated canal sections, occupying approximately 130 km of canal, the lowest recorded fish standing crop estimate was 116 kg ha<sup>-1</sup>. Sixteen of the 24 sections electrically fished supported standing crops greater than 200 kg ha<sup>-1</sup> and six of these sections yielded crops in excess of 400 kg ha<sup>-1</sup>.

Different growth-form categories among aquatic plants support very different mean fish standing crops (Table 2). The highest mean crop estimate (451.3 kg ha<sup>-1</sup>) was recorded from canal sections where submerged plants with broad leaves, e.g. broad-leaved pondweeds (*Potamogeton* spp.), or with complex leaf types, e.g. milfoil (*Myriophyllum* spp.), charophytes, and hornwort (*Ceratophyllum demersum* L.), predominated.

TABLE 2. STANDING CROP ESTIMATES (kg ha<sup>-1</sup>) FOR FISH IN CANALS RELATIVE TO THE GROWTH FORM OF THE AQUATIC VEGETATION PRESENT.

Growth forms	Number of sections	Fish crop estimates (kg ha <sup>-1</sup> )		
		Mean ± S.E.	Minimum	Maximum
Submerged (broad/complex leaf)	7	451.3 ± 116.1	60	825
Mixed	30	201.5 ± 33.3	5	800
Filamentous algae	5	148.2 ± 57.4	25	305
Submerged (strap-shaped/streamlined leaf)	10	120.4 ± 33.8	30	335
Floating leaved	5	30.5 ± 19.5	11	50

A mean standing crop estimate of 201.5 kg ha<sup>-1</sup> was recorded from canal sections where vegetation exhibiting a mixture of growth forms was present. Thirty such sections were electrically fished and 13 of these supported standing crops greater than 200 kg ha<sup>-1</sup>. A further 11 sections supported standing crops of less than 100 kg ha<sup>-1</sup>. This is unlikely to result from sampling error as every effort was made to standardize crews and equipment during these electrical fishing operations. The variation in results probably reflects the wide range of plant species and growth forms included in this category and suggests that further examination, perhaps at plant species level, might yield more definitive results.

A mean fish standing crop estimate of 148.2 kg ha<sup>-1</sup> was recorded from the five sections examined where algae were

the main species. This figure possibly under-represents the value of algae in canal fisheries since two of the sections were totally overgrown with algae and were virtually uninhabitable by fish. This reflects the large diurnal fluctuations in dissolved oxygen concentrations recorded during the summer months at these sites (C. Monahan personal communication). These sections supported only 25 and 35 kg ha<sup>-1</sup> of fish. The remaining three sections supported 116, 260 and 305 kg ha<sup>-1</sup>, respectively, of mixed fish species.

Most of the submerged strap-shaped or streamlined plants present in Irish canals, e.g. unbranched bur-reed (*Sparganium emersum* Rehm.), clubrush (*Scirpus lacustris* L.) and arrowhead (*Sagittaria sagittifolia* L.), are resistant to the activity of dichlobenil and commonly establish dense vegetation stands in dichlobenil-treated areas (Caffrey and Monahan 1991). The mean standing crop value for this growth-form category was 120.4 kg ha<sup>-1</sup>, which contained two high estimates (298 and 335 kg ha<sup>-1</sup>). The remainder of the sections supported values well below that regarded as providing good sport angling.

In the areas where floating-leaved species predominated, poor stocks were recorded from beneath the dense canopy layer (Table 2).

## DISCUSSION

Studies conducted in North American lakes and streams have shown a positive correlation between trophic status, as measured by total phosphorus concentrations, and fish standing crops (Hoyer *et al.* 1985, Hoyer and Canfield 1991). Thus, eutrophic watercourses generally support larger fish crops than oligotrophic habitats. The Irish canals under study may be regarded as mesotrophic and there is little variation in nutrient levels either within or between the three systems (Caffrey and Cooney 1992). It is therefore reasonable to suggest that factors other than water quality or nutrient status of the water are primarily responsible for the variations in fish standing crops recorded in these canals. Among these factors, the aquatic plant regime must be considered an important determinant.

In British canals the level of aquatic plant growth is closely correlated with boat traffic intensity (Murphy and Eaton 1981). Where boat traffic is heavy few plants are present and where little or no traffic is recorded an abundant flora prevails. In Irish canals boat traffic intensity is light and is not sufficient to preclude aquatic plant growth. In these canals the vegetation regime is governed principally by weed control programs.

The levels of aquatic plant growth recorded during this investigation largely reflect past weed control practices. The indiscriminate use of the aquatic herbicides dichlobenil in the

canals prior to the implementation of the Canals Act (1986) probably accounted for the poor floral regimes present in most sparsely vegetated canal sections. Many of these were sprayed each year, whether plants impeded boat traffic or not. This total removal of susceptible plants facilitated the unrestricted movement of boats but also significantly reduced fish habitats, and consequently stocks, within these channels.

Fisheries research conducted on English rivers (Linfield 1981) and on Irish canals (Connolly *et al.* 1991) revealed that watercourses which support 200 kg ha<sup>-1</sup> or greater of coarse fish generally represent good sport fisheries. It is, therefore, clear that good angling may be expected in moderately vegetated canals, while poorer catches may be achieved in densely or sparsely vegetated channels (cf. Table 1).

Dense and obstructive vegetation was recorded in channels where species resistant to the activity of dichlobenil predominated and in many of the sections where mechanical weed control was operated. An examination of the reaction of aquatic plant species to mechanical cutting demonstrated that the rate of regrowth among cut plants is generally rapid and may exceed that recorded among uncut plants (Caffrey 1990b, 1991b, Caffrey and Monahan 1991). If navigation channels must be maintained, therefore, it is often necessary to apply two or even three cuts in each growing season.

While densely weeded channels supported higher mean fish standing crops than sparsely vegetated sections (cf. Table 1), these habitats did not present ideal conditions for coarse fish. This reflects the adverse effect that large diurnal fluctuations in dissolved oxygen concentrations, commonly recorded in densely vegetated watercourses (Simpson and Eaton 1986), can have on fish populations in these areas. It might further reflect the restriction on free movement among open water fish species, *e.g.* roach, rudd, pike and perch, imposed by dense vegetation (Bouquet 1978, Canfield and Hoyer 1992).

The difference in fish standing crop levels recorded from the five growth-form categories of vegetation examined (cf. Table 2) probably relates to the architecture or spatial arrangement of the plant species involved. Submerged plants with broad or dissected leaves provide abundant cover and concealment for adult fish and nursery habitats for fry. They also provide a wide range of microhabitats for fish-food invertebrates and periphyton, and spawning substrates for fish and invertebrates. Submerged plants with narrow strap-shaped leaves offer fewer habitats and provide reduced cover for fish. Furthermore, while coarse fish will deposit their adhesive egg masses on most plant species, they exhibit a preference for submerged species with broad or complex physical forms (Kennedy and Fitzmaurice 1968, 1970, 1974).

Floating-leaved plants offer minimal cover, direct or indirect food supply or spawning substrates for fish or inverte-

brates. This is reflected in the low mean fish standing crop recorded among this vegetation type (cf. Table 2). Filamentous algae are not noted for the cover they provide to fish but they commonly harbor large numbers of invertebrates. This probably explains the good fish crops recorded in sections where moderate growths of algae occupied the channel.

In addition to plant form, another feature that probably influenced the fish standing crops recorded was the seasonality of the vegetation. This reflects the availability of plant cover and an invertebrate food supply for fish throughout the winter and spring (Reynolds and Eaton 1983). A number of aquatic plant species initiate their growth cycle relatively late in spring and die-down completely in autumn, passing the colder months as rhizomes, tubers, turions or other overwintering organs (Caffrey 1990a). Canal sections where these short-lived species dominate the flora are practically devoid of vegetation between October and March each year and, therefore, provide relatively poor habitats for fish. Murphy and Eaton (1981) observed that fish normally resident in canals dominated by short-lived plant species moved out of these sections in winter in search of weeded channels. No such movements were observed in canals where plant populations overwintered. It is noteworthy that the more common short-lived species present in Irish canals are the principal representatives of the two growth-form categories which supported the lowest fish crops: Unbranched Bur-reed, clubrush and arrowhead (submerged with strap-shaped or streamlined leaves) and broad-leaved pondweed (floating leaved).

Plants that maintain vegetation stands for most of the year provide almost continuous cover and food supply, thus ensuring favorable year-round conditions for fish. The more important plant species that exhibit this long-lived pattern include marestail (*Hippuris vulgaris* L.), Eurasian milfoil (*Myriophyllum spicatum* L.) and charophytes, all included in the submerged, broad or complex leaf growth-form category. This helps explain the high standing crop figures for fish recorded from canal sections supporting this vegetation type.

## IMPLICATIONS FOR AQUATIC PLANT MANAGEMENT

Plant management programs operating in recreational fisheries should work to achieve partial rather than total weed control. The results from this study indicate that at least 20% aquatic plant cover should remain following weed treatment. Partial control may be achieved using mechanical means or using herbicides that are specifically formulated for selective control, *e.g.* granules or gels.

Where vegetation that includes a variety of growth forms occupies a channel, those that support low fish densities should be specifically targeted for treatment. This is possible

with current advances in mechanical cutting apparatus and herbicide formulations.

Weed control operations in channels dominated by submerged plants with strap-shaped or streamlined leaves, by floating-leaved plants or by species that die-down completely in winter should aim to treat this vegetation severely, thereby leaving niches available for colonization by plant species with greater fish-harboring capacities.

Water managers should keep abreast of advances in weed management technology to avail themselves of new, more efficient and cost-effective control procedures.

Integrated weed control programs, using a broad combination of techniques, generally provide more efficient, cost-effective and environmentally sensitive plant management (Mitchell 1986, Murphy *et al.* 1987, Caffrey 1990b, 1991b).

Reed fringes should be preserved since they play an important role in bank side stabilization.

Weed control operations should be suspended during and immediately after fish spawning. A knowledge of fish community structure in these watercourses will allow the manager to determine when operations can safely resume.

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