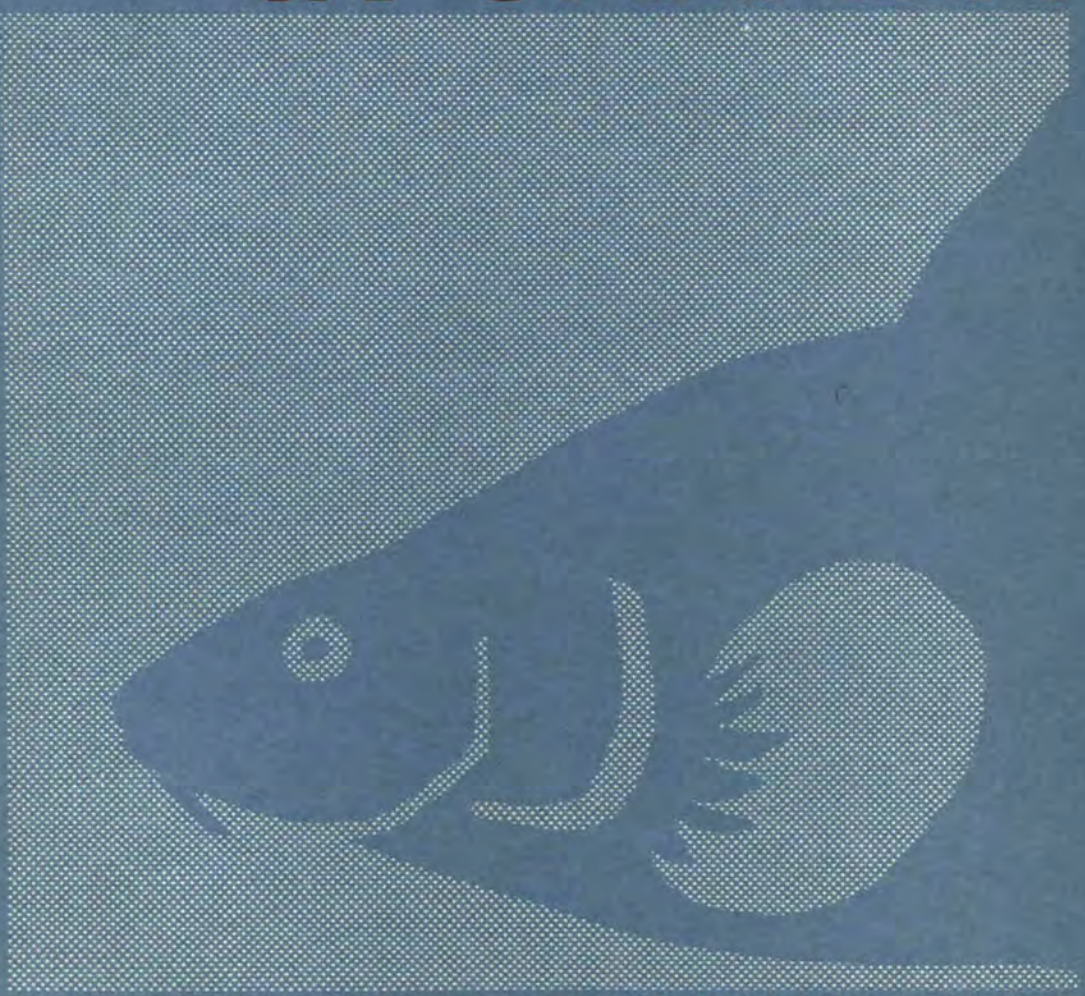
BULLETIN 165

CARP IN CANADA



BY H. R. MCCRIMMON

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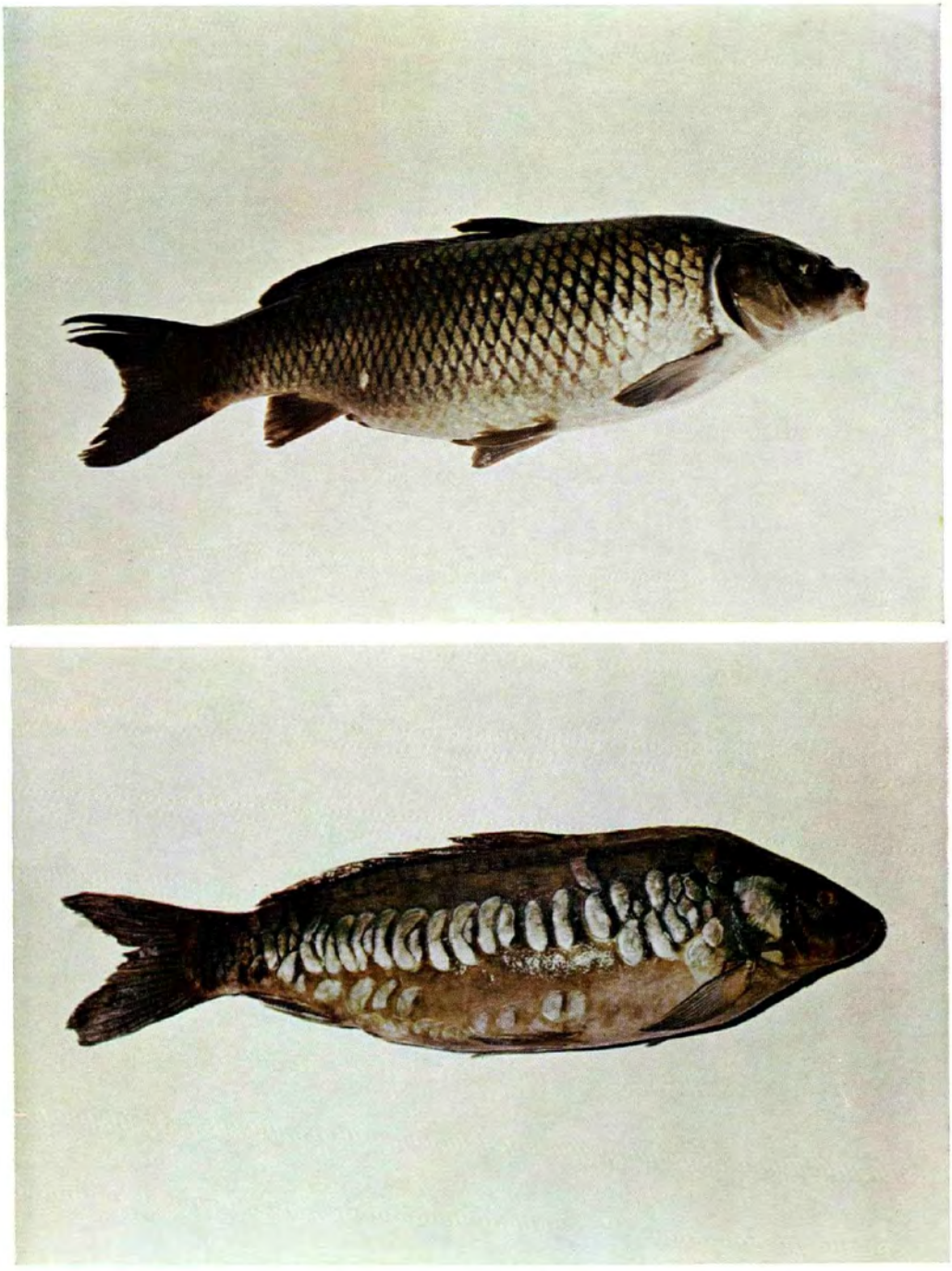

The carp, *Cyprinus carpio* — *top,* scaled carp; *bottom,* mirror carp

BULLETIN 165

Carp in Canada

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FISHERIES RESEARCH BOARD OF CANADA

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ABSTRACT

The carp, *Cyprinus carpio* Linnaeus, as a result of introduction, is resident in the provinces of Quebec, Ontario, Manitoba, Saskatchewan, and British Columbia. Natural barriers and dams deter further range expansion through natural movement into numerous potentially favourable aquatic habitats across Canada.

Present annual commercial harvests, estimated at 2.5 million lb, exploit only modestly available carp populations in Canadian waters. Live, dressed, and smoked fish constitute the traditional market with gefilte fish and caviar being more recent products. In spite of various recreational fisheries, the carp has not received general public acclaim as a sport fish in Canada, although angling, spearing, and bow-fishing are increasing in popularity.

Public prejudice against the carp as a food and sport fish which continues to hamper utilization of the species, can be overcome only by increased effort in public education and product development.

INTRODUCTION

The carp, *Cyprinus carpio* Linnaeus, is one of the most locally abundant and widely distributed of those fish species introduced by Man into North American waters.

Established intentionally as a potential food fish in virtually all of the major watersheds of the United States and in several Canadian waters, the present distribution of carp in Canada would seem to have originated largely from plantings made in the Columbia, Mississippi, and Great Lakes basins.

In spite of the present and potential importance of the carp in Canada, in terms of both positive and negative values, there has been no comprehensive account of its introduction and distribution across Canada, nor has there been an appraisal made of its status in the Canadian fishery. Even in the Great Lakes basin where the carp has been recognized as a significant component of the fish fauna for over three quarters of a century, a survey of the published literature for the region (Hile, 1952; Great Lakes Commission Bibliographies 1956–66; Stansby and Shairer, 1961) has revealed that no active research has been directed towards the species in Canadian waters prior to 1965, although occasional references to the species may be found in faunal checklists and annual government reports.

The objectives of this paper are, firstly, to document all known attempts to introduce the carp into Canadian waters; secondly, to define the 1967 distribution of the species including reference to the origin of local populations; and, thirdly, to appraise the present status and economics of the carp across Canada as a basis for its future management.

SUMMARY OF CARP BIOLOGY

The carp, *Cyprinus carpio,* was first described by Linnaeus in 1758 and is believed to have originated in a region of eastern Asia (Banarescu, 1964; Sterba, 1962; Speirs, 1953; Nikolskii, 1961). It is represented by similar words in several languages, such as the German *karpf,* the French *carpe,* and the Celtic *cerpyn.* Regan (1911) suggested that the Latin *Cyprinus* or *Cyprinianus* was probably derived from Cyprus, the abode of Venus, in allusion to its fecundity. As a result of intensive cultivation in Europe and Asia a number of varieties or races have arisen which are reasonably stable, some more prized as food than others (Huet, 1960).

Hessel (1876) recognized the separation of the species into three subspecies, namely, *C. carpio communis* or "scale carp" with regular concentrically arranged scales (*see* Frontispiece); *C. carpio specularis* or "mirror carp" with extraordinarily large scales running along the side of the body in several rows with the rest of the body naked (*see* Frontispiece); and *C. carpio coriaceus, sive*

nudus, or the "leather carp" with either a few or no scales on the back, and possessing a thick, soft skin, feeling velvety to the touch. Each of these types was reported for Canadian waters early in the present century (Bensley, 1916). Scaled carp predominate among Canadian populations of the species and leather carp would seem to occur only rarely. The relative number of mirror carp varies with location, being virtually absent in some waters and reaching 30–40% in others.

Hybridization of carp with other similar Cyprinids is not uncommon. Hessel (1878) cited as an example *Carpio kollarii,* which was a cross between the carp and the Crucian carp, *Carassius vulgaris,* and, because of its inferior quality was termed the "poor man's carp" of Germany. He noted, however, that sometimes hybrids so resemble the genuine carp, that their identity might be difficult to recognize.

Cross breeding of the carp with the goldfish, *Carassius auratus,* occurred accidentally in rearing ponds in North America as early as 1877 (Baird, 1880). Hybrid fish of similar parentage are known by the author for lakes Erie and St. Clair. Trautman (1957) reported that the carp and goldfish breed freely, that the hybrids are fertile, and that back-crosses are abundant among the carp populations of Sandusky and Maumee bays of Lake Erie.

The purpose of this section on carp biology is to review the general features of the life history of the species with particular reference to the Canadian environment. Because of a lack of published details on carp biology in this country, this review is based primarily on studies undertaken in Ontario by the author and students at the University of Guelph supplemented with data gathered mainly from sources in the United States.

Seasonal Distribution

Populations of carp sustained by natural reproduction in Canadian waters, excluding possibly those of the more temperate west coast, have two basic habitat requirements: firstly, a shallow marsh environment preferably abundant with aquatic vegetation (Fig. 1) and, secondly, an area of deeper water to which the species may retreat during the colder months.

Adult carp typically move each spring from the deeper waters where they have wintered into marsh areas in advance of the spawning season. In Lake St. Lawrence, this onshore movement begins in early May when maximum daily water temperatures approach or exceed 15 C (59 F) (Swee and McCrimmon, 1966). Pre-spawning aggregates of carp swim leisurely about the more open marsh or near the surface of nearby deeper water, the dorsal fins and backs often exposed above the water (Fig. 2). This general behaviour has been described by several authors (Mackay, 1963).

During the spawning season, the carp segregate (Fig. 3) into smaller groups, most typically 1 female with 3 or 4 males although groups as large as 2 or 3 females and 10–15 males have been observed (Cole, 1905; Forbes and Richardson, 1909; Gill, 1905; Seeley, 1886; Swee and McCrimmon, 1966). Preferred spawning sites are shallow areas, often recently inundated, with water

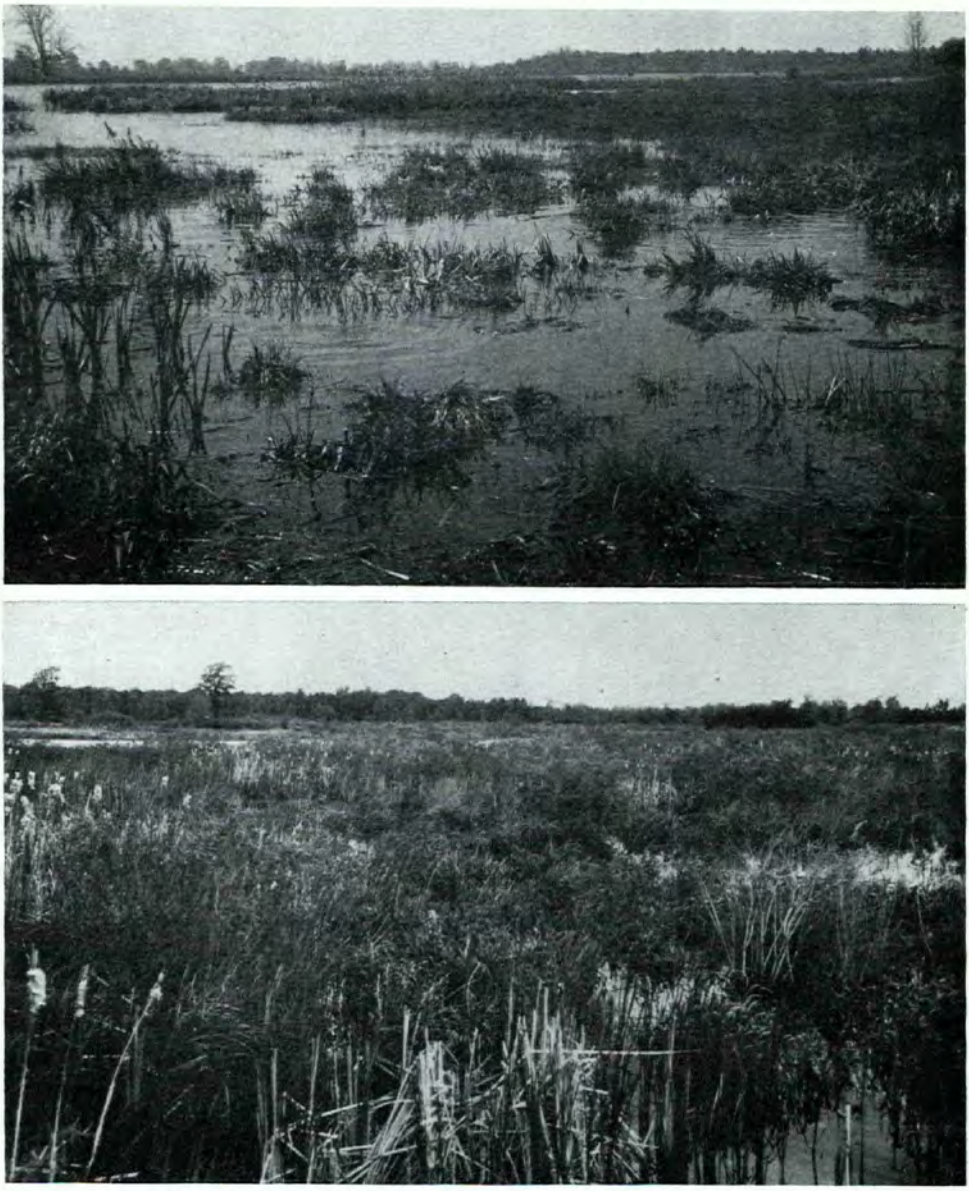

FIG. 1. Typical marsh habitats in southern Ontario utilized by the carp for natural reproduction.

depths less than 0.45 m (18 inches) (Cole, 1905; Richardson, 1911; Sigler, 1958). However, the author has observed spawning near the surface over submerged aquatic vegetation in water of 1.8 m (6 ft) depth and Richardson (1911) reported occasional spawning in water as deep as 1.7 m (5.5 ft). The eggs are adhesive and stick to aquatic vegetation, submerged grasses, or any

FIG. 2. **A.** Congregation of pre-spawning carp moving along the shore of Lake St. Lawrence; **B.** school of pre-spawning carp entering a marsh area.

FIG. 3. **A.** Typical spawning activity of carp in a temporarily inundated area; **B.** in a permanently wet area of marsh.

other material over which they are scattered (Adams and Hankinson, 1928; McCrimmon and Swee, 1966; Struthers, 1931; Sigler, 1958). Actual spawning is accompanied by much physical activity (Fig. 4). The splashing and slapping of the fish on the surface of the water may be audible for a considerable distance from the site (Sigler, 1958; McCrimmon and Swee, 1966).

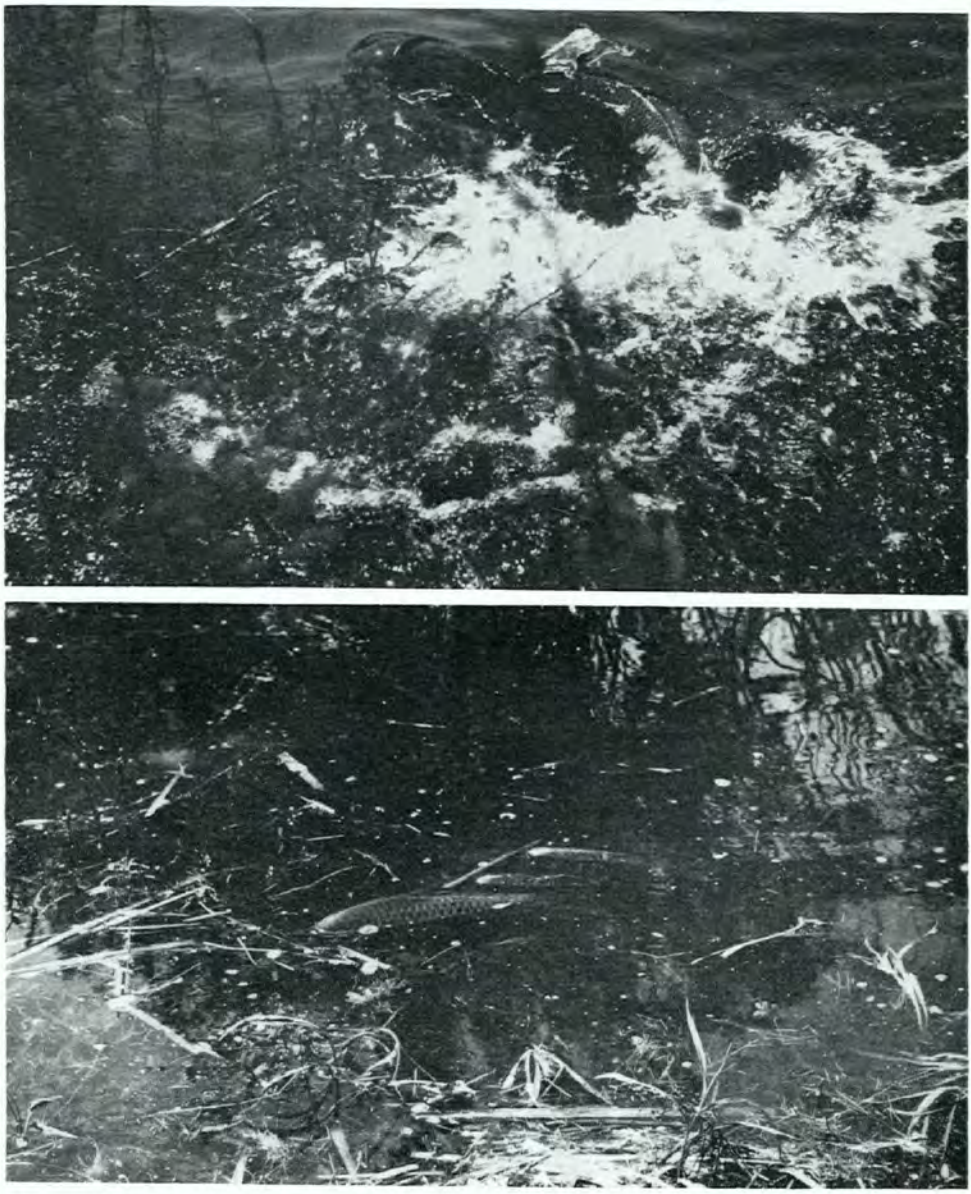

FIG. 4. The association of one mature female with several male carp. *Upper*: active spawning; *lower*: resting on completion of spawning act.

Water temperature is a primary environmental stimulus to spawning (Shields, 1957). In Lake St. Lawrence spawning did not begin until the water temperature reached 17 C (62 F) and ceased temporarily whenever the temperature dropped below that level (Swee and McCrimmon, 1966). These minimum temperatures approximate those recorded by Greeley (1928), Nikolsky (1963), Struthers (1929, 1930), and Atton (1959) for the waters of Manitoba and Saskatchewan. Huet (1959) noted that at summer temperatures between 15 and 18 C (59 and 64 F) carp can maintain themselves and make fair growth but do not reproduce. Optimum spawning in Lake St. Lawrence occurs at water temperatures between 16.5 and 23 C (62 and 73 F). Spawning activity decreases above 26 C (79 F) and ceases at about 28 C (82 F) (Swee and McCrimmon, 1966).

The time and duration of the spawning season have been defined precisely by only a few authors but the general assumption has been that the species is a spring spawner. Cole (1905) gave the spawning time as April for the southern United States and May and June for the more northern States. Langlois (1954) reported June spawning for Lake Erie carp and Mackay (1963) gave the same month for spawning in Ontario. However, there is good evidence that the carp may spawn over a prolonged period of time in warmer environments at least. Peak spawning in Lake St. Lawrence occurs from mid-May through June but fish have been observed to spawn through July and into early August, fertile eggs being recovered from vegetation in August (Swee and McCrimmon, 1966). A similar extended spawning season has been reported for New York State (Bean, 1903). English (1952) suspected spawning in Iowa as late as July. Laventer and Perah (1966) stated that March to May is the normal spawning season for carp under the subtropical conditions of Israel but that spawning could regularly be controlled from February to September. Greeley (1928) reported the common phenomenon of female carp not being spawned out at one time. Shields (1957) and Nikolsky (1963) both noted that a number of unspent females occurred among carp populations during the summer months. Swee and McCrimmon (1966) reported that female carp were seen to spawn successfully a second time during the same breeding season after an interval of 25 days.

During the summer months, adult carp occur in a wide range of freshwater habitats (Adams and Hankinson, 1928; Butcher, 1962; Cahn, 1929; Cole, 1905; Sigler, 1958) and may occupy brackish or saline waters (Nikolsky, 1963; Soller et al., 1965). Carp are able to adapt themselves to a variety of conditions and thrive in warm turbid waters of high mineral content (Moyle, 1956). Contaminated waters seem to have little adverse effect (Forbes and Richardson, 1909; Wallen, 1951). Sigler (1955) noted that the carp is able to tolerate a low oxygen content, a high degree of pollution, and adverse and quick temperature changes. Wallen (1951) demonstrated that carp can tolerate turbidities above those usually found in natural waters and gave 165,000 ppm silicon dioxide equivalents as the average turbidity fatal to juvenile carp.

While more typically inhabiting the warmer eutrophic environments of impoundments, lower reaches of large rivers, and littoral areas of lakes usually in association with vegetation (Neess, Helm, and Threinen, 1955; Scott, 1954), carp may occur in cool clear shoal areas of the upper Great Lakes, in swift rivers of mountainous regions, or occupy good trout waters in small numbers (Sigler, 1958). Water temperature for optimum activity would seem to be in the range of 24 C (75 F) (Beamish, 1964; McKenzie, Collins, and Taylor, 1959). Sigler (1958) observed that wild carp become active at about 4 C (38 F) but require higher temperatures for active feeding and good growth. However, the final preferendum of 32 C (90 F) reported by Pitt, Garside, and Hepburn (1956) from laboratory experiments, is above that temperature at which the species reproduces or would be expected to thrive (Swee and McCrimmon, 1966; Sigler, 1958).

Although generally a fish of shallower waters, carp have been netted at depths of nearly 100 ft (Cady, 1945). However, carp commonly reside within the epilimnion of temperate lakes during the summer months but may move regularly between shallow, weedy areas and adjacent deeper water (Sigler, 1958). In Lake St. Lawrence, carp do not frequent the shallows when water temperatures are below 11 C (52 F). During late summer and early autumn they occupy marginal areas of deeper water, moving onshore only when surface waters are warmed by radiation (Swee and McCrimmon, 1966). Sigler (1958) noted that in early spring the fish may spend only the daytime period in the sun-warmed shallows. Later in the season when surface water temperatures may be high, the inshore movement may be only at night. Black (1953) reported an upper lethal temperature for adults of 34.5 C (96 F).

With the advance of autumn and colder surface temperatures, carp characteristically move into deeper and warmer water where they reside during the winter months (Adams and Hankinson, 1928; Mackay, 1963; Sigler, 1958; Tracy, 1910) and may become concentrated in numbers permitting a profitable commercial harvest from beneath the ice (Hessel, 1884; McCrimmon, 1956). Winter-kills caused by oxygen deficiencies are not uncommon among carp isolated in marsh areas across Canada and may occur locally in shallow inland lakes. For example, in Lake Scugog, Ontario, some 80,000 dead carp were counted along with numerous maskinonge and largemouth bass following the disappearance of the ice-cover during the spring of 1960 (Smith, personal communication, 1964).

Early Development and Growth

The eggs, on being discharged from the female and fertilized, are sticky and soft and adhere to the aquatic vegetation or other objects in the water (Adams and Hankinson, 1928) (Fig. 5). Richardson (1911) noted densities of carp eggs as high as 2500 eggs/yd^2. The eggs water-harden in 15–25 min. Observations on egg masses adhering to aquatic vegetation have indicated a fertility

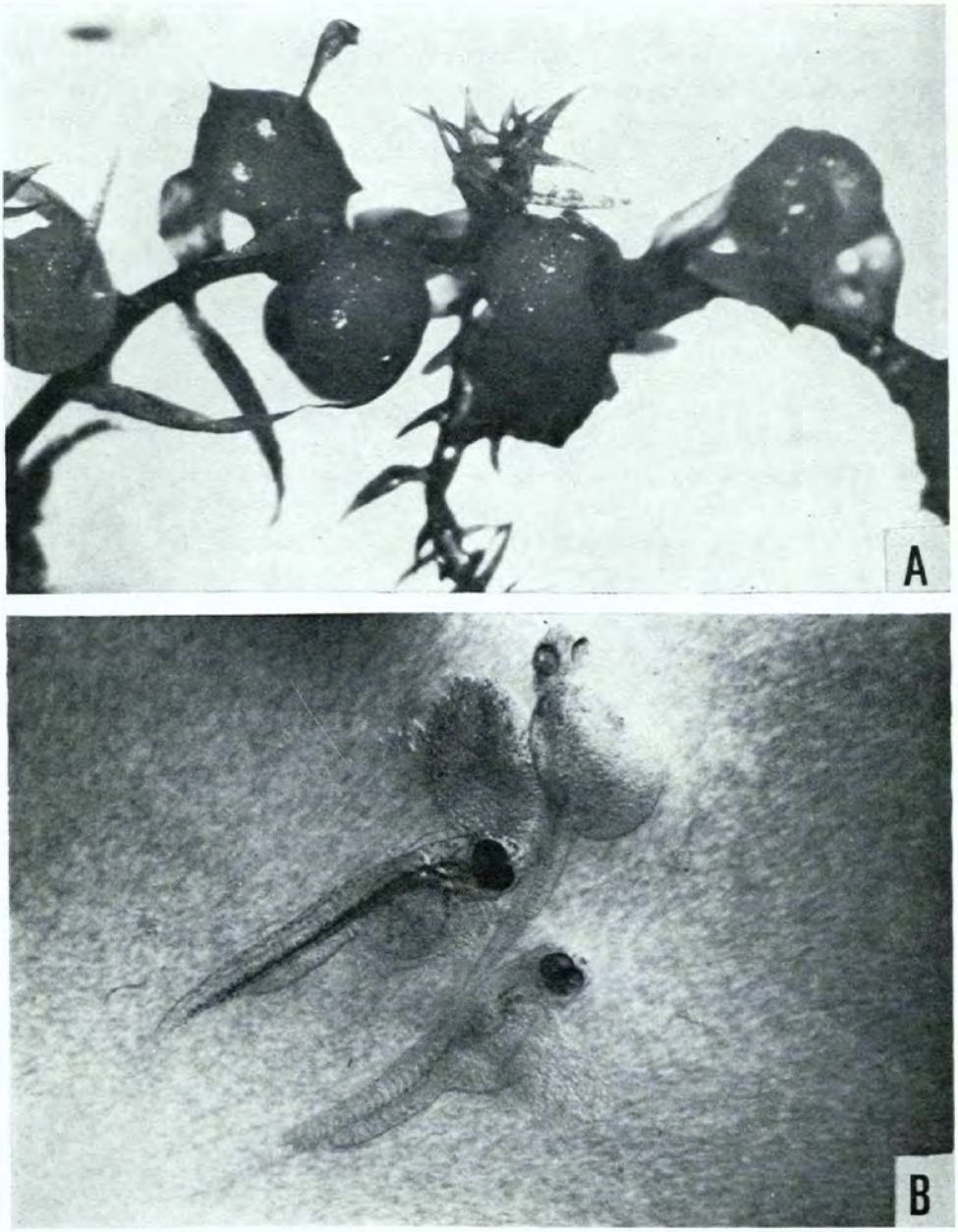

FIG. 5. Stages in the development of young carp: **A.** fertilized eggs adhering to aquatic vegetation; **B.** newly hatched larvae (5.0–5.5 mm).

rate of some 90% (Swee and McCrimmon, 1966). The time for incubation is related to water temperature. Cole (1905) and Struthers (1929) gave a hatching time of 4–12 days. English (1952) stated that eggs incubated at 23 C (78 F) hatched in 4 days. Eggs hatched in less than 3 days at water temperatures ranging between 25 and 32 C (77 and 89 F) in Lake St. Lawrence marshes (Swee and McCrimmon, 1966).

Newly hatched fry average 5.0 and 5.5 mm in total length (Fig. 5). Differences in individual growth, which are influenced by water temperature, stocking density, and availability of food, become pronounced by the 12th week of life. Newly hatched fish settle immediately to the bottom and the subsequent rate of development of the sac-fry is determined by water temperature. Fish of 6 mm are able to attach themselves to aquatic vegetation. By the time the fish reach a length of 8 mm, the yolk-sac has normally disappeared, the fish are feeding actively on plankton, and swim with well coordinated movements although all fins are still absent or incompletely developed (Table I). All fins, apparent on newly hatched fish only as a pair of rudimentary pectorals and a median fin-fold, become fully formed at about 21 mm (McCrimmon and Swee, 1967). The growth of young carp is shown in Fig. 6.

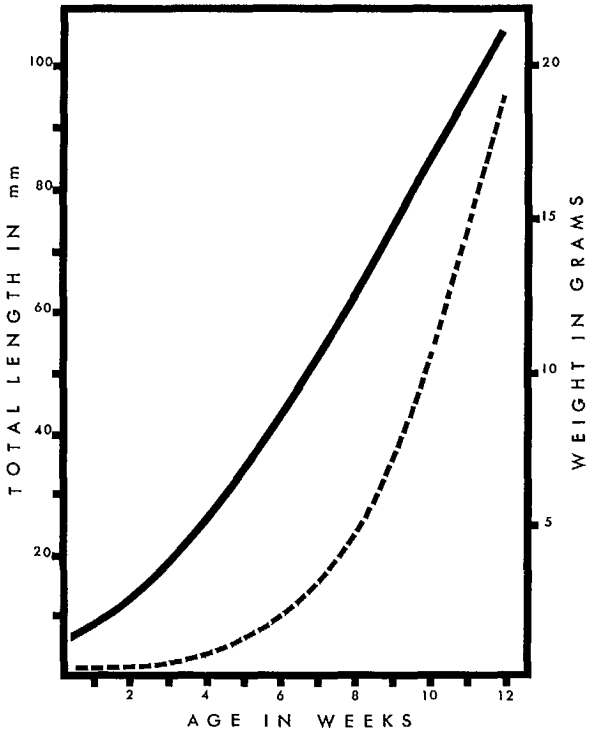

FIG. 6. Growth of newly hatched carp in the waters of Lake St. Lawrence, Ontario.

TABLE I. Some aspects of the development of newly hatched carp with respect to total length in Lake St. Lawrence, Ont. (0 = partial; x = complete development.)

Total length (*mm*)	Stage of development												
	Mouth	Free swimming	Sac	Pectoral fins	Operculum	Filling of posterior gas bladder	Feeding	Dorsal fin	Caudal fin	Anal fin	Pelvic fin	Filling of anterior air bladder	Body scales
5	0	0	x	0									
6	0	0	0	0	0								
7	x	0	0	0	0	0	0						
8	x	x		0	x	x	x	0	0				
9	x	x		0	x	x	x	0	0	0			
10	x	x		0	x	x	x	0	0	0			
11	x	x		0	x	x	x	0	0	0	0	0	
12	x	x		0	x	x	x	0	0	0	0	0	
13	x	x		x	x	x	x	0	0	0	0	0	
14	x	x		x	x	x	x	0	0	0	0	0	
15	x	x		x	x	x	x	0	0	0	0	0	
16	x	x		x	x	x	x	0	0	0	0	x	0
17	x	x		x	x	x	x	0	0	0	0	x	0
18	x	x		x	x	x	x	0	x	0	0	x	0
19	x	x		x	x	x	x	0	x	0	0	x	0
20	x	x		x	x	x	x	0	x	0	0	x	0
21	x	x		x	x	x	x	x	x	x	x	x	0
22	x	x		x	x	x	x	x	x	x	x	x	0x
23	x	x		x	x	x	x	x	x	x	x	x	0x
24	x	x		x	x	x	x	x	x	x	x	x	0x
25	x	x		x	x	x	x	x	x	x	x	x	0x
26–33	x	x		x	x	x	x	x	x	x	x	x	x

The posterior part of the air bladder, beginning to appear within the transparent body of the fish at 5.5–6.0 mm, is filled with air taken at the surface as soon as the fish becomes free swimming at a length of about 7 mm. Scale formation (Fig. 7) is initiated at lengths of 16–18 mm and completed on fish between 22 and 25 mm in length (McCrimmon and Swee, 1967).

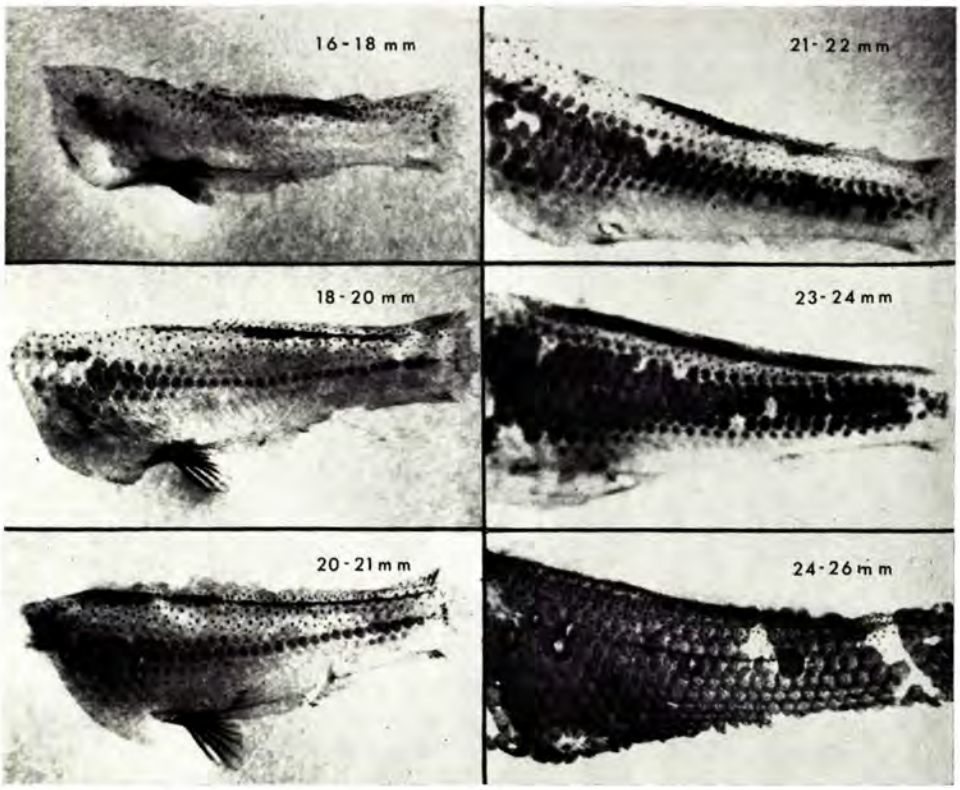

FIG. 7. Scale formation on the body of young carp between 16 and 26 mm (0.6 and 1.0 inch). Small dark spots dorsal to lateral line are caused by pigmentation and are not scales.

Squamation and organogenesis in the carp is closely related to the total length of the fish and proceeds according to a pattern peculiar to the species.

The young carp begin to move about the shallows of the marsh as soon as they become free swimming and gradually are hidden among the vegetation within a week after hatching out. Although Sigler (1958) reported that carp of 7.5–10 cm (3–4 inches) move entirely from the shallow weedy areas (Butcher, 1962), carp of this size could be taken in quantity by electrofishing from the weedy shallows of Lake St. Lawrence during late summer and autumn (Swee and McCrimmon, 1966).

Age, Growth, and Maturity

The rate of growth of carp varies locally and would seem to depend particularly on summer water temperatures, length of growing season, and availability of food. Growth data on carp taken from several Ontario waters are given in Fig. 8 and 9.

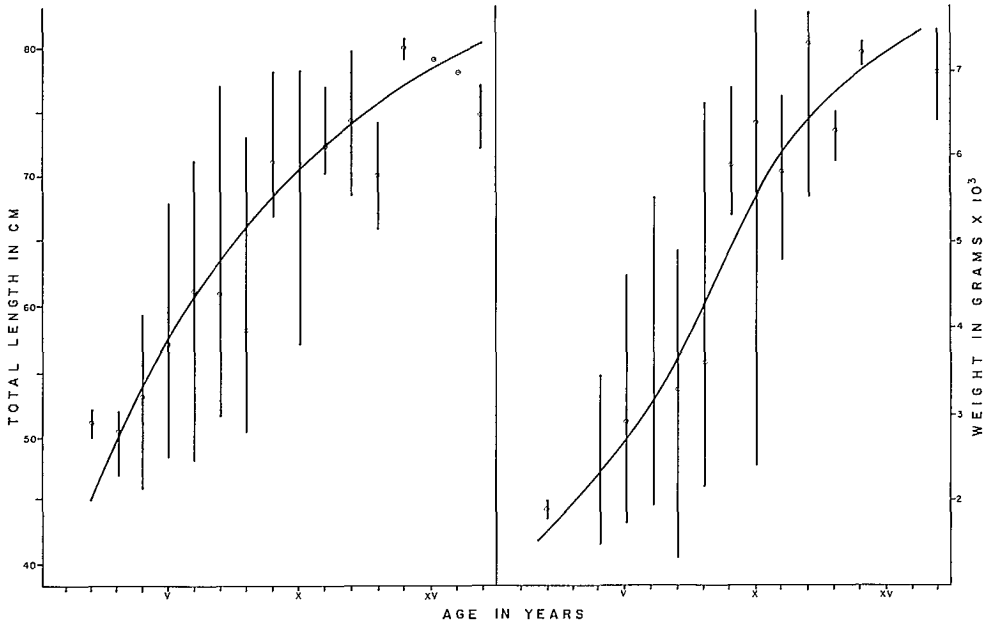

Fig. 8. Average growth rates of carp taken from Great Lakes and inland waters in Ontario.

Carp commonly reach lengths of 130–190 mm (5–8 inches) in the warmer of Ontario waters and those of the northern United States during the first growing season (Sigler, 1958; Mackay, 1963; McCrimmon, 1956). Although several American authors (Shields, 1955; Sigler, 1958; Leach, 1919; Wales, 1942) have reported that carp mature in 2 years, Rheder (1959) noted a later maturity for Iowa carp. Studies on the spawning populations of the species in the Ontario waters of Lake Simcoe (McCrimmon, 1956) and in Lake St. Lawrence (Swee and McCrimmon, 1966) revealed that males typically became mature at ages III and IV, and females at ages IV and V. Sterba (1962) stated that the carp in central Europe were sexually mature in their 3rd and 4th year. Burr (1874) advised that males could be distinguished from females because of their proportionately larger ventral fins. The spawning population in Lake St. Lawrence is composed of carp ranging from age II to age XVI, all fish over 356 mm (14 inches) and females over 432 (17 inches) being mature. Clemens (1939) suggested that carp in Okanagan Lake and nearby waters in British Columbia grew at a slower rate attaining lengths of about 20 inches (508 mm) during their 9th to 11th summers.

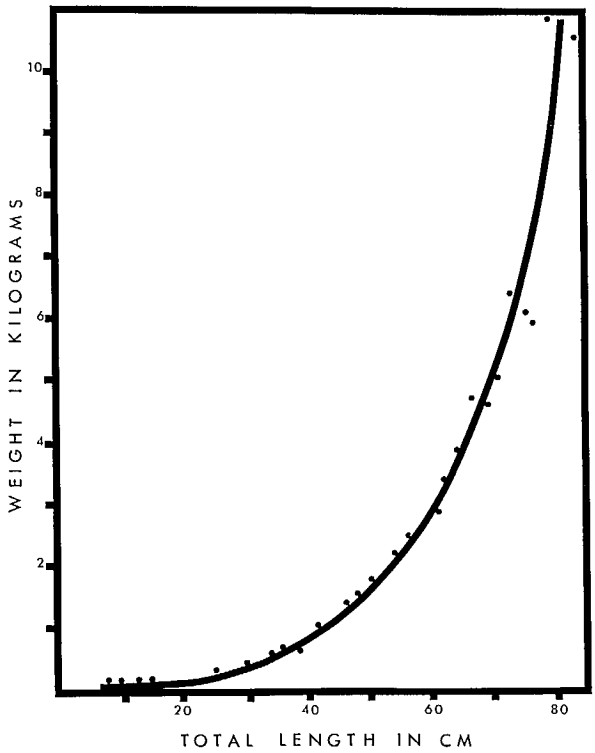

FIG. 9. The length–weight relationship of carp taken from the waters of the Province of Ontario.

In spite of statements attesting to the longevity of carp (living for over 140 years under artificial conditions in Eurasia (Hessel, 1878)), the normal span of life in North American waters seldom would seem to exceed 20 years. In an extensive study of the carp of Lake Simcoe, the largest fish taken measured 32 inches (813 mm) and weighed 34 lb (15,430 g) at age XVII (McCrimmon, 1956). The largest carp collected from commercial fishermen in Ontario during 1965 measured 850 mm (33 inches) and weighed 9500 g (20.9 lb). The spawning population of carp in Lake St. Lawrence during 1965 and 1966 was dominated by fish of age V (Fig. 10). Fish of ages IV–VIII, weighing between 4 and 15 lb, made up over 80% of the total number. Wooding (1959) stated that the carp may reach 40 lb (18,144 g) in weight in Canadian waters and Mackay (1963) noted that in the warm, shallow lakes and bays such as Lake Erie and the Bay of Quinte in Ontario, carp may attain weights of from 30 to 40 lb although Cole (1905), in his extensive study of the species in the Great Lakes, noted a maximum of 20 lb (9072 g). However, fish of larger size are not uncommon in the commercial fishery although unusually large fish are not necessarily preferred by the wholesale market. Cooper (personal communication,

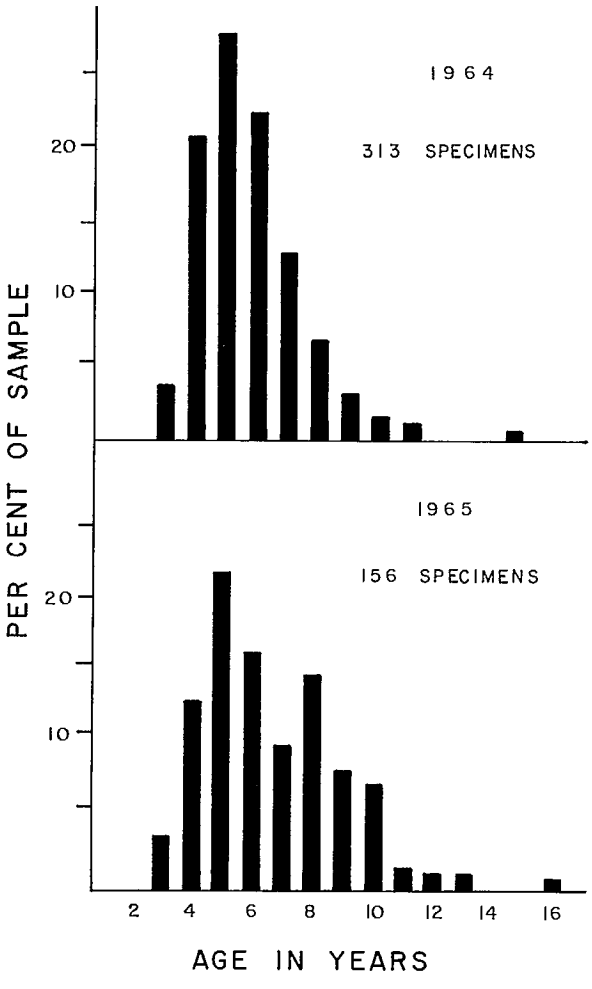

FIG. 10. The age frequency of mature carp on a typical spawning area of Lake St. Lawrence during the spring and early summer of 1964 and 1965.

1967) has advised the author that in recent years he has taken carp, by netting, in the range of 35–50 lb in the waters of Georgian Bay, Lake Ontario, Lake Simcoe, and the Trent Canal system. The North American record recognized in Field and Stream magazine (Anonymous, 1954) was a carp of 59.5 lb (279,000 g).

The carp is one of the most prolific of freshwater fishes. The fecundity of Lake St. Lawrence carp ranged from 36,000 eggs in a 394-mm (15.5-inch) fish to 2,208,000 eggs in a 851-mm (33.5-inch) fish weighing 10,101 g (22.3 lb) (Swee and McCrimmon, 1966). The relation between fecundity and

total length among carp taken from several Ontario waters is shown in Fig. 11 and is in general agreement with data provided by other authors, (Gill, 1905; Carlander, 1950; Butcher, 1962).

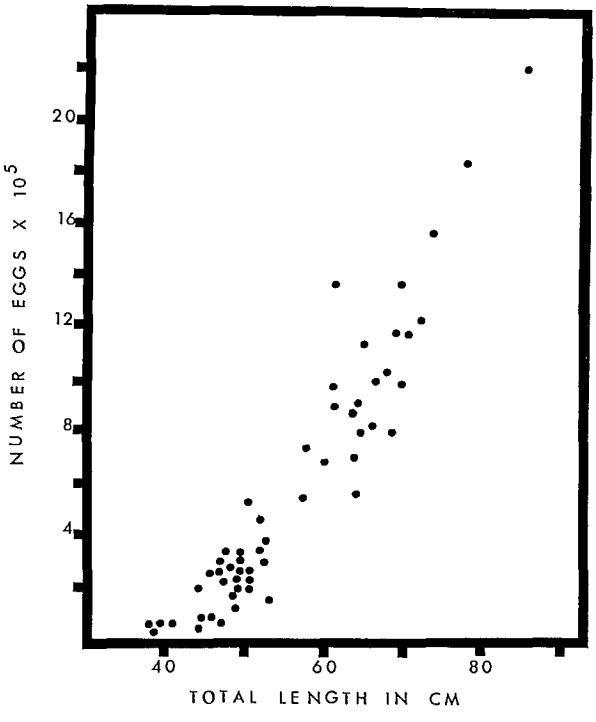

FIG. 11. The numbers of mature eggs in the ovaries of female carp taken from the marshes of Lake St. Lawrence, Ontario.

FOOD AND FEEDING HABITS

The observations of a number of authors confirm that the carp is omnivorous, eating both animal and vegetable materials in quantity (Cole, 1905; Forbes and Richardson, 1909). However, there is good evidence that feeding habits are deliberate and selective (Mackay, 1963).

Newly hatched carp would seem to feed primarily on plankton. In laboratory studies Alikunhi (1958) found that fry fed avidly on zooplankton an hour after hatching, but took little phytoplankton even if no other food was available. However, sac-fry taken from the waters of Lake St. Lawrence (Swee and McCrimmon, 1966) typically had ingested both zooplankton and phytoplankton, the latter material giving a greenish colour to the transparent digestive tract. Gill (1905) noted the principal food of newly hatched fish to be rotifers, copepods, and algae. Insect larvae are taken after the first few weeks (Pearse, 1918)

and, by the end of the first summer, young-of-the-year carp eat a variety of invertebrate life including the larvae and pupae of chironomids, caddis flies and other hexapods, and small molluscs, ostracods, and crustaceans (Clemens, 1939; Ewers and Boesel, 1935; Greeley, 1928; Gerking, 1950; Lindquist et al., 1943; Pearse, 1918).

Seeley (1886) in discussing the food of carp in Europe noted that it subsisted on algae, young shoots of water plants, decomposing plant remains, and mud rich in organisms including insects and worms. Plant materials recorded from carp stomachs include: the roots, leaves, cortex, and fibres of sedges; water plants including the water lily, wild celery, and wild rice; grains including corn, wheat, and oats, and the seeds of elm, swartmeed, foxtail, sourdock, ragweed, and others (Bean, 1903; Dill, 1944; Hunt, 1911). Mottley (1938) believed that aquatic vegetation was more apt to be used by carp when animal food was in limited supply. Authors differ in their opinion of the importance of carp grazing on the welfare of aquatic plant growth. The effect obviously is dictated by local conditions.

Animal materials found in the stomachs of larger carp have included principally: insects (ephemerids, beetles, chironomids, caddis flies); crustaceans (amphipods, entomostracans); annelids (leeches, aquatic, and earthworms); protozoans, crustaceans (crayfish), and molluscs (Baker, 1916; Cole, 1905; Ewers and Boesel, 1935; Harrison, 1950). Fish eggs, including those of whitefish and the carp itself, have been recorded as infrequent constituents of carp stomachs (Cole, 1905; Leach, 1919). Although the carp is not considered to be piscivorous (Cole, 1905), several authors have recorded the presence of fish remains in stomachs (Harlan and Speaker, 1956). It has been generally assumed that these fish were dead at the time of ingestion during the scavengerous feeding of the carp. Dyche (1914) reported seeing carp take dead minnows although making no effort to get live ones which were present in abundance.

The feeding behaviour of the carp has been most vividly described by many authors since the introduction of the species to North America and, because of the alteration of the marsh environment, is of continual concern to wildlife managers. When carp are feeding on the bottom, they typically suck up mud and other materials from the bottom, eject it, and select food when it is suspended in the water (Black, 1946). They have a habit of rooting around in soft bottoms (Miller et al., 1959). Areas where carp are found extensively are characterized by uprooted aquatic vegetation and roiled water, and a paucity of rooted vegetation resulting from a limitation of photosynthesis (Sigler, 1955; Miller et al., 1959; Jessen and Kuhen, 1960).

Surface feeding by carp is a common occurrence at which time the fish may feed on aquatic organisms, or may graze directly on the vegetation (Cole, 1905; Tracy, 1910). The sucking sound which accompanies surface feeding is well described by Dyche (1914) who noted their habit of sucking up pond scums and "blowing" out from their mouths material they did not want.

ORIGIN OF CARP IN NORTH AMERICA

The first record of the introduction of the carp into North America is that reported by de Kay (1842) who described the importation by a Capt Henry Robinson of 6–7 doz carp into his private pond near the village of Newburgh, New York, in 1831 and 1832. In quoting directly from a letter received from Robinson, de Kay apparently wrote with authenticity. Phillips (1882) suggested that some of Robinson's carp came from Holland. Robinson later reviewed before the Farmer's Club in 1850 his own early work in carp culture in which he planted in his pond both carp and goldfish brought over from France (Cole, 1905). Forester (1850) described how Robinson imported carp and planted them in some five fish ponds on the bank of the Hudson River between Newburgh and New Windsor but "in process of time a heavy freshet carried away his dams and flood-gates, and a large proportion of his carp escaped into the Hudson." Following this catastrophy, although the fish soon became abundant, the State Legislature enacted legislation protecting the species from exploitation for a period of 5 years.

In spite of the positive statements documenting Robinson's introduction and culture of the carp, Cole (1905) stated that "we shall never know whether the fish . . . were true carp or whether he happened when procuring the fish in France to get hold of the hybrid form." Cole's statement was apparently stimulated by Baird (1879) who reported that he was unable to find carp in the Hudson River or on the market but that all fish sold as carp were Prussian carp, *Cyprinus carassius,* and suggested, on this basis, that Robinson may have imported only goldfish or perhaps hybrids. Redding (1885) discussed the nature of these fish further with quotes from a letter appearing in a San Francisco newspaper. Goode (1887) accepted Baird's earlier thesis and stated that "the so-called carp of the Hudson appears to be either escaped goldfish or some inferior hybrid form of the *Karausche* type."

However, Forester (1850) stated that at the time of writing, two species of cyprinids had been introduced in the last few years and had "become entirely naturalized in some of our waters." These were the gold carp, *Cyprinus auratus,* living in the Schuylkill and in some streams of Massachusetts, and the common carp, *Cyprinus carpio,* living particularly in the Hudson River in the vicinity of Newburgh. Lydell (1905), Bastedo (1906), and Dymond (1955), among more recent authors, accepted the 1831 planting to be the first authentic introduction of carp into North American waters. An unchallenged remark to this effect by an unidentified member recorded in the minutes of the 1878 Annual Meeting of the American Fish Culture Association would seem to support this conclusion.

The importation of carp into North America during the 1870's is well documented. Although Baird advocated the transfer of European carp to the United States as early as 1872, the private introduction of carp into the waters of California preceded by several years that of the United States Fish Commission.

Poppe (1880) recorded in detail the action of Julius A. Poppe who, in 1872, had 83 scaled carp shipped from Reinfeld, Germany. Of these, only five live fish reached California and were placed in previously prepared ponds on the Poppe farm in the Sonoma Valley. From this meager nucleus began the early carp culture in the western states and, subsequently, the progeny were distributed in the waters of California and neighbouring states (Evermann and Clarke, 1931; Miller, 1943; La Rivers, 1962), and to points as distant as Central America and Honolulu. The success of Poppe's carp breeding programme so aroused the interest of the newly formed California Fish Commission that, in 1877, it initiated its own culture of carp by importing 88 small fish directly from Japan (Peterson and Drews, 1957).

After a series of failures, the first success of the United States Fish Commission in bringing live carp to North America occurred in May 1877, when Rudolph Hessel brought 345 young carp over from Germany (Baird, 1877; Finsch, 1880). The shipment, consisting of 118 scaled carp (*C. carpio communis*) and 227 mirror carp (*C. carpio specularis*), arrived in New York on 26 May and were placed in ponds at Druid Hill Park, Baltimore. These ponds not being adequate, additional ponds were made ready at the Washington Monument, the Washington Arsenal, and the Smithsonian Institute in the City of Washington.

In 1879, 6203 carp were distributed to eager applicants by the United States Government. In 1880, a total of 31,443 fish were distributed causing Hessel (1881, 1884) to state that "the progeny of the 345 carp brought from Germany in 1877 have been distributed to all parts of the United States, and the carp is almost as familiar to our people as any other kind of domesticated animal."

It is of interest that those carp planted in the Druid Hill Park ponds in 1877 were reported to have hybridized with goldfish, *Cyprinus carassius,* which were accidentally present in the ponds. Hessel believed these hybrids to be the same as *C. killari,* an inferior fish found in Europe, and had the stock destroyed (Baird, 1880). The offending goldfish were probably those imported directly from the Orient by Daniel Ammen in 1878 and presented to the United States Fish Commission at Washington where they bred extensively in nursery ponds (Smith, 1924).

In his report for 1879, Baird (1880) stressed the importance of securing a fresh supply of the best variety of carp and Dr Otto Finch, an eminent German naturalist, left Germany for the United States with 100 mirror carp measuring 6–7 inches in length, but only 77 fish survived to be planted in the Washington ponds. A further importation was made in 1882 when Herr von Behr forwarded to the Commission from Germany a number of adult "blue carp," a variety hitherto not believed to have been cultivated by the Commission. On their arrival on 4 January, it was found that only 19 of the carp were "of pure blood" and the remaining fish believed to be hybrids were destroyed (Cole, 1905).

Pond culture was found to be an effective way of producing young carp in quantity (McGovern, 1882) and, as early as 1880, several federal and state

hatcheries were put into service to meet the public demand for carp (Popov and Low, 1950; Zimmerman, 1904). Techniques for transporting carp were devised (McDonald, 1882) and young fish were distributed in vast quantities throughout the United States. Baird (1884) reported that by 1882 all resources of the Commission were taxed to meet thousands of requests for fish and that more than 15,000 ponds had been constructed to receive fish. Distribution was done partly by express, partly by special messenger, and by specially constructed railway cars which could carry as many as 20,000 carp across the continent. Goode (1887) wrote that "the acclimation of the Asiatic carp in America has been wonderfully successful."

Annual distributions remained high until about 1890 when they began to diminish with growing public disapproval of the species. Plantings were finally discontinued in 1897 by which time it was said that resident populations of the species had become abundant in virtually all suitable waters (Cole, 1905), a statement not entirely true.

Those carp reaching Canadian waters either by intentional introduction or by invasion from the United States would seem to have had their origin largely in those stocks imported initially from Europe by the United States Fish Commission, and reared by government and private hatcheries. Private agencies were selling carp to the public as early as 1883. It is conceivable that those carp populations now present in western Canada, particularly British Columbia, may be related to those fish of either Asian or European stock, reared and distributed initially by private and government interests in California and neighbouring states.

INTENTIONAL INTRODUCTIONS OF CARP TO CANADIAN WATERS

It must be recognized that information on early plantings of carp into Canadian waters is sparse and it is unlikely that all attempts at introduction, particularly in Ontario, were recorded in the published literature. Prince (1897) gave the impression that the Government of Canada assumed no responsibility for the establishment of carp in Canadian waters which is true to the extent that there are no records to indicate that carp were ever distributed from a Canadian fish hatchery. However, in the early years of American carp culture, the Canadian Government shared the enthusiasm of the United States Fish Commission and viewed favourably, at least until 1893, the importation of carp under private auspices and, on several occasions, with the assistance of persons in responsible fisheries positions in both the federal and provincial governments.

In 1880, young carp were distributed from the United States Fish Commission ponds in Washington to applicants in two Canadian provinces. On 10 June of that year a planting of 10 fish was made in the pond of Samuel and B. F. Reasor of Cedar Grove, York County, Ontario (MacKay, 1963). A second shipment was sent to W. H. Barber, Andover, New Brunswick.

In 1881, Samuel Wilmot (1882, 1882a), Superintendent of Fish Culture for Canada, sent a messenger to Washington where he obtained 100 carp from Rudolph Hessel. These fish were planted in the trout nursery ponds at the government-operated Newcastle Hatchery on Wilmot Creek of the Lake Ontario drainage (McCrimmon, 1956) with the expressed purpose of making "carp available for public distribution throughout the waters of Canada" including a number of Canadian rivers (Wilmot, 1882). The majority of the fish died during the following winter although a few survived and, by 1883, had grown to a weight of several pounds (Wilmot, 1887).

Wilmot had reared these fish with the hope "soon to see those waters deserted by the salmon now, stocked with a fish that will be welcomed to the poor man's table." In his report Wilmot stated that "demands for carp to stock waters in the Dominion are being frequently made" and "to meet these needs it will be necessary to improve the present ponds." However, the Newcastle Hatchery experienced water problems in 1885 and in his report for 1886, Wilmot was obliged to report that "in former years carp were handled in a small way at the Newcastle Hatchery with a view to their artificial propagation" but that the "nominal trials" had been discontinued "for the want of properly constructed ponds." He further noted that "it is extremely desirable that arrangements should be made at such of the nurseries as may be found to possess the greatest conveniences . . . especially as the demands are becoming numerous from persons in various sections of this country." There is no suggestion that this recommendation was ever acted upon.

The annual reports of the United States Fish Commission list the distribution of 100 carp to one applicant in Ontario in 1883. No further shipments were listed until the autumn of 1888 when 70 fish were sent from Detroit, Michigan, to Canada. However, it was stated in these reports as early as 1881 that "the numbers of carp were greater than recorded" and it is possible that other lots of fish were sent to applicants in Ontario. Also, carp were available from private establishments: the 1883 Bulletin of the United States Fish Commission stated that: "some private speculators have received carp from the U.S. Fish Commission and are now selling them at speculative prices." The U.S. Fish Commission Bulletin for the following year (1884) recorded an advertisement in the Pittsylvania Tribune of Chatham, Virginia, on September 6, 1884, offering 150,000 carp for sale at $5 per 100, or $20 for 500. Breeders were offered from $2 to $5 per pair. The Bulletin for 1885 recorded that a private hatchery in Georgia was selling 1- to 3-inch fish for 10¢ with graded prices reaching $2 each for fish of 12–20 inches. These data would seem to represent the general price structure under which Canadians could purchase fish from various private hatcheries. It is unlikely that carp purchased from private sources and planted in Ontario waters would be recorded.

Although without documentation, fragmentary "hearsay" information from local residents in the counties of York, Ontario, and Durham, would seem to indi-

cate that a number of mill ponds were stocked with carp during the 1880's or early 1890's, to the north and east of Toronto, on streams tributary to lakes Simcoe, Ontario, and Scugog drainages. The escapement of carp from Dykes Pond, York County, in 1896 (McCrimmon, 1956) was held responsible for the establishment of carp in Lake Simcoe (to be described later) while the appearance of carp in Lake Scugog is attributed to the washing out in 1916 of a dam holding back a pond called Browns Lake, in Durham County, which had been planted with carp sometime prior to 1900 (Smith, personal communication, 1966).

In the spring of 1891, Dr McCallum, a member of the Ontario Game and Fish Commission, arranged for the delivery of several hundred carp from Washington, D.C., some of which were placed in a private pond on the Grand River near Dunneville, and the remainder put directly into the river. In 1892 a second consignment of carp was received and planted by the local fisheries officer in the Upper Grand River "where it is believed that they will increase immensely, furnishing in the future a cheap article of food for the residents along the shores of that large river." The First Annual Report of the Ontario Game and Fish Commission stated that "several barrels of carp were taken this spring (1893) for the first time in seines in the Grand River below the dam . . . they are a very desirable food fish, growing and multiplying rapidly and your Commissioners this year have brought several hundreds and transferred them to the Grand River above the dam where there is a large body of water." The local fisheries warden reported that in 1893 he transferred 400 carp upstream from the commercial fishery at Scottsville and, as well, received a case of German carp from the United States Fish Commission which he also planted in the Upper Grand River. These plantings were noted also by Wilmot (1894) although Wright (1892) gave no cognizance of the species in Ontario.

These are the last plantings of carp in Ontario waters to be recorded and, also, the last time that the introduction of carp is viewed with enthusiasm in government publications. No further reference is made to the result of these plantings, presumably because of a growing condemnation of the species within both public and government circles.

In western Canada, only a few carp would seem to have been imported. On November 22, 1885, 100 six-month-old carp obtained from the Government Hatchery at St. Paul, Minnesota, were planted in ponds in Manitoba at Springfield, Portage la Prairie, and Minnedosa (McQueen, 1886). In 1886, the same unspecified person obtained more carp and placed them in the same vicinity as those planted the previous year. Late in the autumn of 1889, a further shipment of carp was received in Manitoba by the Inspector of Fisheries. These fish, obtained directly from the Government ponds at Washington, were planted in a millpond near Rapid City on the Assiniboine River, and in Lake Minnewasta near Glenboro in the southern part of the Province (McQueen, 1890). The United States Government reported that a further 100 carp were sent to the Inspector of Fisheries at Winnipeg, Manitoba, during the autumn of 1890.

In his report for 1889, McQueen (1890) stated that should carp hatcheries be established next year "the good work thus begun can be carried out on a more extensive scale, and it is hoped with fruitful results." In the following year he noted that "a number of applications have been received for carp . . . in western and southern Manitoba and the applicants were informed that no doubt the hatchery, when built, would meet these requirements." No further action would seem to have been taken which is explained perhaps by the waning enthusiasm for the species across North America during the early 1890's.

Carp are said to have been introduced into a swampy pond adjoining Glen Lake on Vancouver Island many years ago (Carl, et al., 1959). Until recently, there was a local population in this pond. Although no record of the planting has been located, most logically it occurred prior to 1897 when the distribution of carp by the United States Government was discontinued and its further spread actively discouraged by both the United States and Canadian governments.

Although Quebec and the Maritime Provinces were, with the exception previously noted, immune from attempts to introduce the carp, enthusiasm for the species existed in Prince Edward Island where it was stated by the Inspector of Fisheries for that Province in the Annual Report of the Department of Marine and Fisheries for 1884 that "the existing ponds in the Province, 22 in number more or less suitable for carp culture (besides 350 mill dams), cover an area of about 400 acres, or sufficient to render an experiment trustworthy . . . it is evidently the coming domestic fish and we Islanders would like to share in the benefits of its early introduction." This proposed introduction would seem not to have been attempted.

The first records of intentional introductions of carp into provincial waters and those of neighbouring states to the south are listed in Table II.

TABLE II. First recorded plantings of carp in the waters of Canada and neighbouring United States.

Location	Year	Location	Year
Canada		Pennsylvania	1879
New Brunswick	1880	Maine	1880
Ontario	1880	Michigan	1880
Manitoba	1885	Minnesota	1880
British Columbia		New Hampshire	1880
(Vancouver Island)	?	Vermont	1880
		Wisconsin	1880
United States		Montana	1881
Illinois	1879	Washington	1882
Indiana	1879		
New York	1879		

DISTRIBUTION OF CARP IN CANADA

British Columbia

The carp, now present in several watersheds of mainland British Columbia (Fig. 12) would seem to have had their origin in populations established in the Columbia River system in the State of Washington during the 1880's (Carl and Guiguet, 1958). The fish apparently moved into the Province through the Okanagan watershed about 1912 (Harris, personal communication, 1966). Whitehouse (1946) traced the likely route of the northward invasion of the carp up the Columbia River to Okanagan Lake through Osoyoos Lake, the Okanagan River, and Skaha Lake. A population of carp was first documented for Okanagan Lake in 1917 (Clemens, et al., 1939) and reached a peak in early abundance about 1934 when some 7 tons were removed by a trap set at the outlet of the lake. Dymond (1936) reported that by 1935 carp were not uncommon in the shallower parts of the lake, a number of small specimens being seined at the northern end of the lake and many larger ones being seen at the foot of Okanagan Falls. He noted their presence also in Kalamalka, Woods, and Shuswap lakes.

Carp were reported from the Fraser River watershed first in 1928 when specimens were taken in the Shuswap Lake region of the South Thompson River near Armstrong (Carl et al., 1959). They noted their presence also in Kalamalka,

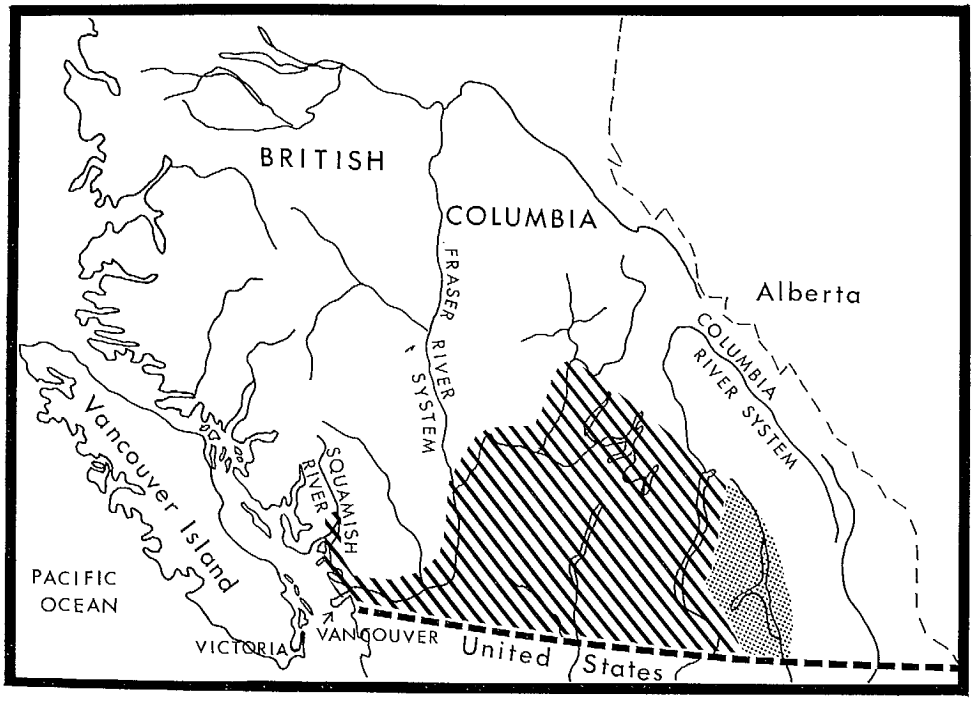

FIG. 12. The known distribution of carp in British Columbia waters (1967).

Woods, and Shuswap lakes. It is believed locally that the carp crossed from the headwaters of the Columbia River to those of the Fraser River by means of irrigation ditches or flooded creeks where the divide separating the two watersheds is of low elevation. From Shuswap Lake, there was an apparent movement of the species downstream with carp being reported at Popkum Creek near Chilliwack in 1939, in Hatzic Lake in 1944, and at Point Grey in brackish water in 1946 (Carl et al., 1959). Lindsey (personal communication, 1966) provided authentic records of further captures of carp from the lower Fraser River at the mouth of the Vedder River and Deas Island Slough.

Information on the appearance of carp to the east of the headwaters of the Fraser River has been made available by Lindsey (personal communication, 1966) for Kootenay Lake 3 miles north of Kaslo, and for Shannon Lake about 8 miles west of Kelowna. Wilde (personal communication, 1967) recalls observing large fish which may have been adult carp about 1960 at the south end of Kootenay Lake, near the Canadian Pacific Railway tressel over the Kootenay River south of Kuskonook. However, the carp, if now present in the Kootenay watershed, is at a population level too low to have been recognized by fish and game management personnel (personal communications in 1967 with Harris, Sinclair, and Vernon).

Lindsey (personal communication, 1966) has also documented the recent appearance of carp some 3 miles upstream in the Squamish River on Howe Sound. It is probable that carp reached this watershed by moving northward through the brackish waters of the Pacific ocean off Vancouver from the estuary of the Fraser River.

A population of carp resident in Glen Lake on Vancouver Island for many years is believed to have been the result of the escapement of fish planted in a swampy pond more or less linked to Glen Lake by drainage ditches (Carl et al., 1959). There is some suggestion that these fish were imported from Oregon as it was reported at about the same time that bullheads, *Ictalurus nebulosus,* were brought in from that State (Carl, personal communication, 1966). The Glen Lake carp population is believed to have been eradicated by poisoning with rotenone in 1961 (Vernon, personal communication, 1967).

Alberta

Although substantial populations of carp are present in neighbouring waters to the south, east, and west of Alberta, there is no evidence that carp are now resident in any waters within the provincial boundaries (Paetz, personal communication, 1966), although they are in adjacent waters of the Saskatchewan River system.

Saskatchewan and Manitoba

Because of the occurrence of carp in parts of the Nelson River watershed lying within both provinces, the distribution of carp within Manitoba and Saskatchewan is reviewed jointly with respect to this watershed.

The earliest acceptable record for the presence of carp in Saskatchewan is from the Missouri watershed in the southwest corner of the Province (Table III). Atton (1959) recorded that there was a population of this species in the Frenchman River, a tributary of the Milk River, as early as 1921. The failure of this carp population to expand geographically since that time would seem to be explained by the general lack of permanent waters and a semi-arid landscape to the north and east.

TABLE III. First documentation of resident carp populations in the waters of the Canadian provinces.

Province	Location	Year
British Columbia		
Vancouver Island	Glen Lake	1900 (approx)
Mainland	Okanagan Lake	1917
Alberta	–	–
Saskatchewan	Frenchman River	1921
Manitoba	Red River	1938
Ontario	Grand River	1910
New Brunswick	–	–
Nova Scotia	–	–
Prince Edward Island	–	–
Newfoundland	–	–

In spite of plantings of carp in Manitoba in 1885, 1886, and 1889, there is no indication of their success in establishing permanent populations, and Hinks (1943) stated that carp were unknown in Manitoba until 1938. The Royal Commission on Fisheries (Anonymous, 1947) stated that unverified reports had been received of the occurrence of carp in streams south of the Cypress Hills area of Saskatchewan.

The initial occurrence of carp in the Nelson River watershed of Manitoba would seem to be the result of an invasion from the bordering states of North Dakota and Minnesota. Atton (1959) noted two possible points of access to the Nelson River system from the headwaters of the Mississippi River where a major commercial fishery for the species was in existence prior to 1900 (Carlander, 1954). One of these points was between the Minnesota River (Mississippi drainage) and Big Stone Lake (Nelson drainage); the other between the headwater of the James River (Mississippi system) and the Red River in North Dakota. The possibility of the intentional or accidental transfer of carp by man cannot be overlooked. The first recorded appearance of the species in the Canadian waters of the Nelson River system was in the Red River at Lockport, Manitoba, near the international boundary in 1938 (Hinks, 1943) and shortly thereafter in Lake Winnipeg.

Scattered reports attest to the gradual spread of carp through the Nelson River system. Although carp would be expected to be locally resident for an unknown time in advance of reports of its appearance, it is of interest that the chronological relationships of first records define a northward spread of the species through the Nelson River system. A specimen was taken in the Winnipeg River in 1943 (Hinks, 1943), from the Mukutawa River near the north end of Lake Winnipeg in 1954 (Keleher, 1956), from Cross Lake on the Nelson River, north of Lake Winnipeg, in 1956 (Keleher and Kooyman, 1957), and from Split Lake, farther downstream on the Nelson River, and north of the rail line to Hudson Bay, in 1963 (Doan, personal communication, 1966). The single specimen taken from Split Lake is the most northerly record for the distribution of carp in North America. Doan (personal communication, 1966) has pointed out that this fish of 6 lb was taken in a commercial gill net, in a "poor thin" condition, and identified by L. Sunde, a biologist.

On the Assiniboine River watershed, the presence of carp was first documented in 1948, at Virden, in the extreme southwest part of Manitoba. In 1953, young-of-the-year carp were found at Kamsack within the Saskatchewan border (Atton and Johnson, 1955) and, in 1954, carp were collected in the Qu'Appelle River. In 1955, a specimen was reported at Pasqua Lake (Atton, 1959). Since 1958, the carp has made an appearance in Last Mountain Lake of the Qu'Appelle area (Johnson, personal communication, 1966).

On the Saskatchewan River watershed, carp populations have become evident since 1958 in the South Saskatchewan River near Saskatoon, in the North Saskatchewan and Shell rivers near Prince Albert, Saskatchewan, and The Pas, Manitoba (Doan, personal communication, 1966; Johnson, personal communication, 1966). Although Atton (1959) did not record the presence of carp in either the North or South Saskatchewan rivers, he noted the possibility of the movement of fish from the Qu'Appelle headwaters to the South Saskatchewan River at Aiktow Creek and it is a matter for conjecture if carp reached the Saskatchewan rivers by this route. Other recent appearances are in the Swan and Red Deer rivers and in Namew Lake flowing into Cumberland Lake and the Saskatchewan River (Johnson, personal communication, 1966).

Among the larger inland waters, carp were first present in Lake Winnipeg shortly after 1938, Lake Manitoba by 1948, Lake Winnipegosis by 1954, Lake Dauphin by 1955, Playgreen Lake by 1958, Cedar Lake by 1959, and Split Lake by 1963 (Doan, personel communication, 1966).

The comparison of a map prepared by Atton (1959) showing the 1957 distribution of carp in Manitoba and Saskatchewan with that presented in this paper (Fig. 13) shows a striking extension of the range of the species in both a westerly and northerly direction. Although inadequate sampling may affect the reliability of a valid comparison of the two distribution maps, it would seem that the carp population of Manitoba and Saskatchewan continues to increase in both range and abundance. Symington (1959) listed the carp as the most notorious of the fish now in Saskatchewan.

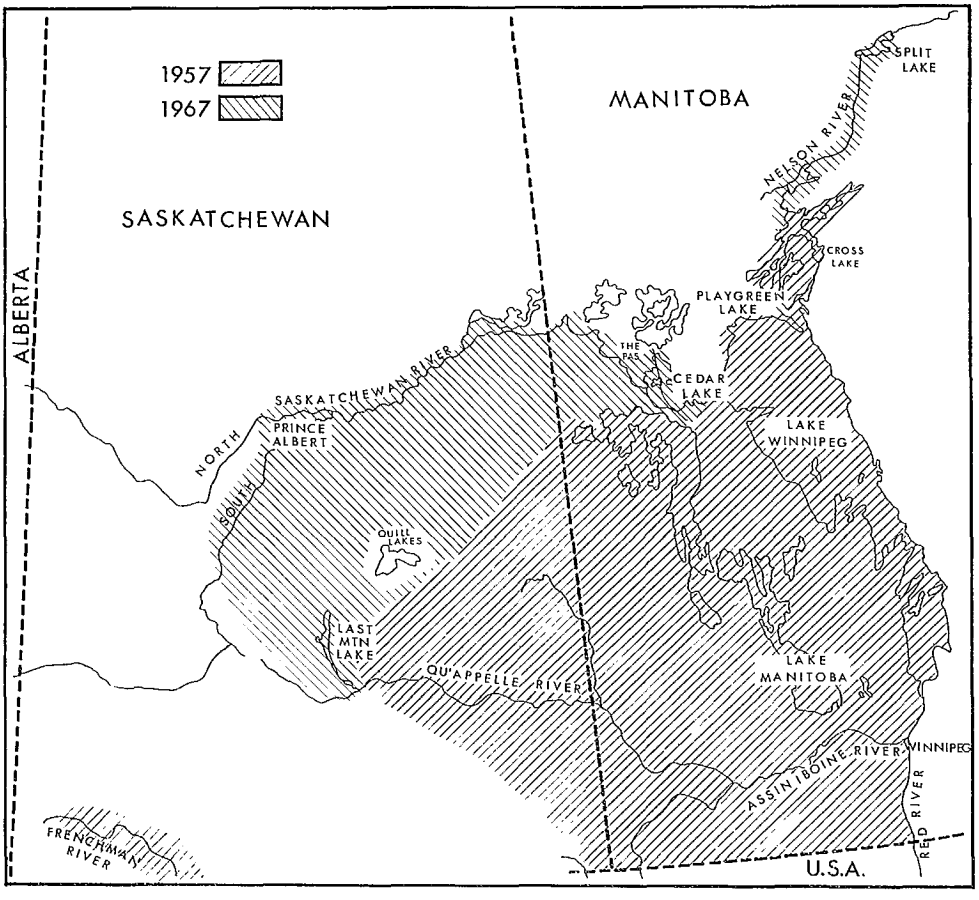

FIG. 13. The known distribution of carp in Manitoba and Saskatchewan (1957 and 1967).

ONTARIO

The spread of carp through Ontario waters is shown in Fig. 14 and is based on known local populations of the species in 1900, 1910, and 1920. The known 1967 distribution is shown in Fig. 15. Because of the extent of the population of the species in Ontario, its distribution is described essentially on a regional basis.

Lakes Erie and St. Clair. The first authentic record of the capture of a carp from Lake Erie would seem to be that of a 3¾-lb fish taken by a commercial fisherman from the Raisin River in Michigan waters in December 1883 (Smiley, 1886). It must be assumed that carp became established about the same time in the favourable habitat offered by the adjacent Canadian waters at the western end of Lake Erie and in Lake St. Clair. The origin of these fish is unknown. However, plantings were made by the Ohio Fish Commission in the Sandusky River

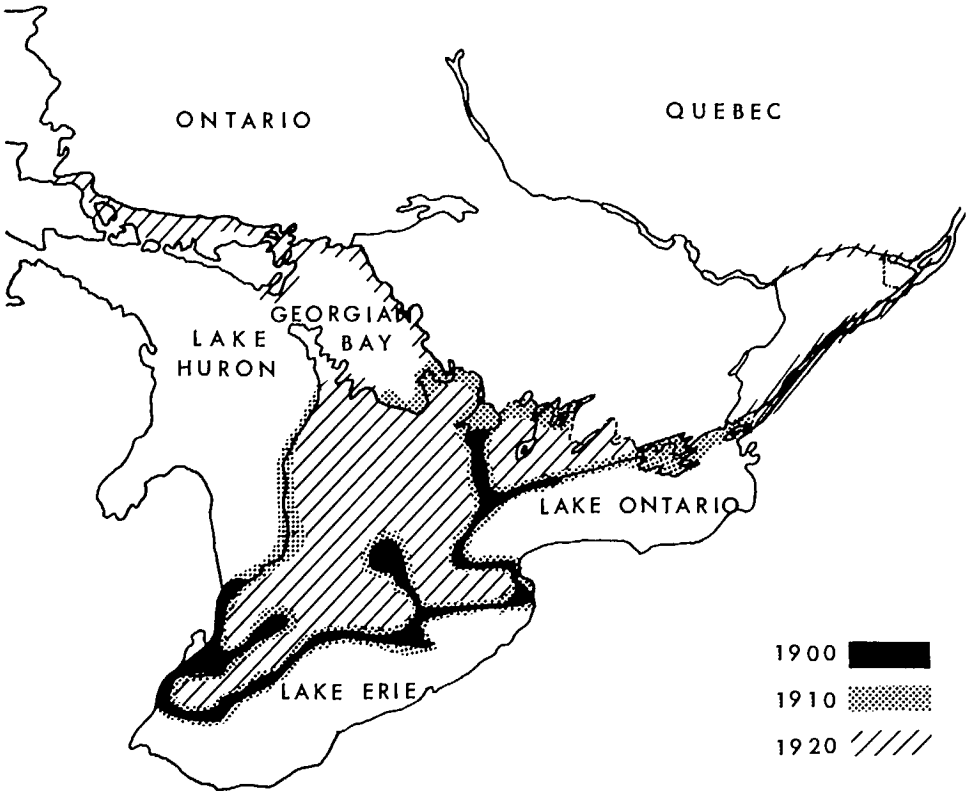

FIG. 14. The spread of carp through Ontario waters based on recorded carp populations in 1900, 1910, and 1920.

during November 1879, and in the Maumee River, Ten-mile Creek, and near Kelley's Island "in the midst of a whitefish breeding ground" during the spring of 1881 (Smiley, 1886). Various plantings were made in natural and impounded waters of Michigan during the 1880's (Peterson and Drews 1957) and in the waters of Erie County, Pennsylvania, as early as 1880.

A major commercial carp fishery had developed on the United States side of both of these waters by 1886 (Smiley, 1886) and by 1900 the species was abundant in the west end of Lake Erie (Kirsch, 1894; Osborne, 1901; Evermann, 1902) but, because of the grouping of carp with coarse fish species in the Canadian catch statistics of that period, no specific reference to commercial harvests of carp from the Ontario waters of either lake occurs until a later date. However, Bean (1892) included carp among the fauna of the western end of Lake Erie previous to 1892 at which time it was present in the lower part of the Grand River watershed at Dunnville (Wilmot, 1894). Smith (1904) stated that by 1900 "with the probable exception of the Illinois River, no body of water appears to be so well stocked as Lake Erie."

Prince (1897) was of the opinion that the carp had wandered across into the Canadian waters of western Lake Erie from its "American haunts" without making mention of the part which private plantings in Ontario waters may have had in the spread of the species. Nash (1908) listed the carp among Ontario fishes but failed to attempt an account of its distribution although deploring its introduction into North American waters. However, Evermann and Goldsborough (1908) in their substantial checklist of Canadian freshwater fishes did not mention the presence of the carp in Canada.

The population of carp which had become established in Lake Erie at the mouth of the Grand River by 1892 would seem to be the result of those plantings in the Grand River as previously described. It is also likely that the presence of carp first reported in the annual reports of the Ontario Government for Long Point Bay in 1893 and along the Ontario shoreline at Port Maitland, Port Colborne, and the upper Welland Canal prior to 1900, had the same origin although there is the possibility that these fish emigrated from American waters as concluded by Prince (1897).

Carp were first reported from Rondeau Bay in 1897, became abundant by 1900, and would seem to have either moved westward along the Lake Erie shore from Long Point Bay, or eastward from the extreme western end of the lake. There is no doubt that, prior to 1900, substantial populations of carp occupied the many favourable habitats along the Canadian shore of Lake Erie from the upper Niagara River to, and including, Lake St. Clair and the St. Clair and Detroit rivers, and up the Lake Huron shore to the vicinity of Southampton. The species soon became one of the more common in Lake Erie (Fish, 1932).

Lake Simcoe and Trent Canal System. The escapement of carp in 1896 from Dykes Pond, York County, resulted in the immediate establishment of a population of young and adult carp in the Holland Marsh and Cook's Bay of Lake Simcoe (McCrimmon, 1956). By 1899, the local overseer reported that large numbers of carp were to be seen in the extensive inundated areas of the Holland Marsh each spring and by that time were being sold in quantity to waiting buyers. By 1900, the marsh abounded in carp and in the next few years thousands of fish were taken by spears and nets (Collins, personal communication, 1952).

By 1902, carp had made an appearance in marshy bays along the north shore of Lake Simcoe and had invaded the shallow waters of Lake Couchiching to the north. From the north shore of Lake Simcoe, the dispersion of carp proceeded northwestward towards Georgian Bay, and eastward towards the Kawartha Lakes.

Bensley (1916), in discussing the distribution of carp within Georgian Bay, stated that they appeared first in the bays around the mouth of the Trent Canal and, by 1907, carp as large as 10 inches were becoming numerous. While Bensley associates the origin of carp in Georgian Bay with a movement of the fish through the Trent Canal from Lake Simcoe, he does not overlook the possibility of invasion from another source.

The eastward spread of carp through the Trent Canal system from the Brechin–Gamebridge area of Lake Simcoe has been documented by an analysis of the annual reports of local overseers. By 1910, carp had become numerous in the drained land of the Canal as far as Bolsover and Kirkfield. In 1913, a catch of 31 tons was taken from the lift-lock at Peterborough, and the Government was being petitioned to undertake carp removal from Balsam, Cameron, and Sturgeon lakes. By 1915, the presence of carp had become evident in most of the waters of the Kawartha Lakes to which it had direct access from the Canal system.

The appearance of carp in Lake Scugog has been attributed to the escape of carp in 1916 from Browns Lake, a pond on East Creek in Cartwright Township, Durham County, then heavily populated with the species (Smith, personal communication, 1966). The date of the appearance of carp in Lake Scugog, which offers one of the better habitats for the species in Ontario, coincides also with the gradual spread of the fish through the Trent canal system of which it is a part.

Lake Ontario. A review of the limited information on the early presence of carp in the Canadian waters of Lake Ontario, recorded in the annual reports of overseers in the annual reports of the Ontario Department of Game and Fisheries, suggests that a nucleus of dispersion was located at the western end of the lake. The likely origin of these stocks would seem to be the waters of New York State where Smith (1892) reported the presence of carp as early as 1890 following plantings in Lake Ontario and the accidental escape of fish with the breaking of dams on tributary streams. He noted further that the species "appears to thrive well in the cold clear waters of the lake and some five examples have been caught by net fishermen."

Carp were first reported in the vicinity of Toronto in 1901 and 1902 and would seem to correlate with earlier plantings in ponds on the Humber and Don River watersheds previously described. By 1905, carp were abundant in most of the river mouths and bays of the western end of the lake from Toronto to the lower Niagara River and complaints of their damage to local habitat were becoming commonplace.

Carp were not reported until 1907 at the eastern end of Lake Ontario at which time the species was noted off Barriefield at the entrance to the St. Lawrence River where, by 1909, small carp were being caught by local fishermen in the vicinity of Barriefield, Kingston, and Wolfe Island. Also in 1907, carp were noted in the bays of Prince Edward County. They were generally distributed along the shore from Brighton to the Bay of Quinte, and to the Upper St. Lawrence River by 1909, reaching "nuisance proportions" by 1911.

The appearance of carp in the eastern end of Lake Ontario and the Upper St. Lawrence River can be associated chronologically and geographically with three possible origins: firstly, an easterly movement of the fish along the Lake Ontario shoreline from the Toronto area; secondly, an invasion through the Trent Canal system from Lake Simcoe, previously described; and, thirdly, from plantings

made in New York State as early as 1879. Although the early distribution of carp in the United States waters of New York State is poorly documented, (Evermann and Kendall, 1901; Smith, 1892), Reed and Wright (1909) reported that carp had been known to inhabit Cayuga Lake since 1889. As Cayuga Lake drains into the eastern part of Lake Ontario through the Oswego River, the possibility of invasion from that watershed exists.

Available evidence is adequate to conclude that the carp became resident, and continued to thrive, in virtually all suitable locations along the Canadian shoreline of Lake Ontario from the Niagara to the St. Lawrence rivers during the first decade of the 20th Century.

Carp populations currently occur in the Ottawa River as far upstream as Ottawa. These populations are concentrated principally in the mouth of the Nation River, Windsor Bay, Azatika Bay, L'Orignal Bay, Lake George, Lake George Creek, and the recently constructed Carillon impoundment (Thurston, personal communication, 1966).

Lake Huron, Georgian Bay, and North Channel. The distribution of carp within Georgian Bay is believed locally to have originated in the extensive marshes adjacent to the mouth of the Trent Canal in the area of Green Island, Waubaushene, and Sturgeon Bay. Carp were first noticed in 1905 and by 1907 small carp up to 10 inches in length had become abundant in Matchedash Bay when the first commercial fishery began (Bensley, 1916). Specimens taken by Capt C. J. Swartman were chiefly of the scaled variety although both mirror and leather carp appeared in the catch. The fishery remained minimal until 1915 after which time it increased in intensity (Boyd, personal communication, 1966).

From the general area off the entrance of the Trent Canal, the carp would seem to have moved along the Georgian Bay shore in both a clockwise and anti-clockwise direction. To the west, carp were first noted by the local overseer in 1909 as far as Meaford Harbour, but it was not until 1915 that they were recorded for Owen Sound Bay. Since that time carp have failed to become numerous up the shore of the Bruce Peninsula. To the north and west of the Trent Canal entrance, the carp gradually occupied the back-bays reaching Honey Harbour by 1908 or 1909, Parry Sound by 1912, and the North Channel by 1914 when the first commercial catch was recorded there.

In view of the preponderance of Precambrian rock, the present distribution of carp in the waters of Georgian Bay is limited generally to numerous relatively small and isolated weedy bays along the inside of the Bruce Peninsula and in the region of the 30,000 islands fronting the districts of Parry Sound and Sudbury. These isolated areas, however, may harbour substantial local populations of the species. The major concentrations of carp occur in Inner Georgian Bay fronting Simcoe County where there are considerable areas of favourable marsh habitat.

In the North Channel, carp are typically rare or absent from the shoreline of Manitoulin Island although a commercial fishery exists at Little Current, at

Sheguiandah Bay at the eastern end of the Island (Hamilton, personal communication, 1966), and carp have been reported in South Bay. Although an ideal habitat would seem to be available for carp, the species is not known to occur in the inland lakes of Manitoulin Island in spite of extensive studies of these waters (Harvey, personal communication, 1966). Isolated populations of carp are distributed along the north mainland shore of the North Channel with the greatest abundance in the vicinity of Spanish.

In Lake Huron, the northward spread of carp along the Ontario shoreline from the St. Clair River is not well documented. From an analysis of local overseer reports (Annual Report of the Province of Ontario, 1899–1937) carp were unquestionably present at the entrance to the St. Clair River as early as 1900 and were recorded as far north as Southampton in 1915. Carp are presently distributed along the shoreline fronting Lambton, Huron, and Bruce counties and occur northward to the tip of the Bruce Peninsula. Although carp are scattered along the shoreline wherever suitable habitat is available, significant concentrations occur only off Lambton County and in the mouths of the major rivers including the Sauble at Grand Bend, the Maitland at Goderich, the Penetangore at Kincardine, and the Saugeen at Southampton.

The origin of the carp which invaded the Canadian waters of Lake Huron would seem to have been the St. Clair River and these fish were most logically the progeny of those carp, planted in the inland waters of Michigan State between 1881 and 1897 (Peterson and Drews, 1957) which had become firmly established in the waters of Lake St. Clair and the St. Clair River prior to 1900. The northward movement of carp from Lake Michigan into Lake Huron and the North Channel is perhaps a possibility as commercial catches of the species were reported for southern Lake Michigan fronting the states of Michigan, Wisconsin, Illinois, and Indiana as early as 1899 (Baldwin and Saalfield, 1962).

Lake Superior. Because of the local use of the word "carp" to describe species other than *Cyprinus carpio* in northwestern Ontario, any records of carp in the commercial returns for Lake Superior and several inland lakes require scrutiny.

The first records with possible authenticity for the carp in Lake Superior appear in the annual reports of the Ontario Department of Game and Fisheries when carp specimens were noted for Rossport in 1915, and in the Thunder and Terrace Bay areas in 1922. However, it was not until 1948 that a positive identification was made of a carp taken from the lake, when a specimen taken at Batchawana Bay, west of Sault Ste. Marie, was identified at the Royal Ontario Museum of Zoology (Scott, personal communication, 1966).

The presence of carp along the northwest shore of Lake Superior was unquestionably confirmed in 1953 when a specimen was taken at the mouth of the Naki River on Lake Helen. Ryder (personal communication, 1966) subsequently observed adult fish in the same locality in a lagoon off the Nipigon

River, at the townsite of Nipigon, in May of 1956 and 1957. Elsey (personal communication, 1966) likewise reported the presence of carp in the proximity of Nipigon.

Identified specimens were taken from Thunder Bay, fronting Port Arthur and Fort William, in 1954 and 1955 (Ryder, personal communication, 1966). Sleeman (personal communication, 1965) stated that carp were common at the mouths of Kaministikwia, McIntyre, and McVicar's creeks, the presence of sewage effluents in the latter two creeks appearing to attract carp to these waters (Elsey, personal communication, 1966). The probability that carp may be generally distributed in the shallower backwaters of Thunder, Black, and Nipigon bays between Fort William and Simpson Island is strengthened by the casual references of commercial fishermen to their presence there.

The source of the carp population present in the Canadian waters of Lake Superior is not known although the prevalent belief locally is that the species was accidentally introduced when used by anglers as a bait fish. However, it should be noted that a planting of carp was made at Duluth in 1889 which Moyle (personal communication, 1966) believes failed to establish a population in either the Duluth area or within the Great Lakes watershed of Minnesota. The possibility that some of these fish, or possible progeny, may have migrated into the Canadian waters of Lake Superior cannot be ignored.

Among these states bordering on Lake Superior, there is no record of carp in that watershed in Minnesota (Surber, 1966), in Wisconsin (Moraz and Copper, 1957) where its northern distribution would seem to approximate the 55 F isotherm (Drubschba, 1959), nor in Michigan (Peterson and Drews, 1957). However, young carp were introduced into the warmer waters of each of these states as early as 1879 (Table II) and the possibility of carp reaching the Lake Superior watershed cannot be ruled out.

Other Inland Waters. The distribution of carp within Ontario waters, other than those previously specified, is limited essentially to a number of small lakes, impoundments, and sluggish stream areas within agricultural southwestern Ontario to the south of the Precambrian Shield (Fig. 13). Here carp, although often abundant enough to attract public attention, are seldom present in adequate numbers to warrant profitable commercial fishing operations.

The results of a questionnaire completed by personnel in all forest districts of the Ontario Department of Lands and Forests revealed no evidence of the presence of carp in any of the inland waters of northwestern Ontario, including Rainy Lake and Lake of the Woods, were the fish listed in the latter lake as carp in the annual commercial fishing records is typically the quillback carpsucker, *Carpiodes cyprinus* (Chambers, personal communication, 1966). Neither is there any record of carp from the inland waters north of Lake Superior, including Lake Nipigon, although carp are present in the lower Nipigon River. Carp are reported to be absent from the northern tributaries of Georgian Bay, including Lake Nipissing, although present in the lower French River draining the lake,

but there are isolated populations present in Manitouwabing Lake (McKellar Township) and Mill Lake (McDougall Township) within the Parry Sound District. Carp were apparently introduced into the former water by an early settler, possibly before 1900, and probably the species subsequently moved downstream into Manitouwabing Lake (Adamson, personal communications, 1966, 1967). Those waters north of the Trent Canal system are reported to be without carp except for isolated lakes including Elsie Lake in Minden Township, Wilbermere Lake in Monmouth Township, and Horseshoe Lake in Glamorgan Township (Waldroth, personal communication, 1966). The absence of a known population of carp in the central part of this Rideau Canal system is of interest as populations are present at both ends of the waterway.

QUEBEC

Published information on the introduction and present distribution of carp within the waters of Quebec is generally lacking. The species was not recorded by Evermann and Kendall (1902) in their annotated list of the fishes of the St. Lawrence River nor by Chambers (1914) or Legendre (1953) in their accounts of the fishes of Quebec, nor did Dymond (1936) mention the carp among the fishes of the Ottawa River. The first recognition of the presence of carp in Quebec waters would seem to be that of Melancan (1936) although absolutely no details were given on its distribution. Jean (personal communication, 1967) has explained the lack of information on the species by the fact that *C. carpio* is of such low commercial value that practically no observations have been made on the species.

Vladykov and McAllister (1961), however, in their list of the marine fishes of Quebec, without giving details of its distribution, recorded that the carp was a freshwater fish being found seaward to Rivière-du-loup (110 miles below Quebec City) where Vladykov (personal communication, 1966) personally has seen carp up to 10 lb in weight. Bergeron (personal communication, 1966) reported commercial catches of carp from the estuary of the Kamouraska River, some 35 miles upriver from Rivière-du-Loup.

Recent enquiries by Courtemanche (personal communication, 1966) revealed that carp have been present in the Montreal area of the St. Lawrence basin as early as 1910. An elderly commercial fisherman, Napoleon Lalumière, reported that at that time small carp began to appear in the nets of Lac Saint-Louis commercial fishermen. The appearance of these fish in the Quebec waters of the St. Lawrence River fits in appropriately with the first records of carp in adjacent Ontario waters of the river between 1907 and 1909. In view of the extensive commercial fisheries in both the Quebec and Ontario waters of the St. Lawrence River, it is likely that the presence of carp was detected soon after their arrival, particularly because small and, presumably, young carp were first caught. The chronological order of the first appearance of carp in the upper St. Lawrence River suggests also a downstream movement in range.

Because of the general suitability of the habitat in those lakes formed by the St. Lawrence River at Montreal, including Saint-François, Saint-Louis, and Deux-Montagnes, it is most probable that carp populations were more or less simultaneously established in these waters about 1910 and have thrived there since that time. Cuerrier et al. (1946) listed carp as being numerous in the area.

The presence of carp in the Ottawa River would seem to be more recent. Courtemanche (personal communication, 1966) related information provided by a commercial fisherman, Fernand Schryer, that he and his father first saw carp at Pointe-au-Chênes, approximately 50 miles above Montreal, in 1941. Carp appeared later further upstream at Papineauville and were first seen at Pointe Gatineau, south of Hull, in 1944. In each case, only small fish under 4 lb were taken, suggesting that a new population was being established. These data support the work of Dymond (1936) who apparently did not find carp to be present in the Ottawa River at the time of his study. The construction of the Carillon Dam, near Pointe Fortune, and just inside the Ontario border, has created a major impoundment with favourable habitat for carp in both Ontario and Quebec areas of the water.

The time of establishment of carp populations in the St. Lawrence River below Montreal has not been documented. It is of interest, however, that Dr J.-R. Mongeau (Courtemanche, personal communication, 1966), a native of Chenal-du-Moine, has advised that the carp was unknown in the Sorel area (about 50 miles below Montreal) as recently as 1924. No confirmation has been found of the presence of carp in the St. Lawrence River below Lac Saint-Pierre previous to 1940, after which time the capture of specimens was reported occasionally in commercial fishery returns and in biological survey records from various locations near the mouths of tributary streams. Records of the presence of carp in the lower St. Lawrence River during the 1940's would seem to reflect improved statistics and more intensive biological inventories, not necessarily a sudden invasion by the carp. However, it is probable that the species was a recent resident in view of its previous absence in commercial fish catches in heavily fished waters.

Because of the possible invasion of Quebec waters from those United States waters to the south, a review of the introduction and distribution of carp in the adjoining states of Vermont, New Hampshire, and Maine, is of interest.

Within the state of Vermont, the biennial reports of the Fish and Game Department record extensive plantings of scaled and mirror carp between 1883 and 1886 in a number of waters including the Lake Champlain and Lake Memphremagog watersheds and the Upper Missessquia and Connecticut River systems (Evermann and Kendall, 1902; Greeley and Greene, 1931). In spite of this major attempt at a general introduction of the species to Vermont waters, only Lake Champlain among those waters adjacent to the International Boundary is now known to support a population of carp (MacMartin, personal communication, 1966). Carp from Lake Champlain, however, have direct access into Quebec through the Richelieu River.

In New Hampshire, carp were first planted in 1881 and, as a result of a planting made in 1883, became established in a few widespread locations (Morrison, personal communication, 1966). Carp are currently present in Mascoma Lake and the lower Connecticut River, and in the Merrimack River, at least as far north as Concord, but not in the northern stretches of the river. There is little likelihood that carp populations were established in Quebec by movement from Vermont waters.

In Maine, a number of plantings of carp were made in privately owned ponds between 1880 and 1896 but most of these were unsuccessful in establishing populations of the species. Foye (personal communication, 1966) states that carp are presently known to occur within the State only in the waters of Merrymeeting Bay, Scarboro Marsh, and a small freshwater pond on the Kennebec drainage. Because of the location of these populations in the extreme southern part of the State, they must be considered geographically isolated from any waters of Quebec. Everhart (personal communication, 1966) considers a major factor in the limited distribution of carp in Maine to be the presence of dams blocking upstream migration rather than a lack of suitable habitat.

Excluding the possibility of intentional or accidental introductions of carp into Quebec waters, it would seem likely that those carp now present in the St. Lawrence drainage migrated there from either or both of two locations; namely, the upper St. Lawrence in Ontario and New York State, and Lake Champlain through the Richelieu River. In order to reach locations on the lower St. Lawrence River from which specimens have been taken, carp migrating downstream must pass through brackish or saline waters.

New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland

Among the provinces of the east coast, a planting of carp is recorded only for New Brunswick in 1880 and was apparently unsuccessful in establishing a population of the species (Table II). Published works on fish distribution (Livingstone, 1954; Scott and Crossman, 1959, 1964) do not recognize the presence of carp in any of the above-mentioned provinces. Personal communications in 1966 with biologists familiar with the waters of these provinces (Bartlett, Legare, Prime, Smith, and Taylor) failed to reveal any positive or likely records of carp.

Although there is a possibility that unrecorded plantings may have been made in these provinces, there is no evidence to suggest that carp populations were ever resident within the waters of New Brunswick, Nova Scotia, Prince Edward Island, or Newfoundland.

Range in Canada

The range of the carp in Canada (Fig. 15) extends eastward from Vancouver Island at 120° long to the lower St. Lawrence River in Quebec at 70° long. The distribution is not continuous, the species being unrecorded from Alberta

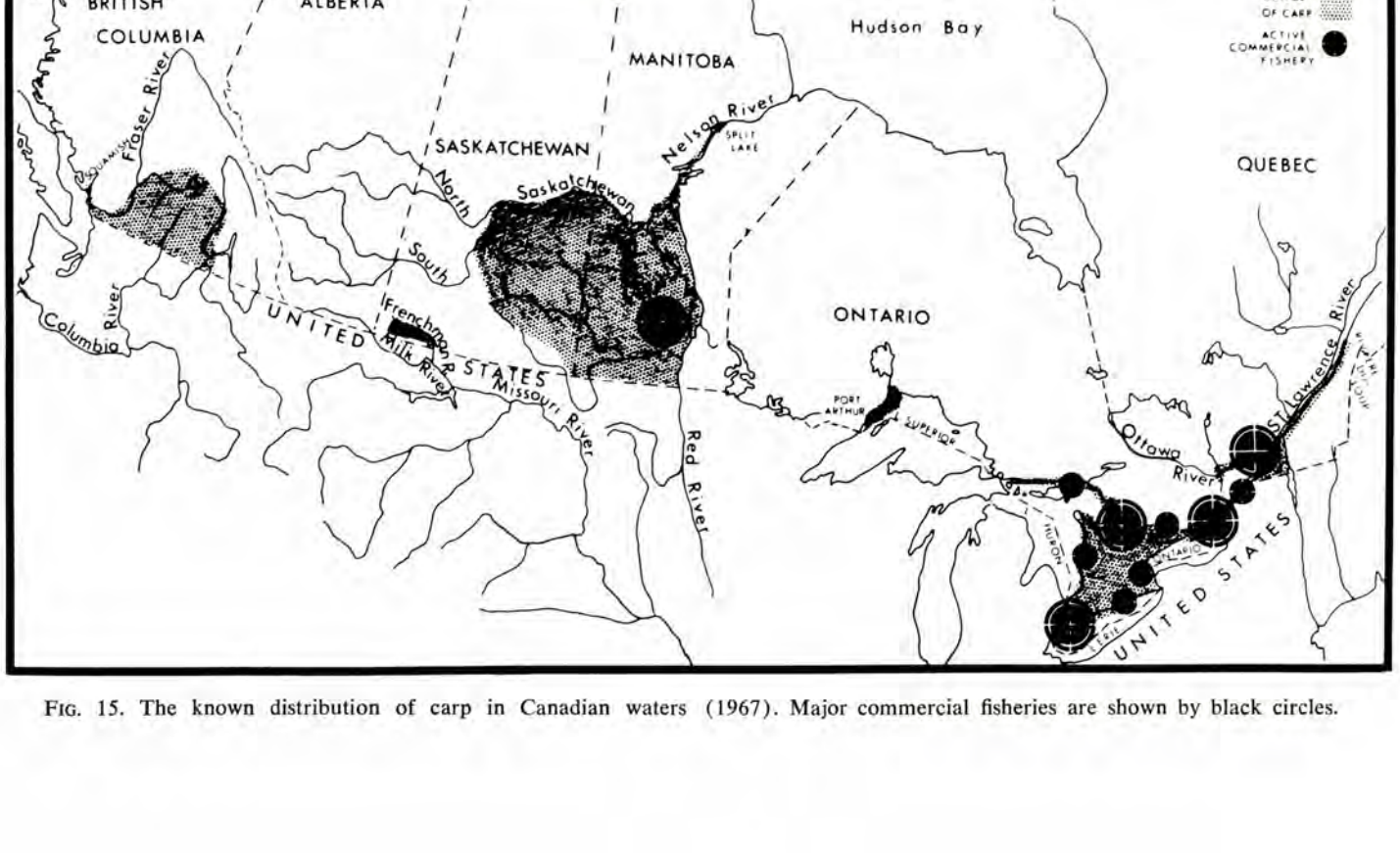

FIG. 15. The known distribution of carp in Canadian waters (1967). Major commercial fisheries are shown by black circles.

and from that area of Manitoba and Ontario lying between Lake Winnipeg and Lake Superior. The species is typically present southward of, or approximate to, international waters, the most southerly occurrence being in southern Ontario at 42°N lat. The most northerly record is that from Manitoba at 65°N lat. Although areas of carp abundance in Ontario are restricted more or less to below the 45th parallel, substantial populations have been established in waters of the Prairie Provinces at least as far north as the 53rd parallel.

An analysis of the present limits in the range of the carp indicates that natural or artificial barriers generally pose a deterrent to a further invasion of Canadian waters through the natural movement of the carp. However, within the natural or impounded waters of all provinces are habitat conditions which would be expected to support populations of carp if introduced intentionally or accidentally into these waters. The westward expansion of the carp population of the Prairie Provinces into Alberta would seem likely if the gradual expansion of the population through the Saskatchewan and Assiniboine River drainage continues. A natural invasion of the waters of the Maritime Provinces would seem remote.

Within the Canadian range shown in Fig. 16 are numerous isolated waters without carp populations. For example, even in southern Ontario where the present distribution of carp was more or less established by 1920, the species is

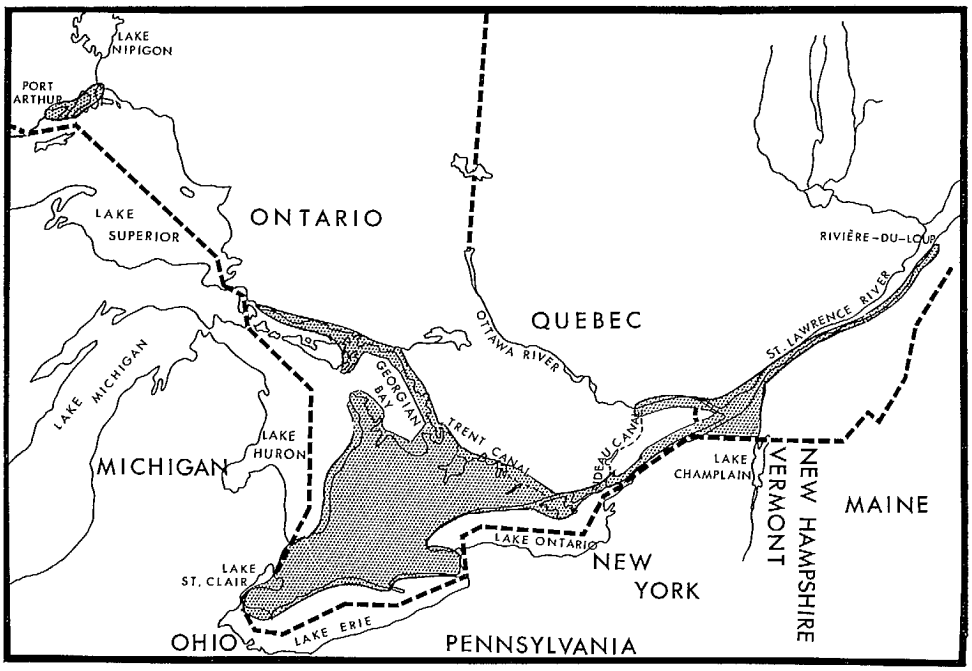

FIG. 16. The known distribution of carp in Ontario and Quebec (1967).

absent from a number of isolated smaller waters, farm ponds, other impoundments and, also, from the central part of the Rideau Canal system to which the species has direct access from both the northern and southern ends through the canal locks.

Of interest is the apparent movement of carp within saline waters on both the east and west coasts, namely, down the St. Lawrence to Rivière-du-Loup and the Kamouraska River, up the British Columbia coast northward to the Squamish River. In both cases, however, salinities decrease substantially with the large volume of fresh water discharged under flood conditions from the Fraser and St. Lawrence rivers, respectively. Vladykov (personal communication, 1966) has advised that the St. Lawrence River as far downstream as Rivière-du-Loup becomes seasonally brackish with a salinity reaching as low as 2000–4000 ‰ of chloride during spring runoff floods and that salinities change locally with tidal action.

The probable migration of carp through saline waters on both coasts of Canada is not surprising in view of the presence of natural carp populations in saline waters of Eurasia (Hessel, 1878; Nikolsky, 1963) and the practice of fish culture in brackish waters in the Far East (Hickling, 1962; Johnson, 1954; Tampi, 1960). Soller et al. (1965) reported that carp are grown in Israeli ponds with salinities as high as 5000 ‰ of chloride, and Sarig (personal communication, 1966) noted that the reproduction of carp was normal in these waters at least up to salinities in the range of 3000 ‰ of chloride. Mairs (personal communication, 1966) in a survey to obtain information on brackish water carp populations in North America, established that populations were seasonally or permanently resident in saline coastal waters of New Jersey, North Carolina, Alabama, Virginia, Maryland, Delaware, and Connecticut. Dill (1944) noted that carp occurred in the brackish waters of the Sacramento–San Joaquin Delta, California, but that their greatest concentration was near freshwater tributaries. Mark (1966) has stated that 2000 mg Cl/liter is generally regarded as being growth-inhibiting for carp. The upper limit of salinity tolerance given by Nakamura (1948) was 6000 mg Cl/liter for young and 4500 mg/liter for eggs.

With respect to the future expansion of the distribution of the carp in Canada, it should be noted that the current policy of federal and provincial agencies with respect to the construction of major impoundments for power development and water conservation across Canada may be expected to create new habitats most favourable for carp survival and reproduction.

THE COMMERCIAL FISHERY

History of Commercial Fishery

The reason for the enthusiastic importation and distribution of the carp into North Amercia as a potential food fish is given in the Report of the United States Fish Commissioners for 1880 in which it is stated that "it is quite safe to say that there is no other species that promises so great a return in limited waters. It has the preeminent advantage over such fish as black bass, trout,

grayling, etc., that it is a vegetable feeder, and, although not disdaining animal matter, can thrive upon aquatic vegetation."

The carp has proved to be an excellent converter of the primary nutrients of marsh and warm water littoral environment into fish flesh and, wherever becoming abundant, has offered a potential harvest of substantial dimensions. This section deals with the history and the present status of commercial carp fisheries across Canada.

ONTARIO

As the oldest established commercial fishery for carp in Canada was that initiated in Ontario prior to 1900, public and government attitudes towards the carp as a potential food fish in Canada found in the literature refer solely to that province. However, statistical information on the early fishery is sparse because of the failure of the commercial fishing returns to identify the carp among those fish harvested prior to 1908, the species being included statistically with "mixed and coarse fish."

A commercial fishery for carp on the United States side of the Great Lakes would seem to have developed first on lakes Erie and St. Clair where populations of the species had reached abundant proportions during the 1880's (Cole, 1905). Carp were taken by Lake Erie fishermen as early as 1883 (Smiley, 1886) and it is possible that Lake Erie fish were among those first appearing on the New York market in 1884 at a price of 30 cents/lb (Brakely, 1885). By 1890 and 1891 Lake Erie carp were beginning to be handled in quantity by fish dealers but the market did not become extensive until 1895 (Cole, 1905). No commercial catch was reported until 1892 (Baldwin and Saalfield, 1962) and then only from American waters because of the failure of the Canadian fisheries statistics to identify the species as distinct from other coarse fish. By 1899, annual carp harvests had reached 3.5 million lb and a value of over $51,000 (Lydell, 1905). Undoubtedly, many pounds of carp were being harvested by commercial fishermen from Ontario waters at the western end of Lake Erie before the turn of the century. Prince (1897) noted that carp were being taken off the south shore of Essex County, where by 1896 "individual pound nets may take 2–3 tons in a single catch."

Prejudice against the carp had become so pronounced in Canada at both the federal and provincial levels during the 1890's that all reference to the species in the annual reports of both governments discouraged its utilization as a food fish. Prince (1897) stated that "their market value can never be great in Canada" and called the carp "a worthless drug on the market . . . which will never be esteemed or demanded." He mentioned, however, that shipments of carp were finding a sale among the Russians and Jews but that this market must be limited. In spite of government propaganda against the carp, the public could not have been so convinced of its negative values, because, for example, in December, 1895, they were still condemning the Canadian fish hatcheries for not giving carp fry to the public for stocking private waters.

By 1898, winter hoop net licences were being issued for carp in Rondeau Bay of Lake Erie but the gear apparently was not too successful in "exterminating" them. All fish were reportedly sold to the Buffalo Fish Company. The First Annual Report of the Ontario Department of Game and Fisheries (1899) stated that "these fish are so destructive of the more valuable fish that it is respectively suggested a dispensation should be granted to fishermen to take them by any legitimate means under, of course, the supervision of the Department." It further stated that "there is practically no market for it, and it is frequently buried by fishermen as the most convenient method of disposing of it" because "as a food fish it is very inferior, its flesh being coarse in texture and insipid in flavour."

The Annual Report of the Ontario Department of Game and Fisheries for 1900 noted that "the continued unfavourable reports as to this fish further demonstrate the desirability of doing everything that can be properly done for its extermination. . . . Every means for its capture has beeen authorized which has been applied for." In 1902 it was stated that "seine permits have been issued wherever feasible" and the opinion was offered that the seine was the most successful implement of capture. The first evidence of a profitable carp fishery appeared in the same year for the Lake Erie–St. Clair region in the notation that "the demand for carp has been good and the prices high." On the other hand, in the same report everyone was of a disposition to expedite its extermination. Carp from Canadian waters were beginning to supplement in quantity harvests from the United States waters of the Great Lakes and from a major fishery on the Mississippi River from which carp were being shipped to eastern markets (Carlander, 1954).

The status of the carp fishery in 1903 was summarized as follows in the Annual Report for that year. "Owing to the fact that the carp increases rapidly and, it is believed at the expense of other and better classes of fish, there has been much prejudice against it; but carp fishing has, nevertheless, become quite an industry during the last year or two, and may yet be one of the most profitable." In 1904 it was reported that "in some localities the carp has already become an important fish of commerce, meeting the demands of the poorer classes. . . . In portions of Lake Erie and Lake St. Clair it has become very abundant. . . . By retaining them during the summer months, much higher prices may be obtained." This latter statement refers to holding ponds which had been built in back marshes and rivers along the Lake Erie–Lake St. Clair shore where carp were held, and often fed, until such time as market prices were most favourable.

By the early 1900's, therefore, the carp had become a very controversial species in areas of southwestern Ontario where it was now abundant. Commercial fishermen were coming to prize it while, at the same time, government agencies and the sporting fraternity continued to condemn it. One of the most outstanding condemnations of the species at that time was a document on the Great Lakes Fisheries published privately by Edward Harris (1905) who compared that

"disgusting fish" with the Canada thistle and the English sparrow while describing its "rampant destruction of fishing waters." The other side of the picture was given by Prince (1907) in a special report on the Unutilized Fishery Products in Canada as follows: "It is true that fishermen generally view the matter with less alarm for, at certain times of the year the carp are in demand in United States markets and bring remunerative prices, especially as the fish increase in numbers very fast and grow rapidly to a large size. . . . It appears that a large new industry could be created with a little enterprise." Prince advocated the sale of smoked rather than fresh fish as "there is no doubt that smoked fish would bring a better price."

In the Federal Government report for 1906 it was stated "that the time is not far distant when carp will not be considered, as now, a nuisance. It is imperative that the immense supply of carp available should be utilized; then there would be no difficulty in keeping them in reasonable bounds. . . . Any man or men who will succeed in devising some method of curing, drying, or salting carp will be public benefactors entitled to the thanks of posterity."

Government agencies gave every encouragement to the harvest of carp in succeeding years and adopted the philosophy that "the Department should allow every latitude to the fishermen in taking these fish from our waters, International and inland, as it will be a benefit to the fisheries in general" (Sheppard, 1913). In the following year Sheppard (1914), as Inspector of Fisheries for Ontario, stated: "I am pleased to report that the much talked about species has not proved nearly as dangerous as anticipated and that large quantities are being shipped to New York and other American cities . . . the demand is increasing in Canada, especially in larger cities and I am inclined to think that as people learn to prepare and cook them in different ways this demand will gradually increase as the prejudice against their use as food is gradually wearing away. . . . I would not, however, recommend any close season for the carp as they are very prolific breeders . . . very little diminution in the numbers may be looked for, even with an all year round open season and every facility given fishermen to take them."

Commercial sales of carp were still comparatively small in 1908 when catch statistics were first published for the species in the Second Annual Report of the Ontario Department of Game and Fisheries. By this time the use of holding facilities had come into vogue along the shores of lakes Erie and St. Clair in order to retain carp for the most favourable price, usually coincident with a Jewish holiday. Carp were held in barges, nets, fenced-off back-bays, stream estuaries, and dug-out ponds. Grain was often fed to the confined fish. A total of 169,000 lb harvested in that year was recorded for lakes Ontario, Erie, and St. Clair, catches from the latter two lakes and their connecting waters making up over 90% of the total harvest. Reported harvests no doubt represented only an unknown percentage of the actual catch. By 1911, some 869,611 lb of carp were harvested from lakes Erie and St. Clair and there was reference in the Annual Report for that year to the Long Point Bay fishery where the "carp

is one of the best paying species" and "should be protected." By this time fishermen were still experimenting with holding facilities and the Annual Report of the Ontario Department of Game and Fisheries for that year (1911) stated that carp ponds had not yet demonstrated that this was a successful way of handling fish. The trend of the commercial fishery of lakes Erie and St. Clair, and the St. Clair and Detroit rivers, is shown graphically in Fig. 17. Catches of carp were taken principally with seines (Figs. 18 and 19).

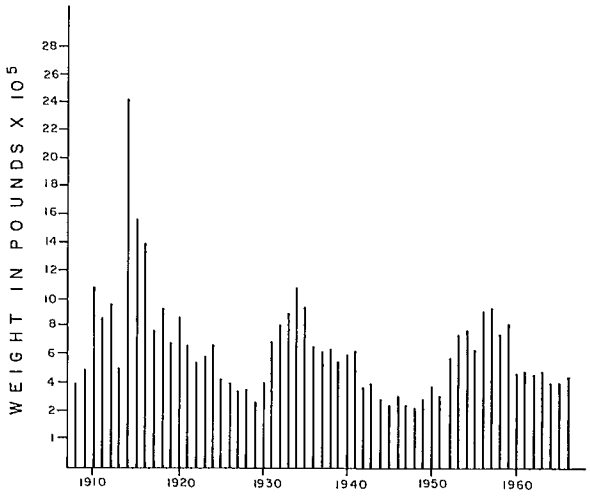

FIG. 17. Annual harvests of carp from the waters of lakes Erie and St. Clair (1908–66).

After the establishment of the first major carp fishery in the extreme southwest part of the Province, a second strong fishery developed in the Cooks Bay and Holland Marsh area of Lake Simcoe, the first inland lake in Canada to witness a population explosion of the carp (McCrimmon, 1956).

A large proportion of the carp in Lake Simcoe were still under 18 inches in length in 1900. During the next few years the carp became highly prized as a food fish and in these early years numerous carp, taken largely by spears, were sold readily to waiting buyers at prices up to $1 each, many coming from Toronto to purchase fish. In spite of a good market, coupled with the demands of local people for the riddance of carp, it was not until 1909 that a commercial seine licence was first issued. The first commercial annual catch of 1000 lb is known to have been only a pittance of the quantity of carp taken in other ways. The fishery reached its peak in 1911 with a reported catch of 462,406 lb. Catch statistics for succeeding years are shown in Fig. 20. In interpreting the catch data, it is of interest to note that the first drainage scheme at the south end of the Holland Marsh was completed in 1923 and made a considerable part of the original spawning grounds of the carp no longer available to them. In the summer

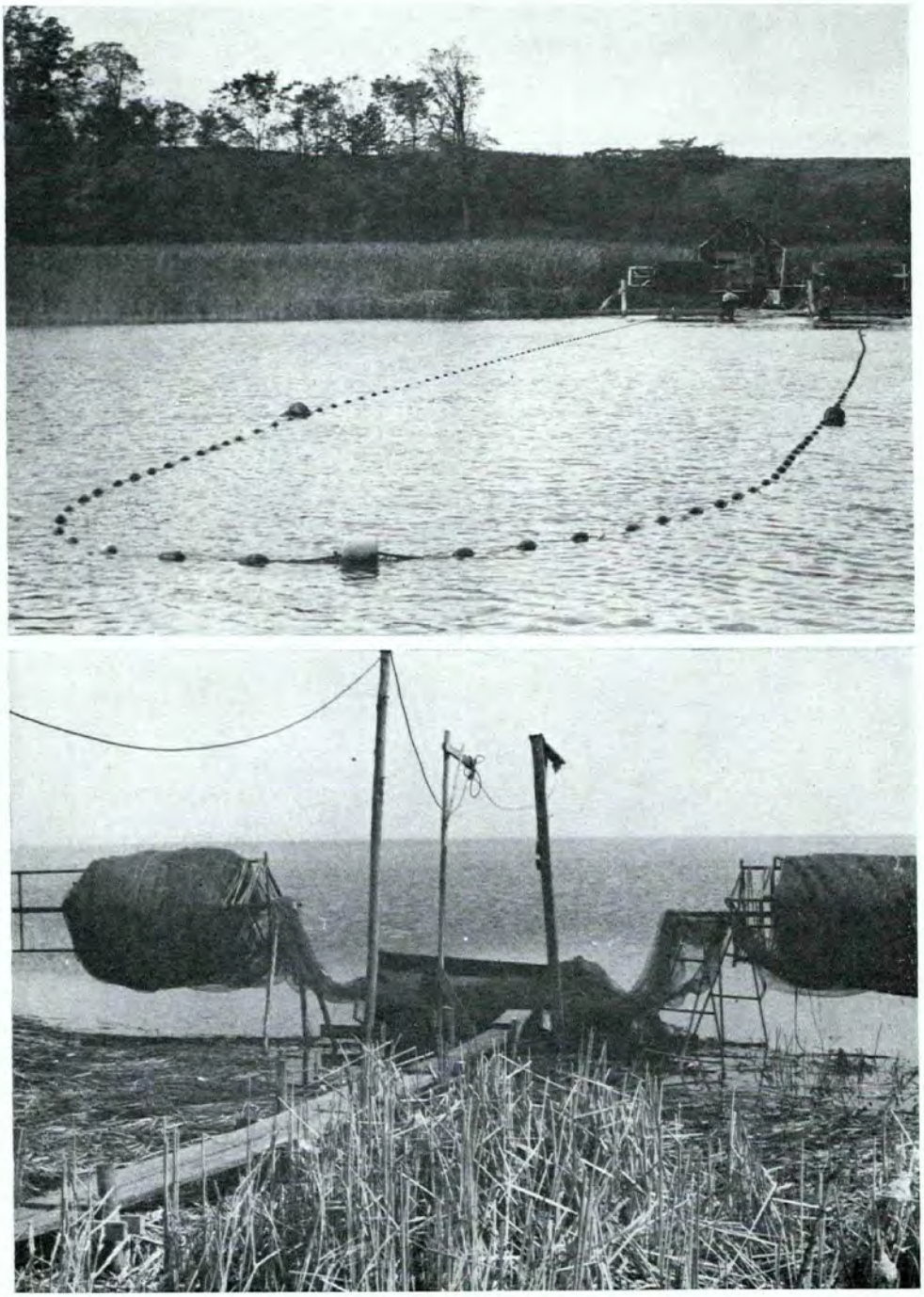

FIG. 18. Commercial carp seine being hauled with gasoline engine and winch on shore of Long Point Bay, Lake Erie. (Ontario Department of Lands and Forests photo.)

FIG. 19. Commercial carp fishing on Lake St. Clair during month of December: *Left*: floating live box in which carp are held before shipment; *right*: preparing carp for shipment. (Ontario Department of Lands and Forests photo.)

of 1928, there occurred a heavy mortality among the carp from an undetermined cause. There was a downward trend in the fishery after 1928 reaching a low in 1950 when there was no commercial fishery.

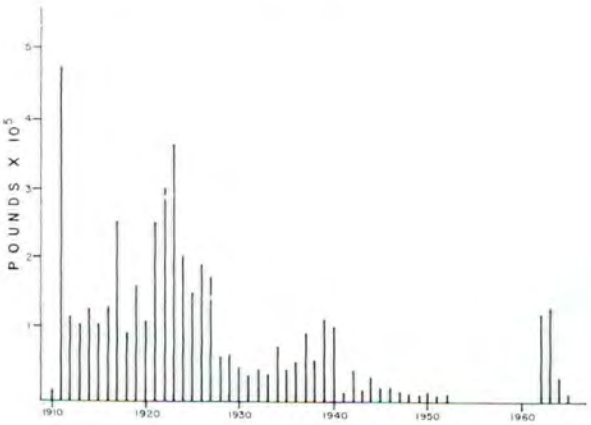

FIG. 20. Annual harvests of carp from the waters of Lake Simcoe (1910–66).

A third important carp fishery was the one initiated in the Port Severn–Waubaushene–Midland area of southeastern Georgian Bay in 1907 with a catch of 1100 lb. Although limited largely to the extensive Matchedash Bay Marsh and adjacent marshes of southeastern Georgian Bay fringing the Precambrian Shield, this fishery was of considerable local consequence. Harvest trends are shown in Fig. 21. Although no catches of carp appeared in the annual statistics until 1922, the fishery had become substantial by 1915 with an abundance of carp of all sizes and several active fishermen (Boyd, personal communication, 1966). A current gill net fishery operation is shown in Fig. 22.

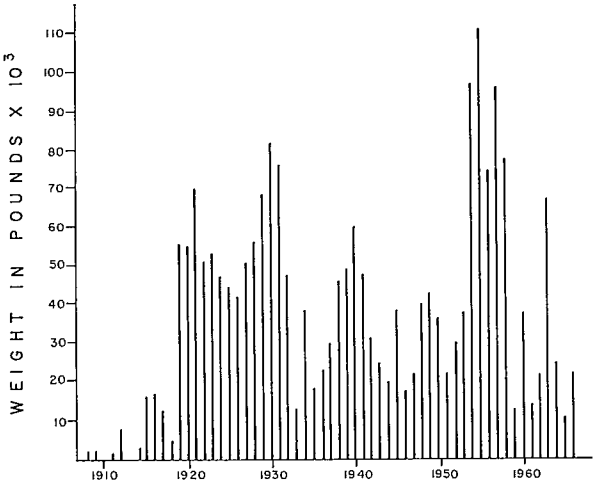

FIG. 21. Annual harvests of carp from the waters of Lake Huron and Georgian Bay (1908–66).

The fourth important commercial fishery to develop in Ontario was at the eastern end of Lake Ontario and the Upper St. Lawrence River and was centered in the Bay of Quinte area. This fishery began about 1908 with the first major catch in 1910 and, in spite of major fluctuations in harvests, has been a sustaining fishery since that time (Fig. 23).

Other fisheries of local consequence developed at various locations particularly on the lower Great Lakes in response to buildups of local populations of carp, usually in river mouths, harbours, or back-bays because of the general unsuitability of the open waters of the Great Lakes as carp habitat. However, with the exception of Lake Simcoe, prospective carp fishermen were typically excluded from potential carp fisheries in inland waters of Ontario by the sport fishing fraternity who, in spite of the alleged damage done by the carp to fish and wildlife habitat, feared the activity of commercial fishermen in sport fishing waters.

It is only recently that permits have been granted for commercial carp fishing in the inland waters of the Province and the most spectacular of these has been that established within the Kawartha Lakes of the Trent Canal system

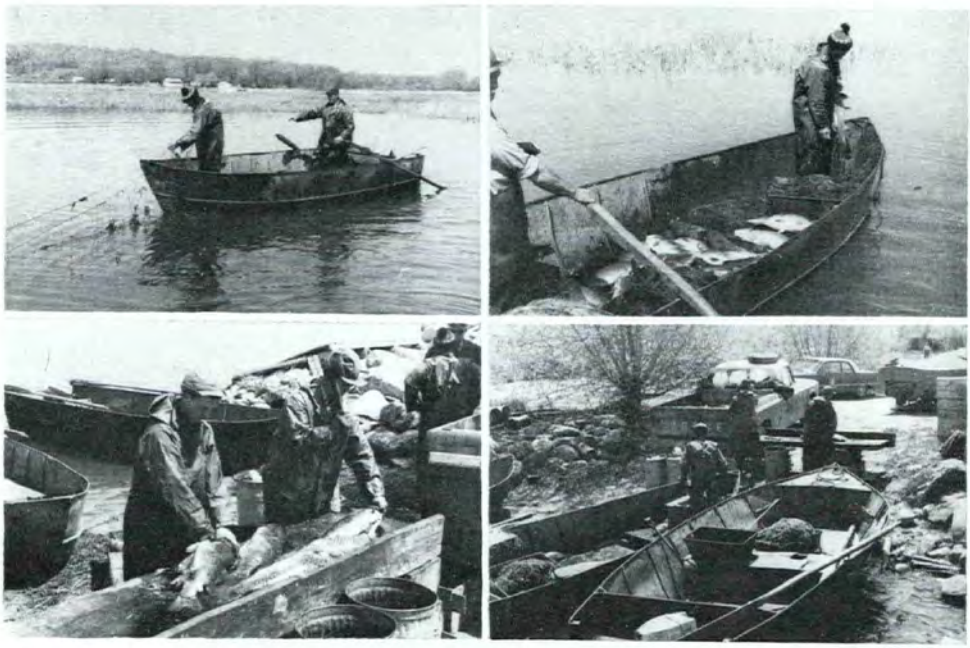

FIG. 22. Operations of a gillnet fishery for carp in southeastern Georgian Bay, Ontario.

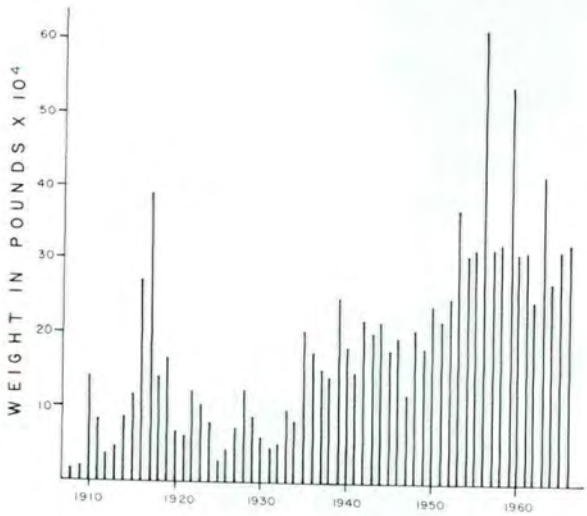

FIG. 23. Annual harvests of carp from the waters of Lake Ontario and the Upper St. Lawrence River (1908–66).

in the Lindsay Forest District. Permission to fish carp with large-meshed gill nets in several lakes was granted in 1960 and subsequently extended to include a number of waters. Data on this fishery are presented in Fig. 24. During the 7-year period 1960–66, over 1.25 million lb of carp were harvested commercially without apparent detriment to the preferred species of sport fishes. The decline in total annual harvests is believed to represent the intensive exploitation of available fish of the large size required by the market.

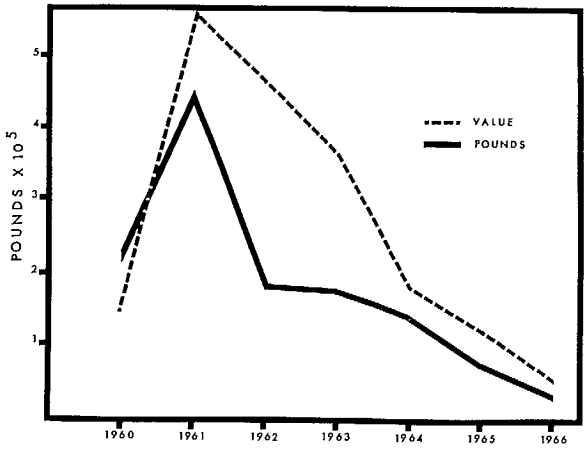

FIG. 24. The trend in the harvest of carp from the Kawartha Lakes where special commercial licences were granted in sport fishing waters beginning in 1960.

Total annual reported commercial catches and land values of carp taken from Ontario waters between 1908 and 1966 are given in Table IV and the trend of the fishery is shown in Fig. 25. During this period a total of 64,455,000 lb valued at $3,230,678 was reported to have been harvested by commercial fishermen. Of the total harvest of carp during the 59-year period, 81% came from the waters of the Great Lakes, the balance from inland waters. The relative harvests of carp by decade from each of the statistical fishing areas in the Province are recorded in Table V.

Carp harvested by commercial fishermen from Ontario waters of the Great Lakes and inland waters during 1966, totalling 940,000 lb with a landed value of $78,000, made up 1.7% of the total Ontario commercial catch of all species by weight, 1.4% in value.

During the decade ending in 1960, reported carp harvests by Canadian and United States commercial fishermen from the waters of the Great Lakes, excluding Lake Michigan, averaged 7,659,000 lb annually and made up 9.1% of the total fishery for all species from these international waters.

TABLE IV. Annual reported commercial harvests of carp from Ontario waters, 1900–66.

Year	Pounds	Value ($)	Year	Pounds	Value ($)
1908	416,963	8,339.06	1938	1,070,510	53,603.50
1909	521,082	10,821.64	1939	1,107,848	55,392.40
1910	1,233,558	24,671.16	1940	1,114,032	55,701.60
1911	1,418,517	28,370.34	1941	973,354	48,667.70
1912	1,140,826	22,816.52	1942	841,594	47,934.80
1913	672,126	33,606.25	1943	756,066	47,532.24
1914	2,664,945	53,298.90	1944	674,008	45,790.85
1915	1,827,777	36,555.54	1945	638,068	48,388.39
1916	1,864,575	37,291.50	1946	759,233	58,026.35
1917	1,419,346	28,386.92	1947	505,640	34,993.09
1918	1,196,257	23,925.14	1948	610,909	39,735.20
1919	1,098,817	43,952.68	1949	646,096	40,232.24
1920	1,098,427	43,973.08	1950	806,295	50,735.00
1921	1,073,241	42,929.64	1951	792,765	52,835.25
1922	1,057,824	42,312.96	1952	1,129,100	70,615.04
1923	1,119,513	44,780.52	1953	1,382,368	78,371.37
1924	1,097,825	43,913.00	1954	1,427,462	145,364.07
1925	805,082	32,203.28	1955	1,313,089	78,931.25
1926	736,131	29,445.24	1956	1,901,554	105,738.89
1927	656,243	26,249.72	1957	1,506,342	85,536.71
1928	717,749	35,887.45	1958	1,350,144	79,283.20
1929	599,281	29,964.05	1959	1,508,489	79,346.52
1930	721,895	36,094.75	1960	1,124,429	63,642.68
1931	1,076,559	53,827.95	1961	1,282,909	87,750.98
1932	1,187,186	59,359.30	1962	1,124,159	86,110.58
1933	1,258,565	62,928.25	1963	1,322,182	105,377.91
1934	1,518,728	75,936.40	1964	937,816	66,866.28
1935	1,479,279	73,963.95	1965	871,825	78,289.89
1936	1,165,460	58,273.00	1966	940,000	78,000.00
1937	1,082,761	54,138.05			
			Total:	64,455,027	$3,230,678

QUEBEC

Waters of the Province of Quebec support the second oldest commercial carp fishery in Canada although the history of the fishery is poorly documented. Because of the general use of the word *carpe* among the French-speaking people to designate the sucker, *Catostomus,* statistics of the Quebec commercial fishery are of no value in providing information on catches of *C. carpio* which may or may not be included among reported harvests of *carpes.*

Regular carp fisheries occur in the lower Ottawa River and in the St. Lawrence River basin from the Ontario boundary to Île d'Orleans, Montagne, and Kamouraska downriver from Quebec City. Vladykov (personal communication, 1966) noted that carp, known locally as *Bar noire,* up to 20 lb in weight, were taken regularly at Montagne in the fascene trap during spring and fall months.

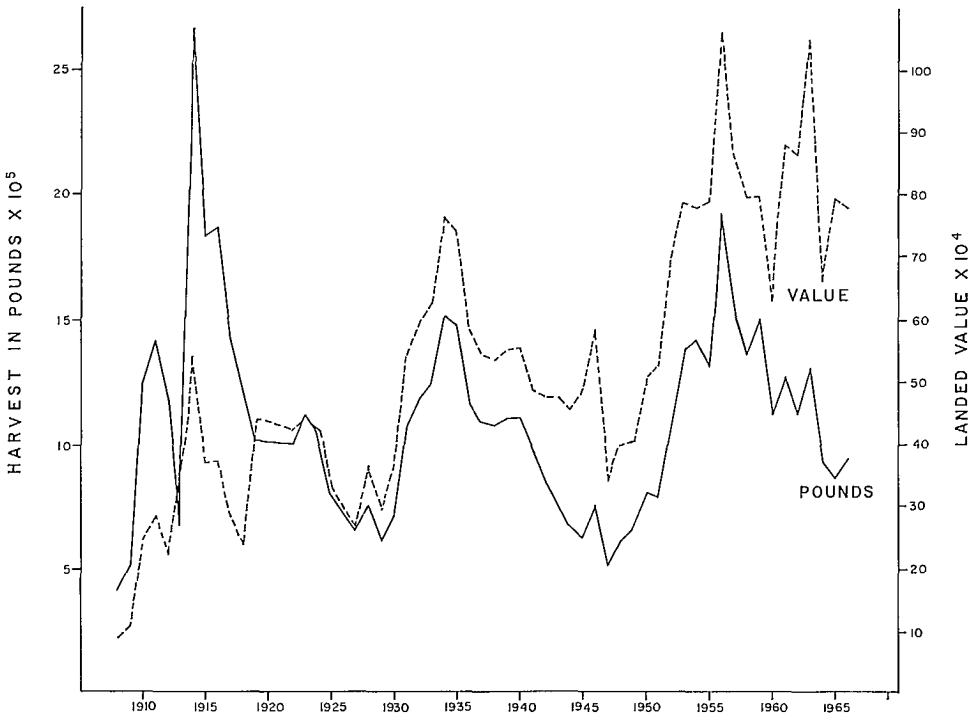

FIG. 25. Annual commercial harvests and value from the waters of the Province of Ontario (1908–66).

Bergeron (personal communication, 1966) referred to carp caught in the estuary of the Kamouraska River when salinities varied with tide levels, and suggested that all catches from Levis eastward are sold locally to a poor market. Annual harvests from the latter water amounted to approximately 15,000 lb in 1965 and 1966. Because of sparse information on the extent of intentional or incidental local harvests of carp from most areas, no estimate of the annual catch from Quebec waters is feasible. However, Berube (personal communication, 1966) stated that a "great quantity" of carp came from the Lac Saint-Louis area to the Montreal market. Bacle (personal communication, 1967) has estimated that Quebec fishermen contribute about 50,000 lb annually to this market.

The carp must be considered as a minor component of the total Quebec commercial fishery but, because of inadequate statistics on the species, the harvest may be greater than is currently recognized. However, both the notable paucity of references to the carp in both the popular and scientific fisheries of Quebec, and the lack of concern by government management personnel about its harvest or control suggests that, except probably in the more turbid waters

TABLE V. Recorded commercial harvests of carp by decade from the various fishing areas in Ontario (1908–66).

Years	Recorded harvests from fishing areas in pounds								
	Lake Superior	Georgian Bay	Lake Huron	Lake St. Clair	Lake Erie	Lake Ontario	Sub-total	Inland waters	Total
1908–10	0	3,600	2,250	251,782	1,719,758	177,160	2,154,550	17,053	2,171,603
1911–20	21,672*	169,661	85,513	3,746,015	7,188,836	1,399,990	12,611,687	1,790,865	14,402,552
1921–30	23,036*	556,968	69,809	2,146,113	2,479,294	774,374	6,049,594	2,635,145	8,684,739
1931–40	7,593	390,893	77,616	3,109,814	4,428,221	1,380,771	9,394,908	2,666,020	12,060,928
1941–50	3,415	312,624	207,422	1,247,703	2,065,490	1,912,815	5,749,469	1,461,089	7,210,558
1951–60	874	588,019	338,481	4,318,192	2,680,112	3,567,142	11,492,820	1,942,927	13,435,742
1961–66	1,215	154,993	173,419	1,608,120	1,036,662	1,894,196	4,868,605	1,615,295	6,488,900
Total:	57,805	2,176,758	954,510	6,427,739	21,598,373	11,106,448	52,321,633	12,128,394	64,455,027

*Unconfirmed as *Cyprinus carpio*.

of the Ottawa and St. Lawrence rivers, where the effects of substantial populations of carp in the aquatic environment could go unnoticed, the species has not reached an abundance typical of the better carp habitats in the provinces of Ontario, Manitoba, Saskatchewan, and inland British Columbia.

It is of interest that, although canned carp from Europe (Bacle, personal communications, 1966, 1967) and live carp from the United States (Molitz, personal communication, 1966) are imported annually into Montreal, the Department of Industry and Commerce (Bourque, personal communication, 1967) would seem to consider that there is a minimal market for carp harvested by Quebec fishermen.

MANITOBA

Annual harvest records of carp from Manitoba waters are presented in Fig. 26. Because of the comparatively recent invasion of Manitoba waters by the carp, the commercial fishery has a history of only 20 years. Butler (1949) made no mention of the carp in his report on the lakes and lake fisheries of Manitoba as recently as 1949.

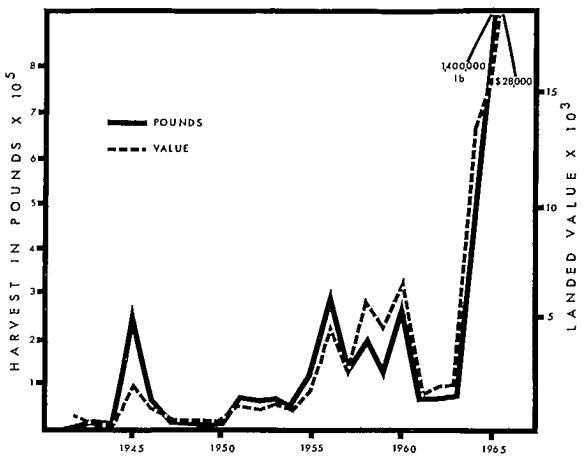

FIG. 26. Annual harvests and value of carp caught in the waters of Manitoba (1942–66).

However, the first annual harvests were reported from Lake Winnipeg in 1945, a little more than a decade after the presence of this species was recognized locally. No specialized carp operations have been established on this lake and the reported catch, exceeding 200,000 lb annually on two occasions, was marketed from the normal gillnet fishery (Doan, personal communication, 1966). Carp first appeared in small quantities in the commercial catch from Lake Manitoba in 1951 and annual harvests exceeded 100,000 lb only once previous to 1964 when a specialized seine fishery was initiated. Harvests of carp from

other waters of Manitoba are of little significance. Total annual commercial harvests of carp from Manitoba waters together with landed values are shown in Fig. 26.

Recent specialization of a carp fishery in Lake Manitoba is reflected by an increase in the carp harvest beginning in 1964 (Table VI). The reported catch of carp for 1965–66 of 825,400 lb made up nearly 3% of the gross commercial harvest of fish of all species by weight and nearly 4% by land value. The 1966–67 catch of trout, although incomplete at time of writing, is expected to exceed 1.4 million lb.

TABLE VI. Annual commercial harvests of carp from Manitoba waters (1943–67).

Year	Harvest in pounds						Landed value ($)
	Lake Winnipeg	Lake Manitoba	Lake Winni-pegosis	Lake Dauphin	Inland lakes	Total	
1943–44	4,300					4,300	262
1944–45	100					100	40
1945–46	94,300					94,300	6,390
1946–47	47,900					47,900	1,198
1947–48	11,900					11,900	241
1948–49	10,800					10,800	216
1949–50	9,100					9,100	182
1950–51	10,600					10,600	212
1951–52	42,000	8,400				50,400	1,324
1952–53	36,000	8,800				44,800	1,191
1953–54	44,300	5,800				50,100	1,198
1954–55	41,300	–				41,300	811
1955–56	64,300	19,800				84,100	2,276
1956–57	67,600	159,000		600		227,200	6,140
1957–58	62,600	63,300		–		125,900	2,483
1958–59	220,100	63,900		–		284,000	3,995
1959–60	139,600	77,000	4,900	100	200	221,800	2,355
1960–61	207,000	95,900	21,300	–	–	324,200	5,738
1961–62	19,800	36,900	5,800	–	100	63,700	1,274
1962–63	65,700	24,400	3,400	1,100	–	93,700	1,217
1963–64	74,300	19,900	1,600	200	–	95,900	1,458
1964–65	119,700	533,800	1,100	200	–	654,700	6,622
1965–66	117,000	705,700	2,700	–	–	825,400	16,878
1966–67						1,400,000*	28,600*
Total:						4,520,600	92,301

*Estimate.

The variation in annual harvests of carp that was evident prior to 1964 would seem to bear no relationship to the abundance of carp but rather to available markets for the product. Doan (personal communication, 1966) was of the opinion that "the increasing catch in recent years is simply a reflection of the market and price which have increased lately." The abundance of carp noted by Leitch (personal communication, 1966) and Bossenmaier (personal communication, 1966) in the peripheral marshes of lakes Manitoba, Winnipeg, and Winnipegosis, endorses this contention.

SASKATCHEWAN

There is currently no commercial fishery for carp in the waters of Saskatchewan. Although now becoming widely distributed through the Saskatchewan River basin of the Province, concentrations of carp probably adequate to provide an efficient commercial fishery occur only in the Qu'Appelle Valley lakes, particularly Pasqua Lake, of the Assiniboine River system. Here, during the summer of 1965 an estimated 400,000 lb of carp were taken in the fishery for buffalo fish but were released because they were unmarketable (Johnson, personal communication, 1966). Johnson cited a low market value and prohibitive transportation costs as two factors discouraging the development of a commercial carp fishery in Saskatchewan.

BRITISH COLUMBIA

In spite of a distribution in the Columbia and Fraser River systems, there is no significant utilization of the carp by the commercial fishermen of British Columbia. Principally because of the very limited use of the species, government records are meager, although it is known that occasionally a few hundred pounds are taken in the Okanagan area. However, the extent of carp damage to the aquatic environment as reported by Harris (personal communication, 1966) in the Okanagan and interior of southern British Columbia suggests that carp are in sufficient abundance to support a substantial fishery. Vernon (personal communication, 1966) stated that there is a limited market for carp in Vancouver but that two licences granted for the area have apparently not resulted in successful commercial ventures, noting that restrictions on commercial gear for the protection of salmon and trout, plus a low local availability of carp, "has probably precluded the development of a successful commercial operation."

Present and Potential Carp Fisheries

The commercial harvest of carp reported from Canadian waters in 1966 was approximately 2.5 million lb with a landed value of $125,000. Of this harvest, the bulk came from the waters of Manitoba and Ontario, the only two provinces where statistics on carp harvests are kept. The Quebec harvest was of unknown magnitude but, on the basis of scattered miscellaneous information and statistics, it is estimated not to have exceeded 75,000–100,000 lb. There is no

official recognition of the carp as a commercial species in either Saskatchewan or British Columbia although this does not exclude the possibility that there may be small numbers caught for local consumption, or animal food, in areas where the species is in relative abundance.

Potentially exploitable carp populations exist in each of the five provinces where the species has become established. Adequate numbers of carp to support local fisheries are resident in several waters of the Columbia and Fraser River watersheds of interior British Columbia including Hatzic Lake, and in the Assiniboine and Saskatchewan River watersheds of Saskatchewan (particularly Pasqua and Round lakes), although there is presently no recognized commercial fishery in either province. In Manitoba, a specialized fishery exists only in Lake Manitoba but extensive harvests of carp would be expected to result from intensive fishing in a number of other lakes including lakes Winnipeg and Winnipegosis.

Commercial fishermen in Ontario report, with a few exceptions, that annual catches could be increased to meet any rise in market demand for the carp and that stocks of young carp are particularly abundant. Similarly, in Quebec it appears unlikely that the carp is currently being exploited to its full capacity although the extent of the resource and its harvest is poorly documented for this Province. Although the possibility exists that marketable carp populations may ultimately be established in Alberta by the upstream movement of fish from Saskatchewan, the likelihood of a major invasion of the Maritime Provinces would seem less probable and the possibility of a commercial fishery remote.

Although carp harvests make up only a small percentage of the total annual production of freshwater fish in Canada, the species can be of major local importance and serve the continuing need of a specialized market demand.

MARKETING

Although listed as a species "especially worthy of cultivation" and its virtues as a food fish extolled in the United States Fish Commission Report of 1874 at the time when its introduction to North America by that Commission was being first proposed, the carp was not generally favourably received by the public as a food fish once the novelty of its appearance in natural waters had worn off. The Commission, by the early 1890's, was finding it difficult to justify the species in the face of increasing denunciations of its inferiority in comparison to native food fishes.

The first scathing attack on the species in Canada was that of Prince (1897) who stated that "the carp is especially subject to parasites and contagious disease . . . suffers from fish leprosy (fungoid growth) . . . tapeworms and other disgusting endoparasites . . . and have a fondness for coarse and loathsome food, and a preference for muddy and tepid waters." The first report of the Ontario Fisheries Branch (1899) described its flesh as coarse in texture and insipid in

flavour. These statements are in contrast to that of Brakely (1885) that "carp start off with a fine reputation as an excellent table fish" and cited a survey in which nearly all participants spoke of the carp "in highest terms."

Those statements would not be expected to stimulate an enthusiastic public acceptance of the carp as a food fish in Canada. However, even at that time a limited commercial fishery had already developed in lakes Erie and St. Clair and carp were being exported to Buffalo and other large American cities.

In view of the substantial fishery which had developed by 1900, federal and provincial authorities could no longer condemn the food quality of the species and so, reluctantly and with obvious prejudice, modified their approach to the species. In the 1903 Report of the Ontario Fisheries Commission it was stated that "friends of the carp say its edible qualities are very much underrated" and when properly prepared is a "most palatable fish." "Salting a few hours previous to eating will cause it to lose much of its muddy or swampy flavour." However, Cole (1905) noted that the salting of fresh carp, as was commonly done with herring, had not proven satisfactory. The so-called "muddy flavour" has been attributed to the presence of soil microorganisms of the *Actinomycetes* group which enter the fish through the gills rather than as the direct result of carp being in contact with the soil (Lewis, 1939).

Active promotion of the carp as a food fish was undertaken by several agencies in the United States (Bartlett, 1900, 1901, 1910). Carp was on the bill of fare of at least one Cleveland restaurant as early as 1893, and, in 1902, "carp with Rhine wine sauce" was listed on the luncheon menu of the Waldorf-Astoria (Cole, 1905). At the North American Fish and Game Protective Association 1902 meetings held at Burlington, Vermont, carp was served as "baked red snapper" and was appraised as a very palatable dish. Cole (1905) during his study of the carp found that it was being sold at Sandusky as smoked sturgeon at 18 cents/lb and "except for the bones was told that it could not be told from sturgeon."

Although the market for carp harvested in Ontario was typically for live fish for the Jewish trade in the larger cities of Ontario, and particularly the northeastern United States, quantities of carp in the 12–15 lb size range were being smoked in southwestern Ontario. Prince (1907) noted that "when smoked, the German carp acquires a dainty favour and a tempting appearance" and "if the fish is properly smoked there is no objection to the adoption of an artificial brown dye or stain, such as burnt-sugar fluid, which will give them a more appetizing colour. Smoked carp appearing on the Ontario market are either their natural colour or dyed reddish." Prince (1907) observed, without explanation, that some of the smoked carp had a "disagreeable black colour."

Rhead (1907) stated that the carp taken from big lakes, including lakes Erie and Ontario, were "fairly good eating" but "if taken from small ponds are both tough and of a peculiar muddy taste." Sheppard (1914) observed that the demand for carp was increasing in Canada, especially in the larger cities and

"I am inclined to think that as people learn to prepare and cook them in different ways that this demand will gradually increase as the prejudice against their use as food is gradually wearing away." In spite of early demonstrations of the palatableness of smoked carp, public acceptance in eastern Canada was slow to develop and comparatively few fish prepared in this way appeared on local markets prior to 1930 (Fig. 27).

FIG. 27. Dressed carp, gutted and head removed, in the form purchased by wholesalers from commercial fishermen for smoking purposes.

The value of the carp as a potential food fish to meet possible emergencies at home and overseas was probed by biologists and administrators during World War II (Day, 1943). A greater utilization of carp was advocated (Stiff, 1943; Westerman et al., 1943) and ways for devising means to stimulate a wider public acceptance of the carp and other so-called rough fish was given serious study (Speaker, 1943). Although there had been a long-established restricted market and the carp had proven to be a cheap source of protein during the depression of the previous decade, there was a general consumer prejudice against the species (Gray, 1943) and it was obvious that research into product development and marketing, including an extensive educational programme, was necessary if public favour for the species was to increase substantially in North America.

In spite of these efforts by conservationists and others in the United States during the 1940's to promote the domestic utilization of carp, public acceptance of the carp did not improve significantly. From interviews with carp wholesalers, it would seem that the marketing of carp in eastern Canada has undergone relatively little change during the last quarter century, and there is little likelihood of a major change in the future without active market promotion and product development.

In eastern Canada, fresh carp dominate the major Ontario and Quebec markets, making up an estimated 80% of the Montreal and Ottawa sales, and some 65% of the Toronto sales, by weight. Smoked carp constitute the balance of the trade with the exception of specialized products to be described later.

The wholesalers purchased carp for smoking, gutted and with heads removed, from the fishermen (Fig. 28). Each year, approximately 0.25 million lb of live carp are imported into eastern Canada from the United States.

FIG. 28. Smoked carp, gefilte fish, and caviar, the three major specialized carp products marketed in Canada.

In western Canada the future of carp marketing would seem less definite although a recent brief of the Prairie Fisheries Federation noted that "varieties such as carp, mariahs and tullibees, which have never been of much value, are being utilized for rendering into fish meal and animal food and could with proper techniques, probably be processed into products suitable for human consumption" (Bryant, 1965). Recent interest in the development of a major commercial carp fishery in Manitoba has increased annual harvests some ten-fold during the past decade. Of the approximate 1.5 million lb currently removed annually from Manitoba waters and handled through Winnipeg dealers, some 65% is sold to United States buyers as frozen fillets to be used in the gefilte fish trade, and the remainder is sold locally, largely as animal food. Although potential carp fisheries exist in both Manitoba and interior southern British Columbia, available markets would seem inadequate at present to justify commercial operations.

Small quantities of canned carp from Japan and Europe have appeared occasionally among Canadian fish imports from overseas, but have not become a popular item on the domestic market. Approximately 10,000 lb of canned stuffed carp were imported into Montreal from Poland during 1966 (Bacle, personal communication, 1966).

Two specialized products appear on the shelves of delicatessen and fish markets catering primarily to customers of European extraction (Fig. 28). These products are gefilte fish, prepared from carp in combination with other fish species particularly mullet, pike, and/or whitefish, and caviar prepared from carp roe. Baked carp may be purchased at some retail outlets. An estimated 125,000 lb of gefilte fish are imported annually into Canada from the United States.

Market Promotion

Attempts to create consumer interest in the carp as an appetizing food fish have included a number of publications on ways of preparing it for the table. Among the best of these are leaflets prepared and distributed by the United States Government beginning in the area of World War II and the post-war period (Slater, 1940; Hopkins, 1943; Jarvis, 1949; Hopkins and Ritchie, 1951). Among the best of recent publications from the northern United States, aimed at the stimulation of public interest in the carp, are those by Bauer (no date) in Ohio, and Atts (1965) and Shiner (1966) in Pennsylvania.

No active promotion of the domestic sale of carp in Canada has come from government agencies nor private interests for many years. McKenzie (1931), in reviewing the fish trade of southern Ontario, did not mention the carp specifically but presumably included it among the "miscellaneous fish" for which a demand and market should be encouraged. Cooper and Linton (1936) did not include the carp among those species of fish for which smoking was advocated. The recent report of the McIvor Commission (1966) gave no specific consideration to the carp as a food fish in the investigation of the marketing of freshwater fish in Canada, except for its mention among "rough fish" which were considered to be normally a by-product from fishing other species. No recognition was given of the specialized carp fisheries in Ontario and Manitoba nor was reference made to unexploited or partially exploited populations of the species occurring in numerous Canadian waters. The prestige of the carp as a food fish was not enhanced by its mention in the report as an occasional item in the Jewish fish trade in the United States, as one of the low-priced rough fish preferred by the Negro population, and as a minor constituent of ready-made gefilte fish which was considered more appealing than fresh fish to the young Jewish suburbanite. The Commission did not focus attention on the traditional carp market in Ontario and neighbouring Quebec.

Price Structure

An initial public demand during the 1880's for young carp to stock private waters was short-lived, but according to the United States Fish Commission Reports brought speculative prices. Although not reared in Canada, young carp were offered for purchase in northeastern North America as early as 1883 at $70 per 100 fish for scaled carp, $75 for mirror carp. When carp of edible size,

usually less than 18 inches in length, first appeared in local waters of Ontario (McCrimmon, 1956) and the midwestern States (Carlandar, 1954), these fish, being a novelty, were frequently sold at $1 per individual fish.

Accompanying the dramatic increase in the abundance of carp in the western end of Lake Erie and in Lake St. Clair, those carp taken, often accidentally, by commercial fishermen were, by 1890, being purchased by dealers along with mullets at 1 cent/lb. By 1900, the landed values of commercial catches in southeastern Ontario had stabilized at about 2–3 cents/lb for live fish. Most of the catch was exported to the United States, usually Buffalo or New York, where wholesale prices averaged approximately 6 cents/lb and occasionally reached 9 cents.

The value of the carp fluctuated both annually and seasonally in succeeding years with landed values typically in the 3–6 cents/lb range which was said to leave the fishermen with a "handsome profit." Wholesale prices were about double the landed value. Discrete marketing, particularly the practice of retaining live carp to await a favourable market, occasionally brought higher than average returns to the fishermen. For example, one lot of live carp weighing 54 tons, taken from Lake Simcoe during the winter of 1910, was purchased by New York dealers at 30–35 cents/lb (McCrimmon, 1956).

A survey of the price structures for carp in Canada during 1966 has shown a difference in landed values between eastern and western Canada. In Ontario and Quebec, fishermen received an average of 3–5 cents for live fish of 5–9 lb, 7–9 cents for larger fish, and 11 cents if gutted and headed. The delivered price for live carp was 12–15 cents/lb, reaching 25 cents on the occasion of a heavy market demand. Gutted female fish with heads removed (for smoking) brought, on the average, 10–20 cents/lb. By contrast, commercial fishermen in Manitoba were paid a basic price of 2½ cents/lb for whole fish, and 4½ cents for headless and gutted fish for processing as fillets.

The retail value of carp on the major Canadian fish markets of Canada in 1966 fluctuated with seasonal demand. Live carp, usually small, averaged about 35 cents/lb. Smoked carp prices ranged between 50 cents and $1/lb and, during August when the survey was made, were being offered in showcases at 85–90 cents/lb. Smoked and baked carp were being sold at a delicatessen in Hamilton, Ontario, at $1.30/lb during May 1967.

THE SPORT FISHERY

Angling

Local sport fisheries of carp have occurred on this Continent for over 100 years. One of the earliest comments on the carp as a sport fish in North America is that of Forester (1850) who, with reference to the existing fishery created by Robinson's previous introduction of the species to the Hudson River (de Kay, 1842), regarded the carp "as a very miserable sport fish for though it is shy

and wary, the difficulty in taking him arises only from his timidity and unwillingness to bite." Goode (1887) described angling methodology because "the place of the carp as a fish for sportsmen has not been discussed fully" although Martin (1885) had previously described how to catch carp in an earlier bulletin of the United States Fish Commission.

In spite of the general reluctance of North American anglers to accept the carp as a sport fish, fishing for carp with hook and line had reached a measure of popularity by the turn of the century. Bartlett (1903, 1905) recorded that "carp fishing had taken its place with bass and other kinds of fishing," that "hundreds fish daily for carp," and that "the best bait is the doughball." Henshall (1903), although expressing "no love for the German carp," recommended the use of a quill float and a split-shot sinker and noted that carp of 5–6 lb could be taken on black bass gear. Rhead (1907) reported that carp could be "readily caught with dough, barley or wheat, worms, maggots, wasp larvae, and sometimes pieces of meat," but cautioned that angling for the species was a difficult and uncertain operation, fish of 2 lb or less being the best to take the bait.

Cole (1905) reported that in the lakes St. Clair and Erie area he had seen "numbers of persons fishing from the wharfs with handlines for carp" and for bait used "usually a boiled potato wrapped in mosquito netting." Sheppard (1902) made reference to angling for carp in Lake Ontario in the vicinity of Toronto.

Sport fishing for carp in Canada during the succeeding 50 years was not well documented. However, there would seem to have been few of the larger carp populations in southern Ontario which failed to experience the angler's hook at some time. Carp were taken accidentally while angling for other species of warmwater fish, particularly the bullhead, and carp fishermen with cork floats, handlines, or bamboo poles, were not unfamiliar sights on the river banks, dykes, or harbour piers. The baits used were typically those previously described. It is interesting, therefore, that Wooding (1959) should state that "generally speaking, all of the minnows—with the exception of the carp, goldfish, and squawfish—are useful to anglers."

At the present time, angling for carp would seem to provide a sport fishery worthy of mention only in southern Ontario and the upper St. Lawrence basin of Quebec (Fig. 29). The most extensive fisheries, although both limited and sporadic, were found in the marshes, the lower reaches of the larger rivers, and particularly the harbours of the larger communities along the shorelines of Georgian Bay, lakes Huron, St. Clair, Erie, and Ontario, and at points along the Trent Canal system including Cook's Bay and the Holland River of Lake Simcoe (McCrimmon, 1956).

At Lake Scugog (Smith, personal communication, 1966) an annual carp derby, sponsored by the Port Perry Rod and Gun Club, became an annual event first in 1950 with the primary objective of promoting the utilization of

FIG. 29. Angler's catch of carp taken during annual derby in Lake Scugog, Ontario. (Ontario Department of Lands and Forests photo.)

carp as a sport fish by educating the public on the way to angle for the species (Fig. 30). The derby proved popular and a large number of anglers now fish regularly through the summer months and harvest hundreds of carp. At one private park, the operator clears out the weeds, attracts the carp with water-soaked grain, and has chairs set out for the use of carp fishermen.

FIG. 30. Headquarters for carp derby held annually at Lake Scugog, Port Perry, Ontario. (Ontario Department of Lands and Forests photo.)

In describing the Lake Scugog sport fishery, Smith (personal communication, 1966) noted that pre-baiting with water-soaked barley or oats attracts carp to an area and that fishing is best on sunny days. The recommended bait is made up of about 80% cornmeal with some sugar added to make it sticky. The remaining 20% is flour kneaded with the cornmeal to form a dough which is rolled into balls about the size of a walnut. These balls are put on the hooks and allowed to lie on the lake bottom until taken by a carp, larger fish putting up a good fight when hooked. This formula is similar to many others appearing in the literature (Bartlett, 1903; Cole, 1905a; Hunt, 1911; Shiner, 1966).

Although there has developed only a nominal interest in angling for the cap in Canada, most popular sport books, written recently on angling in North America, recognize carp as a sport fish. For example, Weatherall (1949) noted

that "the wary and cunning carp, when he can be persuaded to take the angler's bait, can display an amazing turn of speed, strength, and stamina." He further noted that carp provide sport for many anglers in lakes and streams of the United States. Fichter and Francis (1965) stated that carp can provide sport for many anglers. Kreh (1967) noted an increasing interest and concern about carp fishing, and Burns (1966) stated that many anglers hold carp in high esteem. Shiner (1966) wrote that "there are fishermen who specialize for fishing carp . . . and, with these fish so numerous and fishing pressure so vastly reduced, carp anglers have more fun than a swarm of bees turned loose in a florist's shop."

Spearing and Bow-Fishing

The spearing of carp has been a source of local recreation in many areas where carp have become abundant (Fig. 31). Spearing of carp in the ditches and marshes of southern Ontario, during the spawning season, dates back at least to 1900 (McCrimmon, 1956). Although the extent of this practice in Canada is not known, it cannot be considered a significant form of outdoor recreation in terms of public participation. Participants would seem typically to spear for sport, rather than as a source of obtaining food.

Fig. 31. Bow-fishing for carp, Lake St. Lawrence, Ontario.

Recent refinements in spear fishing have been adapted to the exploitation of locally available carp populations in Ontario and Manitoba, and are officially recognized by the governments of both provinces. Bow-fishing for carp has become a sport of increasing popularity in Ontario (Fig. 31). For example, on the upper St. Lawrence River, in the vicinity of Cornwall, a carp bow-fishing derby has been held annually since 1964 and has resulted in the harvesting of 2505 carp weighing 17,095 lb by contestants (Irvine, 1966). The fish taken

in this manner are commonly used for fertilizer or pet food, the penetration of the arrow making the flesh generally unsatisfactory for domestic purposes (Thurston, personal communication, 1966). In Manitoba, a 1-month bow-fishing season is provided in marshes at the south end of Lake Winnipeg but the total catch is relatively small (Doan, personal communication, 1966).

Underwater spearing for carp, using spear guns and scuba equipment, is increasing in popularity in Ontario particularly in the clearer waters of Lake Huron and Georgian Bay. Turbid waters in Manitoba (Doan, personal communication, 1966) typical of many carp habitats in the other provinces, limit, or prevent, the effective use of this sporting gear.

FISHERIES LEGISLATION PERTAINING TO THE CARP

The fisheries of Canada were defined as a Federal Government responsibility under the British North America Act of 1867 and, consequently, the legal basis for carp management is provided by special regulations made for the various provinces under the Fishery Act.

Transfer

A regulation common to the provinces of Canada, although not identically worded, is one requiring government approval for the release of all or certain species of fish into provincial waters. In Newfoundland and the Maritime Provinces, the Regulation refers specifically to nonindigenous species and, therefore, constitutes a legal barrier to the introduction of carp into these provinces. In the other provinces it is illegal without government consent to import any live fish into the respective province, and in Quebec, Ontario, and Saskatchewan, the illegality of transferring live fish from one body of water to another within the province, without permission, is specifically stated.

Use as Bait

Because of the suitability of young carp as bait fish, in those provinces with resident carp populations, the species is included within general bait fish regulations and in Quebec and Ontario is referred to specifically. Manitoba and Saskatchewan prohibit generally the use of live fish as bait. In Quebec it is illegal to raise live carp for bait and, with the exception of some waters where carp are resident, the use of the species is generally prohibited within provincial waters, but preserved carp may be used in waters where regulations permit fishing with bait. In Ontario, carp may not be used for bait, either alive or preserved. Manitoba regulations prohibit the use of fish as live bait but preserved bait fish may be used if they are processed immediately on capture. In British Columbia the rearing or breeding of fish, with the exception of goldfish and tropical fish, may be undertaken only under the authority of a licence.

Commercial Fishing

The fisheries regulations for each of those provinces with carp fisheries provide for the commercial harvest of the species under authority of a licence. One or more types of gear including trap, hoop, seine, and gill nets, may be authorized, and permission may be granted to fish carp in waters otherwise reserved for sport fishing. In British Columbia, Manitoba, and Ontario specific reference is made to the harvest of carp in addition to general commercial fishing regulations. In British Columbia, any person may be authorized to destroy ling and carp within non-tidal waters of the Province and a "Coarse Fish Non-Tidal Licence" may be granted to include carp, specifying type and extent of gear. Saskatchewan grants a special licence for a particular species for commercial purposes, and Manitoba grants special permits for the removal of carp by various types of impounding gear provided that the liberation of game fish is assured. In Ontario, in addition to being included in general fishing regulations on coarse fish species, the carp is dealt with specifically with reference to the use of gill nets and the waiver of restrictions on the setting of nets by commercial fishermen in streams and near river mouths. In Quebec, the carp is not identified but included arbitrarily among coarse fish and harvested under authority of a general commercial fishing licence specifying location, season, and gear. In 1904, Quebec began issuing a special permit to net carp during the fall and under the ice in winter.

Sport Fishing

None of the Canadian provinces recognizes the carp as a game fish and, consequently, there are no restrictions on the angling of carp with respect to season or creel limit. However, the use of commercial gear by sport fishermen is illegal although regulations in three of the provinces authorize the limited use of other types of sporting gear.

In Ontario, for carp and coarse fish, it is permissible to use spears during daylight hours in specified parts of the Province during one or more of the months of March, April, and May. Also permitted is the use of bow and arrow between sunrise and sunset during May, June, and/or July in restricted areas of the Province. Bow-fishing and spearing may be used for rough fish including carp in Saskatchewan, and in Manitoba regulations provide for the taking of carp with spear guns and bow-fishing. In none of these provinces is there a possession limit.

EFFECTS ON NATIVE BIOTA

Historical

During the last quarter of the 19th century when the United States Government was actively promoting public acceptance of the carp as a worthwhile addition to the natural fauna of North America, the less desirable aspects of the carp were not given recognition. It would seem that the Government was either unaware, or chose to ignore, the potential dangers of bringing the species to this Continent.

The results of Robinson's introduction of the carp and goldfish to New York State in the 1830's gave ample warning of the likely consequence of the establishment of the species in natural waters. More than 25 years before the United States Government began its project of carp introductions, writers like Forester (1850) were deploring Robinson's actions in bringing carp and goldfish to North America, expressing deep concern over the accidental escapement of the "scaly foreigners" into the Hudson River. Forester, in particular, attacked the "unutterable blockheadism" of the New York State Legislature for protecting from exploitation those fish which had escaped into the Hudson River and had multiplied with spectacular rapidity.

Warnings like those expressed by Forester (1850) were apparently unheeded by Baird and his colleagues at Washington, and it was not until carp had become established in virtually all of the suitable watersheds of the United States that adverse public opinion became pronounced and the United States Government was forced to reconsider its policy regarding the species. It had become evident to the naturalist, waterfowl hunter, and fisherman when the carp distribution programme was still in its infancy, that newly established carp populations were drastically altering marsh habitats with almost unbelievable rapidity.

As early as 1883, an increase of carp in Lake Erie was causing a drastic decrease in the wild celery and wild rice beds of the Lake (Moyle and Kuehn, 1964). This was typical of the situation which was to develop in literally hundreds of Canadian and American waters within a very few years and it was the flood of adverse reports received prior to that time which led the United States Fish Commission to assign to Leon J. Cole (1905) the task of evaluating the status of the carp in North America.

Prince (1897) was the first Canadian official to condemn openly the introduction of the carp to Canadian waters. It would seem that Prince, although no doubt greatly impressed by the stories of habitat destruction in the United States, based on his evidence in part on the habitat deprecation witnessed in the western end of Lake Erie and in the Lake St. Clair marshes. However, by the turn of the century evidence of carp damage in southern Ontario was building up and, in the First Annual Report of the Fisheries Branch of the Province of Ontario for 1899, it was noted that the carp "feeds on the spawn of other fishes. . . and on the tender sprouts of plants fed upon by the wild duck." In the following year, with reference to Lake Simcoe, fear was expressed that the carp "will be found very destructive to the spawn of the maskinonge." In the Report for 1901, reference was made to Lake Simcoe where "already hundreds of acres of wild rice fields in the Holland Marsh have been destroyed" and to the Toronto area of Lake Ontario where carp were said to be "a great menace to fisheries interests." In the Report for 1902, further evidence was provided on the destruction of wild rice and wild celery beds in Long Point Bay of Lake Erie, and again in Lake Simcoe. Similar observations appeared for each of the aforementioned waters in subsequent years (Chambers, 1904) and confirmed the statement of Cole (1905) that "as to the relation of carp to aquatic vegetation,

the evidence would seem to be pretty strong that in general they are very destructive, and are probably, in part at least, responsible for the great reduction of wild rice and wild celery that has been noted in many of our inland waters in the last few years." Nash (1908), speaking of the carp in Ontario waters, stated that the fish "had become an unbearable nuisance wherever found, for not only are they damaging our fisheries but also, by reason of their destruction of the wild rice beds, they are causing the waterfowl to avoid the feeding grounds to which they formerly resorted during the autumn flight."

During the first decade of the 20th century, there were scattered, throughout government reports, numerous references to the nuisance and damage caused by the carp in southern Ontario waters. As the carp typically thrived in marshes utilized by waterfowl, maskinonge, pike, and largemouth and smallmouth bass, reports of adverse effects on these fish and wildlife species came primarily from those areas where hunting and fishing was best, particularly the marshes of western Lake Erie, Rondeau and Long Point bays of Lake Erie, lakes Simcoe and Couchiching, southeastern Georgian Bay, inundated lands of the Trent Canal system, and the Lake Ontario marshes, particularly those in the region of Prince Edward County and the upper St. Lawrence River. The numerous small harbours fronting communities on the lower Great Lakes offered situations where the effects of local carp populations were readily observed and appraised. The fact that aquatic vegetation was substantially reduced, and on occasion virtually eliminated, by the intensity of carp populations, resulted in the obvious tendency to blame any deterioration in fishing or hunting quality on the carp.

The Ontario Game and Fish Commission Report for 1901 (Bensley, 1902) cautioned that Lake Simcoe carp, if they found their way down the Trent Canal, would be expected to destroy wild rice beds used by waterfowl and as spawning grounds by maskinonge. The report for 1902 noted that carp had become so abundant in Burlington Bay at Hamilton that they had driven native catfish and other coarse fish out of the inlets. The report for 1905 stated that prejudice against the carp had increased as it became more widely distributed and its destructiveness and depredations more generally known.

However, contrary to prevalent contemporary thinking, Harris (1960), although strongly deploring the carp, attributed the phenomenal increase of pike in Burlington Bay of Lake Ontario to the presence of young carp which had, he believed, become the food of the pike and attracted them to the Bay. Also, with reference to Long Point Bay of Lake Erie, he noted that the black bass had "congregated there since the coming of the carp to such an extent that thousands of bass are taken to stock (other waters) without apparently depleting the long Point Bay waters."

It was observed in the United States Fish Commission Report for 1903 that "in Europe they write about the culture of the carp, in North America about its bad points." This report summarized as follows the charges against the carp which reflected public opinion of the time. These charges were that: (i) it thrashes about and stirs up mud so that the breeding ground of other

fishes is spoiled; (ii) it roots up vegetation destroying wild rice and other aquatic plants; (iii) it eats the spawn of other fish; (iv) it eats the young of other fish; (v) it is of no value as a food fish, and (vi) it is of no value as a game fish. There is ample evidence for the Great Lakes region (Moyle and Kuehn, 1964; Druschba, 1959; Foye and Mairs, 1965; Benson, 1960; McCrimmon, 1956; Mackay, 1963; Swee and McCrimmon, 1966; Peterson and Drews, 1957; Burns, 1966) that the first two of these statements are basically valid.

FLORA

The extent of damage which the invading carp imposed on the aquatic environment in the lower Great Lakes basin cannot be accurately assessed on the basis of scanty details recorded at the time. However, the explosion of carp populations undoubtedly caused marked ecological changes to marsh habitats by destroying vast areas of the more susceptible rooted aquatics, especially wild rice, wild celery, and water milfoil, and in some locations would seem to have eliminated temporarily even the more resistant forms like coontail and sago pondweed (Fig. 32).

FIG. 32. Over-grazed aquatic vegetation during May in a marsh area frequented by adult carp.

Submergent and, in particular, emergent plants would seem to have soon become reestablished in most Ontario waters in spite of substantial populations of carp which are still resident in southern inland lakes and peripheral marshes of the Great Lakes. Lumsden (personal communication, 1966) has observed that

"in spite of the presence of high populations of carp in Lake St. Clair, good beds of aquatic vegetation persist and provide waterfowl with extensive feeding areas." Hewitt (1942) noted commercial harvests of carp as a source of revenue from an artificial marsh in Lake St. Clair being managed for waterfowl and muskrat production. McLeod (personal communication, 1966) noted that in the marshes of Lake St. Lawrence "there are many other environmental deficiencies more serious than carp that affect aquatic vegetation." This observation would seem to be generally true for the St. Lawrence and Ottawa rivers, and for the majority of carp-inhabited waters in Ontario and Quebec where other factors, including fluctuation in water levels, industrial and domestic pollution, wind action, etc., may be significant in controlling resident species and abundance of aquatic vegetation. Forbes and Richardson (1909) noted many years ago that the most serious charges against the carp appeared "to rest on uncertain or gratuitously assumed premises."

Of the native flora in Ontario marshes, wild rice would seem to be the species most obviously vulnerable to destruction by the carp. Lake Simcoe commercial fishermen, for example, have relied traditionally on the extent of wild rice beds in Cook's Bay as a measure of the numbers of available exploitable carp. Marshes fenced from carp, such as the Osler Marsh on Lake Scugog and some ditched marshes in the lakes Erie–St. Clair area, typically support more abundant growths of wild rice than do neighbouring areas to which carp have access. However, wild rice production in the Osler Marsh has continued to thrive abundantly although the barrier was removed in 1964 and substantial numbers of carp resumed spawning activity in the area. From studies in the Hamilton Marsh, Lake Ontario, Lamoureux (personal communication, 1966) observed that a rise in water level at the time of spawning may mean that vegetation will be washed out or uprooted, and the exposed substrate may ultimately be utilized by a different and perhaps more useful species of plant.

In western Canada, where the carp is a relatively recent migrant and, in fact, is still extending its distribution, evidence of its destructiveness on aquatic habitat is much more pronounced than in Ontario and Quebec. Bossenmaier (personal communication, 1966), basing his statement on observations of the peripheral marshes of lakes Manitoba, Winnipeg, and Winnipegosis, believes that there are situations in Manitoba where carp have virtually eliminated aquatic vegetation and other situations where they have caused significant reduction in the aquatic flora.

Leitch (personal communication, 1966) confirmed the foregoing statement, with particular reference to those areas where the effects of carp are best known, namely, the Delta marshes at the south end of Lake Manitoba, and the Netley and Liban marshes where the Red River empties into the south end of Lake Winnipeg. With reference to the Delta Marsh, he noted that the effects of the carp were noted only after a significant reduction in aquatic plants had become apparent. Some of the more important food plants, particularly sago pondweed (*P. pectinatus*), were practically eliminated but emergent plants were less affected.

Similarly, in the Netley and Liban marshes, submerged aquatics almost disappeared and the water became turbid following invasion by the carp, but the emergent plants were apparently little affected. Leitch (personal communication, 1966) also made the significant observation that sago pondweed thrives in small ponds within the marshes that are protected from penetration of the carp by thick bullrushes. This indicates the ability of the sago pondweed to flourish if protected from the carp.

In British Columbia, spectacular environmental effects of the carp have been limited to inland waters of the Columbia and Fraser River watersheds. Any effects on the lower Fraser River would be expected to have been masked by the previous influence of human activities on the ecology of the aquatic habitat. Vernon (personal communication, 1966) noted that the carp has made undesirable changes in the characteristics of some lakes, citing particularly Hatzic Lake, tributary to the Fraser River, as an example of a situation where clear water has become turbid and extensive growths of submerged vegetation destroyed.

Similarly at Vasseux Lake, a migratory bird sanctuary south of Penticton, Harris (personal communications, 1966) noted that there was literally no aquatic vegetation in shallows where it should be plentiful. The water was soiled with silt by the activity of the carp, short stubs of plants could be seen, and the soft mud was dented here and there, nosed out by the carp. Harris (personal communication, 1966) observed that a small lake north of Kelowna, Duck Lake, where vegetation once thrived abundantly, was devoid of emergent vegetation and the water was roiled at all times. These observations by Vernon and Harris are indicative of the current situation in a number of small lakes and in marshes of the Okanagan and Kootenay valleys utilized by migratory waterfowl.

The strong evidence of carp damage to aquatic vegetation in western Canada would seem to reflect the destructiveness of newly established carp populations, and is comparable to the situation reported in general from the United States and Ontario some 50–75 years ago when carp were first being disseminated on this continent. Some measure of natural restoration of aquatic vegetation would seem to have occurred in most areas not adversely affected by other environmental factors. As in Ontario, luxuriant and sometimes excessive growths of aquatic vegetation, although not necessarily of the pristine species composition, may occur even in areas frequented by large carp populations. The extent of damage to submergent and emergent vegetation may be influenced by local topographical and geological conditions. Martin and Uhler (1951) stated that "in waters with moderately firm sandy bottoms, rough fish may often be abundant but have little injurious effect on the aquatic vegetation." Moyle and Kuehn (1964) cautioned that "carp have gained such a bad reputation that there is a tendency to blame them, sometimes unjustly, for any and all damage to aquatic habitats" (Linduska, 1964).

In an assessment of the influence of carp populations on the biotic community, the species, if abundant, can unquestionably bring about tremendous

ecological changes in a body of water through rooting up the bottom, creating turbid water, and altering plant communities and aquatic growth. These effects would seem to be most pronounced in the presence of newly established carp populations. It must be recognized, however, that the level of influence on the aquatic community, either initially or on a long-term basis, will be conditioned by any given situation. Consequently, appraisals made of the present effects of carp on aquatic habitat across Canada differ widely, the influence considered to be more extreme in western Canada than in Ontario and Quebec. The difficulty in assessing the extent of ecological change caused by carp, relative to that resulting from human activity and natural forces, often poses a difficult problem, particularly in turbid and polluted waters frequented by the species. In spite of their generally accepted association with turbid waters, it is of interest that numerous carp may be seen during the summer months in the clear littoral waters of Lake Huron at various locations, for example, off Hope Island in Georgian Bay. Errington (1948) noted that some marshes cannot withstand the activities of carp whereas others retain splendid plant growth.

Although the negative effects of carp on aquatic habitat are generally stressed, activity of the fish resulting directly or indirectly in the suppression of aquatic plants may be of benefit in providing open marsh areas necessary for waterfowl. With the continuing eutrophication of those waters typically frequented by carp, the species may already be affecting some measure of aquatic weed control in recreational waters, particularly in the southern Ontario waterways, which would otherwise be choked with vegetation. Uhler (1944) proposed that carp be used in eliminating objectionable submerged vegetation in restricted areas where escape would not endanger valuable species.

Fauna

Knowledge of the effect of carp on fauna utilizing marsh and littoral habitats on a temporary or permanent basis is limited. However, the ecological effects of the carp on marsh habitats have been widely condemned by wildlife managers concerned with waterfowl management. Moyle and Kuehn (1964) noted that "the control of carp has taxed the ingenuity and finances of conservation agencies for more than 50 years."

Evidences of the relationship of waterfowl utilization to unfavourable ecological conditions in marshes attributed to carp activity have been recorded at numerous locations across the United States (Atlantic Waterfowl Council, 1963; Moyle and Kuehn, 1964) and there are a number of examples where the removal of carp from confined areas has brought about a spectacular clearing of the water and a replenishment of aquatic growth. Such situations are documented for Western Canada. In the Delta, Netley, and Liban marshes of Manitoba (Leitch, personal communication, 1966), decreased use of the area by migrant and breeding waterfowl, which appeared to be related to a reduction in aquatic food plants, was the first evidence that carp had become established

there. A subsequent fencing out of the carp from the marsh by Ducks Unlimited led to an improvement in the marsh ecology for waterfowl (personal communications with Leitch, (1966), Bossenmaier, (1966)).

In the Okanagan watershed of British Columbia (Harris, personal communication, 1966) marsh deterioration by carp is believed to have reduced the attractiveness of local marshes for waterfowl. Harris (personal communication, 1966) is of the opinion that, while the presence of carp may not reduce the waterfowl population of western Canada per se, carp control would increase waterfowl food in the Okanagan Valley to a point where more birds would use the migratory route and stop along the way.

In Ontario and Quebec, the general consensus of wildlife biologists is that the effect of carp on waterfowl populations is not known. Whether or not carp control would significantly increase the utilization of the St. Lawrence and Great Lakes basin for waterfowl can be no more than speculation on the basis of present knowledge. The more extensive marshes of the region are typically staging rather than breeding grounds; they provide substantial food and cover, and undoubtedly are attractive to spring and fall migrants. Although wild rice and other less resistant aquatic food plants may not be present in their pristine abundance, terrestrial grain crops would seem to more than compensate for their loss as an attractant for ducks and geese.

No specific research has been undertaken in Canada on the effect of carp on other fish species. Because of the preference of the carp for invertebrate plankton and bottom fauna, the species must be considered competitive with a number of kinds of fish with which they coexist across Canada and which feed on pelagic and benthic organisms during some stage of their life history. Published evidence that a competition for food adversely affects the welfare of other species would generally seem to be lacking. However, the common side effects of the feeding habits of the carp, i.e., disturbed bottom and turbid water, are occasionally cited as detrimental to less tolerant species (Ensign, 1960). In spite of the frequent assumption that spawning areas and the spawn of fish utilizing marsh habitats for reproduction may be destroyed by the activities of the carp, there is ample evidence from Ontario waters that most species of warmwater fish coexist satisfactorily with the carp provided that the habitat is basically suitable. Struthers (1932) reported that carp competed with game fish for food and that they could destroy aquatic vegetation with damage to fish food, fish spawn, and fish shelter. Westerman et al. (1943) pointed out that it is not known whether the damage is offset by the forage which young carp supply to piscivorous species such as pike, maskinonge, and walleyes. It must be recognized that the carp may thrive in situations physically and chemically unsuited to less tolerant species and the absence of these latter species may have no relation to the carp.

Numerous examples of the permanent or seasonal coexistence in Ontario of most, if not all, preferred warmwater species with the carp can be cited. Northern pike, *Esox lucius,* provide important fisheries in many peripheral marshes and bays of southern Lake Huron and Georgian Bay, the lower Great

Lakes, the upper St. Lawrence River, Lake Simcoe, and numerous small inland lakes of southwestern Ontario. Major maskinonge (*Esox maskinongy*) and largemouth bass (*Micropterus salmoides*) fisheries occur in Lake Scugog and the Kawartha Lakes where substantial carp populations exist (Fig. 33). Long Point Bay of Lake Erie provides one of the most intensive fisheries for smallmouth bass (*Micropterus dolomieui*) in North America yet supports one of the oldest, and among the most productive, local carp fisheries in Canada. These observations would seem to confirm the statement of Miller (1952) that when carp are present in moderate numbers, there would seem to be no effect on the size of the game fish population. Hewitt (1942) reported that, following dyking of the marsh in 1930, carp were taken from the Bradley Marsh of Lake St. Clair by seining.

FIG. 33. Mixed catch of carp and largemouth bass taken during experimental netting operations in Lake Scugog. (Ontario Department of Lands and Forests photo.)

Commercial harvests of native coarse fish, chiefly catostomids, ictalurids, and sometimes smaller members of the sunfish family, frequently occur along with local carp fisheries in the Great Lakes, Ottawa River, and St. Lawrence River basins of Ontario and Quebec. In the waters of the Prairie Provinces, the carp now coexists with buffalo fish (*Ictiobus*) and carp suckers (*Carpiodes*) among locally abundant native species of commercial consideration.

The theory that carp are serious predators on the eggs, and sometimes the young, of game and pan fish, is a popular assumption scattered through the North American literature (Meehan, 1904). Over 100 years ago, Forester (1850) expressed serious doubts that predation by carp was of any consequence, a conclusion reached by Cole (1905a) based on extensive studies of spawning grounds (of smallmouth bass in Lake St. Clair, and whitefish in Lake Erie) frequented by carp. Ensign (1960), following extensive studies on the carp, noted that "investigations throughout the country have failed to establish any appreciable egg predation" or that young fish are a common item in the carp diet, noting that in cases where fish remains occur in carp stomachs there is some doubt that the fish were alive when ingested. Harlan and Speaker (1956) stated that fish composed only a small part of the carp diet, but fish eggs often appeared in stomach analyses.

In spite of the prevalent assumption that it is true, the use of carp as forage by piscivorous fishes and waterfowl is poorly documented in the literature. The infrequency with which young carp are reported as forage does not necessarily imply that young carp may not be eaten in quantity, at least on occasion, by fish and fish-eating birds. Smiley (1884) advised that carp should be kept by themselves as there is no kind of fish which will not eat carp eggs and young fish. His list of the enemies of carp included goldfish and other minnows, mudcat, green frogs, turtles, snakes, and mink.

Because of the readiness with which young carp are devoured by other fishes in the laboratory, including esocids, centrachids, and percoids, it would seem likely that juvenile carp would be vulnerable to predation in natural environments not offering adequate protective cover. Turbidity, in some cases, may be a factor also in curtailing predation. In the marshes of Lake St. Lawrence (Swee and McCrimmon, 1966), young-of-the-year carp were difficult to observe because of their utilization of the aquatic vegetation as cover. In spite of the clarity of the water of this marsh it was necessary to undertake local poisoning operations to collect any numbers of young fish which proved to be abundant.

Harris (1913) referred to the utilization of young carp by northern pike in Burlington Bay of Lake Ontario, and by smallmouth bass in Long Point Bay of Lake Erie. Murphy (1949) reported carp as a minor constituent in largemouth bass stomachs in California, being about 1% in frequency of occurrence. Lewis and Helms (1964) included carp among the species eaten by largemouth bass in ponds. Lagler and Hubbs (1940) listed the carp as a food of the longnosed gar (*Lepisosteus osseus*). Young carp have been reported also to provide limited forage for striped bass (*Roccus saxatilis*) and catfish (*Ictalurus* spp.) (Shelby, 1917; Wales, 1942). Kudrynska (1962) noted that cannibalism among the larvae and fry of carp cannot be overlooked. Bellesome (1896) advocated the use of young carp to feed salmonoid fishes in European hatcheries. An interesting complaint of local commercial bait fish fishermen in the upper St. Lawrence has been that carp are attracted by bait put out to concentrate minnows prior to seining operations.

The utilization of carp as food for waterfowl is sparsely documented in the literature. Food items listed among the stomach contents of birds rarely identify fish to species although the Cyprinidae is among the more common families recorded. Martin and Uhler (1951) in their extensive studies on the food of game duck listed fish as an occasional item of food in North America, making up some 1.58% by volume of the stomach contents of the ducks of western Canada. Cottam and Uhler (1936) noted that suckers and carp constituted 7.5% of the stomach contents of fish eating birds on eastern Canadian and Michigan streams, and that low grade commercial fishes, principally carp and suckers, formed 3% of the food of the American merganser. Lucas (1936) noted a pond situation where piscivorous birds completely eliminated the population of carp and forage minnows.

Salyer, and Lagler (1946) listed carp among the food items of the belted kingfisher. However, Munroe and Clemens (1934) did not mention carp among the food of the American merganser in British Columbia, although fragmentary fish species with pharyngeal teeth were found in merganser stomachs.

Brakely (1885), in his treatise on carp and frog culture, noted that both bullfrogs and green frogs "have a reputation for possessing a fondness for young carp."

CONTROL METHODS

The control or elimination of local populations of carp has been advocated in Canada at some time wherever the species has become abundant. However, actual attempts at control have been limited to a relatively few situations in contrast to extensive efforts in many parts of the United States. Moyle and Kuehn (1964) observed that "the control of carp has taxed the ingenuity and finances of conservation agencies for more than 50 years."

The following evaluation of methods available for the control of carp populations is based on a survey of the literature, (Field et al., 1939; Henegar, 1966; Loeb, 1954, 1955, 1960; Martin and Uhler, 1951; Miller, 1952; Miller, et al., 1961; Mottley, 1938; Moyle and Kuehn, 1964; Shields, 1955; Sigler, 1958; Smallwood and Struthers, 1928; Struthers, 1932; Taylor et al., 1957; Sharp, 1942), the collective experience of fish and wildlife biologists in Canada and the neighbouring states, and personal observations of the author.

Sport Fishing Gear

Sport fishermen utilizing techniques in angling, spearing, and archery have been able to harvest substantial numbers of carp (personal communications, Smith, 1966; Sigler, 1958). However, the level of control exerted on any population, even by organized carp derbies, except possibly in a few local instances, would seem to be insignificant. Hook and line fisheries may take fish ranging in size upwards from 2 to 3 lb; carp taken by spear or arrow are typically over 7–8 lb in weight. Legislation concerning these latter tools in most Canadian waters imposes a major restriction on their use for fishing carp as well as the more preferred sport fishes.

Commercial Fishing Gear

Active commercial fisheries utilizing seine, pound, trammel, and gill nets have proven to be most effective in harvesting carp of marketable size but typically capture comparatively few small fish. Carp do not lead readily into hoop and trap nets used frequently for the commercial fishing of coarse fish species particularly in the Great Lakes region. The selective removal of adult carp from local waters typically leaves an environmental vacancy to be occupied by an explosion of young carp. Commercial fishing operations allowed in sport fishing waters under the guise of coarse fish removal, as occurs in Ontario, actually permit an effective utilization of local carp production on a continuous yield basis and constitute sound management for the perpetuation of the species rather than its extermination. However, there is evidence (Miller et al., 1961; Martin and Uhler, 1951) that intensive commercial fishing may reduce carp populations to the level where they do little damage to waterfowl habitats, but it must be recognized (Westman and Fahy, 1940) that commercial fishing will continue only if a carp population is sufficient for a profitable fishery.

The commercial use of gill, pound, and trammel nets for carp within sport fishery waters usually receives favourable public acceptance. However, particularly in Ontario, the seine must be used with discretion because of its action in scouring out aquatic plants and the inherent danger that sport fish may be harmed and their habitat and spawning areas destroyed. Von Oosten (1926) stated that in Lake Erie waters seining may prevent black bass from nesting but did not spoil the actual spawning areas used for this purpose.

Commercial Fishing Techniques

Carp control undertaken by government agencies using commercial type fishing gear has been generally without major long term benefit except in limited local situations where, by the use of pound nets, traps, or weirs, spawning populations have been excluded from marsh areas or where it has been possible to capture the bulk of a local spawning population (Miller et al., 1961) while migrating up a river or through a narrow constriction in lake or marsh (Fig. 34).

No mechanical fishing gear has proven adequate to harvest young carp effectively or to eliminate adult carp populations in other than confined areas. A long-term carp removal program of the Provincial Government of Ontario in Lake Scugog, using pound nets which harvested up to 30,000 lb annually, had no apparent effect on the standing carp population in this small inland lake.

Miller (1952) stated that seining during the times that carp were concentrated was the most practical method of carp removal but presented inherent difficulties for effective control. The practical application of seines is limited to areas with little aquatic vegetation and, in Canada, effective operations must be restricted generally to the early spring, late autumn, or winter seasons. Lamoureux (personal communication, 1966) has reported that seining is an effective means of carp control in the bay at Hamilton on Lake Ontario but that a population explosion would seem inevitable after heavy seining.

FIG. 34. Carp removal operations in Trent Canal system, using pound nets. (Ontario Department of Lands and Forests photo.)

FENCES AND BARRIERS

The exclusion of adult carp from marsh areas has been accomplished successfully by means of screens and fences (Sigler, 1958) but the cost of construction and maintenance is usually considered prohibitive if the enclosure of an extensive area is contemplated. The construction of low earthen dykes, readily built with modern equipment, may present a favourable and economically feasible alternative, particularly if water level control is deemed advantageous to local marsh management (Fig. 35). Electrical barriers, similar to those developed for lamprey control in the Great Lakes, may have limited application in preventing carp migration through narrow channels.

ELECTROFISHING

Electrofishing has been found to have limited application in carp control in spite of experimentation with several types of gear (Burr, 1931; Loeb, 1954, 1955; Taylor et al., 1957). Adequate coverage of the expanse of lake and marsh environment frequented by carp populations poses a most difficult problem for effective carp removal.

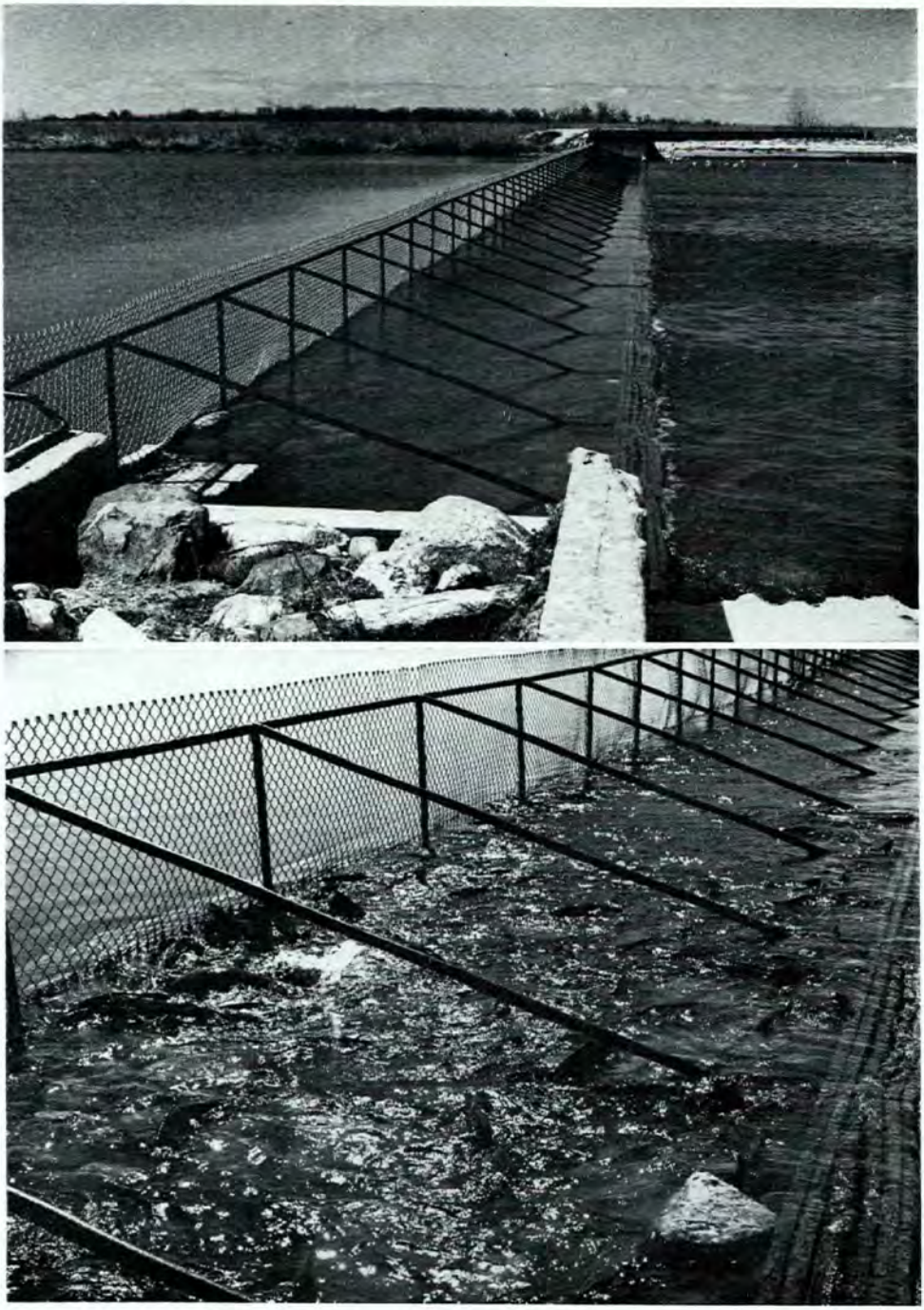

FIG. 35. Carp screen installed on principal outlet from Delta marshes into Lake Manitoba. Lower photo taken May 1964. (Ducks Unlimited photo.)

Toxicants

Several toxicants, generally with a toxaphene or rotenone base, have been used satisfactorily to destroy carp in restricted areas (Loeb, 1954). However, the use of chemical treatment on a large scale is costly and has the serious disadvantage of destroying other aquatic fauna and, particularly if applied from the air, poses a threat to waterfowl, birds, and terrestrial life (Martin and Uhler, 1951). The use of poisoned bait has also been given some consideration as a means of carp control. Except for local application, the use of toxicants for carp control must await the development of a selective poison similar in action to that used in the control of the sea lamprey. The use of carp attractants (Loeb, 1960) may be of use in concentrations of fish for more effective removal. Vernon (personal communication, 1967) has reported on the eradication of the carp population from Glen Lake, Vancouver Island, by means of rotenone in 1961.

Water Level Control

Fluctuating water levels have been generally recognized as a factor in the natural control of carp populations by the exposure of fertilized eggs to the air (Fig. 36). Because of the short incubation period and a prolonged spawning season, the artificial manipulation of water levels to destroy carp eggs must be repeated almost daily for a period which may extend over three or more months. For this reason the method has limited application. However, seasonal fluctuations in water levels within controlled marshes or impoundments may have merit if the technique can be used to prevent mature carp from reaching or using spawning areas (Shields, 1957) or to confine carp of all sizes within shallower areas during the period of ice-cover when they may suffer winterkill (Martin and Uhler, 1951).

Winter mortalities of carp, through oxygen deficiency in shallow ice-covered lakes, are known to occur naturally in Canadian waters. Following the break up of ice in Lake Scugog, Ontario, during the winter of 1959–60, Smith (personal communication, 1964) counted over 80,000 dead carp in association with some 1,500 maskinonge (*Esox masquinongy*) and 5,000 largemouth bass (*Micropterus dolomieui*) which had suffered the same fate.

SUMMARY

1. The present geographic distribution of carp in Canada, which has been the result of accidental, and a comparatively few intentional, introductions into five of its provinces, would seem to be defined by natural barriers or dams limiting a further expansion of its range through natural movement. However, favourable carp habitat is presently unoccupied by the species in each of these provinces, and the probability of a future extension of the range by introduction is probable.

2. Because of the comparative isolation of the fresh waters of the Maritime Provinces and Newfoundland from the carp populations of Quebec and Maine,

FIG. 36. *Upper*: a carp spawning grounds of Lake St. Lawrence exposed temporarily to the air because of water level manipulation by the Ontario Hydro; *lower*: fertilized carp eggs adhering to exposed vegetation.

rigid enforcement of fisheries regulations may be expected to deter the establishment of the species in these provinces. However, because of the proximity of the carp waters of Saskatchewan to Alberta, it would seem unlikely that even stringent regulations can prevent the eventual introduction of the species to the waters of the latter Province.

3. The present annual commercial harvest of carp from Canadian waters, estimated at 2.5 million lb with a landed value of $125,000, exploits modestly,

if at all, many of those local populations of the species resident in the waters of Quebec, Ontario, Manitoba, Saskatchewan, and British Columbia.

4. The domestic consumption of carp in Canada, estimated at over 1 million lb annually, is limited largely to markets in the larger cities of Ontario and western Quebec. In spite of the availability of substantial harvestable carp populations in Canada, and exports to the United States estimated at over 1 million lb, largely from Manitoba, imports into eastern Canada from the latter country in 1966 were estimated at 2.5 million lb of which some 98% reached the Montreal market.

5. The carp as a sport fish has failed to receive wide public acclaim in Canada although sportsmen have pursued the species since its first appearance in Ontario waters. Local but very limited sport fishing for carp would seem to exist from time to time in all provinces with carp populations, reaching the greatest, yet comparatively modest dimensions, in southern Ontario and, to a lesser extent in Manitoba, where angling, bow-fishing, and spearing have increased recently in popularity.

6. Public prejudice against the carp as a food or sport fish has not diminished appreciably in spite of the stated intention through the years by government agencies in North America. Efforts to date, confined essentially to United States Government agencies and popular outdoor magazines, have been generally ineffective in stimulating the Canadian people to a more effective utilization of the resource for food or pleasure.

7. By focusing public attention on the real or supposedly less desirable ecological aspects of carp biology, by considering management of the species in terms of control rather than utilization for food or recreation, and by grouping the species among coarse, rough, or trash fish and thus implying a flesh of inferior quality, conservation agencies in Canada have over a 75-year period caused a public disaste for the carp which would seem difficult to overcome even by creative promotion and public education.

8. Product development of carp as protein for domestic or industrial application would seem imperative if any substantial increase in markets is to be realized by Canadian carp fishermen. Included also should be the further development of specialty foods, now limited essentially to smoked carp, gefilte fish, and caviar.

9. The carp is a firmly established aquatic resource in Canada about which management agencies have surprisingly little factual information relative to the dimensions of the resource, the extent of present harvests by commercial and sport fishermen except in Ontario and Manitoba, the volume of imports and exports, the degree of its utilization as food, and its relation to the welfare of other fish and wildlife species with which it coexists. Procurement of these data on a local and regional basis is fundamental to effective management and utilization of the species in the future.

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