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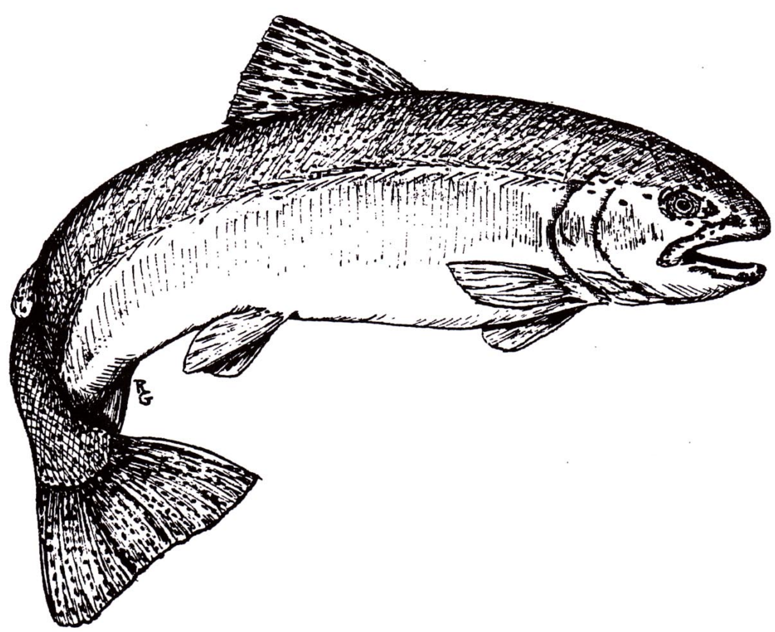

Rainbow Trout Stocking In Inland Lakes and Streams: An Annotated Bibliography and Literature Review

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Preface

This bibliography and literature review is the third in a set of reference documents developed in conjunction with a review of fish stocking policies and guidelines in the Province of Ontario. It has been prepared to summarize information pertaining to the current stage of knowledge regarding rainbow trout stocking into inland waters in a form which can readily be utilized by field staff and stocking proponents.

Material cited in this bibliography includes papers published in scientific journals, magazines and periodicals as well as gray literature such as file reports from Ministry of Natural Resources (MNR) field offices. Unpublished literature was obtained by soliciting information (i.e., unpublished data and file reports) from field biologists throughout Ontario. Most published information was obtained from a literature search at the MNR corporate library in Peterborough. Twenty-one major fisheries journals were reviewed as part of this exercise. These included Aquaculture (1972-1998), California Fish and Game (1917-1999), Copeia (1913-1999), Environmental Biology of Fishes (1976-1999), Fishery Bulletin (1963-1999), Fisheries Management (1975-1984), Journal of Freshwater Ecology (1981-1999), New York Fish and Game Journal (1954-1985), North American Journal of Fisheries Management (1981-1999), Journal of the Fisheries Research Board of Canada/Canadian Journal of Fisheries and Aquatic Sciences (1950-1999), Progressive Fish Culturist (1940-1999) and the Transactions of the American Fisheries Society (1929-1999). Searches were also made of other publications including Proceedings of the Annual Meeting of the Southeastern Association of Fish and Wildlife Agencies, Proceedings of the Annual Meeting of the Western Association of Fish and Wildlife Agencies, Transactions of the Annual North American Fish and Wildlife Conference, Transactions of the Annual Midwest Fish and Wildlife Conference, United States Department of the Interior Fisheries Technical Papers, FAO Fisheries Technical Papers and Circulars, and reports published under the Canadian Technical Report Series of Fisheries and Aquatic Sciences. Some material was obtained by a search on the Fish and Fisheries Worldwide database (1971-present) via the Internet.

Information from over 540 sources has been assembled. Abstracts from published papers have been included wherever possible. In cases where abstracts were not available, an attempt has been made to extract pertinent material from the document to provide a synopsis of the findings. In some cases, we were unable to obtain a copy of the document but have simply included the citation.

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History of Rainbow Trout Stocking in Ontario Inland Waters

Rainbow trout (*Oncorhynchus mykiss*) are considered a naturalized species in Ontario waters. Their native range consisted of the eastern Pacific Ocean and the coastal drainage of western North America from Mexico to Alaska (MacCrimmon 1971).

Although exact dates may be questionable, the earliest introductions of rainbow trout involved the Great Lakes and tributary streams. In the Lake Ontario watershed, the first plants were in New York state in 1878. By 1884 rainbow trout had moved to the Ontario side of the lake. The first Canadian plantings of rainbow trout are believed to have occurred in the late 1920s and early 1930s in Bronte Creek and the Humber River. In the Ontario waters of the Lake Erie watershed, the first plantings of rainbow trout fry (3,000) were made in 1882 with stock from the Northville Hatchery, Michigan, being planted in a small Lake St. Clair tributary (MacCrimmon 1971). There is some confusion about rainbow trout introductions to the Lake Superior watershed. MacCrimmon (1971) reported that the Ontario government planted rainbow trout near Sault Ste. Marie in 1883. Conversely, Lawrie and Rahrer (1973) state that rainbow trout were first stocked as eyed eggs in 1895 by the U.S. Fish Commission and that spawning populations had developed on both sides of the lake within 10 years. Spawning populations of rainbow trout in Lake Huron, believed to have spread downstream from Lake Superior, had developed by 1930.

One of the earliest records of rainbow trout stocking in inland waters of Ontario was in 1918 when 20,000 fish were released in Brough s Creek, a Lake Simcoe tributary, and in Lake Simcoe at the narrows near Atherley, Simcoe County.

In 1922, small plantings of rainbow trout had been made in Eagle Lake, Frontenac County (1,000 fish); Glecian River, Grey County (1,000 fish); Trout Lake, Parry Sound District (1,000 fish); Sturgeon Lake, Victoria County (1,000 fish); and Riverdale Park in Toronto (250 fish). Twelve hundred (1,200) rainbow trout and 5,300 steelhead were also stocked in Lake Simcoe.

In 1924, 10,000 rainbow trout were stocked in the Wahnapitae River near Sudbury and 5,000 were released in Lac des Milles Lacs near Thunder Bay.

Despite some of these early plantings there was apparently little interest in rainbow trout stocking. For example, of 1,268 applications for hatchery-reared fish in 1929, only 20 applicants requested rainbow trout. Seven of these waters were stocked in 1929.

A more active rainbow trout stocking program in Ontario commenced in the mid-late 1930s. The first stocking of Kamloops, a lake resident form of rainbow trout, was recorded in 1938 when a total of 25,800 fish were stocked in Waseosa Lake (Muskoka District), Bernard and Poole lakes (Parry Sound District), and Lake Temagami (Nipissing District).

In the 1940s, Kamloops were reared at both the Normandale and Chatsworth provincial fish culture stations. By 1967 various life stages of rainbow trout were reared and distributed from eleven different provincial fish culture stations. MacCrimmon et al. (1974) reported that at least 14 government and affiliated hatcheries in Ontario were rearing rainbow trout prior to 1973.

In 1999 404,792 rainbow trout were stocked in Ontario waters. Of this total, 155,654 trout (38.5%) were stocked in the Great Lakes while 249,138 fish (61.5%) were released in inland waters of the province (see Table 1).

Table 1. Rainbow trout stocking in Ontario inland waters in 1999.

Region	MNR District	Number of fish stocked
Southcentral	Aylmer	1,054
	Bancroft	29,350
	Kemptville	16,500
	Midhurst	7,505
	Pembroke	38,100
	Peterborough	10,000
	Subtotal	102,509
Northeastern	Chapleau	4,000
	Cochrane	10,000
	Hearst	8,000
	Kirkland Lake	16,500
	North Bay	49,618
	Sault Ste. Marie	12,300
	Sudbury	5,500
	Timmins	14,000
	Wawa	7,253
	Subtotal	127,321
Northwestern	Nipigon	19,308
Total		249,138

Rainbow trout are stocked in most portions of the province with the exception of northwestern Ontario. They are commonly used to diversify local angling opportunities and provide artificial (i.e., put-and-take) fisheries. The vast majority of rainbow trout stocking occurs in lakes and ponds. Rainbow trout are also the most popular species stocked by landowners in private ponds.

Synthesis of Selected Literature

This section is intended to provide a summary and overview of rainbow trout stocking information which has been assembled. This information has been summarized under the following categories:

1. Factors influencing stocking success
2. Survival and contribution of stocked rainbow trout to the fishery
3. Potential impacts of rainbow trout stocking activities
4. Stocking assessment
5. Best management practices for stocking rainbow trout in inland waters.

Factors Influencing Stocking Success

There are a great number of factors which can influence the success of a rainbow trout stocking project (Table 2). Many of these factors are common to other stocked salmonids.

Table 2. A summary of potential factors which can influence the success of a rainbow trout stocking project in an inland waterbody.

Factor	Reference(s)
Poor habitat/water quality	Anonymous (1960), Murphy (1962), Cuplin (1967), Marshall and Johnson (1971), Clady (1973), Soldwedel (1974), Ayles et al (1976), Myers and Peterka (1976), Lashley (1979_a), Donald and Anderson (1982), German et al. (1992), Wiley et al. (1993_a), Bettross (2000)
Water level fluctuations (flooding and/or drawdowns)	Anonymous (1953), Paukzke (1954), Brayton and Armstead (1967), Everett (1973), Soldwedel (1974)
Predation	Rawson (1945), Mueller and Rockett (1961), Murphy (1962), Cordone and Franz (1968), Keith and Barclay (1970), Marshall and Johnson (1971), Fraser (1972), Clady (1973), Axon (1974), Avery (1975), Myers and Peterka (1976), Wright and Sopuck (1979), Minnesota Department of Natural Resources (1982), Stuber et al. (1985), Matkowski (1989), Cunningham and Anderson (1992)
Prey availability	Johnson and Hasler (1954), Cordone and Franz (1968), Clady (1973)
Interspecific competition	Rawson (1945), Burdick and Cooper (1956), Clark (1959), Murphy (1962), Soldwedel (1967, 1974), Soldwedel and Pyle (1969), Fraser (1972), Alexander (1975_a), Bidgood and Barton (1982), Johnson (1982), Minnesota Department of Natural Resources (1982), Stuber et al. (1985), Gipson and Hubert (1991), Wiley et al. (1993_a)
Intraspecific competition	Needham and Slater (1944), Miller (1958), Needham (1959), Clady (1973), Anonymous (Undated_a)
Genetic strain	Soldwedel (1969), Cordone and Nicola (1970), Anonymous (1975, 1978), Dean (1980), Dwyer and Piper (1984), Close et al. (1985), Fay and Pardue (1986), Babey and Berry (1989)
Disease/parasites	Dick et al. (1987), Menzies et al. (1990)
Hatchery background (diet, condition of fish, rearing techniques, etc.)	Bailey (1958), Kennedy (1967), Wiley et al. (1993_a)

Table 2 (cont d)

Factor	Reference(s)
Transport stress	Threinen (1958), Anonymous (1957, Undated_a)
Stocking practice (frequency, time, rate, age/size, etc.)	Anonymous (1953), Cuplin (1967), Donald and Anderson (1982), Anonymous (Undated_b)
Post-stocking weather conditions	Anonymous (1953), Marshall and Johnson (1971)
Emigration of stocked fish	Kuehn and Schumacher (1957), Huston and Vaughan (1960), Murphy (1962), Schumacher (1964), Smith (1967), Cordone (1968), Bailey et al. (1973), Axon (1974), Rawstron (1977_a), Wright and Sopuck (1979), Cresswell (1981)

Habitat and Water Quality — The availability of suitable habitat, including water quality, is an obvious factor influencing stocking success. In several small lakes of western Canada, Donald and Anderson (1982) related rainbow trout stocking success to mean depth, total dissolved solids (TDS) and stocking density. Gipson and Hubert (1991) also found that TDS was related to the condition of stocked rainbow trout in small Wyoming reservoirs. In Beardsley Reservoir, California, Cordone (1968) identified turbidity as a factor partially responsible for the low survival of stocked rainbow trout.

Rainbow trout are known to be more tolerant of a wider range of conditions, including warmer water temperatures, higher pH, and increased salinities, than other salmonids, notably brook trout (see Table 3). For this reason, rainbow trout are often stocked in waters which are considered marginal for other trout. Nonetheless, a substantial proportion (i.e., >40%) of a waterbody should provide oligotrophic conditions to be suitable for rainbow trout.

Table 3. General habitat requirements of rainbow trout.

Parameter	Requirement
Size of waterbody	• Minimum of _ acre for ponds • Lakes less than 100 ha • Streams and small rivers
Water depth	• Moderately deep — deep (e.g., > 10-12 m) water in lakes. • Mean depth of 2-3 m with some areas at least 4-5 m feet deep in ponds. • Presence of deep pools in streams for overwinter habitat.
Bathymetry	• Shoreline/littoral zone should slope deeply into 1-1.2 m of water in ponds.
Water clarity	• Clear (Secchi 4-8 m on average)
Water temperature	• 14-20… C preferred; maximum 22… C
pH	• Minimum of 6.5; optimal range 6.5-8.0
Dissolved oxygen	• Minimum of 5 mg L^{-1}
Water velocity	• Maximum of 22-23 cm sec^{-1} (less for juvenile life stages)
Trophic status of waterbody	• Morphedaphic index (MEI) usually in range of 8-10.

The failure of several rainbow trout stocking programs have been attributed to unsuitable habitat and water quality conditions including adverse water flows (Wiley et al. 1993_a), turbidity (Soldwedel 1974), water temperature fluctuations (Clady 1973, Bettross 2000), low levels of dissolved oxygen (Ayles et al. 1976, Myers and Peterka 1976, Lashley 1979_a, German et al. 1992, Bettross 2000), absence of overwinter habitat in streams (Clady 1973) and environmental conditions associated with extremely harsh winters (Marshall and Johnson 1971, Kerr and Grant 2000).

Predation - Predation is probably the single greatest source of mortality on stocked trout. Johnson and Hasler (1954) reported that, in several Wisconsin and Michigan lakes, natural mortality post-stocking was almost entirely predator dependent. They reported mortality rates of 32-60% for age I rainbow trout and 15-19% for age II rainbow trout. Hatchery-reared rainbow trout are vulnerable to a wide range of predators (Table 4). In streams the susceptibility of stocked fish to predation is probably related to the amount of available cover.

Table 4. Predators of stocked rainbow trout.

Predator	Reference(s)
Fish	
Brown trout	Stuber et al. (1985), Kerr and Grant (2000)
Burbot	Cunningham and Anderson (1992)
Chain pickerel	Keith and Barkley (1970)
Lake trout	Cordone and Franz (1968), Kerr and Grant (2000)
Largemouth bass	Stocek and MacCrimmon (1965), Swor and Bulow (1975), Keith and Barclay (1970), Avery (1975), Minnesota Department of Natural Resources (1982)
Northern pike	Wright and Sopuck (1979), Minnesota Department of Natural Resources (1982), Cunningham and Anderson (1992), Kerr and Grant (2000)
Rainbow trout	Stocek and MacCrimmon (1965)
Smallmouth bass	Axon (1975), Avery (1975), Swor and Bulow (1975), Minnesota Department of Natural Resources (1982)
Spotted bass	Swor and Bulow (1975)
Striped bass	Axon (1974), Walters et al. (1997)
Utah chub	Modde et al. (1996)
Walleye	Mueller and Patterson (1972), Swor and Bulow (1975), Wright and Sopuk (1979), Minnesota Department of Natural Resources (1982), Cunningham and Anderson (1992), Yule et al. (2000)
Yellow perch	Mueller and Rockett (1961), Minnesota Department of Natural Resources (1982)
Birds	
Common loon	Matkowski (1989)
Common tern	Ayles and Lark (1975)
Double breasted cormorant	Modde et al. (1996)
Great blue heron	Matkowski (1989), Anonymous ($Undated_a$)
Osprey	Anonymous ($Undated_a$)
Pelicans	Dick et al. (1987)
Western grebe	Modde et al. (1996)
Mammals	
Mink	Anonymous ($Undated_a$)

In Lake Quachita, Arkansas, Keith and Barclay (1970) reported that chain pickerel and largemouth bass preyed heavily upon stocked rainbow trout. Swor and Bulow (1975) found that several warmwater species preyed heavily on stocked rainbow trout in the Cumberland River, Tennessee. Wright and Sopuk (1979) cited predation by walleye and northern pike as the reason for poor survival of stocked rainbow trout in Max and Sleep lakes, respectively, in Manitoba. Avery (1975) recommended that fingerling (i.e., 3-4) rainbow trout not be stocked in lakes with smallmouth bass and yellow perch to create a two-story fishery because of poor survival from predation. Myers and Peterka (1976) attributed poor survival of stocked rainbow trout in three South Dakota prairie lakes to bird predation. Matkowski (1989) concluded that the pelagic habits of rainbow trout made them more susceptible to avian predation than other salmonids.

Prey Availability — Rainbow trout are opportunistic feeders and have a diverse diet (Table 5). Diet varies with the size of fish. Juvenile rainbow trout feed on smaller organisms until they become large enough to switch to a piscivorous diet. Beachamp (1990) reported that rainbow trout in Lake Washington, Washington, under 250 mm fork lengthy fed primarily on *Daphnia* spp. while larger trout were predominantly piscivorous.

Table 5. Food items of stocked rainbow trout.

Food item	Reference(s)
Aquatic insects (e.g., mayflies, dragonflies, damselflies, midges, caddisflies, etc.)	Burdick and Cooper (1956), Kennedy (1967), Overholtz (1974), Alexander (1975_a), Kerr and Grant (2000)
Aquatic crustaceans (e.g., *Gammarus, Daphnia,* cladocerans*, etc.)*	Barrows (1962), May et al. (1967), Groutage (1968), Brynildson and Kempinger (1973), Alexander (1975_a), Barton and Bidgood (1979), Beauchamp (1990), Lucas (1993), Wang et al. (1996)
Terrestrial insects	Needham and Welsh (1953), Stocek and MacCrimmon (1965), Johnson (1981), Kerr and Grant (2000)
Snails	Kerr and Grant (2000)
Crayfish	Alexander (1975_a) Hepworth and Duffield (1987), Kerr and Grant (2000)
Fish	
Alewife	Youngs and Oglesby (1972)
American smelt	Bridges and Hambly (1971), Lynott et al. (1995)
Bloater chub	Kerr and Grant (2000)
Bluegill	May et al. (1967)
Brook trout	Wales and Borgeson (1961)
Brown bullhead	Stocek and MacCrimmon (1965)
Fathead minnow	Stocek and MacCrimmon (1965), Dick et al. (1987)
Five spined stickleback	Dick et al. (1987)
Green sunfish	May et al. (1967)
Johnny darter	Kerr and Grant (2000)
Largemouth bass	Stocek and MacCrimmon (1965)
Longfin smelt	Beauchamp (1990), Swartzman and Beauchamp (1990)
Nine spined stickleback	Dick et al. (1987)
Prickly sculpin	Beauchamp (1990)
Rainbow trout	Stocek and MacCrimmon (1965), Anonymous ($1990,1994_a$)
Redside shiner	Crossman and Larkin (1959)
Slimy sculpin	Kerr and Grant (2000)
Sockeye salmon	Swartzman and Beauchamp (1990), Kerr and Grant (2000)
Speckled dace	Johnson (1982)
Threadfin shad	Kirkland and Bowling (1966), May et al. (1967), Axon (1974)
Three-spined stickleback	Engel (1970)
Yellow perch	Beauchamp (1990), Kerr and Grant (2000)
Algae	Stocek and MacCrimmon (1965)

The abundance of food is known to influence the growth and survival of rainbow trout, particularly juvenile life stages (Johnson and Hasler 1954, Kerr and Grant 2000). Clady (1973) concluded that starvation was a common source of overwinter mortality. The availability of food can also influence the amount of competition which occurs.

Intra- and Interspecific Competition - It is well known that stocking success is usually maximized in waters where there is minimal competition with other fish species. Hatchery-reared rainbow trout compete with both wild rainbow trout (intraspecific competition) and with other resident fish species (interspecific competition).

Although there is evidence that hatchery-reared trout are inferior in condition and wild rainbow trout may have some competitive advantage, there can be little doubt that stocked rainbow trout compete with wild trout for both food and space. In Flint Creek, Montana, growth and condition of stocked rainbow trout was best in sections of the creek where they were subjected to less competition with wild rainbow trout (Anonymous Undated_a). After a review of post-stocking rainbow trout survival, Miller (1958) and Needham (1959) noted that, where resident rainbow trout populations were already present in streams, post-stocking losses of hatchery-reared fish were immediate and heavy. Needham and Slater (1944) concluded that plantings of rainbow trout fingerlings in streams with wild trout were largely ineffectual.

A number of researchers report poor stocking success in waters where competition is significant (Clark 1959, Murphy 1962, Soldwedel 1974, Stuber et al. 1985, Gipson and Hubert 1991). Rawson (1945) concluded that great difficulty would be encountered in attempting to successfully introduce rainbow trout in waters where competitor and predator fish were already present. Donald (1987) concluded that the presence of mountain whitefish, longnose suckers and lake trout prevented the colonization by or restricted the population size of stocked rainbow trout. Clark (1969) found that, where competition was severe, Kamloops trout introductions were not successful. Fraser (1972) demonstrated an inverse relationship between the complexity of the resident fish community and the yield of planted salmonids, including rainbow trout, in several Ontario lakes.

Several studies have demonstrated a negative relationship between white suckers and rainbow trout. The diet of rainbow trout, white sucker and longnose sucker was found to overlap considerably in Paine Lake, Alberta (Barton and Bidgood 1979). Bidgood and Barton (1982) noted that the presence of suckers resulted in a decreased growth rate of stocked rainbow trout. Alexander (1975_a) found survival of stocked rainbow trout was reduced after the introduction of white sucker to East Fish Lake, Michigan. Similar observations were made in Fuller Pond, Michigan (Alexander 1975_b). This was attributed to a reduction in benthos populations.

Several small fish species are known to compete with rainbow trout. Johnson (1982) reported that speckled dace competed with young rainbow trout for food. Three spined stickleback have been found to adversely influence the survival and growth of rainbow trout fingerlings (Engel 1970). Soldwedel (1967) found that rainbow trout survival was poor in ponds containing alewife and fathead minnows. Burdick and Cooper (1956) concluded that minnows were more detrimental, through competition for food, than beneficial in providing forage for rainbow trout.

Genetic Strain — Rainbow trout have been artificially propagated for many years. Hatchery practices have involved the selective crossing of various strains to maximize performance in terms of a number of variables (Table 6).

Table 6. Some genetically determined traits reported for hatchery-reared rainbow trout.

Trait	Reference(s)
Behavior	Rawstron (1972, 1973)
Physiology	Utter (1971)
Growth	Smith et al. (1969), Anonymous (1978), Ford (1978), Reinitz et al. (1978), Dolan and Piper (1979), Dwyer et al. (1979), Hepworth and Lippink (1979), Dean (1980), Brauhn and Kincaid (1982), Ayles and Baker (1983), Dwyer and Piper (1984), Close et al. (1985), Nelson (1987), Pawson and Purdon (1991)
Movements	Huston and Vaughan (1960), Cordone and Nicola (1970), Cargill (1980), Moring (1982, 1993)
Contribution to fishery	Dwyer and Piper (1984), Moring (1982), Mueller (1985)
Catchability	Boles and Borgeson (1964), Rawstron (1972, 1973, 1977_a), Anonymous (1978), Dolan and Piper (1979), Dwyer et al. (1979), Kmiecik (1980), Brauhn and Kincaid (1982), Dwyer and Piper (1984), Close et al. (1985), Mueller (1985), Faye and Pardue (1986), Babey and Berry (1989), Pawson and Purdon (1991)
Meristic characters	MacGregor and MacCrimmon (1977), Nelson (1987)
Maturation	Hume and Tsumara (1992)
Swimming ability	Thomas and Donahoo (1977), Duthie (1987)
Survival	Smith et al. (1969)Rawstron (1972, 1973), Ayles (1973), Hepworth and Leppink (1979), Hassler et al. (1986), Nelson (1987)
Susceptibility to diseases/parasites	Smith et al. (1969), Kinunen and Moring (1978), Babey and Berry (1989)

Fisheries managers need to ensure that the most appropriate strains of rainbow trout are selected to achieve the objectives of their particular stocking project.

Stocking Technique — Stocking technique includes parameters such as the age/size of fish stocked, time of stocking (e.g., spring vs. fall), stocking density, frequency of stocking and stocking site. All of these parameters can have a pronounced effect on the success of a stocking project.

The life stage and size of rainbow trout stocked usually depends on the stocking objective and conditions in the waterbody being stocked. Early life stages, such as fry, are only stocked in waters having abundant cover and food with very few predators present. Needham (1969) recommended that advanced fry to small (2) fingerlings be stocked in lightly fished streams having ample cover and access to a deep, cold lake. Parish (1979) concluded that the poor survival of rainbow trout fry did not justify it s consideration as a management practice. Fingerlings and yearlings are more commonly stocked in put-grow-take situations where an immediate return to the fishery is not desired. Size at this age is an important consideration.

Johnson (1978) recommended that fingerlings should not be stocked at sizes smaller than 100/lb. Needham (1969) felt that 3-5 fingerlings should be stocked in more heavily fished lakes and streams. Mueller and Rockett (1961) suggested that planted rainbow trout needed to be at least 4 inches long (e.g., 40/lb.) to escape predation from yellow perch. Mueller and Peterson (1972) reported that walleye predation was greater on rainbow trout stocked at sizes of 44/lb than trout released at sizes of 7/lb. In a rainbow trout stocking study involving fingerlings planted at 2, 3 and 4 inches in length, the four inch fingerlings were returned to the fishery at a more consistent rate (Parish 1977). In Lake Taneycomo , Missouri, Turner (1972) compared angler returns of rainbow trout stocked at lengths of 4, 6, 8 and 10 inches, and concluded the best return, in terms of the numbers harvested and harvest duration, were the trout released at 6 inches in length. In waters stocked to provide an immediate fishery, catchable or legal-sized trout are usually used. In these situations, larger is usually better. Based on a review of rainbow trout stocking in reservoirs and tailwaters, Turner (1971) concluded that larger trout provided higher immediate returns but small trout were able to sustain the fishery longer. Muckenheim (1987) recommended stocking rainbow trout at least 30 cm in length in Oastler Lake, Ontario, to maximize returns to park users. In the Hoover Dam tailwater, Colorado River, angler returns from two stockings of rainbow trout, released at 21-25 cm in length, were 1 and 2%. Conversely, returns from trout released at 33+ cm were 47% and 22% (Walters et al. 1997). Yule et al. (2000) concluded that catchable-sized rainbow trout (> 208 mm) were the most efficient size of fish to plant in Wyoming reservoirs when compared to smaller (178-207 mm) or subcatchable-sized (127-177 mm) fish.

Stocking rates vary considerably among different jurisdictions according to the stocking objective, size/age of fish being stocked, amount of fishing pressure and the type of waterbody (Table 7). Stocking rate is known to influence angling success (Helfrich and Barton 1979). Barton (1979_a) reported that, in Paine Lake, Alberta, the trout catch rate increased from 0.11 to 0.94 over three years when stocking rates increased from 1028 fish/ha to 2475 fish/ha, respectively. Similarly, in Beavermines Lake, Alberta, Barton (1979_b) found that an increase in stocking rate from 1237 fish/ha to 2471 fish/ha increased the catch rate of age I fish twofold.

Table 7. Rainbow trout stocking rates reported in various North American jurisdictions.

Waterbody	Stocking Density	Reference(s)
<u>Ponds</u>		
Ontario ponds	• 1,000 fry (1-2) per surface acre. • 300-500 fingerlings (3-5) per surface acre. • 200-300 yearlings (6-8) per surface acre.	Ayers et al. (1976)
Ontario ponds	• 1,000 fry per surface acre. • 300 fingerlings per surface acre.	Norman (1976)
Alberta potholes	• Year 1 — 500 fingerlings per acre. • Year 2 — 250 fingerlings per acre. • Year 3 - > 50 fingerlings per acre.	Bidgood (1975)
Montana ranch ponds	• 250-1,000 fingerlings per acre.	Brown and Thoreson (1958)
New York farm ponds	• 300-600 fall fingerlings per acre.	Brumstread (1960)
United States ponds	• 1,000 eyed eggs per acre. • 350 fry per acre. • 300 fingerlings per acre.	Swingle (1949)

Table 7 (cont d)

Waterbody	Stocking Density	Reference(s)
Lakes		
New York lakes	• 30ˆMEI fiigerlings per acre. • 15ˆMEI yearlings per acre. • 10ˆMEI catchables per acre.	Engstrom-Heg (1979)
California lakes	• 50-100 small (>75/lb) fingerlings per acre. • 35-75 large (16-50/lb) fingerlings per acre. • 20-30 subcatchables (6-16/lb) per acre.	Hopelain (2000)
Michigan lakes	• 2-25 yearlings per acre in large, oligotrophic multi-species lakes. • 25 yearlings per acre in multi-species two story mesotrophic lakes. • 50-150 fingerlings (3-4) in single species trout lakes.	Michigan Department of Natural Resources (1977)
Ohio lakes	• 75 fish/ha in lakes < 16 ha. • 50 fish/ha in lakes 17-32 ha. • 25 fish/ha in lakes >33 ha. • Minimum of 500 fish per lake and maximum of 4,000 fish per lake.	Ohio Department of Natural Resources (Undated)
Ontario lakes	• Based on a formula involving total dissolved solids and the amount of angling pressure: (TDS > 100 mg L^{-1} stock 150 yearlings per acre of water less than 20 deep; if TDS < 100 mg L^{-1} then stock 100 yearlings per acre of water less than 20 deep) (Angling pressure factor — light (0-10 days/acre/year) — 0.5; moderate (10-20 days/acre/year) — 1.0; heavy (> 20 days/acre/year) — 1.5).	Ontario Department of Lands and Forests (1970)
	• Where TDS< 100 mgL-1 stock 4.5 kg (225 fish) yearlings per ha water < 6 m in depth; where TDS> 100 mgL-1 stock 7.0 (350 fish) yearlings per ha of water < 6 m in depth.	Ontario Ministry of Natural Resources (1982)
	• For put-grow-take purposes stock 4.5 kg/ha of lake greater than 6 m in depth.	Ontario Ministry of Natural Resources (2000_a)
Qu bec lakes	• Under low levels of competition stock fry or fingerlings at the rate of 1500 fry/ha or 300 fingerlings/ha. • Under moderate levels of competition stock either fingerlings or yearlings at rates of 200 fingerlings/ha or 100 yearlings/ha. • Under high levels of competition, stock yearlings at 50 fish/ha.	Qu bec Minist re du Loisir, de la Chasse et de la P che (1988)
British Columbia lakes	• 16-64,000 fry/mile of lake shoreline.	Smith (1959)

Table 7 (cont d)

Waterbody	Stocking Density	Reference(s)
Wyoming lakes and reservoirs	• 150-300 catchable trout per surface acre	Eiserman (1966)
Streams		
Michigan streams	• 50-150 yearlings per acre in large fertile trout streams (maintenance stocking). • 50-100 yearlings per acre in small to moderate sized trout streams of average fertility. • 100-200 fingerlings in small to moderate sized trout streams of average fertility.	Michigan Department of Natural Resources (1977)
Qu bec streams	• Under low levels of competition stock either fry or fingerlings at the rate of 450 fry/m x km (maximum 9000/km) or 90 fingerlings/m x km (maximum 1800/km). • Under moderate levels of competition stock fingerlings or yearlings at the rate of 60 fingerlings/m x km (maximum 1200/km) or 30 yearlings/m x km (maximum 600/km). • Under high levels of competition stock yearlings at the rate of 15/m x km (maximum 300/km).	Qu bec Minist re du Loisir, de la Chasse et de la P che (1988)

It is possible to overstock, however. In East Fish Lake, Michigan, Alexander (1975_a) found that the mortality rate of hatchery-reared rainbow trout increased substantially with an increase in stocking density. In a comparative study of angler returns from three catchable rainbow trout stocking rates (700 fish/ha, 1400 fish/ha and 2100 fish/ha), Miko et al. (1995) reported that the highest catch rates were at elevated stocking densities but angler effort, proportion of stocked fish caught or angler satisfaction did not differ among stocking treatments. Similar observations were reported by Hazzard and Shetter (1940) in Michigan streams. In California waters, Butler and Borgeson (1965) concluded that increased plantings of catchable-sized trout did not increase the overall catch-per-unit-of-effort. In five Oregon streams, Moring (1979) found that the proportion of stocked trout was maintained at 25-50% reductions in stocking density. When stocking was terminated in the Madison River, Montana, the abundance of wild rainbow trout increased eightfold (Goodman 1991). Overstocking can also result in slow growth and reduced condition (Bailey 1958). Overall, it is better to understock than to overstock (Brown and Thoreson 1958).

Rainbow trout stocking has occurred throughout the year but there is considerable evidence to suggest that plantings in the spring and early summer are the most successful. Recoveries of planted legal-sized trout in five streams were greatest when released in the spring as compared to the fall (Halloway 1945). In an assessment of four different rainbow trout strains stocked in Porcupine Reservoir, Utah, survival to the creel was always greater for spring versus fall stocked trout. In Michigan streams, four times as many legal-sized rainbow trout stocked in the early spring and open season were recovered as compared to those stocked in the fall. Returns of marked rainbow trout stocked in the American Falls Reservoir, Idaho, in April, June and September were 8%, 7% and 1%, respectively (Anonymous 1965_b). Nesbit and Kitson (1937) reported the best returns from Massachusetts streams were from rainbow trout stocked during the late spring immediately before the opening of the fishing season.

Fall-stocked rainbow trout generally survive poorly (Anonymous 1963_{a}, O Bara and Eggleton 1995). This has been attributed to the fact that they may not disperse as readily (Anonymous 1953) and that overwinter mortality is extensive (Needham 1959, Heimer 1967).

In some artificial (i.e., put-and-take) fisheries, trout are released several times over the course of the fishing season. In these instances, returns from plants early in the season usually are best. The best returns of catchable rainbow trout in two Idaho reservoirs was highest for spring (April) releases as compared to releases later in the season (July and August) (Casey 1966_{b}). Early season (i.e., early July) provided better returns than fish planted in mid August in Upper Salmon Lake, California (Boles and Borgeson 1964). In Alturas Lake, best returns of stocked rainbow trout were from fish released prior to July (Anonymous 1965_{c})

In terms of stocking frequency, the best approach depends on the stocking objective. For projects designed to provide immediate (i.e., put-and-take) angling opportunities, it may be prudent to stock fish several times during the same season. More trout were caught under a system of semi-annual stocking than an annual stocking regime in Corey Lake, Michigan (Anonymous Undated_{b}). In situations where establishing a longer term (i.e., put-and-delayed-take fishery) is the goal, annual or alternate year stocking is probably more appropriate. Alternate year stocking was recommended for put-and-delayed take lakes of southcentral Ontario (Bradbury 1980) and in northwestern Ontario (Marks 1979).

There has been considerable debate over the years with regard to the method of releasing hatchery-reared rainbow trout particularly in a stream environment. Two techniques are commonly employed: spot planting whereby the entire lot of fish are released at one location and scatter planting where an effort is made to release the allotment of fish at several different sites. Ratledge and Cornell (1953) found that the dispersal of rainbow trout from a spot stocking was not comparable to the results observed from releasing fish at several locations. Butler and Borgeson (1965) concluded that, since trout did not readily disperse when released in streams, distributional practices played a major role in their catchability. In spite of that observation, several researchers have found there to be no difference in returns from fish stocked by the two techniques (Shetter 1947, Anonymous 1953, Cooper 1953, Casey 1966_{a}). Casey (1966_{a}) reported that scattering catchable-sized rainbow trout in two Idaho reservoirs did not increase the return of fish to the creel. Clady (1973) concluded that the return to the creel of scatter planted catchable trout was equal to or poorer than trout which were spot planted .

Rainbow trout seem to disperse quickly in lakes but lake stocking sites may be important however. Mueller and Rockett (1961) reported that yellow perch predation was high on rainbow trout stocked through the ice over shoals but was significantly less when fish were released over deep (e.g., 12-18 m) water sites. Returns of stocked rainbow trout have been found to be greater when released in more heavily fished portions of a lake (Corley 1966).

Emigration of Stocked Fish — There have been several instances where post-stocking movements of stocked rainbow trout have been recorded. Moring (1993) reported downstream movements of 84 kilometers within 4 days of release. Kuehn and Schumacher (1957) reported a loss of 5.3% of stocked rainbow trout from downstream movements in four Minnesota streams. Movements from release sites in streams may be in both upstream (Hazzard and Shetter 1938) and downstream (Swartzman 1950, Bailey et al. 1973, Cresswell 1981, Helfrich and Kendall 1982) directions. In the Clinch River below the Norris Dam, Tennessee, Bettinger and Bettoli (1998) noted that stocked trout dispersed quickly in both upstream and downstream directions. In Big Stony Creek, Virginia, Kendall and Helfrich (1982) reported that, of stocked fish which were planted, 45% moved downstream, 33% moved upstream and 22% displayed no movement. Donald (1987) attributed losses of stocked rainbow trout to emigration from outlets in several western Canadian lakes. He concluded that the amount of post-stocking emigration was proportional to the size of the lake outlet. In Lake Cumberland, Kentucky, Axon (1974) considered emigration as a reason for major losses of stocked rainbow trout. MacManus (1950) captured lake-stocked rainbow trout in Byer s Creek, a tributary to Round Lake, Ontario. In spite of these observations, there is considerable evidence that many rainbow trout move little after their release in streams (Rayner et al. 1944, Anonymous 1959, 1969, Cooper 1953, Newell 1957$_a$, Butler and Borgeson 1965, Brynildson 1967, Cargill 1980).

Several parameters have been noted to influence post-stocking movements (Table 8). If emigration is a concern, effort should be taken to address as many of these variables as possible.

Table 8. Variables which influence post-stocking movements of hatchery-reared rainbow trout.

Parameter	Reference(s)
Elevated discharge or flooding	Huston and Vaughan (1960), Smith (1967), Cordone (1968), Kendall and Helfrich (1982)
Reductions in water levels	Murphy (1962)
Stocking density (i.e., overstocking)	Clady (1973), Anonymous (Undated$_a$)
Water temperatures	Anonymous (1965$_b$), Casey (1965$_a$), Cresswell (1981), Kendall and Helfrich (1982)
Formation of frazil ice	Simpkins et al. (2000)
Genetic strain	Cordone and Nicola (1970), Moring and Buchanon (1978), Moring (1982)
Pollution	Scullion and Edwards (1979)

Transport and Stocking Stress — Stress associated with transfer and stocking activities may be a factor in post-stocking mortality in some instances. Capture, confinement, transport and release are all sources of stress for hatchery-reared fish (Black and Barrett 1957, Barton et al. 1980, Barton 1982, Barton and Peter 1982). Gresswell (1973) found that stresses associated with handling, transporting and stocking were sufficient to induce stress-mediated diseases such as furunculosis. Every precaution should be taken (see OMNR 2000$_b$) to ensure that these stressors are minimized to optimize post-stocking survival.

Survival and Contribution of Stocked Trout to the Fishery

Post-stocking survival varies considerably between lakes and streams. Generally, stocking success is better in lakes (Curtis 1951, Anonymous 1953). This has been attributed to a greater carrying capacity in lakes (Wiley 1995). Stringer et al. (1980) generalized survival rates for stocked rainbow trout in lakes as follows: yearlings (40-60%); fall fingerlings (10-30%); and fry (2-6%). Additional information on post-stocking survival rates, which has been assembled is presented in Table 9.

There are numerous reports of poor survival of rainbow trout stocked in streams (Swartzman 1950, Anonymous 1953, Stone 1995). In Taylor Creek, California, Murphy (1962) reported a one month survival of 10.6% of hatchery-reared rainbow trout fingerlings compared with young-of-the-year survival of 11.7%.

Table 9. Post-stocking survival rates reported for rainbow trout stocked in various North American waterbodies.

Waterbody	Life Stage Stocked	Time from Release	Survival Rate (%)	Reference
Lakes				
East Fish Lake (Michigan)	-	6 months (October-April)	86%	Alexander (1975$_a$)
Fox Lake (Minnesota)	Fingerlings	4 months	37%	Kmiecik (1980)
Little Bass Lake (Minnesota)	Fingerlings	4 months	11%	Kmiecik (1980)
Little Shell Lake (Minnesota)	Fingerlings	4 months	18%	Kmiecik (1980)
McCall Lake (Minnesota)	Fingerlings	4 months	4%	Kmiecik (1980)
Muerlin Lake (Minnesota)	Fingerlings	4 months	0%	Kmiecik (1980)
Quemado Lake (New Mexico)	Fry	Time required to achieve 7.5 in length	9.2%	Pausch (1979)
Misc. prairie lakes (North Dakota)	-	1 month	15-54%	Myers and Peterka (1976)
Misc. lakes (Michigan and Wisconsin)	Age I (yearling) Age II	5 months 5 months	32-60% 15-19%	Johnson and Hasler (1954)
Misc. lakes (Colorado)	-	-	20-60%	Nelson (1987)
Reservoirs				
Porcupine Reservoir (Utah)	Fingerlings	14 months	6.5-7.6%	Hudy and Berry (1991)
Unnamed Reservoir (Utah)	Fingerlings Fingerlings	- -	39-55% (1987) 19-25% (1988)	Hepworth et al. (1991)
Ponds				
Fuller Pond (Michigan)	- -	6 months (fall-spring) 6 months (spring-fall)	50% 10%	Alexander (1975$_b$)
Streams/rivers				
Convict Creek (California)	Large (2.8-3.7) fingerlings Small (1.3-1.7) fingerlings	89-151 days 89-151 days	46.6% 44.2%	Needham and Slater (1944)
Flint Creek (Montana)	Catchables	6 weeks (summer) Overwinter	83% 68%	Anonymous (Undated$_a$)

Table 9 (cont d)

Waterbody	Life Stage Stocked	Time from Release	Survival Rate (%)	Reference
Fool Creek (Wyoming)	-	1 year (1974-1975)	41.6-48.5%	Mueller (1975)
Little Missouri River (Arkansas)	-	5 months	3-10%	Ebert and Filipek (1989)
Platte River drainage (Nebraska)	Fingerlings	4-6 months	3.6-54.1%	Van Velson (1978)
Taylor Creek (California)	Fingerlings	1 month	10.6%	Murphy (1962)
Three Streams (Tennessee)	Fall fingerlings Spring yearlings	5 months 3 months	1-3% 2-7%	O Bara and Eggleton (1995)

Potential Impacts of Rainbow Trout Stocking Activities

The introduction of hatchery-reared rainbow trout can have a wide variety of impacts on native biota (Table .10).

Table 10. Potential impacts of rainbow trout stocking.

Impact	Reference(s)
Increased angling pressure and harvest of native trout	Hazzard and Shetter (1938), Ratledge (1966), Clady (1973)
Reduction in abundance/biomass of native salmonids	Smith (1968), Vincent (1972, 1975, 1985, 1987), Welcomme (1988), Goodman (1991),
Alteration of invertebrate communities (e.g., predation)	Wang et al. (1996), Brynildson and Kempinger (1973)
Competition for food	Johnson (1981), Krueger and May (1991), Kerr and Grant (2000)
Introduction/transmission of disease or parasites	Mitchum and Sherman (1981), Dick et al. (1987), Fuller et al. (1999)
Hybridization and dilution of native gene pool	Miller et al. (1990), Hindar et al. (1991), Fuller et al. (1999), Dillon et al. (2000), Kerr and Grant (2000)
Predation on resident fish	Wales and Borgeson (1961), Krueger and May (1991), Fuller et al. (1999)
Displace native fish	Wales and Borgeson (1961), Miller et al. (1990), Vermont Department of Fish and Wildlife (1993), Rinne and Janisch (1995), Williams et al. (1996), Fuller et al. (1999), Kerr and Grant (2000)

It is widely believed that hatchery-reared fish have a negative impact on wild trout. Butler (1975) found that stocked trout caused physiological stress on native trout. Stocking hatchery-reared trout over wild trout increased mortality of wild trout in two Idaho streams (Petrosky and Bjornn

1988). Johnson and Abrahams (1991) showed that hybrids from wild x hatchery-reared parents were more susceptible to predation than wild fish. Byrne et al. (1992) suggested that long-term stocking of hatchery-reared fry or smolts could lead to the extinction of native trout. Miller and Alcorn (1943) reported that introduced rainbow trout readily hybridized with resident cutthroat trout and the cutthroat trout were quickly eliminated. Fuller et al. (1999) reported that rainbow trout stocking programs were responsible for the introduction of whirling disease into 20 U.S. states.

There are numerous reports of stocked rainbow trout displacing other resident salmonids, notably brook trout (see Kerr and Grant 2000). Rinne and Janisch (1995) attributed the introduction of non-native salmonids, including rainbow trout, as being responsible for the decline of two threatened fish species (Apache trout and little Colorado spinedace) in east-central Arizona. Potential impacts of hatchery-reared rainbow trout should always be carefully evaluated before stocking activities are initiated.

Stocking Assessment

Fish stocking is an important but expensive component of a management program. Releases of hatchery-reared fish also have the potential to impact other aquatic biota. Post-stocking assessment is necessary to evaluate the cost : benefit of the stocking event, identify factors responsible for the success or failure of the program and to refine stocking practices as required. Cowyx (1994) suggested that stocking should not be approved or conducted without post-project evaluation. Few jurisdictions appear to have a comprehensive stocking program however. Some of the problem seems to be the absence of any well defined, quantified criteria to determine stocking success or failure and the lack of standardized assessment protocols. A wide variety of criteria are currently utilized to describe the outcome of a stocking project (Table 11).

Table 11. Assessment criteria used to evaluate rainbow trout stocking programs.

Criteria	Details	Reference(s)
Fishing quality	• Put-grow-take stocking will ensure an average catch of one trout for two hours of fishing. • Achieve a stable catch rate of 0.5 fish/hour for catchable stockings.	Engstrom-Heg (1979) Delisle (1959), Eiserman (1966)
Cost effectiveness	• Cost:benefit	Manitoba Department of Natural Resources (1988), Wiley et al. (1993_a)
Angler/public opinion	• Support for stocking program	Anonymous (1974), Nielsen et al. (1978), Johnston (1979)
Angling opportunities	• Fishing pressure directed toward stocked fish • Provide an amount of angler use equivalent to 1 angler trip generated per trout stocked. • Number of angler days generated	Ontario Ministry of Natural Resources (1982) Pennsylvania Fish and Boat Commission (1997) Hopelain (2000)
Contribution to spawning population (where applicable)	-	Ontario Ministry of Natural Resources (1982)

Table 11 (cont d)

Criteria	Details	Reference(s)
Returns of stocked fish to angler	• Harvest of trout in terms of the number stocked must be at least 50%. • At least a 65% return to creel from a preseason plant; 75% from an inseason plant in streams — 75% return from lakes.	Eiserman (1966), Qu bec Minist re du Loisir de la Chasse et de la P che (1988), Hopelain (2000), Pennsylvania Fish and Boat Commission (1997)
	• Harvest of stocked fish.	Ontario Ministry of Natural Resources (1982), Wiley et al. (1993_a)
	• A minimum 60% return of the number stocked.	U.S. Fish and wildlife Service (Undated)
	• Put-and-take fisheries must provide 90% removal of stocked fish within 60 days.	Engstrom-Heg (1979)
	• 80% return of catchables.	Louder (1969)
	• Return of 100% of weight of stocked trout with a catch comprised of two or more age classes.	Vermont Department of Fish and Wildlife (1993)
Post-stocking survival	• Survival and growth of age I+ trout	Deyne (1990_b)
Post-stocking growth	• Survival and growth of age I+ trout.	Deyne (1990_b)
	• Weight gain in first year after release should be at least twice that when originally stocked	Qu bec Minist re du Loisir de la Chasse et de la P che (1988)
Relative abundance	• Contribution to gill net catch.	Deyne (1990_b)

In an independent review of Ontario s fish culture and stocking program, it was recommended that assessment be a mandatory component of any stocking activity (Ecologistics Ltd. 1990). Ontario currently does not have a standardized protocol for evaluating rainbow trout stocking programs. Deyne (1990b) suggested that rainbow trout stocking should be evaluated by targeting age I+ fish using monofilament gill net and a stratified random sampling technique. Standardized assessment criteria and sampling protocols for stocked waters in Ontario need to be developed.

Best Management Practices for Stocking Rainbow Trout in Inland Waters

In Ontario, rainbow trout are stocked in inland waters largely to provide artificial fisheries on a put-and-take or put-grow-and-take basis. Based on a review of the literature and collective experiences to date, the following best management practices have been developed in an effort to maximize the likelihood of stocking success:

> **Stocking Objective** — Identify the objective of the individual stocking project and establish quantified goals to evaluate its success. For the stocking of catchable-sized rainbow trout, it is recommended that there be at least a 50% return to the angler.
>
> **Habitat in Recipient Waterbody** — Stock waters having suitable habitat conditions for rainbow trout. A detailed aquatic habitat inventory should be completed prior to stocking. Public access should also be considered. The presence and size of lake outlet

should be evaluated in terms of emigration of stocked trout. Stream stocking with rainbow trout should be considered a very low priority.

Fish Community in Recipient Waterbody — Avoid stocking waters containing other top predators such as walleye or northern pike. Rainbow trout should not be stocked in waters containing viable populations of other salmonid species. In order to prevent hybridization and intraspecific competition, waters containing wild populations of rainbow trout should not be stocked with hatchery-reared fish.

Genetic Strain — Select the most appropriate genetic strain to meet the stocking objective. For the provision of short term angling opportunities, a fast growing domestic strain is usually most appropriate.

Stocking Rate — Adjust stocking rates according the conditions of the waterbody and the amount of fishing pressure. Use catchable-sized trout only where justified by sufficient angling pressure.

Age/Size of Fish — Catchable-sized fish are most appropriate in situations where the goal is to provide an immediate, short term fishery. Yearlings are more appropriate in instances where the stocking objective is put-and-delayed-take. Younger life stages of rainbow trout should generally be stocked only in ponds or lakes where there is little, if any, competition from other fish species.

Handling and Transport — Take precautions to minimize stress on hatchery-reared fish during transport and stocking activities. Some general guidelines include:

- Fast fish before transporting.
- Minimize handling.
- Maintain cool water temperatures (near 5-6… C) during transport.
- Ensure a sufficient rate of water circulation to provide adequate circulation and remove metabolites.
- Stock fish early in the season when air temperatures are cool.
- Use anaesthetics where necessary to reduce excitement and swimming activity.
- Consider the use of salt additives to protect fish from osmoregulatory disturbance.

Stocking Frequency — Stocking frequency should be based on the type of fishery being provided. For put-and-take fisheries, catchable-sized fish should ideally be stocked several times during the fishing season. For put-grow-take situations where fingerling or yearling trout are stocked, annual or alternate year releases are most appropriate.

Stocking Conditions - Time stocking activities to minimize the differential between holding water and recipient waterbody temperatures. Generally, optimal water temperatures for stocking rainbow trout are between 7 and 18… C. Conditions (e.g., pH, hardness, etc.) of hatchery water and water in the recipient waterbody should be matched as closely as possible.

Stocking Site — In streams, rainbow trout should be released at or near access points avoiding periods of flood or high water. Hatchery-reared trout should not be discharged from off a bridge. In lakes, early life stages of rainbow trout should be dispersed over deep water to avoid littoral predators. Older life stages (i.e., fish ‡ 8 inches in length) can be released in waters varying in depth between 0-6 meters.

Stocking Assessment — Assess a representative number of stocked waterbodies on a regular (e.g., annual) basis. Assessment should include survival and growth of stocked fish, yield of stocked fish and an estimate of the amount of angling effort and fishing quality.

Annotated Bibliography

AITKEN, W. W. and E. W. SURBER. 1932. Observations on plantings of fingerling rainbow, brown, and brook trout from circular pools. Transactions of the American Fisheries Society 62 : 133-140.

Summary of findings:

(1) Gregariousness has been characteristic of all species of trout planted from circular pools. The probability that the trout in the circular pools use one another as points of reference while swimming is not supported by observations of trout planted from an ordinary pool, unless they also use one another as points of reference.

(2) The circular pool fish begin taking natural food almost immediately after planting.

(3) Changes in colour undoubtedly due to natural food are noticeable within two weeks after planting.

(4) Rainbow trout distributed themselves from the planted pool more quickly downstream than upstream, while the opposite was true for brook and brown trout.

(5) In general, fingerling trout show a tendency to remain for a considerable length of time in the pool in which they were liberated. When thus congregated, they are quickly located by their natural enemies.

ALBERTA MINISTRY OF THE ENVIRONMENT. 1994. Alberta s fish stocking program: Fish and Wildlife Services Policy #40, Fisheries and Wildlife Management Division, Natural Resources Service. Edmonton, Alberta.

The Alberta fish stocking policy is committed to the stocking of rainbow trout in Alberta but not eastern brook trout or brown trout. The unique Athabasca rainbow trout will be considered when stocking hatchery trout in drainages where this strain occurs.

In general, trout are stocked only in lakes where there is no natural reproduction to create put-grow-take fishing opportunities. It is the policy not to stock streams except where it is desirable to introduce a new species or where catchable-sized trout can be stocked in high use locations with small resident fish populations (e.g., Elbow River in Calgary). Trout should not be stocked in waterbodies that have northern pike.

ALEXANDER, G. R. 1975$_a$. Growth, survival, production and diet of hatchery-reared rainbow and brook trout stocked in East Fish Lake under different stock densities, cropping regimes and competition levels. Fisheries Research Report 1828, Michigan Department of Natural Resources. Ann Arbor, Michigan.

Hatchery-reared brook trout and rainbow trout were stocked in East Fish Lake in mid-October during the falls of 1958-1968. No trout were stocked during 1969-1971. All plants of trout were size selected for an average length of 8.9 inches (range 8.5-9.5). The various plants were fin-clipped for identification. The trout population size, survival rate, growth rate, production, angler cropping, and diet were monitored. The standing crop of invertebrate benthos was also monitored.

Rainbow trout survival averaged 86%, compared to 41% for brook trout, from mid-October planting until mid-April just prior to the opening of the trout fishing season. Survival was low for both rainbow trout and brook trout from mid-April to mid-October, mainly because of successful angler exploitation or experimental cropping by research personnel. Anglers were responsible for 76% of the loss of rainbow trout, and 80% of the brook trout, during that period. During seasons of public fishing, only 3 to 10 % of the rainbow trout and less than 1% of the brook trout survived for more than one year in the lake.

The proportion of trout dying of natural causes increased substantially with an increase in the stocking rate, particularly for rainbow trout the first 6 months after stocking. Further, during the first 2 years of no public fishing, total mortality was less, resulting in high standing crops of trout. Survival was much less with the advent of a white sucker population to the lake.

Trout growth was excellent during early years of the study, with rainbow trout attaining average sizes of 16.5 inches (1.75 pounds) after 1 year s growth and 19.9 inches (3.07 pounds) after 2 year s growth. Brook trout growth was good, but not so good as that of rainbows. A few surviving brook trout grew to 13.6 inches (1.06 pounds) in 1 year, and to 14.8 inches (1.36 pounds) after 2 years. Rate of growth of trout deteriorated badly with the increase of white sucker population, and with an increase in the biomass of standing crop of the trout themselves. Trout condition C also decreased proportionally with the decline in trout growth. Flesh colour and fat content of trout decreased with loss in condition factor.

Production of trout flesh in the lake varied from a high of 37.2 pounds per acre per year to a low of only 4.6 pounds per acre per year. High production resulted when angler cropping was reduced and when the lake was relatively free of suckers. Better than 80% of the production was made by rainbow trout, compared to 20% by brook trout. Trout production in 1973, following a three-year period of no trout stocking in the lake, did not improve, apparently because of sucker competition.

The average quantity of food found in trout stomachs was strongly correlated with rate of trout growth. Rainbow trout ate more food per day than did brook trout. Rainbow trout in their second year after planting ate more food per day than did first-year rainbows, but they were poorer converters of food into trout flesh. Crayfish, cladocerans, midges, mayflies and forage fish comprised most of the rainbow trout diet; crustaceans were the most important. Brook trout diet was more varied than that of rainbow, but was mainly composed of forage fish, crustaceans, mayflies and dipterans, in that order of importance. Suckers were rarely eaten by either rainbow trout or brook trout. Food composition stayed relatively stable during the study, but amount of food per trout stomach was reduced when suckers entered the lake.

Trout food conditions were reflected in the benthos populations. When benthos populations were high, trout growth was good. Benthos populations declined considerably when suckers entered the lake, and also when high stocks (biomass) of trout were being maintained. Benthos populations were lowest during the year after the lake was treated with rotenone to eradicate sucker and minnow populations.

ALEXANDER, G. R. 1975$_b$. Growth, survival, production and diet of hatchery-reared rainbow trout stocked in Fuller Pond, Montmorency County, Michigan. Fisheries Research Report 1829, Michigan Department of Natural Resources. Ann Arbor, Michigan.

Hatchery-reared rainbow trout were stocked in Fuller Pond in mid-October of 1969 to 1972. Population size, survival rate, growth rate, production, and diet of these fish were monitored, along with pond benthos. Trout survival was about 50% from planting date in the fall to the following spring. Survival from spring to the next fall was about 10%; much of the mortality was due to experimental cropping to monitor trout diet. We experimentally cropped about 140 trout per year, or 28% of the number stocked. Natural mortality tended to increase during the four years of study. Growth of the trout was good, with annual increments of 0.58 to 0.35 pound per fish. Growth rate and condition factor dropped as the study progressed, coincidentally with a reduction of food and with an increase in sucker and minnow populations. Production of trout flesh ranged from 7.9 to 2.7 pounds per acre per year. A decline in production was coincident with a decline in growth, a decrease in food supply, and an increase in the populations of suckers and minnows.

ALEXANDER, G. R. and D. S. SHETTER. 1933. Trout production and angling success from matched plantings of brook trout and rainbow trout in East Fish Lake, Michigan. Michigan Department of Conservation. Ann Arbor, Michigan.

ALEXANDER, G. R. and D. S. SHETTER. 1961. Seasonal mortality and growth of hatchery-reared brook and rainbow trout in East Fish Lake, Montmorency County, Michigan, 1958-59. Michigan Academy of Science Arts and Letters 16 : 317-328.

ALEXANDER, G. R. and D. S. SHETTER. 1969. Trout production and angling success from matched plantings of brook trout and rainbow trout in East Fish Lake, Michigan. Journal of Wildlife Management 33 : 682-692.

We studied survival, growth, exploitation, and production from five consecutive matched plantings of brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*) (8.5-9.5 inches long) in East Fish Lake, Montgomery County, Michigan, 1958-1962. Stocked fish were given varying fin clips for later recognition. Population numbers at several intervals between introductions were determined by Peterson-type estimates. Angler exploitation was tabulated from a complete creel census. Rainbow trout survival was about 98 percent from stocking in October to the following fishing season in April, whereas brook trout survival averaged only 49 percent. About one-third of brook trout deaths occurred between 15 October and the date of ice formation (approximately 15 December). Brook trout stayed in shallow water along shore more than did rainbow trout.

Anglers caught 86 percent of the stocked rainbow trout, but only 39 percent of the brook trout. For each pound of trout stocked, anglers caught 3.59 lb of rainbow trout, but only 0.76 lb of brook trout. In addition to a better return on a poundage basis, rainbow trout provided a fishery throughout the angling season, whereas nearly all brook trout were caught within the first ten days.

The brook trout grew well (average increment 0.9 lb per year), but the rainbow trout averaged 1.3 lb increment per year. Possibly a greater poundage return on rainbow trout would accrue if the beginning of the angling season could be delayed to take advantage of the early summer growing season.

ANONYMOUS. Undated$_a$. Comparison of survival, growth, and condition of hatchery rainbow trout and wild trout in Flint Creek. Project No. F-14-R-2. Montana Department of Fish and Game. Helena, Montana.

The Flint Creek Test Stream study was continued during the period July 1955 to July 1956 with the objectives (1) to study intraspecific competition and carrying capacity in terms of survival, growth, condition, and movement of catchable-sized, hatchery-reared, jaw-tagged rainbow trout planted at two stocking levels, and (2) to determine the effect of jaw tags on trout.

A total of 3,264 hatchery and wild trout were used to stock one, one-half mile section at the rate of two and one third times its original poundage inventory and another one-half mile section at three and two-third times its original poundage of game fish. The Test Stream was sample-censused by a D. C. shocker two weeks after planting and was completely inventoried six weeks after planting. Survival rates were calculated on the basis of the numbers of fish actually recovered by the D. C. shocker with no correction for shocker efficiency.

Jaw-tagging was found to have a measurable and detrimental effect upon fish after planting. One percent of the 6,284 tagged fish used to date for the study are known to have shed their tags.

Over-winter survival of the tagged Anaconda Hatchery rainbow trout planted in the summer of 1954 was at the rate of forty and sixty percent with the lower survival found in the section of the lowest resident wild trout competition. Wild trout during the same over-winter period survived at the rate of seventy percent. Although all the Anaconda Hatchery trout planted in 1955 were suffering from gill disease and fourteen percent of those tagged died before planting, 89 percent survived to six weeks after stocking into the section of lightest stocking and 86 percent survived the six-week post planting period in the section of the heaviest stocking. Anaconda Hatchery trout planted into a control section in 1955 survived at the rate of 83 percent during the six weeks, post-planting period and 68 percent over-winter. These fish were from fall-spawning stock but both sexes were ripe and capable of spawning during April 1956 at the age of 28 months. Hatchery-reared trout, from a hatchery requiring two years to produce catchable-sized fish, survived the six week, post-planting period at a much lower rate (50 and 59 percent survival) than trout from a station requiring only one year to rear catchable trout.

Mortality during shocking operations was less than one percent. Peak mortalities occurred after planting and shocking of hatchery fish. Peak mortalities among wild fish in an area open to fishing was coincidental with the opening of the fishing season and the spring warm-up , as well as shocking. Evidence of mink, great blue heron and osprey predation was noted during the period of study.

Growth and condition among Anaconda hatchery trout was better among fish subjected to a lower level of wild trout competition. No difference in performance between fish in the more heavily stocked section and fish in the more lightly stocked section could be measured six weeks after planting. Poor performance among fish from the colder-water station may have been a result of influences in the hatchery environment or the longer distribution trip.

Seventy-nine to 86 percent of the hatchery trout planted in 1955 remained in the area where planted with the most movement being recorded in the section of heaviest stocking. Eighty-six percent of the wild trout tagged in 1954 were found in the same 300-foot station where they were tagged. Movement of catchable-sized, hatchery trout through the barriers could be correlated with their emaciated condition.

It was concluded that the over-winter survival of stream-planted, catchable-sized, hatchery trout can be comparable to wild trout survival; therefore, such fish can be considered for management practices other than mere put-and-take stocking. Since some lots of hatchery fish did not compare favorable with wild trout, the need for investigating the effects of diets, feed levels, and transportation on survival was pointed out.

ANONYMOUS. Undated$_b$. Tests of the effects of winter angling for rainbow trout in a warm-water lake. Research Project No. F-27-R-2, Job No. 4. State of Michigan Department of Natural Resources. Ann Arbor, Michigan.

Corey Lake was censused to evaluate the effects of a winter fishing season on rainbow trout. The study was conducted for two years before such fishing was permitted, and five years after it became legal. Also, recovery rates were compared between annual and semi-annual plantings and between the plantings made in December and in the spring.

For five complete years of census when winter trout fishing was permitted, the mean annual estimated catches amounted to 150 rainbow trout in the winter season and 2,074 in the open-water season (spring, summer, fall). The moderate exploitation by winter angling demonstrated that the special season was not detrimental to the trout fishery.

Appreciably more trout were caught under the system of semi-annual stocking than under the annual system. One comparison indicated that recovery was greater from December plantings than from spring plantings, whereas another comparison indicated approximately equal recovery.

ANONYMOUS. Undated$_c$. Rainbow trout stocking assessment on Blakely Lake, Denbigh Township. Unpublished data, Ontario Ministry of Natural Resources. Bancroft, Ontario. 4 p.

Blakely Lake is a small (9.8 ha) lake in south-central Ontario which has been stocked with rainbow trout for a number of years. On June 22, 1978, a gill net, with mesh sizes ranging from 1.5-4 inches, was set overnight (netting effort of 15 hours) to evaluate stocking success. Forty-six white suckers and 4 rainbow trout were captured. Voluntary creel reports were submitted for 1985 (8 angler hours effort; rainbow CUE 0.000), 1983 (6 angler hours; rainbow trout CUE 0.500) and 1982 (30 angler hours; rainbow trout CUE 0.367).

ANONYMOUS. Undated$_d$. Rainbow trout stocking assessment on Chouinard Lake, Ashby Township. Unpublished data, Ontario Ministry of Natural Resources. Bancroft, Ontario. 2 p.

Chouinard Lake (7.7 ha) is stocked with rainbow trout to provide local trout angling opportunities. Volunteer creel reports have been submitted in 1982 (18 angler hours; 2 trout caught; CUE 0.111), 1983 (6 angler hours; 4 trout caught; CUE 0.700) and 1984 (69 angler hours; 6 trout caught; CUE 0.130).

ANONYMOUS. Undated$_e$. Angler success for stocked rainbow trout on Mair (Green) Lake. Unpublished data, Ontario Ministry of Natural Resources. Bancroft, Ontario. 2 p.

Mair Lake (48.6 ha) is stocked with rainbow trout on a put-and-delayed-take basis. With the exception of 1984, voluntary angler diaries have been submitted by local anglers from 1980 to 1986 (inclusive). Rainbow trout catch-per-unit-of-effort (CUE) values have ranged from 0.205 in 1980 to 0.467 in 1981.

ANONYMOUS. Undated$_f$. Angler success for stocked rainbow trout on Kilbourne Lake, Abinger Township. Unpublished data, Ontario Ministry of Natural Resources. Bancroft, Ontario. 1 p.

Kilbourne Lake (13.8 ha) is stocked with rainbow trout on a put-and-delayed-take basis. Voluntary angler logs have been maintained and submitted by local anglers in 1978 and from 1980-83 (inclusive). Rainbow trout catch rates (CUE) have ranged from 0.192 in 1982 to 0.671 in 1980.

ANONYMOUS. Undated$_g$. Angler success for stocked rainbow trout on Wolfe Lake, South Canonto Township. Unpublished data, Ontario Ministry of Natural Resources. Bancroft, Ontario. 2 p.

Voluntary angler logs have been maintained on Wolfe Lake each year between 1982 and 1986 (inclusive) as a means of evaluating the success of the rainbow trout stocking program. Angler success has ranged from 0.053 in 1985 to 0.340 in 1983.

ANONYMOUS. 1953. Trout planting. Fisheries Division Pamphlet No. 10, Institute for Fisheries Research, Michigan Department of Conservation. Lansing, Michigan.5 p.

Stocking of small (fingerling) trout at any season of the year adds little to the angler s catch in streams having suitable conditions for natural reproduction. In 12 experiments with rainbow trout fingerlings, an average of 2.02% survived to the fishermen s creel. Although a few fingerlings from hatchery plantings do survive to the angler s creel and, unless marked, cannot be distinguished from wild fish, it is our belief that they do so at the expense of an equal number of wild fingerlings so that planting may actually lower the yield by increasing the competition for food and shelter. It is concluded that in the great majority of Michigan streams having suitable spawning grounds enough or more than enough young are produced to fully seed the waters with all the fish which they can feed and house.

In smaller lakes found suitable for trout except for the lack of spawning places (rainbow trout generally require inlet or outlet streams with gravel bottom to spawn), annual planting of fingerling trout in the fall is an economical and generally satisfactory method of maintaining trout fishing. In trout lakes having adequate spawning grounds, stocking is unnecessary and probably harmful.

In order to learn the value of stocking trout reared to legal size (‡ 7 inches), the State of Michigan conducted 68 experiments between 1937-1945. The main results may be summarized as follows:

- Four times more rainbow trout were recovered by anglers from early spring and open season plantings as were recaptured from comparable fall releases. The few trout surviving from fall plantings were caught out as fast or faster than those planted in the spring or open season.
- Fall-planted trout did not spread out over the stream appreciably more than those planted in the spring and open season and were generally caught close to where they were planted.
- The average recovery of legal-sized trout planted in the spring or open season was approximately 25% for rainbow trout.
- The significant effect of plantings on the catch lasted about two weeks for rainbow trout.
- Less than 1% of the trout not caught in the season planted contributed to the catch in subsequent years.
- Even where streams were heavily stocked with legal-sized trout in early spring and in the open season, only an average of 27% of the catch was made up of hatchery fish.
- Only one angler out of nine fishing these planted waters caught any hatchery trout. The majority were taken by fishermen who happened to be on the streams shortly after plantings were made.

Shortly after the establishment of the Pigeon River Trout Research Station in 1949, a series of experiments with marked hatchery-reared trout, all of legal size, was begun. The most important conclusions reached were:

- Scatter planting has no advantage over spot planting.
- Despite the release of about 4,500 legal-sized fish annually, about one-half of the 2,160 to 2,850 fishing trips each year were unsuccessful.
- Plantings of rainbow trout and brook trout gave noticeably higher returns to the fishermen than did equal number of brown trout. Brook trout and rainbow trout planted in 1949 were recovered at the rate of 40 and 45% respectively; brown trout recaptures amounted only to 25.6% of the numbers released.
- Legal-sized rainbow trout planted in streams subjected to heavy fishing pressure contributed to the catch for a relatively short time.
- In Pigeon River plantings, there was a considerable unexplained loss which was greatest when poor angling conditions (rain, high water, cold weather, extreme hot weather) prevailed over the initial 20-40 days following planting.

In larger lakes suitable for trout except for a lack of spawning grounds, plantings of legal-sized trout have generally given more satisfactory results than in streams: growth is remarkably fast, condition, colour and fighting quality are equal to that of wild fish and plantings usually contribute to the catch for two or more years. Planting legal-sized trout in small lakes is on a par with stream planting or even less desirable since the fish are more concentrated and are removed even more rapidly.

ANONYMOUS. 1957. Comparison of survival, growth, and condition of hatchery rainbow trout and wild trout in Flint Creek. Project No. F-13-R-3. Montana Department of Fish and Game. Helena, Montana.

A total of 772 jaw-tagged Anaconda Hatchery rainbow trout of catchable size were planted into the two _ mile sections of Flint Creek in 1956. One-hour, three-hour and six-hour trips were used in transporting these fish to the stream. Six weeks after planting there was no significant difference in condition factors associated with the trip length but the recapture rate of fish from the six hour trip was significantly less than the rates of recapture for the shorter trips.

In 1955 the game fish population of the upper section was increased to approximately two and one third times its former average rate of 210 pounds and the lower section population was increased to three and one third times its former average of 210 pounds by planting tagged Anaconda and Hamilton Hatchery fish. By the spring following the heavy overstocking, the total weight of game fish in the two sections was again nearly equal but a higher poundage level of 340 pounds of catchable-sized game fish per section. By the fall of 1956 the average weight was still approximately 340 pounds per section but 100 pounds of hatchery trout had been planted into each section six weeks before the fall census. Lower condition factors and lower overwinter survival rates were associated with the heavier stocking rate in the lower section.

Although Anaconda Hatchery rainbow trout survivals have compared favorable with wild trout survivals in Flint Creek, the Hamilton Hatchery trout were definitely inferior. It was recommended that further work on hatchery trout survival ability should include tests of the effects of various hatchery diets on trout reared at the Hamilton Station.

ANONYMOUS. 1959. Closing catchable trout waters after they are stocked. Inland Fisheries Administrative Report No. 59-3, California Department of Fish and Game. Sacramento, California. 15 p.

Patterns of angler pressure differ greatly on lakes and streams. Peak pressures after planting are most extreme on small streams in areas with many anglers. They are not a problem on large lakes. Small lakes and large streams are intermediate. The same sort of corrective action may not be appropriate for all waters.

Different types of waters differ in the speed with which anglers remove newly planted fish. Half may be fished out of a small stream in less than two days. Conversely, relatively few fish are removed from large lakes the first few days after a plant. Larger streams and small lakes are again intermediate.

The assumption that a closure of two or three days while fish can adjust to their new environment will reduce their vulnerability does not appear to be valid. Catchable trout distribute themselves around a lake fairly rapidly. Migration in streams is usually negligible.

It is characteristic of catchable trout fisheries for about half the anglers to catch nothing, and for about half the total catch to be made by about 10% of the anglers.

Post-planting closures have been tested in California and in the east. They aggravate the situation they are intended to correct, and they create serious new problems.

There is no single ready solution to this problem. A partial solution can perhaps be achieved by dropping the smallest, most crowded streams from the programs and diverting their fish to more suitable waters, or by regulating the numbers of anglers by access control and permits. Strong economic forces reinforce the support this program receives from the angling public.

ANONYMOUS. 1960. Final observations on survival of rainbow trout reared in hatchery waters of differing mineral content. Project No. F-13-R-6. Montana Department of Fish and Game. Helena, Montana.

In 1958, 201 rainbow trout from the Bluewater hatchery and 218 rainbow trout from the Lewistown hatchery were planted into the test stream. The mineral content of the water at Bluewater was 2462 ppm total dissolved solids compared to 375 ppm at Lewistown and 156 ppm at Flint Creek. All other conditions of rearing and transportation were nearly identical. Survival from fall census to spring census was 68 percent for the Lewistown trout and 58 percent for the Bluewater trout. The last Bluewater fish observed in Flint Creek was a mortality found in November, 1959. Several Lewistown fish were still present at the 1960 spring census. The highly saline water at Bluewater did not reduce the survival ability of catchable trout to the point where they would be useless in put-and-take management. The possible affect of this saline water on longevity of trout should be studied more thoroughly as it could have an important bearing where trout are planted with the intention of contributing to the wild brood stock.

ANONYMOUS. 1963$_a$. Fishery investigations of the Pawcatuch River drainage. Research Project Report No. F-20-R-4, Job No. 16. Rhode Island Department of Environmental Management. Providence, Rhode Island.

Field work was completed on 17 streams and 7 ponds in the Pawcatuck River drainage. Analysis and interpretations of data is incomplete, but will be presented in the final report. A tagging program was carried out to evaluate the success of the trout program in the watershed. From the 11,350 trout tagged, voluntary returns totaled 3,594 or 31.7%. Returns were higher for rainbow trout (37.1%) than either brook trout (29.5%) or brown trout (27.2%). Rainbow and brown trout sustained fishing pressure over a longer period of time. Returns from the fall stocking were poor (12.1%)

ANONYMOUS. 1963$_b$. Lake Pend Oreille Kamloops rainbow marking and recovery. Job Completion Report, Project No. F-32-R-6, Job 3b. Idaho Fish and Game Department. Boise, Idaho.

Some 5,000 two year old Kamloops (12-14 inches in length, 1 pound in weight) and 944 three year old Kamloops (16 inches in length, 2 pounds in weight) were marked with left ventral-adipose and left pectoral-adipose clips, respectively, and planted in Pend Oreille Lake in 1963. A total of 340 (36.9%) and 930 (18.6%) of the three year olds and two year olds, respectively, were recovered during their first summer in the lake. Growth of the fish averaged _ inch for the three year olds and 1 _ inches for the two year olds during their first summer in the lake.

A total of 24 fish (13.4 inches in length, 1 pound in weight at planting), which had been marked and planted in 1962, were recovered in 1963. This produced a total of 20.0% recovery on these fish over a two year period. Growth was estimated at an average of 2.4 inches over this same period (fish were all caught in May and so growth is for one season).

An additional 12 fish (9-11 inches in length at planting), which had been planted in 1961, were recovered in 1963. This brought the total to 2.5% recovery on these fish by their third season in the lake. Average growth over this period was 5.0 inches (fish were all caught in May and so growth is for two seasons).

ANONYMOUS. 1965$_a$. Physical, biological and ecological factors affecting rate of return of planted trout. Completion Report, Job F-32-R-6, Job 4. Idaho Fish and Game Department. Boise, Idaho.

During the census period from June 7, 1963 through September 2, 1963, it was estimated that 1,995 anglers fished 3,676 hours in Deadwood Reservoir to harvest 5,664 game fish. During the same census period it was estimated that 965 anglers fished 1,593 hours in the Deadwood River to harvest 4,090 game fish. Fishing success in Deadwood Reservoir averaged 1.5 game fish per hour during 1963 as compared to 1.0 game fish per hour during 1962. Fishing success in Deadwood River averaged 2.6 game fish per hour during 1963 as compared to 0.7 game fish per hour during 1962.

Percentage composition of the 1963 Deadwood Reservoir game fish harvest was cutthroat trout 33.6%, rainbow trout 20.2%, rainbow-cutthroat trout hybrids 2.7%, and kokanee salmon 43.1%. Percentage composition of the 1963 Deadwood River fish harvest was cutthroat trout 36.1%, rainbow trout 50.2%, rainbow-cutthroat hybrids 4.9%, kokanee salmon 6.8%, Dolly Varden 1.0% and whitefish trace.

ANONYMOUS. 1965_b. The survival of planted rainbow trout to the creel as related to their time and place of planting. Completion Report, Job F-32-R-6, Job 3a-1. Idaho Fish and Game Department. Boise, Idaho.

Some 10,000 jaw-tagged rainbow trout were planted in American Falls Reservoir and the Snake River above the reservoir during 1963. The number of tags returned from the reservoir-released fish was 8%, 7% and 1% for the April, June and September plants respectively. The tag returns of river-released fish varied from 8.3 to 15.0% with the highest returns from the river above Tilden Bridge. Fish planted in the river grew very little while fish planted in the reservoir gained weight rapidly.

The location of the tag recoveries indicated a migration of fish out of American Falls Reservoir after the water temperatures warm up. Seventy-five percent of the fish planted in the reservoir in April were caught in waters other than the reservoir with 68% coming out of the American Falls forebay. Eighty-five (85) percent of the June planted fish were caught in the river with 68% coming from the forebay.

ANONYMOUS. 1965_c. The survival of planted rainbow trout to the creel as related to their size and time of planting. Completion Report, Job F-32-R-6, Job 3a-2. Idaho Fish and Game Department. Boise, Idaho.

Studies were conducted at Alturas Lake during 1963 to determine if mid-season plants of hatchery-reared, catchable-sized rainbow trout would maintain fishing success at a relatively high rate during the normally slow fishing period of mid-summer. Angling success was maintained at a relatively high level during mid-summer by the mid-summer plants. The surface waters of Alturas Lake, located at an altitude of 7,000 feet, do not become as warm as many lowland lakes and reservoirs and thus the planted trout appeared to remain in the surface layers of the lake throughout summer.

The return to the creel of rainbow trout planted in Alturas Lake during 1963 was related to fishing pressure. A near maximum expected return from plants made prior to mid July was obtained. The percentage return from plants made after mid July was smaller due to a lesser amount of fishing pressure.

The program of rearing Kamloops rainbow trout for an extended period in a hatchery prior to planting may be of limited value based on the information collected at Alturas Lake during 1963. Few of the hatchery-reared Kamloops observed in anglers creels had food in their stomachs when examined. In addition, a high percentage of the fish planted became sexually mature during the spring after planting. The natural losses associated with spawning may offset any gain achieved by rearing the Kamloops to a larger size before planting.

ANONYMOUS. 1968_a. Evaluation of fall planting of fingerling trout. Project F-7-R-11, Work Plan 1&2, Job R-2. Arizona Game and Fish Department. Phoenix, Arizona.

A comparison of data available from ten years of creel census on two trout lakes, failed to disclose any peculiar value to stocking of fingerling rainbow trout in the fall and spring, as opposed to spring only. Some fall plants contributed heavily to the harvest during the following year, however, similar results could be obtained with spring plants of similar or slightly larger fish.

Future stocking should consist of plants of trout stocked in a manner to provide two separate groups of harvestable sized trout for the creel during each fishing season (May to September).

ANONYMOUS. 1968$_b$. Creel census and fishing pressure. Federal Aid Project No. F-15-R-5, Job No. 10-E. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma.

The total estimated fishing pressure during 1966 was 29,582 fisherman trips, exceeding that of 1965 by 4 percent or 1,175 trips. Fishing pressure was closely correlated with the frequency and number of trout stocked. Fishing pressure increased during the periods of trout releases and decreased during the periods of small to no stocking. The average fishing trip was 2.6 hours, the same as the previous year, but the catch per man-hour was 0.2 trout higher in 1966. The number of trout carried over from stocking to stocking is not as high as indicated. Approximately 66 percent of all fishermen drove 50 to 100 miles or more to utilize the trout fishery. Bank or wading was the most common method of fishing. Boat fishing continued to be restricted by low stream flows. The most popular baits were natural (worms, etc.) and other baits (cheese, corn, etc.). Sightseeing, followed by fishing represented a combined total of 85 percent of the total utilization.

ANONYMOUS. 1968$_c$. Rainbow trout marking studies. Progress Report, Job F-20-R-3. Division of Wildlife. Nevada Department of Conservation and Natural Resources. Reno, Nevada. 2 p.

During 1967, all catchable rainbow trout were marked by fin clipping prior to being planted. This totaled 5,260 fish and 2,035 pounds: the fish ranging from 9.7 to 10.0 . All were marked using the same clip even though three separate plants were involved as we were interested only in the total annual return of catchables.

The known harvest of marked catchables was 200 fish which represented 3.8% of the total plants. The expanded harvest totaled 23.1% as the first year return. Growth rates were not calculated as the plants carrying the same mark were planted some 72 days apart. The expanded weight return of catchables totaled 901.3 pounds or 0.44 pounds returned for each one pound stocked.

The 1966 sub-catchable plant continued to show fair returns during 1967 as 35 were checked in the creel. The expanded harvest for the second year (1967) was 11.5%. Therefore, the total expanded return to date is 22.3%, a two-year return. The calculated weight of this two-year harvest is 400.3 pounds or 1.07 pounds returned for each pound planted. The cost-per-pound to the creel for this plant stands at approximately $0.23 after two years of contribution to the harvest.

A second sub-catchable plant was made in September 1967, with fish at 5.5 inches and 12.8 per pound. These began to show in the creel in October and November at 7.08-7.92 inches. The known first year harvest was 86 fish (0.7%) while the expanded harvest totaled 884 fish (7.4%).

By August, 1967, the sub-catchable plant of June 1966 at 6.9 inches was averaging 14.4 inches. The monthly growth rate for this 14 month period was 0.48 inches per month. The second year growth rate from March to August was slightly less than 0.41 inches per month, while the first year growth rate from June through September was 0.86 inches.

Of the known total catch, 321 or 22.2% were marked fish originating from two sub-catchable and three catchable plants.

ANONYMOUS. 1969. Development of trout management practices in Spruce Run Reservoir and its drainage. Project No. F-20-R-7, Job No. II-5. New Jersey Division of Fish and Game and U.S. Fish and Wildlife Service. Trenton, New Jersey.

An estimated 4,568 trout anglers utilized the reservoir during 1967 which is considerably more than in previous years. As in the past, trout angling pressure was greatest during April and early May with a secondary peak of trout angling activity occurring in late July and early August. Catch rates were relatively similar to those experienced in the past (0.15 trout-per-man-hour for shore anglers, 0.04 trout-per-man-hour for boat anglers and 0.10 trout-per-man-hour overall).

Return percentages of freshly stocked trout were the highest recorded to date for Spruce Run Creek (52.4%) while those from Mulhochaway Creek also represented a slight improvement over the preceding project segment. There was little movement of stocked fish and the extent of the harvest in terms of a delayed take was quite limited.

Weekly electrofishing of Spruce Run Creek during March and early April validated the absence of a trout spawning run but gave some indication of the enormity of the drainage s white sucker population. The November population sampling indicated the stream s trout population to be dwindling while typically warm-water species were on the increase. Naturally reproducing populations of brook and rainbow trout were found in Black Brook.

The results obtained during this project segment indicated that the present management techniques were not providing an early season, fall or holdover trout fishery, and that these conditions should be rectified, if at all possible, in an attempt to meet the maximum trout fishery potential afforded by this drainage.

ANONYMOUS. 1970. Studies on mixed species of trout planted in unfished lakes. Federal Aid Project No. F-30-R-4, Job No. 3. State of Michigan Department of Natural Resources. Ann Arbor, Michigan.

Plantings of brook trout and rainbow trout of similar size were made in East Fish Lake each October for several years (1958-1969). Cropping of the population was limited to trout needed to monitor the mean volume of food per stomach and the composition of the diet. Mark-and-recapture population estimates were carried out to determine trout survival. Trout growth rate and benthic invertebrate populations were monitored.

In general, survival and growth rates of rainbow trout have been reduced considerably during this study. Increasing the planting rate of rainbow trout from 19 to 38 per acre, plus lowering the annual kill by eliminating angler harvest, and/or competition from suckers, have resulted in the change. Average volume of food per trout stomach was much reduced. Brook trout were stocked at the rate of 19 per acre every year. Their survival, growth, and mean stomach content have changed little during the duration of the study.

Standing crop of invertebrate benthos has been monitored periodically during this study. These data show little change in total numbers of organisms present. Further analysis may show a change in species composition of the benthic community.

ANONYMOUS. 1972. Influence of special regulations and stocking on fishermen and the trout population at Parvin Lake, Colorado. State of Colorado Division of Game, Fish and Parks. Denver, Colorado.

Special regulations including a size limit and the prohibition of live bait was introduced to Parvin Lake. These restrictions guarantee that a substantial number of trout will reach the size limit providing conditions for growth are suitable. Excellent returns to the creel from plants of fingerling rainbow trout were obtained in a situation where a size limit was in force and many trout were caught and released by fishermen using only artificial lures.

Further manipulation of stocking no doubt would make for further improvement, in terms of more 12 inch trout, over the fishery that evolved under special regulations. With a size limit, the number of trout become too few to offer a substantial advantage over the number that can be produced with conservative stocking and no special regulations by the time stocking is reduced to the point of good growth.

ANONYMOUS. 1974. Evaluation of a catchable trout stocking program in Delaware. Project No. F-23-R-3. Delaware Department of Natural Resources and Environmental Control. Dover, Delaware.

All of Delaware s trout streams are located within or near the urbanized areas of northern Delaware. These streams are in the Piedmont area of Delaware where the only suitable coldwater habitat for freshwater trout is found. Increasing demands by trout fishermen for a put and take trout program and the availability of additional trout from federal sources prompted Delaware to increase the number of trout stocked. An evaluation of this increased stocking program was necessary to determine if the catch rate came within the fifty percent minimum return rate necessary for any put and take fishery to be feasible.

Public acceptance of the program increased as catches of the stocked trout increased. This led to the recommendation of continuing the program at its present level, unless changes in fishing pressure warrant program changes.

ANONYMOUS. 1978. Evaluation of four strains in rainbow trout fingerling stocking in Black Hills Reservoirs. Fisheries Report No. 78-6. South Dakota Department of Wildlife. Parks and Forestry, Pierre, South Dakota.

Four strains of rainbow trout stocked as fingerlings were evaluated for growth and catchability in two impoundments. The fish were distinctly marked with fluorescent dye and stocked in the reservoirs in June 1976. A creel census was conducted beginning in July 1976 through March 1978. The Growth (32.5% return) and Kamloops (27.4% return) strains were the most catchable, followed by Washington (23.6% return) and Manchester (15.7% return). The Kamloops and Washington strains exhibited the best growth in the reservoirs. The Growth strain grew at a much faster rate than the other strains in the hatchery environment but once stocked in the natural environment it s growth slowed down. At the end of the study, all strains were about equal in length.

ANONYMOUS. 1989. Rainbow trout stocking assessment on Kilbourne Lake, Abinger Township. File Report, Ontario Ministry of Natural Resources. Bancroft, Ontario. 1 p.

Kilbourne Lake has been stocked with rainbow trout since 1959. Brook trout were stocked previous to this and once again in 1962. It has been stocked annually since 1970 with 700-3,500 yearling rainbow trout.

Kilbourne Lake was initially surveyed in 1970, water chemistry results showed suitable water quality to the 30 foot depth. Netting produced white sucker, yellow perch, brown bullhead and rainbow trout. On this assessment water chemistry showed suitable water quality to the 6 meter depth. Index gill netting involving one overnight set of 1,000 feet of 2.5 inch mesh gill net produced 15 rainbow trout, 1 lake trout and 6 white suckers. The gill net was hung up off the bottom so the net was fishing the thermocline between 4 and 6 meters. It has been proven that rainbow trout are very hard to catch in a gill net after they have been in a lake for more than two years. All 15 rainbow trout caught were from the 1989 stocking and ranged in size from 27.0-32.2 cm and weighed between 275-330 grams. The lake trout caught had no fin clips and we have no records of stocking lake trout in Kilbourne Lake. Angling results show that there is the odd lake trout caught every year so there is the possibility that there are natural lake trout in Kilbourne Lake.

From this assessment it is recommended to continue stocking Kilbourne Lake with rainbow trout and to keep a good account of angling success to see if more lake trout are present and reproducing in the lake.

ANONYMOUS. 1990. 1990 Hart Lake stocking assessment. File Report. Ontario Ministry of Natural Resources. Parry Sound, Ontario. 2 p.

The purpose of this stocking assessment was to determine if the 1988 and 1990 stockings of rainbow trout had been successful. Six-gill nets (mesh sizes ranging from 2.5-5.0) were set at five locations for a total set duration of 66 hours. Only two rainbow trout were captured. The lake was angled on May 31 and June 6 for a total of 11 rod hours. Only one rainbow trout was angled. A rainbow trout stocked in 1990 was found in the stomach of the angled rainbow trout. It appears that the trout are surviving but not in great numbers as only three were captured during the assessment.

ANONYMOUS. 1994$_a$. Rainbow trout stocking assessment on Hart Lake, Gill Township. Unpublished data, Ontario Ministry of Natural Resources. Hearst, Ontario. 2 p.

Hart Lake was stocked annually with brook trout between 1953 and 1974. Rainbow trout were stocked in 1988 (2,500 yearlings) and again in 1990 (2,500 yearlings). Assessment gill netting (6 gill nets for a fishing effort of 66 hours) were set in 1990 but produced a catch of only 2 rainbow trout. A stocked rainbow trout was found in the stomach of an angled rainbow trout. In 1992, 11 hours of angling effort produced a catch of 1 rainbow trout, 1 white sucker and 1 yellow perch. Six gangs of gill net (netting effort of 27 hours) produced a catch of 93 white sucker, 3 longnose sucker, 16 yellow perch, 5 lake herring and 1 rainbow trout. Due to the poor results of these stocking assessment projects, rainbow trout stocking was discontinued in Hart Lake.

ANONYMOUS. 1994$_b$. Rainbow trout stocking assessment on Lake #68, Frost Township. Unpublished data, Ontario Ministry of Natural Resources. Hearst, Ontario. 1 p.

Unnamed lake (#68) was stocked with rainbow trout in 1985 (2,000 yearlings), 1988 (2,500 yearlings), 1990 (2,500 yearlings) and 1992 (2,500 yearlings). The lake is popular among local anglers. Some anglers were contacted in 1987. They reported 9 rod hours of angling effort without catching any trout.

AREY, S. D. 1991. Strategies and considerations for effective management of winter put-and-take rainbow trout fisheries in Lubbock, Texas. M. Sc. Thesis, Texas Technical University. Lubbock, Texas.

ATKINSON, N. J. 1932. A study of comparative results from stocking barren lakes with rainbow trout. Transactions of the American Fisheries Society 62 : 197-200.

The present paper deals with the comparative conditions and results obtained with rainbow trout (*Salmo irideus*) in two lakes. None of these lakes contained any game fish or large competing fish such as suckers at the time of planting which naturally resulted in the accumulation of a large food supply.

Three lakes were planted with rainbow trout fingerlings, between two and one-half and three inches in length, in 1931. These lakes were Three Point (2,000 fish stocked August 31), Sugar Bush (2,970 fish stocked on September 2 and 3), and Green Lake (2,000 fish stocked on September 1). Assessment was conducted by the use of gill nets having stretched mesh sizes ranging from 1 _ to 4 inches. Recoveries were 3 fish from Three Point Lake, 4 fish from Sugar Bush Lake and 14 fish from Green Lake. The majority of fish were taken in the 2 _ inch mesh. All fish taken were in extremely fat condition and showed indications that they would spawn next spring at two years of age.

These results indicate an apparently wide variation in relative survival. Until a further study has been made it seems well to consider, however, that the survival from even fingerling plantings in lakes and even where no predaceous fish are present, may not be as high as one might expect except where the food conditions are exceptionally favourable.

AVERY, E. L. 1975. An evaluation of stocking fingerling trout in a two story trout lake. Research Report No. 83. Wisconsin Department of Natural Resources. Madison, Wisconsin.

On 31 May 1973, 4,500 brown trout and 4,500 rainbow trout fingerlings were stocked in Nebish Lake. Trout ranged from 3.0 to 4.2 inches in total length. Large smallmouth bass captured in fyke nets set in early June 1973 were satiated and regurgitated half a dozen fingerling trout during handling. Only 1 brown trout was captured during fyke netting and electrofishing conducted in the spring and fall both 1973 and 1974. Survival of fingerling trout was essentially nil after 5 _ months in Nebish Lake. Total angler harvest consisted of 1 rainbow trout caught by an ice fisherman in January 1975. Growth of the trout that survived in Nebish Lake was excellent.

Stocking fingerling trout 3-4 inches in length in a two-story lake containing smallmouth bass and an abundant, slow growing yellow perch population is not recommended because of the high probability of poor trout survival due, at least in part, to fish predation.

AXON, J. R. 1974. Evaluation of the two-story trout fishery in Lake Cumberland. Fisheries Bulletin No. 60, Kentucky Department of Fish and Wildlife Resources. Frankfort, Kentucky.

Lake Cumberland has been stocked with rainbow trout (*Salmo gairdneri*) since 1962. A two-story trout fishery has been established in the lower section of the lake but with marginal success. Trout have adequate habitat and forage, in the form of threadfin shad (*Dorosoma petenense*), throughout the year. When stocked at 203 mm (8 inches), trout approximately doubled their length and increased their weight ten-fold. The vertical distribution study revealed that trout were most active from 4 pm to midnight during the summer months. It was during this period, particularly between sunset and midnight, that a majority of the trout were sought after and caught. The best year for trout fishing during the investigation was in 1969 when trout were harvested at a rate of 0.16 fish per hour from May through September.

As the water temperatures increase during the summer, trout have a tendency to seek lower depths. The depths that trout prefer are primarily dependent upon water temperature. During the distributional study, the greatest frequency of occurrence for trout was between 59… and 63… F. The greatest depth at which a trout was captured was 73 feet in August of 1972.

The two major problems encountered in developing the trout fishery in Lake Cumberland are the loss of trout by predation and escapement through the discharge at the dam. By stocking trout that average 230 mm (9 inches) in length, most of the predation by black basses can be avoided. Results of the predation studies indicated that black basses utilized trout that were less than 203 mm (8 inches) in length. Whether the stocking of 230 mm trout will also reduce predation by striped bass (*Morone saxatilis*) is questionable. To minimize the escapement of trout through the dam, trout should be stocked a safe distance from the dam, preferably at Ramsey s Point (20 miles above the dam). A more suitable stocking location would be at Rowena Ferry (4.5 miles above the dam) but the lake is being held at least 23 feet below normal summer pool through 1979 in order to repair the dam. A greater than normal annual discharge is anticipated to keep the lake at this lower level so Ramsey s Point appears to be a more appropriate stocking site until the dam is repaired.

The stocking date, either October or February, had an enormous effect on the harvest. Trout stocked in February contributed more to the catch than did the October stocking every year between 1969 and 1972. In 1971, returns from the February stocking outnumbered returns from the October 1970 stocking by a ratio of 74:1 Since 1971, trout have been stocked in either late January or in February.

A re-evaluation of the trout fishery in Lake Cumberland should be made after the fishery has been given at least three years to develop following the recommendations described.

AYERS, H. D., H. R. McCRIMMON and A. H. BERST. 1976. Farm ponds. Publication 515, Ontario Ministry of Agriculture and Food. Toronto, Ontario. 43 p.

Ponds to be used for fish production should have certain features which may not be necessary for ponds used for other purposes. Water levels on trout ponds should be kept stable. The surface area of the pond should be at least one-quarter of an acre. Ponds with a continuous outflow of water should have an average depth of 6 to 8 feet with some deeper water (i.e., 12-15 feet). The margin of the pond should slope as steeply as possible to a water depth of 3-4 feet. In ponds colder than 65… F both rainbow trout and brook trout survive and grow at similar rates but in warmer ponds the environment usually favors the rainbow trout which give it a possible advantage over the brook trout in terms of growth and competition.

The stocking rate recommended for average Ontario ponds expected to provide 100-200 hours of recreational angling per year is 1,000 advanced fry (1-2 inches in length), or 300-500 fingerlings (3-5 inches in length), or 200-300 yearlings (6-8 inches in length) per surface acre of water. Stocking with fry is initially less costly but mortality is usually greater than with older fish. Maintenance stockings should be based on a knowledge of the past performance of the fishery and whether or not there is natural reproduction in the pond.

High natural mortality rates are characteristic of both brook trout and rainbow trout populations averaging about 80% from the fry to the yearling stage. Rainbow trout tend to live longer, a few fish occasionally reaching an age of seven or eight years. The chief causes of natural trout mortality in an otherwise favourable environment include predation by large trout, aquatic mammals and birds, disease, and old age. The growth rates in Ontario trout ponds are dependent primarily on water temperatures and available food. Rainbow trout may grow to 18 inches or more.

AYLES, G. B. 1973. Comparative growth and survival of matched plantings of wild and domestic rainbow trout in prairie potholes. Technical Report No. 382. Fisheries Research Board of Canada.

Match plantings were made in May 1972 of a wild strain and of two size groups of a domestic strain of rainbow trout in 10 prairie pothole lakes in Manitoba. The trout were harvested as marketable fish (over 200 g) in the fall of 1972. The growth and survival of fish from the domestic strain was better than that of the fish from the wild strain. There was considerable variability between lakes and there was significant lake x strain interaction.

The results indicated that the cross breeding of different strains would lead to the greatest increase in growth and survival of trout in these lakes.

AYLES, G. B. 1975. Influence of the genotype and the environment on growth and survival of rainbow trout (*Salmo gairdneri*) in central Canadian aquaculture lakes. Aquaculture 6(2) : 181-188.

Strains of rainbow trout (*Salmo gairdneri*) were evaluated for suitability for use in extensive aquaculture operations in central Canada. Matched plantings were made of three strains of trout in a number of small, shallow, eutrophic, winterkill lakes. Growth and survival were measured at the time of harvest.

There were significant effects of the genotype and the environment and significant genotype-environment interactions in the differential growth and survival of the trout.

AYLES, G. B. and R. F. BAKER. 1983. Genetic differences in growth and survival between strains and hybrids of rainbow trout (*Salmo gairdneri*) stocked in aquaculture lakes in the Canadian prairies. Aquaculture 33 : 269-280.

Several thousand small, shallow, highly productive lakes across the Canadian prairies are used by farmers for commercial and recreational production of rainbow trout. This report summarizes the results of evaluations of genetic differences between strains of trout from 1972 to 1978. Strains of fish were obtained from the wild and from private and government hatcheries in Canada, the U.S.A. and Europe. Matched plantings of different strains were made in several experimental lakes annually and growth and survival were determined. The relative effects of strains (genetic effect), lakes (environment effects) and strain x lake interactions were determined in each study. Significant hybrid vigour for both growth and survival was observed for some but not all crosses.

AYLES, G. B. and J. G. I. LARK. 1975. Summer mortality of rainbow trout (*Salmo gairdneri*) in Canadian pothole lakes. Report No. 360, Freshwater Institute. Winnipeg, Manitoba. 17 p.

Unexplained mortality is the major biological factor impeding development of extensive culture of rainbow trout in prairie pothole lakes. In the summer of 1974, an experiment was set up in the area around Erickson, Manitoba, to examine this problem. Our objective was to improve the survival of the trout either by avoiding those lakes we predict will have low survival or by circumventing some causes of mortality. Relative population size was monitored by means of survey gill nets and small holding cages in four high summerkill risk lakes and four control lakes. Mark-recapture techniques were used to obtain monthly population estimates 5 of the 8 lakes.

The study of fish mortalities following the collapse of an algal bloom has shown in the lakes 60% and 95% of the fish still in the lake were killed as a direct result of anoxic conditions. There were also other sources of mortality in both high-risk and low-risk lakes. The two probable causes are stocking stress and predation. Predation by common terns is believed the major source of this additional mortality.

AYLES, G. B., J. G. I. LARK, J. BARICA, and H. KLING. 1976. Seasonal mortality of rainbow trout (*Salmo gairdneri*) planted in small eutrophic lakes of central Canada. Journal of the Fisheries Research Board of Canada 33 : 682-692.

The seasonal mortality pattern and the census of the mortality of planted rainbow trout *(Salmo gairdneri)* were studied in eight small eutrophic lakes in central Canada used for extensive aquaculture. Two periods of mortality were revealed. The first occurred in all lakes during the first 60 days of residence in the lakes and resulted in the mortality of 60-90% of the numbers of fish stocked. The second period occurred in about 20% of the lakes and was due to low oxygen levels following the collapse of a bloom of *Aphanizomenon flos-aquae*. Rainbow trout are close to their physiological upper tolerance levels in lakes. Possible environment and biological causes of mortality during the first period are discussed.

BABEY, G. J. 1983. Evaluation of three strains of rainbow trout stocked in a reservoir where the ectoparasite *Lernaea cyprinacea* is endemic. M. Sc. Thesis, Utah State University. Logan, Utah. 93 p.

BABEY, G. J. and C. R. BERRY, Jr. 1989. Post-stocking performance of three strains of rainbow trout in a reservoir. North American Journal of Fisheries Management 9(3) : 309-315.

Rainbow trout (*Oncorhynchus mykiss*) of three strains - Ten Sleep (TS), Shepherd of the Hills (SH), and Sand Creek (SC) - were stocked as fingerlings in East Canyon Reservoir (277 hectares), Morgan County, Utah, in April and May 1981 and 1982. Growth, sport catch, and intensity of infestation with the anchorworm (*Lernaea cyprinacea*) were compared during the fishing seasons of 1982 and 1983. The harvest of TS strain fish was 5.7 times greater than that of the two other strains in 1982, and 1.9 and 5.2 times greater than that of SC and SH, respectively, in 1983. Length added by the TS strain 20 months after stocking in 1981 (mean 242 mm) was significantly greater than that added by other strains (SC 211 mm; SH 214 mm); growth after stocking was similar among strains in 1982. Higher whole body fat and protein in the TS strain than in the other strains in 1981 might have contributed to increased survival and growth. The SC strain was more susceptible than the other strains to anchorworm infestation in both years. The mean capture depth of the SC strain in vertical gill nets was 6.7 m in August 1982 but was 8.3 m for TS and 8.9 m for SH. In other months there were no significant differences among strains in vertical distribution in gill nets or in frequency of occurrence in catches of anglers fishing from boats of from shore. Use of only the TS strain for stocking this reservoir might improve the fishery at no additional cost.

BAGLEY, M. J., B. Y. BENT and G. A. E. GALL. 1994. A genetic evaluation of the influence of stocking density on the early growth of rainbow trout *(Oncorhynchus mykiss)*. Aquaculture 121 : 313-326.

The influence of stocking density on mean body weight and on genetic and environmental components of phenotypic variation for body weight was explored. It was hypothesized that high stocking density may suppress environmental variation in body weight arising from hierarchical interactions, resulting in a larger ratio of genetic to environmental variation. Thirty-two genetically marked full-site families were reared to 130 days at five stocking densities ranging from 5 to 95 fish L^{-1} in blocks of eight families. Intermediate densities of 20 and 45 fish L^{-1} provided the best growth through 81 days, though no differences in mean body weight were encountered among stocking densities at older ages. A family by environment interaction was observed at 130 days; subsequent analyses suggested that both genotype by rearing container and genotype by density effects might have contributed to the interaction. Genetic variation was significantly smaller, and environment variation significantly larger, at 20 fish L^{-1} than at stocking densities of 45 fish L^{-1} or more. It could not be determined whether differences in expression of social behaviors or differences in genes controlling growth were primarily responsible for the observed differences in variation across densities.

BAILEY, J. E. 1957. Comparison of survival, growth, and condition of hatchery rainbow trout and wild trout in Flint Creek. Federal Aid in Fish Restoration, Project F-13-R-3, Job 1, Montana State Department of Fish and Game. Helena, Montana.

BAILEY, J. E. 1958. Comparing survival, growth and condition of wild trout and hatchery rainbow trout reared on two different diets. Project No. F-13-R-4. State of Montana Department of Fish and Game. Helena, Montana.

A 230-volt smooth direct current shocking machine was used to census the entire length of the _ mile enclosures of the Flint Creek test stream twice annually. Standing crops of catchable-sized game fish have had a usual range of from 190-251 pounds per _ mile section (161 — 224 pounds per surface acre).

Spring census recapture rates for jaw-tagged hatchery-reared rainbow trout in Flint Creek have generally varied from 30 to 60 percent of fish planted the previous summer. Comparable wild trout recapture rates range from 35 to 70 percent.

In 1955, 893 pounds of hatchery trout were superimposed upon the resident trout populations in the two _ mile enclosures. Lower average condition factors (c $100{,}000W/L^3$) and greater overwinter loss in weight correlated directly with degree of overcrowding. Weight of standing crops of catchable-sized fish in the two sections approached the previously established range of 180-251 pounds within one year after the overstocking. Loss in total weight by the standing crops was due more to loss in weight and slower growth by individuals than to the slight decrease in survival rates.

In 1956, rainbow trout were hauled one, three and six hours before they were planted into the test stream. The six-hour trip was associated with a 10 percent reduction in recapture rates six weeks later. There was no difference in spring capture rates among fish of these three groups that survival the first six weeks.

In 1957, rainbow trout reared on three different diets were planted into the test stream. Only 28 percent of one nutritionally deficient pellet group was recaptured eight weeks later. This compared very unfavorably with the 72 and 75 percent recapture rates for a meat-meal diet group and a brand name commercial pellet group.

All eastern brook trout captured during the shock census from 1954 through the 1956 spring census were removed from the stream. Brook trout decreased from 18 percent of the total fish population by weight to 2 percent. In later census, brook trout were returned to the stream and by the 1957 fall census they comprised 10 percent of the total weight of fish captured.

During the 1957 fall census, 12 percent of the wild trout tagged in 1954 were still in the test stream. On the basis of scale annuli examined in 1954, these fish would be at least six years old when last recaptured. Two percent of the hatchery trout planted in 1954 were recaptured during the same census. They were nearly five years old at the time of last recapture. Both hatchery and wild trout had grown only two inches in average length from 1954 to 1957. The wild trout had gained 0.10 pounds in average weight compared to 0.13 pounds for the hatchery trout.

BAILEY, J. E. 1959. Montana trout hatchery diets and their effects on survival. Proceedings of the Annual Conference of Western Association of State Game and Fish Commissioners 39 : 263-264.

Rainbow trout were reared to catchable size on three different diets. A total of 711 fish: 220 from a brand name commercial pellet group, 215 from a vitamin deficient pellet, and 276 from a meat-pellet diet were jaw tagged and planted into the Flint Creek test stream. The mile-long test enclosure was censused by electric shocking in the fall after planting and again the following spring. Survival from fall census to spring census was about 70 percent for the brand name pellet group and the meat-pellet group and 56 percent for the unfortified pellet group. Ninety percent of the tagged resident wild trout survived the same period. Despite the fact that three hatchery groups appeared about equal by ordinary criteria such as growth rate, conversation, hatchery mortality rate, and cost per pound, there was a marked difference in quality of the fish, which was apparent within two weeks after tags, had been applied. It is suggested that for quality control purposes a short-term endurance or stress test should be applied to all hatchery fish before they are planted.

BAILEY, J. E. 1960. Test stream study: Final observations on survival of rainbow trout reared in hatchery waters of differing mineral content. Montana Department of Fish and Game. Helena, Montana. 3 p.

BAILEY, J. and J. SPINDLER. 1955. The fate of hatchery trout in the wild Flint Creek, Montana s test stream. Montana Department of Fish and Game Department. Helena, Montana.

Available information on survival and contribution to the creel of catchable-size hatchery trout planted into streams indicated that satisfactory results are not always obtained. Among the many factors that might operate in the hatchery to adversely affect survival of these fish are deficient diets, improper feeding and handling techniques, selective breeding for domestication rather than qualities that might improve survivability, and raising lake strains of fish that perhaps do not have sufficient inherent ability to cope with stream environments. At the time of planting, the fish are often subjected to rapid physical and chemical changes in their environment. For example, the effects, if any, of temporary oxygen starvation during the distribution upon subsequent survival of planted trout is not known. Several test streams have been and are being operated in North America for the purpose of measuring the effects of some of these factors.

To study the survival, growth, and condition of hatchery trout planted in a stream and to learn what factors are most effective in causing low survivability, a west slope mountain stream, Flint Creek in Granite County, Montana, was selected. This stream flows from Georgetown Lake through an electric power plant. The upper fish barrier of the mile-long study area is located about 2 miles downstream from the power plant. Altitude at the study area is approximately 5,500 feet. The usual volume of flow is about 15 cubic feet per second in the winter and 30 cubic feet per second in the summer. Water temperature varies from a winter minimum of 32° F. to a summer maximum of about 65° F. Daily fluctuation in water temperature ranges from 4° to 9° F. during the summer months. Anchor ice and frazzle ice does not form in the study area but icing of the fish barriers is severe when air temperatures fall to 20° to 30° F. Methyl purple alkalinity values ranged from 87 to 129 p.p.m. being highest in April and lowest in August. Willow growth is profuse and overhanging along practically all of the test stream. Bottom types vary from silt or detritus in pool areas to rubble in riffle areas.

The test stream is divided into two half-mile sections by three fish barriers. During the first year of operation, jaw-tagged hatchery rainbow trout were planted into the upper half-mile section at the same poundage level at which wild trout and whitefish were found there by D. C. electric shocking. All wild trout and whitefish captured were removed from this section. In the lower half-mile section, approximately one-half of the wild trout were jaw-tagged and left in the stream while the wild trout and whitefish removed was replaced by an equal poundage of tagged hatchery-reared rainbow trout. Planting was done July 30th in the upper section and August 12th in the lower section. These fish were hauled 24 miles and spent no more than one hour and fifteen minutes in the distribution tank. Recirculation of water in the tank used is sufficient to maintain adequate oxygen levels and low carbon dioxide levels, but does not prevent the accumulation of metabolic waste products. Mortality during the period from planting to six weeks after planting was not excessive as survival of the hatchery rainbow trout in the upper section was about 92.4 percent and 95.0 percent in the lower section, compared to 96.4 percent for the wild rainbow trout in the lower section. So-called delayed mortality , if it occurred at all among these fish, must have been insignificant. It is planned that overwinter survival of these fish will be determined by electric-shock census early in the summer of 1955.

The next series of observations on the test stream will be based on two planting levels, both considerably higher than the present stocking rate. An attempt will be made to measure the effect of stocking level in relation to minimum volume of flow during the winter on overwinter survival.

BAILEY, R. E., O. E. MAUGHAN and C. B. SCHRECK. 1973. An evaluation of catchable trout movement using two marking techniques. Proceedings of the Annual Conference Southern Association of Game and Fish Commissioners. 27 : 574-578.

Two marking techniques, freeze branding and subcutaneous tags, were used to evaluate movement of catchable rainbow trout *(Salmo gairdneri)* stocked into Rich Creek, West Virginia. These marks proved to be a valuable tool in studies requiring both rapid recognition of marked fish and identification of individuals. In general, there was a marked movement of trout downstream from the point of release, even during periods of low water conditions. Mean distances moved in both directions were 465 meters downstream and 197 meters upstream, respectively.

BAILEY, R. E. 1974. Development of recommendations for efficient use of catchable trout in West Virginia. M. Sc. Thesis, Virginia Polytechnic Institute and State University. Blacksburg, Virginia.

Two marking techniques, freeze branding and subcutaneous tags, were used to evaluate movement of catchable trout (*Salmo gairdneri*) stocked into Rich Creek, West Virginia. These marks proved to be a valuable tool in studies requiring both rapid recognition of marked fish and identification of individuals. In general, there was a marked downstream movement from the point of release, even during periods of low water conditions. Mean distances moved during the spring stocking season were 465 meters downstream and 197 meters upstream, respectively. Mean distances moved 7 months after initial stockings were 1169 meters downstream and 934 meters upstream, respectively. Catchable trout management recommendations for Rich Creek emphasized the use and movement data to optimize angler utilization. Stocking of fish near the upstream end of access points would maximize the number of fish available to the angler. Estimated harvest of the stocked fish was 73.5 percent.

BAKER, R. F. and W. P. MATHIS. 1967. A survey of Bull Shoals Lake, Arkansas, for the possibility of an existing two-story lake situation. Special publication No. 2, 21st Annual Conference, Southeastern Association of the Game and Fish Commissioners. New Orleans, Louisiana.

The position of Bull Shoals Lake as the lower lake in a chain of four large reservoirs located on the main stem of the White River in Arkansas and Missouri is described. During the three years of 1961, 1962, and 1963, physical-chemical determinations were made at three sampling stations situated along the channel of the lake.

Trout requirements with respect to temperature and dissolved oxygen as reported by other authors in the southeastern United States are reviewed. Data collected showed that trout could survive year-round in the vicinity of all stations. Concurrent experimental stocking of tagged rainbow trout (*Salmo gairdneri*) and tag returns during this study are discussed

BANDOW, F. 1987. Fluorescent pigment marking of seven Minnesota fish species. Investigational Report No. 393, Division of Fish and Wildlife, Minnesota Department of Natural Resources. St. Paul, Minnesota.

The use of sprayed fluorescent pigment for marking small fish was tested on seven fish species including rainbow trout (*Salmo gairdneri*). More than 96% of rainbow trout marked as emergent fry (mean total length 25 mm) retained marks throughout a 267 day assessment period. Emergent fry were adequately marked only when the spraying force was high enough to cause 25% mortality. Initial pigment marks were readily visible and short term retention was greater than 95% for fingerlings of all species and for yearling lake trout. Pigment marking did not influence growth of rainbow trout or lake trout fingerlings.

Particles from bulk pigment were separated into four size ranges and tested for mark quality in an experiment with rainbow trout fingerlings. Particles less than 250 m in diameter comprised approximately 88% of the bulk pigment but did not provide adequate marks. Long term retention remains problematical and should be monitored.

BANKS, S. M. and P. W. BETTOLI. 1999. Identification of the factors necessary for successful trout reproduction in Tennessee tailwaters. *In* Proceedings of the 1999 Southern Division Meeting, American Fisheries Society. Chattanooga, Tennessee. (Abstract Only).

Tennessee tailwaters are routinely stocked with brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) to sustain put-and-take and put-grow-and-take fisheries. Natural reproduction is known to occur in some Tennessee tailwaters. Natural reproduction can enhance the quality of a fishery and reduce the reliance on hatcheries to maintain a fishery. However, current stocking regimes ignore natural reproduction as a source of population enhancement because the subject is not well researched. The factors which control trout reproduction in Tennessee tailwaters are poorly understood. The objective of this study is to identify the factors necessary for natural reproduction to occur. This study is focusing on four east Tennessee tailwaters; little or no natural reproduction is thought to occur in two rivers (Clinch and Hiwassee) but substantial reproduction has been documented in two other rivers (South Fork of the Holston and Watauga). Complete censuses of spawning activity commenced in October 1998 and will continue through two spawning seasons. In addition to assessing habitat quality, other factors such as fecundity and brood stock size will be investigated.

BARKER, R. E. 1955. The fate of hatchery trout in the wild. p. 112-116 *In* Proceedings of the 35th Annual Conference of Western Association of State Game and Fish Commissioners. Moran, Wyoming.

In a three year period between 1949 and 1952, a number of trout tagging studies on hatchery-planted rainbow and brown trout, between six and twelve inches in length, were conducted. Of the 7,190 rainbows tagged and planted in streams, only 18.8% of the tags were ever recovered; of the 1,200 brown tagged and planted about the same time only 1.5% were recovered.

The Lake Maloya tagging study furnished the most conclusive proof of the losses that do occur. Lake Maloya, a 100 acre reservoir which is the municipal water supply for Raton, has a regularly employed caretaker and every angler is checked in and out and the number of trout caught recorded every day of the open season. This caretaker examined the trout and collected the tags. The extent of disappearance of the hatchery-planted trout can be judged from the two plants of tagged rainbow trout made in 1952 and 1953. These rainbows averaged about eight inches in length and the plants were made in the spring of the year. Of the five hundred planted in April 1952, 302 or 60% were returned to the creel during the two seasons following the plant. Seventy-one percent of the returned fish were caught within four months. Only fifteen percent of the returned fish were caught during the second year. The returns of the 1953 plant of 500 tagged trout is almost identical. Fifty-four percent were caught during the first season. In this case, the first two months accounted for a much greater percent of the total than in the previous year. Despite this early gain, the total for the year was approximately the same.

BARRETT, T. 1991. Investigation of angling for stocked rainbow trout (*Oncorhynchus mykiss*) at Springwater Pond and Lake Whittaker (April 27-May 31, 1991). File Report, Ontario Ministry of Natural Resources. Aylmer, Ontario. 15 p.

This report is focused on angling activity for stocked rainbow trout in Lake Whittaker, in the Kettle Creek Conservation Authority watershed, and Springwater Pond, in the Catfish Creek Conservation Authority watershed.

An initial April 19 stocking of 450 rainbow trout at each site was followed on May 13 by an additional stocking of 300 trout at Springwater and 450 at Lake Whittacker. Roving creel surveys were carried out at both Lake Whittacker and Springwater Pond from April 27 (opening day of trout season) through May 31, 1991.

In Springwater Pond, a total of 418 anglers were interviewed of whom 390 (93%) were fishing specifically for rainbow trout. A total estimated fishing effort of 5,474 hours produced an estimated 633 rainbow trout at a rate of 0.116 trout/angler hour. Anglers kept an estimated 589 rainbow trout. This represents 78.5% of the number stocked. Only 26% of interviewed anglers rated their fishing day as at least good.

On Lake Whittacker, a total of 225 anglers were interviewed of whom all were seeking rainbow trout. A total estimated fishing effort of 2,086 hours produced an estimated 776 rainbow trout at a rate of 0.372 trout/angler hour. Anglers kept an estimated 750 rainbow trout. This represents 83.3% of the number stocked. Sixty-six percent of interviewed anglers rated their fishing day as at least good .

BARROWS, P. T. 1962. The relationship of creel size and two inch plants of trout in Big Eggleston and Island lakes, Grand Mesa, Colorado, 1953-1958. Technical Bulletin 13, Colorado Department of Game and Fish. Denver, Colorado. 8 p.

Eggleston and Island lakes are located on Grand Mesa, Delta County, in west-central Colorado. The lakes are situated at an elevation of approximately 10,000 feet. Both lakes are stocked with rainbow trout.

During a six year creel census, 3,641 fishermen and 7,039 fish were censused on Eggleston Lake. The average fisherman fished 3.6 hours and caught 1.9 fish. Nearly 38% of the fishermen censused caught no fish. Rainbow trout comprised 98.7% of the catch; brook, brown and native trout the remainder. The average length of the rainbow trout for the six years of the study was 9.2 inches. The length range of rainbow trout in age group I was 5.5-8.9 inches; age group II was 7.9-11.8 inches, and age group III was 12.5-13.4 inches.

In Island Lake, 3,169 fishermen, 11,425 hours and 8,318 fish were censused during the six year study. The average CUE was 0.73. The average fisherman fished 3.6 hours and caught 2.6 fish. Approximately 40% of the fishermen censused caught no fish. Rainbow trout comprised 96.1% of the catch; brook trout the significant remainder. The average length of rainbow trout censused was 8.8 inches. The length of rainbow trout in age group II was 8.7-11.4 inches and age group III 11.6-14.5 inches.

Daphnia spp. was the most frequently occurring food organism occurring in rainbow trout from both lakes.

BARTON, B. A. 1979$_a$. Angler harvest of rainbow trout from two stocking rates in Paine Lake, Alberta. Fisheries Research Report No. 18, Alberta Department of Recreation, Parks and Wildlife. Edmonton, Alberta.

Rainbow trout catch ratio in Paine Lake increased from 0.11 on 1974 to 0.94 in 1977 as a result of increasing the stocking rate from 1,028/ha to 2,475/ha in the previous year. Year I+ fish comprised 97.1%

of the angled trout. Fork length and weight of I+ rainbow trout declined by 31.0% and 71.8% respectively from 1974 to 1977. Estimated total angler harvest of I+ rainbow trout in 1977 was 1.39% of the number of fingerlings planted in 1976. In both years, angling pressure was heaviest on weekend days but the average catch rate was higher on weekdays. In 1977, angling pressure and total trout harvest were highest in May.

BARTON, B. A. 1979$_b$. Angler harvest of rainbow trout from two stocking rates in Beavermines Lake, Alberta. Fisheries Research Report No. 18, Alberta Department of Recreation, Parks and Wildlife. Edmonton, Alberta.

Fingerling rainbow trout were planted in Beavermines Lake at rates of 1,237/ha in 1976 and 2,471/ha in 1977. Catch ratios for all trout one year later were 0.42 in 1977 and 0.74 in 1978, an increase of 76%. In the two successive years, 82.5% and 80.7% respectively of the estimated 4-month harvest were I+ trout. In the summer of 1977, 12.1% of the I+ rainbow trout were angled and 9.1% were angled in 1978. The catch ratio of I+ fish increased by 65% from the two-fold increase in stocking rate. In both anglers catches and test nets, I+ rainbow trout significantly decreased in mean fork length by 10 to 15% from 1977 to 1978. In both years, angling pressure was heaviest on weekend days, but the average catch rate was higher on weekdays. The largest angler harvest occurred in May and June in 1977 and June and July in 1978, although daily angling pressure was highest in June and July in both years.

BARTON, B. A. 1982. Stress and corticoid response from handling, transport and stocking in fish culture. Paper presented at Quality Improvement in Finfish Aquaculture Workshop, Boulder, Colorado, February 8-12, 1982.

Normal fish culture practices of handling, transport and stocking are mildly to moderately stressful to fish. In addition to many other physiological non-specific stress responses, elevation of plasma corticosteroids is a relatively useful indicator of the magnitude of stress experienced by fish. When under stress, the performance capacity of the fish is reduced because of the metabolic cost associated with adaptation and maintenance of homeostasis. Experimental evidence demonstrates that the degree of stress experienced by fish depends upon both the severity and duration of the stressor. Fish are usually able to cope with and compensate for the stress normally associated with handling, transport and stocking. However, if the ability to perform is reduced from stress, fish are likely to be more susceptible to additional subsequent stressors. Further, if the stressor is overly severe or long-lasting, mortality can occur. The practices of handling, transport and stocking are discussed separately with experimental examples in relation to the concept of stress and the general adaptation syndrome. Some general management recommendations for these practices presented in summary are:

- Ensure that the fish are in good condition initially.
- Avoid conditions which may cause additional stress.
- Spread out unavoidable stressful situations over time to allow for adaptation.
- Take steps to provide optimal acclimation conditions at the time of stocking.

BARTON, B. A. and B. F. BIDGOOD. 1979. Competitive feeding habits of rainbow trout, white sucker and longnose sucker in Paine Lake, Alberta. Fisheries Research Report No. 16. Fish and Wildlife Division, Alberta Department of Recreation, Parks and Wildlife. Calgary, Alberta. 27 p.

Competition for food between two resident sucker populations and introduced rainbow trout in Paine Lake was evident during the summer of 1977. Cladocerans, mostly *Dapnhia*, were the major food items for all three species, particularly in July and August, being 15.9% of the total food volume present in the rainbow trout diet, 33.7% of the white sucker diet and 74.2% of the longnose sucker diet for the four month study period. Tendipedidae larvae were also important in the diet of the three species in 1977 contributing 18.3% to food volume in rainbow trout, 21.0% to food volume in white sucker and 4.7% to food volume in longnose sucker. Certain food items present in rainbow trout stomachs (Hymenoptera 17.3%; Coleoptera 6.2%; Tendipedidae pupae 11.9%) were scarce or absent in sucker diets. When these food items were not available for rainbow trout there was direct competition between trout and suckers for *Daphnia* and chironomid larvae. Feeding selectivity for *Daphnia* by all three species was apparent since copepods, which were also common in the lake, were virtually absent in the fish stomachs.

BARTON, B. A. and R. E. PETER. 1982. Plasmal cortisol stress response in fingerling rainbow trout (*Salmo gairdneri*) to various transport conditions, anaesthesia and cold shock. Journal of Fish Biology 20 : 39-51.

Plasma cortisol levels of fingerling rainbow trout were measured as an index of the stress resulting from various procedures used for transport of the fish for stocking. When transported under normal conditions, which included water at the hatchery acclimation temperature (10-11° C), O_2 saturation or supersaturation, and neutral pH, there was a marked increase in plasma cortisol levels within 0.5 hours, which was maintained over the next 4 hours of transport; there was a significant decrease in plasma cortisol by 8 hours of transport. It was found that the plasma cortisol levels at 4 and 8 hours were not appreciably altered by transport under partial O_2 desaturation, O_2 saturation, O_2 supersaturation, or 0.5% NaCl, or by anaesthesia with tricaine methanesulfonate (MS 222) prior to capture and transport in MS 222-free water or 0.5% NaCl. A 15 minute exposure to an immobilizing dose of buffered or unbuffered MS 222, or 2-phenoxyethanol, caused an increase in plasma cortisol of about 2 hours duration, indicating that anaesthetics are themselves stressful. Exposure to chilled water (1° C) caused a large increase in plasma cortisol levels by 4 hours after initiation of exposure; plasma cortisol had decreased at one day, and by two days a constant level was reached which was above the level in fingerling trout under normal hatchery conditions. Trout acclimated to chilled water for 24 hours and transported in chilled water had an increase in plasma cortisol during transport. Anaesthesia prior to transport or addition of salt did not reduce the stress of transport as judged by plasma cortisol levels. The results indicate that stress from capture and transport during stocking cannot be avoided using present methods.

BARTON, B. A., R. E. PETER, and C. R. PAULENCU. 1980. Plasmal cortisol levels of fingerling rainbow trout (*Salmo gairdneri*) at rest and subjected to handling, confinement, transport and stocking. Canadian Journal of Fisheries and Aquatic Sciences 37 : 805-811.

Fingerling rainbow trout, acclimated to hatchery raceways or laboratory aquaria, had low plasma cortisol levels (≤ 2 ng/mL), with no apparent daily cycle in levels. Netting of cohorts out of an aquarium, without agitation, did not cause a rise in plasma cortisol concentrations in remaining fish. However, following 90 seconds of handling and confinement by netting, fingerlings had a sharp rise in plasma cortisol to a peak at 15 minutes, and then a gradual decline to the basal level over 2 hours. Gentle agitation and intermitted restraint with a dip net in the aquarium caused a gradual increase in plasma cortisol concentrations. Intense handling and severe confinement caused a rapid increase in plasma cortisol to a plateau, two to four times greater than the peak levels found in fingerlings subjected to the less vigorous stressors; high levels of plasma cortisol were maintained to the median tolerance limit. During a stocking operation, there was a rapid rise in plasma cortisol concentrations during the initial capture from the rearing ponds, and high levels were maintained through to stocking into the lake 6 hours and 10 minutes later, although a small decrease occurred during transit while the fish were in the truck tanks. After stocking, plasma cortisol concentrations in caged fingerlings did not decrease to the basal level until 8 days poststocking.

BARWICK, D. H. 1985. Stocking and hooking mortality of planted rainbow trout in Jocassee Reservoir, South Carolina. North American Journal of Fisheries Management 5(4) : 580-583.

Attempts to establish a put-grow-and-take fishery for rainbow trout (*Salmo gairdneri*) in Jocassee Reservoir, South Carolina failed despite planting of 200,000 fish from 1972-1979 because few of the stocked fish survived to legal size. At the same time, a fishery for brown trout (*S. trutta*) was established successfully by planting far fewer fish. Experiments were conducted to determine if stress at stocking and injuries and stress associated with catch-and-release of fish by shoreline anglers were responsible for the poor survival of rainbow trout. Only 1 of 606 rainbow trout stocked in floating wire cages anchored in the reservoir died during the first three days, and fewer rainbow trout than brown trout died as a result of catch and release fishing during the first 11 days after stocking. Thus these factors were not responsible for the lack of success in establishing a rainbow trout fishery in the reservoir.

BEAUCHAMP, D. A. 1987. Ecological relationships of hatchery rainbow trout in Lake Washington. Ph. D. Dissertation, University of Washington. Seattle, Washington.

BEAUCHAMP, D. A. 1990. Seasonal and diel food habits of rainbow trout stocked as juveniles in Lake Washington. Transactions of the American Fisheries Society 119 : 475-482.

I examined food habits of rainbow trout (*Oncorhynchus mykiss)* in Lake Washington, Washington, for relationships to the spatial and temporal distribution of their prey. Rainbow trout smaller than 250 mm (fork length) ate primarily *Daphnia pulicaria* during summer and autumn; larger fish were piscivorous throughout the year. Long fin smelt (*Spirinchus thaleichthys)* made up the largest fraction of fish prey in the diet of the rainbow trout from the nearshore zone during autumn and winter, whereas prickly sculpin (*Cottus asper)* (in 1984) and yellow perch (*Perca flavescens)* (in 1985) were most important in spring and summer. Rainbow trout in the offshore zone (> 15 m deep) ate mostly longfin smelt in spring and summer. Longfin smelt exhibited a 2-year cycle of abundance that appeared to influence the feeding habits of rainbow trout. When adult longfin smelt were less abundant during the 1985 winter, the fish fraction of the rainbow trout diet and the apparent ration size were roughly half the levels observed the previous winter.

BERNARD, D. and C. HOLMSTROM. 1978. Growth and food habits of strains of rainbow trout (*Salmo gairdneri*) in winterkill lakes of Western Manitoba. Canadian Fisheries and Marine Service Manuscript Report 1477 : iv + 20 p.

Fingerlings of different strains of rainbow trout, stocked in winterkill lakes, gained an average of 200 grams in approximately 160 days (May to October). Seasonal growth was best described by the Gompertz growth curve. Within lake the domestic strains, Idaho and Nisqually, had the same growth rates, though there was some variability in growth between lakes at harvest time. The wild strain, Tunkwa, was smaller at harvest time than the Idaho domestic strain. The three strains of trout showed the same general pattern of seasonal change in specific growth rate and this pattern was influenced by water temperature.

Amphipods were the major food organism consumed by trout in one lake in 1970 and 1971, but studies in 1973 and 1974 showed marked seasonal differences in food organisms consumed between lakes and harvest years. Amphipods were important to the trout diet but other organisms such as corixids, Odonata nymphs, Chaoborus and other fish were also important. The changes in food habitats are discussed in relation to changes in growth.

BERRY, C. R. and M. HUDY. 1983. Survival of stocked fingerling rainbow trout of different lactate dehydrogenase phenotpyes. Progressive Fish-Culturist 45 : 13-16.

Lactate dehydrogenase (LDH), an important enzyme in animal metabolism, regulated the ratio of pyruvate to lactate and governs the balance between aerobic and anaerobic metabolism. The objective of the present study was to compare survival to the creel of three lots of fingerling rainbow trout, each with a distinct LDH liver isozyme, over a 23 month period.

The Beitey strain of rainbow trout was used and the study was conducted in Porcupine Reservoir, a multi-use, coldwater reservoir in Cache County, Utah. The Beitey fish were stocked on July 15, 1978 when they were 85.4 – 8.7 mm long and weighed 6.9 – 2.1 grams each. Fish caught by anglers were checked for snout tags during a period of 10 to 23 months after they were stocked.

Survival to the creel for the Beitey strain was an estimated 4.8% at 12 months and 5.5% at 23 months. At 12 months after stocking, 172 Beitey strain fish had been recovered from anglers; an additional 6 were recovered in the remaining 11 months of the study.

Livers of 73 Beitey strain fish were collected and analyzed. There was no statistical difference ($P > 0.05$) in return to the creel among the three LDH genotypes when actual and expected returns were compared. Stresses associated with stocking and those imposed by the reservoir environment may not have been sufficient to select for either genotype if survival differences did exist. However, we recovered only about 2% of the stocked fish and therefore the sample size may be inadequate to conclude that liver LDH genotype is not linked with survival in a lentic environment.

BERST, A. H. and A. M. McCOMBIE. 1975. Rainbow trout and splake in a southern Ontario reservoir. Research Report No. 96. Ontario Ministry of Natural Resources. Maple, Ontario. 21 p.

Glasgow Glen Pond, an artificial impoundment of 13 ha (32 acre) area and 7.5 m (25 ft) maximum depth, is supplied mainly by intermittent surface runoff. Although in midwinter and midsummer the water temperatures and dissolved oxygen concentration lay outside the ideal range for trout, this pond supported a sport fishery for planted rainbow trout *(Salmo gairdneri),* splake *(Salvelinus namaycush* x *S. fontinalis)* and brook trout backcrosses (splake x *S. fontinalis).*

During a 5-year period, 2529 rainbow trout and 850 splake and backcrosses were recovered in 858 angler-trips averaging 2.9 hours duration. The average harvest per trip was 2.9 rainbow trout and 1.0 splake or backcross. The 5-year CUE for rainbow trout declined from a peak of 1.5 fish per rod-hour in early June to 0.6 in late summer then rose again to 2.0 in late October. Over the first 4 years the mean annual CUE rose from 0.77 to 1.75 fish per rod-hour, as fish stocks accumulated. The total harvest each year from 1968 to 1972 averaged 12.1 kg/ha (10.8 lb./acre) for rainbow trout and 1.9 kg/ha (1.7 lb./acre) for splake and backcrossess. Estimated recoveries for rainbow trout and splake were 36% and 10% of the numbers planted respectively. Rainbow trout planted as yearlings survived to age VI and reached 40 cm (16 inches) total length and 0.91 kg (2 lb) weight. Splake planted as yearlings survived to age IV and attained a maximum length of 33 cm (13 inches) and a weight of 0.32 kg (0.7 lb.).

BETTINGER, J. M. and P. W. BETTOLI. 1999. Movement and activity of resident and recently stocked rainbow trout in the Clinch River below Norris Dam, Tennessee. *In* Proceedings of the Annual Meeting of the Southern Division of the American Fisheries Society, Chattanooga, Tennessee . (Abstract Only)

Approximately 36,000 catchable (> 200 mm total length) rainbow trout (*Oncorhynchus mykiss*) are stocked annually into the Clinch River below Norris Lake, Tennessee, but return rates of these fish are poor. Radio telemetry was used to monitor the movements and activity patterns of resident rainbow trout and rainbow trout recently stocked into the Clinch River. Resident rainbow trout (N=20) were collected from the river and implanted with radio transmitters. Hatchery rainbow trout (N=20) were implanted with radio transmitters and stocked into the river two weeks after implantation. All rainbow trout quickly dispersed: of 15 fish that were located 24 hours post-stocking, seven moved upstream (mean displacement = 809 m) and eight moved downstream (mean displacement = 1855 m). Stocked rainbow trout disappeared rapidly;

there were significantly fewer stocked rainbow trout remaining in the study area then resident rainbow trout 29 days post-stocking. Differences in home range size and activity of the two groups were also documented.

BETTROSS, E. 2000. Savannah River trout stocking evaluation. *In* Proceedings of the 2000 Meeting of the Southern Division of the American Fisheries Society, Savannah, Georgia. (Abstract Only).

Water temperature, dissolved oxygen, fish species assemblage and creel data were collected from the 36 mile section of the Savannah River tailwater between Clarks Hill Dam and the New Savannah Bluff Lock and Dam for the purpose of evaluating stocking trout. A test stocking of 10,000 rainbow trout and 9,500 brown trout was made at the request of the Savannah River Trout Association. Five hundred of each species was tagged. Water temperature exceeded criteria previously used for classifying secondary trout streams in northwest Georgia at most sample locations. Dissolved oxygen concentrations in the uppermost portion of the study area were below minimum state water quality standards for trout water (5.0 mg/l) from July through September. Dissolved oxygen increased but water warmed rapidly as it flowed over the August shoals, 16 miles downstream from Clarks Hill Dam. In the upper 15 miles of the study area, where temperatures remained marginally cool enough for trout survival, oxygen levels were severely depressed. Farther downstream, where oxygen levels were reasonably high, temperatures became too high to expect significant trout survival. The study area supports a diverse assemblage of warmwater fish species, many of which could be expected to compete with or prey upon stocked trout. No trout tags were returned and only two trout were recorded in the creel survey. The studied reach of the Savannah River is unable to support trout due primarily to low dissolved oxygen and high temperature.

BIDGOOD, B. F. 1968. An attempt to establish a self-sustaining population of rainbow trout in Grist Lake. Management Report No. 6, Alberta Fish and Wildlife Division. Edmonton, Alberta. 9 p.

Grist Lake is a small oligotrophic lake of 2,780 surface acres located about 175 miles northeast of Edmonton, Alberta. The lake at present can only be reached by aircraft or winter road. In 1967, introductions of rainbow trout were made in York Creek and Grist Lake in an attempt to provide a sport fishery by establishing a self-sustaining populations that would spawn in York Creek, migrate to Grist Lake and feed on cisco.

On July 13, 1967, about 10,800 fall spawning yearling rainbow trout from the provincial hatchery in Calgary, Alberta, were transported by tank truck to Lake La Biche, Alberta. The fish were loaded into the water jacket of a Canso aircraft leased by the Alberta Department of Lands and Forests for fire bombing. The fish were flow to Grist Lake in three trips and dropped from heights that varied from about 50 to 100 feet from the surface. Personnel in a surface craft observed some minimal drop mortality immediately after the fish struck the water.

On July 14, 1967, about 20,000 fingerling spring spawning rainbow trout from Seattle, Washington, that were distant progeny of the Kootenay Lake stock of trout, were flown in oxygenated polyethylene containers to Edmonton, Alberta. These fish were transported by vehicle to Cold Lake and by aircraft equipped with floats to Grist Lake. The fingerlings were placed in York Creek about two miles upstream from Grist Lake.

The growth rate and feeding habits of the yearling fish planted in Grist Lake have yet to be evaluated. The success of creating a homing, self-sustaining population of rainbow trout in York Creek will be determined in the future when the fish mature.

BIDGOOD, B. F. 1975. Stocking rates for Alberta pothole fisheries. Alberta Division of Fish and Wildlife. Edmonton, Alberta. 31 p.

Numerous Alberta pothole lakes are stocked with hatchery-reared rainbow trout (*Salmo gairdneri*) to provide public recreational sport fisheries. Since suitable tributary spawning streams for rainbow trout neither flow into nor out of most of these stocked potholes, natural production is limited. Potholes with water depths sufficient to maintain dissolved oxygen concentrations under ice cover at a level that allows these introduced fish to survive through the winter months are stocked annually in the spring with fingerling rainbow trout. The stocking rates employed in the creation of these fisheries is as follows: an initial introduction of 500 fingerlings/surface acre, an introduction of 250 fingerlings/surface acre in the spring of the second year, and an introduction of 750 fingerlings/surface acre the third year. In 1973, Fisheries Research Section initiated investigations of several pothole fisheries to attempt to develop a simple procedure that would determine the annual stocking rate of each Alberta pothole fishery. A criteria to determine stocking rates for each pothole fishery is presented.

The most promising criteria to determine stocking rates of individual pothole fisheries is the length-weight technique. The size of the stocked fish and the date of stocking should be more closely controlled by the grading and stocking program employed at the hatchery level. Variations in stocking rates that produce a wider range in length-weight ratios of age 1+ fish are needed before a formula can be established and tested in each pothole fishery.

BIDGOOD, B. F. 1980. Temperature tolerance of hatchery-reared rainbow trout (*Salmo gairdneri)*. Fisheries Research Report No. 14. Alberta Department of Recreation, Parks and Wildlife. Edmonton, Alberta.

The upper incipient lethal temperature of rainbow trout reared at 10^0 C fell between 24 and 25^0 C. The size ranges of fish used in the four experiments did not alter these results. Rainbow trout, subjected to ten rates of daily increases in water temperature, tolerated water temperatures up to and including 26^0C, an increase of 1 to 2^0C above that of the upper incipient lethal temperature. The size of the fish used in these experiments did not alter the results. The highest recorded surface water temperature in several Alberta stocked pothole lakes was below the lethal temperature of rainbow trout of the size ranges used in these experiments. The tolerance of rainbow trout to the synergistic effect of both water temperature and water chemistry present in these pothole fisheries warrants further investigation.

BIDGOOD, B. F. 1980. Tolerance of rainbow trout to direct changes in water temperature. Fisheries Research Report No. 15, Department of Recreation, Parks, and Wildlife. Edmonton, Alberta.

Rainbow trout reared at 10° C, placed in 1° C water for periods of 2, 4, 6, 8 and 10 hours, and then placed in 15° C water for 4 days did not exhibit any mortality. Test fish reared at 10° C, placed in 1° C water for the above five exposure periods, and then placed in a final water temperature of 20° C for 4 days, did not die. The size of the test fish used in this experiment did not alter the results.

BIDGOOD, B. F. and B. A. BARTON. 1982. Stocking rates for pothole lake fisheries. Fisheries Research Report. Alberta Department of Energy and Natural Resources. Edmonton, Alberta.

Manipulation of stocking rates and sizes of fingerling rainbow trout in three, overwintering pothole lake fisheries for eight sequential years was precendential for the development of a multiple regression stocking evaluation. The effect of these two variables on growth and harvest in these fisheries was documented by sampling and by creel census. The size of yearling trout in August of year two was inversely correlated with both the number and size of the fingerling trout introduced in year one. Smaller yearling trout were harvested more efficiently by anglers during the summer months. About 80 percent of the angler harvest in the summer months was yearling trout. The presence of suckers in one fishery decreased the growth rate of the stocked trout but increased the angler harvest.

BJORNN, T. C. 1959. The relationship of diets of hatchery trout and their return to the creel. Idaho Department of Fish and Game. Boise, Idaho.

The development of the pellet type dry diets in recent years has made it possible to substantially reduce the costs of producing hatchery trout. However, the savings made through lower feed costs and reduced amount of labor are savings only if trout raised on the pellet diet are recovered by fishermen at a rate equal to that of fish raised on the regular production diets containing fresh meats. This study was conducted to determine the rate of return to the creel of fish raised on the pellet type diet and fish raised on the regular production diet containing fresh meat used by the Idaho Department of Fish and Game.

BJORNN, T. C. 1969. Steelhead trout production studies, Lemhi Big Springs Creek. Project No. F-49-R-6 , Idaho Fish and Game Department. Boise, Idaho.

The survival of 549,471 eyed steelhead eggs placed in the Big Springs Creek incubation channel in 1967 was 39.5% and 213,599 fry were released into the stream. Chinook salmon eggs were not placed in the channel in the fall of 1967 due to poor survival in previous years. Chinook salmon eggs were taken from Lemhi River adults and incubated at the Hayden Creek hatchery. On December 4, 1967, 156,000 swim-up fry were released into Big Springs Creek. Large numbers of the fry migrated downstream and left the stream immediately after release.

Age class I rainbow-steelhead trout, again comprised a high percentage (83.7%) of the age 1 and older fish collected from the sample sections of the stream. Juvenile steelhead continue to predominate in the rainbow-steelhead populations in the stream.

The yield of both sub-yearling and yearling rainbow-steelhead trout from Big Spring Creek continued to be proportionate to the number of fry released. The number of 1964 year class smolts leaving the upper Lemhi River was 4,500 fish, the largest number so far. Survival from fry to smolt stage was 1.4 and 1.5% for 1963 and 1964 year classes.

BJORNN, T. C., P. JEPPSON and M. RICHARDS. 1963_a. Tests for increasing the returns of hatchery trout (June 1, 1962 to September 30, 1962). Idaho Fish and Game Department. Boise, Idaho.

Some 30,000 fingerlings (two to three inches), of which 14,000 had a right ventral clip, were planted in Stanley Lake in 1961 to determine if fingerlings would grow to catchable size in the Lake and enter the sport fishery. Of 620 fish examined in 1962, 19 had a right ventral clip. It would, therefore, appear that fingerlings planted in 1961 might have comprised six to seven percent of the catch in 1962. Most of these clipped fish were observed in July and ranged from six to eight inches in length.

Catchable-sized, hatchery-reared rainbow trout were planted in Alturas Lake in midsummer to determine if such a plant would improve fishing success during the usually slow fishing period of July and August. Prior to the planting of 10,000 trout (approximately 2.2 per pound) on July 20, the catch-per-hour for rainbow trout has been less than 0.5. For the first two weeks after the plant, the catch-per-hour averaged 1.8 and subsequently declined to 1.1 and 1.0 for the following two-week periods. At adjacent Redfish Lake where a similar total number of fish planted, but all at the beginning of the season, the catch-per-hour was 0.8 during July, and declined to 0.5 and 0.3 during the two-week periods in August.

BJORNN, T. C., P. JEPPSON and M. RICHARDS. 1963$_b$. Tests for increasing the returns of hatchery trout. Idaho Fish and Game Department. Boise, Idaho.

During the census period from June 23 through August 12 an estimated 1683 anglers fished 5550 hours in Deadwood Reservoir to harvest 5733 fish. An additional estimated 2104 anglers fished 9031 hours in Deadwood River above the reservoir to catch 5931 fish. Fishing success averaged 1.0 and 0.7 fish per hour for the reservoir and river, respectively.

Percentage composition of the reservoir harvest was 23, 37, 20, and 20 percent, respectively, for rainbow trout, cutthroat trout, rainbow-cutthroat hybrids, and kokanee. Percentage composition of the river harvest was 30, 38, 18, 6, and 8 percent, respectively, for rainbow trout, cutthroat trout, rainbow-cutthroat hybrids. Kokanee, and whitefish.

BJORNN, T. and D. CORLEY. 1964. The survival of planted trout to the creel as related to their size and time of planting. Research Project No. F-32-R-6, Job No. 3 a-2. Idaho Fish and Game Department. Boise, Idaho. 19 p.

Studies were conducted at Alturas Lake during 1963 to determine if mid-season plants of hatchery-reared, catchable-size rainbow trout would maintain fishing success at a relatively high rate during normally slow fishing periods of mid-summer. Angling success was maintained at a relatively high level during mid-summer plants. The surface waters of Alturas Lake, located at an altitude of 7,000 feet, do not become as warm as many lowland lakes and reservoirs and thus the planted trout appeared to remain in the surface layers of the lake throughout the summer.

The return to the creel of rainbow trout planted in Alturas Lake during 1963 was related to fishing pressure. A near maximum expected return from plants made prior to mid-July was obtained. The percentage return from plants made after mid-July was obtained. The percentage return from plants made after mid-July was smaller due to a lesser amount of fishing pressure.

The program of rearing Kamloops rainbow trout for an extended period in a hatchery prior to planting may be of limited value based on the information collected at the Alturas Lake during 1963. Few of the hatchery-reared Kamloops observed in anglers creels had food in their stomachs when examined. In addition, a high percentage of the fish planted became sexually mature during the spring after planting. The natural losses associated with spawning may offset any gain achieved by rearing the Kamloops to a larger size before planting.

BJORNN, T. C. and J. MALLET. 1964 . Movements of planted and wild trout in an Idaho river system. Transactions of the American Fisheries Society 93 : 70-76.

During 1959-61, catchable-sized, hatchery-reared rainbow trout were jaw tagged and released in the upper Salmon River, Idaho and 2,246, 619, and 539 wild cutthroat trout, Dolly Varden, and rainbow trout, respectively, were caught on hook and line, tagged and released in the Middle Fork of the Salmon River. More than 1,500 of the tagged, hatchery-reared rainbow trout were recovered after being in the stream up to one year. Of those recovered the same season as released, more than 90% were taken within two miles of the release site. Ninety percent of those recovered after having been in the river overwinter were taken within five miles of the release site. Of 253 tagged wild cutthroat trout recovered, 64 were recovered in release areas, and 189 were recaptured one or more miles from their release sites (average for the latter about 19 miles). Of 95 tagged wild Dolly Varden, 27 were recovered in the release areas and 68 were recovered one or more miles from release sites (average for the latter 22.2 miles). Twenty-seven tagged wild rainbow trout or steelhead trout were recovered; 14 in release areas and 13 downstream from the release sites. Only 25.3% of the cutthroat trout and 28.4 % of the Dolly Varden were recovered within one mile of release sites.

BLACK, E. C. and I. BARRETT. 1957. Increase in levels of lactic acid in the blood of cutthroat and steelhead trout following handling and live transportation. Canadian Fish Culturist 20 : 13-24.

Alterations in the blood levels of lactic acid were investigated in hatchery-raised cutthroat and steelhead trout in the following conditions:

- After transferring from outside ponds to troughs inside the hatchery 60 yards = 54.9 metres away.
- Transportation run for two hours in a tank truck.
- Holding cutthroat for 40 hours, steelhead for 16 hours in hatchery troughs before transportation run of 2 hours 50 minutes.

The following results were noted:

(1) Significant increases in blood lactic acid occurred in both species as a result of minimal handling, i.e. in transporting the fish from outside ponds to inside hatchery troughs.

(20 Very significant increase in blood levels of lactic acid following a transportation run for 2 hours in a tank truck. The levels were higher in both species than those observed for lake trout and Kamloops trout in 1955.

(2) Storage of cutthroat for 40 hours resulted in significant lowering of blood level of lactic acid (range 0.8 — 17.5 mg %) following transportation run of 2 hours and 50 minutes.

Storage of steelhead trout for 16 hours before the same transportation run of 2 hours and 50 minutes resulted also in a lower blood level of lactic acid (range 9.5 — 88 mg %).

BOLES, H. D. and D. P. BORGESON. 1964. Upper Salmon Lake experimental trout management. Report No. 65-13, California State of Fish and Game. Sacramento, California.

An experimental trout stocking program was carried on at Upper Salmon Lake, Sierra County, from 1954 through 1960. The tests were designed to determine the strain of catchable-sized trout that should be stocked in this type of water and the best time of year to put them in.

In an effort to improve the fingerling stocking program various plants of wild and domestic strains were evaluated. All planted fish were marked for identification by fin removal and contribution to the fishery was evaluated by 75 to 90 percent complete creel census.

Early (July 11) planted Mount Shasta strain rainbow of catchable size gave better results than late (August 14) planted fish. Anglers caught 70 and 90 percent, respectively, of these plants. The smaller harvest of the late plant was a result of heavy overwinter mortality following the relatively low first-year catch.

Mount Shasta and Hot Creek strains of catchable-sized rainbows gave better returns than Mount Whitney or Virginia strains. This difference is believed due to higher catchability of the Mount Shasta and Hot Creek strains, which reduced overwinter mortality. Thus, these results may not be applicable to more heavily fished waters where few fish survive the fishing season (Upper Salmon Lake receives very light angling effort compared with most California catchable trout waters).

All plants of catchable-sized trout lost condition steadily from the time they were stocked until the following spring. This occurrence is believed to play a major role in overwinter mortality.

Fingerling returns varied from 3 to 30 percent but no plants proved economical in terms of cost in the angler s creel (the three most economical plants provided trout in the creel at a cost to the Department of around $1.25 per pound). Costly large fingerlings gave good returns but put on little growth whereas the less expensive smaller fingerlings grew better but gave poorer returns.

In a single test comparing fingerlings of domesticated strain (Mount Whitney) with steelhead and resident wild rainbow fingerlings, no strain proved decidedly superior.

Trout growth was slow. Over 75 percent of those caught were between 6 and 9 inches long and fish over 11 inches long were rare.

BORGESON. D. P. 1987. Fish stocking guidelines. Fisheries Management Report No. 11, Michigan Department of Natural Resources. Lansing, Michigan. 32 p.

There are few stream situations in Michigan where populations of sizable resident (non-migratory) rainbows exist. The young of migrant rainbows (steelhead) rarely reside in streams long enough to produce fish of attractive size to the angler. Therefore, the stocking of rainbow trout in streams has limited application in management for a growth potential.

Rainbow trout are a major trout species for inland lake plantings. Newly treated trout-only lakes should be stocked with rainbow fry as soon as detoxification is assured. These lakes should be replanted with fingerlings (100 per pound) annually thereafter in May or June. Two-story lakes shall generally be maintained by production stocking of 7 inch (5 per pound) yearlings in April, May or June. Two story lakes are those managed in combination with the non-trout species existing in the lake by the stocking of yearling or large fingerling trout. In large oligotrophic lakes, larger (10 per pound) fingerlings stocked in August may be substituted for yearlings.

BRADBURY, G. 1980. 1980 Assessment of brook and rainbow trout populations in Frost Centre put-and-delayed-take lakes. File Report, Ontario Ministry of Natural Resources, Leslie M. Frost Centre. Dorset, Ontario. 16 p.

The Leslie M. Frost Centre s brook trout and rainbow trout lakes provide fisheries on a put-and-delayed-take basis. In 1980 assessment was conducted on Avery and Partridge lakes to determine the success of hatchery plantings, the relative abundance of year classes and growth rates of planted rainbow trout. Assessment was carried out by gill-netting using one cotton and one monofilament gill net. Mesh sizes varied from 5.1 cm to 10.2 mm. Creel surveys were also carried out.

Both Avery and Partridge lakes received heavy winter and spring angling in 1979. Harvest from Avery Lake was very low however and 1980 gill netting indicated good survival and growth of rainbow trout. A much larger harvest from Partridge Lake likely had a substantial effect on rainbow trout abundance and only those fish stocked in 1980 were caught during the gill net assessment. Rainbow trout abundance decreases markedly after their first year. Survival in Partridge Lake is uncertain after their stocking year but extends through at least two winters in Avery Lake. Rainbow trout growth in both lakes was excellent. It is recommended that alternate year stocking efforts with rainbow trout be continued.

BRAUHN, J. L. and H. KINCAID. 1982. Survival, growth and catchability of rainbow trout of four strains. North American Journal of Fisheries Management 2(1) : 1-10.

Fingerling rainbow trout (*Salmo gairdneri*) of genetically different strains survived, grew and were caught at different rates by anglers and in gill nets after release from a hatchery into a 1 hectare pond. When two domestic strains were compared, more fish of the strain genetically selected for fast growth were caught per unit of angling effort than were fish of a strain not selected for this characteristic. When fish of a natural and domestic strain were released together, survival was higher in the natural strain but growth was slower. Strain population estimates reflected differences in catchability and were erroneous for the strain selected for growth. These observations imply that rainbow trout of different strains vary in their suitability for different fishery management practices.

BRAYTON, S. and K. ARMSTEAD. 1997. Stocking success a function of discharge in the Flaming Gorge tailwater, Utah. 1996-1997 Final Report. Utah Department of Natural Resources, Division of Wildlife Resources. Salt Lake City, Utah. 44p.

The Utah Division of Wildlife Resources conducted a three year study from 1993-1995 to develop a spring stocking regime optimizing survival and growth of fingerling trout. The study was extended in 1996 and 1997 to evaluate stocked trout survival during a moderate extended flow expected in 1996 and to monitor stocked trout survival and moderate gas supersaturation during high bypass flows in 1997. Fingerling rainbow trout were stocked at three stages of the discharges for the first three study years. The first group was stocked by raft prior to increased flows, the second group was stocked by raft during the downramp period, and the third group was stocked by helicopter after flows had stabilized at minimum discharge. Due to significant losses of the first group from 1993-1995, only the latter two groups were stocked in 1996-1997 to eliminate unnecessary loss of fish. Fingerling trout were spray-dyed to differentiate year classes and fin clipped to differentiate stocking groups.

Survival and growth rates of current year fingerlings were assessed approximately one month after stocking and again in late September. Fingerling rainbow trout collected by electrofishing were examined for cohort and stocking group marks, and total lengths and weights were recorded. Each season s data were analyzed separately and results combined for annual assessments.

Study results indicate that trout should be stocked by raft during the downramp period in years when base flows will be attained within a week of stocking. In years when moderate discharges will be held in excess of one week following the high flow, stocking should occur no sooner than one week prior to the beginning of base flows. The size of trout stocked should be increased in years when extended high discharges are anticipated to compensate for a potential reduction in growth. Scheduled size of stocked trout should assure attainment of a 300 mm fingerling by the beginning of winter. Monitoring of gas saturation should be continued in years where high, unevaluated flows are expected. The food habits of brown trout in the upper tailwater should be evaluated to determine the level of predation on the fingerlings following stocking.

BRICKER, M. J. 1970. Effects of starvation and time at stocking on survival of stocked rainbow trout (*Salmo gairdneri*). M.Sc Thesis, Utah State University. Logan, Utah.

Investigations of effects of starvation and time at stocking on the survival of catchable rainbow trout in two areas of Mammoth Creek in Dixie National Forest, Utah, were conducted from May 24 to December 6, 1969. Fish were starved for 6 days and 1 day and stocked in the morning (5:40-7:00 a.m.) and in the afternoon (1:45-5:30 p.m.). Out of 7,000 tagged fish stocked, 4,751 tags were returned by fishermen. The 6-day starved fish, stocked in the morning returned to the creel in highest numbers (1,240); followed by 1-day starved, afternoon-stocked fish (1,194); 6-day starved, afternoon-stocked fish (1,163); and 1-day starved, morning-stocked fish (1,154). For the entire stream, the main effects of starvation and time at stocking were not significant at the 10 percent level, but their interaction was significant at the 1 percent level.

In the upper area however, both 6-day starved lots returned to the creel in greater numbers (692) than the 1-day starved lots (643), and the main effect of starvation was significant at the 1 percent level in addition to the interaction being significant at the 5 percent level.

About 81 percent of the tags returned were from fish caught in the sections stocked. One percent of the tags were from fish that moved upstream and 18 percent from fish that moved approximately 3 miles or less downstream. No consistent downstream movement patterns were related to either starvation or time at stocking.

One week after the fishing season, 68 percent of all (19) tagged fish captured by electrofishing were 6-day starved fish, but this difference was not significant at the 10 percent level.

BRIDGES, C. H. and L. S. HAMBLY. 1971. A summary of eighteen years of salmonid management at Quabbin Reservoir, Massachusetts. p. 243-254 *In* G. E. Hall [ed.]. Reservoir Fisheries and Limnology, Special Publication No. 8, American Fisheries Society, Bethesda, Maryland.

Quabbin is a deep, softwater reservoir with two-thirds of the volume consisting of coldwater habitat. Three fisheries management programs have been implemented: lake trout-walleye, 1952-1960; lake trout-brown trout-rainbow trout, 1957-1965; and lake trout-landlocked salmon, 1965-1970. During the initial management program, walleye establishment failed.

In the second program, an experimental plant of brook, brown and rainbow trout was made in 1957. Harvest of the three species during the year of introduction amounted to 66.2%, 22.6% and 36.1%, respectively. The second year harvest of brown and rainbow trout from this plant was 10.2% and 14.4% respectively. The importance of rainbow smelt forage was apparent since brown and rainbow trout averaged a fourfold gain in weight within six months. From 1957 through 1965, 87,463 rainbow and 209,514 brown trout, both yearling and two year old fish, were planted. The angler catch of fin clipped and tagged lots indicated a higher percent total harvest of brown trout stocked as two year olds than of rainbow trout of the same age. Conversely, angler harvest of trout stocked as yearlings was higher for rainbows than browns. However, the total harvest weights of browns in both age groups were greater than those for rainbow trout of the same ages because the browns contributed to the harvest over a longer period of time. Consequently, brown trout plants were increased and rainbow trout stocking was greatly curtailed in 1963.

The lake trout and landlocked salmon shows signs of success. Throughout the three programs, rainbow smelt abundance has fluctuated primarily due to a chemical control program instituted to reduce the population which was interfering with the water supply distribution system.

BRITISH COLUMBIA MINISTRY OF FISHERIES. 1999. Fish stocking policies for British Columbia. Sustainable Economic Development Branch. Victoria, British Columbia.

It is government policy to give first priority in the fisheries program to the protection, maintenance and enhancement of wild indigenous fish stocks and that hatchery-reared or exotic species or races will be released only where there is a previous history of stocking or where wild stocks or listed rare species will not be compromised as a result.

The British Columbia hatchery program stocks about 1,100 lakes and streams with approximately 10 million fish annually. Rainbow trout make up half of the fish released (5.25 million) followed by kokanee, steelhead and brook char.

Stocking rates are loosely based on a carrying capacity model. Adjustments to the formula are made based on the objective for the lake, whether non-reproducing forms are to be stocked, the fishery potential and any natural recruitment which might occur.

The size of yearling rainbow trout stocked is based on the resident fish community and the objective of stocking. In a water with few predators 4-10 gram fish are stocked; when piscivorous species are present, fish 15-25 grams are stocked; for put-and-take purposes, domestic trout approximately 150 grams in size are stocked. Some rainbow trout are also released into selected lakes in the fall at about 1.0 grams in size.

BROCK, I. R., P. A. HANSEN, D. N. McBRIDE and A. C. HAVENS. 1994. Culture and performance of triploid rainbow trout in Alaska. Transactions of the North American Wildlife and Natural Resources Conference 59 : 263-273.

Rainbow trout (*Oncorhynchus mykiss*) are the mainstay of the lake stocking program in Alaska. Stocked lake fisheries provide significant fishing opportunities particularly in the Anchorage urban area. In 1992, stocked lake fisheries in the Anchorage area accounted for an estimated 71,194 angler days of fishing effort (50% of the total fishing effort to the area). The management objective for these fisheries is to maximize fishing effort at the lowest possible cost without compromising wild stock integrity where present.

With diminished survival and slower growth, widespread utilization of all-female triploid fish would result in less efficient management. Most stocked lakes in Alaska are landlocked and devoid of wild stocks. However some candidate lakes either are open systems which contain indigenous stocks of rainbow trout or are subject to periodic flooding such that stocked fish likely would spawn with wild stocks in other systems. In these applications only a sterile hatchery product could be considered.

Recruitment from stocking into the fishery must be such that sufficient angling effort is attracted to make the extra expenditure worthwhile. Comparison of this value with those calculated for competing management strategies provides a basis for decision.

BROWN, C. J. D. and N. THORESON. 1958. Ranch fish ponds in Montana: Their construction and management. Bulletin 554, Montana Agricultural Experiment Station, Montana State College. Bozeman, Montana.

The pond building program in Montana began in 1936 under the Resettlement Administration and other federal programs. More than 100 ponds were constructed in this area during the 3 ensuing years. Since that time, the number of ponds within the state has increased to about 50,000. More than _ of these were constructed solely for stock water purposes and most of the others for either irrigation or the control of erosion and floods. Less than 100 ponds are known to have been built specifically for fish production although possibly more than 1,000 have been stocked with fish at one time or another. The results from those plantings have not been encouraging since fewer than 250 ponds are known to have produced fish populations suitable for fishing.

In Montana, most ponds deep enough to support fish are suitable for trout. In a number of successful trout ponds the midsummer surface temperatures exceed levels tolerable to trout but the lower waters remain cold enough to provide a suitable place for these fish. Rainbow trout (*Salmo gairdneri*) and brook trout (*Salvelinus fontinalis*) are known to be adapted to Montana ranch pond conditions. They should not be planted together in the same pond, however. In new ponds devoid of fish, the planting of fry (soon after hatching) is usually very successful and is most economical. However, fry may not be available as the ice leaves the ponds in the spring when conditions are most favourable for planting. Brook trout may be as large as 2-3 inches at that time. Fingerlings of 1_ - 3 inches in total length should be stocked at a rate of 250-1,000 per surface acre depending upon food conditions. It is much better to understock than to overstock and more conservative numbers are best suited for untried ponds. Growth of the fish planted in ponds is extremely variable depending upon temperature, food conditions, etc. As soon as fish reach a useable size (6-7 inches) the pond should be fished. Ordinarily, good fishing will be enjoyed for 2 or 3 years depending upon the fishing pressure.

BROWN, G. E. and R. J. SMITH. 1998. Acquired predator recognition in juvenile rainbow trout (*Oncorhynchus mykiss*): Conditioning hatchery-reared fish to recognize chemical cues of a predator. Canadian Journal of Fisheries and Aquatic Sciences 55(3) : 611-617.

In this study, we exposed predator-na ve, hatchery-reared juvenile rainbow trout (*Oncorhynchus mykiss*) to the chemical stimuli from northern pike (*Esox lucius*) and either trout skin extract (a chemical alarm signal) or a distilled water control to test for acquired recognition of a novel predator. Trout exposed to conspecific skin extract and pike odour significantly increased antipredator behaviour (i.e., decreased foraging and area use and increased shoaling and freezing), while those exposed to distilled water and pike odour did not. Conditioned trout were exposed to pike odour alone (versus a distilled water control) either 4 or 21 days later. When presented with pike odour 4 days post-conditioning , trout significantly increased antipredator behaviour (i.e., decreased foraging and area use and increased time under cover and freezing). Trout tested 21 days post-conditioning still exhibited a significant increase in antipredator behaviour when presented with pike odour alone (i.e., decreased foraging and increased freezing). These data are the first to demonstrate that hatchery-reared trout can be conditioned to recognize the chemical cues of a predator and suggest that this may serve as a strategy to train hatchery-reared fish to recognize predators prior to stocking into natural waterways.

BRUMSTEAD, H. B. 1960. Stocking farm fish ponds. Cornell Extension Bulletin 1046, New York State College of Agriculture. Ithaca, New York. 4 p.

Increasing numbers of rural landowners who have a pond or who plan to build one consider stocking fish. Increasing numbers of ponds in which summer water temperatures in the deepest part of the pond do not exceed 74… F are being stocked with brook (speckled) trout or rainbow trout. Recommended stocking rates for rainbow trout are 300-600 fall fingerlings per acre surface area of the pond. Both trout species, stocked in the fall as 5 inch or 6 inch fingerlings will increase in length by the following spring and be 10 inches long and 8 ounces in weight the first fall after stocking. At the end of the second year, length averages 12.8 inches and 14 ounces in weight. Natural reproduction of trout in farm ponds is rare. This fact, together with a high natural death rate averaging 60% each year, determine the simple management scheme of fishing heavily 2 or 3 years then restocking. Brook trout are more easily caught than rainbows and some fishermen claim have superior flavor. Rainbows are noted for their fighting qualities. Stock trout alone. Add no other fish and do not stock them if other fish are already present.

BRYNILDSON, O. M. 1967, Dispersal of stocked trout in five Wisconsin streams. Fisheries Research Report No. 26, Wisconsin Conservation Department. Madison, Wisconsin.

Brook trout stocked as fingerlings during early summer and during the fall remained near the stocking sites or tended to disperse a short distance above the stocking sites by the following spring. Yearling brook trout released in winter were concentrated 3 to 4 miles above the stocking site the following spring. Yearling brook trout released in March were distributed in a one mile section below the stocking site within 10 days after release.

Brown trout stocked as fingerlings during early summer and during the fall remained near the stocking sites or dispersed upstream from the stocking sites by the following spring. Yearling brown trout released during January were distributed above and below the stocking sites but were concentrated at the stocking sites the following April. Out of six stocks of yearling brown trout released during March, four had greater dispersal downstream than upstream from the area of release and two had greater dispersal upstream than downstream a week to a month after release.

Various strains of rainbow trout stocked as fingerlings during early summer and during the fall remained near the stocking sites the following spring. Yearling fall hatched rainbow trout released in March were concentrated at the stocking sites and had only limited dispersal upstream and downstream from the stocking sites 3 to 4 weeks after release.

BRYNILDSON, O. M. and L. M. CHRISTENSON. 1961. Survival, yield, growth and coefficient of condition of hatchery-reared trout in Wisconsin waters. Miscellaneous Report No. 3, Wisconsin Conservation Department. Madison, Wisconsin. 23 p.

BRYNILDSON, O. M., P. E. DEGURSE, and J. W. MASON. 1966. Survival, growth and yield of stocked domesticated brown and rainbow trout fingerlings in Black Earth Creek. Fisheries Research Report 18, Wisconsin Conservation Department. Madison, Wisconsin. 15 p.

Fall-stocked fingerling brown trout had 51 to 90 percent survival to the following spring. Fall-hatched rainbow trout fingerlings stocked in the fall, had 42 to 60 percent survival to the following spring.

June-stocked fingerling brown trout had 13 percent survival to the following September. June-stocked fingerling fall-hatched rainbow trout had 26 to 30 percent survival to the following September, whereas 40 percent of the June-stocked winter-hatched rainbow trout fingerlings survived to the following September.

All stocks of rainbow trout had higher total weights in April than the total weights stocked the previous June or September. The highest gain in total weights from June to the following April was 894 percent. Out of 5 stocks of brown trout, 3 stocks weighed more than the following April than when stocked the previous June or September.

All stocks of rainbow trout censused yielded more pounds of trout flesh to the creel the following fishing season than was originally stocked. None of the brown trout stocks yielded more pounds to the creel the following fishing season than was originally stocked.

BRYNILDSON, O. M. and J. J. KEMPINGER. 1973. Production, food and harvest of trout in Nebish Lake, Wisconsin. Technical Bulletin No. 65, Wisconsin Department of Natural Resources. Madison, Wisconsin. 20 p.

In June 1967, stocks of 4,500 age 0 brown trout and 4,500 age 0 rainbow trout were stocked in Nebish Lake, a softwater lake which had been chemically treated in 1966 to remove all resident fish. Relative production, growth, harvest and food of the two species of trout were compared for 4_ years after their release.

Rainbow trout had the higher production of the two stocks because they survived better and grew faster than the brown trout. Poundage of rainbow trout in the angler s catch during the first two years of fishing was higher than the total poundage of brown trout produced in the lake during 4_ years. For each pound of brown and rainbow trout stocked, 5.2 and 15.0 pounds, respectively, were harvested by anglers.

Copepods were not found in the trout stomachs. *Daphnia,* 1mm and larger, was the staple food of brown and rainbow trout less than 16 inches, whereas fish was the prominent food of larger trout.

After three years of grazing by trout and by a burgeoning population of yellow perch, three of four species of *Daphnia* disappeared from Nebish Lake and small *Bosmina ongirostris*, which had not appeared in the Clarke-Bumpus samples before, became the dominant open-water cladoceran. After four years of grazing by perch, two species of *Daphnia* reappeared but in relatively low numbers.

Based on these data, it appears that trout growth can be rapid in a softwater lake containing large species of *Daphnia* if the lake s production capacity is not taxed by large stocks of planktivorous fishes.

BURDICK, M. E. and E. L. COOPER. 1956. Growth rate, survival and harvest of fingerling rainbow trout planted in Weber Lake, Wisconsin. Journal of Wildlife Management 20(3) : 233-239.

The present report is a summary of the management of a small, infertile lake in Wisconsin for which a complete record of fishing was maintained for the period 1947-1952. Weber Lake, Vilas County, is in the highland lake district of northern Wisconsin and is rather typical of the small landlocked lakes in this area. It consists of a single depression of 40 acres with a maximum depth of 47 feet. The water is very soft with a total alkalinity of 5 ppm.

Rainbow trout were first introduced in 1945 and annual plantings of this species were subsequently made. In addition, redbellied dace (*Chrosomus eos*) and fathead minnows (*Pimephales promelas*) were introduced in October 1946 to furnish trout with a forage fish.

Rainbow trout fingerlings were stocked each year beginning in 1945 at densities varying from 100 to 250 trout per acre. The average size of the fish in these annual plantings ranged from 1.2 inches to 3.6 inches in total length. The size of the fish was largely dependent upon the time of planting, with the larger fish being stocked during September and October and the small fish as early as May. The fish were stocked at different times, sizes and densities in order to determine the best way to manage a lake of this kind.

During the period of study, the total annual production to anglers ranged from 2.2 to 12.3 pounds of rainbow trout per acre and averaged 7.4 pounds per acre. The returns from individual plantings varied considerably; anglers accounted for 0.3 to 18.3% of the total number of the fish planted in different years. The average total return of 6.3% was based on a recorded catch of 2,652 trout resulting from a combined six year planting of 42,000.

The superiority as a management practice of planting trout in lakes over stream plantings of either fingerling or catchable-sized fish may be demonstrated by comparing the total pounds of fish produced to anglers with the pounds planted. In Weber Lake, 4.4 pounds of rainbow trout were produced to the anglers for each pound of trout planted. Stream planting of either fingerlings or catchable-sized trout rarely, if ever, produce a total weight to anglers equal to the original weight of the fish planted.

Plantings of trout from 1.2 to 2.3 inches in length yielded very poor returns compared with fish from 3.1 inches to 3.6 inches, especially when the smaller fish were introduced in the lake at a time when many larger fish were present.

A very few of the trout planted in Weber Lake lived to be five years old and fish in their 2nd and 3rd years of life dominated the catch. The largest trout caught was 25.0 inches in length and the average size of fish in the catch was approximately 14 inches.

Stomach samples were obtained from nearly all of the rainbow trout caught by anglers during the six year period. Larvae of caddisflies, burrowing mayflies and midges were consistently important items of the trout diet. Minnows and cladocerans were also taken in abundance in some years. It seems probably that minnows are more detrimental to the survival of trout through competition for food than they are beneficial in furnishing forage for the larger trout.

BUTLER, D. W. 1973. Federal aid in fisheries restoration act. Federal Aid Project No. F-2-R-19, Job No. E-9, Texas Parks and Wildlife Department. Austin, Texas.

Catchable rainbow trout (*Salmo gairdneri*) were stocked in the Quadalupe River below Canyon Reservoir during March, 1966 by the Texas Parks and Wildlife Department in cooperation with the Lone Star Brewing Company when it was established that the deep discharge from Canyon Reservoir might provide suitable conditions for a cold water species of fish. Creel census indicated a return of 59 percent of the 6,000 rainbow trout stocked during the seven month period following the stocking. Studies during the period of experimental stockings indicated that the tailrace waters would provide suitable conditions for trout during the most years unless severe drought conditions existed.

Catchable trout were provided by the Lone Star Brewing Company until 1969 at which time trout were provided by the U.S. Bureau of Sports Fisheries and Wildlife. Catchable rainbow trout have been stocked in the fishery every spring and fall at the rate of approximately 9,000 per year. Over 60,000 have been stocked since the program began. The program has proven to be a great boost to the economy of the area and increased angler utilization of the river over 2000 percent in the first years of a fishery. Creel census has indicated a slight decrease in utilization since the beginning of the program and it appears that publicity of the stocking has a great influence upon fishermen harvest and utilization.

BUTLER, R. L. 1975. Some thoughts on the effects of stocking hatchery trout on wild trout populations. p. 83-86 *In* Proceedings of the Wild Trout Management Symposium at Yellowstone National Park, September 25-26, 1974. Trout Unlimited Incorporated.

BUTLER, R. L. and D. P. BORGESON. 1965. California catchable trout fisheries. Bulletin 127, California Department of Fish and Game. Sacramento, California.

Trout fishing has long dominated California s freshwater angling picture. In 1963 roughly half of the state s 300,000 angling licensees caught trout. In 1962, with 1,588,000 licensees, the proportion remained unchanged.

Heavy angling pressure depleted trout in many roadside waters. The stocking of catchable-size hatchery trout soon followed, beginning in the southern California and Mono-Inyo area before World War II. It spread rapidly throughout the state after World War II, as the Wildlife Conservation Board provided more than 4 million dollars for the trout hatcheries.

Currently about seven million 7 to 8 inch rainbow trout *(Salmo gairdneri)* are stocked annually in California, at a cost of $1,366,000 (fiscal year 1962-63).

This program created a need for rapid inexpensive survey methods to determine if the many new catchables fisheries were functioning satisfactorily. Accordingly, a research project, D-J F-14-R, Evaluation of Catchable Trout Stocking was set up in 1954 to develop such a method, and to evaluate the new program. In 1956, this project was incorporated into the broader " Trout Management Study" D-J F-8-R.

This project answered many troublesome questions. It quickly developed the desired new survey methods and used them during 1957 and 1958 to conduct many short-term (one to three week) creel census studies on a cross section of California s catchable trout fisheries.

Marked catchable-sized trout were planted in a routine manner and their contribution to the fishery was measured by creel census combined with angler counts.

Total harvest was estimated by plotting daily catch per hour against cumulative catch and fitting a straight line to the linear portion of this relationship. The x intercept of this line is the estimated total harvest, since it is the cumulative catch when catch-per-hour (and also the population) drops to zero. The slope of the line is the instantaneous total mortality rate per hour of angling effort. It is the sum of the instantaneous fishing mortality rate per angler hour (catchablilty) and the unaccounted mortality rate per angler hour.

Seventeen of the 20 test waters had harvests that met the minimum 50 percent required by Fish and Game Commission policy. The average return from 7 lakes was 83 percent and from 13 streams 73 percent.

The fish were always caught rapidly. Fifty percent of the fish eventually harvested were taken within 2 to 9 days (average 3.6 days) from the study streams and within 4 to 12 days (average 6.6 days) from the study lakes.

Returns of trout 8.0 to 8.9 inches long were consistently about 15 percent greater than those of 7.0 to 7.9 inch fish.

The catchability of planted trout averaged about 7 times greater in the study streams than in the large study lakes. It was generally greater in small streams and lakes than in their larger counterparts.

Variations in catchability depended primarily on differences in the waters stocked rather than on differences in the trout or the fishermen. Data from waters receiving more than one experimental plant showed little variation in catchability from month to month during a given summer or from one summer to the next.

Planted trout do not disperse readily in streams. Hence, their catchability can be greatly influenced by distribution practices. Conversely, planted trout disperse rapidly in lakes, so that distributional practices affect catchability very little.

Compared with wild trout fisheries, angling effort was extremely high on all study waters. Effort was proportional to the number of trout stocked. On lakes, daily angling effort ranged from 0.6 to 58.8 angler days per acre and averaged 3.5. The daily effort on streams ranged from 41.0 to 314.9 angler hours per mile and averaged 102.5.

The generalization may be made that the yearly averaged catch-per-angler-hour from individual waters is unaffected by changes in the annual allotment of catchable-size trout because angling effort adjusts proportionally. Increased planting does not increase overall catch-per-angler-hour unless some factor, such as limited access or inadequate parking, limits angling effort.

The average catch-per-angler-hour for study streams ranged from 0.63 to 1.56 and averaged 0.94; for lakes it ranged from 0.40 to 0.75 and averaged only 0.60. Thus, to provide equal numbers of angling days, three trout must be stocked in streams for every two in lakes (assuming equal harvest).

Fluctuations in catch-per-angler-hour were much more pronounced on streams than on lakes.

Truck following results when the plant size for a given water is too large. Anglers familiar with planting schedules are attracted by the successful fishing that briefly follows a large plant. The opportunities for poaching and greediness are great at this time and angling etiquette suffers. The average catch-per-hour is lowered by uninformed anglers who should have been here last week. Most of the planted trout are caught before the next plant is made (plant-to-plant survival is low). Among the waters studied, truck following was most evident on small streams.

The key to eliminating truck following and attendant distasteful conditions lies in reducing the plant size, thereby increasing the survival of stocked trout from one plant to the next. When nearly all stocked fish are caught before the next lot is stocked, catches drop off to nothing toward the end of the planting interval. Conversely, when most of the plant survives, angling is nearly as good at the end of the planting interval as at the beginning, discouraging truck following.

The data indicate that the largest (and, therefore, the most economical) plant size that will effectively eliminate truck following is one that allows about half the planted fish to remain uncaptured until the next plant is made.

Using the following formula, creel census data similar to those obtained in these studies can be used to calculate the most economical plant size that will produce a satisfactory fishery on a given water:

$$R = \frac{(C/h)(-\log_e s)}{C}$$

where
R = routine plant size (recruitment)
C/h = overall catch per angler hour
c = catchability of planted trout
s = desired plant-to-plant survival (lowest that will provide a satisfactory fishery)

Stream plants of catchable-sized trout must be quite small to create satisfactory fisheries, because of high catchability of such trout in streams. The scope of stocking programs for small streams is further limited by physical restrictions. It takes relatively little angling effort to create crowded fishing conditions on small streams.

Small roadside streams with wild trout populations are usually the first to suffer from overfishing. As a result, many of them have been stocked with catchable-sized trout even though they are much less suitable for the program than larger streams and lakes. California s trout program would be strengthened considerably if these waters were not stocked and their allotments were planted in more suitable waters.

Angling effort is a far more important factor than time in reducing stocked trout populations. Thus, all planting intervals should include, as nearly as possible, equal amounts of angling effort regardless of their length in days and weeks.

The distribution of trout among anglers in catchable trout fisheries is no better than in wild trout fisheries. A large portion (usually between 35 and 70 percent) of the fishermen catch nothing and 50 percent of the catch is taken by less than 10 percent of the fishermen.

BUTLER, R. L. 1975. Some thoughts on the effects of stocking hatchery trout on wild trout populations. p. 83-87 *In* Wild Trout Management. Trout Unlimited Incorporated.

I propose that behavior, genetically based and influenced by interaction with other fish in the environment through time, produces differences in wild and hatchery trout that may not at first appear reasonable. High densities imposed by planting catchable trout on wild populations may bring about physiological stresses in wild fish characterized by aspects of the general adaptation syndrome.

BYRNE, A., T. C. BJORNN, and J. D. McINTYRE. 1992. Modeling the response of native steelhead to hatchery supplementation programs in an Idaho river. North American Journal of Fisheries Management 12(1) : 62-78.

A life history model was used to predict the response of native steelhead (*Oncorhynchus mykiss)* in the Lochsa River, Idaho, to long-term supplementation with hatchery fry and smolts. The four key factors affecting the response of the native fish to a stocking program were (1) the number of native spawners, (2) the number of stocked fish, (3) the number and fitness of progeny from stocked fish, and (4) the amount of mating between hatchery and native fish. Long-term stocking of fry or smolts led to the extinction of native fish in some scenarios. The model can be used to help assess the risks and benefits of proposed stocking programs.

CADWALLADER, P. L. 1983. A review of fish stocking in the larger reservoirs of Australia and New Zealand. FAO Fisheries Circular No. 757. Rome, Italy.

This is a review of stocking native and exotic fish species in Australia and New Zealand reservoirs. As the sport fishery is the far dominant type of fishing activity on these water bodies, most effort has been spent on stocking salmonids. *Salmo gairdneri* and *S. trutta* have been the main species stocked in reservoirs in New Zealand, *S. gairdneri* are self-sustaining and form the basis for a major recreational fishery. Trout stocking aspects are dealt with in detail and alternatives to stocking with trout are suggested. More recently, there has been a tendency to stock preferentially native fish wherever ecological conditions allow. There is a great scope and potential in southeastern Australia, but Queensland is at present the only Australia State whose reservoir stocking is now based entirely on Australian native fish.

CALHOUN, A. 1966. Habitat considerations for catchable trout. p. 254-256 *In* Proceedings of the 46th Annual Conference for Western Association of State Game and Fish Commissioners, July 12-14, Butte, Montana.

There is a great diversity of habitat among the 500 California lakes and streams stocked with catchable trout.

Catchable-sized trout shall not be stocked in streams when water temperatures reach 75… F and it appears that such temperatures will continue to occur regularly or when stream flows drop below 10 cubic feet per second. Stocking shall be discontinued sooner if conditions are unsuitable because of shallow water, lack of pools, growth of algae, poor water quality or other reasons.

Catchable-sized trout shall not be stocked in streams until water temperatures attain 45… F or higher most afternoons or while serious flood threats exist. Catchable-sized trout shall not be stocked in lakes and reservoirs after surface water temperatures reach 78… F and it appears that such temperatures will continue to occur regularly or after occurrence of a trout die-off attributed in whole or in part to an oxygen deficiency. Catchable-sized trout shall not be stocked in lakes and reservoirs until water temperatures attain 42… F or higher most afternoons.

Anglers regularly catch 90% of the fish stocked in these waters in a couple of days. Harvest rates on 13 streams averaged 73%. Anglers averaged 0.94 trout per hour. The daily effort averaged 102 anglers per mile.

The pressures on catchable trout lakes near Los Angeles are fantastic. June Lake, 300 miles northeast of Los Angeles in the Sierra Nevada, typifies lakes in the area. In the late 1930s, stocking of catchable trout resurrected the fishery with a 54% harvest. Twenty years later the harvest approaches 100%. Currently the lake receives about 80,000 catchables annually. The average harvest from seven of these lakes was 83%. Effort ranged from 1-59 anglers per day, per acre averaging 3.5; again much higher than on wild trout lakes.

CARGILL, A. S. 1980. Lack of rainbow trout movement in a small stream. Transactions of the American Fisheries Society 109 : 484-490.

Wild rainbow trout (*Salmo gairdneri*) were marked and released (N = 470) in Valley Creek, a small stream in east-central Minnesota. Subsequent sampling indicated no significant upstream or downstream movement over 2.5 years. A regression analysis of the transformed and weighted ratios of marked to total fish captured against time was used to determine if significant movement occurred. The lack of movement may be a feature of a genetically distinct nonmigratory race, individuals of which may occupy home territories throughout their lifetime.

CARL, L. M., J. R. RYCKMAN and W. C. LATTA. 1976. Management of a trout fishing area in a metropolitan area. Fisheries Research Report No. 1836, Michigan Department of Natural Resources. Ann Arbor, Michigan.

Rainbow trout of legal size or larger were stocked in a 5 mile length of the Huron River, Oakland County, Michigan, where conditions of flow and temperature are favorable for trout only during the spring months. Special fishing regulations were enacted. For April and May only artificial flies could be used and all trout caught had to be released. In June, bait was restricted to flies or other artificial lures, the creel limit was two trout, and the minimum legal size was 10.0 inches. Between July 1 and September 30, natural bait or artificial lures could be used, the creel limit was five trout and the minimum size was 10.0 inches (normal state-wide regulations). From April through September trout anglers fished 10,411 hours in 3,297 trips. Sixty-four percent of the fishing took place in April and May. A total of 5,706 trout were caught. Each fish was caught approximately 2.35 times. Fishermen spent an average of $10.92 per trip. Total net benefits for the program were $37,375 and the total expenses were $3,708, giving a benefit to cost ratio of 10.1 to 1. The mean personal income of the anglers was $14,570, well above average. Fishermen traveled an average of 50.4 miles for each fishing trip. The program was successful in utilizing hatchery trout efficiently to provide fishing in an urbanized area.

CASEY, O. E. 1965$_a$. The survival of planted trout to the creel as related to their time and place of planting. Research Project No. F-32-R-6, Job No. 3 a-1. Idaho Fish and Game Department. Boise, Idaho. 4 p.

Some 10,000 jaw-tagged rainbow trout were planted in American Falls Reservoir and the Snake River above the reservoir during 1963. The number of tags returned from the reservoir-released fish was 8, 7, and 1 percent for the April, June, and September plants respectively. The tag returns of river-released fish varied from 8.3 to 15 percent, with the highest returns from the Snake River above Tilden Bridge. Fish planted in the river grew very little, while fish planted in the reservoir gained weight rapidly.

The location of the tag recoveries indicated a migration of fish out of American Falls Reservoir after the water temperature warms up. Seventy-five percent of the fish planted in the reservoir in April were caught in waters other than the reservoir, with sixty-eight percent coming out of the American Dam forebay. Eighty-five percent of the June planted fish were caught in the river with sixty-eight percent coming from the forebay.

CASEY, O. E. 1965$_b$. American Falls reservoir, Blackfoot reservoir, and Snake River fisheries investigations. Project No. F-32-R-7, Job No. 2. Idaho Fish and Game Department. Boise, Idaho.

The creel census on American Falls Reservoir revealed that 87 percent of the catch was made up of hatchery fish planted after reaching catchable 3.4 pounds for cutthroat, and 2.1 pounds for kokanee.

The 1964 returns of tagged fish released in 1963 were best from fish released in September. Returns for the two years 1963 and 1964 were better from the April and June releases. Tags returned during the two years from the April, June and September releases were 11, 10, and 9.6 percent, respectively, of the number planted.

Surface water temperatures were above 70° F in the reservoir by July 1 and reached 80° F near Aberdeen in August. The peak migration downstream out of the reservoir preceded the higher water temperatures and occurred the first two weeks in July.

There was a decrease in the number of cutthroat in the creel during 1964. Cutthroat comprised 33 percent and 21 percent of the fish examined in creels in 1963 and 1964, respectively.

CASEY, O. E. 1966$_a$. Tests for increasing the returns of hatchery trout: American Falls reservoir, Blackfoot reservoir, and Snake River investigations. Idaho Fish and Game Department. Boise, Idaho. 6 p.

The scattering of catchable-size rainbow trout with the fish planting barge did not increase the return of catchables to the creel. The return of fish planted with the barge was 3.4%, while the return of fish planted from the fish truck at the boat ramp was 4.1%.

Eighty-one percent of the trout caught in American Falls Reservoir-Forebay area were hatchery fish. Approximately one-half of the remaining 19% came from the plant of fingerlings made with the fish planting barge. No kokanee were checked in the fishermen creels.

Growth of the marked fish was excellent. The fish averaged 10.75 inches when planted in April and averaged 16.25 inches on July 15.

The Blackfoot Reservoir produced mostly rainbow trout again in 1965. The percentage of cutthroat decreased from 20% in 1964 to 9% in 1965. Catchable-size rainbow provided 29% of the catch and provided the best return in relation to the number stocked.

CASEY, O. E. 1966$_b$. Tests for increasing the returns of hatchery trout: Crowthers and Deep Creek Reservoirs. Idaho Fish and Game Department. Boise, Idaho. 4 p.

Deep Creek and Crowthers Reservoir in Oneida County were studied in 1965 to determine the return of catchables to the creel. Three lots of marked fish were released in Deep Creek Reservoir. The rate of return was 65%, 48%, and 20% for the April, July, and August releases, respectively. Total harvest from Deep Creek was 10,800 fish. This was an average of 60 per surface acre for the 180 surface acre reservoir.

Angler counts, conducted during the fishing season, gave an estimate 4, 700 man days of fishing for the season on Deep Creek Reservoir.

Gill net samples taken in both Deep Creek and Crowthers reservoirs revealed a good cutthroat population. Nets from Deep Creek Reservoir contained 86% cutthroat and 14% rainbow, while angler creels contained 24% cutthroat and 76% rainbow. Gill nets from Crowthers Reservoir contained 74% cutthroat and 23% rainbow, while the angler creel was 98% rainbow and 2% cutthroat.

CLADY, M. D. 1973. Catchable trout: A literature survey and recommendations for use. Federal Aid Progress Report F-94-R, Oregon State Wildlife Commission. Portland, Oregon. 26 p.

An intensive literature search was conducted from July to December 1972 to review information relating to catchable trout fisheries in streams. Some generalizations can be made based on the common finding of many studies:

- The decision as to whether to stock trout of legal length depends largely on whether there is adequate angling pressure to harvest trout rapidly at a rate that is acceptable to fishermen. Poor returns of catchable trout have been attributed to insufficient angling pressure.
- Downstream movements of rainbow trout have been attributed to lower (< 50… F) water temperatures and overstocking. Movements are often found to occur in both directions and to vary greatly between seasons and years indicating that unknown environmental, rather than genetic, factors are dominant.
- With only a few exceptions, catchable trout from a release are rapidly reduced to insignificant

numbers in the stream and in the angler s creel — usually within 1 to 4 weeks.

- The overwinter survival of catchable trout in streams (of necessity measured mostly from releases made in the fall) may be poor and approach zero in some situations. Possible causes are fluctuating temperatures and lack of overwinter habitat leading to exposure, exhaustion and starvation, or predation, competition with wild fish and floods.
- Returns to the creel of fish of legal length planted in the spring and during the open season when angling pressure in sufficiently heavy to remove rapidly a large portion of the fish is several (up to 32) times the return from fall releases or plants made early or late in the year.
- The return to the creel of scatter-planted catchable trout is equal to or poorer than that from spot-planted trout. The higher density of the spot-planted fish does not adversely affect condition of trout.
- The practice of releasing a few trout in a stream as often as possible has generally been a highly successful and recommended technique. Proven benefits are a higher return to the creel, more anglers sharing in the catch, higher survival of trout, prevention of decline in angling quality between releases and distribution of fishing effort over the entire season.
- Hatchery-reared trout have been found to be inferior to wild trout in condition, vigor and appearance in a stream environment.
- Catchable trout possibly have a negative effect on wild trout populations. One of the most common explanations is that increased fishing pressure caused by the release of catchable trout results in an increase of harvest of wild trout.

CLARK, F. 1993. 1993 rainbow trout stocking assessment on Moon Lake. File Report, Ontario Ministry of Natural Resources, Blind River, Ontario. 6 p.

Moon Lake is a small (4.3 ha) lake situated north of Elliot Lake, Ontario. The lake is stocked with rainbow trout to provide put-and-delayed-take angling opportunities. Two gill nets were set to evaluate stocking success. Four rainbow trout (39.0-48.5 cm in total length and 580-960 grams in weight) and 2 brook trout were captured.

It is recommended that rainbow trout stocking be continued and that small stockings of brook trout be continued since both species seem to be doing well. Investigations should be conducted to determine if there is some natural reproduction by brook trout.

CLARK, H. W. 1958. Trout production at Harrington Pond. Ontario Department of Lands and Forests, Southwestern Region. London, Ontario.

Harrington Pond is located in the township of West Zorra, Lot 30, and Concession 2, of the County of Oxford. The Upper Thames Valley Authority purchased the site in 1953 to provide additional recreational grounds for the public.

Fish stocking and management of this pond has been carried out by the Ontario Department of Lands and Forests as requested. It was first stocked with Kamloops trout in July, 1953, and had been restocked each year since that time. Size of the pond is approximately three acres. On May 1st, 1954, the fishing was good and the trout averaged eleven inches in length. On June 23rd, 1954, the pond was restocked and closed to fishing. May 1st, 1955, the pond was reopened to fishing and we found that the growth was not as good as the previous year. The average length was nine inches and fewer trout were taken by anglers. On June 24th, 1955, the pond was again restocked and closed to fishing and on May 1st, 1956, the fishing was almost nil, very few trout were taken and the average length was seven and one-half inches. After considerable discussion, it was decided to drain the pond as low as possible and poison the remaining water. The pond had become infested with aquatic plants as well as suckers and other coarse fish. This program was carried out on June 27th, 1956. Several hundred pounds of suckers were removed, and the pond was allowed to stand dry for approximately two days before refilling. On August 1st, 1956, the pond was restocked.

CLARK, H. W. 1959. Trout production at Harrington Pond. Ontario Department of Lands and Forests, Southwestern Region. London, Ontario.

This paper is a continuance of that written in 1958 and includes a census of the Kamloops and speckled trout populations. Results demonstrated that the growth rate of the Kamloops trout is fast, provided there is no severe competition. Where competition is severe, introductions of Kamloops trout are not successful, either from the point of view of growth rate, or returns to the angler s creel.

CLOSE, T. L., S. E. COLVIN and R. L HASSINGER. 1985. Kamloops, Madison and Donaldson strains of rainbow trout in an oligotrophic Lake. Project No. DJ F-26-R. Minnesota Department of Natural Resources. St. Paul, Minnesota. 10 p.

Three rainbow trout (*Salmo gairdneri*) strains were stocked in an oligotrophic Minnesota lake to evaluate growth, survival and return to the creel. Donaldson and Kamloops strain rainbow trout grew to larger average sizes than Madison. Differences in growth rates by strain, however, were not significant. Strain survival rates were highly variable and not significantly different. Kamloops returns to the creel were highest by number and weight and had the largest average size. Madisons were the most vulnerable to angling immediately after stocking. After age II, Kamloops and Donaldson strains provided similar average CPUE s which were higher than for Madisons. Angling success for Madisons and Donaldsons was highest in May while success for Kamloops peaked in July. Benefit:cost ratios of each strain were similar and favorable. Diets of the strains were similar with invertebrates predominating. Kamloops strain rainbow trout are recommended for stocking in Minnesota s oligotrophic lakes as a single strain or in combination with Donaldson or Madison rainbow trout in order of preference, respectively.

COLES, T. F. 1981. An analysis of the put-and-take trout fishery at Toft Newton Reservoir. Fisheries Management 12(4) : 129-138.

The operation of a put-and-take trout fishery at Toft Newton reservoir is analyzed from detailed studies of the 1978 and 1979 seasons. Toft Newton is only a small reservoir but the anglers that utilize the fishery mean that the stocking rates per hectare of water have to be very high. As a result of these high densities and a short average residence time in the reservoir, rainbow trout, which were the predominantly stocked species, do grow after release. The success rate of the 8-9% of anglers not returning their catch data was examined using a postal survey. Partial correlation analysis indicated that the numbers of fish in the reservoir, the number of anglers fishing and the number of hours of sunshine significantly affected the catch rate. A regression between catch rate and number of fish in the reservoir only explained 35% of the variability but the addition of the other two factors did not significantly improve the accuracy of the model. The market area of the fishery was studied from the register of anglers. Most anglers attending Toft Newton travel a considerable distance to the fishery, the peak number driving from 98-129 km (61-80 miles) round trip. The present and future management policy of the fishery is discussed in the list of this analysis and many of the recommendations may also apply to other small put-and-take trout fisheries.

COOPER, E. L. 1953. Returns from plantings of legal sized brook, brown, and rainbow trout in the Pigeon River, Ostego County, Michigan. Transactions of the American Fisheries Society 82 : 265-280.

A complete census of fishing on 4.9 miles of the Pigeon River, together with population estimates made at the end of the open season, made possible an accurate evaluation of the yield and survival of open-season plantings of hatchery trout. Fishing intensity in this research area for 3 years averaged 2,414 daily trips per year, which was equivalent to 278 hours of fishing effort per acre per year. Sections in which hatchery fish were planted attracted about three times as much fishing as did the unplanted sections.

Fishing quality measured by the catch per hour per fishing trip, was generally poor for native fish, averaging less than one fish for five hours of effort. Hatchery fish made up about 70 percent of the total catch for the three years.

Planting trout from a live-crate a few at a time (scatter-planting) did not prove to be advantageous over the practice of liberating large numbers of fish in one hole (spot-planting). Trout that had been scatter-planted did not contribute to the catch for a longer period of time, and produced fewer successful fishing trips, fewer total fish returned to anglers, and slightly fewer anglers sharing in the total catch. However, the practice of making several plantings on different dates, a few fish at a time, permitted more individual anglers to share in the catch.

Although 4,500 legal-sized trout were planted every year, about half of the fishing trips were unsuccessful. Limiting the daily catch to 5 trout, instead of 15, did very little to reduce the percentage of unsuccessful anglers. Further reduction to 2 fish per day lowered the unsuccessful fishing trips to 36 percent.

Plantings of rainbow trout and brook trout gave much higher returns to the fishermen than did equal numbers of brown trout. Rainbow trout also survived over winter as well as did brown trout, although in both species the survival was less than 10%. Over-winter survival of brook trout was less than 3 percent. Fin-clipped trout were recovered by fishermen more readily than those which were jaw-tagged. This difference was especially apparent during the first week following planting.

Rainbow trout and brook trout, planted when water temperatures were below 50° F. showed very little movement.

Legal-sized brook, brown, and rainbow trout, planted in a stream subjected to heavy fishing pressure, contributed to the catch for a relatively short time. Brook trout were exploited most readily; only 4 percent of the recoveries were taken after 40 days of liberty. For brown trout and rainbow trout values were 26 percent and 22 percent, respectively.

Planting large numbers of hatchery fish (up to 431 trout per mile) apparently had no effect upon the catch of wild fish in the stream. Although the catch-per-hour of the planted trout increased greatly at the time of planting, the corresponding weekly data on catch-per-hour of the wild trout showed no similar increase.

COOPER, E. L. 1959. Trout stocking as an aid to fish management. Bulletin 663, Pennsylvania State University. University Park, Pennsylvania. 21 p.

Artificial propagation and stocking of brook, brown and rainbow trout is one of the oldest and best known tools of fish management in the United States. Sufficient information about the technology of fish culture and the ecology of natural trout populations is now available to assure satisfactory management of this resource. An accurate appraisal of the desires of the angling public has seldom been made. Opinions as to the type of trout management ranges from one extreme of no stocking: fish for fun only to the other of completely artificial propagation put-and-take fishing .

The emphasis and publicity accorded propagation and stocking has often belittled the greater contribution of natural trout populations in furnishing both recreation and fish in the creel. The low survival rates of both hatchery and native trout, although consistent with the high reproductive potential of these fishes, usually are sufficiently high to allow a large exploitation of the residual population by anglers without danger of depletion of the fish stocks.

Regulation of fishing historically has been considered an important part of trout management. Many regulations, such as a minimum size, daily bag, or closed season, either are too liberal to afford much protection to native populations or have little application to modern put-and-take stocking programs.

Differences in catchability among trout species make it difficult to manage this resource by means of blanket type regulations.

Further advances in managing trout resources are more likely to occur when fishery biologists clearly recognize the essential differences between native trout populations and domesticated hatchery trout. It is unlikely that fish which have been selected for numerous generations to perform in a superior manner under hatchery conditions will maintain characteristics of behavior, physiology, and anatomy which will enable them to survive in a natural environment at the same rate as wild fish. Based on a large number of trials by different investigators the best returns from planted trout are likely to occur:

- When trout of any size are stocked in suitable lakes, ponds or streams where there is little or no competition from fish already present in the waters, or
- When catchable-sized trout are stocked in streams where and when heavy fishing pressure is exerted promptly after stocking.

CORDONE, A. J. 1968. Experimental fingerling management of Beardsley Reservoir in California. Proceedings of the Western Association of Game and Fish Commissioners 48 : 442-460

Most west slope Sierra Nevada coldwater reservoirs are managed with annual plants of fingerling rainbow trout (*Salmo gairdneri*). However, the strain of rainbow trout used (currently four domesticated and one wild Kamloops strain), size planted, planting date and density vary considerably from water to water.

Trout were first stocked in Beardsley Reservoir in 1958. In the ten years from 1958 through 1967, about 891,000 fingerling rainbow trout were planted for an average of about 89,100 per year. This averages about 124 trout per acre per year. Beardsley Reservoir supports relatively high angler use compared with other waters managed with fingerling trout. Trout fishing effort averages about 40 hours per acre per year.

The basic objective of this study was to measure the relative success of various planting practices with emphasis on comparisons of the contributions of different rainbow strains to the reservoir fishery. Our findings may be summarized as follows:

- Harvest of rainbow trout stocked as fingerlings (1.0-51.5 fish/ounce) varied from 1.8%-32.8% of the number planted.
- The highest and most consistent harvest rates resulted from spring plants of yearling Kamloops fingerlings. Of the various domesticated strains, only Shasta fingerlings provided harvests which were considered successful.
- Plants made later in the spring gave better returns.
- Of the total catch for any given plant, the greatest number and weight almost always were recovered in the second year.
- Emigration via the spillway is certainly partly responsible for poor survival of stocked fish but other factors, such as increased turbidity, may also be important. There was an inverse relationship between the magnitude and duration of spill and fishing success and yield.

CORDONE, A. J. and T. C. FRANTZ. 1968. An evaluation of trout planting in Lake Tahoe. California Fish and Game 54(2) : 68-89.

Experimental plants of various strains of rainbow and cutthroat trout (*Salmo gairdneri* and *S. clarkii*) made in Lake Tahoe from 1960 to 1963 were evaluated for both immediate and long-range contributions to the sport fishery. None of the plants was considered as successful as was desired. Lahontan and Yellowstone cutthroat (*S. c. henshawi and S. c. lewisi*) contributed least to the fishery. Estimated total harvest of various Kamloops rainbow (*S. g. kamloops*) plants were never greater than 4%. However, they showed some potential for providing a long-range or premium fishery. Domestic rainbow contributed relatively few premium fish to the creel but had the highest immediate returns (3-36%). The majority of those caught were recaptured within 60 days of release. An occasional Kamloops and domestic rainbow trout survived in the lake for as long as 3 to 4 years. To demonstrate other characteristics (e.g., movements, growth, etc.) of trout stocked in Lake Tahoe, returns from plants made over a nine year period (1956-1964) were used. Kamloops and Williams Lake rainbow (a wild strain from Idaho) distributed themselves widely in Tahoe s limnetic zone, and the Kamloops commonly entered its tributaries. Domestic and Pyramid Lake rainbow (a wild strain from Nevada) tended to remain in the lake in shallow, rocky areas. Initially, planted trout grew at a rate of about 0.4 inches per month and then gradually tapered off to about 0.1 inches per month after 30 months in the lake. The largest premium trout came from plants of domestic rainbow trout. Lack of an adequate food supply, mortality associated with life in the tributaries and predation by lake trout (*Salvelinus namaycush*) appear to be the factors most responsible for the poor survival of stocked trout. Put-and-take plants of large (10-14 inch) domestic rainbow made from the shore during summer months appear to offer the best means of improving fishing through stocking, particularly for anglers fishing from the shore or from piers.

CORDONE, A. J. and S. J. NICOLA. 1970. Harvest of four strains of rainbow trout (*Salmo gairdneri*) from Beardsley Reservoir, California. California Fish and Game 56 : 271-288.

Four strains of rainbow trout, a wild strain of Kamloops rainbow trout and three domestic strains utilized in California s catchable trout program, were planted as fingerlings in Beardsley Reservoir, Tuolumne County, from 1961 through 1966. Kamloops and Shastas, the most recently developed domestic strain, was decidedly superior to Whitneys and Virginias, two strains domesticated since near the turn of the century. The best time of year to plant Kamloops was in April and May when they were 1.0 to 3.2 per ounce. Shastas planted in July and August from 2.5 to 6.2 per ounce were most successful. Comparing groups of these strains planted only at these times we found that Kamloops were harvested at a significantly higher rate than Shastas. Shastas, however, had a higher average ratio of pounds caught to pounds planted and a lower average cost per pound in the creel.

Kamloops displayed a greater tendency to leave the reservoir during periods of spillway discharge and was less available to shore anglers than the domestic strains. Moreover, they were more difficult to raise in the hatchery. The performance of Shastas we believe could be greatly improved if they were available for planting at a larger size in the spring

CORLEY, D. R. 1966. Tests for increasing the returns of hatchery trout. Idaho Fish and Game Department. Boise, Idaho.

An interview-type creel census was conducted on Alturas, Redfish, and Yellow Belly Lakes during the 1965 fishing season. Information was gathered to determine the effect of mid-season plants of catchable-size hatchery trout upon the rate of fishing success at Alturas and Redfish Lakes. The angling success in these two lakes was maintained at a relatively high level during the summer by the mid-summer plants. At both Alturas and Redfish Lakes, it was inadvertently demonstrated that fish planted near the most heavily fished areas of the lake will contribute more to the rate of fishing success and the return to the creel than fish planted in the more lightly fished areas.

Return to the creel of mid-summer plants of catchable-size rainbow trout in Redfish Lake was not good. The return to the creel from the first, second and third plants were 28.9 percent, 31.7 percent, and 12.3 percent, respectively. This low rate of return to the creel is related to the amount of fishing pressure, and during 1965 fishing pressure was believed to be lower than usual.

The survival of Kamloops trout in Alturas Lake appears to be poor. None of the large Kamloops planted in 1962 and 1963 was observed in the catch of 1965.

Fingerling kokanee that were planted in Redfish Lake in 1962 did not make a significant contribution to the sport catch in 1965. Some of these fish migrated out of the lake in the winter of 1963 with the ocean-going sockeye smolts.

COWYX, I. G. 1994. Stocking strategies. Fisheries Management and Ecology 1 : 15-30.

Stocking, transfer and introduction of fish are commonly used to mitigate loss of stocks, enhance recreational or commercial catches, restore fisheries or to create new fisheries. However many stocking programs are carried out without definition of objectives or evaluation of the potential or actual success of the exercise.

The first step when considering any stock improvement activity must be to ensure proper clarification of the management policy and objectives. Stocking generally does not tend to improve the catches in waters where there is adequate natural recruitment. Where the limiting factors can be isolated, efforts should be made to resolve the problems before resorting to stocking. Stocking should not be approved without building in a post-project evaluation.

Considerations which must be taken into account include maintaining the genetic integrity of the indigenous stocks, ecological interactions and the introduction of disease and/or parasites.

Stocking strategies should include source of fish, handling and transportation of stock, stocking density, size and/or age to stock, and timing of the stocking event.

CRAGG-HINE, D. 1975. Studies on overwinter mortality of autumn-stocked rainbow trout in some lakes in Northern Ireland. Journal of Institute of Fisheries Management 6(1) : 1-7.

An extensive program of development of inland waters for public angling has been carried out over the last seven years by the Department of Agriculture for Northern Ireland. An essential part of this work has been the conversion of small, derelict lakes containing coarse fish into the trout fisheries. The course fish, usually pike and perch, have been eradicated using rotenone fish toxicant, and after a short recovery period the lakes have been re-stocked with trout. Both brown trout (*Salmo trutta)* and rainbow trout (*Salmo gairdneri*) have been used, either in combination or as a single species. Rotenone treatments have usually been carried out during the late summer and re-stocking has taken place the following autumn i.e. some 2 or 3 months later. The fish used for these autumn stockings have been 0+ year group fingerlings, ranging from 3 to 4 in length for brown trout and 4 to 6 for rainbow trout. Stocking rates have varied from 200 to 300 per acre, depending on the degree of productivity of the water concerned. Rainbow trout have usually reached catchable size (10 fork length) by June of the following year, and have given excellent returns to anglers during the summer and early autumn following the initial stocking. For example, Castledillon Lake in County Armagh was stocked with 20000 rainbow trout of mean length 12.9 cm (5.1) in October 1968. Between July 1st and October 31st 1969 the estimated catch was 8300 rainbow trout averaging about _ lb. in weight, the mean catch per angler day was 2.96 fish, and the catch-per-hour rate was 0.61 fish. Similar results were obtained in other lakes following the initial stocking with rainbow trout.

As there is no natural recruitment of new stock in these lakes, annual restocking is necessary. During the first few years of development program the rainbow trout lakes were all restocked in late October (i.e., at the end of the angling season) with 0+ rainbow trout of 5-6 average length and then re-opened for angling at the beginning of June the following year. Without exception this gave disappointing results, although the lakes concerned had all provided excellent angling during the season following their initial stocking. For example, Castledillon Lake gave a catch rate of only 0.085 fish per hour in 1971, despite restocking with 12,000 fish and 10,000 fish during the autumns of 1969 and 1970 respectively. Test netting carried out during the angling season in the lakes concerned showed that the stocks of fish were small, and it was evident that considerable mortality was taking place during the close season. It was suspected that these losses were occurring during the winter months and experiments were therefore carried out on four established rainbow trout lakes to determine over-winter mortality of autumn-stocked rainbow trout. The lakes concerned were Roughan and Brantry Loughs in County Tyrone, and Castledillon and Gentle Owens Lakes in County Armagh. This suggests that conditions for survival may be less favourable later in the year, but it does seem that the presence of resident trout in the water is the major factor in influencing survival.

In summary, overwinter mortalities of 0+ rainbow trout ranged from 71-98%. It therefore seems reasonable to conclude that the poor angling experiences in these lakes in earlier years following restocking resulted from loss of fish over the winter. The poor survival of autumn-stocked rainbow trout obviously makes this an unsatisfactory management policy. An alternative policy of stocking in the spring with smaller numbers of yearling trout, length approximately 20 cm (8), together with adjustments to the angler season, has therefore been adopted.

CRANDELL, P. A. 1991. Genetics of domestic California rainbow trout (*Oncorhynchus mykiss*): Implications for wild stocks. p. 18 *In* International Symposium on Biological Interactions of Enhanced and Wild Salmonids, June 17-20, 1991, Nanaimo, British Columbia. (Abstract only)

This paper reviews current quantitative genetic knowledge about domestic California rainbow trout. The genetic implications for wild trout are discussed.

Although artificially propagated rainbow trout have been stocked in California waters since the last century, artificial selection was not practiced at a State hatchery until 1938. Early selection was performed with no knowledge of genetic parameters and little genetic principles. In 1968, a selection index-based breeding program was implemented for all State hatchery domestic broodstocks. The breeding program was designed to decrease production costs by improving growth and reproductive traits. It was developed based on prevailing animal breeding techniques. Selection responses and estimates of realized heritabilities are not yet available except for the trait of spawning date.

Many rainbow trout breeding experiments have been conducted over the past 20 years, and estimates of genetic parameters evaluated using California rainbow trout are available for many traits. Selected traits may directly or indirectly affect fitness. Consequently, heritability estimates for selected traits and genetic correlations between selected and unselected traits are particularly valuable for evaluating potential genetic impacts of domestic stocks on wild stocks. Fingerling, sub-catchable, and catchable trout from the State hatchery system continue to be stocked in waters throughout California. Undoubtedly, introgression between hatchery and wild stocks has occurred with unknown genetic effects.

CRESSWELL, R. C. 1981. Post-stocking movements and recapture of hatchery-reared trout released into flowing waters-a review. Journal of Fish Biology 18: 429-442.

The success of stocking with hatchery-reared trout has been the subject of varied investigations for the past half-century. Percentage returns are summarized, and literature on the post-stocking movements of hatchery-reared trout is reviewed. Factors affecting the post-stocking movements are considered, special attention being paid to studies on industrial rivers. Highest returns are obtained from stockings, with trout of a size suitable for angling, made during or shortly before the angling season. The majority of stocked brown trout (*Salmo trutta)* tend to remain close to the area of stocking, but brook trout (*Salvelinus fontinalis)* and rainbow trout (*Salmo gairdneri)* show greater movement, usually in a downstream direction. Greater dispersion of all species occurs if they have overwintered prior to capture or have been stocked in cold water or in small upstream stretches of river.

CROSSMAN, E. J. and P. A. LARKIN. 1959. Yearling liberations and change of food as effecting rainbow trout yield in Paul Lake, British Columbia. Transactions of the American Fisheries Society 88 : 36-44.

Some effects of the introduction of redside shiner (*Richardsonius balteatus*) on the rainbow trout (*Salmo gairdneri*) in Paul Lake from 1952 to 1957 are considered together with results of yearling trout liberations since 1953. Changes in the diet of rainbow trout from invertebrates to redside shiners, already noticeable in 1952, have since intensified. By 1956, shiners comprised over 90 percent of the summer diet of trout over 35 centimeters in length. In the diet of trout larger than 25 centimeters, shiners replaced plankton, amphipods and other bottom organisms to a marked degree. Trout under 25 centimeters utilized more shiners than previously, but in lesser proportion than the larger trout.

A program of yearling trout liberation since 1953 has shown considerable success, these trout forming up to eight percent of the anglers catch in the fall of the year of liberation and as high as 50 percent in the following spring. Hatchery fish of a given age were less variable in size and grew faster than wild fish of the same age. Both wild and hatchery trout showed growth rates in their second and third years suggesting increased use of shiners as food. Wild fish, which began the year at fork lengths over 17 centimeters in 1955 and 1956, had growth rates equivalent to wild fish in years prior to the introduction of shiners. The contribution of yearling liberations, growth rates of wild and hatchery trout and the effect on the fishery of the changing relations of rainbow trout and redside shiners are discussed.

CUNNINGHAM, P. K. and C. S. ANDERSON. 1992. Effect of size at stocking on harvest of rainbow trout in Bad Medicine Lake. Fisheries Investigational Report 421, Minnesota Department of Natural Resources. St. Paul, Minnesota. 17 p.

The effect of size at stocking on probability of harvest and on cost-per-harvested fish were examined in Bad Medicine Lake, a 323 hectare lake managed as a two-story fishery for rainbow trout and walleye. In 1990 and 1991, 16,000 age-1 rainbow trout (160-310 mm) were marked with oxytetracycline (OTC) before stocking. At stocking, vertebrae were removed from subsamples and the circular bands formed by OTC were digitized to measure backbone mark area (BMA). The relationship established between BMA and stocking length was used to calculate stocking lengths from BMA of rainbow trout harvested by anglers. Stocking lengths of harvested trout were estimated monthly and combined with traditional effort and harvest data to calculate total harvest by size group. The total first year return rate was 51.1% in 1990 and 58.6% in 1991. Return rates were strongly related to length at stocking. The three largest length groups (236-310 mm) contributed 78% of the harvest of age-1 trout in 1990, and 91.6% of the harvest of age-1 trout in 1991. Mortality associated with hauling and stocking stresses was only 1.6% and was not size dependent. Size selective predation by northern pike, burbot, and walleye likely accounted for the lower return rates among smaller sized trout.

CUPLIN, P. Undated. The survival of planted trout to the creel in Pebble and Toponce creeks as related to size and time of planting. Idaho Fish and Game Department. Boise, Idaho.

Pebble and Toponce Creeks, located in Caribou County in southeastern Idaho, were used as test streams to determine survival of catchable-size trout to the creel in relationship to numbers of trout planted and time of planting.

The initial stocking of fish, during early June, gave the greatest return to the creel in both streams. The subsequent planting of a second lot of fish, one month later, resulted in poor returns in Pebble Creek, while Toponce Creek returns compared favorably with the first lot of fish planted.

The carry-over of catchable-size trout from the 1958 fish plantings was negligible.

CUPLIN, P. 1967. Methods of increasing returns of hatchery fish. Idaho Fish and Game Department. Boise, Idaho.

The Idaho Fish and Game Department has carried on studies during the past ten years to estimate the harvest of hatchery fish. Methods of increasing returns to the fisherman s creel were the primary object of each study.

The procedures involved in transporting fish from the hatchery to the release site have been successful and the fish are in good physical condition when they leave the hatchery. Other variables that influence harvest are fish size and time of release, species, type of environment and amount of fishing pressure. Evaluation of some of these variables is reported in this paper.

CURTIS, B. 1951. Yield of hatchery trout in California lakes. California Fish and Game 37(2) : 197-215.

This paper brings together information obtained over ten years from hatchery trout yield experiments on nine California lakes. Most of these lakes have no or insufficient natural spawning. It is emphasized that lakes produce very different results from streams. The results of the different projects vary widely. From fingerling plants, three large lakes (800 acres and up) produced low yields in comparison with three small lakes (33 to 68 acres). Average yield from the former was 1% with a range of 0.2 to 1.5%; from the latter 8.7% with a range of 2.7 to 25.3%. In all combined, fingerling plants averaged a yield of 5.4%. Extraordinary improvements in yield from fingerling plants occurred in one 47 acre lake when a population of three planted trout species plus resident lake trout was eliminated and replaced by one species. Plants from catchable trout in seven lake experiments, in which areas ranged from 10 to 800 acres, gave an average yield of 44.9% with a range of 27.4 to 71.6%.

DAVIS, H. S. 1940. Artificial propagation and the management of trout waters. Transactions of the American Fisheries Society 1940 : 158-168.

The effectiveness of artificial stocking as compared with natural propagation is one of the most fundamental problems in fisheries management. Recent studies show that natural spawning is much more efficient than was formerly supposed, the hatch often comparing favorably with that at hatcheries. Good results from artificial stocking have been obtained in so-called barren waters and with the use of large fish. Frequently, however, stocking has been a failure and whether it has been generally successful is still problematical. Results of some recent studies on the effects of stocking are summarized. It is believed that a major cause of the failure of stocking is the lack of complete correspondence between the ecological requirements of the fish and the environment. The great need for further studies is stressed.

DEAN, E. H. 1980. An evaluation of fish cultural characteristics of the rainbow trout strains utilized for fingerling stocking programs in Utah. Project 1-116-R, Utah Division of Wildlife Resources. Logan, Utah. 35 p.

Water developments in Utah have created numerous coldwater reservoirs and a major portion of the trout fishing effort is expended on these waters. The Utah Division of Wildlife Resources must depend on stocking fingerling trout to meet increased fishing demands on these reservoirs. This study was initiated to characterize the cultural traits of rainbow trout presently reared in Utah s hatchery system and utilized in the fingerling stocking program.

There are currently three fall spawning rainbow trout strains (Shepherd-of-the-Hills, Sand Creek and Ten Sleep) and two spring spawning rainbow trout strains (Fish Lake-DeSmet and DeSmet). In overall ranking, the Sand Creek fingerlings were generally the poorest growers and were the lowest in most categories. Ten Sleep fish were intermediate in growth and rankings while Shepherd-of-the-Hills fingerlings were the best growers and overall performers in this study.

DeSmet fish were superior in every parameter studied except percent cripples and there was only a small difference in crippling losses. Despite smaller egg size and lower initial weight, the DeSmet fish equalled the Fish Lake-DeSmet fingerlings in average size after 13 weeks. DeSmet fish had less variation in weight and length and would require less labor to produce uniform fish for stocking.

DEGROOT, S. J. 1985. Introductions of non-indigenous fish species for release and culture in the Netherlands. Aquaculture 46(1985) : 237-257.

A total of 27 non-indigenous fish species has been introduced into the waters of the Netherlands, mainly during the 19^{th} and 20^{th} centuries. The introductions were made with the aims of restocking declining populations of commercially important species, introducing new species as substitutes for the former, establishing new fisheries or for culture to produce fish for consumption, ornament and game.

The rainbow trout is one of the most successful introduced and transferred species. Indigenous in North America, the species was imported into Japan back in 1877 and fully acclimatized in 1880. The first rainbow trout shipment to Europe was to France in 1882. Between 1884 and 1890, some 156,000 fertilized eggs were exported from France to Germany and 260,500 eggs were imported directly from the United States. Presumably the first rainbow trout imported into the Netherlands came from Germany. They were stocked as fry in Hasselbeek s fish farm at Zwaanspreng (province Gelderland). In 1898, 1500 1 year old fish were released in the moat of a fortress near Spaarndam north of Amsterdam under government supervision. Since then rainbow trout strains have regularly been imported and reared in Dutch waters. At present (1984), about 250 t/year is produced in fish farms.

DELISLE, G. E. 1959. Catchable trout evaluation studies in Inyo-Mono Counties, 1957. Project F-8-R-7, California Department of Fish and Game. Sacramento, California. 41 p.

An investigation was made on four catchable trout waters in Inyo and Mono counties during the summer of 1957. These waters were June Lake, Convict Lake, upper Rush Creek (between Grant Lake and Silver Lake) in Mono County and South Lake, Inyo County.

The purpose of the evaluation was to determine what effect the planting of various numbers of catchable trout (in waters with varying amounts of angling pressure) had on catch-per-hour and the percentage harvest.

Regularly scheduled plants were marked with a fin clip, and followed with an intensive dawn-to-dark creel census. Use counts were made every two hours, where possible, to determine daily angling pressure. The DeLury method was applied to the creel census data to estimate the total eventual return to the angler.

The estimated returns were: June Lake, 110%; Convict Lake, 48.6%; South Lake, 74%; Rush Creek, 90%.

The dynamics of catchable trout fisheries is discussed in terms of the effect of a new plant of fish on availability of fish already present, the factors responsible for a lower return from some waters, and the contribution of a plant to the catch and its effective longevity.

From the daily removal rates, a management program based upon achieving a stable 0.5 catch-per-hour is outlined for each water except Convict Lake. The program includes planning a seasonal allotment and determining the planting interval and the size of successive plants.

DELL, M. B. 1974. Tag returns and movements of rainbow trout (*Salmo gairdneri*) and rainbow-steelhead trout released in the Lake Washington system. Transactions of the American Fisheries Society 103 : 250-254.

Similar patterns of dispersion were observed over 90 day periods among hatchery-reared rainbow trout and rainbow-steelhead hybrid trout released in the Lake Washington system in 1966 and 1967. In both experiments 90% of recaptures were within 3.2 km of the release site. Returns were generally the same for the three tags tested (Carlin dangler, Petersen disk, Floy anchor pendant). Of the total fish released in 1966, 47.3% were recovered and of those in 1967, only 40.5%. A reward was offered in the 1966 experiment. Loosening and loss of tags and infection of tag wounds appeared minimal.

DENNIS, J. A. 1990. Evaluation of different rainbow trout stocking densities in an urban lake in Lubbock, Texas. M. Sc. Thesis, Texas Technical University. Lubbock, Texas.

DEVLIN, G. J. and P. W. BETTOLI. 1998. Performance of stocked salmonids in the Caney Fork River below Center Hill Dam, Tennessee. *In* Proceedings of the 1998 Meeting of the Southern Division of the American Fisheries Society, Lexington, Kentucky. (Abstract Only)

Population characteristics of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) stocked into the Caney Fork River below Center Hill dam in 1997 were investigated. Three cohorts of rainbow trout (N=7,000) and one cohort of brown trout (N=16,500) were microtagged and stocked during the spring and summer of 1997. The river was sampled monthly by electrofishing to assess the survival, growth, condition and movement of trout. Electrofishing catch-per-unit-of-effort (CPUE) for rainbow trout stocked in March declined linearly ($r^2 = 0.92$) and CPUE reached zero within 167 days. The CPUE for rainbow trout stocked in June declined rapidly ($r^2 = 0.93$) and approached zero within 102 days. All tagged cohorts exhibited a decline in condition throughout the study. A mark-recapture experiment in April 1997 estimated that 2,826 brown trout and 4,818 rainbow trout overwintered.

DEYNE, G. 1990$_a$. Fish stocking guidelines. File Report. Algonquin Region, Ontario Ministry of Natural Resources. Huntsville, Ontario. 11 p.

These new guidelines attempt to further refine stocking decisions with respect to the suitability of waters. Criteria for stocking salmonids are based on the percentage of natural recruitment, available habitat (temperature and oxygen profiles) and resident fish communities.

Rainbow trout are better able to utilize the littoral zone, including surface waters, longer than other salmonids perhaps giving them a competitive edge in shallower, warmer waters.

It is recommended that rainbow trout not be stocked with other trout species in inland waters within the Algonquin Region given enforcement concerns related to the all year open season for rainbow trout.

DEYNE, G. 1990$_b$. Standards for rainbow trout post-stocking assessment. Draft Guidelines, Algonquin Region, Ontario Ministry of Natural Resources. Huntsville, Ontario.

The objective of preparing stocking assessment guidelines is to establish consistency in sampling procedure for inland waters within the Algonquin Region. Consistency in the sampling procedure will allow for comparative results between districts to achieve stocking assessment priorities with increased efficiency.

For rainbow trout the sampling objective will be the post-stocking evaluation of age 1+ fish for the purpose of establishing a catch-per-effort (CUE) index. The technique involves the use of green monofilament gill net and the concept of a limited kill.

The shoreline of the lake should be divided into sectors which are then randomly sampled without replacement. Equal amounts of small and large mesh should be set next to the shore.

Netting will be conducted in May and June prior to strong thermal stratification. Nets should be set between 1600 and 2200 hours and left fishing for a period of 30 minutes. In some cases it may be necessary to set nets overnight. The sampling effort will be determined by either 40 short net sets or the capture of a minimum of 20 rainbow trout.

DEYNE, G. and G. ARNETT. 1987. Inventory and assessment of Crosson Lake, Oakley Township. File Report, Ontario Ministry of Natural Resources. Bracebridge, Ontario. 9 p.

Crosson Lake is a small (58.8 ha) coldwater lake supporting a number of species including yellow perch, white sucker, pumpkinseed and brown bullhead. The lake has been stocked repeatedly since 1939. In 1986, the lake was stocked with 1,500 catchable sized (20-26 cm) rainbow trout in an attempt to establish a put-and-take fishery.

Assessment netting was conducted from September 28-29, 1987. One section of monofilament gill net, with mesh sizes ranging from 2.5-7.6 cm, was set straddling the thermocline and left fishing overnight. The netting assessment yielded a total of 183 yellow perch, 69 golden shiner, 35 brown bullhead, 19 pumpkinseed, 2 creek chub and 2 white sucker. No rainbow trout were taken. Yellow perch were most abundant accounting for 59% of the catch by number and 44.1% by weight.

The failure to capture rainbow trout considering the 1986 planting of 1,500 catchable sized fish suggests that the survival rate was low. Local anglers indicate the occasional rainbow trout is taken but angler success is poor. The attempt to establish a put-and-take rainbow trout fishery in Crosson Lake appears to have met with only marginal success. Late summer water chemistry does not appear to offer a plausible reason for the apparent failure of the introduction. The implementation of a more intensive netting program in other areas of the lake is recommended before further introductions are considered.

DICK, T. A., M. H. PAPST and H. C. PAUL. 1987. Rainbow trout (*Salmo gairdneri*) stocking and *Contracaeacum* spp. Journal of Wildlife Diseases 23(2) : 242-247.

A stocking program with rainbow trout (*Salmo gairdneri*) at High Rock Lake, Manitoba failed due to infections with large numbers of *Contracaeacum* spp. larvae. Nematode larvae in the intestinal tract, body cavity and musculature made the fish unmarketable. A combination of experimental infections of rainbow trout and pelicans (*Pelecanus erythrohynchos*), observations on the behaviour of fish-eating birds, and numbers of larval *Contracaeacum* spp. in minnow species led to the following conclusions. The introduction of rainbow trout attracted large numbers of fish-eating birds, particularly pelicans. Concurrent predation by rainbow trout on fathead minnows (*Pimephales promelas*), five-spined sticklebacks (*Culaea inconstans*), and nine-spined sticklebacks (*Pungitius pungitius*) concentrated the parasites. The combined increase in densities of the numbers of introduced fish host and fish-eating birds, and the short life cycle of the parasite, increased the number of parasites in rainbow trout over a season and in the indigenous minnow species between years. Number of larvae in the indigenous minnow species declined when stocking of rainbow trout was stopped and use of the lake by fish-eating birds, particularly pelicans, returned to normal levels.

DICKSON, I. W. and R. H. KRAMER. 1971. Factors influencing scope for activity and active and standard metabolism of rainbow trout (*Salmo Gairdneri*). Journal of the Fisheries Research Board of Canada 28 : 587-596.

Scope for activity was similar for hatchery and wild rainbow trout (*Salmo gairdneri*), except at 25° C where values for wild trout were significantly higher than those for hatchery trout. In hatchery and wild rainbow trout, respectively, scope for activity was highest at 15 and 20° C. Active metabolism increased with temperature to 570 and 592 mg O_2/kg per hour at 15 and 20° C, respectively. At 25° C, active metabolic rates of wild trout were higher than those for hatchery trout. In hatchery and wild trout, respectively, standard metabolism increased from 36 to 42 mg O_2/kg per hour at 5° C to 138 and 120 mg O_2/kg per hour at 25° C.

Scope for activity of hatchery trout was highest after 6 days of starvation. Starvation had no effect on the active metabolism of hatchery trout, but decreased their standard metabolism for 2 days.

Scope for activity and active and standard metabolism of wild trout were similar during forenoon to those during afternoon when light simulated natural day and night and also when lighting was constant for 24 hr.

Active metabolism of hatchery trout was higher during the spawning period than other periods of the year and was consistently higher for males throughout the year.

DILLON, J. C., D. J. SCHILL and D. M. TEUSCHER. 2000. Relative return to the creel of triploid and diploid rainbow trout stocked in eighteen Idaho streams. North American Journal of Fisheries Management 20 : 1-9.

Introductions of fertile non-native hatchery trout have led to interspecific and intraspecific hybridization of native salmonid stocks throughout North America. Use of specific triploid hatchery trout in stream-stocking programs could reduce genetic risks to native stocks while addressing public demand for consumptive fishing opportunities. Techniques to produce triploid salmonids are well developed, and triploid rainbow trout (*Oncorhynchus mykiss)* are readily available from commercial sources. However there is no published information on the return to creel of triploid trout in stream recreational fisheries. We purchased mixed-sex triploid and diploid rainbow trout eggs from a commercial supplier and reared the resulting fish to catchable size. Flow cytometry was used to verify triploid group. Estimated cost to produce a triploid catchable rainbow trout was about 15% higher than for a diploid fish. We jaw-tagged and stocked 300 triploid and 300 diploid fish into each of 18 streams throughout Idaho and used tag returns to assess relative return to creel and timing of returns for the two groups. In all, 1,849 tags were returned by anglers, 931 from triploid fish and 918 from diploid fish. Overall returns were not significantly different between groups (paired *t*-test; P=0.08). Mean time to harvest also did not differ between groups (paired *t*-test; P=0.35). These results suggest that triploid rainbow trout can provide stream angling opportunity equal to that provided by fertile diploid fish. Although there are other concerns regarding the stocking of hatchery trout in streams containing native trout, we suggest that using triploid rainbow trout in stream-stocking programs can help balance the demands for both consumptive fishing opportunities and conservation of native stocks.

DOLAN, J. J. and R. G. PIPER. 1979. Hatchery and field evaluation of four strains of rainbow trout (*Salmo gairdneri).* Information Leaflet No. 10, Fish and Wildlife Service. United States Department of the Interior. Bozeman, Montana.

The performance of four strains of rainbow trout was evaluated under hatchery and field conditions. The hatchery evaluation was based on growth, conversion, and survival, while the field evaluation was based on catchability, growth and condition factor (K). All strains were stocked in two ponds chosen as replicates for the field evaluation. Domestic Winthrop and Spring Standard Growth strains had greater length increase, better feed conversion, and were harvested at a faster rate than the wild McConaughy and Fish Lake strains. The percent mortality during hatchery rearing was greater for Spring Standard Growth and McConaughy strain than for Winthrop and Fish Lake strains. Condition factor (K) of all strains in both ponds consistently decreased during the field evaluation due to poor forage conditions.

DONALD, D. B. 1987. Assessment of the outcome of eight decades of trout stocking in the Mountain National Parks, Canada. North American Journal of Fisheries Management 7 : 545-553.

The majority of the 1,464 lakes in the Canadian mountain national parks (22,376 km^2) were devoid of fish prior to the 20^{th} century and those lakes that supported fish populations were usually dominated by either mountain whitefish (*Prospoium williamsoni*) or longnose suckers (*Catastomus catastomus*). From the early 1900s to 1980, about 305 lakes were stocked with either cutthroat trout (*Salmo clarki*), rainbow trout (*Salmo gairdneri*), brook trout (*Salvelinus fontinalis*), or a combination of these. Results from fisheries surveys conducted primarily in the 1970s and 1980s indicated that, for lakes originally barren of fish, the probability of either rainbow trout or cutthroat trout (referred to as *Salmo*) species or brook trout becoming established was directly related to the size of the lake outlet. When *Salmo* and brook trout were stocked into lakes that were suitable habitats for both, brook trout displaced *Salmo* from lakes with small outlets but not from lakes with large outlets. When mountain whitefish, longnose suckers, and lake trout (*Salvelinus namaycush*) were present in mountain lakes, they prevented colonization by or restricted the population size of *Salmo*. Mountain whitefish and lake trout had a similar effect on brook trout but *Salmo* and longnose suckers had no obvious effect on populations of brook trout.

DONALD, D. B. and R. S. ANDERSON. 1982. Importance of environment and stocking density for growth of rainbow trout to maintain lakes. Transactions of the American Fisheries Society 111 : 675-680.

The weight of age-2 rainbow trout (*Salmo gairdneri)* from 23 small lakes located in west-central North America ranged from 40 grams to 2,066 grams. These lakes were primarily in mountainous terrain and ranged in elevation from 305 m to 3,354 m above sea level. Rainbow trout populations in most of the lakes were maintained by stocking hatchery-reared fish. Stepwise multiple regression analyses attributed 42% of the lake-to-lake variation in weight at age-2 to total dissolved solids, 30% to stocking density, and 3% to mean depth. Models derived from regression analyses can be used to determine approximate stocking densities for some lakes in this region.

DUNCAN, W. M. 1991. Variation in habitat use by the native salmonids and the rainbow trout (*Oncorhynchus mykiss*) that have escaped from a fish farm in Loch Awe, Scotland. p. 52 *In* Proceedings of the International Symposium on Biological Interactions of Enhanced and Wild Salmonids, Nanaimo, British Columbia. (Abstract Only)

Seasonal variation in the abundance and habitat use by the native salmonids, particularly brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) that had escaped from two fish farms in Loch Awe, Scotland, was assessed by setting a series of gill nets in the main habitat types that were found in the loch.

Although rainbow trout were caught throughout the loch they were only caught in large numbers in the immediate vicinity of the fish farms and it was only when they were present in very high numbers that the distribution of the native species was adversely affected. The brown trout showed distinct seasonal variation in their habitat use. There was also some evidence suggesting that rainbow trout followed a similar pattern.

The impact of the introduction of the feral rainbow trout on the important brown trout fishery in Loch Awe and the wider implications of stock losses from fish farms on native species in the light of the large expansion of the aquaculture industry in Scotland are also discussed.

DUTHIE, G. G. 1987. Observations of poor swimming performance among hatchery-reared rainbow trout (*Salmo gairdneri)*. Environmental Biology of Fishes 18(4) : 309-311.

The swimming performance, as judged by maximum sustained swimming speed, of rainbow trout from a fish farm in southwestern England, is low when compared to previous published values for this species. This may be a localized peculiarity resulting from hatchery selection and rearing procedures.

DWYER, W. P., R. G. PIPER, and J. K. MORRISON. 1979. Second year of hatchery and field evaluation of four strains of rainbow trout (*Salmo gairdneri).* Information Leaflet No. 10. Fish and Wildlife Service. United States Department of the Interior.. Bozeman, Montana.

The performance of four strains of rainbow trout (*Salmo gairdneri*) was evaluated under hatchery and field conditions for the second consecutive year. Growth, conversion, and survival were the factors measured under hatchery conditions; catchability, growth, and condition factor information was collected from the field evaluation. The fish were stocked at equal rates per acre into two ponds for a replicated field evaluation. Winthrop and Spring Standard Growth strains had a greater length increase, better feed conversion, and were harvested at a faster rate than the McConaughy and Fish Lake strains. Condition factor of all strains decreased during the summer months but increased from September to May.

DWYER, W. P. and R. G. PIPER. 1984. Three year hatchery and field evaluation of four strains of rainbow trout. North American Journal of Fisheries Management 4(2) : 216-221.

The performance of three strains of rainbow trout, (*Salmo gairdneri*) was evaluated under hatchery and field conditions. Growth, conversion, and survival were measured in the hatchery; catchability, growth and longevity data were collected in the field. Fish from each strain were stocked at equal densities into two ponds near Three Forks, Montana, for a replicated field evaluation. The domestic Winthrop and Spring Standard Growth strains grew faster, converted food more efficiently, and were harvested at a faster rate than the wild McConaughy and Fish Lake strains. However, the McConaughy and, to some extent, the Fish Lake strains remained in the fishery longer (up to three years) at which time the project was terminated.

EBERT, D. J. and S. P. FILIPEK. 1989. Evaluation of feeding and habitat competition between supplementally stocked rainbow trout (*Oncorhynchus mykiss*) and native smallmouth bass (*Micropterus dolomieu*) in a coolwater stream. p. 22 *In* Proceedings of the First International Smallmouth Bass Symposium, Nashville, Tennessee.

Population characteristics and habitat utilization of smallmouth bass (*Micropterus dolomieu*) and supplementally stocked rainbow trout (*Oncorhynchus mykiss*) in the upper Little Missouri River, Montgomery County, Arkansas, were evaluated from habitat and biological variables. Thirty-one variables were measured at eighteen sites from October 1985 to January 1989. During this period more than 30,000 rainbow trout (15-40 mm) were supplementally stocked (about 10,000 trout/year) in sample reaches. Survival rates for supplementally stocked trout averaged 3 to 10 percent through the trout fishing season (January-May) due to intensive angling pressure. Population levels, habitat utilization and competition during the intensive angling season and the remainder of the year were analyzed for three years. Variability of both species was associated with preference for large substrate (boulder-cobble), large woody debris, and undercut bank pools. During all seasons, both rainbow trout and smallmouth bass used similar habitat. Analyses of more than 100 rainbow trout stomachs showed little or no feeding. This indicated no dietary overlap between the two species during the intensive stocking period and the remainder of the year. Electrofishing depletion samples, direct underwater observations, angler creel surveys and mark-recapture techniques were used to assess distribution, feeding habitats and habitat utilization of rainbow trout and smallmouth bass.

ECOLOGISTICS LIMITED. 1990. An assessment of the use of hatchery stock for fisheries management. Report prepared for Fisheries Branch, Ontario Ministry of Natural Resources. Waterloo, Ontario. 50 p. + appendices.

The study documented in this report is an evaluation of Ministry of Natural Resources (MNR) fish stocking and assessment activity. The main purpose of this study was to describe and evaluate the process of determining requirements of hatchery-reared fish and evaluating the success of fish stocking programs.

Some of the recommendations include:

- MNR should introduce a policy requiring mandatory assessments of stocking activity.
- MNR should give high priority to the task of preparing comprehensive stocking assessment guidelines and a supporting complement of standardized assessment tools.
- Explicit stocking objectives should be set for all stocking projects to assure that stocking activity can be effectively evaluated.
- Means of evaluating stocking activity at a corporate level should be reviewed and revised to facilitate a more meaningful analysis of the efficacy and efficiency of stocking and stocking assessments.
- Fisheries Branch of MNR should consider the routine use of socio-economic tools for the evaluation of future fish culture and stocking investments.
- Any changes that are introduced in stocking and stocking assessment activity should serve to reinforce accountability and foster efficiency in stocking activity.

EIPPER, A. W. and J. L. FORNEY. 1965. Evaluation of partial fin clips for marking largemouth bass, walleyes and rainbow trout. New York Fish and Game Journal 12(2) : 233-240.

Partial clips did not produce an easily recognizable mark on the ventral fins of bass or on the pectoral, ventral, dorsal or anal fins of 5-inch rainbow trout. It seems likely that the conspicuousness of the mark produced by partial clipping varies with the relative size of the fish when marked. As an adjunct to complete fin removal, partial clipping increases the number of groups of fish that can be distinctively marked at one time. Adverse effects of fin mutilation on survival and behavior are probably minimized because initial injury is less severe and partially clipped fins usually regenerate rapidly. Partial clipping is a fast marking procedure that requires almost no training and no special equipment other than a pair of diagonal wire-cutting pliers.

EISERMAN, F. 1966. The use of catchables in relation to habitat. p. 257-262 *In* Proceedings of the 46th Annual Conference of Western Association of State Game and Fish Commissioners. Butte, Montana.

We are currently stocking a number of lakes and reservoirs in Wyoming which periodically have kills during the winter or summer or both. These lakes or reservoirs are stocked at a rate which generally results in a catch of approximately five-tenths trout per hour and generally 50% or more of the trout are taken in a single season.

Another catchable trout stocking situation which we consider justifiable is in those waters that are low in basic fertility, easily accessible and having sufficient numbers of people to harvest trout over and above an annual increment of growth and to some degree over natural reproduction. Our stocking rates for situations such as these depend primarily on fishing pressure and rates vary from 150 to 300 trout per surface acre.

In Granite Reservoir, in 1964, 25,441 catchable rainbow trout , from 9-12 inches in length, were stocked in nine plants with a return of approximately 17,500 resulting in an estimated 64% return of that year s plant. Cost-per-pound back to the creel was $1.05. Fishing pressure amounted to 14,314 fishermen or 51,000 hours of fishing pressure.

In Wyoming, catchables are generally not stocked in:

- Easily accessible lakes or reservoirs that are fertile enough to produce an 8-10 inch trout at an age of 10 months from 3-4 inch fingerling.
- High elevation lakes having light fishing pressure.
- Streams, lakes or reservoirs recently chemically treated.
- Any stream having sufficient natural reproduction and an annual increment of growth to satisfy current fishing demands.
- Small reservoirs of 10 acres or less, available to the public and rich in basic productivity.

ELLIOT, W. P. 1975. Returns of stocked yearling brook, brown and rainbow trout from six two story ponds, 1971-74. File Report, New York State Department of Environmental Conservation. Albany, New York. 23 p.

ENGEL, L. J. 1970. Evaluation of sport fish stocking on the Kenai Peninsula-Cook Inlet areas. Project F-9-2 Job 7-C-1, Alaska Department of Fish and Game. Juneau, Alaska.

Growth and survival rates are compared for rainbow trout (*Salmo gairdneri*) in four rehabilitated Kenai Peninsula lakes. Moderate, uniform trout growth was recorded from waters where threespine stickleback (*Gasterosteus aculeatus*) had been eradicated. The study shows that threespine stickleback adversely affect fingerling survival. Upon achieving a length of approximately 230 mm, stocked trout utilized stickleback as forage and entered a growth phase superior to that of fish in lakes containing only trout. Initial fingerling plants grew more rapidly than supplemental plants, but survival rates were similar after one year of lake residency.

The results of a rainbow trout feeding habit study in Gruski Lake are presented. Threespine stickleback comprised more than 75% of the food (by volume) of trout larger than 254 mm. Nearly the entire winter diet of large trout consisted of stickleback. Food habits of trout 254 mm or less showed definite seasonal variation. Aquatic insects contributed most to the summer diet of small trout, but stickleback were the principal winter food.

ENGSTROM-HEG, R. 1979. Salmonid stocking criteria for New York s fisheries program. Bureau of Fisheries, New York State Department of Environmental Conservation. Albany, New York. 36 p.

Stocking of hatchery-reared salmonids is one of the major means of developmental management of inland fisheries in New York. Coldwater fisheries management will be directed toward providing satisfactory angling experiences by making maximum use of a waters natural productive capacity. When stocking is indicated, salmonids will be planted only where growth potential exists.

Stocked coldwater lakes and ponds will ordinarily be managed as put-grow-and-take fisheries. Typically, these waters are characterized by an exploitation rate that will remove 90% of a stocked lot of fish within 60 days. Base stocking rates will be 30ˆ MEI fish/acre for fingerlings and 15 ˆMEI fish/acre for yearlings. Two story ponds will be stocked with 9 inch yearling rainbow trout at a base rate of 10ˆMEI fingerlings/acre. Medium sized two-story lakes (between 100 and 10,000 acres) will be stocked at an adjusted rate based on surface area.

Stocked coldwater streams will ordinarily be managed as put-grow-and-take fisheries with stocking used to maintain a trout population similar in biomass and number to one that would occur in a stream of similar habitat quality with adequate natural recruitment and light to moderate fishing pressure.

EVEREST, F. H. and E. H. EDMUNDSON. 1967. Cold branding for field use in marking juvenile salmonids. Progressive Fish Culturist 29(3) : 175-176.

We used cold branding to mark juvenile chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus gairdneri*) in the field as part of a behavioral study. The branding tools were cooled in acetone and dry ice (mixture at -78… C). The thoroughly cooled applicator was placed between the lateral line and dorsal fin of the anesthetized fish for about 3 seconds. The tool is recooled and applied to the opposite side of the fish. The cold brand freezes the integument of the fish and produces a mark that is readily visible in 2-3 days.

Consistently visible cold brands are easy to apply in the field, where it is difficult to maintain precisely controlled conditions. Cold branding is satisfactory for marking small fish when individual identification is required in the field for short-term behavioral studies.

EVERETT, G.V. 1973. The rainbow trout (*Salmo gairdneri)* fishery of Lake Titicaca. Journal of Fish Biology 5 : 429-440.

Rainbow trout were introduced to Lake Titicaca in 1942. A commercial trout canning operation started in 1961 but terminated in 1970. Data for this study were collected in 1966 and 1967, with the object of examining the life history, biology, and commercial fishery of Titicaca rainbow trout. Trout were caught commercially and experimentally by gillnets in different parts of the lake.

Lake Titicaca lies across the border of Peru and Bolivia at 3212 m above sea level. The physio-chemical characteristics of the lake appear ideal for self-sustaining populations of rainbow trout. Growth was constant throughout the year, and was good in relation to tributaries in the winter. Recruitment to the fishery occurs in 7.62 cm stretch mesh gillnets at about 27 cm fork length.

The total annual commercial catch increased to 500 metric tons in 1965 before subsequently decreasing. The simplest explanation for the decline in total catch would be the increase in fishing mortality due to increased fishing effort, although it is possible that the decline in water level has had some effect. It appeared possible that the lake could sustain an annual catch of about 350 tons.

FALK, M. R. and G. LOW. 1981. Growth of stocked rainbow trout (*Salmo gairdneri*) in Polar Lake, Northwest Territories, 1977-1979. Canadian Manuscript Report, Fisheries and Aquatic Sciences 1578 : iv + 20p.

Polar Lake, situated on the south shore of Great Slave Lake, Northwest Territories, was stocked with rainbow trout in 1977 and 1978. Growth of the trout was monitored through gillnet sampling in the spring and fall of each year from 1977 to 1979.

Rainbow trout were stocked in Polar Lake (188 ha) at rates of 64 and 53 fish/ha (3.5 kg/ha) in 1977 and 1978 respectively. Trout stocked in 1977 at approximately 76 grams grew to 494 grams after one year and to 761 grams after two years. The 1978 stock (29 grams) grew to 282 grams in 1979. Annual growth rates for the 1977 stock were 1.2 grams/day during the first year and 0.7 grams/day during the second year while that for 1978 stock was 0.6 grams/day to 1979. Both the growth rates and the sizes attained were similar to those reported for Yukon and Manitoba. This is attributed to the comparatively large size of trout at stocking rather than high productivity of Polar Lake.

The stocking of rainbow trout in Polar Lake is considered successful, in that trout grew to catchable-size after one year and a recreational fishery was created in an area where such opportunities are limited. There were no data to assess the success in terms of survival of the stocks and catch-per-angler-effort. Recommendations are presented for future research and management of Polar Lake.

FAY, C. W. and G. B. PARDUE. 1986. Harvest, survival, growth and movement of five strains of hatchery-reared rainbow trout in Virginia streams. North American Journal of Fisheries Management 6(4) : 569-579.

Catchable size (minimum length 17.8 cm) rainbow trout (*Salmo gairdneri*) of five genetically distinct strains were harvested by anglers at significantly different rates when the fish were stocked into four put-and-take trout streams in southwestern Virginia. Fish from Standard Winter (SW) and Ennis (EN) strains were caught easily; 85.7 and 93.2% of their respective total harvests occurred during the first 2 days of the fishing season. Sand Creek (SC), Fish Lake (FL), and McConaughy (MC) strains were harvested more uniformly over the first three weeks of fishing; 64.6, 58.4 and 43.4% of their respective total harvests occurred over the first two days. The average total harvests of SC (47.7%) and SW (46.7%) strains were similar and ranked highest among the five strains; however, no strain showed statistical superiority in all four streams. Harvest of the MC strain was consistently and significantly lower than the other four strains within each stream and averaged 25.6%. Average harvests of FL (42.8%) and EN (39.5%) strains were intermediate. Significant environmental (stream) influences and genotype-environment interactions were evident. No significant differences in tendency to move downstream were found. Fish of the EN, SW, and SC strains were significantly more vulnerable to fishing with bait (versus artificial lures) than fish from FL and MC strains. Differences in natural mortality rate, growth, and downstream movement among strains in a fifth, unfished, stream were not significant. Condition factor (K) decreased significantly for all five strains in an unfished stream. The MC strain appeared to be poorly suited for put-and-take streams, while SW and SC strains performed about equally well and are worthy of further evaluation in stocked stream environments. Managers should select strains (other than SW or SC) for future evaluation in put-and-take streams based on hatchery performance, but should give consideration to potential masking or damping effects of natural environments.

FETTEROLF, Jr, C. M. 1956. Stocking as a management tool in Tennessee reservoirs. p. 275-279 *In* J. W. Webb [ed.]. Proceedings of the 10th Annual Conference Southwestern Association of Game and Fish Commissioners. Little Rock, Arkansas.

The Tennessee Game and Fish Commission is responsible for the fisheries management of 26 major impoundments which total approximately 400,000 acres. The introduction of a desirable new species which shows up in the creel is a tangible example of reservoir management that the fishing public can appreciate.

In the past three years, fingerling stockings of rainbow trout in two impoundments have proven successful. Watauga Reservoir produces occasional catches of 16-22 fish for deep trolling fishermen. In February, 1955, observers noted a run of rainbow trout in the lower section of a tributary trout stream, Doe Creek. In 1956, the same run developed with fish in greater numbers and larger sizes, but the trout season did not open until most of the fish had returned to the reservoir. Restrictions will be lifted in 1957 to make these fish available to anglers.

Calderwood Reservoir (536 acres) is influenced by the cold tailwater of Fontana Dam in North Carolina. Before the original stocking of 60,000 two inch rainbow trout in 1955, a few trout were present. Since the introduction, a spring run developed in Cheoah River in North Carolina and some limit catches of 12-14 trout have been made in the reservoir proper. Fingerling stockings on a put-and-take basis can be justified if these fisheries develop as expected.

FITCH, L. A. 1977. Trout stocking in streams: A review. Alberta Department of Recreation, Parks and Wildlife. Lethbridge, Alberta. 24 p.

The objective of this review was to update information on trout stocking in streams for fisheries management purposes in Alberta. The present policy concerning the stocking of streams in Alberta is that trout are only planted in streams where it is considered desirable to introduce a new species, where suitable trout waters contain no trout, or where beaver dams have interfered with natural reproduction and where these dams have created a suitable pond-like habitat.

With few exceptions, the mortality of stocked trout is high and greater than that of wild trout of comparable size and species. The inferior quality of the domesticated hatchery trout is often blamed for the undue mortality experienced in trout stocking.

Based on the literature review, acceptable survival and yield of stocked trout are achieved when the following four conditions are met:
(1) Use of catchable-sized trout.
(2) Stocking prior to or during the angling season.
(3) High angler use.
(4) Resident trout population absent of non-reproducing.

The decision to stock or not to stock should be based primarily on the ability and potential of a resident trout population to sustain a fishery. If it is unable to do so due to some environmental inadequacy then stocking should be considered. However, if the stream will support trout throughout the year and has the potential for maintaining a self-sustaining population, pending the correction of environmental limitations, the funds would be best spent improving trout habitat.

FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS (FAO). 1999. Global characterization of inland fishery enhancements and associated environmental impacts. FAO Fisheries Circular No. 945. Rome, Italy. 89 p.

This paper summarizes the results of an effort to characterize inland fishery enhancements on a global scale. Stocking and introductions are the most commonly used fishery enhancement techniques in inland waterbodies.

In Victoria, Australia, rainbow trout have been stocked for recreational purposes. In Tasmania, rainbow trout are frequently stocked in impoundments close to population centers. Morocco reports the highest number of freshwater species stocked in Africa notably brown trout, rainbow trout and common carp. In Mexico, 23 of the 39 introduced species, including rainbow trout, have become established in the wild. The main species stocked in France are brown trout, rainbow trout, pike, carp tench and eel. Rainbow trout is one of the most commonly stocked fishes in North America. For example, in British Columbia, 10.1 million fish were released into over 1,000 lakes and streams in 1993. This release included 5.4 million rainbow trout and 1.1 million steelhead.

FORD, R. C. 1978. Evaluation of four strains in rainbow trout fingerling stockings in Black Hills reservoirs. Dingell-Johnson Project F-21-R-12, Study No. VI Job-1. Report No. 78-6. South Dakota Department of Wildlife, Parks & Forestry. Pierre, South Dakota.

Four strains of rainbow trout stocked as fingerlings were evaluated for growth and catchability in two impoundments. The first were distinctly marked with fluorescent dye and stocked in the reservoirs in June 1976. A creel census was conducted beginning in July 1976 through March 1978. The Growth (35.2 percent return) and Kamloops (27.4 percent return) strains were the most catchable, followed by Washington (23.6 percent return) and Manchester (15.7 percent return). The Kamloops and Washington strains exhibited the best growth in the reservoirs. The Growth strain grew at a much faster rate than the other strains in the hatchery environment; but once stocked in the natural environment, it s growth slowed down. At the end of the study, all strains were about equal in length.

FORSHAGE, A. 1975. Cost/benefit analysis of a catchable rainbow trout fishery in Texas. Proceedings of the 29th Annual Conference of Southeastern Association of Game and Fish Commissioners. St. Louis, Missouri.

An evaluation of stocking catchable rainbow trout (*Salmo gairdneri*) in a section of the Brazos River was made in 1972-1973 to determine if trout stocking is an economically and recreationally justifiable fishery management technique in Texas. A creel survey to measure fishing pressure and harvest, gross annual expenditures, and net economic value of the fishery was made before and after trout introduction. Benefits, in terms of increased harvest and utilization, were found to be substantially higher than the cost of stocking catchable rainbow trout.

FRASER, J. M. 1972. Recovery of planted brook trout, splake, and rainbow trout from selected Ontario lakes. Journal of the Fisheries Research Board of Canada 29 : 129-142.

Recoveries of hatchery-reared brook trout (*Salvelinus fontinalis*), splake (*Salvelinus namaycush* x *S. fontinalis*), and rainbow trout (*Salmo gairdneri*) planted in lakes having different resident fishes, were highest (9-30%) in a lake in which minnows and the brook stickleback were the only other fishes. Recoveries, by angling and gill netting, were considerably lower (2-15%) in two lakes containing the white sucker and minnows, and still lower (0.5-5%) in two lakes containing spiny rayed species as well. Recoveries were lowest (< 0.5%) in a lake having a complex fish community that included native brook and lake trout. Planted splake and rainbow trout generally yielded higher returns, in weight, than brook trout in comparable situations.

The low survival of planted fish was apparently due to the low fertility of the waters and to competition with, or predation by, resident fish species. Predation by fish eating birds and mammals may also have had an effect. The weight of the catch of salmonids exceeded the weight planted in only one lake. Here, the mean yield of planted salmonids was 8.4 kg/ha per year in comparison with 2.6 to < 0.5 kg/ha per year in the five other study lakes.

FUJIHARA, M. P. and R. E. NAKATANI. 1967. Cold and mild heat marking of fish. Progressive Fish-Culturist 29(3) : 172-174.

Adult fish captured from the Columbia River and hatchery-reared rainbow trout (*Salmo gairdneri*) served as the test fish for experimental cold and mild heat marking of fish. For cold marks, rods were cooled to -80… C by immersion in a slurry of theanol and dry ice kept in vacuum container. Similar procedures were used for the mild heat marking, except that the rods were heated in boiling water instead of being cooled.

Cold marks applied above the dorsal-lateral area and on the head of 45 yearling and 45 2-year-old rainbow trout were all clear after 2 _ months, faint but legible after 4 months and undetectable 6 months after application. Eight-five percent of the cold marks and 75% of the mild heat marks were readily identified on all adult fish 2 _ months after application. The cold marking technique did not appear to cause undue stress. There was no mortality during the test. The growth of the fish tended to enlarge and blur the marks.

Our findings indicate that, for short-term studies, fish retain equally well the marks made by both methods. More experimental work is needed on the design of marking symbols.

FULLER, P. L., L. G. NICO and J. D. WILLIAMS. 1999. Non-indigenous fishes introduced into inland waters of the United States. American Fisheries Society Special Publication 27. Bethesda, Maryland. 613 p.

Beginning in the late 1800s there have been many stockings of this species for sport fishing purposes, by state and federal agencies and by private individuals, mostly into streams and spring branches. Rainbow trout have become established in many states including Hawaii. Some states stock on an annual basis frequently to replenish populations harvested by fishing pressures or in other areas where populations are not self-sustaining.

The rainbow trout hybridizes with other more rare trout species, thereby affecting their genetic integrity. Stocking of hatchery rainbow trout in rivers has led to introduction of whirling disease into open waters in approximately 20 states. Rainbow trout have the potential to consume native fishes and compete with native salmonids. Rainbow trout drive nongame fishes, such as suckers and squawfish, from feeding areas.

GEBHARDS, S. 1966. Lake Pend Oreille Kamloops rainbow marking and recovery. Project No. F-32-R-8, Job No. 4. Idaho Fish and Game Department. Boise, Idaho.

Survival of the plants of the various-sized Kamloops utilized and their contributions as trophy-size fish appear to be quite limited. It appears that fish planted at an average size of 13 to 16 inches in length return a large percentage to the creel in their first summer in the lake and very little in subsequence years. Initial indications are that these plants return very little to the creel as trophy-size fish. Available data would also indicate that very little is realized from plantings of 10 to 12 inch fish, either during their first summer in the lake or in subsequent years as trophy-size fish. However, additional data from subsequent seasons or in subsequent years as trophy-size fish should be available before these indications can be completely borne out.

GEE, M. A. 1942. Success of planting legal-sized trout in the southwest. p. 239-244 *In* Proceedings of the 7th North American Wildlife Conference. Toronto, Ontario.

On May 5, 1939, 2,000 rainbow trout (*Salmo gairdneri irideus*) 7 to 9 inches in length were tagged and planted in Willow Creek on the Gila National Forest in New Mexico. A creel census was operated from May 15, the opening of the fishing season, until September 16 when practically all fishing had ceased. During this period 806 or 40% of the tagged fish were caught. The greater part of the catch was taken during the first three weeks of the fishing season.

On May 12, 1939, 799 rainbow trout, 6 to 8 inches in length, were planted in the Upper Pecos River on the Santa Fe National Forest in New Mexico. The returns of this group were checked by means of a creel census which was in operation from May 15, the opening of the season, until September 21. Of the 799 tagged fish planted, 458 or 58.8% were returned and 30% of the tagged fish caught were taken in the first 10 days of the fishing season.

It appears that the best returns from legal-sized trout are obtained from releases made shortly before the opening of the fishing season and during the fishing season up to the point when the fishing effort begins to drop off. The data presented indicate a poor overwinter survival of legal-sized trout regardless of the time or release. In every instance, legal-sized fish are removed quite rapidly after planting. Most of these are caught close to the point of release in the deeper and more quiet pools.

GERMAN, J. F., Z. E. BUNCH, and J. P. DURNIAK. 1992. Evaluation of rainbow trout stockings on Richard B. Russell Reservoir. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 46 : 495-504.

Establishment of a trophy (≥500 mm TL) rainbow trout (*Oncorhynchus mykiss),* put-grow-and-take fishery was evaluated with tag rewards and creel surveys. Over 310,000 catchable rainbow trout were stocked in Richard B. Russell Reservoir from 1988 to 1991. A $5.00 reward was offered for return of tags from 28,000 trout. Yearly tag returns ranged from 9.8% to 2.6%. Averaged tag reporting rate was 42% with a high of 50% and a low of 37%. Tag loss was estimated at 16.6% in 1991. About 60% of tags returned were captured within 14 days after stocking and an additional 19% between 61 and 210 days after stocking. Creel surveys since 1988 indicated an increase in the weight of trout harvested the first 3 years before a decline in the last year. Growth of trout within the year of stocking approached 150 mm; carryover exceeded 250 mm. Low dissolved oxygen levels in 1990 and 1991, resulting from Lake Hartwell releases, appeared to limit the development of the trophy fishery. However, improvements in water quality of late summer releases would offer the potential for a quality (≥400 mm TL) trout fishery.

GILLESPIE, D. I. 1965. A costly lesson in lake reclamation, Nameless Lake, Gordon Township, 1958-1965. File Report, Ontario Department of Lands and Forests. Sudbury, Ontario. 8 p.

Rotenone was first used in the Sudbury area when it was applied to a 211 acre privately owned lake, Nameless Lake. The intent of the landowners was to establish a desirable fishery and offer it to the public as an attraction that would cost the public a fee for access to it.

On August 29, 1958, Nameless Lake was treated with 3,850 pounds of 9.6% rotenone in powdered form at a calculated concentration of 1 part per million. On September 8, 1958, five charges of dynamite were exploded at depths of 20 feet or more. It was estimated that from 12 to 20 tons of fish were removed as a result of the rotenone application.

The rainbow trout introduced into Nameless Lake after the reclamation, were purchased from the Ottawa Trout Ponds, Michigan. The initial introduction in May, 1959, was 15,000 3-4 inch yearlings and one hundred 7 _ inch two year olds. This was followed by 3,000 6-7 inch fish in October, 1961 and 10,000 4-5 inch yearlings in July of 1962. It was noted that the original stock attempted to spawn in the spring of 1961 and in subsequent springs, but no survival of naturally produced progeny has been recorded.

In the fall of 1959, fifty yards of 1 _ inch gill net was set to assess the success of the original planting of rainbow trout. In addition to rainbow trout, two common white suckers were taken suggesting that the reclamation was incomplete.

During the three angling seasons of 1960, 1961, and 1962, a total of 4,224 trout were removed by 2,242 anglers who fished 12,132 hours. The average catch-per-unit-of-effort (CUE) for the three years was 0.348. In 1963 and 1964 interest in the lake declined and catches were too small to provide reliable calculations.

By 1964 the quality of angling had deteriorated to such a degree that it was decided to reclaim the lake once again. An additional quantity of toxicant (Copper Tox #6) was added to ensure a complete fish kill but there was evidence that the lake had not completely detoxified as later as August 1965.

GIPSON, R. D. and W. A. HUBERT. 1991. Factors influencing the body condition of rainbow trout in small Wyoming reservoirs. Journal of Freshwater Ecology 6(3) : 327-334.

Possible relations between the body condition of rainbow trout (*Oncorhynchus mykiss*) and the density of salmonid fishes, the abundance of non-salmonid fishes, and two measures of biological productivity — total dissolved solids and elevation above mean sea level — were assessed for 13 small (< 170 surface hectares) reservoirs in Wyoming. The mean condition of rainbow trout was positively related to total dissolved solids and negatively related to the abundance of non-salmonid fishes.

GJERDE, B. and T. REFSTIE. 1988. The effect of fin-clipping on growth rate, survival and sexual maturity of rainbow trout. Aquaculture, 73: 383-389.

Ten groups of 150 individually tagged rainbow trout *(Salmo gairdneri)* were marked by removal of either (1) the adipose and/or the left and/or the right pelvic fins (seven groups) or (2) the left and/or the right maxillary bones (three groups). One group of 150 individually tagged fish was kept unmarked. Average body weight at marking was 115 grams. The marked fish were reared in a concrete pond in freshwater for about 3 months and in a net cage in the sea for about 18 months up to an average body weight of about 3.2 kg. Removal of (1) one or more of the adipose and pelvic fins or (2) one or both maxillary bones, was found to have no effect on growth rate, survival and early sexual maturity. It was concluded that the adipose and pelvic fins and the maxillary bones can be used to mark rainbow trout reared in net cages in the sea.

GOLDMAN, C. R., W. A. WURTSBAUGH and R. W. BROCKSEN. 1975. Food and distribution of underyearling brook and rainbow trout in Castle Lake, California. Transactions of the American Fisheries Society 104 :88-95.

A difference was found in the summer distribution of underyearling brook trout (*Salvelinus fontinalis)* and planted rainbow trout (*Salmo gairdneri*) in Castle lake, California. Brook trout underyearlings oriented to the bottom and were found primarily in shallow water on the eastern shore of the lake near springs. The rainbow trout underyearlings were more pelagic and were found in the littoral areas along the entire shoreline.

Gravimetrically, the food eaten during the summer by brook trout underyearlings was 13% terrestrial, 11% limnetic, and 76% benthic. Rainbow trout ate 15% terrestrial, 15% limnetic and 70% benthic food.

In summer, rainbow trout adults are located in the epilimnion in Castle Lake, whereas adult brook trout are found near the bottom of the lake beyond the littoral zone. Due to this spatial isolation, their diets differ considerably. An earlier study showed that during the summer, adult brook trout ate 20% terrestrial, 31% limnetic and 49% benthic food (by volume). Adult rainbow trout ate 49% terrestrial, 33% limnetic and 18% benthic.

GOODMAN, B. 1991. Keeping anglers happy has a price — Ecological and genetic effects of stocking fish. Bioscience 41(5) : 294-299.

The unintended biological consequences of fish stocking are increasingly being investigated. Fisheries biologists are finding more and more that introduced game fish can have a variety of deleterious effects on local species.

One of the clearest demonstrations of the ill effects of stocking on wild fish populations was shown in a Montana study. The Madison River of southwestern Montana has non-native, wild populations of rainbow trout (*Oncorhychus mykiss*) and brown trout (*Salmo trutta*) and also was stocked for some years with hatchery-raised rainbows. When stocking was ceased at one site, the numbers of wild rainbow and brown trout increased, the rainbows by more than eight times. On the second section of the river where rainbows were planted, the biomass (but not the number) of wild brown trout declined.

When hatchery rainbows are planted on top of wild rainbows, there is quite a notable difficulty in communication, like two people speaking different dialects of the same language. The hatchery fish do not recognize the territorial signals of the wild fish and the wild fish do not fight. Instead, they move to other parts of the stream where cover or food is probably poorer. In the Montana study, the hatchery fish did not make proper use of the usurped territories. They used more energy going after food than a wild sit-and-wait trout would, and they opened themselves up to predators. As a result, both wild and hatchery fish suffered after planting.

GRESSWELL, R. E. 1973. An evaluation of stress induced mortality of stocked catchable-sized rainbow trout in Temple Fork of the Logan River. M. Sc. Thesis, Utah State University. Logan, Utah.

The level of stress imposed by population pressure, handling and live transportation on planted catchable-size rainbow trout in a northern Utah stream was examined. Production of adrenocorticotrophin, as measured by inter-renal ascorbic acid and serum cortisol levels, did not occur in transported or planted fish.

Dead or moribund fish collected from stream or live boxes comprised 13 percent of the 2,000 fish planted. *Aeromonas salmonicida*, the causative agent of furunculosis, was isolated from 41 percent of 106 moribund fish sampled. In addition, 39 percent of the samples exhibited bacteria growth and other than *A. salmonicida*. Apparently, handling, transportation, and planting did cause low levels of stress sufficient enough to induce stress-mediated disease such as furunculosis.

GRESSWELL, R. E. and C. B. STALNAKER. 1974. Post-stocking mortality of catchable-size rainbow trout in Temple Fork of the Logan River, Utah. Proceedings of the Utah Academy of Science and Letters 51 (1) : 69-84.

The effects of handling, transportation and planting were examined in rainbow trout reared at the Utah Division Wildlife Resources Hatchery, Logan, Utah, and planted into Temple Fork of the Logan River, Utah, during June-September, 1972. All fish utilized during the study were catchable-size (165-334 mm) rainbow trout of the Mount Whitney strain. Prior to the study, resident fish were removed by electrofishing from the 500 m study section. Capture fish were released downstream. The 500 m study section of Temple Fork was closed to sport angling during the entire 1972 fishing season. A 12 m barrier, similar to the trap wings, was placed 500 m above a fish trap to isolate the study section. The barrier was placed diagonally across the stream to prevent water backup. The study consisted of five two-week experimental periods separated by one-week intervals. In order to determine the effects of transportation and handling on mortality, the 400 fish of the untagged lot were transported in the hauling tank an equal period of time and returned to the hatchery.

It appears that in Temple Fork of the Logan River, levels of stress of stocked catchable-sized rainbow trout were not extensive enough to produce interrenal ascrobic acid depletion or increased levels of serum cortisol. Instead, most mortalities were attributed to disease carried from the hatchery. Apparently, handling, transportation and planting did not induce low stress levels sufficient to mediate disease such as furunculosis.

The need for further research is indicated. Future studies should involve a more efficient method of monitoring the downstream fish movement so that a more accurate estimation of mortality can be made. The use of additional sensitive measurements as indices of physiological status — such as plasma glucose, calcium, cholesterol and free amino acid composition — would make possible a more accurate estimation of the level of stress. Refinement of sampling technique for interrenal ascorbic acid should lower the variability considerably. Extensive laboratory experimentation to better define the effect of different levels of stress on fish would be beneficial in evaluating levels encountered in the field. Finally, more extensive field sampling for infectious diseases known to occur in hatchery stocks would aid in evaluating the effect of planting fish from such stocks.

GRIM S, U., N.-A. NILSSON and C. WENDT. 1972. Lake V ttern: Effects of exploitation, eutrophication, and introductions on the salmonid community. Journal of the Fisheries Research Board of Canada 29 : 807-817.

V ttern, the second largest lake of Sweden, contains 28 species of fish, of which Arctic char (*Salvelinus alpinus*) and whitefish (*Coregonus* spp.) are the most important economically. There is both a commercial fishery and a sport fishery. The former has decreased steadily, while the latter is increasing. A modest eutrophication is occurring due, amongst other factors, to an increasing input of phosphorus and resulting, for instance, in a decrease in transparency.

The lake is, however, still to be characterized as typically oligotrophic. The input of polluting matters is alarming, especially regarding toxic substances. Exploitation of fish populations has on the whole increased, although the number of commercial fishermen has decreased. The fishery on the char population and military activity may in the long run result in over-exploitation. An inverse correlation between the catches of char and whitefish has been explained as a result of interaction between the two species. An obvious increase in catches of the *Coregonus* species (whitefish and cisco) is taken to be the result of eutrophication. Introductions of exotic species have only resulted in one recorded case of reproduction of rainbow trout (*Salmo gairdneri).* Several promising experiments with the release of hatchery-reared fish, e.g. land-locked salmon (*Salmo salar*), have been carried out. Growth rate of several fish species in V ttern has appeared to be faster than normal.

GROUTAGE, T. M. 1968. Unique Illinois pond supports rainbow trout. Progressive Fish Culturist 30 : 9-12.

Rainbow trout (*Salmo gairdneri*) are stocked in some Illinois waters for put-and-take fishing but none have been known to survive through two successive summers. This is the first Illinois water known to support rainbow trout for more than two years.

The pond is on the Robert C. Hummel farm, 8 miles west of Liberty, Melrose Township in Adams County. A natural spring flows into the bottom of a man-made pool at the base of a limestone bluff. Volume of flow is 85 gallons per minute. Dissolved oxygen concentrations ranged from 7.0 to 9.4 ppm in the spring pool and from 8.8 to 18.4 ppm in the pond. pH readings ranged from 6.4 to 7.5. Total alkalinity ranged from 105 to 220 ppm. Secchi disc readings ranged from 27 to 96 inches.

Natural food consisted primarily of freshwater scud (*Gammarus* sp.) which were abundant in detritus along the shore. A few unidentified snails and aquatic insect larvae were also eaten. To attract the fish for visitors trout in the pond were occasionally fed small amounts of commercial trout pellets.

Potential spawning habitat was improved in 1965 by placing suitable gravel in the spring pool and connecting channel. Three redds were seen in the gravel at the pool outlet in November 1965. Pairs of trout were seen spawning but no fry or fingerlings were ever observed.

GROVES, A. B. and A. J. NOVOTNY. 1965. A thermal marking technique for juvenile salmonids. Transactions of the American Fisheries Society 94 : 386-389.

The purpose of this report is to describe a marking system. The method consists of marking juvenile salmonids by topical application of mild heat to dorsal skin surfaces. Fish used in the tests included rainbow trout (*Salmo gairdneri*).

Fish to be marked were anesthetized and held in aerated solutions of M.S. 222. Two hundred and forty-two juvenile rainbow trout were individually marked with serially consecutive Arabic numerals. One month later any of these fish could be identified by its number. After two months the numbers were still evident on all fish but apparent local differentials in skin growth had distorted some numerals. Ten months later the fish had grown from about 100 mm to over 200 mm in length. All fish still had visible marks. Marking caused no mortalities in these tests. Overall comparisons between marked fish and control groups indicated no differences in general behavior responses or activity.

Based on the testing to date, the method shows considerable promise as a simple system for placing an impressive variety of short-term marks on fingerling salmonids.

GUNNES, K. and T. REFSTIE. 1980. Cold branding and fin clipping for marking of salmonids. Aquaculture 19(1980) : 295-299.

Identification of individual fish is important under many research circumstances and is essential in breeding and selection work. This paper gives results of marking from several year classes of rainbow trout (*Salmo gairdneri*) and Atlantic salmon (*Salmo salar*). Results are presented from the marking system used at the Norwegian Research Station for salmonids. Trained personnel and good light conditions are necessary to obtain a high percentage of correct identifications. The best result obtained was 99% identification 22-28 months after marking. It is estimated that 1.4% of the fish read were incorrectly identified. The frequency of misidentified fish was higher when different cold branded symbols were included in the system, increasing to a mean of 8% for salmon and 15% for rainbow trout.

Cold branding using five different symbols at two of six different positions on the fish gives 600 permutations when used in conjunction with clipping of the adipose and right or left pelvic fins. A satisfactory degree of correct identification is possible for use in a program of selection in salmonids.

HAMBLY, Jr, L. S. 1968. Planting success of marked brown and rainbow trout. Job Progress Report, Project No. F-6-R-14, Job No. I-3. Massachusetts Division of Fisheries and Game. Boston, Massachusetts. 1 p.

HAMILTON, J. G. 1981. 1980 Creel census on Farren Lake, Lanark District. File Report, Ontario Ministry of Natural Resources. Lanark, Ontario.

Between the period of May 19 and August 25, 1980, a creel survey was conducted on an irregular schedule on a number of Lanark County waterbodies including Farren Lake. Farren Lake is stocked with rainbow trout and is the only rainbow trout lake in Lanark County. This project was intended to evaluate angling activity and the contribution of stocked rainbow trout to the Farren Lake fishery.

Based on interview with 21 anglers who reported a total fishing effort of 16.0 rod hours to catch one fish, the rainbow trout CUE was 0.063. The harvest of rainbow trout was approximately the same as that recorded in 1978 but the bass harvest has increased four fold. It is recommended that we continue with the stocking of rainbow trout in Farren Lake but investigate the suitability of the inflow stream for a spawning site.

HARPER, D. D. and P. W. JAMES. 1994. A comparison of the food habits and microhabitat use of wild and hatchery-reared rainbow trout (*Oncorhyncus mykiss*) in the Teanaway River. Northwest Scientist 68(2) : 128. (Abstract Only).

The proposed supplementation of declining wild anadromous salmonid stocks with hatchery-reared fish has raised many questions about what effects these fish will have on the resident fishes. Two critical factors in determining resource partitioning and species composition are food and microhabitat use. We examined fish stomach contents and snorkeled to determine the microhabitat use of wild rainbow trout and hatchery-reared steelhead smolts. The North Fork of the Teanaway River which received an experimental release of 30,000 hatchery-reared steelhead smolts and contains a population of wild rainbow trout served as the study area. The Middle Fork of the Teanaway which also contains wild rainbow trout but did not receive supplementation served as the control.

HARSHBARGER, T. J. 1979. Scraping improves silver nitrate brands on trout. Progressive Fish Culturist 41(4) : 209.

A clear mark can be made by attaching a scraper made from a removable pencil clip to the end of a standard mechanical drafting pencil. In use, the pencil containing the applicator is angled to place the silver nitrate tip and scraper in firm contact with the surface of the fish. Silver nitrate from the applicator is deposited in the narrow zone cleaned of mucosal material and scales. Brands produced by the modified applicator have remained distinct on wild rainbow trout (*Salmo gairdneri*) for one year.

HARTZLER, J. R. 1977. An analysis of angler effort and the catch of one- and two-year-old hatchery trout on Spring Creek (Centre County), Pennsylvania. M. Sc. Thesis, Pennsylvania State University Graduate School.

Creel census and angler use counts were conducted on the 4.8 km (3.0 mile) Penitentiary section of Spring Creek (Centre County), Pennsylvania, in 1976. The study began on the first day (April 17) of the trout season and continued for 65 days. Five stockings (one pre-season and four in-season) of one- and two-year-old brown (*Salmo trutta*) and rainbow (*S. gairdneri*) trout and one-year-old brook (*Salvelinus fontinalis*) and palomino rainbow trout were made. Each age of trout in each stocking was given an identifying fin clip prior to planting. In addition, electrofishing surveys were done before the pre-season stocking and after the study was terminated to estimate the resident trout population.

Eventual estimates of harvest which were calculated using a modification of the Delury technique indicated that 77% of the 6268 stocked trout were caught by anglers. Returns of yearling brook, brown, and rainbow trout were 83, 77, and 74 percent respectively. Eighty-three percent of the 4131 trout in the pre-season stocking were captured, while 60-77 percent of those planted during the season were caught.

In each stocking brook trout displayed the highest catchability (instantaneous fishing mortality rate) of the three species. The catchability of all three species increased with each successive in-season stocking. The percent harvest of brook and brown trout from each plant also rose, whereas that for rainbow trout declined. Returns for brook and brown trout seemed to be related to their catchability while the catch of rainbow trout was determined by angling intensity. In general, brook trout were caught most rapidly, followed by rainbow trout, and brown trout showed the greatest longevity.

Nearly 25 percent of the total angler effort during the study was expended on opening day, when 43 percent of the pre-season stocking was captured. Sixty-three percent of angler effort occurred on weekend days. Fishing pressure rose noticeably on in-season stocking days, but the estimated harvest of trout stocked on these days was only 8-14 percent.

Although each stocked trout provided more than three hours of angling recreation, the quality of fishing, as measured by the catch-per-hour, was low; the mean catch per hour for the entire study period was 0.192. Mean daily catch per hour for all trout rose above 0.5 on just two of the 65 days and this occurred on low effort days (less than 150 angler hours).

The electrofishing surveys showed that trout densities were higher prior to the pre-season stocking than after the study was completed. Twenty-six of the 46 trout collected in the post-study survey had been planted in 1976. There was no evidence of natural reproduction of trout in the study area.

Management suggestions for this section of Spring Creek include:

(1) More frequent stockings of fewer trout to distribute angler effort more evenly throughout the season and prevent truck-anticipating . Plants should precede weekends, when records show fishing to be greatest.

(2) Increase the proportion of brown trout in each subsequent planting. This species showed not only higher returns with each successive in-season stocking but provided more recreation by contributing to angler harvest for a longer period of time than either brook or rainbow trout.

(3) Adjust stocking rates to anticipated fishing pressure. Heavier stockings, however, may not increase the catch-per-hour substantially.

(4) Extend the closing date of the sucker fishing season to the pre-season trout stocking date. This would provide anglers with added recreation time and increased opportunity to harvest a portion of the abundant sucker population.

In addition, the capture of unmarked brown trout above Fisherman s Paradise suggests a loss of stocked trout from this catch-and-release section by migration upstream. Studies are needed to determine if these trout are providing maximum angling recreation.

HARTLZER, J. R. 1988. Catchable trout fisheries: The need for assessment. Fisheries 13(2) : 2-8.

State fisheries agencies were questioned regarding their catchable-size (> 178 mm) salmonid stocking programs specifically: (1) number, species and propagation cost of catchables stocked; (2) total length of stream and area of impoundments stocked; (3) methods used to estimate angler effort and harvest of catchables; and (4) extent to which these techniques have been employed in the past 10 years.

In 1983, 43 states stocked in excess of 50 million catchable-size trout at a production cost of nearly $37 million. Rainbow trout (*Salmo gairdneri*) was the most popular species, predominating in 28 states and accounting for more than 77% of catchable salmonids stocked. Brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) were the next most frequently stocked salmonids (11.0% and 10.1% of total, respectively). More than 54,000 km of streams and 550,000 ha of ponds, lakes and reservoirs were planted with catchables in 1983. Most methods utilized by management agencies to assess use and harvest required field personnel (complete creel census, partial creel survey with or without angler counts, spot checks); others were voluntary (fish tags, questionnaires, individual diaries). Although few states have conducted extensive surveys recently, most believe greater than 50% of stocked catchables are harvested.

Possible reasons for the current de-emphasis of field surveys include: (1) budget and manpower limitations; (2) dependence on historical survey results; (3) increasing attention to wild trout fisheries; (4) lack of specific management objectives; and (5) labor intensive nature of creel survey work. Recognition of the value of creel and angler use surveys for evaluating and improving catchable salmonid programs is stressed.

HASSLER, T. J., M. E. COLEMAN and B. R. NIELSON. 1986. Hatcheries and wild trout management. p. 129-146 *In* R. H. Stroud [ed.]. Fish Culture in Fisheries Management. Fish Culture Section, American Fisheries Society. Bethesda, Maryland.

Lake McConaughy, in western Nebraska, was formed by the completion of the Kingsley Dam on the North Platte River in 1945. The reservoir is 22.5 miles long, has a surface area of 35,980 acres and a maximum depth of 140 feet.

Nebraska began stocking rainbow trout of hatchery origin in the upper North Platte River drainage in 1911 and continued doing so until 1967. It is not known whether any natural reproduction resulted from these plants. Large rainbow trout from the reservoir began to appear in tributary streams in 1945. The establishment of a self-sustaining rainbow trout population in Lake McConaughy could have resulted either from the stocking program or from upstream natural or hatchery stocks or both.

Studies of the spawning runs, during the early 1960s, indicated that the effect of stocking valley tributary streams with hatchery fish was negligible. Since 1968, valley nursery streams that lack spawning habitat but support trout have been stocked with rainbow trout of the McConaughy strain.

In an evaluation of the stocking program, three groups of rainbows — those of hatchery origin, natural reproduction of the McConaughy strain, and stocked fish of the McConaughy strain — were marked and the returns evaluated at the Lewellen trap. The marking experiment clearly demonstrated that McConaughy strain trout survived better than hatchery strain trout.

HATCH, M. D. 1976. Rainbow fry survival. Performance Report, Job C-15, New Mexico Department of Game and Fish. Santa Fe, New Mexico. 10 p.

HAVENS, A. C. 1991. Evaluation of enhancement efforts for rainbow trout in southcentral Alaska. Alaska Department of Fish and Game. Juneau, Alaska. 42 p.

HAXTON, T. 1987. 1987 Stocking assessment on selected rainbow trout lakes within Minden District. File Report, Ontario Ministry of Natural Resources. Minden, Ontario. 6 p.

The objective of the 1987 stocking assessment program was to determine the effectiveness of past rainbow trout stocking efforts in eight selected artificial rainbow trout lakes within Minden District. The project was conducted between June 3 and August 7, 1987. Lakes were netted with gill nets of varying mesh size (_ — 2 _).

Of the eight lakes surveyed, three lakes (Beanpole, Buckskin and Leaf) show promising results, two lakes (Lower Welch and Little Esson) show potential for rainbow trout stocking, whereas the other three (Coleman, Little Gull and Minnicock) show little potential and should be given low priority for future rainbow trout stocking programs. Recommendations for the future include implementing a volunteer creel survey to evaluate fishing pressure and angling success.

HAZZARD, A. S. and D. S. SHETTER. 1938. Results from experimental plantings of legal-sized brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo irideus*). Transactions of the American Fisheries Society 68 : 196-210.

An intensive creel census in conjunction with monthly releases, during the fishing season, of legal-sized trout, approximately one-half of which were jaw-tagged or fin-clipped, furnished data for the evaluation of such plantings in the Pine River, Michigan. Nearly 8,500 hours of fishing yielded 3,171 brook trout and 3,333 rainbow trout for an average catch of 0.77 fish per hour. Forty-six percent of the brook trout and 21% of the rainbows were from these plantings. Incomplete records of the marked fish showed recovery of 19.8% of the 7,513 brook trout and 17.5 % of the 4,007 rainbows planted. The catch-per-hour by weekly periods ranged from 0.32 to 1.35. The average catch-per-hour for the Pine River was considerably higher than for the other streams that were covered by a similar census but not planted with large fish. The plantings influenced the catch for a period of from two to three weeks. Apparently few of these fish survive to the next season. Movement of planted fish was mainly upstream regardless of the method of planting. Within two weeks the fish which remained were uniformly distributed over the stream. Spot planting resulted in a larger percentage caught than did scattering by boat, but increased meat fishing. Every planting during the open season caused a decided rise in the catch of wild fish of the same species. It is concluded that although planting legal fish during the season temporarily and artificially increases the catch, it may deplete a stream of wild adults. This depletion will affect natural production and may result in poorer fishing in succeeding years. A program for planting legal-sized trout seems justified only in heavily fished waters incapable of supporting a permanent trout population during the summer or where no results from natural reproduction are possible, or where an overpopulation of stunted trout exist.

HEALEY, T. P. 1977. A review of Whiskeytown Lake fisheries management from 1963-1975. Inland Administrative Report No. 77-2. California Department of Fish and Game. Sacramento, California.

Whiskeytown Lake is a cold, non-fluctuating reservoir with a high flushing rate. Efforts to establish an effective forage base for game fish have been unsuccessful. Because of the forage deficiency the lake offers very little potential for management as a trophy trout water. It is now managed by stocking yearling trout for immediate harvest. Planted yearling rainbow trout (*Salmo gairdneri*) comprised 65-90% of the catch observed in creel surveys from 1968-1973, while kokanee (*Oncorhynchus nerka*), originating from annual plants of fry and some natural recruitment, accounted for 9.1 — 23.9%.

The results of tagging catchable-sized trout with nonreward and $5 reward tags have generally shown that: (1) trout migrate to the Carr Powerhouse when planted at other locations, (2) trout return to the creel at higher rate when planted at the powerhouse rather than at other locations, and (3) angler response for nonreward tags ranged from 46-100%. The possibility of planting pond smelt (*Hypomesus transpacificus nipponensis*) to improve the forage base for game fish is discussed.

HEIDINGER, R. C. 1999. Stocking for sport fisheries enhancement. p. 375-401 *In* C. C. Kohler and W. A. Hubert [eds.]. Inland Fisheries Management in North America. American Fisheries Society. Bethesda, Maryland.

Fish are currently being raised for stocking in sport fisheries by federal and state agencies and by private fish culturists. In 1995-1996, 70 federal hatcheries, 48 states and 8 provinces stocked 276 million coldwater sport fishes. Rainbow trout accounted for the greatest proportion of any species stocked (117,243,000 fish, 42.4% of total).

The popularity of rainbow trout is the fact that it tolerates low oxygen better than most trout, can grow to a harvestable size on zooplankton, can be used to establish two-story fish populations, and is highly vulnerable to sport fishing.

Two-story (that is a warmwater fishery above a coldwater fishery) rainbow trout populations in reservoirs may have to be maintained by stocking large, less vulnerable rainbow trout. Often 40-50% of the stocked fish are creeled when 20-23 cm rainbow trout are stocked, and no fishery may develop if 5-10 cm fish are stocked. By its nature, a put-and-take fishery requires stocking of what is usually called a catchable size fish. The operational definition of catchable is a fish large enough to be acceptable to the angling public.

HEIMER, J. T. 1967. Survival of trout in Anderson Ranch Reservoir. Project No. F 53-R-2 Job No. A5. Idaho Fish and Game Department. Boise, Idaho.

A total of 94,500 catchable-sized rainbow trout were released in Anderson Ranch Reservoir in the fall of 1965. Of this total, 28,000 trout were marked by a pelvic fin-clip. In the spring of 1966, a total of 10,200 catchable-size trout marked with an adipose clip were released in the reservoir. In addition 100,000 fingerlings were released in the fall of 1966 and 10,000 of these were marked by clipping both pelvic fins.

In 1966, anglers caught rainbow trout at a rate of 0.49 and 1.12 fish per hour in the spring and fall fisheries, respectively. Marked trout planted as catchables in the spring of 1966 were three times as catchable as those planted in the fall of 1965, probably because of overwintering mortalities or movements out of the reservoir.

Fishing pressure during the summer months was quite low, possibly because of squawfish were quite active and a nuisance to anglers. Creel census data collected in April, May and June indicated a decreasing catch rate for rainbow trout as the water warmed and squawfish became more active.

HEIMER, J. T., W. M. FRAZIER, and J. S. GRIFFITH. 1985. Post-stocking performance of catchable size hatchery rainbow trout with and without pectoral fins. North American Journal of Fisheries Science 5(1) : 21-25.

We compared to the creel, survival, movements, and growth of several groups of hatchery rainbow trout (*Salmo gairdneri*), half with fully developed pectoral fins and half without pectoral fins. We stocked the fish at two locations on two different dates in Idaho s Portneuf River during 1979, and used angler interviews and electrofishing to assess their characteristics. There was no significant difference in total numbers of angler-caught trout with and without pectoral fins (632 vs. 630) or trout with and without pectoral fins (163 vs. 179) caught by electrofishing. There also were no significant differences in growth for 15 groups of trout measured at eight 2-week intervals throughout the summer stocking. There were no significant differences in the movement of the two different groups of fish. Most (66% of the total recovered) were recaptured within a few hundred meters of the stocking site. Only 17 trout (of 8,000 stocked in 1979) were reported caught in 1980, indicating poor over-winter survival and/or extensive movement from the study areas.

HELFRICH, H. and B. A. BARTON. 1979. Angler catch level success from increased stocking rates in Paine Lake and Beavermines Lake, Alberta. Alberta Department of Recreation, Parks and Wildlife. Edmonton, Alberta.

Doubling the stocking rate of rainbow trout reduced the number of unsuccessful anglers from 66% to 24% in Paine Lake and from 41% to 23% in Beavermines Lake. At both stocking rates, the majority of anglers caught less than 3 fish in both lakes. For both lakes, a theoretical reduction in daily catch limit at the higher stocking rate would affect a greater percentage of the total trout harvest than at the lower stocking rate.

HELFRICH, L. A. and W. T. KENDALL. 1982. Movements of hatchery-reared rainbow, brook, and brown trout stocked in a Virginia mountain stream. Progressive Fish Culturist 44 : 76-80.

During May, 1979, 1,061 catchable sized hatchery-reared rainbow trout (*Salmo gairdneri*), brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) were tagged and stocked in pool and riffle habitats in Big Stoney Creek, Giles County, Virginia. Of this total, the movement patterns of 275 recovered trout were determined through voluntary tag return and creel census information. Most (75%) of the trout were recovered within 1 km of their respective release sites; 16% remained within the initial stocking locations. Most of the recaptured brook trout (69%) and rainbow trout (59%) were recovered downstream, whereas brown trout (69%) moved primarily upstream. The median dispersal distances for brook trout (195 m downstream) and rainbow trout (60 m downstream) were not significantly different from on another, but were significantly different ($P < 0.001$) from that of brown trout (90 m upstream). Although trout stocked in pools generally exhibited less movement that those stocked in riffles, the type of stream habitat into which the trout were introduced had no significant effect on the distance or direction of dispersion of the three species.

HEPWORTH, D. K. and J. D. LEPPINK. 1979. Results of stocking four different strains of fingerling rainbow trout in lower Bowns Reservoir, 1978. Utah State Division of Wildlife Resources. Salt Lake City, Utah.

The New Zealand strain of rainbow trout had an estimated first year return by anglers from fingerling stocking of 12 percent. Growth was poorest out of the four strains compared. Because of the small size of New Zealand fish at the beginning of the 1978 fishing season, harvest may have been delayed, and consequently, New Zealand fish made up the largest percentage of marked fish observed later in the year.

Sand Creek returns indicated good survival and high catchability and also had the best growth rate. Estimated first year harvest (24 percent) was also much better than the other three strains. Overall, Sand Creek Fish produced, by far, the best results.

First-year creel return from the total number of Fish Lake-DeSmet fingerlings stocked was only 7 percent, the lowest among the four strains compared. The low gill net catch of 13 percent indicated poor survival based on a predicted catch of 25 percent. Catchability, judging from low survival, was about as expected with the composition of marked fish in the creel being 14 percent Fish Lake-DeSmet. Growth of this strain was second best, being exceeded only by Sand Creek fish.

The Shepherd-of-the-Hills strain gave a 10 percent return to the creel during the first year of stocking. Gill net returns were proportionally about as expected (29 percent in nets, 25 percent stocked). Composition in the creel was only 18 percent compared to the expected 25 percent, indicating low catchability. Shepherd-of-the-Hills ranked third in growth behind Fish Lake-DeSmet.

HEPWORTH, D. K. and D. J. DUFFIELD. 1987. Interactions between an exotic crayfish and stocked rainbow trout in Newcastle Reservoir, Utah. North American Journal of Fisheries Management 7(4) : 554-561.

Crayfish (*Orconectes virilis)* appeared in Newcastle Reservoir, Utah, in the 1970s. Rainbow trout (*Salmo gairdneri)* are stocked annually in the reservoir to support a sport fishery. Predation of rainbow trout on crayfish was studied during 1983-1985. This predation was seasonal, occurring only during June-December. It was greatest during June-August, when up to 100% of fish stomachs contained crayfish. Relative sizes of predators and prey helped to limit crayfish consumption by fish, but seasonal behavior and distribution of crayfish also influenced their availability. Crayfish of ingestible sizes occupied the reservoir throughout the year, though rainbow trout did not eat them in winter and early spring. Crayfish were consumed up to the size of 38 mm in carapace length (CL). They grew to a size of 22 mm CL during their first year and attained a maximum size of 60 mm CL. Rainbow trout growth declined after crayfish became abundant in 1979. Crayfish changed the reservoir ecosystem by altering the food web and thereby reducing the energy transfer to rainbow trout. Fish stocking rates were cut in half in 1983 and 1984 to improve the growth rate of rainbow trout.

HEPWORTH, D. K., D. J. DUFFIELD, and T. MODDE. 1991. Supplemental stocking for estimating population size and first year survival of fingerling rainbow trout stocked in a Utah reservoir. North American Journal of Fisheries Management 11(1) : 11-19.

The traditional method of estimating population size with mark-recapture techniques was compared to estimates made by using stocked hatchery fish as the sample of marked fish. The study was conducted on a 401-hectare reservoir with a put-grow-and-take sport fishery for rainbow trout (*Oncorhynchus mykiss)*. Populations were estimated in September 1987 and 1988 for rainbow trout (mean total lengths [TL] of 212-226 mm) that were stocked between March and June as fingerlings (89-102 mm TL). Population estimates for mark-recapture and hatchery-fish methods, respectively, were 68,000 and 67,000 in 1987 and 51,000 and 63,000 in 1988. Survival estimates for stocked fingerlings ranged from 39 to 55% in 1987 and from 19 to 25% in 1988. The numbers of marked and released fish recaptured were proportionally similar to recaptures of hatchery fish used as the marked fish sample; there was no significant difference in recapture rates between methods. Confidence limits of the estimates were much narrower for the hatchery fish method because of larger sample size. Thus, use of hatchery fish as the marked fish sample removed the limitation of low sample size that commonly restricts the use of population estimation for management. Supplemental stocking of hatchery fish also made it possible to estimate the population size of older rainbow trout of larger size (380-394 mm TL). Assumptions used to make estimates were evaluated, which was necessary to validate population estimates based on use of hatchery fish.

HILL, T. K., J. L. CHESNESS and E. E. BROWN. 1972. Utilization of rainbow trout, (*Salmo gairdneri)* in a double-crop fish culture system in south Georgia. *In* Proceedings of the 26th Annual Conference Southeastern Association of Game and Fish Commissioners. Knoxville, Tennessee.

Techniques were investigated for growing rainbow trout (*Salmo gairdneri)* from fingerlings to market size during the winter months in a recirculation, flowing water fish culture system where channel catfish (*Ictalurus punctatus*) are grown in summer. Trout stocked having a mean weight of 0.1 pound had a mean weight of 0.7 pound in approximately 100 days with a feed conversion ratio of 1.29 to 1. Survival of the fish was 82%. Water quality parameters and control of parasite infestations during the culture period are also discussed.

HINDAR, K., N. RYMAN and F. UTTER. 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48 : 945-957.

This paper addresses the genetic consequences of aquaculture on natural fish populations. The study is motivated by rapidly increasing numbers of intentionally and accidentally released fish and is based on empirical observations reported in the literature. A wide variety of outcomes, ranging from no detectable effect to complete introgression or displacement, has been observed following releases of cultured fish into natural settings. Where genetic effects on performance traits have been documented, they always appear to be negative in comparison with the unaffected native populations. These findings are consistent with theoretical considerations of the implications of elevated levels of gene flow between cultured and locally adapted natural populations; they raise concerns over the genetic future of many natural populations in the light of increasing numbers of released fish. Strategies for the genetic protection of native populations from the effects of aquaculture are outlined including more secure containment, the use of sterilized fish, and modifying the points of rearing and release. We recommend strong restrictions on gene flow from cultured to wild populations and effective monitoring of such gene flow.

HIRSCH, S. 1987. Evaluations of rainbow trout stocking on Foster-Arend Lake, 1986. Fisheries Section Report, Minnesota Department of Natural Resources. St. Paul, Minnesota.

HOCHACHKA, P. W. 1961. Liver glyogen reserves of interacting resident and introduced trout populations. Journal of the Fisheries Research Board of Canada 18(1) : 125-135.

Three groups of trout, two introduced populations of *Salmo gairdneri*, and a resident *Salmo clarkii*, were studied in stream sections. Large glycogen deposits, which were reduced to low levels during transportation to the stream, were restored in 2-3 weeks in all groups, with recovery rates being approximately inverse to the population density. Within the hatchery groups, larger fish laid down greater glycogen stores. Wild trout maintained their high glycogen reserves throughout the experiment.

HOCHACHKA, P. W. and A. C. SINCLAIR. 1962. Glycogen stores in trout tissues before and after stream planting. Journal of the Fisheries Research Board of Canada, 19(1) : 127-136.

Changes in the glycogen reserves of epaxial and heart muscle of trout were followed after stream planting. Muscle glycogen recovered quickly in large fish; more slowly in smaller ones, and was related to earlier reported changes in the liver glycogen and blood lactic acid. Heart glycogen increased initially, but fell again shortly after feeding became stabilized. Muscle glycogen reserves of wild trout were lower in the presence of hatchery fish than in their absence. A depletion of some metabolite, such as glycogen, in conjunction with an increased body demand due to raised basal metabolite was suggested as a factor in delayed mortality.

HOLLOWAY, A. D. 1945. Summary of trout stocking experiments. Fishery Leaflet 137. Fish and Wildlife Service, United States Department of the Interior. 16 p.

This leaflet attempts to summarize and evaluate stocking experiments with trout. Based on assessment from five streams in Michigan, North Carolina and Virginia, the percentage of planted fingerling rainbow trout recovered ranged from 0.0-3.3% (average 1.6%). From the experiments on survival and recovery, it is obvious that winter kill is a very important factor that must be considered in trout planting.

Recoveries from plantings of legal-sized rainbow trout varied from 0.9-62.4%. Recoveries were higher for fish planted in the spring (average 47.7%, N=10) compared to the fall (average 14.6%, N=11).

HOLLOWAY, A. D. and T. K. CHAMBERLAIN. 1942. Trout management and stocking results in the national forests of the southern Applachians. p. 245-249 *In* Proceedings of the 7th North American Wildlife Conference. Toronto, Ontario.

In 1937, the Pisgah National Game Preserve and the Sherwood Cooperative Wildlife Management Area were designated as experimental areas for trout management. In 1941 approximately 58% of the total catches on the managed areas consisted of rainbow trout.

For the first season after planting, records collected on the Pisgah National Game Preserve show an average recovery of 2.8% for fall planted rainbow trout between 6 and 8 inches in length; 15.7% for fall plantings of 8 inches; and 42.3% for spring plantings of 8 and 9 inches. The recovery of legal length (8 inches) spring planted rainbow was 2.6 times greater than fall plantings of approximately similar sizes; and 15 times greater than fall planted fingerlings between 6 and 8 inches. On the management areas where only rainbow trout fingerlings between 4 and 6 inches in length were planted in the fall, the estimated number of trout taken varied from 6 to 24% of the number planted.

HOLTON, G. D. 1966. Montana s need for a firm policy on use of catchable-size trout. p. 263-268 *In* Proceedings of the 46th Annual Conference of Western Association of State Game and Fish Commissioners. Butte, Montana.

In Montana, we have long been concerned with the problem of bringing our catchable-size trout program into balance with the rest of our fisheries programs. We believe the planting of catchables is justified in certain small heavily fished lakes and possibly in others where it is necessary to overcome predation. Most plantings of catchable size trout are released in streams.

Our state hatchery system raises just under 1 _ million catchable rainbow trout (7 inches and longer) each year. The National Fish Hatcheries in Montana equal our production so together we plant about 2,800,000 catchables a year. It amounts to 13 catchables for each fishing licence buyer. Catchable-size rainbow trout comprise 78% of all pounds of fish raised in our state hatcheries and 95% of the total pounds raised by the federal stations in Montana. There is practically no stream of importance without its allocation of catchable rainbow trout. We feel fortunate if we realize a 40% return from stream plants of catchables.

HOPELAIN, J. S. 2000. Strategic plan for trout management — A plan for 2000 and beyond. Draft plan, California Department of Fish and Game. Sacramento, California. 21 p. + appendices.

Trout culture has been a part of California s history almost since statehood in 1850. California currently stocks about 3 million pounds of rainbow trout, averaging about one-half pounds each. In addition we also stock about one million pounds of sub-catchable and fingerling sized trout. Rainbow trout comprise approximately 85% of stocking allotments.

Current trout policies include:

- Stocking fingerling and sub-catchable trout shall take priority over planting catchable-sized trout in the stocking program when smaller fish will maintain satisfactory angling.
- Hatchery trout shall not be stocked in waters where they may compete or hybridize with trout which are threatened, endangered or of special concern.
- Catchable-sized trout shall be stocked only in lakes, reservoirs and streams where natural production and growth are inadequate to maintain populations capable of supporting fishing.
- Catchable-sized trout shall be stocked only when it is reasonable to expect at least 50% by number or weight will be taken by anglers.
- When stocking catchable-sized trout, lakes and larger streams shall have priority over smaller

streams.

- Subcatchable-sized trout may be stocked in lakes, reservoirs and streams where appropriate to augment trout populations in such waters to increase fishing opportunities and success.
- Fingerling-sized trout shall be stocked primarily in waters where reproduction is limiting and satisfactory angling can be supported with fingerling stocking where the populations has been destroyed and in lakes where they will establish a new fishery or augment the existing fishery.
- Domestic strains of catchable-sized trout shall not be planted in designated wild trout waters.

Trout stocking densities are as follows:

- Fingerling trout (75/lb or smaller) in large reservoirs — 150-200 fish/acre
- Fingerling trout in high mountain lakes — 50-100 fish/acre
- Large fingerling trout (16-50/lb) in lakes and reservoirs — 35-75 fish/acre
- Subcatchable trout (6-16/lb) — 20-30 fish/acre
- Catchable trout (2/lb) — As many as we can get in waters with good returns.

HORAK, D. L. 1966. Evaluation of hatchery-reared rainbow trout. Fisheries Report Colorado Game, Fish and Parks Department. Fisheries Research Review 3 : 18-21.

HORAK, D. L. 1968. Evaluation of hatchery-reared rainbow trout. Project No. F-28-R-4. Colorado Department of Fish and Game. Denver, Colorado.

Good quality hatchery rainbow trout have comparable stamina to wild rainbow trout in a stream environment and better stamina than wild : trout in a lake environment. Poor quality hatchery rainbow trout have less stamina than stream reared wild trout, while poor hatchery fish varied from slightly lower to slightly better stamina than wild trout in a lake. The Colorado dry diet with no supplemental liver feeding produced fish with average growth, average mortality, low stamina, and nutritional disorders, which suggests that liver feeding is still necessary. Stamina was not reduced by transporting one group of trout for eight hours using standard hauling equipment. Low stamina fish had a greater survival than high stamina fish in a lake environment while in a stream environment, high stamina fish had greater survival than low stamina fish. The indication is that high stamina fish have a survival advantage in a stream but not a lake. Fish with a two inch length advantage had increased survival in a stream habitat.

HORAK, D. L. 1969. The effect of fin removal on stamina of hatchery-reared rainbow trout. Progressive Fish Culturist 31(4) : 217-220.

Studies of stamina have shown that the swimming ability of 3.3 to 4.0 inch rainbow trout has not been significantly reduced by removal of either the dorsal, both pelvic, both pectoral, anal, or adipose fins. As survival potential is thought to be influenced strongly by stamina, these fin clips can be used in future studies with minimal likelihood of reducing survival. Through removal of both pelvic and both pectoral fins did not significantly reduce swimming ability, one group showed lower stamina; therefore, removal of all paired ventral fins should be used with caution. A caudal fin clip severely reduces stamina; therefore, this fin clip is not recommended in studies where it is important that marking does not affect survival.

HORAK, D. L. 1971. Evaluation of hatchery-reared rainbow trout. Job Report No. F-28-R-8. Colorado Department of Fish and Game. Denver, Colorado. 45 p.

A cheaper vitamin premix (HVP) proved satisfactory to replace the costly #21 premix in crumbled feeds. No adverse effect was found by placing only one-half the vitamins in the SD-3 crumbled feeds. Hartman and Trout Lodge fish strains showed comparable growth which was superior to Plymouth strain fish. A pelleted feed having 13% less herring meal raised suitable fish with only a slightly slower growth. Faster growth and lower conversion were experimented for a diet formulated with higher levels of herring meal. Feed quality control inspections have substantiated that the private sector now has the equipment and technological skill to produce quality trout feeds. By modifying stamina testing procedures this year, still no survival advantage has been found for high stamina fish. A discussion of stamina versus fish survival conducted under Job 5 from 1966-71 is presented. Gastric evacuation was not affected by the absence of a lignin binder or the addition of a bentonite binder. Neither was it affected by the use or absence of steam during pelleting. The rate of gastric evacuation was significantly reduced by using coarsely ground feed ingredients as opposed to finely ground ones.

HORAK, D. L. 1972. Survival of hatchery-reared rainbow trout (*Salmo gairdneri*) in relation to stamina tunnel ratings. Journal of the Fisheries Research Board of Canada 29 : 1005-1009.

No conclusive evidence was found in tests from 1966 to 1969 in either lentic or lotic environments to support the hypothesis that hatchery-reared rainbow trout (*Salmo gairdneri*) with a high-stamina index had higher survival potential than those whose stamina index was low. Physical stamina was measured by determining the length and time each fish could withstand sustained swimming in a specific construction stamina tunnel. For high-stamina rating fish swam in the tunnel for 80 minutes; for low stamina 1-10 minutes.

In tests of reproducing stamina ratings, improved swimming ability of low-stamina fish was demonstrated upon retesting in the tunnel. In 1970, with retested fish, still no evidence was found to indicate higher survival of fish rated as high stamina. Additional studies are needed to determine if performance of hatchery-reared salmonids in a stamina tunnel is a valid indicator of their survival potential in the wild.

HORTON, H. F. 1956. An evaluation of some physical and mechanical factors important in reducing delayed mortality of hatchery-reared rainbow trout. Progressive Fish Culturist 18(1) : 3-14.

A water temperature of 40° F during transportation offered an effective control of delayed mortalities from Roaring River and Wizard Falls trout hatcheries.

Sodium amytal at the rate of one-half grain per gallon of water, as used at the Roaring River hatchery, was ineffective as a control of delayed mortalities.

Variation of loading and unloading techniques did not significantly affect the delayed losses at either Roaring River or Wizard Falls.

Use of Venturi-aerated liberating units offered effective control of delayed losses from all four stations.

In reducing delayed mortalities at the Leaburg and Klamath trout hatcheries, the California-type Venturi aeration tank was superior to the side delivery design described here.

Diet, fish condition, water turbulence in liberating tanks, and density of fish per gallon of transporting water may have important bearing on delayed losses. Future work should include exploration of their importance.

HUDY, M. 1980. Evaluation of six strains of rainbow trout (*Salmo gairdneri*) stocked as fingerlings in Porcupine Reservoir, Utah. M. Sc. Thesis, Utah State University. Logan, Utah. 72 p.

Different strains of rainbow trout (*Salmo gairdneri*), Ten Sleep, Sand Creek, Beitey, Shepard-of-the-Hills, New Zealand, Fish Lake-Desmet, were compared for survival to the creel, growth and catchability after being stocked in a fluctuating 80 ha Utah reservoir. Fish were stocked in the spring and fall as fingerlings and monitored by creel census, gillnetting and electrofishing. Fish were tagged with coded wire snout tags prior to stocking. An angler opinion survey was conducted to determine angler satisfaction with numbers and size of fish caught.

Regardless of strain, spring stocking was superior to fall stocking in survival to the creel. In the spring 1978 stocking the Ten Sleep strain had the highest survival to the creel (33.7 percent), followed in order by Shepherd-of-the-Hills (11.0 percent), Beitey (5.5 percent), Sand Creek (5.4 percent), New Zealand (4.1 percent), and Fish Lake-DeSmet (2.9 percent). In the spring 1979 stocking the Shepherd-of-the-Hills strain had the highest survival to the creel (7.6 percent), following in order by the Sand Creek (7.3 percent) and the Ten Sleep (6.5 percent). Similar trends in survival were found in gill netting and electrofishing samples. Migration out of the reservoir was negligible for each strain. There were no strain differences in catchability by different methods (shore, boat) or gear (bait, artificial lure). Differences in growth between the fastest growing strains (Ten Sleep, Sand Creek) and the slowest growing strains (New Zealand , Fish Lake-DeSmet) averaged as great as 16 mm in length and 43 grams in weight. Differences in growth and survival among strains were great enough to span the range of angler satisfaction with numbers caught and size of fish caught from satisfactory and unsatisfactory. Therefore, strain selection can be useful tool to improve fingerling stocking programs and manipulate the number of anglers who are satisfied with the angling experience.

HUDY, M. and C. R. BERRY, Jr. 1983. Performance of three strains of rainbow trout in a Utah reservoir. North American Journal of Fisheries Management 3(2) : 136-141.

The three strains of rainbow trout were monitored for 14 months after being stocked as fingerlings in Porcupine Reservoir (80 hectares), Cache County, Utah. The Sand Creek, Ten Sleep, and Shepherd of the Hills strains had no significant differences in survival to the creel, catchability by month, or vulnerability to different fishing methods or gear. Estimated survival to the creel ranged from 6.5 to 7.6%. The Sand Creek and Ten Sleep strains grew faster than the Shepherd of the Hills strain in the reservoir; however, differences were not large enough to be of management importance. Because no differences among strains were found, strain selection, at least until additional field information is obtained, should be based on hatchery criteria.

HUME, J. M. B. and K. TSUMARA. 1989. The management implications to a recreational lake stocking program of the differences between two wild strains of rainbow trout. p.164 *In* Proceedings of the 19th Annual Meeting of the American Fisheries Society. Anchorage, Alaska. (Abstract Only)

Stocking of rainbow trout is a major tool used in the management of recreational lake fisheries in British Columbia. These fish are mainly from egg-takes of non-domesticated trout in Pennask and Premier Lakes. We examined the growth, survival, and early maturation characteristics of these two strains in three lakes of differing productivities. We also determined the proportion of fish that had become catchables (>255 mm). Fish were stocked in May 1985 and sampled with gillnets in the fall of 1985 and 1986. There was no difference in growth between the two strains in the lowest productivity lakes but the Premier strain was significantly larger at both sampling periods in the other two lakes. Both the males and the females of the Premier strain matured earlier and at a higher rate than did the Pennask strain, effectively removing them from the fishery due to loss of quality. We conclude that the Premier strain is best for a high intensity fishery where the fish are caught by age 2+ while the Pennask strain is more suited to a lower harvest rate where a large proportion are caught as age 3+ or older.

HUME, J. M. B. and K. TSUMARA. 1992. Field evaluation of two rainbow trout strains introduced into three British Columbia lakes. North American Journal of Fisheries Management 12(3) : 465-473.

Stocking of rainbow trout (*Oncorhynchus mykiss)* is one of the major tools used in the management of recreational fishing in small British Columbia lakes. These fish originate mainly from eggs of native trout in Pennask Lake and partly domesticated trout in Premier Lake. Using samples of the two strains collected with gill nets, we examined growth, survival, and early maturation characteristics of fish stocked as yearlings in three lakes of different productivity. We also compared the proportion of the fish that had attained catchable size (>255 mm) and large catchable size (>305 mm) in the first and second year after stocking. There was no difference in growth between the two strains in Headwater #3 Lake, the least productive lake, but the Premier strain weighed at least 22% more than the Pennask strain in Yellow and Madden Lakes. At the end of 2 years neither strain had reached a catchable size in Headwater #3 Lake, but in the other two lakes the Premier strain had produced at least 8% more catchable fish and at least 32% more large catchable fish than the Pennask strain. Males and females of the Premier strain matured earlier and at a higher rate than did those of the Pennask strain, which reduced their desirability. We conclude that the Premier stock is better suited to a high-intensity fishery in which most fish are caught by age 2, whereas the Pennask strain is better suited to a lower-harvest fishery whose catch includes a large proportion of age-3 or older fish. Neither strain is suitable for stocking as yearlings into a low-productivity lake.

HUNT, C. 1971. Angler harvest of a small reservoir, Pebble Lake. File Report, Alberta Department of Recreation, Parks and Wildlife. Red Deer, Alberta. 4 p.

Pebble Lake is an abandoned, water filled gravel pit. The pond was stocked with 3,000 yearling rainbow trout (14 fish/pound) on May 18, 1971. One hundred of the fish were tagged. The Red Deer Fish and Game Association sponsored a contest to encourage tag returns.

Anglers returned 45 tags to the Fish and Wildlife office. Seventy-five percent were captured before June 1 and none were reported after the end of June.

Gill nets (100 yards, 2 _ inch mesh) set for one hour caught three trout and set overnight caught an additional 4 trout. Seining with a gill net captured 4 trout. None were tagged. The low gill net returns suggests the harvest was greater than the tag returns indicated.

A creel census collected data on four days during 1970 and two days during 1971. Angling success (CUE) was 0.197 in 1970 and 0.447 in 1971. The census indicated that fishing success was fair but declined rapidly during the summer months.

The rapid recovery of stocked fish probably explains the decline in fishing success. The planting of larger trout at frequent intervals may be warranted, however, this small biologically unproductive pond could not be easily managed to provide much better fishing. The results of the project suggest that a small investment in trout provided a high return in recreation and there is a demand for more trout ponds within easy bicycle range of the city.

HUSTON, J. E. 1959. Harvest of hatchery-reared, catchable size rainbow trout from a controlled section of stream. M. Sc. Thesis, Colorado State University. Fort Collins Colorado.

HUSTON, J. and T. VAUGHAN. 1960. Temporal movement of rainbow trout in reservoirs. Proceedings of the Western Association of Game and Fish Commissioners 48 : 428-441.

The Montana Fish and Game Department and the Washington Water Power Company have been cooperatively investigating the fishery resource of two impoundments: Noxon Rapids and Cabinet Gorge reservoirs, since 1952. A sustained sport fishery through liberations of hatchery-reared rainbow trout (*Salmo gairdneri*) has not been successful in terms of an accepted rate of catch-per-hour. Flow regimes appear to have an effect on rainbow trout s ability to maintain themselves in the reservoir environment.

A tag and recovery study of rainbow trout conducted in the two reservoirs in 1963 through 1965 showed definite patterns of downstream movement. Tagged fish planted in Noxon Rapids, the uppermost reservoir, were recovered several miles downstream each year of the study. Period of greatest recovery from these areas followed spring runoff and reservoir spilling. A correlation did exist between tag recovery and volume of water discharged from the reservoir. Spills in excess of 40,000 cfs resulted in increased catch rate of tagged fish downstream.

Rainbow trout planted in Noxon Rapids Reservoir in 1964 were from two different brood sources. Part of the tagged fish planted were from commercial brood sources and part were from the State of Montana stock. Tag recoveries showed that the commercial fish had less tendency to migrate downstream that the State stock.

INSTITUTE FOR FISHERIES RESEARCH. 1953. Trout planting. Fish Division Pamphlet No. 10, Michigan Department of Conservation. Lansing, Michigan. 5 p.

JENKINS, R. M. 1970. Reservoir fish management. p. 173-182 *In* N. G. Benson [ed.]. A century of fisheries in North America. Special Publication No. 7, American Fisheries Society. Bethesda, Maryland.

Research has demonstrated that stocking is most profitable in the following situations: in new or reclaimed reservoirs, to introduce desirable new species, to restore balance by introducing substantial numbers of large predators, or to replace year class failures of major species, and to stock catchable trout in suitable reservoirs where natural reproduction does not occur.

Many of the best trout waters are fertile and relatively warm. To turn this condition to management advantage, at least 31 states now produce both trout and warmwater fishes in reservoirs having a cool, oxygenated hypolimnion. Rainbow, brown, brook and lake trout have been introduced with rainbows yielding the highest returns in these two-story waters. Most southern agencies prefer to stock rainbow trout 200-300 mm in length in late fall or winter. At cold temperatures, young shad are more vulnerable to hatchery trout.

Periodic plants of subcatchable (< 150 mm) rainbows are necessary in most heavily fished coldwater reservoirs. Fingerlings (< 100 mm) have been used successfully in new reservoirs where the resident fish population has been eradicated from the stream before impoundment and in waters after complete population control. Once warmwater fishes are firmly established, fingerlings are usually unable to compete.

JENKINS, T. M. 1971. Role of social behavior in dispersal of introduced rainbow trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 28 : 1019-1027.

Hatchery-reared rainbow trout (*Salmo gairdneri*) planted under partially controlled conditions in an observation stream failed to show social density regulations or socially induced dispersal. Aggression frequency was only an imprecise function of density and density may not have been influenced by aggression at all. Dispersal following planting was extensive, but it apparently resulted from individual differences in response to the habitat. Group behavior (schooling) affected dispersal radically in some instances, when fish in large groups undertook movements they would not have undertaken along or in small groups.

JEPPSON, P. W. 1960. Tests for increasing the returns of hatchery trout: Survival of rainbow trout to the creel as related to time of planting in lowland lakes of northern Idaho. Idaho Fish and Game Department. Boise, Idaho. 5 p.

JEPPSON, P. W. 1963. Test for increasing returns of hatchery trout: Lake Pend Oreille Kamloops rainbow marking and recovery. Idaho Fish and Game Department. Boise, Idaho. 2 p.

JESIEN, R. V. and D. W. COBLE. 1979. Contribution of stocked legal-size trout to the sport fishery of three small Wisconsin (U.S.A) lakes. Fishery Management 10(4) : 139-146.

Legal-sized trout stocked in spring in three lakes in Wisconsin U.S.A. provided a short-term, popular, sport fishery. Frequently, half or more of the stocked fish were caught in the first month of the fishing season, and few were caught thereafter. Separate estimates of the percentages of numbers (and weight) returned in the first month of the fishing season were 46 (47), 73 (76), 62 (113), and 31 (22) for rainbow trout *(Salmo gairdneri)* and 64 (81) for brook trout *(Salvelinus fontinalis)*. Most anglers interviewed at two of the lakes were fishing primarily for trout, including in one case 95% of the anglers interviewed over the 9-month season, even though the trout fishery persisted for less than 2 months. Fishing pressure also was highest at the opening of the angling season and declined exponentially thereafter. Of an estimated total of 7,906 angler-hours in one lake, 67% occurred in the first month of the season and 79% in the first 2 months. Because the trout were harvested rapidly, relatively little of the productive capacity of the lakes were channeled into production of trout flesh. Therefore, the stocked trout provided a put-and-take fishery at little expense to the existent warmwater fishery.

JOHNSON, D. E. and P. E. FIELDS. 1959. The effectiveness of an electric hot wire branding technique for marking steelhead fingerling trout. Fisheries Technical Report 47, University of Washington. 4 p.

JOHNSON, D. M., R. J. BEHNKE, D. A. HARPMAN, and R. G. WALSH. 1995. Economic benefits and costs of stocking rainbow trout: A synthesis of economic analysis in Colorado. North American Journal of Fisheries Management 15(1) : 26-32.

Many fish and wildlife management agencies expend a large proportion of their fishery management budgets to provide catchable-size trout for the creation and maintenance of put-and-take fisheries. Increasingly, this practice has been called into question. This study examines the economic issues involved and compares the economic costs of providing catchable rainbow trout (*Oncorhynchus mykiss)* in two Colorado streams with anglers willingness to pay for them. The apparent discrepancy between the economic costs of providing catchable trout and their economic benefits suggests that the Colorado catchable trout program and those in other states should be reviewed on efficiency grounds.

JOHNSON, D. M. and R. G. WALSH. 1998. An economic analysis of the cost effectiveness of privatizing additional production of catchable rainbow trout: A case study in Colorado. North American Journal of Fisheries Management 18(1) : 168-174.

This study examines the cost of increasing state production of catchable rainbow trout (*Oncorhynchus mykiss)* and compares this cost with the cost of purchasing fish from private producers in Colorado. The results suggest that the scope of the analysis and the manner in which costs are identified will determine whether purchasing fish can result in cost savings. When the scope of the study is the state and reported state costs are used, purchasing fish could result in a loss of US$0.53/lb. When the scope of the study is the state and opportunity costs are estimated, purchasing could result in a loss of as much as US$0.02/lb or a savings of as much as $0.51/lb. When the scope of the study is the nation, and opportunity costs are estimated, purchasing could result in a cost savings of $1.71-2.24/lb. Further research is needed to determine whether private producers are a reliable source of supply and to assess the quality of rainbow trout purchased from private producers.

JOHNSON, J. H. 1981. Food interrelationships of coexisting brook trout, brown trout and yearling rainbow trout in tributaries of the Salmon River, New York. New York Fish and Game Journal 28(1) : 88-99.

A total of 267 overyearling salmonids from four tributaries of the Salmon River were examined for diet composition from June through September during 1977-1979. The specimens were grouped in six categories, i.e., wild yearling rainbow trout, yearling rainbow trout of hatchery origin, large brown trout, small brown trout, large brook trout and small brook trout. Terrestrial annelids, tricopterans, semi-aquatic vertebrates and decapods comprised the major food of wild rainbow trout, while hatchery fish fed most heavily on trichopterans and decapods. Large brown trout fed principally on decapods, subyearling coho salmon and rainbow trout, and frogs, while small brown trout relied chiefly on decapods. Fish were the primary prey of large brook trout, while trichopterans were important to the diet of both large and small brook trout. Size of the predator appears to be an important factor in both inter-and intraspecific food choice for resident brook trout and brown trout. The diet of hatchery rainbow trout was found to overlap significantly those of small brook trout and small brown trout but not that of wild rainbow trout.

JOHNSON, J. H. 1982. Comparative diets of planted rainbow trout *(Salmo gairdneri)* and speckled dace *(Rhinichthys osculus)* in a prairie impoundment. *In* Proceedings of the 62nd Annual Conference of the Western Association of Fish and Wildlife Agencies. Las Vegas, Nevada.

The diets of planted rainbow trout *(Salmo gairdneri)* and speckled dace *(Rhinichthys osculus)* were examined from Talmaks Lake, a small, 5-hectare impoundment on the Nez Perce Indian Reservation. Yearling rainbow trout (N=92) were grouped into three size categories (i.e. <250 mm, 250-289 mm, ≥290 mm) based on apparent differences in diet composition. Chironomid larvae were generally the principal prey of trout, although speckled dace were the major dietary component of trout more than 290 mm. Speckled dace (N=285) were grouped into four size categories (i.e. <70 mm, 70-79 mm, 80-89 mm, ≥90 mm). Chironomid larvae were the chief prey of speckled dace followed in importance by baetid nymphs. Dietary overlap for trout was greatest between fish <250 mm and 250-289 mm and lowest between fish <250 mm and ≥290 mm. Because of minor dietary variation among the size groups of speckled dace, overlap values were high. The data suggest that speckled dace may provide forage for rainbow trout in excess of 290 mm in small lacustrine environments. However, the data also indicate that speckled dace may compete for available food with rainbow trout less than 290 mm.

JOHNSON, M. W. 1978. The management of lakes for stream trout and salmon. Project No. F-26-R. Minnesota Department of Natural Resources. St. Paul, Minnesota.

The introduction and maintenance of populations of stream trout or salmon in lakes of the kind discussed in this manual almost always depend on annual stocking since the spawning habitat required by salmonids is rarely found in these lakes.

Trout and salmon are usually stocked either in the spring or in the fall (preferably October) because of the high summer surface water temperatures. Stocking a lake during winter ice cover is not recommended because of the difficulty in tempering fish to low temperatures. Substantial mortality has been noted in wintering plants in Minnesota Lakes.

Fingerling trout stocked in the fall are subject to only a short period of predation before freeze up and fish surviving to the following spring are apparently not as seriously reduced by avian or mammal predators.

The fisheries manager usually has the choice of stocking spring fingerlings, fall fingerlings or yearlings. Because spring fingerlings are subject to high mortality from bird predators for nearly the entire open water-season and fall fingerlings are exposed for only a short time, the fall fingerlings usually show good survival and attain a significant weight gain in the lake. Yearling stocking is an expensive practice and the fish are usually removed by anglers during the first summer in the lake.

In Minnesota it has been found with brook or rainbow trout, when fish are stocked at a size of 100 to the pound or smaller there is usually a substantial mortality. It is therefore recommended that fingerlings larger than this be used for any stocking.

The number of fish to be stocked per unit of lake area depends on species, size of fish, productivity of the lake, time of the year stocked, expected intensity of fishing pressure, cost and availability of fish and the mechanical problems of hauling and stocking the fish. Ideally, stocking rates should be governed by the biological factors, but budget limitations and production capabilities often necessitate modifications in stocking plants.

These stocking recommendations are based on recorded returns to the creel from various stocking rates used in Minnesota lakes over the past 20 years.

JOHNSON, W. E. and A. D. HASLER. 1954. Rainbow trout production in dystrophic lakes. Journal of Wildlife Management 18(1) : 113-134.

After rotenone removal of resident fishes, rainbow trout were established and maintained by stocking in some small dystrophic lakes in northern Wisconsin and upper Michigan. The vital statistics of these populations at various levels of standing crop were followed.

Based on a decline in growth rate at higher levels of standing crop, the carrying capacity of these lakes for pure populations of rainbow trout appears to be approximately 50 pounds per acre. Most of the growth of the trout occurs from May through October, little growth being accomplished from November through April. Availability of zooplankton (the principal food of these trout), size of standing crop of trout, temperature and size of trout are considered as the factors determining growth in these lakes. Analysis of these factors indicate that rate of growth at low levels of standing crop is largely regulated by length of growing season and water temperatures during that season. However, as size of standing crop increases, competition within the trout populations results in a slower rate of growth; food being the source of competition and the space in which food is concentrated and density of the food within this area of concentration determining the degree of competition and therefore carrying capacity. Multiple and partial correlation coefficients indicate that these factors are all important in determining growth of trout in these lakes with competition being the most important factor at high levels of standing crop. The results suggest that availability of food, temperature, and size of the trout are all density dependent factors.

Estimates of natural mortality which seem to be largely a result of predation from time of stocking in May until mid October, 1952, ranged from 32 to 60% for age group I trout and 15 to 19% for age group II trout. The amount of such natural mortality appears to be entirely dependent on the number of predators present and not on the density of trout.

JOHNSSON, J. I. and M. V. ABRAHAMS. 1991. Interbreeding with domestic strain increases foraging under threat of predation in juvenile steelhead trout (*Oncorhynchus mykiss*): An experimental study. Canadian Journal of Fisheries and Aquatic Sciences 48 : 243-247.

The foraging behavior of laboratory-reared juvenile steelhead trout (*Oncorhynchus mykiss*) and steelhead/domesticated rainbow trout hybrids were compared. In 10 replicate experiments, 10 fish from each strain were allowed to choose between foraging in a safe area or an area containing a predator. The hybrid trout were significantly more willing to risk exposure to the predator than were the steelhead. It was possible that differences in the relative willingness to risk exposure may have reflected differences in their susceptibility to predation. A second experiment measured the susceptibility of these two strains to the predator by simulating standardized encounters between predator and prey. Both strains suffered identical mortality rates and therefore were considered to be equally susceptible to the predator. This experiment confirmed that the hybrid trout were significantly more willing to take risks than the wild steelhead. These results indicate that interbreeding between escaped hatchery and wild fish may have a potentially damaging effect to the population.

JOHNSTON, T. B. 1979. Catchable trout — A consensus needed. Fisheries 4(5) : 14-15.

In the past decade we have seen a substantial increase in the practice of stocking adult or catchable trout. Over 70 million adult rainbows, brookies and browns are stocked in the United States annually creating thousands of temporary fisheries designed to generate additional angling activity and to provide a high percentage return of stocked fish. The success of the various stocking programs in accomplishing these two goals has been admirable but the programs have remained shrouded in controversy because of their high cost and the artificial nature of the fisheries created. I have not seen any publication that has analyzed the catchable trout management technique in terms of its philosophy or has discussed the sociological impacts involved.

We should attempt to accumulate all existing information on the results of catchable trout stocking programs throughout the nation. This will allow us to formulate guidelines and make general statements concerning catchable trout programs. We should also work with sociologists to discover ways to clarify and minimize the adverse sociological impacts of catchable trout programs.

JOHNSTON, T. B. and R. F. CARLINE. 1982. Evaluation of four rainbow trout/warmwater species fisheries in southeast Ohio. Ohio Academy of Science 82 : 201-211.

JONES, A. R. 1982. The two story rainbow trout fishery of Laurel River Lake, Kentucky. North American Journal of Fisheries Management 2 : 132-137.

Rainbow trout (*Salmo gairdneri*) were introduced into Laurel River as 4 inch fish in 1974 and as 8-10 inch fish each year thereafter. Studies were initiated in 1975 to evaluate the success of these stocking. Trout preferred 54-61… F water temperatures during the summer months and this preference influenced their depth distribution in June-October. The mean monthly growth rate of trout was 0.56 in and 0.10 lb in 1977; 0.78 in and 0.20 lb in 1978. The trout fishery steadily improved during the 1977-1979. Trout harvest in 1979 was 2.5 lb per acre, a 73% addition to the fish yield. The recovery rate, by weight of trout stocked, was 63%. The night fishery during the summer months contributed to most of the trout harvest. The mean size of the trout creeled at night in 1978 was 14.0 inches and 0.93 lb, compared to a size of 9.9 inches and 0.33 lb when stocked. Recommendations were to (1) stock rainbow trout annually in February at a mean length of at least 9 inches; (2) include Craigs Creek boat ramp as a stocking site; (3) evaluate the success of stocking larger numbers of trout, if available; (4) inform anglers of the preference for 54-61… F water temperatures by trout in order to improve success at locating and catching trout in late summer.

KEITH, W. E. and S. W. BARKLEY. 1970. Predation on stocked rainbow trout by chain pickerel and largemouth bass in Lake Quachita, Arkansas. *In* Proceedings of the 24th Annual Conference Southeastern Association of Game and Fish Commissioners. Atlanta, Georgia.

In many reservoirs predation on stocked fish has been considered as one of the major limiting factors in establishing a particular population.

Following several years of water quality determinations it was found that Lake Ouachita maintained a sufficiently oxygenated hypolimnion to support trout. As a result several thousand catchable rainbow trout (*Salmo gairdneri)* were stocked into the lake. The results of this attempt to establish a trout fishery have been disappointing for a combination of reasons; however, while collecting for broodstock chain pickerel (*Esox niger)* and from fisherman reports, it became evident that predation on the stocked trout must be very high.

Collections of largemouth bass (*Micropterus salmoides)* and chain pickerel were made with a boom-type electro-shocker during January and February, 1970. Sampling was done at night within an approximate 100-acre area adjacent to a trout stocking point. Two separate areas were collected and collections were made the date on which trout were stocked, one day after stocking, two days after stocking, and eight days after stocking.

During the collection period a total of 14,840 nine inch trout were stocked in the two collecting areas.

Eighty-six (86) largemouth bass, weighing 162.9 pounds and twenty-four (24) chain pickerel, weighing 33.1 pounds, were collected for stomach analysis. The smallest size bass containing trout in its stomach was sixteen (16) inches total length. The smallest chain pickerel in which a trout was found was fifteen (15) inches in length.

Of all chain pickerel, fifteen inches and over, 54.5% has trout in their stomachs and 48.6% of the largemouth bass, sixteen inches and longer, contained trout. One hundred percent of the chain pickerel, nineteen inches or larger, and ten of the eleven bass, eighteen inches and larger, contained trout.

Although the size of trout stocked during these collections averaged nine inches in length, 79.6% of the trout consumed were eight inches or less. No trout over nine and one-half inches were found in bass or pickerel stomachs; however, two or more trout per stomach was common and five was the maximum number of trout found in one stomach.

KELLEY, D. W. 1953. A study of the suitability of abandoned granite quarries near St. Cloud, Minnesota, for put-and-take fishing of brown and rainbow trout. Investigational Report 141, Minnesota Department of Natural Resources. St. Paul, Minnesota.

Abandoned granite quarries near St. Cloud, Minnesota, have long been stocked with trout to supply trout fishing. These quarries usually contain 50 to 75 feet of water and range in size from less than one-quarter acre to more than two acres.

Past fishing history of these quarries suggested that a good return to the creel has been had from plantings of catchable-sized trout and that fingerling stocking has been of little value. To gather definite information on survival of stocked catchable-sized trout to the creel, Dodd Quarry was poisoned with rotenone in the fall of 1950 and stocked in the spring of 1951 with 337 brown trout weighing 4.5 per pound. Subsequent check of anglers catches showed a known return of 45 percent of the stocked fish and a probable total return of 60 percent.

Eight quarries were selected in 1953 to determine their capabilities for supplying put-and-take fishing of brown and rainbow trout. Stocking was done at the rate of about 75 pounds per acre and a total of 2,411 brown trout weighing 5.4 to the pound and 1,386 rainbow trout weighing 3.0 to the pound were planted in the eight quarries.

Despite tag loss, 33 percent of the tagged brown trout were taken by anglers and tags returned and 50 percent of the rainbow trout. No consistent difference of the percentage return of tags was noted from the two types of quarries.

An estimate of fishing pressure on the different quarries was obtained from 33 morning or evening counts of anglers on all of the quarries. To obtain an index of the comparative capability of each quarry to supply put-and-take fishing; the percentage return of tags for the season was divided by the total number and anglers counted on the quarry during the 33 counts.

By this index no consistent difference was found in the capabilities of the two types of quarries to supply put-and-take fishing. However, its use showed that the quarries were about three times more efficient in supplying put and take fishing for rainbow trout than they were for brown trout.

KENDALL, W. T. and L. A. HELFRICH. 1982. Dispersion patterns of hatchery-reared rainbow trout stocked in a Virginia mountain stream. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 34 : 318-329.

Dispersion patterns of 578 tagged rainbow trout stocked into pool and riffle habitats of Big Stony Creek, Giles Country, Virginia, were determined from voluntary tag returns and a creel census of fishermen during the 1979-80 trout fishing season. Twenty-two percent of the trout remained within the original 30 m stocking location; 45 percent of the trout moved downstream while 33 percent moved upstream. The median dispersion distance and direction for all trout that moved beyond the initial release sites was 30 m downstream. The majority (75%) of the marked fish were caught within 400 m of the stocking locations. There was no significant difference ($P>0.136$) between the median distance moved of trout stocked into pools and those stocked into riffles.

Three major physical factors (residence time, water temperatures, and stream flow rates) were found to strongly influence stocked trout dispersion. The distance trout moved was directly correlated ($R = 0.5$, $P>0.001$) with the amount of time in the stream. During stream conditions of low water temperatures and high flow rates, trout dispersion increased. Movement of spring stocked rainbow trout was primarily downstream, while movement of fall stocked trout was upstream. Summer stocked rainbow trout showed little movement.

KENDEL, R. E. 1972. Growth and survival of rainbow trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*) in four pothole lakes of the Yukon Territory. Technical Report No. PAC/T-73-7. Pacific Region. Department of Fisheries and Oceans.

Four lakes which were low in oxygen during the winter were selected for planting with young rainbow trout and coho salmon. The mortality of coho salmon was greater than the mortality of trout during the transport to Whitehorse. The mortality of coho salmon was also greater in the lakes. There appeared to be an inverse relationship between the initial planting density and growth of rainbow trout. Gill nets were effective in harvesting the fish. There was a good market for the harvested trout in restaurants and supermarkets in Whitehorse.

KENNEDY, J. J. and D. B. WOOD. 1977. Fisherman reaction to the stocking of albino rainbow trout in Utah. The Progressive Fish-Culturist 39(1) : 16-17.

A strain of albino rainbow trout (*Salmo gairdneri*) developed by the Utah Division of Wildlife Resources was found to be biologically advantageous for fish culture. These albinos grew as fast as, or faster than, standard strains of rainbow trout and appeared to be resistant to many hatchery diseases.

In 1973 about 49,000 albinos of legal size (about 22 cm long or longer) were stocked with standard size hatchery rainbow trout of similar size in three Utah rivers. They were easily visible in the water and served somewhat like tracer bullets in locating fish concentrations. The common complaint of fishermen that there are no fish in this stream, the state isn t stocking enough, etc. had little credibility after these easily visible fish had been stocked.

KENNEDY, H. D. 1967. Seasonal abundance of aquatic invertebrates and their utilization by hatchery-reared rainbow trout. United States Department of the Interior. Technical Paper 12 : 1-41.

A two year study of the composition of the bottom fauna, its seasonal and annual variations, and its utilization by hatchery-reared rainbow trout was made in experimental stream channels of Convict Creek, Mono County, California. Three orders of aquatic invertebrates, Trichoptera, Coleoptera, and Ephemeroptera, comprised 70 percent of the total bottom fauna. Caddisflies were most numerous. Analysis of 289 rainbow trout stomachs indicated that Trichoptera, Ephemeroptera, and Diptera made up 75 percent of the total number of insects ingested. The trout relied heavily on dipterous insects in summer and on caddisflies in winter. Terrestrial insects were an important food source between June and November but were absent from the diet between December and February. An average square foot of bottom area contained approximately 9.5 times the number and a little more than 7 times the volume of food organisms per stomach. Gross comparisons were made of the distribution and abundance of the aquatic fauna with water velocity, mean depth, and substrate particle size. Forage ratios and frequency of occurrence of the primary food organisms are given. Post-hatchery survival of rainbow trout in small high altitude streams appears to be more dependent upon the physical condition of the trout at time of stocking than on a highly favorable physical environment.

KERR, S. J. 1983. 1982 summer creel census and stocking assessment program on six artificial fisheries near Owen Sound, Ontario. File Report, Ontario Ministry of Natural Resources. Owen Sound, Ontario. 60 p.

A creel census program was carried out from May 1 to September 7, 1982 on six selected lakes and ponds within the Owen Sound district in order to determine fishing pressure, harvests and angling quality from artificial (put-and-take) fisheries. These fisheries were found to be utilized almost exclusively (99.4%) by Ontario residents with local and non-local anglers accounting for 29.4% and 70.0%, respectively, of the anglers interviewed.

Estimated fishing pressure for any individual water over the study period ranged from 43.4 to 1,102.9 rod hours/hectare. Seasonal angling quality for planted rainbow trout was high (CUE values 0.24-0.45) in all waterbodies except Eugenia Lake (CUE of 0.05) where rainbow trout accounted for only a small portion of the total catch. Total rainbow trout harvest estimates varied from 845 fish in Wilcox Lake to 1,928 fish from Williams Lake. Planted rainbow trout were believed to contribute from 7.5% to 97.8% of the total estimated harvest.

Planting success and angling returns do not appear to be correlated with the stocking density in the six artificial fisheries which were studied. The artificial stocking program in the Owen Sound district is reviewed and recommendations for future stocking assessment and lake inventory programs are offered.

KERR, S. J. and R. E. GRANT. 2000. Rainbow trout — Potential interactions and impacts. p. 385-386 *In* Ecological Impacts of Fish Introductions: Evaluating the Risk. Ontario Ministry of Natural Resources. Peterborough, Ontario. 473 p.

The interactions of rainbow trout with other salmonids, notably brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*), have been well studied. There are numerous examples where native brook trout stocks have declined after the introduction or encroachment of rainbow trout. Water temperatures, gradient and current velocity are important factors determining the competitive outcome of interactions between rainbow trout and brook trout in streams. There is also evidence of competitive interactions between rainbow trout and brown trout. Interactions with other salmonids, including bull charr, cutthroat trout, coho salmon, and sockeye salmon, have also been reported. There are few reported incidence of interactions between rainbow trout and other resident fishes.

Rainbow trout are subject to a wide range of diseases and parasites. They are also known to hybridize with several other salmonids.

KILAMBI, R. J., J. C. ADAMS, A. V. BROWN, and W. A. WICKIZER. 1976. Effects of stocking density and cage size on growth, feed conversion, and production of rainbow trout and channel catfish. University of Arkansas. Little Rock, Arkansas.

Cages of 3.82 and 5.35 m^3 were used in raising rainbow trout (*Salmo gairdneri*) and channel catfish (*Ictalurus punctatus*) in 24 ha Crystal Lake, Arkansas. Cages were stocked with 23.4 cm trout at densities of 183, 301, and 524/m^3. Neither growth nor feed conversion were affected by cage size, but both were significantly better at stocking densities of 183 and 301/m^3. Rainbow trout can be successfully raised in cages at initial stocking weights of up to 45 kg/m^3.

KINUNEN, W. 1975. A review of rainbow trout stocking and catch statistics in Oregon streams, 1952-1975. Fisheries Report No. 6, Research Division, Oregon Wildlife Commission. Salem, Oregon. 13 p.

KINUNEN, W. and J. MORING. 1978. Origin and use of Oregon rainbow trout broodstocks. Progressive Fish-Culturist 40 : 87-89.

A historical analysis of Oregon s brood stocks of rainbow trout (*Salmo gairdneri*) revealed six distinct strains now in use within the state. Three spawn in spring, and three in fall. At least four strains originated from McCloud River trout, which have been transferred around the country and genetically altered over the past one hundred years. Current use of these strains includes special applications, such as the use of *Ceratomyxa shasta*-resistant Deschutes River rainbow trout in areas with bacterial disease problems, Eagle Lake trout in alkaline waters, and Cape Cod trout in waters where it is essential that downstream movements be limited.

KIRKLAND, L. and M. BOWLING. 1966. Preliminary observations on the establishment of a reservoir trout fishery. Proceedings of the Annual Southeastern Association of Game and Fish commissioners Conference. 20 : 364-374.

A sport fishery for rainbow trout (*Salmo gairdneri)* and brown trout *(Salmo trutta)* was created in the lower one-third of a 38,000 acre oligotrophic reservoir. Maximum temperatures of 70° F and a minimum of 3 p.p.m. oxygen were evaluated as criteria for establishing this two-story fishery. Stocking of 8-10 inch trout were made in the winter months and weight gains were up to threefold in a six-month period. Food utilized by the trout was primarily the threadfin shad *(Dorosoma petenense).* Movement of the trout did not exceed ten miles from the stocking locations, and a majority was caught within five miles.

KLEIN, W. D. 1972. Analysis of a creel-sized trout plant in Parvin lake under artificial lure fishing. Colorado Division of Wildlife. Denver, Colorado.

A plant of 497 hatchery-reared, creel-sized rainbow trout was rapidly decimated by angling with artificial lures, primarily spinning gear with flies as terminal tackle. Of the original plant, 31.2 percent were harvested in the first week, 73.4 percent in the first 6 weeks, 82.1 percent in the first year, 5 percent in the second year, and 0.6 percent in the third year, for a total harvest of 87.7 percent.

Comparison of return-to-the-creel data of stocked, creel-sized, rainbow trout taken without restriction of terminal tackle with artificial-lure fishing indicated that relief was not afforded the hatchery fish by the latter procedure. The larger trout tagged in 1967 probably placed this group of fish on a more comparable basis with smaller fish used in the 1950 s than if they had been of similar size. Smaller trout would likely have been caught and released to a significant extent by more selective fishermen using the lake under the artificial-lure fishing regulation. Conversations with fishermen at the check station left little doubt that many artificial-lure fisherman return fish in the 8 to 10 inch range to the water. This type of selectivity undoubtedly played a part in the observed early harvest of larger trout from the 1967 tagged-fish plant.

Comparative information on the pattern of return to the creel of fingerling and creel-size trout of hatchery origin provided some measure of difference in response to angling of domestic strains of rainbow trout artificially sustained until stocked with fish having extended exposure to a natural environment. The latter demonstrated an ability to sustain a fishery for a longer period of time.

Faster growth among the smaller of the fish remaining after 2 weeks of fishing, similar survival to the creel of smaller and larger fish of the plant, and continuing survival and contribution to the creel of a few fish into the third year following stocking are demonstrated responses at Parvin Lake that may be repeated by stocked catchable-size rainbow trout in other lentic situations.

KLEIN, W. D. 1974. Special regulations and elimination of stocking: Influence on fishermen and the trout population at the Cache la Poudre River, Colorado. Technical Publication No. 30, Colorado Division of Wildlife. Denver, Colorado. 66 p.

A wild population of brown and rainbow trout observed in the Cache la Poudre River was not endangered by normal fishing and stocking procedures or substantially improved by special management that included elimination of stocking, elimination of bait fishing and imposition of a 12.0 inch minimum size limit on rainbow trout.

Hatchery rainbow trout exhibited considerable movement from a planting area when stocked in April but otherwise showed only limited movement from a planting point. Hatchery-reared rainbow trout normally were thoroughly decimated by fishermen by October of the year stocked while wild trout were not so readily harvested. In situations where hatchery fish escaped capture by fishermen they demonstrated an ability to survive over winter and establish residency in the area where stocked.

Elimination of stocking, along with regulation change, produced no measured improvement in length-weight relationship or growth rate in the wild population. Without stocking and with a 12.0 inch limit on rainbow trout, fishing success for trout kept dropped drastically. Rainbow trout of legal size made only a trace contribution.

KLEIN, W. D. 1975. Evaluation of fingerling trout planting methods at Parvin Lake and West Lake, Colorado. Colorado Division of Wildlife. Denver, Colorado. 17 p.

KLEIN, W. D. 1983. Lake DeSmet rainbow trout in Parvin Lake, Colorado, 1972-1978. Special Report No. 55, Colorado Division of Wildlife. Denver, Colorado. 10 p.

Two plants of Lake DeSmet fingerling rainbow trout were made at Parvin Lake, Colorado, one in 1972 and the other in 1973. The 1972 release was accompanied by a similar but larger group of domestic strain rainbow trout. The plants were identified by different fin clips. Observations on growth, angler catch, seasonal harvest patterns, and longevity did not suggest an advantage of the DeSmet over the domestic strain trout. DeSmet fish, however, entered inlet and outlet traps as spawners in proportionately greater numbers than did the domestic strain fish. Also, the contribution of smolts to the outlet trap was dominated by DeSmet fish.

KMIECIK, N. E. 1980. An evaluation of rainbow trout strains in the sport fishery of three Wisconsin lakes and for trout ranching in Minnesota winterkill lakes. M. Sc. Thesis, University of Wisconsin. Stevens Point, Wisconsin.

Various strains of rainbow trout (*Salmo gairdneri*) were stocked at legal size in spring in three Wisconsin lakes containing warm water fish populations. Angler harvest was determined by creel surveys. Estimated percentage of stocked rainbow trout harvested at Sunset Lake in May of 1975, 1976, 1978, and 79 was 41, 64, 67, and 50, respectively.

Variation in the harvest of the Nevin strain was the result of differences in catchability and not to differences in fishing pressure or number of trout stocked. When more than one strain was stocked in a lake in the same year the Nevin strain was found to be most vulnerable to angling under both observed patterns of fishing pressure. The Nevin strain was more vulnerable than a hybrid strain (Desmet male x McConaughy female) to both shore and boat anglers in Sunset Lake in 1979. It was more vulnerable (more caught) than another hybrid strain (Manchester x Wytheville) and the Erwin strain in the Menominee lakes in 1978. The ratio of estimated percentages of stocked trout harvested was the same in the Menominee lakes 3:2:1, for the Nevin, Hybrid, and Erwin strains, suggesting that differences in catchability were genetically determined.

Three strains of spring spawning rainbow trout were stocked as fingerlings in five winterkill lakes, 430-483 trout/ha, on the Red Lake Indian Reservation, Minnesota in June 1978. Estimated percentages of stocked trout that survived to October were 37, 18, 11, 4, and 0 for a hybrid strain (Desmet male x McConaughy female) in Fox Lake, the Erwin strain in lakes Little Shell and Little Bass, and the Wisconsin Spring Spawning strain in Lakes McCall and Muerlin, respectively,. The major cause of mortality was believed to be predation, especially from birds. Because predacious birds or fish were more abundant at the lakes stocked with the Wisconsin spring spawning strain, its survival could not be compared with that of other strains in the other lakes.

Success of trout ranching on the Reservation was limited by small size of trout (mean of 131 grams in all lakes combined in October), muddy flavor , and low yield, 11.2 kg/ha.

KOSA, J. 1999. Evaluation of rainbow and brown trout stockings in the Lake Cumberland tailwater. Fisheries Bulletin 102, Kentucky Department of Fish and Wildlife Resources. Frankfort, Kentucky. 42 p.

We evaluated the movement and exploitation of stocked brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) and the attitudes of anglers in a 38 mile section of the Lake Cumberland tailwater. Trout were batch-marked according to stocking location and time using multiple body locations of tags, tag types and tag combinations. Tag returns in a creel survey were used to assess dispersal and harvest patterns.

A total of 81,364 rainbow trout were stocked. Dispersal was similar for brown and rainbow trout. The longitudinal distribution of brown and rainbow trout catches were segregated based on stocking locations and this pattern was similar for brown and rainbow trout. In few cases did brown trout and rainbow trout move beyond the boundaries of their upper and lower stocking sites.

Harvest was greatest among trout stocked in upstream locations. Exploitation rates were greatest for rainbow trout stocked in August and September. From March-November 1995, anglers fished an estimated 269,123 hours and angler effort peaked in July. Approximately 91% of the angling effort was targeted at trout. The average trip length was 5.1 hours and the estimated number of trips was 52,431. Approximately 82% of the anglers interviewed were Kentucky residents and 21% were residents of counties proximal to the river. Anglers caught an estimated 79,326 trout and harvested 61,052 (77%). The harvest of brown trout (95%) and rainbow trout (89%) was dominated by fish stocked during 1995. Of the 81,364 rainbow trout stocked, 0.9% (769 fish) were inspected during the creel survey. Angling practices (release and harvest) differed dramatically between two strata within the study section. We recommend increasing the number of sites stocked and shifting stocking densities in consideration of spatial patterns of angler exploitation.

KRUEGER, C. C. and B. MAY. 1991. Ecological and genetic effects of salmonid introductions in North America. Canadian Journal of Fisheries and Aquatic Sciences 48 (Supplement 1) : 66-77.

Stocking of non-native *Salmoninae* into North American waters began around 1870. Introductions of native salmonids within North America but outside their native ranges have been common. Ecological effects of salmonid introductions include competition, predation on native salmonids and other fishes, environmental modification through digging of redds in stream bottom substrates during spawning and introduction of parasites and disease to native fish. Direct genetic effects from stocked salmonids are caused by interbreeding with native species. Indirect genetic effects may result through selective forces and/or a reduction of effective population size, genetic drift and interbreeding. Salmonid stocking as a management practice is appropriate for species or population rehabilitation. Continued stocking of non-native salmonids should cease where viable native salmonid populations exist. The era of widespread, intentional introductions of salmonids by man justifiably is drawing to a close.

KRUSE, K. C. and L. DURHAM. 1989. Impacts of put-and-take rainbow trout on juveniles of other fish species. Final Report F-78-R, East Illinois University. Carbondale, Illinois.

KUEHN, J. H. and R. E. SCHUMACHER. 1957. Preliminary report on a two-year census on four southeastern Minnesota trout streams. Report No. 186. Minnesota Department of Conservation. St. Paul, Minnesota.

A creel census was conducted on four southeastern Minnesota trout streams over a two year period. Electrofishing population estimates were made before and after each season. A two-way fish weir was installed at the lower end of the one stream to measure migration into and out of the one stream. Stocked trout made up 51 percent and 79 percent of the catch in each of the two respective years. Returns varied from 29.7 percent to 72.8 percent among the various streams and brown and rainbow trout which were stocked in equal numbers contributed almost equally to the catch. A natural mortality of 40 percent was found for brook, brown and rainbow trout stocked. The streams having the best number of trout available per-angling-hour provided the highest rate of catch. Downstream movement resulted in a loss to the stream of 5.3 percent of the stocked trout and consisted mostly of rainbow and brook trout. Sixty-seven percent of all fall stocked brown trout were lost before the angling season began.

LAARMAN, P. W. 1979. Evaluation of a chemical reclamation and restocking program on the Huron river in the Detroit Metropolitan area. Fisheries Research Report No. 1866. Michigan Department of Natural Resources. Ann Arbor, Michigan.

About 40 miles of the Huron River, including seven impoundments (1215 ha) in Washtenaw and Wayne Counties, were treated with 2 ppm of rotenone. Chemical treatment was done in three segments between October 1972 and October 1973. An estimated 1, 016 metric tons of fish were eradicated and more than 17 million fish of desirable species were stocked to provide a sport fishery.

The major evaluation was done by post-treatment creel censuses on the three segments of the river. Post treatment censuses were conducted during the open-water seasons from 1974-1977 on Ford Lake, and 1975-1978 on Belleville Lake. Pre-treatment data were taken from a one-year census in 1972 on the upper section and from a mail survey in 1973 on Belleville Lake. On the upper segment of the river, no significant change in fishing pressure was evident after treatment. On Ford Lake and Belleville Lake post-treatment periods, the mean annual increases in angler trips were 18, 259 and 83,388, respectively. Based on an expanded 5-year pre-and post-treatment period and a recreational value of $8.99 per angler trip, the benefit:cost ratio was 4.1:1 (±5.3:1) on the upper segment, 5.7:1 (±1.0:1) on Ford Lake, and 25.3:1 (±4.5:1) on Belleville Lake. The benefit:cost ratio for the entire reclamation project was 13.9:1 (±2.2:1)

LANE, C. M. and S. B. COOK. 1999. Distribution and status of introduced rainbow trout in Dekalb and Warren Counties, Tennessee. *In* Proceedings of the 1999 Meeting of the Southern Division of the American Fisheries Society, Chattanooga, Tennessee. (Abstract Only)

The Tennessee Wildlife Resources Agency (TWRA) has introduced rainbow trout (*Oncorhynchus mykiss*) into five typically warmwater streams in Dekalb and Warren Counties, Tennessee. These introductions are made as frequently as three times annually to support put-and-take fisheries but the post-stocking status of these fish has not been evaluated and any over-summer survival has not been considered significant. However, other studies in these watersheds have reported large rainbow trout (> 400 mm) which suggest that some of these introduced fish are surviving elevated summer water temperatures. Also, rainbow trout have been reported in streams that are tributaries to the stocked streams indicating that the stocked fish are expanding their distribution. In addition, several fingerling rainbow trout have been collected during the spring months and TWRA only stocks fingerlings in September, suggesting that natural reproduction may be occurring.

This study will examine the geographic distribution, over-summer survival, age structure, mean length at age, and relative weight of rainbow trout within the two county region. Electrofishing surveys are being conducted to develop summer and winter distributional maps for trout inhabiting the stream drainages. Global positional system coordinates are being obtained for each fish located and the habitat characteristics of each collection location are being measured to assess habitat variables associated with over-summering trout. All introduced fish are being fin clipped to assess post-stocking and over-summer survival. Additionally, fin clipped fingerlings will be used to determine if natural reproduction is occurring or if the collection of fingerlings during the spring and summer months is due to poor growth of fingerlings stocked during September.

LARKIN, P. A. 1954. Introductions of the Kamloops trout in British Columbia Lakes. Canadian Fish Culturist 16 : 15-24.

British Columbia, like the rest of the northwestern slope of the North American continent, has a meager freshwater fish fauna. This consequence of recent extensive montane glaciation has set the background for many of the problems of fresh water fish culture in the province today. The majority of lakes utilized in the widespread but light sport fishery contained no fish as little as 50 years ago. By far the most spectacular results of fish culture practices have resulted from introduction of fish into these barren lakes, and there are undoubtedly still several hundred more which as yet contain no fish. In most drainage systems tributary to major river valleys in British Columbia, upstream migration of fish has been obstructed and in consequence the only species which frequently occur above natural obstructions are those which have been introduced by man. It is thus apparent that introduction of fish into lake sand streams of British Columbia has been and will continue to be a prominent feature in development of its sport fish culture.

British Columbia lakes and streams thus provide many types of localities in which the effects of both natural and man-made introductions can be observed. The situations which occur are so simplified that rare opportunities are provided for study. The Kamloops trout (*Salmo gairdneri kamloop*) is the most important species of sport fish in British Columbia and some features of its ecology and management in barren lakes are discussed below as an example of the results of introductions.

LARKIN, P. A., G. C. ANDERSON, W. A. CLEMENS and D. C. G. MacKAY. 1950. The production of Kamloops trout (*Salmo gairdneri kamloops*) in Paul Lake, British Columbia. Management Publication, British Columbia Game Department. Victoria, British Columbia.

LASHLEY, J. W. 1979$_a$. Angling success study on Darling Long Lake, 1979. File Report, Ontario Ministry of Natural Resources. Lanark, Ontario. 9 p.

In order to determine the success of the planting of rainbow trout yearlings in Darling Long Lake, Lanark County, in terms of angling success, a one day fishing excursion on the lake was undertaken in August, 1979. Twenty-five rod hours of fishing by various methods produced no captures of rainbow trout. The only fish caught was a single pumpkinseed (*Lepomis gibbosus*). Physical and chemical analysis of the water performed the next week demonstrated a lack of acceptable oxygen concentration at a depth at which optimal rainbow trout temperatures are encountered. It is evident that the management scheme for producing a viable rainbow trout fishery on Darling Long Lake is not being realized. Therefore, planting of rainbow trout should be discontinued.

LASHLEY, J. W. 1979$_b$. 1979 Trapnet/gill net study on Farren Lake. File Report, Ontario Ministry of Natural Resources. Lanark, Ontario. 59 p.

In order to gain baseline information on the fish population of Farren Lake, Lanark County, and to attempt to evaluate the Ministry program of rainbow trout planting in the lake, a combined trapnet/gill net study was undertaken in June and early July, 1979.

Three eight-foot trapnets and one six-foot trapnet were set for 19 days in June, giving a total of 76 net days. Panfish were the prime contributor to the trapnet catch of 1,471 fish with 1,148 individuals caught. Yellow perch were the most abundant panfish (631 captured) with pumpkinseed second (499). Coarse fish made up approximately 20% of the catch dominated by white sucker. Game fish comprised only 3.7% of the trapnet catch and were represented mostly by smallmouth bass.

The gill net study, aimed primarily at securing a sizeable cross-section of the rainbow trout population was largely unsuccessful. Only 12 trout were caught and these were all of similar size. In all, 471 fish were taken in the two days of July gill netting and the composition of the catch was similar to that for the trapnetting operation.

It is recommended that rainbow trout plantings be continued at the same levels until the fishery has been adequately evaluated. An intensive creel census program should be employed in the spring and summer of 1980 to better gauge the status of the rainbow trout fishery.

LAWLER, G. H., A. SUNDE and J. WHITAKER. 1974. Trout production in prairie ponds. Journal of the Fisheries Research Board of Canada 31 : 929-936.

Experimental plantings of rainbow trout (*Salmo gairdneri*) in prairie winterkill lakes commenced in 1968 to test the feasibility of their commercial production. These trials were highly successful and by 1970 a small but rapidly expanding trout farming industry had been established. Trout planted early in the spring as 5 to 8 cm long fingerlings grew to marketable size (200 gram minimum), without supplementary feeding, in the 6 month period of open water that prevails in this region. Recoveries as high as 86% of the fingerlings stocked have been achieved and the quality of the trout produced is usually excellent in flavor and color. These experiments are continuing to improve management techniques and to determine the long-term productive capacity of pothole lakes. Three serious problems-summerkill, muddy flavor, and harvest inefficiency-are also subjects of continuing investigations. Use of prairie winterkill lakes as nursery ponds for production of advanced fingerlings of walleye and whitefish for use in resource-enhancement programs has also been tested with considerable success.

LEMMIEN, W. A., P. I. TACK, and W. F. MOROFSKY. 1957. Results from planting brown trout and rainbow trout in Augusta Creek, Kalamazoo County, Michigan. Quarterly Bulletin of Michigan State University 40 : 242-249.

LE ROUX, P. 1968. Artificial stocking of dams in trout management. Fauna and Flora 19 : 25-33.

For several years there has been a trend in the Transvaal (Africa) to promote the sport of trout fishing in dams. A dam on a small tributary of the Crocodile River created a reservoir with a surface area of more than 5 acres. The impoundment has been stocked with between 50-1500 (average 390) rainbow trout annually between 1950 and 1965. Recoveries in the period during which marked fish were used gave an average return of 6.6% for fingerling stockings whereas 44.4% of the yearling stockings were caught.

Trout thrive in cold impoundments and artificial stocking gives good results provided the fishing is heavy enough to crop the available fish. Natural mortality is fairly high and present results indicate that stocking rates of 60-100 yearling fish per acre in unfertilized dams may be expected to give an angling yield from 20-40 pounds-per-acre annually. A higher return could probably be attained if the fishing in summer were more efficient. Continual restocking on an annual basis is unavoidable if the fishing is to be maintained.

LITTLE, R. G. 1966. Are catchable trout a substitute for good habitat? Proceedings of the Annual Conference of Western Association Game and Fish Commissioners 46 : 271-272.

With the limited water New Mexico has, catchable-size rainbow trout are a necessity in keeping abreast with the increase in fishing pressure. During the 1965-66 fiscal year, six New Mexico trout hatcheries produced 7,827,334 trout (398.289 pounds) and stocked 1,423,624 rainbow trout (371,019 pounds) averaging 8 _ inches long.

Bonito Lake, a 40 acre impoundment, is a good example of a waterbody stocked with catchable trout. The estimated harvest, derived from a creel census from May 7 — June 3, 1966, was 28,568 fish. The estimated angler hours were 22,912. The catch rate is somewhat higher than the 0.50 fish per man hour that we strive to fulfill.

In summary, if New Mexico is to provide a fishery that the fishing public demands with the limited water we have, the use of catchables at this time is the only solution.

LOCKARD, D. V. 1966. The Nevada catchable program. Proceedings of the 46th Annual Conference of Western Association Game and Fish Commissioners 46 : 273-274.

We, in Nevada, are highly dependent upon the production of reared trout to support the quality fisheries of many of our waters. During the 1964-65 fiscal year, our catchable program resulted in the stocking of near 250,000 pounds of rainbow, Lahontan cutthroat, brown and brook trout. Rainbow trout dominated the allocation at 84.6%.

During 1963, the catchable stocking rates was near 2.15 fish per angler day of usage on all trout waters, a decrease from 4.00 during the year 1957. The average number of trout taken per angler day ranged from a low of 0.46 on large lakes to a high of 4.47 on the smaller streams. These quality fisheries could not be maintained without catchable trout.

LOOMIS, J. and P. FIX. 1999. A statistical approach to estimating costs of propagating hatchery rainbow trout. North American Journal of Fisheries Management 19(1) : 110-119.

A statistical cost function is estimated and used to calculate the marginal cost and average total of production of rainbow trout (*Oncorhynchus mykiss)* in Colorado. The marginal cash costs in the short run to produce another rainbow trout caught by anglers from the existing hatchery system is US$0.61, which is less than three different estimates of the marginal recreational benefit of harvesting another rainbow trout. However, the average total cash costs and long-run economic cost per catchable-size rainbow trout harvested by a recreational angler are estimated at $1.85 and $2.69, respectively. These costs are considerably higher than the $1.10 average benefit of a rainbow trout caught.

LORD, R. F. 1941. Keeping books on a Vermont trout stream. Progressive Fish Culturist 55 : 19-22.

In 1941, a twenty mile section of the Battenkill River was designated as a Vermont test water. Anglers fishing this section of the Battenkill were required to secure a special permit, issued without charge, and to report their daily catches on forms provided for the purpose.

The first test water study on the Battenkill resulted in obtaining angling reports from 2,823 fishermen who caught 6,711 trout (rainbow, brook and brown). The fish were caught at a rate of 1 trout per 1.5 hours of angling. The fishing pattern was entirely normal. Most of the angling took place in the early part of the season with 59.5% of the anglers reporting during the month of May and their catch representing 70.2% of the season s total. Sixty-five fish in the May catch (approximately 8%) were large brown and rainbow trout that had been marked by the removal of the right or left pelvic fin and planted in late fall and early winter by the Vermont State trout hatchery at Bennington.

LOUDER, D. E. 1969. Principles of trout management. Wildlife in North Carolina 33(9) : 14-16.

The trout streams of western North Carolina constitute an unique and valuable resource. The crisis faced is an increasing fishing pressure on a limited and shrinking mileage of trout water. The first decision must be which way to go — increase hatchery production and stock more trout in the streams or go to a catch-and-release fishery. These, of course, are the two extremes and there are areas in between which appear to be the most economical and practical.

Presently, North Carolina is stocking 603,600 catchable size trout which can be subdivided into 175,700 brook, 292,100 rainbow, and 153,900 brown trout. Present trout stocking consists of one pre-season stocking and five in-season stockings in most streams. A large percentage of the hatchery trout released are harvested immediately after stocking. To obtain a more even catch rate than is observed, the number of stockings could be increased and the number of trout stocked per trip decreased. The ideal return of the hatchery product under the principles of put-and-take management should be 80, 80, and 60%, respectively, for brook, rainbow and brown trout.

LUCAS, M. C. 1993. Food interrelationships between brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) in a small put-and-take stillwater fishery. Aquaculture and Fisheries Management 24(3) : 355-364.

The food of brown trout (*Salmo trutta)* and rainbow trout (*Oncorhynchus mykiss*) in a small stillwater put-and-take fishery was examined by stomach content analysis of fish caught by angling between the months of April and September 1985. Overall, brown and rainbow trout tended to utilize different food sources. Mann-Whitney U-tests showed most major food items to be eaten in significantly different amounts, the most important exceptions being Chironomid pupae and adult Diptera. In all months except April, rainbow trout utilize mainly midwater food, particularly Cladocera. Brown trout fed mainly on benthic food organisms and fish. Spearman rank correlations showed diets to be dissimilar during this period, with significant negative corrections in May and August. These results indicate an absence of interspecific competition for food and imply spatial separation of brown and rainbow trout. In April both brown and rainbow trout fed extensively on the temporary bottom fauna, mainly trichopteran and megalopteran larvae, and diets were significantly positively correlated.

LUDWIG, B. 1995. British Columbia s trout hatchery program and the stocking policies that guide it. American Fisheries Society Symposium 15 : 139-143.

In British Columbia, management of anadromous and inland trout is the responsibility of the provincial government. The Fisheries Program Strategic Plan specifies key objectives for the program, including conserving wild stocks and serving the public interest. The latter involves providing a diversity of angling opportunities including harvest. The provincial government operates five hatcheries. In 1993, 101.1 million fish were released into over 1,000 lakes and streams. This release included 5.4 million rainbow trout (*Oncorhynchus mykiss*) and 1.1 million steelhead (anadromous rainbow trout). Over one-half of the rainbow trout eggs collected to supply the hatchery program come from wild parents. Most of the stocked lakes are high productivity, high use lakes in the southern portion of the province and these lakes generally do not support wild populations. A number of safeguards have been built into the steelhead program to protect wild stocks including (1) marking all hatchery smolts, thus allowed a directed harvest; (2) collecting eggs from wild broodstock; (3) avoiding transplants of steelhead to nonnative streams; and (4) releasing hatchery smolts to the lower portion of the river. Formal policies have been described to guide the inland lakes program including policies on fish stocking, conservation, wild indigenous fish and water designation.

LYNOTT, S. T., BRYAN, S. D., HILL, T. D. and DUFFY, W. G. 1995. Monthly and size-related changes in the diet of rainbow trout in Lake Oahe, South Dakota. Journal of Freshwater Ecology, 10(4) : 399-407.

We analyzed the food habits of rainbow trout *(Oncorhynchus mykiss)* from Lake Oahe, South Dakota, from May through September, 1993-1994. Rainbow trout were captured in surface, suspended and bottom monofilament gill nets. Diets were analyzed using the relative importance index (RI). Composition of the diet differed among months and among size categories of rainbow trout. Greatest RI values for zooplankton prey occurred during the May, July and August. Terrestrial invertebrates had the highest RI value during June and September. Overall, RI values for aquatic macroinvertebrates and rainbow smelt *(Osmerus mordax)* were lower than the two prey categories. Zooplankton were the most important prey for rainbow trout <330 mm and decreased in importance as rainbow trout increased in length. Rainbow trout between 330-459 mm fed predominantly on terrestrial invertebrates. Rainbow smelt were incorporated into the diet of rainbow trout between 201-330 mm and increased in importance as rainbow trout length increased. Rainbow smelt dominated the diet of rainbow trout >460 mm.

MacCRIMMON, H. R. 1971. World distribution of rainbow trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 28 : 663-704.

The pristine distribution of the rainbow trout (*Salmo gairdneri*) after the last glacial period was restricted primarily to the Pacific Ocean and the coastal drainage of North America extending from Alaska southward to Mexico. Since 1874, the endemic range of the rainbow trout has been extended through introduction to include eastern North America and the continents of Africa, Asia, Australasia, Europe and South America. The present range of the species extends into low latitudes to the use of waters at high elevations to over 4500 m above sea level.

Environmental factors considered to be of primary importance in the survival of introduced populations are water temperature and precipitation. The presence of suitable spawning grounds, coupled with seasonal water temperatures below 13… C are essential for the establishment of a self-sustaining population.

A further extension of the world range of rainbow trout seems unlikely except perhaps in northeastern Asia. However, distribution within the present range is likely to be increased through the use of new ponds and reservoirs as they are constructed for water supply and flood control by many countries throughout the world. The farming of rainbow trout, now of local significance in parts of eastern Asia, western North America and central and western Europe, offers an unrealized potential on all continents if warranted by a protein and market demand.

MacCRIMMON, H. R. and A. H. BERST. 1961. An analysis of sixty-five years of fishing in a trout pond unit. Journal of Wildlife Management 25(2) : 168-178.

This paper reviews the history and analyzes the present fishery in a trout pond unit owned by the Glen Major Angling Club. The Club was organized on January 12, 1895 and in that year purchased the 35 acres site of an old mill at the headwaters of Duffin Creek. The fishing unit consisted of three ponds located in series on the creek, the lower two ponds receiving additional cold water from springs and tributaries. The purchase in 1897 of upstream and other adjacent property gave control of the headwaters to the Club. The three original ponds with occasional renovations have continued to provide angling for a period of 65 years.

The speckled trout (*Salvelinus fontinalis*) is native to the watershed and has provided the fishery exclusively except for a brief experimentation with rainbow trout (*Salmo gairdneri*) stocked in the lowest pond. Plantings of 2,400 yearling rainbow trout were made in Pond C in 1936, 1938 and 1939. The stocking of hatchery-reared trout (brook and rainbow) was considered to be necessary for the maintenance of fish stocks in the ponds although some natural spawning was known to occur in the tributary streams feeding the ponds.

Records of the annual catches of trout by members and their guests are available since 1896, the first year of angling by the Club. These records represent the total harvest of trout from the ponds except for an unknown quantity of fish, presumable insignificant in numbers, removed by poaching. There were some restrictions on the method of angling during the earlier years but spinning gear was permitted in Pond C during 1960 to encourage the harvest of rainbow trout, which have continued to reproduce there in small numbers since their introduction between 1936 and 1939. Approximately 450 rainbow trout have been harvested from the pond since 1937.

MacCRIMMON, H. R., J. E. STEWART and J. R. BRETT. 1974. Aquaculture in Canada: The practice and promise. Fisheries and Marine Service, Department of the Environment. Ottawa, Ontario.

The earliest records of rainbow trout culture in Canada date back to 1887. From that point until 1973, there were 14 government and affiliated freshwater hatcheries in Ontario which were rearing rainbow trout.

MAGOULICK, D. D. and M. A. WILZBACH. 1997. Microhabitat selection by native brook trout and introduced rainbow trout in a small Pennsylvania stream. Journal of Freshwater Ecology 12(4) : 607-614.

Due to species introductions, brook trout *(Salvelinus fontinalis)* and rainbow trout *(Oncorhynchus mykiss)* occur together in many North American streams. Some have suggested that the two species do not compete because they select different habitats or are adapted to different environmental conditions. We assessed whether native brook trout and introduced rainbow trout selected different microhabitats in a small Pennsylvania stream. Underwater observations of brook and rainbow trout showed adult fish (≥90 mm total length) of both species were found significantly more often in deep water microhabitats than would be expected based on habitat availability. Total depth was the most important microhabitat variable in discriminating between the two species, irrespective of fish size. Adult rainbow trout were found in significantly deeper water than adult brook trout. Adult brook trout also were found significantly farther from cover and closer to the stream bottom than adult rainbow trout. Age-0 brook trout were found in significantly deeper water than age-0 rainbow trout. In small streams during low flow, water depth and distance to nearest cover are likely to be major factors in discriminating between brook and rainbow trout.

MacGREGOR, R. and H. MacCRIMMON. 1977. Meristic variation among world hatchery stocks of rainbow trout (*Salmo gairdneri*). Environmental Biology of Fishes 1 : 127-143.

Sixteen meristic characters were examined among 10 stocks of rainbow trout to establish their inter- and intrastock variability and relative discriminating power. The number of vertebrae, dorsal fin rays, scales above and below the lateral line, oblique scale rows and pectoral fin rays were found to be the most useful meristic characters in identifying stocks. Examination of the extent of meristic divergence among 10 hatchery or naturalized stocks from various regions of the world, using analysis of variance, the generalized distance function and percent overlap, revealed that each stock exhibited highly significant differences in at least one meristic character, thereby demonstrating a high degree of intraspecific variability in meristic expression.

In multivariate terms, stocks from Idaho and Alaska were almost totally divergent from all other stocks examined. Multivariate analysis of meristic features proves to be useful method for identifying the extent of phenotypic variability among and within divergent stocks of rainbow trout. The observed meristic variability in test stocks of hatchery fish is seemingly genetically set within the limits previously described for native populations of rainbow trout.

MacMANUS, J. S. 1950. Round Lake, Renfrew County, creel census survey, 1949. File Report, Ontario Department of Lands and Forests. Pembroke, Ontario. 2 p.

Round Lake originally supported a lake trout population. Yearling Kamloops trout were planted in the lake in 1948 with further plantings in 1949. They may have left the lake and gone up the inflowing creeks. A catch of two rainbow trout was recorded in the 1949 creel census. The fish were angled in Byers Creek quite a distance up from the lake.

MALHIOT, M. 1980. Trout creel census. File Report, Ontario Ministry of Natural Resources. Wingham, Ontario.

During the opening of the 1980 trout season, a creel census was conducted on selected waters of Wingham District to obtain quantitative information on the sport fishery. In addition to the streams which posses native populations of brook trout and migrant populations of rainbow trout, numerous ponds within the District are stocked annually by MNR to provide a put and take fishery. In 1980, 10,000 trout were stocked for this purpose, although only 40% of this stocking had been completed prior to the season opening.

The primary objectives of this census were to determine angler success (CUE), an estimate of fishing pressure and total harvest, and the origin of the angling population.

A similar census was conducted in 1979 which was of value for comparative purposes.

MALLET, J. L. 1965. Lake Pend Oreille Kamloops rainbow marking and recovery. Federal Aid Project F-32-R-6, Job Completion Report No. 3-b. State of Idaho Fish and Game Department. Boise, Idaho. 2 p.

Some 5,000 two year old Kamloops (12 to 14 inches in length, 1 pound in weight) and 944 three-year old Kamloops (16 inches in length, 2 pounds in weight) were marked with left ventral-adipose and left pectoral-adipose clips, respectively, and planted in Pend Oreille Lake in 1963. A total of 340 (36.9 percent) and 930 (18.6 percent) of the three-year olds and two-year olds, respectively, were recovered during their first summer in the lake. Growth of the fish averaged _-inch for the three-year olds and 1_ inches for the two-year olds during their first summer in the lake.

A total of 24 fish (13.4 inches in length, 1 pound in weight at planting), which had been marked and planted in 1962, were recovered in 1963. This produced a total of 20.0 percent recovery on these fish over a two year period. Growth was estimated at an average of 2.4 inches over this same period (fish were all caught in May and so growth is for one season).

An additional 12 fish (9 to 11 inches in length at planting), which had been planted in 1961, were recovered in 1963. This brought the total to 2.5 percent recovery on these fish by their third season in the lake. Average growth over this period was 5.0 inches (fish were all caught in May and so growth is for two seasons).

MALLET, J. L. 1967. Tests for increasing the returns of hatchery trout: Lake Pend Oreille Kamloops rainbow trout marking and recovery. Idaho Fish and Game Department. Boise, Idaho. 4 p.

MANITOBA DEPARTMENT OF NATURAL RESOURCES. 1988. A strategy for stocking fish in Manitoba. Fisheries Branch. Winnipeg, Manitoba.

Historically, rainbow trout have been the species most frequently requested by regional managers. Two year old rainbows are often preferred over yearlings. Although it is more costly to produce two year old rainbows these fish can generate more recreational benefits than yearling fish.

A total of 81,600 rainbow trout were planted in Manitoba waters in 1990. Over the past three years production has been revised toward the production of more older fish including two year olds. In 1990, 27,700 yearling trout were stocked and 53,900 two year old trout were stocked.

MARKS, D. R. 1979. Brook trout and rainbow trout test netting program, Ignace District, 1977 and 1978. File Report , Ontario Ministry of Natural Resources. Ignace, Ontario. 35 p.

During the summers of 1977 and 1978, a total of fourteen lakes were test netted in order to evaluate the brook and rainbow trout stocking program in the Ignace District. The program was conducted to determine the survival of planted fish, investigate signs of natural reproduction, examine growth rates of planted fish, determine changes in the species composition of the lakes, and assist in establishing a priority list of lakes to be stocked. Graduated gill nets were used. All nets were set overnight.

In Big Snowstorm Lake there appears to have been some survival of the 1978 planting of rainbow trout. These fish were planted in March 1978 through the ice. It is recommended that brook trout plantings be discontinued in favor of continued plantings of rainbow trout which generally give greater angler success.

Nine rainbow trout were captured in Little Norman Lake. The rainbow trout planted in 1977 appear to be doing well and show signs of good growth rate. Angling for rainbow trout over the last year has been quite successful. It is recommended that MNR continue to stock with rainbow trout yearlings every other year.

MARSHALL, T. L. and R. P. JOHNSON. 1971. History and results of fish introductions in Saskatchewan 1900-1969. Fisheries Report No. 8, Fish and Wildlife Branch, Saskatchewan Department of Natural Resources. Regina, Saskatchewan. 27 p.

Rainbow trout were first introduced from Alberta in 1924. Not until 1951 were a variety of strains from Alberta, British Columbia, Montana and Washington distributed extensively. Since 1951, 4.6 million rainbow trout have been stocked in Saskatchewan — more than triple that of brook trout and 30 times that of brown trout.

Nineteen of the 188 rainbow trout introductions have been to streams. Self-sustaining populations are established in four streams in the Cypress Hills. Stocking is recorded in two of these (Battle River and Belanger Creek) while the population in East and West Fairwell Creeks is attributed to migration or unrecorded stocking. Survival without reproduction is reported in portions of the Wood and Frenchman Rivers of the southwest. Between 1948 and 1952, 15 introductions to northern streams scattered in Nipawin Provincial Park and the Meadow Lake and Hudson Bay areas, were complete failures. Limitations of the more northernly stream environments would appear to include both the presence of predators and the rigorous winters.

The 99 standing waters into which rainbow trout have been introduced vary in surface area from 0.1 to 2,486 ha and in locations from Latitude 49… to 56…. Since 1952, survival has been recorded in approximately 35 ponds, reservoirs and lakes either rehabilitated or naturally devoid of pike, perch and walleyes. Although most waters lack significant spawning areas, spawning in two lakes has been observed over natural gravel shorelines or artificial cribs through which lake water was circulated. In all cases, embryonic development was curtailed by siltation and development of fungus. Failure of rainbow trout to survive in the remaining 54 water areas may be attributed primarily to winterkill or the presence of predators.

Lentic conditions successfully encountered by yearling and older rainbows include a pH range of 6.2 to 9.6 and an upper salinity of 1,690 ppm. While fry thrived at a TDS of 3,530 ppm in Nora Lake, Manitoba, they succumbed at a pH of 9.6 in a small reservoir near Willow Bunch, Saskatchewan.

The complete failure of natural reproduction necessitates maintenance plantings to provide a number of attractive sport fisheries. One such water in the mixed forest region is Piprell Lake which has a surface area of 99 ha, maximum depth of 20 m, a TDS of 183 ppm and endemic populations of northern redbelly dace (*Chrosomus eos*), fathead minnow (*Pimephales promelas*) and brook stickleback (*Culea inconstans*). A stocking program initiated in 1956 has produced a popular sport fishery realizing specimens weighing up to 8.2 kg. The most recent phase of rainbow trout propagation utilizes shallow, productive lakes and sloughs which annually winterkill. Introduced as fingerlings in May, growth is generally rapid enough to produce commercially saleable 15 to 25 cm trout prior to October freeze-up. Problems encountered in the differing physical and chemical environments include the harvest of a uniform sized product and the common attainment by trout of a muddy flavour.

MATKOWSKI, S. M. D. 1989. Differential susceptibility of three species of stocked trout to bird predation. North American Journal of Fisheries Management 9 : 184-187.

Piscivorous birds can remove substantial proportions of stocked salmonids from lakes. To determine whether susceptibility to bird predation differs among trout species, 321 brook trout (*Salvelinus fontinalis*) 330 rainbow trout (*Oncorhynchus mykiss*) and 321 splake (*S. namaycush* x *S. fontinalis)* were stocked in a small lake in Duck Mountain Provincial Park, Manitoba, in spring 1982. Principal avian predators were common loons *Gava immer* and great blue herons (*Ardea herodias*) which together averaged 1.5 visits per day to the lake from June through October. No post-stocking mortality was observed; the primary cause of mortality appeared to be birds. Intensive gillnetting in fall 1982 and spring 1983 produced 41 rainbow trout, 138 brook trout and 173 splake. The pelagic habits of rainbow trout make them most susceptible to bird predation; brook trout, which stay nearer the substrate, and splake, which prefer deep areas, would be more difficult for birds to see and capture.

MAXFIELD, G.H. 1958. Record of a hatchery-reared rainbow trout (*Salmo gairdneri gairdneri*) with three pelvic fins. Copeia 3 : 232-233.

On April 26, 1954 at the U.S, Fish and Wildlife Service Fish Cultural Station, Winthrop, Washington, a yearling rainbow trout was found which had three pelvic fins. In formalin it was 16.9 cm in total length. The third pelvic fin was located between the normally placed pelvic, and appeared to be normal in every respect. The pelvic girdle appeared normal in X-rays.

MAY, B. E., D. K. HEPWORTH, V. STAROSTKA and S. P. GLOSS. 1967. Impact of a threadfin shad introduction on food habits and growth of rainbow trout in Lake Powell, Utah. Proceedings of the Annual Conference of the Western Association of Game and Fish Commissioners 55 : 228-248.

Lake Powell, located on the Arizona-Utah border, has been stocked with rainbow trout since 1963. Fingerling plants have ranged from approximately 60,000 to in excess of 4,000,000 with the majority being introduced into the lower portion of the reservoir. Threadfin shad were introduced into lake Powell in 1968 and again in 1969. Rainbow trout were collected annually (1964 to 1975) by a variety of techniques. Stomach contents from 773 rainbow trout (157-656 mm total length) were examined.

Rainbow trout less than 300 mm fed predominantly on zooplankton during the period from 1964 to 1969. Zooplankton ranged from 71-95% of the total food volume. Cladocerans were the predominant planktonic organism in the diet of small trout prior to shad availability. Other planktonic food items, such as copepods and phytoplankton, were consumed to a lesser extent. Fish, primarily young-of-the-year green sunfish (*Lepomis cyanellus*) and bluegill (*Lepomis macrochirus*), were consumed occasionally by young rainbow trout.

Introduction and establishment of threadfin shad in Lake Powell as a new forage base markedly influenced diets and significantly increased growth of rainbow trout. Average lengths of trout sampled increased from 360 mm, prior to introduction of threadfin shad, to 470 mm after shad became established.

McAFEE, W. R. 1966. Rainbow trout. p. 192-215 *In* A. Calhoun [ed.]. Inland Fisheries Management. California Department of Fish and Game. Sacramento, California.

The rainbow trout (*Salmo gairdneri*) is the most widespread and popular California game fish. Rainbow trout are the dominant or co-dominant game fish in 658 natural lakes in California. They are self-sustaining in some but must be maintained or supplemented in others by artificial stocking. The most suitable lakes for rainbow trout are waters with accessible spawning tributaries and few or no competing fishes. Periodic plants of fingerlings or subcatchable-sized rainbow trout are necessary to maintain satisfactory angling in most coldwater reservoirs which range up to several thousand acres in size.

Wild rainbow populations cannot sustain themselves in small streams under heavy fishing pressure unless restrictive regulations are imposed so stocking catchable-sized fish is commonly done as an expedient measure. Planting small rainbow trout in streams usually gives poor results; on heavily fished Rush Creek, Mono County, for example only 3.2% of fingerlings planted and 8.3% of subcatchables were eventually caught by anglers.

McDONALD, D. 1972. An evaluation of planting catchable-size rainbow trout in the Elbow River, Alberta. Proceedings of the Great Plains Fisheries Working Association 1972. 27 p.

McKEE, A. C. 1984. 1983 summer creel census and stocking assessment program on seven artificial fisheries in the Owen Sound district. File Report, Ontario Ministry of Natural Resources. Owen Sound, Ontario.

A summer census and stocking assessment program was carried out on seven selected lakes and ponds within the Owen Sound district from June 13, 1983 to August 19, 1983 to determine the success of artificial stocking of domestic rainbow trout. Nine rainbow trout were harvested in 304 hours for a catch success of 0.029. The estimated harvest of rainbow trout was 287 representing 7.9% of the number stocked. Factors that could contribute to the low harvest are discussed.

McKEOWN, W. J. 1974. McConnell Lake creel census, 1971-1973. File Report, Ontario Ministry of Natural Resources. North Bay, Ontario. 52 p. + appendices.

The number of brook trout, rainbow trout and lake trout harvested from waters in the McConnell lakes area between 1971-1973, expressed as a percentage of the number of fish stocked during the same period averaged 17% for brook trout, 8% for lake trout and 3.2% for rainbow trout. Rainbow trout returns ranged from 0.2% to 9.1% of the numbers planted in six different lakes. Man hours of recreation for stocked rainbow trout ranged from 11.3 to 130.2 person hours per 100 fish stocked.

McMICHAEL, G. A., T. N. PEARSONS and S. A. LEIDER. Undated. Minimizing ecological impacts of hatchery-reared juvenile steelhead on wild salmonids in a Yakima basin tributary. Proceedings of the Sustainable Fisheries Conference. Ann Arbor, Michigan.

McNEILL, A. 1998. 1997 annual fish distribution report. Inland Fisheries Division, Nova Scotia Department of Fisheries and Aquaculture. Pictou, Nova Scotia.

Rainbow trout (*Oncorhynchus mykiss*) were first introduced in Nova Scotia in 1899. They have been widely stocked throughout the province since that time but other than in very localized areas, they have not become established in the wild. The rainbow trout fishery has been sustained through stocking efforts which have been somewhat sporadic over the years largely due to the availability of seed stock. In recent years, eggs from fall spawning rainbow trout from the USA and Ontario have been the source for the stocking programs. These stocks have been domesticated over many generations and perform well in the hatchery giving both good growth and survival rates. The majority of rainbow trout production is directed towards the release of yearling fish for the urban recreational fishery in lakes which have had a long history of rainbow trout stocking. Although distribution has been lower in recent years compared to the mid 1980s, stocking efforts in recent years have focused on producing a larger yearling fish for the put-and-take and trout derby programs.

One of the most successful rainbow trout fisheries in recent years appears to be in the Bras d Or lakes where tagging studies have indicated good growth rates and high return to the anglers creel. The winter of 1997 was the first year of an experimental winter fishery on selected inland lakes. In spite of poor ice conditions, this fishery was very popular and plans are underway to stock more late season rainbows in support of winter fisheries in selected lakes around the province.

A total of 365 lakes, rivers and streams were stocked with brook, brown and rainbow trout and landlocked salmon in 1997. Rainbow trout were stocked in six of eighteen counties in Nova Scotia in 1997. A total of 57,430 trout (13,160 kg) were stocked as yearlings.

McRAE, A. H. 1966. A catchable trout program s place in Alaska. p. 269-270 *In* Proceedings of the 46th Annual Conference of Western Association of Game and Fish Commissioners. Butte, Montana.

MENEZES, J., M. A., RAMOS, T. G. PEREIRA and A. M. DA SILVA. 1990. Rainbow trout culture failure in a small lake as a result of massive parasitosis related to careless fish introductions. Aquaculture, 89: 123-126.

This note describes an unsuccessful attempt to implement intensive trout culture in a small lake. The failure was due to epizootics of a parasite (*Argulus foliaceus),* a branchiuran crustacean, present in the local fauna, which probably was carried into the lake by introduced fish species originating from Europe at the end of the last century.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES. 1977. Fish stocking guidelines. Fisheries Division, Lansing, Michigan.

There are few stream situations in Michigan where populations of sizable resident (non-migratory) rainbows exist. The progeny of migrant rainbows (steelhead) rarely remain in streams long enough to produce fish of legal size (10) for the angler. Therefore, the stocking of rainbow trout in streams has limited application in management for a growth potential.

Rainbow trout are the major trout species for inland lake plantings. Newly treated trout-only lakes should be stocked as soon as detoxification is assured. Treatments should be completed early in the year (in summer where possible) so that newly planted fingerlings have a chance to grow before winter sets in. These lakes should be replanted with fingerlings (100/lb) annually thereafter in May or June. Two story lakes shall generally be maintained by production stocking of 7 inch (5/lb) yearlings in May and June at the rate of 25 fish/acre. In large oligotrophic lakes, larger (10/lb) fingerlings stocked in August may be substituted for yearlings.

MIKO, D. A., H. L. SCHRAMM, Jr., S. D. AREY, J. A. DENNIS, and N. E. MATHEWS. 1995. Determination of stocking densities for satisfactory put-and-take rainbow trout fisheries. North American Journal of Fisheries Management 15(4) : 823-829.

By developing a winter fishery for rainbow trout (*Oncorhynchus mykiss)* to complement an existing warmwater sport fishery, fishery managers can promote higher angler use by providing year-round recreational fishing opportunities. However, the high cost of providing harvestable-size rainbow trout coupled with limited hatchery production capabilities and limited funds available for hatchery expansion and fishery programs will limit the expansion of these successful programs. We evaluated three stocking densities of harvestable-size rainbow trout: low (700 trout/ha), medium (1,400 trout/ha), and high (2,100 trout/ha), to determine a stocking strategy that provides maximum fishery benefits from a limited number of fish. Catch rates were significantly higher for lakes with medium and high stocking densities. However, angler effort, proportion of stocked fish caught, angler fishing success rating, and angler trip satisfaction rating did not differ among shocking treatments. Despite catch rates of 0.5 trout/h, anglers rated fishing success less than fair and trip satisfaction less than good. Before a stocking strategy can be designed, a management goal must be set because no single stocking strategy proved superior for all management goals considered.

MILLER, R. B. 1958. The role of competition in the mortality of hatchery trout. Journal of the Fisheries Research Board Canada 15(1) : 27-45.

The literature on the survival of hatchery-reared trout after release in streams is reviewed and the conclusion is reached that survival is poor in lakes and streams where a resident trout population already exists. In streams the deaths of planted trout occur very soon after their release and have been referred to as delayed mortality . However, a comparison of survivals after planting in occupied and unoccupied streams shows that many of the deaths are not attributable to hatchery background or transportation methods, but largely to some aspect of competition with resident trout. Some investigations which have sought to measure the relative survivability of wild and hatchery trout have not used resident wild trout and thus a crucial aspect of the competition has been omitted. Investigations at the Alberta Biological Station test stream, Gorge Creek, are described; in these a significant difference in blood lactic acid levels was found between hatchery trout with and without competition from resident trout. A tentative role is assigned competition as follows: introduced trout must compete for niches and for food. In the early stages of this competition they are continuously exercising; they exhaust stores of some metabolite and die either of acidosis or starvation.

MILLER, R. B. and F. MILLER. 1962. Diet, glycogen reserves and residence to fatigue in hatchery rainbow trout. Part II. Journal of the Fisheries Research Board of Canada, 19(3) : 365-375.

Violent or prolonged exercise increased blood lactate content of hatchery-reared rainbow trout, confirming earlier findings. In stream tests, two groups of hatchery-raised rainbow trout were planted in a mountain stream containing a resident population of cutthroat trout. One group had been raised on a fortified pelleted ration, the other on the standard raw liver diet. In five weeks 7.1% of the pellet-fed fish were recovered dead or moribund, and 20% of the liver-fed fish. Adverse environmental conditions (high water) did not prolong the usual two-week acclimatization period for the pellet-fed trout, as shown by cessation of mortality at the end of that time. The liver-fed trout continued to die in appreciable numbers until three weeks had clasped. After the two week acclimatization period the pellet-fed trout accommodated to high water conditions as well as or better than the resident trout in respect to blood lactate level, whereas live-fed trout maintained a higher than normal lactate level. Ten hatchery-raised trout, 2 from the pellet-fed group and 8 from the liver fed group, were recovered from the stream in a moribund state. These had blood lactate levels four or more times as high as the non-moribund trout on the same date

MILLER, R. B. and R. C. THOMAS. 1957. Alberta s pothole trout fisheries. Transactions of the American Fisheries Society 86 : 261-268.

Scattered across the prairies and foothills of Alberta lie a series of warm, shallow, rich lakes and reservoirs that vary in size from 15 to 100 acres. These potholes are distinguished from the larger lakes of the province by their lack of inlets and outlets. Some contain northern pike and yellow perch; others have small cyprinids only, or cyprinids and sticklebacks; one contains yellow perch and sticklebacks.

The potholes without northern pike, when stocked in the spring with fry or fingerlings of rainbow trout, provide fishing for 13 to 16 ounce fish by fall and for two to three pound fish by the second summer. From the first two stockings, it is estimated that anglers recover roughly one-fifth of the total number and some sixty times the total weight of fish stocked. In the spring and fall the anglers catch about one fish per hour; during July to mid September angling is poor and from 12 to 20 hours are required to catch one fish. This poor fishing is attributed to warm surface waters and low oxygen concentrations in deeper waters.

Trout fry or fingerlings stocked in third and subsequent years grow poorly and survive in small numbers. This is believed to be due to competition with the population established by the first two stockings. The management problems are discussed and it is concluded that poisoning the whole population every three or four years and beginning again is the best procedure.

MILLER, R. R. and J. R. ALCORN. 1943. The introduced fishes of Nevada with a history of their introduction. Transactions of the American Fisheries Society 73 : 173-193.

At least 39 species and subspecies of fishes have been introduced into the waters of Nevada since 1873. Of these, 24 kinds are now known to occur in the state.

The stocking of cutthroat trout and rainbow trout in the same creek should be discouraged since these two species hybridize extensively and the cutthroat trout are speedily eliminated. A suggested practice would be to select separate streams when planting rainbow and cutthroat species, a procedure greatly simplified by the presence of many isolated creeks throughout the state.

MILLER, W. H., T. C. COLEY, H. L. BURGE, and T. T. KISANUKI. 1990. Analysis of salmon and steelhead supplementation: Emphasis on unpublished reports and present programs. Project No. 88-100, U. S. Fish and Wildlife Service. Ahsahka, Idaho.

Supplementation or planting salmon and steelhead into various locations in the Columbia River drainage has occurred for over 100 years. All life stages, from eggs to adults, have been used by fishery managers in attempts to establish, rebuild or maintain anadromous runs. This report summarizes and evaluated results of past and current supplementation of salmon and steelhead. Conclusions and recommendations are made concerning supplementation.

Hatchery rearing conditions and stocking methods can affect post-release survival of hatchery fish. Stress was considered by many biologists to be a key factor in survival of stocked anadromous fish. Smolts were the most common life stage released and size of smolts correlated positively with survival. Success of hatchery stockings of eggs and pre-smolts was found to be better if they are put into productive, underseeded habitats. Stocking time, method, species stocked and environmental conditions of the receiving waters, including other fish species present, are factors to consider in supplementation programs.

Our conclusions based on the published literature and the unpublished projects reviewed are as follows:

- Examples of success at rebuilding self sustaining anadromous fish runs with hatchery fish are scarce. We reviewed 316 projects in the unpublished and ongoing work. Only 25 were successful for supplementing natural existing runs although many were successful at returning adult fish.
- Successes from outplanting hatchery fish were primarily in harvest augmentation, a term we use to describe stocking where the primary purpose is to return adults for sport, tribal or commercial harvest.
- Adverse impacts to wild stocks have been shown or postulated for about every type of hatchery fish introduction where the intent was to rebuild runs.
- Re-establishing runs or introductions to areas not inhabited by wild/natural populations have shown good successes.
- The stock of fish is an important factor to consider when supplementing. The closer the hatchery stock is genetically to the natural stock, the higher the chances for success.
- Short-run stocks of salmon and steelhead have responded more positively to supplementation than longer-run stocks.
- Wild/natural fish have consistently shown a much higher smolt to adult survival rate than hatchery fish.
- Overstocking of hatchery fish may be a significant problem in many supplementation projects.
- The use of wild broodstock by British Columbia has shown success in their chinook and steelhead supplementation programs.
- Both Alaska and British Columbia are having some success using streamside incubation boxes and subsequent outplanting of fry.

Overall, we concluded that protection and nurturing of wild/natural runs needs to be a top management priority. There are no guarantees that hatchery supplementation can replace or consistently augment natural reproduction. For the Columbia River system, we concluded that all hatchery fish should be marked for visual identification. This will not only permit a more precise harvest management but also better broodstock management and supplementation evaluation. Currently, only hatchery steelhead are marked to identify hatchery fish.

We recommend that supplementation efforts in the northwest be annually summarized. There are several supplementation projects where future information will be of great benefit. All investigators are encouraged to evaluate the supplementation projects they are conducting and write up formal reports. We found a heavy bias toward not reporting negative or unsuccessful results.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES. 1982. Lake management planting guide. Fisheries Division Special Publication No. 132. St. Paul, Minnesota. 61 p.

Stream trout for lake management in Minnesota consists of brook, rainbow and splake trout. Lakes managed intensively for stream trout should be small (under 100 acres) at or near the top of the watershed and have an outlet which allows control over ingress of undesirable fish species. Water quality should be good and there should always be an adequate volume of oxygenated water under 70… F to support the trout population desired. Rainbow trout often do well in water a little too warm for brook trout or splake.

Stream trout stocked in Minnesota study lakes have usually shown good growth. With the exception of some marginal lakes, stream trout stocked at 100 to 300 per acre have not experienced slow growth.

Competition with or predation by other fish species is a common cause of trout mortality. Generally, fingerling trout stocked in waters containing northern pike, walleye, perch and various centrarchids suffer severe losses in the sub-catchable stage. Stream trout stocked as yearlings (about eight inches) have produced a fishery in spite of incompatible fish populations. However this is an expensive procedure and is generally not recommended.

MITCHUM, D. L. and L. E. SHERMAN. 1981. Transmission of bacterial kidney disease from wild to stocked hatchery trout. Journal of the Fisheries Research Board of Canada 38(6) : 547-551.

Natural, horizontal transmission of bacterial kidney disease (BKD) from infected wild brook trout (*Salvelinus fontinalis*) to newly stocked hatchery brook trout, brown trout (*Salmo trutta*) and rainbow trout (*Salmo gairdneri*) was shown in a small lake and stream system in southwestern Wyoming, USA. Stocked trout were infected naturally and died in 9 months or less after exposure to infected wild fish. Dead and live fish collected from each of three stations were necropsied. Fluorescent antibody techniques (FAT) were used to detect the BKD organism in all samples. Low severity infections were often detected by FAT at a higher rate when feces wee examined as compared to kidney tissues from the same fish. Because other know pathogens were essentially absent, BKD was diagnosed as the cause of all deaths in both stocked hatchery fish and wild fish. Rainbow trout were found to be the most refractory species.

MODDE, T., A. F. WASOWICZ, and D. K. HEPWORTH. 1996. Cormorant and grebe predation on rainbow trout stocked in a southern Utah reservoir. North American Journal of Fisheries Management 16(2) : 388-394.

We investigated post-stocking losses of rainbow trout (*Oncorhynchus mykiss)* to avian predation in Minersville Reservoir, Utah. Double-crested cormorants (*Phalacrocorax auritus)* and western grebes (*Aechmophorus occidentalis)* consumed 31.3% and 8.8% of the planted fingerlings in a 2-week period following stocking in April and June 1988, respectively. Piscivorous birds were associated both spatially and chronologically with fingerling trout in the reservoir. The birds consumed hatchery trout far more frequently than they did Utah chub (*Gila atraria*) which were abundant in the reservoir. Subadult rainbow trout and cutthroat trout (*O. clarki)* composed 75.0% of the diet, by biomass, of double-crested cormorants sampled. Double-crested cormorants removed more trout from Minersville Reservoir than did anglers.

MOFFETT, J. W. 1942. A fishery survey of the Colorado River below Boulder Dam. California Fish and Game 28(2) : 76-86.

Curbing of the rampant Colorado River by construction of Boulder Dam has formed a body of water of great magnitude in an arid desert region and changed the river itself below the dam. This paper provides a summary of data collected during a preliminary survey and formulates a tentative management plan for the fishery.

Discharged water from the lower levels is cold. During 1940 and 1941, it ranged in temperature between 54… and 57… F at the 900 foot level and between 55… and 61… F at the 1,050 foot level. At the time of this study, water volumes ranging between 27,000 and 35,000 cubic feet per second were flowing down the Eldorado Canyon stretch of the river. There are very few aquatic plants, with the exception of algae, in the Colorado River.

According to available stocking records the first rainbow trout were planted in the Colorado River below Boulder Dam on November 7, 1935. At this time, 25,000 four-inch fish were placed in the river just below the dam. Since stocking began, 21,000 six inch fish, 50,000 four inch fish and 148,000 fish one to two and one-half inches long have been introduced into the Colorado between the dam and Eldorado Canyon.

As long as angling pressure does not increase materially and natural reproduction remains an unknown quantity, stocking of 30,000 five to seven inch rainbow trout annually should more than adequately fill all fishermen needs. It is recommended that trout destined for this river be held in rearing ponds until they are 5-7 inches long.

MORING, J. R. 1976. Catchable rainbow trout evaluation. Federal Aid Project F-94-R, Oregon Department of Fish and Wildlife. Corvallis, Oregon.

MORING, J. R. 1978. An economic evaluation of small Oregon catchable trout fishery with means of improving the value through stock selection. Oregon Department of Fish and Wildlife. Corvallis, Oregon.

Mill creek is a tributary of the South Yamhill River, in the west-central portion of the Willamette Valley, Oregon. It is a typical stream representative of Oregon s catchable trout stocking program, and can be used as a case history of the economical aspects of an Oregon catchable trout fishery. Since 1974, an average of 5,138 legal-sized (> 15 cm) rainbow trout (*Salmo gairdneri*) have been stocked in the stream, from April to July. In that same time period, anglers have annually caught between 53.1 and 76.8% of the trout stocked. The stocking has generated between 3,689 and 6,226 angler-days of recreation. Based on the currently utilized value of $10.60/day for resident trout (development in the state of Oregon), this stocking program generates a trout fishery averaging $47,676. The cost of producing these fish during 1974-1977 averaged $3.85/kg ($1.75/lb). Based on the breakdown of average sizes of fish released, this results in an average annual expenditure of $3,372. The gross benefit/cost ratio for recreation value: production cost for this fishery is a high 14.1:1 annually.

There are several means of improving this ratio further, primarily by selection of more efficient stocks. A series of field experiments on two streams have indicated the most commonly stocked rainbow strain in western Oregon (Roaring River) exhibits significantly higher (95% confidence limits) downstream movement patterns than the commonly stocked strain in Washington (Cape Cod). The value of the loss of recreational days from fish leaving the planted area may exceed $12,900. A conversion of stocking strain from Roaring River to Cape Cod (also demonstrated to result in higher catch rates at 95% confidence limits) could increase the benefit/cost ratio to 18.0:1.

The high benefit/cost ratios of stocking in this typical Oregon stream fishery economically support policies of catchable stocking in high-demand waters. Although these data accurately apply only to this one stream case history, the value generated by Oregon s stocking program (2.4 million annually), by implication, is much higher than generally assumed.

MORING, J. R. 1979. Changes in catch rates following reduction of trout stocking density in five Oregon streams. Oregon Department of Fish and Wildlife. Corvallis, Oregon. 9 p.

The research objective was to assess changes in catch rates and percentage return on five Willamette Valley streams in response to a programmed reduction in numbers planted. Five Willamette Valley streams were selected for density studies and stocked with catchable rainbow trout. Stocking began prior to opening day in April 1975 and 1976 and continued until late June in both years. On each planting date, there were 25%

fewer trout planted in 1976 as in 1975. To evaluate fishing pressure and success, creel surveys were conducted on all streams.
In light of the decrease in density of fish planted, the numbers of anglers rose on two streams from 1975 to 1976 but declined on the other three streams. It was also noted that fishermen were less likely to catch their limit (10 fish) and more likely to be unsuccessful at catching any fish although the differences were not statistically significant at the 95% level. In almost all cases, the proportion of fish caught remained approximately the same over the two years despite a 25-50% reduction in the numbers planted.

The data appear to indicate a reduction in fish stocked of 25% or 50% in the case of the Middle Fork of the Willamette River, has no significant effect on the proportion of fish caught. Therefore, stream management policies setting minimum return goals for stocking should, in most cases, be unaffected by a 25% reduction in numbers stocked.

MORING, J. R. 1982. An efficient hatchery strain of rainbow trout for stocking Oregon streams. North American Journal of Fisheries Management 2(3) : 209-215.

Increased costs of raising and stocking trout threaten many catchable trout programs, because benefit to cost ratios are declining and budgetary constraints further limit the number of fish that can be stocked. Varieties of cultured rainbow trout (*Salmo gairdneri*) differ in efficacy in a hatchery situation, but their comparative performance in the wild is little known. A case history is presented of creel survey and migration studies conducted in Mill Creek, a popular angling stream in the Willamette Valley, Oregon, to identify cost- and performance- effective trout strains for catchable trout stocking programs. One variety, Cape Cod, comparatively recent to the state, yielded significantly better results (higher catches and less out-migration) than the other two varieties, Roaring River and Oak Springs, and a change in management policy for trout stocking was implemented.

MORING, J. R. 1993$_a$. Records of long range, downstream movements of stocked rainbow trout (*Oncorhynchus mykiss*). Fisheries Research 16(2) : 195-199.

The Cape Cod, Roaring River and Oak Springs strains of rainbow trout (*Oncorhynchus mykiss*) are highly domesticated; fertilized eggs have been distributed both throughout the western United States and also to other countries. Analyses of tag recapture data indicate that 22% of Roaring River trout moved at least 12 km downstream, some as far as 84 km within four days; 11% of the Oak Springs and 7% of the Cape Cod strain fish moved at least 12 km downstream.

MORING, J. R. 1993$_b$. Effect of angling effort on catch rate of wild salmonids in streams stocked with catchable size trout. North American Journal of Fisheries Management 13 : 234-237.

Angler catches of wild salmonids including cutthroat trout (*Oncorhynchus clarki*), rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka)* and bull trout (*Salvelinus confluentus*) changed in direct responses to changes in angler effort during two or more years on three of four Oregon streams stocked with rainbow trout. Percentages of wild fish in the catch were highest in the smallest streams (overall range 3-19%). Increased catchability of wild salmonids may be due to synchronous behavior in the presence of stocked fish, but this was not tested in this study. There are, however, direct links between stocking of legal size rainbow trout in streams, changes in angler effort, and harvest of wild populations.

MORING, J. R. and D. V. BUCHANAN. 1978. Downstream movements and catches of two strains of stocked trout. Journal of Wildlife Management 42(2) : 329-333.

Downstream movements and angler catches of two strains of planted yearling rainbow trout (*Salmo gairdneri*) were monitored for two years in a small Oregon stream, Mill Creek. The Roaring River strain showed a tendency for rapid downstream movement, while the Cape Cod strain tended to remain in the planted area for a longer period and were also caught in higher numbers. As many as 37.2% of the Roaring River trout moved out of the stream compared to a maximum of 18.2% of the Cape Cod trout.

MOTTLEY, C. M. 1941. The effect of increasing the stock in a lake on the size and condition of rainbow trout. Transactions of the American Fisheries Society 70 : 414-420.

An investigation in the changes in length, weight and the length-weight relationship of rainbow trout from Paul Lake, British Columbia, is presented. As a result of the management policy adopted in 1931 the stock in the lake increased from 1932 to 1935; at the same time both the length and weight decreased significantly as evidenced by representative samples of yearling and 2-year old fish. A valid method of comparing the length-weight relationship is presented. The findings indicate that, although significant fluctuations occurred, and there was a significant decrease in the condition of the first fish planted when they reached 2 years of age, the factors involved require further study. A recommendation for modifying the stocking policy for depleted waters is given.

MUCKENHEIM, O. 1987. The effectiveness of the rainbow trout stocking program in Oastler Lake — A personal assessment. File Report, Ontario Ministry of Natural Resources. Parry Sound, Ontario. 8 p.

In May, 1987, three thousand and two hundred rainbow trout were planted in Oastler Lake. One thousand fish had a mean weight of approximately 45.4 grams and two thousand two hundred fish had a mean weight of approximately 245.0 grams. The purpose of this stocking was to provide immediate, short term recreational fishing opportunities on a put-and-take basis. This report provides a personal assessment of the success of the program based on the author s contact with Oastler Lake Provincial Park users and residents of the area as well as personal angling success.

Verbal responses to the stocking program was very positive but written responses to a survey was poor. Angler success for rainbow trout was primarily determined by three factors: the time of year; the availability of a boat; and whether rainbow trout was the species being targeted. Angler success was highest in the spring of the year, for those anglers fishing offshore using a boat, and by those anglers who were using techniques which targeted rainbow trout.

It is my estimate that approximately 200 rainbow trout in the 245 gram range were harvested. This is about 9.1% of the fish stocked in this size range. I would also estimate that less than 50 trout in the 45.4 gram range were taken for a harvest of 5.0% of the stocked fish in this size class. In total, approximately 7.8% of the stocked trout were harvested between the time of stocking and mid September, 1987.

The availability of rainbow trout (spring) and the greatest abundance of camp users (e.g., summer) do not coincide. Although the fishing opportunities and the actual harvest of rainbow trout were limited, the stocking program is still a definite asset for the short term recreational fishery. The public relations benefits for Oastler Lake Provincial Park have been excellent. Rainbow trout stocking should continue in Oastler Lake on a short term basis using only fish greater than 30 cm in length.

MUELLER, J. W. 1975$_a$. Survival and growth of spring and fall variety advanced fingerling rainbow trout in Fool Creek, Sheridan County. Project No. 3075-14-7301. Wyoming Game and Fish Department. Cheyenne, Wyoming.

About 1,800 spring rainbow at 54.2 per pound (3.5 inches) were stocked in Fool Creek in August, 1973. About 2,200 fall rainbow at 45 per pound (3.6 inches) were stocked simultaneously. Total planting density in the 7.5 miles of stream was 540 trout per mile (242 per mile of the spring variety and 298 per mile of the fall variety). One year after planting, 54.5 percent of the population (228 per mile) were spring rainbow and 45.5 percent (190 per mile) were fall rainbow. Two years after planting, 50.7 percent (95 per mile) of the population were spring rainbow and 49.3 percent (92 per mile) were fall rainbow. Survival from 1974 to 1975 was 41.6 percent for spring rainbow and 48.5 percent for fall rainbow. In 1974, spring rainbow averaged 6.3 inches and 0.12 pounds. They averaged 7.6 inches and 0.20 pounds in 1975. In 1974, fall rainbow averaged 6.3 inches and 0.10 pounds. They averaged 7.8 inches and 0.23 pounds in 1975. Growth and survival rates of spring and fall rainbow trout to the second year were similar, therefore, information to date indicates that fall rainbow are as effective as spring rainbow in establishing a fishery.

It is recommended that the four electrofishing stations be monitored in 1976 to collect length, weight and survival data to the third year. A check in 1977 is suggested to determine longevity of the two variations.

MUELLER, J. W. 1975$_b$. Comparison of the catchability by angling of spring and fall variety rainbow trout, Tass Reservoir #2, Johnson County. Project No. 3074-14-7401, Wyoming Game and Fish Department, Cheyenne, Wyoming.

The objectives of this study were to determine the catchability by angling of two varieties stocked as sub-catchables and compare harvestability of the two varieties with fin clips compared to mass marked fish.

Tass Reservoir #2 was stocked on October 8, 1974 with 620 spring rainbow trout (17.7 per pound) and 620 fall rainbow trout (15.7 per pound) for a density of 200 fish per acre. Half of the spring rainbow trout were marked by removing the right pelvic fin and the remainder were mass marked with Day-Glow red pigment. Half of the fall rainbow trout were marked by removing the left pelvic fin and the remainder were mass marked with Day-Glow yellow pigment.

Seventy-one rainbow trout were caught by angling. Twenty-seven (38%) were spring rainbow and 44 (62%) were fall rainbow. Fifty-two percent of all fish caught were finclipped and 48% were spray marked. There were no differences in growth rates within varieties regardless of marking methods. The average weight of fall rainbow (0.53 pounds) was significantly greater than the average spring rainbow weight (0.42 pounds) and a highly significant difference existed between condition factors for fall rainbow (39.3) and spring rainbow (35.3) Analysis of 18 spring and 25 fall rainbow trout stomachs indicated both varieties fed on similar organisms during the summer months.

MUELLER, M. E. 1985. Field evaluation of four strains of rainbow trout (*Salmo gairdneri)* M. Sc. Thesis, Montana State University. Bozeman, Montana. 61 p.

The performance of four strains of rainbow trout (*Salmo gairdneri)* was evaluated under field conditions. Data on field performances of specific strains is needed in order to best utilize a particular fish in a natural environment. Growth, catchability and longevity data were collected in the field by a summer-long creel survey. Fish from each strain were stocked at equal densities in two ponds near Three Forks, Montana, for a replicated field evaluation The Winthrop strain had the highest catchability followed by Arlee, Erwin and DeSmet. The Desmet strain and the Winthrop strain appeared to remain in the fishery longer, being found in the highest proportions in population estimates taken 5 months after termination of the creel survey.

MUELLER, J. W. and L. PETERSON. 1972. Walleye predation on planted rainbow trout, Keyhole Reservoir. Project No. 03-06-371, Wyoming Game and Fish Commission. Cheyenne, Wyoming.

Rainbow trout have been planted in Keyhole Reservoir since the spring of 1965. Trout planted ranged from small fingerlings to large catchables and planting times have varied from April to October. Substantial plants of rainbow trout have failed to provide an acceptable trout fishery.

In June, 1966, walleye stomachs were analyzed to determine predation of fingerling trout that averaged 44 per pound. Forty-one percent of the stomachs contained one to seven after the first day of planting. One hundred percent of the walleye examined after the second day of planting contained one to four trout. This report deals with fall predation on sub-catchable rainbow trout.

Gill netting to determine walleye predation on recently planted rainbow trout was conducted on October 3 and 4, 1972. Over 58,000 rainbow trout that averaged 7.4 per pound (6.9 inches) were distributed by barge throughout the reservoir. Two 125 foot and two 150 foot experimental monofilament gill nets were set overnight (19 hours) following the first day of planting. Two 150 foot gill nets were set a total of 2.5 hours the afternoon following the second trout plant scheduled. This plant is scheduled to be eliminated if a northern pike fishery is established.

Predation by walleye on recently planted rainbow trout indicated that 14% of the walleye stomachs sampled contained trout after the first day of planting. Twenty-seven percent of the walleye stomachs contained trout after the second day of planting. Walleye predation on planted trout is probably greater than indicated by limited sampling but appears less on seven per pound trout in October than on 44 per pound trout in June.

MUELLER, J. W. and L. C. ROCKETT. 1961. Effect of harvest, migration, and stocking on rainbow trout spawning potential in a Wyoming lake. Transactions of the American Fisheries Society 91 : 63-68.

Spawn taken annually from trout entering the inlet ditch at Lake DeSmet constitutes Wyoming s primary source of rainbow trout eggs . The number of eggs taken has fluctuated between 500,000 and 4,000,000. In 1957, this study was begun to determine the influences of winter and spring sport angling, planting policies, and rainbow trout life history on the annual spring spawning run. The effects of planting rainbow trout of spring and fall races and locations of plants were studied from marked fish. Rainbow trout of the spring spawning race entered the spawning run in an 11 to 1 ratio over the fall spawning strain. Rainbow trout planted in the inlet ditch returned in a 3 to 1 ratio over trout planted in the far end of the lake.

Anglers harvested marked trout randomly from all portions of the lake regardless of the planting location. Trout apparently migrated to the spawning trap from all portions of the lake. Rainbow trout were shore trapped when they appeared on shoal areas in the spring. Ten percent of the adult trout shore trapped and tagged migrated to the inlet ditch and spawning trap. Seventeen percent of the female rainbow trout which entered the trap in 1957 returned in 1958 to make up 13 percent of the female run. The bulk of the spawning run is made up of fish spawning for the first time.

Winter and spring (January to June) creel census during 1958, 1959 and 1960 indicated harvest of rainbow trout was not large enough to seriously affect the spawning run. Between two and four trout per surface acre were harvested. Present angling regulations have little affect in restricting the catch during the winter and spring, as only two percent of the winter and spring anglers made limit catches.

Planted trout must be at least four inches long (forty per pound) to escape predation by yellow perch. An annual plant of 500,000 spring spawning rainbow trout appears sufficient to maintain the rainbow trout population. At least 40,000 of these fish should be planted in the inlet ditch to insure an annual take of 2,000,000 eggs.

MULHOLLAND, H. C. 1969. Construction of artificial trout spawning beds at Bass Lake, Simcoe County. File Report, Ontario Department of Lands and Forests. Midhurst, Ontario.

Rainbow trout have been planted in Bass Lake, Oro Township, Simcoe County, since 1962, first, as one-year old trout, then as two year olds. As a result of these plantings, rainbow trout were seen, in the spring of 1968, attempting to spawn in the very limited facilities, in one of the small inlet creeks flowing into Bass Lake. These trout appeared in large enough numbers to warrant the building of spawning beds in a portion of this creek, an attempt to produce some natural regeneration in the lake.

MULLAN, J. W. 1956. The comparative returns of various sizes of trout stocked in Massachusetts streams. Progressive Fish-Culturist 18 : 35-38.

During the year 1954, slightly less than one million legal-sized trout (6 inches plus) were distributed to public fishing waters. Approximately one-half million of these were in the 6-8 inch class and averaged less than 7 inches in total length. These were planted in streams on a put-and-take basis. By cutting the numerical stocking rates by one-third and stocking a similar poundage of 8 inch plus fish, the same numbers of trout could be harvested by the angler but the creel weight would be increased by 33%. This is predicated in terms of yearlings only and would necessitate artificial inducement of early spawning by light manipulation and the holding of the groups of smaller fish for in-season stocking at larger sizes. These procedures would reduce the mortalities produced by stocking smaller trout during that period of high water which normally precedes the trout season in Massachusetts.

MURPHY, G. I. 1962. Trout survival in Taylor Creek, a tributary of lake Tahoe, California. California Fish and Game. Sacramento, California.

During the summer of 1940, a short-term experiment on trout survival was conducted in a 295-foot section of Taylor Creek, tributary to the southwest end of Lake Tahoe, California. A minimum of 10.6 percent of 500 hatchery rainbow trout fingerlings survived after a month in the stream. Wild rainbow trout-of-the-year had an 11.7 percent survival. One month of some summer is not enough time to reach definite conclusions on young hatchery trout survival. However, a low survival is indicated where competition and predation are as great as they were here, and shade and shelter are limited.

Late summer and early fall seem to be extremely critical times in the life histories of many fishes. The mortality of *Richardsonius* was very high, large numbers of *Catostomus*-of-the-year suddenly moved upstream, enormous numbers of *Richardsonius* seemed to move toward Lake Tahoe, and trout-of-the-year started to move upstream at the end of August, when the water level was dropping.

MURRAY, C. A. and C. D. ZIEBEL. 1984. Acclimation of rainbow trout to high pH to prevent stocking mortality in summer. Progressive Fish-Culturist 46(3) : 176-179.

Rainbow trout (*Salmo gairdneri*) were exposed to gradual and rapid increases in pH to determine if they would acclimate to values above 9.0. The trout became acclimated to a pH of 9.8 when they were exposed to gradual increases over a period of 5 days. When trout were exposed to an increase of pH to 9.5 in 6 hours, marked stress and 50% mortality occurred. However, when the pH increase was to 9.3 in 6 hours, the trout only had temporary loss of appetite.

MYERS, G. L. and J. J. PETERKA. 1976. Survival and growth of rainbow trout *(Salmo gairdneri)* in four prairie lakes. North Dakota. Journal of the Fisheries Research Board of Canada 33 : 1192-1195.

Survival of rainbow trout *(Salmo gairdneri)* in three North Dakota prairie lakes was low the 1st month after stocking ranging from 15 to 54%; high mortality may have been due to bird predation. In the fourth lake, where 77% survived the 1st month, no predatory birds observed . All fish in two lakes died in August when dissolved oxygen levels dropped to below 1.0 mg/liter following July blue-green algae blooms of 28 and 63 mm^3/liter. In the other two lakes, harvests in October ranged from 0.1 to 4.4% of fish stocked. Mean wet weights at harvest of up to 272 grams were sufficient for commercial use; however, special management to improve survival rates would be necessary in the lakes studied.

NEEDHAM, P. R. 1959. New horizons in stocking hatchery trout. p. 395-407 *In* Transactions of the 24th North American Wildlife Conference. New York, New York.

This paper summarizes the returns from more than 244 separate trout planting experiments. After thirty years of investigation I think it is time that fisheries workers came to a few general conclusions with regard to planting of hatchery trout:

- Lake plants of fingerlings made at all seasons. Creeled fish averaged 7.4% of the numbers planted and ranged from 0.06-36.4%.
- Lakes plants of legal-sized trout made at all seasons. Recoveries of stocked fish ranged from 1.1-88.4% and averaged 34.5%.
- Stream plants of fingerlings made at all season. The average recovery rate is 2.5% from 21 experiments ranging from 0.0-14.0%. One experiment in Oregon is of interest in connection with the planting of fingerlings in cold mountain streams. A plant of 30,363 marked 3-4 inch rainbow trout fingerlings was made in the Clackamas River near Portland, Oregon, in the fall of 1946. Just nine fish (0.3%) returned from this plant. The cost of rearing the entire lot had to be charged against this which brought the cost to $28.53 per fish.
- Stream plants of legal-sized/catchables made in advance of the angling season. In the 54 experiments reported, an average recovery rate of 28.6% was determined (range 2.6-82.0%). Twenty-four of the 54 experiments produced returns of less than 20%.
- Stream plants of legal-sized/catchables made during the open angling season. These experiments yielded the highest average return rate of 41.3% (1.0-92.2%) from 68 tests. Twenty-six of the 68 tests gave returns of less than 30%.
- Stream plants of legal-sized/catchables made after the close of the season. The mean rate is 16.8% (0.2-88.6%) from 31 experiments. These findings, with others, confirm the fact that over-winter carryovers of stocked trout are negligible.
- Approximately 10 percent of the anglers catch over 50 percent of the catchable trout. A way to obtain a better distribution of catchable trout is to plant them in lakes.
- 10-30% of hatchery trout die immediately after planting. Where resident trout populations are already present in the streams, losses of hatchery trout are often immediate and heavy. This might result from competition with wild trout for living space or niches rather than for food, forcing the introduced fish to constant, excessive exercise resulting in death by either acidosis or starvation.

NEEDHAM, P. R. 1969. Propagation, stocking and protection. p. 154-179 *In* Trout Streams: Conditions that Determine their Productivity and Suggestions for Stream and Lake Management. Winchester Press, New York, New York.

The place where large trout should be planted depends on the intensity of the angling. The problem of whether to plant legal-sized trout in spring or fall has caused considerable discussion in recent years. Discussion has arisen especially with regard to the planting of rainbow trout because these fish are generally known to be more migratory than eastern brook trout or brown trout. It is important that the migratory habits of any given strain of trout be carefully considered in connection with both times and places of planting. Aside from the migratory instincts of the fish to be planted two other problems of importance with regard to time of planting must also be considered: (1) the added costs of holding large fish in hatcheries over the winter for spring planting; and (2) losses of fall-planted compared to spring-planted trout. Recommended sizes of rainbow trout for planting may be summarized as follows:

(1) Advanced fry to 2 fingerlings — Planted in smaller tributaries of streams preferably with unobstructed access to deep, cold lakes or the ocean. Also can be used to stock lightly fished streams with ample shelter.
(2) 3 -5 fingerlings — Moderately and heavily fished lakes and streams preferably with access to deep cold lakes or the ocean; wide rugged mountain streams.
(3) 6 or larger yearlings or older — Large streams and lakes which are heavily fished. Preferably white water mountain streams near recreation centers or large cities and towns.

NEEDHAM, P. R. and R. J. BEHNKE. 1962. The origin of hatchery rainbow trout. Progressive Fish Culturist 24(4) : 156-158.

Rainbow trout (*Salmo gairdneri*) have been propagated for almost 83 years in hatcheries in the United States. Trout for breeding purposes were taken from both the tributaries and the main channel of the McCloud River. The large (8-10 pound) coarse-scaled trout of the McCloud probably represented the steelhead and the fine-scaled trout in the tributaries were most likely resident fish. From the circumstantial evidence, it seems highly probable that the original Shasta rainbow of fish culture fame had a large measure of steelhead influence in its heredity and did not represent a strictly resident trout from the tributaries and the anadromous steelhead from the main stream. The original hatchery rainbow trout taken from the McCloud River, California, has since been crossed with many other strains and selectively bred for hatchery conditions until no present day hatchery rainbow trout truly represents the original McCloud River type.

NEEDHAM, P. R. and D. W. SLATER. 1944. Survival of hatchery-reared brown and rainbow trout as affected by wild trout populations. Journal of Wildlife Management 8(1) : 22-36.

The survival of 63 experimental plantings of fingerling brown and rainbow trout under controlled conditions is reported for five seasons, 1939 to 1942, inclusive, at Convict Creek, California.

A method is described for the analysis of the effects of competition by wild trout on the survival of planted fish; this embodies a food ratio that is shown to correlate with observed survivals.

A gross survival of 63.7 percent was obtained for brown trout fingerlings, from 1.25 to 1.56 inches in total length. Larger rainbow fingerlings, 2.88 to 3.72 inches, under more severe competition, had a gross survival of 46.6 percent. Other rainbows, of 1.32 to 1.69 inches, gave a gross survival of 44.2 percent. These results were obtained in experimental periods of 89 to 151 days.

Plantings of fingerlings are largely ineffectual in streams containing numerous wild trout, since competition and predation prevent any significant survival.

Natural propagation adds large numbers of fish to stream stocks annually.

The bearing of these findings on the stocking of streams is discussed.

NEEDHAM, P. R. and D. W. SLATER. 1945. Seasonal changes in growth, mortality and condition of rainbow trout following planting. Transactions of the American Fisheries Society 73 : 117-124.

The results of experimental plantings of rainbow trout in Convict Creek (California) are presented as related principally to changes in growth, mortality, and condition, from month to month over two summer seasons. Survivals are discussed in relation to a food requirement ratio that has been shown to correlate positively with survival rates obtained.

Survivals of 33% and 56% were obtained over periods of 151 days and 179 days, respectively. Wild fish grew approximately twice as fast as planted fish each season. The coefficient of condition of the planted rainbow trout fell consistently for the first few months following planting. A parallel loss in condition of wild trout occurred but was less marked. Conditioning of hatchery trout for from 1 to 3 weeks prior to planting had no appreciable effect on survival rates.

NEEDHAM, P. R. and J. P. WELSH. 1953. Rainbow trout (*Salmo gairdneri*) in the Hawaiian Islands. Journal of Wildlife Management 17(3) : 233-255.

Rainbow trout were first introduced to the Hawaiian islands in 1920 when 34,500 fry and 4,000 eggs were planted. Heaviest annual plants were made in 1928 when 46,000 additional eggs were imported and in 1941 when 48,000 fry were secured. In the former year the eggs were planted in the waters of Hawaii, Maui, Molokai, Oahu and Kauai while the fry of the latter year were all planted in waters of the Kokee area on Kauai. Evidently, in the period between 1928 and 1941, it was becoming evident that best results were being obtained on Kauai and all later imports were stocked in the waters of this island. No trout of any species have been planted since 1941. According to records of the Division of Fish and Game, total imports since 1920 were 146,000 rainbow eggs and fry.

Rainbow trout are growing and reproducing satisfactorily only in the upper streams of the Kokee area on the island of Kauai. Many attempts have been made to establish trout but they have failed in most streams on both Kauai and Maui which have excellent growing temperatures but which evidently lack a sufficiently long period of cold water each winter to permit proper development of the gonads and the production of viable ova. A thorough study of winter water temperatures should be made in relation to gonad development and spawning of rainbow trout. Selective breeding of the Kokee strain of rainbow trout is suggested to secure a better adapted fish for Hawaiian waters.

Approximately 90% by number of foods utilized by trout on Kauai are terrestrial in origin. Dominant forms were angleworms, millipedes, red shrimp and isopods. Dominant aquatic foods were midge larvae (Chironomidae), dragonfly nymphs and aquatic damselfly nymphs (Odonata).

NEILSEN, L. A., W. T. KENDALL and L. A. HELFRICH. 1978. Comparison of angler use and characteristics at three catchable trout in fisheries in Virginia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 34 : 330-340.

Creel census data for three catchable trout fisheries in Virginia revealed that desirable attributes of the fisheries increased from a lightly-stocked stream to a lightly-stocked lake to a heavy-stocked stream. Total effort, participation by non-local anglers, evenness of seasonal use, catch rate, and return rate all were higher for the heavily-stocked stream than for the lightly-stocked stream. For the trout lake, total effort and participation by non-local anglers were similar to the heavily-stocked stream, but catch-per-effort, return rates of stocked fish, and seasonal distribution of effort were similar to the lightly stocked stream. Most anglers at the lake fished from shore, so that a large portion of the potential fishing area was not utilized. Management of catchable trout fisheries may provide higher fishing value if streams are managed so that stocking density, stocking frequency, accessibility of angling, publicity, and opportunities for associated outdoor recreation are maximized.

NELSON, W. C. 1960. A comparison of the effects of the removal of the adipose and pelvic fins on fingerling brook and rainbow trout. File Report, Colorado Department of Game and Fish. Denver, Colorado. 15 p.

Groups of 302 adipose (Ad) clipped, 300 left ventral-right ventral (LVRV) clipped, and 443 unmarked rainbow trout were held for 5.5 months at the Bellvue Hatchery, Colorado. Percent survivals and (in parentheses) Su/Sm were Ad, 71 (1.10); LVRV, 66 (1.18); and unmarked 73 (-). These differences are not significant. Similar results were also recorded for brook trout marked and held under the same conditions.

NELSON, W. C. 1987. Survival and growth of fingerling trout planted in high lakes of Colorado. Technical Publication No. 36, Colorado Division of Wildlife. Denver, Colorado.

Experimental stocking schedules for aerial (fixed wing) plants of fingerling (mean length 47-73 mm or 2-3 inches) trout made in July and August were tested for three species in 35 high elevation lakes in Colorado over the period from 1967 to 1984. The schedules specified stocking rates that decrease exponentially with linear increase in elevation of a lake (e.g., from 200 trout/acre (500/ha) at 8,000 feet (2,400 m), to 40 trout/acre (100/ha) at 13,000 feet (4,000 m) for lakes receiving moderate fishing pressure (10-100 trips/acre/year or 25-250 trips/ha/year). Following planting, the lakes were sampled one or more times by means of graduated mesh gill nets which caught fish from 5 to 21 inches (12 to 54 cm) effectively. Results are evaluated primarily in terms of trout growth and survival rates.

Regressions (2^{nd} degree polynomial) fitted to trout lengths at planting and in successive years thereafter differ significantly among species in a given plant or lake, among different plants of the same species in a given lake, and among plants of the same species in different lakes in the same year. However, the fitted curves show a similar pattern for most plants — increase in length at a decreasing rate, usually culminating in a peak length followed by a decrease. Domestic strain rainbow trout grew faster than wild type rainbow trout, cutthroat trout or brown trout. However, the wild type trout lived longer and eventually reached the same or greater size. Domestic strain rainbow trout planted at a larger size (65 mm or 2.6 inches) had a somewhat greater growth rate than did those planted at a smaller size (55 mm or 2.2 inches). Trout from most plants of fingerlings reached catchable size (23 cm or 9 inches) in their second year and quality size (36 cm or 14 inches) in an additional 1-3 years. Sex ratios of recovered trout did not differ significantly from 1:1. Length-weight relationships varied significantly among species, plants and lakes; but the differences were of little practical significance. Body length-scale relationships differed significantly between some of the species and plants. Mean back-calculated lengths differed at some annuli between species and plants. Growth rate regressions fitted to back calculated lengths at annuli differed somewhat from those fitted to lengths at capture. Annual survival rates differed significantly among trout species and among some of the plants. The rate varied from 0.2 to 0.6 for rainbow trout, 0.7 to 0.8 for brown trout, and was 0.6 for cutthroat trout. Mean survival rate of rainbow trout in one lake increased by 50% following imposition of a flies and lures only regulation.

The experimental stocking rates gave satisfactory results in terms of trout growth rates, but some modifications for management purposes may be desirable. Annual plants are recommended for domestic strain rainbow trout but alternate year plants may suffice for wild type trout of all three species.

NEMUTH, M. L. and P. W. BETTOLI. 1998. Survival and population size of rainbow trout and brown trout in the south Fork of the Holston River, Tennessee. *In* Proceedings of the Midyear Meeting of the Southern Division of the American Fisheries Society, Lexington, Kentucky. (Abstract Only)

The south Fork of the Holston River in east Tennessee last year received over 900 hours per hectare of fishing pressure. The 20 mile tailrace is stocked annually with about 72,000 catchable rainbow trout (*Oncorhynchus mykiss*), 11,000 brown trout (*Salmo trutta*) and some natural reproduction by both species occurs. To obtain more information about the survival of trout in this tailrace, four microtagged cohorts of rainbow trout (> 5800) and one cohort of brown trout (16,670) were stocked between March and September 1997. Survival was investigated by electrofishing each month and conducting a creel survey. Rainbow trout stocked in early summer survived better than trout stocked earlier in the year. A change in ratio mark-recapture technique estimated the combined population of rainbow trout and brown trout at 56,493 fish in the first 16 km of the tailrace; total trout biomass was estimated to be 214 kg/ha.

NESBIT, R. A. and J. A. KITSON. 1937. Some results of trout tagging in Massachusetts. Copeia 1937(3) : 168-172.

To determine whether it is more advantageous to plant trout in the autumn or to hold them in rearing ponds until the following spring, several thousand rainbow and brown trout were tagged and released in two lots in Massachusetts rivers and ponds, one lot in the fall and the other lot the following spring. It is estimated from the returns that for a given cost, anglers can be given more and larger fish if trout of legal size are held overwinter in hatcheries and planted just before the opening of the season. It was also found, incidentally, that the internal tagging method is unsatisfactory on trout.

NESLER, T. P. 1981. Studies of the limnology, fish populations and fishery of Turquoise Lake, Colorado, 1979-80. Research Report, Bureau of Reclamation, U. S. Department of the Interior. Denver, Colorado.

Turquoise Lake is a dimictic, oligotrophic reservoir that is well oxygenated, relatively unbuffered and slightly acidic. Some oxygen depletion in the reservoir s hypolimnion occurs regularly in late summer and late winter though seasonal turnover and perhaps the outlet at the reservoir bottom prevents anoxic conditions from developing.

The fishery of Turquoise Lake is based on the stocked, creel-sized rainbow trout. The stocked rainbow trout return in the harvest at a relatively low level in one summer season but continue to contribute to the fishery in the following season. Fall stocking of creel-sized rainbow trout also appears to be quite effective in providing good catch rates in the following spring. Catch rates have remained relatively high despite increased fishing effort.

NEWCOMB, H. R. 1955. The fate of hatchery trout in the wild: Delayed mortality during the first week after transportation. p. 121-127 *in* Proceedings if the 35th Annual Conference of Western Association of State Game and Fish Commissioners. Moran, Wyoming.

In 1954 four different liberation trucks of two basic aeration principles (overhead spray and Venturi) were employed in a study. The transported fish were rainbow trout (*Salmo gairdneri*) originating from four separate Oregon State Game Commission trout hatcheries. Eighty-four experimental hauls were made in which the mechanical and physical factors were manipulated. These modifications were arranged into several experimental designs for the purpose of statistical analysis.

An examination of the voluminous data gathered and observations made on these experimental hauls indicate that:

- The chemical conditions of water in which fish are transported, including the factor of chemical changes, is not responsible for delayed mortality as encountered during the investigation.

- Analysis of transport water sampled after six hours revealed that dissolved oxygen generally decreased in concentration while ammonia, nitrogen and carbon dioxide always increased.
- The type of aeration system does affect the chemical factor concentrations in transport water. Carbon dioxide increases and pH decreases in Venturi aerated systems.
- Ice influences the chemical factor concentration if much is used.
- Regardless of the type of aeration, there was virtually no loss when water temperatures were kept near 40… F.
- Fish transported in units aerated by the Venturi principle suffered negligible delayed losses. Such units can probably transport greater load densities than 1.2 pounds of fish per gallon of water.
- Sodium amytal, as used, was ineffective in reducing delayed mortality.
- Rough handling when loading or unloading had no bearing on the problem of delayed mortality.
- A high rate of water circulation is desirable as long as it is accompanied by an increase in dissolved oxygen and does not create turbulence or agitation at a level detrimental to the fish being transported.

NEWELL, A. E. 1957$_a$. Two year study of movements of stocked brook trout and rainbow trout in a mountain stream. Progressive Fish Culturist 19(2) : 76-80.

The expected movement of stocked fish is an important item to consider in the stocking of many streams. This paper has been prepared to contribute to the general knowledge of fish movements and some factors influencing the movements of hatchery-reared fish in a wild environment.

The area in which these fish were stocked is a 3 mile portion of the 25 mile Swift River in Albany County, New Hampshire. The movements of brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*) were studied in 1953 and 1955. All fish used in this study were marked with serial-numbered jaw tags and records were made of the exact locations in which the fish were stocked.

The largest percentage of the fish stocked tended to be captured in the immediate vicinity of the original release site. It may also be seen that in all plantings, brook trout exhibited a greater tendency to move than did rainbow trout. It may also be seen that fish stocked in the cold water (all May stockings) exhibited a greater tendency to move than did those stocked in warmer water.

From the foregoing, it may be seen that low water temperatures apparently have a decided influence on the movements of stocked trout and that flow may have little or no influence on the movements of these fish. There is need for additional study, however, with regard to the effects of high temperatures, flow, population densities, competition and so forth on the movements of stocked trout.

NEWELL, A. E. 1957$_b$. Effects of jaw tags and fin clipping on returns of stocked trout. Progressive Fish Culturist 19 : 184.

To compare the effects of jaw tags and fin clipping on returns of stocked trout experiments were conducted in 1955 and 1956. The data for seven stockings of legal-sized, fin clipped and tagged rainbow trout in 1956 certainly indicate that the use of a jaw tag on hatchery-reared rainbows has no greater influence on the returns of these fish to the creel than fin clipping.

NICOLA, S. J. and A. J. CORDONE. 1973. Effects of fin removal on survival and growth of rainbow trout (*Salmo gairdneri*) in a natural environment. Transactions of the American Fisheries Society 102 : 753-758.

The long-term survival of fin-clipped and unmarked rainbow trout was studied in Castle Lake, California. The results of this study confirmed the generally held belief among fishery workers that fin removal has a serious detrimental effect on fingerling salmonids. Moreover, the relative magnitude of this effect for each of the seven fins that could be removed was determined; via: (1) removal of the adipose fin may reduce survival by as much as 50%, (2) removal of ventral fin may reduce survival by as much as 60 to 70%, (3) removal of a pectoral or dorsal fin may reduce survival as much as 70 to 80%, and (4) removal of the anal fin may be no worse than removal of the pectoral or dorsal fins, but can have an inconsistent effect. The absence of a single fin did not reduce significantly the rate of growth of the members of a group possessing that mark.

NIELSON, R. S., N. REIMERS, and H. D. KENNEDY. 1957. A six year study of the survival and vitality of hatchery reared rainbow trout of catchable size in Convict Creek, California. California Fish and Game 43(1) : 5-42.

It is evident from these experiments that rainbow trout hatched and reared to catchable size at Hot Creek Hatchery, of both fall spawning and spring spawning stock, exhibited an ability to survive equal to that of resident wild brown trout of comparable size. It is also clear that the hatchery trout were capable of competing with wild brown trout of the same size even though the hatchery fish were compelled to make rather drastic adaptations to the wild and entirely foreign environment. There was no evidence to indicate that the survival of the hatchery trout was influenced by the absence of the processes of natural selection during early life stages in the hatchery. It was demonstrated beyond reasonable doubt that mortality in small streams in indeed high among wild trout as well as among hatchery trout. It is therefore of paramount importance that hatchery-reared trout of catchable size be stocked immediately prior to and during the open season in areas of heavy angling pressure in order to realize greatest benefits.

NORMAN, A. 1976. Fish and wildlife management in ponds. File Report, Ontario Ministry of Natural Resources. Maple, Ontario. 31 p.

Two species of trout have met with the most success in Ontario ponds: the brook (speckled) trout and the rainbow trout. Stocking has its greatest effect if accomplished in the spring time, at least before the surface water temperature warms up above 65… F. Barring the possibility of spring introduction of trout, fall plantings are usually successful if made after the water temperature has returned to 65… F.

Minnows should not be introduced as food as they might reproduce and establish themselves in the pond. Minnows compete with small trout for a common and usually limited food supply and should not be encouraged.

Stocking rates for Ontario ponds are not firmly established. Satisfactory results will usually be obtained by planting 1,000 fry per acre of pond surface or about 300 fingerlings for the same area.

The artificial feeding of trout in farm ponds is not usually essential or desirable unless the pond has been stocked above its carrying capacity. When you feed the trout, the natural carrying capacity of the pond is raised as you will increase the growth rate of the trout and the ultimate productivity of the pond. Consequently, feeding, once started, must be continued or mortality might ensue.

NORTH, E. 1983. Relationships between stocking and anglers catches in Draycote Water trout fishery. Fisheries Management 14(4) : 187-198.

The trout fishery at Draycote Water was investigated during the 1980 fishing season. Fish stocked were batch-marked according to the data of introduction by freeze branding, and catch data were obtained by the cooperation of anglers. Population estimates were made at the end of the fishing season using gill nets and marked-recapture techniques.

Of the 32,960 marked brown and rainbow trout stocked, 69.8% were caught and declared by anglers. Returns of rainbow trout were better (78.1%) than those of brown trout (44.2%). Over 90% of all fish caught were taken within 45 days of stocking. Catch per unit effort fluctuated widely but was closely associated with stocking of fish. Catchability (Q) of stocked fish was found to diminish rapidly with time after stocking.

At the end of the fishing season the estimated population of marked trout was 4045 (2 x SE = 250), compared with a theoretical number (stock less total catch) of 10,802, giving a mean daily apparent natural mortality, made up of the true natural mortality plus the undeclared catch, of 1.36%.

NUHFER, A. J. 1996. Relative growth and survival of three strains of rainbow trout and three strains of brown trout stocked into small Michigan Island lakes. Fisheries Research Report No. 2026. Michigan Department of Natural Resources. Ann Arbor, Michigan.

The relative growth and survival was assessed over a three year period of three strains of rainbow trout (*Oncorhynchus mykiss)* stocked as yearlings into small oligotrophic lakes. Their relative tendency to emigrate was evaluated in one lake that had an outlet. The strains tested were Shasta (SH), Eagle Lake (EL), and Michigan steelhead (STT). Relative growth and survival was similarly evaluated of three strains of brown trout (*Salmo trutta)* stocked into four small, landlocked oligotrophic lakes. Brown trout strains examined were Wild Rose (WR), Seeforellen (SF), and Plymouth rock (PR). No significant differences in survival of rainbow trout stains were found. However, point estimates of survival and standing crop in both lakes were highest for STT, intermediate for EL, and lowest for SH. EL rainbow trout were significantly heavier than STT in four of the five samples collected over a 3-yr period from both lakes. EL trout were consistently heavier than SH in both lakes during the first 30 months after stocking. In West Lost Lake, EL were significantly larger than SH in all samples collected throughout 30 months after stocking, but at East Fish Lake weight differences were significant only for the sample collected ten months after trout were stocked. After 37 months residence, EL and SH in both lakes were similar size. Overall results indicated few significant differences in growth of SH and STT. There was little evidence that any rainbow trout strain tested was more likely to emigrate from the experimental lake which had a outlet. Mean lengths and weights of WR and SF brown trout were similar during sampling periods from 6-37 months after stocking. WR and SF brown trout strains produced far more legal-sized fish (≥254 mm total length) than PR by six months after stocking because they were larger when stocked. There were no significant differences in survival or standing crops among brown trout strains after 30 months residence in the study lakes. When Ford Lake survival estimates were excluded from ANOVA analyses, survival of PR was significantly higher than for SF or WR, and survival of WR was higher than for SF after 30 months residence. After 30 months residence there were no significant differences in standing crops among brown trout stains.

O BARA, C. J. and M. A. EGGLETON. 1995. Evaluation of three small scale, put-and-take rainbow trout fisheries in Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 49 : 78-87.

Percent return, survival, and harvest rates of stocked rainbow trout (*Oncorhynchus mykiss*) were evaluated in three Tennessee streams from 1991 through 1994. Harvestable-size trout were stocked 2-4 times during spring at densities of 29-188/km. Mean annual returns ranged from 13% to 29% over the four years of the study and averaged 23% for all three streams. Returns for fall stocked trout were negligible. Survival of spring stocked (March-May) trout was low, ranging from 2% to 7% by July of each year. Similarly, survival of fall stocked trout was also low and ranged from 1% to 3% by the following March. No significant relationship ($P > 0.05$) was detected between stocking densities and mean harvest rates or percent returns of individual stockings. Thus, altering stocking densities and periods did not achieve a greater return to the anglers in these streams.

OHIO DEPARTMENT OF NATURAL RESOURCES. Undated. Fish hatchery tactical plan and prioritization. Division of Wildlife. Columbus, Ohio. 23 p. + appendices.

Stocking is one of many strategies used by the Ohio Division of Wildlife to manage Ohio s fisheries resources. Stocking may also be used as an angler recruitment and retention strategy. In such situations, adult-sized fish will be stocked to create fishing opportunities in urban areas and for special youth events related to outdoor activities.

Ohio s catchable trout program has been expanded into urban areas throughout the state. The program now consists of 38 locations and approximately 80,000 fish of which the vast majority are rainbow trout.

Catchable trout should be requested for inland water areas where a high profile and maximum utilization fishery is desired, often under short-term limitations. Catchable trout will not be stocked in streams. Catchable trout are generally stocked in lakes from March through the second week of May before water temperatures reach the mid 60s (… F) to ensure high angler utilization without adding undue stress to the fish. Catchable trout are also stocked in two-story lakes where deep, cold water (< 68… F) is available through the summer with adequate dissolved oxygen (> 6 mg L^{-1})

Requests for catchable trout should reflect the following suggested stocking rates:

- Waters † 40 acres (16 ha) — 75 trout per acre
- Waters 41-80 acres (17-32 ha) — 50 trout per acre
- Waters > 80 acres (33 ha) — 25 trout per acre
- Minimum trout stocked — 500
- Maximum trout stocked — 4,000

ONTARIO DEPARTMENT OF GAME AND FISHERIES. 1930. Fish culture report. p. 23 *In* 1929 Annual Report. Toronto, Ontario.

The distribution of this species for the year approximated 35,030 fingerlings. The parent stock are provided with a suitable natural pond in the lower waters of Normandale Creek.

The Branch anticipates, providing the collection of eggs from our domesticated stock is successful, that more extensive plants of this species may be made in our waters. Their introduction, however, must be carefully controlled.

ONTARIO DEPARTMENT OF GAME AND FISHERIES. 1931. Fish culture report. p. 38-52 *In* 1930 Annual Report. Toronto, Ontario.

More than twice as many rainbow trout fingerlings were distributed as in 1930 and 1929; ten thousand yearlings were also distributed. It should be stated that no general distribution is anticipated but a controlled distribution is underway and the plantings should be followed up in order to determine the most satisfactory basis for future stocking. The experimental work so far includes the following waters:

- Bronte Creek, Halton County.
- Stoney Creek, a tributary of the Coldwater River, Simcoe County.
- Rapid River, Geneva Creek, Windy Creek and Pumphouse Creek, Sudbury District.
- Lake Simcoe and Brough s Creek.

ONTARIO DEPARTMENT OF GAME AND FISHERIES. 1934. Report of the biological and fish culture branch. p. 18-23 *In* 1933 Annual Report. Toronto, Ontario.

Distribution of rainbow trout was confined largely to the waters of Lake Simcoe and its tributaries in an effort to establish the species. It is too early to make a definite pronouncement regarding the establishment of this species in the waters in which they have been distributed.

The officials of the Branch are of the opinion that the northern streams tributary to large bodies of water are apparently the most suitable planting locations on account of the success achieved by their original introduction to the St. Mary s River from which they have spread along the north shore of Lake Superior and penetrated the lower reaches of streams adjacent thereto.

ONTARIO DEPARTMENT OF GAME AND FISHERIES. 1935. Report of fish culture branch. p. 11 *In* 1934 Annual Report. Toronto, Ontario.

Production of rainbow trout was twelve times greater than in 1933. This was the result of more intensive operations for the collection of spawn from the natural waters in the vicinity of Owen Sound and Sault Ste. Marie as well as from our own domesticated stock of breeders. In addition, the Department succeeded in obtaining a small supply of eyed rainbow trout eggs through the courtesy of the Minnesota Department of Conservation. Consignments of rainbow trout yearlings and fingerlings and brown trout yearlings were introduced into two spring-fed trout lakes in Algonquin Park.

The Department succeeded in obtaining a consignment of eyed Kamloops trout eggs through the courtesy of the British Columbia Department of Fisheries. This is a very interesting trout of large size, slender in form and graceful in appearance and movement. It resembles its close relative the steelhead but it is reported that it does not show the same tendency to descent to the sea preferring to remain permanently in freshwater.

ONTARIO DEPARTMENT OF LANDS AND FORESTS. 1970. Fish stocking rates for brook trout and rainbow trout. Fisheries Policy Circular, Fish and Wildlife Branch. Toronto, Ontario. 4 p.

This procedure outlines the method to be used for establishing fish stocking rates. It doesn t apply to put-and-take fisheries where the harvest rate is directly dependent on regular stocking and ease of access and less dependent on the carrying capacity of the water.

Two factors (total dissolved solids and area of the zone most suited to the species concerned) were selected as measures of production capacity in lakes. Two ranges of total dissolved solids (TDS) were selected as an index to lake productivity. Assuming other physical and chemical conditions of the environment are favorable, the total area of littoral and shoal zones (< 20 feet deep) is the most significant area of production. For this reason we selected a basic stocking rate per acre of lake surface having a water depth not greater than 20 feet for each of the two ranges of TDS.

To calculate stocking rate, you must first determine the area of littoral zone (acres), then multiply this area by the basic stocking rate as follows:

(a) More than 100 ppm — 150 yearling fish per acre of water between 0-20 feet; or
(b) Less than 100 ppm — 100 yearling fish per acre of water between 0-20 feet.

This product is then multiplied by the appropriate fishing pressure factor selected from the following angling pressure index:

(a) Light (0-10 person days/acre/year) — Factor 0.5
(b) Medium (10-20 person days/acre/year) — Factor 1.0
(c) Heavy (> 20 person days/acre/year) — Factor 1.5

ONTARIO MINISTRY OF NATURAL RESOURCES. 1982. General guidelines for stocking hatchery fish. Fish Culture Section, Fisheries Branch. Toronto, Ontario. 21 p.

The purpose of these guidelines is to assist fisheries managers throughout the province to design fish stocking programs which make the most efficient and effective use of fish hatchery products. Those guidelines pertaining to rainbow trout may be summarized as follows:

- Angler demand must justify the need to consider stocking a particular waterbody.
- Minimum dissolved oxygen levels should be > 5 mg L^{-1} and > 4 mg L^{-1} in the winter.
- Water temperatures should be in the preferred range of the species concerned (12-22… C for rainbow trout) during the growing season.
- For stocked waters it is strongly recommended that pH be greater than 5.5.
- The resident fish community in the recipient waterbody must be determined. Returns of stocked fish decrease as the complexity of the fish community increases.
- When stocking in waters where competitors and/or predators are present, yearling fish should usually be stocked. In waters containing forage species only, fingerlings will do relatively well. In barren or reclaimed waters fry stocking may be justified for introductory plants.
- Generally, stocking in spring will produce better results than fall planting.
- In waters where grow rates are slow or exploitation rates are relatively low, it may be most effective to stock in alternate years or every third or fourth year.
- Stocking rates should be determined as follows:
  Where TDS > 100 mgL^{-1} , stock 7.0 kg (350 fish) yearlings per ha of water less than 6 m in depth; where TDS < 100 mg L^{-1} stock 4.5 kg (225 fish) yearlings per ha of water less than 6 m in depth. For waters stocked with catchable-sized fish, stocking rates will be based on the exploitation rate or the catch-per-unit-of-effort.
- Any water which is to be stocked with fish must have suitable access to the public.
- Fish should only be marked when assessment studies are planned.
- The most practical means of transportation to reduce mortalities, cost and distance travelled to a minimum should be employed.

ONTARIO MINISTRY OF NATURAL RESOURCES. 1999. Rainbow trout. *In* Stocks Catalogue, Fish Culture Section, Fish and Wildlife Branch. Peterborough, Ontario.

There is presently one strain of rainbow trout in the provincial fish culture system. This is the Ganaraska River strain which represents a naturalized strain from this Lake Ontario tributary. Ganaraska River rainbow trout spawners are probably a mix of lake run fish (of Ganaraska River origin and rainbow trout stocked elsewhere). Biochemical (genetic) analysis undertaken in the early 1990s, from six rainbow trout populations from the lower Great Lakes, indicated that electrophoretic differences were minor.

Fish in the system are based on captive broodstock developed using Ganaraska River spawners as the founding parent stock. A rotational line crossing technique, based on three year classes (four year old females crossed with three year old males, five year old females crossed with four year old males, and six year old males crossed with 4 year old females), has been successful in minimizing genetic changes during broodstock propagation.

The Ganaraska River strain is intended for use primarily in the Lake Ontario watershed to establish or re-establish self-sustaining populations and provide fishing opportunities. It may also be used to stock inland waterbodies where the demand for fishing opportunities cannot be met from local, wild stocks and where rainbow trout plantings do not endanger wild fish communities.

ONTARIO MINISTRY OF NATURAL RESOURCES. 2000$_a$. Best management practices for fish stocking inland waters of the Northeastern Region. Unpublished guidelines. South Porcupine, Ontario. 14 p.

These best management practices for fish stocking have been developed as a starting point for making sound stocking decisions. Stocking decisions made outside these best management practices should reflect either new science, recommendations from stocking assessment and/or local knowledge which is defensible.

The best management practices for rainbow trout stocking may be summarized as follows:

- Rainbow trout stocked for put-grow-take purposes should be planted at the rate of a maximum of 4.5 kg/ha of lake > 6 m in depth.
- Rainbow trout should not be planted in streams or rivers.
- Rainbow trout should not be stocked in any waterbody containing a resident or stocked population of salmonid.
- Preference for rainbow trout stocking should be given to lakes which are easily accessed by road during the open water season.
- Lakes being considered for rainbow trout stocking should stratify and have some water with more than 5 mg L^{-1} of oxygen in the hypolimnion.
- Rainbow trout stocking should not occur in waters that already have a sport fishery (e.g., bass, walleye or yellow perch).

ONTARIO MINISTRY OF NATURAL RESOURCES. 2000$_b$. Fish transportation and stocking. Chapter 12 *In* 2000 Fish Culture Course Manual. Fish Culture Section, Fish and Wildlife Branch. Peterborough, Ontario.

Stocking is the final stage of the fish culture operation and is critical to the success of both the fish culture program and the fisheries management program for which the fish were produced. The procedures involved in harvesting the fish from the rearing units, transporting them to the stocking site and introducing them into the lake or river are critical to both the immediate post-stocking and long-term survival of the fish.

Transportation and stocking intensifies the fish culture process. The fish are subjected to a number of physiological stressors resulting from handling and crowding during harvest, crowding and deteriorating water quality in transportation containers which have no water exchange, possible repeat handling if transfer to subsequent transportation containers is required, and finally release to fend for themselves in the wild; all compressed into a time frame that may vary from an hour to several hours depending upon the distance between the fish culture station and the stocking site.

The design and successful operation of fish transportation equipment requires a thorough understanding of the physiological requirements of fish, the physiological responses of fish to stress, water chemistry and fish-water interactions. Success in transporting fish is determined by the ability to mitigate the physiological problems created for fish exposed to multiple stressors and held in a relatively small volume of water at relatively high densities for a number of hours. The life support system must prevent or minimize the adverse water quality changes and meet the physiological needs of the fish. As well, fish handling procedures during loading and release must minimize the stress as much as possible. The corticosteroid hormone response has shown that the stress of the initial harvest (crowding and netting) and loading operation is more severe than the hauling process. Reducing the stress involved with each step in the process is important because the effects of the individual stressors are cumulative and the total effect may reduce long-term survival.

ORENDORFF, J. A. and N. C. FRASER. 1984. Stocking of salmonids in inland lakes: A summary for Algonquin Region, 1974-1983. Provincial Stocking Assessment Program Report No. 84-3. Fish Culture Section, Ontario Ministry of Natural Resources. Toronto, Ontario. 43 p.

Stocking information from the Algonquin Region between 1974 to 1983 was collated and reviewed. Lake area and mean depth were the main factors distinguishing lakes stocked with the four salmonid species. Rainbow trout stocked lakes had mean values of 87 ha and 6.2 m, however rainbow trout stocked lakes had areas less than 50 hectares 75% of the time. Rainbow trout stocked lakes had an average morphoedaphic index (MEI) of 8.7, TDS of 43.7 mg L^{-1}, and Secchi reading of 4.5 m.

OSTASZEWSKI, A. 1990. A catch-and-release fishery for stocked adult trout in the Huron River, Proud Lake Recreation Area, Oakland County, Michigan. Fisheries Research Report No. 1980, Michigan Department of Natural Resources. Ann Arbor, Michigan.

A portion of the Huron River in the Proud Lake Recreation Area, Oakland County, has been stocked yearly with legal-size trout since 1974. Special regulations provide a catch-and-release flies-only season prior to the regular statewide trout season. A creel census was conducted in 1975 and again in 1987 to evaluate the program. Total angler hours in 1987 were equal to those of 1975 but were concentrated in fewer angling days (21 and 30 days respectively). Anglers had a higher catch-per-effort and stock utilization in 1987 than in 1975. Economic return generated by anglers expenses resulted in a benefit:cost ratio of 2.78:1. In 1987 the value of the program to the anglers in terms of dollars was $174,632. The program cost was $8,686. The benefit to the angler:cost ratio for 1987 was 20.1:1. In 1975, this benefit:cost ratio was 10.1:1.

Stocked trout were efficiently recycled during the catch-and-release season. Catch data indicated stocked trout were caught an average of 3.45 times. Catch-per-unit-effort over the study period was 0.82 fish per hour. During the regular season, an intense harvest occurs over a short period of time. The program is successful because it provides a substantial amount of stream fly fishing for big trout at a time when anglers are anxious to fish but have few opportunities. Under such conditions a relatively few adult trout support heavy angling effort yet provide high success rates due to the catch-and-release feature. The program is highly valued by the anglers and is economically beneficial. The Huron River trout program fills a void with quality trout angling in lower Michigan.

OTTE, L. E. 1975. An evaluation of the rainbow trout-warmwater species fishery in Parker Canyon Lake. M. Sc. Thesis, University of Arizona

The sport fishery of Parker Canyon Lake was studied from October 24, 1973 through November 1, 1974. Emphasis was placed on the biology and harvest of the stocked rainbow trout and their compatibility to the warmwater species of channel catfish, largemouth bass, green sunfish and bluegill.

The first of five monthly stockings of 8-10 inch rainbow trout began on November 6, 1973. After stocking, the rainbow trout dispersed to the littoral areas around the lake. Rainbow trout fed primarily on zooplankton during the winter (December-February) and on midge pupae or larvae during the spring (march-May). Growth was good and condition factors were comparable to rainbow trout in the lake before introduction of warmwater species. By the end of April, 90-95% of all the rainbow trout had been harvested from the lake. Rainbow trout could have survived through the summer stratification period because of adequate water quality in the thermocline. The littoral plant beds provided the warmwater species with food, cover and spawning sites throughout the year. Crayfish was the primary food for most of the warmwater species during the year. Although food and habitat overlap occurred between rainbow trout and warmwater species, it did not adversely affect the fish and the fishery of Park Canyon Lake was biologically compatible.

OVERHOLTZ, W. J. 1974. A method of stocking trout in the hypolimnion of a lake. Progressive Fish-Culturist 36(3) : 175-176.

Rainbow trout (*Salmo gairdneri*) experience high mortality when exposed to temperatures of 24… C for prolonged periods of time. When rainbow trout are acclimated to high temperatures they may survive for short periods of time but they suffer high mortality when moved from a hatchery truck directly into the warm epilimnion of a lake. It is therefore necessary to use a modified method of stocking trout in an aerated system.

One thousand catchable (22.9-35.6 cm) rainbow trout were stocked in Ottoville Quarry using plastic corrugated drain pipe which was suspended in the hypolimnion using a system of floats and anchors. Water from the hypolimnion was pumped into the pipe using a 1.5 hp gasoline water pump. Water flowed in such a manner that there was a downward movement of water through the pipe and back into the hypolimnion. Fish were dipped from the hatchery truck, fed into the pipe via a funnel apparatus and flushed into the hypolimnion.

Observations by SCUBA indicate that the fish left the pipe tail first, apparently swimming against the downward current. Upon leaving the tube their initial movement was upward until reaching the thermocline after which they dispersed throughout the hypolimnion. Creel census data indicated that well over 200 fish were taken by anglers in the first two months after stocking. Vertical gill nets accounted for another 100 fish in this time period. The trout were in excellent condition, feeding mainly on the *Chaoborus* population in the quarry.

The technique of stocking rainbow trout through a length of plastic drain pipe has been shown to be successful. The fish were not subjected to thermal shock and their corresponding survival rate was high.

PAETZ, M. J. 1967. The relationship of fingerling rainbow trout stocking to the sport fishery in Beauvais Lake, Alberta. File Report, Fish and Wildlife Division, Alberta Department of Lands and Forests, Edmonton, Alberta.

PARISH, R. B. 1977. Fingerling growth and survival as related to size and time of plant. Project No. F-22-R-18, Job No. C-14. New Mexico Department of Fish and Game. Santa Fe, New Mexico.

Rainbow trout (*Salmo gairdneri*) fingerlings 2, 3, and 4 inches in length, were marked with different colors of fluorescent pigment and planted in 11 lakes and rivers. These fish were later sampled with gill nets or electrofishing gear. The data obtained were analyzed to determine the most suitable time and size of fingerling to plant to produce the most economical catchable size fish.

There was no significant difference in the cost:benefit of the three different sizes planted; however, the four inch fingerlings returned at a more consistent rate and were considered more predictable in becoming catchable-size fish.

Spring plants were significantly more successful than fall plants. There was no significant difference between early and late spring plants. Early fall plants appeared to do better than late fall plants.

Fingerlings planted exhibited phenomenal growth rates in most of the study waters. Fingerlings would start returning to the creel in three to four months after planting. Many marked fish could be harvested prior to sampling if not sampled within a few months after planting.

Most of the fingerling planted in lakes return in significant numbers to analyze the results. Fingerlings planted in streams and rivers either yielded low or no returns. In waters, with populations of predaceous fish, fingerling plants did not do well.

PARISH, R. B. 1979. Rainbow fry survival. Project No. F-22-R-20, Job No. C-15. New Mexico Department of Game and Fish. Santa Fe, New Mexico.

Rainbow trout, (*Salmo gairdneri*) fry, approximately one inch in length, were stocked at a rate of 2,000 per surface acre for streams and 1,000 per surface acre for lakes during the winter months (January and February) for two consecutive years and then during the spring months (May and June) for two consecutive years. Fry stocked during the winter months provided no appreciable survival in either the lakes or streams.

A spring plant at Quemado Lake indicated a 9.2 percent survival to a length of 7 _ inches. The cost of producing the same number of 7 _ inch fish in the hatchery system is almost equal to the cost of raising the fish in the lake from the fry plant.

The only streams which indicated possible fry survival were the Red River and Cimarron. However, if all rainbow trout less than eight inches in length are considered to have originated from the fry plant (assuming no natural reproduction) it would not be economically feasible to plant fry to produce an eight inch fish in these streams. None of the study waters produced enough eight inch trout from fry plants to justify the planting of fry as a management practice.

PARSONS, J. W. 1955. The trout fishery of the tailwater below Dale Hollow Reservoir. Transactions of the American Fisheries Society 85 : 75-92.

The 7.3 miles of tailwater below Dale Hollow Dam were initially stocked with rainbow trout (*Salmo gairdneri*) in 1950. In 1953, creel records indicated that a minimum of 16% of the 16,500 fingerling stocked fish were captured by anglers within 12 months after stocking. The rainbow trout creeled averaged 9.4 inches long and had grown at a monthly rate of 15 millimeters in length and 26 grams in weight. On the basis of growth rates it was decided that an annual stocking of approximately 25,000 fingerling rainbow trout would most benefit the fishery. To maintain suitable water temperatures throughout the tailwater in the summer, a minimum coldwater discharge below the dam was established. Threadfin shad (*Signalosa petenensis*) were stocked in the reservoir in an attempt to establish a supplemental food supply for trout in the tailwater. The stocking of brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*) and cutthroat trout (*Salmo clarki*) in the tailwater has been only slightly successful. The Dale Hollow tailwater presently supports 7,000 put-and-take trout fishing trips per year at a cost to the Tennessee Game and Fish Commission of less than 20 cents per trip.

PARTRIDGE, F. E. 1985. Effects of steelhead trout smolt size on residualism and adult return rates. Idaho Department of Fish and Game. Boise, Idaho.

PARTRIDGE, R. M. 1981. Test netting in the Ignace District. File Report, Ontario Ministry of Natural Resources. Ignace, Ontario.

Test netting was performed on several lakes in the Ignace District from August 30 through September 3, 1980. Four artificially stocked lakes were tested. They were Snowstorm, Shrimp, McLaurin and Little Notman lakes.

Snowstorm and Notman lakes should be maintained as a put-and-take fishery for rainbow trout. While McLaurin and Shrimp lakes should be maintained as a put-and-take fishery for brook trout. Snowstorm Lake appears to be producing brook trout naturally.

PATRICK, N. D. 1965. Annual report of fish plantings in the Tweed District, 1965. File Report, Ontario Department of Lands and Forests. Tweed, Ontario. 17 p.

In 1965, a total of 30,100 rainbow (Kamloops) trout were stocked in fifteen different Hastings County lakes. Ten lakes in Lennox-Addington County were stocked with a total of 11,000 rainbow (Kamloops) trout. A total of 19,250 rainbow (Kamloops) trout were distributed among 13 different lakes in Frontenac County. There were 12 lakes in Renfrew County stocked with a total of 17,830 rainbow (Kamloops) trout.

Based on volunteer angler returns, a total of 926 rainbow trout were caught during 871 fishing trips in 1964. This represents an average of 1.06 trout per fishing trip. The highest catch rate was recorded during the month of September.

PATTERSON, R. R. 1975. Rainbow fry survival. Performance Report, Job C-15. New Mexico Department of Game and Fish. Santa Fe, New Mexico. 6 p.

PAUTZKE, C. F. 1954. The contribution of artificially propagated trout to total angler success. Washington Department of Game. Olympia, Washington.

The waters of Washington vary in their physical and chemical nature. We have both numerous lakes and streams. So far as is known no lakes have been lost through the draining of water. In the twenty-one years that I have been associated with the Washington State Game Department the lakes have remained the same. The only variance has been in our management of them. In comparison, the rivers and their tributary streams are constantly in a state of change. Each year due to additional irrigation rights we lose a quantity of water sufficient to create a stream of 70 cubic feet per second (cfs). Associate this ever increasing loss of water with a heavier silt load plus pollution and you have decreased production of resident fish in our streams and rivers. The production of resident trout in streams affords less than five percent of our total resident fisheries. Thus it is lowland lakes which carry the burden of resident fishing in Washington.

PAWSON, M. G. 1982. Recapture rates of trout in a put-and-take fishery analysis and management implications. Fisheries Management 13(1) : 19-32.

Stock, catch and effort data for a small put-and-take trout fishery were analyzed to determine a stocking strategy fulfilling the needs of both anglers and management. The assumptions of negligible natural mortality and constant catchability implicit with stock determinations using catch-per-effort and catch successions techniques were tested, and found to be largely upheld in this instance. The calculations of optimal stocking rates based on these results are described and indicated that frequent restocking with sufficient fish to maintain a stock capable of giving the desired catch-per-effort is preferable, both from the viewpoint of angler satisfaction and to facilitate management of the fishery.

PAWSON, M. G. 1986. Performance of rainbow trout (*Salmo gairdneri*) in a put-and-take fishery and influence of anglers behaviour on catchability. Aquaculture and Fisheries Management 17 : 59-73.

Stock, catch and fishing effort statistics for a 12.5-ha lowland put-and-take trout fishery have been used to compute the catchability of rainbow trout (*Salmo gairdneri*) during the fishing seasons 1980-1983.

Seasonal trends in the fishes susceptibility to capture by fly-fishing are apparent but there is no indication that, in this fishery, newly stocked fish were more vulnerable than the longer-term residents. This consistency of recapture rates of rainbow trout, relative to the population available, is a function both of the fish s behaviour and that of the anglers themselves, and it is suggested that for management purposes the latter must be taken into account. In the fishery studied, rainbow trout grew well at fish densities below 60 kg ha^{-1}, but even with overall recapture levels exceeding 80% the yield of the fishery was less than the weight of fish stocked. The selection of strains of rainbow trout which satisfy the requirements of sport fisheries is discussed.

PAWSON, M. G. 1991. Comparison of the performance of brown trout (*Salmo trutta)* and rainbow trout (*Oncorhynchus mykiss)* in a put-and-take fishery. Aquaculture and Fisheries Management 22 : 247-257.

Stock and catch statistics for a small (5.5ha) lowland put-and-take trout fishery have been used to investigate the relative catchability of brown (*Salmo trutta)* and rainbow trout (*Oncorhynchus mykiss).* Brown trout were consistently less vulnerable to fly fishing than rainbows, and were particularly difficult to catch between mid-June and September. As a consequence, the turn-over of rainbow trout stock was more rapid than that of brown trout, but eventual recapture levels of both species were similar at around 90% of the fish stocked. In these circumstances, brown trout could be regarded as a long-term investment for fishery managers with rainbows providing more instant sport.

PAWSON, M. G. and C. E. PURDON. 1987. Relative catchability and performance of three strains of rainbow trout (*Salmo gairdneri*) in a small fishery. Aquaculture and Fisheries Management 18(2) : 173-186.

The performance of two strains of rainbow trout (*Salmo gairdneri)* and a hybrid were assessed in a put-and-take fishery against stock from the normal supplier. The three batches of experimental fish were reared to the size usually stocked in the fishery and they and two batches of the normal stock fish were given distinctive dye marks using a Panjet inoculator. Anglers returns were analyzed and demonstrated that they were significant differences in the catchability of the various types of fish throughout the trial period. There are no apparent difference between strains in their susceptibility to the fly-fishing methods employed, nor between their growth rates while still in the fishery, despite the clear superiority of some genotypes under fish-farm conditions. These factors are discussed in relation to the management of put-and-take trout fisheries.

PAWSON, M. G. and C. E. PURDON. 1991. Influence of pre-stocking feeding levels on catchability of rainbow trout (*Oncorhynchus mykiss)* in a small fishery. Aquaculture and Fisheries Management 22 : 105-111

The effects of different pre-stocking feeding levels on the subsequent catchability of rainbow trout (*Oncorhynchus mykiss*) were investigated in a 12 ha put-and-take fishery. Two sibling batches of Winthrop strain were fed high or low rations of a pelleted diet to produce similar sized, but recently fast-and slow-growing fish. Each batch was given a distinctive dye mark. Anglers catch records showed that although the slow-growing fish were significantly the more easy to catch during the first week after stocking, over the remaining 5 months of the fishing season there was little difference in catchability between batches. This suggests that previous observations of sustained between-strain differences were not the result of selection of fast-and slow-growing fish *per se,* but were probably genetically determined.

PENNSYLVANIA FISH AND BOAT COMMISSION. 1987. Management of trout fisheries in Pennsylvania waters. Bureau of Fisheries. Harrisburg, Pennsylvania. 123 p.

It is the policy of the Fish Commission to use hatchery fish to provide recreation in those waters where fish populations are inadequate to sustain the fishery at desired levels.

The approach to stocking trout in streams includes the following considerations:

- No stream shall be approved for stocking prior to a field survey.
- Minimum stream flow must be at least 5 cubic meters per second (3 cfs) at the time of stocking at any time prior to June 15.
- Water temperature shall not exceed 24… C at any time prior to June 15 in any stocked stream section.
- pH at time of stocking shall not be less than 6.5 for rainbow trout.
- Public access must be available to at least 70% of the stream section and the accessible area must be at least 1.6 km in length to be approved for stocking.
- The stocking strategy and angler harvest should provide a 50% return to the creel of the preseason plant and a 75% return to the creel of an inseason plant.
- Stream sections classified as Class A wild trout fisheries shall not be stocked with hatchery trout.

Guidelines for stocking trout in lakes may be summarized as follows:

- The suitability of a lake for trout stocking must be determined through a field survey.
- Fingerling trout stocking will generally be in waters with a total alkalinity of at least 10 mg L^{-1}.
- Ponds less than 2.4 hectares (6 acres) or reservoirs greater than 80 hectares (200 acres) which are not presently managed with catchable trout will not be considered for catchable trout.
- A minimum of 1.0 meter (3.3 feet) of water column with temperatures of 21… C or lower and 5 mg L^{-1} or greater of dissolved oxygen should be present to May 1 for preseason stocking and to June 1 for inseason stocking.
- pH at the time of stocking should not be less than 6.5 for rainbow trout.
- Program success will be defined as the harvest in proportion to the number planted. For Class 1 lakes this is 75% of the preseason plant and a 75% harvest of inseason plants. For Class 3 lakes this is defined as 50% harvest of the preseason plant and a 65% harvest of the instream plant.

PETROSKY, C. E. 1984. Competitive effects from stocked catchable size rainbow trout on wild trout population dynamics. Ph. D. Dissertation, University of Idaho. Moscow, Idaho. 118 p.

PETROSKY, C. E. and T. C. BJORNN. 1988. Response of wild rainbow trout (*Salmo gairdneri*) and cutthroat trout (*Salmo clarki*) to stocked rainbow trout in fertile and infertile streams. Canadian Journal of Fisheries and Aquatic Sciences 45(12) : 2087-2105.

Wild rainbow trout (*Salmo gairdneri*) and cutthroat trout (*S. clarki*) were unaffected by stocking of catchable-size rainbow trout in two Idaho streams, except at the highest stocking rates, and even then the effects were limited. In the infertile stream, stocking 50 or 150 trout per section (doubling or tripling the density) did not reduce the abundance of wild cutthroat trout. Wild trout abundance declined at a faster rate in an unreplicated section stocked with 500 trout than in unstocked sections. In the fertile stream, stocking 50 or 100 hatchery trout in sections containing 26-120 similar-sized wild trout did not increase the dispersion or reduce the abundance, growth or survival rates of wild rainbow trout. When we stocked 400 trout (100 on four dates) in sections containing 32-53 tagged wild trout of similar size, the summer mortality rate of wild trout was higher in stocked than in unstocked sections; the other parameters were not significantly different.

PLATTS, W. 1965. Physical, biological and ecological factors affecting the rate of return of planted trout. Federal Aid Project F-32-R-6, Job Completion Report No. 4. Idaho Fish and Game Department. Boise, Idaho. 8 p.

During the census period from June 7, 1962 through September 2, 1962, it was estimated that 1,995 anglers fished 3,676 hours in Deadwood Reservoir to harvest 5,664 game fish. During the same census period in 1963, it was estimated that 965 anglers fished 1,593 hours in Deadwood River to harvest 4,090 game fish. Fishing success in Deadwood Reservoir averaged 1.5 game fish-per-hour during 1963 as compared to 1.0 game fish-per-hour during 1962. Fishing success in Deadwood River averaged 2.6 game fish per hour during 1963 as compared to 0.7 game fish per hour during 1962.

Percentage composition of the 1963 Deadwood Reservoir game fish harvest was: cutthroat trout, 33.6; rainbow trout, 20.2; rainbow-cutthroat trout hybrids, 2.7; and kokanee salmon, 43.1. Percentage composition of the 1963 Deadwood River fish harvest was: cutthroat trout, 36.1; rainbow trout, 50.2; rainbow-cutthroat trout hybrids, 4.9; kokanee salmon, 6.8; Dolly Varden, 1.0; and whitefish, trace.

POTTER, B. A., B. R. ZALEWSKI, B. A. BARTON and N. C. FRASER. 1982. Summary and annotated bibliography of salmoninae stocking investigations, stocking assessment methodology and stocking policies in North America. Fish Culture Section, Fisheries Branch, Ontario Ministry of Natural Resources. Toronto, Ontario. 183 p.

This bibliography was prepared as a reference document for Ontario fisheries managers. Over five hundred and seventy references, pertaining to stocking and assessment of various salmonids, are cited. Highlights of stocking information presented for rainbow trout may be summarized as follows:

- Hatchery-reared rainbow trout experience high overwinter mortality rates. Overwinter survival is generally better than brook trout but poorer than brown trout.
- Rainbow trout have been selectively bred for may characteristics and various strains exhibit increased resistance to disease and high water temperatures, earlier maturity, improved growth, increased egg production, and degree of downstream movement.
- Although there are exceptions, plants of catchable-sized rainbow trout provide the highest returns to the angler.
- Post-stocking movements of rainbow trout have been found to be related to residence time, water velocity, water temperature and strain of fish.
- Generally, the best returns are from rainbow trout which are planted during the spring or early summer.
- Introductions of hatchery-reared rainbow trout do not provide a buffer for wild trout, that is the harvest of wild trout was not reduced.
- Catchability of stocked trout can vary with the strain stocked, with habitat (streams versus lakes), the density of stocked fish and with ambient water temperatures.
- In some situations, predation of stocked salmonids by a variety of avian and mammalian predators can be a significant source of mortality.
- Stocked trout exhibit a density dependent relationship in terms of growth. This has been documented in both a lake and stream environment.

PYLE, A. B. and R. H. SOLDWEDEL. 1973. Investigations in the mortality of stocked trout in New Jersey streams. Miscellaneous Report No. 36, New Jersey Department of Environmental Protection. Lebanon, New Jersey. 28 p.

The New Jersey Division of Fish, Game and Shellfisheries stocks over 500,000 catchable trout each year to support a largely put-and-take recreational fishing program. The stocked trout range from seven to twelve plus inches in total length and includes brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and rainbow trout (*Salmo gairdneri*).

Out of the eighteen streams employed in this study, six were found to be unsuitable for stocking with hatchery-reared trout until their temperatures increased to about 42… F after April 1st. These six streams are located in central New Jersey and their chemical characteristics are considered to be largely responsible for the inability of brook, brown and rainbow trout from New Jersey s hatchery in Hackettstown to adjust and survive when stocked at colder temperatures. Toxicity is discounted as a factor because their waters maintain resident trout populations throughout the year.

Sulfate and aluminum concentration increases are associated with the colder water temperatures but they alone are not considered adequate to recognize other streams posing similar trout adjustment problems. Therefore, the fingerprinting of streams is suggested as an aid in dealing with this problem.

Mortality of newly stocked trout is quite rapid, usually being complete in less than a week, with the order of decreasing susceptibility being rainbow trout, brown trout and brook trout.

QU BEC MINISTØRE DU LOISIR, DE LA CHASSE, ET DE LA P CHE. 1988. Technical file for introducing rainbow trout (*Salmo gairdneri*). *In* Stocking guidelines for fish species other than anadromous Atlantic salmon. Direction de la gestion des esp ces et des habitats. Qu bec City, P. Q.

Introducing this species where a population of brook charr or lake charr are found is not recommended. The strain of rainbow trout should preferably be F_1, F_2 or domestic. Stocking should occur on an annual basis and during a season relative to the developmental stage of the fish stocked.

For lakes the following rates are the maximum permitted for introductions:

Level of Competition	Stage	Rate
Nil to low	Fry or fingerling	1,500 fry/ha; 300 fg/ha
Moderate	Fingerling or age 1+	200 fg/ha; 100 age 1+/ha
High	Age 1+	50 fish/ha

For all plantings, a minimum quantity corresponding to 75% of the rates prescribed below is mandatory while not exceeding 250,000 fry or 50,000 fingerling or 25,000 age 1+ per project. It is recommended that the fish be dispersed in zones that vary in depth from 0-6 meters.

On watercourses (streams and rivers) the following rates are the maximum permitted for introductions:

Level of Competition	Stage	Rate
Nil to low	Fry or fingerling	450 fry/m x km (maximum 9000/km) 90 fg/m x km (maximum 1,800/km)
Moderate	Fingerling or age 1+	60 fg/m x km (maximum 1,200/km) 30 age 1+/m x km (maximum 600/km)
High	Age 1+	15/m x km (maximum 300/km)

These rates apply to the average width of the watercourse (in meters) per kilometer to be stocked. For all plantings, a minimum quantity corresponding to 75% of the rates prescribed below is mandatory while not exceeding 250,000 fry or 50,000 fingerlings or 25,000 age 1+ per project. In a watercourse, dispersion must be carried out at various points not more than five kilometers apart from one another.

In situations where rainbow trout are being planted for put-grow-take purposes, fish should be stocked on an annual basis. Other guidelines apply as above with the exception that it may be advantageous to use sterile hybrids where reproduction conditions are poor in order to benefit from the greater growth potential of these strains.

For this type of stocking, the following rates are the maximum permitted:

Level of Competition	Stage	Mesotrophic	Oligotrophic
Nil to low	Fingerling	200/ha	100/ha
Moderate	Fingerling or Age 1+	125 fg/ha	60 fg/ha
		60 Age 1+/ha	30 Age 1+/ha
High	Age 1+	30/ha	15/ha

The maximum quantity for all projects is 50,000 fingerlings or 25,000 yearlings.

RADFORD, D. 2000. Alberta s fish stocking program. *In* 2000 Alberta Guide to Sportfishing Regulations. Alberta Ministry of the Environment. Edmonton, Alberta.

Over 300 lakes are regularly stocked with rainbow trout as part of Alberta s world renowned pothole stocking program. These generally small, landlocked lakes are often barren of fish. Although water quality can be marginal for a trout in some of these lakes they are often highly productive ecosystems capable of sustaining large numbers of big trout. In exceptional cases, rainbow trout can grow to more than 4 pounds in just one year although 1 pound per year would be closer to the average. Most of these plantings are of trout in the 5-10 cm range in lakes that are capable of overwintering rainbows. Larger fish in the 15-20 cm range are planted in lakes that experience high fishing pressure and/or are susceptible to winterkill.

RADFORD, D. S. and S. H. CLEMENTS. 1971. A creel survey and population estimate of rainbow trout in Tyrrell Lake, Alberta. File Report, Fish and Wildlife Division, Alberta Department of Lands and Forests, Edmonton, Alberta. 35 p.

During the period 22 May to 30 September, 1971, a creel survey was in daily operation at Tyrrell Lake, Alberta. Data were collected on the residence of the anglers, number of anglers, number of angler hours, and the harvest of stocked rainbow trout. Growth rates and coefficients of condition of these fish were determined. A population estimate of the rainbow trout population was made by means of a mark-recapture experiment.

It was found that the residence of 90.5% of the anglers was local in nature (less than 50 miles distant from Tyrrell Lake). A total of 3,773 anglers were censused. The number of angler hours was determined to be 16,754. No statistically significant difference was found between the actual and reported times spent angling. 1,411 rainbow trout were taken by angling during the study period. The average catch ratio (number of fish per angler hour) was 0.084; approximately 11.9 angler hours were required to catch one trout. The growth rate of trout was rapid and the average fork length and weight at the end of September was 419 mm and 1,163 gm, respectively. The average coefficient of condition (K_{FL}) at this time was 1.57. Based on the number of fish recaptured by gill nets and anglers, the population of 1+ rainbow trout was determined to be 7,762 – 1,025. Since 1,748 were removed from Tyrrell Lake by angling and gill nets during the study, the size of the population at the end of September would be approximately 6,000. Since 1,103,800 fingerling rainbow trout were stocked in 1970, the percent mortality would be about 99.3%.

RATLEDGE, H. M. 1966. The impact of increasing fishing pressure upon wild and hatchery-reared trout populations. Proceedings of the Annual Meeting of the Southeastern Association of Game and Fish Commissions 20 : 375-379.

Twelve years of trout stream management on the Standing Indian Wildlife Management Area in North Carolina has involved a fixed annual stocking of marked hatchery-reared trout. A complete creel census has been mandatory on the area streams so that the catch of both stocked and wild trout could be followed.

It was concluded from this study that: (1) wild trout populations deteriorated after two consecutive years of 40 trips per acre per year; (2) hatchery-reared trout provided only a buffer to the destructive harvest of wild trout up to a point when the wild trout have been depleted the hatchery fish became dominant in the harvest; (3) up to that point, harvest of wild trout, not the harvest of stocked trout, upheld the trout fishery; and (4) increased fishing pressure resulted in decreased average catch and catch-per-hour, whereas, decreased pressure resulted in higher average catches.

RATLEDGE, H. M. and J. H. CORNELL. 1953. Migration tendencies of the Manchester (Iowa) strain of rainbow trout. Progressive Fish-Culturist 15(2) : 57-63.

The rainbow trout propagated at the Manchester Station are a pure strain and the purpose of the study was to determine whether or not this strain might be less migratory than the rainbow trout generally being used in the eastern United States for stocking purposes.

Three streams in three different management areas were selected as test sites. The streams selected were considered better than average rainbow trout streams and annually they support a moderately heavy fishing pressure. Numbered signs were posted along the stream banks at 0.25 mile intervals. Each fish was tagged on the operculum and stocked during the latter half of March 1952.

On Fires Creek and on Big Santeetlah Creek, the test fish were stocked in four equal parts at various places in the test area. On Nantahala River, the test fish were all stocked at one location. The purpose in the two types of stocking was to obtain some indication of whether or not rainbow trout might be expected to disperse through a stretch of water from one stocking point or whether the customary procedure of numerous smaller stockings is necessary to ensure an adequate distribution of fish throughout the length of the stream.

Considerable difficulty was experienced in the transportation and propagation of the Manchester (Iowa) trout. Only 1,100 remained when the fish were stocked at a size of 7 inches. Throughout this study, the recovery of Manchester (Iowa) trout was consistently smaller than the recovery from the controls.

From the one spot stocking made on the Nantahala River, it can be concluded that the dispersal of fish from such a stocking is not comparable to the results obtained by using several stocking locations. Within the few weeks available for migration, the fish failed to distribute themselves in desirable numbers throughout available waters of the test area. Finally, it can be concluded that there is no significant difference in the migratory tendency of the Manchester (Iowa) strain of rainbow trout as compared with the rainbow trout being used as controls.

RAVENEL, W. deC. 1896. Report on the propagation and distribution of food fishes, 1895-96 — Steelhead and rainbow trout. Report of the U. S. Commissioner of Fisheries 22 : 80-84.

RAVENEL, W. deC. 1898. Report on the propagation and distribution of food fishes, 1897-98 — Steelhead and rainbow trout. Report of the U. S. Commissioner of Fisheries 24 : cx-cxiv.

RAVENEL, W. deC. 1899. Report on the propagation and distribution of food fishes, 1898-99 — Steelhead and rainbow trout. Report of the U. S. Commissioner of Fisheries 25 : ciii-cv.

RAVENEL, W. deC. 1900. Report on the propagation and distribution of food fishes, 1899-1900 — Steelhead and rainbow trout. Report of the U. S. Commissioner of Fisheries 26 : 100-105.

RAVENEL, W. deC. 1901. Report on the propagation and distribution of food fishes, 1900-01 — Steelhead and rainbow trout. Report of the U. S. Commissioner of Fisheries 27 : 88-92.

RAWSON, D. S. 1945. The failure of rainbow trout and initial success with the introduction of lake trout in Clear Lake, Riding Mountain Park, Manitoba. Transactions of the American Fisheries Society 75 : 323-335.

In 1936, after a biological survey and a consultation of several fish-culturists, it was decided to attempt the introduction of rainbow trout (*Salmo gairdneri*) into Clear Lake. This decision was influenced by the urgent need for a suitable game fish in this lake, the chief resort in Riding Mountain Park, and by the wish to check the feasibility of rainbow trout for stocking in lakes of this life zone. Planting, in the years 1937-1942, was carried on according to a plan which made use of rearing ponds to increase the size of the fish released. In 1942, when it was found that the rainbow trout were not surviving it was recommended that planting be discontinued and an attempt made to establish lake trout (*Cristivomer namaycush*). After three years of planting with adult lake trout it was found that they were surviving in the lake but yet no evidence of spawning has been obtained. In this report the physical and biological conditions in the lake are described and discussed in relation to the fish-culture experiments. It is concluded that great difficulty will be encountered in attempting to introduce rainbow trout into lakes in which a heavy population of competitor and predator fish is already present.

RAWSTRON, R. R. 1971. Harvest and survival of rainbow trout infected with *Sanguinicola davisi*. California Fish and Game 57(4) : 253-256.

Rainbow trout, heavily infested with the blood fluke (*Sanguinicola davisi*) showed good annual harvest and survival rates, good growth, and a low cost to the angler s creel in an intermediate type of reservoir with a few limnetic predators or competitors.

RAWSTRON, R. R. 1972. Harvest, survival and cost of two domestic strains of tagged rainbow trout stocked in Lake Berryessa, California. California Fish and Game 58(1) : 44-49.

Tagged rainbow trout of the Coleman Kamloops strain and the Mount Whitney strain were planted in Lake Berryessa, Napa County, California. The former was less vulnerable to shore anglers shortly after planting and had a more rapid limnetic distribution, equal mean annual harvest rates, a higher survival, and a lower cost to the angler s creel compared to the latter.

RAWSTRON, R. R. 1973. Harvest, mortality and cost of three domestic strains of tagged rainbow trout stocked in large California impoundments. California Fish and Game 59(4) : 245-265.

Rainbow trout of three strains were tagged and planted in four California impoundments: Lake Berryessa, Merle Collins Reservoir, Pine Flat Lake and Lake Isabella. Coleman Kamloops consistently outperformed the Shasta and Whitney strains. They had similar mean annual exploitation rates, the highest survival rates, highest ratio of weight returned to weight planted and lowest cost/lb to the angler s creel compared to the other strains. Their superior performance is attributed to their limnetic distribution and their decreased vulnerability to shore anglers shortly after planting. Where emigration into downstream areas occurred, Whitney rainbows emigrated at the highest rate followed in order by the Coleman Kamloops and Shasta strains. No difference in growth rate occurred among the three strains.

RAWSTRON, R. R. 1977$_a$. Effect of a reduced bag limit and later planting date on the mortality, survival, and cost and yield of three domestic strains of rainbow trout at Lake Berryessa and Merle Collins Reservoir, 1971-1974. California Fish and Game 63 : 219-227.

Rainbow trout of three domestic strains were tagged and planted in Lake Berryessa and Merle Collins Reservoir after imposition of a reduced bag limit and a later planting date. Coleman showed a clear superiority over the Shasta and Whitney strains. Anglers landed a higher percentage of the originally planted weight of Coleman at both lakes than of the other two strains. Coleman also produced the lowest cost to the angler s creel at both lakes. I concluded that the reduced bag limit was primarily responsible for the substantial increase in mean weight landed and cheaper cost to the angler s creel for all strains, compared to that of two of my previous experiments.

RAWSTRON, R. R. 1977$_b$. Harvest, survival and weight returns of tagged Eagle Lake and Coleman rainbow trout stocked in Lake Berryessa in 1972. California Fish and Game 63 : 274-327.

Annual stocking of catchable-sized rainbow trout (*Salmo gairdneri*) is an established management practice in California s low and mid-elevation reservoirs that possess threadfin shad (*Dorosoma petenense*) and are limnologically suited for salmonids. In 1972, 5,000 Eagle Lake trout (*Salmo gairdneri petenense*) became available to compare with Coleman rainbow trout. Trailer tags (modified Carlin) offering a $5 reward were placed on 400 Eagle Lake trout and 500 Coleman rainbow trout and stocked in Lake Berryessa in May. The remaining Eagle Lake trout and 20,000 Coleman rainbow trout were marked with distinctive fin clips for future identification in growth studies.

A creel survey on three weekends in October 1972 revealed similar growth for both trout strains after 6 months in the lake. Mean weight of 26 Eagle Lake trout was 0.43 kg ±0.06 kg and 106 Coleman rainbow averaged 0.39 kg ± 0.05 kg. No subsequent growth information was obtained. Anglers landed 190% of the originally planted weight of Eagle Lake trout and 127% of the Coleman rainbows. Similarly, Eagle Lake trout returned at a significantly higher mean weight than Coleman trout. Since Coleman rainbow had shown a clear superiority over two other strains in earlier studies and Eagle Lake trout outperformed Coleman trout in this trial, Eagle Lake rainbow trout should also rank high in experimental management plans for lakes similar to Lake Berryessa.

RAYMOND, S. 1971. Kamloops — An angler s study of the Kamloops trout. Winchester Press. New York, New York. 209 p.

The story of the Kamloops trout began during the last glacial period, about 20,000 years ago. Streams and rivers, formed by runoff from vanishing glaciers, were used by runs of steelhead and salmon to become established in interior lakes and tributaries. Over thousands of years some of the progeny of the steelhead became permanent residents of the large interior lakes. Others were landlocked when their exits to the sea were blocked as rivers changed their courses or landslides closed off migratory routes.

Very little was known about the Kamloops trout or its life history when the fish culture service began experiments with trout at the salmon hatchery on Granite Creek near Shuswap Lake. In 1908, eggs were obtained from Kamloops trout spawning in a tributary of Shuswap Lake. Fry developed from these eggs were planted in two previously barren lakes northeast of Kamloops — Paul and Pinantan. The first planting of Paul Lake consisted of 5,000 free-swimming Kamloops trout fry. Feeding eagerly on a plentiful supply of natural food these fish grew rapidly and within a few years Paul Lake was producing large trout for local anglers. By the early 1920s, the fame of Paul Lake had spread and, in 1922, a fish hatchery was established on one of its tributaries to take advantage of spawning runs which had developed. Other hatcheries were established including one at Gerrard on Trout Lake and one at Pennask Lake, between Merritt and Kelowna. From these sources previously barren lakes received their first trout and expanded the original range of Kamloops trout. Many of the other efforts to transplant Kamloops trout failed because the environments to which the fish were transferred lacked the elements necessary to produce fish with the growth characteristics of the Kamloops.

RAYNER, H. J. 1940. Planting fish in lakes. Progressive Fish Culturist 51 : 33-34.

In order to make some experimental plants of 4-10 inch lake and rainbow trout in the Finger Lakes of central New York a method of planting from a boat was devised to meet the need for spreading fish over a large area. The steep slopes of the lakes and scarcity of landing places made it necessary to take as many fish in as few loads as possible.

Compartments or partitioned walls in the boat for holding fish made planting very easy. The compartments were filled with water by removing wooden plugs in the bottom of the boat and allowing water to flow in. The flow of water in and out of the boat was controlled.

A long handled dip net was used to take fish out of the compartments and place them in the lake far enough away from the boat to prevent injury by the propeller. At a speed of approximately 4 miles per hour, 9,000 fish with a total weight of 190 pounds were thus planted in two hours.

By the use of this apparatus, steep sided lakes where it is difficult to bring a truck to the water s edge are easily planted with fish.

RAYNER, H. J., D. A. WEBSTER, and L. M. THORPE. 1944. Population depletion in brook, brown, and rainbow trout stocked in the Blackledge River, Connecticut, 1942. Transactions of the American Fisheries Society 74 : 166-187.

A section of the Blackledge River, 1.7 miles long, was blocked off by weirs and fish traps and a total of 4,757 marked brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and rainbow trout (*Salmo gairdneri*) were stocked in the experimental area in three plantings. Only a small number of the marked trout attempted to leave the area as indicated by the 46 fish taken in the traps. Subsequent recapture of these trout, which were tagged, indicated no inclination to move any great distance. The mortality of the marked trout after planting was slight during the period of observation, except in one planting where the brook and brown trout stocked showed advanced symptoms of furunculosis. The total catch of marked trout during the season of April 17 to August 31 was 3,466 trout taken by 3,152 anglers spending 9,746 hours on the stream. That was about an 80% return of the available population from each planting and from each of the three species of trout planted. Of the 97 unmarked trout which were caught, only 23 were judged to be wild fish, the others being recently stocked trout which had moved into the area from adjoining waters before the weirs were put in place. The distribution of the angling pressure was such that each planting was depleted within a few days. About _ of the total catch of trout made from any one planting was taken within four days of the date of stocking. The population of brook trout was depleted most rapidly, that of brown trout most slowly and rainbow trout intermediate. Only 5 days of fishing were provided during the season where the catch-per-unit-effort approached one trout-per-hour or more. There was a high correlation between the population of trout in the stream and the catch-per-unit-effort, except in the second planting of brown trout. The relationship between the available population and the catch-per-unit-effort showed progressively higher yields for the same number of trout as the season advanced. Because of the rapid population depletion, in only one instance could possible differences on behavior between newly stocked trout and those from previous plantings be noted. The number of brown trout caught from the second planting showed no correlation with the fishing effort while brown trout caught from the first planting at the same time were closely related to the fishing effort. The distribution of each angler s catch indicated that under a limit of 15 fish about 1/3 of the total number of anglers accounted for _ of the catch on the first few days following each planting.

RECKAHN, J. A. 1961. Evaluation of an extended angling season for lake trout and rainbow trout in Cayuga, Seneca and Skaneateles lakes. M. Sc. Thesis, Cornell University. Ithaca, New York. 109 p.

An extended angling season was experimentally tried on Cayuga, Seneca and Skaneateles lakes in the Finger Lakes region in an attempt to increase the angling exploitation of rainbow and lake trout stocked. Weekend creel census, voluntary records, angler diaries and angling tag returns were utilized to evaluate the extended trout season.

The extended season increased the weekend catch of rainbow trout in Skaneateles Lake by 57%. In Seneca and Cayuga lakes the extended season was of little value in producing an increased harvest. Rainbow trout are of relatively minor importance in the catch of the lake fishery of Cayuga and Seneca lakes but dominate in the catch of the fall fishery in Skaneateles Lake.

Stocked rainbow trout composed approximately 66% of the rainbow trout catch in Skaneateles Lake and are comparable to naturally produced trout in size and age distributions.

REIMERS, N. 1963. Body condition, water temperature, and overwinter survival of hatchery-reared trout in Convict Creek, California. Transactions of the American Fisheries Society 92(1) : 39-45.

Catchable-sized, hatchery-reared rainbow trout (*Salmo gairdneri*) undergoing survival tests in controlled sections of a mountain stream repeatedly declined in coefficient of condition for several months after being stocked. Examples of this decline, together with records of stream temperatures and associated mortality are used to demonstrate the relationship among poor body condition, rising temperature, and breakdown of trout vitality during the critical late-winter period. Possible advantages of fall stocking and of breeding some hatchery trout for superior adaptability are discussed.

REINITZ, G. L., L. E. ORME, C. A. LEMM, and F. N. HITZEL. 1978. Differential performance of four strains of rainbow trout reared under standardized conditions. Progressive Fish Culturist 40 : 21-23.

Four strains of rainbow trout were evaluated for average weight gain, feed conversion, daily length increment, and percent mortality. Significant differences were found to exist between certain strains for all characteristics measured. The rank of the four strains in rate of growth was the same whether the fish were fed a diet high in plant protein or high in animal protein, suggesting genetically distinct strains of rainbow trout may exhibit the same relative growth rates, irrespective of diet.

RINNE, J. N. and J. JANISCH. 1995. Coldwater fish stocking and native fishes in Arizona: Past, present and future. American Fisheries Society Symposium 15 : 397-406.

Since the 1930s, almost 70 million fish representing 17 non-native species have been introduced into lakes and streams of the Little Colorado and Black River drainages in the White Mountains of east-central Arizona. The two drainages historically contained populations of native Apache trout (*Oncorhynchus apache*) and a native cyprinid species, Little Colorado spinedace (*Lepidomeda vittata*). Both are classified as threatened species. The declines of these fishes have resulted from stocking of nonnative species, principally rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*). Establishment of nonnative salmonids was facilitated in many cases by stream renovations with fish toxicants and baitfish introductions. Habitat alterations related to land management activities, principally timber harvest and livestock grazing, further affected the Apache trout and Little Colorado spinedace. Proposed changes in stocking strategies and innovative management activities will be instrumental in sustaining these two species and other native fishes of the state.

ROBINSON, A. T., S. D. BRYAN and M. G. SWEETSER. 2000. Interactions between rainbow trout and Little Colorado spinedace: A summary of study results. *In* Proceedings of the Meeting of the Arizona and New Mexico Chapters of the Wildlife Society, Sierra Vista, Arizona. (Abstract Only)

For the past four years we have studied interactions between introduced rainbow trout (*Oncorhynchus mykiss*) and Little Colorado spinedace (*Lepidomeda vittata*), a federally threatened cyprinid endemic to the Little Colorado River basin. We documented species habitat use, diet and dispersion in natural and experimental settings. In natural settings, overlap in habitat use between the species was high (Schoener s index = 88.9%); both selected for pool habitat and avoided riffles and shallows. However, rainbow trout occurrence was independent of Little Colorado spinedace. Comparisons of habitat use between the two species indicated that spinedace tended to use habitat with less undercut banks than rainbow trout. Extensive overlap in habitat use between the species was also evident in stream enclosures, but we detected no displacement of spinedace by rainbow trout in these experiments. However in laboratory experiments, changes in spinedace habitat use were dependent on the density of rainbow trout present. In natural settings and in stream enclosures we may have detected a shift in spinedace diet with presence of rainbow trout; more *Corixidae* were eaten when trout were absent than when present. In addition, when species co-occurred, rainbow trout tended to consume more *Corixidae* than spinedace. We did not detect rainbow trout predation on Little Colorado spinedace in natural settings but did observe it during experimental situations. Although thousands of rainbow trout were stocked into Nelson Reservoir each year, we believe that few escape from the reservoir; we have only recaptured one tagged rainbow trout in Nutrioso Creek. We believe that negative interactions between rainbow trout and Little Colorado spinedace are density dependent. As such, current management practices (rainbow trout stocking is restricted to reservoirs and to the spring time and fishing regulations allow unlimited harvest of rainbow trout during the fall and winter months) have resulted in extremely low densities of rainbow trout in streams where spinedace occur, and thus, have likely decreased the likelihood of negative interactions between species.

ROHRER, R. L. 1987. Harvest of planted rainbow trout of catchable size from five reaches of Henry s Fork, Idaho. North American Journal of Fisheries Management 7(1) : 142-144.

Harvest of planted rainbow trout (*Salmo gairdneri*) of catchable-size varied greatly in the study sections of Henry s Fork. Returns to the creel of a single strain of rainbow trout were correlated with fishing effort. For the range of returns (low to high) from Henry s Fork, it cost from about $109 to $7 to put a kilogram of hatchery trout in the creel. To maximize efficiency of catchable trout programs, biologists should monitor catches from all unique reaches within a contiguous river system.

ROHRER, R. L. and G. H. THORGAARD. 1986. Evaluation of two hybrid trout strains in Henry s Lake, Idaho, and comments on the potential use of sterile triploid hybrids. North American Journal of Fisheries Management 6(3) : 367-371.

Cutthroat trout (*Salmo clarki*) x rainbow trout (*S. gairdneri*) hybrids were introduced in Henry s Lake, Idaho, to produce a trophy fishery. The performance of two strains of F_1 hybrids (cutthroat trout x rainbow trout and cutthroat trout x steelhead was monitored. Growth rates of both strains were comparable, but cutthroat trout x rainbow trout hybrids were caught in greater numbers than the other hybrid during the third and fourth years of life. Hybrid trout are considered to be an excellent sport fish with value as a trophy species. However, hybrid trout are fertile and potentially could spawn with native cutthroat in this lake. Initial heat-shock experiments showed that several time-temperature regimes effectively induced triploidy in F_1 hybrids. Stocking the sterile triploid hybrids would maintain the genetic integrity of the indigenous cutthroat trout.

RYDER, R. A. 1970. Major advances in fisheries management in North American glacial lakes. p. 115-127 *In* N. G. Benson [ed.]. A Century of Fisheries in North America. Special Publication No. 7, American Fisheries Society. Bethesda, Maryland.

The rainbow, brown and lake trout have been planted widely in the glacial lakes region. Rainbow trout, introduced at varying times from western North America, has been a major contributing factor in the small lake angling fishery. More tolerant of warm water temperatures than the brook trout, rainbows often thrive in water that is marginal for the former species. Successful rainbow trout fisheries have even been developed in prairie potholes.

RYDER, R. A. and L. JOHNSON. 1972. The future of salmonid communities in North American oligotrophic lakes. Journal of the Fisheries Research Board of Canada 29 : 941-949.

Traditionally, the introduction of exotic fish species into oligotrophic lakes of North America has not had significant consequences except on a local basis. Those species best adapted for transplanting into cold unproductive waters are usually the salmonids themselves and only one of these has had any large degree of success until recently, in areas east of the Western Cordillera, namely the rainbow trout (*Salmo gairdneri*). The rainbow trout has often been planted in combination with the two native salmonines, the lake trout and the brook trout. More often it is introduced as a replacement for the latter, where the environment has deteriorated or where the brook trout has been unable to compete satisfactorily with other introduced fish species.

In the future we might expect more salmonid introductions as environments deteriorate beyond the lower tolerances of native species.

SCHNEIDERVIN, R. W. and S. L. BRAYTON. 1992. Evaluation of three strains of rainbow trout in Flaming Gorge Reservoir, Utah-Wyoming. Publication 92-5, Utah Department of Natural Resources. Salt Lake City, Utah. 32 p.

SCHRAEDER, H. A. 1989. Creel survey report for four Conservation Area ponds stocked with rainbow trout (*Oncorhynchus mykiss*), May 8 — June 2, 1989. File Report, Ontario Ministry of Natural Resources. Aylmer, Ontario.

A roving creel survey was conducted to investigate sport fishing for rainbow trout (*Oncorhynchus mykiss*) stocked in Embro, Harrington and Springwater Conservation Area ponds and Lake Whittaker. The objectives of the survey were to quantify fishing effort, catch, and catch and harvest-per-unit-effort (CUE and HUE) primarily for anglers seeking rainbow trout at the four sites; summarize angler characteristics; and provide information with which to review stocking strategies at these and similar bodies of water in the district.

The survey was conducted May 8 through June 2, 1988 (26 days) and focused on the second of two stocking dates (May 16). Limited manpower precluded a systematic survey of fishing activity at these ponds beginning opening day (April 29). During the period May 8 through June 2, 1989, total fishing effort at these sites by anglers seeking rainbow trout amounted to 5,742 angler hours (90% of the total fishing effort). These anglers caught an estimated 1,004 rainbows (89% kept) for a total harvest of 265 kg.

The catch of rainbow trout by anglers seeking them over the course of the survey accounted for 96% of the number stocked on May 16 and 35% of the total number stocked in 1989. It was not possible to distinguish between trout stocked on either of the two stocking dates but it appeared that the April 18 lot had been fished down to an unacceptable level just before the May 16 stocking occurred. Stocking sustained one month of sport fishing occasions, due largely to the timing of the second stocking date which renewed fishing activity for an additional two weeks. Daily catch trends suggest that few rainbow trout were harvested after the end of the survey. Thus, acceptable fishing quality standards (those which result in some fishing activity) were short lived.

Angler satisfaction with fishing opportunities at Conservation Area ponds in the district appears to be determined by overall CUE of all species caught. Thus, Springwater Pond (CUE of 0.721 sport fish per angler hour) provided the most favoured angling opportunities over the course of the survey.

This survey demonstrates that put-and-take stocking of rainbow trout results in significant numbers of sport fishing occasions. Stocking strategies should be reviewed periodically to optimize selection of recipient waters, and frequency of stocking of any given pond in a season

SCHRAEDER, H. A. 1990. An investigation of angling for stocked rainbow trout (*Oncorhynchus mykiss*) at Springwater Conservation Area pond and at Lake Whittaker (April 28-May 31, 1990). File Report, Ontario Ministry of Natural Resources. Aylmer, Ontario.

Stocking rainbow trout at Conservation Area ponds provides important fishing opportunities for local anglers many of whom are inexperienced and unfamiliar with fishing regulations. Fishing activity peters out quickly after opening weekend because anglers seeking stocked trout are opportunists who demand a high quality standard for their fishing occasions. Such quality standards are impossible to maintain without artificial fishing opportunities.

The data reported reinforce last season s findings that stocked trout are quickly depleted by anglers. Springwater Pond provides comparatively better fishing opportunities than Lake Whittaker because it returns proportionately more stocked fish to anglers in relatively shorter time. Factors which may constrain trout fishing at Lake Whittaker include its remote location (drawing primarily from London) and difficult access to shoreline areas with the exception of the southern end where fishing now occurs. Interestingly, individual anglers are more likely to fare better at Whittaker because of low fishing activity.

We recommend that the district s commitment to put-and-take stocking be reviewed in the context of management of healthy aquatic ecosystems and the desire to maintain viable fisheries at publicly accessible bodies of water. It will be necessary, for example, to weigh maintenance costs against expected quality standards for fishing occasions.

SCHUMACHER, R. E. 1954. Dusche Creek tagged trout study. Investigational Report No. 160, Bureau of Fisheries, Minnesota Department of Conservation. St. Paul, Minnesota. 12 p.

On April 27, 1954, 564 tagged brown trout yearlings, averaging 4.44 per pound, and 561 tagged rainbow trout yearlings, averaging 4.56 per pound, were stocked in Dusche Creek. A second stocking of 534 tagged brown trout and 523 tagged rainbow trout was made on May 27.

From a creel census 2,070 trips were recorded with a total of 6,264 man-hours of fishing effort. The total estimated number of fishing trips was 2,400 with an estimated effort of 7,377 man-hours. The total recorded rainbow trout catch was 889 trout of which 234 bore tags. The observed fishing success was 0.43 rainbow trout per fishing trip or 0.14 rainbow trout per man-hour. The tagged rainbow trout stocked and caught during the season amounted to 21.6%.

SCHUMACHER, R. E. 1964. Preliminary results from experimental introduction of rainbow trout as an additional game fish in large Minnesota Lakes. Investigational Report No. 279. Minnesota Department of Natural Resources. St. Paul, Minnesota. 42 p.

Observation made during the test-netting in 1963 have led to some generalizations which will be helpful in understanding the netting results. Some of these conclusions should be considered to be of a tentative nature and may need the proof which only more time can provide. The two lakes which showed the greatest numbers of rainbow trout were Long Lake and Hungry Jack Lake which had 1.1 and 2.0 trout per gillnet set respectively. Rainbow were taken by gillnets at 0.1 trout per gillnet set for both Greenwood and Kabekona lakes. No trout were caught in either Lily Lake or Big Trout Lake.

Long and Hungry Jack Lake are both characterized by relatively small outlets and flows, and both lakes have about 45 percent of their surface area in the zone termed trout water . A portion of stocking quota of both lakes were made up of surplus yearling trout, Long Lake in 1963 and Hungry Jack in 1962.

Kabekona and Greenwood lakes had rainbow populations of a density similar to each other and were also similar in having the zone termed trout water approximately three-fourths of their surface acreage.

Lily Lake was lacking in area suitable for trout as limited by physical and chemical conditions and no further consideration should be given for two-story management on it.

The single and greatest physical shortcoming characteristics in Big Trout Lake is its large and unobstructed connection to the Whitefish chain of lakes. The plan to include Big Trout Lake among those for experimental two-story management was predicated on the assumption that a barrier to emigration could be established in the connection with Whitefish Lake. No trout have shown up in the test-netting and only an occasional report of trout being caught by anglers has come to the attention of Conservation Department employees. Without an adequate barrier it is unlikely that a population of these migratory fish could be built up to sufficient density in Big Trout Lake to provide much angling.

SCHUMACHER, R. E. 1965. Over-winter mortality and contribution to the creel by fall-stocked catchable-sized trout in Minnesota. Investigational Report No. 289. Minnesota Department of Conservation. St. Paul, Minnesota.

Fisheries management is repeatedly confronted with sportsman s demands for more fish and larger fish. These demands are especially pronounced in connection with trout streams wherein production is almost entirely dependent on hatchery stocking of catchable-size trout. The trout fisherman s demands should be equitable distribution of trout among all classes of anglers, or where these demands can be met within the economics of the state trout production budget.

One major point of controversy is fall stocking versus spring stocking in the streams in southeastern Minnesota. The question is whether trout should be stocked as 15 month old trout during the angling season or whether they should be stocked as 20 month old trout in the fall after the legal trout angling season closes. Some anglers feel quality of the two year old trout is much greater than that of the 15 month old trout caught during the season in which they are stocked.

The most recent study by creel census and population estimates for southeastern streams has just been completed. It is intended to present the effect of winter mortality on brown and rainbow trout spending the winter between the age one year and the age two years in the southeastern streams.

SCOTT, W. B. and E. J. CROSSMAN. 1973. Rainbow trout, Kamloops trout, steelhead trout. p. 184-191 *In* Freshwater Fishes of Canada. Fisheries Research Board of Canada. Ottawa, Ontario.

The native range of the rainbow trout (including all varieties) was the eastern Pacific Ocean and the freshwater mainly west of the Rocky Mountains from northwest Mexico to the Kukokwim River, Alaska. There are several forms of rainbow trout including the steelhead, a migratory stock which spends its adult life in the ocean and returns to a freshwater tributary to spawn, and the Kamloops trout which is an inland lake form. The stock originally introduced into the Great Lakes was steelhead and the purely freshwater stocks retain a life history pattern which utilizes these large lakes as they originally did the sea.

Some of the first introductions in Canada were Newfoundland (1887); New Brunswick and Nova Scotia (1899); Prince Edward Island (1925); Great Lakes (1895); Ontario at least by 1904 and possibly as early as 1833; Manitoba 1938; Saskatchewan 1924; Alberta 1958 and Yukon Territory (1943).

SCULLION, J. and R. W. EDWARDS. 1979. The movement of hatchery-reared rainbow and brown trout in a polluted river in the South Wales coalfield. Journal of Fish Biology 14(2) : 173-178.

Hatchery-reared rainbow and brown trout (length 20 cm) were released in March 1974 and April 1975 respectively into the Taff Bargoed, a small river in south Wales, polluted by coal wastes and containing a low resident population of brown trout. From subsequent electrofishing surveys and catch returns from anglers, extensive downstream movements occurred in both species. About 50% had either been caught or had moved out of the river, a distance of about 5 km, after two months only some 10% remained. Within the fishing season it was estimated that 3 and 22% of brown and rainbow trout respectively were caught.

SEAMAN, W. R. 1966. Use of catchable trout in Colorado. p. 248-249 *In* Proceedings of the 46th Annual Conference of Western Association of State Game and Fish Commissioner. July 12-14, 1966, Butte, Montana.

Colorado has used a formula system of catchable trout stocking since 1948. Prior to that time stocking was the responsibility of the individual hatchery superintendent and encompassed only the local area served by the hatchery. Many waters were overlooked completely and others received a disproportionate high share of the fish available.

A suitable stream having 75 acres of water and in a heavy fishing pressure area would therefore receive 75 planting factors (75 x 1.0 x 1.0). Lakes are scaled down by size on factors as follows: 100% first 100 acres; 75% next 100 acres ; 50% next 100 acres and 25% for the balance. We now schedule approximately 1,200,000 pounds of catchable trout each year at a rate of 70 pounds per planting factor.

Catchables may not be a substitute for good habitat, but where they are used let s plant the best possible product we can turn out tailored to the management needs of the water planted.

SHARPE, F. P. 1961. A midsummer plant of rainbow trout in a stratified Tennessee impoundment. Progressive Fish Culturist 23(4) : 152-155.

The problems encountered when stocking rainbow trout in large Tennessee impoundments has been the availability of suitable rainbow trout at the optimum time of stocking in relation to the surface temperature of the water. An experimental plant of rainbow trout in a thermocline was undertaken in an effort to make observations and to derive a method of stocking trout in stratified water at the most opportune time. The basic goal was to introduce trout to the cooler waters of the thermocline without subjecting them to the rigors of passing through the hot surface water.

Standing Stone Lake, located in the north-central section of the Cumberland Mountains in Tennessee was chosen for the study. Five hundred 6-8 inch rainbow trout were transported 126 miles from Flintville State Fish Hatchery to the lake in an aerated tank. The temperature of the tank water at the time of arrival at the lake was 61… F. Lake water was added to the tank to temper the trout, allowing the temperature to rise slowly to the desired level. After the trout had been adequately tempered, they were put in plastic bags containing about 3 gallons of water taken from the tank truck. Twenty to twenty-five fish were put in each bag and quickly taken to the anchor boat from which they were handed to a diver already in the water. He allowed the bag to float on the surface of the water and forced the excess of air from the bag. Then he followed a marked line to a depth of 12-15 feet. Here the diver opened the bag and allowed the fish to swim free. The time elapsing from the removal of the fish from the tank truck until their release at the 12 foot level was approximately 5 minutes. A relatively slow descent was made allowing the fish to adjust to the slight change in pressure encountered.

Before the first descent, 25 fish were released on the surface of the water. Trout released on the surface appeared to be severely affected by the high water temperature; they were immediately in distress.

During the descent, the trout showed signs of confusion upon approaching the 6 foot level and all turned toward the surface. After passing the six foot level the trout became quiet and less mobile. Upon release, the fish appeared more confused than distressed but no adverse effects were noted during this observation period. Practically all fish returned to the 6-8 foot level.

The main derivation from this study was the association of the thermocline to the fish. This type of stocking definitely has merit but is limited by the small number of fish that may be transported to any depth at one time. Also, in large impoundments, the thermocline surface will probably be at depths of 20-35 feet and a definite pressure barrier may exist.

SHETTER, D. S. 1947. Further results from spring and fall plantings of legal-sized, hatchery-reared trout in streams and lakes of Michigan. Transactions of the American Fisheries Society 74: 35-58.

Further tagging experiments in Michigan with spring and fall plantings of brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta),* and rainbow trout (*Salmo gairdneri irideus)* from which recoveries were made during the 1942 trout season confirmed the conclusion that spring release of adult or near-adult hatchery-reared brook trout and rainbow trout is more desirable than the fall planting of fish a similar size. In some instances fall stocking of brown trout may furnish as good fishing in the following seasons as does spring planting.

Recoveries of planted fish past the first season of availability ranged from 0.0 to 2.5 percent in the second season from 0.0 to 0.5 percent in the third season.

In either spring or fall planting of legal-sized fish, no advantage was gained by scattering the fish widely over the stream areas stocked.

Eighty-five percent or more of the planted trout recovered were caught within ten miles of the point of release, regardless of the season or method of planting. Brown trout moved the least and rainbow trout the most. About one-fourth of the brook trout tended to move 3 to 10 miles downstream, and the majority of the remainder were caught within 3 miles of the locality of release. More rainbow trout than any other species were recaptured 10 or more miles from the point of release.

Fall plantings of adult brook trout in lakes were recovered at the rate of 56.7 percent (range, 13.0 to 88.1 percent). Unfortunately, a small percent of anglers removed an average of 89.4 percent of the total catch during the opening weeks of trout season. The average recovery from the two springs plantings of brook trout in East Fish Lake in Michigan was 68.5 per cent.

A brief review of the literature substantiates the conclusions reached as a result of Michigan experiments. Differences in experimental procedure are pointed out, and some reasons are offered for the failure of fish planted in streams in the fall to survive the winter season.

SHETTER, D. S. 1967. Effects of jaw tags and fin excision upon the growth survival, and exploitation of hatchery rainbow trout fingerlings in Michigan. Transactions of the American Fisheries Society 96: 394-399.

Approximately equal numbers (995 to 1,000) of jaw-tagged, fin-clipped, and unmarked rainbow trout fingerlings were planted in experimental sections of Hunt Creek in October, 1952. Observations on these fish during 1952-1957 provided data on the effects of marking on growth, survival, and angler exploitations.

Jaw-tagged fish grew more slowly than did either the fin-flipped or unmarked fish; differences in growth increments were between 0.53 and 0.47 inch over an 11-month period. There was little difference in growth between fin-clipped and unmarked fish. Relatively few rainbow trout attempted to migrate, and no difference in extent of attempted migration was detected between marked and unmarked fish.

There was no significant difference in angler exploitation rates among the three groups of fish in any one year, but the 5-year totals for the three groups showed highly significant differences. Tagged, fin-clipped, and normal rainbow trout were caught in increasing numbers, in that order.

More tagged fish than control fish were lost to causes other than fishing, and fin-clipped fish were intermediate in this regard.

The superimposition of 3,000 rainbow trout fingerlings on the Hunt Creek brook trout population in 1.75 miles of stream did not noticeably affect either the brook trout population or brook trout angling during the 5 years involved.

SHETTER, D. S. and A. S. HAZZARD. 1940. Results from plantings of marked trout of legal size in streams and lakes of Michigan. Transactions of the American Fisheries Society 70 : 446-467.

Intensive creel censuses served as the chief basis for estimates of the effectiveness of plantings of marked legal-sized brook trout, brown trout and rainbow trout at various seasons over a period of from 1-3 years in sections of five public streams and in two private streams. Similar data are presented for plantings of rainbow trout in five lakes. Returns from fall planting in streams never exceeded 5.3%; spring and open season plantings resulted in the recovery by anglers of from 4.9-61.9% of the fish released. Fall plantings of rainbow trout in lakes yielded returns up to 66%. Plantings of from 100-160 trout per mile of stream averaging 50 feet in width yielded higher percentage returns than did plantings of larger numbers of fish, benefited more anglers and did not stimulate the catch of native fish. The increase in the catch-per-hour and the percentage of hatchery fish in the total catch appeared to be inversely proportional to the density of the native population of the species stocked and directly proportional to the number of fish planted. The percentage of the total catch contributed by plantings of moderate numbers of trout in the spring or during the season varied from 1.8-30.4. It is concluded that in northern Michigan streams, major dependence for good fishing must be placed on the native or wild stock. Rainbow trout and brown trout were caught for at least 8 weeks following planting although the majority were removed by the end of four weeks; few, if any, brook trout were taken after four weeks. Very few planted trout survived one or more winters even in private streams not subject to intensive angling. Most of the trout were taken within 5 miles of the point of release and usually downstream: of the three species, rainbow trout migrated most extensively. From 5.7-20.6% of the fisherman day records showed the capture of marked trout. Apparently as many anglers benefited from spot plantings as from wider distribution by boat. Control experiments proved that jaw tagging and fin clipping provided effective methods of tracing fish during the period of investigation and that mortality and the effect on growth of either method was negligible.

SHETTER, D. S., W. C. LATTA, M. G. GALBRAITH, J. W. MERNA and G. P. COOPER. 1964. Returns on hatchery trout in Michigan. Report No. 1691, Institute for Fisheries Research, Michigan Department of Conservation. Ann Arbor, Michigan.

The trout stocking program is a well regarded activity of a public agency dating back to 1873. Reference to the planting records of the 1920-1935 period indicates that total trout plantings (brook, brown, rainbow and lake trout) were in the tens of millions annually. As the result of research findings in Michigan and elsewhere, there have been major changes in the size and type of trout produced in hatcheries. The planting program has changed from fingerlings to trout of legal size. Also production of rainbow trout was increased and that of brown trout decreased. Numerically, Michigan now plants less than 5% of the annual stocking of the 1900-1925 period.

SHIROBOKOV, I. I. 1993. On the adventitious introduction of the trout (*Oncorhynchus mykiss*) into the Irkutsk Reservoir. Vopr. Ikhtiology 33(6) : 841-843.

SHRADER, T. and B. MOODY. 1997. Predation and competition between largemouth bass and hatchery rainbow trout in Crane Prairie Reservoir, Oregon. Oregon Department of Fish and Wildlife. 28 p.

SIMON, D. C., G. G. SCALET and J. C. DILLON. 1993. Field performance of triploid and diploid rainbow trout in South Dakota ponds. North American Journal of Fisheries Management 13 : 134-140.

Triploid fish theoretically divert energy from sexual development and reproductive behavior into somatic growth. We found lengths, weights, and relative weights of triploid rainbow trout (*Oncorhynchus mykiss)* to be significantly ($P < 0.05$) less than those of diploid fish at the age of 45 months in three South Dakota ponds. Gonadal development in triploid females was negligible in 1989 and 1990 and reduced in triploid males during 1990. Catches of triploid fish were always lower than catches of diploid fish, suggesting lower survival. Physiological factors, perhaps environmentally induced, may have diminished the growth potential of triploid rainbow trout. Results of this study indicate that the use of triploid rainbow trout is not justified as a means of obtaining increased growth and survival under the conditions present in our study ponds.

SIMPKINS, D. G., W. A. HUBERT and T. A. WESCHE. 2000. Effects of fall-to-winter changes in habitat and frazil ice on the movements and habitat use of juvenile rainbow trout in a Wyoming tailwater. U.S Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming. Laramie, Wyoming.

Overwinter declines in the abundance of small rainbow trout (*Oncorhynchus mykiss)* have been observed in a section of the Big Horn River that lies downstream from Boysen Reservoir, where reservoir releases prevent surface ice formation. To provide insight into possible causes of these declines in abundance, radiotelemetry was used to determine movement and microhabitat use of juvenile (20-25 cm total length) rainbow trout during the fall and winter of 1995-1996. Throughout the fall and winter, both stocked (hatchery) and natural spawned (wild) fish were generally found in main channel pools with cover that reduced current velocities to less than 2 cm/s near the bottom and with nearby (< 2 m) water velocities that were greater than 15 cm/s. These locations provide refuges from the current, with adjacent flowing water that could deliver drifting aquatic invertebrates. The fish were generally associated with cover that formed by aquatic vegetation early in the fall, but they shifted to cobble and boulder cover (in deeper water) as the aquatic vegetation decomposed and as winter progressed. Episodes of frazil ice in January and early February were associated with movements of wild fish in the upstream portion of the study area-from normal activity areas to refuges at the bottom of deep pools under shelf ice in shallow water near shore. Frazil-ice episodes often initiated long-term movements among fish. Our results suggest that changing habitat features from fall to winter and frazil-ice episodes can cause juvenile rainbow trout to move and to modify their habitat use, depending on their location in tailwater.

SLANEY, P. A. and T. G. NORTHCOTE. 1974. Effects of prey abundance on density and territorial behavior of young rainbow trout (*Salmo gairdneri*) in laboratory stream channels. Journal of the Fisheries Research Board of Canada 31 : 1201-1209.

When rainbow trout (*Salmo gairdneri*) fry (underyearlings) were introduced into laboratory channels at three different prey levels and permitted to emigrate voluntarily, their density remained highest at the highest prey level. The distribution of fry was positively associated with a gradient in prey abundance. Both territory size and frequency of aggressive encounter varied inversely with prey level; the higher the prey level, the smaller the territory and the lower the frequency of aggressive encounter. Emigration from the channels was neither as rapid nor as marked when prey level was reduced, compared to when fry were initially introduced to different prey levels. However, frequency of aggressive encounter significantly increased when the prey level was decreased and significantly decreased when the prey level was increased.

SMALL, I. 1987. The performance of a small catch-and-release fishery stocked with rainbow trout (*Salmo gairdneri)* and thoughts on stocking densities. Aquaculture and Fisheries Management 18 : 291-308.

An assessment of the angling performance of a small put-and-take or release fishery stocked with rainbow trout (*Salmo gairdneri)* at a density in the range 345-565 fish/hectare (140-230/acre) showed that the correlations of mean daily and weekly catch per unit effort with population of fish were low and uncertain significance at the 5% level.

A pilot comparison with other fisheries indicates that the annual mean catch over a full day and the annual mean population density may be related by the equation: Catch/full day = 0.74 fish/hectare $^{0.33}$

The roles of catch-per-unit effort and frequency distribution in the estimation of fish abundance are discussed.

SMITH, E. L. 1961. Fish census taken at Spence s Pond, Mono Township, 1961. Conservation Officers Projects, Ontario Department of Lands and Forests, Southwestern Region. London, Ontario. 2 p.

This census was taken to determine how many fish were harvested from a 5.5 acre trout pond during the regular fishing season and also the number of fish per acre. Census forms were posted in the boat house at the pond requesting the information from each party who fished the pond. Anglers reported taking 446 trout. Only 7 of these fish were rainbow trout.

SMITH, M. W. 1967. Movement of planted hatchery-reared trout from a natural lake. Canadian Fish Culturist 39 : 35-40.

Extent to which hatchery-reared underyearling and yearling brook and rainbow trout in 21 plantings attempted to leave Crecy Lake, New Brunswick, was determined by year-round operation of a trap on the outlet. A greater proportion of brook than rainbow trout left the lake. Yearlings of both species, particularly those maturing, were the most prone to run. Most prominent runs were associated with greatest water discharge from the lake.

SMITH, M. W. 1968. Fertilization and predator control to increase growth rate and yield of trout in a natural lake. Journal of the Fisheries Research Board of Canada 25(10) : 2011-2036.

Enrichment in 1946 of Crecy Lake (20 ha; mean depth 2.4 m), New Brunswick, with commercial fertilizers to provide 210 ppb of nitrogen (N), 396 ppb of phosphorus (P) and 270 ppb of potassium (K) had increased the growth rates of native and planted brook trout. When underyearling and yearling rainbow trout were planted instead of brook trout with a third fertilization in 1959 and continued predator control, they grew faster than brook trout of comparable size. Rainbow trout produced more fish flesh in the lake than brook trout when the percentage returns to anglers for the two species were similar. However, the percentage return to the anglers from most plantings of underyearling rainbow trout was low, with the net result that the rainbow trout did not provide as consistently good angling as the brook trout nor did they utilize the productive capacity of the lake more effectively.

Brook and rainbow trout spawned in the littoral areas of the lake. However, yields of naturally-reared trout were poor, particularly when the survival of planted fish was high.

SMITH, N. W. 1991. Fish stocking in the southwestern region, 1974-1989: An historical review and rationalization. File report, Ontario Ministry of Natural Resources. London, Ontario. 80 p.

Fish stocking, as a fisheries management technique used in the southwestern region, Ontario Ministry of Natural Resources, is reviewed for the period from 1974 to 1989. This review includes Ministry initiatives as well as those undertaken by groups participating in the Community Fisheries Involvement Program (CFIP). The magnitude of the stocking effort in southwestern Ontario is indicated by the 27,298,200 fish stocked from 1974 to 1989. Rainbow trout and chinook salmon, mostly fry and fingerling size, are the main species that CFIP groups stock.

A total of 10,680,000 rainbow trout were stocked in southwestern Ontario waters during that period. Approximately half of the fish (5,356,600) were released as fry. Rehabilitation and supplemental stocking were the most common objectives. Over one-quarter of these rainbow trout (2,849,050) were stocked in the Owen Sound district.

SMITH, S. B. 1957. Survival and growth of wild and hatchery rainbow trout (*Salmo gairdneri*) in Corbett Lake, British Columbia. Canadian Fish Culturist 20 : 7-12.

It would appear, from subsequent rates of growth of wild and hatchery fish, that wild-reared fish which possibly are better able to compete, grow faster under natural conditions than hatchery fish from the same parental stock. The results of this experiment suggest that where survival, growth and behaviour of wild fish of any species are being assessed, either by comparison with hatchery-raised fish or by handling of wild stocks, an awareness of possible conditioning of young fish during early life or at time of handling is of considerable importance. The present experiment would appear to indicate that conditions limiting survival of trout in lakes likely are not as stringent and that hatchery trout are as well able to utilize the resources of a natural lake environment as are wild trout of the same size and age. It is therefore apparent that where a heavy demand exists for angling in lakes, the presence of wild trout does not preclude the possibility of supplementing stocks by hatchery plantings.

SMITH, S. B. 1959. A mathematical basis for stocking lakes. Proceedings of the Annual Conference of Western Association of State Game and Fish Commissioners 39 : 295-298.

The British Columbia Fish and Game Branch currently stocks slightly over two hundred lakes with rainbow, cutthroat and eastern brook trout (over 90% of hatchery output composed of rainbows). Four years ago (1955), a mathematical basis for stocking lakes was proposed for our use in British Columbia and except for minor variations to suit local conditions, now forms the foundation on which our lake stocking schedules are based.

We rely principally on research on the biology of native rainbow trout and on research on the limnology of lakes to determine a basic stocking policy. By establishing a general stocking policy on what was known of results of stocking Paul Lake, and arbitrarily adjusting stocking density directly in proportion to the amount of dissolved nutrient, a standard theoretical requirement per mile of lake shoreline was achieved. Arbitrary stocking limits were imposed of not less than 16,000 fry per mile of shoreline and not more than 64,000 fry per mile of shoreline. Lakes are stocked with trout no smaller than 500/lb. and if competitor or predator species are also present, larger fingerlings may be planted. Where fishing pressure is more intense and available fishing waters less plentiful, it is doubtful if our schedule would be applicable.

SMITH, S. B., T. G. HALSEY, R. A. H. SPARROW, and G. E. STRINGER. 1969. The comparative survival of wild and domestic juvenile rainbow trout planted in British Columbia lakes. Fisheries Management Report No. 61, British Columbia Fish and Wildlife Branch. Victoria, British Columbia.

Trout hatcheries in British Columbia have, for many years, planted rainbow trout derived from native, wild stocks. Because of much increased demand in the last decade or two, the planting of wild stock has been supplemented by imported, domestic stocks. The latter have had the advantage of better survival, reduced disease incidence and a rapid growth rate in the hatchery. However, it soon appeared that survival of domestic stocks, about one year after planting in lakes, was considerably poorer than that of the wild stock.

There was some evidence that domestic stocks were subject to a high incidence of disease after planting and anglers reported them to be poor fighting fish.

An experiment was designed to test for differences in survival between wild and domestic stocks after introduction into lakes in two limnological areas. Equal numbers of two domestic stocks (Oregon-F and California-S) and one wild stock (Beaver) were planted at about the same size, in three lakes. Fish were planted in the standard manner from a hatchery tank truck. All lakes were open to angling during the experiment. Fish were sampled at age 1+ with multifilament nylon gill nets 280 feet long and 8 feet deep with 7 stretched mesh sizes ranging from 1 to 4 inches in half inch intervals.

The relative survival of all strains in all samples differed significantly from the expected 1:1:1 or 1:1 ratio. Even though there was variability between lakes, the wild stock never had survival lower than expected, whereas one domestic stock (Oregon-F) survived in numbers less than expected in three out of four samples. Survival of California-S was almost two times greater than expected compared to Oregon-F which was only about one quarter of that expected. Considering all four lakes, the relative survival of wild Beaver stock was better than that of the domestic stocks.

Because of generally better survival of wild stocks indicated in this study and others and because of the preference for wild stocks generally reported by anglers, it is recommended that for normal planting, wild native strains of rainbow trout be used in British Columbia. Nevertheless, domestic stocks can still provide good angling in put-and-take fisheries where survival beyond one year is not essential.

SMITH, S. B., T. G. HALSEY, G. E. STRINGER and R. A. H. SPARROW. 1969. The development and initial testing of a rainbow trout stocking formula in British Columbia lakes. Fisheries Management Report No. 60, British Columbia Fish and Wildlife Branch. Victoria, British Columbia.

SOLDWEDEL, R. 1967. The survival and growth of three strains of rainbow trout (*Salmo gairdneri)* under conditions of high natural temperatures with and without other fishes. Report No. 29. New Jersey Department of Conservation and Economic Development. Trenton, New Jersey.

Two adjacent farm ponds, located near Rosemont, New Jersey on a poultry farm owned by Mr. Charles Cane, New Jersey Fish and Game Council member, were used to obtain information on thermal tolerance of three strains of rainbow trout (Donaldson, New Jersey, and Donaldson x New Jersey cross) and gain information on their applicability to trout management in New Jersey. All three strains were found to have survived temperatures of as high as 84.5° F., when other fish species were absent. Trout failed to survive less critical conditions in a pond containing additional species (alewife and fathead minnows). Differences found to exist between the three strains, in regards to growth and survival varied between the two ponds. In the pond with competing species present the cross exhibited the greater rates of growth and survival, presumably because of the larger size when stocked which enabled it to be better able to compete with the pond s established population. In the pond containing only the trout stocked for this study, size when stocked was not a factor and the cross had inferior rates of growth and survival when compared to the other strains used. The difference in the growth rates of the Donaldson and New Jersey strains was found to be insignificant, while the New Jersey strain seemed best adapted to survival in the test environment.

SOLDWEDEL. R. 1969. Comparisons with the New Jersey hatchery are made with regard to several characteristics. Report No. 31. New Jersey Department of Conservation and Economic Development. Trenton, New Jersey.

Spruce Run Reservoir, located northwest of Clinton, New Jersey, and a portion of its drainage was used to compare the Donaldson strain of rainbow trout with the New Jersey Hatchery strain. The reservoir was constructed in 1963 and it together with its drainage were reclaimed just prior to its flooding. The Donaldson strain of rainbow trout, developed by Dr. Lauren Donaldson of the University of Washington in Seattle, purportedly had exhibited superior growth rates under certain environmental conditions in its home State, and it was desirous to determine whether these or other benefits could be realized in New Jersey.

Various characteristics such as growth rates, return to the angler, and harvestability with regard to environmental conditions were compared. When stocked as fingerlings the Donaldson exhibited a superior growth rate over that of the New Jersey strain, about 0.70 inches per month as compared to 0.49. When stocked as catchable size fish there was no advantage of one strain over the other with regard to growth rates or percentage of return to angler. However, there was an indication that the Donaldsons were less responsive to environmental stimuli such as temperature in their feeding habits, a characteristic considered desirable in put and take trout management.

SOLDWEDEL, R. 1974. Development of trout management practices in the Spruce Run reservoir tributaries. Under Project No. F-30-R. New Jersey Department of Environmental Protection. Trenton, New Jersey.

Spruce Run Creek and Mulhockaway Creek, two tributaries of Spruce Run Reservoir, located northwest of Clinton, New Jersey served as the sites for an evaluation of the practice of establishing put-and-take trout stocking programs in minor streams. The period of evaluation extended from 1965 through 1972. However, it was not until 1969 that the program was given direction (in terms of its present objective) with all three species of trout (brook trout, *Salvelinus fontinalis*; brown trout, *Salmo trutta* and rainbow trout, *Salmo gairdneri*) being utilized in the stockings.

The close geographic proximity of the two streams to each other did not mean that they were identical in nature and the study indicated that quite the reverse was true. A more definitive division of streams on the basis of their individual characteristics should be considered in the allocation of trout and the Bureau s trout stocking policy.

On the basis of the findings of this report it was recommended that Spruce Run Creek be stocked with rainbow trout and only that species for it appeared that there existed inter-specific competition when other salmonids were introduced or established, which tended to suppress the return of rainbow trout. In view of the tag returns from Mulhockaway Creek and realizing inter-specific competition could not be removed there through stocking practices alone, it was recommended that it be stocked with and/or managed for brown trout.

Holdover trout and the long term duration of the fishery were considered as relatively insignificant aspects of this program. Streamflow, so important a factor contributing to the loss of stocked trout in major streams, was shown to have relatively little effect on returns in these instances. Turbidity apparently retarded the harvest of trout from Mulhockaway Creek in 1969 and 1971.

SOLDWEDEL, R. 1975. Evaluation of winter trout stocking programs in Round Valley and Spruce Run Reservoirs. Miscellaneous Report No. 40. New Jersey Department of Environmental Protection, Division of Fish, Game and Shellfisheries. Lebanon, New Jersey.

Trout stocking during the months of November, December, January and February was compared with the normally practiced March pre-season stocking in two reservoir types; (1) an eutrophic reservoir having a marginal year-round trout supporting capability (Spruce Run Reservoir), and (2) an oligotrophic reservoir with an established year-round trout supporting capability (Round Valley Reservoir). The study included a comparison of the relative merits of brook trout, brown trout, and rainbow trout, the three species of trout normally stocked under New Jersey s program.

It was determined that at Round Valley Reservoir, where the opportunity for movement of stocked trout out of the impoundment did not exist and pre-season angling was minimal, stocking during the month of December with brown trout would provide an acceptable immediate return and would take best advantage of the potential for growth offered. Although rainbow trout rated higher than brown trout in terms of the immediate return, the low margin by which they exceeded the immediate return of brown trout was offset by the brown s return by weight advantage. If brook trout were to become available, this species would be recommended over either the brown trout or the rainbow trout.

At Spruce Run Reservoir a considerable percentage of the trout (especially brook trout) stocked prior to February were lost as a result of pre-season angling and movement from the reservoir into its tributaries. Despite this, the return by weight of brown trout from the December stocking (86.4%) was far above that for any other stocking period.

The most effective use of pre-season stocked rainbow trout proved to be derived from the March stocking. The recommendation, therefore, was to stock brown trout in December and rainbow trout in March splitting the quota on a 50-50 basis.

SOLDWEDEL, R. and A. B. PYLE 1969. Aspects of trout management employing reclamation and restocking with fingerling rainbow trout in a marginal trout pond. Report No. 30. New Jersey Department of Fish and Game. Trenton, New Jersey.

Holmdel Park Pond, a marginal trout pond located near Holmdel, New Jersey on Monmouth County Park Commission Property was used to evaluate the management procedure involving annual plantings of fingerling rainbow trout with reclamation as determined necessary. Results showed that this procedure can produce an excellent fishery, extending through the summer and fall, under the conditions tested. An average monthly growth increment of about 0.49 and survival of up to an estimated 90% made this possible. Competition from other species was considered the most serious factor influencing survival and growth, and measures effectively preventing the establishment of other species are considered essential to the success of this management procedure. Estimated poundage of fish produced in Holmdel Park Pond compares favorably with results elsewhere. Considerations related to the application of this management procedure are also discussed.

SOLDWEDEL, R. and A. B. PYLE. 1970. Aspects of trout management employing reclamation and restocking with fingerling rainbow trout in a stream environment. Miscellaneous Report No. 32. New Jersey Department of Conservation and Economic Development, Division of Fish and Game. Lebanon, New Jersey.

The practice of reclamation employing rotenone followed by the planting of fingerling rainbow trout can produce a substantial fishery, even to an extent greater than indicated in this report if adequate controls are imposed to prevent angling until the fish reach an acceptable length for harvest (approximately 8), and thereby minimize waste. For Spruce Run Creek this technique produced an estimated 1,000 harvestable trout from an initial saturation stocking of 30,000 2.2 inch fingerlings after about a year. The return on these fish by weight substantially exceeded the input. Results indicated that when the stream alone is considered (Spruce Run Reservoir in this investigation acted to receive excess fish), that benefits could be realized by adjusting stocking quotas so as to make them more in line with the stream s carrying capacity.

Redevelopment of the bulk of the stream s original fish population, in terms of species but not in terms of size or age of individuals, took place within about two years. Fingerling trout plantings made subsequently that were subjected to increasing inter- and intra-specific competition generally provided a lesser yield. Other factors influencing yields were the time of stocking and size of trout planted in relation to periods of heavy trout angling activity; stream flow with particular reference to the summer; and growth influenced by competition, position of trout in the stream, and stream flow.

Fingerlings planted in December so as to be too small to catch unless especially sought after, during periods of heavy angling in the spring, but which reached harvestable length in the fall, improved an otherwise negligible fall fishery. Fingerlings planted that were large enough to catch but too small to keep during heavy spring angling produced poor returns to the creel.

Reclamation was considered beneficial primarily in that it provided for increased survival and production of trout, but it apparently did not enhance their growth. Perhaps the greatest benefit was that within five years a naturally reproducing population of rainbow trout had built up to a point where it was comprising a greater percentage of the total harvest than those trout originally stocked as fingerlings.

SOLDWEDEL, R. H. and A. B. PYLE. 1973. Investigations in the mortality of stocked trout in New Jersey streams. Miscellaneous Report No. 36. New Jersey Department of Environmental Protection. Trenton, New Jersey. 28 p.

Out of the eighteen streams employed in this study six were found to be unsuitable for stocking with hatchery-reared trout until their temperatures increased to about 42° F after April 1st. These six streams are located in Central New Jersey and their chemical characteristics are considered to be largely responsible for the inability of brook, brown and rainbow trout from New Jersey s hatchery in Hackettstown to adjust and survive when stocked at colder temperatures. Toxicity is discounted as a factor because their waters maintain resident trout populations throughout the year.

Sulfate and aluminum concentration increases are associated with the colder water temperatures but they alone are not considered adequate to recognize other streams posing similar trout adjustment problems. Therefore, the fingerprinting of streams is suggested as an aid in dealing with this problem.

Mortality of the newly stocked trout is quite rapid, usually being complete in less than a week, with the order of decreasing susceptibility being rainbow trout, brown trout and brook trout.

SOLMAN, V. E. F., J. P. CURRIER and W. C. CABLE. 1952. Why have fish hatcheries in Canada s National Parks? Proceedings of the North American Wildlife Conference. 17 : 226-234.

The first national park fish hatchery was established in Banff Park in 1913 when there was general agreement that hatcheries were the most important tool in fishery management. Nearly 120 lakes in Waterton, Banff, Yoho, Kootenay, Glacier, Mount Revelstoke and Jasper Parks were virgin until they were stocked with hatchery products. Cutthroat trout, rainbow trout and eastern brook trout were widely distributed.

The percentage of marked rainbow trout as reported caught by anglers varies considerably from lake to lake. Returns of stocked fish to the angler ranged from 5.0-100.0% (average 50.0%) in eight lakes in Jasper National Park. In some lakes where rainbow trout are thought to spawn quite successfully, a small percentage of the rainbow trout caught by anglers are marked fish. In other lakes such as Edith, Patricia and Mina, the proportion of marked rainbow trout is more than 75%.

In Leach Lake, in which rainbow trout have been stocked since 1933 and in which a large population of chub minnows (*Couesius plumbeus*) is present, 12% of the yearling and 2 year old rainbow trout planted in 1948, 1949, and 1950 were reported caught during the same year and 11% the year after making a total recorded return of 16% to anglers.

In Mina Lake, which has been stocked with rainbow trout since 1936, 2 year olds, selected as fast growing trout, were planted in 1950. Eight percent of these were caught by anglers in the same year and an additional 9% in 1951. Only 1% of an equal number of slow growing 2 year old rainbow trout planted at the same time has been reported caught in the two year period.

SPENCE, L. 1971. Rock Creek creel census, May 1958-November 1967. Federal Aid in Sport Fish Restoration, Job Final Report, Montana Fish and Game Department. Helena, Montana.

This is the final report summarizing a ten year creel census on Rock Creek near Missoula, Montana. The census was designed to yield information on the survival of stocked, catchable-sized rainbow trout to the creel and their effect on fishing in a stream containing a wild trout populations. Catchables were planted during the first three years of the study. No fish were planted during the following four years; but were again planted, in increasing numbers, during the last three years.

The first year return of catchables ranged from 25.6% to 39.3% and averaged 34.6% through Labor Day. During years of stocking the first plant of fish was made between June 16 and July 2; 78-94% of the stocked fish caught were harvested by the end of August; 1-5% of fish stocked were harvested the second year. The average catch-per-hour for all fishermen combined was 26% higher for the six years with stocking than it was for the four years without stocking (0.77 compared to 0.61) and the average number of fish caught per angler was 40% higher during the stocked years than during the non-stocked years (2.8 compared to 2.0). These differences were significant at the 95% probability level. However, the analysis showed that the more skillful fishermen benefited more than the less skillful fishermen when catchable-sized trout were stocked. There was not a significant difference in the number of hours fished per fisherman or the number of fishing trips made to Rock Creek between stocked and non-stocked years. On the average, 47% of the fishermen caught zero fish during the non-stocked years and 41% during the stocked years. This difference was significant at the 90% probability level. Even in stocked years the lower 50% of the fishermen, in terms of success, averaged only 4% of the game fish caught.

STAUFFER, T. M. and M. J. HANSEN. 1969. Mark retention, survival, and growth of jaw-tagged and fin-clipped rainbow trout. Transactions of the American Fisheries Society 98(2) : 225-229.

Five groups (200 each) of rainbow trout were held in a hatchery pond for 2 years and grew from 229 to 444 mm TL. Three groups were marked with different jaw tags, one was fin-clipped, and one was unmarked. Condition factors of tagged, fin-clipped and unmarked rainbow trout from Lake Michigan were also available. Tagged trout held in a hatchery retained virtually all of their tags for one year, but at the end of two years, the three groups had lost 5% (No. 10 ring), 15% (No. 8 ring) and 21% (No. 3 strap) of the tags. Jaw tags inhibited growth slightly but had no effect on fish condition factors. Trout bearing the No. 3 jaw tag in Lake Michigan had significantly lower condition factors than the unmarked trout, but No. 10 ring-tagged trout did not. In the hatchery, 95% or more of the pelvic, pectoral, adipose, and maxillary clips were recognizable at the end of 2 years. Growth and condition of trout held in the hatchery were unaffected by a combination of pectoral and pelvic fins. The clipped pectoral fin had no effect on condition of rainbow trout in Lake Michigan.

STERNBERG, D. 1988. Hatchery trout versus wild trout. p. 29 *In* Trout. The Hunting and Fishing Library Colwes Creative Publishing Incorporated. Minnetonka, Minnesota.

To many trout enthusiasts, hatchery is a dirty word when coupled with trout. But other trout fishermen realize that without hatchery-reared trout they would have no trout fishing opportunities.

There is no denying that hatchery-reared trout lack many of the desirable attributes of wild ones. They are much less wary and considerably easier for fishermen and predators to catch. Many are caught within a few days of stocking; few make it through the first season. When hooked, they wage a comparatively weak battle and are much less likely to jump. From a fisheries manager s point of view, the hatchery product is very expensive: an 8-10 inch yearling costing from $0.50 to $1.00.

The main gripe against hatchery trout is that they compete for food and space with wild trout. Often, the size and number of trout in a stream increase dramatically when stocking is discontinued. Another problem is genetic contamination. When hatchery trout breed with wild trout the offspring are normally less suited to the environment than the wild trout were.

Hatchery trout are also inferior on the dinner table. They have white meat often with a faint liver taste from the pellets they are fed. Wild trout normally have pinkish meat with a tasty salmon-like flavour. For all of these reasons most natural resources agencies have reduced the number of trout they stock; on many streams stocking has been discontinued altogether. The money saved is often spent to improve degraded stream habitat. Unskilled trout fishermen continue to pressure agencies for more hatchery trout because they find wild ones too difficult to catch. But most serious trout anglers prefer the wild trout management.

Of course, streams that do not have suitable conditions for natural reproduction must be stocked if there is to be a trout fishery. Managers continue to stock catchable-sized trout in many such put-and-take streams, particularly near large cities. But the put-and-take management is gradually giving way to a put-and-take philosophy; the trout are stocked as fry and fingerlings then allowed to grow up in the stream. This type of stocking is considerably cheaper and the trout that survive to catchable size bear a much closer resemblance to wild trout.

STOCEK, R. F. and H. F. MacCRIMMON. 1965. The co-existence of rainbow trout (*Salmo gairdneri*) and largemouth bass (*Micropterus salmonides*) in a small Ontario lake. Canadian Fish Culturist 35 : 37-58.

A sport fishery was maintained between 1958 and 1962 in a 41.7 acre lake by annual plantings of yearling hatchery-reared rainbow trout and the natural reproduction of introduced largemouth bass. Because of unfavourable summer limnological conditions in the hypolimnion and lower thermocline, both species were obliged to co-exist in the upper 10-15 feet of surface water. An average annual fishing pressure in 1961-62 of 155 anglers-hours per surface acre harvested 5.1 trout and 5.5 bass, or 4.6 pounds of these species per surface area. Angling success was 0.05 bass and 0.06 trout per angler-hour. Factors affecting the survival, distribution and fishing quality of both species are discussed.

STONE, M. D. 1995. Fish stocking programs in Wyoming: A balanced perspective. American Fisheries Society Symposium 15 : 47-51.

Introduction of non-native salmonids into Wyoming began with stocking brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorhynchus mykiss*) in 1880. Both good and bad experiences from the use of cultured fishes to manage sport fisheries have been documented. Fifty-three fish species are native to Wyoming; four of these are now considered extirpated from the state. None were extirpated by fish stocking. The Wyoming Game and Fish Department (WGFD) has developed a balanced fisheries management program that addresses both the ecological integrity of waters capable of sustaining native or wild fisheries and public demands for sport fisheries. Practices appropriate for one setting may be inappropriate for another. Maintenance of native subspecies of cutthroat trout (*Salmo clarki*) has been a management priority for over 40 years. Early stocking of brook trout and rainbow trout was detrimental to certain native trout stocks. Cultured trout have since been instrumental in cutthroat restoration. Most trout streams in Wyoming are managed as wild fisheries in accordance with WGFD guidelines. Low returns of stocked trout in streams and the demonstrated ability of streams to support acceptable wild trout fisheries, lead to these guidelines. Reservoirs constitute 68.5% (159,800 acres) of the standing water acreage in Wyoming. Most reservoirs are managed with cultured fish due to habitat conditions that limit natural trout reproduction. Altered habitats present the greatest challenges in terms of overall fisheries management and use of cultured fish.

STONE, R. and J. LIVESAY. Undated. The development of a coldwater fishery on a newly-formed large impoundment. Utah Department of Fish and Game. Salt Lake City, Utah. 11 p.

Flaming Gorge Reservoir is located on the Green River near the southwestern corner of Wyoming and the indented portion corner of Utah. To the present time, two species of game fish, rainbow trout (*Salmo* *gairdneri*) and Kokanee salmon (*Oncorhynchus nerka*) have been stocked in the reservoir. Rainbow trout fingerlings, reasonably close to two inches in length, were planted in 1963 (3,333,497 fish), 1964 (3,982,135 fish) and 1965 (1,657,976 fish).

The 1963 plants of trout exhibited rapid growth during the first year reaching a length of about 11 inches in the canyon areas and 12 inches in the open areas. During their first year of reservoir life, the fish of the 1964 plants also grew rapidly reaching about 11 inches in both the canyon and open areas. This pattern of growth has been paralleled by a decline in the condition of the fish.

STRINGER, G. E., A. F. TAUTZ, T. G. HARTSEY, and C. HOUSTON. 1980. Further development and testing of a lake stocking formula for rainbow trout in British Columbia. Fisheries Management Report No. 75, British Columbia Ministry of the Environment. Victoria, British Columbia.

Between 1959-1963 a preliminary assessment of stocking practices was undertaken in order to estimate the carrying capacity of stocked lakes and determine what numbers of fry, fall fingerlings and yearlings produced a given number of adults when stocked at rates derived from a formula derived from total dissolved solids and length of shoreline.

Several conclusions and recommendations were presented from the study. Gill nets should not be used for estimation of growth and/or relative abundance for different lakes without giving attention to the selective nature of the nets and the effects of lake size and probability of capture. For lakes which maintain fisheries, one should expect a 40-60% survival for yearlings, 10-30% survival for fall fingerlings, and 2-6% survival for fry to 16 months of age. Although fall fingerlings appear to grow at rates comparable to yearlings and provide more than twice the number of adults per kilogram stocked, two major advantages remain favouring a yearling emphasis. Firstly, the egg requirement and early rearing space is halved and, secondly, lake survival is more predictable allowing for more precise management. By applying expected mortality rates to lakes without natural recruitment and determining extraction rates from creel census or resort records, stocking rates can be calculated to maintain the status quo if we make the assumption that natural mortality for II and III age groups is insignificant. Determining natural mortality from age II to age III would help refine the estimate of standing crop as well as calculating stocking needs. Additional studies on the relative importance of benthic vs. water column production would aid in improving the predictability of the stocking formula.

STUBER, R. J., C. SEALING and E. P. BERGERSEN. 1985. Rainbow trout returns from fingerling plantings in Dillon Reservoir, Colorado, 1975-1979. North American Journal of Fisheries Management 5(3B) : 471-474.

Fingerling rainbow trout (*Salmo gairdneri*) were stocked in Dillon Reservoir, Colorado, in 1974-1978 and evaluated in terms of harvest, percent return to the creel, and cost per fish harvested. The average annual harvest of stocked rainbow trout was 18,300 (14/hectare). The average return to the creel was 4.8% and the average cost per trout harvested was $6.78. Two factors are suspected to be responsible for these low returns and resultant high costs predation by resident brown trout (*Salmo trutta*) and competition with kokanee (*Oncorhynchus nerka*) for a limited zooplankton forage base. Thus, Dillon Reservoir is not considered to be a good site for a put-grow-and-take rainbow trout fishery. Based on our findings, fishery managers should be hesitant to stock fingerling rainbow trout in impoundments with substantial populations of predatory fish and/or potential competitors.

SWANSON, M. E. 1979. Survival, growth and food or rainbow trout and splake trout in ponds on the Canadian prairies. M. Sc. Thesis, University of Idaho. Moscow, Idaho. 30 p.

SWARTZMAN, A. L. 1950. Report on the results from trout stocking in the Deerfield River. Journal of Wildlife Management 14(2) : 183-189.

In 1946, 12,955 trout, ranging in length from 9 to 13 inches were planted. Of this total, 7,480 were brook trout, 3,050 were brown trout and 2,065 were rainbow trout. The majority of the fish were released during the month of March and prior to the open season. In 1947, the stocking totaled 13,800 fish and was comprised of an equal number (4,600) of brook trout, brown trout and rainbow trout. To supplement information on the results of stocking legal-sized trout in streams and rivers of Massachusetts, creels were sampled in the 1946 and 1947 seasons on the Deerfield River.

In 1946, 11.8% and in 1947, 16.2% of the sampled catch was comprised of wild fish. Evidence regarding the extent and direction of rainbow trout migration is meager but it does indicate that such movement is chiefly downstream. Recovery, expressed as a percentage of the marked fish planted, was 13.0% for rainbow trout. In 1947, it was estimated that 9,400 anglers caught a total of 5,288 trout. Of this total, 4,336 were planted in 1947. This number represents a return of about 31% of the 1947 stocking.

On the basis of data obtained in 1946 and 1947, it is clear that planted trout provide most of the fishing on the Deerfield River. Under present stocking methods, however, only a small part of the planting is recovered in the current season (31% in 1947) and there is scarcely any carry-over from year to year. At present the poor returns from planted fish and the low yields of native fish make for expensive but none the less poor fishing. It would be in the interests of economy, obviously, to encourage the production of native trout and to increase the efficiency of recovery of planted trout.

SWARTZMAN, G. L. and D. A. BEAUCHAMP. 1990. Simulation of the effect of rainbow trout introductions in Lake Washington on juvenile sockeye salmon. Transactions of the American Fisheries Society 119 : 122-134.

We developed a simulation model based on energetics, habitat selection, feeding selectivity, and population dynamics to examine the effect of introductions of rainbow trout (*Oncorhynchus mykiss*) on parr of sockeye salmon (*O. nerka*) and longfin smelt (*Spirinchus thaleichthys*) resident in Lake Washington (Washington State). We modeled growth and population dynamics of rainbow trout cohorts introduced between 1981 and 1984 and compared results with length-at-age data obtained from marked released fish and with data on diets. Graphical comparisons indicated a reasonable fit to the growth data over the 150-400 mm size range. The model gave a close prediction of the size at which rainbow trout begin to eat fish, these results being sensitive to a size selective feeding function. Diet data showed that model predictions for the major prey fish (longfin smelt and sockeye salmon) were reasonable. However, prey vulnerability had to be set lower for sockeye salmon than for longfin smelt to produce reasonable rainbow trout diets. Simulation experiments examined the effect of altered rainbow trout enhancement, fishing pressure, prey vulnerability and prey abundance and species composition on prey fish survival. These experiments indicated that the effect of rainbow trout predation on prey fish strongly depended both on the magnitude of rainbow trout introductions and on the prey fish abundance and species composition which varied from year to year.

SWINGLE, H. S. 1949. Some recent developments in pond management. Proceedings of the North American Wildlife Conference 14 : 295-311.

Possibly the most promising development in the fishery field in the United States within the 20th century is the tremendous increase in the acreage of freshwater for the purpose of producing fish and for providing water for livestock. Thousands of new ponds have been constructed for the principal purpose of providing fishing.

Rainbow trout (*Salmo gairdnerii irideus*) are being used in coldwater ponds in various parts of the United States where the summer water temperatures rarely exceed 70… F. They will, however, tolerate warmer waters up to 85… F for short periods. The stocking rate used in the northwest is 1,000 eyed eggs or 350 fry, or 300 fingerlings per acre. Ponds in the northeast are stocked with fingerlings at the rate of 300 per acre. The rate of growth of this fish is often excellent in these ponds but their average percentage of survival is unknown. This species rarely spawns in farm ponds and must be restocked periodically.

SWINK, W. D. 1983. Surveys of stocking policies for tailwater trout fisheries in Southern United States. Progressive Fish-Culturist 45(2) : 67-71.

A survey of the 16 southern states showed that 48 tailwaters in 13 states were stocked with trout in 1980. Of the almost 3.7 million trout released in these waters, 81% were catchable size and 19% were fingerlings (<150 mm). Tailwaters received 32% of all trout stocked in the South; nearly 95% of the tailwater fish were rainbow trout (*Salmo gairdneri*). A trend away from put-grow-and-take fisheries toward put-and-take fisheries was noted. Limited creel data confirmed that fishing pressure in southern tailwaters was heavy, and that 25 to 90% of the trout stocked were recovered by anglers.

SWOR, C. T. and F. J. BULOW. 1975. Changes in the food habits of various game fishes after stocking rainbow trout in the Cordell Hull section of the Cumberland River. Journal of the Tennessee Academy of Science 50(1) : 12-15.

A study of the food habits of seven species of warmwater game fishes in the Cordell Hull section of the Cumberland River, prior to the impoundment of Cordell Hull Reservoir, revealed predation on rainbow trout by four of these species. Largemouth bass, spotted bass, smallmouth bass and walleye consumed rainbow trout when large numbers of small trout were stocked in the Cumberland. Black crappie, white crappie and channel catfish were not found to consume trout. Stocked trout were most vulnerable to predation for a period of three to four weeks after stocking. Trout up to 210 mm (8.3 inches) total length were found in stomachs and as many as 12 trout were found in a single stomach.

THOMAS, A. E. and M. J. DONAHOO. 1977. Differences in swimming performance among strains of rainbow trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 34 : 304-306.

Swimming performance profiles, relating fish size to swimming time, were established for three strains of rainbow trout (*Salmo gairdneri*). No differences were found in slope of regressions; only in level at each size of fish. Swimming performances of New Zealand and Sand Creek strains did not differ, but were superior to the Manchester strain. In stamina results from 189 day old fish from individual matings of seven strains and various crosses, similar strains and crosses had closely matching profiles whereas profiles of unrelated groups were variable. Comparison of slowest, average and fastest growing fish within the New Zealand strain showed that swimming ability was not related to growth rate.

THORN, W. 1984. Evaluation of fall-stocked rainbow trout fingerlings in southeastern Minnesota streams. Fisheries Management Report 27, Minnesota Department of Natural Resources. St. Paul, Minnesota. 26 p.

THORNE, G. R. 1982. Statewide fisheries investigations: Stocking catchable rainbow trout in Navajo Lake. New Mexico Department of Game and Fish. 8 p.

THORPE, L. M., H. J. RAYNER and D. W. WEBSTER. 1944. Population depletion in brook, brown and rainbow trout stocked in the Blackledge River, Connecticut, in 1942. Transactions of the American Fisheries Society 74 : 166-187.

A section of the Blackledge River, 1.7 miles long, was blocked off by weirs and fish traps and a total or 4,757 marked brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and rainbow trout (*Salmo gairdneri*) were stocked in the experimental area in three plantings. Only a small number of the marked trout attempted to leave the area as indicated by the 46 fish taken in the traps. Subsequent recapture of these trout, which were tagged, indicated no inclination to move any great distance. The mortality of the marked trout after planting was slight during the period of observation except in one planting where the brook and brown trout stocked showed advanced symptoms of furunculosis. The total catch of marked trout during the season of April 17 to August 31 was 3,446 trout taken by 3,152 anglers spending 9,746 hours on the stream. There was about an 80% return of the available population from each planting and from each of the three species of trout planted. Of the 97 unmarked trout which were caught, only 23 were judged to be wild fish, the others being recently stocked trout which had moved into the area from adjoining waters before the weirs were in place. The distribution of the angling pressure was such that each planting was depleted within a few days. About three-fourths of the total catch of trout made from any on planting was taken within four days of the date of stocking. The population of brook trout was depleted most rapidly, that of brown trout most slowly and rainbow trout were intermediate. Only five days of fishing were provided during the season where the catch-per-unit-of-effort approached 1 trout per hour or more. There was a high correlation between the population of trout in the stream and the catch-per-unit-of-effort except in the second planting of brown trout. The relationship between the available population and the catch-per-unit-of-effort showed progressively higher yields for the same number of trout as the season advanced. Because of the rapid population depletion in only one instance could possible differences in behavior between newly stocked trout and those from previous plantings be noted. The distribution of each angler s catch indicated that under a limit of 15 fish about one-third of the total number of anglers accounted for three-fourths of the catch on the first few days following each planting.

THREINEN, C. W. 1958. Cause of mortality of a midsummer plant of rainbow trout in a southern Wisconsin lake with notes on acclimation and lethal temperatures. Progressive Fish Culturist 20(1) : 27-32.

When rainbow trout were stocked on August 9, 1956 in Lower Nashotah Lake in southeastern Wisconsin, they immediately displayed distress and died soon after. This occurred when surface water temperatures were 74… F, well below the temperature reported lethal for the species. The circumstances were unusual enough, particularly in view of the fact that other lakes had been stocked at the same time with no apparent ill effects, to warrant an investigation into the causes.

A sample of fish from the Nevin Hatchery (Madison, Wisconsin) were hauled to the stocking site at Lower Nashotah Lake. Water temperatures of the hauling water were initially 51… F and rose to 54… F during the 1.5 hour haul. For the first series (A) trout were transferred directly from the tank truck to the lake and released under a variety of conditions. Trout for the second series (B) were given an acclimation period of 45 to 60 minutes during which the temperature of the water in the tank truck was gradually raised to that of the lake. For the third series (C) trout were given a full 24 hour acclimation period during which the hatchery water in which the trout were reared was allowed to warm up gradually to the temperature of the air.

These experiments established heat as the cause of death for trout planted in Lower Nashotah Lake. Rainbow trout should not be stocked when the temperature of the receiving water is 20… more than the holding water (usually spring water of about 50… F). Before they are stocked in water that is above 70… F, rainbow trout should be acclimated through a 24 hour period to a temperature within 10… F of the receiving water.

THURSTON, L. D. W. 1977. Evaluation of plantings of brook and rainbow trout within Parry Sound District. File Report, Ontario Ministry of Natural Resources. Parry Sound, Ontario. 7 p.

Brook and rainbow trout populations in lakes planted within the Parry Sound District were assessed using either winter creel census or gillnetting statistics. The success of brook trout in Cadgeroad, Wilds, Hunter, and Silver Sands lakes (which do not have populations of spiny rayed fish such as perch and rock bass) has been most gratifying. The success of rainbow trout has however been less spectacular. We have decided to double the stocking rate on Boy Lake as a last resort to manage waters in the Parry Sound District for rainbow trout. The future management of rainbow trout in this district will be dependent on the success of a planned 1978 planting in Boy Lake.

TREMBLEY, G. L. 1943. Results from plantings of tagged trout in Spring Creek, Pennsylvania. Transactions of the American Fisheries Society 73 : 158-172.

Data on anglers catches, the growth and migration of stocked trout and the efficiency of fall and spring plantings were obtained by means of a creel census in Spring Creek, Pennsylvania, during 1939. Of 2,130 tagged trout planted, 50.8% were recovered by anglers. Due to heavy fishing pressure, more than 40% of all tagged trout taken during the entire season were removed on the first day. The quality of fishing declined rapidly during the early season. Fishing for brook trout was good for only a few days, brown trout fishing was fair for about a month while rainbow trout fishing lasted slightly longer. Catches of tagged trout after 6 weeks were negligible. Only 10 trout were recovered during 1940 and 1 during 1941. Six of these fish were brown trout and 5 were rainbow trout. There was no evidence that any brook trout survived from one fishing season to the next.

Growth studies of trout planted in the fall indicated that rainbow trout grew fastest, followed by brown trout and brook trout. There was evidence that the growth rates of brown trout and rainbow trout decreased as the size of the fish increased. This was not true of brook trout.

Migrations of fall-planted trout were not extensive. Those undertaken averaged considerably less than 1 mile. Brown trout favored upstream and brook trout downstream movements while rainbow trout moved in equal numbers in either direction. Spring-planted trout captured after less than a month in the stream had moved very little. About half the rainbow trout migrated.

Fall planting of the three species of trout was nearly as efficient as spring planting, as 49% of the former and 54% of the latter were recovered. Recoveries of spring-planted brook trout and rainbow trout exceeded those of fall-planted trout by 8.8% and 13.6% respectively. Contrary to the common belief of anglers, fall-planted trout did not become wild over the winter. They were taken even more readily in the early fishing season than were trout of the spring plantings. The high returns from the fall plantings were attributed largely to the heavy fishing pressure, the moderate winter conditions, the lack of important predators and to a possible scarcity of wild trout from natural spawning in Spring Creek.

TROJNAR, J. R. 1973. Marking rainbow trout fry with tetracycline. Progressive Fish Culturist 35 : 52-54.

This study was designed to determine if a mark can be administered at a very early stage (swim-up fry), study the effect of diet on marking success, find a suitable minimum dosage, evaluate long-term retention and find a satisfactory way to store specimens before examining them.

Concentrations of tetracylcline were 100, 400 and 700 milligrams per kilogram body weight per day and fish were fed the treated food for 4-8 consecutive days. Fish were examined for marks with a dissecting microscope under ultraviolet light.

The conclusions from this study may be summarized as follows:

- Fry can be marked with tetracycline as early as 7 days after they start to feed.
- Marking efficiency is improved by the use of a beef liver diet.
- The minimum dosage for fry is below a concentration of 100 mg/kg body weight/day fed for 4 consecutive days, but the intensity of the mark increases at higher concentrations and longer feeding durations.
- Fry retain their mark for at least 1 year under hatchery conditions.
- Although freezing sampled fish is preferable, they can be kept cold for 4 days and bones can be stored dry for at least 12 days without loss of mark.

TRZEBIATOWSKI, R., J. FILIPIAK and R. JAKUBOWSKI. 1981. Effect of stock density on growth and survival of rainbow trout (*Salmo gairdneri*). Aquaculture 22 : 289-295.

The objective of the study presented was to determine the effects of various stock densities on the growth and survival of rainbow trout (*Salmo gairdneri*) in a cage culture located in power station cooling waters. Over the experimental period of 147 days, the cages were stocked with 150-900 individuals/m^3 of water. The cooling water quality proved satisfactory.

The results showed the fish production and weight gain per m^3 water as well as the feed conversion rate to increase with stock density. Individual growth rate and natural losses were inversely proportional to stock densities. Moreover, increased densities were found to yield a high production in a culture system of a relatively small capacity.

TURNER, S. E. 1971. A review of the literature on trout stocking. Project No. F-1-R-20, study No. I-11, Job No. 1. Missouri Department of Conservation. Jefferson City, Missouri.

Eleven papers pertaining to tailwater trout fisheries and reservoir trout fisheries were reviewed. Rainbow trout were used extensively in stocking both tailwaters and reservoirs. In tailwaters, 4 to 6 inch trout were considered the most economical stocking size with supplement stockings of larger trout during high use periods or when forage became available. Growth rates of 0.9 inches per month were reported. Harvest varied from 16 percent to 59 percent with large trout having higher returns, but small trout were able to support the fishery longer.

In reservoirs, rainbow trout stocked at a size large enough to compete with warm water predators gave returns of 1.7 to 22.6 percent by number and 1 to 43 percent by weight. Growth rates varied from 0.53 to 0.96 inches per month, and trout growth increased where forage fish were available. A harvest of 50 percent or better by weight was suggested to justify stocking trout in reservoirs.

TURNER, S. E. 1972. Survival and growth of various sizes of trout stocked in Lake Taneycomo. Project No. F-1-R-21, study I-11, Job 2. Missouri Department of Conservation. Jefferson City, Missouri.

The objective of this study is to select the combination of strain, length and number of trout and the location, time of year and method of stocking which will give the most favorable cost/benefit ratio in return to the creel in Lake Taneycomo. Five experimental size groups of rainbow trout (4, 6, 8, and 10+ inches) and three groups of steelhead trout have been marked and released in Lake Taneycomo in 1970 and 1971. Harvest of the groups released in 1970 was 55 percent (6 inch group), 35 percent (8 inch group), 12 percent (4 inch group), 12 percent (10+ inch group) and 52 percent (steelhead). Harvest of the groups released in 1971 was 100 percent (10+ inch group) and 38 percent (8 inch group). Harvest of the remaining groups has been low. Growth rates of the groups released in 1970 were 0.74 inches and 1.25 ounces per month (4 inch), 0.79 inches and 2.0 ounces per month (6 inch), 0.73 inches and 2.04 ounces per month (8 inch) and 0.78 inches and 1.24 ounces per month (steelhead). The best return in terms of numbers harvested and harvest duration was the 6 inch group released in October, 1970.

TURNER, S. E., G. W. PROCTOR and R. L. PARKER. 1974. Rapid marking of rainbow trout. Progressive Fish Culturist 36 : 172-174.

Personnel could mark approximately 2,000 trout per hour or from 12,000 to 16,000 trout per day. Mortality of the branded trout was extremely low ranging from 0.05 to 1.80%. Most mortality was a direct result of handling or anesthetizing and not branding. All of the marks were easily identified in the field by the creel census clerk; even an increase in trout from 4 to 24 inches did not hinder identification. After 2 years in the reservoir, trout from the 4 and 6 inch groups have been easily identified by the creel clerk. This method of marking proved very successful for identifying rainbow trout and steelhead trout released and later recaptured in Lake Taneycomo, Missouri.

U.S. FISH AND WILDLIFE SERVICE. Undated. Standards for put-and-take trout stocking. United States Department of the Interior, Washington, D. C.

The following put-and-take trout stocking standards apply to all waters under Fish and Wildlife Service management. The primary objectives of put-and-take trout stocking programs are to supplement natural fish populations where they are incapable of satisfying fishing pressure and to provide public recreational fishing where the habitat is suitable. Catchable trout are defined as those hatchery-reared trout of any species which are of suitable size for angler harvest at the time of stocking (8 inches or longer). The following criteria shall apply:

- Catchable trout will be stocked at densities no higher than necessary to provide an average catch rate within the range of 0.5-0.8 fish per hour between planting intervals for the length of the fishing season.
- Catchable trout will be stocked only under those conditions that ensure a minimum harvest of 60% of those stocked.
- If surplus brood stocks are to be stocked with a scheduled stocking of catchable trout, they shall not comprise more than 1% by weight of the catchable fish per stocking trip. Brood stock will be not be used to regularly bolster fishing programs in individual waters.
- Catchable trout will not be stocked in any impoundments where public access is completely denied nor in any streams where public access is not available for at least 75% of that portion of the stream under management.
- Profit-motivated fish farming ventures or individual waters that have been charging for fishing shall not be eligible for catchable trout.
- Catchable trout will not be stocked in waters where their introduction would create a threat to an endangered species of plant or animal, either directly or indirectly.

UTTER, F. M. 1971. A comparison of biochemical genetic variation between four hatchery stocks of rainbow trout. American Fisheries Society 101st Annual Meeting, September 16-18, 1971, Salt Lake City, Utah. 52 p.

Biomedical variants of the enzymes alpha glycerophosphate dehydrogenase (AG), lactic dehydrogenase (LDH), malic dehydrogenase (NDH), tetrazolium oxidase (TO), and phosphoglucomutase (PGM) and of the serum protein transferrin (Tfn) have been identified in stocks of rainbow trout that are being reared at the Seattle Biological Laboratory of the Nation Marine Fisheries Service. Various lines of evidence indicate that each type of variant reflects genetic variation at discrete loci. (The LDH, MDH, and PGM variants have been previously described by other investigators). Each of four stocks of rainbow trout tested had distinct genetic profiles based on the frequency of different biochemical variants.

The findings have considerable potential for application including: (1) characterization and identification of stocks; (2) indicators of inbreeding in hatchery and wild populations; (3) studies of physiological differences of genetically related forms of a particular enzyme and of environmental factors influencing retention of these variant genes in different stocks; and (4) use as genetic markers in seeking linkages.

VAN VELSON, R. C. 1970$_a$. Stocking of Lake McConaughy rainbow trout fry. File Report, Nebraska Game and Parks Commission, Lincoln Nebraska. 3 p.

VAN VELSON, R. C. 1970$_b$. A future rainbow trout stocking plan for Lake McConaughy and the North Platte River drainage. File Report, Nebraska Game and Parks Commission. Lincoln, Nebraska. 7 p.

VAN VELSON, R. C. 1978. The McConaughy rainbow life history and a management plan for the North Platte River Valley. Nebraska Technical Series No. 2, Nebraska Game and Parks Commission. Linoln, Nebraska. 41 p.

Located in Scotts Bluff County, Nine Mile Creek is the major spawning stream for the McConaughy rainbow trout population. The first rainbow egg collections in the North Platte River drainage, since the 1948 Otter Creek artificial spawning operations, came from McConaughy rainbow trout captured in Nine Mile Creek during January 1966. The demand for McConaughy rainbow eggs and fingerlings increased until, by 1974, 278,000 rainbow eggs were collected in the North Platte River drainage.

Streams representative of the North Platte River drainage were stocked with McConaughy rainbow fingerlings at various rates and sizes during 1971-1974. Selected streams were then sampled to determine the growth and survival. Streams were stocked April through July and sampled November through February. Survival varied from 6.1% to 54.1%.

Alliance Drain is the most productive stream stocked in the North Platte River drainage. Stocked with 18,000 fingerlings per surface acre of water, it produced a 36% survival rate. The standing crop of rainbow trout in this stream averaged 589 pounds per acre. A standing crop of approximately 100 pounds per acre can be expected in most of the streams now stocked with McConaughy rainbow fingerlings. Fingerlings stocked at 400 fish/pound had the best survival, consequently this is the recommended stocking size.

VEHANEN, T. 1997. Fish and fisheries in large regulated peaking power river reservoirs in northern Finland, with special reference to the efficiency of brown trout and rainbow trout stocking. Regulated Rivers Research and Management 13(1) : 1-11.

The Oulujoki, Iijoki and Kemijoki Rivers in northern Finland, all of them previously important rivers for the fishing of migratory salmonids, were dammed for hydropower production in the 1940s-1960s. Some 20 years after the construction of the last power plant, the fish communities, fishing and the effects of brown trout (*Salmo trutta lacustris*) and rainbow trout (*Oncorhynchus mykiss*) stocking were studied in fifteen reservoirs, five in each of these rivers. Test fishing, echo sounding and fish tagging were used to collect descriptive information about the fishing communities and the distribution and movements of fish. Catch statistics were used to estimate the yields and the fishing in the reservoirs. The results showed similarity in the fishing effort and the fish stocks in the reservoirs studied. Cyprinids, especially roach (*Rutilus rutilus*), were the most numerous species in the area. The hydroacoustic survey suggested that most of the fish occurred near to the river banks. Fishing in these reservoirs has recently increased, but it is mostly directed at predatory species rather than roach. The increase in the amount of fishing can partly be attributed to the stocking of rainbow trout of a takeable size (0.8-1.2 kg), which give good yields. Poor yields resulting from the previously standard stockings of brown trout smolts have been improved by stocking fish exceeding 30 cm in length. The results, however, show that stocking is not profitable in all the reservoirs. The future prospects for recreational rod fishing in the reservoirs are good, but improvements on the conditions for operating traps and gill nets are needed to optimize yields. This could include an intensive stocking of predatory fish, brown trout and rainbow trout.

VERMONT DEPARTMENT OF FISH AND WILDLIFE. 1993. The Vermont management plan for brook, brown and rainbow trout. Waterbury, Vermont.73 p. + appendices.

Rainbow trout were introduced into Vermont waters in 1886 with a planting in the town of Lunenburg. Over the years it has become an important component of the state s fisheries in both river and lake habitats. Rainbow trout were ranked second by Vermont resident anglers behind brook trout as the fish species targeted (73%) by most anglers and preferred for open water fishing. Rainbow trout was also the fish species targeted by the greatest number of nonresident anglers (57%) and third most preferred during open water fishing.

Even though rainbow trout have been, and continue to be, stocked extensively in drainages of southeastern Vermont, these waters characteristically have low alkalinities, a condition which does not support rainbow trout reproduction. Establishment of rainbow and brown trout in many Vermont streams and rivers has undoubtedly resulted in the partial or complete displacement of native brook trout populations. In the absence of quality spawning streams, most lake populations must be maintained by stocking. The goal of stocking in coldwater lakes and ponds is the return of 100% of the weight of stocked trout with a catch comprised of two or more age classes.

VESTAL, E. H. 1943. Creel returns from hatchery trout in June Lake, California. California Fish and Game 29(2) : 51-63.

Annual plants of rainbow trout of catchable size in June Lake from 1939 to 1942 have built up fishing from a low level and have provided a sustained yield in the face of increasingly heavy fishing. Over the four year period catches have averaged about 3 trout per angler day, about 0.6 per angler hour. In 1942, it is estimated that 19,830 anglers caught 55,965 trout. The majority of fish caught in any season were fish planted early the same season while the minority catch was composed mainly of fish planted the previous year.

The ratio of average total recorded catch to average total plant for 1939, 1940 and 1941 indicated a minimum survival of fish to the creel of 30.7 percent. A similar ratio for the estimated total catch for the same period indicated a minimum survival of fish to the creel of 44.5 percent. Of the 1942 plant of 100,000 trout it is estimated that 43,000 were caught the same season, indicating a yield of 43 percent the first year and other figures suggest a probably yield of at least 54 percent before this year class is exhausted.

Marked fish planted in 1939 grew an average of 10.5 inches in length and 21.3 ounces in weight in nearly 24 months in the lake. Marked fish planted in 1940 grew an average of 6.3 inches in length in 12 months in the lake. Marked fish planted in 1941 grew an average of 7 inches in length in 12 months in the lake. Growth is greatest during the first year of life.

The average condition factor of marked fish planted in 1939 was 1.38; 24 months later the average condition factor was 1.25. The average condition factor of marked fish planted in 1941 was 1.39; 12 months later it was 1.24. High at planting, the condition factor declines during the first few months of adjustment in the lake to about 1.22; it then increases a small extent to approximately 1.25, a point apparently limited by the lake environment.

VESTAL, E. H. 1954. Creel returns from Rush Creek test stream, Mono County, California. California Fish and Game 40 : 89-104.

The rise in angling pressure on California s roadside trout waters since 1944 has been tremendous. Poorer catches have been accompanied by demands from the angling public for increased plants of catchable trout. In response to these demands the California Department of Fish and Game is rapidly expanding hatchery production of catchables . It is vitally important to get the greatest possible number of these expensive fish back into the anglers creels. The Rush Creek experiments were designed to find out how this could be done in a representative stream in the great Inyo-Mono recreation area.

The experiments of the first five years, 1947 through 1951, dealt primarily with catchable rainbow trout. Smaller rainbow and brown trout were also planted during the first three years to determine their survival to following seasons, and to learn if such plants were more economical, in terms of fish in the angler s creel, than in-season plants of catchable trout.

This paper marks the completion of the rainbow trout phase of the project, the first four years of which were under the direction of the writer. Comparable experiments with brown trout are now under way.

VINCENT, E. R. 1972. Effect of stocking catchable trout on wild trout populations. *In* Proceedings of the Western Association of State Game and Fish Commissioners 52 : 602-608.

A trout population study started on two sections of the Madison River in the spring of 1967. This initial study was set up to determine the effects of low spring water flows on wild trout populations. The low flows resulted from water storage operations in Hebgen Reservoir. When water flows were improved in 1968, the only section to show significant trout population increases was the section which received no catchable rainbow plants. The other section, Varney, which had been receiving catchables during the period showed little improvement.

A basic Peterson mark-and-recapture method was used to estimate total numbers and biomass. Estimates were made only on two-year-old and other wild brown and rainbow trout. Electrofishing gear was used to sample the fish population. Electrofishing was carried out while floating through the various study selections. Anchor tags are placed in trout during the spring. These tags, when returned by anglers, are used to compute trout harvest.

Three study selections were used to determine the effect of stocking catchable on wild trout populations. Two selections were started in 1967. The Madison River selection (Varney) had received catchables since the early 1950s, while the lower O Dell Creek selection had received no catchables since 1963. With the cessation of planting in Varney in 1970, the wild trout population increased 180% in numbers and 186% in biomass by the fall of 1971. On lower O Dell Creek where stocking was stopped in 1970, the population size decreased 49% in numbers and 46% in biomass by the fall of 1971. A third section (upper O Dell Creek) which was set up in the spring of 1970, continued not to be stocked. The trout population showed no significant change from 1970 to 1971.

Angler tag returns indicated that there was a slight decrease in the harvest (2-3%) after stocking ceased in the Varney section of the Madison River. A similar decrease was also noted in O Dell Creek after stocking was started. The unstocked section of O Dell Creek had a higher return rate than the stocked section.

VINCENT, E. R. 1975. Effect of stocking catchable trout on wild trout populations. p. 88-91 *In* Wild Trout Management, Trout Unlimited.

In 1967, Montana started a trout population study on two sections of the Madison River. We were trying to find out if unusually low spring flows affected the numbers of trout. The flows were regulated by Hebgen Dam. In 1968, releases from the dam changed and spring flows were improved. However trout increased in only one of our two study sections. There was only one major difference in management between them. The section which didn t show improvement was being stocked annually with catchables, while the section that improved hadn t been stocked for over ten years.

In 1970, the study was changed to check on the effect of planting. We continued sampling the two Madison River sections and stopped planting the one that had been stocked annually. We also began sampling two sections of O Dell Creek, which is a tributary of the Madison. One of the O Dell Creek sections had been sampled before the other hadn t. The creek had not been planted for seven years. We began planting one O Dell Creek section; the other remained unstocked. By 1971, in the Madison section where we stopped planting, wild trout had increased over 180% both by numbers and by weight. At the same time in the O Dell creek section that we started stocking, wild trout numbers decreased over 45% in both numbers and weight. In the O Dell Creek section that remained unplanted, both numbers and weight of wild trout stayed about the same. In the Madison River section that has remained unplanted for over ten years, wild trout have continued to increase. This is probably still in response to the better spring flows that the river has had since 1968.

Fish were sampled by electrofishing which was conducted by floating through the study sections. A basic mark-and-recapture method was used to estimate total numbers and pounds. These estimates were made only for two year old and older wild brown and rainbow trout. Trout were marked with tags in the spring. Return of these tags by fishermen was used to estimate angler harvest. This harvest appeared to drop slightly both in the Madison section where stocking ceased and in the O Dell section where stocking was started.

VINCENT, E. R. 1985. Effect of stocking hatchery rainbow trout on wild stream dwelling trout. p. 48-52 *In* F. Richardson and R. H. Hamre [eds.]. Wild Trout III, Federation of Fly Fishers and Trout Unlimited. Vienna, Virginia.

The purpose of this study was to determine what effect, if any, long-term stocking of catchable-sized hatchery rainbow trout had on a resident, stream dwelling, wild trout population. The cessation of stocking in the Varney section of the Madison River in 1970 after 15 consecutive years of stocking resulted in a 162% and 133% increase in two-year-old and older wild brown trout numbers and biomass, respectively, and a 809% and 1,016% increase in the number and biomass of two-year-old and older wild rainbow trout, respectively. It took two years of no stocking to fully expand the wild brown trout populations and at least four years for the wild rainbow.

VINCENT, E. R. 1987. Effects of stocking catchable size hatchery rainbow trout on two wild trout species in the Madison River and O Dell Creek, Montana. North American Journal of Fisheries Management 7(1) : 91-105.

The fall population of 2-year old and older wild brown trout (*Salmo trutta*) more than doubled (106% increase), in both total numbers and biomass, 4 years after the last catchable-size hatchery rainbow trout were stocked in the Varney section of the Madison River, Montana; wild rainbow trout (*Salmo gairdneri*) numbers increased eight times (868%) and their biomass increased ten times (1,016%) during the same period. Brown trout biomass peaked within 2 years after stocking ceases, whereas wild rainbow biomass continued to increase for 4 years. Numbers of wild brown trout and rainbow trout 10.0-17.9 in long showed the greatest increases after stocking ceased. Flow variations had little effect on the total biomass of 2-year-old and older wild trout during stocking years (t=1.24), but stocking had a significant negative correlation (r=-0.953) with total biomass. When catchable-sized hatchery rainbow trout were stocked for three consecutive years into a previously unstocked section of O Dell Creek, Montana, the 2-year-old and older wild brown trout population was reduced 49% in total number and biomass. Wild brown trout 10.0-

17.9 in long showed significant declines in numbers after stocking was initiated, whereas those smaller than 10.0 in showed no significant change in numbers. A temporary decline in growth rates of yearling through 4-year old brown trout was observed in O Dell Creek during the first 2 years of stocking. Measurable movement of marked wild trout in the lower (stocked) section of O Dell Creek accelerated during the years of stocking. Stocking of catchable-size hatchery rainbow trout had no detectable adverse effect on wild brown trout through their first 18 months of life in either lower O Dell Creek or the Varney section of the Madison River.

WAGNER, E. J., T. BOSAKOWSKI, and S. IINTELMANN. 1997. Combined effects of temperature and high pH on mortality and the stress response of rainbow trout after stocking. Transactions of the American Fisheries Society 126(6) : 985-988.

To improve survival of stocked fish, field and laboratory tests were conducted to evaluate the survival and stress response of rainbow trout (*Oncorhynchus mykiss)* after exposure to waters with various combinations of high temperature and high pH. For each of four laboratory experiments, fish were transported by truck for 90 minutes. Fish were than put in replicate tanks for each of the four treatments of the experiment: (a) controls, pH 7.8, temperature 14… C; (b) control pH and high temperatures (19… C), experiment 2; 22… C (experiments 1 and 4) or low temperatures (7-9… C, experiment 3); (c) control temperature and fluctuating high pH (8.4-9.6); and (D) a combination of high or low temperature with high pH. Blood was sampled at 1.5, 3, 6, and 24 hours after stocking. At 1.5 hours, plasma glucose, chloride, and cortisol levels in all fish indicated a stress response from hauling and stocking. High temperatures (19… C, 22… C) alone did not produce additional changes in the stress indicators. However, high pH induced significant additional rises in glucose and cortisol levels in both high- and control-temperature tanks. At low temperatures the stress response was delayed; low temperature alone (8-9… C) produced significant elevations in glucose and cortisol compared with controls at 24 hours, suggesting that cold water acted as a stressor, albeit with a delayed reaction. Cold water combined with high pH induced higher cortisol concentrations after 24 hours than did high pH alone. Warm temperatures combined with high pH did not synergistically affect the stress response, but they significantly increased mortality at 22… C. Mortality in the field occurred at pH levels greater than 9.3-9.4 and temperatures of 19.9-22.8… C. Diel fluctuations in pH measured in four reservoirs ranged 0.1-0.5 units. Laboratory and field tests indicated that pH values greater than 9.4 resulted in mortality, especially at higher temperatures. There was also a significant stress response to pH 9.0 or greater.

WAGNER, R. A. 1954. Investigation of planted trout mortality survival studies in the main stem of the Colorado River. Special Report Project F-2-R-1, Wildlife Restoration Division, Arizona Game and Fish Commission. Phoenix, Arizona. 7 p.

The objective of this study was to determine the best size of fish or age class for introduction and the most feasible source from where these fish should originate.

Rainbow trout, varying in size from 0.75 to 10.0 inches were reared under controlled conditions from soft and hard waters and introduced into live boxes located in the Colorado River. Colorado River water is considered to be hard. Although the best survival was found with unfed and very small fry, only the progressively larger fish from the Page Spring Hatchery exhibited any desirable degree of survival success. Fish from the Pinetop Hatchery over three inches in standard length should not be introduced into the Colorado River.

WALES, J. H. 1950. Introduction of Kamloops rainbow trout into California. California Fish and Game 36(4) : 437.

The first known introduction of Kamloops rainbow trout (*Salmo gairdnerii kamloops*) into California waters was made on June 17, 1950. At that time 1,000 fish were liberated in certain tributaries to Shasta

Lake, Shasta County, California. At the time of liberation these fish were 11 months old and averaged 12 per pound. All of these Kamloops trout were marked by removal of the left ventral and adipose fins so that they may be distinguished from native rainbows.

The fish were scattered in these streams directly above the confluence of each with Shasta Lake in the hope that they will drop down into the lake soon after they have become acclimated. It is realized that plants of fish as small as these may not establish spawning runs, even with reasonably good survival. However, since it is not known which tributaries will be best suited to their needs, it seemed wise to scatter them throughout six of the better streams.

WALES, J. H. 1954. Relative survival of hatchery and wild trout. Progressive Fish Culturist 16 : 125-127.

Several workers have shown that the survival of hatchery fingerlings in streams is lower than that of comparable wild fingerlings. There is no evidence to indicate that hatchery life is not partially responsible for the relatively lower survival. However there are two other factors which may have some bearing on survival and it is evident that the relative importance of these factors should be studied. My contention is that our hatchery practices are, in certain respects, so very good that survival after planting is bound to be low. Even though our hatchery technique might be perfected so that the planted fish would be as well able to take care of themselves as comparable wild fish we would still have the problem of the suitability of the fish to the particular water where it was planted.

WALES, J. H. and D. P. BORGESON. 1961. Castle Lake investigation — Third phase: rainbow trout. California Fish and Game 47(4) : 399-414.

Experimental lots of marked fingerlings were stocked in Castle Lake annually from 1952 through 1958. These experimental plants were evaluated by means of a total (1952 and 1953) and a five day per week creel census (1954-1959). The mean return to the angler of four plants of catchable-sized, fall spawning domestic rainbows was 79.9%. The percentage returned to the angler of a plant of 2,500 rainbow trout, weighing 7.8 per pound, was slightly better than the return from an equal lot weighing 13.1 per pound. However, in terms of the weight stocked, the smaller fish gave a substantially higher return. A plant of 3,833 untagged rainbows, 5.0 per pound, returned significantly better than 980 of the same lot tagged with an experimental subcutaneous tag. Returns to the angler from air plants was appreciably less than that achieved through truck plantings in Castle Lake.

Angling success during the rainbow trout phase was high with the catch-per-angler averaging 1.0 trout. Fishing pressure dropped appreciably after 1957 due probably to deterioration of the Castle Lake road and the recent development of good trout fishing in nearby Dwinnell Reservoir. Under a species catch composition similar to 1958 and 1959, 10,000 rainbow trout fingerlings appear to be the proper number to stock in Castle Lake annually. This amounts to 210 fish per surface area. Due to insufficient data, a decision regarding the best strain of rainbows for Castle Lake was not reached.

The annual yield during the rainbow trout phase was greater than that during the earlier phases. However, the actual gain in yield (pounds harvested minus pounds planted) during the rainbow phase over that of naturally produced brook trout was only 1.4 pounds per acre. The gross increase in yield (119 pounds per year or 2.5 pounds per acre per year) brought about by the stocking of rainbow trout fingerlings was found to cost $1.26 per pound. This increase in yield was costly, since the heavy rainbow trout stocking established a rainbow population chiefly at the expense of, not in addition to, the naturally produced brook trout population.

The steady decline of the brook trout population since 1954 is believed to be due primarily to competition brought about by heavy rainbow stocking and predation by large rainbows. Most western lakes of the Castle Lake type are relatively inaccessible and are subject to very light fishing pressure. Under these conditions, self-sustaining brook trout populations generally provide excellent fishing. It must be concluded that, when spawning tributaries are absent, such waters can be more economically managed with wild brook trout alone than with hatchery supported brook-rainbow populations.

WALLIS, O. L. 1950. The status of the fish fauna of the Lake Mead National Recreational Area, Arizona-Nevada. Transactions of the American Fisheries Society 80 : 84-92.

The Colorado River flows for nearly 225 miles through the Lake Mead National Recreational Area, Arizona-Nevada. Its character has been controlled and changed as the result of construction of Hoover and Davis dams. The composition of the fish fauna has changed also. Introduced species have increased since the building of the Hoover Dam. For 30 miles below Hoover Dam the rainbow trout is the most important game fish and this portion of the Colorado River is one of the outstanding trout waters of the county.

Nearly one million trout fingerlings have been planted according to the National Parks Service records. After the initial stocking in 1935, the trout were rigidly protected. When the first season opened in 1940, fishermen discovered that rainbow trout were prospering in the Colorado River and, in 1946, it was estimated that 20,000 pounds of trout were caught. The record trout, which measured 32 3/8 inches and weighed 18 pounds, was taken in 1950.

WALSH, M. G., D. B. FENNER and D. L. WINKELMAN. 2000. Evaluation of rainbow trout introduction in northeastern Oklahoma streams: A conceptual framework. *In* Proceedings of the Midyear Meeting of the Southern Division of the American Fisheries Society, Savannah, Georgia. (Abstract Only).

Recently, angling groups in Oklahoma have indicated interest in stocking rainbow trout (*Oncorhynchus mykiss)* into coolwater, spring fed streams of northeastern Oklahoma. Possible negative impacts of trout stocking on native fish populations have prompted the Oklahoma Department of Wildlife Conservation (ODWC) to adopt a risk-free position, denying all stocking permits pending evaluation of trout introduction in these stream ecosystems. Of particular interest are possible impacts of trout introductions on smallmouth bass (*Micropterus dolomieu*) populations which support an active recreational fishery in northeast Oklahoma. Trout may compete with smallmouth bass for food and habitat and may prey on juvenile smallmouth bass. Effects of trout stocking on native non-game fishes, invertebrates and trophic interactions are also unknown. Project design involves characterization of fish communities, mesohabitat and fish (particularly smallmouth bass) microhabitat use and diet in two streams for one year prior to trout introduction. Beginning in the fall of 2000, rainbow trout will be stocked into one of the streams to evaluate changes in resource use and community structure of native fishes in the presence of trout.

WALTERS, J. P., T. D. FRESQUES, and S. D. BRYAN. 1997. Comparison of creel returns from rainbow trout stocked at two sizes. North American Journal of Fisheries Management 17(2) : 474-476.

Creel returns of stocked rainbow trout (*Oncorhynchus mykiss)* are often below management objectives. In the Hoover Dam tailwater, Colorado River, predation by striped bass (*Morone saxatilis)* limits creel returns of stocked rainbow trout. On two occasions, we stocked large (33+ cm) and small (21-25 cm) rainbow trout into the tailwater to compare returns to the creel. Angler return rates for the two stockings were 47% and 22% for the large fish and 1% and 2% for the small fish. Costs of large fish returned to the creel were US$6.02 and $12.86 per fish for the two stockings. Costs of small fish returned to the creel were $59.00 and $29.50 per fish for the two stockings. Annual survival of large rainbow trout did not increase compared with small fish. Stocking large rainbow trout is a cost-effective option for the Hoover Dam tailwater and may improve creel returns in other waters where predation limits survival of stocked fish.

WANG, L., K. ZIMMER, P. DIEDRICH and S. WILLIAMS. 1996. The two-story rainbow trout fishery and its effect on the zooplankton community in a Minnesota lake. Journal of Freshwater Ecology 11(1) : 67-80.

We studied the two-story rainbow trout fishery and its influence on zooplankton communities in Big Watab Lake, Minnesota, in 1993. The main trout diet components were *Chironomidae* (larvae and pupae) and *Dapnia pulex* > 1.3 mm (53% and 37% dry weight respectively). Smaller trout were more dependent on *D. pulex.* Trout consumption of large *D. pulex* peaked in May (50% of diet) and decreased dramatically as the season progressed (3% of diet in August), being replaced by *Chironomidae*. This size selective predation influenced the mean size of *D. pulex* in the water column with 3% > 1.3 mm in May and 64% > 1.3 mm in September. The change in trout diet was associated with changes in vertical distribution of trout (detected by sonar surveys) as the lake stratified in mid June. By August, trout were restricted to the thermocline and *Daphnia* found refuge at greater depths. Results from a creel survey showed Big Watab Lake is providing an excellent trout fishery. Trout stocked at 245 mm gained an average of 152 mm and 575 gm after eight months in the lake. Angler return rates were 58% in number and 285% in weight for the first year. Estimated annual mortality was 32% for age 1 and 12% for age 2 and older trout. Estimated fishing pressure was 337 hours/ha and catch rates were 0.27 and 0.18 fish/hour in open water and ice fishing seasons respectively.

WANGILA, B. C. 1994. Electrophoretic characterization of three hatchery-reared strains of rainbow trout (*Oncorhynchus mykiss)*. Aquaculture and Fisheries Management. 25 : 565-570.

Significant differences were found in allelic frequency distribution among three strains of rainbow trout, (*Oncorhynchus mykiss*). The isocitrate dehydrogenase (IDH-3,4* 1.1.1.42) locus was fixed in two of the strains while the superoxide dismutase (SOD-1* 1.15.1.1) locus was absent in one of the strains.

Similarity indices ranged from 0.973 to 0.988 on the scale 1.000 among pairwise comparisons of the strains while Nei s genetic distance was 0·012 between Mount Lassen and Manx, 0·025 between Mount Lassen and Tagwerker and 0·027 between Manx and Tagwerker. Gene diversity was highest in the Mount Lassen strain, followed by Manx, with Tagwerker having the least. These differences in gene diversity were attributed to breeding and management practices used at the hatchery. The need for characterization of strains of rainbow trout, especially in crossbreeding programmes that aim to increase genetic variation, was emphasized by these results.

WARFEL, H. E. and G. W. MORRILL, Jr. 1939. Stocking policy for the streams and lakes of the Connecticut watershed. p. 9-81 *In* Biological Survey of the Connecticut Watershed. New Hampshire Fish and Game Department. Concord, New Hampshire.

There are eight lakes in the Connecticut watershed which are stocked with rainbow trout. Between 1928 and 1938 a total of 59,840 fingerlings and 17,779 legal-sized rainbow trout were stocked.

The stocking policy for lakes is based on temperature differential which divides bodies of water into those suitable for warmwater species and those in which salmonid species can live. In so far as possible, priority has been given those species of fish native either to New Hampshire or to the northeastern states. Rainbow trout and brown trout have been recommended in several cases where suitable water exists each only after a careful consideration of the possible effect on adjacent waters

WARREN, G. R. 1978. Gill net study on Darling Long Lake. File Report, Ontario Ministry of Natural Resources. Lanark, Ontario. 8 p.

Darling Long Lake is one of the more remote lakes within Lanark County. The lake has a maximum depth of 43 feet and a surface area of 191 acres. Despite the fact that very little oxygen exists below the 17 foot depth in late summer, it was decided that rainbow trout could survive in the lake. Therefore, in 1977, 4,000 rainbow trout were stocked in Darling Long Lake.

In 1978 a gill net survey was conducted to determine if there was a sufficient survival of trout to warrant more stocking. Three 500 foot sections of gill net, having mesh sizes varying from 1.5-4 inches, were set at strategic locations. The nets were placed in areas where oxygen and temperature requirements were optimal. Two students camped along the shore to maintain constant observation on the nets and ensure that no one removed any fish.

After two nights (August 17 and 18, 1978) of netting the catch consisted of 291 white sucker, 22 yellow perch, 12 shiners, 5 pumpkinseed, 4 rainbow trout and 21 brown bullhead were captured. The lengths of rainbow trout captured were 8.5, 11.2, 6.6 and 10.2 inches, respectively.

WEBSTER, D. A. 1950. Fishery research program at Cornell University. Progressive Fish Culturist 12(2) : 77-80.

The principle fishery projects at Cornell University are long-term investigations (5-10 years or more) set up to evaluate plantings of hatchery-reared fish, to obtain various population statistics which are valuable for fishery management and to contribute to the general fund of knowledge regarding fishery biology.

Although rainbow trout have been more or less systematically planted in tributaries of the Cayuga watershed for a number of years, no population which approaches those of the other Finger lakes has been established. Cayuga Lake seemed to offer possibilities and, when the project was initiated in 1946, it appeared that there was a niche in the environment which could be filled by the rainbow trout. The program to date has consisted largely of planting 39,000 hatchery-reared rainbow trout, 5 to 9 inches in length. Thus far, recoveries by angling and netting have been meager although specimens taken have exhibited rapid growth. A few fish, mostly males, have appeared in the spring spawning run but there has been virtually no natural reproduction.

WEBSTER, D. A. 1960. Fishery management report for 1959. Adirondack League Club, New York. 33 p.

The 1959 observations in First Bisby Lake confirmed the low survival of the large yearling rainbow trout planted in 1957 and 1958. They also indicated satisfactory survival and growth of the current (1959) planting forecasting a good stock of trout for the 1960 season. The experimental plantings of 1955-57 have made the bulk of their contribution to the fishery by the end of the 1959 season.

In Green Lake, the total catch during the past three years represents 57, 46 and 46 % of the annual stocking of 500 yearlings (there is no known successful natural spawning). This represents an excellent return particularly when the seven fold increase in weight is considered. Fishing pressure, as measured by successful anglers reporting, consisted of 139, 133, and 165 fishermen in 1957-59.

Based on a review of the rainbow trout catch from Green Lake, the following points are pertinent to lake management:

- Yearling trout stocked during the same season as caught constituted 41% of the total rainbow trout catch. This is an inefficient use of these fish particularly when they are taken in June, as they are removed during a period when they will rapidly grow into the pound class if left in the lake for a second year.
- Separation of yearling, two year old, three year old and older trout on the basis of weight

distribution is evident. Rapid growth takes place in all groups as shown in the May through September samples.

- The 1959 season is conspicuous for a low July-August catch. In previous years one or both months have produced excellent fishing during the period of high member participation. A minimum size of 12 inches and reduced daily bag limit of five fish is suggested for Green Lake rainbow trout.

WEBSTER, D. A. 1962. Fishery management report for 1961. Adirondack League Club, New York. 29 p.

Five hundred yearling rainbow trout, averaging 7.8 inches in length, were stocked in Little Moose Lake on May 17, 1961. Poor survival of landlocked salmon yearlings stocked in recent years resulted in the change to planting this species on a trial basis.

Several rainbow trout were caught by angling in the 1961 season and a trap net sample of 18 specimens was taken in November suggesting that survival was much more satisfactory than preceding releases of salmon. The growth of these trout was exceptional as they averaged 13.8 inches and 1.0 pound after five months of feeding in Little Moose Lake. Continued stocking with rainbow trout is anticipated for the next few years.

WEIDLEIN, W. D., A. J. CORDONE and T. C. FRANTZ. 1962. Trout catch and angler use at Lake Tahoe. California Fish and Game 51(3) : 187-201.

Estimates of total use and catch were obtained by a joint California and Nevada creel census by boat, and at Cave Rock boat landing. Angler-hours and catches on censused days were expanded to monthly totals. Possible biases were estimated and considered unimportant, although an underestimate of use and catch was indicted. Total use was 144,147 angler-hours (47,732 angler-days); this amounted to 1.2 angler-hours per surface acre. The total catch was 20,018 fish, or 0.14 fish per angler-hour. About 60 percent of the catch was lake trout, with wild rainbow and planted trout comprising 21 and 17 percent, respectively. Estimated yield, excluding planted trout, was 0.34 pounds per acre.

WEITHMAN, A. S. and M. A. HAAS. 1982. Socioeconomic value of the trout fishery in Lake Taneycomo, Missouri. Transactions of the American Fisheries Society 111 : 223-230.

Lake Taneycomo, a 700 hectare hydroelectric impoundment in southwestern Missouri, support an excellent put-grow-and-take fishery for rainbow trout (*Salmo gairdneri*). When the fishery became threatened by releases of deoxygenated water from an upstream reservoir, it became important to determine its value. We used three methods for estimating the value of the fishery: replacement cost of fish; travel costs; and income multiplier. Information for the latter two methods was based on 500 angler interviews. Replacement cost of the rainbow trout would be $0.5 million. The travel cost method provided an estimate of $2.9 million for the value of the fishery to anglers (consumers surplus). The income multiplier method provided an estimate of $9.9 million for the net economic benefit to the local economy or about 7% of all economic activity in the area. The benefit:cost ratio of the rainbow trout stocking program at Lake Taneycomo was 22:1 for the local economy.

WELCOMME, R. L. 1988. International introductions of inland aquatic species. FAO Fisheries Technical Paper 294, Food and Agriculture Organization of the United Nations. Rome, Italy.

The rainbow trout is one of the most widely introduced of fishes and may be regarded as global in its present distribution although in the tropics it is only established at altitudes above about 1200 m. First introductions of rainbow trout were for sporting purposes but is adoption for aquaculture led to an accelerated spread in the 1950s. Furthermore, although introduced for angling many host countries subsequently expanded the distribution of the species for culture. It is now one of the main species cultured in temperate zones and at higher altitudes in the tropics.

Rainbow trout have been implicated in the disappearance or decline of many small native species through either predation or competition. They have, together with the pejerrey been responsible for some decline in stocks of *Orestias* and *Trechomycterus* species in lake Titicaca. *O. cuvieri* has disappeared since the introduction and *O. pentlandii*, *T. rivulatus* and *T. dispar* have been considerably reduced in abundance. The contribution of introduced species to this decline is obscured by recent overfishing and other bad management practices. Rainbow trout have also been involved in the reduction of native salmonid populations in Lake Ohrid, Yugoslavia, *Schizothorax* species in Himalayan rivers, *Oreodaimon gnathlambae* in Lesotho, *Trachyistoma euronotus* and *Sandelia capensis* in South Africa, *Protroctes oxyrhynchus* and *Galaxias gracilis* in New Zealand and other galaxiids in Australia.

WELSH, T. L. 1967. Tests for increasing returns of hatchery trout: Conditioned fish study (Little Salmon River segment). Idaho Fish and Game Department. Boise, Idaho. 7 p.

WHALLS, M. J. and D. SHETTER. 1955. Survival of tagged, fin clipped and unmarked rainbow trout fingerlings in Hunt Creek, Montmorency County, Michigan. *In* Proceedings of the 17th Midwest Fish and Wildlife Conference, Lafayette, Indiana.

WHEELER, A. and P. S. MAITLAND. 1973. The scarcer freshwater fishes of the British Isles. I. Introduced Species. Journal of Fish Biology 1973(5) : 49-68.

The purpose of this paper is to give an account of some of the scarcer species of freshwater fish occurring in the British Isles with special reference to their origin, past dispersion and present distribution and status.

Rainbow trout (*Salmo gairdneri*) was first introduced to the British Isles about 1884 when batches of eggs were brought from Delaford to various parts of the country; a good breeding stock being established at Howietown in Scotland. Further shipments of stock continued to come into the country for many years and rainbow trout were introduced to many parts of England, Ireland, Scotland and Wales. Stocks of rainbow trout were also introduced to Europe about 1882 and the species is now established in many countries there.

In spite of such widespread introductions, the species appears to have established breeding populations in relatively few places. This includes 14 waters in the south of England and one in Ireland. The reason for the lack of success in establishing viable populations is obscure.

WHITAKER, J and J. MARTIN. 1974. The cage rearing of rainbow trout in Precambrian lakes. Fisheries Research Board of Canada Technical Report No. 446. 13 p.

Experiments designed to evaluate the feasibility of rainbow trout cage culture in Precambrian lakes were carried out at Heming Lake, Manitoba during the ice free seasons of 1972 and 1973.

Seed fish averaging 1.7 grams did not produce marketable trout (173 grams round weight) by freeze up in 1972. In 1973, both 7.8 gram and 13.9 gram fingerlings produced marketable fish. Survival rates were 52% in 1972 and 54% in 1973 and bacterial disease was the major cause of mortality.

The results indicated that the cage culture of rainbow trout is biologically feasible. However, the high cost of fish food and fingerlings and the relatively low price for the finished product make the economic feasibility of cage culture uncertain.

WHITE, R. L. 1969. Evaluation of a catchable rainbow trout fishery. Federal Aid Project F-2-R-6, Texas Parks and Wildlife Department. Austin, Texas.

WIERICH, C. B. 1974. An initial study of the return and movements of brown and rainbow trout stocked pre-season and in-season and of the use of wired areas in sustaining a catchable trout fishery after in-season stocking. Pennsylvania Fish and Boat Commission. Bellefonte, Pennsylvania.

WILDE, C. W. 1957. Comparative recovery rates of brook, brown and rainbow trout in a Connecticut Lake. Proceedings of the Northeast Division, American Fisheries Society. 7 p.

WILEY, R. W. 1995. A common sense protocol for the use of hatchery-reared trout. American Fisheries Society Symposium 15 : 465-471.

Fish hatcheries are vital to fisheries management, maintenance of high quality angling and restoration of endangered fishes. However, people tend to expect too much from hatcheries and rely on stocking to provide more fish than lakes and streams can sustain. In the Rocky Mountains, salmonids were imported for rearing in hatcheries and stocked to supplement native fish for sport angling, commercial use and food. Fish were stocked in any water that looked suitable. No one understood that natural waters have productive limits, introduced fishes might extirpate native fishes and fish stocks might be adapted to specific stream and lake conditions. People believed that rearing and stocking fish was necessary to continued good angling. Without evidence to the contrary, fisheries biologists and fish culturists thought one fish was just as good as another. The idea that differences in fish stocks could be hereditary, adaptive and result from local evolution was slowly recognized.

In western streams in seven ecoregions, trout biomass averaged 67 kg/ha or less for 56-96% of stocks measured. Salmonids occupy stream habitat to its potential carrying capacity so survival of trout stocked in streams beyond this relatively small biomass is low. Survival is usually higher in lakes because salmonids may not fill lake habitat to its potential capacity. Regulations are used to control fishing effort and harvest. Regulations could also be used to govern the use of hatchery fish by specifying rearing and stocking objectives based on environmental requirements of the species to be stocked as dictated by habitat conditions and productivity of the receiving water. For successful fish stocking, habitat must be in good condition, the species must be physiologically and behaviorally capable of surviving where stocked and biologists must be sure that stocking solves the real problem.

Stocking fish according to regional fish stocking protocols would improve consistency in the use of fish. Foresighted fisheries management should (1) be based on drainage surveys that document habitat conditions and natural limits of production; (2) determine genetic strengths of broodstocks and stock hatchery fish are best suited; (3) manage for native or wild fish first; (4) establish priorities for fish stocking in standing waters; and (5) understand public desires.

WILEY, R. W., R. A. WHALEY, J. B. SATAKE, and M. FOWDEN. 1993$_a$. Assessment of stocking hatchery trout: A Wyoming perspective. North American Journal of Fisheries Management 13 : 160-170.

We evaluated Wyoming Game and Fish Department (WGFD) file information to determine the species of trout raised, the number of catchable- and subcatchable-sized trout stocked, the return rate of stocked fish to the creel, reasons for variability of return rates, and the direct costs associated with stocking trout. About 8.9 million trout were planted from 11 WGFD hatcheries during 1987-1990; 86% were of subcatchable size (< 8.25 inches) and the rest were of catchable size (≥ 8.25 inches). Rainbow trout (*Oncorhynchus mykiss*) and cutthroat trout (*Salmo clarki*) were most often stocked. Evaluation showed that return rates (percent of number planted that were caught) to anglers were usually greater for catchable than for subcatchable fish. Catchable trout should be stocked in spring and when fishing pressure is highest for best returns; few catchable trout planted after the fishing season survive to the next season. Return rates of subcatchable trout planted in streams varied due to differences in water quality in the hatchery and receiving waters, post-stocking competition with other fish, time of stocking, and size of fish stocked. Subcatchable trout should be stocked in streams in spring and only when hatchery and receiving water are of similar quality, water temperature and flows are not limiting and few competing fish are present. Higher returns in streams also occur as larger fish are stocked. Return rates of subcatchable trout were greater for lakes than for streams. For highest lake returns, subcatchable trout should be stocked in productive waters (indicated by total dissolved solids) where competing planktivores and piscivores that prey on stocked trout are few. The cost of production and distribution was US$0.68/fish for catchable and $0.13/fish for subcatchable trout. Mean cost of fish reaching the creel was less for catchable trout (lakes, $2.32; streams, $3.67; 1953-1989) than for subcatchable trout (lakes, $37.44; streams $6.29; 1953-1988). Research opportunities include developing foresighted management plans based on a combination of biological technology and public desire, evaluating the elimination of subcatchable plantings in streams and alternative management for wild trout, evaluating the transplantation of wild trout or eyed eggs of wild fish as a means of establishing fisheries, evaluating stocking guidelines applicable to various Wyoming conditions, determining the effect on harvest of behavioral differences between hatchery and wild trout, and comparing the genetic backgrounds of hatchery trout to determine their effects on postplanting survival.

WILEY, R. W., R. A. WHALEY, J. B. SATAKE, and M. FOWDEN. 1993$_b$. An evaluation of the potential for training trout in hatcheries to increase post-stocking survival in streams. North American Journal of Fisheries Management 13 : 171-177.

An average of 8.9 million trout (*Oncorhynchus* spp. , *Salmo trutta*, *Salvelinus* spp.) were planted in Wyoming each year from 1987 through 1990; 86% were of subcatchable size (< 8.25 inches) and 14% were of catchable size (≥ 8.25 inches). Of the total fish planted, 1.9 million subcatchable trout and 177,000 catchable trout were planted in streams. Harvest rates of trout stocked in streams was low (average 5.7%) possible because of the hatchery conditions under which they were reared. Hatchery-reared trout were raised in conditions far different from those of natural waters; densities hundreds of times those in the wild, nearly constant water flow and water temperature, regular feedings, lack of cover, and absence of predators. Hatchery trout may become disoriented, fail to seek cover, forage inefficiently and die when planted in streams with competing fish. Evaluating the survival of hatchery trout fed natural food, rearing hatchery trout in simulated natural conditions, raising them at moderate densities, and evaluating costs associated with management of wild and hatchery trout would provide additional means for judging the potential to train hatchery trout to survive in the wild. Such evaluations also would provide more criteria upon which to judge the success of planting hatchery trout.

WILKINS, P. L. Undated. Trout management investigations. Project Report No. F-6-R-8. Tennessee Wildlife Resources Agency. Knoxville, Tennessee.

A complete creel census was in operation on North River from April 6 through September 4, 1961. A total of 218 wild rainbow trout was caught, the lowest number recorded. This suggests that the minimum size limit has failed to increase the catch of wild trout. Population studies, however, do not show a decline of year class I fish, but year class II rainbows are in sufficient numbers to assure good reproduction. Plantings of marked trout in North River show an average recovery of 53 percent. This is a result of a 14 percent recovery of all planted Kamloops rainbow trout to a high of 87 percent of a spring planting of brook trout.

During the quarter 1,000 12-inch rainbows and 10,000 6.5 inch rainbows were marked and planted in Watauga Reservoir.

The collection of bottom samples continues on Citico Creek to evaluate long range effects of multiple land use development on trout stream ecology.

WILKINS, P. L. 1955. Creel census on wildlife management areas and evaluation of results. Project No. F-6-R, Job No. A. Tennessee Wildlife Resources Agency. Nashville, Tennessee. 13 p.

A system for the intensive management of Tennessee trout streams evolved on Tellico Wildlife Management Area between 1941 and 1951. Basically the plan required a daily permit fee to help defray program costs, fishing on weekends plus two weekdays, replenishment stocking of catchable size trout on the days not fished, and an open season from early April through September. All hatchery trout were marked by fin excision or numbered strap tags clipped into the base of the dorsal fin. Approximately half of the fish were released one week prior to the season opening and the remainder in two equal plants four weeks apart. The creel census period in 1954 was April 13 through September 1 and in 1955 from April 12 through July 4.

On Unicoi Creek, rainbow trout stockings gave 74 and 65% returns for 1954 and 1955, respectively. On Laurel Fork Creek, fishermen took 70% of 3,055 stocked rainbows. Over half of the liberated trout were recorded within two weeks and all but a few scattered individuals were in within eight weeks.

A September, 1953 release of 5,000 rainbow trout fingerlings (4 to 7 inches) well scattered in Tellico area streams resulted in an 18% first season return to the creel. These fish entered the catch throughout the season and returns from a complete census would have been much higher.

Two pre-season releases of 1,000 (8-10 inch) rainbow trout each were made in January and February, 1954, in Beaverdam Creek on the Kettlefoot area. These produced returns of 58 and 69% after the season opened in mid April.

WILKINS, P. L. 1968. Influence of diet and conditioning on survival rate of hatchery trout. Research Project No. F-6-R. Job A. State of Tennessee.

To test the hypothesis that hatchery diets affect the muscle-stamina of trout, a total of 11,490 rainbow trout were fed various preparations and released in five streams on four wildlife management areas. Two district hatchery strains and fish reared under both raceway and pond conditions were also compared. Recovery of these trout by fishermen, during the two fishing seasons, demonstrated no conclusive superiority among the five diets, two hatchery strains, and two rearing mediums evaluated.

WILKINS, P. L. 1970. Management of a rainbow trout fishery in Watauga reservoir and certain tributaries. Research Report No. F-6-R. Tennessee Wildlife Resources Agency. Nashville, Tennessee.

A plant of eyed rainbow trout eggs in a spring-fed tributary to Watauga Reservoir resulted in a unique spawning run in trophy size trout. Efforts to supplement this fishery with introductions of hatchery produced fish were largely ineffective.

The contribution of 355,000 rainbow fingerlings to the lake and stream fishery was negligible. One release of 10,000 rainbow, averaging 7.8 inches, produced a recovery of 34 percent by weight.

Various exotics failed to complement the coldwater fishery.

WILLIAMS, R. N., R. F. LEARY and K. P. CURRENS. 1997. Localized genetic effects of a long-term hatchery stocking program on resident rainbow trout in the Metolius River, Oregon. North American Journal of Fisheries Management 17(4) : 1079-1093.

Hatchery rainbow trout (*Oncorhynchus mykiss)* have been stocked in the Metolius River in central Oregon since 1938, and legal sized (≥160 g) yearling trout were stocked annually from 1947 until 1995. In 1996, management objectives shifted to emphasize wild trout, and hatchery stocking ceased. We examined allozyme and mitochondrial DNA (mtDNA) variation among three naturally occurring populations of rainbow trout in the Metolius River to investigate possible hybridization with hatchery-produced rainbow trout. We also examined two commonly used hatchery strains of rainbow trout, one of which has supplied nearly all of the catchable hatchery trout in the Metolius. Both allozyme and mtDNA data showed the two hatchery samples to have genetic characteristics typical of hatchery populations derived from coastal rainbow trout (*O. mykiss irideus)*. Rainbow trout sampled from the lower Metolius River, approximately 30 km downstream of the headwaters, had allozyme and mtDNA characteristics typical of interior rainbow trout (*O. m. gairdneri)*. The two samples from the upper Metolius River, where stocking activities occurred, has allozyme profiles intermediate between interior and coastal types and mtDNA haplotypes characteristic of both interior and coastal populations. We attributed the upper river results to hybridization between indigenous rainbow trout and the hatchery rainbow trout that had been stocked there for nearly 60 years. We attribute the lack of hybridization in the lower Metolius River to ecological isolation: the upper river meanders through park-like habitat, whereas the lower river has greatly increased water flows and velocities and a steep gradient, creating a habitat that may be inhospitable to hatchery-reared rainbow trout. Stocked hatchery trout that migrate or drift downstream into the lower river likely perish or are carried farther downstream into Lake Billy Chinook, where they are subject to lethal infection by the myxosporean parasite (*Ceratomyxa shasta)* and where a robust population of bull trout (*Salvelinus confluentus)* exists. If some fish from the genetically pure interior rainbow trout population in the lower Metolius River were to migrate to the upper river and spawn there, the hybridized upriver population would receive a steady infusion of genes from native fish. Future monitoring of life history and genetic attributes of the upper and lower rainbow trout populations could reveal whether such an infusion occurs.

WILLIAMSON, L. O. and E. SCHNEBERGER. 1942. The results of planting legal-sized trout in the Deerskin River, Vilas County, Wisconsin. Transactions of the American Fisheries Society 72 : 92-96.

A creel census was conducted on the Deerskin River to determine the results of stocking trout of legal size. The stocking was done in December and May and consisted of 1,002 brook and 1,621 rainbow trout. A yield of 3,438 trout was obtained. Native fish made up 71% of the catch. Native brook trout supplied the most fishing (50.5% of the total). All stocked fish, especially the larger rainbow trout planted in December, were inferior in condition and sporting value. There were no reports of either species carrying over to the second season.

WILLIAMS, R. N., D. K. SHIOZAWA, J. E. CARTER and R. F. LEARY. 1996. Genetic detection of putative hybridization between native and introduced rainbow trout populations of the upper Snake River. Transactions of the American Fisheries Society 125(3) : 387-401.

Native trout populations throughout western North America have declined because of habitat alteration, introgression with introduced trout, or competitive exclusion by nonnative species. Consequently, identification and preservation of native trout are now the goals of many management programs. We examined allozyme and mitochondrial DNA (mtDNA) variation in seven naturally occurring populations and one hatchery population of rainbow trout (*Oncorhynchus mykiss)* from southern Idaho and northern Nevada to determine their genetic origins. Allozyme and mtDNA results were concordant in identifying three populations as genetically pure interior rainbow trout and one population as a hybrid swarm. Results for the remaining four populations were discordant. However, these latter four populations were best classified as hybrid swarms due to the nature of either the allozyme of mtDNA, which included genetic characteristics of both coastal and interior rainbow trout. Our study demonstrates the utility of mtDNA analysis in conjunction with independent criteria such as allozymes for detecting hybridization at the population level. Hybridized populations exhibited a greater number of mtDNA halotypes than did genetically pure populations. Halotypes within hybridized populations differed more from one another than did mtDNA halotypes within non-hybridized populations.

WILTON, M. L. 1963. White River District rainbow trout transfer. File report, Ontario Department of Lands and Forest. White River, Ontario. 2 p.

Because of the increasing abundance of rainbow trout *(Salmo gairdneri*) in Lake Superior and relatively small harvest of this population, it was felt that the introduction of adult individuals of this species to several inland lakes in the vicinity of the Trans-Canada Highway would, while not depleting the Lake Superior stock to any appreciable degree, bring this species within the range of the average tourist-angler. Further, the transfer of adults would permit such introductions into lakes already supporting populations of predaceous game fish, whereas introduced hatchery stock may not be able to compete with the other species and successfully establish a perpetuating population.

While several lakes in the District appear to meet the requirements of rainbow trout, it was felt advisable to attempt only one pilot introduction this year to ascertain the feasibility of such a program.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES. 1999. An evaluation of stocking strategies in Wisconsin with an analysis of projected stocking needs. Bureau of Fisheries Management and Habitat Protection. Madison, Wisconsin. 38 p.

This report presents the desired state for our stocking program and should be viewed as a working document that is open to continuous improvement and update. The recommendations contained herein should be implemented as opportunities arise.

The inland trout stocking program consists of stocking brook trout, brown trout, rainbow trout, lake trout and splake. Currently, Wisconsin stocks a total of 286,100 rainbow trout inland. Most of these are planted as yearlings. There are no wild rainbow trout because Wisconsin does not have any wild rainbow trout populations in streams that are large enough to use as a brood stock and most rainbows are used in put-and-take fisheries. Lakes are higher priority than streams because they generally have better return and higher use.

WITSCHI, W. A. and C. D. ZIEBEL. 1979. Evaluation of pH shock on hatchery-reared rainbow trout. Progressive Fish-Culturist 41(1) : 3-5.

The effect of transferring hatchery-reared rainbow trout (*Salmo gairdneri*) from water with a pH of 7.2 to water with pH s ranging from 8.5 to 10.0 was evaluated in 48 hour tests. All fish survived in the control (pH 7.2) and at pH 8.5. Survival was 88% at pH 9.0, 68% at pH 9.5 and 0% at pH 10.0. After the 48 hour exposure, the remaining test fish were fed their usual pelleted food. Trout in the control and those held at pH 8.5 fed well. Only a few of the fish held at pH 9.0, and none of those held at pH 9.5 fed. These data indicate that it is not advisable to stock rainbow trout reared in nearly neutral hatchery water into lakes with a pH of 9.0 or higher.

WOODWARD, C. C. and R. J. STRANGE. 1987. Physiological stress responses in wild and hatchery-reared rainbow trout. Transactions of the American Fisheries Society 116 : 574-579.

Stress induced changes in plasma cortisol, glucose, and chloride were more extreme in wild rainbow trout (*Salmo gairdneri)* than in hatchery-reared fish subjected to confinement in a net and electroshock. During 12 h of net confinement, plasma cortisol increased from resting levels of 10 ng/ml to 480 ng/ml in wild fish, and from 2 ng/ml to 155 ng/ml in hatchery fish. Plasma glucose was also higher in wild fish , increasing from 55 to 284 mg/dl, versus an increase from 58 to 196 mg/dl in hatchery fish. Plasma chloride decreased from resting levels of 132-135 meq/L to 53 meq/L in wild fish (and it continued a decline to 33 meq/L during the first 24 hours after confinement), but only to 102 meq/L in hatchery fish. Both wild and hatchery-reared fish required more than 24 hours after they were removed from the net to recover resting levels of plasma constituents. Plasma concentrations of cortisol, glucose, and chloride were less altered in response to electroshock than they were in response to net confinement. One hour after galvanonarcosis, plasma cortisol concentrations in wild fish peaked at 234 ng/ml and remained moderately elevated for 4 days; cortisol in hatchery fish peaked at 70 ng/ml within 0.5 h of the electrical stimulus and then returned to resting levels within 1 hour. No substantial changes in plasma glucose or plasma chloride occurred in either the wild or the hatchery-reared rainbow trout after galvanonarcosis.

WRIGHT, B. H. and R. D. SOPUCK. 1979. A history of fish stocking in northern Manitoba. Fisheries Research Report 79-6, Manitoba Department of Mines, Natural Resources and Environment. Winnipeg, Manitoba. 70 p.

The past several decades have seen thousands of fry, fingerlings, yearlings or eggs planted into northern Manitoba waters to provide better sport fishing. It is hoped that this report can be used as an office or field reference text based on northern stocked waters.

Rainbow trout have been the most common species stocked accounting for 31 of 55 lakes presented in this summary. Many of these plantings have been made into borrow pits to provide put-and-take fisheries. While some of these stockings have been successful, many have not. Reasons for failure of rainbow trout stocking include migration from lake (Amphipod Lake), presence of pike (Max Lake) and presence of walleye (Sleep Lake).

WYDOSKI, R. S., G. A. WEDEMEYER and N. C. NELSON. 1976. Physiological response to hooking stress in hatchery and wild rainbow trout (*Salmo gairdneri*). Transactions of the American Fisheries Society 105(5) : 601-606.

This study evaluated the physiological response of rainbow trout to hooking stress after being played under standardized conditions (0-5 min) and estimated the time needed for recovery (to 72 h). Plasma osmolality and chloride measurements were used to evaluate osmoregulatory disturbances and gill ion-exchange function, and plasma glucose was used as an index of the generalized, non-specific physiological stress response. Hooking stress caused more severe blood chemistry differences in hatchery fish than in wild trout. Also, hooking stress imposed a greater stress on larger than on smaller hatchery rainbow trout. Higher water temperatures aggravated the delayed hyperglycemia in both hatchery and wild trout but only about three days were needed for recovery at 4, 10, or 20° C.

YOUNGS, W. D. and R. T. OGLESBY. 1972. Cayuga Lake: Effects of exploitation and introductions on the salmonid community. Journal of the Fisheries Research Board of Canada 29 : 787-794.

Cayuga Lake, a glacially formed warm monomictic lake in New York State, has an area of 172.1 km^2 and a mean depth of 54.5 m. Although the rainbow trout was introduced to Cayuga Lake in the 1800s, it is only in recent times that a population has been established that has supported a very popular though limited fishery. Establishment of the population seems to have resulted from the introduction during the 1950s of migratory strains found in the other Finger lakes.

Successful spawning of rainbow trout occurs in both Cayuga Inlet and Salmon Creek although the two streams differ greatly in character thus influencing the populations associated with them. Little is known of the distribution in the lake proper. Very limited tag returns show rather extensive movement in the lake. Food habits of the trout while in the lake are not known but most likely the alewife is the prime source for larger individuals.

YULE, D. L,, R. A. WHALEY, P. H. MAVRAKIS, D. D. MILLER and S. A. FLICKINGER. 2000. Use of strain, season, stocking, and size at stocking to improve fisheries for rainbow trout reservoirs with walleyes. North American Journal of Fisheries Management 20 : 10-18.

We evaluated stockings of rainbow trout (*Oncorhynchus mykiss)* in Pathfinder and Alcova reservoirs, Wyoming to determine what combination of strain, season of stocking, and size at stocking maximized angler catch in the presence of walleyes (*Stizostedion vitreum)*. Coded wire tags were used to identify individual rainbow trout to stock group. Angler catch of Kamloops rainbow trout and fall rainbow trout in Pathfinder Reservoir exceeded returns of Eagle Lake rainbow trout. Differences in strain performance in Alcova Reservoir were less pronounced. The importance of season of stocking was identified with fall-stocked trout during the spring (March-June). Size-at-stocking evaluations indicated that large catchable-size (>208 mm total length) rainbow trout maximize use of hatchery facilities over stocking greater numbers of small, catchable (178-207 mm) or subcatchable (127-177 mm) sizes. Pond feeding trials conducted with three walleye size-classes and three rainbow trout sizes showed that 127-mm rainbow trout were highly vulnerable to walleyes as small as 330-378 mm. Intermediate-size rainbow trout (178 mm) were not readily consumed by 381-432 mm walleyes, but they were vulnerable to 483-533 mm walleyes. At 229 mm, rainbow trout appeared invulnerable to walleyes in the largest size class (483-533 mm) we studied. Rainbow trout stocked at large, catchable sizes are probably vulnerable to fewer walleyes compared with small. Catchable and subcatchable sizes, allowing greater numbers to survive predation and recruit to the sport fish.

ZAPLITNY, B. W. 1975. An evaluation of a catchable trout stocking in a marginal reservoir habitat. M. Sc. Thesis, Pennsylvania State University. University Park, Pennsylvania.

A creel census was conducted during the 1974 trout season at Stone Valley Reservoir to assess the success of the two-story fishery that exists in the reservoir which has a self-sustaining warm-water fishery. Little was known about angler returns from the 8000 trout stocked each year or about trout survival in the reservoir. The 1974 stocking of trout, 8000 rainbows, were all marked with fin clips to identify the stocking of April and May, 1974, from those of previous years and from each other. The creel census started on April 13, the opening day of trout season, and lasted until July 7. During this time, 33.7% of the available fishing time was intensively censused.

High returns of stocked rainbow trout to the angler were indicative of the success of the trout fishery at Stone Valley Reservoir. The reservoir is managed as a catchable trout fishery, catering primarily to the inexperienced fishermen. Success in this type of fishery is measured by high terms (by number) of the stocked trout. Spreading the fishing pressure and the catch of stocked trout over as much of the fishing season as possible is also a measure of success in catchable trout fisheries. Return from the 8000 stocked rainbow trout was approximately 56%. This high return of stocked trout was recovered over the entire length of the trout season, catch and effort never really falling off until late June. Contrary to local folklore, the bulk of the stocked trout was not taken early in the season but instead in late May and early June. The second stocking of trout actually provided a higher return to the angler by about 8% over the first stocking.

Characteristics of the fishery were determined through the creel census. Significant differences were found between the success of morning and afternoon fishermen and between boat and shore fishermen, with the morning and boat fishermen catching a larger share of the stocked trout, especially as the season progressed. Differences in catch rates were found among specific geographic sections of the reservoir. Generally, greater catch rates of stocked trout were obtained in deep water sections.

Evidence of very low survival from one year to the next of stocked trout in the reservoir was uncovered. Only 21 unmarked trout among 1521 trout caught were observed in the creel census. A temperature and oxygen squeeze on the trout that intensifies through late summer is believed to be very detrimental to trout survival in the reservoir. Chain pickerel and largemouth bass predation on the stocked trout is suggested, though the extent of warm-water species predation on trout is as yet undetermined. Loss of trout over the dam occurs but its timing and magnitude are unknown. Further research into the dynamics of the trout planted in Stone Valley Reservoir will be necessary to completely answer the question as to why carryover is so low in the reservoir.

The success of seasonal two-story fisheries, which can be maintained in marginal trout habitat, is very encouraging. Many warm-water lakes and reservoirs throughout the country are being under-utilized. Their resource potential as fisheries and recreation facilities could be measurably increased, especially near the larger cities. With the increasing alteration of our natural trout streams, trout managers will be forced to tap the vast potential of marginal reservoirs as trout habitat. With the construction of many high dams with low level discharge, once completely warm-water habitat is now being opened up to salmonids. Careful planning and prudent manipulation can create good fishing as well as more electricity, flood control, and other benefits of such projects.

Acknowledgements

We are very grateful for information provided to us from field biologists across Ontario as well as colleagues in other North American jurisdictions. Margaret Wells and Elizabeth Gustafsson provided assistance in obtaining reference material from the Ontario Ministry of Natural Resources library in Peterborough. Rainbow trout stocking information was provided by Wendylee Stott and Ola McNeil. Jeanette Arminio and Danielle Bartlett assisted in the formatting of this publication.

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1.2 Reports of Stocking Activities

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Nielsen et al. (1957)
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Ayers et al. (1976)
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Bidgood (1975)
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British Columbia Ministry of Fisheries (1999)
Brown and Thoreson (1958)
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Cragg-Hine (1975)
Dennis (1990)
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Brown and Thoreson (1958)
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3.0 Stocking Assessment

APPENDIX 1. Rainbow trout and Kamloops trout stocking in inland lakes and streams of Ontario from provincial fish culture stations, 1900-1999. This table does not include fish stocked in the Great Lakes or tributary streams or fish purchased from the private sector.

	Number of Fish Stocked[1]						
Year	Eggs	Fry	Fingerlings	Yearlings	Subadults/Adults[2]	Unknown	Total
1900	-	-	-	-	-	-	-
1901	-	-	-	-	-	-	-
1902	-	-	-	-	-	-	-
1903	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-
1905	-	-	-	-	-	-	-
1906	-	-	-	-	-	-	-
1907	-	-	-	-	-	-	-
1908	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-
1910	-	-	-	-	-	-	-
1911	-	-	-	-	-	-	-
1912	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-
1918	-	-	-	-	-	20,000	20,000
1919	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-
1922	-	5,450	-	-	-	-	5,450
1923	-	-	-	-	-	-	-
1924	-	-	-	-	-	15,000	15,000
1925	-	-	3,000	-	-	-	3,000
1926	-	-	1,800	-	-	-	1,800
1927	-	-	-	-	-	-	-
1928	-	-	419	-	-	-	419
1929	-	-	35,030	-	-	-	35,030
1930	-	-	71,500	10,005	-	-	81,505
1931	-	-	183,000	10,925	-	-	193,925
1932	-	216,235	-	-	-	-	216,235
1933	-	-	-	27,016	-	-	27,016
1934	1,000	4,480	218,130	25,014	-	-	248,624
1935	-	-	134,075	314	-	-	134,389
1936	-	-	55,000	1,740	-	-	56,740
1937	-	-	52,800	-	-	-	52,800
1938	-	-	201,500	3,600	-	25,800	230,900
1939	-	-	125,000	10,700	-	-	135,700
1940	-	-	298,400	35,600	-	-	334,000
1941	-	-	252,150	36,750	-	-	288,900
1942	-	-	111,000	37,700	-	-	148,700
1943	-	-	64,242	17,900	-	-	66,142
1944	-	-	36,086	7,200	-	-	43,286
1945	-	5,563	-	9,900	-	-	15,463
1946	-	-	-	1,610	4,850	-	6,460
1947	-	-	3,850	16,100	115	-	20,065
1948	-	-	27,900	12,450	100	-	40,450
1949	-	-	2,000	32,000	-	-	34,000
1950	-	-	-	52,000	-	-	52,000

Year	Eggs	Fry	Fingerlings	Yearlings	Subadult/Adult[2]	Unknown	Total
1951	-	-	4,000	34,600	-	-	38,600
1952	-	-	2,500	74,850	-	-	77,350
1953	-	-	25,000	108,990	-	-	133,990
1954	2,000	-	500	140,950	-	-	143,450
1955	2,000	-	3,000	82,640	750	-	88,390
1956	10,000	-	-	77,560	400	-	87,960
1957	13,000	-	31,600	123,060	380	-	168,040
1958	26,000	10,000	15,000	94,944	32,297	-	178,241
1959	20,000	-	19,517	95,036	1,400	-	135,953
1960	-	-	28,120	77,090	122	-	105,332
1961	3,000	-	101,896	225,375	-	-	330,271
1962	-	-	60,300	291,158	8,650	-	360,108
1963	-	-	3,000	173,152	11,380	-	187,532
1964	-	-	140,500	318,890	14,553	-	473,943
1965	-	65,000	11,750	269,285	62,750	-	408,785
1966	100,000	-	30,820	125,510	10,000	-	166,330
1967	676,500	6,000	87,810	147,850	43,100	-	961,260
1968	383,000	-	60,522	353,604	22,766	-	819,892
1969	20,000	85,750	44,050	434,316	20,395	-	604,511
1970	-	5,000	28,970	268,360	22,050	-	324,380
1971	198,500	158,000	58,179	479,750	42,180	-	936,609
1972	-	-	87,750	380,659	21,975	-	490,384
1973	37,000	145,132	25,900	359,275	2,129	-	569,436
1974	-	-	-	312,324	-	-	312,324
1975	30,000	22,700	161,114	-	-	-	213,814
1976	-	-	20,000	160,512	-	-	180,512
1977	8,000	-	46,743	86,864	-	-	141,607
1978	6,000	-	9,000	175,760	-	-	190,760
1979	-	8,000	-	238,517	1,161	-	247,678
1980	800	-	15,000	191,169	-	-	206,969
1981	16,000	-	1,000	224,258	192	-	241,450
1982	1,000	-	-	226,726	1,643	-	229,369
1983	-	-	52,700	86,163	1,132	-	139,995
1984	8,500	-	-	139,077	500	-	148,077
1985	25,150	-	16,800	143,299	4,400	-	189,649
1986	13,500	10,000	27,010	68,500	8,350	-	127,360
1987	-	-	50,622	86,260	5,232	-	142,114
1988	1,600	14,190	40,700	174,867	1,601	-	232,964
1989	1,500	24,000	115,380	314,393	3,209	-	458,482
1990	400	31,000	20,800	273,990	3,246	-	329,436
1991	3,000	65,000	16,849	131,892	8	-	216,749
1992	6,000	162,500	-	141,925	-	-	310,425
1993	-	105,000	32,306	66,953	-	-	204,259
1994	-	111,200	72,105	97,062	250	-	280,617
1995	-	160,000	40,101	68,927	-	-	269,028
1996	-	-	91,983	78,341	-	-	170,324
1997	-	-	7,642	168,339	-	-	175,981
1998	-	20,000	55,156	193,304	2,907	-	271,367
1999	-	-	21,530	226,554	1,054	-	249,138

1. Records prior to 1970 based on annual reports of Ontario Fish and Game Commission and Department of Lands and Forests. Records from 1970-1999 based on information archived in the Ontario Fisheries Information System.
2. Subadult fish are those 20 months of age and older.

APPENDIX 2. Contribution of stocked rainbow trout to the recreational fisheries of various North American waterbodies.

Waterbody	Size/Life Stage of Fish Stocked	Contribution to Fishery	Time Period from Release	Reference
Lakes				
Bad Medicine Lake (Minnesota)	Yearlings	51.1-58.6% of the number stocked	-	Cunningham and Anderson (1992)
Beauvais Lake (Alberta)	Fingerlings (18.0 ounces)	3.68% of the number stocked	1-1_ years	Radford and Clements (1971)
Big Eggleston Lake (Colorado)	-	98.7% of the catch	-	Barrows (1962)
Big Watab Lake (Minnesota)	-	58% of the number stocked	6-8 months	Wang et al. (1996)
Blakely Lake (Ontario)	Yearlings	CUE of 0.000-0.500	-	Anonymous (Undated$_c$)
Bonito Lake (New Mexico)	8-9 inches	CUE > 0.500	-	Little (1966)
Burt Lake (Michigan)	Adults	64.0% of the number stocked	-	Shetter and Hazzard (1940)
Castle Lake (California)	Catchables	79.9% of the number stocked	-	Wales and Borgeson (1961)
Chain Lake (Alberta)	Fingerlings (14.5 ounces)	4.05% of the number stocked	1-1_ years	Radford and Clements (1971)
Chouinard Lake (Ontario)	Yearlings	CUE of 0.111-0.700	-	Anonymous (Undated$_c$)
Convict Lake (California)	Catchables	48.6% of the number stocked	-	Delisle (1959)
East Fish Lake (Michigan	8.5-9.5 inches	86% of the number stocked	-	Alexander and Shetter (1969)
Fairfax Lake (Alberta)	Fingerlings (4.8 ounces)	17.3% of the number stocked	1-1_ years	Radford and Clements (1971)
Farren Lake (Ontario)	Yearlings	CUE of 0.063	4 months	Hamilton (1981)
Heart Lake (Ontario)	Yearlings	37% of the number stocked	-	Stocek and MacCrimmon (1965)

Waterbody	Size/Life Stage of Fish Stocked	Contribution to Fishery	Time Period from Release	Reference
Hemlock Lake (Michigan)	Adults	37.3% of the number stocked	-	Shetter and Hazzard (1940)
Irish Lake (Ontario)	Catchables (2.5/lb)	80.5% of the number stocked	4 _ months	Kerr (1983)
Island Lake (Colorado)	-	96.1% of the catch	-	Barrows (1962)
Jasper National Park lakes (Alberta)	-	5-100% (mean 50.0%) of number stocked	-	Solman et al. (1952)
June Lake (California)	Catchables	54% of the number stocked	2 years	Vestal (1943)
Kilbourne Lake (Ontario)	Yearlings	CUE of 0.192-0.671	-	Anonymous (Undated$_f$)
Lake Pend Oreille (Idaho)	Catchables	20.0% of the number stocked	2 years	Anonymous (1963$_b$)
Lake Tahoe (California)	-	17% of the total catch	-	Weidlein et al. (1962)
	Catchables (domestic strain)	3-36% of the number stocked	9 years (1956-64)	Cordone and Franz (1960)
Lake Whittacker (Ontario)	Catchables	83.3% of the number stocked and a CUE of 0.372	5 weeks (May)	Barrett (1991)
Mair (Green) Lake (Ontario)	Yearlings	CUE of 0.205-0.467	-	Anonymous (Undated$_e$)
McConnell lakes (Ontario)	-	0.2-9.1% (mean 3.2%) of number stocked	2 years (1971-1973)	McKeown (1974)
North Twin Lake (Michigan)	Adults	66.0% of the number stocked	-	Shetter and Hazzard (1940)
Oastler Lake (Ontario)	Yearlings (45 gm) Catchables (245 gm)	9.1% of number stocked 5.0% of number stocked	-	Muckenheim (1987)
Parker Canyon Lake (Arizona)	Catchables (8-10 inches)	90-95% of the number stocked	6 months	Otte (1975)

Waterbody	Size/Life Stage of Fish Stocked	Contribution to Fishery	Time Period from Release	Reference
Parvin Lake (Colorado)	Catchables	87.7% of the number stocked	-	Klein (1972)
Pearl Lake (Ontario)	Catchables (200 gm)	15.3% of the number stocked	4 months (April-August)	McKee (1984)
Pebble lake (Alberta)	Yearlings	CUE of 0.197 (1970) and 0.447 (1971)	-	Hunt (1971)
Pickerel Lake (Ontario)	Adults	23.3% of the number stocked	-	Shetter and Hazzard (1940)
Police Lake (Alberta)	Fingerlings (19.5 ounces)	6.86% of the number stocked	1-1_ years	Radford and Clements (1971)
Proud Lake (Michigan)	Catchables	CUE of 0.820 (Catch & Release Only)	5-6 months	Ostaszewski (1990)
South Lake (California)	Catchables	74.0% of the number stocked	-	Delisle (1959)
South Twin Lake (Michigan)	Adults	64.0% of the number stocked	-	Shetter and Hazzard (1940)
Sunset Lake (Wisconsin)	Legal sized	41-67% of the number stocked	-	Kmiecik (1972)
Tyrrell Lake (Alberta)	Fingerlings (32.9 ounces)	0.13% of the number stocked	1-1_ years	Radford and Clements (1971)
Weber Lake (Wisconsin)	-	6.3% of the number stocked	5 years (1947-1952)	Burdick and Cooper (1956)
Wildhorse Lake (Alberta)	Fingerling (18.0 ounces)	5.82% of the number stocked	1-1_ years	Radford and Clements (1971)
Wilcox Lake (Ontario)	Catchables (2.5/lb.)	65.2% of the number stocked	4 _ months	Kerr (1983)
Wilder Lake (Ontario)	Catchables	2.8% of number stocked	4 months (May-August)	McKee (1984)
Williams Lake (Ontario)	Catchables (2.5/lb.)	100% of the number stocked	4 _ months	Kerr (1983)

Waterbody	Size/Life Stage of Fish Stocked	Contribution to Fishery	Time Period from Release	Reference
Wolfe Lake (Ontario)	Yearlings	CUE of 0.053-0.340	-	Anonymous (Undated$_g$)
Misc. lakes (California)	Catchables	83% of the number stocked and a CUE of 0.600	-	Butler and Borgeson (1965)
Misc. lakes (United States)	Fingerlings	0.06-36.4% (mean 7.4%) of number stocked	-	Needham (1959)
	Legal-sized	1.1-88.4% (mean 34.5%) of number stocked	-	
Reservoirs				
Beardsley Reservoir (California)	Fingerlings (1.0-51.5 ounces)	1.8-32.8% of the number stocked	2_ years	Cordone (1968)
Black Hill Reservoir (South Dakota)	Fingerlings	15.7-35.2% of the number stocked	-	Ford (1978)
Bown Reservoir (Utah)	Fingerlings	12% of the number stocked	1 year	Hepworth and Lippink (1979)
	Fingerlings	24% of the number stocked	1 year	Hepworth and Lippink (1979)
	Fingerlings	10% of the number stocked	1 year	Hepworth and Lippink (1979)
Deadwood Reservoir (Idaho)	-	CUE of 1.0 fish/hour	3 months (June-August)	Bjornn et al. (1963$_b$)
	-	20.2% of the catch	4-5 months	Anonymous (1968$_c$)
Dillon Reservoir (Colorado)	Fingerlings	4.8% of the number stocked	-	Stuber et al. (1985)
Draycote Reservoir (Great Britain)	-	78.1% of the number stocked	2-3 months	North (1983)
Eugenia Lake (Ontario)	Catchables (2.5/lb)	39.4% of the number stocked	4 _ months	Kerr (1983)
Lake Cumberland (Kentucky)	Catchables (8 inch fish)	CUE (May-September) of 0.16	7-11 months	Axon (1974)
Lake Maloya Reservoir (Wyoming)	8 inches	54% of the number stocked	2 years	Barker (1955)
	8 inches	60% of the number stocked	2 years	Barker (1955)

Waterbody	Size/Life Stage of Fish Stocked	Contribution to Fishery	Time Period from Release	Reference
Stone Valley Reservoir (Pennsylvania)	Catchables	56% of the number stocked	3 months	Zaplitny (1975)
<u>Ponds and Quarries</u>				
Allan Park Pond (Ontario)	Catchables (200 grams)	0.0% of the number stocked	4 months (April-August)	McKee (1984)
Durham Pond (Ontario)	Catchables (200 grams)	0.4% of the number stocked	4 months (April-August)	McKee (1984)
Flesherton Pond (Ontario)	Catchables (2.5/lb)	100% of the number stocked	4 _ months	Kerr (1983)
Glasgow Glen Pond (Ontario)	-	36% of the number stocked	5 year period	Berst and McCombie (1975)
Holstein Pond (Ontario)	Catchables	0.0% of the number stocked	4 months (April-August)	McKee (1984)
Markdale Pond (Ontario)	Catchables (2.5 lb.)	82.8% of the number stocked	4 _ months	Kerr (1983)
Springwater Pond (Ontario)	Catchables	78.5% of the number stocked and a CUE of 0.116	5 weeks (May)	Barrett (1991)
Misc. abandoned quarries (Minnesota)	Catchables	50% of the number stocked	-	Kelley (1953)
Misc. Conservation Area Ponds (Ontario)	Catchables	96% of the number stocked	-	Schraeder (1989)
<u>Streams and Rivers</u>				
Blackledge River (Connecticut)	-	80% of the number stocked	4 months	Rayner et al. (1944)
Dale Hollow Reservoir tailwater (Tennessee)	Fingerlings	16% of the number stocked	12 months	Parsons (1955)

Waterbody	Size/Life Stage of Fish Stocked	Contribution to Fishery	Time Period from Release	Reference
Dusche Creek (Minnesota)	Yearlings (4.56/lb)	21.6% of the number stocked	4_ months	Schumacher (1954)
Mill Creek (Oregon)	Legal-sized	53.1-76.8% of the number stocked	-	Moring (1978)
Quadalupe River (Texas)	-	59% of the number stocked	7 months	Bulter (1973)
Pecos River (New Mexico)	6-8 inches	58.8% of the number stocked	-	Gee (1942)
Pine River (Michigan)	Legal-sized	17.5% of the number stocked	-	Hazzard and Shetter (1938)
Rock Creek (Montana)	Catchables	25.6-39.3% of the number stocked (ten year average was 34.6%)	2_ months	Spence (1971)
Rush Creek (California)	Catchables	90.0% of the number stocked	-	Delisle (1959)
	Fingerlings	3.2% of the number stocked	-	McAfee (1966)
	Subcatchables	8.3% of the number stocked	-	McAfee (1966)
Spring Creek (Pennsylvania)	Age I and II fish	74% of the number stocked	-	Hartzler (1977)
Willow Creek (New Mexico)	7-9 inches	40% of the number stocked	-	Gee (1942)
Misc. Streams (California)	Catchables	73% of the number stocked and a CUE of 0.94	-	Butler and Borgeson (1965)
Misc. Streams (Michigan)	Fingerlings	2.02% of the number stocked	-	Anonymous (1953)
Misc. Streams (Michigan, North Carolina & Virginia)	Fingerlings	0.0-3.3% (mean 1.6% of the number stocked	-	Holloway (1945)
Misc. Streams (United States)	Fingerlings	0.0-14.0% (mean 2.5%) of the number stocked	-	Needham (1959)
	Legal-sized/Catchables	2.6-82.0% (mean 28.6%) of the number stocked	-	Needham (1959)

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