AN EXPERIMENTAL INTRODUCTION OF COHO SALMON INTO A LANDLOCKED LAKE IN NORTHERN WISCONSIN

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ABSTRACT

An attempt was made to establish a coho salmon *(Onchorhynchus kisutch)* fishery in Pallette Lake, a 169-acre, oligotrophic lake in north central Wisconsin. Age 0 coho stocked in October 1968 grew only 5.4 inches in length and 116 grams in weight during three years in the lake. Age I coho stocked in April 1969 grew only 4.2 inches and 91 grams in 2½ years. Growth of Age I coho stocked in October 1970 could not be determined because none were captured by electrofishing or in fyke nets and because angler harvest was selective for fish over 10.0 inches. Few coho from either the 1968 or 1969 stocks ever attained the minimum legal size of 10.0 inches. Though a few coho lived until their fourth fall in Pallette Lake, survival during their first two years was poor.

Angler harvest of coho from the October 1968 stock and the October 1970 stock accounted for 0.04 percent and 9.0 percent, respectively, of the numbers stocked and 0.4 percent and 1.9 percent, respectively, of the pounds stocked. Anglers failed to capture any coho from the April 1969 stock.

Planktonic Crustacea (especially *Daphnia)* in Pallette Lake were overgrazed by resident fishes. Coho salmon did not prey upon forage fishes such as the common shiner *(Notropis cornutus)*, white sucker *(Catostomus commersoni)*, cisco *(Coregonus artedii)* or yellow perch *(Perca flavescens)*, but fed primarily upon terrestrial and aquatic insects. An inadequate food supply of insects and planktonic crustaceans stymied the growth of coho, prevented their eventual conversion to a piscivorous diet and was the primary reason for their failure in the lake.

Results of other attempts to create coho fisheries in the U.S. and Canada are discussed. In general, such stockings in inland waters have not been successful except in the Great Lakes.

Any future attempt to create a salmonid fishery in Pallette Lake should consider chemical eradication of all fish, followed by a waiting period to allow insect and zooplankton populations to build up, then introduction of the selected salmonid species.

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By
Eddie L. Avery

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INTRODUCTION

Many northern Wisconsin lakes are plagued with large populations of stunted yellow perch in association with many other pelagic and littoral forage fish species. Although chemical eradication and restocking with desirable fishes has proven to be an effective method of managing such lakes, it is often short term and usually expensive. The spectacular success of coho salmon, *Onchorhynchus kisutch* (Walbaum), in Lake Michigan during the 1960's kindled hopes of establishing similar sport fisheries in smaller landlocked lakes. Furthermore, the piscivorous feeding habits of coho suggested the possibility of creating a sport fishery for this fish in "stunted panfish" lakes.

To determine if stocking coho would provide an alternative to chemical eradication, 3 groups of coho were released in Pallette Lake during 1968-1970. Pallette Lake was selected for this experiment because it contained a cisco *(Coregonus artedii* Lesueur) population and an abundant population of stunted panfish and because it was state-owned, thereby making a complete creel census possible.

DESCRIPTION OF LAKE

Pallette Lake is an oligotrophic, seepage lake located in the Northern Highland Fishery Research Area in north central Wisconsin (Fig. 1). Surface area is 169 acres and depth averages 31 feet with a maximum of 63 feet. Specific conductance is 26 micro-mhos/cm^2 and total $CaCO_3$ alkalinity is 13 ppm. The lake is surrounded by state-owned land and access is by a scenic 0.3-mile hike through northern hardwood forest.

The lake has a long history of poor fishing and a wide assortment of fish species. Northern pike, *Esox lucius* Linnaeus, muskellunge, *Esox masquinongy* Mitchill, splake, *Salvelinus fontinalis* (Mitchill) X *Salvelinus namaycush* (Walbaum), and largemouth bass, *Micropterus salmoides* (Lacepede), are sparse, while slow-growing smallmouth bass, *Micropterus dolomieui* Lacepede, and stunted yellow perch, *Perca flavescens* (Mitchill), are abundant. Ciscos, white suckers, *Catostomus commersoni* (Lacepede), creek chubs, *Semotilus atromaculatus* (Mitchill), and common shiners, *Notropis cornutus* (Mitchill), are also present in large numbers. Other species present include: bluntnose minnow, *Pimephales notatus* (Rafinesque), brook stickleback, *Culaea inconstans* (Kirtland), burbot, *Lota lota* (Linnaeus), pumpkinseed, *Lepomis gibbosus* (Linnaeus), logperch, *Percina caprodes* (Rafinesque), mottled sculpin, *Cottus bairdi* Girard, Iowa darter, *Etheostoma exile* (Girard), black bullhead, *Ictalurus melas* (Rafinesque), golden shiner, *Notemigonus crysoleucas* (Mitchill), and rock bass, *Ambloplites rupestris* (Rafinesque).

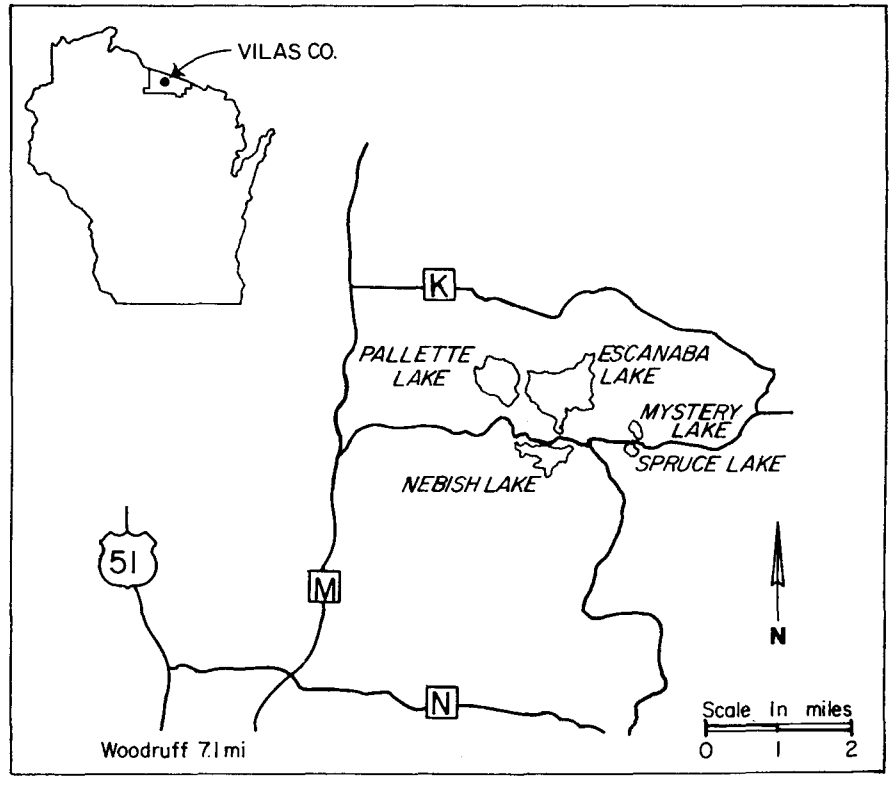


FIGURE 1. *Location of Pallette Lake within the Northern Highlands Fishery Research Area, Vilas County.*

METHODS

Salmon Stocking

Three groups of coho salmon were released in Pallette Lake during 1968-1970. An initial group of 2,500 Age 0 coho was released on 30 October 1968. A second group of 2,500 Age I coho from the same hatchery stock, was released on 18 April 1969. A third group of 1,650 Age I coho was released on 20 October 1970. Samples of coho in each group were measured to the nearest 0.1 inch and weighed to the nearest gram prior to release in the lake. Each group was given a different finclip to assist in future identification. All coho were released in shallow water along the southeast shore of the lake and observed until they had dispersed.

Estimating Population Size and Growth

To estimate the size of the coho population and obtain growth information, Pallette Lake was electrofished and fyke-netted in late April–early May and again in October during 1969-1971. Four to six fyke nets (½-inch stretch mesh and 30- to 40-foot leads) and a boom shocking boat equipped with a 230-volt, AC generator were used to capture coho. Electrofishing was done between 8:00 and 12:00 p.m. At least two complete trips around the periphery of the lake were made each night. Fyke nets were fished from sunset to the following morning. Coho captured by electrofishing were held overnight in a screened fish box until fyke nets were raised in the morning. All fish were then measured to the nearest 0.1 inch, weighed to the nearest gram, given a temporary finclip, taken to the approximate center of the lake and released.

Population estimates were made using the Bailey modification of the Petersen mark and recapture method. Confidence intervals (x=.95) were determined using Clopper and Pearson (1934) charts for binomial distribution.

Conducting Creel Census

Anglers fishing Pallette Lake were required: (1) to obtain a free fishing permit at the Northern Highlands Fishery Research headquarters, (2) to return this permit upon completion of their fishing trip and (3) to submit their catch to DNR personnel for examination. Total length, weight and finclips of all coho harvested were recorded.

Analyzing Stomach Contents

Stomachs were collected from a sample of the coho caught by anglers and preserved in 10 percent formalin. Since the minimum legal size of coho was 10.0 inches, stomachs were also collected from smaller coho captured by electrofishing and taken on hook and line by DNR personnel. Food items in coho stomachs were counted, identified and most insects classified to Order.

RESULTS

Population Size

Low stock densities (15-30 coho/acre), poor efficiency of fyke nets and poor efficiency of electrofishing gear in the soft water of Pallette Lake prevented the capture of sufficient numbers of coho to make reliable population estimates. Seven of 14 possible population estimates were made but wide confidence limits attest to their low level of precision (Table 1).

TABLE 1
Population Characteristics of the Three Stocks of Coho Planted in Pallette Lake, 1969–1971

Sampling Date	Coho Captured from Each Stock			Population Estimate of Each Stock			95% Confidence Limits for Population Estimates of Each Stock		
	1968	1969	1970	1968	1969	1970	1968	1969	1970
1969									
Spring	334	287	–	2,277	2,172		*	*	–
Fall	96	125	–	456	364		239–2,257	222–736	–
1970									
Spring	75	125	–	268	366		143–1,000	200–788	–
Fall	1	6	–	–	–		–	–	–
1971									
Spring	9	7	67	–	–	130	–	–	85–270
Fall	3	7	0	–	–	–	–	–	–

*Low recapture values made it impossible to determine confidence limits from Clopper and Pearson charts.

In September-October 1971, 3 survivors of the 1968 stock, 7 survivors of the 1969 stock and no survivors of the 1970 stock were captured during 10 nights of fyke netting (Table 1). This fyke netting was part of an inventory of the fishes in Pallette Lake conducted by DNR personnel stationed at the Northern Highlands Fishery Research Area. Since population estimates were not a major objective of these operations, coho were not marked and it was possible that some of them were captured more than once.

On 14 October 1971, 10 days after completion of fyke netting, no coho were seen during the first night of electrofishing and sampling efforts were discontinued. Significant declines in numbers of coho salmon seen and captured during successive elctrofishing surveys in Pallette Lake suggested that survival was poor and too few coho remained to warrant further sampling efforts in 1972.

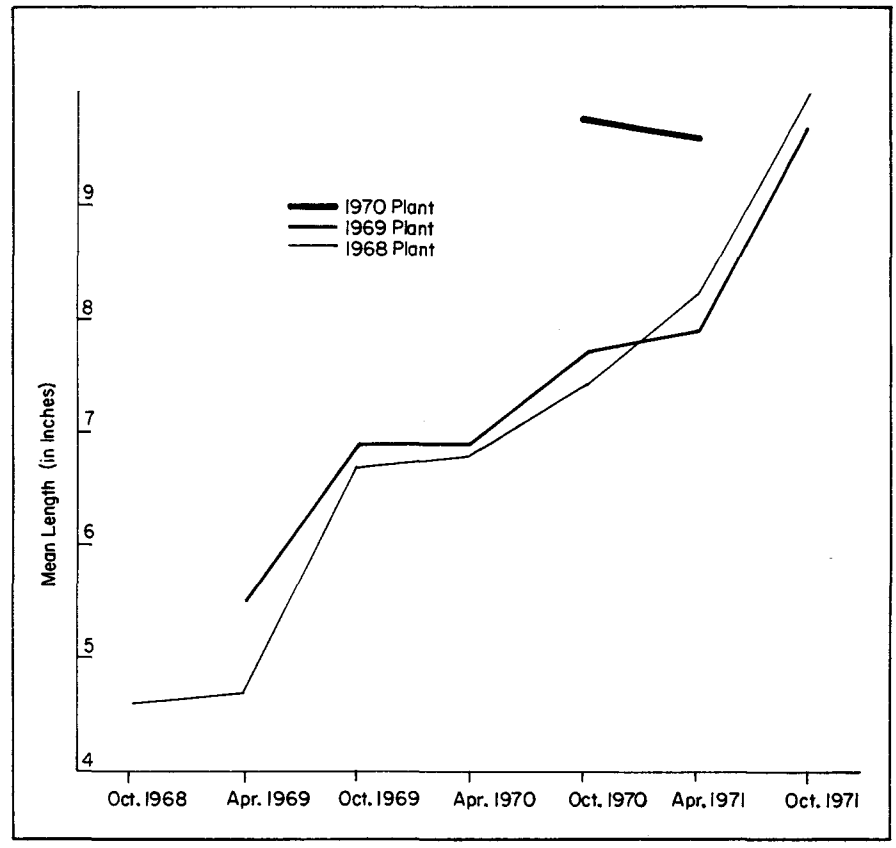


FIGURE 2. *Growth in length of coho salmon stocked in Pallette Lake.*

Growth and Condition

Average total lengths of coho stocked in 1968, 1969 and 1970 were 4.6, 5.5 and 9.8 inches, respectively. Average weights of these same stocks were 15, 25 and 155 grams, respectively.

Growth of Age 0 coho stocked in 1968 was only 5.4 inches and 116 grams during three years of residence in Pallette Lake. Average total length and weight of these coho in the fall of 1971 was 10.0 inches and 130 grams, respectively (Figs. 2 and 3).

Growth of Age I coho stocked in 1969 was 4.2 inches and 91 grams in 2½ years of residence. Average total length and weight of these coho in the fall of 1971 was 9.7 inches and 116 grams, respectively (Figs. 2 and 3).

No Age I coho from the 1970 stock were captured in the fall of 1971, thus growth after one year of residence in the lake could not be determined. Average length and weight of these coho in the spring of 1971, after six months of residence, was 9.6 inches and 119 grams, respectively (Figs. 2 and 3). These averages were 0.2 inches and 36.0 grams less than the average length and weight of the coho when stocked. This decrease in average size from fall to spring was due to loss in weight overwinter and size-differential mortality of larger coho resulting from angler harvest of coho over 10 inches

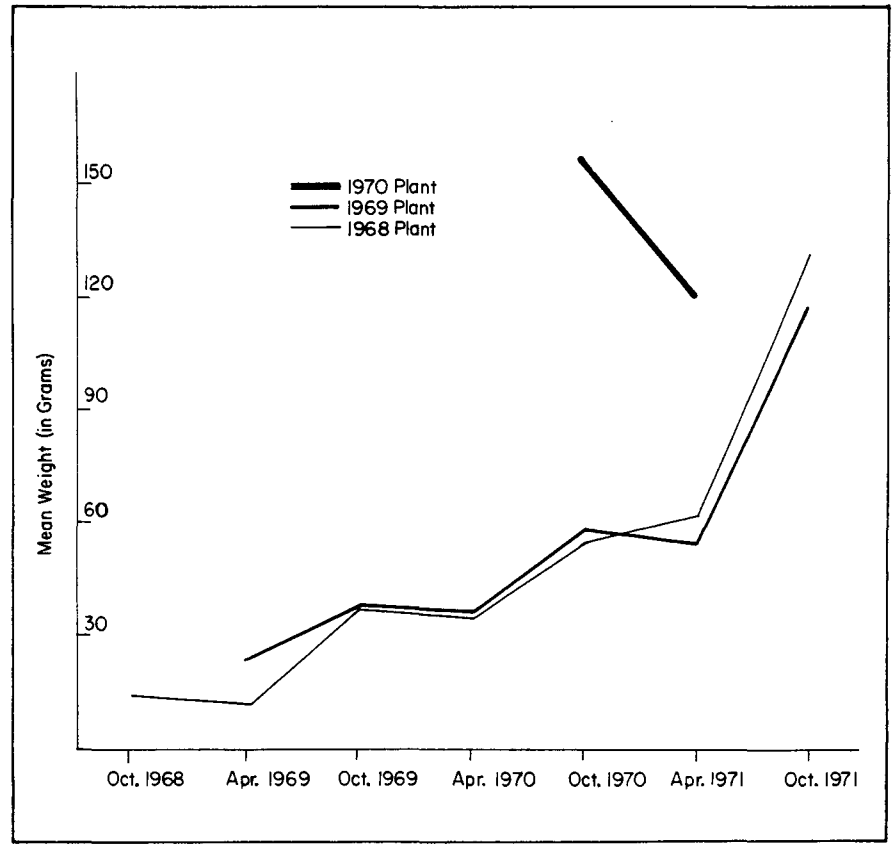


FIGURE 3. *Growth in weight of coho salmon stocked in Pallette Lake.*

(minimum legal size).

Average coefficients of condition (R) of coho when stocked in Pallette Lake in 1968, 1969 and 1970 were 1.38, 1.49 and 1.65, respectively (Table 2). By April 1971, these coefficients declined to 1.08, 1.13 and 1.32 (for the 1968, 1969 and 1970 stocks, respectively) and never approached their initial values.

TABLE 2
Average Coefficients of Condition (R) of Coho in Pallette Lake, 1968–1971

Year Stocked	Sampling Dates 1968 Apr.	1969 Apr.	1969 Oct.	1970 Apr.	1970 Oct.	1971 Apr.	1971 Oct.
1968	1.38	1.21	1.18	1.10	1.33	1.08	1.29
1969		1.49	1.14	1.12	1.26	1.13	1.26
1970					1.65	1.32	–

Harvest

Angler harvest from Pallette Lake during 1969-1972 was 149 coho (minimum legal total length of 10 inches), representing a total return of 2.2 percent. Total weight of these coho was approximately 11 pounds or 1.4 percent of the total number of pounds stocked.

Angler harvest of coho from the 1968 and 1970 stocks was 1 and 148 coho, respectively, or 0.04 percent and 9.0 percent of the numbers stocked. Total weights of harvested coho from the 1968 and 1970 stocks were 0.3 and 10.7 lbs, respectively, or 0.4 percent and 1.9 percent of the pounds stocked. Anglers failed to capture any coho from the 1969 stock.

The single coho harvested from the 1968 stock was taken through the ice on 10 January 1972 after field work for this study had been completed. It measured 10.7 inches in length and weighed 136 grams. All coho from the 1970 stock were caught through the ice between 1 January and 3 April 1971. Average total length and weight of these coho was 10.7 inches and 149 grams, respectively. Coho were readily taken by ice fishermen visiting Pallette Lake in early 1971. However, because most coho were sublegal and all of them were in poor condition, anglers soon lost interest.

TABLE 3
Contents of 49 Stomachs from Coho Salmon Collected During January–March 1971 (Percentages in Parentheses are Based on 19 Stomachs Containing Food)

Food Items	Frequency of Occurrence	No. of Food Items
Insects (total)	13 (68.4)	20 (95.2)
Diptera	4 (21.1)	5 (23.8)
Chironomidae larvae	4 (21.1)	5 (23.8)
Chaoboridae larvae	5 (26.3)	8 (38.1)
Trichoptera larvae	7 (36.8)	7 (33.3)
Fish (total)*	1 (5.3)	1 (4.8)
Plant remains (total)**	9 (46.9)	***

*The fish was a brook stickleback.
**Included remains of Trichoptera cases, conifer needles, etc.
***Could not be itemized.

Food Habits

During the winter of 1970-71, stomachs from 49 angler-caught coho were collected and their contents examined. One coho was collected on 1 January while the remaining 48 were collected during the first 10 days of March. Ten stomachs were from coho stocked in 1968-69 and 39 were from coho stocked in 1970. Average length of the 49 coho was 9.9 inches, while the range was from 8.0-12.0 inches. All stomachs resembled thickened tubes indicative of fish that had gone a considerable period without substantial food. The maximum

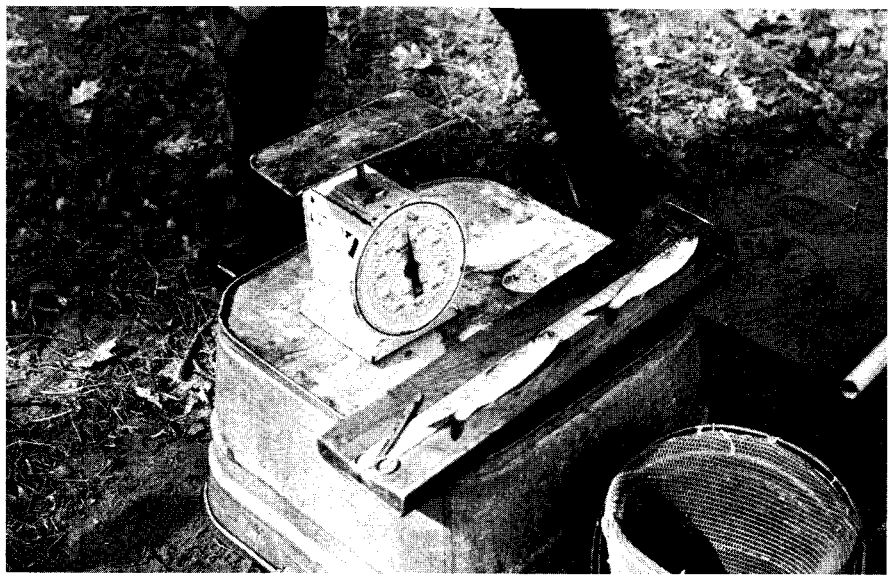
TABLE 4
Contents of 21 Stomachs from Coho Salmon Collected During May 1971 (Percentages in Parentheses)

Food Items	Frequency of Occurrence	No. of Food Items
Insects (total)	21 (100.0)	356 (100.0)
Diptera	18 (85.7)	194 (54.5)
Chironomidae	18 (85.7)	191 (53.6)
larvae	8 (38.1)	9 (2.5)
pupae	13 (61.9)	20 (5.6)
adults*	13 (61.9)	162 (45.5)
Unidentified adults	3 (14.3)	3 (0.8)
Hydracarina	18 (85.7)	121 (34.0)
Coleoptera	9 (42.9)	10 (2.8)
aquatic	7 (33.3)	8 (2.2)
terrestrial	2 (9.6)	2 (0.6)
Hemiptera (Corixidae)	8 (38.1)	8 (2.2)
Trichoptera adults	1 (4.8)	1 (0.3)
Misc. terrestrials	8 (38.1)	18 (5.1)
Annelida (Hirudinea)	2 (9.6)	2 (0.6)
Amphipoda (Hyallela)	1 (4.8)	2 (0.6)
Plant remains (total)**	4 (19.0)	***

*Includes some Chaoboridae (*Chaoborus*) which were misidentified as Chironomidae.
**Included remains of Trichoptera cases, conifer needles, etc.
***Could not be itemized.

number of food items found in any one stomach was three and 30 of the 49 stomachs were empty. One coho from the 1970 stock contained a small brook stickleback, otherwise the coho diet consisted of a few Diptera and/or Trichoptera larvae (Table 3).

On 14 May 1971, stomachs were collected from 21 coho captured by electrofishing. All of these coho were from the 1970 stock. All stomachs contained food and several contained as many as 50 items. Average length of the 21 coho was 9.7 inches while the range was from 8.6-11.0 inches. Their diet consisted primarily of aquatic and terrestrial insects (Table 4). Of the total number of food items present in coho stomachs, 53.1 percent were adult chironomids and *Chaoborus.* Water mites (Hydracarina) comprised 34.0 percent of the food items and were the only other item of numerical importance. Water mites often parasitize chironomid and *Chaoborus* larvae, and their presence in coho stomachs was thought to be at least partially due to the cohos feeding upon their hosts rather than upon them. Miscellaneous terrestrial insects, Coleoptera and Hemiptera comprised 10.1 percent of the food items present. Terrestrial Coleoptera were probably more important in the diet than indicated because of their large size.



Typical coho in Pallette Lake were in poor condition.

DISCUSSION

Prior introductions of rainbow trout and splake in Pallette Lake both failed due to severe overgrazing of planktonic crustaceans (especially *Daphnia)* and other invertebrates by resident fishes (Brynildson, 1961; Brynildson, 1962 and Brynildson and Kempinger, 1970). The success of coho salmon in Pallette Lake was therefore dependent upon the availability of resident fishes to the coho and upon the ability of coho to prey upon them.

In 1969-1970, Engel and Magnuson (1971) found coho salmon sharing the same areas of Pallette Lake with either yellow perch, common shiners and/or ciscos throughout the entire year. Fish remains, however, were found in only 19 of 190 Age I coho examined between April and November 1969. These coho were between 5.0 and 7.0 inches in length and their diet consisted primarily of aquatic and terrestrial insects (Engel, 1972).

Except for one brook stickleback, aquatic and terrestrial insects were the only food items found in stomachs of Age II and Age III coho from Pallette Lake (Tables 3 and 4). Since these coho were between 8.0 and 12.0 inches in length, one might conclude that coho must be larger than 12.0 inches before they include appreciable amounts of fish in their diet. This was not the case, however, in a successful coho fishery established in Stormy Lake, Wisconsin in 1969.[1] Fish were the most important food items (volumetrically) in coho between 9.5 and 11.5 inches in length and became more important in the diet as the size of the coho increased. Insects and planktonic Crustacea were the most important food items of coho smaller than 9.5 inches and were important supplements in the diet until coho reached 13.5 inches (McKnight and Serns, 1972). In Pallette Lake, insect and planktonic Crustacea populations were overgrazed and in the absence of these basic food supplies, coho in the 8.0- to 12.0-inch size range were not able to make the transition to a piscivorous diet.

Insufficient food and the resulting poor growth of coho in Pallette Lake were responsible for their increased longevity in this landlocked lake. Most coho in Lake Michigan attain reproductive maturity and complete their life cycle in their 3rd fall of life. Coho from the 1968 and 1969 stocks in Pallette Lake lived into their 4th fall. Extended longevity of coho is common in Alaska where slow growth in freshwater delays the age at which most adults mature, to their 4th fall (Drucker, 1972).

In addition to Pallette Lake and Stormy Lake, 8 other lakes in Wisconsin have been stocked with coho salmon between 1969 and 1971.[2] In each case the desired sport fishery failed to develop, generally, because of low survival and poor growth. Six of the 8 lakes were infertile softwater lakes with either a

poor history of sport fishing and/or stunted "panfish" populations. The remaining two lakes were hardwater lakes; one characterized by slow-growing panfish, the other by a good trout fishery. No follow-up surveys were made on the trout lake but some coho were known to have escaped downstream.[3]

Coho have failed to create a successful fishery in most other inland lakes where they have been stocked in the United States and Canada. In California, coho stocking began in Lake Almanor in 1937. Return to the creel between 1937 and 1943 was less than 3 percent, survival was poor and most of the fish caught weighed about one pound. The experiment was considered worthwhile, however, because coho added variety to the fishery and were considered better fighters than resident rainbow trout (Wales, 1943). Since 1937, many California lakes have been stocked with coho but not until 1970 was another successful fishery established. Yearling coho were stocked in Lake Berryessa in the spring and return to the creel during the first year was 42 percent. Overwinter survival was good and fish up to 12.5 pounds were taken by the following fall. Coho fed heavily upon the threadfin shad population which was considered a primary reason for their success.[4]

In 1970-71, coho were stocked in a 35-acre Michigan lake which contained a stunted perch population. No coho from the 1970 stock and only a few from the 1971 stock were ever seen again.[5] In the fall of 1968, the Pennsylvania Fish and Game Commission stocked coho in a trout lake which contained an abundant population of golden shiners. Although the coho averaged 9.0 inches in length, they failed to prey upon the shiners, lost weight throughout the winter and were taken by ice fishermen in large numbers.[6]

Coho stocked in Granby Reservoir, Colorado exhibited better growth and survival to catchable size than rainbow trout and a favorable seasonal distribution to the creel. In contrast, coho in Parvin Lake, Colorado exhibited poorer growth than a similar stock of rainbow trout, an unfavorable pattern of seasonal distribution to the creel and extensive downstream migration (Klein and Finnell, 1969). Downstream migration was responsible for the failure of coho salmon stocked in Cold Lake, Alberta in 1971.[7]

Results of coho salmon studies in Minnesota have generally shown little difference in survival, growth, food habits and catchability between coho salmon and rainbow trout.[8]

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MANAGEMENT IMPLICATIONS

Coho salmon do not appear to be the panacea for cold water lakes with a poor history of sport fishing and/or those lakes containing stunted "panfish" populations. In landlocked lakes, coho are ecologically similar to rainbow trout, thus growth and survival of coho should be best where growth and survival of rainbow trout would also be good (i.e., in lakes supporting *Daphnia*—at least ten 1mm and larger *Daphnia* per liter—and a schooling forage fish, like alewife or threadfin shad, which inhabits the pelagic zone).

Based on this study and previous studies of other salmonids in Pallette Lake, any future attempt to create a salmonid fishery in this lake should be preceded by chemical eradication of all fish. Such eradication should be followed by at least a 1-year waiting period to allow insect and planktonic Crustacea populations to build up. Since Pallette Lake is one of relatively few Wisconsin lakes containing a native cisco population, some of these fish should be saved for reintroduction along with the other salmonid species selected.

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