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Abstract.–This study was initiated because fisheries managers were concerned, and anglers were complaining, that steelhead *Oncorhynchus mykiss* populations in Lake Superior tributaries were declining during the late 1970s and early 1980s. Juvenile steelhead and coho salmon *Oncorhynchus kisutch* population dynamics were monitored in 305-m linear sections of three streams tributary to Lake Superior (Chinks Creek, Little Garlic River, Chocolay River) during 1982-97 to provide data that could be used to evaluate trends in annual steelhead and coho salmon reproduction relative to time, parental stock size, and exogenous factors such as precipitation and air temperature. Resident salmonine populations were present in Chinks Creek (brook trout *Salvelinus fontinalis*) and Chocolay River (brook trout and brown trout *Salmo trutta*) during the study period. Abundance of age-0 steelhead decreased in study sections on Chinks Creek and the Chocolay River at Beckman Road, abundance of age-1 steelhead decreased in the Little Garlic River, age-0 brown trout decreased in the M-94 section of the East Branch of the Chocolay River, and age-1 and older brook trout and brown trout decreased in the Beckman Road section of the Chocolay River. Only age-1 coho salmon in Chinks Creek increased. Density of juvenile steelhead in Chinks Creek during 1982-97 was generally higher than in 1967-74, but in Little Garlic River it was lower. Coho salmon densities were higher than in 1968-74 in both streams. Relocation of the study section in Chinks Creek may be the reason for decreased abundance of age-0 steelhead there during 1982-97. Habitat degradation is believed responsible for decreased abundance during of age-0 steelhead in the Beckman Road section of the Chocolay River during 1985-97, for decreased age-1 abundance in the Little Garlic River during 1982-97, and for decreased age-0 and age-1 steelhead in Little Garlic River between 1967-74 and 1982-97. I concluded that increased abundance of steelhead was responsible for decreased densities of brook trout and brown trout in the Chocolay River. Steelhead and coho salmon spawning runs were adequate to provide carrying capacity of juveniles in Chinks Creek and Little Garlic River but not in the Chocolay River. Age-0 coho salmon abundance in the tributaries could not be used to predict that cohort's contribution to the Lake Superior sport fishery, nor was contribution to the sport fishery an index of parental stock size that could be used to predict age 0 abundance. No relationships between juvenile populations and precipitation or air temperature were found. Continued juvenile population monitoring is recommended.

Various species of non-native salmonines have been introduced into Lake Superior during the past 100 years. The two most successful introductions have been the steelhead *O. mykiss* in 1895 (MacCrimmon 1971) and the coho salmon *O. kisutch* in 1966 (Peck 1970).

Steelhead is a common name for rainbow trout in the Great Lakes and the anadromous rainbow trout in the Pacific Ocean and tributaries. Rainbow trout in both ocean and Great Lakes waters take on a silvery or steely appearance after they smolt and reside in the ocean/lake environment. Although steelhead do not contribute substantial numbers to the Lake Superior sport catch, they are the most sought-after fish in tributaries during their annual spring spawning runs and most are harvested at this time (Peck 1992). In two tributaries (Carp and Chocolay rivers), harvested steelhead averaged 22-24 inches and 4-5 pounds (Peck 1992). Steelhead anglers are dedicated to their sport and have formed numerous angler groups that lobby to enhance steelhead populations and fisheries. Many steelhead anglers "catch and release", especially in stream fisheries.

Coho salmon are the "panfish" of the Michigan waters of Lake Superior and the fishery is almost entirely "catch and harvest". Harvest of coho salmon has ranked second behind lake trout in recent years in Michigan, Minnesota, and Wisconsin, and has exceeded lake trout in some years at some sites (Peck 1992; Peck et al. 1994). Most coho are harvested during late winter and early spring of their second year in the lake when they are still immature and average about 15-16 inches long and 1.0-1.5 pounds (Peck 1992).

All jurisdictional agencies on Lake Superior (Michigan, Minnesota, Ontario, and Wisconsin) have stocked steelhead at one time or another (Peck et al. 1994), and most agencies have stocked them annually in recent years. Coho salmon have been stocked by Michigan, Minnesota, and Ontario, but only during 1969-72 by Minnesota and Ontario. Although steelhead and coho salmon have been stocked more or less annually in Michigan waters of Lake Superior, assessments during the mid 1980s and early 1990s indicated that most fish in the lake and most spawning fish even in stocked tributaries were naturally produced (Wagner and Stauffer 1978; Peck 1992; Seelbach and Miller 1993). Consequently, Michigan phased out coho stocking in Lake Superior during 1993-96, and has maintained steelhead stocking at about 100,000 yearlings annually distributed among 5-6 tributaries.

Steelhead likely established natural populations in Lake Superior shortly after their initial introductions. Adults or juveniles were reported in over 70% of Michigan tributaries by the early 1960s (Moore and Braem 1965). Coho salmon established natural populations throughout the lake immediately after introduction in 1966. Adult coho salmon, stocked as yearlings in one tributary in 1966, were reported in at least 48 Michigan tributaries in 1967 (Peck 1970), and adults or juveniles had been found in at least 60 Michigan tributaries by 1974 (Hannuksela and Stauffer 1975).

The Michigan Department of Natural Resources (MDNR) had conducted some studies on steelhead in its Great Lakes waters in the 1950s and 1960s, but had not looked at naturalized populations in Lake Superior (Stauffer 1972). In 1967, a study of juvenile steelhead production was initiated on five Lake Superior tributaries. This study documented year-to-year fluctuations in age-0 and age-1 and older juveniles, month-to-month survival, age composition, and growth of juvenile steelhead and coho salmon during 1967-74 (Stauffer 1975; Stauffer 1977). It was hoped sustained natural reproduction could be demonstrated on at least one stream, and that stream would be suitable for an expanded study to include the relationship between adult spawning runs and juvenile production. The study was not expanded to evaluate adults due to lack of funds, but was expanded to include production of juvenile coho salmon that were present in most tributaries after 1967. Also Seelbach and Miller (1993) examined population dynamics of steelhead in the Huron River during 1987-92 and concluded that limitations in stream habitat, primarily modified by flow, resulted in a bottleneck for smolt production.

Complaints by anglers of decreasing abundance of adult steelhead in Lake Superior tributaries during the late 1970s and early 1980s prompted concern and renewed interest by fisheries biologists in evaluation of rainbow trout natural reproduction. A study was initiated by the Marquette Fisheries Research Station (MFRS) of the MDNR in 1982 to continue the assessment of juvenile steelhead and coho salmon production on two of the tributaries studied in 1967-74, Chinks Creek and Little Garlic River. Objectives of this study were to track fluctuations in abundance of age-0 and age-1 and older steelhead and coho salmon and determine if these fluctuations could be related to factors such as cohort abundance, estimates of adult abundance (redd counts and creel estimates), or climatological factors such as precipitation and air temperature. Two sites on the Chocolay River were added in 1984 and 1986, primarily to determine if steelhead stocked in this tributary would contribute to rehabilitation of spawning runs following removal of a sea lamprey barrier weir, but secondarily to assess year-to-year population fluctuations. Peck (1994) documented the contribution of hatchery fish to rehabilitation of steelhead spawning runs in the Chocolay River.

Methods

Chinks Creek is a small stream that originates in Marquette County, flows through wooded (hardwood and hemlock) terrain for about 7 km, and into the East Branch of the Huron River in Baraga County. Discharge is about half surface water and half ground water with a drainage area of 20 km^2 (MFRS, unpublished data). The salmonine population in Chinks Creek during 1967-74 was mainly juveniles of steelhead and coho salmon, but also included a small resident population of brook trout (Stauffer 1977). Pink salmon *Oncorhynchus gorbuscha* have spawned in the Huron River (Wagner and Stauffer 1981) and have been reported also in Chinks Creek (MFRS, unpublished data). Other fishes present included mottled sculpin *Cottus bairdii*, longnose dace *Rhinichthys cataractae*, and blacknose dace *Rhinichthys atratulus* (MFRS, unpublished data). Yearling steelhead were stocked in the Huron River prior to and during most years of this study. Yearling coho were stocked in the Huron River in 1966-67, 1974, and 1980.

Little Garlic River is a small Lake Superior tributary located in Marquette County, has 10 km of mainstream and 23 km of tributaries, a drainage area of about 31 km^2, discharge that is mostly surface water and generally ranged from 0.1 to 0.4 m^3/sec (higher during spring runoff), total alkalinity of 18 to 78 ppm, total hardness of 26 to 82 ppm, and water temperature of 0° to 22° C (Zimmerman 1968). The salmonine population during 1967-74 was dominated by juvenile steelhead and coho salmon (Stauffer 1977) with brook trout population described as virtually absent (Stauffer 1977). Pink salmon have sometimes spawned in the Little Garlic River (Wagner and Stauffer 1981). Other fishes observed include mottled sculpin, longnose dace, blacknose dace, and juvenile burbot *Lota lota* (MFRS, unpublished data). No rainbow trout or coho salmon have been stocked in the Little Garlic River.

Chocolay River is a larger Lake Superior tributary that flows through mostly wooded terrain and enters the lake near Marquette, Michigan. The main stream is 26 km long, has 208 km of tributaries, and drains about 412 km^2 (Brown 1944). Discharge is generally 0.8 to 2.0 m^3/sec, total alkalinity 22 to 74 ppm, total hardness 34 to 80 ppm, and water temperature 0° to 18° C (Zimmerman 1968). This stream contains more fish species, both salmonine and non-salmonine, than the two smaller tributaries. Salmonines included steelhead, brook trout, brown trout, coho salmon, chinook salmon *Oncorhynchus tshawytscha*, pink salmon, lake trout *Salvelinus namaycush*, and splake *S. namaycush* x *S. fontinalis* (Peck 1992; Peck 1994: MFRS, unpublished data). Non-salmonines included sculpins *Cottus spp.*, suckers *Catastomus spp.*, northern pike *Esox lucius*, and numerous cyprinid species (Peck 1992; MFRS, unpublished data). Steelhead were stocked in the Chocolay River most years of this study and contributed to spawning runs during the 1980s (Peck 1992; Peck 1994). Coho salmon were stocked in the Chocolay River in 1990-93 and 1996. These hatchery fish returned as adults and contributed up to 35% to the sport catch in the lower river near the mouth, and a few were identified in spawning runs in the upper river during 1991-94 (MFRS, unpublished data).

MFRS personnel made trout and salmon population estimates in 305-m linear sections of Chinks Creek, Little Garlic River, Chocolay River, and East Branch of Chocolay River during August-September 1982-97 (Figure 1). The section on Chinks Creek (T.51N, R.30W, Section 1, Baraga County) extended upstream from the confluence with the East Branch of Huron River during 1982-93 but was relocated to start about 100 m above the head of the former section in 1994 due to a conflict with the landowner. The section on Little Garlic River (T.49N, R.26W, Section 3, Marquette County) started 121 m downstream from the County Road 550 bridge. The Chocolay River section at Beckman Road (T.46N, R.24W, Section 14, Marquette County) started and extended upstream from the Beckman Road bridge, and the East Branch of the Chocolay River section (T.46N, R.24W, Section 25, Marquette County) started and extended upstream from the M-94 bridge (This roadway was County Road 460 until 1999, when it became an extension of M-94.). Numbers of age-0 and age-1 and older trout and salmon in each section were estimated using the Bailey modification of the Petersen mark and recapture method (Ricker 1975), with marking on one day and recapture the following day. Fish density (number/m^2) was determined by dividing the estimated number of fish by the estimate of stream surface area in each section each year. Fish were captured using DC electrofishing gear, and marked by clipping the tip of the upper lobe of the caudal fin. Population estimates in each stream section were determined to be significantly different between years if values for ±2 SE did not overlap. Fish were measured to nearest mm so population estimates could be made for age-0 and age-1 and older juveniles. Stauffer (1977) found that the length frequencies of age-0 and age-1 juveniles were discrete in five Lake Superior tributaries including Chinks Creek and Little Garlic River, and that juvenile steelhead populations included few fish older than age 1. In this study, scale samples, total length, and weight were collected from a sample of fish (five fish per 5-mm size group) in each of the three tributaries in 1994 to verify the discreteness of age-0 in length frequency distributions, the frequency of age-2 and age-3 fish in samples of age-1 and older juvenile steelhead, and to estimate weight-length coefficients for juvenile steelhead and coho salmon.

Stream parameters measured in each study section during the population estimate were width (m), depth (m), area (m^2), volume (m^3), discharge (m^3/sec), water temperature (°C), and conductivity (µmhos). Stream width and depth were measured at the downstream end of each section and at 30.5-m intervals to the end of the section to calculate section surface area (mean width x 305 m) and volume (area x mean depth). Means with confidence intervals (±95 %) were determined for the 11 measurements of width and 33 measurements of depth in each section, with non-overlapping confidence intervals indicating a significant difference ($P \leq 0.05$). The float method and Embody's formula (Welch 1948) were used to estimate velocity and determine discharge at one site within each 305-m section.

MFRS personnel conducted visual surveys in Chinks Creek, Little Garlic River, and Chocolay River to assess abundance of spawning adult steelhead during April-June, and coho salmon during October-November. Some adult steelhead and coho salmon in the Chocolay River were collected with electro-fishing gear to determine origin during 1986-92. Redds and adult fish were counted on one to five days during the spawning period annually during 1987-97 for steelhead and 1990-96 for coho salmon. Stream sections surveyed for spawning activity were: Chinks Creek - from confluence with East Branch of Huron River upstream 1,300 m; Little Garlic River - from 1,125 m below County Road 550 bridge upstream for 2,500 m (1,375 m above bridge) for steelhead and coho plus in some years an additional 5,650 m up to falls were surveyed for adult steelhead (8,150 m); Chocolay River - 1,700 m upstream from Beckman Road bridge; East Branch of Chocolay River - 1,400 m upstream from the M-94 bridge. The juvenile population estimate sections were included in the middle or lower end of these spawning assessment sections. These redd and adult fish counts were used as an index of parental stock size to determine if there was a relationship between parental stock size and subsequent age-0 steelhead and coho salmon abundance.

Additional adult abundance data for steelhead and coho salmon were based on the number caught per angler hour in a creel survey of the Lake Superior sport fishery at Keweenaw Bay, Marquette, AuTrain, and Munising (Peck 1992; G. Rakoczy, MDNR, Charlevoix Fisheries Station, unpublished data). These sites collectively encompassed the area of Lake

Superior receiving the three tributaries. Marquette has been surveyed since 1984 and the remaining sites since 1987. Estimated sport catch was based on stratified on-site angler interviews and instantaneous counts of angler effort (Ryckman 1981; Lockwood et al. 1999). The salmon coho catch each year was essentially all from one cohort (age 2) so these data were used to determine if there was a relationship between age-0 coho salmon abundance in the tributaries and coho salmon harvest in Lake Superior 2 years later.

Juvenile steelhead and coho salmon abundance in the study sections was evaluated for trends during 1982-97 and effect of endogenous and exogenous factors using linear regression analysis. Endogenous factors included parental stock size indexed by adult fish and redd counts during spawning runs and catch rate in the Lake Superior sport fishery (number per angler hour), cohort abundance the previous year and abundance of competing species (e.g. abundance of age-0 steelhead vs. abundance of age-0 coho salmon or other salmonines). Precipitation prior to or during steelhead and coho salmon spawning runs (January-April, September-October), precipitation during and after the age-0 steelhead and coho salmon hatch (May-July), and winter air temperatures (October-April) were the exogenous factors examined. Precipitation and winter air temperatures were expected to be important factors in small tributaries with substantial surface water contribution such as Chinks Creek and Little Garlic River.

Monthly precipitation and air temperature data were obtained from the NOAA National Climatic Data Center in Asheville, North Carolina for the National Weather Service station at Marquette, Michigan for 1966-98. This station was 30 miles from the Chinks Creek section, 9.5 miles from the Little Garlic River section, and 17.5 miles and 18.5 miles from the Beckman Road and M-94 sections of the Chocolay River, respectively. Mean annual January-April precipitation was related to age-0 steelhead abundance to determine if the level of spring run-off influenced the size of the spawning run as measured by number of age-0 fish produced. Mean annual September-October precipitation was related to age-0 coho salmon abundance to determine if precipitation influenced stream discharge sufficient to affect the abundance of age-0 fish, presumably by raising water levels which would allow better access to the stream and increase the amount of available spawning area during this normally low-water period. The number of winter days that the maximum air temperature was at or below 0° C was selected from the available data as an index of winter severity and related to age-1 steelhead abundance the following August during 1982-94 in an attempt to determine if air temperature had an effect on over-winter carry-over from age-0 to age-1 in Chinks Creek and Little Garlic River (These data were not provided for 1995-97.). Seelbach (1987) had demonstrated a negative relationship between cold air temperatures and over-winter survival of age-2 smolts in a Lake Michigan tributary (Little Manistee River).

Significance of relationships between independent and dependent variables were based on F values with $P \leq 0.05$. Analyses of trends in abundance were done for all years when population estimates were made except in the Chocolay River at Beckman Road where analyses of age-0 steelhead trend was based on 1985-97 data and age-1+ steelhead tend was based on 1986-97 data. In this section, steelhead reproduction increased substantially in 1985 due to spawning by hatchery fish that were stocked as yearlings in 1983 (Peck 1994).

Results

Study Section Parameters

Chinks Creek was the smallest of the four study sections and Chocolay River at Beckman Road the largest in terms of width, depth, area, and discharge (Table 1). Conductivity in the Chocolay River sections was higher than either Chinks Creek or Little Garlic River. Water temperatures tended to be warmest in the Little Garlic River.

Salmonine Population Dynamics

Juvenile salmonine populations in Chinks Creek during 1982-97 were composed of a nearly equal abundance of steelhead and coho salmon with a small population of brook trout. Juvenile population dynamics during the period, as measured by density (number per m^2 of stream substrate), were characterized by a decrease in age-0 steelhead density, an increase in age-1 coho salmon and age-1 and older brook trout densities, and age-1 steelhead, age-0 coho salmon, and age-0 brook trout densities that fluctuated without trend (Table 2, Figure 2). Variation in densities during 1982-97 were least for age-0 steelhead (CV = 36.4) and greatest for age-1 and older brook trout (CV = 99.7). Age-0 steelhead density was highest in 1982 and lowest in 1997 with a mean of 0.840. A significant regression (F = 9.422; r^2 = 0.402; df = 1, 14; P = 0.008) with a slope of –0.041 described the decrease in density during 1982-97. Age-1 steelhead density was highest in 1994 and lowest in 1988 with a mean of 0.0556 and there was no significant change in density with year (F = 3.118; r^2 = 0.182; df = 1, 14; P = 0.099). Age-0 coho salmon density was highest in 1984 and lowest in 1985 with a mean of 1.041 and there was no significant change in density with year (F = 0.184; r^2 = 0.013; df = 1, 14; P = 0.675). Age-1 coho density was highest in 1993 and lowest in 1986 with a mean of 0.017. A significant regression (F = 6.667; r^2 = 0.323; df = 1, 14; P = 0.022) with a slope of 0.002 described the increase in age-1 coho salmon density during 1982-97. Age-0 brook trout abundance was low and variable being highest in 1991 and lowest in 1986 with a mean of 0.005 and no trend in abundance (F = 0.213, r^2 = 0.015; df = 1, 14; P = 0.652). Age-1+ brook trout abundance was highest in 1997 and lowest in 1986 with a mean density of 0.013. Abundance of age-1+ brook trout increased during 1982-97 (F = 9.039; r^2 = 0.392; df = 1, 14; P = 0.009) with a slope of 0.002.

Juvenile steelhead dominated the salmonine population in Little Garlic River. Coho salmon abundance was low and highly variable. Juvenile steelhead and coho salmon populations, except age-1+ steelhead, fluctuated without trend in Little Garlic River during 1982-97 (Table 3, Figure 3). Variation in densities during 1982-97 were least for age-0 steelhead (CV = 45.2) and greatest for age-0 coho salmon (CV = 86.1). Age-0 steelhead abundance was highest in 1990 and lowest in 1987 with a mean density of 1.066, and there was no significant trend in density (F = 0.467; r^2 = 0.032; df = 1, 14; P = 0.506). Age-1+ steelhead abundance was highest in 1985 and lowest in 1988 with a mean density of 0.106, and there was a significant decrease in density described by a regression (F = 4.761; r^2 = 0.254; df = 1, 14; P = 0.047) with a slope of –0.006. Age-0 coho salmon abundance was highest in 1989 and lowest in 1995 with a mean of 0.214, and there was no significant trend in density (F = 0.012; r^2 = 0.001; df = 1, 14; P = 0.913). Age-1 coho salmon were present in 9 of the 16 years but densities were low, ranging from 0.001 to 0.009.

The salmonine population in the Chocolay River at Beckman Road in 1984 was dominated by brook trout, brown trout with lesser numbers of juvenile coho salmon, steelhead, and a few juvenile chinook salmon (Table 4). Age-0 steelhead abundance increased substantially in 1985 and juvenile steelhead were the dominant salmonine during 1985-97. Juvenile steelhead and coho salmon population dynamics in this section were characterized by decreased abundance of age-0 steelhead during 1985-97, age-1 steelhead abundance that fluctuated without trend during 1986-97, and age-0 coho salmon populations that fluctuated without trend during 1984-97 (Table 4, Figure 4). Variation in densities during 1986-97 were least for age-1 steelhead (CV = 34.0) and greatest for age-1 and older brown trout (CV = 70.8). Age-0 steelhead density was highest in 1985 and lowest in 1984 with a mean density of 0.399. A regression with a slope of –0.032 described a significant decrease in density during 1985-97 (F = 11.344; r^2 = 0.508; df = 1, 11; P = 0.006). Age-1 steelhead abundance was highest in 1994 and lowest in 1984 with a mean density of 0.072 during 1986-97 and no significant trend in density (F = 3.638; r^2 = 0.267; df = 1, 10; P = 0.086). Age-0 coho salmon abundance was highest in 1992 and lowest in 1988 with a mean density of 0.034, and no trend in density during 1984-97 (F = 0.539; r^2 = 0.043; df = 1, 12; P = 0.477). No age-1 coho salmon were found in this section. A few age-0 chinook salmon were found in 1984, 1986, and 1991 but numbers sufficient for an estimate were present only in 1986 (55±49). Resident populations of brook trout and brown trout were present in this section, with ages ranging from 0 to 4. Age-0 brook trout abundance was highest in 1985 and lowest in 1989 with a mean density of 0.047 and no trend in density (F = 0.035; r^2 = 0.003; df = 1, 12; P = 0.854). Age 1+ brook trout abundance was highest in 1985 and lowest in 1990 with a mean density of 0.017. A regression with a slope of –0.001 described a significant decrease in density of age-1+ brook trout during 1984-97 (F = 5.101; r^2 = 0.298; df = 1, 12; P = 0.043). Age-0 brown trout abundance was highest 1988 and lowest in 1996 with a mean density of 0.036 and no significant trend in density (F = 2.162; r^2 = 0.153; df = 1, 12; P = 0.167). Age-1+ brown trout abundance was highest in 1985 and lowest in 1993 with a mean density of 0.006 and a significant decrease in density during 1984-97 described by a regression with a slope of –0.001 (F = 25.765; r^2 = 0.682; df = 1, 12; P = 0.000).

Steelhead dominated the salmonine population in the east branch of the Chocolay River at M-94 during 1986-97, followed in abundance by age-0 coho salmon, brook trout, and brown trout. All but age-0 brown trout fluctuated without trend during 1986-97 (Table 5, Figure 5). Variation in densities during this period were least for age-0 steelhead (CV = 35.4) and greatest for age-1 and older brown trout (CV = 157.1). Age-0 steelhead abundance was highest in 1993 and lowest in 1996 with a mean density of 0.535 and no trend (F = 0.077; r^2 = 0.008; df = 1, 10; P = 0.787). Age-1 steelhead abundance was highest in 1994 and lowest in 1990 with a mean density of 0.053 and no trend (F = 0.209; r^2 = 0.021; df = 1, 10; P = 0.657). Age-0 coho salmon abundance was highest in 1997 and lowest in 1988 with a mean of 0.097 and no trend (F = 1.731; r^2 = 0.148; df = 1, 10; P = 0.218). Brook trout and brown trout abundance was sparse in this section with none of some ages observed in some years. No estimates for brook trout and brown trout were presented for 1987 because a tabulation error precluded separation of the species. Age-0 brook trout abundance was highest in 1991 and lowest in 1992 and 1994 with a mean density of 0.002 and no trend (F = 0.000; r^2 = 0.000; df = 1, 9; P = 0.987). Age-1+ brook trout abundance was highest in 1986 and none were found in 1989, 1993, and 1995 with a mean density of 0.002 and no trend (F = 1.302; r^2 = 0.126; df = 1, 9; P = 0.283). Age-0 brown trout abundance was highest in 1986 and lowest in 1990-91 and 1994-97 when none were found, with a mean density of 0.002. A significant regression with a slope of –0.001 described the decrease in density observed during 1986-97 (F = 14.652; r^2 = 0.619; df = 1, 9; P = 0.004). Age-1+ brown trout were not found in 1986, 1989, 1993, and 1995-97 and the highest density was 0.001.

Relationships between Abundance, and Endogenous and Exogenous Factors

Count of adult fish and redds for steelhead and coho salmon were either without trend or were increasing (Tables 6 and 7). Steelhead adult and redd counts in the Little Garlic River in 1992-93 were highest but were based on a smaller stream segment (Table 6). Counts in the longer Little Garlic River segment during 1994-97 were lower but increasing. Adult fish counts in the Chocolay River at Beckman Road decreased after 1992 likely because electro-fishing gear was used in the survey prior to 1993 and visual-only counts were not separated from the total. This section contains deep pools and runs where fish likely would go unseen in a visual-only survey. Catch rate (number per angler hour) in the Lake Superior sport fishery was without trend for steelhead but decreased for coho salmon during 1984-99 (Table 8). Total precipitation recorded at the NOAA Weather Service Office at Marquette, Michigan averaged 36.1 inches during 1982-97 and fluctuated without trend during 1966-98 (Figure 6). What appeared to be a downward trend during 1985-97 was not (F = 0.869; r^2 = 0.073; df = 1, 11; P = 0.371). January-April and September-October precipitation also fluctuated without trend during 1966-98, averaging 10.6 and 7.6 inches, respectively. The number of days that the maximum air temperature was 0° C or less during 1982-94 ranged from 79 in 1987 to 105 in 1982 and 1983 with a mean of 96, and no trend ($F = 0.068$; $r^2 = 0.006$; df = 1, 11; $P = 0.799$).

Densities of age-0 steelhead and age-0 coho salmon in Chinks Creek were not related to parental stock size as indexed by steelhead redd counts ($F = 0.806$; $r^2 = 0.302$; df = 1, 5; $P = 0.201$), coho salmon redd counts ($F = 0.179$; $r^2 = 0.035$; df = 1, 5; $P = 0.690$), adult steelhead counts ($F = 5.111$; $r^2 = 0.561$; df = 1, 4; $P = 0.087$), and adult coho salmon counts ($F = 1.031$; $r^2 = 0.171$; df = 1, 5; $P = 0.356$). Cohort abundance at age 1 was not related to abundance at age 0 for either steelhead ($F = 2.423$; $r^2 = 0.157$; df = 1, 13; $P = 0.144$) or coho salmon ($F = 3.346$; $r^2 = 0.205$; df = 1, 13; $P = 0.090$). Density of age-0 steelhead was not related to that of age-0 coho salmon ($F = 2.021$; $r^2 = 0.126$; df = 1, 14; $P = 0.177$). Catch of age-2 coho salmon per angler hour at sites in Lake Superior encompassing Chinks Creek (Keweenaw Bay to Munising) was not related to age-0 coho density in Chinks Creek 2 years earlier ($F = 2.922$; $r^2 = 0.196$; df = 1, 12; $P = 0.113$), nor was age-0 coho density related to adult catch in these water the year previous ($F = 4.702$; $r^2 = 0.343$; df = 1, 9; $P = 0.058$). Age-0 steelhead density was not influenced by precipitation amount during the previous January-April ($F = 0.004$; $r^2 = 0.000$; df = 1, 14; $P = 0.950$), nor was age-0 coho salmon density related to precipitation during the previous September-October ($F = 3.701$; $r^2 = 0.209$; df = 1, 14; $P = 0.075$). A significant relationship with a slope of – 0.164 was obtained between age-0 coho salmon density and May precipitation ($F = 5.097$; $r^2 = 0.267$, df = 1, 14; $P = 0.040$), but not for June or July precipitation. There were no significant relationships between age-0 and age-1 steelhead densities and May, June, or July precipitation. Density of age-1 steelhead was not related to number of days that maximum air temperature was at or below 0° C the previous winter ($F = 1.299$; $r^2 = 0.106$; df = 1, 11; $P = 0.279$).

Densities of age-0 steelhead and age-0 coho salmon in Little Garlic River could not be related to parental stock size as indexed by steelhead redd counts ($F = 1.742$; $r^2 = 0.303$; df = 1, 4; $P = 0.257$), steelhead adult counts ($F = 0.001$; $r^2 = 0.000$; df = 1, 4; $P = 0.981$), coho salmon redd counts ($F = 3.229$; $r^2 = 0.392$; df = 1, 5; $P = 0.132$), and coho salmon adult counts ($F = 1.496$; $r^2 = 0.230$; df = 1, 5; $P = 0.276$). Steelhead density at age 1 was not related to density of the cohort at age 0 ($F = 3.118$; $r^2 = 0.182$; df = 1, 14; $P = 0.099$). Age-0 coho salmon density was not related to density of age-0 steelhead ($F = 0.001$; $r^2 = 0.000$; df = 1, 14; $P = 0.982$). Density of age-0 coho salmon was also not related to sport catch of age-2 fish the year previous ($F = 0.132$; $r^2 = 0.014$; df = 1, 9; $P = 0.725$). The sport catch of age-2 coho salmon was not related to density of that cohort as age-0 in Little Garlic River in either central Lake Superior (Keweenaw Bay to Munising) ($F = 0.378$; $r^2 = 0.031$; df = 1, 12; $P = 0.550$) or at Marquette which was the site closest to the river ($F = 1.327$; $r^2 = 0.100$; df = 1, 12; $P = 0.272$). Abundance of age-0 steelhead was not related to precipitation the previous January-April ($F = 0.203$; $r^2 = 0.014$; df = 1, 14; $P = 0.660$), nor was age-0 coho salmon related to precipitation the previous September-October ($F = 0.731$; $r^2 = 0.050$; df = 1, 14; $P = 0.407$). Age-0 coho salmon densities were positively related (slope = 0.073) to June precipitation ($F = 4.503$; $r^2 = 0.243$; df = 1, 14; $P = 0.052$), negatively related (slope = -0.068) to July precipitation ($F = 6.800$; $r^2 = 0.327$; df = 1, 14; $P = 0.021$), but not related to May precipitation. Age-0 and age-1 steelhead densities were not related to May, June, or July precipitation. There was no relationship between density of age-1 steelhead and number of days that maximum air temperature was 0° C or less ($F = 1.673$; $r^2 = 0.132$; df = 1, 11; $P = 0.222$).

Age-0 steelhead density in the Chocolay River at Beckman Road was not related to either steelhead redd counts ($F = 0.118$; $r^2 = 0.013$; df = 1, 9; $P = 0.740$), adult counts ($F = 4.383$; $r^2 = 0.328$; df = 1, 9; $P = 0.066$), or January-April precipitation ($F = 0.073$; $r^2 = 0.006$; df = 1, 12; $P = 0.792$). Age-0 coho salmon density was not related to September-October precipitation ($F = 0.642$; $r^2 = 0.051$; df =1, 12; $P = 0.439$) but was related to coho salmon redd counts ($F = 11.884$; $r^2 = 0.704$; df = 1, 5; $P = 0.018$) and adult counts ($F = 7.943$; $r^2 = 0.614$; df = 1, 5; $P = 0.037$). The density of age-1 steelhead was significantly related to the density of the cohort at age 0 ($F = 15.747$; $r^2 = 0.589$; df = 1, 11; $P =0.002$), but similar relationships were not significant for brook trout ($F = 2.776$; $r^2 = 0.201$; df = 1, 11; $P = 0.124$) or brown trout ($F = 1.053$; $r^2 = 0.087$; df = 1, 11; $P = 0.327$).

Age-0 steelhead density in the East Branch of the Chocolay River at M-94 was not related to either number of steelhead redds ($F = 0.027$; $r^2 = 0.003$; df = 1, 8; $P = 0.873$), steelhead adult counts ($F = 0.369$; $r^2 = 0.039$; df = 1, 9; $P = 0.558$) or January-April precipitation ($F = 1.299$; $r^2 = 0.115$; df = 1, 10; $P = 0.281$). Age-0 coho salmon was not related to either number of coho redds ($F = 2.098$; $r^2 = 0.296$; df = 1, 5; $P = 0.207$), coho salmon adults ($F = 3.930$; $r^2 = 0.440$; df = 1, 5; $P = 0.104$), or September-October precipitation ($F = 0.483$; $r^2 = 0.046$; df = 1, 10; $P = 0.503$). There was no relationship between density of age-1+ steelhead and density of the cohort at age 0 ($F = 3.898$; $r^2 = 0.302$; df = 1, 9; $P = 0.080$).

Juvenile Coho Salmon and Steelhead Age and Size Structure

Age-0 fish dominated juvenile steelhead and coho salmon numbers in the three tributaries. Age-1 and older steelhead in Chinks Creek, Little Garlic River, and the two Chocolay River sections made up 6%, 9%, 15%, and 9% of the total populations, respectively (Tables 3-5). No age-2 steelhead were found in the sample of fish from Chinks Creek in 1994, and they made up only 2% in Little Garlic River and 8% in the Chocolay River (Table 9). Age-0 and age-1 steelhead and age-0 coho salmon were larger in the Chocolay River than in Chinks Creek and Little Garlic River (Table 9, Figures 7 and 8). Age-2 steelhead and age-1 coho salmon were either not found, or too few, for weight or length comparisons. Weight-length coefficients for age-0 steelhead were not different among streams in 1994, but coefficients for age-1 steelhead and age-0 coho salmon in the Chocolay River were greater than in Chinks Creek and in Chinks Creek and Little Garlic River, respectively (Table 9). Mean total length of age-0 steelhead and age-0 coho salmon fluctuated without trend over the total sampling periods in the four streams sections, but has decreased for age-0 steelhead in Chinks Creek and Little Garlic River since 1991 and in the Chocolay River at Beckman Road since 1992 (Figures 7 and 8).

Discussion

Juvenile steelhead and coho salmon were the most abundant salmonines in the study sections of the three Lake Superior tributaries during 1982-97. This predominance appears to be typical for most Lake Superior tributaries. In the 1960s and prior to introduction of coho salmon, steelhead were found in almost as many U. S. tributaries as the native brook trout, and in many more tributaries than brown trout, lake trout, or pink salmon (Moore and Bream 1965). Steelhead have also been reported in most major Ontario tributaries (MacCallum et al. 1994). Juvenile steelhead were the most abundant salmonine in two Minnesota tributaries sampled in 1960-63, in five Michigan tributaries sampled in 1967, and in an Ontario tributary sampled in 1973 (Hassinger et al. 1974; Stauffer 1977; Kwain 1983). After coho salmon were introduced in 1966, most Michigan tributaries receiving steelhead runs also received coho salmon runs (Peck 1970). With the exception of Minnesota, naturalized populations of coho salmon have been reported throughout Lake Superior (Peck et al. 1994). The addition of coho salmon juveniles to stream salmonine populations in 1968 did not have a detectable effect on steelhead juvenile populations, even in Chinks Creek where coho salmon were more abundant than steelhead during 1968-74 (Stauffer 1977). It is therefore likely that juveniles of these two Pacific-origin salmonines, either singularly or in combination, outnumber other salmonines and perhaps other fishes in many or most Lake Superior tributaries. Part of the reason for this is that most tributaries are small surface-water streams with highly variable flow regimes making them less-than-optimal habitat for maintaining large populations of stream-resident salmonines such as native brook trout and non-native brown trout. The steelhead and coho salmon adults in spawning runs from Lake Superior are sometimes more numerous, and almost always larger and more fecund, than stream-resident brook and brown trout. Many Lake Superior tributaries used to have lake-run brook trout (coasters) but all but a few of these populations have been extirpated (Newman et al. 1998). Some tributaries receive spawning runs of brown trout but these are few in number and mainly in the western end of the lake. In Wisconsin's Sioux and Brule rivers, anadromous brown trout adults generally outnumbered coho salmon adults in spawning runs during the 1980s, but steelhead adults were more abundant in the Brule River than adults of other salmonine species (Harvey 1990; Peck et al. 1994). Chinook salmon and pink salmon also use some Lake Superior tributaries for spawning but most of the juveniles reside there for only a few weeks (Bagdovitz et al. 1986; Peck et al. 1994).

Juvenile steelhead and coho salmon densities in Chinks Creek, Little Garlic River, and Chocolay River were within the range reported for most other tributaries to Lake Superior, tributaries to other Great Lakes, and a West Coast tributary. Among five tributaries studied by Stauffer (1977) in 1967-74, Chinks Creek ranked third in age-0 steelhead density, fifth in age-1 steelhead density, and first in coho salmon density; whereas Little Garlic River ranked second in age-0 and age-1 steelhead density and fourth in coho salmon density. Data contemporary with this study for other Michigan tributaries or elsewhere in Lake Superior during the 1982-97 period were not available in published literature but some unpublished data were available. Estimated densities (number per m^2) of age-0 steelhead, age-1 and older steelhead, and age-0 coho salmon in an eastern Ontario tributary (Carp River) during 1983-84 were 0.17-0.29, 0.003, and 0.001-0.004, respectively (unpublished Ontario Ministry of Natural Resources, Fisheries Research Section report by K. B. Armstrong and W. Kwain). Although the steelhead densities were higher than reported in this study, the coho salmon densities were considerably less. In three western Ontario tributaries in 1984, densities of age-0 steelhead ranged from 0.265 to 1.192 (unpublished Lakehead Region Conservation Authority report by J. Entwistle). This range was generally comparable to densities in the Chocolay River but less than in Chinks Creek and Little Garlic River. Age-0 steelhead and coho salmon densities were greater and age-1 steelhead densities were comparable in the three Lake Superior tributaries to densities in some Lake Michigan tributaries during 1967-72 (Taube 1975), 1977-79 (Carl 1983), and 1981-83 (Seelbach 1993). Steelhead densities in this study were less than late summer-fall densities reported for age-0 (1.20-2.30) and age-1 (0.16-0.21) steelhead in 1970 in Bothwell's Creek, Lake Huron (Alexander and MacCrimmon 1974). I could not locate published data on steelhead densities in West Coast tributaries and contemporary data for coho salmon. Densities of age-0 coho salmon in Chinks Creek during 1982-97 were comparable but densities in the other streams were less than densities reported for three Oregon tributaries during 1959-62 by Chapman (1965).

Decreased abundance of certain steelhead age groups in the three tributaries appeared to be related to specific in-stream situations rather than a lakewide decrease in steelhead abundance. Although age-0 abundance in Chinks Creek decreased during 1982-97, the decrease may be due to moving the study section upstream in 1994 as there was no trend in age 0 abundance during 1982-93 ($F = 3.126$; $r^2 = 0.238$; df = 1, 10; $P = 0.107$). Moving this study section might also explain the increase in age-1 and older brook trout density in Chinks Creek. Densities of age-0 steelhead in Chinks Creek during 1982-97 were generally slightly higher than reported by Stauffer (1977) for 1967-74, but not significantly so. Annual stocking of hatchery steelhead in the Huron River during 1982-97 did not appear to influence age-0 steelhead densities, but this was problematic as stocking was also done in the Huron River during 1968-70. However, hatchery fish were found to contribute 3% or less to spawning populations in the Huron River during both periods (Wagner and Stauffer 1978; Seelbach and Miller 1993). In Little Garlic River, age-0 abundance was without trend during 1982-97, but was less than reported by Stauffer (1977) for 1967-74. This may be due to decreased spawner abundance or a loss of spawning area upstream from the study section during the interval (1975-81) between the two studies. Number of adults in the spawning runs were not estimated during 1967-74. However, observations by MFRS personnel during spawning run surveys in 1990-97 indicated that some upstream areas that had been recorded as spawning areas in substrate surveys during 1967-74 were covered with sand and silt due to beaver activity and stream crossing by vehicles engaged in logging operations (MFRS, unpublished substrate survey data). On the other hand, what happens in a 305-m section of a stream may be indicative of only that section and not the whole stream. The decrease in age-1 steelhead abundance during 1982-97 is believed to be related to habitat changes within the study section during this period. During this 16-year study, a major pool in the lower end of the section filled in, and in the early 1990s road crews removed tree and brush cover along a 60-m segment of the section that paralleled County Road 500 (MFRS, unpublished observations). In Chocolay River, reasons for the decreased age-0 steelhead abundance in the Beckman Road section are more elusive. Steelhead reproduction was artificially enhanced by stocking in 1983-85, which resulted in spawning runs that were mainly hatchery-origin fish (Peck 1994). However, spawning runs after 1991 were all wild fish, spawner abundance indicated by redd counts did not decrease, and juvenile production in the upstream M-94 section in the East Branch also did not decrease. There was some increased sand bedload upstream from the Beckman Road section in the West Branch of the Chocolay River due to road construction and beaver activity (MFRS, unpublished substrate survey data). If the age-0 steelhead from the West Branch contributed to the population at Beckman Road, this sedimentation may be the reason for the decrease in age-0 abundance.

Juvenile coho salmon abundance in Chinks Creek and Little Garlic River during 1982-97 was greater than Stauffer (1977) reported for 1968-74. The average density of 0.76 in 1968-74 in Chinks Creek was exceeded in 10 of the 16 years of this study, and the average of 0.15 in Little Garlic River was exceeded in 9 of 16 years. Coho salmon reproduction was more consistent in Chinks Creek during 1982-97 than during 1968-74 when no age-0 fish were produced in 1970. The Little Garlic River was more inconsistent as no spawning fish were observed in 1994 there was no detectable reproduction in 1995. No reproduction occurred in the Little Garlic River in 1970. Despite these occasional missed year classes, reproduction has occurred in subsequent years and these and numerous other Lake Superior tributaries are considered to have naturalized self-sustaining coho salmon populations.

Steelhead and coho salmon reproduction at least in the two smaller tributaries likely provided adequate smolts to maintain those populations. The carrying capacity of age-1 steelhead appears to be critical for production of age-2 smolts and perpetuation of steelhead spawning runs. Most adult steelhead in spawning runs in Lake Superior and other Great Lakes have been determined to be from juveniles that lived 2 years in the stream and smolted at age 2 (Hassinger et al. 1974; Biette et al. 1981; Kwain 1981; Seelbach and Miller 1993). Most adult steelhead in Little Garlic River spawning runs during 1979-81 had smolted at age 2 (Edinger 1987). Age-1 steelhead abundance in Chinks Creek and Little Garlic River was relatively stable and not related to cohort abundance at age-0, which indicated that steelhead spawning runs in these two tributaries and numerous similarly-small Lake Superior tributaries are likely adequate or more than adequate to provide the carrying capacity of age-1 steelhead. Stauffer (1977) also concluded this when he studied steelhead populations in Chinks Creek, Little Garlic River, and three other tributaries during 1967-74, as did Seelbach and Miller (1993) for steelhead in the Huron River. Most coho salmon smolt at age 1, so age-0 abundance is the critical reproduction index. Although age-1 coho were present annually in Chinks Creek, they were present in very low numbers and were rare to absent in the other tributaries sampled in this study and by Stauffer (1977). Practically all adult coho aged from creel surveys of Lake Superior and tributaries were age-2 fish that had spent 1 year in the stream (Peck 1992). There was no relationship between parental stock indices and age-0 coho salmon abundance in Chinks Creek and Little Garlic River, which suggested that spawning populations were adequate to maintain the juvenile coho salmon carrying capacity in these two small tributaries. On the other hand, reproduction in larger tributaries may be less than adequate. The significant relationship between age-0 coho salmon abundance and parental stock size and between age-0 and age-1 steelhead in the larger Chocolay River indicated that in at least some years coho salmon and steelhead spawning runs were less than adequate, and age-0 steelhead abundance were too low to provide sufficient carry-over to age 1 to achieve carrying capacity.

The lack of relationships between pre-spawn precipitation and age-0 steelhead and coho salmon abundance, and between winter severity and age-1 steelhead abundance in Chinks Creek and Little Garlic River was unexpected for these small streams. However, this result is consistent with the lack of a relationship between adult fish or redd counts and age 0 abundance in these two streams. The relationship was close to being significant between precipitation and age-0 coho density in Chinks Creek, but not close in Little Garlic River. Although not tested, there appeared to be no relationship between precipitation and adult fish and redd counts for either steelhead or coho salmon. Although I could find no relationship between winter severity and density of age-1 steelhead the following August, Seelbach (1987) and Newcomb and Coon (1997) found significant negative correlations ($r^2 = 0.95$-1.00) between number of days with a minimum air temperature of –12 °C or less and overwinter survival of steelhead smolts. It is possible that fluctuations in growth or spring and summer discharge influenced age-1 smolting enough to mask any relationship with winter severity, or that the index I used was inappropriate. The index Seelbach and Newcomb and Coon used was not available in the data I received from the National Climatic Data Center. Although one might expect a positive relationship between May-July precipitation and August abundance of juvenile steelhead and coho salmon, relationships were absent for age-0 and age-1 steelhead and inconsistent and possibly spurious for coho salmon. Precipitation should be more critical for age-0 steelhead than age-0 coho salmon in small surface-water dependent streams as age-0 steelhead occupy mainly riffle habitat in contrast to age-0 coho salmon that occupy mainly pool habitat (Hartman 1965). I can think of no reasons why there were relationships for coho salmon and not steelhead, or why the relationships for coho salmon were inconsistent.

Juvenile steelhead and coho salmon abundance in the tributaries was not useful to predict subsequent sport fishery catch rates in Lake Superior waters encompassing the tributaries. This result was expected for steelhead because relatively few are caught and the catch includes as many as seven cohorts (Peck 1992). Coho salmon, on the other hand, have ranked first or second in the sport catch and annual catches are generally all of one cohort (Peck 1992; Peck et al. 1994). The relationship was better for coho salmon than for steelhead, but neither was significant. It is likely that coho salmon in the central Lake Superior (Keweenaw Bay to Munising) sport catch came from tributaries all around the lake that received different amounts of precipitation. Coho salmon and other stocked Pacific salmon have been found to move extensively within and among the Great Lakes, and those stocked in specific areas of Lake Superior have been found to contribute to sport fisheries throughout the lake (Peck 1992; Peck et al. 1999).

Mean lengths during August for age-0 steelhead in Chinks Creek and Little Garlic River reported in this study were greater than August lengths reported in these tributaries during 1969-72 by Stauffer (1975), but mean lengths for age-0 coho salmon were similar. Abundance of age-0 steelhead in Little Garlic River during 1969-72 was higher than during this study and may have contributed to the smaller size, but abundance in Chinks Creek during 1969-72 was lower (Stauffer 1977). The larger size of juvenile salmonines in the Chocolay River than in the two smaller tributaries was likely due to lower density of age-0 fish and more and better habitat for both age-0 and age-1 fish. The Chocolay River is larger with a less variable discharge and temperature regime, which makes it a more favorable habitat for retention and growth of juvenile salmonines (Seelbach 1993). Lack of spatial habitat in Chinks Creek or Little Garlic River likely resulted in greater competition for available food and space, and may have forced larger age-1 steelhead to lower stream reaches or out into Lake Superior.

The introduction of steelhead in the late 1800s and subsequent establishment of naturalized populations may have been a major factor in the demise of coaster brook trout populations in Lake Superior tributaries, and coho salmon may represent another nail in the coaster coffin. Angling and habitat destruction were certainly factors for some populations, but I suggest that competition from steelhead may be responsible for the lakewide extirpation reported for coaster brook trout (Newman et al. 1998). In this study, age-1 and older brook trout and brown trout abundance in the Beckman Road section of the Chocolay River decreased during 1984-97. It is quite possible that competition from increased steelhead populations after 1984 resulted in decreased brook trout and brown trout survival between age 0 and age 1, and decreased niches for age-1 fish. In streams where naturalized steelhead populations have been established for some time, brook trout and/or brown trout populations have likely stabilized but at levels lower than before steelhead. Age-0 brook trout and brown trout abundance in the Chocolay River was not affected by the increased steelhead abundance. Kocik and Taylor (1996) found that age-0 steelhead had little impact on earlier-emerging and larger age-0 brown trout and that any interaction was usually to the detriment of the steelhead. Although coho salmon were introduced well after the demise of coaster brook trout populations, their naturalized populations may present an obstacle to coaster brook trout restoration. Stauffer (1977) suggested that coho salmon were responsible for decreased brook trout populations in two Lake Superior tributaries and decreased brown trout populations in a third. Taube (1975) found that age-0 brown trout populations in a Lake Michigan tributary (Platte River) decreased in the presence of coho salmon. Fausch and White (1986) reported that coho salmon were most likely to compete with brook trout and brown trout because they had similar life histories and ecologies in Great Lakes tributaries and had a competitive advantage over juvenile brook trout and brown trout because they emerged earlier and were larger. Densities of age-0 steelhead or coho salmon did not influence densities of each other in Chinks Creek and Little Garlic River in this study. This supports the findings of Stauffer (1977) who reported no effect of coho salmon on steelhead biomass or growth in these tributaries during1968-74. On the other hand, Harvey and Nakamoto (1996) found a definite negative relationship between juvenile steelhead abundance and weight change in age-0 coho salmon. Although I did not do a statistical analysis, a visual inspection of age-0 steelhead density and age-0 coho salmon mean length did not detect a negative relationship in the Little Garlic River where steelhead dominated.

Adult steelhead abundance in Lake Superior appears to be adequate for maintaining self-sustaining populations, but may be lower than in former years. Concerns about decreased steelhead spawning runs and inadequate steelhead reproduction have been expressed for Lake Superior tributaries since at least the 1970s (Wagner and Stauffer 1978; Scholl et al. 1984; Seelbach and Miller 1993; DuBois and Pratt 1994; MacCallum et al. 1994; Schreiner 1995). The axiom "fishing isn't what it used to be and never was" might apply here, but on the other hand it is likely that survival of steelhead has decreased in Lake Superior. Peck et al. (1999) reported a decrease in abundance of chinook salmon and other salmonines in Lake Superior since the mid 1980s, which they thought was due to competition and/or predation by rehabilitated lake trout populations. Long-term data sets for steelhead spawning runs in Lake Superior are generally lacking but some data from the Brule River, Wisconsin indicated decreased spawning runs in the 1980s compared to the 1970s (B. Swanson, Wisconsin Department of Natural Resources, Bayfield, Wisconsin, unpublished data). Steelhead angling has been restricted during the 1980s and 1990s by decreased creel limits and increased minimum size in response to these perceived or real declines. Some anglers believe that steelhead abundance is still declining but catch rates in the lake sport fishery reported in this study and spawning runs in the Brule River have not decreased in recent years (Peck et al. 1994), and age-0 steelhead abundance in most Minnesota and Michigan tributaries has either not decreased or not decreased enough to effect smolt production (This study and T. Jones, Minnesota Department of Natural Resources, Duluth, Minnesota, unpublished report). Mortality rates (u) of adult steelhead averaged 0.24 during 1977-81 in Pikes Creek, Wisconsin (Swanson 1985) and ranged from 0.20 to 0.23 during 1980-81 in Little Garlic River (Edinger 1987). Both authors considered these acceptable rates for maintaining steelhead spawning populations.

Although most steelhead and coho salmon populations in Lake Superior appear to be currently self-sustaining, key populations should be monitored to determine if acceptable levels of reproduction are being maintained. Although the mortality rates described above for Pikes Creek and Little Garlic River were considered low enough to allow for self-sustaining populations, the percentage of repeat spawners in both tributaries were lower than in the Huron River where Seelbach and Miller (1993) recommended no increase in exploitation. Populations in many Lake Superior tributaries may be at or near the edge of sustainability and bear watching. Concurrent juvenile population estimates in selected tributaries including at least the three tributaries in this study, along with a creel survey of sport-caught steelhead in the selected tributaries and coho salmon in the encompassing Lake Superior waters is recommended. My inability to positively identify factors related to juvenile population fluctuations in this study may be due to inadequate study area, inappropriate methods, or simply a need for more years of data. Additional analysis of these 1982-97 data is recommended. Stocking hatchery fish appears to be a rather limited management option to enhance populations in most Lake Superior tributaries due to poor returns and reproduction by hatchery fish. Evidence in this study points to loss of habitat as the probable cause where juvenile populations have decreased. Agencies should look to habitat protection and enhancement as the best means for maintenance or restoration of steelhead, coho salmon, or other stream salmonine populations.

Acknowledgments

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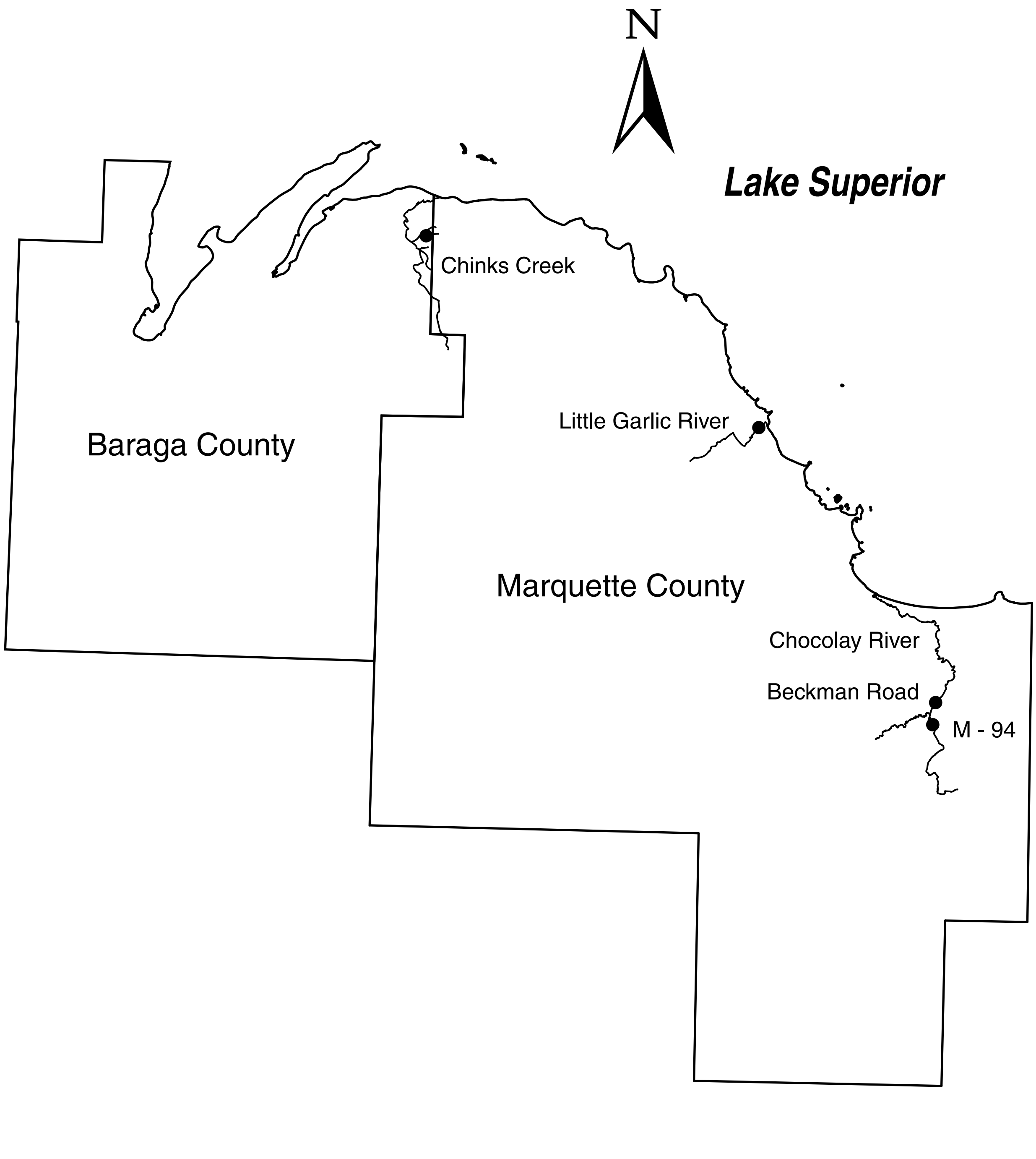

Figure 1.–Location of 305-m study sections on three Lake Superior tributaries (Chinks Creek, Little Garlic River, and Chocolay River.

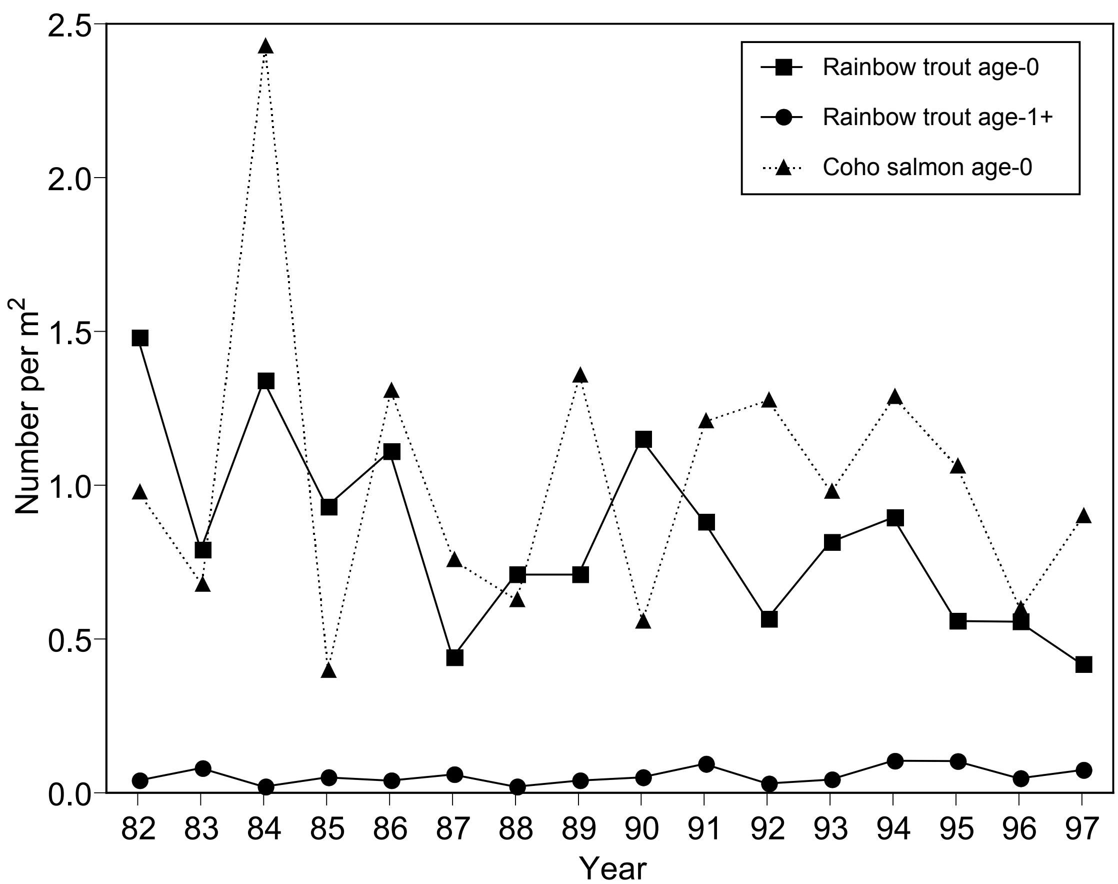

Figure 2.–Density of juvenile rainbow trout and coho salmon in Chinks Creek during August and September 1982-97.

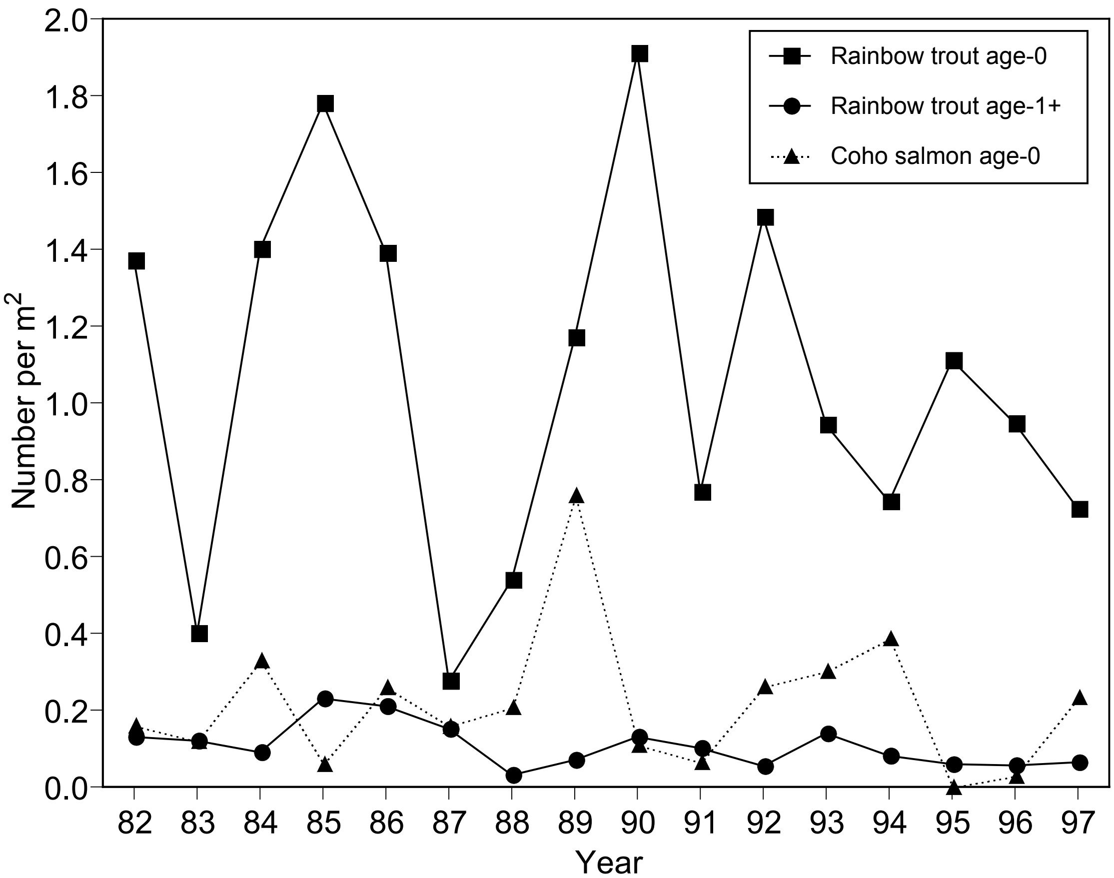

Figure 3.–Density of juvenile rainbow trout and coho salmon in Little Garlic River during August and September 1982-97.

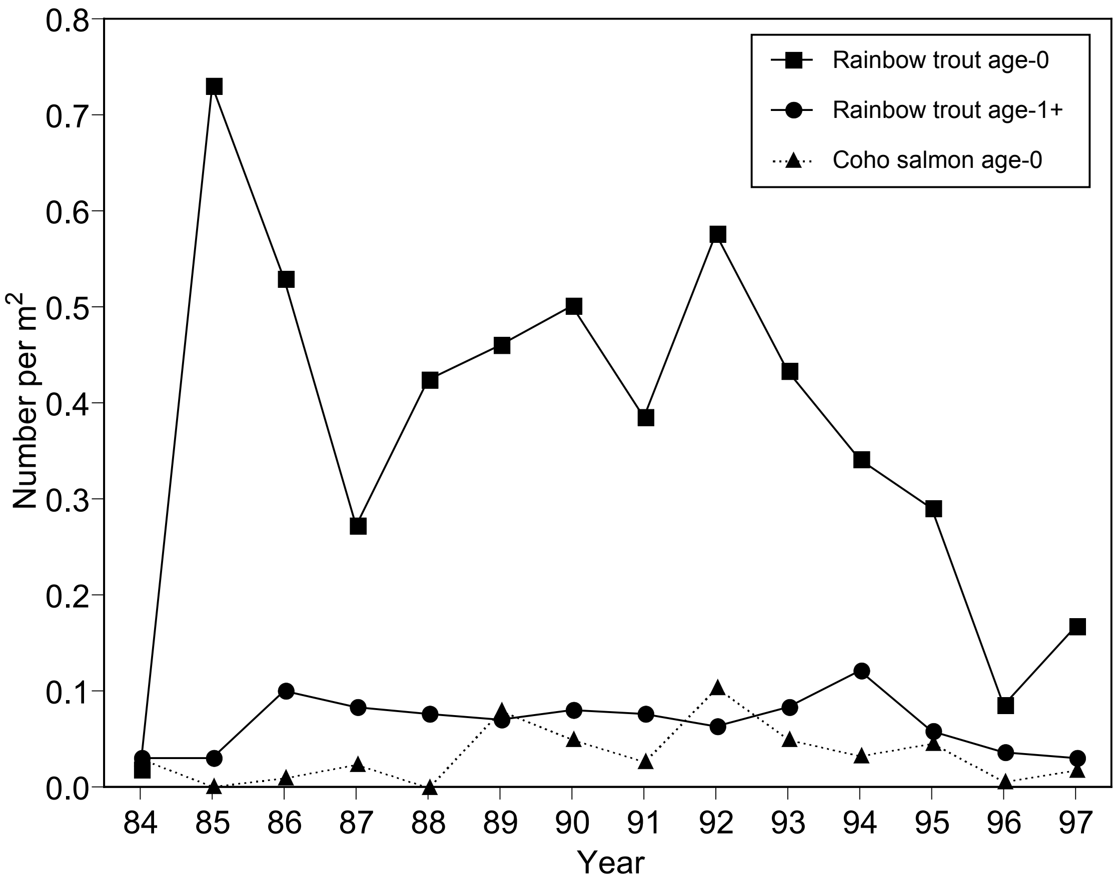

Figure 4.–Density of juvenile rainbow trout and coho salmon in Chocolay River at Beckman Road during August and September 1984-97.

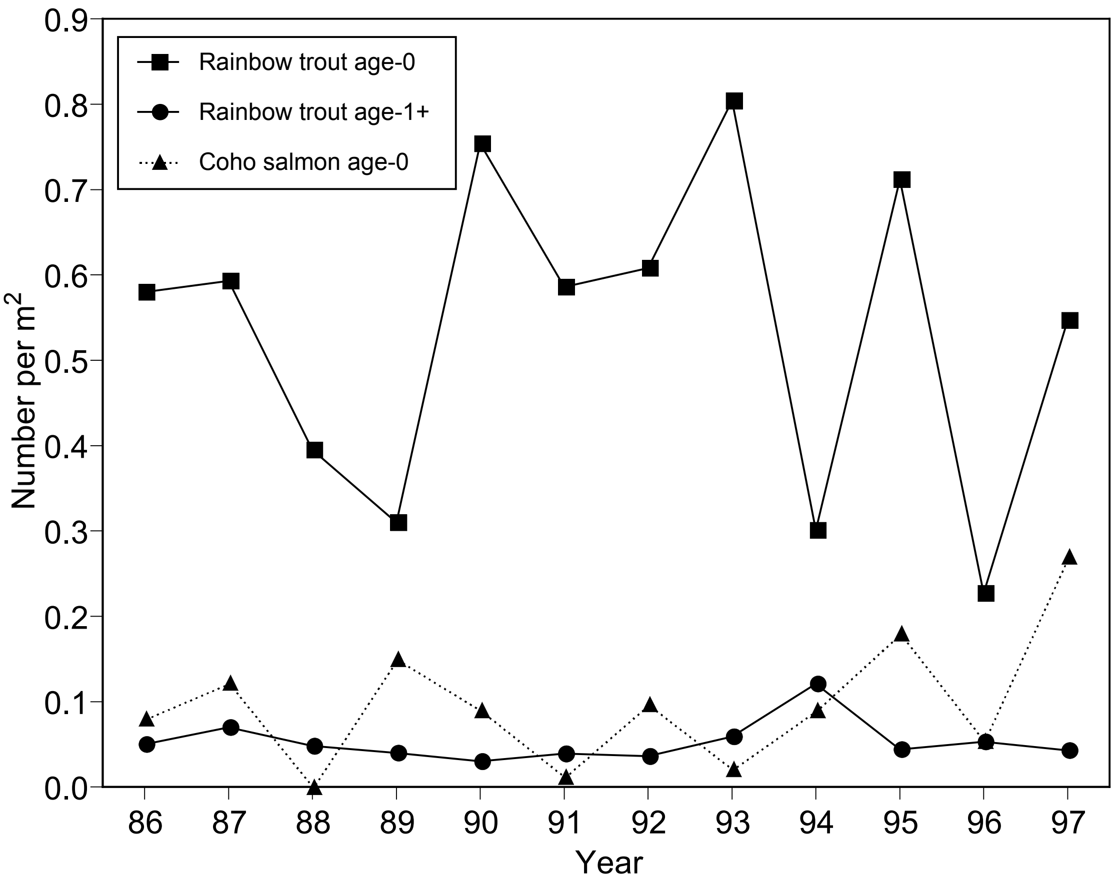

Figure 5.–Density of juvenile rainbow trout and coho salmon in east branch of the Chocolay River at M-94 during August and September 1986-97.

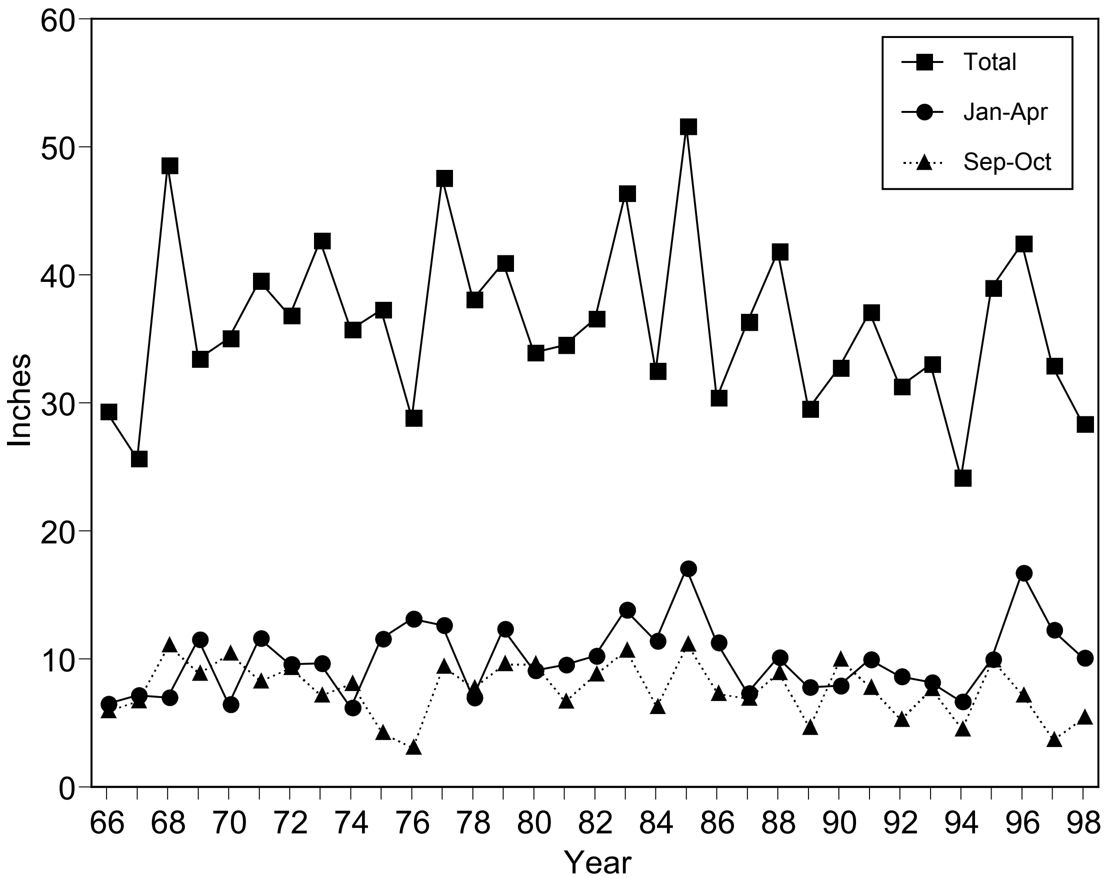

Figure 6.–Precipitation recorded at the NOAA Weather Service Office, Marquette, Michigan, 1966-98.

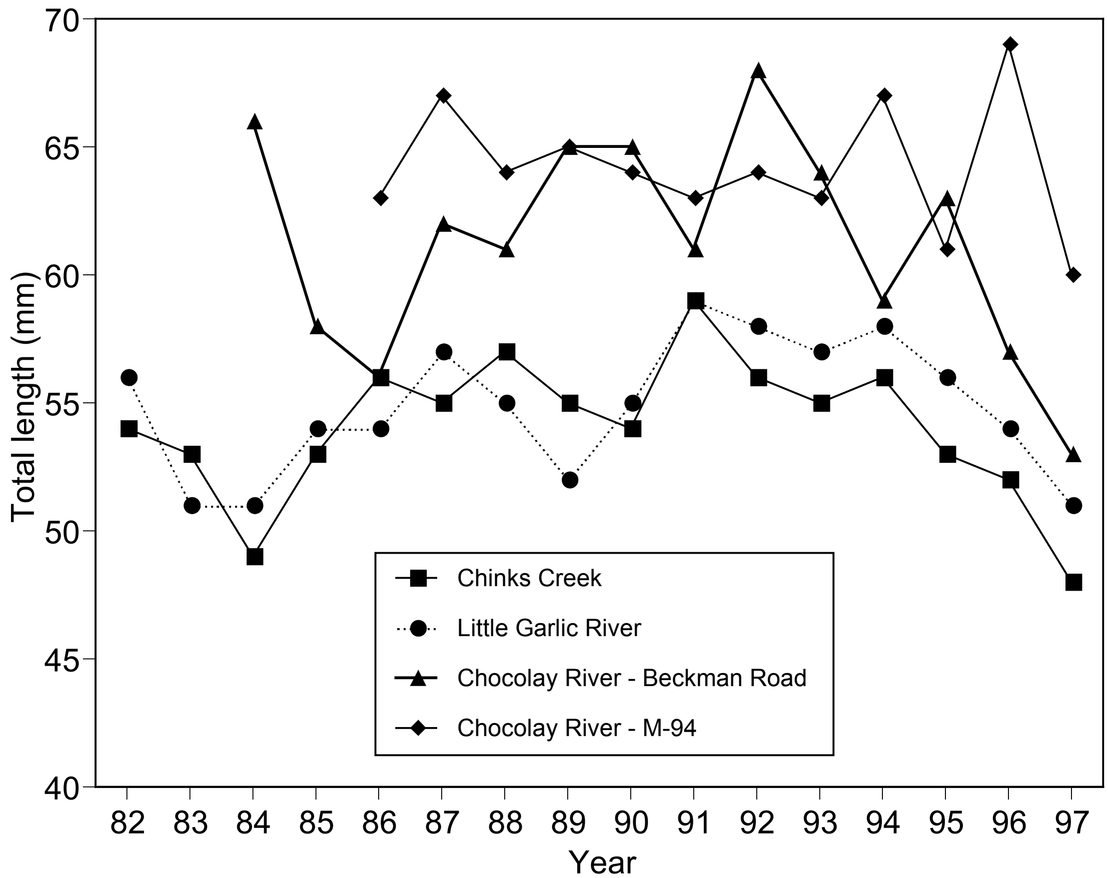

Figure 7.–Mean total length of age-0 rainbow trout sampled in three Lake Superior tributaries during August and September 1982-97.

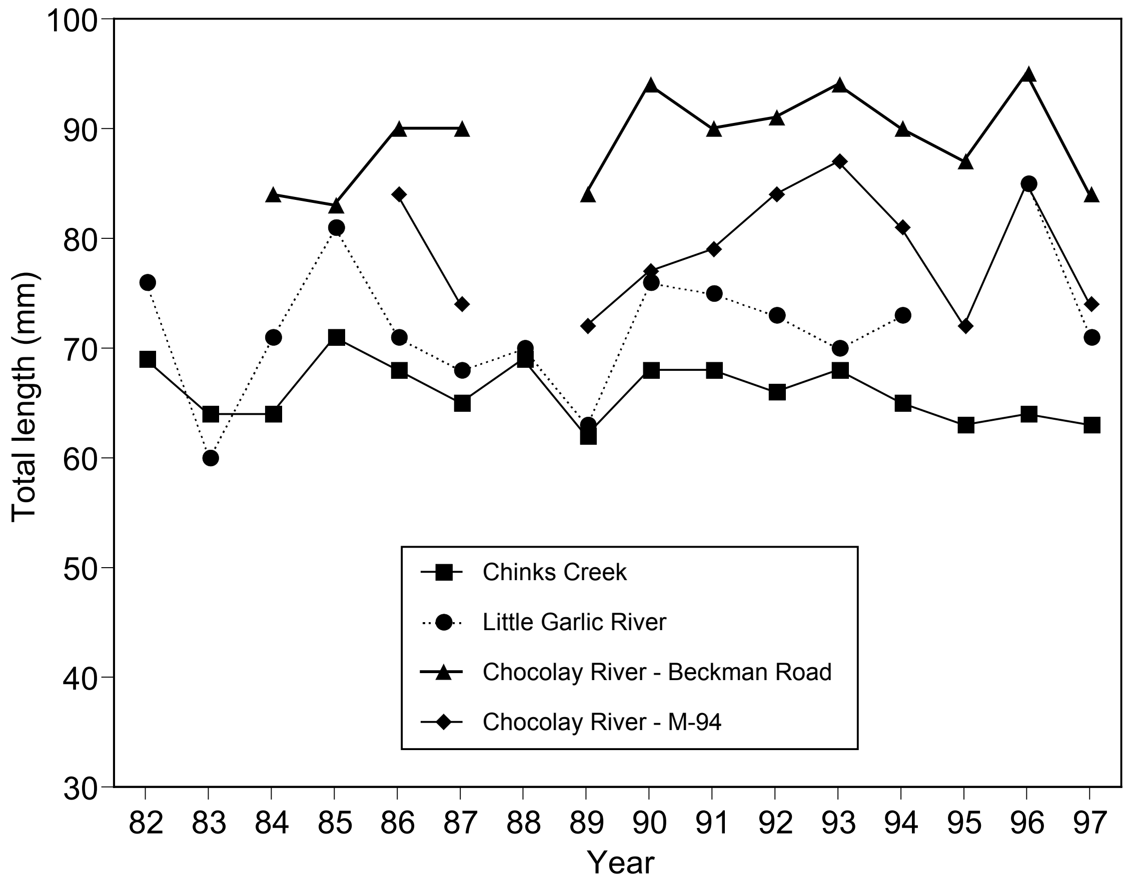

Figure 8.–Mean total length of age-0 coho salmon sampled in three Lake Superior tributaries during August and September 1982-97.

Table 1.–Mean physical characteristics of 305-m study sections in three Lake Superior tributaries measured during annual trout and salmon population estimates during August-September 1982-97.

Mean parameter values ± 95% C.I.	Tributary and section: Chinks Creek	Little Garlic River	Chocolay River	
	Big Bay Road	County Road 550	Beckman Road	East Branch, M-94
Width (m)	3.58±0.22	5.47±0.39	9.08±0.23	7.44±0.39
Depth (m)	0.14±0.01	0.19±0.02	0.31±0.02	0.21±0.02
Area ($m^{2)}$	1,092±67	1,668±119	2,768±71	2,269±120
Discharge (m^3/sec)	0.07±0.02	0.11±0.04	0.84±0.15	0.19±0.09
Conductivity (µmhos)	177±20	165±23	244±25	214±31
Temperature (°C)	13±0.7	17±1.6	13±1.0	15±1.5

Table 2.–Estimated number (N) and density (D) (number per m^2) of juvenile steelhead and coho salmon (± SE) in Chinks Creek, 1982-97.

Year and parameter		Steelhead		Coho salmon		Brook trout	
		Age-0	Age-1+	Age-0	Age-1	Age-0	Age-1+
1982	N	1,401±337	28±20	927±316	10±8	8±8	8±5
	D	1.467±0.353	0.029±0.021	0.971±0.331	0.10±0.008	0.008±0.009	0.009±0.006
1983	N	980±258	104±41	852±290	2±0	12±11	6±6
	D	0.786±0.207	0.083±0.033	0.683±0.232	0.002±0	0.010±.0.009	0.005±0.005
1984	N	1,524±195	28±9	2,869±284	16±8	6±5	9±2
	D	1.344±0.172	0.025±0.008	2.530±0.250	0.014±0.007	0.005±0.005	0.008±0.003
1985	N	1,054±118	57±14	452±70	32±16	6±7	10±3
	D	0.934±0.105	0.051±0.013	0.401±0.062	0.028±0.014	0.005±0.006	0.009±0.003
1986	N	1,086±181	38±15	1,277±294	1±0	0	5±4
	D	1.113±0.186	0.039±0.015	1.308±0.301	0.001±0		0.005±0.004
1987	N	564±149	72±19	951±324	2±3	1±0	7±3
	D	0.440±0.116	0.056±0.015	0.742±0.253	0.002±0.003	0.001±<0.001	0.005±0.003
1988	N	847±99	18±6	735±98	8±8	11±5	6±4
	D	0.712±0.083	0.015±0.005	0.618±0.082	0.007±0.007	0.009±0.004	0.005±0.003
1989	N	904±82	48±9	1,741±137	11±6	3±0	14±4
	D	0.726±0.066	0.039±0.007	1.397±0.110	0.009±0.005	0.002±<0.001	0.011±0.004
1990	N	1,261±100	59±9	609±59	29±7	2±0	10±0
	D	1.155±0.092	0.054±0.008	0.558±0.054	0.027±0.007	0.002±<0.001	0.009±0.002
1991	N	860±76	92±12	1,182±100	6±4	12±11	12±5
	D	0.881±0.078	0.094±0.012	1.211±0.102	0.006±0.004	0.013±0.011	0.012±0.005
1992	N	757±119	40±16	1,712±176	19±11	12±6	7±3
	D	0.620±0.098	0.033±0.013	1.403±0.194	0.016±0.009	0.010±0.005	0.005±0.003
1993	N	923±139	49±17	1,112±225	53±22	2±0	8±10
	D	0.815±0.123	0.043±0.015	0.982±0.199	0.047±0.019	0.002±<0.001	0.007±0.009
1994	N	807±92	94±14	1,164±115	30±21	8±8	22±6
	D	0.895±0.102	0.104±0.015	1.290±0.127	0.033±0.024	0.009±0.009	0.024±0.006
1995	N	512±65	94±11	975±75	15±3	1±0	15±6
	D	0.559±0.071	0.103±0.012	1.064±0.082	0.016±0.003	0.001±<0.001	0.016±0.006
1996	N	577±99	47±9	599±81	30±22	2±2	19±9
	D	0.577±0.099	0.047±0.009	0.599±0.081	0.030±0.022	0.002±0.002	0.019±0.009
1997	N	449±86	80±15	971±130	29±12	6±6	60±35
	D	0.417±0.080	0.074±0.014	0.902±0.121	0.027±0.011	0.006±0.005	0.056±0.032

Table 3.–Estimated number (N) and density (D) (number per m^2) of juvenile steelhead and coho salmon in a 305-m section of Little Garlic River, 1982-97.

Year and parameter		Steelhead Age-0	Steelhead Age-1+	Coho salmon Age-0	Coho salmon Age-1
1982	N	2,449±366	200±31	243±92	6±4
	D	1.482±0.221	0.121±0.019	0.147±0.056	0.004±0.003
1983	N	722±150	216±29	212±80	0
	D	0.398±0.083	0.119±0.016	0.117±0.044	
1984	N	2,332±240	144±30	553±155	3±0
	D	1.403±0.144	0.087±0.018	0.333±0.093	0.002±0
1985	N	3,272±205	421±39	107±28	3±1
	D	1.782±0.112	0.229±0.021	0.058±0.015	0.002±0.001
1986	N	2,478±210	386±41	459±83	0
	D	1.377±0.117	0.214±0.023	0.255±0.046	
1987	N	493±84	270±51	284±11	0
	D	0.276±0.047	0.151±0.029	0.159±0.006	
1988	N	1,184±170	68±13	456±143	0
	D	0.539±0.077	0.031±0.006	0.208±0.065	
1989	N	1,730±189	105±23	1,125±159	0
	D	1.167±0.127	0.071±0.016	0.759±0.107	
1990	N	3,088±182	203±17	172±41	14±5
	D	1.911±0.113	0.126±0.011	0.106±0.025	0.009±0.003
1991	N	1,444±102	189±21	123±26	2±0
	D	0.768±0.054	0.101±0.011	0.065±0.014	0.001±0
1992	N	2,104±140	76±10	371±54	7±0
	D	1.484±0.099	0.054±0.007	0.262±0.038	0.005±0
1993	N	1,380±131	204±19	442±76	5±0
	D	0.943±0.090	0.139±0.013	0.302±0.052	0.003±0
1994	N	967±74	106±15	504±99	1±0
	D	0.743±0.057	0.081±0.011	0.387±0.076	0.001±0
1995	N	1,574±121	83±14	0	0
	D	1.111±0.085	0.059±0.010		
1996	N	1,517±130	89±17	47±14	3±2
	D	0.947±0.081	0.056±0.011	0.029±0.009	0.002±0.001
1997	N	1,270±188	113±21	410±74	0
	D	0.724±0.107	0.064±0.012	0.234±0.042	

Table 4.–Estimated number (N) and density (D) (number per m^2) of juvenile steelhead, juvenile coho salmon, brook trout, and brown trout (± 2 SE) in a 305-m section of Chocolay River at Beckman Road, 1984-97.

Year and parameter		Steelhead		Coho salmon	Brook trout		Brown trout	
		Age-0	Age-1+	Age-0	Age-0	Age-1+	Age-0	Age-1+
1984	N	47±39	69±40	74±37	188±54	76±21	106±56	29±6
	D	0.018±0.015	0.026±0.015	0.028±0.014	0.071±0.020	0.029±0.008	0.040±0.021	0.011±0.002
1985	N	1,924±362	79±33	3±2	254±70	78±18	65±28	39±8
	D	0.730±0.137	0.030±0.013	0.001±0.001	0.096±0.026	0.030±0.007	0.025±0.011	0.015±0.003
1986	N	1,499±539	273±84	12±10	97±31	57±25	106±63	32±24
	D	0.528±0.190	0.096±0.030	0.004±0.003	0.034±0.011	0.020±0.009	0.037±0.022	0.011±0.009
1987	N	739±100	226±31	66±18	72±18	48±11	169±45	18±4
	D	0.272±0.039	0.083±0.011	0.024±0.007	0.027±0.007	0.018±0.004	0.062±0.017	0.007±0.001
1988	N	1,164±136	209±23	0	99±23	60±8	292±70	24±6
	D	0.424±0.050	0.076±0.008		0.036±0.008	0.022±0.003	0.106±0.025	0.009±0.002
1989	N	1,231±219	185±35	203±93	26±12	39±14	119±127	15±6
	D	0.458±0.081	0.069±0.013	0.075±0.034	0.010±0.005	0.014±0.005	0.044±0.047	0.006±0.002
1990	N	1,472±172	221±42	156±33	150±34	14±4	49±21	14±5
	D	0.501±0.059	0.075±0.014	0.053±0.011	0.051±0.012	0.005±0.001	0.017±0.007	0.005±0.002
1991	N	1,178±206	232±45	84±25	134±33	33±10	87±34	7±4
	D	0.385±0.067	0.076±0.015	0.027±0.008	0.044±0.011	0.011±0.003	0.028±0.011	0.002±0.001
1992	N	1,657±211	181±43	298±80	68±23	28±10	45±20	5±0
	D	0.576±0.073	0.063±0.015	0.104±0.029	0.024±0.008	0.010±0.024	0.016±0.007	0.002±0
1993	N	1,218±166	233±33	142±38	126±50	38±12	60±18	2±0
	D	0.433±0.059	0.083±0.012	0.050±0.013	0.045±0.018	0.013±0.004	0.021±0.006	0.001±0
1994	N	911±161	322±43	88±17	136±42	57±14	148±34	11±4
	D	0.341±0.060	0.121±0.016	0.033±0.006	0.051±0.016	0.021±0.005	0.055±0.013	0.004±0.001
1995	N	774±109	155±22	123±23	183±44	31±6	94±20	14±4
	D	0.290±0.041	0.058±0.008	0.046±0.009	0.069±0.017	0.012±0.002	0.035±0.007	0.005±0.002
1996	N	236±72	101±20	16±16	97±31	38±16	18±7	6±0
	D	0.085±0.026	0.036±0.007	0.006±0.006	0.035±0.011	0.014±0.006	0.006±0.003	0.002±0
1997	N	445±117	79±19	48±29	183±68	47±15	43±24	8±2
	D	0.167±0.044	0.030±0.007	0.018±0.011	0.069±0.026	0.018±0.006	0.016±0.009	0.003±0.001

Table 5.–Estimated number (N) and density (D) (number per m^2) of juvenile steelhead, juvenile coho salmon, brook trout, and brown trout in a 305-m section of the East Branch of the Chocolay River at M-94, 1986-97.

Year and parameter		Steelhead		Coho salmon	Brook trout		Brown trout	
		Age-0	Age-1+	Age-0	Age-0	Age-1+	Age-0	Age-1+
1986	N	1,433±143	113±14	186±91	3±2	12±7	28±19	0
	D	0.581±0.058	0.046±0.006	0.075±0.037	0.001±0.001	0.005±0.003	0.011±0.008	
1987	N	1,301±147	149±28	267±64				
	D	0.593±0.067	0.068±0.013	0.122±0.029				
1988	N	963±84	116±15	0	5±0	6±2	11±6	1±0
	D	0.395±0.034	0.048±0.006		0.002±0	0.002±0.001	0.005±0.002	>0.001±0
1989	N	729±63	107±13	369±60	5±3	0	19±11	0
	D	0.305±0.026	0.045±0.005	0.155±0.025	0.002±0.001		0.008±0.004	
1990	N	1,475±87	57±7	170±50	8±3	1±0	0	1±0
	D	0.756±0.045	0.029±0.004	0.087±0.026	0.004±0.002	0.001±0		0.001±0
1991	N	1,421±192	95±19	28±28	16±5	6±6	0	1±0
	D	0.586±0.079	0.039±0.008	0.012±0.012	0.007±0.002	0.002±0.002		<0.001±0
1992	N	1,493±145	89±22	237±103	1±0	7±4	1±0	2±2
	D	0.608±0.059	0.036±0.009	0.097±0.042	<0.001±0	0.003±0.002	<0.001±0	0.001±0.001
1993	N	1,949±232	143±23	52±22	3±2	0	6±5	0
	D	0.804±0.096	0.059±0.009	0.021±0.009	0.001±0.001		0.002±0.002	
1994	N	659±107	265±55	197±65	1±0	2±0	0	1±0
	D	0.301±0.049	0.121±0.025	0.090±0.030	<0.001±0	0.001±0		<0.001±0
1995	N	1,462±144	90±13	369±80	4±3	0	0	0
	D	0.712±0.070	0.044±0.006	0.180±0.039	0.002±0.002			
1996	N	507±95	119±21	120±48	2±0	1±0	0	0
	D	0.227±0.043	0.053±0.009	0.054±0.022	0.001±0	<0.001±0		
1997	N	1,100±154	87±22	543±117	9±6	6±0	0	0
	D	0.547±0.077	0.043±0.011	0.270±0.058	0.004±0.003	0.003±0.001		

Table 6.–Abundance of spawning adult steelhead in three Lake Superior tributaries based on adult fish and redd counts in surveyed[1] sections, April-June 1987-97.

Stream and year	Inclusive dates of survey	Section length (m)	Fish	Fish/ 1,000 m	Redds	Redds/ 1,000 m
Chinks Creek						
1992	23 Apr-6 May	1,300	1	0.77	4	3.08
1993	20 Apr-23 May	1,300	0	0	5	3.85
1994	3-23 May	1,300	0	0	8	6.15
1995	27 Apr-22 May	1,300	3	2.31	14	10.77
1996	31 May-18 Jun	1,300	1	0.77	7	5.38
1997	7-23 May	1,300	14	10.77	10	7.69
Little Garlic River						
1992	14 Apr-19 May	2,500	7	2.80	11	4.40
1993	20 Apr-19 May	2,500	25	10.00	11	4.40
1994	3 May-9 Jun	8,150	9	1.10	14	1.72
1995	2 May-9 Jun	8,150	13	1.60	15	1.84
1996	30 May-20 Jun	8,150	31	3.80	19	2.33
1997	8-22 May	8,150	21	2.58	21	2.58
Chocolay River - Beckman Road						
1987	14 Apr-4 May	1,700	20	11.76	7	4.12
1988	20 Apr-8 May	1,700	27	15.88	15	8.82
1989	11 Apr-30 May	1,700	26	15.29	–[2]	–[2]
1990	18 Apr-1 May	1,700	13	7.64	3	1.76
1991	16 Apr-30 Apr	1,700	17	10.00	9	5.29
1992	15 Apr-4 May	1,700	22	12.94	10	5.88
1993	21 Apr-7 Jun	1,700	7	4.12	5	2.94
1994	2 May-8 Jun	1,700	3	1.76	8	4.71
1995	26 Apr-8 Jun	1,700	9	5.29	14	8.24
1996	5-27 Jun	1,700	7	4.12	23	13.53
1997	10-29 May	1,700	1	0.59	1	0.59
East Branch Chocolay River - M-94						
1987	14 Apr-4 May	1,400	5	3.57	12	8.57
1988	20 Apr-8 May	1,400	5	3.57	4	2.86
1989	11 Apr-30 May	1,400	5	3.57	–[2]	–[2]
1990	18 Apr-1 May	1,400	9	6.43	21	15.00
1991	16 Apr-30 Apr	1,400	15	10.71	15	10.71
1992	15 Apr-4 May	1,400	4	2.86	16	11.43
1993	21 Apr-7 Jun	1,400	3	2.14	6	4.29
1994	2 May-8 Jun	1,400	0		11	7.86
1995	26 Apr-8 Jun	1,400	2	1.43	8	5.71
1996	5-27 Jun	1,400	4	2.86	15	10.71
1997	10-29 May	1,400	0		2	1.43

[1] Surveys were visual except that electro-fishing gear was used on the Chocolay River prior to 1993.

[2] No count.

Table 7.–Abundance of adult coho salmon in three Lake Superior tributaries, based on fish and redd counts in surveyed[1] sections during October-November 1990-97.

Stream and year	Inclusive dates of survey	Section length (m)	Fish	Fish 1,000 m	Redds	Redds/ 1,000 m
Chinks Creek						
1990	25 Oct	1,300	20	15.38	17	13.08
1991	14 Oct-5 Nov	1,700	1	0.59	19	11.18
1992	26 Oct	1,700	3	1.76	13	10.00
1993	6 Oct-4 Nov	1,300	13	10.00	12	9.23
1994	20 Oct-7 Nov	1,300	110	84.62	80	61.54
1995	11-26 Oct	1,300	57	43.85	22	16.92
1996	1 Oct-6 Nov	1,300	33	25.38	38	29.23
Little Garlic River						
1990	29 Oct	2,500	5	2.00	5	2.00
1991	24-28 Oct	2,500	4	1.60	5	2.00
1992	22 Oct-5 Nov	2,500	0		0	
1993	14 Oct-2 Nov	2,500	15	6.00	8	3.20
1994	18 Oct-2 Nov	2,500	0		0	
1995	11-30 Oct	2,500	12	4.80	17	6.80
1996	1 Oct-6 Nov	2,500	32	12.80	38	15.20
Chocolay River – Beckman Road						
1990	16-30 Oct	1,300	19	7.41	1	1.11
1991	22 Oct-5 Nov	1,700	26	15.29	3	1.76
1992	21 Oct-4 Nov	1,700	3	1.76	8	4.71
1993	27 Sep-10 Nov	1,700	8	4.71	8	4.71
1994	13-31 Oct	1,700	1	0.59	4	2.35
1995	13 Oct-6 Nov	1,700	1	0.59	4	2.35
1996	3 Oct-5 Nov	1,700	2	1.18	10	5.88
East Branch Chocolay River – M-94						
1990	16-30 Oct	1,400	1	0.71	2	1.43
1991	22 Oct-5 Nov	1,400	26	18.57	21	15.00
1992	21 Oct-4 Nov	1,400	5	3.57	14	10.00
1993	27 Sep-10 Nov	1,400	5	3.57	8	5.71
1994	13-31 Oct	1,400	21	15.00	21	15.00
1995	13 Oct-6 Nov	1,400	5	3.57	3	2.14
1996	3 Oct-5 Nov	1,400	18	12.86	15	10.71

[1] Surveys were visual except that electro-fishing gear was used in the Chocolay River prior to 1993.

Table 8.–Catch of steelhead and coho salmon in the Lake Superior sport fishery in the creel-surveyed lake area encompassing Chinks Creek, Little Garlic River, and Chocolay River (Keweenaw Bay, Marquette, AuTrain, and Munising) during 1984-99[1], expressed as number caught (N) and number caught per angler hour (AH).

	Keweenaw Bay		Marquette		Munising/AuTrain		Total	
Species and year	N	N/AH	N	N/AH	N	N/AH	N	N/AH
Steelhead								
1984			333	0.0040			333	0.0040
1985			341	0.0032			341	0.0032
1986			627	0.0043			627	0.0043
1987	53	0.0018	357	0.0034	270	0.0055	680	0.0037
1988	339	0.0033	204	0.0030	412	0.0057	955	0.0040
1989[1]								
1990	0	0	280	0.0058	20	0.0014	300	0.0038
1991	81	0.0015	331	0.0036	382	0.0053	794	0.0037
1992	142	0.0023	276	0.0031	314	0.0034	732	0.0030
1993	307	0.0033	383	0.0047	602	0.0077	1,292	0.0051
1994	282	0.0023	269	0.0045	306	0.0047	857	0.0034
1995	372	0.0059	83	0.0016	171	0.0038	626	0.0039
1996	128	0.0016	203	0.0034	187	0.0034	518	0.0027
1997	635	0.0151	217	0.0030	227	0.0039	1,079	0.0063
1998	200	0.0052	137	0.0024	159	0.0033	496	0.0034
1999	139	0.0029	98	0.0017	216	0.0038	453	0.0029
Coho salmon								
1984			3,598	0.0435			3,598	0.0435
1985			16,773	0.1584			16,773	0.1584
1986			22,133	0.1518			22,133	0.1518
1987	197	0.0067	5,125	0.0488	3,643	0.0735	8,965	0.0487
1988	5,868	0.0572	5,584	0.0834	9,412	0.1310	20,864	0.0864
1989[1]								
1990	96	0.0055	403	0.0084	193	0.0139	692	0.0087
1991	2,567	0.0483	9,007	0.0976	5,488	0.0765	17,062	0.0786
1992	1,139	0.0184	5,858	0.0660	8,184	0.0897	15,181	0.0628
1993	4,736	0.0507	3,385	0.0419	4,984	0.0640	13,105	0.0520
1994	6,941	0.0555	4,928	0.0830	5,458	0.0842	17,327	0.0695
1995	3,016	0.0475	2,718	0.0516	1,991	0.0440	7,725	0.0479
1996	942	0.0118	1,621	0.0274	2,673	0.0489	5,236	0.0270
1997	1,608	0.0381	1,714	0.0237	3,034	0.0525	6,356	0.0369
1998	2,553	0.0669	1,324	0.0232	1,618	0.0331	5,495	0.0381
1999	1,264	0.0262	3,270	0.0263	2,166	0.0378	6,700	0.0412

[1] Survey during 1984-86 was only at Marquette, no survey in 1989, and no winter (January-March) survey in 1990.

Table 9.–Mean total weight (g), mean total length (mm), weight and length ranges, and weight-length coefficients, with 95% confidence intervals (CI) on means and coefficients, by age for samples[1] of steelhead and coho salmon in Chinks Creek, Little Garlic River, and Chocolay River, 22 August-7 September 1994.

Stream and species	Age	N	Mean weight 95% CI, range	Mean length 95% CI, range	Weight-length coefficients ±95% CI: a	Weight-length coefficients ±95% CI: b	R^2
Chinks Creek							
Rainbow	0	33	1.7±0.4, 0.5-5.0	56±4, 40-81	0.09±0.01	-3.65±0.70	0.88
	1	26	12.5±2.3, 6.2-29.5	112±6, 87-152	0.35±0.05	-26.24±5.17	0.91
	2	0					
Coho	0	53	3.2±0.5, 1.0-7.7	70±4, 47-94	0.13±0.01	-5.82±0.71	0.93
	1	5	9.2±1.9, 7.2-10.9	101±5, 95-106	0.35±0.10	-26.53±10.39	0.98
Little Garlic River							
Rainbow	0	36	1.7±0.3, 0.3-4.0	56±4, 37-77	0.09±0.01	-3.60±0.43	0.95
	1	40	13.3±2.5, 4.1-40.3	109±6, 81-164	0.42±0.03	-32.78±3.44	0.95
	2	1	28.8	145			
Coho	0	34	3.7±0.6, 1.3-7.3	74±4, 56-95	0.15±0.01	-7.54±0.93	0.95
	1	0					
Chocolay River							
Rainbow	0	91	2.3±0.3, 0.4-8.3	61±3, 36-92	0.10±0.01	-3.70±0.35	0.93
	1	99	18.1±1.7, 7.3-39.9	123±4, 93-163	0.45±0.02	-36.98±2.71	0.94
	2	9	53.5±10.2, 34.2-74.2	176±11, 152-197	0.90±0.17	-105.59±29.57	0.96
Coho	0	47	5.6±0.6, 1.5-9.9	86±3, 63-102	0.19±0.02	-11.02±1.54	0.91
	1	0					

[1] Five fish of each species per 5-mm size group were weighed, measured, and scale sampled.

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