# Methods

This study creates a sub-population of rearing coho salmon that are coded-wire tagged as fry that have emerged in recent days or weeks such that their age when recaptured and sampled at a later stage in life can be determined. The scale patterns from these samples can then be examined to determine how they relate to the known age of the fish. Two systems were chosen for study in order to compare the scale patterns from different habitat types: Berners River as a “river type” habitat and Hugh Smith Lake as a “lake type” habitat. Methods used to capture both fry and smolt differed at the two systems as a result of these habitat differences.

This study was greatly facilitated by the fact that long-term, coho salmon stock assessment studies were already established (in the early 1980s; Shaul et al. 2011) and conducted annually at both Berners River and Hugh Smith Lake. These stock assessment studies included capturing, sampling, and coded-wire tagging smolt in the spring, and capturing and sampling adults in the fall. Thus, infrastructure, experienced field crews, equipment, and logistical support were already available for these remote field sites. The only additional procedures required for a known-age study were the capture and tagging of newly emerged fry and the recovery and sampling of known-age specimens concurrent with ongoing smolt trapping and sampling activities. Known-age studies were initiated at Berners River and Hugh Smith Lake in 1996 and 1997 respectively. Known-age studies were also conducted on coho salmon by Craig Farrington at Auke Lake from 1992 to 1997, and some of the results and samples are incorporated into this report.

## Study Sites

### Hugh Smith Lake

Hugh Smith Lake is located 97 km southeast of Ketchikan on the Southeast Alaska mainland in Misty Fjords National Monument (55˚ 06’ N, 134 ˚ 40’ W; FIGURE?). The lake is organically stained, with a surface area of 320 ha, mean depth of 70 m, and maximum depth of 121 m. It is meromictic, and water located below 60 m does not interact with the upper freshwater layer of the lake. The lake drains into Boca de Quadra inlet via 50-m long Sockeye Creek and is supplied by two major inlet streams: Buschmann Creek flows northwest 4 km to the head of the lake and Cobb Creek, the primary spawning stream, flows north 8 km to the southeast head of the lake. Cobb Creek has a barrier to anadromous migration approximately 0.8 km upstream from the lake.

Coho salmon rear in both the inlet streams and around the shoreline of the lake. Much of the shoreline is relatively steep and rocky, with limited vegetation; however, a large log jam at the outlet of the lake and numerous deadfalls and rock slides around the shoreline provide important habitat structure for rearing juveniles (Shaul et al. 2009). Coho salmon production from Hugh Smith Lake is relatively low for the amount of surface area and the length of stream and shoreline area compared to other Southeast Alaska lake systems (Shaul et al. 1985; Shaul and Van Alen 2001).

### Berners River

The Berners River is located 69 km northwest of Juneau (58˚ 23’ N, 134˚ 38’ W; FIGURE?). It flows southeast 24 km into upper Berners Bay, and is a relatively compact drainage. The major spawning ground is the headwater area upstream of the confluence of two river branches and above the glacial tributaries.There are minor spawning locations in the east branch lake and other small tributary streams (Gray and Marriott 1986). Most coho fry migrate downriver several kilometers to rear in prime habitats that are comprised of ponds, sloughs and wetlands. [[ More needed ?? ]]

### Auke Lake

Auke Lake is located 19 km northwest of Juneau (58˚ 23’ N, 134˚ 38’ W; FIGURE?). The lake has a surface area of 67 ha, mean depth of 19 m, and maximum depth of 31 m. The outlet stream, Auke Creek, is less than 1 km long and of moderate gradient, with few natural pools or spawning gravel except for a small number of man-made backwater pools filled with gravel for spawning. The main inlet stream, Lake Creek, is the largest of five tributary streams to the lake, and is a low gradient stream of pools and riffles with an abundance of suitable spawning gravel. Much of the lake is bordered by forest; however, at least 50% of the shoreline has been urbanized by residential development (Lum and Taylor 2004). The lake shore includes areas dominated by emergent vegetation, such as *Equisetum* sp. and *Nuphar* sp., while other areas are characterized by large quantities of woody debris (Lum and Taylor 2004).

The NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, operates the Auke Creek Research Station located on the outlet of Auke Lake in conjunction with ADF&G and the University of Alaska, Fairbanks. The research station maintains a concrete and steel fish weir structure located on Auke Creek just above the highest high tide level (Lum et al. 1998). The weir was operated annually in a downstream trapping configuration from early March through June to intercept emigrating salmon smolt and trout, then changed to an upstream trapping configuration and operated through early November to capture migrating adult salmon. It is assumed that 100% of migrating salmonids were captured in the weir trap.

## Hugh Smith and Berners Studies

### Fry Capture and Tagging

An annual target of 5,000 fry was to be coded-wire tagged each site, which provided a large enough known-age sub-population to yield 100 to 300 potential known-age smolt samples each year. A maximum size limit of 42 mm (snout to fork length) was initially established to ensure that fry actually hatched in the year they were tagged. That size limit was determined from a small quantity of length frequency data collected at the Berners River in 1996; however, later field observations suggested that some fish in the low 40 mm range may not be newly emerged fry, as fish with the coloration and subtle body shape characteristics of age-1 juveniles were occasionally seen. Also, juvenile coho salmon less than 40 mm have been captured at Hugh Smith Lake in November; since little or no growth is thought to occur during the winter months, this suggested that very small fish may be found in the spring that are not newly emerged fry. As a result, the size cut-off was reduced to 38 mm. In order to tag such tiny fish, half-length coded wire tags were used. [[ Insert info on tagging methods? – or could say methods described by Magnus et al. 2006? ]]

Coho fry were captured annually at Hugh Smith Lake from approximately mid-May to early June using a fyke net (1 m tall × 2 m wide at the mouth) installed near the mouth of Cobb Creek, the primary spawning stream. Newly hatched fry were passively captured as they migrated downstream and were funneled into the fyke net. A lidded holding box at the terminal end of the net protected captured fry from the stream current and predators. Fry were collected daily and transported in buckets to the tagging site at the lake outlet where they were adipose-clipped, coded-wire tagged, and held overnight in holding pens to check for tag retention and mortality. Tagged fry were transported back to Cobb Creek and released downstream of the fyke net to avoid recapture.

At the Berners River, coho fry were captured annually from approximately mid-May to early June. Newly hatched fry congregated in eddies and small sloughs out of the main flow after drifting downriver from spawning areas. They were also concentrated in good numbers in quiet water where spills from beaver ponds occurred. Presumably they waited for high water events that would allow them to swim into these beaver pond areas, which appeared to provide the preferred rearing habitat. Fry were simply captured by stalking these holding areas and scooping them up with a 1/8” or 3/16” mesh dip net. Typically 200–400 fry were tagged per day, this number could be captured in 10–15 minutes of dip netting effort. Captured fry were transported in buckets to the field camp where they were adipose-clipped, coded-wire tagged, and held overnight to check for tag retention and mortality. Tagged fry were transported and released into a large beaver pond complex (ShaulPond) at whos outlets most of the fry were captured as they congregated there.Known-Age Smolt Collection

Coho smolt were captured each year from mid-April to early June at a weir operated at the outlet of Hugh Smith Lake. The weir, composed of plastic screen panels supported by a cable across the stream and an incline plane trap to capture fish, was described in detail by Magnus et al. (2006) and Shaul et al. (2009). Coho smolt were captured annually at the Berners River from approximately early May to mid-June using two styles of traps (Shaul and Crabtree 2014). Custom-built traps, similar to oversized Gee minnow traps (Magnus et al. 2006), were baited with salmon roe and fished in the slough and river, and passive “spill traps” were installed in beaver ponds. Spill traps consisted of a dewatering trough placed in the effluent flow from a beaver pond—water was directed through a flexible 4 in. pipe attached to the end of the trough and into a floating holding box where migrant smolt were captured. A large perforated panel on one side of the box allowed for water flow. Other spills along the beaver dam were blocked with sand bags or plastic mesh to concentrate flow at the trough. Four or five of these traps were installed at different locations in the drainage. (Photographs of various Berners River spill traps were provided by Magnus et al. 2006, pages 60–62).

As captured smolt were processed for coded-wire tagging, those fish already missing their adipose fin were set aside as potential known-age specimens. Adipose-clipped smolt were passed through a coded wire tag detector to determine which specimens contained tags. Those with tags were carefully examined at the adipose excision to determine if the cut was fresh or healed over. Only those that were healed were collected as known-age samples. A few samples turned out to be fish that were tagged as presumed smolt the previous spring but which remained in freshwater another year. This error occurred almost exclusively with smolt captured at the Berners River in the slough rather than beaver pond areas, since those areas were semi-isolated (flood events provide opportunity for pond access) from one another and fish tagged as smolt were released into the slough.

Smolts that were selected as known-age samples were measured (snout to fork length, mm), weighed (to the nearest 0.1 g), and sampled for scales. Ten to fifteen scales were taken from the left side of the fish approximately two rows above the lateral line along a diagonal downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). The scales were collected by scraping with a surgical scalpel and then were spread on a glass slide, two samples per slide. An individually numbered Floy tag was attached to the smolt carcass and the entire fish was preserved in a bottle of ethyl alcohol. These samples were later delivered to the ADF&G Mark, Tag and Age Laboratory where coded wire tags were removed and decoded. Using this tag information ages are assigned to the collected samples.

## Auke Lake Study

As a routine part of monitoring the Auke Lake coho salmon population, all smolts and adults are counted as they pass the weir, and examined for presence or absence of a coded wire tag. Additionally, before release downstream of the weir all emigrating coho smolts were sorted into four size categories by fork length: small (<90 mm), medium (90–110 mm), large (111–125 mm), and extra-large (>125 mm).

In October 1992, 13 adult female and 11 adult male coho salmon were captured at the weir, held for several weeks, and artificially spawned in November, which is similar to the natural spawning time in the Auke Lake system. The fertilized eggs were incubated in Heath trays at the Auke Creek Research Station. Water for incubation came from Auke Creek, and matched water temperature regimes expected for naturally spawned coho salmon eggs. A total of 10,411 of the resulting coho fry were marked with an adipose clip. During 25–28 May 1993, they were planted as unfed fry into two different habitat types in the Auke Lake watershed: 1) shallow, weedy waters along the lake margin, considered prime juvenile coho salmon rearing habitat, and 2) pools in Lake Creek where coho fry were frequently observed in spring. Adipose-clipped fish were recovered as migrant smolt at the weir during April–June in 1994 and 1995. Not all marked fish were sampled. In 1994, only marked fish up to 110 mm fork length were sacrificed for known-age samples, 125 of 488 mark recoveries. In 1995, all mark recoveries, 61 fish total, were sacrificed for known-age samples.

In spring 1995, nomadic, young-of-the-year wild coho fry were captured in the downstream trap of the weir. Additional fry were caught with dip nets upstream of the weir to supplement weir numbers. Fry were measured (snout to fork length, mm), marked with an adipose clip, and tagged with half-length coded wire tags in groups according to three release sites: Lake Creek, Auke Lake, and Auke Creek. Each group was sampled for length (snout to fork, mm) and absence of scales, and then released on 2 June, 19 June, and 19 June 1995, respectively. Pre-release tag retention was 100%, 100%, and 99.5%, respectively. In summer and fall 1995, baited minnow traps were used to catch juvenile coho salmon in Auke Lake. The few adipose-clipped fish that were captured were checked for the presence of a coded wire tag using a field detector, sampled for length and scales, then released back into the lake. Adipose-clipped fish were also recovered and sampled as migrant smolt at the weir during April–June 1996 and 1997, all of which were sacrificed for tag removal.

Auke Lake coho smolt were measured, weighed, and sampled for scales following the same protocols used at Hugh Smith Lake and the Berners River. [[ More on how samples were shared with ADF&G; other stuff? ]]

Age determinations were based on examinations of scale images at 70× on a microfiche viewing projector. Criteria used to assign ages were similar to those of Mosher (1968). Photographs of selected scales were taken on a Leitz Laborlux S (trademark) microscope mounted with a Wild Leitz MPS 46 Photoautomat (trademark) camera using 35 mm Kodak Kodalith (trademark) film.

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