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Juvenile Salmon Capture and Coded Wire Tagging Manual

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gal	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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by

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ABSTRACT

Tagging with coded wire tags (CWT) is the most common marking method used for studies of Pacific salmon released from hatcheries. CWTs can also be used in studies of wild stocks to estimate harvest, total adult production (harvest plus escapement), exploitation rates, smolt production, marine survival or return rates, and spawner-recruit relationships. This manual documents what we have learned in over 25 years of working with coded wire tags and wild salmon in lakes, streams and rivers in Alaska. We hope it will be a practical and useful tool in the planning and operation of similar projects with tips on what has worked and not worked for us over the years. It will also be a citable reference for methods in future reports. Also included is an annotated bibliography of references on related subjects and links to useful websites. For project planning, we have also included an appendix listing sources of some of the specialized equipment used in these projects.

Key words: coded wire tag, salmon, smolt, fingerlings, project planning, wild stock, minnow trap, smolt trap, beach seine, smolt weir, trapping methods, net pen, Chinook salmon, coho salmon, scale sampling, tagging methods, field operations, smolt, age-weight-length sampling, fork length, Northwest Marine Technology (NMT).

INTRODUCTION

Coded wire tags (CWTs) are used for marking a wide variety of animal species. More than 65 million animals are tagged annually with coded wire tags (NMT 2005). By far, coded wire tagging is the most common marking method used for studies of Pacific salmon released from hatcheries (Johnson 1990). These studies have been used to estimate or infer statistical properties for wild stocks thought to be similar in life history, maturation and distribution to the hatchery stocks. Less frequently, coded wire tagging of wild stocks has been used to estimate population statistics including harvest, total adult production (harvest plus escapement), exploitation rates, smolt production, marine survival or return rates, and spawner-recruit relationships (McPherson et al. 2000; Pahlke 1995).

Armstrong and Argue (1977) described one of the first applications of CWTs to wild stocks of Chinook *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* on the Cowichan River in British Columbia in 1975. The Alaska Department of Fish and Game (ADF&G) conducted the first tagging of wild Chinook stocks in Southeast Alaska on the Taku River in 1977 and next on the Stikine River in 1978 (Kissner and Hubartt 1986). Five stocks of wild Chinook salmon are currently being coded-wire-tagged in Southeast Alaska: on the Taku River (Yanusz et al. 2000), the Unuk River (Weller and McPherson *In prep*), the Chilkat River (Ericksen 2004; Ericksen and McPherson 2004), the Stikine River (Richards et al. *In prep*) and the Chickamin River (Weller et al. *In prep)*. CWT projects for Chinook salmon have also been conducted in the past on the Situk and Alsek Rivers (Kissner and Hubartt 1986; McPherson et al. 1998; Thedinga et al. 1998) and several rivers in Southcentral Alaska (Appendix A1).

Juvenile coho salmon were first marked with CWTs in Southeast Alaska in 1976 (Koerner 1977). Since then, a large number of wild stocks have been or are currently being tagged (Shaul 1984; Shaul et al. 1991; Shaul et al. 2003; Appendix B1). Some of these projects took many years of trial and error to meet their objectives and some never did.

This manual documents what we have learned in over 25 years of trapping and coded wire tagging wild salmon and in lakes, streams and rivers in Alaska. We hope it will be a practical and useful tool in the planning and operation of similar projects with tips on what has worked and not worked for us over the years. It will also be a citable reference for methods in future reports. Rather than reinvent the wheel and try to describe in detail all the various methods people have used over the years, we have included a lengthy annotated bibliography of references on related subjects and links to useful websites. Some may not be directly relevant but were included for planning purposes and as an information resource. For project planning, we have also included an appendix listing sources of some of the specialized equipment used in these projects. Since we started on the production of this manual in 2004, Northwest Marine Technology (NMT) has published a Coded Wire Tag Project Manual (NMT 2005), which addresses some of the same issues, but without the focus on wild salmon.

PLANNING A CODED WIRE TAG PROJECT

Coded wire tagging of wild salmon stocks to produce useful results is not an easy nor trivial task. The objectives of the project must be considered, for both statistical and practical considerations. Before a project is begun, adequate funding must be obtained, the population and the potential fisheries exploiting them must identified, and thorough project planning for both the field work and analysis must be completed. Successfully tagging enough fish depends on a talented and dedicated field crew, the right equipment and training, rigorous quality control and diligent record keeping. When the adults return, adequate sampling of fisheries and the escapement is required to meet precision requirements and to produce defensible estimates. Finally, project leaders and biometric staff need to have the training and the time to analyze the data and report on the results.

Detailed planning is necessary to successfully implement a CWT project that will produce satisfactory results and meet objectives (Bernard et al. 1993; Nielsen 1992; NMT 2005; Willis and Murphy 1996). Before deciding to implement a coded wire tagging project, you should review the advantages and disadvantages of coded wire tags to determine if using them will allow you to achieve your project goals (Hammer and Blankenship 2001). Advantages of coded wire taging include 1) CWTs have little effect on the growth, behavior or mortality of fish; 2) do not protrude from the body; 3) are suitable for long term studies; 4) have a high retention rate when properly implanted; 5) can be used on most sizes of salmonids; and 6) can be economically applied to large numbers of fish; and 7) sequentially numbered tags are available which allow identification of individual fish. Disadvantages of coded wire tagging include: 1) initial expense of specialized tagging and field equipment; 2) detailed training of the trapping and tagging crew is necessary to catch a representative sample of the population and achieve good tag retention; 3) tag recovery usually requires sacrificing the fish; 4) recovery and reading of the tag requires specialized equipment and is labor intensive. Crozier and Kennedy (2002) had poor survival rates in wild Atlantic salmon smolt and suggested that wild smolt were more susceptible to handling than hatchery fish. Clark (2004) estimated costs of $1.70 per wild coho and $2.00 per wild Chinook salmon coded-wire-tagged in Southeast Alaska and a wild CWT recovery cost of perhaps $100 per coho and $700 per Chinook salmon.

The American Fisheries Society (AFS) has published guidelines for the use of fishes in research (AFS 2004) that were developed to provide a structure that ensures appropriate attention to valid experimental design and procedures while also ensuring humane treatment of the experimental subjects. At a practical level, the guidelines are intended to provide general recommendations on field and laboratory activities, such as sampling, holding, and handling fishes; information on administrative matters, including regulations and permits; and advice concerning ethical questions, such as perceptions of pain or discomfort that may be experienced by experimental subjects. This guideline should be reviewed when planning any new project involving fish.

STATISTICAL CONSIDERATIONS

Bernard et al. (1998) gives a detailed description of the technical aspects of planning a CWT program. Considerations include:

1) What is the population of interest?
2) How do you tag this population representatively?
3) How many smolt do you need to tag? (this depends on what population parameters you want to estimate and with what precision).
4) Population size?
5) Exploitation rate?
6) Sampling rates in various fisheries?
7) How many adults you can sample to estimate the tagging rate (θ) in the inriver run or escapement.

Bendock (1996) describes how to determine sample size requirements for a new project based on assumptions of smolt survival and desired precision. A ball park figure for minimum number of fish to tag is 10,000 for a small coho salmon system, and 25,000 or more for a larger coho system like the Taku River. For Chinook, the minimum is about 30,000 for a smaller stock like the Unuk River and 35,000-50,000 for large systems like the Taku and Stikine rivers. Sometimes if you can not tag enough fish to estimate harvest or smolt abundance you can make up for some of the lost precision by sampling more fish in the harvest or escapement (Clark 2004).

When a hatchery releases smolt they have a good estimate of the total number released and the proportion of that total that is coded-wire-tagged (theta or θ). When we tag wild salmon with CWTs, θ is unknown at the time of release and must be estimated by sampling returning adults. A good estimate of θ is required to estimate harvest in fisheries, smolt survival and other run reconstruction parameters.

Sometimes another option to economically tag a large number of fish is to collect eggs from wild brood stock, rear them in a hatchery, tag them and release them back into their natal system (Pahlke 1991; Sweet 1999). Usually, implemented as part of an enhancement or rehabilitation program, these tags will provide much of the same information as trapping and tagging wild juveniles.

Size selectivity of capture methods and the timing of a tagging project in relation to the smolt migration can have a significant effect on the results from a study. Weller et al. (2003) reported smolt to adult survival of coho smolts over 82 mm FL to be 2.5 times that of smolts in the 70-82 mm range. They also estimated that the larger smolts were 2.1 times more likely to be captured by minnow trapping than 70-82 mm smolts. Lum (2003) found that larger, older coho smolt tend to emigrate earlier than smaller ones. Couple this with the higher survival rate of larger smolts and skewed data may be generated by not distributing tagging effort throughout the entire smolt emigration. Carlon and Hasbrouck (1993) found that on average, coho smolts recaptured by inclined plane traps on the lower Kenai River were smaller than the smolts tagged upriver at weir sites. Ed Jones (Sport Fish Biologist, ADF&G, Douglas; personal communication) found no size selectivity with rotary screw traps on the Taku River, but decided to stop using them because minnow trapping was more productive.

PRACTICAL CONSIDERATIONS

Planning field operations for a wild stock coded wire tagging project involves consideration of many factors.

1) How long is the species life cycle? For example, are you able to commit to at least 5 years for a Chinook salmon study?
2) How do you tag a representative sample of the population? For example, do the juveniles rear or migrate through an area where you can capture them such that the marked fractions in returning adults are similar regardless of where they are captured?
3) Is the tagging goal feasible for a spring project? If fall tagging is done on rearing fish, what is the projected overwinter mortality of these fish?
4) How accessible is the system? Do you have boats, motors, and experienced river runners on your crew?
5) Will a field camp be necessary? Do you need to build a camp? What permits are needed?
6) What methods of fish capture would be most practical for this project?
7) How will you get materials, supplies and personnel to the study site?
8) How will adult recovery be conducted?
9) How much will the project cost (i.e. building materials, weirs, boats, supply delivery, personnel costs)?
10) In addition, most agencies, including ADF&G have Standard Operating Procedures (SOP) for many situations that should be reviewed during project planning.

In Southeast Alaska and northern British Columbia most Chinook salmon are designated "stream-type" (Healey 1991). Most stream-type Chinook spend one year as fry in fresh water before migrating to the sea as yearling smolt in the spring; a small portion emigrate after two years of rearing. After spending one to five years at sea, adults return to their natal river in the spring or summer, one to three months prior to spawning. In contrast, "ocean-type" Chinook salmon migrate to sea during their first year of life, normally within three months of emergence. Following one to five years at sea the adults return to their natal river in the fall, just weeks before spawning. Ocean-type Chinook salmon are typical of populations south of Alaska, although a few are found in Alaska, most significantly in the Situk River near Yakutat. We commonly refer to stream-type fish as 1-check (age-1.), and ocean-type as 0-check (age-0.) fish, in reference to the presence or absence of a freshwater check, also known as an annulus, on the scale.

Knowing the juvenile life history of the target stock is important in planning. For example; Chinook salmon from the Unuk River are almost all from a single freshwater age and near uniform size, overwintering one year as fingerlings (parr) and emigrating as age-1. smolt. The fingerlings are large enough (>55mm, typically 65-75mm) by October to be coded-wire-tagged, which allows us two opportunities to catch a given cohort, in the late fall and following spring. The number of fall fingerlings captured in the Unuk River from 1993-2002 averaged 35,703, and the average number of spring smolts captured was 10,308. Fall and spring capture methods are similar, with all fish captured in minnow traps. The cost of tagging a fall fingerling in 1995 was \$0.90/fish, which equates to \$1.20/smolt assuming a 75% overwinter survival. The cost of tagging a Chinook smolt in the spring of 1996 was \$3.00/fish, indicating in this case it is more effective to tag fingerlings in the fall (Jan Weller, Sport Fish Biologist, ADF&G, Ketchikan, personal communication). We tag this stock in both the fall and spring to achieve a goal of 30,000-40,000 tagged smolt emigrating each spring. This level of tagging allows us to estimate a full complement of population statistics with acceptable precision, including freshwater overwinter and marine survival, smolt abundance, total adult production and exploitation rates.

Tagging coho salmon fingerlings in the fall is usually not feasible because of their variable fresh-water residence. Coho juveniles may spend one, two or three years in freshwater before migrating to sea. In the fall, it is impossible to tell if coho juveniles are going to become smolt the next spring or remain in freshwater another year. Even in the spring, you need to be careful what you tag. Our coho tagging projects usually set a minimum size for fish smolt (as determined from previous years results) and fish below that size are not tagged. The minimum size ranges between 70 and 85 mm, while some projects in Southcentral Alaska set the minimum size at 50 mm. The spring smolt migration can provide very efficient trapping opportunities. Nearly 100% of the catch at smolt weirs and other projects that capture primarily outmigrating fish can be smolt (Massengill and Carlon 2004). Some good indicators that fish are smolt are similar behavior (mass downstream migration), appearance (silver skin pigmentation obscuring parr marks), migration timing, and narrow length distributions, while highly visible parr marks, less silver pigment, and purple sheen are indicators that the fish are not smolts. The tagging of migrating smolt verus presmolt enables estimation of marine survival without the added element of freshwater mortality.

The cost and number of tags per roll should be considered. Coded wire is sold in uniquely coded lots of 5,000, 10,000, and 20,000 tags and you can usually get about 10% more tags out of a roll. Partially used rolls can not be reused another season, so we usually try to tag in multiples of full rolls. A 10K roll costs about $900 and should never be cracked open for just a few hundred fish.

PERSONNEL

It is important that personnel on the project are knowledgeable of the methods and goals of the project, the conditions they will be working and living under and the skills they will need to successfully complete the project. Training should be completed prior to entering the field, if possible, or planned and continued during the field season. In addition to basic field skills such as first aid, firearm safety, boat operation and equipment maintenance, we also recommend swift water rescue training (Appendix C1). Berry (1996) coined the term SAFE, which is an acronym to remind the project leader to have the Skills, Attitudes, Facts, and Equipment needed to travel and work safely in the field.

EQUIPMENT

Equipment lists from previous seasons and similar projects should be examined for completeness and items should be identified that may need repair or maintenance well before the next season. Maintaining thorough equipment lists is one of the most important duties of project personnel, especially for projects in remote locations. It is important at the end of the season to make a list of equipment and supplies that are stored at a remote work site, as well as a list of any materials or supplies needed for camp repairs or improvements. These lists are indispensable when making preparations for the next year. Keep a file box containing equipment lists, an operational plan with crew responsibilities noted, data sheets, grocery lists, a first aid reference, a phone number list with emergency contact numbers and service manuals for all power equipment in camp.

SITE CONDITIONS

When setting up a project in a new location, campsite selection is best accomplished well before you are sitting in the woods with a pile of gear around you. Several factors should be taken into consideration when selecting a campsite.

Number one is safety. If possible, the site should be above the floodplain and away from major game trails, active cut banks, and unstable trees. Be aware that large trees, especially cottonwoods, can shed large branches or topple completely.

Who is the land manager? What permits are required, how long will they take to get, and what kind of operations and structures are allowed?

If you are conducting a CWT operation, you will need a place to set up net pens for holding fish. This location needs to be out of strong current for a wide range of water levels, yet close enough to camp so you can monitor the condition of the fish and possible damage to the nets from debris or predators. If there are no convenient locations with suitable current requirements for net pens, holding boxes with screened openings may be necessary (see below for details).

Location of the camp in relation to trapping or sampling areas should also be considered. Is the weir site easily monitored from camp? Is the tagging site close to camp? Can the parked boats be monitored from camp? Orientation regarding sun exposure or to prevailing winds are other possible considerations.

If you are returning to an ongoing project, a preseason scouting trip is advised. Check:

1) Are the tent frames still serviceable?
2) Is the site still accessible? If there are trees across the river channel that will need to be cut, will you need a permit to cut them?
3) Are stored materials still there?
4) Have there been major changes to the river that could affect capturing or holding of fish? Is the weir site still usable? Has high water eliminated habitat areas?

METHODS FOR CAPTURING JUVENILE SALMON

MINNOW TRAPS

Minnow trapping is an excellent way to catch juvenile Chinook and coho salmon. The traps most commonly used in our projects are Gee® minnow traps manufactured by Cuba Specialty Manufacturing Co[1] (Appendix A1). Minnow traps are composed of two galvanized wire-mesh baskets that fit together to form a trap. Funnels on the end of each basket with $^{7}/_{8}$ in openings allow smolts to enter the trap. The baskets interlock and fasten together with a wire clip. The traps are approximately 16 in long by 9 in diameter and come in two mesh sizes: $^{1}/_{8}$ and ¼ in (Figure 1). We use the ¼ in mesh size for trapping fingerlings (over 50 mm FL) and smolts. It may be a good idea to age new minnow traps in a pond or stream for a few days before use. We have found that new minnow traps are not as productive as traps that have been used for a week or more. The fresh galvanizing is the likely cause.

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

We have found that larger traps often catch more fish, especially coho salmon. A Gee® trap can be enlarged by inserting a wire mesh cylinder between the two trap halves. This roughly doubles the trap volume. However, using any number of these inserts becomes problematic when storing, transporting, or working with them in a boat, because they do not stack or nest, and are relatively fragile. Suitable traps larger than the Gee® minnow traps are not commercially available, so over the years we have tried a few custom designs. One earlier design mimicked that of the Gee® trap, consisting of two identical halves that connect together. These were used at Ford Arm Lake to trap juvenile coho salmon. They were over two ft in diameter and caught fish very well; however, these traps were very cumbersome to work with in a small boat. They were also difficult to handle when removing fish and when rebaiting.

Other improvised designs were simple large cylinders about 2 ft in diameter and 3½ ft long, with cone shaped entrances at one or both ends. We used three traps of this type in the Situk and Tawah rivers in the Yakutat area. They were used extensively for trapping coho smolts during emigration with impressive results in 2004. In one night, three of these traps baited with salmon roe captured over 3,500 coho smolts from an eddy next to a rotary screw trap that caught only a few hundred during the same time. The screw trap operation was abandoned in favor of the large cylinder traps.

The success of these traps inspired the most recent version that makes it possible to nest the traps, and stack one inside another (Figure 2). This is a very desirable attribute that conserves space when transporting, storing, and working out of a boat. These traps were built to trap coho smolt in the Yakutat area during the spring of 2005. The traps are shaped in a tall tapered cylinder like a tall wastebasket. They have a removable cone entrance at the large end, which allows the catch to be poured out, gives access for baiting, and enables the nesting and stacking of the traps.

We have also used large traps for cutthroat trout *O. clarki* with good success. They were a collapsible design made of Vexar® (a stiff plastic mesh) and put together with cable ties or laced together with cord. Large minnow traps can also be fashioned out of two five-gal buckets joined mouth to mouth and with the ends cut out and replaced with Vexar® funnels (Rob Massengill, Sport Fish Biologist, ADF&G, Soldotna; personal communication).

Large minnow traps in several styles are available from Aquatic Eco-Systems but we do not know anyone who has used them (Appendix C1). They also sell small plastic minnow traps, marketed as having a longer life than metal traps in alkaline, brackish or salt water.

There is a version of the minnow trap that is coated with black plastic. We have fished these side by side with the galvanized wire mesh version of the trap and found that the metal traps consistently catch more fish. Among the custom built large traps there have been versions made with galvanized wire mesh and versions with black plastic mesh. Both versions have fished successfully, however the wire mesh traps seemed to produce larger catches.

Minnow traps can also be used to sample fish in ice-covered waters. A hole just larger than the trap diameter is drilled with an auger and the trap can be lowered through the ice endwise. The string should be run out through one end of the trap so that the trap comes up endwise through the hole, rather than jamming sideways. Working on ice introduces completely new safety considerations (Berry 1996). You need to determine if ice conditions are safe and how much water is under the ice. Boring a hole in ice can be dangerous, especially with a 10 in ice auger.

A hoop trap is another version of a minnow trap. Hoop traps look like an oversize minnow trap but are collapsible and are covered with nylon mesh instead of wire or hard plastic mesh. Detachable plastic pipes, clipped to metal hoops in the ends of the trap, hold the trap open. The soft nylon mesh on hoop traps is less abrasive to the fish than wire or plastic mesh (Bob Chadwick, Sport Fish Biologist, ADF&G, Sitka, personal communication).

Running a Trap Line

Standard Gee® traps can be broken down and the baskets stacked one within the other for carrying or storing. Pushing the stacked baskets tightly together or laying them in sand can make the baskets difficult to separate. If a tall stack is set down hard this rams them tightly together. Before you start fishing, an 8 to 10 ft long line is tied to each clip. Neptune size 320 braided nylon leader material made by Sunshine Line & Twine Co. (available at commercial fishing supply stores; Appendix A1) is a good choice because it is very strong and its stiffness reduces tangles and twisting that is common with softer lines. The ends should be melted to prevent unraveling. Green line seems to be less likely to be chewed by beavers than white line. The line should be tied to the clip with a bowline pulled tight using pliers. A piece of bright colored surveyors tape or flagging should be tied near the other end of the line to mark the location of the trap. If someone on the crew is color-blind, blue flagging can also be tied to the lines. Sometimes it may be necessary to remove the flagging if bears start destroying traps. In lakes and ponds, a float can be used instead of flagging. Doughnut shaped PVC sponge floats have been used extensively for this purpose, (Memphis Net & Twine, Stock # SB4, 1½ by 3 in). These floats require painting with a white undercoat, and fluorescent orange works well as a topcoat. We usually put two flags on the first and last trap of each line as an aid to anyone checking the trap line. A GPS unit may also be used to mark the location of a group of traps and good trapping sites. This is especially useful in multi year projects in case of personnel change between years. (See Appendix D1 for GPS data collection procedures). Trappers should carry extra flagging, line, and trap clips when setting and checking minnow traps. Assigning names to trapping locations will help the crew to identify them and remember the locations. It is important to account for all the traps in your study area. If a trap is lost during high water, it should be marked as lost in the field notebook and the site flagged so the trap can be searched for during lower water levels. It is important to recover traps displaced by high water or lost through poor record keeping because they may continue to catch fish, re-baiting themselves as trapped fish die.

Traps should be set with the long axis parallel to the current, alongside of logs, or parallel to the bank in calm areas or in slow currents. Current running through the trap will stress fish, and may bury the trap with silt or debris. The trap should sit on the river bottom, not suspended from the twine or in a position where it will roll into the current. Tie the trap line to a branch or stake at least 2 ft above the water level using an over-hand knot followed by a slipknot. If this knot is cinched tight, it will hold during high water, yet it is easy to untie, even with gloves on, for quick trap retrieval. Be aware of changing water levels and set your traps accordingly. During quick rises in water level, it may be necessary to pull all traps from the river to avoid killing fish and losing traps.

Check the traps after they have been fishing a suitable period of time. Personal experience and a study by Swales (1987) indicate that in areas of moderate to high fish densities, maximum catches in a minnow trap are approached within one to two hours, with catches dropping off sharply when the traps are fished longer than 24 h between checks. Bloom (1976) estimated that

10 minnow traps fished 2 h caught on average, 57% of the coho salmon and Dolly Varden *Salvelinus malma* in a small area. Water temperature, current speed and bait quality can affect this. On many large river systems where 75 or more traps are fished over several miles of river, 24-h checks may be the only practical interval.

When checking the trap line first fill a five-gallon bucket with water and have a container of bait close at hand. Lift each trap from the water and tip it to move the fish into one end. Separate the two halves leaving the clip attached to the empty half so it can be easily retrieved if it should fall into the river. Pour the fish from the trap half into a bucket of water. Throw the bait into the river so it does not foul the water in the bucket or attract animals to your trap line. Do not attempt to count each individual fish of each species, but try to get an estimate of the target species so that trends in catch rates can be noted. These numbers will indicate when an area is fished out or if a site is worth trapping based on your capture goal and the average catch per trap. These numbers can also indicate when a migration has begun and help you plan a trapping strategy. The idea is to get a catch estimate of the target species and to **get the fish back into the water as quickly as possible**. Sorting out large Dolly Varden and sculpins *Cottus spp.* on site can reduce salmon mortalities in the net pens. When sorting is frequent or when other species are being enumerated it is effective to pour the catch immediately into a shallow pan, such as a plastic dish pan, containing one or two inches of water. This is a gentler means of sorting and allows more time for sorting and estimating the catch. Record catch estimates for each trap line in a field notebook. Rite in the Rain™ makes a handy, waterproof notebook (Appendix A1). A standard method of notation in the trap-line field book should be followed when recording daily trapping effort and catches (Table 1).

Table 1.–Example of trap and catch data in field notebook. This tracks the number and location of traps and estimates the number of tagable fish.

Area	To Check	Set	Pulled	Missed	Traps Remaining	Fish	Comments
Spruce Row	10		2	1	8	60	
Moose Bar	7	2			9	50	
King Jam	3	3			6	25	

According to the above notation, 9 traps were checked at Spruce Row (one trap was not checked), and two of the traps were pulled because of poor catches, leaving 8 traps on that line. Approximately 60 fish were captured there. At Moose Bar, 7 traps were checked and caught 50 fish. Two more traps were set on that line, leaving 9 traps there. Daily trapping effort (traps checked) and estimated catches are recorded on a summary form at the end of each day.

An alternative method of data recording focuses on the number of fish caught by species and trap (Table 2). Pouring the catch into a shallow pan of water is essential for this method allowing time for counting and sorting by species. Each trap checked is recorded on a numbered row with columns for the target species that are the size range to be tagged, for those too small to be tagged, and other species.

Table 2.–A second example of trap and catch data in field notebook. This tracks all catch by species and has less information about trap locations.

Trap	Coho	Fry	SB	DV	Other
1	17	3	20	-	3CT
2	11	3	20	3	3CT,1RB
3	2	2	15	-	6SC

Table 2 is an example from a Ford Arm Lake field notebook where all species are recorded. The target species as well as the most commonly occurring species appear in the headings. Species that occur less frequently are detailed under the "Other" column. When using short-hand or abbreviations provide a key to the meanings inside the cover of the field book so that it can be clearly understood by other readers. In this example the following key was included:

Coho = coho > 61mm (size to be tagged).
Fry = <62mm (too small to tag, released).
SB = sticklebacks.
DV = Dolly Varden.
CT = cutthroat.
RB = rainbow.
SC = sculpin.

It is a good idea to deploy some water temperature loggers in areas where juveniles rear and overwinter. Water temperature records along with age, weight and length data (AWL) may be useful in estimating juvenile survival and growth rates. The Hobo® Water Temp Pro v2 is inexpensive, can be downloaded quickly in the field and can collect daily temperature data for several years. The data loggers must be securely attached to shore or a tree and the location well documented.

Bait

Our preferred bait consists of 1 in to 1½ in diameter chunks of salmon eggs. Hamburger, canned cat food, salmon flesh, canned corn, shrimp and sardines have also been used successfully but salmon eggs are the most widely used (Shepard and Ginetz 1978). To prevent the possible spreading of disease we recommend that if the eggs are collected from out of the watershed that the chunks be treated, by soaking for 15 mins in an organic iodine-water solution (Al Didier, ADF&G Pathologist, Memorandum to Paul Kissner 1979). Use 4 oz. of Betadyne™ per 3 gals water or 3 oz. of Wescodyne™ per 3 gals water (Wood 1974). Betadyne™ and Wescodyne™ are available at drug stores, hospitals or aquaculture suppliers. Stir the eggs frequently during the soak period. Disinfecting the eggs is not necessary if you are able to procure bait eggs from the river system that you are working on. Borax can be used to preserve bait without refrigeration in warm weather or to keep it for extended periods. Borax is available in the detergent section of most grocery stores. A 5-lb box of borax thoroughly mixed into a 5-gal bucket of cut egg clusters will preserve the eggs for up to two weeks. An alternative method that uses both a more concentrated iodine solution and borax produces a drier mix and can be frozen a year in advance (See Appendix H1 for recipe). Keep the bait as cool as possible to prevent spoiling. It is best to store bait in a cooler and out of the sun. Salmon eggs for bait are available from Petersburg Fisheries Inc. (Appendix C1) and other commercial roe processors or may be collected from various projects that sample adult salmon. Occasionally substandard roe is available for free from caviar producers. Commercial roe is usually available in 50 lb boxes or 5-gal buckets. Our crews go through about one gal of prepared bait per day per 100 trap pulls, or about 50 lbs per week/100 traps.

Salmon eggs attract bears. The bait must be managed conscientiously to minimize this potential problem. Avoid getting bait juice or smells on clothing or equipment or on the ground near camp. Frequently rinse the boat, tubs, buckets, waders, raingear, and anything else that comes into contact with bait. Old bait and bait juice should be disposed of in deep or flowing water. If a bear figures out that there are snacks in your traps, he can wreak havoc on your trap line. Bait containers should be covered with a lid when not in use. Ideally, at night or when camp is unattended, all bait and smelly bait containers should be consolidated in a cooler and hoisted 12 ft in the air using a block and tackle. By whatever means, the bait should be routinely stored out of reach of bears, martins, and other wildlife. Your crew should be familiar with the techniques of working safely in bear country and firearm safety. The ADF&G web site has a section on working and living around bears (ADF&G 2006).

Habitat Preferences: Where to Trap

Learning to recognize specific habitat preferences can greatly enhance the ability to target a particular species when trapping. Although rearing habitats for Chinook and coho salmon often overlap, it is possible to target either species by paying close attention to particular physical characteristics within those areas.

Fall Trapping Rearing Chinook Salmon

Habitat used by Chinook salmon fingerlings in the fall will have three main characteristics: cover, suitable current velocity and available feeding areas (Figures 3-6).

Cover is the most apparent characteristic and probably the most critical. The cover type most commonly utilized by rearing Chinook salmon in Southeast Alaska rivers is woody debris. This can be brush piles, root wads and fallen trees, or log jams of almost any size. It is important that the woody debris contact the riverbed. Floating debris with open area and current below does not provide adequate concealment opportunity or refuge from the current. If woody debris is scarce, remember that high densities of rearing fish can be found in certain debris piles and can provide good catches for several weeks. Rearing Chinook salmon will also utilize large gravel-cobblestone substrate for cover. Cobblestone bottoms provide cover in the spaces between the rocks. Although cobble is usually associated with fast current, these areas can be very productive in spring and fall when water levels are low and much of the woody debris has gone dry. It may be necessary to dig pits in the gravel to submerge the traps and drive a stick or picket into the ground to anchor the trap (Figure 7). A few sticks or bark laid over the traps will provide more cover and increase catches. It is critical to monitor changing water levels when trapping these areas as changes in water level can cause stress or death to fish in the traps.

Current velocity is the next most important characteristic. Traps must be set in eddies or other low current areas. A current of less than 20 cm/sec is preferred by rearing Chinook (Murphy et al. 1988). Cover such as large woody debris can be in the midst of very fast current yet still provide an ideal trap location in the calm areas and slow currents created by the obstruction. Care must be taken to place the trap in a calm pocket so that fish are not stressed while in the trap. Coho salmon prefer slower water than Chinook. They intermingle with Chinook salmon in areas of light currents and are found in high concentrations in the still water of side channels, sloughs, and ponds.

Rearing Chinook salmon feed on aquatic invertebrates that also inhabit the same areas of cover. Woody debris, cobblestone and gravel substrates are all excellent habitat for these insects. Gravel and cobblestone bars in slow current are heavily used by feeding Chinook, and minnow trapping these areas can be very productive. Braided channels are excellent areas to trap as long as some main river flow is entering the upper ends. Once the water levels drop to the point where the flow is cut off at the top end of the braid, rearing Chinook will abandon these areas until very late fall. Small tributaries entering the main river have not proven to be productive areas for trapping rearing Chinook. Scour holes that form around root wads of fallen trees during higher water levels are excellent trapping locations when the water level drops. Shallow gravel-cobble bottom lagoon areas are sometimes found along the rivers which can also provide excellent trapping, even in 4 to 6 in deep water. These areas tend to be warmer than the main flow, provide good feeding habitat, and cover is provided by spaces in the gravel. The coloration of glacial rivers also provides cover for these shallow areas. To submerge the traps you may need to dig pits in the substrate, as previously described, for gravel bar trapping.

Log jams can provide great trapping success even in deeper water (2 to 3 m). Some log jams, however, seem to be mainly inhabited by Dolly Varden. If you are having problems with Dolly Varden or trout entering the traps you can pinch down the funnel openings to exclude the larger fish (Figure 8). Use caution when venturing out onto log jams. Loose bark or slippery logs are common and the logs in many jams may be unstable or rotten. Trapping the edge of a jam reduces risk and can be quite productive.

Overall, when searching for Chinook rearing habitat, look for wider areas of the river valley where the river has room to meander about and cut new channels during high water events. There will be visible gravel bars and braided areas that have captured large woody debris (trees) washed down from upriver.

Traps should be checked at least once per day. If catches are good, more frequent checks may be effective. Up to 100 Chinook can be caught in a trap in 30 minutes, under favorable conditions. Minnow trapping seems to lose its effectiveness in late fall when water temperatures drop below 2°C. Bustard and Narver (1975) found that fish spending the winter in near freezing water have lowered metabolism and reduced food requirements. Hillman et al. (1987) reported that juvenile Chinook moved to different habitats when water temperatures fell below 4°C. We have observed that as temperatures and water levels drop in the fall, a general downstream movement of rearing Chinook occurs as they reposition themselves into overwintering habitat. One morning you may notice the river flowing with slush. That means it is time to go home.

Spring Trapping for Rearing Chinook and Smolts

Trapping Chinook in the spring is similar to fall trapping, until the smolt outmigration occurs. Low water levels and snow accumulation make getting to trapping areas difficult. Although the water may be only 1-2°C, fish are more active than in late fall. In addition, Chinook have moved back into some of the side channels they abandoned when water levels dropped in the fall. Average trap catches will be lower because of overwinter mortality and limited access to good trapping areas, due to snow depth, ice, and low water. Many sites, especially those located off the main river, tend to trap out quickly. We have had good success on the Unuk River by getting into the field well before the start of spring runoff and trapping all the accessible habitat before the fish start moving. There is much less woody debris in the water due to low river levels in the spring, and the glacial rivers are usually clear until the snow is mostly gone from the riverbanks. It provides a good opportunity to experiment with setting traps in atypical locations. For instance, setting traps under ice shelves can be effective. Murray and Rosenau (1989) documented upstream migration of juvenile Chinook salmon into nonnatal tributaries.

Once smolting starts and fish begin moving downstream, trapping should be concentrated on the main river channel. As with fall trapping, woody debris should be targeted (Figures 9–11). Long gravel bars on the inside of bends may also be productive sites for spring trapping. You may have to create pockets and provide sticks or bark pieces for overhead cover as in lagoon and gravel bar trapping. Catch rates can be very erratic during the smolt migration, so give sites a few days to see if they will be productive. Checking traps once per day is generally adequate, though during periods of heavy migration multiple checks may be worthwhile.

Trapping outmigrating Chinook smolt has not proven to be very productive on the Unuk and Chickamin Rivers. This could be due to the short distance between overwintering areas and the estuary. On the Taku River, a very large and long mainland river, smolt trapping has been very successful. This could be due to the combination of abundant upriver overwintering habitat and good holding areas for smolt on the lower river where trapping takes place, or the long outmigration from multiple subpopulations in this large river.

Trapping Juvenile Coho Salmon

Coho salmon juveniles can be found in a more diverse range of habitat types than rearing Chinook salmon (Bramblett et al. 2002). Coho will rear in lakes, sloughs, beaver ponds and small creeks. They are also found in the glacial main river habitat associated with rearing Chinook, usually in the calmer areas such as braided channels and large log jams. Although rearing coho are generally more numerous than Chinook, trapping them on the large mainland rivers is more labor intensive because few sites are directly accessible by boat. The best areas are off-river locations like beaver ponds, sloughs and pools in high water channels (Peterson 1982). Taylor (1988) found that at all water temperatures, juvenile coho salmon were more associated with cover objects and were found at lower average water velocities than were Chinook salmon.

Cobblestone and gravel substrate, which seems critical to defining rearing Chinook habitat, is not an important factor in locating rearing coho. Coho salmon are found in the same types of log jams, root wads and brush piles that rearing Chinook utilize, but in locations more removed from the main current. Trapping in lakes and ponds is similar to trapping calm areas and backwaters on rivers. Floats are used instead of, or in addition to, flagging to mark the end of the twine. Traps can then be set in shallows that are too distant to be secured to shore. In ponds, sloughs, lakes, and backwaters, the favored cover includes logs, root wads, and other woody debris. Coho also use the cover afforded by aquatic weed beds and near shore areas where rushes, sedges or horsetails grow out from shallow water. The most productive coho trapping occurs in shallows of about 1 m depth or less. Trapping at depths of more than 2 m is usually less productive and the catches of other species such as Dolly Varden and sculpins will likely increase. Care must be taken when trapping lakeshores with sloping bottoms because traps can roll and be lost in the depths. The trap will pull the small floats under. Set traps so that they lodge against obstacles, sunken woody debris or rocks, or set them perpendicular to the slope. Watch the trap settle on the bottom and see that it is not going to roll before releasing the string. When setting traps in shallow, weedy lakes or ponds, be aware that some areas can become anoxic, killing fish in the traps, especially on overnight sets. Be particularly cautious in areas with a noticeable abundance of orange colored algae.

The reduced current in typical coho habitat makes trap orientation less critical, except for traps rolling on sloping bottoms. In calm water, it is effective to place the trap snug against a log or a bank. This makes one side of the trap unapproachable and facilitates fish finding the trap entrances. This also orients the trap openings in the natural path of the fish since their movements tend to be parallel and near to banks, logs, or other structures. Unless trapping migrating smolt, traps need to be moved to new locations often because rearing coho utilize territories. Bryant (2000) estimated that up to 65% of all coho, Dolly Varden, cutthroat and rainbow trout *O. mykiss* caught at a location are taken in the first check of the trap. This was based on repetitive sets made during a 6 to 7 h sample period. When trapping smolt that are continuously moving through an area, a good trap location can be fished successfully for the duration of the migration.

Similar strategies are used to trap both Chinook and coho salmon smolt, the primary difference is each species' preferred habitat types. Investigate the feasibility of using spill traps, Wolf traps, smolt weirs or inclined plane traps for capturing coho smolts before committing to using minnow traps. Coho smolts coming out of lakes, backwaters or beaver ponds may be more efficiently captured by these methods.

BEACH SEINES

Beach seining can be used as the principle method of capture or as a way to supplement catches when high water makes minnow trapping ineffective. Seining has primarily been used in spring to target moving smolts, but it has potential for use during fall when juveniles are feeding in areas of large gravel and small cobble.

Seines can be obtained in any length and mesh size you may need (Appendix C1). Common sizes are 50 to 150 ft long, 4 to 6 ft deep with ¼ in Delta style soft nylon mesh. Small seines often have poles attached vertically at each end that are used as handles. Seines can be used in lakes, ponds, or almost any river where there are no snags, limited currents and concentrations of juvenile fish. Seining in a river may require heavier leadlines. On the Stikine River we are using 95/100 (95 lb/100 fathom) leadlines. Gravel bars protected from the full force of the river current are ideal for seining activity (Figure 12). Once a good site has been identified, you can clean out snags when the water level is low. If possible, avoid muddy and silty areas as they foul the net and stress the fish.

A seine is used to encircle an area containing fish and then is drawn carefully onto shore to concentrate the fish at the waters edge. A person stands at each end of the net in shallow water. If the seine is stacked in shallow water it is easier to pull into the river than from dry land. The person upstream wades out into the river, turns downstream, and tries to move fast enough to keep the seine from billowing out downstream. The net is then pulled toward shore trapping the fish. The net must be worked quickly enough to prevent the fish from escaping around the ends of the seine and the leadline must be kept on the bottom. In open areas, long stretches of shoreline may be seined by two people dragging the seine downriver with most of the net parallel to the bank and the upriver end hooked towards shore. If available, a third person can be used to help pay out the net from shore, to help remove any snags encountered, and carry buckets. A boat may be used to drag the seine while seining large or deep areas. Once the net is deployed, the ends of the net are worked onto the bank and the lead line is then pulled to shore. The fish can then be concentrated into a small section of the seine and transferred into holding buckets by hand or dipnet, or a section of the seine can be lifted into a tub of water and the fish sorted and released into the tub. Care should be taken not to fold the netting over onto the smolts to keep injuries and scale loss at a minimum. Also, watch out for warm water temperatures, both in the shallow water and in your holding buckets to minimize stress on the fish.

Smolts tend to move more at night, especially in clear water systems where predation by birds can be high (Groot and Margolis 1991). Beach seining after dark has been a very productive method to capture Chinook smolt in the Stikine River, even though it is a glacial and muddy river. Headlamps allow the crew to sort fish quickly in the dark. Running a boat on these rivers at night is dangerous, so night seining can only be conducted close to camp or in very well known sections of the river. Spare lights should be packed in the boat along with the usual safety and survival gear.

Bait can draw in higher concentrations of fish and can help to position them for easy capture. The "bait and seine" technique has been used successfully for the capture of both Chinook and coho salmon on the Situk River. Coho salmon were also captured with this technique in the silty bottomed estuary of the Ahrnklin River during the height of the smolt migration. Bait can be put in a weighted mesh sack or held in a minnow trap and allowed to soak for an hour or two, or loose bait chunks can be thrown into a current free area only minutes before making the set. If the bait is rigged with a retrieval line it can be reused as you progress down a bar or move to another site. Seining may be an effective technique on the large mainland rivers during fall tagging projects. Lister et al. (1970) seined juvenile Chinook salmon at night on the Big Qualicum River B.C. with good results. In the fall, on the Unuk and Stikine Rivers, we have observed juvenile Chinook in very shallow water along gravel bars at night. A purse seine fished from a 28 ft boat was successful in catching juvenile salmon and steelhead in the Columbia River estuary (Johnsen and Sims 1973).

SMOLT WEIRS

A weir is a fence-like structure that spans the entire width of a waterway. Water can flow through, but the weir obstructs the passage of fish. Weirs can be extremely effective at capturing coho and sockeye salmon smolt, however they are seldom used for capturing Chinook smolt in Alaska. It is impractical or impossible to operate a weir in the larger tributaries and rivers where Chinook salmon are found. A weir is only effective at capturing moving fish so it can only be used to capture outmigrating smolt. The time to install a smolt weir is the early spring when water levels are low and before the smolt migration has begun.

Smolt weirs can work well on small creeks and streams and are often located at lake outlets (Figures 13-17). A well-installed weir is capable of capturing nearly all of the outmigrating smolt. Weirs may require considerable initial investment in materials and labor, but once a weir is assembled and installed it can be operated quite efficiently.

The following is a generic description of a smolt weir installed at a small creek or lake outlet where no bedrock is encountered. Every weir location is different and requires certain variations in construction technique. Erosion prevention and preparation for high water are always important considerations and are often overlooked. If these issues are not dealt with at the outset, a project can turn into a disaster literally overnight.

Choose a site that is easily accessed, has stable banks, a firm gravel bottom, and is 2 to 3 ft deep at normal water levels. Begin weir installation by covering the entire area with erosion control fabric or matting such as Mirafi® to prevent scouring of the bottom and bank erosion that could defeat the weir. The covering should extend many feet upstream and downstream of the location of the structure. It should also extend high up the banks to cover the highest possible flood stage. All the edges of the covering should be completely protected with sandbags. A thorough scattering of sandbags should be applied to the area inside of this perimeter. While the water is low and sand and gravel is accessible, fill a pile of extra sandbags and stack them high on the bank. During high water additional sandbags are often needed, and by then the best bag fill material may be under 5 ft of water.

Sandbags are available in burlap and polypropylene. Burlap is not as tough but it is cheaper and biodegradable so recovering every last bag is not crucial. Polypropylene is durable and the bags can be used for several years if intact. If they are used more than once the plastic bags are more economical because burlap lasts only one season. The polypropylene bags are available in several colors. We have used brown or olive green to minimize the visual impact.

After the bottom covering is in place, a row of vertical supports are driven into the streambed through the center of the covered area. The supports may be steel fence posts or lengths of 1 in diameter black iron pipe. The supports are spaced several feet apart as needed and are driven with a fence post driver or a sledgehammer. A fence post driver is both easier and safer to use. Panels covered with plastic mesh or perforated metal plate are then strung across the upstream side of the vertical supports (Appendix C1). The mesh size or perforations on smolt weir panels is typically ¼ in or $^{3}/_{8}$ inch. After the panels are in place, stakes are driven into the streambed about 20 ft directly upstream of the support posts. A taut rope connects the tops of the support posts to the stakes near the stream bottom. The stakes provide essential reinforcement when rising water and debris accumulation increases pressure on the weir. Nass (1997) describes the installation of two hinged panels in the wings of the fence for emergency release of water during floods.

A trapping device incorporated into the weir directs the smolt into a holding box. The method chosen for a particular site will depend on the current velocity, gradient, depth, and other factors. Inclined plane traps, fyke-faced trap boxes, and fyke funnels of netting are a few of the devices that have been used in weirs. In some situations simply installing a pipe in the weir face has worked to direct smolt from the weir into a holding box (Figures 13-15). The holding box should have screened panels to allow water circulation but should also provide refuge from current and protection from predators. Concentrations of smolt inside a holding box are very vulnerable to predation by birds, mammals or other fish. Any lid discourages birds, but deterring otters, minks, and weasels requires a solid, sturdy lid that can support the weight of multiple otters. The lid should have a latch or be sufficiently heavy to prevent animals from opening it. It is difficult to achieve the ideal balance between allowing smolt easy access to the trap's holding box and discouraging access by predators. Various combinations of entrance height and wire barriers have been tried and all have limitations. Providing a refuge from predators inside the holding box has been the most effective measure. A sturdy slotted panel divides the holding box space into two parts. The panel, a stout grid that will not "gill" fish, allows smolt to pass through to safety while excluding larger creatures that might like to eat them. A holding box that floats with changing water levels is ideal.

Regular weir maintenance includes periodic inspections for torn screen or gaps in skirting and panel joints. The bottom and the banks should be inspected for scouring, especially during or after high water events. A mask and snorkel is handy for getting a good look under the surface. The weir should also be cleared of debris routinely to relieve pressure on the weir and to prevent water from backing up. A stiff bristled brush or push broom is useful for removing algae and fine aquatic weeds.

Many weir adaptations have been devised. On very small creeks a fyke net with wings is portable and simple to install. At sites with greater than average water forces, a weir can be constructed in a V or W shape. The adjacent legs of this arrangement can be cabled to each other to strengthen the entire setup (Conlin and Tutty 1979). Dempson and Stansbury (1991) had good success in capturing Atlantic salmon *Salmo salar*, smolt with a partial weir constructed from adult weir materials. Because only a portion of the river was blocked off, the likelihood of washouts was reduced. A similar set up might work in a river with boat traffic where a full weir is not practical.

A smolt weir has been operated since 1992 at the Moose River, a tributary of the Kenai River in Southcentral Alaska. Coho salmon are abundant in this small stream and the operation is set up for high production. As many as 10,000 coho salmon smolt have been tagged in one day, and 169,000 in one season (Carlon 2003). The Moose River weir consists of a series of overlapping rectangular panels. The panels are aluminum frames covered with ½ in Vexar® mesh. Each panel measures 4 x 8 ft. A 1 ft wide skirt of Vexar® extends beyond the frame of each panel along the length and width and seals against the stream bottom and against adjacent panels. Panels are secured with bailing wire or cable ties to one another and to vertical support posts that are driven into the streambed. Sandbags placed along the bottom of the panels secure the bottom skirt and seal openings along the bottom.

A smolt weir has been installed and operated at Hugh Smith Lake in Southeast Alaska almost every spring since 1980 as part of long term sockeye and coho salmon research projects (Figures 16 and 17). The weir is positioned in moderate current flow near the outlet, before the lake necks down to stream width. At that point the span is about 150 ft wide and 8-10 ft deep in the center (at normal water level).

The deep portion of the smolt weir consists of 8 rigid 10-ft wide panels, supplemented by lighter Vexar® fencing on the shallow edges. The panel frames are constructed of 3 in ABS plastic pipe covered with ¼ in mesh Vexar®. The Vexar® is attached to the plastic frame with aluminum strips and pop rivets. The plastic pipe is sparsely perforated with $^{3}/_{8}$ in holes, to allow it to flood with water and reduce its buoyancy. The vertical sides of each panel has 2 large eyebolts. A 10 ft length of ¾ in steel conduit inserted through the eyebolts serves to pin the panels together. The plastic panels are supported by a cable stretched across the outlet 2 to 4 ft above the water level. Some panels rest on the outlet bottom, leaning back with the current, and others are suspended entirely from the cable. Sandbag anchors upstream of the weir secure ropes that run under the panels and are tied to the cable. This arrangement keeps the panels leaning at the desired angle of 10 to 20° from vertical. Eyebolts on the tops of the panels are attached directly to the cable with ropes, or with shackles when possible. Additional Vexar® extends beyond the edge of each panel frame by about 18 in on one vertical edge and by 3 to 8 ft along the bottom edge. The overlapping vertical flap serves to seal the joint between the panels where there is a 1 in gap either side of the steel conduit "pin". The flap is secured to the adjoining panel with cable ties. The wide skirt along the bottom edge is spread out on the outlet bottom and sandbags are used to hold it in place; this seals against the uneven bottom under the panels and also anchors the bottom of the panels in place. The Vexar® panels are very tough and have lasted many years. Holes are easily patched with small pieces of Vexar® and plastic cable ties.

The shallow water between the shore and the ends of the panel structure is closed off by installing a line of vertical stakes at about 4 ft intervals and securing a fence of ¼ in Vexar® to the stakes with cable ties. Lengths of ¾ in galvanized conduit are supported by the main cable and a supplemental rope. The mesh is placed so that a narrow strip lies flat on the lake bottom where a line of sandbags can be placed. The top edge of the mesh is secured to the stakes with cable ties.

The weir structure leads outmigrating fish to an inclined plane trap near the center of the structure. The inclined plane and the holding box are supported by floating pontoons made of styrofoam and plywood. The float is held in position by part of a wood panel that extends about a foot on each side of the trap on the upstream side of the weir, which allows the trap to move up and down with changing water levels. The floating trap is also secured to the main cable with ropes. The area under the trap is sealed by a smaller stationary panel the same width as the trap structure, which is held in place by eyebolts and conduit pins. A wood frame attached to the trap on the upstream side of the weir seals between the stationary panel and the floating trap. The wood frame supports a mesh skirt that overlaps to the sides and at the bottom, and is free to slide up and down. The wood frame is connected to the mouth of the inclined plane with nylon netting. A floating walkway made of Styrofoam logs and plywood provides access between the trap and the tag shed. The entire weir can be installed in three days by three people, and can be operated by two people.

A consideration that is often overlooked in smolt weir design is the need to accommodate movement of non-targeted species. At Hugh Smith Lake weir, adaptations have been necessary to provide for steelhead *O. mykiss* traveling upstream as well as steelhead kelts traveling downstream. There are also periods when large schools of outmigrating Dolly Varden and steelhead smolt accumulate above the weir. Because these species are larger than salmon smolt, they are more hesitant to pass through the shallow water of the inclined plane as they head seaward. A tunnel door installed near the bottom permits upstream passage of steelhead. The tunnel can be opened or blocked with a dip net as needed. A narrow panel with sliding 1 x 2 ft Vexar® screens makes it possible to allow large numbers of Dolly Varden or individual steelhead kelts to pass downstream.

At extremely low water smolt have trouble finding the trap entrance. A layer of plastic sheeting that directs current to the trap entrance has proven very effective during low water.

SPILL TRAPS

Spill traps have been used very effectively for trapping outmigrating coho salmon smolt (Elliott 1992; Figures 18-22). Properly installed in a good location a single trap can catch several thousand smolt per day during the height of migration. Spill traps are a very efficient means of catching coho smolt in terms of the ease of installation and the minimal daily service time needed. The use of this trap design is limited by the need for at least a few inches of step in water level (head) provided by a beaver dam or perhaps a sandbag dam to function. This creates a rapid current that deposits the smolt into the holding box and discourages their exit. Another limitation is that it is only useful during the time of fish migration because its passive action depends on the downstream movement of fish. These traps work especially well for coho smolt because beaver ponds are often excellent coho rearing areas and may support them in high densities. In addition, beaver dams are ideally suited for spill trap installation providing both a concise outflow and the required head. The trap may be useful for work with other species as well; notable numbers of sockeye salmon smolt, Dolly Varden, and cutthroat trout have been captured in conjunction with the coho smolt migration.

A spill trap consists of a dewatering trough and a floating holding box joined by a length of flexible 4 in corrugated plastic drainpipe. The trough mouth is installed in a spillway to take in the flow. It may sit directly on the sticks and mud of the dam; or a sandbag bed may be used if it sits too deeply. The outflow end of the trough is supported by 2 x 4 in stakes driven along either side of the trough with a cross support fastened under the trough forming an "H" arrangement. The trough should rest nearly horizontal; too much slope causes the fish to be agitated before they find their way into the pipe. The holding box should be designed to float so that it functions properly despite changing water levels, which eliminates the need for frequent adjustments.

The trough and the box must have lids to provide cover for the fish and prevent predation. Troughs have been targeted by minks and weasels as desirable "fishing sites". When this has occurred 1 x 2 in wire mesh was fitted at the front of the trough to prevent the animals from getting inside. Smolt will pass through this mesh if it is kept clear of debris. It is fairly common to have issues with a resident beaver. If undeterred, a beaver may completely plug the trough with sticks and sod night after night. To solve this problem a beaver guard may be installed. This is a small corral, 3 or 4 ft diameter of heavy duty 2 x 2 in wire fencing held by two or three stakes that encompasses the mouth of the trough.

It is typically necessary to block some areas of flow to concentrate the outflow of water and migrating fish to one or two locations where traps can be installed. Small channels are easily blocked with a few sandbags. If pond outflow volume is greater than one or two traps can manage, other spills can be allowed to flow. They can be fenced-off using ¼ in Vexar® to prevent escape and direct smolt toward the traps. Extensive leaky areas can be efficiently secured by fencing off a section of the pond perimeter.

It is best to place Vexar® fencing 1 or 2 ft up-flow of the crest of the dam. This allows a greater area of screening to function so that it withstands a greater amount of debris before becoming plugged. It also puts the fence in a slow current environment. If screen is used near the dam crest in fast flow, small pockets can form where fish are trapped against the screen and cannot escape the current. A screen fence is built by driving 4 ft long vertical stakes at 2 to 3 ft intervals. A length of ¼ in mesh (4 ft wide) Vexar® is placed on the upstream side with 1 ft of the bottom forming a skirt that lays flat against the bottom the remainder forming the vertical screen. There should be 6 to 12 in of screen above the surface of the water. The top edge of the screen can be secured to the stakes with cable ties or bailing wire. The skirt needs to be held down tight to the bottom with sandbags. If the bottom is flat a bag every 3 ft is adequate. Sand bags can be tied to the stakes by a length of twine if the bottom is sloped and they tend to slide off the skirt. It is efficient to place fences as straight as possible rather than be guided by the convolutions of the pond perimeter. A straight run of fencing is easier to install and will have fewer spots where billowing or crumpling require additional sand bags.

Turbulence in the trough or in the box can cause stress or scale loss. If fish eyes are cloudy, like cataracts forming, it is likely caused by abrasion resulting from turbulence. The trough should be nearly horizontal so that there is a peaceful current just ahead of the pipe where the fish can pause and be gently guided into the holding box. High flow into the holding box can cause turbulence or whirl pools. This can be eliminated by placing a 90° pipe elbow on the pipe end inside of the box, or by installing a baffle or divider inside the box. Overcrowding must be avoided. The box should be checked each day and sometimes two or three times per day as needed to accommodate the fluctuations of fish movements. The box must be inspected for adequate water circulation. Poor circulation can result from beavers blocking off the trough, from low water conditions, or when the screen sides get clogged with debris. Stress from overcrowding or low oxygen levels may be indicated when fish are abnormally dark or crowd near the water surface.

In addition to collecting fish from the box, the installation requires daily inspection and maintenance. All screening and wire mesh needs to be cleaned of debris to keep water flowing freely. The dewatering screens of the trough and the screen sides of the holding box are especially important. Beaver or mink guards must be cleaned regularly.

If the trap is stored in a field location, the trough should be tightly tied upright to a tree trunk so that it is not in a position to be easily crushed by snow load or a meddling bear. The holding box should be stored upside down or on its side so that it does not pool water during the winter and suffer ice damage. It should also be tied tightly to a tree so that is not moved by wind, water or wildlife. If the traps are built of wood they should be secured with blocking underneath so that they do not rest on damp ground.

FYKE NETS

A fyke net is a mesh cone or series of concentric cones that lead into a cod end or to a live box (Craddock 1961; Hare 1973; Conlin and Tutty 1979; Davis 1980; Figure 23). Usually net wings or leads are affixed to the opening of the fyke and these wings are staked out angling upstream from the mouth of the fyke net to help funnel migrating fish into the trap. Milner and Smith (1985) describe a floating fyke net designed to rise and fall with varying flows. The wings were loosely attached to floating logs. Fyke nets can also be tied off to bridges or placed in culverts (Zafft 1992).

They are also easily adaptable for fishing in lakes or backwaters. When fished in still water, the fyke net usually has a single lead that extends from the fyke directly to shore. The lead is anchored to the shore at one end. The other end is attached to the center of the fyke mouth leaving half of the mouth open to either side of the lead net. This allows fish moving either direction along the shoreline to be guided to the mouth of the trap. Fyke nets in lakes or ponds can be baited to increase catches. Due to the large funnel openings on most fyke nets, the bait should be placed in mesh bags to prevent fish from taking it out of the trap. On rivers, fyke nets need to have holding boxes attached to them where captured fish are protected from the current.

ROTARY SCREW TRAPS

A screw trap consists of a cone covered in perforated plate that is mounted on a pontoon barge (Kennen et al. 1994; Figure 24). Within the cone are two tapered flights that are wrapped 360° around a center shaft. The trap cone is oriented with the wide end facing upstream and uses the force of the river acting on the tapered flights to rotate the cone about its axis. Downstream migrating fish are swept into the wide end of the cone and are gently augured into a live box at the rear of the trap.

Typically one or more winches are used to adjust the fore and aft elevation of the trap. A small drum screen, powered by the rotating cone, is located at the rear of the live box and removes small floating debris from the live box but sticks and branches usually have to be removed manually. The most common sizes are 5, 8, and 12 ft diameter cones. Five and 8 ft models can be assembled and moved easily by three or four people. The 12 ft models are much more difficult to assemble and move. The screw trap is tied off to shore using a cable and held away from the bank by one or more boom logs. Mesh wings attached to the front of the screw trap, like the leads on a fyke net, can help funnel fish into the trap. Screw traps are also very effective for capturing outmigrating salmon fry and sockeye salmon, which are not attracted to baited traps. Two screw traps operated on the Chignik River captured over 450,000 sockeye salmon smolt in two months (Perez-Fuentetaja et al. 1999). Screw traps are often used to estimate the emigration of smolt either with mark-recapture estimates or by estimation of trap efficiencies (Roper and Scarnecchia 2000).

Debris can be a serious problem with screw traps and must be removed often. On the Taku River a gasoline water pump and short fire hose was used to clean the traps, sometimes as often as every hour (McPherson et al. 1997).

Water velocity, depth, and proportion of the flow screened are important considerations for trap placement (King and Breakfield 2002). Velocity is an especially important consideration when targeting strong swimming species such as steelhead trout, and becomes less important when trapping newly emerged fry. For most species, water velocities of at least 1 m/s are desirable for screw trap operation and over 2 m/s may be required to capture and retain most steelhead smolts (Seiler et al. 1981). Screw traps should rotate at least 5-6 rotations per minute (RPM) for retention of larger smolts. RPM should be recorded to get an idea of flow. Some projects also record water temperature, flow, turbidity, time of day and phase of moon to try to determine what triggers migration (Demko et al. 2000). Care must be taken that the water depth under the trap and live box will be sufficient over all flow conditions expected during the outmigration period. Traps are most effective at sites where a high proportion of the total flow can pass through the trap. The need for adequate velocity and depth usually argues for placing the trap in the main flow of the channel. Screw traps are inherently noisy due to the rotation of the trap about its central axis. Migrants will avoid a trap if they are aware of its presence; therefore, it is best to select a site where the trap noise can be masked by other stream noise such as a nearby riffle or water sifting woody debris. Great care must be taken when trying to move large screw traps in river currents. The Washington Department of Fish and Wildlife website has good examples of many projects using screw traps and incline plane traps (WDF&W 2005) and the American Fisheries Society is publishing a new book that has detailed chapters on the use of incline plane and rotary screw traps to estimate salmon production (Johnson et al. *In prep*). They are also used extensively in the Sacramento and San Joaquin River systems in California (USFS 1997; Demko et al. 2000).

We have found that success with rotary screw traps is, in large part, dependent on the proportion of the river volume funneled through the traps. For example, in 1992 about 60,000 coho smolt out of an estimated outmigration of 612,000 were captured in two 8 ft diameter traps on the Situk River, a moderate sized stream near Yakutat (Ericksen and McPherson 1997). About 10,000 of an estimated outmigration of 116,000 coho smolt were captured in 1998 in a single 8 ft screw trap on the Naha River, a small system near Ketchikan (Freeman 2003). In contrast, on the Taku River four rotary traps, two 8 ft and two 12 ft, produced annual catches of about 10,000 coho and 10,000 Chinook smolt between 1991 and 1996, out of estimated smolt migrations of 1-2 million fish (McPherson et al. 1997). The use of rotary screw traps on the Taku was abandoned in favor of minnow traps. Fishing 200-300 minnow traps for about eight weeks has produced catches of 20,000 to 50,000 of each species (Yanusz et al. 2000).

INCLINED PLANE TRAPS

An inclined plane or scoop trap is a stationary box trap that is fished on bottom in shallow water or as a floating trap in deeper areas of rivers (Figure 25). Like the screw trap it is used in medium to large rivers and functions best at flows in excess of 0.5 m/s. The front opening of the trap has a perforated aluminum ramp that lets water flow through but forces migrating smolts up the ramp and over a lip into the holding box portion of the trap. The ramp on the front of the trap is adjustable so that it can be raised or lowered to maintain ½ to 1 in of water flowing over the top lip of the ramp. In some traps, a drum screen powered by a paddle wheel has been used to remove debris from the live well (McLemore et al. 1989).

Water velocity through the trap must exceed the swimming speed of the target fish. As swimming ability is directly related to body length, higher velocities are required to trap large migrants. Fry (<50 mm FL) may be captured at relatively low velocities, while trapping the larger migrants, such as steelhead smolts (up to 250 mm), requires velocities of more than 2 m/s (Seiler et al. 1981). At less than optimal velocities, larger migrants may avoid or swim out of the trap. If velocities into the trap are excessive, the screens require more frequent cleaning, as a greater volume of water is being strained. Todd (1994), Conlin and Tutty (1979) and Meehan (1964) cover construction, installation and maintenance of the inclined plane trap very well. Reported efficiency of inclined plane traps for sockeye salmon in three Southcentral Alaska rivers varied from 6.5 to 12.5% in streams with flows of 5-60 m/s (Todd 1994). Dubois et al. (1991) describes an adjustable screen inclined plane trap for highly variable flows.

A large scoop trap was operated on the Taku River in the early 1960s in the same vicinity as the screw traps were operated in the 1990s. It was fished 24 h/day and cleaned every 2 h from April 13 to June 15, 1961, with total catches of about 1,000 Chinook and 2,000 coho smolt (Meehan and Siniff 1962). Peak activity of Chinook smolt was during the early morning hours (0200-0600).

Both scoop and screw traps may require cables across the river that could pose a navigation hazard. Signs may be needed to warn river users how to avoid the trap (Demko et al. 2000). Flashing lights improve visibility and log deflectors help prevent large woody debris, dogs, people, etc. from entering the trap. Theft and vandalism are also a concern if left unattended in populated areas.

WOLF AND FAN TRAPS

Wolf traps are similar in function to inclined plane traps but are adapted for use at barriers i.e. dams or weirs at the pool riffle break in a stream (Wolf 1950; Lister et al. 1961). On Slippery Creek, west of Petersburg, AK, a Wolf trap has been used successfully at the top end of a fish ladder (Beers 2003). The fish are directed to an opening in the dam or weir and pass downstream over a perforated metal ramp that drains off most of the water yet lets the fish drop into a holding box with little current present. A skimmer located in front of the opening helps prevent floating debris from clogging the ramp. Fan traps are another variation of the incline plane trap usually used in a more permanent type of weir (WDF&W 2005). Fan traps have been used for many years at the Auke Creek, AK, weir to capture the entire outmigration of smolt and fry.

TRAWLS

Some projects in California have used trawls to capture juvenile salmon. The projects are primarily aimed at documenting relative abundance and distribution and not on capturing a large number of fish for tagging (McLain 1998; Brandes et al. 2000; USFWS 2006). Trawls and townets are often used to sample juvenile sockeye salmon in lakes, but the numbers caught are usually low and mortality high.

SUMMARY OF CAPTURE METHODS: PROS AND CONS

MINNOW TRAPS

Pros:

Minnow traps are an efficient method of capturing freshwater rearing juvenile salmonids. The traps can be used effectively in ponds and lakes, as well as on any size river or creek. Twenty-five minnow traps can be easily carried on a pack frame while working on small, unnavigable streams or backwaters of large river systems. One person can easily set and check a series of minnow traps. The funnels can be pinched down to exclude larger, non-target fish species. They are cheap and portable.

Cons:

Minnow traps are very susceptible to changes in current speed when river levels change; the traps get pushed out of position or the entrapped fish are subjected to greater stress. Minnow traps do not catch juvenile sockeye salmon or chum and pink salmon fry effectively. Minnow traps are size selective against very small or very large juveniles. The use of bait in minnow traps can attract bears, otters and even wolves. These animals, lacking the skill to open the clips on the traps, destroy them. Minnow trapping is labor intensive, especially on big rivers. Lost minnow traps can continue to capture and kill fish until they silt in, rust away or are crushed by river action (Hubert 1996).

BEACH SEINES

Pros:

Beach seines can be a very efficient method of catching large numbers of juvenile salmonids. They are also effective on other species that are not attracted to baited minnow traps, such as white fish, *Coregonus sp.* and sockeye salmon. You can purchase or make seines in just about any length or depth you need. Smaller seines are easy to move around on a pack frame and can be used by a two-person crew. Larger seines are stackable in boats and can be set from the boat in deep water. Seines can be used regardless of water level, provided you have a clear stretch of beach to seine along. Any size water body can be seined. Beach seines are inexpensive.

Cons:

The efficient use of beach seines requires concentrations of fish and areas free of snags. Large seines are very heavy when wet so a boat or ATV is needed to transport them any distance.

Scale loss is common on smolts captured in seines. At least two people are necessary to conduct a seining operation. Seining can be size selective (Lister and Genoe 1970).

Smolt Weirs

Pros:

Smolt weirs can catch virtually all of the smolts coming out of a lake or small river system. An efficient weir can eliminate the need to sample adult returnees for estimating smolt production numbers and tagging fractions. They are low maintenance much of the time. A boat may not be necessary to set up or maintain a weir. Camp and tagging operation can usually be set up right at the weir site, eliminating the need to transport fish. Tagged fish can be released below the weir, eliminating recaptures. Once installed, the maintenance and operation of a smolt weir is easy for a two-person crew under normal conditions.

Cons:

Smolt weirs are large and expensive to setup and operate. Boats, planes, helicopters or ATVs are often required to transport the weir materials to the weir site. Initial cost of a smolt weir is much higher than most other capture equipment. Smolt weirs can require 24 h monitoring during rising water periods, when the debris load increases, and when large numbers of fish are migrating (often at night). Smolt weirs are not an "eight to five" job. Diving suits and boats are needed in deep water to inspect the weir for scouring, positioning sandbags and cleaning the weir. Weirs can cause significant bank erosion. Smolt weirs must be maintained throughout the entire migration if the goal is to tag all the outmigrants. Smolt weirs are usually very difficult to maintain on large rivers. Smolt weirs catch all sizes and species of fish. This can lead to large fish preying upon smolts in the holding box. It may be necessary to make special provisions for passing certain fish such as steelhead kelts.

Spill Traps

Pros:

Spill traps are low maintenance; two people can set up and run four or five for a season. They are not very susceptible to changing water levels. They can catch lots of fish with very little effort. They are not size selective. Properly installed and maintained they cause almost no injury or stress to the fish and require minimal handling of the fish.

Cons:

The greatest drawback is that there are limited locations where a trap can be installed due to the requirement of a step in water level such as that provided by a beaver dam; they only catch migrating fish. Spill traps are bulky, a boat or an ATV may be needed to get them near the site. They can be carried by hand for only short distances. They are not commercially available and may have to be custom built.

Fyke Nets

Pros:

Fyke nets are affordable, portable, and can be adapted to fish a variety of water conditions. They are easily installed, removed, and transported.

Cons:

Fyke nets are difficult to clean and can be damaged by large drifting pieces of wood. The nets are difficult to use in fast current. A holding box is required when used in flowing water situations, otherwise the device may cause scale loss and stress.

ROTARY SCREW TRAPS

Pros:

They can be effective on small to medium size streams; may be cleaned relatively quickly (Thedinga et al. 1994; Freeman 2003). Once installed, they are not very labor intensive or affected by normal water level changes. Screw traps are effective during the smolt outmigration. The funnel can be raised up out of the water for cleaning or during periods of heavy debris load in the river. Mesh wings can be attached to increase efficiency. They provide information on migration timing and triggers.

Cons:

Screw traps are very site specific. They need to be located in a steep banked fairly deep location with enough current to turn the rotor. The whole apparatus is bulky and heavy, requiring three or four people to move it to a site and set it up. You may need to install deflectors upstream of the trap if the river is subject to logs floating down during higher water levels. The trap may need to be modified to keep predators out of the holding box. Fry can be forced against the cleaning drum and be rolled out of the trap. Larger smolts may avoid the trap causing some size selectivity. The action of these traps can inflict significant mortality if operated under conditions of high RPMs and high debris loads. They can catch a lot of debris due to the necessity of having to locate in the main current. Screw traps are very expensive and not very portable. When parts wear out they can be difficult to obtain and difficult to install. The trap, especially with additional net wings, can present an obstacle to navigation.

INCLINED PLANE TRAPS

Pros:

Inclined plane traps are effective on small to large rivers. Two people can install a small one. They are easy to maintain once installed. Floating plane traps can be used in variable water levels and velocities. They do not inflict significant numbers of mortalities. Inclined plane traps can be very effective for capturing sockeye, pink and chum salmon juveniles.

Cons:

A helicopter may be required to transport parts to remote sites. Larger smolts may be able to avoid the trap (Carlon and Hasbrouck 1993). They may catch a lot of debris. The installation may present a hazard to navigation.

WOLF AND FAN TRAPS

Pros:

These traps are very effective at straining lots of water and capturing a high percentage of the outmigration. They are durable and easy to use, once installed.

Cons:

These traps are very site specific and are primarily used at permanent structures. Initial construction is expensive and labor intensive. Significant scale loss and mortality can occur.

TRANSPORTING AND HOLDING JUVENILE SALMON

Five gal buckets are commonly used for holding fish. Because they are easily carried they are used for tending traps, seining and other means of fish collection and transport. Buckets are also used to move fish from holding pens to the tagging operation. A bucket can hold up to 250 juvenile salmon depending on water temperature and fish size. When fish density is high the fish must be watched closely and the water needs to be refreshed frequently.

Modifications and techniques make buckets more useful for fish handling. One method uses a modified bucket lid and bucket. The bucket lid has an 8 in diameter circular screened panel. It is made by cutting a circle from the center and covering the hole with a piece of ¼ in Vexar®. It is secured by cable ties through ¼ in holes drilled around the perimeter of the circular cutout. The lid can be a screw-on type or it can be a regular lid that is secured by a bungee cord arrangement to allow quick removal and replacement (when using a regular lid do not press it firmly enough to actually snap it on). As a simple alternative to a modified bucket lid, a piece of ¼ in square mesh nylon netting can be stretched across the bucket top and secured with a band of bungee cord. A bucket can easily be modified to allow it to drain by drilling a series of holes about 2½ in below the lip and half way around the bucket, from handle attachment to handle attachment. The hole size should be ¼ to $^{5}/_{16}$ in and the holes should be spaced about ¾ in apart. This method allows the user, with the lid secured, to drain off much of the old water through the lid panel by tipping the bucket. The bucket can be refilled simply by dipping the tipped bucket into the water and allowing fresh water to wash back in through the lid. This type of bucket can also be used as a holding pen for longer periods or for refreshing the fish. The whole bucket can be laid on its side and submerged so that constant fresh water circulates through the large lid panel.

An alternative modification that serves a similar purpose uses a screen covered cut-out about 2 in high by 6 in long, ¾ the way up the side of the bucket. Water can be poured out through the opening and the bucket can be dipped to let fresh water flow in. Screens can be made from Vexar or wire mesh from broken traps attached with pop rivets.

It is often necessary to change or refresh the water in a large container. Buckets with screened lids are ideal for dewatering large containers of fish so that new water can be added. The bucket can scoop water while the screened lid prevents scooping fish. Use care when dewatering by this method. If the bucket bumps the side or bottom of the container it may crush a fish. Use two hands on the bucket, hold the handle and the bucket's bottom edge, and don't be in too big of a rush.

Modified buckets are useful for transporting fish long distances on foot because they are easy to refill with fresh water. Backpack frames have been used in certain circumstances to transport buckets of fish that are strapped on with bungee cord. This is not a recommended procedure because it is impossible to closely monitor and easily tend the fish. It is difficult to get a backpack on and off and would probably require using an airtight lid, which is never recommended except for the shortest of durations and with frequent checks. For long distance hauls it is best to carry a modified bucket by hand to allow frequent monitoring and water changes.

Larger containers are typically used inside a boat or at a tagging operation. Trash cans have been used but their size and shape is not ideal. Plastic totes (18 gal Rubbermaid®) and coolers with appropriate volume and dimensions are preferred. Buckets can be easily scooped inside of them, they have long straight sides for mounting the rigid aerator spray tubes, and they have adequate handles. Coolers have the added benefit of keeping water cold on warm, sunny days.

In large containers aerators offer a tremendous advantage when large numbers of fish are being held or when the holding period is longer than 20 or 30 minutes. Using an aerator can greatly reduce or eliminate the need for frequent water changes, saving time and minimizing stress on the fish. Many types of aerator systems have been tried, and several are of little use. The most effective aerators consist of a small bilge pump that sits on the bottom of the container and pumps through a short length of hose to a piece of pipe. The pipe has a series of spray holes and mounts horizontally on the side of the fish container a few inches above the water level. This system sprays vigorously across the surface of the water keeping it circulating and aerated. Examples we have used include the 12 V Super Fish Saver Aeration System® by Marine Metal Products and various products from Cabelas (Appendix A1).

Most outboard motors can be equipped to charge a 12 V battery. This is ideal because that battery can be used to run several aerators at once. If aerators are used only when the outboard motor is running, several can be run simultaneously for extended periods with no drain on the battery. At one coho salmon project, four aerators are powered simultaneously off the outboard motor battery during the run from the trap site to camp (Figure 26).

Keep a watchful eye on fish during transport. Look for signs of stress and refresh water as necessary. Signs of stress include darkening of color, gasping and crowding towards the surface, and increasing numbers of 'jumpers'. It is sometimes necessary to interrupt trapping to make a fish haul to camp when catch rates are high, or when the weather is warm.

Avoid putting airtight lids on containers of fish. This practice has two serious drawbacks. First, it is impossible to watch the fish except by frequent peeking. When the fish can be easily watched it is clear when they need attention. Second, the only source of oxygen for an unaerated tote of fish is the fresh air passing over the surface of the water. An airtight lid on the container cuts off this supply. Putting an airtight lid on a fish container for any length of time is similar to putting a plastic bag over your head. An aerator does not help if there is no fresh air at the water surface. If fish jumping or water sloshing is a problem it is best to devise a screened lid that allows plenty of air movement as well as visual monitoring of the fish.

NET PENS AND HOLDING BOXES

Net pens and holding boxes are needed to retain and separate untagged and tagged salmon at the tagging site. Net pens are typically 3 to 4 ft square, cube shaped, nylon ¼ in mesh bags designed to contain smolts and provide maximum water circulation. A minimum of two pens are needed for most Chinook salmon tagging projects and four or more pens may be necessary for multi-species or otherwise complex tagging projects. Typically, two holding pens are needed for every tag code you use, one pen for untagged fish and another for tagged fish. In some circumstances, at a smolt weir or when the tagging station is located amid good rearing habitat, the fish might be released after a brief recovery period following tagging. This eliminates some amount of captivity, handling, and stress. It also may reduce the number of net pens that are necessary to the operation.

Net pens can be mounted on floating frames built with 2 x 4 in lumber and foam dock floats (Figures 27 and 28). Zippered covers on the net pens, or mesh lids framed with 2 x 2 in lumber so that the lid can be securely tied down, will deter birds and mink from preying on the fish. The net pens are tied off to shore so they do not drift away. Clear an area of debris and branches from around the net pens to prevent tears and to facilitate moving the nets during changing water levels. An extra net pen should be kept on hand in case one is damaged or if additional capacity is needed. Occasionally fish are held for multiple days before tagging and additional net pens can be used to prevent crowding. Small rocks can be tied in the bottom corners of a net pen to keep it from billowing.

Rigid boxes are also used to hold fish. They are usually wood-framed plywood as described in (Elliott 1992). Commonly used sizes are 3 to 4 ft square or rectangular and 3 to 4 ft deep. Holding boxes should have flotation to accommodate changing water levels and a lid to keep out predators. At Hugh Smith Lake the crew devised a holding box design with a sliding door in the side so that fish can be released after their recovery period with no further handling or netting stress. Holding boxes provide a better deterrent to predation and work better in woody areas and higher currents than net pens. Sometimes it is difficult to dipnet fish from a holding box. A useful technique is to install a net pen inside of a holding box. When dipnetting fish, the pen can gradually be pulled up to concentrate the fish for easy capture. Net pens and holding boxes should be clearly marked with signs labeled "UNTAGGED FISH, TAGGED KINGS, TAGGED COHOS," etc.

Suitable net pen sites were not available near camp on the Chickamin River and fish were held in commercial fish totes on shore. Each tote was equipped with a Rule® 700 gal/hr pump to recirculate the water and the water was periodically changed with freshwater pumped from a shallow well with a Flowjet model 4325 pump (Figure 29).

At the Moose River smolt weir, fish are collected in a 10 x 4 ft holding box made of welded aluminum and perforated metal sheets. The inside of the box has a metal tube that acts as a rail to slide a crowding fence along so that fish can be concentrated in one end of the box. Then removable panels can be slipped into channels in the box to hold the fish in one end for easy dip netting (Figure 30).

The first priority in any tagging program is taking good care of the fish. While the process of tagging and the presence of the tag represents minimal trauma for the fish, careless handling and treatment of fish before, during, and after the tagging process can have significant adverse affects (NMT 2005; Vander Haegen et al. 2005). Fish should not spend too much time in water containing anesthetic, and should be allowed to recover fully before they are released (AFS 2004). When holding fish in pens, live boxes, or buckets, care should be taken to ensure that the water source is cool and well oxygenated. Adequate circulation must be provided to keep oxygen levels high, or in the case of hand carried buckets the water must be changed regularly. The fish should be provided shade, especially in summer. Sedated fish in pans on the tagging table must be shaded, otherwise they may lay sideways and sunburn their eyes. When catches are low it may not be worth setting up to tag every day. Fish may be held 1 or 2 days routinely, with three days the maximum. The stress of prolonged containment and lack of feeding opportunity may impact the survival of fish.

Each time a fish is netted it may lose some scales so the number of times should be kept to a minimum (Matthews et al. 1997). It is especially important when scooping fish from pens that large numbers of fish not be lifted at one time. The weight of the fish on top, push the unlucky few at the bottom heavily against the rough netting while struggling. Make several scoops of few fish rather than one that has many. Net scooping technique can be another source of scale loss and mortality. Occasionally a dead fish is retrieved from a pen with a wide band completely devoid of scales. This is caused by reckless netting technique that pins and scrapes the fish between the net and the pen side. When scooping the net bring it close to the side but try not to touch the walls of the pen, or do so very gently. Rather than rapidly chasing fish with the dip net, practice herding and slow scooping. Use two nets coming together slowly to catch the last few fish. When dipnetting fish out of a net pen, the pen can gradually be pulled up out of the water to concentrate the fish for easy capture.

CODED WIRE TAGGING

MODEL MARK IV TAG INJECTOR

The Mark IV tag injector manufactured by Northwest Marine Technology, Inc. (NMT), is the standard tag injector used on CWT projects throughout the U. S. and Canada. It is portable, fast and reliable. It is thoroughly described in the NMT Mark IV manual (NMT 2001) and in other parts of this manual.

HAND HELD MULTISHOT INJECTOR

The NMT Multishot Hand-held Injector is intended for tagging small batches of fish or for tagging fish at their capture sites. It can be used with or without a head mold, is very portable and doesn't require a 12 V battery or generator to power it. The hand-held injector can also be used to tag larger fish, or many other animals. They have not been used extensively by ADF&G in Southeast Alaska but Sarafin (2000) reported tagging up to 28,000 Chinook smolts in a season on the Copper River drainage with the hand-held injector. Tag retention was poor in that study (Brase and Sarafin 2004).

Portable Sampling Detector (PSD, V-DETECTOR)

The PSD or V-Detector is a self-contained machine designed to detect wire tags in animals. It is fairly water resistant, light weight (8 lbs), durable and easy to use. The tag detector works by detecting changes in the magnetic field when a tagged fish is passed over the sensors located in the sides of the V trough. A 9 volt battery powers the detector and will usually last for a whole season. Rechargeable batteries are not recommended for powering the tag detector, as they often do not deliver a full 9 volts of power. The detector has a sensitivity adjustment to accommodate different size fish or tags. The tag detector has two methods of indicating the presence of a tag when a fish is tested - an audible beep or a red light. The tag detector will also detect rings, wristwatches, metal buttons, bracelets, magnetic interference from motors and generators, and will react to jarring of the machine. Test your arms and clothing carefully before conducting tag retention checks. NMT recommends using the tag detector sitting on end with the control panel down. This works when using the audible signal. When using the light to indicate tags, the machine should be placed in a control up position with the included splashguard in place. The detector has an area of maximum sensitivity on each side of the V trough. These are located on the upper part of the left panel and the lower part of the right panel. The fish being tested should be held so it is oriented headfirst perpendicular to the plane of the panel and moved in an up and down motion over the sensitive spot on the panel. Holding the fish still or moving it too slowly through the detection area will usually result in a false negative reading so if no tag is detected, move the fish faster or try a different orientation of the fish to the panels.

If the tag detector fails to function or performs erratically, check the battery condition, for sources of magnetic interference, and for water inside the case. If you suspect magnetic interference, test the unit in a different location. If there is water inside the machine, remove the control panel and remove the circuit assembly, being careful not to disconnect the wires from the unit's case. Drain out the water and let the machine dry out before reassembly.

QUALITY CONTROL DEVICE

The quality control device (QCD) automatically scans and separates tagged from untagged fish. It is electronically linked to the Mark IV injector and uses water jets to sort tagged and untagged fish as they are flushed through it. Controls on the Mark IV injector control the sensitivity of the QCD and can be set to sound an alarm when untagged fish are passed through the QCD. The QCD has adjustments for sensitivity that may need to be adjusted when tagging different size fish or tag lengths. Due to its size (35 in long, 39 lb), expense and the requirements of a water pressure system, many projects have avoided using a QCD during remote field tagging operations. However, several projects have used them for many years and enthusiastically endorse them.

The operation of the QCD is well covered by the NMT manual for the Mark IV tagging machine. There is no substitute for reading the relevant section from the manual for developing competence at using, adjusting and trouble shooting the QCD. However, the manual does not address the equipment and adaptations needed to use the QCD in a remote field situation where 120V power and water pressure are not readily available.

Field tagging operation gear typically includes a generator, so the only additional gear requirements needed to operate a QCD in a field camp situation is an electric water pump (Little Giant® model 4E-34NR or Teel) and a system of hoses, another extension cord or two, and a power strip (Figure 31).

The QCD has a water requirement of 2 gal/min, at a minimum water pressure of 40 psi (lb/in^2). In water with a lot of sediment, the pump can be put into a burlap bag and then into a 5-gal bucket suspended off the stream bed using a metal post. The burlap bag will cut down on debris sucked into the pump and helps to keep the QCD filter clean. The bag may need to be cleaned often. Commercially made pump filter bags are also available (Appendix C1). The water pressure and hose system, besides operating the QCD, can also extend holding times for fish by supplying containers with a constant flow of fresh water. The hoses can also be used to fill buckets and for clean up (Figure 32).

The hose system consists of the main supply hose that comes from the submersible water pump, and joins to a four-valve fitting that supplies four separate hoses 10 ft or less in length. One connects to the QCD, one is dedicated to providing a flow of water to the bucket that receives tagged fish from the QCD, and the other two hoses are used to supply a flow of water to buckets or tubs of incoming fish or for filling buckets. The hose to the QCD includes a small inline filter to prevent plugging valves or jets in the QCD. The other hoses all end with a small valve fitting so the flow can be adjusted conveniently. The four-valve fitting may be hard to find; another solution is to use a series of three Y-fittings that are readily available. Customized spill buckets to receive fish from the QCD can be made by drilling a series of ¼ in drain holes about three inches below the edge of the bucket. The holes should be spaced ½ to ¾ in apart and should go only half way around the bucket, from handle attachment to handle attachment. This leaves one side of the bucket that will not spill water against the legs of someone carrying the bucket.

Using the QCD provides continuous feedback on the function of the tagging machine and on the efficacy of the person tagging. This helps to immediately address tagging problems and helps to improve overall tag retention. The QCD is a very valuable training tool for new taggers by providing immediate indications of tag injection problems. Good quality smolt or presmolt tagging can be accomplished without a QCD, but it is a tremendous aid for the learning process. Because tag retention becomes an increasing problem with smaller sized fish, use of a QCD for tagging fish <60 mm is highly recommended and must be considered indispensable for fry tagging.

HANDHELD WAND DETECTOR

The wand detector is a portable tag detector usually used in the field or in cold storages for checking adipose clipped adult fish. The wand detector's size (not much larger than a flash light) makes it very useful when tagging juvenile fish with the handheld multishot injector at the capture site. It is sensitive to motors and metal, so precautions as outlined with the other styles of detectors must be followed. The wand is used by waving the end over a fish's snout. A recent study Haegen et al. (2002) shows that using the wand detector inside the mouth of adult salmon can greatly improve the tag detection rate. For Chinook salmon the mouth wanding technique detected 98% of tags versus 89% for the standard wanding technique.

Detailed information on any of NMT's equipment and supplies can be obtained at their website. www.nmt.us

ELECTRIC GENERATORS

Generators are an important piece of equipment for most field tagging operations. A generator must be run to use a Mark IV and QCD while tagging (e.g., Honda EU1000 or EU 2000. With a generator supplying ample electricity and a water pump sending water pressure to the operation suddenly additional benefits are realized far beyond the mere ability to operate the QCD. The generated power, besides running the tagging machine and the water pump, can also be used to power lights, a music system or charge batteries.

Filter the gas and check the oil level every time you refill the tank. The oil needs to be changed at the intervals specified in the maintenance manual or when it appears dark and dirty. Check the air filter and spark plug regularly, and make sure you have spares. Empty the fuel tank and carburetor for winter storage.

TAGGING SHELTERS

A tagging shelter provides a place to set up equipment and tag fish with protection from the elements. It also provides relatively dry storage for tagging gear and spare equipment. The tagging shelter can be a tarp over a line, a Weatherport® style tent, or a framed structure on floats with lights and running water, depending on your needs and the duration of the project. During summer tagging projects where bugs are a problem, we have used screened beach or patio tents but for spring and fall projects sturdier shelters are used. Generally, an 8 x 10 ft shelter is adequate for most operations requiring one or two tagging machines. If you have a larger operation or a QCD and running water, you may need a larger structure (Figures 33 and 34). A common design is a shed-roofed frame of dimensional lumber covered with clear 6-mil polyethylene sheeting. An A-frame of native materials covered with plastic sheeting has also been used satisfactorily. The tagging table is usually a 3 x 6 ft piece of $^5/_8$ in plywood on a 2 x 4 in frame with a shelf underneath for storage. The table works well for either a single or a two machine tagging operation.

The Moose River smolt weir has a very efficient set up (Figure 35). A black plastic culvert pipe directs smolt from the weir face opening to a holding box situated in deeper water about 100 ft from the weir. This avoids crowding the fish and locates the holding box close to the inriver tagging tent. The tagging (Weatherport®) facility is built above the river on a temporary platform installed in the river. This facility eliminates the need to transport fish up a bank in buckets. The crew can dip fish directly from holding boxes located just outside their tagging tent. Tagged fish are dropped into a QCD device attached to a flex pipe that sends tagged fish directly into a holding box for recovery.

Mobile tagging trailers have been used at hatcheries in Washington and Idaho, and something similar might be feasible for projects tagging wild fish along a road system (Duke 1980; Schurman and Thompson 1990; Heinl et al. 2000).

EQUIPMENT SET UP

Before starting the tagging operation review the NMT Mark IV Manual to make sure you are familiar with basic set up and operation of the machine. The Mark IV Manual fully explains all the functions and operations of the machine. An aspiring tagger should study the manual to gain a thorough understanding of how to operate the machine. This will prevent errors in machine set up. It will also greatly enhance the ability to quickly troubleshoot machine problems when they occur and will minimize tagging operation down times.

Untagged fish are held in net pens marked "UNTAGGED" until the Mark IV tagging machines are up and running and until the buckets and dishpans are filled. If more than one species or size lot of fish are to be tagged and you have several injectors, each Mark IV should be clearly marked with a sign identifying what species or lot is to be tagged by the machine. If only one Mark IV is available, take extra care to remember to switch spools of wire when tagging different lots or species of fish. Make sure each spool is clearly labeled according to species and lot. Sorters and clippers should remind the tagger to switch spools each time a new species or lot is to be tagged to avoid mistakes. If a batch of fish is tagged with the wrong tag code, keep that batch of fish in a separate pen and consult with your project leader.

When starting to use a new spool of tags, cut a one inch length of tag wire and tape it to the data sheet for safe keeping. Circle the sample and record the date and the tag code next to it. At some point the wire sample will be taped to the ADF&G Coded Wire Verification Form (Appendix E2) and is used to verify the tag code.

The tagger should record, in a field notebook or directly onto a daily data form (Appendices E2-G1), the total number of fish tagged on each tag code daily. During tagging the number of retags or mistags can be tracked by using a tally whacker. This number must be subtracted from the machine's number of injected tags for the accurate number of tagged fish. Record all of these numbers and calculations with the data so that the process is clear and documented. This record keeping and accounting process is done every time a new size group is tagged or the tag wire is changed. Each tagging session the tagger records the data including the number of fish tagged by species by size group and by tag code, the retention rate data including the number of fish examined and the number of these with a tag, and the number of mortalities. A daily data form must be completed for each tag code used each day. The data must be accurate and kept up to date.

Tagging information from any project marking fish with CWTs in Alaska is entered in the ADF&G Online Release Entry (ORE) program. This program, new in 2006, is available at the ADF&G Mark, Tag, and Age Laboratory website (http://www.taglab.org/; online release entry). Contact the lab at (907) 465-3483. The ADF&G Lab maintains a statewide database that summarizes all the fish tagged for each specific tag code. This information can then be used to quantify survival of fish groups, timing of runs through the commercial fisheries, harvest rates of tagged fish, and biological parameters. Projects outside of Alaska should provide similar information to their respective Tag Coordinator who will in turn provide the data to the Regional Mark Processing Center of the Pacific States Marine Fisheries Commission (Johnson 1990).

On cloudy days and at night a fluorescent light can be used with generator power. Full-spectrum tubes are easier on the eyes and provide some advantage for species identification. If the tagging shed is covered with clear plastic sheeting, a tarp can be used to shade the structure on sunny days. The tagging machine is usually set up on one side of the table with the sorter and clipper on the opposite side. The sorter scoops unsorted fish into a plastic dishpan of anesthetic solution, sorts by species and size and passes fish to be tagged to another dishpan in front of the fin clipper. Once the fish are clipped, the fish go into a pan with netting suspended in it so the tagger can easily grab them. Tagged fish are dropped into a QCD or a bucket of fresh water at the tagger's feet for recovery.

ANESTHESIA

Anesthetics are necessary to minimize stress to fish and reduce injury during the CWT process (Kelsch and Shields 1996). Summerfelt and Smith (1990) provide a detailed description of the use of anesthesia with fish including the characteristics of the most commonly used chemicals.

MS222

Tricaine methanesulfonate (MS222®, Finquel®, Tricaine-S) is the most common drug used to anesthetize juvenile salmon and smolts. It is the only drug registered with the U.S. Food and Drug Administration (FDA) for use with food fish. MS222 is a light sensitive powder that will degrade prematurely if not stored in an ultraviolet resistant container. We often store MS222 in a Nalgene™ bottle wrapped with electrical tape. MS222 also degrades with age, so fresh supplies should be acquired every 2 to 3 years.

The correct dosage will vary for different species. For example, Chinook and sockeye smolts are very susceptible to the drug, while coho smolts and Dolly Varden require stronger solutions to be anesthetized. Although MS222 is recommended for use in water above 10°C, we have had no problems using it in water at 2°C although a stronger solution is needed. For colder water a good starting point is to use 1 g (about ½ teaspoon) of MS222 per 5 gal of water (about 5 ppm). In water above 10°C, reduce the amount to just over ¼ teaspoon. Note that fish will be anesthetized faster as the water warms up in your dishpans. A sample of 5-10 fish can be used to test the mixture until the correct dosage is established. Optimally, the fish should start to roll onto their sides after being in the anesthetic for about three minutes. McFarland (1959) developed a scale for five stages of anesthesia ranging from normal opercular movement, swimming motion and sense of equilibrium to a cessation of all functions. If the mixture is too strong and the fish roll right away, add more water to dilute the mixture. If they do not roll over soon enough, add more

MS222. Summerfelt and Smith (1990) recommend adding 200-250 mg of baking soda (sodium bicarbonate) per 100 mg MS222 to the mixture to help neutralize the low pH of the MS222, but at concentrations under 500 mg/L, MS222 has little effect on pH (PSU 2005; Appendix I1). We usually skip this neutralization procedure without any ill effect.

To work efficiently the sorter should alternate working between two pans of anesthetic solution so that when sorting from one pan of anesthetized fish, another batch of fish is becoming sedated in the other pan. This provides a more constant flow of sedated fish to the clipper. Fish should be drugged in small batches (30-50), sorted, clipped and tagged, then placed back into fresh water as quickly as possible to minimize stress. If a problem arises such as a tagging machine malfunction, the sorter should get the fish back into fresh water immediately. Care must be taken to keep the clipped, untagged fish (those in the tagger's pan) separate from the unclipped fish because the clipped fish could be mistaken for recaptures.

At the Moose River weir the tagging crew mixes 8-9 gal of MS222 solution in the morning and uses it for up to 5,000 fish. The mixture is held in a large cooler on the floor and pumped into two tubs where the smolt are sedated and fin clipped, then the solution flows back into the cooler (Figures 36-38). Fresh river water is pumped through a coil of copper tubing submerged in the cooler to refrigerate the MS222 solution. For ease and consistency the side of the cooler is marked with a line to indicate the proper water level for mixing the anesthetic solution.

On the Taku River the tagging crew uses a shallow aluminum water table containing MS222 solution and a number of plastic colanders to hold fish while sorting and clipping (Figure 39). Similar to the Moose River set up, fresh water is pumped through copper coils in the water table to keep the solution cool.

Precautions for the use of MS 222

Argent Chemical Laboratories, a principal manufacturer of MS222 recommends using the chemical in well-ventilated areas and avoiding direct contact or breathing the dust while handling the dry chemical. They also state that "Working with solutions of Finquel" (their brand of MS222) "according to label directions does not pose any known health hazards, however we advise the use of proper safeguards in any situation where chemicals are handled." In light of this, many people working with MS222 solutions wear latex or nitrile gloves. If you do not wear gloves, wash your hands thoroughly after exposure to MS222. MS222 is not allowed for use on fish that may be caught and eaten within 21 days of being exposed to the chemical.

Do not use galvanized or brass containers for anesthetizing fish as zinc, which is poisonous to fish, can leach into the water.

Clove Oil

Clove oil has shown promise as an anesthetic for both adult and juvenile salmonids (Cho and Heath 2000). The FDA allows researchers some degree of choice in the selection and use of drugs, including anesthetics, if the intended purpose of the fish is for research only and the fish will not be consumed or released. Strict interpretation of FDA policies would allow such choice only for approved studies on drugs; however enforcement practices typically allow greater flexibility (AFS 2004). The complexities related to FDA drug approvals and the experimental use of drugs in research situations is illustrated by recent actions relative to clove oil. Clove oil or eugenol may not be used in any form on fish that could possibly be consumed by humans, even if the treatment occurs in a laboratory setting. The only exception would be under the auspices of an Investigational New Animal Drug (INAD) exemption in which a treatment authorization, including an appropriate withdrawal time, has been obtained from the FDA. AQUI-S® isoeugenol is a possible substitute for clove oil or eugenol. At this time (Feb 2006) there is one publicly disclosed INAD exemption file for the use of isoeugenol as a fish anesthetic and it is held by the USFWS. The product has been given an investigational withdrawal time of 21 days for the dosing regimen being used in the current studies (Schnick 2006). Studies that could be cited to help demonstrate the safety or effectiveness of isoeugenol in fishes should be coordinated with the USFWS National INAD Office. For information on using AQUI-S® through the USFWS INAD program contact Dave Erdahl or Bonnie Johnson (406-994-9905) in Bozeman MT.

FISH SORTING

As the juvenile salmon are being anesthetized, one person should identify and sort the fish by species and size. The fin clippers also get a very good look at each fish and can function as quality control for fish identification. Any fish showing signs of stress prior to anesthesia, with injuries or with malformations should be removed from the tagging process. The adipose fin is the primary physical characteristic used for identifying juvenile Chinook, coho and sockeye salmon. The adipose fin is a small fleshy fin located between the dorsal fin and the upper lobe of the caudal fin. Chinook juveniles have a black line along the post-dorsal edge of the adipose fin and a clear window in the middle while juvenile coho have even pigmentation throughout the entire adipose fin. Sockeye smolts have a totally clear adipose fin. The size of the eyes, shape of the head and contour of the body, parr marks and coloration of anal fin are also used as identifying characteristics. Occasionally fish are identified correctly but mistakenly sorted so always be on the watch for species misidentification and mis-directed fish. Encourage discussion at the tagging table regarding fish that are difficult to identify so that everyone can learn. Refer to “Field Identification of Coastal Juvenile Salmonids” (Pollard et al. 1997) and (Figure 40) for help with species identification. In late spring fish ID becomes harder as fish undergo smoltification, become silvery, and lose the juvenile colorations that help to differentiate between species. Experience is the best way to learn the many different variations in characteristics you will see in each of these species. If you are unsure of the species identification then don't clip or tag that fish. It is better to release a few untagged fish than to tag the wrong species. A magnifying device can help with species ID and fin clipping. Many of our crews use a magnifying headset (Appendix C1; Figure 39). If you suspect you have an Atlantic salmon juvenile, sacrifice the fish and preserve it for verification (Figure 41).

CLIPPING ADIPOSE FINS

The removal of the adipose fin is the standardized method to signify that a salmon has been coded-wire-tagged. To remove the fin, hold the fish with one hand with its head toward your palm and the tail extending out from your grip. Hold the scissors parallel with the fish’s back. Starting near the base of the caudal fin slide the open scissors up against the back of the adipose fin, and snip the fin flush along the back. Sharp dissecting scissors make the job much easier. Try not to gouge or leave projecting nubs. Dull scissors or poor technique can produce imperfect cuts. If the scissors are dull or the cut stroke is not fully completed before pulling the scissors away this can tear away a small patch of skin leaving a light colored spot of exposed skinless tissue. A good cut is nearly invisible leaving no fin and tearing no skin. Adipose fins will not regenerate like other fins if excised at the base. Thompson and Blankenship (1997) found that complete regeneration occurred in 23% of the fish where the back $^2/_3$ or the top $^2/_3$ of the adipose fin was removed. Partial regeneration of the adipose fin was noted in 35% of the fish with the back $^2/_3$ clip and 63% of the fish with the top $^2/_3$ clip. The tagger will act as quality control and point out bad clips and pass them back for further attention if necessary. The sorter will help with clipping if he has time. Clippers should clean their scissors with isopropyl alcohol at the end of each tagging session.

Naturally missing adipose fins on wild stocks of coho and Chinook salmon are very rare. In over 20 years of tagging projects we have observed only a handful of juveniles with naturally missing adipose fins. Occasionally, a fish will have a stunted adipose fin no larger than the nub left from a poor clip. Hatchery stocks of coho and Chinook salmon have higher frequencies of naturally missing adipose fins and can vary from stock to stock as can the rate in wild stocks. Blankenship (1990) found rates varying from 0.05 to 0.23% for hatchery coho and 0.01 to 0.03% for hatchery Chinook. In wild stocks he found an average of 0.06% naturally missing adipose fins for coho salmon. At the start of a new project, before there are marked fish in the system, any occurrence of naturally missing adipose fins should be noted. The number found and the number of fish that were examined should be recorded to provide a rate of occurrence.

Recaptured fish, identified by a missing adipose fin, should be checked for tag retention, counted on a tally-whacker and placed in a tote of fresh water to recover from the anesthetic. They must be kept separate from the newly tagged fish so that they are not included in the overnight tag retention sample. Recaps that have not retained their tags are given to the tagger to be tagged again. Taggers will make note of recaptures in the field notebook to determine long-term tag retention. The number with tags and the number without tags should be recorded and it must be noted how many are retagged. Any number of fish that are retagged must not be included towards the total number of fish tagged because they were counted when tagged originally.

CODED WIRE TAGGING

The following is a synopsis of procedures covering tagging machine set up and use. An aspiring tagger should be guided through the process by an experienced tagger and the Mark IV manual should be read and kept handy for reference.

The Mark IV can be powered by an AC power source or a 12 V battery. The power cord is plugged into the back of the Mark IV and held in place by screwing down the ring fitting on the small plug. There are two identical plugs on the back of the machine and the touch switch can be plugged into either one. The QCD, if used, is plugged into the other one. The touch switch can be placed in a plastic bag to prevent water from dripping on it. Silt from river water may lodge in the mechanism and cause the button to stick.

The Mark IV is turned on by depressing the black button located on the back of the machine above the plugs. After the machine is turned on, press the button that reads [LOAD] on the keyboard on top of the machine. Open the hinged door on the side of the Mark IV. Select the spool of wire to be used and label it with species, year, and location. Push the roll of coded wire tag onto the spool holder, making sure that it is in position to rotate freely. Run the coded wire through the guide until it is between the set of green rubber rollers. The Mark IV should always be stored with the rollers apart to avoid getting flat spots on the rollers. Work the lever at the base of the rollers to close them onto the wire. In [LOAD] mode, the rollers can be rotated by hand. Rotate the rollers, feeding the wire into the cutter and through the needle, until a small section of wire protrudes from the needle tip. Close the side door. Press [OK] on the keyboard.

If not using a QCD, the screen will read "NO QCD OK?" Press [OK]. Press the touch switch button twice. Two lengths of wire will eject from the needle, a longer length and a section that is 3 mm long. The next piece cut will be the size of a tag. This is 1 mm for a full length tag. Cycle the machine a few more times to make sure it is operating smoothly.

Examine a tag for proper length and for square cleanly cut ends. Inconsistent tag lengths can indicate worn or dirty rollers that are causing the tag wire to slip as the machine cycles. A minor problem may be fixed by scrubbing the rollers with a cotton swab. If the problem persists, the top roller can be loosened with an Allen wrench and moved in or out on its shaft so that fresh surface contacts the wire. New rollers can be installed if both top and bottom rollers are too worn.

Tag ends that are not cut smooth and square may indicate a dull cutter edge. Cuts produced by a dull cutter can look smeared, may not be square, and may have a burr. The end of the tag may also have a slight bend to it. None of these characteristics are necessarily a problem, but may cause problems with the machine operation, signaled by error messages such as “stuck wire.”

Needle Penetration and Tag Placement Depth

Good tag retention is essential to the success of a project. Correct tag placement should be established at the start of every tagging session and whenever changing head molds or after changing the tagging needle. Correct tag placement is a function of how the machine is adjusted and how the fish is held in the head mold.

Different species and sizes of juvenile salmon require different head molds (Table 3). Good long-term tag retention requires selecting the proper head mold for the size and species being tagged (Peltz and Hansen 1994). The head mold is specially shaped to align the fish’s head with the injector needle on the tagging machine. A number etched on the base of the head mold indicates the size of smolt it is shaped to fit. Unfortunately, the fish species that a head mold is shaped for is not denoted on the head mold. A 65/lb size head mold works for Chinook salmon 55 to about 80 mm FL. A 30/lb size head mold is used for Chinook too large for the 65/lb mold. Use a 65/lb head mold for coho smolt between 70 and 85 mm, and a 30/lb head mold for coho 85 -120 mm and a 15/lb head mold for larger fish. Carlon and Hasbrouck (1993) had good tag retention using 30/lb head mold for coho smolt up to 125 mm, and a 20/lb head mold for smolt in the 125-150 mm range.

Head size of some salmon varies, especially longer rearing fish like coho salmon. These “big head” coho, usually encountered later in the smolt migration, may need to be tagged with a larger head mold than their length would indicate. Because there are variations in head shape among species and in the individual head molds, you may have to test the fish for fit, especially when tagging larger fish. Jenkinson and Bilton (1981) have an interesting section in their paper on making your own head molds.

Table 3.–Head mold size for different species and sizes of salmon.

Species and Fork Length	Head Mold Size and Color			
	65/lb blue	30/lb yellow	20/lb	15/lb purple
Chinook 55-80 mm	X			
Chinook > 80 mm		X		
Coho 70-85 mm	X			
Coho 85-120 mm		X	X	
Coho 125-150 mm			X	X

Needles are available as either "etched" or "non-etched". The etched needle is designed to make a smaller injection hole and should be used in conjunction with head molds for Pacific salmon. The etched needle will not work as well (i.e. it has a greater likelihood of bending) on fish with tougher tissue, such as steelhead (NMT 2005).

There are several steps to setting up the tagging machine for proper tag placement. First press the [SHOW] button on the Mark IV to extend the needle to its maximum forward position and to extend the tag wire to where a cut tag would be positioned. Adjust the wire so that it extends about ¼ to ½ of a tag length beyond the tip of the needle. This embeds the end of the tag into solid tissue not disturbed by the needle tip, which grips the tag piece and prevents movement or loss of the tag. Page 14 of the Mark IV manual covers this. Press the [OK] button and put the head mold into the head mold receiver.

Press the [SHOW] button to extend the needle and position a tag at the needle tip. Typically about three or four millimeters of the needle tip will be exposed inside the head mold. Visually adjust the head mold and gently tighten the two setscrews that hold the head mold in place. Press [ESC] and tag one of the smaller salmon from the group to be tagged. This fish should be killed by an overdose of anesthetic before tagging. Use a QCD or another detector to verify that the fish received a tag. Split the snout back to the eyes using a single-edge razor blade. Make the incision slightly off center to avoid hitting the tag with the razor. Fold back the thin half of the snout, using the corner of the razor blade and look for the tag. A magnifying monocle and adequate lighting are helpful for locating the tag (Figure 42). Ideally, the tag should be centered in the back portion of a cartilaginous wedge in front of the optic nerve in the smallest fish to be tagged for a given head mold. In the largest fish the tag should be at least one tag length into the cartilaginous wedge (Figure 43 and NMT MKIV Manual, p.5). You may be able to see the tag without cutting if you hold the fish up to the light. This is a quick way to check tag placement during tagging, but whenever adjusting a new head mold or training a new tagger, sacrifice fish until you are sure of good tag placement. Once it is established that tag placement is good, mark your head mold with a piece of black electrical tape or draw a line with a permanent marker to indicate how far the head mold should slide into the head mold holder. When the machine is properly adjusted, good tag placement and tag retention depends on the tagger developing a consistent technique for holding fish, with proper positioning and gentle pressure against the head mold.

Press the [TOTAL] button. The display should now read “T INJ XXXX”. The number displayed is the total number of tags that have ever passed through the machine. This total accumulates throughout the life of the tagging machine and cannot be cleared. Record this number in the data book next to "Start Number." Next press [BATCH] on the keyboard to monitor the number tagged during this session. To reset the batch count to zero press [CLEAR]. The screen will read "OK TO CLEAR". Press [OK] and a zero will appear on the screen. The machine is now prepared to begin tagging fish.

Take a clipped, sedated smolt from the tagger’s tub next to the Mark IV machine with your chosen tagging hand. Put the other hand ready at the tagging button. Rotate and orient the fish as necessary to match the orientation of the head mold. **Gently** squeeze at the operculum of the fish causing the mouth to open. Press the snout of the fish into the large cavity of the head mold; the lower jaw should be positioned in its own indentation on the head-mold. The snout should be pressed gently all the way into the large cavity. Hold the fish against the head mold with a very gentle pressure. Press the tag button and a tag is injected. Sacrifice this fish and examine it for tag placement. If necessary, reposition the head mold to adjust the tag depth. Examine the tag placement on several fish making adjustments until tag placement is satisfactory.

As tags are injected the head should not push back or “bounce”. If the tagger feels push-back, the needle may be missing the proper target. If the fish is positioned properly and held firmly and this push-back still occurs, then the needle should be inspected - a dull tip or a burr can cause this problem. If the needle needs to be sharpened or replaced, follow the procedures in the Mark IV manual carefully as positioning the needle properly in the needle carrier is very important. Please note that the needle carrier should never be gripped with pliers. The needle carrier is a moving part that is polished to slide smoothly through a bushing. If proper methods are used, it is never necessary to grip this part with pliers, which will cause damage. Workers clipping and sorting fish should be careful not to bump against the table because it can cause the machine to move during tag injection and may contribute to poor tag retention.

After a fish is tagged, it is dropped into the QCD, a tote, or bucket placed under the table. Totes and buckets should be to the side rather than directly beneath the tag machine so that a fish that an untagged fish that flips out of hand will not fall in. A fine mesh safety net extending out from the edge of the table under the tagging machine is helpful to catch dropped fish. To reduce stress tagged fish can be put into a mild salt solution after tagging but this is not a common practice in our projects (Kelsch and Shields 1996; Aquatic Ecosystems 2006). A solution of 5 to 10 g salt/L (WDFW 1996) may help the clip wound to heal and can prevent the growth of fungus on the wound. An aerator can be used in the container of tagged fish to help them revive.

The condition of the fish in the various containers around the tagging operation must be constantly monitored. If water temperature is < 4° C, a 5 gal bucket can hold up to 300 small Chinook smolt before it needs to be emptied; when water temperature is warmer or larger fish are being tagged the bucket must be emptied more frequently. The bucket should be changed for about every 200 coho. The clipping and sorting pans should be changed whenever the water gets noticeably warmer. At the end of the tagging session or when switching tag codes, make sure all the fish are returned to the proper holding pens. Record the number shown on the display screen after pressing the [TOTAL] button. Record the number of retagged fish and the number of tagging mortalities from this session. At this point you may change to a different tag code or start cleaning the machine.

Maintenance of the Tagging Machine After Use

The Mark IV tag injector has proven to be a very reliable machine. Most problems we have had with the machine are directly related to poor maintenance and needle damage. Cleaning the machine after each use will prevent many problems and can be done in ten minutes or less with practice. Disassembly and cleaning of the machine is done with the power on. In addition to the tool kit provided with the Mark IV, you will need the Mark IV Manual, a squirt bottle of alcohol, water, cotton swabs, a three to four inch piece of tag wire, a small flashlight, a jeweler's loupe and paper towels.

Start by placing a dry paper towel next to the machine to lay parts on.

1) Using the keyboard put the Mark IV into the [LOAD] mode. Loosen the setscrews and remove the head mold. Rinse the head mold with fresh water using soap if necessary. Do not use alcohol on the head mold. It may degrade the plastic. Once the head mold is off, be careful not to impale yourself or bend the needle.
2) Open the hinged door on the side of the machine. Turn a roller to advance the wire until it pushes a tag out of the needle. Then open the rollers using the lever and rewind the spool until the end of the wire exits the rear wire guide. Remember to use the hub of the rollers to turn the rollers to keep body oil off of the roller surfaces. The black build up on the rollers can usually be wiped with water and a cotton swab. Do not use alcohol on the rollers.
3) Loosen the Allen bolt on the needle carrier arm.
4) Using the hollow tube hex tool, put it over the needle clamping nut and turn the needle carrier clockwise while applying slight side pressure, simultaneously pulling backward to extract the needle carrier. Sometimes the needle carrier assembly can be removed simply by pulling gently on the needle while simultaneously wiggling the needle carrier clamp up and down to help the needle carrier to slip out.
5) Clean the needle carrier and needle using a squirt bottle of alcohol and cotton swabs. Also squirt some alcohol into the needle and run the piece of tag wire through it. Inspect the needle for sharpness and straightness and check the funnel end for wear. With proper care, one needle can last for a field season or more.
6) Press the spring-loaded cutter in place while removing the two Allen bolts to avoid uneven torque on the bolts. As the cutter is removed note the position of the notch on the back of the cutter and return it to this position when reassembling the machine so the same cutter edge is used during the next tagging session. The cutter can be separated into two pieces for cleaning. Handle the cutter very carefully. It is a very expensive piece of tungsten carbide and can chip easily if dropped. Clean the cutter parts with alcohol and cotton swabs.
7) Clean the cutter motor block and head mold holder with cotton swabs and alcohol. When the parts are dry, reassemble the machine. The needle protector or a head mold blank should be installed when the machine is not in use. If the machine is to be used again soon the head mold can be reinstalled to protect the needle and to be ready for use.

To help prevent the spread of fish diseases between culture facilities or watersheds, Northwest Marine Technology recommends that disinfection procedures be conducted on tagging equipment. The Mark IV Manual describes the disinfection procedure starting on page 48.

AWL Sampling

On most smolt tagging projects age-weight-length (AWL) data is collected from a sub sample of the fish tagged (Appendices G1-G3). Length and weight data can be used to calculate a condition factor and may be useful in estimating survival, carrying capacity and other habitat related parameters (Lum 2003; Novotny and Beeman 1990). Larger smolt tend to have better survival rates and may return at an earlier age (Scheuerell 2005). Normally you are instructed to collect AWL samples every 10^{th} or 25^{th} or x^{th} fish you tag in order to meet your sample goal. This is done to ensure a random sample of fish sizes. In order to do this you will need another bucket to separate the AWL fish from the other tagged fish. Having the batch displayed on the tag injector instead of the machine total will make it easier to keep track of when you need to save an AWL fish. Some projects have used stratified sampling where at least 10 scale samples were collected from each 5 mm size class of coho (Nass 1995).

Once the tagging session is done and the machine is cleaned, set out an electronic balance accurate to 0.1gm, a measuring trough, scale slides, a small scalpel and data sheets. A simple measuring trough can be inexpensively made by cutting a piece of 2 in PVC pipe in half and gluing a small ruler in it (Figure 44). A pencil, a probe and a roll of Scotch™ tape are also necessary. We generally have one basin for anesthetizing the fish and a bucket of fresh water for recovery. One person anesthetizes the fish, measures and weighs them and then records on the data sheet while the other person takes scale samples. Calibration of the scale can be checked by weighing a penny or dime (Appendix I1). In Southeast Alaska we seldom take scales from Chinook smolt because they are typically all the same age. However, scales are routinely collected from coho juveniles to estimate freshwater age. While recent analyses have shown the procedures used to estimate ages from coho smolt scales may be inaccurate, dramatic changes in age class compositions are still believed to be detectable. Although this approach is qualitative, it may provide important perspective when assessing population status. Collecting scales also provides an archive in the event that more accurate reading techniques are developed. In Southeast Alaska we generally put scales from four fish on a microscope slide. Other projects put six or even ten fish per slide, which would save considerable storage space. In large crews, one person may do the AWL sampling while the others are involved in tagging.

Tag Retention, Overnight Recovery and Release

Overnight holding of coded wire tagged fish is done to monitor short-term tag retention and mortality that occurs from the capture, handling and tagging operation. Short-term survival and tag retention rates are used to adjust the number of fish marked to estimate the number of healthy tagged fish released. Overnight holding of the fish also provides a recovery period for fish after undergoing anesthesia and the stresses incurred during the capture and tagging operations (Hansen and Jonsson 1988). Sharpe et al. (1998) found elevated glucose levels indicating stress in tagged juvenile Chinook salmon. They recommend, "a recovery period of at least 24 h, and perhaps longer, is warranted, especially if the animals are to be released into an environment more challenging than a hatchery raceway, such as a natural watercourse." We are not able to retain the fish for this long in most field situations so it is very important to release tagged fish into areas with available cover, minimal currents, and free of predators. It should be noted that we have several long term projects where tagged coho smolts are released after only a 20 to 30 min recovery period with no apparent adverse effects (Shaul et al. 2003).

If there is a problem with tag retention it will likely become evident within the first 16 h after a group of fish is tagged (Blankenship 1990). Tagged fish are held in clearly marked net pens overnight. On most ADF&G projects, 100 fish of each tag code used are checked for tag retention the following morning before release. Select them randomly to minimize size biases. If you tag less than 100 in a day, test all of them for tag retention. We aim for an overnight tag retention rate of at least 98%. If tag retention is 98% or better record your retention rate and release the fish. However, if more than 2 fish in 100 (less than 98% retention) do not have tags, check another 100 of that tag lot. If retention is still less than 98% the tag retention is unacceptable and the entire batch of fish must be tested for tags. Examine the machine and adjust as necessary then retag all fish that have lost their tag. After the machine is checked and retagging is completed the tag retention process is finished and the fish can be released. In this case tag retention will be recorded as 100% for the day because every fish with no tag was retagged. The tag retention rate is entered into the daily tagging form and the CWT release form. The tag retention rate is used when determining the harvest rate of that particular group of fish.

Some common reasons for poor tag retention are:

1) Insufficient needle depth,
2) Incorrect tag projection beyond the needle,
3) Improper orientation of the needle bevel, i.e. the angle of the needle tip bevel should be oriented opposite to the angle of the face of the head mold,
4) Dull needle,
5) Wrong head mold size,
6) Human error, this includes tagging too quickly or inconsistent technique. Some of these problems can result from fatigue.

When releasing rearing fish, find calm areas in good rearing habitat. Release the fish in several different areas so they are not all competing for the same habitat. This could be a critical factor in overwinter survival in late fall when the water is cold and water levels are low. Turn off the outboard motor to avoid injuring fish. Migrating smolts are usually released in calm areas near the tagging facility unless predators start concentrating there for a free meal. Release of fish at dusk or night will reduce predation, especially in clear water systems (Miller et al. 2000).

Remember that thoroughness and quality work is essential for any CWT project. By the time you have captured, clipped and tagged a fish, there is a lot of time and money invested in it. Do the best job you can and take good care of the fish. A fast tagging operation is achieved gradually as all individuals acquire proficiency at their roles and as teamwork skills develop. Quality work should be the focus before speed and efficiency are pursued. Quality work consists of complete and accurate record keeping, good consistent tag retention, good fin clips, tagging only healthy fish of the correct species using correct tag codes, and conscientious handling of fish achieving negligible levels of mortality. After a crew is proficient at the basic skills then they can work toward speed and efficiency. This requires practicing teamwork where each crew member is proficient at multiple tasks and can work flexibly, responding to the needs of the operation.

Speed is important when you have a lot of fish to tag. However, if there are problems with species ID, fin clipping, tag retention or data collection, even if you break last years tagging record, the project may not meet its objectives and you may not have a job next season.

BOAT SAFETY

Most juvenile salmon capture projects require a boat to access the camp or capture sites and for moving gear and fish to and from your tagging site. On the large mainland rivers we commonly use 16-18 ft long, flat-bottom skiffs with 40-70Hp outboard jet units with tiller steering. The boats should be outfitted with a set of oars, water separator filter for the fuel line, a bilge pump, a come-along, a rescue bag (bagged throw rope), anchor, bow rope and a complete toolbox. Additionally, at least one person in the boat should have a waterproof survival pack containing a VHF radio, first aid kit, a tarp for emergency shelter, flares and a satellite phone or emergency location transmitter (ELT). Boat operators should be able to perform routine maintenance and basic troubleshooting on the motor. Toolboxes should contain: spare spark plugs and spark plug wrench, a spare water filter element, wrenches for the removal of the lower unit and jet foot, screw drivers for draining the carburetors, spare starter cord, a grease gun for lubricating the jet unit, file, spare T-key, shims, cotter pin, an impellor nut for the jet unit, and boat patching materials. Epoxy patch sticks are good for cracks and small holes in the boat hull. Make sure they can be applied underwater and cure quickly. In addition, the boat must be able to meet U.S. Coast Guard requirements for its length. These include a horn, lights, flares, throwable flotation device and a secondary propulsion device like oars or a kicker motor.

Running boats on rivers can be much more challenging than running boats on lakes or the ocean. Although there are tides, waves and currents in the ocean, waves and sometimes currents in lakes, boating on rivers means constantly being affected by the current. Large mainland rivers like the Stikine, Taku, Unuk and Chickamin can have current speeds approaching 10 mph during high flows. Drifting downriver without power in these rivers can be very dangerous. These rivers have a variety of hazards such as rapids, riffles, rocks, log jams, shallow gravel bars, sweepers, split channels and other boaters. Negotiating any of these obstacles can be dangerous.

Use caution and build boating skills gradually. Do not take a boat into a situation without reasonable certainty that you have the skills to manage it. If it is necessary to get a boat past a section of rapids or some other hazard and you are not comfortable with running the boat through the hazard, see if you can walk the boat along in the shallows of the river’s edge. This is especially doable when going downstream because the current helps to move the boat. In perilous sections of fast water it is easier to run a boat upriver than downriver. The boat can then be walked or lined back down with ropes if necessary. If a dangerous situation seems to be unavoidable call your supervisor and discuss options. Do not risk lives to accomplish project objectives.

The shallow draft of flat bottomed boats combined with jet unit equipped outboards allows access to very shallow, woody or rocky stretches of river where propeller equipped boats cannot go. Outboard motors equipped with jet units have less thrust than the same motor equipped with a propeller; thus, larger, heavier motors are required and more fuel is burned. Jet units have poor maneuverability at low speed, a weak reverse and flat bottom boats have a tendency to slide sideways or skid during fast sharp turns.

Before starting off in a boat make sure it is properly equipped as listed above and that you have plenty of fuel for the trip. How much fuel is enough? This you learn on each river and with each boat. A good rule-of-thumb is to turn around when you have burned half your gas when going upriver from camp and to turn around when you have used one third of your gas when going downriver. Make sure someone in camp or in town is informed of your destination, route, and time of return. Set up a contact schedule and make a backup plan in case you fail to return on time.

The boat operator should wear hearing protection. Jet units are loud. Long term exposure can damage your hearing. The earmuff style hearing protectors not only protect your hearing, they keep your ears warm and hold your hat on. Check the balance of the load and if necessary adjust until the boat is floating level. Be sure that the boat is not overloaded or that the center of gravity of the load is too high. It is the boat operator’s responsibility to see that everyone in the boat is wearing a personal floatation device (PFD or life vest). Allow the motor to warm up and check to see that the gas tank vent is open before leaving shore.

Running a boat on a river can be dangerous and requires the full attention of the operator. Knowing how your boat handles is critical to safe successful river running. When operating an unfamiliar boat try some maneuvers in a safe open area to get the feel for the boat. Be aware that a heavily loaded boat will handle differently than a lightly loaded boat. Totes full of water or a barrel of gas will significantly affect the handling characteristics of your boat.

“Reading the river” is a skill you have to learn if you want to have a long and illustrious career on rivers. Knowing a path to follow through a stretch of river is not enough. You need to understand why that particular path is followed. Rivers are very dynamic with ever changing channels, currents, and obstacles. Safe river running routes often change day-to-day due to changing water levels. The best way to learn the basics of river running and how to read a river is from an experienced instructor. If possible, ride as a passenger a few times before taking the controls. Pay close attention to current speed, boat speed and the path the boat follows through different water conditions. Note log jams, rocks, boils, currents and water depth. Study the surface patterns of the water and try to learn what causes them, and how they relate to water depth. On glacial or muddy rivers you cannot see the bottom to determine the water depth. The size and shape of disturbance features on the waters surface can indicate depth. The shoreline can also help you to determine depth. Steep banks and cut banks indicate deep water. Flat or low gradient shorelines often indicate shallows that extend far into the river. The inside of a river bend is likely to be shallow and the outside is usually deepest and swiftest.

Note that the route used is often different when running upriver and downriver. When traveling upriver it can be an advantage to stay in shallows near shore to avoid the main current and rough water, also this makes for an easy landing in case of motor problems. Going downriver the fastest currents may be sought out for increased overland speed though you may have to dodge waves and riffles. Whether you are running upriver or downriver, pay attention to what is down current of you. Where will you drift if the motor quits? Where is the safest landing site? If you experience a motor shutdown or loss of power, immediately head toward the safest landing site. Passengers should react and assist in getting to shore when this happens, paddling or rowing or pushing with oars and jumping out to pull the boat to a landing when the water is shallow enough. Whenever possible, choose a course that will not wash the boat into the face of a log jam or into sweepers should the motor falter.

Usually a loss of power is due to gravel or other debris wedged in the foot of the jet unit. This is easily corrected by prying the debris out with a long shaft screwdriver. If the motor has quit or is not running well, check for the simplest problems first. Check that the fuel line is properly connected at both ends, check for a kink or gear that is pinching the fuel line and make sure the gas tank vent is open. Water in the fuel is another frequent problem, check filters, and the tank, and drain the carburetor if water is suspected there. Also check the spark plug wires for a good connection and examine the plugs for fouling. Clean them with a wire brush or replace if needed.

When approaching a rough stretch of water (rapids, braided channels or woody areas) from down stream, slow down or pull over until you can figure out a safe route through it. You may want to flag a safe route through a complex braided area. Remember you must come back downstream through the same area and you will be traveling much faster due to the current. Running upriver is usually less dangerous than running downstream due to the slower boat speed and the quickness with which you can slowdown or stop. If possible, do not run down through any tough stretches of river unless you have already been up through them. If there are other boaters on the river, be alert entering constricted areas or areas of reduced visibility. You will probably not hear another boat coming and the combined speed will leave little time to react. When approaching an unfamiliar landing site turn the boat upriver, idle into the current and look the area over. How fast is the current? Is there a good spot to anchor or tie the boat up? How shallow is it? Are there obstructions immediately downstream of the site that may make it dangerous when departing? If the landing is shallow enough that the jet might suck up gravel then shut the motor off as the boat glides into the shallows with enough momentum to get to shore. If there is adequate depth, especially if there is current, keep the motor running until the boat is secured.

Towing heavy objects in river currents should be avoided whenever possible and done with extreme care when necessary. Using a boat to position fish wheels or rotary screw traps, or moving logs or pulling boats out of jams or recovering a snagged gillnet are extremely dangerous activities. If the boat must be used to pull in current always pull from the stern of the boat and always keep the bow heading into the current. Use a quick release hitch to connect the towline to the boat. If the boat starts to swing downstream immediately stop pulling and release the towline. Cut the line if necessary. If the boat gets pointed downstream and the towline is still attached and goes tight to the load it can suddenly pull the stern under and swamp the boat. Keep a good rope cutting knife handy within easy reach.

Passengers should provide more than just ballast to the boat. They must be responsible for having and properly wearing a personal floatation device. If the snaps, zipper or belt on a PFD are not in good shape or not worn properly the vest may be lost quickly during an emergency in the water. It is especially valuable to have a good bow person. This person is the last one in the boat and is the first one out of the boat. When departing a landing, the bow person unties the boat and stands ready holding the bowline until the driver has the engine warmed up and gives a nod that everything is ready to go. Then the bow person gives a push and hops onto the bow. Then he quickly dresses the bowline making sure the line is completely inside the boat and not in a tangled heap to be tripped on and then sits or kneels down braced for acceleration. When arriving at a landing the bow person steps out of the boat with the bowline or an anchor, whichever is needed, and quickly pulls the boat snug to the bank and secures it tight either tying off the bowline or by stretching the anchor line tight and kicking the anchor firmly into the ground. This allows the driver to remain at the engine with it running until the boat is secured.

It is the responsibility of all passengers to remain alert and be aware of possible hazards at all times. When running in narrow channels or along brushy shorelines, keep your hands inside the boat. Branches, logs or rock faces scraping along the gunnels can mangle your fingers. It is sometimes necessary to duck under overhanging brush or sweepers. Passengers should also avoid obstructing the boat operator's view. When approaching a shallow landing with swift current the operator may need to shut down the motor before reaching shore. Passengers should be ready to jump out and walk the boat to shore. Passengers should also be aware of the balance of the boat and should adjust their sitting positions to help achieve balance. If power is lost passengers should quickly aid with paddling or poling with oars to get to the nearest safe landing.

General tips

- Get the feel of your boat. Different boats and various loads will affect handling characteristics. Learn how to put it in a skid and control the skid. Find a sloping gravel beach area and run the boat in shallow water. Feel for the hull lifting in very shallow water.
- Always keep a hand on the tiller handle when traveling at speed. Letting go of the tiller can cause the boat to go into an abrupt sharp turn.
- Keep your boat clean. Sand and silt can add a lot of weight making the boat handle sluggishly and unnecessarily waste fuel.
- Have a clear pathway to the bow and make sure the bowline is accessible.
- Carry polarized sunglasses. They will help you read the water and lessen eye fatigue from sunshine and water glare and protect them from blowing sand and flying insects. On bright days glare off the water can make it very difficult to see on the river.
- Gun barrels, net handles, fishing rods or pack straps sticking over the gunnel of the boat can catch on brush and be pulled from the boat.
- Know what to do in an emergency. If the boat must be abandoned, grab the survival gear and stay with your companions. Practice rowing your boat in a safe area, practice poling off the stern with an oar. It is harder than you would think. Practice using a rescue throw bag. Learn and review swift water rescue techniques (Appendix A1).
- Wear and secure your life vest. Personal floatation devices save lives and when they do not they still aid in body recovery.
- Jet boating on a river is a little like flying a small plane in that you never want your motor to quit. Make sure to keep up on maintenance. Know how to perform general troubleshooting on the motor. Grease the jet foot regularly as prescribed. Learn how to remove the jet foot, adjust the impellor fit, change the key and file the impellor blades. Know how to drain the carburetor and fuel filter, change the spark plugs and replace the starter chord. Read the manuals.
- Know what your responsibilities are each time you get in a boat.

Footwear

Minnow trapping may be conducted on a variety of waters ranging from ponds to large glacial rivers and under conditions ranging from warm summer days to early spring when up to 5 ft of snow may still be on the ground. Your choice of footgear will depend on the conditions you will be working in. In the 1970s and early 80s light rubber hip boots were the standard footwear while trapping rivers where a lot of walking and climbing around in log jams is necessary. The short height of hip boots limits access to some habitat but on fast rivers may prevent one from wading into dangerous currents. The durable chest waders available at the time were very heavy, cumbersome and uncomfortable in warm weather. With the increasing comfort levels afforded by the advent of neoprene chest waders in the 1980s and, more recently breathable chest waders in the 1990s, more field personnel prefer wearing chest waders. The modern breathable chest waders typically are 'stocking foot' which means they require a separate wading boot. These boots are available with several options for the type of sole, including felt, studded, and rubber. Felt soles are the most common choice of our field personnel. Felt soles grip well on logs and algae covered rock and stream bottoms and are comfortable on long hikes. Drawbacks to felt soles are their lack of traction on mud and their tendency to collect and build up compacted snow. Studded felt soles have good grip on algae bottoms and are excellent for climbing around on logs. The studded soles are not good on large boulders or smooth bedrock. In addition, snow will build up on them the same as on regular felts and they are not as comfortable on long hikes. Cleated rubber soles are quite slippery on algae and wet logs but are a good choice for work in sand, mud, snow or clean gravel. Some companies offer interchangeable soles on wading boots so you can switch from rubber to felt or studded felt soles. We have had some problems with the interchangeable sole attachment systems when sand or silt binds the screw fittings.

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FIGURES

Cover photo–Minnow trap being picked from root wad set. Note the overhand knot that can be untied while wearing gloves.

Figure 1.–Checking minnow trap. This is when we do a quick estimate of catch and toss out old bait and most of the non target species.

Figure 2.–Large stacking fish traps designed by Kent Crabtree. The large cone entrance is removed for easy access to the catch and for baiting.

Figure 3.–Deep water logjam habitat. Good coho habitat and often overwinter Chinook habitat. Note cleated-felt soles for walking on logs.

Figure 4.–Excellent spring or fall juvenile Chinook habitat on Unuk river. Good gravel, root wads and slow current.

Figure 5.–Side channel set. Chinook will usually drop out of side channels as the main river drops.

Figure 6.–Braided channel root wad habitat. Note how during higher water the current has scoured out a pocket among the roots.

Figure 7.–Spring moving fish site. Also potential seining site. Note picket pounded into gravel for anchor. Shovel is needed to dig hole for set.

Figure 8.–Under ice set on backwater area. Opening on funnel of trap has been pinched down to exclude larger Dolly Varden from entering.

Figure 9.–Good habitat for minnow trapping Chinook salmon in the spring.

Figure 10.–Spring high water, moving fish set.

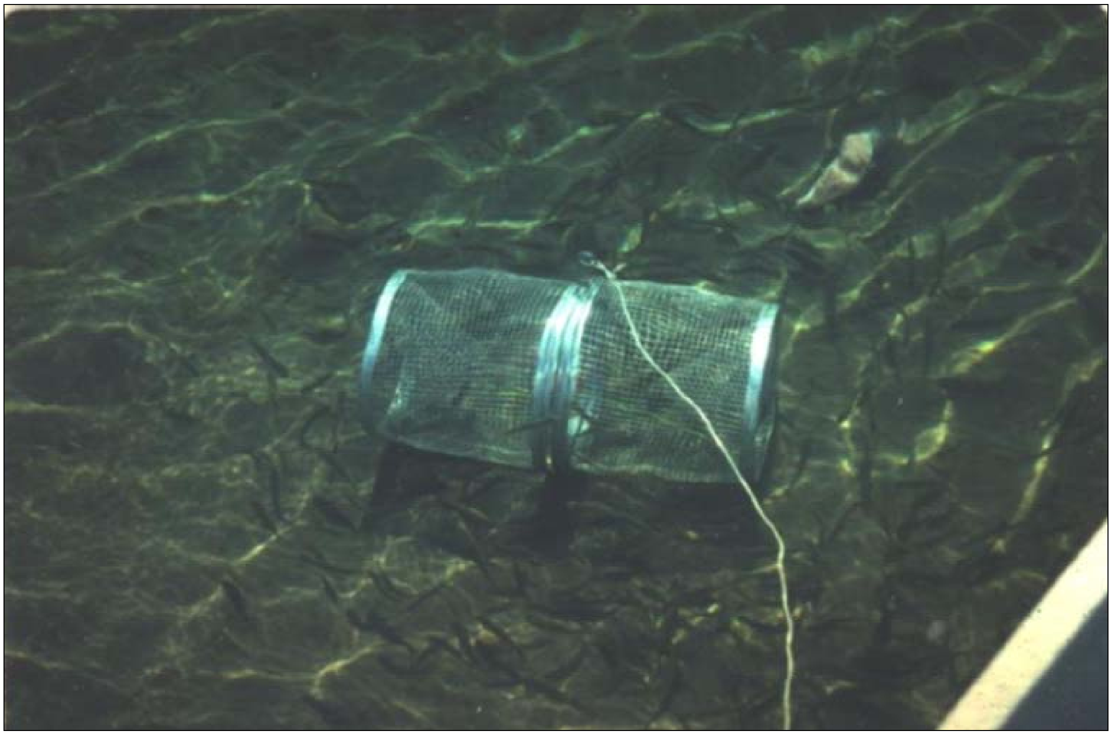


Figure 11.–Age-0. check Chinook smolts on the Situk river. Not good habitat but fish were in large schools in the estuary.

Figure 12.–Seining smolt along a gravel bar on glacial Stikine river.

Figure 13.–Example of a simple Vexar® panel smolt weir on a tributary of the Nakwasina River.

Figure 14.–Cottonwood Creek weir. The water level on the upstream side of the weir was higher than the downstream side and the tube had an acute upward bend. Debris on the weir served to dam the creek and, water flowed out the elevated tube only when the water level was high enough. The weir was cleaned only in the early evening and this temporarily dropped the water level and stopped the flow of water (and smolt) from the tube. Debris accumulated on the weir during the evening hours, and, by about 8 am, water was flowing from the tube again. This negated the need for around-the-clock crew shifts. The crew worked a normal day shift and one crew slept on site. Smolt occasionally attempted to jump from the trap back into the tube, so a funnel of Vexar® was placed around the discharge end of the tube to prevent smolt from missing the tube and landing in the creek.

Figure 15.–Moose Creek smolt weir and culvert leading to live box. Note culvert must be staked down to keep it from being pushed downriver and separating at joints.

Figure 16.–The coho salmon smolt weir at the outlet of Hugh Smith Lake and the aluminum framework of the adult weir. The smolt weir is located in deeper water where the current is less severe. A cable provides support along the top. A floating walkway provides convenient access between the inclined plane trap and the tagging operation.

Figure 17.–The smolt weir panels at Hugh Smith Lake are constructed of four-inch ABS plastic pipe and covered with ¼ inch mesh Vexar®. The panels rest against the lake bottom and are supported by a cable at the top.

Figure 18.–A spill trap is installed in a beaver dam taking advantage of an 8-in difference in water level. Numerous small trickles are blocked by a fence of mesh on the inside slope of the dam. The mesh fence is also a preparation for higher water levels. Note floating aluminum live box with solid lid.

Figure 19.–Spill trap weir combination. Note bank stabilizing efforts, and the use of perforated metal panels and plastic cable ties.

Figure 20.–The trough of a spill trap installed in a long beaver dam on a tributary of the Berners river. A mesh fence blocking many trickles should be installed in 6 to 12 in of water, upstream of the crest of the dam.

Figure 21.–Water has risen at this spill trap site. A small corral of very sturdy 2-in square mesh wire is installed at the entrance of the trough. This prevents beavers from damming the trough opening. Smolt will readily pass through the large mesh if it is kept clear of debris.

Figure 22.–This spill trap was plugged by a busy beaver. This photo illustrates one reason that daily inspections are needed even when fish numbers are low.

Figure 23.–The pot end of a fyke net. The leads on fyke net act as a weir on small streams.

Figure 24.–Rotary screw trap raised from water for cleaning. Note boom log and safety light.

Figure 25.–A battery of inclined plane traps deployed on the Thumb River. Note cable hinders river navigation.

Figure 26.–Four aerators are powered by the 12V battery that is used to start the outboard motor. Buckets are also being used to hold fish. The totes are 18-gal size; they have long straight sides suitable for mounting the aerator spray tube. In the background is the dewatering trough of a spill trap installed in the outflow from a beaver dam.

Figure 27.–Construction of floating net pens with Styrofoam floats. Note lid to keep out predators.

Figure 28.–Floating net pens in calm area near the tagging shed.

Figure 29.–On-land fish holding box on the Chickamin River with aeration and 12 volt fresh water pump.

Figure 30.–Live box on Moose River weir. Note perforated metal panels and welded tube for crowder to slide on. Live box is about 10 x 4 ft, so crowder is used to concentrate fish in one end and then moveable panels are dropped in to hold them in small area for easy netting.

Figure 31.–A Quality Control Device is included in this tagging operation. Hoses are used to refresh fish holding buckets. The buckets are modified with drain holes. Also note the use of rubber foot relief mats and the cut-down side of the tagging pan.

Figure 32.–QCD with submersible water pump and two examples of hose set ups and spill buckets.

Figure 33.–The coho salmon tagging camp at Berner's River. A T-shaped floating dock provides convenient access to the fish holding pens. Stairs are installed on the cut banks for convenience and to prevent undue erosion.

Figure 34.–Taku river floating tagging shed mounted on sealed steel drums. Note holding pens in front.

Figure 35.–The live box and sorting tub at Moose River smolt weir. Note moveable panels in live box and base mount talley counters for counting other species and upstream migrants.

Figure 36.–Tagging table at Moose River weir. Note small tub with dip net of fish in it and plexiglass cover to keep them from jumping out. That tub and upper tub have MS222 solution pumped through them. Tub on the right has fresh water pumped through it. Stainless steel industrial sink with overflow tube is used to hold fish prior to tagging, fresh water pumped through it. Note cooler on floor contains the MS222 solution. Quality control device drops tagged fish directly into holding pens in the river for recovery.

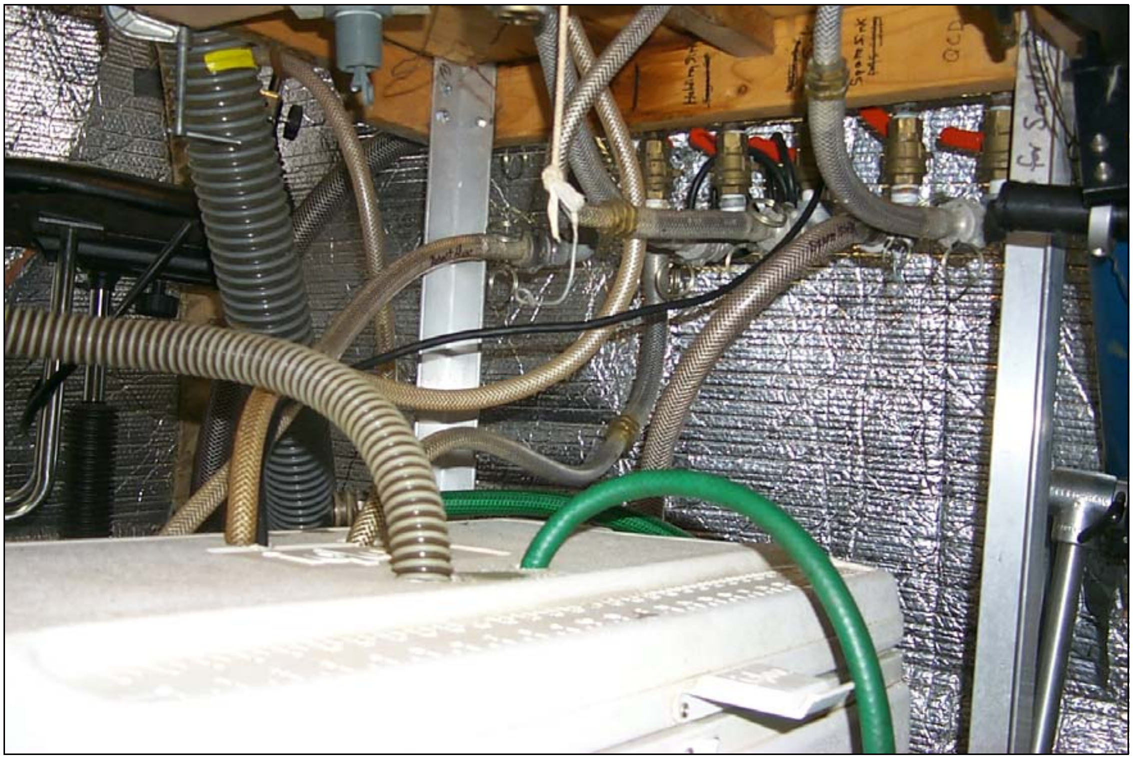


Figure 37.–Underside of tagging table at Moose River. Note water manifold at the top right of the picture. Large pump provides freshwater to the manifold where it is then directed to holding tank, tagger tub, QCD, and cooling tubes in MS222 cooler. Note quick release hose couplings and braid reinforced tubing.

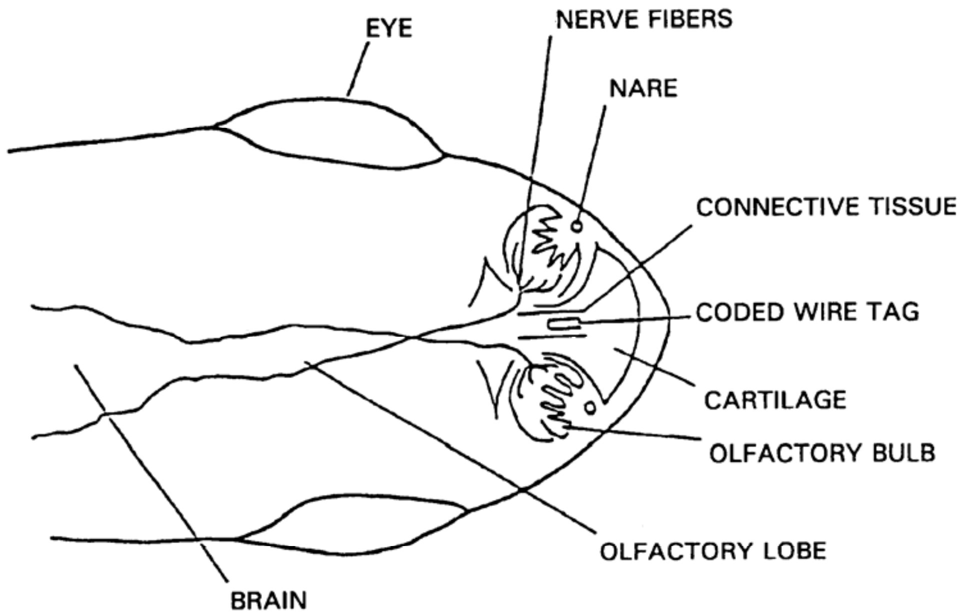
Figure 38.–Pump for recirculating MS222 solution and coil of copper tubing to circulate fresh river water through cooler to keep the MS solution from getting too warm.

Figure 39.–Sorting and clipping set up at Taku river smolt camp. Note water table and colanders labeled for sorting fish by size. Water table contains MS222 solution. River water is pumped through copper tubes in the water table to keep the water cool.

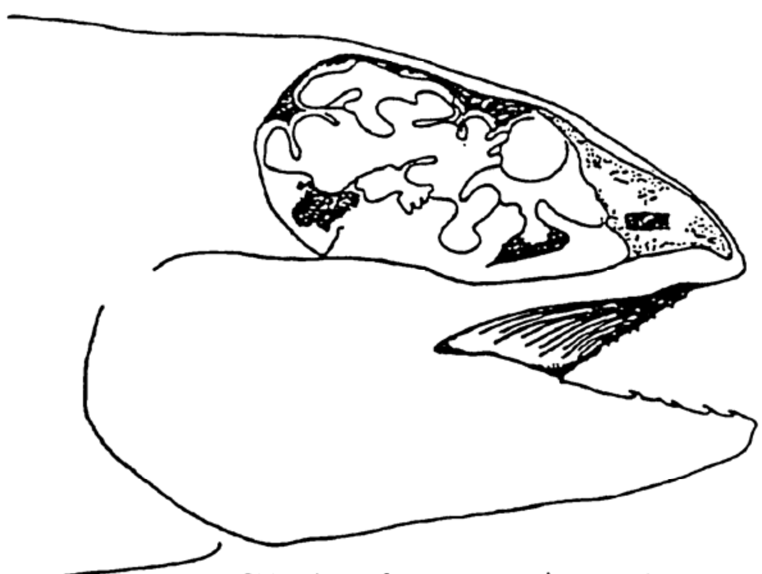
Figure 40.–Sockeye, Chinook, and coho salmon smolt, top to bottom. Note variation in color, parr marks and adipose fin.

Figure 41.–Atlantic salmon fingerling. Keep an eye out for these and collect any that you find.

Figure 42.–Checking tag placement with jewelers loupe and single edge razorblade.



Top view of proper placement of coded wire tag in fish's head.



Side view of proper tag placement.

Note: From Peltz and Hansen 1993.

Figure 43.–Tag placement diagram.

Figure 44.–Smolt measuring trough made from 2 in PVC plastic pipe.

APPENDIX A: WILD CHINOOK SALMON CODED WIRE TAGGED IN SOUTHEAST AND SOUTHCENTRAL ALASKA

Appendix A1.–Releases of wild Chinook salmon coded wire tagged in Southeast and Southcentral Alaska, by river system and primary capture gear, 1995-2004.[a]

Chinook System	Primary Gear	Release Year 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	Reference
Chilkat River[b]	MT					771	1,996	34,610	27,832	34,187	42,347	141,743	Ericksen 2004
Taku River	ST, MT	11,124	21,586	37,873	32,722	19,537	17,302	41,856	37,772	28,000	23,078	270,850	McPherson et.al. 2000
Stikine River	MT, BS						14,560	5,774	17,411	19,927	26,630	84,302	Richards et al. *In prep*
Unuk River[b]	MT	37,540	61,453	65,483	92,823	55,635	43,783	62,275	70,132	80,172	72,683	641,979	Weller and McPherson 2006
Chickamin R[b]	MT								25,485	36,732	32,340	94,557	Freeman et al. *In prep*
Southeast Total		48,664	83,039	103,356	125,545	75,943	77,641	144,515	178,632	199,018	197,078	1,233,431	
Copper River	MT			71,367	71,116	71,900						214,383	Sarafin, 2000
Kenai River	IP, MT	58,741[c]	6,532	19,385	9,970							94,628	King and Breakfield 2002
Killey River	SC			12,543	6,165	47,325						66,033	King and Breakfield 2003
Willow Creek	MT		39,987	94,436	77,585							212,008	www.taglab.org

Gear: MT = minnow trap, SC = rotary screw trap, IP = incline plane trap, ST = spill trap, BS = beach seine.

[a] Not all inclusive, numbers from www.taglab.org

[b] Includes age-0 fingerlings and age-1. smolt.

[c] Includes 57,262 age-0 fingerlings captured in minnow traps (Bendock 1996).

APPENDIX B: WILD COHO SALMON CODED WIRE TAGGED IN SOUTHEAST AND SOUTHCENTRAL ALASKA

Appendix B1.–Releases of wild coho salmon coded wire tagged in Southeast and Southcentral Alaska, by river system and primary capture gear, 1995-2004.

Coho System	Primary Gear	Release Year											
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total	Reference
Tawah Cr	MT					30,556	22,571				31,034	84,161	
Situk R	MT										29,930	29,930	
Chilkat R	MT					25,876	24,992	35,977	25,289	24,559	17,279	153,972	Ericksen and Chapell 2005
Berners R	SP,MT	26,017	40,954	16,733	35,179	34,166	58,092	33,615	29,980	38,148	29,821	342,705	Shaul et.al. 2003
Ford Arm Lk	MT	6,564	10,993	10,093	12,050	7,129	8,095	12,634	10,547	8,858	6,483	93,446	Shaul et.al. 2003
Nakwasina R	MT				9,980	3,972	10,309	10,381	5,685	15,763	9,771	65,861	Tydingco 2005
Auke Cr	SW	4,798	3,919	6,082	7,379	5,121	4,862	5,684	3,401	3,533	4,550	49,329	Shaul et.al. 2003
Jordan Cr	SW								7,860	9,135	11,485	28,480	Taglab.org
Taku R	MT	12,244	14,891	15,359	19,832	30,687	44,797	50,897	23,262	32,545	16,116	260,630	Yanusz et.al.2000
Slippery Cr	WT					12,956	12,391	19,193	15,874	24,907	21,874	107,195	Fleming 2005
Stikine R	MT, BS						17,460	22,262	14,719	8,757	13,762	76,960	Richards et al. *In prep*
Chuck Cr	SW								8,993	23,010	15,327	47,330	McCurdy 2006
Naha R	SC				12,631	7,100						19,731	Freeman 2003
Unuk R	MT		7,813	11,358	16,773	10,877	21,280	23,620	13,345	15,296		120,362	Weller et al. 2003
Chickamin R	MT								12,781	18,086	29,031	59,898	Freeman et al. 2006
Hugh Smith	SW	12,585	24,220	26,367	20,213	11,975	19,655	29,388	18,933	15,572	23,517	202,425	Shaul et al. 2003
Southeast Total		62,208	102,790	85,992	134,037	180,415	244,504	243,651	190,669	238,169	259,980	1,742,415	
Moose River	SW	94,557	97,744	96,124	100,728	113,824	102,300	146,776	107,069	119,640	82,128	1,060,890	Massengill and Carlon 2004
Cottonwood Cr.	SW					34,701	40,997	19,039	14,574	19,479		128,790	Namtvedt et al. *In prep*

Gear: MT = minnow trap, SC = rotary screw trap, IP = incline plane trap, ST = spill trap, BS = beach seine, SW = smolt weir, WT = wolf trap
Numbers from www.taglab.org

APPENDIX C: LIST OF VENDORS

Appendix C1.–Partial list of vendors of gear useful in CWT projects.

Listing here is not an endorsement by ADF&G or the State of Alaska.

Vendor	Web Site	Phone	Item	Cost	Date	Comments
Aquatic Eco-systems,Inc	www.aquaticeco.com	877-347-4788	Tricaine-S MS-222 #TRS1	61.00/100gm ; $325/Kg	2005	MS-222
Aquatic Eco-systems,Inc	www.aquaticeco.com	877-347-4788	airstones, air pumps, dip nets, water pumps, povidone egg disinfectant, pump filter bags			Many different items in this catalog, useful “tech talks” on many subjects
Aquatic Eco-systems,Inc	www.aquaticeco.com	877-347-4788	standard minnow trap MT2	10.65 ea 57.00/6	2005	looks like G-40
Aquatic Eco-systems,Inc	www.aquaticeco.com	877-347-4788	large minnow trap 30 in.x15 in. or 36 in.x18 in.	$79 or 90ea	2005	Oversize minnow traps
AQUI-S New Zealand	www.aqui-s.com	805-542-0871	AQUI-S clove oil anesthetic		2005	Not FDA approved yet, can be used with INAD exemption
Argent Chemical Labs	www.argent-labs.com	800-426-6258	Argentyne, #c-arge-nt egg disinfectant	$24/gal	2003	bait disinfectant, haven't used this brand
Argent Chemical Labs	www.argent-labs.com	800-426-6258	MS-222 Finquel #c-finq-ue-100g	90.00/100g $459/kg	2005	MS-222
BassPro	www.basspro.com	800-227-7776	Catch-saver 12V #12-576-735-00	36.99 each	2005	water pump aerator kit for holding tanks
Cabelas	www.cabelas.com	800-237-4444	Superfish saver, 12v #IF-013318	39.99	2005	looks like Catch-saver?
Cabelas	www.cabelas.com	800-237-4444	Rule model 1100 bilge pump #IF-012155	33.99	2005	Used for holding fish in tubs overnight
Cabelas	www.cabelas.com	800-237-4444	Optivisor order no.TS-31-5395	$34.99	2005	Good for fin clipping and machine maintenance.
Carolina Biological Supplies	www.carolina.com	800-334-5551	iris micro-dissecting scissors, stainless steel, #62-3555	20.50 each	2003	adipose fin clippers
Carolina Biological Supplies	www.carolina.com	800-334-5551	dissecting needles (bent) #62-7203	2.60 each	2003	for smolt scales
Carolina Biological Supplies	www.carolina.com	800-334-5551	frosted end slides #62-2100	10.60/box of 72	2003	for smolt scales

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Vendor	Web Site	Phone	Item	Cost	Date	Comments
Carolina Biological Supplies	www.carolina.com	800-334-5551	Ohaus digital balance 200 X0.1gm CS200 #70-2215	$105 each	2005	portable scale for weighing smolt, make sure you get 0.1gm accuracy
Christensen Net Works	www.christensennetworks.com/	800-459-2147	Beach seines, net pens, dip nets		2007	Easy to work with, based in WA
Cuba Specialty Manufacturing	www.tackle-factory.com	800-991-2822	Gee's improved G-40 minnow trap	7.35 each	2004	The original minnow trap
Dayton Bag and Burlap	www.daybag.com	800-258-8000	sand bags, both burlap and polypropylene	100/$125 -	2005	>500 $.75 each
Duraframe Dipnet	www.duraframedipnet.com	888-289-3140				Heavy duty dipnets
E. G. Solutions	http://home.teleport.com/~egs/	541-757-4263	rotary screw traps			Corvallis, OR
Forestry Suppliers, Inc.	www.forestry-suppliers.com	800-543-4203	Base mount tally counter #53035	9.95 each	2003	counting recaptures
Forestry Suppliers, Inc.	www.forestry-suppliers.com	800-543-4203	Landscape fabric, sand bags, surveyors tape		2006	Biodegradable erosion control cloth, lots more good stuff
Forestry Suppliers, Inc.	www.forestry-suppliers.com	800-543-4203	Hobo water temp pro logger	$110, 10+$100 ea	2006	Version 1, needs Boxcar software
Grainger	Grainger.com	800-245-6316	Water pumps, filters, hoses,			Huge Catalog, similar to McMaster-Carr
Grainger	Grainger.com	800-245-6316	Little giant model 4E-34NR, stock no. 1P322	$159	2006	9 ft. of head pumps 630 GPH preferred models for QCD use
Grainger	Grainger.com	800-245-6316	Dayton High capacity submersible, no.1P809	$129	2006	9 ft. of head pumps 800 GPH preferred models for QCD use
Internet Plastic Inc.	www.internetplastic.com	800-328-8456	plastic weir mesh			XV1020 0r XV1170
McMaster-Carr Supply Co.	www.mcmastercarr.com	562-692-5911	Headband Flip-up magnifier *#1490t1*	27.43 each	2003	Smolt ID and fin clipping
McMaster-Carr Supply Co.	www.mcmastercarr.com	562-692-5911	quick release hose couplings and reinforced hose			Tagging shed plumbing

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Vendor	Web Site	Phone	Item	Cost	Date	Comments
McNichols Company	http://www.mcnichols.com/	800-237-3820	perforated metal plates and wire mesh			
Memphis Net & Twine	www.Memphisnet.net	800-238-6380	Net pen 4'x4' 1/4 in.mesh H-Delta NHB7-4	50.75	2005	Holding pens, available in many sizes and mesh, also beach seines, buy with covers
Memphis Net & Twine	www.Memphisnet.net	800-238-6380	wind + sand fence	$63.50/50'	2005	like Vexar
Mirafi	www.mirafi.com	706-693-4400	Erosion control cloths			Filter weave 400? Couldn't get consensus on specific type
Murray Pacific	www.murraypacific.com	800-478-3135 800-4783171	Neptune leader material, boat gear			Stores in Ketchikan and Sitka
Murray Pacific	www.murraypacific.com	800-478-3135 800-4783171	Foam Logs 10in x 20in x 9ft	$33 ea $60 ea	2006	Polyfoam logs for docks and floats, 'wrapped' cost more
Northwest Marine Technology	www.nmt-inc.com	360-468-3375	CWT injectors, tags detectors, online help	List on website	2005	Sole source
Northwest River Supply	www.nrsweb.com	800-635-5202	throw bags, knives, dry bags			river running supply specialists
Onset Computer Corp	www.onsetcomp.com	800-564-4377	Temperature, depth, data loggers, software		2006	Record temperatures, up to 6 year battery life
Petersburg Fisheries		907-772-4294	Bait eggs			
Redden Net Company	www.redden-net.com	800-667-9455	Vexar plastic mesh	$160/100'	2005	smolt weirs,holding boxes, seines, fyke nets.
Rescue 3 International	www.rescue3.com	800-457-3728	Swiftwater rescue training	325/person	2005	Good course. 3 days
Rite in the Rain	www.riteintherain.com	253-922-5000	3-11M Level, small notebook 3x4	20.20/doz	2005	Little yellow book
Rite in the Rain	www.riteintherain.com	253-922-5000	#611 level notebooks Dura-rite paper	$55/doz	2005	water proof plastic paper
Rotonics Manufacturing	http://www.rotonics.com/rivers/durafloat.htm	325-646-1566	Dura-float pontoons		2006	Heavy duty pontoons for docks, incline plane traps,
Roy Manufacturing	http://www.roymfg.com/	800-284-6009	perforated metal plates for weirs and live boxes			

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Appendix C1.–Page 4 of 4.

Vendor	Web Site	Phone	Item	Cost	Date	Comments
South Padre Island Nets	http://www.spinets.net/marine.html	866-243-6387	Beach seines and fyke nets	$3.26/ft	2005	¼ in, 35lb Delta, 6ft deep
Sportsman's Guide	www.sportsmansguide.com	800-882-2962	Gamma Seal bucket lids	$5.97	2005	very handy.
Seattle Marine	http://www.seattlemarine.net/	800-426-2783			2006	Huge catalog of fishing gear
VWR Scientific	www.vwrsp.com	800-932-5000	Ohaus digital balance 200 X0.1gm CS200 #65500-204	$109	2005	portable scale for weighing smolt, make sure you get 0.1gm accuracy
Wave Train	wavetrain@ak.net	907-586-2321	ACA river safety and rescue seminar	call for prices		Good course
West Marine	Westmarine.com	800-262-8464	Boat supplies, water pumps, 12v hardware		2005	Epoxy sticks, Marine-Tex

APPENDIX D: UNUK AND CHICKAMIN RIVER SMOLT TRAPPING/GPS DATA COLLECTION 2004

Appendix D1.–Unuk and Chickamin River smolt trapping/GPS data collection 2004.

SF Staff will implement procedures and techniques for the collection of spatial data using Global Positioning System (GPS) units at specific locations on the ground that are associated with smolt trapping sites within the Unuk and Chickamin Rivers. These projects include coded wire tagging of Chinook and coho salmon presmolt and smolt as a component of full stock assessment.

The procedures for this work are fairly straightforward and repeatable given a few guidelines. First and foremost, Sport Fish Division (SF) crews are NOT being asked to change their mode of operations, as it pertains to smolt trapping methods. Rather, the collection of spatial data from GPS units (waypoints) is a task that occurs coincidentally with smolt trapping work. Generally, we are looking to collect waypoints at all smolt-trapping sites (sites are not exact trap locations; sites encompass more than one trap), providing a means to put on a map, exactly where smolt-trapping is occurring. If trapping sites were all the same size and configuration (we know they are not), we could simply grab one waypoint for a group of traps known collectively to encompass what SF field crews call 'spaghetti flats' and another waypoint for the next group of traps up/down river and associated with another generic named location, as recorded in their field notebooks.

The reality however (as observed on smolt trapping work on the Unuk) is that these trapping sites differ in size and configuration and may "move" up or down river as crews trap out portions and reposition traps in new areas, sometimes in close proximity. Rather than re-naming their generic site name in those areas where traps were moved short distances, they may keep the same name. In other instances, SF crews move into new areas as snow/ice break up which get a new generic name for the site.

Capturing waypoints in a manner that represents the whole extent or area of individual trapping sites can accommodate each of these scenarios. This may entail taking single waypoints at small sites (which may represent 4-5 traps placed at a small log-jam) or 3-4 waypoints, which outline the "corners" of a relatively larger trapping site that resembles a square area. It may also entail taking additional waypoints as a single trapping site is fished out and traps are 'shifted' or moved down/up stream; field crews may decide to keep their generic site name, since its in close proximity. One additional waypoint may be sufficient such that we would be able to map out the entire extent of the trapping area.

The bottom line is that waypoints are collected at each individual trapping site, which depict the general area of trapping effort, and are precise enough to be mapped. If two waypoints are collected for a single trapping area, generally identifying the upper and lower portions of the site and a few traps (associated with the same SF site name) are below or above these waypoints by 20-30 meters, this is fine. We are looking for a precision of under 50 meters in most cases; although 100 meters may be the best we can do in large braided areas of the Unuk floodplain, without unduly creating chaos for field crews where the primary responsibilities are trapping large numbers of fish. Figures D1-D3 illustrate the use of waypoints in delineating or 'outlining' the extent of trap sites (areas) with an acceptable level of precision. In these figures, the polygons representing the trap sites (areas) may appear to be arbitrarily drawn, considering that

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although the points fall inside, they don't provide all the corners. We should note that stream banks and islands present obvious boundaries for the delineation of smolt trapping areas, in absence of other information. We also were there on the ground ourselves for part of this work, specifically taking related information on estimated length and width of the trapping area, and thus we were able to extend the trapping area past waypoints, even though they might have signified the upper and lower extents of these sites. All of this comes down to a matter of scale and acceptable accuracy, which is a balance between extra tasks asked of the SF smolt crews.

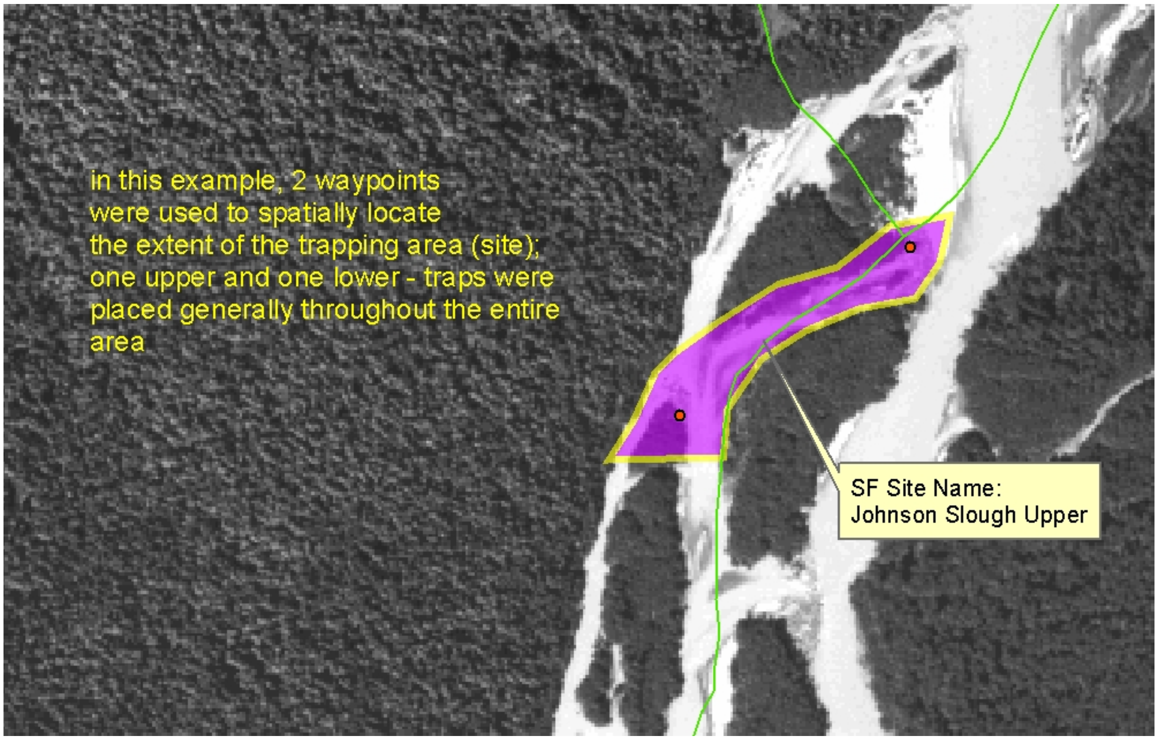

Figure D1.–Sportfish (SF) smolt trapping site on the Unuk River. The outlined polygon represents a single trapping site or area known as Johnson Slough Upper. Individual trapping sites may contain an infinite number of traps. The dots represent 2 waypoints collected to delineate the 'approximate' extent of trapping effort associated with this site.

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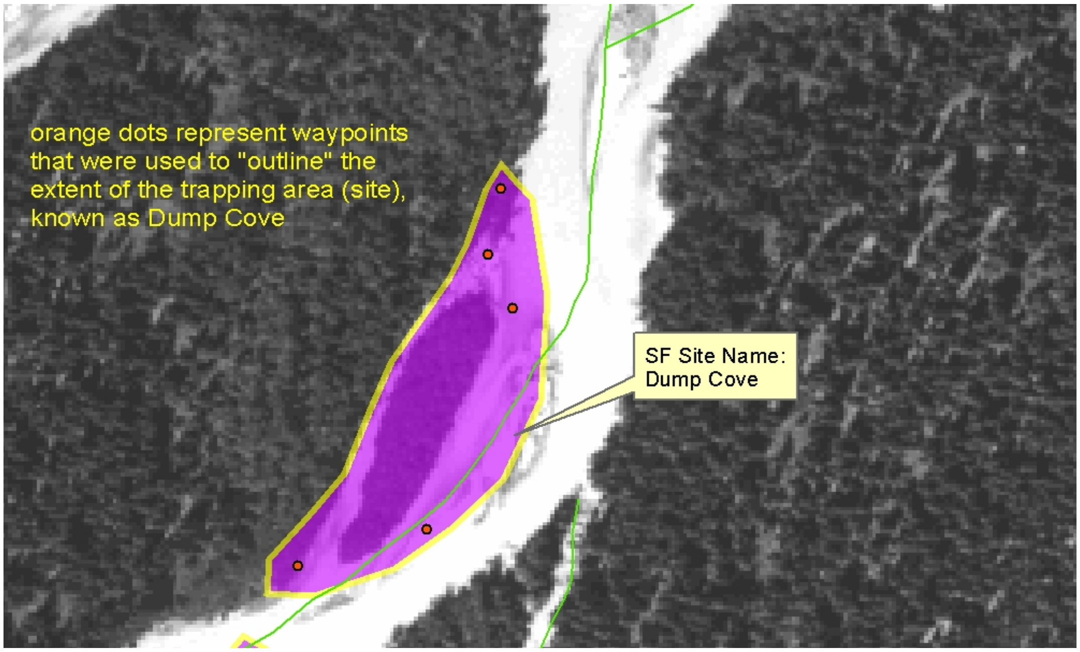

Figure D2.–In this example, SF Crews elected to take more than 2 waypoints to delineate the extent of the trap site Dump Cove. The upper and lower most waypoints are critical, although the 3 other points allow us to more accurately represent traps that were placed on the river left side of the island.

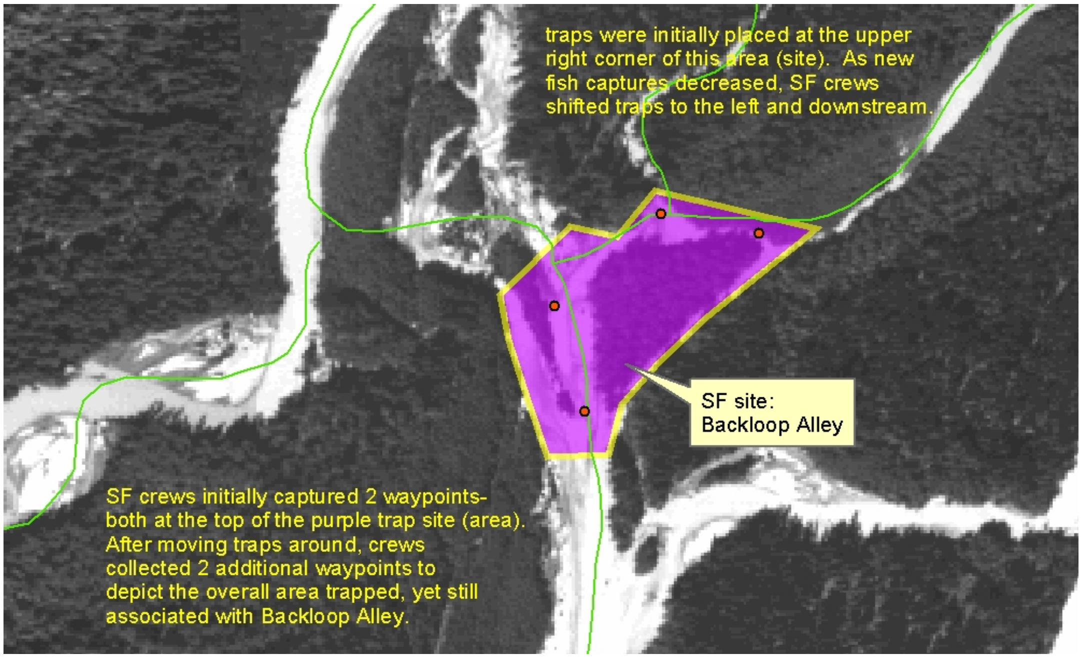

Figure D3.–Again, SF crews shifted traps in response to decreasing numbers associated with initial trap locations (upper portion of polygon). Rather than re-name the SF site, they elected to capture 2 more waypoints associated with new trap locations thereby providing 4 “corners”, where we could delineate the Backloop Alley trap site (area).

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GPS Units and data collection

All GPS data will be collected in NAD83 or WGS84 (Garmin default) datum, and should be checked before any GPS points are recorded. Jeff Nichols and Amy Holm will confirm that GPS units sent to the field, will be setup properly according to datum. The collection of waypoints associated with individual trap sites (areas) should accompany trap related data in field notebooks used by SF staff. This would include recording the GPS Unit (Magellan 320, Garmin 12XL, Garmin 450, etc), the waypoint number, the GPS positional error (or accuracy) and a very brief description of what the individual waypoint depicts (e.g., upper most river right or lowest point on river left, etc). If only one GPS unit model (Garmin 12XL, Magellan 320, etc) is used by a crew throughout the smolt trapping season, then it will be unnecessary to record this information daily; just make sure it's on the first page of each field notebook used. One additional piece of information to be recorded includes species and fish numbers. If this data is generally collected concurrent with checking trap lines, then it should be recorded in field notebooks. This information will accompany trap related records associated with the trap site (area), which field crews collect each day, such as number of traps placed, number of traps checked, number of fish, number of traps pulled, etc. **An example of the data collected during smolt trapping which captures all the relevant GPS data is provided in Table D1**. The format for this table is essentially what field crews collected in their field notebooks during smolt trapping on the Unuk River in past seasons; several additional columns (fields) have been added which absorb the necessary GPS info. Keep in mind that waypoints identifying a unique location (e.g., upper most point on moose slough) only need to be captured once through a season, assuming the upper most point on moose slough doesn't change); this means that if SF crews lay out traps on a site (e.g., moose slough) and take waypoints associated with the extents ("corners") on that day, no other waypoints are necessary for this site…unless crews decide to "shift" or move traps down or upstream without changing the site name. If sites shift, field crews should take another waypoint on the day they are shifted or moved, which depicts this extension of the trapping area (site), and code this information in their field notebooks.

If traps are placed in areas where no site name is given (especially locations where only 1 or 2 traps are placed), specific comments should include a concise description of the general location (e.g., on small tributary to mainstem approximately 250m from the main channel or in beaver pond complex on west side of mainstem approximately 400m from the main river channel). In general, observers should *always describe features as to right or left as if they were looking downstream (e.g., confluence right bank)*—in other words, "**going with the flow**".

-continued-

Table D1.–Example of field data collected during smolt trapping which collects all relevant information necessary for spatial data (GIS, GPS) absorption.

Date: 10/20/2003 GPS Unit Model: Magellan 320

SF Site Name	Traps set	Traps pulled	Traps checked	Total traps	# of fish by species	Waypoint number	Waypoint Accuracy (m)	Waypoint description
Shotgun slough	12	0	12	12	220 coho; 110 king	1-4	8, 11, 7, 15	1&2 – lowest most right/left bank; 3&4 – upper most right/left bank;
Spaghetti flats	10	0	10	10	140 coho; 140 king	5,6	10; 10	5 – upper; 6 – lower
Wolfkill	6	0	6	6	40 king	7,8	8, 12	7- upper; 8 – lower
Snowball	0	4	4	0	35 coho; 10 king	9	13	Center of trap area
Sanjay's channel	0	6	6	0	50 king	10, 11	6, 9	10 – upper; 11 – lower
Dump cove	8	0	8	8	60 coho	12, 13, 14	8, 7, 15	12 – upper 13 – central(rt bank) 14 - lowest
Backloop alley	4	0	4	4	20 coho	15	10	Central
Leaner	6	2	6	4	40 coho	16, 17	10, 11	16 – upper 17 – lower
Moose slough	22	0	22	22	340 coho; 100 king	18, 19, 20	8, 9, 11	18 – upper 19 – lower 20 - central

In summary, GPS locations should be taken at all CWT trapping sites where minnow traps are deployed. Rather than taking a GPS reading at each and every minnow trap, observers should attempt to define the bounds of the area being trapped (e.g., Spaghetti Flats, 6-pack slough). If a site has an upper and lower reach, then 1-2 waypoints should be taken at the upper and lower extents of the upper portion and additional waypoints as necessary taken at the extents of the lower reach. Smolt trapping data books should reflect these occurrences, by identifying upper and lower reaches in the site name (Log Jam – upper), as well as in the comments field.

Observers should always attempt to get the best possible "fix" from satellites when taking a GPS reading. Often, fixes with accuracy (or error, as it is labeled with some GPS units) under 15 m are possible in less than 30 seconds, especially on the larger river systems where canopy cover is minimal, and the view of the horizon is not obscured (e.g., high ridge immediately above river bank). There will be days when the constellation of the satellites is insufficient to allow for good fixes (i.e., > 15 m accuracy); in these instances, it is preferred that GPS locations be acquired on a return visit. If no return visit is anticipated, then observers should spend an extra 1-2min, if possible, to let the GPS instrument acquire the best fix under the circumstances. **All GPS reading should be taken on foot or from a stationary boat**.

APPENDIX E: EXAMPLES OF DAILY CWT TAGGING LOG

Appendix E1.–Example of a daily CWT tagging log.

Daily Smolt Tagging Record, Moose River Weir, May-June 2006

Code:		Tagging Data					Wire Sample	Overnight Retention Data			
			A	B	C	(B-A-C)		D	E	F	G
Date	TagTeam Initials	Head mold Size	Injector Start Count	Injector Stop Count	Tallywacker Adjustment	Total Tagged	Accum Tagged To Date	Number Detained Overnight	Overnight Mortalities	Live fish Tested	Tags Retained
		30									
		20									
		15									
					TagTeamTotal:				E/D=		G/F=
		30									
		20									
		15									
					TagTeamTotal:				E/D=		G/F=
		30									
		20									
		15									
					TagTeamTotal:				E/D=		G/F=
		30									
		20									
		15									
					TagTeamTotal:				E/D=		G/F=
		30									
		20									
		15									
					TagTeamTotal:				E/D=		G/F=

Appendix E2.–Another example of a daily CWT tagging log.

FORM 1. A daily summary for <u>each tag code</u> of the number of coho smolt injected, number retagged, number of overnight and quality control mortalities and number of naturally missing adipose fins, Cottonwood Creek, 2003.

Tag Code: ______

CWT Machine Number: ______

Date	Head Mold Size	Injector Count	Number Retagged	Sample Size	Mortalities Quality Control	Mortalities Overnight	Naturally Missing Adipose Fins	Comments
		[a]	[b]	[c]	[d]	[e]	[f]	

Appendix E3.–Another example of a daily CWT Log.

SPORT FISH DIVISION SALMON CWT DAILY LOG

TAGGING SITE: __________________________ **DATE:** _______________ **PAGE:** ____________

SPECIES: __________________________ **Fall Juvenile** or **Spring Smolt** (circle one)

AIR TEMP: Minimum _________ **(°C) ; Maximum** __________ **(°C)**

WATER: Temperature ________ **; Depth** ________ **(ft/cm/m)**

PRECIPITATION: ________ **(in/mm) MACHINE S/N:** __________ **HEAD MOLD SIZE:** __________

YESTERDAY'S TAGGING

1. TAG RETENTION AND SHORT-TERM MORTALITY EVALUATION

a. Number held 24 hrs ___________ (Yesterday's line 7 entry)

b. Tag Retention (Number of positive beeps/100) ___________ (Test 100 fish)

c. Mortalities ___________ (Overnight mortality)

d. Released Live Today (1a – 1c) x 1b ___________ (Release)

TODAY'S TAGGING

2. TODAY'S TAG CODE ___________

3. RECAPTURES ___________ (Ad-clipped fish in traps)

a. Total with CWTs ___________ (Release)
b. Number without CWTs ___________ (Tag and Release)

4. NEW CWTs APPLIED:
a. Ending Number ___________ (Machine Counter)
b. Beginning Number ___________ (Machine Counter)
c. Subtotal (a-b) ___________
d Retags ___________ (Tallywacker)
e. Subtotal (c-d) ___________ (Total CWTs Applied)

5. POST TAGGING MORTALITY: ___________ (Croakers)

6. NUMBER TAGGED (4e – 5) ___________

7. NUMBER HELD FOR TAG RETENTION AND SHORT-TERM MORTALITY (sum line 6) ___________ (Carry over to next day)

Notes

APPENDIX F: ADF&G CODED WIRE VERIFICATION FORM

Appendix F1.–ADF&G Coded Wire Verification form.

Alaska Department of Fish & Game

Mark, Tag & Age Lab Tel: 907- 465-3498

PAGE ___ OF ___

CODED WIRE VERIFICATION FORM for: ______________________

Facility/release site/project

TAG CODE	# K	WIRE SAMPLES (one per spool)				
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					
__ __ __ __ __	__					

Fold here

ENTRY STAMP

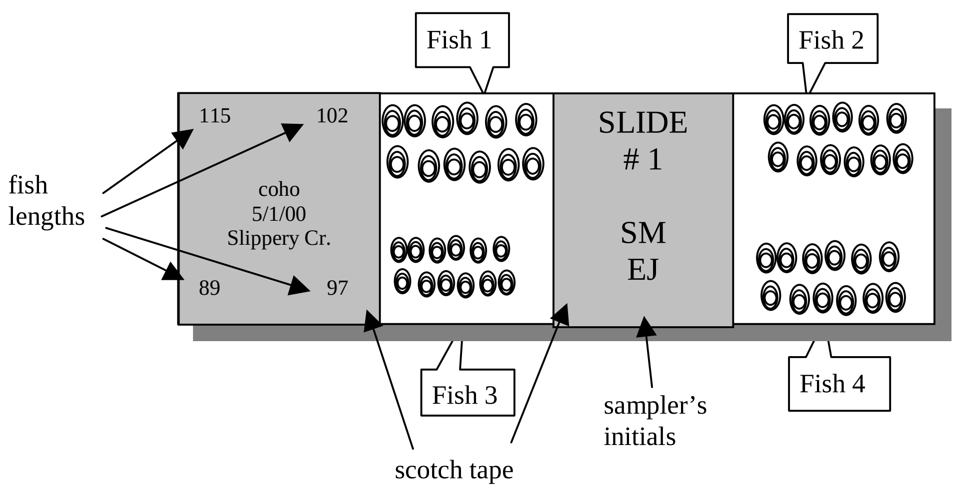
VERIFICATION STAMP

APPENDIX G: SMOLT SCALE SAMPLING PROCEDURES USED BY ADF&G

Appendix G1.–Smolt scale sampling procedures used by ADF&G in Southeast Alaska.

For coho salmon smolt sampled for length, weight, and scales, 12-15 scales will be removed from the preferred area (Scarnecchia 1979) on the left side of coho salmon smolt. Scales from up to four fish will be sandwiched between two 1"x 3" microscope slides, and the slides will be taped together with frosted scotch tape. The length of each fish will be written in the corners of the tape portion that correspond to the position of the fish (Figure). Location, species, and date will also be recorded **on each slide**. Length, weight data for each fish will be recorded on a LENGTH, WEIGHT, AND SCALE form. Instructions to improve our ability to read scales have been established by ADF&G employee Sue Millard. These instructions are as follows:

1) Don't tape over scales;
2) Make sure scales are placed and remain in the designated area for each fish;
3) Always number each slide at the top;
4) Always put your initials under the slide number; and
5) Spread scales out so they do not contact one another (Figure 4)
6) Apply tape evenly, starting and ending tape on the same side of a glass slide, so that slides will lay completely flat when placed in the scale reader.
7) Remember to clean scalpel of scales between samples.



Appendix G2.–An alternative smolt scale sampling procedure used by ADF&G in Southeast Alaska.

Small Scale Sampling Procedures Using Glass Slides

Small fish scales can be mounted on glass slides and viewed directly under a microfiche machine. Use 1mm thickness glass slides, frosted at one end for labeling. Glass slides come in boxes of ½ gross (72). This procedure recommends mounting 4 samples on a slide and then taping another slide on top as a permanent cover, this requires one glass slide for every two fish sampled. One box of slides will accommodate 144 samples at 4 samples per pair of slides.

Procedures:

Pre-label the slides that are expected to be filled for the sampling session with location, species, date, and slide number. Then only lengths need to be recorded on the slide as the samples are collected. The samples are applied to the slide ordered left to right and top to bottom. Lengths are recorded in the frosted field in the same fashion. The slide number is written in the center of this field leaving space for the lengths to be recorded around it. The slide should be held between the thumb and index finger by its edges. If the slide is gripped top and bottom at the frosted end the writing wears off and becomes illegible.

The anesthetized fish is placed on a measuring board and the snout-fork length is taken and recorded on the glass slide in the appropriate location (see figure). (After a little practice at scrapping the scales it may be efficient to remember the length momentarily and record it after releasing the fish with the glob of scales still on the scalpel.) A small patch of scales is collected on the tip of a scalpel by scrapping (towards the head) gently across the preferred area (no cutting!). With practice a patch of about 10 to 12 scales can be obtained. The fish is then placed in a recovery bucket or basin. The scales are then smeared onto the glass slide and quickly spread out in a cluster. Organization of the scales into rows is not necessary. The important aspects of spreading the scales is to get them spread so that they are not stacked one on top of the other and position the group on the slide towards the corners of the slide area so that there is good separation between samples on the slide. If they do not get spread out singly they are worthless since they cannot be viewed for aging. If samples are not spread with a sufficient margin between them it becomes confusing when trying to identify a given sample under the microfiche machine or they may be hidden by tape when it is applied to the slide.

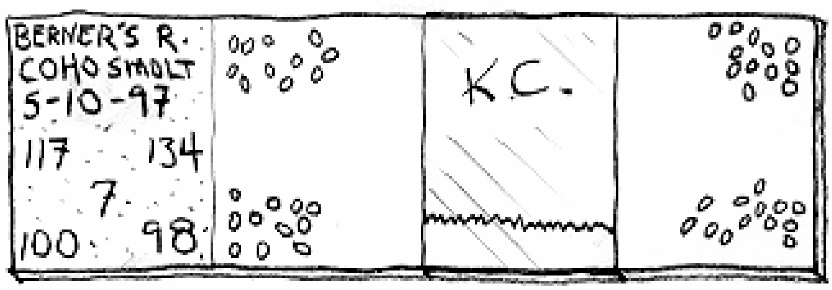
It is critical that the scalpel is cleaned of all scales between samples so that erroneous scales are not transferred between samples. A brisk swishing in water and a physical wipe of both sides of the scalpel blade against a sponge (or shirt-sleeve?) is required. A visual inspection, at least intermittently, is also a good measure. Scale spreading needs to be done very quickly if there is sunshine or a dry breeze. The fish slime that is acquired with the scrape of scales is a helpful lubrication during the spreading process but dries very quickly in these conditions. As the slime dries it becomes a useful adhesive sticking the scale to the glass, but not if you are still trying to spread the scales. In addition to the scale-collecting scalpel it is usually helpful to use the tip of a dissecting probe or another scalpel to work together like chopsticks in getting the scales to separate from each other.

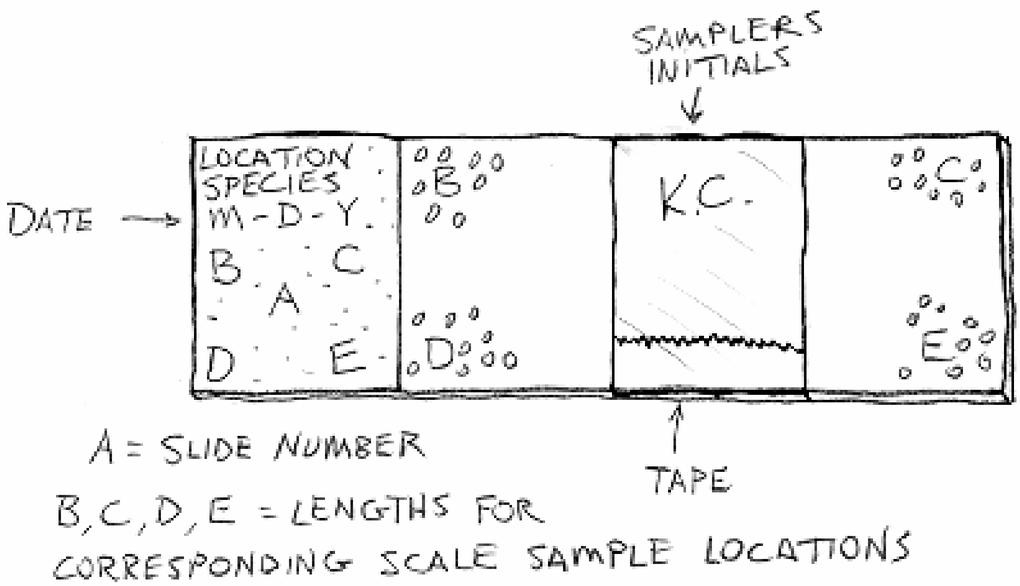
When the four samples are all spread out on the fully labeled slide as desired and the lengths are recorded, a cover slide is placed on top and taped permanently in position with a single wrap of tape around the center. Place the frosted ends on top of one another and put the frosted side of the cover slide to the inside so that the writing is seen clearly. If the samples were positioned well towards the corners of the slide area the tape will not obscure any of the scales.

-continued-

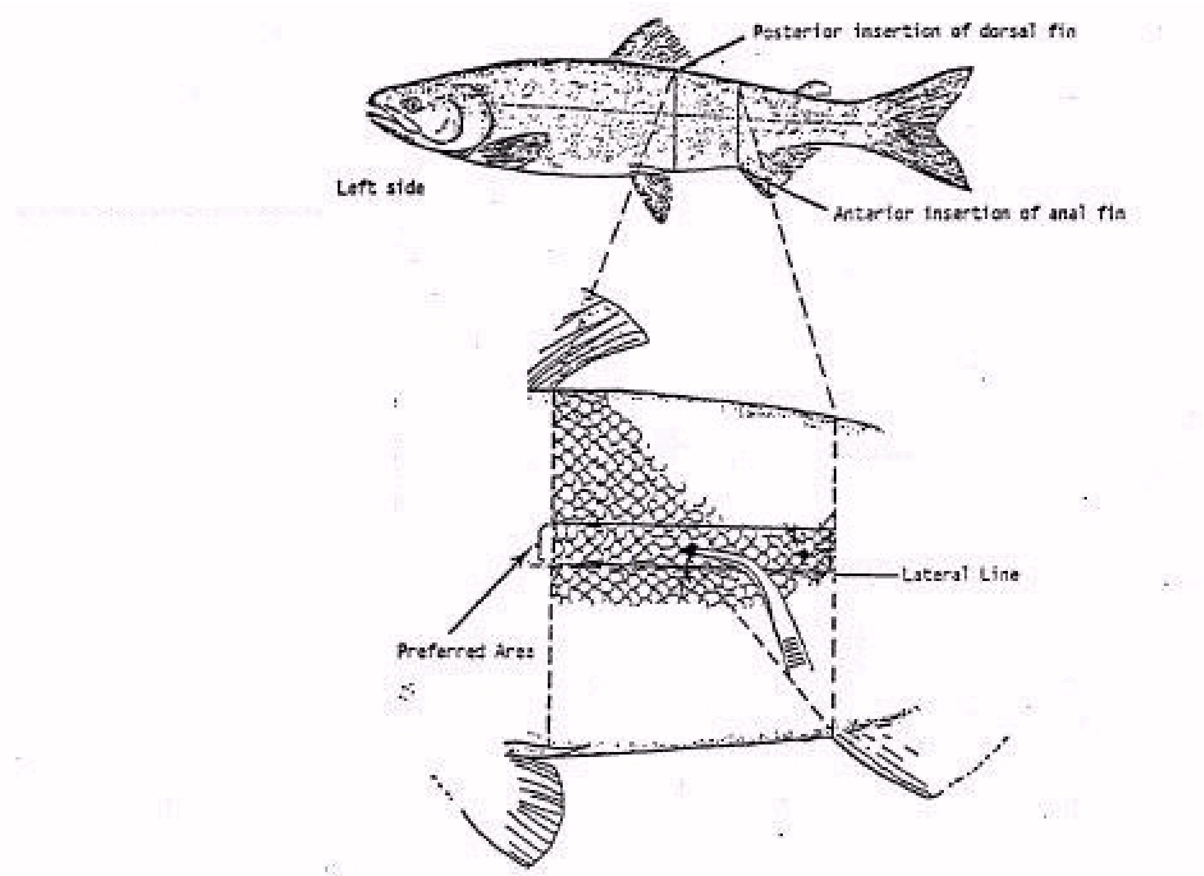
Tape application technique is important! The tape should be only one layer on the bottom side and with no wrinkles on the bottom. Apply a piece of tape about 2 1/2 inches long to the bottom side first, centering it, and then wrap it snugly and neatly to the top side where it can overlap. The sampler then initials the tape on the completed slide.

A completed slide.

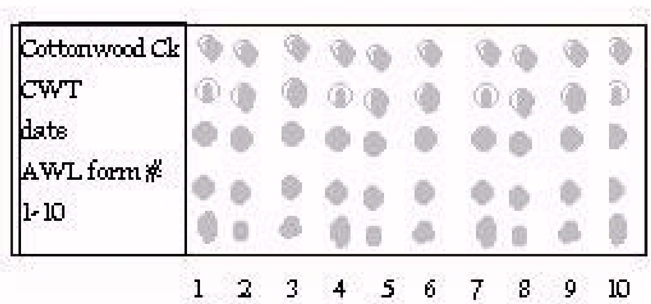




Appendix G3.–Scale sampling procedures used by ADF&G in Central Region of Alaska.



Take at least 5 scales from the preferred area on the left side of the fish.



Mount scales on one glass slide and cover with <u>only one</u> other glass slide. Label the slide as above.

APPENDIX H: BAIT PREPARATION FOR MINNOW-TRAPPING OF JUVENILE CHINOOK AND COHO SALMON

Appendix H1.–Bait preparation for minnow-trapping of juvenile Chinook and coho salmon.

Ingredients:

1) Salmon roe in the skein, preferably any species other than pink. I have usually been able to get chum or coho roe. Pink salmon roe can work but the eggs are small and do not make a *succulent* bait.

2) Borax, plain borax, not laundry detergent "with borax". This is usually found associated with laundry detergents and household cleaning products. I use about a box per five-gal bucket of prepared bait.

3) Iodine solution, Betadyne or Wescodyne etc.
Dilute the iodine solution with an equal part water, 1:1 and put in a squirt bottle for ease of application.

Materials:

Three five-gal buckets
Gal size Ziploc freezer bags (the freezer bags are heavy duty)
Sharp knife and cutting board or large scissors
Latex gloves
Squirt bottle or old dish soap bottle for applying iodine solution (I don't recommend a spray bottle, it may produce a breathable mist)
Plastic tote (an 8-gal low Rubbermaid tote for instance works nicely)
3 lb. Coffee can or equivalent

Procedure:

This procedure prepares about a five-gal bucket volume of bait at a time and is repeated as necessary. Use latex gloves during preparation to avoid overexposure to the iodine solution.
Cut skeins into walnut-size chunks and drop into bucket into a single layer. I find it efficient to work into two buckets at the same time. Sprinkle an ample handful of Borax over the layer. Squirt the equivalent of about 3 tablespoons of the diluted iodine solution over the layer. Repeat this layering procedure until each bucket is about half full. Using the third empty bucket gently pour each ½ full bucket back and forth a time or two until reasonably mixed. Do not stir since the action will crush eggs and break eggs loose of the skein chunks. A coffee can or similar sized container can be used to hold a Ziploc bag open to allow pouring the prepared bait into the bag. Set the bag inside and fold the top down around the top on the container. Top the bag off by hand filling if necessary. It is beneficial to keep the plastic zip mechanism as clean as possible during the process or it needs to be wiped off to get the zipper to close properly. As the bags are filled they are stood in zipper-up position in the plastic tote until the tote is full of a single layer of upright bags. This whole unit goes into the freezer. One or more bags, with near certainty is going to ooze egg juice from a hole, or most likely an imperfect zipper seal. Packing the bags in an upright position and inside a plastic tote mitigates the mess potential that could occur inside the freezer. Been there, done that! After they are frozen solid they can be taken out of the tote and packed more efficiently in the freezer if necessary. Turn on the radio and happy baiting!

APPENDIX I: CONVERSION FACTORS USEFUL IN FISHERIES

Appendix I1.–Conversion Factors useful in fisheries.

Many conversion factor calculators are available online, including the Aquatic Eco-systems web site at aquaticeco.com.

Volume
1 liter =0.26 gal; 1,000 cc; 1,000 ml
1 liter of water = 1,000 g; 1 kg; 2.205 lb
1 ounce = 28.35 grams
1 gal = 128 fluid ounces; 8 pints; 4 qts;
1 fluid ounce = 28.4 grams
1 cubic centimeter of water = 1 gram;1 ml
1 cubic foot of water = 7.48 gals;
62.4 pounds; 28.3 liters; 28.3 kilograms
1 cubic meter of water = 1,000 liters; 35.2 cubic feet of water; 2,205 pounds of water
1 gal of water = 8.34 pounds
1 gram = 0.0353 ounces
1 kilogram = 2.205 pounds
1 pound = 454 grams
1 gal = 3.785 liters
1 gal of water = 3,785 grams

1 gram = 15.43grains
1 ounce = 437.5 grains
1 ounce= 28.34 grams
1 pound = 453.6 grams
1 kilogram = 2.205 pounds
1 kilogram = 35.274 oz

1 penny (since 1983) = 2.5g
1 nickel = 5.0 g
1 dime (since 1964) = 2.27g
1 quarter = 5.67g

1 cubic centimeter(cc) = .061 cubic inches
1 cubic inch = 16.4 cc
1 cubic foot = 1728 cubic inches
1 teaspoon = 4.9 cc or ml
1 tablespoon = 14.79 ml or 3 teaspoons
1 tablespoon = 0.5 fluid oz

Length Conversion Factors
1 inch = 25.4 mm
1 meter = 39.37 inches
1 meter= 3,281 feet
1 km = 0.62 miles
1 statute mile = 1.6 km
1 nautical mile = 1.15 statute miles
1 foot = 30.48 centimeters

Surface Area
1 hectare = 10,000 square meters
1 hectare = 2.47 acre
1 acre = 0.405 hectare
1 acre = 43,560 square feet

Velocity Conversion Factors
1 foot/sec = 30.48 cm/sec
1 foot/sec = 0.68 miles/hr
1 foot/sec = 1.1 km/hr
1 meter/sec = 3.6 km/hr
1 meter/sec = 2.2 miles/hr

Flow Rate Conversion Factors
1 cubic foot/sec = 0.28 cubic meters/sec
1 cubic meter/sec = 35.3 cubic feet/sec
1 gal/minute = 3.785 L/min

1 ppm (mg/L) = 0.38 grams per 100 gals of water
3.8 milligrams per gal of water
0.0283 grams per cubic foot of water
0.38 milliliters per 100 gals of water
1 milligrams per liter of water
1 grams per cubic meter of water
0.001 milliliters per liter of water

For 1 percent solution add:
38 grams per gal
1.3 ounces per gal
10 grams per liter
38 cc per gal
10 cc per liter

Table Salt
Level ¼ teaspoon = 1.6g
Level 1 teaspoon = 6.5 g
Level ¼ cup = 78.0 g

Sodium Bicarbonate
Level ¼ teaspoon = 1.1 g
Level 1 teaspoon = 4.4 g
Level ¼ cup = 53.0 g

Centigrade to Fahrenheit temperature conversion chart

°C	°F	°C	°F	°C	°F	°C	°F
0	32.0	11	51.8	22	71.6	33	91.4
1	33.8	12	53.6	23	73.4	34	93.2
2	35.6	13	55.4	24	75.2	35	95.0
3	37.4	14	57.2	25	77.0	36	96.8
4	39.2	15	59.0	26	78.8	37	98.6
5	41.0	16	60.8	27	80.6	38	100.4
6	42.8	17	62.6	28	82.4	39	102.2
7	44.6	18	64.4	29	84.2	40	104.0
8	46.4	19	66.2	30	86.0		
9	48.2	20	68.0	31	87.8		
10	50.0	21	69.8	32	89.6		

Temperature Conversion Centigrade to Fahrenheit = (°C X 9/5) + 32
Fahrenheit to Centigrade = (°F - 32) X 5/9

ANNOTATED BIBLIOGRAPHY

ADF&G (Alaska Department of Fish and Game). 2006. Division of Wildlife Conservation. Accessed 12/31/2006. http://www.wildlife.alaska.gov/index.cfm?adfg=bears.main

Good source of information on natural history of bears. Includes sections on:

Safe homes and camps,
Bear-resistant food storage containers,
Electric fences,
Bear-safe garbage incinerators,
Safety in Bear Country,
Traveling in bear country,
Fishing in bear country.

AFS (American Fisheries Society). 2004. Guidelines for the use of fishes in research. Use of fishes in research committee, J. G. Nickum, Chair. Available at the American Fisheries Society website, Accessed 12/31/06: http://web.fisheries.org/main/images/stories/afs/guidelines2004.pdf

This is the latest revision of guidelines on all aspects of fish in research including capture techniques, anesthetics, stress management, ethics. Good overview that should be reviewed when planning a project.

Anderson, W. G., R. S. McKinley, and M. Colavecchia. 1997. The use of clove oil as an anesthetic for rainbow trout and its effects on swimming performance. North American Journal of Fisheries Management 17:301-307.

The only anesthetic registered in North America for use in fisheries science is 3-aminobenzoic acid ethyl ester methane sulfate (tricaine or MS-222). The authors of this report are proposing that clove oil be considered as an alternative to MS-222 for use as a fish anesthetic. This report discusses the effectiveness of clove oil, and compares MS-222 and clove oil**.** Clove oil is not an FDA approved fish anesthetic.

The clove oil anesthetic is concocted by combining the solution at the following strength:

Solution: 180 ml clove oil, added to 1620 ml Everclear
Ratio solution to water for use on fish: 18ml per 30 liters water

Armstrong, R. W., and A. W. Argue. 1977. Trapping and coded-wire tagging of wild coho and Chinook juveniles from the Cowichan River system, 1975. Fisheries Marketing Service of Canada. Pacific Region. Technical Report Series PAC/T-77-14:58 p.

This was a pilot study to assess logistics and field methods of tagging sufficient numbers of juveniles from a wild stock, at a reasonable cost, for assessment of ocean migration patterns and fishery contributions. The study demonstrated that tagging of wild coho and Chinook juveniles, particularly coho, is highly feasible under field conditions. The authors suggest further work on delayed tagging mortality of juvenile coho and Chinook in fresh and estuarine waters.

Aquatic Ecosystems Inc. 2006. http://aquaticeco.com/. Accessed March 2006.

This company carries a wide variety of aquaculture gear, including water pumps, air pumps, and chemicals. The web site has access to dozens of useful references called Tech Talks on subjects as varied as selecting a water pump, how to glue PVC, or measuring salinity. Site also has online calculator for common conversions in volume, flow rate, etc.

British Columbia Ministry of Environment, Lands and Parks. Fish Inventory Unit for the Aquatic Ecosystems Task Force. 1997. Fish collection methods and standards, *fourth version*. District of British Columbia, Resources Inventory Committee.

This document provides information for standard data collection, methods and procedures for fish inventories in lakes and streams in British Columbia. A sample copy of the fish collection form is provided along with associated user notes. The fish Inventory methodologies section of the guide includes procedures for fish handling, fish collection methods, length and weight measurements and determination of fish age, sex and level of maturity**.** Preservation techniques and requirements for collecting voucher specimens are also discussed. A glossary of common biological terms is provided.

Their information on Trap Nets and Fyke Nets is informative. Trap nets and Fyke nets are usually used in near-shore or shallow areas of a lake. There are sinking versions of the trap net that can be used in deepwater sections of a lake but they are normally designed to fish the surface. They are designed to be light, portable, and relatively simple to assemble. On page 17 their information continues in greater detail and includes a figure that provides a visual of typical fyke net designs with and without wings (Figures 5).

Beckman, B. R., and D. A. Larsen. 1998. Relation of fish size and growth rate to migration of spring Chinook salmon smolts. North American Journal of Fisheries Management 18:537-546.

The authors examined the relation of size and growth rate to downstream migration of yearling spring Chinook salmon *Oncorhynchus tshawytscha*. A group of juvenile Chinook salmon was graded by size into small and large categories; half the fish in each category were reared at an elevated temperature beginning in mid-February, resulting in four distinct treatment groups. Fish from warm water treatment groups displayed significantly higher growth rates through the spring than cool water groups. This study was undertaken to evaluate the influence of fish body size and growth rate on the parr-smolt transformation of yearling Chinook salmon. Differences in smoltification between juvenile Chinook salmon of different sizes and from different spring growth regimes were assessed by downstream migration. Specifically, they tested the hypothesis that relatively faster-growing fish, upon release into a natural creek, would migrate downstream sooner than relatively slower-growing fish. The research included the use of PIT tags (passive integrated-transponder tags) that were implanted into the intraperitoneal cavity of the fish, and the fish were later tracked using a PIT tag detector that was placed at the apex of each of two separate V-shaped weirs.

Beers, D. E. 2003. Production of coho salmon from Slippery Creek, 2000-2001. Alaska Department of Fish and Game, Fishery Data Series No. 03-08, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-08.pdf

Recovery in 2001 of coded wire tags from adult coho salmon tagged as smolts in 2000, and an adult escapement project, was used to estimate smolt abundance, harvest, exploitation rate, and production of coho salmon from Slippery Creek, on Kuiu Island in Southeast Alaska. This paper discussed their use of a "Wolf" smolt trap and an incline plane trap. The authors included diagrams of their designs.

Bendock, T., and A. E. Bingham. 1988. Feasibility of estimating winter distribution and habitat preference for juvenile salmonids in the mainstem Kenai River, Alaska, 1986-1987. Alaska Department of Fish and Game, Fishery Data Series No. 38, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds038.pdf

This study attempted to determine winter habitat preferences by seining, minnow trapping and substrate sampling. Has a section on limitations of seining and minnow trapping. Used 30 minute soaks for minnow traps. The procedure did not work well in winter and was a very limited study. Total minnow trap hours less than one day's trap hours for Unuk River tagging project.

Bendock, T. 1996. Marking juvenile Chinook salmon in the Kenai River and Deep Creek, Alaska, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-33, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds96-33.pdf

A long-term study has been initiated to assess growth and characteristics of the marine fishery, evaluate ongoing efforts to supplement harvests using hatchery fish, and estimate the contributions of specific wild stocks to the marine harvest. As part of this long-term effort, the contributions of wild Kenai River and Deep Creek Chinook salmon as well as all hatchery smolt released in Cook Inlet will be estimated using a coded wire tag (CWT) marking and recovery program. Good discussion of study design and how to estimate sample size requirements.

Bergman, P. K., F. Haw, H. L. Blankenship, and R. M. Buckley. 1992. Perspectives on design, use, and misuse of fish tags. Fisheries 17(4):20-25.

This paper discusses the capabilities and limitations of coded wire and external fish tags and attempts to develop an improved identification system. The discussion includes: characteristics of external, coded wire, and visible implant tags, the importance of certain tag characteristics for experimentation, and development of V.I. Tag and extension of CWT utility.

ANNOTATED BIBLIOGRAPHY (Continued)

Bernard, D. R., D. W. Arvey, and R. A. Holmes. 1993. Operational planning: the Dall River and rescue of its sport fishery. Fisheries (Bethesda) 18(2):6-12.

This document describes the operational planning process to insure that information gathered meets the needs of management, is obtained accurately and at minimal cost. Specific objectives of research are tailored to the perceived requirements of fisheries management, risks of errors in judgment are calculated as functions of samples sizes and sample sizes are expressed as functions of budgets.

Bernard, D. R., and J. E. Clark. 1996. Estimating salmon harvest with coded-wire tags. 1996. Canadian Journal of Fisheries and Aquatic Science 53:2323-2332.

The authors present a simple, comprehensive method to estimate harvest from one or more hatchery-produced or wild cohorts of Pacific salmon (*Oncorhynchus* spp.) caught simultaneously in one or more stratified commercial or recreational fisheries. The estimator is based on the return of coded-wire tags as modeled with multivariate compound probability distributions for catch sampling programs in which some samples are lost and some tags are not decoded. Knowledge of catches in strata and of tagging rates of cohorts need not be exact as in previously developed methods. Examples concerning historical and hypothetical commercial and recreational fisheries exploiting for cohorts of Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch)* are provided. Estimated covariances among cohorts proved to be negligible to the point of nonexistence for estimated harvests in commercial fisheries, but could be large and positive for estimated harvests in recreational fisheries. Normal approximations of confidence intervals were almost identical to confidence intervals developed with the parametric bootstrap for estimates in commercial fisheries and were less similar when significant harvest came from recreational fisheries.

Bernard, D. R., R. P. Marshall, and J. E. Clark. 1998. Planning programs to estimate salmon harvest with coded-wire tags. Canadian Journal of Fisheries and Aquatic Science 55:1983-1995.

Methods are presented for planning individual catch-sampling, tagging, and field-sampling programs to estimate salmon (*Oncorhynchus* spp.) harvest in recreational and commercial fisheries from several hatchery-produced and wild cohorts through recovery of coded-wire tags. The authors show how to determine sample sizes sufficiently large to detect harvest and link sample sizes to expenditures through linear and allometric cost functions to determine optimal tagging and catch-sampling rates. Sample sizes that will minimize bias and variance are charted for field-sampling programs designed to estimate the fraction of a cohort with tags. The authors describe sampling strategies that can be used to detect or to minimize bias in harvest estimates from tag loss, tag-induced mortality, tag-induced straying, and nonrandom sampling. Methods are demonstrated with data on cohorts of Chinook and coho salmon from Alaska.

Berry, C. R. Jr. 1996. Safety in fisheries work. Pages 63-82 [*In*] Murphy, B. R., and D. W. Willis, editors. Fisheries techniques, *second edition*. American Fisheries Society, Bethesda, Maryland.

This selection discusses SAFE protocol, and basics of boating safety, wading safety and safety on ice.

Blankenship, H. L. 1990. Effects of time and fish size on coded wire tag loss from Chinook and coho salmon. American Fisheries Society Symposium 7:237-243.

This report provides information on CWT loss rates, factors influencing tag loss, length of time over which tag loss occurs, and frequency of naturally occurring adipose fin loss.

Blankenship, H. L., and P. R. Hanratty. 1990. Effects on survival of trapping and coded wire tagging coho salmon smolts. American Fisheries Society Symposium 7:259-261.

The effects of trapping and tagging on the survival of migrating coho salmon smolts were tested. Fish were trapped by means of a temporary V-shaped weir of small-mesh screened panels, which channeled migrating smolts into live boxes. Fish were then tagged with coded wire tags. Survival was measured over three brood years with hatchery-reared coho salmon that were planted above the weir (test group) and below the weir (control group). Over three brood years, survival of the test groups averaged 84% of that of the control groups.

ANNOTATED BIBLIOGRAPHY (Continued)

Blankenship, H. L., and J. H. Oven. 1993. Benign recovery of coded wire tags from rainbow trout. North American Journal of Fisheries Management 13:852-855.

Rainbow trout were tagged with coded wire tags in transparent post ocular tissues, dorsal fins, and adipose fins, and were later checked for tag visibility, retention, and benign recoverability. A slow method of coded wire tagging but can be a useful tool when working with small populations of fish.

Blankenship, H. L., and D. A. Thompson. 2003. The effect of 1.5-length and double-length coded wire tags on coho salmon survival, growth, homing, and electronic detection. North American Journal of Fisheries Management 23:60-65.

Tag length and wire composition had little bearing on electronic detection; however, coho salmon adults in this study returned at relatively small sizes (mean fork length, <50cm). Managers concerned with high CWT detection rates in larger coho salmon, Chinook salmon, and steelhead trout should consider implanting 1.6- or 2.2-mm CWTs, because larger tags can be detected at greater distances with the wand than can 1.1-mm CWTs.

Bloom, A. M. 1976. Evaluation of minnow traps for estimating population of juvenile coho salmon and Dolly Varden. Progressive Fish Culturist 38(2):99-101.

Ten minnow traps baited with salmon eggs were fished in blocked-off sections of tributaries of Kadashan River. In 2h soaks the author estimated that they caught between 40% and 73%, (average 57%) of the population of coho and Dolly Varden between 51 and 130mm long.

Bouck, G. R., and S. D. Smith. 1979. Mortality of experimentally descaled smolts of coho salmon (*Oncorhynchus kisutch*) in fresh and salt water. Transactions of the American Fisheries Society 108:67-69.

Removal of slime from 25% of the body caused no deaths in fresh or salt water. Loss of only 10% of scales caused 50% of fish to die in salt water. Removal of scales in rib cage area was most deadly. Seawater tolerance restored within one day if fish remained in fresh water.

Bramblett, R. G., M. D. Bryant, B. E. Wright, and R. G. White. 2002. Seasonal use of small tributary and main-stem habitats by juvenile steelhead, coho salmon, and Dolly Varden in a Southeastern Alaska drainage basin. Transactions of the American Fisheries Society 131:498-506.

Used small immigration/emigration weirs constructed of lumber and plastic mesh to capture fish entering and leaving two small tributaries, and documented that juvenile coho salmon enter beaver ponds and other off-channel habitat during the fall. It also showed that baited minnow traps are effective for capturing juvenile steelhead.

Brandes, P., K. Perry, E. Chappell, J. McLain, S. Greene, R. Sitts, D. EcEwan, and M. Chotkowski. 2000. Delta juvenile salmon monitoring program review. www.delta.dfg.ca.gov/jfmp/docs/delta_juvenile_salmon_monitoring_program_review.pdf

This review of the Interagency Ecological Program (IEP) on the Sacramento-San Joaquin Estuary discusses use of trawls to sample juveniles. Catches were not high, and most fish were not smolt.

Brase, A. L. J., and D. R. Sarafin. 2004. Recovery of Copper River Basin coded wire tagged Chinook salmon, 2001-2002. Alaska Department of Fish and Game, Fishery Data Series No. 04-25, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-25.pdf

This is an example of a project that did not achieve its objectives. The adult return was only sampled two years after three years of coded wire tagging. Low sampling effort of adults upriver led to not obtaining production or harvest estimates. 56% of the adipose clipped fish sampled in the commercial fishery did not have coded wire tags. 20% of tagged fish were of Copper River origin. The remaining coded wire tagged Chinook salmon were of various origins including Alaskan, Canadian and other U.S. hatcheries. The number of recoveries from the Upper Copper River tagging events was not sufficient to perform the analysis and complete the project objective.

Bryant, M. D. 2000. Estimating fish populations by removal methods with minnow traps in Southeast Alaska streams. North American Journal of Fisheries Management 20:923-930.

Passive capture methods, such as minnow traps, are commonly used to capture fish for mark-recapture population estimates; however, they have not been used for removal methods. Minnow traps set for 90-minute periods during three or four sequential capture occasions during the summer of 1996 were used to capture coho salmon *Oncorhynchus kisutch* fry and parr, Dolly Varden *Salvelinus malma*, cutthroat trout *O. clarki*, and juvenile steelhead *O. mykiss* to estimate population size with the Zippin or generalized removal method. Bryant's results showed that removal estimates can be obtained with minnow traps if sampling procedures conform to the assumptions required for the method.

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon *Oncorhynchus kisutch* and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Resource Board of Canada 32:667-680.

In cold water, fish have lowered metabolism, reduced food requirements and less energy available. Hiding response is probably a means of avoiding predators and unprofitable energy expenditure, physical damage from ice scouring and reducing downstream displacement during high water periods.

Carlon, J. 1992. Feasibility of capturing and marking juvenile coho salmon for stock assessment in the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 92-57, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds92-57.pdf

The goal of this study was to estimate the harvest of Kenai River coho salmon in the commercial fishery while a companion project is investigating techniques to estimate escapement. To allow identification of Kenai River adult coho salmon in the 1993 commercial harvest, juvenile coho salmon were captured at three locations in the Kenai River drainage and marked with coded, micro wire tags and an adipose fin clip. Rearing fingerlings were captured with a modified Fyke trap. Coho salmon marked as fingerlings were recaptured as smolt emigrating using inclined-plane traps. Fish were removed from traps using dip nets. The authors have a nice juvenile capture and tag deployment section. They describe their modified fyke trap, knotless nylon seine, wing leads attached to the fyke trap, holding pen, and provide a schematic diagram of fyke traps used.

Carlon, J. 2003. Assessment of coho salmon from the Kenai River, Alaska, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 03-06, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-06.pdf

This report documents results of the Moose Creek weir coho smolt tagging program. In 1997 over 96,000 smolt were tagged with long-term tag retention rate of about 96%.

Carlon, J. A., and J. J. Hasbrouck. 1993. Marking juvenile coho salmon in the Kenai River with coded, microwire tags. Alaska Department of Fish and Game, Fishery Data Series No. 93-52, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds93-52.pdf

This report describes the use of weirs, modified fyke nets and inclined plane traps to capture juvenile cohos for CWT project. Recapture of marked fish suggests that inclined plane traps were selective toward smaller fish. Report illustrates tag retention problem encountered in some projects.

Carlson, S. R., L. G. Coggins Jr., and C. O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5(2):88-102.

The authors describe a mark-recapture (M-R) technique in which a stratified design and sampling at 1 or 2 stream locations are used to estimate the abundance of a migrating salmon smolt population. Two approaches to the sampling are described, which result in separate estimators: (1) One capture site is used for all smolt sampling; and (2) Two capture sites are used, one upstream for marking and releasing and one downstream for capturing marked and unmarked smolt. An example of the method is given using the 1997 sockeye salmon *Oncorhynchus nerka* smolts migrating from Akulura Lake, Kodiak Island, Alaska. The Akalura Lake study included a weir count of smolts, which the authors used to evaluate the accuracy of the M-R estimate. They also explained their tests for consistency, mark survival, bootstrap technique, sample size, and made recommendations for sampling proportions for age (scale samples) and size (weight and length) data. Additionally, this paper includes a schematic of the trap and weir configuration for capturing sockeye salmon smolts.

ANNOTATED BIBLIOGRAPHY (Continued)

Carmichael G. J., and J. R. Tomasso. 1988. A survey of fish transportation and techniques. Progressive Fish Culturist 50:155-159.

This article cites the use of sodium chloride (salt) to reduce fish stress in transport water and in water used to hold tagged fish. Dosage used is 0.5% to 1% of NaCl dissolved in the water.

Cho, G. K., and D. D. Heath. 2000. Comparison of tricane methanesulphonate (MS222) and clove oil anesthesia effects on the physiology of juvenile Chinook salmon *Onchorhynchus tschwatscha* (Walbaum). Aquaculture Research 31:537-546.

This research investigated the feasibility of using clove oil as a fish anesthetic as an alternative to MS222. Haematocrit, serum cortisol and serum glucose concentrations, serum lysozyme activity and differential leucocyte counts were measured from blood samples collected before, during and upon recovery from anesthesia and at specified intervals up to 72h after recovery. Results indicated that clove oil may be a safe and cost-effective alternative to MS222 and clove oil does not pose an environmental hazard. This paper is also a reference to other research on clove oil.

Clark, J. H. 2004. Approximate costs that can be associated with the coded wire tag program in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 04-16, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/sp04-16.pdf

ADF&G spends about $850,000/year coded wire tagging Southeast Alaska wild stocks of coho and Chinook salmon. Approximately 1.7% of the tagged coho and 0.3% of the tagged Chinook are eventually recovered at a total cost of about $700/Chinook and $100/coho recovered. Discusses ways to increase data collection, more tagging versus more port sampling, and costs of "no tags" to the program.

Conlin, K., and B. D. Tutty. 1979. Juvenile salmonid field trapping manual (Manuscript Report No. 1530). Department of Fisheries and Oceans, Fisheries and Marine Services, Vancouver, B.C.

The Salmonid Trapping Manual compiles successful field techniques used by the Canada Fisheries and Marine Service to capture juvenile Salmonids in rivers, lakes, and estuaries of the Pacific Region. The manual reviews past trapping methods, installation techniques, and operating conditions which have been successfully utilized. Although parts of manual are out of date, it can be very useful for obtaining information on a variety of juvenile salmonid capture methods.

Craddock, D. R. 1961. An improved trap for the capture and safe retention of salmon smolts. Progressive Fish Culturist 40:57-60.

Used a fyke net and floating live box to capture sockeye smolt. Trap was size selective towards smaller fish. Good drawings of floating live box plans.

Crawford, D. L., and F. C. Tilly. 1995. Bristol Bay upward-looking sonar sockeye salmon smolt enumeration project instructional manual. Alaska Department of Fish and Game, Regional Information Report No. 2A95-14, Anchorage.

This manual is a source of information concerning the use of MS-222, fish handling and data collection. Also of interest are sections on fyke nets and a list of necessary camp supplies.

Crozier, W. W., and G. J. A. Kennedy. 2002. Impact of tagging with coded wire tags on marine survival of wild Atlantic salmon (*Salmo salar* L.) migrating from the R. Bush, Northern Ireland. Fisheries Research 59(2002)209-215.

Migrating smolt were captured in a Wolff trap, anesthetized with benzocaine, clipped, tagged and released within one hour. Wild smolts were observed to run mainly at night and are known to be more susceptible to handling than hatchery fish. Tagged fish survived at a rate of only 54% of untagged fish. Authors suggest that handling, fin clipping and anesthetization are primary causes of mortality and that application of CWT itself has little additional mortality. See (Hansen 1988) and (Hansen and Jonsson 1988).

ANNOTATED BIBLIOGRAPHY (Continued)

Davies, B. 1989. Construction of a Wolf trap built at Slippery Lake, Kuiu Island. United States Department of Agriculture Forest Service, Pacific Northwest Research Station, Juneau. File Code: 6000.

A brief description of the requirements needed to construct a Wolf Trap, along with a description of the Wolf Trap constructed at Slippery Lake on Kuiu Island. On file at Forestry Science Lab, Juneau.

Davis, S. K. 1980. Modified fyke net for the capture and retention of salmon smolts in large rivers. Progressive Fish Culturist 42:235-237.

Demko, D. B., C. Gemperle, A. Phillips, and S. P. Cramer. 2000. Outmigrant trapping of juveniles salmonids in the lower Stanislaus River Caswell State Park site 1999. Submitted to USFWS, by S. P. Cramer and Assoc. Inc. www.fishsciences.net/reports/1999/oakdale99.pdf

A mark-recapture study to estimate smolt outmigration conducted using 8 ft screw traps and includes a description of screw trap site preparation. Because the river is used for recreational use, safety precautions were taken to warn river users of the dangers of the traps. Smolting appearance was rated on a scale of 1 to 3, with 1 an obvious fry, and 3 an obvious smolt.

Dempson, J. B., and D. E. Stansbury. 1991. Using partial counting fences and a two-sample stratified design for mark-recapture estimation of an Atlantic salmon smolt population. North American Journal of Fisheries Management 11:27-37.

A crew of four people operated two partial counting fences after they were installed. The fences provided an effective means of capturing and holding smolts. Debris was easily removed. The crew used weir materials including pickets. Effective fishing area could be changed by adding or deleting sections of fence or removing some of the pickets. This weir design is possibly useful in a river that has boat traffic.

DerHovanisian, J. D., K. A. Pahlke, and P. Etherton. 2004. Abundance of the Chinook salmon escapement on the Stikine River, 2002. Alaska Department of Fish and Game, Fishery Data Series No. 04-08, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-08.pdf

Didier A. 1979. Memorandum to Paul Kissner, 2/15/1979. Subject: Egg disinfection. Alaska Department of Fish and Game, Commercial Fisheries Division, Juneau. On file with Keith Pahlke, Alaska Department of Fish and Game, Division of Sport Fish, P.O. Box 110024 Juneau, AK 99811-0024.

Procedures for disinfection of salmon eggs used for minnow trap bait.

Dubois, R. B., J. E. Miller, and S. D. Plaster. 1991. An inclined-screen smolt trap with adjustable screen for highly variable flows. North American Journal of Fisheries Management 11:155-159.

An inexpensive inclined-screen smolt trap was designed and constructed for use in rivers having highly variable flow regimes. The trap included a pontoon-supported floating catch barge and an adjustable inclined screen made of parallel aluminum rods that effectively strained large volumes of water, transported smolts without injury, and was highly resistant to debris buildup and easily cleaned. The inclined screen was supported by a movable carriage within a stationary frame that permitted the screen to be deployed at a wide range of depths and angles depending on flow conditions and amount of water-borne debris. The design could be adapted to most locations where a low-head dam exists or can be established. Includes a really nice schematic diagram of the smolt trap used.

Duke, R. C. 1980. Fish tagging mobile unit operation, repair, and service manual. Idaho Department of Fish and Game. Idaho Fish and Game Library Vol. 058, Article 16.

As the title states this covers mobile tagging units. It also has a good explanation of CWT procedures, the use of MS-222, tag placement and disinfection of tagging equipment.

Elliott, S. T. 1992. A trough trap for catching coho salmon smolts emigrating from beaver ponds. North American Journal of Fisheries Management 12:837-840.

Smolts of wild coho salmon *Oncorhynchus kisutch* were captured at Yehring Creek, Southeast Alaska, with trough traps as they emigrated from beaver pond rearing areas. Each trap consisted of a fence along the rim of the beaver dam, a trough, an A-frame to support the trough, and a floating live box connected to the trough by a rigid pipe. The traps caused little mortality, cost about US $240 each to build, and were easy to install and maintain.

Ericksen, R., and R. Chappell. 2005. Production and spawning distribution of coho salmon from the Chilkat River, 2002-2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-18, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-18.pdf

Ericksen, R. 2004. Escapement, terminal harvest, and fall fry tagging of Chilkat River Chinook salmon in 2003. Alaska Department of Fish and Game, Fishery Data Series No. 04-20, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-20.pdf

Ericksen, R., and S. A. McPherson. 1997. Smolt production and harvest of coho salmon from the Situk River, 1992-1993. Alaska Department of Fish and Game, Fishery Data Series No. 97-26, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds97-26.pdf

Used two 8 ft screw traps to capture over 60,000 coho smolt out of estimated outmigration of 612,000.

Ericksen, R., and S. A. McPherson. 2004. Optimal production of Chinook salmon from the Chilkat River. Alaska Department of Fish and Game, Fishery Manuscript No. 04-01, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fm04-01.pdf

Summarizes the use of a successful CWT project to estimate marine harvest and production and incorporate them into spawner-recruit analysis.

Fleming, D. F. 2005. Production of coho salmon from Slippery Creek, 2001-2002. Alaska Department of Fish and Game, Fishery Data Series No. 05-08, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-08.pdf

Successfully used a Wolf trap to capture coho smolt in a small river.

Freeman, G. M. 2003. Smolt production and adult harvest of coho salmon from the Naha River, 1998-2000. Alaska Department of Fish and Game, Fishery Data Series No. 03-07, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-07.pdf

Successfully used an 8ft screw trap to capture coho smolt in a small river.

Gray, P. L., J. F. Koerner, and R. A. Marriott. 1985. *Unpublished.* The use of minnow traps for evaluating rearing coho salmon (*Oncorhynchus kisutch*) populations and habitat in Southeastern Alaska. Alaska Department of Fish and Game, Juneau. On file with Keith Pahlke, Alaska Department of Fish and Game, Division of Sport Fish, P.O. Box 110024 Juneau, AK 99811-0024.

Essentially of history of use of minnow traps in S.E. Alaska in the 1960s and early 1970s. Interesting reading about life history studies and catalog and inventory surveys of Alaska watersheds.

Gray, P. L., J. F. Koerner, and R. A. Marriott. 1986. Rearing coho salmon (*Oncorhynchus kisutch*) surveys of 16 Southeastern Alaska watersheds. Alaska Department of Fish and Game, Technical Data Report No. 173, Juneau, Alaska. http://146.63.229.113/pubdata/pdfs/tdr/tdr-173.pdf Accessed January 2006.

Summer surveys of 16 watersheds were conducted from 1970-1975 to evaluate coho salmon rearing habitat and important areas of production for coho salmon. The 16 watersheds included Chilkat Lake, Chilkoot Lake, Berners River, and Windfall Lake on Lynn Canal, Yehring Creek an Johnson Creek on the Taku River, Pavlof River and Kadashan Creek on Chickagof Island, Plotnikof Lake on Baronof Island, Castle River on Kupreanof Island, Thorne River, Sweetwater Lake, Sarkkar Lake and Staney

Creek on Prince of Wales Island, Naha River on Behm Canal, and the Situk River near Yakutat. Baited minnow traps were used to capture fish during float and foot surveys. Habitat descriptions and evaluation, species, fish sizes and ages, trap soak times and water temperatures are presented and discussed. Information on distribution and habitat preference, a general index of abundance, size and age composition of coho salmon juvenile, and interspecific relationships with other salmonids was determined for each watershed.

Gries, G., and B. H. Letcher. 2002. A night seining technique for sampling juvenile Atlantic salmon in streams. North American Journal of Fisheries Management 22:595-601.

They describe an alternative to electrofishing by sampling at night with small one-person seines. Used in small clear water streams.

Groot, C., and L. Margolis, editors. 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver.

Very complete references of all aspects of salmon life histories and summary of literature through 1990.

Habicht, C., S. Sharr, D. Evans, and J. E. Seeb. 1998. Coded wire tag placement affects homing ability of pink salmon. Transactions of the American Fisheries Society 127:652-657.

The results of this study were interpreted to indicate that tag position can affect adult homing ability in pink salmon tagged as fry.

Haegen, G. E., A. M. Swanson, and H. L. Blankenship. 2002. Detecting coded wire tags with handheld wands: effectiveness of two wanding techniques. North American Journal of Fisheries Management 22:1260-1265.

The standard wanding technique recommended by the manufacturer was compared with a recently developed mouth wanding technique for their efficacy in detecting CWTs. For Chinook salmon, the mouth wanding technique detected 98% of the tags present, which was significantly greater than the standard wanding technique (89% detection rate).

Hammer, S. A., and H. L. Blankenship. 2001. Cost comparison of marks, tags, and mark-with-tag combination used in salmonids research. North American Journal of Aquaculture 63:171-178.

Interesting results of a survey of many agencies. Useful for planning and cost-benefit analysis.

Hansen, L. P. 1988. Effects of Carlin tagging and fin clipping on survival of Atlantic salmon (*Salmo salar* L.) release as smolts. Aquaculture 70:391-394.

Smolts were caught in a Wolf trap, anesthetized with MS222, tagged and released after 0.5 hr. Mortality estimated at 47% and 60% for adipose fin-clipped and Carlin-tagged fish respectively. Author believes that salmonids do not fully recover from anesthesia, handling, transport and stocking stress for 1-2 weeks after treatment.

Hansen, L. P., and B. Jonsson. 1988. Salmon ranching experiment in the River Imsa: effects of dip-netting, transport and chlorobutanol anesthesia on survival. Aquaculture 74:301-305.

Dip netting and transport did not affect survival but chlorobutanol immediately prior to release increased mortality. Recommended all smolt be given a period of recovery prior to release.

Hare, G. M. 1973. A modified stake net for collecting migrating smolts of Atlantic salmon. Journal Fisheries Research Board of Canada 30:128-129.

The author used an interesting modification, with the trap opening facing down river and a curved wing leading to the opening. This kept the debris out of the trap. Authors included photo and drawing.

Healy M. C. 1991. Life history of Chinook salmon. [*In*] Groot, C., and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver.

Very complete reference of all aspects of salmon life histories and summarizes literature through 1990.

Heinl, S. C., J. F. Koerner, and D. J. Blick. 2000. Portland Canal chum salmon coded-wire-tagging project 1988-1995. Alaska Department of Fish and Game, Regional Information Report No. 1J00-16, Juneau.

Fry were captured with two 0.45m x 0.9 fyke nets spaced 4.0 m apart in the center of the stream. Early in the season, 1.0m high leads of plastic netting (3.2 mm mesh Vexar) were placed from the fyke nets to the stream banks, effectively capturing all migrant salmon fry. Coded-wire-tagged over 900,000 chum salmon fry with ½ length tags and experienced a high degree of tag loss. This was most likely the result of tagging very small fish (0.34 to 0.42 g). A tagging trailer was used.

Hesthagen, T., and E. Garnas. 1986. Migration of Atlantic salmon smolt in River Orkla of central Norway in relation to management of a hydroelectric station. North American Journal of Fisheries Management 6:376-382.

A trap consisting of a steel frame 1m square captured the smolts. A net pouch 5.6 m long (mesh size 10.5mm) with a removable hindmost part was fastened to this frame (Figure 2). Two such traps were operated from movable racks fastened to a bridge. A winch mounted on the rack made it easy to lower the trap into the river. During operation, about 90 cm of the trap was submerged. To make the trap more stable at high-water discharge, a 25-kg weight was attached under the trap.

Hillman, T. W., J. S. Griffith, and W. S. Platts. 1987. Summer and winter habitat selection by juvenile Chinook salmon in a highly sedimented Idaho stream. Transactions of the American Fisheries Society 116:185-195.

This report covers habitat use and growth of juvenile Chinook salmon in summer and winter seasons. Fish growth slows at temperature drop below 2°C. Chinook moved into heavier cover and interstitial spaces in cobble substrate in winter. Also found dense clusters of up to 250 individuals that displayed little reaction when disturbed.

Hubert, W. 1996. Passive capture techniques. Pages 157-192 [*In*] Fish techniques, *second edition*. Murphy, B., and D. Willis, editors. American Fisheries Society, Bethesda, MD.

Jenkinson, D. W., and H. T. Bilton. 1981. Additional guidelines to marking and coded wire tagging of juvenile salmon. Department of Fisheries and Oceans. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1051.

An old out-of-date manual on coded the wire tagging process. Illustrations of needle orientation and tag exposure at end of needle. Has good trouble shooting and maintenance sections for the old Mark II machines and an interesting section on making head molds.

Johnsen, D. R. and C. W. Sims. 1973. Purse Seining for juvenile salmon and trout in the Columbia River estuary. Transaction of the American Fisheries Society 102:341-345.

A 28-ft gillnetter was modified to catch juvenile salmon and steelhead by purse seining in the estuary. The vessel and equipment were effective in sampling with relative economy, practicality and safety. The main limitation was the lack of space for handling fish. Juvenile salmon and steelhead comprised the majority of the catch.

Johnson, J. K. 1990. Regional overview of coded wire tagging of anadromous salmon and steelhead in Northwest America. American Fisheries Society Symposium 7:782-816.

Good description of the evolution of coded wire tagging, the extent of its use, recovery operations, advantages and problems with coded wire tagging programs.

Johnson, D. H., B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, I. G. Cowx, editors. *In press.* Measuring and Monitoring Biological Diversity – Standard Methods for Freshwater Fishes. American Fisheries Society, Bethesda, Maryland.

Detailed chapter on all aspects of using scoop and rotary screw traps to estimate juvenile salmonid production in boatable river systems. Discusses sampling design, efficiency tests, and much more.

ANNOTATED BIBLIOGRAPHY (Continued)

Kelsch, S. W. and B. Shields. 1996. Care and handling of sampled organisms. Pages 121-156 [*In*] Murphy, B. R., and D. W. Willis, editors. Fisheries techniques, *second edition*. American Fisheries Society, Bethesda, Maryland.

Discusses how to minimize mortality and stress associated with the capture, handling and holding of fish. This selection covers specific situations such as anesthetics, tagging, pollutants, genetic studies, holding and handling, shipping temperature, oxygen levels and salinity and also covers preservation of specimens and tissue.

Kennen, J. G., S. J. Wisniewski, N. H. Ringler, and H. M. Hawkins. 1994. Application and modification of an auger trap to quantify emigrating fishes in Lake Ontario tributaries. North American Journal of Fisheries Management 14:828-836.

This report investigated the feasibility of sampling salmonids and other fish emigrants with an auger trap in Lake Ontario tributaries that carry high debris loads. A variation of rotary screw trap was used. Good drawings of screw trap.

King, B. E., and J. A. Breakfield. 2002. Chinook and coho salmon coded wire tagging studies in the Kenai River and Deep Creek, Alaska 1998. Alaska Department of Fish and Game, Fishery Data Series No. 02-03, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds02-03.pdf

Used incline plane traps with limited success for capturing Chinook smolt. The trap worked very well for capturing sockeye smolt. They fished only after dark and used an 8ft screw trap on Deep Creek with limited success.

Kissner, P. D., and D. J. Hubartt. 1986. Status of important native Chinook salmon stocks in Southeast Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1985-1986, Project F-10-1, 27 (AFS-41-13). http://www.sf.adfg.state.ak.us/FedAidPDFs/f-10-1(27)AFS-41-13.pdf

Koerner, J. F. 1977. The use of the coded wire tag injector under remote field conditions. Alaska Department of Fish and Game, Informational Leaflet No. 172. http://www.cf.adfg.state.ak.us/geninfo/pubs/fredrpts.pdf

During the summer of 1976 the coho salmon research project of ADF&G Commercial Fisheries Division, Region I coded wire tagged 45,514 wild juvenile coho salmon under remote field conditions in Southeastern Alaska. This report covers some techniques and instructions in the use of the Northwest Marine Technology coded wire tag injector that should be useful to biologists attempting to use the machine under similar conditions. This was the first large-scale CWT marking of wild salmon in S.E. Alaska. I still refer to parts of this manual. Especially useful if you have an old Mark II machine around.

Lister, D. B., R. A. L. Harvey and C. E. Walker. 1961. A modified Wolf trap for downstream migrant young fish enumeration. Progressive Fish Culturist 23:190-192.

Used on the Big Qualicum River on Vancouver Island.

Lister, D. B., and H. S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. Journal of the Fisheries Research Board of Canada 27:1215-1224.

To determine seasonal trends in the habitat distribution and size of underyearling Chinook and coho, fish were collected by daytime seining at weekly intervals. Used two pole seines of nylon netting (8 mm stretched mesh): a two-man seine (4 X 2 m) for general netting, and a smaller seine (1.5 m long) for use under banks and tree roots. They seined at night for Chinook because they could not catch many during the day. The study had 2 apparent sources for error in the fish collection procedure. High velocity and coarse substrate probably reduced seining efficiency somewhat, and in one of their areas they could not always ensure that fish from an adjacent subarea did not enter the catch. The authors feel that despite these shortcomings, seining provided adequate comparative data on trends of distribution and size of the two species. On two occasions, underwater observations were conducted with facemask and snorkel, generally by moving upstream slowly along the stream margins. The study found that, "species differences in spawning and emergence timing play an important role in segregating ecologically similar species."

Lum, J. L. 2003. Effects of smolt length and emigration timing on marine survival and age at maturity of wild coho salmon (*Oncorhynchus kisutch*) at Auke Creek, Juneau, Alaska. Master of Science Thesis, University of Alaska Fairbanks. Fairbanks, Alaska.

Massengill, R., and J. A. Carlon. 2004. Assessment of coho salmon from the Kenai River, Alaska, 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-24, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-24.pdf

Matthews, G. M., N. N. Paasch, S. Achord, K. W. McIntyre, and J. R. Harmon. 1997. A technique to minimize the adverse effects associated with handling and marking salmonids smolts. Progressive Fish Culturist 59:307-309.

They designed a system to apply anesthetic before netting, and handling "preanesthesia". Fish struggle less in dip nets and lose less scales. The most likely application is in hatchery situations, but possible use in large scale wild fish tagging.

McCurdy, J. S. 2006. Production of coho salmon from the Chuck Creek in Southeast Alaska, 2003-2004. Alaska Department of Fish and Game, Fishery Data Series No. 06-10, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds06-10.pdf

McLain, J. 1998. Relative efficiency of the midwater and Kodiak trawl at capturing juvenile Chinook salmon in the Sacramento River. Interagency Ecological Program Newsletter Fall 1998. http://iep.water.ca.gov/report/newsletter/1998fall/

Kodiak trawl uses two boats, while midwater trawl used one boat and some discussion of trawl construction and technique. Results were inconclusive as to whether the Kodiak trawl was more effective.

McFarland, W. N. 1959. A study of the effects of anesthetics on the behavior and physiology of fishes. Institute of Marine Science, University of Texas, Port Aransas, Texas.

This study investigated anesthetic effects of 21 chemicals on fish, including MS222 and described five stages of anesthesia: Stage 0 - Stage IV. On file with Keith Pahlke, Alaska Department of Fish and Game, Division of Sport Fish, P.O. Box 110024 Juneau, AK 99811-0024.

McLemore, C., F. Everest, W. Humphreys, and M. Solazzi. 1989. A floating trap for sampling downstream migrant fishes. PNW Research Note PNW-RN-490.

This research describes the Humphrey trap, inclined-plane with a self-propelled traveling screen and self cleaning roller powered by either a paddlewheel or electric motor. Optimum performance was at flows between 1.5 and 2.0 meters/second.

McMenemy, J. R., and B. Kynard. 1988. Use of inclined-plane traps to study movement and survival of Atlantic salmon smolts in the Connecticut River. North American Journal of Fisheries Management 8:481-488.

McPherson, S. A., D. A. Bernard, and M. S. Kelly. 1997. Production of coho salmon from the Taku River, 1995-1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-24, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds97-24.pdf

Operation of rotary screw traps and minnow traps in a large glacial river.

McPherson, S. A., P. Etherton, and J. H. Clark. 1998. Biological escapement goal for Klukshu River Chinook salmon. Alaska Department of Fish and Game, Fishery Manuscript No. 98-02, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fm98-02.pdf

Summarizes CWT work on Alsek River Chinook salmon and incorporates the results into escapement goal analysis.

ANNOTATED BIBLIOGRAPHY (Continued)

McPherson, S. A., D. A. Bernard, and J. H. Clark. 2000. Optimal production of Chinook salmon from the Taku River. Alaska Department of Fish and Game, Fishery Manuscript No. 00-02, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fm00-02.pdf

This report uses smolt production figures obtained from coded wire tagging projects as a tool to establish a biological escapement goal for Taku River Chinook salmon and contains a history of Chinook harvests and fishery regulations for Taku stocks.

Meehan, W. R. 1964. A modified scoop trap for sampling downstream-migrant salmon in turbid glacial rivers. Progressive Fish Culturist January 1964:42-46.

Good schematic plans of the large scoop trap operated near Canyon Island 1960-1961.

Meehan, W. R., and D. B. Siniff. 1962. A study of the downstream migrations of anadromous fishes in the Taku River, Alaska. Transaction of the American Fisheries Society 91(4):399-407.

A large scoop trap was operated near Canyon Island from April 13 to June 15. Fished 24 h/day, cleaned every 2 h. Caught about 1,000 Chinook and 2,000 coho smolt, peak movement of Chinook was during early morning hours (0200-0600). Condition factor increased over the season.

Miller B. A., J. D. Rodgers, and M. F. Solazzi. 2000. An automated device to release marked juvenile fish for measuring trap efficiency. North American Journal of Fisheries Management 20:284-287.

This report suggests that fish be released at night, especially in clear water to reduce predation from cutthroat trout.

Milner, A., and L. Smith. 1985. Fyke nets used in a Southeastern Alaskan stream for sampling salmon fry and smolts. North American Journal of Fisheries Management 5:502-506. 1985.

Good description of a floating fyke net that could fish at various water levels. Wings were attached to floating logs with one end secured to the bank. Diagrams of live box with removable baffles.

Murphy, M. L., K. V. Koski, J. M. Lorenz, and J. F. Thedinga. 1988. Migrations of juvenile salmon in the Taku River, Southeast Alaska. NWAFC Processed Report 88-31.

Migrants appear to use the lower river in May to grow and transform to smolts before going to sea. Many age-0 coho and Chinook also moved downstream in summer and fall as the river level dropped, but were not caught in the estuary. Fyke nets were fished in the river and the estuary was seined.

Murphy, M. L., K. B. Koski, J. M. Lorenz, and J. F. Thedinga. 1997. Downstream migrations of juvenile Pacific salmon (*Oncorhynchus* spp.) in a glacial transboundary river. Canadian Journal of Fisheries and Aquatic Science 54:2837-2846.

Differences between fyke-net catches in the river and seine catches in the river's estuary indicated that many downstream migrants remained in the lower river instead of migrating to sea. To catch fish in the estuary, a beach seine (37 x 2m, with 6-mm-mesh central bag and 16-mm-mesh wings).
Discusses run timing for Taku River Chinook and coho smolts.

Murray C. B., and M. L. Rosenau. 1989. Rearing of juvenile Chinook salmon in nonnatal tributaries of the lower Fraser River, British Columbia. Transactions of the American Fisheries Society 118:284-289.

Absence of spawners does not mean absence of good rearing habitat. Juvenile Chinook were shown to move upriver to nonnatal tributaries, perhaps aided by high tide backup. Coho feeding more successful and growth rate better in less turbid water.

Namtvedt, T. B., D. Evans and R. Yanusz. *In prep*. Coho salmon smolt abundance, harvest, and escapement at Cottonwood Creek, Alaska, 1999-2001. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

This report is a summary of a very successful coho tagging project.

Nass, B. L. 1997. Adult and juvenile coho salmon enumeration and coded-wire tag recovery analysis for Zolzap Creek, BC, 1995. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2423.

A smolt weir and fyke net was used to capture coho smolt. The report estimated harvest and survival of the stock. Scale sampling followed the stratified method with crews attempting to collect at least 10 scale samples from each 5 mm size class.

Nielsen, L. A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication No. 23. American Fisheries Society, Bethesda, Maryland.

This report discusses four conditions that are fundamental to a successful holding process; water quality, minimize handling, anesthesia, and antibiotics; advantages and disadvantages of Coded Wire Tags and reading of the tags; and covers advantages and disadvantages of CWTs and a wide variety of tagging and marking methods.

NMT (Northwest Marine Technology). 2001. Mark IV Manual. Northwest Marine Technology, Inc. P.O. Box 427 Shaw Island, WA, 98286. Document MK4H2. . http://www.nmt.us.htm

This manual can be downloaded in PDF format from their website. This is a very complete and up to date manual on the operation and maintenance of the Mark IV tagging machine and QCD. Many good illustrations, some of which are hard to see if printed in black and white.

NMT (Northwest Marine Technology). 2005. Coded wire tag project manual. Compiled by D. J. Solomon. Northwest Marine Technology, Inc. P.O. Box 427 Shaw Island, WA, 98286. Document APC15. http://www.nmt.us.htm

This manual can be downloaded in PDF format from their website. Good introduction to CWTs and details on formats and coding. Summarizes the various equipment used on different sizes and species of animals. Discusses design of experiments and gives examples of successful projects. Good reference, very similar to this manual, without the focus on wild salmon.

NMT (Northwest Marine Technology). 2005. http://www.nmt.us.htm. Accessed 03/2005.

This site covers everything from the history of coded wire tagging, descriptions and downloadable PDF files of manuals for the operation of CWT equipment, prices, references, and contacts.

Novotny, J. F., and J. W. Beeman. 1990. Use of a fish health condition profile in assessing the health and condition of juvenile Chinook salmon. Progressive Fish Culturist 52:162-170.

The fish health condition profile is a simplified system for assessing fish health and condition, but more detailed than simple condition factor; requires length, weight, blood sample, and observations of the gills, pseudobranchs, thymus gland, and eyes. A decrease in condition factor occurs during parr-smolt transformation. Condition factor should therefore be interpreted as an index of health and condition with caution in consideration of the physiological and physical changes that take place during smoltification.

Pahlke, K. A. 1991. Migratory patterns and fishery contributions of Chilkat River Chinook salmon, 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-55, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds91-55.pdf

Shows data derived from a wild broodstock, hatchery-reared and back-planted smolt program. Harvest and harvest patterns are reported.

Pahlke, K. A. 1995. Coded wire tagging studies of Chinook salmon of the Unuk and Chickamin Rivers, Alaska. 1983-1993. Alaska Department of Fish and Game. Alaska Fishery Research Bulletin 2(2):93-113. http://www.adfg.state.ak.us/pubs/afrb/vol2_n2/pahlv2n2.pdf

Shows data derived from CWT Program. Smolt to adult survival. Harvest and harvest patterns.

Parsley, M. J., D. E. Palmer, and R. W. Burkhardt. 1989. Variation in capture efficiency of a beach seine for small fishes. North American Journal of Fisheries Management 9:239-244.

Studied capture efficiency of beach seining for fishes on the Columbia River and compared of efficiency over different substrates. This report did not find water temperature to be a factor in salmonid catch rates.

Peltz, L., and M. Haddix. 1989. Coded-wire tagging of wild sockeye salmon smolts at Hugh Smith Lake, Alaska. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development Number 91. http://www.cf.adfg.state.ak.us/geninfo/pubs/fredrpts.pdf

This report covers some problems encountered on a sockeye smolt tagging project. Short-term mortalities of tagged smolts ranged from 3.0 to 9.1% and smolt to adult tag retention rates improved from 42.9% to 97.1% as problems with headmold size were corrected. A very low smolt to adult survival rate for tagged fish was thought to be due to smolt mortality caused by tagging induced stress.

Peltz, L., and P. Hansen. 1994. Marking, enumeration, and size estimation for coho and Chinook salmon smolt releases into Upper Cook Inlet, Alaska, in 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-21, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds94-21.pdf

This report showed that grading fish by size and using different sizes of head molds for tagging improves long-term tag retention rates in smolt.

Penn State University Animal Research Program. www.research.psu.edu/arp/euthanasia.shtml

This site has information on chemicals used for anesthesia and euthanasia of fish and states that at concentrations of 500mg/liter or more of MS222, the solution should be buffered.

Perez-Fuentetaja, A., D. F. Kaplan, and T. Doubt. 1999. Sockeye salmon smolt emigration studies,. Chignik Lakes system, 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K99-26, Kodiak, Alaska.

With one 8 ft and one 5 ft screw trap they captured over 450,000 sockeye salmon smolt. Fish ran at night, traps were checked frequently at night to minimize mortality.

Peterson, N. P. 1982. Immigration of juvenile coho salmon into riverine ponds. Canadian Journal of Fisheries and Aquatic Science 39:1308-1310.

This is a discussion of juvenile coho migration into wintering areas and habitat preferences.

Pollard, W. R., G. F. Hartman, C. Groot, and P. Edgell. 1997. Field identification of coastal juvenile salmonids. Federal Department of Fisheries and Oceans and Weyerhaeuser Ltd. Harbour Publishing, Madeira Park, British Columbia, Canada.

Taxonomic keys for juvenile salmon, trout and char of British Columbia exclusive of brook trout. Covers some life history data and has photos or paintings of each species. Does not cover identification of fish in smolt coloration. Water resistant and handy to have as a field camp reference.

RMPC (Regional Mark Processing Center). 2006. http://www.rmpc.org/

The Regional Mark Processing Center (RMPC) provides essential services to international, state, federal, and tribal fisheries organizations involved in marking anadromous salmonids throughout the Pacific region. These services include regional coordination of some tagging and fin marking programs, maintenance of databases for Coded Wire Tag Releases, Recoveries, Locations, and Catch and Effort data, as well as the dissemination of reports of these data in electronic or printed form when requested. These databases are known collectively as the Regional Mark Information System (RMIS).

Richards, P., K. A. Pahlke, and P. Etherton. *In prep.* Abundance and distribution of the Chinook salmon escapement on the Stikine River, 2005. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Rodgers, J. D., R. D. Ewing, and J. D. Hall. 1987. Physiological changes during seaward migration of wild juvenile coho salmon (*Onchorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Science 44:452

Increased deposition of guanine in the skin is associated with the silvering that is characteristic of the transition from par to smolt. Smolts have a lower condition factor than parr. (The body shape slims down) Chemical changes can distinguish smolts from migrants that are not smoltifying. Fish caught in migrant traps in fall did not show increase in gill (Na + K)-ATPase activity.

Roper, B. B., and D. L. Scarnecchia. 2000. Key strategies for estimating population sizes of emigrating salmon smolts with a single trap. Rivers 7(2):77-88.

This report discusses use of a single screw trap to estimate smolt out migration using trap efficiency. Good discussion of how to estimate trap efficiency. The study states that because of wide confidence intervals trap efficiency should be at least 10% if estimates are to be reliable.

Rosberg, G. E., and D. Aitken. Juvenile Chinook salmon studies in four tributaries to the upper Fraser River, 1981. Beak Consultants Limited. For Department of Fisheries and Oceans. DSS Contract No: 05B.FP501-0-SP124.

The study focused on habitat descriptions of the watersheds. Shows fry utilizing silt bottom habitats, including lakes and beaver ponds, early in the year then moving into habitat with larger substrate and deeper water.

Sarafin, D. R. 2000. Progress report of Copper River Basin Chinook salmon coded wire tag releases, 1997-1999, and outlook for adult recovery. Alaska Department of Fish and Game, Fishery Data Series No. 00-10, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-10.pdf

Relatively large scale tagging project using the hand held CWT tagger. Results were disappointing (Brase and Sarafin 2004).

Scarnecchia, D. L. 1979. Variation of scale characteristics of coho salmon with sampling location on the body. Progressive Fish Culturist 41(3):132-135.

Scheurerell, M. D. 2005. Influence of juvenile size on the age at maturity of individually marked wild Chinook salmon. Transactions of the American Fisheries Society 134:999-1004.

The author found a significant positive relations between juvenile length and the proportion of adult salmon returning at age 4 versus age 5, but the effect of juvenile length varied among the three watersheds. This suggests that local environmental conditions supporting juvenile growth largely control the ultimate age composition for a given brood but that genetic differences also exist. More reason for routine collection of AWL and water temperature data.

Schmidt, A. E., and F. S. Robards. 1975. Inventory and cataloging of the sport fish and sport fish waters in Southeastern Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. Annual Report of Progress, 1974-1975. Project F-9-7, 16 (G-I-A), Juneau.

This study compared a variety of minnow trap designs. A modified minnow trap like the Gee™ but 1m long and 40 cm diameter proved to be most effective in lakes. The study also compared day and night trapping and various set durations.

Schnick, R. 2006. Zero withdrawal anesthetic for all finfish and shellfish: need and candidates. Fisheries 31(3):122-126. http://www.fisheries.org/html/fisheries/F3103/F3103p122-126Schnick.pdf

Good summary of process involved in approval of a anesthetic with zero withdrawal time, i.e. drug which can be used on fish which may be immediately consumed. Discusses the most current status of AQUI S®.

Schurman, G. C., and D. A. Thompson. 1990. Washington Department of Fisheries' mobile tagging units: construction and operation. American Fisheries Society Symposium 7:232-236.

ANNOTATED BIBLIOGRAPHY (Continued)

Seelbach, P. W., R. N. Lockwood, and G. R. Alexander. 1985. A Modified inclined-screen trap for catching salmonid smolts in large rivers. North American Journal of Fisheries Management 5:494-498.

Designed a modification of the inclined-screen trap initially described by Wolf (1950) that can be used in rivers of medium to large size (with flows >100cfs and depths >3ft, provided a low-head dam can be established. This report has useful diagrams.

Seiler, D., S. Neuhauser, and M. Ackley. 1981. Upstream/downstream salmonid trapping project, 1977-1980, progress report #144. State of Washington Department of Fisheries, Olympia, WA.

This 197 page report summarizes 3 years of work on 3 projects aimed at estimating smolt production, fishery contribution and escapement goals at South Fork Skykomish, Big Beef Creek, and Deschutes River. Primarily a coho study, but many other species dealt with. Good description and pictures of large incline plane traps and their operation, early CWT programs and adult traps. On file with Keith Pahlke, Alaska Department of Fish and Game, Division of Sport Fish, P.O. Box 110024 Juneau, AK 99811-0024.

Sharpe, C. S., D. A. Thompson, H. L. Blankenship, and C. B. Schreck. 1998. Effects of routine handling and tagging procedures on physiological stress responses in juvenile Chinook salmon. The Progressive Fish Culturist 60:81-87.

Juvenile Chinook salmon were subjected to handling and tagging protocols typical of normal hatchery operations and monitored for their physiological response to stress. Treatments included coded wire tagging, counting, ventral fin clipping, adipose fin clipping, and a procedure simulating a pond split. Treatment fish were also subjected to a standardized stress challenge to evaluate their ability to deal with disturbances subsequent to a handling or tagging procedure. Circulating levels of cortisol and glucose were used as indicators of stress. The cortisol and glucose responses to the confinement stress did not differ over time or among treatments. However, the confinement stress results do suggest a small but significant cumulative response, indicating small residual effects of the original handling protocols. No deaths were noted among treatment groups.

Shaul, L. D., P. L. Gray, and J. E. Koerner. 1984. Migratory patterns and timing of Stikine River coho salmon (*Oncorhynchus kisutch*) based on coded-wire tagging studies, 1978-1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 232, Juneau.

Coho salmon smolts and rearing juveniles were minnow-trapped and tagged on the main Stikine River and four lower tributaries during 1978-1979.

Shaul, L. D., P. L. Gray, and J. E. Koerner. 1991. Coded wire tag estimates of abundance, harvest, and survival rates of selected coho salmon stocks in Southeast Alaska, 1981-1986. Alaska Department of Fish and Game, Fishery Research Bulletin No. 91-05. Juneau.

This report summarizes coho studies at 23 different sites in Southeast Alaska, including Chilkoot, Chilkat, Politofski, Warmchuck, Klakas, Unuk and Chickamin watersheds. Estimated marine survival rates.

Shaul, L., S. McPherson, E. Jones, and K. Crabtree. 2003. Stock status and escapement goals for coho salmon stocks in Southeast Alaska. Alaska Department of Fish and Game, Division of Sport Fish, Special Publication No. 03-002, Anchorage.
http://www.sf.adfg.state.ak.us/FedAidPDFs/sp03-02.pdf

The status of coho salmon stocks in Southeast Alaska was assessed from information on escapement, smolt abundance, marine survival and total adult abundance from coded wire tagged indicator stocks. Good example of the value of well planned long-term CWT programs on wild stocks.

ANNOTATED BIBLIOGRAPHY (Continued)

Shepherd, B. G., and R. M. J. Ginetz. 1978. Proceedings of the 1977 Northeast Pacific Chinook and coho salmon workshop. Fisheries and Marine Service Technical Report No. 759.

Traps were set in the Babine River in 1976 for 24 hr. Further study of bait preference also was made on wild coho that were captured and held in a rearing pen at the Babine Fence. Baits included liver, salted herring roe, frozen salmon roe, and canned salmon. Results indicated a preference for canned salmon, followed by salmon roe. However, the canned salmon tended to disintegrate even in slight water velocities. Also, when the traps were first set, there was immediate and obvious feeding on the salmon roe, but no marked reaction to the canned salmon. **Salmon roe therefore was kept as the standard bait.** Beach seines, dip nets, fyke nets, and incline planes were also tried in the collection of Chinook and coho juveniles, but the bulk of the effort was put to Gee minnow traps**.**

Summerfelt, R. C., and L. S. Smith. 1990. Anesthesia, surgery and related techniques. Pages 213-272 [*In*] Shreck, C. B., and P. B. Moyle, editors. Methods for Fish Biology. American Fisheries Society, Bethesda, Maryland.

This study discusses the nature of anesthesia, the properties and physiological effects of anesthetics, and some regulatory issues related to the use of chemicals on fish. Has specific information on the use of the most commonly applied anesthetics like MS222, Quinaldine, carbon dioxide, ethyl aminobenzoate, etomidate, 2-phenoxyethanol, hypothermia and electroanesthesia. Also covers basic surgical techniques used on fish.

Sweet, D. E. 1999. Performance of the Chinook salmon enhancement program in Willow Creek, Alaska, through 1996. Alaska Department of Fish and Game, Fishery Manuscript No. 99-02, Anchorage.

Summarizes results of releases of CWT tagged Chinook smolt reared in hatchery from wild egg takes.

Swales, S. 1987. The use of small wire-mesh traps in sampling juvenile salmonids. Aquaculture and Fisheries Management 18:187-195.

The most widely used small fish-trap in the Pacific Northwest is the Gee minnow trap, a form of pot-gear produced commercially as a bait-catching device for sport-fishermen. Juvenile salmonids are most strongly attracted to baits which emit a strong odor, salmon roe is highly effective and most widely used.

Taylor, E. B. 1988. Water temperature and velocity as determinants of microhabitats of juvenile Chinook and coho salmon in a laboratory stream channel. Transactions of the American Fisheries Society 117:22-28, 1988.

Coho salmon were more associated with cover objects and were found at lower average velocities than were Chinook salmon at all water temperatures. Low water temperatures and, to some extent, increases in water velocity, may be important stimuli for microhabitat shifts often reported in stream observations of juvenile salmonids during the fall-winter transition.

Thedinga, J. F., M. L. Murphy, S. W. Johnson, J. M. Lorenz, and K. V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14:837-851.

Rotary-screw traps are effective at capturing migrant juvenile salmonids, but overall trap efficiency is affected by river stage, trap placement, and rotation speed and can vary among species and life stages. Correct placement of rotary-screw traps in rivers (e.g., narrow locations with sufficient current and depth) is important to ensure that sufficient fish are caught for reliable population estimates. Fences upstream of the trap may be needed to catch enough fish. Small migrants, particularly fry, can become impinged against the cleaning drum, which then expels them along with the debris from the live box. Large migrants are able to avoid the trap; therefore, modifications or changes in fishing techniques are necessary to accurately estimate steelhead smolt yield.

ANNOTATED BIBLIOGRAPHY (Continued)

Thedinga, J. F., S. W. Johnson, and K. V. Koski. 1998. Age and marine survival of ocean-type Chinook salmon *Oncorhynchus tshawytscha* from the Situk River, Alaska. Alaska Fishery Research Bulletin 5(2):143-148.

The objectives of this study were to validate, by using juveniles (10,191 smolts) that were captured using a pole seine, coded-wire-tagged and sampled for scales in 1989, the freshwater aging of adult Situk River Chinook salmon and to estimate their marine survival. This information will help managers to determine freshwater ages from scales of Situk River Chinook salmon, which are predominantly ocean-type stock and rare in Alaska. The Situk River Chinook salmon are unique because they are the only known stock in Alaska that migrates to sea primarily at age 0. The methodology in the research paper is weak in that it does not describe the capturing of the smolt very well. The length and mesh size of the pole seine is not included, and does not mention if bait was used to attract the smolt for capture.

Thompson, D. A., and H. L. Blankenship. 1997. Regeneration of adipose fins given complete and incomplete clips. North American Journal of Fisheries Management 17:467-469.

No fish from which the entire adipose fin was clipped exhibited regeneration. Complete regeneration was observed in 23% of the fish that had either the back two-thirds or the top two-thirds of the adipose fin clipped and partial regeneration was observed in an additional 35% and 63%, respectively. This study shows examples of complete and partial removals of the adipose fin.

Todd, G. L. 1994. A lightweight, inclined-plane trap for sampling salmon smolts in rivers. Alaska Fishery Research Bulletin 1(2):168-175. Alaska Department of Fish and Game.
http://www.adfg.state.ak.us/pubs/afrb/vol1_n2/toddv1n2.pdf

Floating traps sample top two feet of water column. Can also be fished on bottom in shallow areas. Efficiency averaged about 7% on the Kasilof River. Works best in flows over 0.7 m/sec. Has a list of materials used for construction of the inclined-plane trap and live boxes and provides visual diagrams to put them together.

Triton Environmental Consultants Ltd. 1990. Juvenile outmigration. Nechako Fisheries Conservation Program Data Report No. M90-3, 1996.

A combination of index sampling (seining and electrofishing) and trapping was used. Also, W fence weirs, inclined plane traps and rotary screw traps were used. The rotary screw trap captured similar size fish as the W fence weir.

Tsumura, K., and J. M. B. Hume. 1986. Two variations of a salmonid smolt trap for small rivers. North American Journal of Fisheries Management 6:272-276.

Trap nets were designed and constructed to capture steelhead smolts; they are variations of weirs. The authors modified the design so that it could be built with less expensive nylon netting suspended from an overhead cable. This paper described the design, construction, operation, and efficiency of the two trap nets built for Lynn Creek and the Englishman River. Looks like weirs were supported by overhead cables instead of tripods. Individual panels could be raised or lowered for cleaning or repair. “Flexgard™” an antifoulant, was used to reduce algae growth on the weir panels.

Tydingco, T. A. 2005. Smolt production, adult harvest, and spawning escapement of coho salmon from Nakwasina River in Southeast Alaska, 2002-2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-26, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-26.pdf

This report is an example of a successful small scale CWT program on a small coho salmon system.

USFS (U.S. Fish and Wildlife Service). Juvenile fish monitoring program. Accessed 2006.
www.delta.dfg.ca.gov/jfmp/trawling.asp

Web site documents work on Sacramento Delta juvenile fish. Discusses trawls and beach seines. Links to many reports.

ANNOTATED BIBLIOGRAPHY (Continued)

USFS (U.S. Fish and Wildlife Service). Aquatic Animal Drug Approval Partnership Program - Dr. David Erdahl, 4050 Bridger Canyon Road, Bozeman, Montana 59715; Phone: 406-994-9904; Fax: 406-582-0242; E-mail: Dave_Erdahl@fws.gov http://www.fws.gov/fisheries/aadap/signup.htm

Use this site for information and contacts for questions on any new drug approvals for use with fish and wildlife such as AQUI-S.

USFS (U.S. Fish and Wildlife Service). 1997. Comprehensive assessment and monitoring program (CAMP) implementation plan. Prepared by M. Watson, Jones & Stokes, CH2M Hill. http://www.fws.gov/sacramento/fwr/CAMP%20Implementation%20Plan_March%201997.pdf

This is a large document summarizing dozens of programs in Sacramento-San Joaquin Delta. Most use screw traps

Vander Haegen, G. E., H. L. Blankenship, A. Hoffmann, and D. A. Thompson. 2005. The effects of adipose fin clipping and coded wire tagging on the survival and growth of spring Chinook salmon. North American Journal of Fisheries Management 25:1161-1170.

Using otolith marked fish as controls they conclude that coded wire tags and adipose fin clips did not affect juvenile-to-adult survival. Mortality of tagged Chinook salmon during 11 months in the hatchery after tagging was significantly higher than untagged fish, although only about 1-2% more. They suggest further work on wild fish.

WDF&W (Washington Department of Fish and Wildlife). 1996. Fish Health Manual. Hatcheries Program, Fish Health Division.

Cites use of salt (5 to 10 grams/liter) to reduce stress during fish handling. Cites 100 ppm iodine for egg disinfection. On file with Keith Pahlke, Alaska Department of Fish and Game, Division of Sport Fish, P.O. Box 110024 Juneau, AK 99811-0024.

WDF&G (Washington Department of Fish and Wildlife). Wild salmon population monitoring. http://wdfw.wa.gov/fish/wild_salmon_monitor/ Accessed January 2006.

This site contains summaries of several ongoing smolt and adult salmon monitoring projects. Excellent photos and descriptions of fan traps, screw traps, incline plane traps and smolt weirs.

Weller, J .L., E. L. Jones III, D. R. Bernard and A. B. Holm. 2003. Production of coho salmon from the Unuk River, 2001–2002. Alaska Department of Fish and Game, Fishery Data Series No. 03-27, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-27.pdf

Baited minnow traps were fished daily on the Unuk River from 31 March through 23 April, 2001. Captured smolts were marked with coded-wire tags and excision of adipose fins. Different codes were used for small (70–82 mm FL) and for large (>83 mm FL) smolt. Sampled smolts averaged 84 mm FL and 6.4 g in weight. Smolt-to-adult survival of coho smolts over 82 mm FL was estimated to be 2.47 times that of smolts in the 70-82 mm range. They estimated that the larger smolts were 2.12 times more likely to be captured by minnow trapping than 70-82 mm smolts.

Weller, J. L., D. Reed, and A. Holm. *In prep*. Spawning abundance of Chinook salmon in the Chickamin River in 2005. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Weller, J. L., and S. A. McPherson. *In prep.* Coded wire tagging studies of Unuk River Chinook salmon 1993-2000. Alaska Department of Fish and Game, Fisheries Manuscript, Anchorage.

Whelan, W. G., M. F. O'Connell, and R. N. Hefford. 1989. Improved trap design for counting migrating fish in rivers. North American Journal of Fisheries Management. 9:245-248.

Details plans for trap at a weir that can be easily converted from adult to smolt. Uses conduit pickets and welded steel corner pieces. Some good ideas, but most of the design has since been improved on with the aluminum channel design.

ANNOTATED BIBLIOGRAPHY (Continued)

Willis, D. W., and B. R. Murphy. 1996. Planning for sampling. Pages 1-16 [*In*] Murphy, B. R., and D. W. Willis, editors. Fisheries techniques, *second edition*. American Fisheries Society, Bethesda, Maryland.

Good introduction into planning a field project. This study discusses sampling considerations, logistics, ethics and cost-benefit hierarchy.

Wolf, P. 1950. A trap for the capture of fish and other organisms moving downstream. Transactions of the American Fisheries Society Vol. 80.

Development of original Wolf trap with a description, drawings and photos. With small mesh screens, the trap can be used for aquatic drift sampling.

Wood, J. W. 1974. Diseases of pacific salmon their prevention and treatment. State of Washington Department of Fisheries, Hatchery Division.

This report recommends a disinfectant soaking of salmon eggs for 10 minutes in a 1:150 solution of Wescodyne™. The author explains BKD, IHN and other diseases of concern that could be transferred through infected salmon or eggs.

Yanusz, R. J., S. A. McPherson, D. R. Bernard, and I. M. Boyce. 2000. Production of coho salmon from the Taku River in 1998. Alaska Department of Fish and Game, Fisheries Data Series No. 00-31, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-31.pdf

Yoshikawa, H., Y. Ishida, S. Ueno, and H. Mitsuda. 1988. Changes in depth of anesthesia of the carp anesthetized with a constant level of CO_2. Bull. Japan. Soc. Sci. Fish. 54(3):457-462.

Looked at CO2 for anesthetics, legal and safe for humans, but it was not too effective with carp; also discusses McFarlands five levels of anesthesia.

Zafft, J. 1992. Migration of wild Chinook and coho salmon smolts from the Pere Marquette Rive, Michigan. Masters Thesis. Michigan State University.

This study used a modified fyke net with a floating live box to capture smolt. Lots of discussion of influences on outmigration, estimation of total smolt yield and estimation of trap efficiency.

NOTES