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Tetracycline, coded wire, and cold branding are three promising fish marking methods.

Marking Fishes and Invertebrates. I. State of the Art of Fish Branding

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ABSTRACT

Advantages and disadvantages of various methods of marking fish are briefly described. Evolution of branding as a method of marking fish (mainly juvenile Pacific salmon, Oncorhynchus *spp., and steelhead trout,* Salmo gairdneri*) is traced from use of a wood burning tool to present day cold and laser-beam branding. Problems associated with cold branding today are stressed, particularly the variability in retention of brands. Suggested causes of variability include: (1) differences between fish markers with respect to duration of, and pressure of, application of the branding tool on the fish; (2) physiological differences among races, species, and sizes of fish; and (3) differences between smolting and nonsmolting fish, feeding and nonfeeding fish, tool sizes, and symbols. Additional research along the lines suggested above could help isolate the major causes of variability and bring us closer to standardizing the methodology required to affix permanent brands on fish.*

INTRODUCTION

Fishery scientists have long recognized the need to identify groups of fish and individual fish by marking. Methods of marking used to date include fin-clipping, external tagging, tattooing, tetracycline injection, coded-wire tagging, and branding. While some methods have been partially successful, none has been entirely satisfactory.

Most experiments with Pacific salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, have been with fin clips. In recent years, mass fin-clipping of juvenile salmon, released from hatcheries on the Pacific Coast of North America, has provided sufficient data to permit evaluation of the hatchery contribution of fall chinook, *O. tshawytscha*, to the sport and commercial fishery (Worlund, Wahle, and Zimmer, 1969). Advantages of fin-clipping are:

(1) Permanence of the mark if the fin is properly excised.

(2) Easy identification by fishermen.

(3) Inexpensive to mark.

Disadvantages are:

(1) High mark mortality on some combainations of excised fins, especially pectoral and maxillary. Weber and Wahle (1969) reported that sockeye salmon, *O. nerka*, with excised adipose-left maxillary fins suffered a 39 percent higher mortality than those marked with tetracycline.

(2) Fin regeneration—if the fin is not properly excised, there is considerable regeneration, particularly on the anal fin. Worlund et al. (1969) indicated 5-11 percent regeneration on ventral and maxillary clips. We noted up to 35 percent regeneration of partially excised anal fins in 1971.

(3) Limited number of combinations. Only four fins of salmon and trout are considered adequate for experiments by researchers—the adipose, dorsal, and the left and right ventrals. Excision of these fins would allow only two experiments between comparably paired groups, or up to a maximum of 10 combinations of single and double fin-clips, which would be totally inadequate for a river system such as the Columbia, with its extensive network of hatcheries. In past years researchers have been forced to use more inferior clips such as pectoral, anal, and maxillary at some hatcheries, creating a potential bias on the interpretation of results.

External tags, such as spaghetti and dart tags, are useful in experiments involving small numbers of fish and for limited periods. Such

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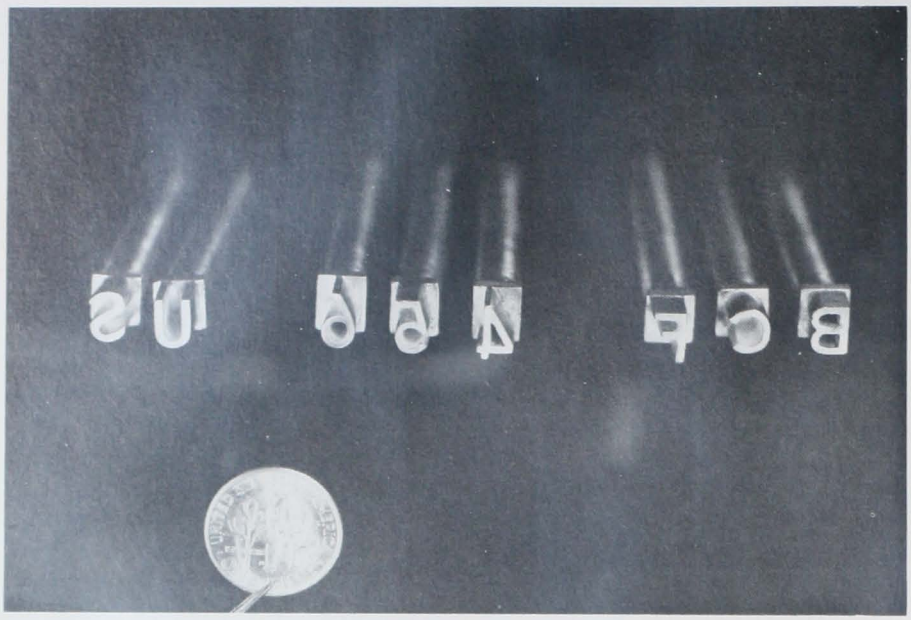

Figure 1.—Closeup of solid silver tips on marking tools; 10-cent piece shows size relationship. (Courtesy Groves and Novotny, 1965.)

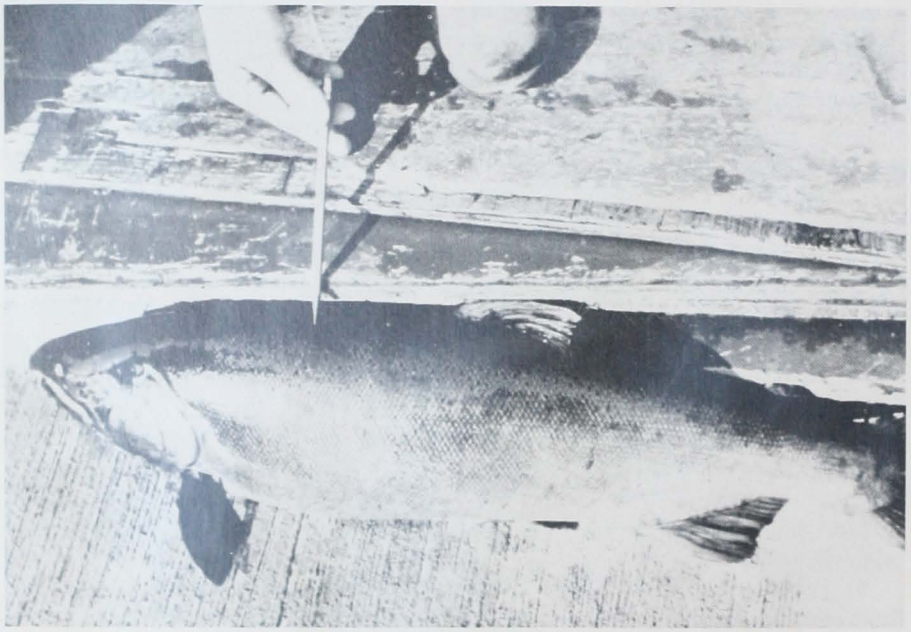

Figure 2.—Brand mark "FC" on 2-year-old adult coho salmon. Mark appears dark because of absence of reflective pigment and altered scale growth. (Courtesy Groves and Jones, 1969.)

methods are not practical on a production scale, since the tags generally require more time to apply than other marks and are often rejected or lost as the fish grow.

Tattooing also is useful in short-term experiments (Schoeneman, Pressey, and Junge, 1961) but is also limited in duration and numbers of combinations.

Tetracycline is most promising not only as a permanent mark but as an excellent control for assessing fin-clip or other mark mortalities in hatcheries (Weber and Wahle, 1969). Its disadvantages are limited combinations and lack of external marking. The fish must be killed and a vertebra removed to determine whether the fish is marked.

The coded wire identification system developed by Jefferts, Bergman, and Fiscus (1963) appears promising. Its major advantage is the almost unlimited number (10^6) of experimental groups that can be identified. Disadvantages are high initial cost of equipment and tags as well as some tag loss and malfunctioning of tagging gear and adult detection equipment. Recent experiments using coded wire tags for marking juvenile fish are discussed by Ebel (1974).

Marking with a laser beam has recently been attempted and may afford another means of identifying origin of fish. Maximum disadvantage to date is cost ($26/1,000 fish) and inability to produce accurate beams of the wavelengths of light required. Recent field trials with a laser device have been disappointing. Laser-marked coho salmon, released in the Columbia River and subsequently recovered during their downstream migration, actually looked as though holes had been blown through their bodies. The problem apparently was fluctuating voltage of the machine. It appears that considerable research is still required in this field before laser branding becomes feasible.

Branding of fish was reported by Buss (1961), who used a wood-burning pencil to mark juvenile brook trout, *Salvelinus fontinalis*. He reported that some brands remained visible after 21 months and one after 4 years. Johnson and Fields (1959) tried to mark fingerling steelhead trout by applying to the skin surface a nichrome wire electrically heated to white heat. This induced injuries which were slow to heal, and after 5 months no distinguishable marks or scars were left. Similarly, white hot wire was used by Watson (1961) to mark young

Atlantic herring, *Clupea harengus harengus*. He reported that scars were discernible after 7 months, but differences between marks were evident only during the first few days.

Groves and Novotny (1965) marked fish with a specially designed marking tool immersed in boiling water (Fig. 1). All fish had visible marks after 10 months. Marks grew with the fish which increased in size from 100 to 200 mm. In 1965, 15,000 yearling coho salmon were branded at the Fish Commission of Oregon OxBow Hatchery, fin-clipped, and released into the Columbia River (Groves and Jones, 1969). The clipped fins permitted a double check of all branded fish. Six months later 171 of the fish returned as 2-year-old adults (Fig. 2). All had clips and brands intact. Subsequently, 30 additional fish, all with identifiable brands and clips, were observed among returning 3-year-olds of the same group.

Cold branding was initiated by Fujihara and Nakatani (1967) and by Everest and Edmundson (1967). They used a slurry of dry ice and ethanol ($-78°C$). Mighell (1969) tried this method and found it unsuccessful when large numbers of fish were marked rapidly. Ice and frozen mucus accumulated on the branding tool and apparently disrupted heat transfer between the fish and the tool; resultant marks were poor. Good marks were produced when the tool was cleaned regularly, but the rate of marking was greatly reduced. When liquid nitrogen ($-196°C$) was used, however, the tool remained free of ice and mucus and produced consistently clear brands at rapid rates. The marking tool, the reservoir to hold the liquid nitrogen, and a closeup of the male connector used for rotating or changing marking tools are shown in Figure 3. Mighell marked juvenile chinook, coho, and sockeye salmon, and steelhead trout ranging from 50 to 160 mm in fork length, varying brand application times from ½ to 3 sec. In general, the marks remained dark with sharp definition for about 7 weeks, after which they became lighter in hue and consisted mainly of altered scales and scarred epidermis (Fig. 4).

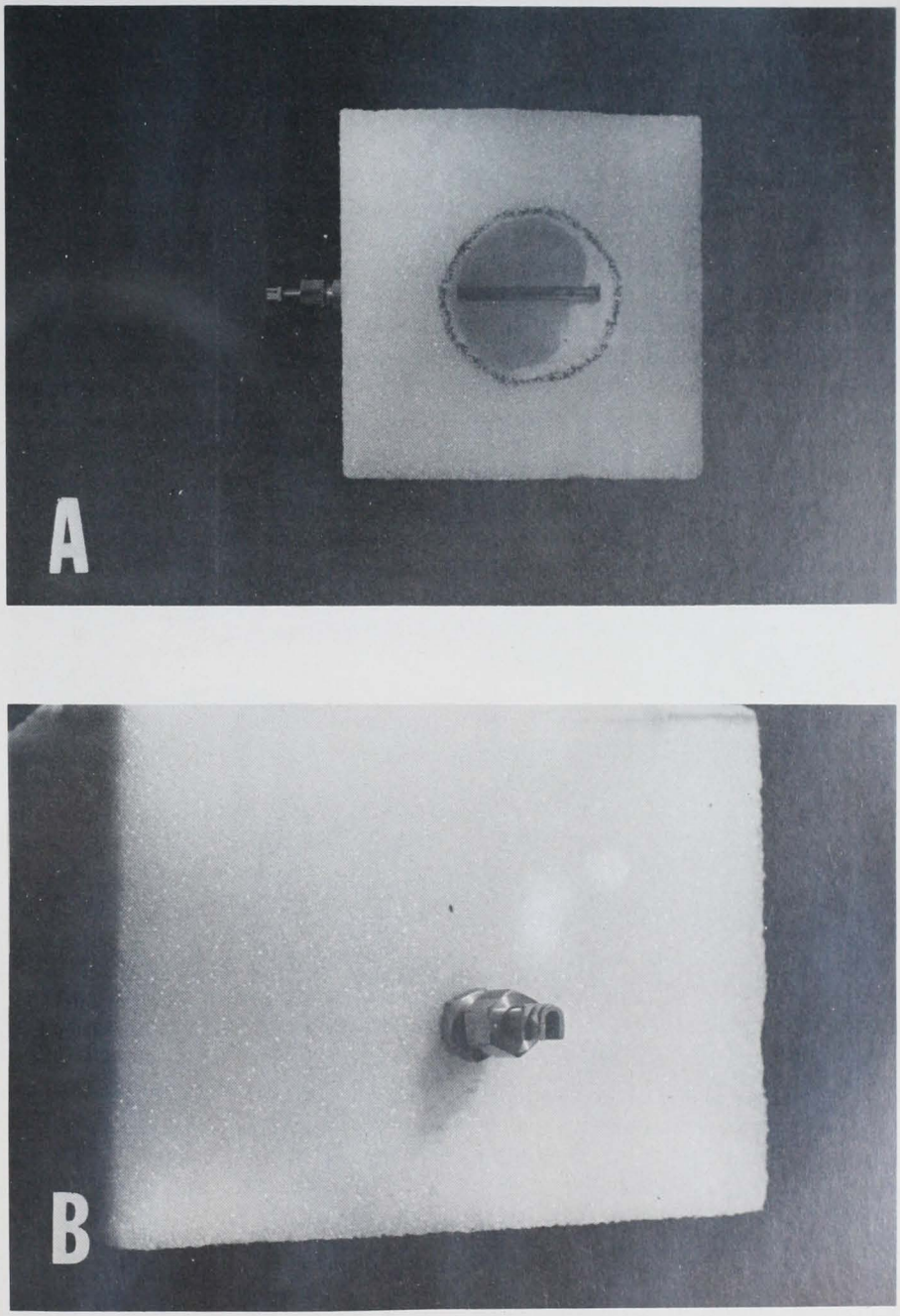

Figure 3.—(A) View from the top of cold-branding apparatus; lid is removed to show reservoir for liquid nitrogen (outlined in black on foam). (B) Closeup of male tubing connector and "U"-shaped cold-branding tool mounted for marking. (Courtesy Mighell, 1969.)

Mighell concluded that more work is needed to determine the optimum duration of brand application to the epidermis of the fish and the best size and age at which brands should be applied to ensure identifiable development and maximum retention. From his work he felt that fish should be over 55 mm in length (marks on fish smaller than 55 mm disappeared

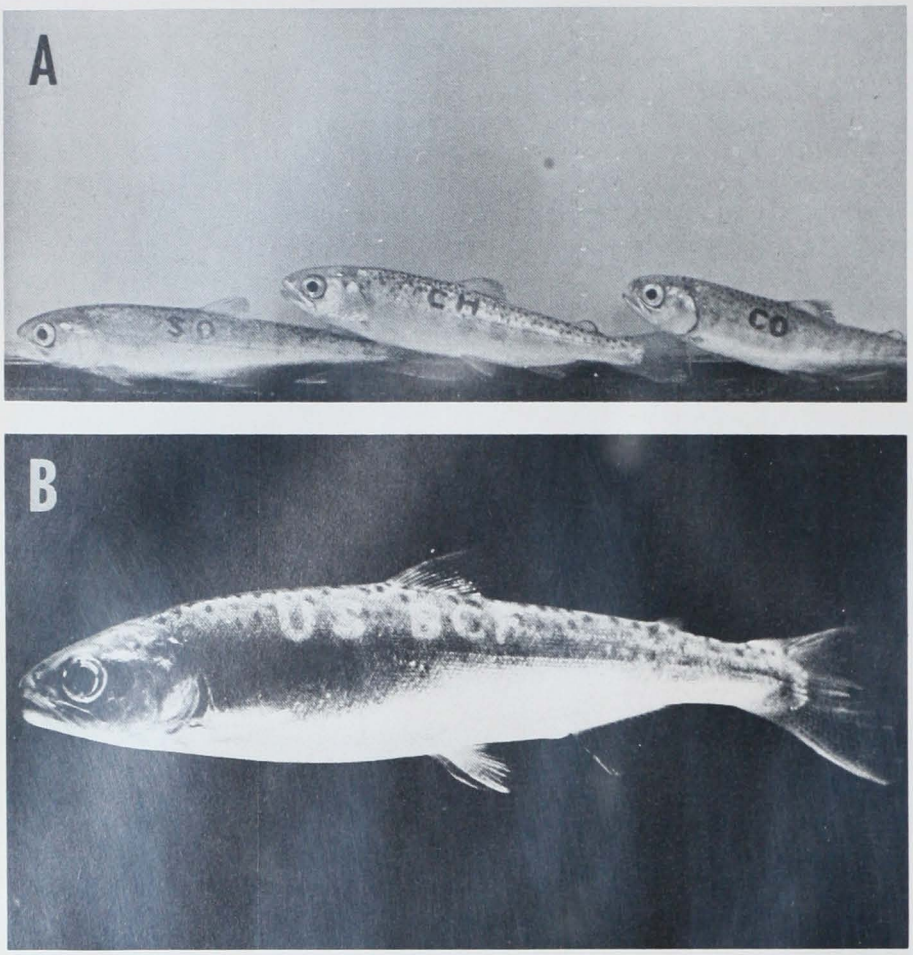

Figure 4.—(A) Cold brands 48 hours after marking. (B) Cold brand 3 months after marking. (Courtesy Mighell, 1969.)

after 3 weeks) and brands should be applied for at least 1 second.

Smith (1973) tried to determine why marks fade on fish under 55 mm by marking various groups of chinook, coho, and sockeye salmon, ranging from 32 to 48 mm. His findings substantiated those of Mighell. Most marks could not be distinguished after 2 months. They feel the problem is primarily lack of maturity of the scale producing cells.

Work on the Columbia River by the National Marine Fisheries Service (NMFS) has resulted in the branding of several million juvenile salmon and trout annually since 1964. Our primary requirement in the initial phases of these studies was a short-term mark with a capacity for numerous combinations (which the brand provided). We were not looking for adult returns. In more recent years, though, branded adults started returning to hatcheries such as OxBow on the lower Columbia River, Rapid River on the Salmon River (a tributary of the Snake River), to the Seattle laboratory of NMFS from releases by Mighell, and to the University of Washington in Seattle. Furthermore, the fish counters at dams started seeing a number of brands and sportsmen reported catching branded fish.

In recent years branding of fish has spread from the Pacific Northwest to other parts of the United States and even to Kenya in Africa. The most extensive branding program outside of the Pacific Northwest was probably that held in the Great Lakes Region (R. Saalfeld, Great Lakes Fisheries Commission, pers. comm., 1971). A total of 246,000 yearling lake trout, *Salvelinus namaycush*, were fin-clipped, branded, and released in southern Lake Michigan in the spring of 1969. Of those recovered, 80 percent had marks, but visibility was extremely varied, ranging from barely perceptible to very perceptible. Saalfeld concluded that if identification depended on the brand alone (no fin-clip), a high percentage of marked fish would have gone undetected.

The Washington Department of Game marked juvenile steelhead trout in 1969 using a larger mark than that previously applied in our Columbia River studies. Adults returning from these releases bore highly visible brands as reported by the fish counters who observed migrants as they passed by the viewing window in the fish ladder of Little Goose Dam on the Snake River (Tony Eldred, Washington Department of Game, Moses Lake, Washington, pers. comm.). The obvious legibility of this brand indicated that brand size might be a significant factor in permanency of the brand on fish.

By 1972, the consensus of most researchers was that branding had great potential but results were highly variable. Why did some fish retain clear brands to adulthood and not others? Is the variation related to difference in size or condition of fish, or does the time of year make a difference? Is there a method yet unknown that is less variable?

With these thoughts in mind, we held a workshop in Seattle 17-19 January 1972, assembling many qualified workers in the field of branding. Discussion panels included: (1) evolution of branding; (2) methodology; (3) physiology; (4) results to date; (5) where we are in the state of the

art of branding; and (6) additional research required to perfect branding of fish.

Conferees generally concluded that permanent brands on fish could be obtained if the problems with fluctuation in clarity and retention of brands could be resolved. Some of the reasons for the high variability and obvious areas where research is still required to perfect brand methodology include:

(1) Improperly sized brands for the size of fish being marked.

(2) Use of both open and closed brands and simple and complex symbols on comparable groups of fish.

(3) Branding comparable lots of fish on different parts of the body (there is considerable variation in both retention and clarity of brand, depending upon area of branding on fish).

(4) Differences between performance of fish markers branding fish, with respect to time and pressure of application, may be the single most important cause of variation in brand retention to adulthood. If too much pressure is used or the brand is held on the fish too long, excess cellular damage frequently results. Actual scarring occurs—the mark folds up and disappears. By contrast, if application time is too short, the marks will not be retained for more than a few months.

(5) Degree of scale development and smoltification and condition of fish at time of marking.

(6) Physiological differences among race, species, and size of fish.

Following the workshop, some additional research commenced on brand size, shape, and topical location. Donn Park (NMFS, Northwest Fisheries Center, Seattle, pers. comm.) compared different brand sizes and shapes placed above the lateral line near the dorsal fin on salmon and steelhead smolts at Little Goose Dam on the Snake River. Adult returns of fish marked with standard size letters in 1968-70 (Ebel, Park, and Johnsen, 1973) served as comparative data for the 1971-72 tests. Results (Table 1) indicated that retention is considerably improved by using larger brands. Furthermore, Park found that symbols with the simplest lines and fewest angles produced the sharpest brands.

Raleigh, McLaren, and Graff (1973) in Pennsylvania, using liquid nitrogen as a coolant, have obtained identifiable and reasonably durable brands on three species of trout: rainbow (*Salmo gairdneri*), brown (*Salmo trutta*), and brook (*Salvelinus fontinalis*), and three species of centrarchids: smallmouth bass (*Micropterus dolomieui*), rock bass (*Ambloplites rupestris*), and redbreast sunfish (*Lepomis auritus*).

Table 1.—Legibility of brands on returning adult steelhead trout and chinook salmon as related to brand size at time of marking.

Brand size		Legibility (%)		
Line width	Height	Legible	Partly Legible	Illegible
Steelhead				
3/64"	3/16"	47	30	23
1/16"	3/8"	81	12	7
Chinook				
3/64"	3/16"	38	22	40
3/64"	1/4"	82	15	3

They had four suggestions that they felt would aid in controlling much of the variability formerly observed in the quality of cold brands. Three of the four factors generally agreed with our findings: type of brand, application time, and location. The fourth suggestion on changes in hue is worth passing on: "Changes in hue occurred in both dead and live fish, and significantly affected the readability of brands. Fish with unreadable or poor quality brands should be placed in holding containers that will stimulate a maximum change in hue and the brands reexamined. Fish captured by fishermen should be examined for marks at the time of capture, before being creeled."

Although Raleigh et al. (1973) appear to have resolved some of the problems associated with branding trout and bass, we still have not perfected branding on anadromous salmon and steelhead trout. Much still needs to be learned about the effect of differences in size, condition, and age of fish, differences between smolting and nonsmolting fish, variability among fish markers, etc., on brand retention. Park and others, I feel, are on the right track in emphasizing increased brand size on smolt-size fish.

To date much of our knowledge on salmon branding has come from experiments designed to obtain information on aspects other than fish marking. What is really needed is a series of controlled experiments on various sizes and species of salmon and steelhead trout, carried out for a sufficient period of time. On the basis of knowledge at hand, we can suggest a series of experiments in an attempt to standardize the methodology required to affix a permanent brand on salmon and steelhead trout.

A salmon and steelhead hatchery where returns to the hatchery could be examined immediately on arrival should be selected. A series of controlled experiments could be run, testing the effect of the following on clarity and retention of brands:

(1) Relation of fish size to application time and size of brand.

(2) Relation between time of year, degree of smoltification, scale development, and condition (feeding, nonfeeding) of fish at time of marking.

(3) Variation among different species and sizes of fish.

(4) Symbols—which brand configuration should be eliminated?

(5) Differences in methods of heat transfer—boiling water, dry ice and alcohol, liquid nitrogen, freon.

(6) Compare tissue sections taken in branded area of fish for each variable at time of marking and on adult returns.

(7) Time and pressures of application—as mentioned previously, this aspect could be the most important of all.

An experiment I have in mind would involve a test group of fish marked with six markers, each with a different brand, marking as before without any control other than holding the brand on the fish for about 1 second. Returns could be compared with returns from another test group

marked with a machine (presently being engineered) that maintains constant pressure and application time. These results could provide considerable insight into the degree that differences in fish markers play on variability in brand retention.

These are only a few of the areas where research is needed on fish branding. Concurrent experiments with centrarchids could be conducted in other areas of the country. I feel that graduate students in fisheries schools could do the research. If properly designed and executed, the results of the research would provide suitable thesis material.

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