An Inexpensive, Nondisruptive Method of In Situ Dart Tagging for Visual Recognition of Fish Underwater

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Abstract.—We describe two devices for the underwater application of external dart and anchor tags to fish. The general method appears useful for applying individual-specific marks to many relatively large-bodied, approachable species. We observed high tag retention rates, low incidence of fish injury, and minimal behavioral disruption when applying tags. In situ tagging eliminates the need to capture, handle, and anesthetize individuals and it is particularly valuable for behavioral studies, where temporary removal of individuals may affect their social status.

Common methods of tagging wild fish necessitate capture (often en masse) and handling and frequently involve anesthetization. These three procedures can result in stress and even mortality (Wydoski and Emery 1983) and almost certainly disrupt the normal activities of a fish. Such disruption is especially problematic in behavioral studies, because temporary removal of a fish from its habitat can affect its social standing (Robertson 1972). Moreover, mass capture methods (e.g., beach seines) usually gather fish from a broad area; hence, subsequent behavioral observations cannot be referenced to a fish's original territory. As an alternative to methods with these drawbacks, we have developed inexpensive devices for applying dart tags to fish in situ with a minimum of disturbance to the individual. Our experiences suggest that this method should be applicable to a variety of fish species.

The first tagging device we developed was a pole spear that was constructed by attaching a 75-cm loop of surgical tubing to a 1.5-m length of aluminum rod with a combination of twine and electrical tape. A hollow needle (3 mm diameter) into which the tag was inserted was attached to the free end of the rod with two small hose clamps or electrical tape (Figure 1). We used 12-cm-long barbed plastic dart tags (model FT-1, Floy Tag & Manufacturing Co., Seattle, Washington; see Everhart and Rupp 1960). Tags were labeled with unique sequences of color bands made with colored labeling tape or marine enamel paint.

A color-coded tag was inserted into the needle so that the tip of the needle extended 2–3 mm in front of the tip of the tag barb. A swimmer grasped the surgical tubing with one hand and pulled the aluminum rod back 30–40 cm with the other. The swimmer then approached a fish, placed the tip of the needle 10–20 cm from a spot approximately 2 cm below the base of the dorsal fin, and released the aluminum rod. This procedure attached the tag to the fish.

The pole spear was used successfully to tag spawning male and female sockeye salmon Oncorhynchus nerka on island beaches in Iliamna Lake, Alaska, but the major effort was directed at females. Ninety-two females were tagged; 54 individuals received multiple tags, which allowed us to estimate tag loss rates and to read some tags that otherwise became unreadable several days after application. Each female was observed daily from the time of tagging until her death, which allowed us to calculate tag loss rates and the life spans of tagged fish under natural conditions.

The second tagging device was a modified spear gun. Trials with this device were conducted off the North Carolina coast with two different types of external anchor tags: a tag with a stainless steel head (model FH-69, Floy Tag) and a tag with a nylon head (series E tag, National Marine Fisheries Service, Southeast Fisheries Center, Miami). The tags were connected to the spear bolt with an adapter constructed from a solid stainless steel rod (Figure 2). The pin that held the tag was inserted into the adapter and secured with a set screw (Figure 3). A curved 31.8 X 6.3 mm stainless steel fender washer with a short piece of 15.9 mm rubber tubing...
glued inside with contact cement was slid over the pin to act as a stopper. The washer's hole was larger than necessary to accommodate the pin, allowing the washer to pivot and remain parallel to the body of the fish on impact, thus controlling the depth of tag insertion. Tags were mounted on the pin and secured to the adapter by a rubber band.

The pole spear technology was the more extensively tested of the two methodologies. From 1,001 observations of 54 multiply tagged sockeye salmon females, we observed a tag loss rate of 1.2% per day. The incidence of injury due to tagging was low (9 of 161 taggings resulted in an injury, 6 of 9 injured fish survived 2 d or less) and improved as we became more experienced. Principal causes of injury were the application of too much force and poor tag placement. Placement below the lateral line or more than a few centimeters posterior to the dorsal fin resulted in severe bleeding. Excluding fish obviously injured during tagging, the median life span of 83 spawning females after tagging was 13 d (M. D. Adkison, M. B. Ward, and T. P. Quinn, University of Washington, unpublished data). This is a longer life span than is usually reported for spawning female sockeye salmon and exceeds by several days that reported for this site by Quinn and Foote (1994) who used mass capture and disc-tagging techniques.

Territorial females generally exhibited a minor reaction to the insertion of the tags. Nearly half (roughly 45%) showed no reaction. A similar fraction reacted by abandoning their territory for 1-2 min and then returning. In the majority of instances, if the first attempt at tagging failed, a second attempt was successful within 2 min. About 10% of territorial females were difficult to ap-

![Figure 1](image1.png)

**Figure 1.**—Mechanism used in pole spear trials for underwater application of tags to sockeye salmon in Iliamna Lake, Alaska.

![Figure 2](image2.png)

**Figure 2.**—Adapter used for connecting the shaft of the spear to the tag inserter. Parts supplied were in English units (" denotes inch).
approach, especially if previously tagged. However, all territorial females selected were eventually tagged. Fish were much less approachable prior to the onset of territorial behavior.

The composition and diameter of the rod were important. A steel rod shot with sufficient velocity to reach a fish had too much inertia at impact and caused injuries. A lightweight rod (aluminum or hollow fiberglass) was more suitable. The diameter of the end of the tagging device proximal to the fish (rod diameter plus attached needle) was also important. Salmon were startled by the close proximity of a wide object but not by a rod of approximately 0.5 cm diameter.

Needle tips were frequently blunted during tagging, especially when the needle contacted the substrate on a missed attempt. It was necessary to carry a supply of extra needles and to attach the needles to the rod so that they could be easily removed and replaced. We found it helpful to align the rod parallel to the substrate when tagging fish. This improved the accuracy of tag placement and consequently reduced injury to the fish; it also reduced the frequency of blunting needles against the substrate.

There was considerable gradual wear of the colored bands on the tags after they were inserted. Painted bands became illegible at a rate of 2.7% per band-day (81 illegible bands over 2,964 band-days). Preliminary trials suggest this rate can be reduced if a thin coating of marine varnish is applied to the body of the tag after the colored enamel paint has dried. Taped bands degraded at a much higher rate and were essentially useless. The band closest to the body of the fish deteriorated fastest.

Tag wear was apparently caused by territorial aggression from neighboring females; the aggression seemed to be directed at the fish itself and not the tag. Certain color combinations were best for marking tags. On red tags, yellow, white, and black marks were easily distinguishable underwater. Green was difficult to distinguish from black under some lighting conditions.

Trials with the spear gun have so far been limited to 14 fish. Three gags *Mycteroperca microlepis* (a reef-associated bottom fish) ranging from 50 to 76 cm and 11 greater amberjacks *Seriola dumerili* (a schooling midwater fish) ranging from 61 to 112 cm have been tagged. Gags moved rapidly away from the diver after being tagged. Greater amberjacks flared their gills for 15–30 s and then continued their normal behavior. Fish were tagged during seven different dives from October 27, 1992 to August 8, 1993. One gag and seven greater amberjacks have been tagged with stainless steel dart tags. Two gags and four greater amberjacks have been tagged with the nylon head dart tags. Fish have been tagged from as far away as 4 m and at depths of up to 30 m.

Most fish appeared uninjured when the tag was properly inserted in the dorsal musculature. One greater amberjack was seen emitting a stream of bubbles after being tagged, suggesting a pierced swim bladder. Another greater amberjack had an impression mark left by the washer at the insertion site when it was tagged at close range with too much force. Problems with the tagger so far have been limited to one bent pin (straightened underwater with a pair of pliers), one broken pin, and the loss of one washer due to separation of the...
rubber tubing (replacement was effected under-
water). Pin problems were associated with the ny-
lon head tag pins, which have a small point that
inserts into the head of the tag. These points bend
easily; one broke off after being twice straight-
ened. We advise carrying spare parts and pliers on
dives to minimize lost tagging time.

Most methods of tagging fish involve capture,
handling, and anesthetization. Each of these op-
erations results in some degree of stress to the fish.
A common method of tagging involves seizing or
other mass capture methods, followed by a tagging
procedure that involves some handling and pos-
sibly anesthetization of the fish. Dart and anchor
tags, which can be applied without handling or
anesthetizing fish, have been in use for over 40
years (McFarlane et al. 1990), especially for ex-
ceptionally large-bodied species (Mather 1963).
Generally, fish have been captured with hook and
line before they are dart tagged (Fable 1990; Guth-
ierz et al. 1990). This capture process itself may
stress or injure fish, although for some species bai-
ting can bring fish close enough to tag without cap-
ture (Klimley and Nelson 1984).

We used pole spears and spear guns to apply
individually marked dart tags underwater without
capturing fish, and our experiences suggest that this
method may be applicable to many approachable
and relatively large-bodied species. A similar meth-
od has been used effectively by Klimley (1993) to
attach ultrasonic transmitters to scalloped hammer-
head sharks _Sphyrna lewini_. Whale researchers have
used a variety of devices, including crossbows
(Goodyear 1993), to attach tags to free-swimming
individuals from the surface. Matthews and Reavis
(1990) used an anesthetic underwater to immobilize
rockfish _Sebastes_ spp. so they could make vital mea-
surements and attach tags without removing indi-
viduals from their territories.

In situ underwater spear tagging sacrifices one's
ability to collect tissue samples and obtain weight
and length data, but it obviates the need for han-
dling and anesthetization and avoids the stresses on
the fish associated with these procedures. It is
quick and thus minimizes disruption of normal be-
havioral patterns. Because fish remain in situ,
spear tagging minimizes potential social disrup-
tions, such as loss of territory or dominance status,
which are frequently observed when animals are
temporarily removed from their environment, thus
this method is particularly useful for behavioral
studies.

Limitations of in situ underwater tagging in-
clude practical constraints on the number of fish
that can be tagged (especially for scuba applica-
tion), particularly when fish are cryptic or shy.
Foregoing handling of fish sacrifices the ability to
collect morphological measurements. Application
of tags requires some skill, and the success of tag
application is difficult to evaluate. There is a risk
of injury to the fish, although this can be mini-
imized with proper construction of the tagging de-
vice. The rate of injury to salmon from this method
was fairly small, and it was reduced even further
when we lowered the inertia of the tagging device
and gained experience in its use. Appropriate
placement of tags also minimizes injury (Gutherz
et al. 1990). The rate of tag loss (1.2% per day)
makes this technique most suited to short-term
studies. If tag retention could be improved, this
method could be applied to longer-term studies
such as archival tagging, where mortality from
capture and handling (particularly of very large
fish) is a major concern. The other principal dif-
ficulty with the method was wear of the bands of
colored paint applied to the plastic dart tags. This
problem may be peculiar to the very aggressive
salmon and may be resolved by improved fabri-
cation techniques.

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**References**

tic fish tag. Transactions of the American Fisheries

Fable, W. A. 1990. Summary of king mackerel tagging
in the southeastern USA: mark–recapture tech-
niques and factors influencing tag returns. American

Goodyear, J. D. 1993. A sonic/radio tag for monitoring
dive depths and underwater movements of whales.

of hydroscopic molded nylon dart and internal an-
chor tags on red drum. American Fisheries Society
Symposium 7:152–160.

Klimley, A. P. 1993. Highly directional swimming by
scalloped hammerhead sharks, _Sphyrna lewini_, and
subsurface irradiance, temperature, bathymetry, and


