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EXPERIMENTAL TESTING OF FISH TAGS ON ALBACORE IN A WATER TUNNEL

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INTRODUCTION

Albacore tuna tagging (as an adjunct to the North Pacific fisheries exploration rogram of the Branch of Commercial Fisheries of the U. S. Fish and Wildlife Serv-ce) was carried out during the summer of 1950 aboard the vessel John N. Cobb (Pow-ll, 1950). The tagging was undertaken in an effort to ascertain the practicability using tags as one means of tracing the movements and migration patterns of alba-ore tuna in the fishery off the coasts of Washington, Oregon, and adjacent regions. uring the exploratory fishing and gear-testing activities of the North Pacific tuna xploration) survey, a number of albacore were caught which were surplus to program eeds. Thus, an opportunity was presented for gaining practical experience with tag-ing problems including the development of suitable techniques for handling albacore uring tagging operations. Because previous experiments in tagging of several spe-ies of tuna by various investigators have met with little or no success, difficul-ies were expected. Due to the relatively high velocity at which albacore move rough the water, one of the first questions concerned the effect of the swimming peed on the loosening or tearing out of external tags applied to the fish.

A total of 397 albacore was tagged with Peterson disc tags 14.5 mm. in diame-r and 35 were tagged with 16 mm. x 3 mm. plastic strip tags, attached either at e base of the second dorsal or on the caudal keel. Although no tagged fish were covered, a letter from the Oregon Fish Commission stating that an albacore bearing g marks had been landed at Astoria, Oregon, suggested that the fish were surviv-g the tagging ordeal but that the tags were somehow being detached from the fish. seemed plausible that the velocities at which albacore are capable of swimming ght well exert a force which would be sufficient to tear loose and free from the sh these types of tags. If this is true, the tag designed for albacore or other ift-swimming fish must not only be chosen according to sound biological principles, t must also be so designed as to withstand the physical forces that will be cre-ed by movement of the fish through the water. A tag that would satisfy these con-tions might possibly be found by a trial-and-error tagging program; however, the thors believed that certain physical characteristics of fish tags could be tested der laboratory conditions. To conduct these laboratory tests, a water tunnel was nstructed in which tags attached to fish could be observed while subjected to va-ous water velocities.

The experiments were carried out at the University of Washington Hydraulics boratory at Seattle, Washington, and the authors wish to express their apprecia-on for suggestions and help contributed by its members. Thanks are also extended

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to the California Department of Fish and Game, Oregon Fish Commission, Washington State Department of Fisheries, and the Fisheries Research Board of Canada for submitting samples of fish tags used by their organizations.

EQUIPMENT USED

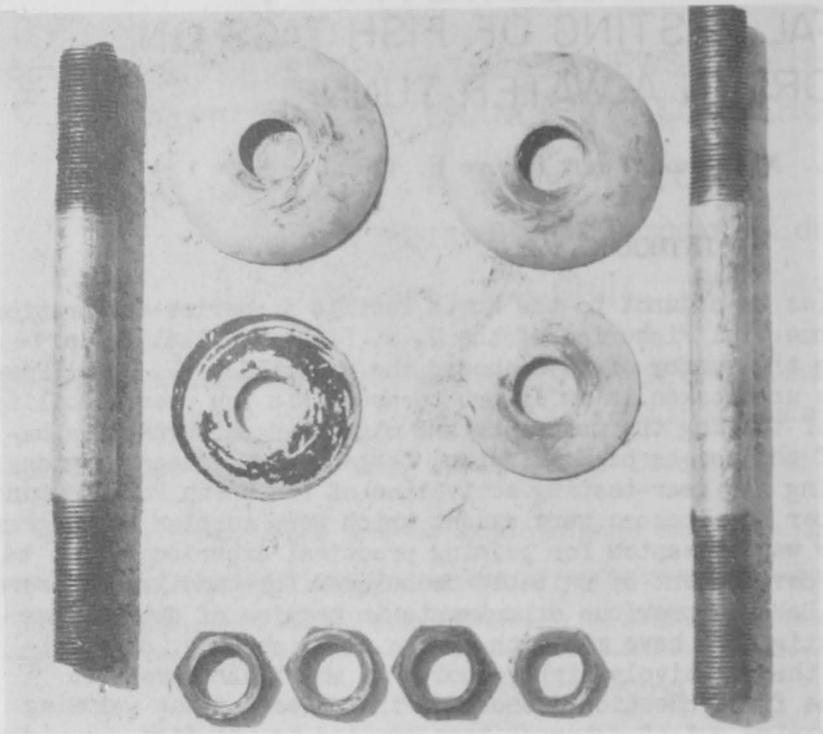

FIGURE 1 - FISH HOLDERS AND WASHERS.

The water tunnel was essentially a 5-foot-long box (8 inches wide and 10 inches deep) with channel steel sides and clear lucite top and bottom (see cover). Along the sides, teak wood was designed in a fusi-form pattern to keep the distribution of water velocity past the fish nearly constant by maintaining the net flow area approximately equal. The entrance of the tunnel section was well rounded to eliminate eddy currents, and the kinetic energy in this section was partially recovered by an expander section downstream from the tunnel.

The fish was held in place by two transverse rods through the body. The ends of the rods were carried in sockets on each side of the tunnel. Originally, brass holders were used, consisting of 3/8-inch brass rods that were screwed out from an internally-threaded 1/2-inch rod through the fish. These proved inadequate both as to strength and to speed of assembly and were replaced with 3/8-inch standard pipes (see figure 1), that were held in place by 3/8-inch steel rods inserted through the pipes from the exterior of the tunnel. These new holders were considerable timesavers and of adequate strength. Cup-shaped aluminum washers, bolted against the fish, held it against any lateral motion.

Water was obtained from a one-acre holding pond with an operating head of one hundred feet. This head produced a maximum flow of 12.6 cubic feet per second, which was equivalent to a velocity flow of approximately 28 m.p.h. The water velocities in the tunnel were determined by a differential mercury gauge (see figure 2) measuring pressure difference between the 12-inch approach pipe and a restricted section near the tunnel entrance. This pressure differential was converted to miles-per-hour by a graph constructed from theoretical considerations and verified by a series of draw-down tests from a known volume of water held in a 6-foot-diameter surge tank connected with the approach line. The connections between the differential mercury gauge and the piezometers were made with plastic tubing. This tubing was ideal for such connection because entrapped air could easily be seen and hence eliminated. A separate high-pressure water line to the gauge was used in freeing the instrument of air and in holding it in readiness for the test runs.

METHODS

Fish tags (see figure 3) were tested on albacore that had been frozen and partially thawed before being placed in the tunnel. In preparing a fish for the water tunnel, it was removed from cold storage and taken directly to the University of Washington Hydraulics Laboratory. There, the fish was placed under a drill press and two 5/8-inch holes, 9 inches apart, were made in the frozen meat for the holders, one slightly above the pectoral base, the other above the mid-line in the region of the second dorsal fin. On completion of drilling, the two 3/8-inch pipe holders were inserted through the holes and the cup-shaped washers were bolted against the sides of the fish (see figure 4). Several tags were then selected and arranged on the fish in various positions. In preparing the albacore for the tunnel, sufficient thawing occurred so that tags could be easily inserted in the fish; however, the interior portion remained frozen, holding the fish in position against the water flow. The fish was then arranged in the tunnel (see figure 5), the lucite coverplate bolted in position, the mercury gauge freed of air bubbles, and the valve controlling the water flow was opened slowly until the mercury reading corresponded to the desired velocity. Results of the experiment were then observed through the lucite plates.

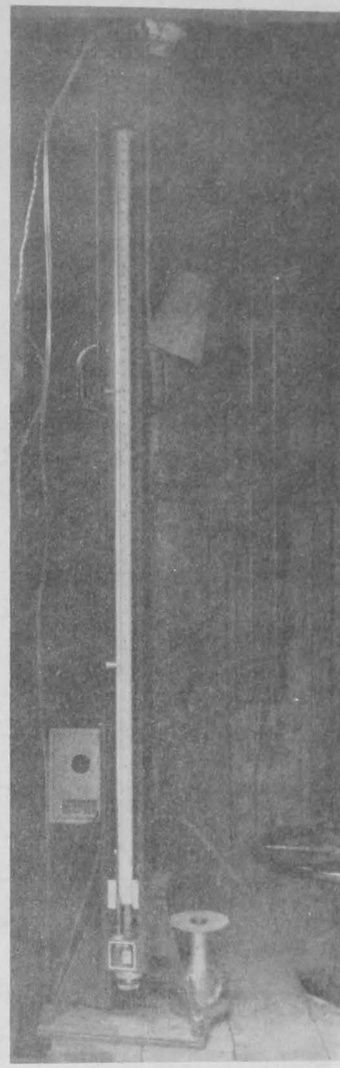

FIGURE 2 - DIFFERENTIAL MERCURY GAUGE USED IN TEST TO MEASURE PRESSURE DIFFERENCES.

Several limiting factors made it necessary to conduct each test for only a short period. The fish would thaw rapidly in the water and become difficult to hold at high velocities; and bruises to the fish received during landings or storage would open up under these high water velocities and result in the water forcing portions of the skin from the fish. The trials lasted from 5 to 14 minutes, the average being approximately 10 minutes. The general procedure was to increase the velocities at fixed intervals throughout the test until the tags were either dislodged or the fish showed signs of tearing loose from the holders. If the tags were not torn from the fish during the trial, the coverplate was removed and the condition of the tag and its effect on the fish was noted.

RESULTS

PETERSON TAGS: Peterson (Rounsefell and Kask 1943) tags of 8 mm. diameter and of 14.5 mm. diameter were subjected to a number of tests in the tunnel. The tags of 14.5 mm. diameter were dislodged from under the dorsal fin at water velocities between 18 and 22 m.p.h. At water velocities approaching 15 m.p.h., the leading edge of the disc was forced outward from the fish, and with increasing velocities, the pin would gradually bend into a bow. It was then only a matter of seconds before the tags pulled from the meat of the fish. Disc tags of 8 mm. diameter secured under the second dorsal were dislodged at velocities from 23 to 25 m.p.h. Ten tests were made with the large disc and four with the smaller. Because of the shape of the

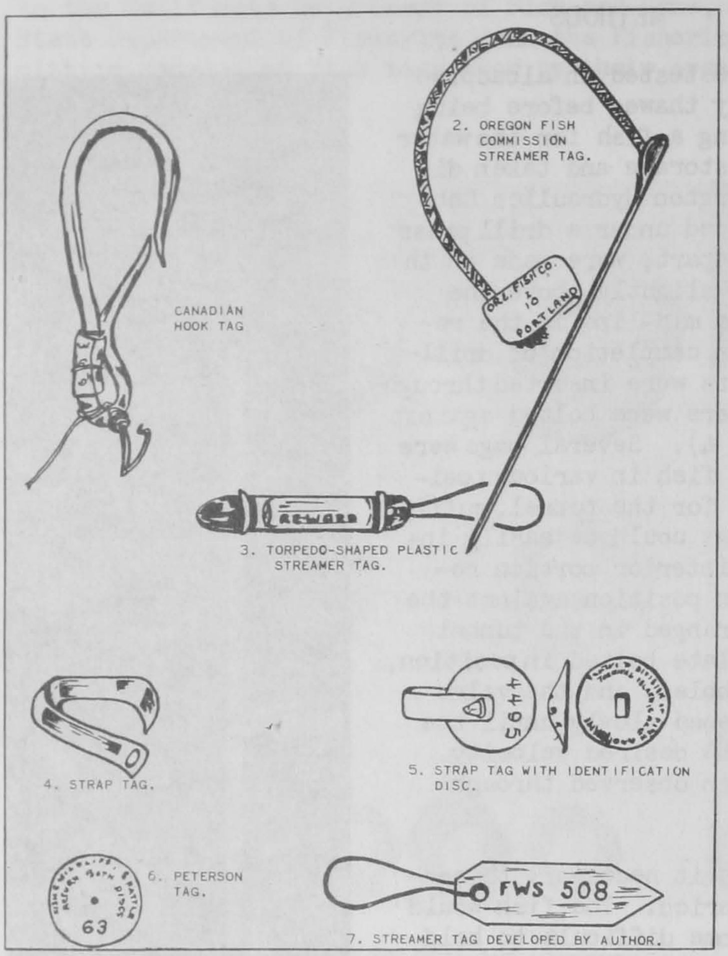

FIGURE 3 - TYPES OF TAGS TESTED ON ALBACORE IN WATER TUNNEL.

albacore, it is difficult to obtain a close fit of the disc under the dorsal fin, and thus the water wedges under the tags and forces them from the fish. Peterson tags were also tried on the caudal peduncle and above the anal fin. Both of these regions were superior to the dorsal area and tags of 14.5 mm. diameter located in these positions were not lost until water velocities between 25 and 27 m.p.h. were reached.

PLASTIC STRIP TAGS: Plastic strip tags used were merely an adaptation of an internal body tag with a hole cut in the forward end. These tags, 4 mm. wide and 16 mm. long, designed to reduce water resistance, were secured under the second dorsal in the same manner as a Peterson tag. Four trials made in the tunnel were unable to tear these tags loose at maximum velocities (approaching 29 m.p.h.).

STRAP OR CATTLE TAGS: Strap, or cattle, tags of various sorts have been adopted for use on a variety of fish and good results have been obtained on several species. A modified strap tag was developed by Godsil (1938) and used to tag 4,000 yellowfin and skipjack tuna. No recoveries were reported. The tag consisted of two parts: (1) a sterling silver strap 16 to 17 mm. long (crimped) by 3 mm by 0.5 mm. and (2) a celluloid, cup-shaped disc 14.5 mm. in diameter. The tags were applied with modified long-nose pliers to the preopercle. Eight trials were made with tags of this style received from the California Department of Fish and Game.

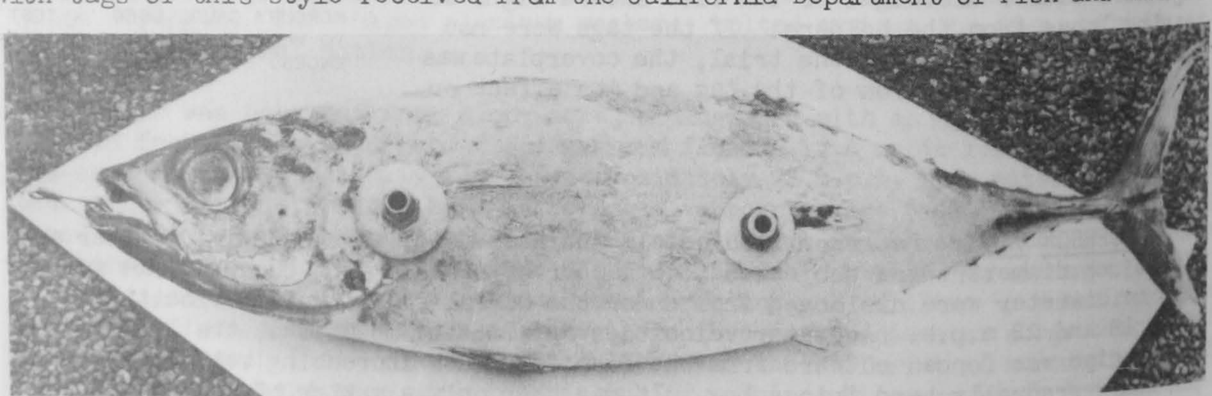

FIGURE 4 - ALBACORE READY FOR TESTING, WITH HOLDERS INSERTED AND SEVERAL TAGS IN PLACE.

Four of the tests were made with the convex side of the disc facing the gill cover and four with the concave face of the disc facing the gill cover. Tags applied with the convex face of the disc against the preopercle were torn from the fish at relatively low water velocities; 15, 16.2, 16.8, and 18 m.p.h. The longest a tag remained attached at the above velocities was 2 minutes and 20 seconds at 16.2 m.p.h. The remainder of the tags were dislodged in less than one minute. On reversing the celluloid disc so the concave face was against the gill cover, the tags were not torn out so easily; but nevertheless, were forced from the fish at velocities of 21, 22.3, 22.5, and 23.8 m.p.h. These tags did not slowly work free but seemed to be suddenly jerked from the gill cover.

Small strap tags, 17 mm. long (crimped) and 3 mm. wide, as used by the California Department of Fish and Game in experimental mackerel tagging, were placed on the opercles of albacore. Eight tests made with this tag did not dislodge the tags at maximum velocities. When the fish were examined at the end of the test, some wearing was observed on the opercle, and in several instances the hole in the opercle had doubled in size. Fry and Roedel (1949) reported that of 14,053 fish tags of this type released in the California mackerel investigation, only 19 were recovered more than one year from the date of release.

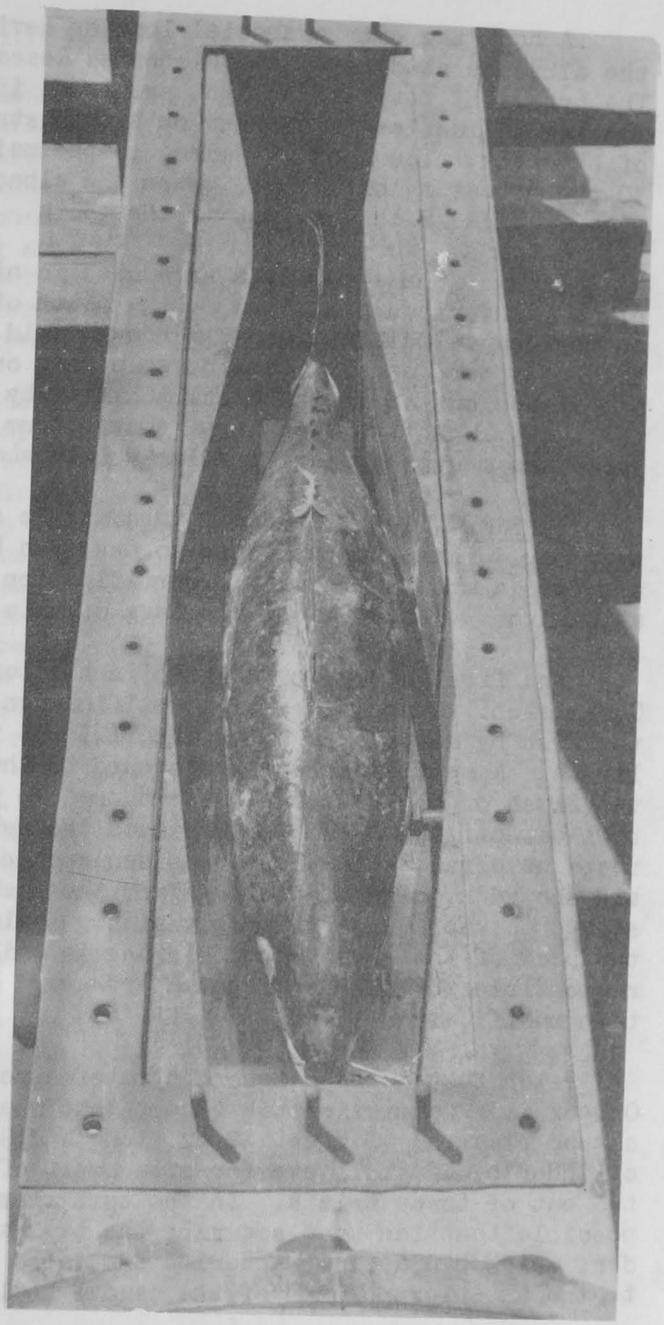

FIGURE 5 - ALBACORE IN TUNNEL PRIOR TO ACTUAL TESTING OF FISH TAGS.

HOOK TAGS: Fish hooks have enabled investigators to follow to a limited extent the migration of bluefin tuna (*Thunnus thynnus*) in the eastern Atlantic. Heldt (1928, 1929, 1932) relates a number of authentic cases in which hooks have been removed from bluefin tuna in the Mediterranean. These hooks from 4 to 8-1/2 cm. in length were traceable by their style and manufacturer, and were reported to have been lost by fishermen along the west coast of Spain and France. Many of the hooks were encysted in the stomachs of the fishes. These hooks were found in tuna of large size, and in most instances, the fish weighed over 200 pounds.

A hook tag with a special locking device is under experimentation for use in the albacore studies by the Fisheries Research Board of Canada (Anonymous 1950). The hooks, of patented design, are 6 cm. in length and are made of nickle wire. The identification is carried on a thin strip of metal secured around the shank of the hook. The hook is joined to the main trolling line by a short section of 30-pound test nylon leader. When the albacore strikes, the leader breaks and the fish is freed with the hook in the mouth.

Tags of the above type were used in nine trials in the water tunnel, being placed in various positions on the mouth of the albacore. These tags were subject to maximum velocities, and the hooks could not be dislodged. It was observed that the hooks were causing considerable drag on the jaws, which were forced as much as two inches out of their normal position by the force of the water on the shank of the hook. When the fish were removed from the tunnel, the tag had noticeably injured the mouth by tearing a large hole where the shank passed through the jaw.

STREAMER TAGS: Streamer tags may be considered as a modification of the Atkin type tag. These are attached to the fish by a wire or thread piercing the flesh and have a metal or plastic identification streamer that trails behind the place of attachment. To our knowledge tags of this type have not been used for tagging tuna.

The first streamer tag used in the tunnel was one developed by the Oregon Fish Commission. A small, metal identification plate, 9 mm. by 15 mm., was secured to the fish by means of a nylon line 1.5 mm. in diameter and approximately 133 mm. in length. A metal needle was attached to the free end of the nylon line which pierced the flesh of the fish and was returned to the identification plate where a special tool cut off the needle and crimped the nylon to the tag in one operation. Four tests were made with these tags secured under the second dorsal, and all held firm and showed no sign of pulling from the fish. The metal identification plate was observed to vibrate considerably at high velocities and to continually strike against the back of the albacore. This tag is still in the experimental stage, and those responsible for its development are aware of the condition and are considering certain modifications.

Also tested was a second type of streamer tag, similar in most respects to the Oregon Fish Commission tag except that the metal plate was replaced by a torpedo-shaped plastic cylinder, 32 mm. long and 3 mm. in diameter. The forward end of the cylinder had a small eye for attachment of the thread. The tags held securely in two out of three trials. In the test that failed the meat was not torn and it is possible that the knot securing the tag was not properly tied. The plastic cylinder, which had a blunt anterior end, also vibrated greatly. This tag was attached to the anterior portion of the caudal keel.

The third streamer tag tested was developed by the senior author. It consisted of a flexible plastic streamer 8 mm. wide, 34 mm. long, and less than 1 mm. thick. The streamer was rounded on the anterior portion and tapered towards the back. A hole was punched close to the forward end through which braided nylon thread was passed. The two ends of the nylon thread were tied in such a manner that the thread formed a complete loop through the eye of the streamer. The tag was attached to the fish by means of a needle that had the eye at the piercing end. The double end of the nylon thread was passed through the eye, and the needle was then pushed through the anterior portion of the caudal keel of the tuna. The plastic streamer portion was brought through the double end and the tag was secured. This operation can be completed rapidly. This tag was tested seven times at maximum velocities and remained fixed throughout the trials.

DISCUSSION OF RESULTS

The authors are aware that a number of factors involved in these experiments allowed variations from conditions which would exist in nature. The texture or consistency of the frozen fish to resist deformation would not be equal to that of a live albacore. The sides of the tunnel undoubtedly caused a certain amount of back turbulence; also the distribution of velocity along the body of the fish would vary slightly because of the changing area of flow. The muscular actions of live fish were also lacking. The experiments were conducted only for short periods, and tags would likely be dislodged at velocities lower than those experimentally determined when subject to the same forces over a longer period of time.

Despite these limitations, the tests indicated that the use of Peterson-type tags or any other tag which offers considerable resistance to the water flow will probably result in failure when used on a fish which swims at high speeds. This would include such tags as the batchelor button, Heincke stud, and the strap tag with identification disc. The plastic strip tags held in all tests and from the hydraulic standpoint should be satisfactory. Strap tags such as used in the California mackerel fishery could not be dislodged, but tests made in the water tunnel indicated that these tags would gradually work free. Hook tags developed by the Fisheries Research Board of Canada were not dislodged but resulted in injury to the jaw of the fish. This tag is still in the experimental stage and modifications could partially eliminate these faults. Reduction in the shank size and stamping the identification on the shank would reduce drag.

From the experimental results, it appears that the streamer tags (among those tested) offer the greatest chance of developing successful external tagging operations for tuna-like fish. In selecting a position to attach a tag, it should be kept in mind that any tag attached on the head or anterior region of the fish will receive maximum force from the water. Tags located on the caudal keel or in this region will receive the greatest action from lateral vibrations of the tail.

The solution to a successful tuna tagging operation first demands a tag which remains attached securely and will not impair the normal activities of the fish. Until a tag of known dependability has been developed, attributing the lack of returns only to such factors as insufficient tags released, high tagging mortality, poor tagging techniques, or to other causes does not seem justified.

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