Techniques Used in the Tagging of Yellowfin and Skipjack Tunas in the Eastern Tropical Pacific Ocean During 1955-1957

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INTRODUCTION

THE INTER-AMERICAN TROPICAL TUNA COMMISSION is charged with the maintenance of the populations of tropical tunas and tuna bait-fishes in the Eastern Tropical Pacific Ocean at levels which will permit maximum sustained catches year after year. The fishery for tropical tunas ranges from Southern California to northern Chile and offshore to a distance of several hundred miles, a sea surface area of about one and one-quarter million square miles. From this vast area some 300 million pounds of yellowfin tuna, *Neothunnus macropterus*, and skipjack, *Katsuwonus pelamis*, are taken each year, in approximately equal amounts by species during recent years. Over 95 per cent of this catch is landed in the United States or transhipped there from foreign ports. The present fishing fleet consists of about 165 long-range live-bait clippers and 45 large purse-seine vessels. This fleet operates from San Diego and San Pedro in California, from Ensenada in Baja California, from Ponce in Puerto Rico and from Paita and Chimbote in Peru. There are also local fisheries for tuna near Cape San Lucas in Baja California, near Manta in Ecuador and near Mancora in Peru, all using small vessels employing either bait or purse-seine methods.

It appears well documented that the stocks of yellowfin tuna in this area are distinct from those in the central and western Pacific. While the relationships of the skipjack populations of these areas are less well understood, they are probably distinct also, but may be subject to limited mixing in the intervening oceanic areas. At present, the nature of the population structure of each species within the boundaries of the eastern Pacific fishery are considerably less well understood. Since December 1955, the Commission has been conducting an intensive tagging program to approach this problem directly by the interpretation of the movements of recovered tagged individuals.

TAGGING METHODS AND RESULTS

The first successful tagging of Pacific tunas was done by scientists of the California State Fisheries Laboratory who developed a vinyl plastic loop tag (Wilson 1953) which was threaded beneath the second dorsal fin of the tuna and was secured in place by knotting the free ends of the plastic tubing. This tag was moderately successful but the rates of recovery from early experiments were low, probably due to tagging mortality, tag shedding and the failure of the fishermen and cannery workers to see and return the fish on capture.

From the inception of our tagging program we felt that the plastic loop tag was of sound basic design, but that considerable improvement could be made in the tag and its method of application. A possible weak point in the tag was at the knotted area and the first modification was the use of a stainless steel or monel metal clamp to securely fasten the two ends of the plastic loop, as shown

FIGURE 1. A yellowfin tuna tagged with a white plastic loop tag and recovered from the cutting line of a San Diego cannery.

in Figure 1. From December 1, 1955 to December 31, 1957, 6,227 yellowfin and 16,428 skipjack tunas were tagged with various modifications of this plastic loop tag. Of these, 73 yellowfin and 73 skipjack were tagged from purse-seine operations and the remainder from bait-boat operations.

Handling and Tagging Mortality

Because the tunas are powerful, yet delicate fish, their tagging has presented many difficulties not encountered with most fish. Their vigorous struggles during tagging may cause injury or excessive muscular fatigue and subsequent death after release. Black (1958) has shown that a prolonged exercise period resulted in a rapid increase in lactic acid levels in the blood and tissues of salmonoids. Death resulted, in many cases, either directly or indirectly from the experimental treatments. No direct measure of muscular fatigue has been possible with the tunas, but there appears to be good indirect evidence that fatigue may so debilitate the fish that they die or are easy prey to sharks and other predators after tagging.

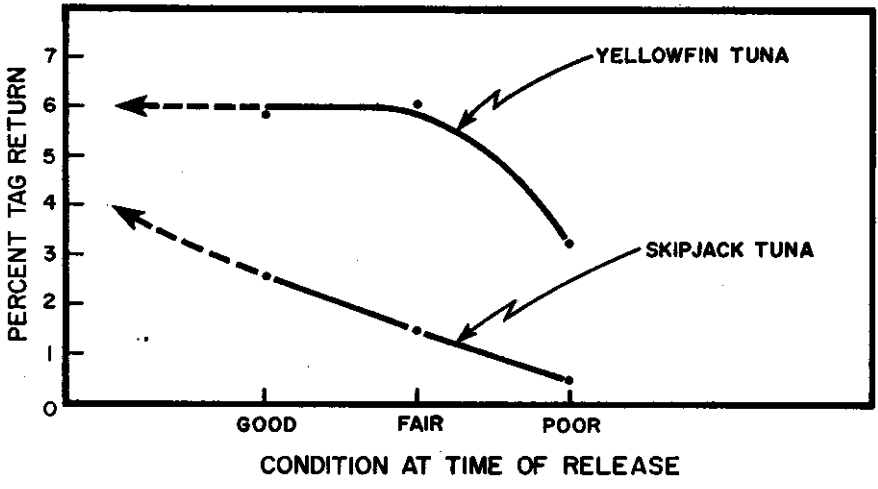

FIGURE 2. The percentage return of tagged yellowfin and skipjack tuna (to November 1, 1958) for the categories "good," "fair" and "poor."

To examine indirectly the possibility of tagging and handling mortality, yellowfin and skipjack tunas were graded as "good," "fair" or "poor," based on the time out of water, amount of struggling during handling, evidence of body injury and the swimming action of the fish on return to the water. The recovery rates of these three groups for all fish tagged to December 31, 1957, are plotted for each species in Figure 2. The curves are fitted by inspection and a dotted line extended in each case to indicate the possible rate of tag return on a further improvement in condition of the fish on release. For yellowfin tuna it appears that little improvement in tag return rate can be expected with further improvement in the condition of the fish at the time of release. However, for the skipjack, further improvement in handling techniques might result in a considerable increase in tag return rates. A chi-square test of the hypothesis that handling techniques do not affect the tag return rates was highly significant for skipjack and not significant for the yellowfin tuna.

Since tropical tunas cannot be held successfully in live-wells aboard the fishing vessel, they must be tagged and released directly after capture. From the inception of the program it was realized that the tagging and handling methods might result in a substantial initial mortality. A canvas tub filled with running sea water was used at first to immerse the tuna during tagging, but it was discarded when the splashing of the water hindered the tagging operation and did not seem to reduce fish injury. The use of anesthetics was also considered but it was found that the time necessary to quiet the fish before, and to effect recovery after tagging, was too great to make the method practical.

The following techniques were gradually evolved after many tagging cruises aboard live-bait vessels. The fisherman, positioned in the stern racks of the vessel, swings the tuna from the water to the tagger, who guides the suspended fish into a foam rubber lined "V" cradle placed on the stern rail of the vessel. The forward portion of the tuna, including the eyes, is covered with a wet burlap sack, the plastic loop tag is threaded through the fish about one-half inch below the second dorsal fin and the two free ends of plastic are fastened together with a metal clamp. The fish is immediately released over the stern and the tagging procedure is repeated as the next fish is captured.

A stopwatch was used to measure the time-out-of-water on a sample of fish during tagging by both experienced and inexperienced personnel on six cruises during 1957. A summary of these times is given in Table 1.

TABLE 1

THE RANGE AND MEAN TIME-OUT-OF-WATER, IN SECONDS, DURING THE TAGGING OF TUNAS WITH THE PLASTIC LOOP HELD IN PLACE WITH A HAND-APPLIED METAL CLAMP.

Cruise No.	*No. Observations*	*Time in Seconds*	
		Range	*Mean*
9	63	26-61	40.0
12	8	15-70	29.0
13	3	23-38	32.0
14	25	20-48	33.4
15	114	10-61	27.1
17	14	25-55	30.4

The mean time-out-of-water for the 227 observations was 31.7 seconds, with experienced taggers usually able to complete the operation in less than the mean time and inexperienced taggers taking longer.

Several models of an automatic tag applicator were designed and field-tested during 1956 and 1957 with the hope of reducing the tagging time. The first device threaded the plastic loop through the fish and applied a monel clamp in a single operation but numerous field difficulties prevented its successful use at sea. A simpler set of pliers, shown in Figure 3, was then designed to secure the two ends of the plastic loop together with a .040 monel wire staple, after the tag is threaded through the fish with a hand needle. After several modifications this device was tested during August and September, 1957, while fishing off the coast of Baja California (Cruise 14) and the recoveries compared with the hand clamp method of applying the loop tag. The releases and the subsequent recoveries of yellowfin and skipjack tuna tagged by each method are shown in Table 2.

TABLE 2

TAG RELEASES AND SUBSEQUENT RECOVERIES (TO NOVEMBER 1, 1958) OF YELLOWFIN AND SKIPJACK TUNA TAGGED WITH THE PLASTIC LOOP TAG SECURED WITH HAND CLAMP OR AUTOMATIC STAPLE.

	Yellowfin		*Skipjack*	
Method	*Tagged*	*Recovered*	*Tagged*	*Recovered*
Hand clamps	258	27	451	12
Automatic staples	315	31	455	55

The timing of a sample of 44 fish tagged with the automatic pliers gave a mean time out-of-water of 20.6 seconds. The returns of the skipjack tagged with the automatic pliers were much greater than those tagged with the hand clamps while the returns for each type of tagging of yellowfin tuna are quite similar. As the time-out-of-water is probably a fair index of fish condition on release after tagging it is not surprising that these data agree with the analysis of the condition experiment data. The automatic pliers offer two advantages in tagging skipjack,

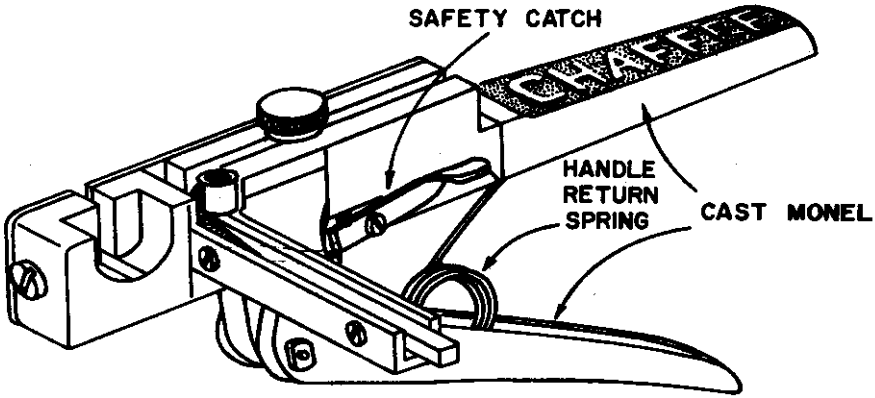

FIGURE 3. The automatic pliers for stapling the ends of the plastic loop tag.

a reduction in tagging time and presumable tagging mortality, and an increase in the number of fish that can be tagged in a given time of fishing; for yellowfin the latter appears to be the sole advantage of the automatic method of securing the loop tag.

Loop Tag Improvements

Examination of the tags returned from our first experiment indicated that the No. 18 XTE-30 vinyl plastic tubing was weakening after immersion in sea water, probably due to the leaching of the plasticizer, and that many of the tags could be easily broken. Beginning in August of 1956, 4,176 tagged tunas were released with every second tag strengthened by means of a No. 50 monofilament nylon core and by November 1, 1958, 75 of the strengthened tags and 48 of the non-strengthened ones had been returned from the fishery. A chi-square test of these returns indicated that the use of the nylon core resulted in significantly greater numbers of recovered tags. Losses of loop tags from breakage of the plastic can be estimated roughly at $\frac{(75-48)}{75} = 36$ per cent, if it is assumed that the addition of the nylon completely eliminated the breakage and shedding of the tags.

The search for a vinyl compound that would weather satisfactorily in sea water resulted in the development, by the Resinite Division of the Borden Company, Santa Barbara, California, of a material, resinite 271-1. This material, strengthened with nylon core for added tensile strength, is now being used in the manufacture of all our loop tags. Minnesota Mining and Manufacturing Co. has recently developed a tubing of braided spun glass dipped in liquid vinyl, which we are planning to test in the near future, because of its added strength and the ease of fabrication of the tags.

Plastic Dart Tag

Yamashita and Waldron (1958) have recently reported on a rapidly applied plastic dart tag used successfully to tag skipjack tunas in the Central Pacific area. We have tested a similar dart tag on 296 fish released during the summer of 1957 in the Gulf of Panama and on 986 fish released off Baja California during August, 1958. There have been no returns from the first experiment and five from the second, up to November 1, 1958. Four of the latter were returned from cannery operations and this suggests that the plastic dart tag (visible from one side of the fish only) is difficult to detect in the large catches of the American vessels, in contrast with the plastic loop tag (visible from either side of the fish), which has a better chance of detection during handling.

Detection of Recaptured Tagged Tunas

The fishing, handling and storage methods used aboard American tuna vessels are designed to handle large volumes of fish. It became evident during 1956 that a substantial number of the fish tagged with the white plastic loop tags were being overlooked by the fishermen, and that many of these tagged fish were being processed and the tags lost. To estimate these losses, a series of experiments were conducted in cooperation with scientists of the California State Fisheries Laboratory. Scientists aboard the commercial fishing vessels placed among the vessel catch, unknown to the crew, several tunas tagged with white plastic loop tags. On four separate vessels a total of twelve tagged yellowfin

tuna in all were planted in this manner. One fish was returned during the unloading of the vessel and another two were returned by cannery employees. The remaining nine tags were never found. At that time about three-quarters of our regular tag returns were coming from the vessels and the remaining one-quarter from the cannery operations. Excluding the one return from a portion of the vessel operation (unloading), the ratio of returns from the cannery to those lost suggests that about one half of the tagged tunas caught at that time were being lost during the normal course of handling and processing the fish. Some additional evidence of these losses was obtained by sifting the metal refuse from magnets in the meal line at a San Diego cannery. Two of the stainless steel clamps (slightly magnetic), used at that time to clamp the vinyl tag, were found in the refuse from several weeks canning operations. Because of the extreme inefficiency of the magnets in picking up these clips this examination of refuse was not continued.

To test the visibility of white, clear and yellow plastic loop tags, white and clear were used in alternate batches on three cruises during 1956, and white and yellow loop tags were used in 1957 during two trips from San Diego and several trips from Paita, Peru. The recoveries (to November, 1, 1958) from these experiments are given in Table 3.

TABLE 3

THE NUMBER OF RELEASES AND RECOVERIES (TO NOVEMBER 1, 1958) OF YELLOWFIN AND SKIPJACK FROM SEVERAL TAGGING EXPERIMENTS USING WHITE, CLEAR AND YELLOW PLASTIC LOOP TAGS.

	White		*Clear*		*Yellow*	
	Tagged	*Recov.*	*Tagged*	*Recov.*	*Tagged*	*Recov.*
Experiment #1.	1086	30	1062	23		
Experiment #2.	2405	50			2429	87

The testing of clear and white was abandoned when it became evident from the early recoveries that the clear vinyl tubing was not an improvement over the white. The yellow, however, showed immediate promise of improved tag return rates and a chi-square test of the returns shown in Table 3 indicated that there is a significant difference in the returns of yellow compared with the white plastic loops. Scientists at the California State Fisheries Laboratory tested red, blue and white (Personal communication) with no apparent improvement in tag return rates.

An Incentive Program for Obtaining Tag Returns

In addition to the recaptured tagged fish that pass undetected through the cannery operations, there was also the possibility that some of the detected recaptured tagged fish were not being reported due to a lack of interest or knowledge of our program. Since March 1957 we have been offering a reward of $1.00 per tag return and one chance at winning $300.00 at an annual drawing of one lucky tag number from those turned in during the calendar year. The tagging program was given wide publicity by means of English and Spanish posters placed in strategic waterfront locations in the tuna fishing ports of the United States, Mexico, Central America, South America and Puerto Rico. Results are

difficult to assess but we do feel that tag returns, especially from Latin American areas, have increased since the initiation of this reward program.

CONCLUSIONS

The returns of tagged fish from many of these experiments, especially those during 1957, are yet incomplete, and estimates of mortality rates, tag dispersion and the geographical distribution of sub-populations in the fishery are not yet possible. It can be said, however, that,

1. Improvements in the original plastic loop tag for tunas, in handling techniques and the establishment of a reward program have resulted in considerable increases in the rates of tag return for both yellowfin and skipjack tunas.
2. The results of the testing of the plastic dart tag are still inconclusive but it appears that the tag visibility is poor in the American fishery and may result in high losses of recovered but undetected tagged fish.

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Accumulation of Radioactive Materials by Fishery Organisms

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WE ARE NOW LIVING in a period in which there is tremendous expansion in the use of atomic energy. There is great interest in possible hazards to man of the radioactivity associated with the release of the energy of the atom. Of considerable concern is the contamination of man's environment with radioactive materials. Such materials added to the atmosphere, soil, and natural waters may be taken in by man and levels of radioactivity may be built up in the body sufficient to be damaging. In marine environments radioactive contaminants may accumulate in seafood organisms and affect their utilization or availability.

In discussing radioactive materials we need to consider that these materials are radioactive isotopes of chemical elements. In most cases the atoms that compose a chemical element differ in mass and those of like mass members, the isotopes, are present in definite ratios. For instance carbon, wherever it is found in nature, is composed almost 99 per cent of carbon atoms of mass