DETERIORATION OF FLOY FD-67 INTERNAL ANCHOR TAGS[a]

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Abstract: Yellow Floy FD-67 internal anchor tags were utilized in an experimental and field study of tag discoloration, tag legibility and fouling organisms. Most tags exhibited some degree of discoloration over time. The rate and extent of discoloration varied between two batches of tags purchased in different years. The legibility of a tag was not affected to a great extent by the degree of discoloration. Legends of some completely discolored tags were still readable. Fouling organisms eroded the vinylite covering and deteriorated the legends of some tags. Bryozoans, barnacles and tunicates were the most commonly encountered fouling organisms. Barnacles were the most erosive of these organisms. Other causes of tag discoloration were believed to be chemical reactions between the vinylite covering and environmental factors such as salt concentration.

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Tagging has become a very useful technique in studies of the biology and management of fish populations. Over the last 100 years, many types of tags have been developed for marking fish (Rounsefell and Kask 1945; Calhoun 1953; Wilson 1953; Tebo 1957; Vladykov 1957; Davis 1959; Eschmeyer 1959; and Chadwick 1962). However, the successful use of several of these tags has been questionable because of the small percentages of returns reported in some tagging programs. Tags must possess several qualities if valid results are to be obtained: (1) the tag must not affect mortality; (2) the tag must not affect the fish's vulnerability to fishing gear; (3) the tag must not be shed; and (4) the tag must be easily recognized by capturers (Chadwick 1962).

As new tags were developed and utilized, more experimental research was needed on the deterioration of the plastics and metals used in tags. Calhoun et al. (1951), Collyer (1954), Davis (1959), Chadwick (1962), T. Duncan (1972, U.S. Fish & Wildlife Service, personal communication), and other biologists have observed the discoloration of plastic tags over time. Chadwick (1962) found most dart and spaghetti tags became illegible within 2 years, yet he contended that darkening of tags in itself did not make them illegible. Davis (1959) maintained that streamer tags were more legible and less subject to physical and chemical changes than either hard or soft spaghetti tags. Returned Floy FD-67 internal anchor tags were evaluated by T. Duncan for color retention, ink retention, flexibility of tag, and stain resistance. He found that yellow tags (most widely used of the plastic tags) were less stain resistant than blue and red tags. However, Duncan maintained that yellow was the best color for a tag, because yellow tags were easier to read when tagging at night and were more recognizable by fishermen.

Davis (1959) and Chadwick (1962) briefly described the organisms that were occasionally found attached to returned tags. Chadwick asserted that spaghetti tags rapidly became covered with heavy algal growths after a period of 12-18 months at large, and that fading resulted from the algae since writing lasted considerably longer on portions of the tag in the flesh of the fish.

In a striped bass tagging project of the Virginia Institute of Marine Science (VIMS), researchers observed that cartridges of both newly purchased tags and returned tags (yellow Floy FD-67 internal anchor tags) were turning black (Fig. 1). In some cases tag numbers and/or the VIMS address on returned tags were partially or completely illegible.

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Also, it was apparent that fouling organisms were eroding the outer vinylite covering and, at times, the legend itself. We presented these problems to Floy Tag and Manufacturing, Inc., but they had no suggestions. In 1973 VIMS initiated an experimental tag discoloration and fouling growth study to observe the extent and causes of tag discoloration and to identify fouling organisms encountered on tags. In addition, 2 samples of 150 returned Floy FD-67 internal anchor tags from the VIMS striped bass tagging project were examined for degree of discoloration.

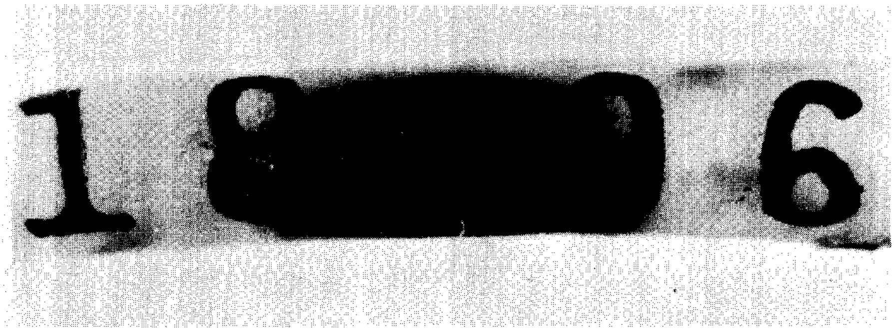

Fig. 1. Discoloration on Floy FD-67 internal anchor tags from the experimental study.

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MATERIALS AND METHODS

A 127 cm x 102 cm rectangular frame of 1.3 cm galvanized pipe was constructed to hold 200 FD-67 internal anchor tags vertically in the water column (Fig. 2). Four galvanized pipes were welded to the corners of the frame to insure that tags were never in direct contact with the bottom sediment and fauna.

After characterizing their initial condition, 100 new 3.2 cm (long shank) tags and 100 new 2.0 cm (short tank) tags[a] were inserted (approximately 3.2 cm apart) into polypropylene lines attached lengthwise across the frame. These 200 tags were originally placed in approximately 2.4 m of water on 17 January 1973, near the VIMS Pier on the York River, Virginia. Salinity ranged from 11.6-21.2 ppt during the test.

Between February and July, 4 tags (2 long shank and 2 short shank) were removed approximately every 2 weeks from the frame. During August and September, 4 tags were removed monthly. These 60 tags constituted Sample A in the data analysis. The frame (along with 140 tags) was recovered 9 months later. These 140 tags constituted Sample B.

In 1977, all 200 tags of the experimental study were analyzed for fouling organisms, discoloration and legibility. In addition, 150 tags (long shank) from the 1968 Rappahannock Rivers returns of the VIMS tagging project were examined for discoloration.

All tags from the experimental study were examined first for a tentative identification of fouling organisms, then for the extent of the growths' coverage. Subsamples of each general type of growth were identified to the lowest taxonomic level possible. Tags were then cleaned and analyzed for the degree of discoloration and legibility.

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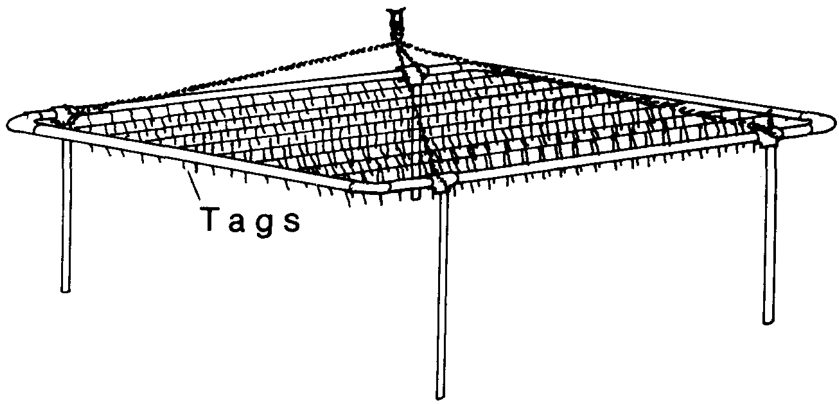
[a]Floy FD-67 Series D Internal Anchor Tag No. 20, Floy Tag and Manufacturing, Inc. Use of this trade name does not constitute endorsement of the product.

Fig. 2. Galvanized pipe frame and suspended tags used in experimental study.



Data were compiled for absolute and relative frequencies of discoloration, legibility and major types of fouling organisms. The Statistical Package for the Social Sciences (SPSS) was used to calculate chi-square statistics for the statistical independence or dependence of several variables including discoloration, legibility, return month, days out, and bryozoan, barnacle and tunicate growths.

RESULTS

Discoloration.

Preliminary examination of the 200 tags utilized in the experimental study revealed that all long shank tags purchased in 1968 were in excellent condition and that most short shank tags purchased in 1972 were slightly discolored. This discoloration was believed due to the type of glue used on the upper portion of the tags.

In a statistical analysis of all 200 tags, a chi-square of 39.7 (2 df, $p = .0001$) was obtained for a cross-tabulation of the 2 types of shank by legibility. The relationship between the 2 types of shank and their degree of discoloration was not statistically significant. This was probably due to the initial and earlier occurrences of minor and spotted discolorations of short shank tags. The chi-square for the relationship between discoloration and legibility was insignificant, thus, in agreement with Chadwick's statement that discoloration does not necessitate illegibility. The relative frequencies of the degrees of discoloration reflected the periodic sampling from the frame between months 1 and 9 in Sample A and long term exposure in Sample B (Tables 1 and 2). The periodic sampling in Sample A and the long term exposure in Sample B were not distinct for the relative frequencies of legibility.

A chi-square of 30.7 (2 df, $p = .0001$) was obtained in a cross-tabulation of discoloration and legibility of Sample A tags. This relationship imples that there was a decrease in legibility with an increase in discoloration. Also, the chi-square statistics for discoloration over time (return month) were very significant for long and short shank tags ($p = .0001$ and $p = .0007$, respectively). Discoloration appeared to increase over time (Fig. 3); however, there was some apparent stain resistance in long shank tags, since no degree of discoloration was observed until month 5.

After 17 months in the water, 5% of Sample B tags were completely black, while 3% were illegible in portions of the tag that were critical to their recognition and return. Partially illegible short shank tags outnumbered partially illegible long shank tags (40 tags to 4 tags) ($\chi^2 = 46.2$, df $= 2$, $p = .0001$).

Table 1. Relative frequencies of discoloration among experimental and returned tags.

Discoloration	*Sample A*	*Sample B*	*1968 Returns*	*1973 Returns*
None	53.3	---	65.3	59.2
Minor	5.0	---	27.3	29.9
Spotted	35.0	23.6	7.3	5.4
Major	6.7	71.4	---	4.8
Complete	---	5.0	---	0.7
Number of tags Examined	60	140	150	147

Table 2. Relative frequencies of legibility among experimental and returned tags.

Legibility	*Sample A*	*Sample B*	*1968 Returns*	*1973 Returns*
Legible	78.3	65.7	99.3	95.9
Partially illegible	20.0	31.4	0.7	4.1
Illegible	1.7	2.9	---	---
Number of tags	60		150	147

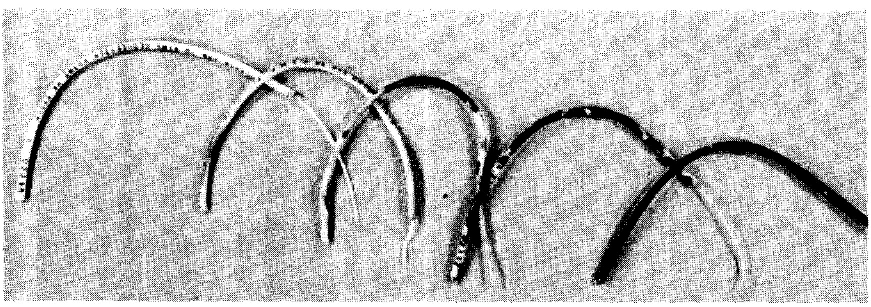


Fig. 3. Floy FD-67 tags exhibiting increasing degrees of discoloration over time (from left to right; none, minor, spotted, major, and complete discolorations).

Both the 1968 and 1973 returns were possibly biased because data were available only for legible and partially illegible returned tags (Table 2). In an analysis of the 1968 returns (150 long shank tags), tags of only minor and spotted discoloration were encountered because 80% of the tags were returned during the year of release. Similar degrees of discoloration were apparent even on tags which were returned after 0-30 days at large. Thus, we found no signficant relationship for discoloration over time (days out) using 1968 tags. On the other hand, a chi-square of 124.2 (36 df, $p = .0001$) was obtained for the cross-tabulation of discoloration by days out of the 1973 returns (147 short shank tags) (Table 3). Again, the general trend appeared to be an increase in discoloration with an increase in the total number of days out. In extreme examples, a tag returned after 3 years exhibited minor discoloration, and a tag returned during the year of release exhibited complete discoloration.

Growths.

After a preliminary examination of the fouling organisms encountered on the 200 experimental tags, 6 major invertebrate categories (bryozoan, tunicate, barnacle, anemone, mollusk and unidentifiable) were established. Relative frequencies of the invertebrate species encountered are presented in Table 4. Bryozoans were the most common fouling organisms followed by barnacles, tunicates, unidentifiable organisms, anemones, and mollusks. Combinations of bryozoan and barnacle growths were common (Fig. 4). All fouling organisms were most abundant during the summer months. Anemones, mollusks, and unidentifiable organisms proved to be insignificant in any further statistical analysis and therefore, were not included in the following discussion.

Table 3. Relative frequencies of tag discoloration by days out of the 1973 tag returns.

	Days Out										
Discoloration	0-30	31-59	60-90	91-121	122-152	153-183	184-215	216-245	246-276	277-1300	Total
None	23.8	15.0	7.5	5.4	1.4	1.4	1.4	1.4	---	2.0	59.2
Minor	5.4	8.8	6.1	3.4	0.7	1.4	---	0.7	---	3.4	29.9
Spotted	---	---	---	---	---	2.0	1.4	0.7	---	1.4	5.4
Major	---	---	----	---	0.7	0.7	---	1.4	0.7	1.4	4.8
Complete	---	---	---	---	---	---	0.7	---	---	---	0.7
Total	29.3	23.8	13.6	8.8	2.7	5.4	3.4	4.1	0.7	8.2	100.0

The bryozoan *Electra crustulenta* is the most abundant bryozoan in the shallow waters of the Chesapeake Bay, and is considered to be a serious oyster competitior in Virginia (Wass 1972). Minor growths of bryozoans were apparent on tags recovered during month 1. When scattered, major or complete bryozoan growths were present, tags displayed degrees of spotted and major discoloration (Sample A, $X\Theta = 55.1$, df = 12, $p = .0001$). This was also true for Sample B tags. All tags in Sample B exhibited some degree of discoloration. Chi-square statistics for bryozoan coverage and tag legibility were not significant for Samples A and B.

The barnacle *Balanus improvisus* is one of the common barnacles found in the shallow waters of the Chesapeake Bay. Barnacles secrete an adhesive cement which may chemically react with the vinylite on the tags. Barnacles were found to be singly the most erosive of all fouling organisms (Figs. 5 and 6). Shrinkage and wrinkling on portions of a tag were apparently caused by scattered growths of bryozoans and barnacles. Barnacles were not abundant on tags of Sample A; however, most tags of Sample B with major discoloration (71.4%) were covered with minor or scattered growths of barnacles (31.4% and 44.3%, respectively).

Table 4. Relative frequencies of fouling organisms encountered on Sample A and B tags.

	Electra crustulenta Bryozoan		*Balanus improvisus* Barnacle		*Perophora viridis* Tunicate	
COVERAGE	*Sample A*	*Sample B*	*Sample A*	*Sample B*	*Sample A*	*Sample B*
None	45.0	---	78.3	19.3	65.0	---
Minor	13.3	22.1	8.3	31.4	5.0	---
Scattered	11.7	53.6	5.0	44.3	11.7	---
Major	25.0	23.6	6.7	5.0	16.7	---
Complete	5.0	0.7	1.7	---	1.7	---
	Diadumene leucolena Anemone		*Amygdalum papyria* Mollusk		Unidentifiable Organisms	
COVERAGE	*Sample A*	*Sample B*	*Sample A*	*Sample B*	*Sample A*	*Sample B*
None	93.3	97.1	---	97.1	75.0	---
Minor	5.0	2.9	---	2.9	25.0	---
Scattered	1.7	---	---	---	---	---
Major	---	---	---	---	---	---
Complete	---	---	---	---	---	---

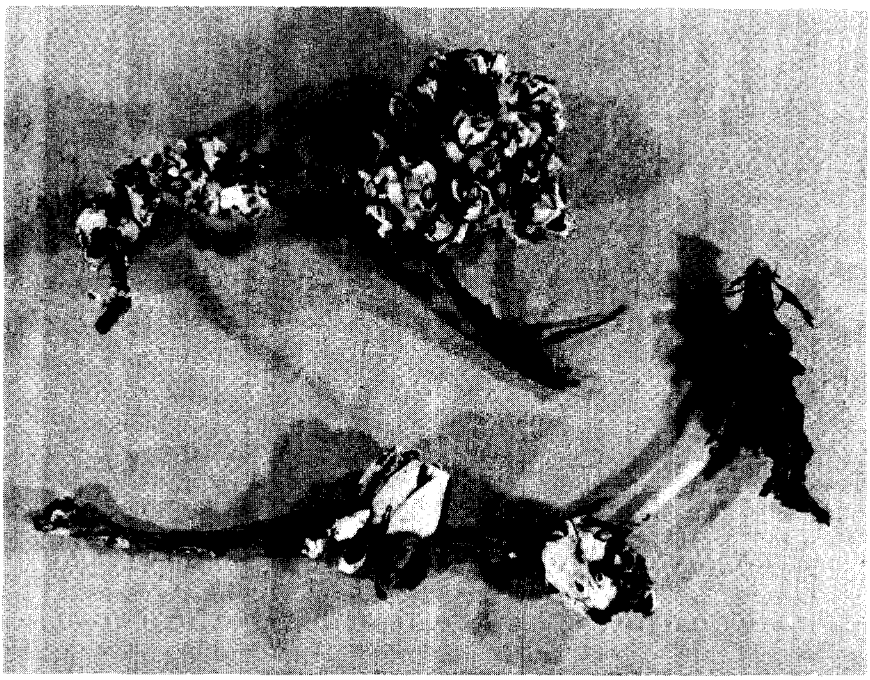


Fig. 4. Bryozoan and barnacle growths on two FD-67 tags which exhibited major discoloration after cleaning.

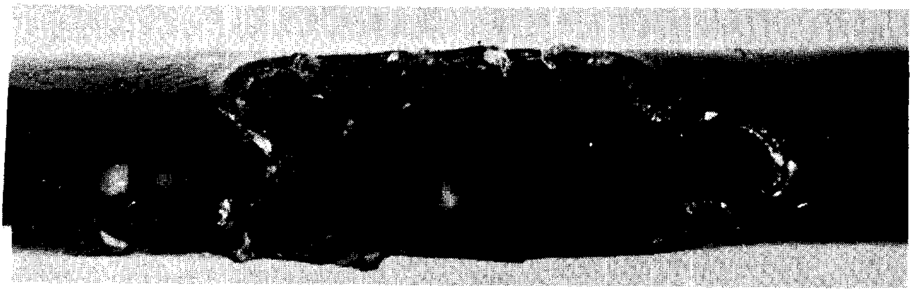


Fig. 5. Erosive effects of barnacle growths on Floy FD-67 tags from the experimental study.

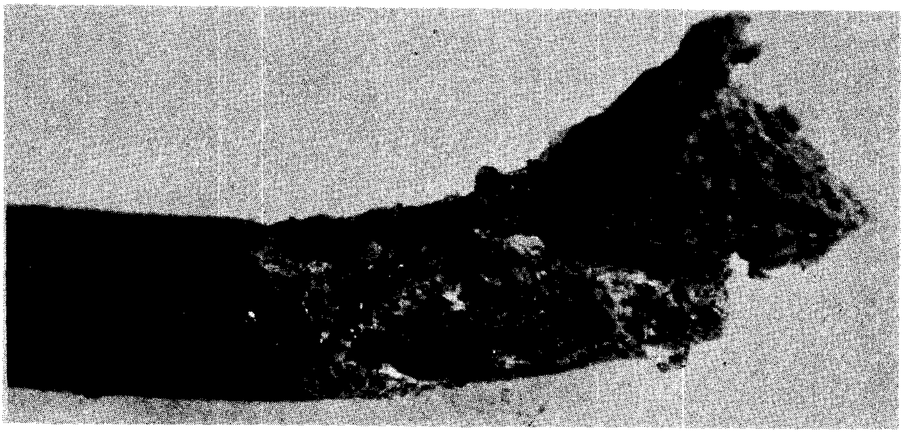


Fig. 6. Erosive effects of barnacle growths on Floy FD-67 tags from the experimental study.

The tunicate *Perophora viridis* was not a major cause of tag discoloration. In Sample A, most tags with tunicate growths exhibited only spotted discoloration ($X\Theta = 60.7$, df = 12, p = .0001). Tunicates grew as basal stolons on the tags and were only present during the summer and fall of 1973.

DISCUSSION

In general, the legibility of a tag was not affected to a great extent by the degree of discoloration. Eighty-four percent of the 200 experimental tags displayed some degree of discoloration; only 28% were partially illegible, with 2.5% completely illegible. Since the actual percentage of tags returned in most tagging programs is low (approximately 10-20%) valuable data may be lost because of illegible tags.

An increase in discoloration over time was noted in both long and short shank tags. Short shank tags showed a greater tendency to fade, whereas long shank tags showed a greater stain resistance. In Sample A, minor discolorations were apparent during month 1 on short shank tags, whereas spotted discolorations were not apparent until month 5 on long shank tags. Furthermore, in Sample A partially illegible short shank tags were encountered during month 1, but partially illegible long shank tags were not encountered until month 6. In Sample B, partially illegible short shank tags occurred more frequently than partially illegible long shank tags. Thus, there was a difference in the quality of the 2 batches of tags which were purchased in different years. Therefore, a tagging program utilizing tags of different stocks may be biased since the tags may not have an equal chance of being returned.

Chi-square statistics for discoloration by days out were significant for the 173 tag returns; however, the relationship between legibility and days out was insignificant for 1968 and 1973 tag returns. This was probably because data were not available for tags that were not returned, and illegible tags that were returned.

Growths of bryozoans, barnacles, and tunicates were directly responsible for the deterioration of tags in some cases; however, the cumulative effect of several types of growths appeared to be more destructive. Combinations of bryozoan and barnacle growths were apparent on many of the illegible tags. Also, the season of the year was an important factor in the abundance of fouling organisms, and therefore an important factor in tag discoloration and legibility. Fish should be tagged, if possible, during the fall, winter, or spring periods of low fouling potential.

Some tags without growths were discolored in varying degrees; thus, the presence or absence of fouling organisms may be a secondary cause of discoloration of plastic tags. Other causes of discoloration were probably chemical reactions betwen the vinylite in the tag and environmental factors such as salt concentration.

If plastic fish tags are to be utilized more extensively in the aquatic environment, more research is needed on the chemical nature of the plastics and their reaction to environmental factors. Evaluation of non-returns due to illegibility must be made to meet the criterion of uniform catch of tagged and untagged fish. We have shown potential bias in the range of 2-3% for totally illegible tags or up to 32% if a partial illegible tag resulted in non-return. The effects of these biases upon population estimates and measured rates of exploitation would be quite large. It would be prudent for all investigators to test their tags for illegibility and discoloration potential and adjust calculations on returns accordingly.

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