Gulf Research Reports, Vol. 5, No. 1, 1–5, 1975

A COMPARISON OF PETERSEN TAGS AND BIOLOGICAL STAINS USED WITH INTERNAL TAGS AS MARKS FOR SHRIMP[1]

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ABSTRACT During May 20–31, 1968, 14,301 brown shrimp (*Penaeus aztecus*) were marked and released in Biloxi Bay, Mississippi. Of these 7,023 were marked by injection with a combination of Niagara Sky Blue 6B stain and polyvinyl chloride (PVC) internal tags and 7,278 were marked with Petersen tags. The objectives of this experiment were to compare the two methods as marks for shrimp and to obtain information on growth rates and migrations. Eighteen weeks after release, 1,942 (28%) of those marked with the biological stain–internal tag combination and 2,286 (31%) of those marked with Petersen tags had been recovered. The difference in proportions recaptured (significant at $P < 0.01$) could have resulted from greater ease in recognition of the Petersen tag by commercial fishermen or from differential marking mortality, although no evidence was found that differential marking mortality occurred. Marking mortality was observed for both marks and appeared inversely related to size at time of marking. No significant differences were found between growth rates of shrimp marked with the biological stain–internal tag combination and those of shrimp marked with the Petersen tag, although most weekly average increments for stained shrimp were higher. Rates of return were similar in the vicinity of the release area, although a significantly higher proportion ($P < 0.01$) of returns from waters outside of Biloxi Bay were marked with Petersen tags. Again, this was attributed primarily to greater ease in recognition by commercial fishermen. It was concluded that the Petersen tag was the more effective of the two marks as it appeared to be recognized more readily over longer periods of time than the biological stain.

INTRODUCTION

Development of yield models for penaeid shrimp fisheries of the Gulf of Mexico requires reliable estimates of rates of growth and mortality. Mark–recapture studies are useful in obtaining such information, and several have been conducted on penaeid shrimp in the Gulf of Mexico; a review of the marks and marking procedures used is to be found in Neal (1969).

The Petersen tag was used in such studies from 1935 through 1947 by Lindner and Anderson (1956), and later by McRae (1952), Iversen and Idyll (1960), Iversen and Jones (1961), Iversen (1962) and Klima (1964). In these studies, marking mortality in smaller shrimp was often higher than in larger shrimp; Iversen and Jones (1961) also noted that swimming was impaired. These problems led to experiments to devise more suitable marks, and as early as 1955 Menzel (1955) successfully marked white shrimp (*Penaeus setiferus*) by injection with a solution of Fast Green[2] biological stain. Dawson (1957) experimented with several biological stains and found that injected solutions of Fast Green FCF (National Aniline), Niagara Sky Blue 6B, Trypan Red, and Trypan Blue provided marks which lasted over 100 days. Subsequent field and laboratory tests (Costello 1959; Costello and Allen 1962) verified the effectiveness of biological stains as marks for shrimp, and the stain-injection method was later used in a series of mark–recapture experiments in the Gulf area (Klima 1964; Allen and Costello 1966; Knight and Berry 1967; Klima 1974).

Utility of the stain-injection technique was limited because only groups of shrimp and not individuals could be identified. This led to use of fluorescent pigments (Klima 1965) to identify different classes and small PVC internal tags (Neal 1969) to identify individuals. These tags could be inserted into the musculature directly under the exoskeleton, whereas the pins holding the Petersen tags had to be thrust completely through the abdomen. Therefore, the stain–internal tag combination showed promise in reducing the trauma of marking and in avoiding impairment of swimming and burrowing that might be expected from use of the Petersen tags.

The objectives of this study were (1) to compare recapture rates of shrimp marked with the biological stain–internal tag combination and with Petersen tags, and (2) to obtain information on growth rates and migrations.

MATERIALS AND METHODS

The study was conducted in Biloxi Bay, Mississippi (Figure 1), which supports an intensive bait shrimp fishery and also contributes to the food shrimp fishery in Mississippi Sound and adjacent offshore waters. A portion of the Bay is closed to shrimping (Figure 1); the remainder is subjected to heavy fishing pressure.

To obtain cooperation of local fishermen, news releases were published and posters were distributed. These described the types of marks used and offered a reward for the return of marked shrimp together with the date and location of capture. Returns were handled by National Marine Fisheries Service personnel in cooperation with shrimp dealers who

[1] Contribution No. 386, National Marine Fisheries Service Gulf Coastal Fisheries Center, Galveston Laboratory, Galveston, Texas 77550.

[2] The use of trade names in this publication does not imply endorsement of commercial products.

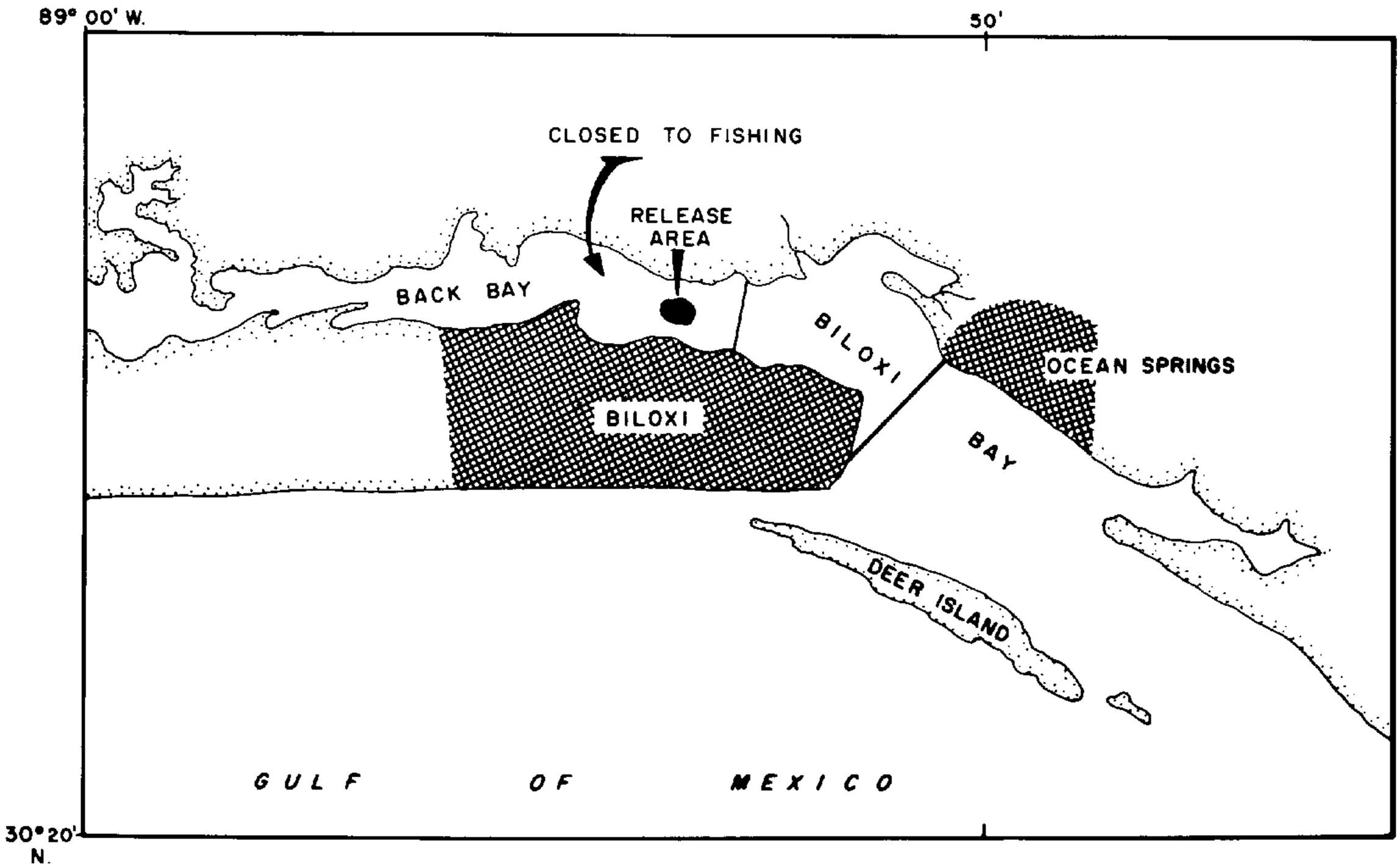

Figure 1. Biloxi Bay, Mississippi and location of the release area.

were provided fixative to preserve marked shrimp and forms for recording data.

Brown shrimp (*Penaeus aztecus*) to be marked were caught in the Bay with a 4.6-m otter trawl and were held in a closed recirculating system of the type described by Emiliani (1971). These shrimp were divided into two groups; the first group was marked with Niagara Sky Blue 6B stain and internal tags, while the second group was marked with Petersen tags. Each shrimp marked with the former combination was injected first with 0.12 ml of a 0.125-percent solution of Niagara Sky Blue 6B stain in distilled water (Neal 1969); a numbered PVC tag approximately 5 mm long, 2 mm wide and 0.25 mm thick was then dipped in a 10% mixture of the antibiotic Aureomycin in white petroleum jelly (Benton, personal communication) and inserted with forceps into the abdominal musculature behind the carapace. The combination was used to mark 7,023 shrimp.

A modified Petersen tag (Benton, personal communication) was used to mark the second group of 7,278 shrimp. The tag consisted of two green PVC disks (one numbered and coded and one blank) approximately 6 mm in diameter and 0.5 mm thick attached to the shrimp with a stainless steel pin. In tagging, the numbered disk was placed on the pin, then the pin was dipped in the antibiotic mixture and inserted through the articular membrane between the first and second abdominal segments. The blank disk was slipped onto the protruding end of the pin, which was cut and crimped to secure the tag. A 6-mm excess length of pin was left to accommodate growth.

After each shrimp was marked, its total length (tip of rostrum to tip of telson) was measured to the nearest mm. Groups of marked shrimp then were released below the surface through a release tube described by Emiliani (1971). Because all marked shrimp were released within the area closed to fishing (Figure 1), they initially received some protection. As they moved out through the bay and into adjacent offshore areas, however, they were subjected to heavy fishing pressure.

RESULTS AND DISCUSSION

A total of 1,942 (28%) shrimp marked with Niagara Sky Blue 6B stain and internal tags and 2,286 (31%) shrimp marked with the Petersen tags were recovered. The difference between these proportions was significant (chi-square = 24.1 with 1 degree of freedom, $P < 0.01$). Recapture rates for both marked populations were high initially but declined rapidly as the experiment progressed (Figure 2). We attributed this pattern to migration and to the distribution of fishing effort. The shrimp were marked as large juveniles immediately prior to offshore migration and had to pass through a heavily fished channel where the opportunity for capture was much higher than in adjacent offshore waters. Thus, the bulk of the recoveries were made within a relatively

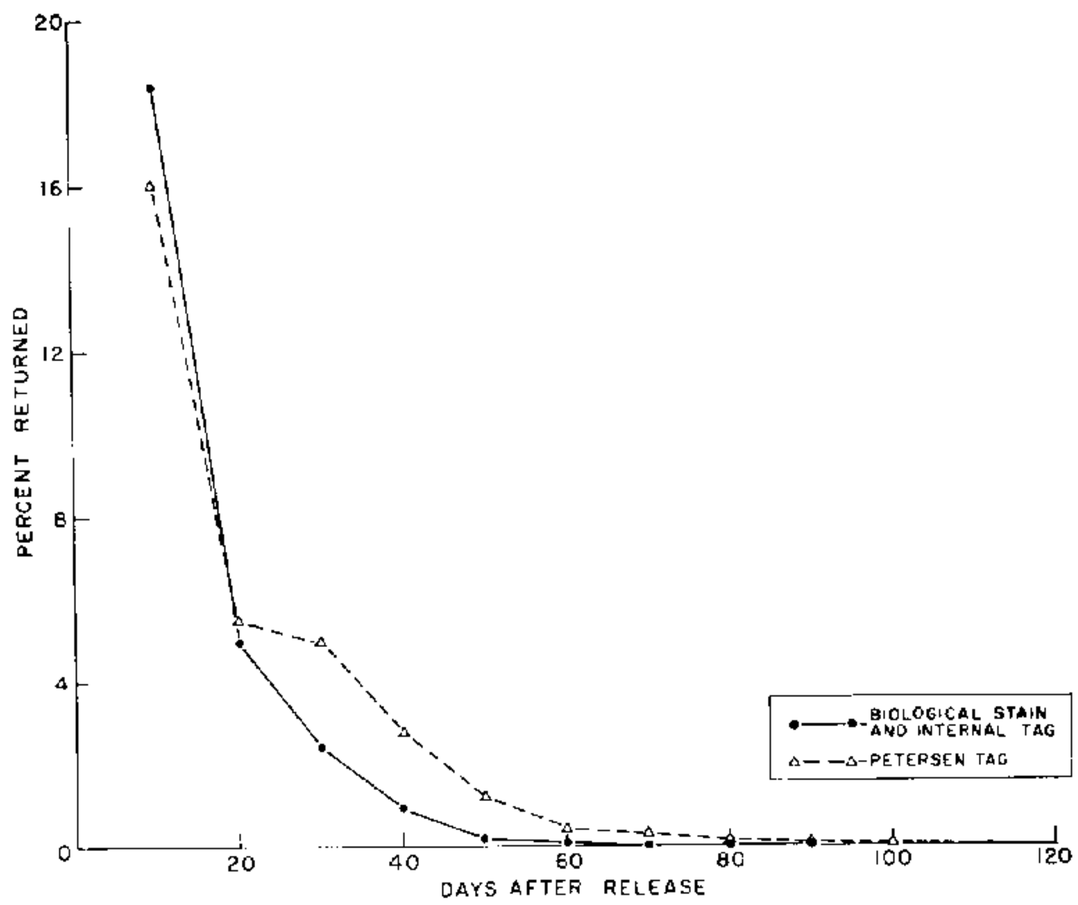

Figure 2. Relationship between percent returns and time for brown shrimp marked with Niagara Sky Blue 6B stain and internal tags and brown shrimp marked with Petersen tags, Biloxi bay and vicinity, 1968 (plotted points represent percentages recaptured during the preceding 10-day time interval).

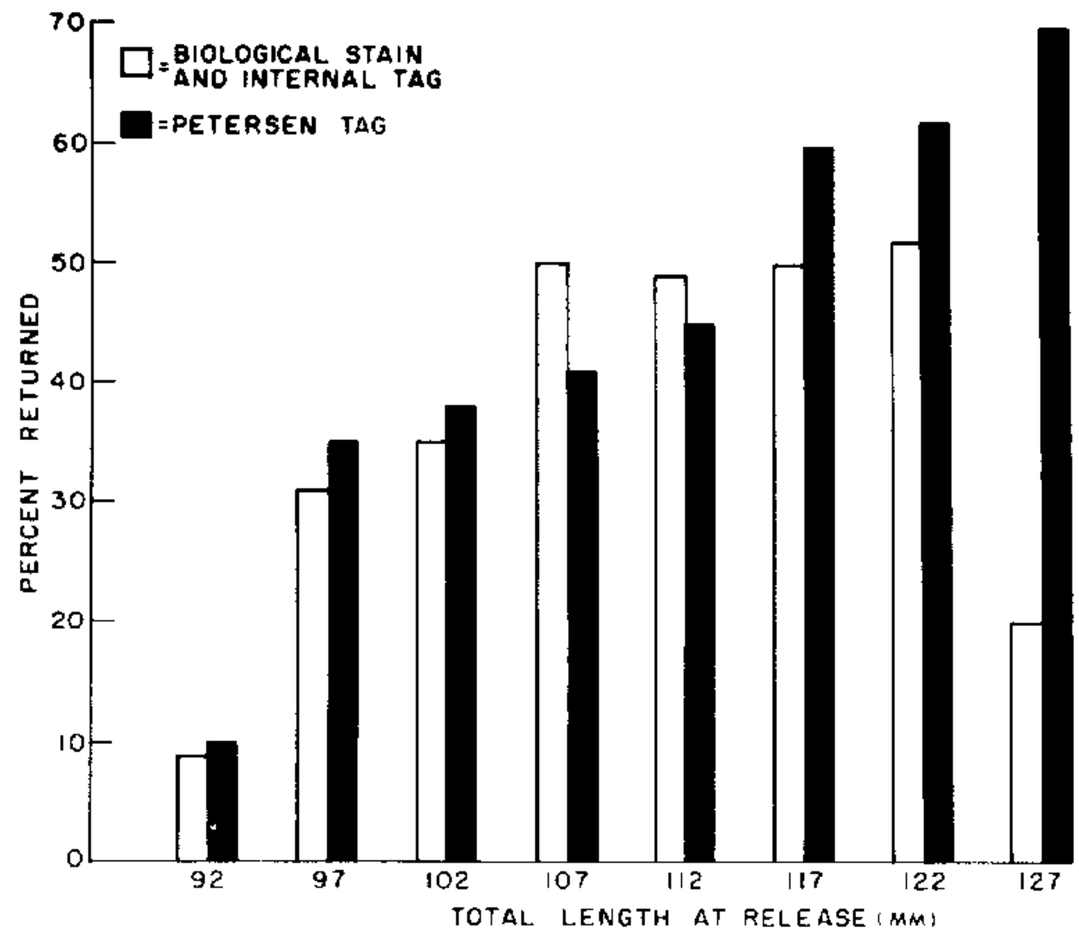

Figure 3. Relationship between percentage recaptured and size at release of brown shrimp, Biloxi Bay, Mississippi, 1968 (each length presents the midpoint of the corresponding 5-mm total length group).

short time. Percentage returns were consistently higher for the Petersen tag after the first 20 days of the experiment (Figure 2).

The reasons for the observed difference in the proportions returned are uncertain, but we judged two factors to be of importance. First, marking mortality would be expected from either procedure, and accordingly we felt that differential marking mortality could have biased return rates. To evaluate this possibility, we plotted percent returns for each mark type by 5-mm size class (at time of release). No consistent trends were observed (Figure 3). Thus, there is no evidence that differential marking mortality occurred in this study, although marking mortality is evident for both marking methods in the smaller size classes studied. It is also possible that the two marking procedures could have had a differential effect on catch rates although the extent to which this may have occurred is impossible to determine.

Another possible explanation for the higher proportion of Petersen tag returns, and one which appears more tenable, is that this mark would be much more easily recognized than biological stain by commercial fishermen because the stain becomes localized and fades. Immediately after injection with Niagara Sky Blue 6B stain, shrimp retain a distinctive blue color in the abdominal region for a brief period, and if released immediately (as was the case in our study) they can be easily recognized. Within a few days, however, the stain concentrates in the branchiae and is much less easily recognized. Thereafter, this stain remains fast for at least 5 or 6 months (Neal 1969), although it fades to varying degrees depending on volume and concentration administered, growth of the shrimp, and other variables (Emiliani, personal communication). In contrast, the Petersen tag can be recognized with ease regardless of elapsed time. We believe that this factor was primarily responsible for the observed difference in rates of return between the two marking methods.

The possibility for differential effects of the two marking methods on growth and movement remains to be considered. To evaluate the relative influence of the Niagara Sky Blue 6B stain–internal tag combination and the Petersen tag on growth, we again combined recovery data by 5-mm size classes at time of release and calculated mean increments in total length for 10-day time intervals between release and recovery. We then conducted paired t-tests for each 5-mm size class to compare growth rates between the two marked populations. Time intervals were not included unless the number of recoveries for each mark type exceeded ten. Results of these tests are given in Table 1.

TABLE 1.

Results of paired t-test comparisons of mean increment in total length of brown shrimp marked with the Niagara Sky Blue stain and internal tag combination and Petersen tags, Biloxi Bay, Mississippi, May 1968. Recovery data for each mark were sorted by size at time of release and by 10-day intervals between release and recovery; observations consisted of mean increment in millimeters attained in each interval.

Size at Release (Total Length in mm)	Value of t	Degrees of Freedom[1]
090–094	1.30	3
095–099	1.73	3
100–104	1.90	3
105–109	0.09	3
110–114	−8.40	1
115–119	0.38	1

[1]One less than the number of 10-day time intervals used.

None of the observed differences were significant (P >0.05). Thus, no evidence was found that the two methods had a differential effect on growth. It appeared, however, that both procedures had an initial effect on growth; throughout the range of size classes studied, growth rates for both marked populations were considerably lower during the first 10 days after marking than later in the experiment (Figure 4), apparently the result of stress and trauma (Fontaine and Dyjak 1973; Fontaine and Lightner 1973). Growth rates for both populations were quite similar during the first 10 days, but as the experiment progressed, shrimp marked with the stain–internal tag combination grew faster than did shrimp marked with the Petersen tag (Figure 4). This suggests that growth rates determined from returns of shrimp marked by the former procedure may be more accurate.

We evaluated the relative effects of the two marking procedures on local migrations by referencing recoveries to a prearranged grid system (Figure 5). We then compared proportions of each marked population recaptured in the immediate vicinity of the release area and in the surrounding

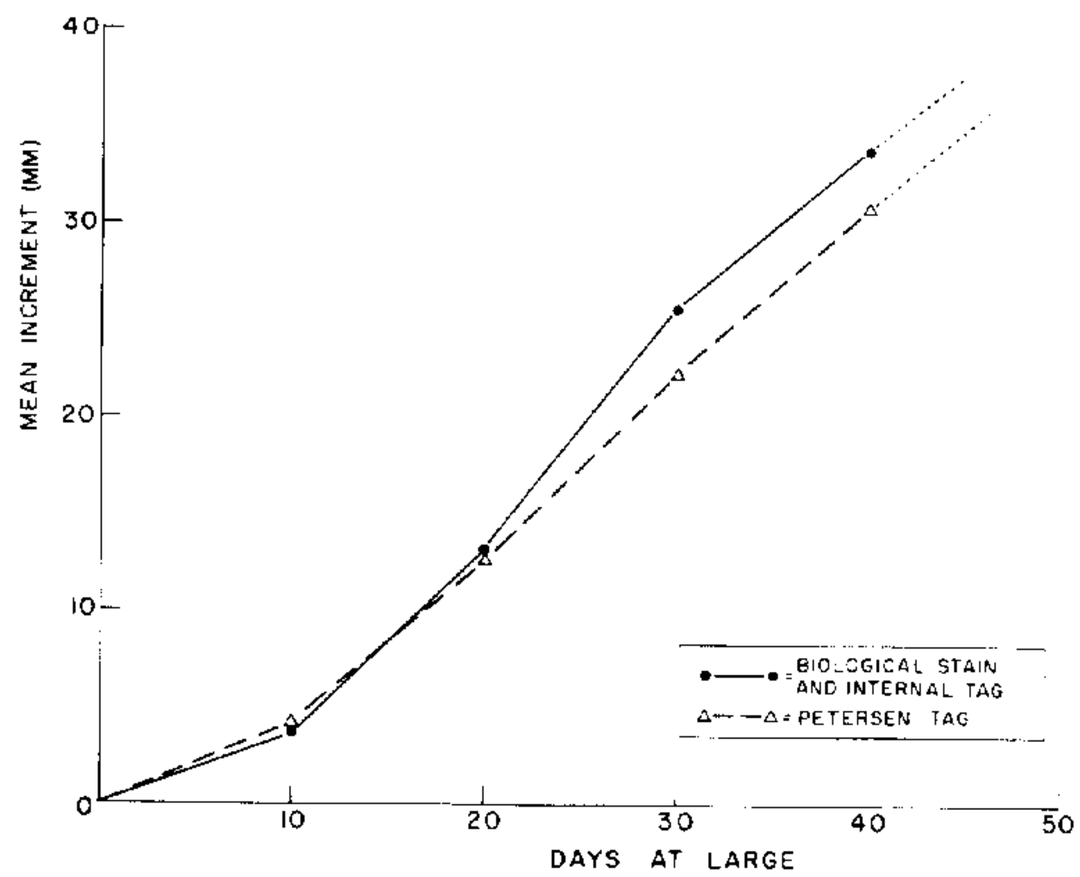

Figure 4. Growth of brown shrimp (size classes combined) marked with Niagara Sky Blue 6B stain and internal tags and Petersen tags, Biloxi Bay, Mississippi.

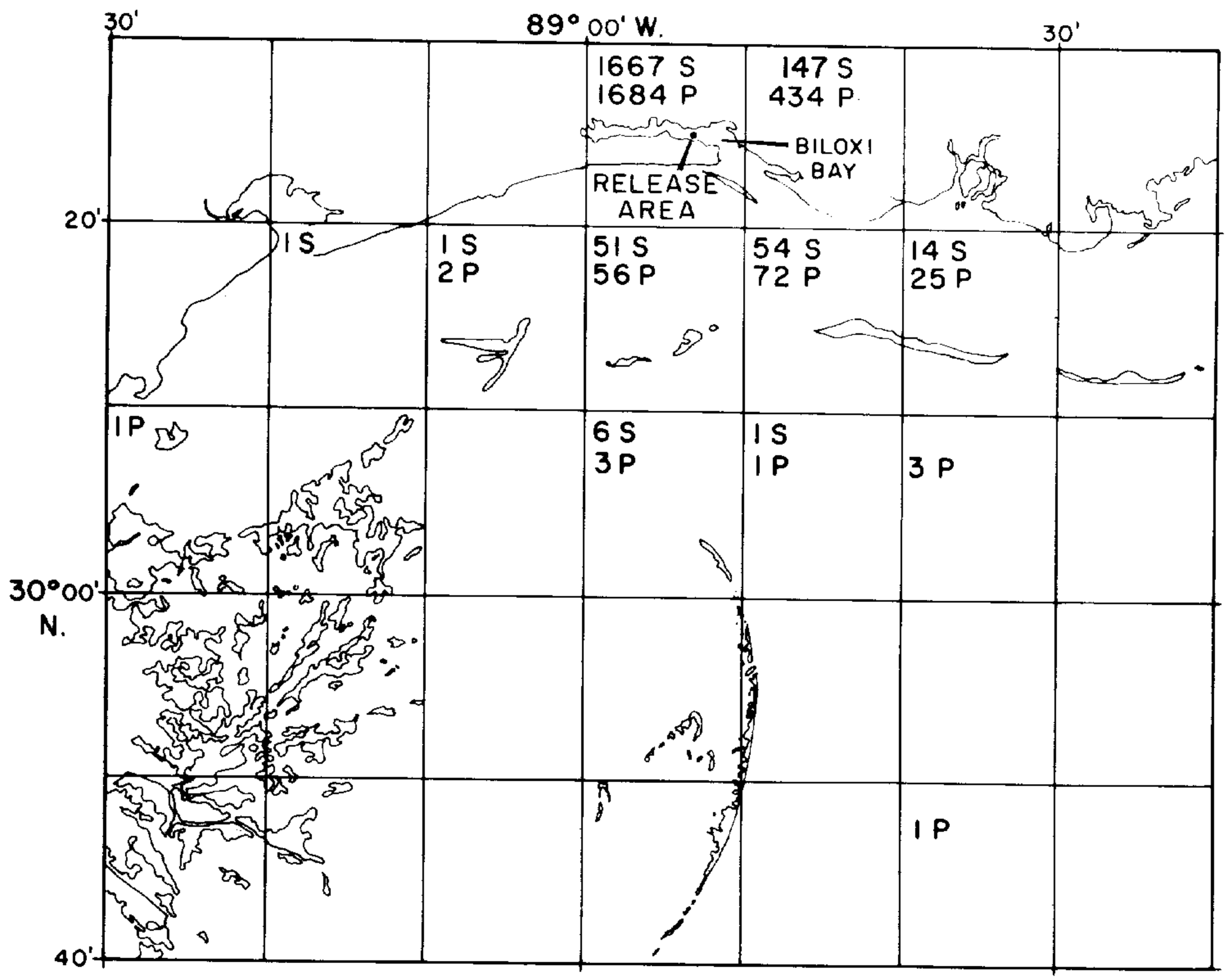

Figure 5. Distribution of brown shrimp recoveries by area, Biloxi Bay and vicinity, 1968. "S" refers to stain–internal tag combination; "P" refers to Petersen tag. (Note that area of recovery was not reported for four Petersen tag returns.)

areas. No significant differences in recovery rates between the two marking methods were found near the release area (chi-square = 0.41 with 1 degree of freedom, $P > 0.05$), but a significantly greater proportion of shrimp tagged with Petersen tags was recovered in the surrounding area (chi-square = 103.6 with 1 degree of freedom, $P < 0.01$). As the time factor is again involved, however, it appears likely that these results may have been biased by localization and fading of the biological stain. For this reason the relative effect of these methods on migration remains undetermined.

In summary, a greater proportion of Petersen tags was returned in this experiment, apparently because they could be more easily recognized by commercial fishermen. Attempts to compare marking mortality and to determine the relative influence of each method on growth and movement were inconclusive although there was some indication that growth rates after marking were slightly higher for stained shrimp. We conclude that the Petersen tag should be used in preference to the biological stain and internal tag combination in long-term mark-recapture experiments.

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