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VARIATION IN WEIGHT OF CAGE-REARED CHANNEL CATFISH

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AN UNDERSTANDING OF THE CAUSE of variation in growth within populations of channel catfish (*Ictalurus punctatus*) would be valuable in commercial fish farming. If the marked variation in growth is inherited, genetic selection will prove profitable. If the variation is a product of antagonistic behavior related to size difference between fish, then insuring uniformity of size at stocking and subsequently is highly desirable. Conversely, if large fish do not intimidate smaller fish and prevent their feeding, there is less reason to be concerned about uniformity of size at stocking. In fact, stocking fishes of different sizes should insure better utilization of natural food supplies, although too great a difference in size could lead to cannibalism.

In the present work, we examined the contribution of behavior to variations in weight gain, and the relationship between variation in weight at stocking and at harvest.

PROCEDURE

Even though pronounced variation in growth occurs in open pond culture as well as in cage culture, our observations here are limited to caged populations. The use of cages permits greater control over the environment and allows more replications for a given investment.

To investigate possible behavioral effects, the following environmental variables were introduced:

NOTE.—This study was sponsored by NOAA, National Marine Fisheries Service Project 4-51-R, under Public Law 88-309.

1. Variation in depth of water in the cage, i.e., variation in depth of submersion of the cage. Twelve cages, each 1.2 meters in diameter and 1.8 meters deep were used in this aspect of the study. Six cages were set at a depth of 0.6 meters, three at 1.1. meters, and three at 1.5 meters.

2. Escape areas. Twelve cages were also used in this phase of the study. Three of the cages were equipped with 46-cm sections of 10-cm (inside diameter) plastic pipe stacked horizontally in the center of the cage. The fish could move freely into the sections of pipe from either end. Three of the cages were fitted with a removable screen with the objective of forming a sanctuary area for the smaller fish. Three cages contained both the sections of plastic pipe and the screens. The remaining three cages served as controls. Cages representing the four conditions were distributed among four ponds.

In the investigation of the relationship between variation in size at stocking and variation in size at harvest, data from the above populations plus data from additional populations were analyzed. In total, data were used from over 10,000 fish grown a full season in 56 cages.

The fish were individually weighed when they were stocked. After stocking, the fish were fed daily all the feed they would consume in 30 minutes. At the termination of the study all fish were weighed and the weight-frequency distribution of each population was examined to determine if the distribution was normal, skewed, or bimodal. The magnitude of variation was measured on basis of coefficient of variation $(CV = SD/\overline{X})$.

RESULTS

When fish were reared in cages with "rest areas" (sections of 10-cm pipe), underwater observations indicated that at any one time many of the fish occupied the rest areas. However, the coefficient of variation in weight of the fish at harvest was essentially identical to that of the three control cages (table 1). Further, there is no identifiable difference in the two weight-frequency distributions (figs. 1 and 2).

Table 1.—Variation in weight of channel catfish reared in cages with and without escape areas

Conditions	Coefficient of variation
Unmodified cage	0.30
	.30
	.34
Sections of 10-cm pipe in cage	.32
	.34
	.32
Screen divider in cage [1]	.31
	.29
	.37
Both pipe and screen	.33
	.31
	.35

[1] There was not sufficient variation in size of the fish to insure function of screen in separating population.

Screens were used in 6 cages (3 in combination with rest areas and 3 alone), but they did not result in reasonable separation of the fish. The data from these 6 cages do, however, give additional opportunity to evaluate rest areas. It is evident from table 1 that the coefficient of variation was again unaffected by rest areas and that the populations of all 12 cages exhibited similar variation in weight. The weight-frequency distributions of the fish in these populations (fig. 2) indicate no identifiable effects of rest areas.

Although the populations in the cages with less water depth were characterized by a significantly lower coefficient of variability (Friedman two-way analysis of variance by ranks at 0.05 level), the fish exhibited evidence of fighting, suffered higher mortality, and showed poorer feed conversion (table 2). It is also noteworthy that increasing the density of fish in the shallow cages appears to have reduced mortality and damage from fighting, but otherwise the two different shallow water series are similar (table 2). Cage depth does not appear to have affected the normality of the weight-frequency distributions, with the possible exception that four or five exceptionally large fish occurred in at least three of the deeper cages (figs. 3 and 4).

A comparison of the initial and final CV (fig. 5) indicates that, within the limits of variation considered here, the final CV tends toward a typical value of 0.30 to 0.40. Thus, an initial CV value above this level tended to decrease, while initial CV value below this level tended to increase. Figure 6 is an additional analysis of the data given in figure 5. This analysis further suggests that final variation in weight is to a degree independent of initial variation, i.e., within the limits considered here the final variation tends toward a typical value.

Although the weight-frequency distributions (figs. 1 and 2) appear reasonably normal, there is a slight tendency toward skewness to the right. A few exceptionally large individuals occur in a number of the populations.

The reduction in CV values that was observed in some populations did not appear to be a result of selective mortality. Thus it is more important to note, relative to the caged populations represented in figures 5 and 6, that among the 16 populations exhibiting a reduction in relative variation, only six had mortality

Table 2.—Variation in weight at harvest, mortality, and food conversion of channel catfish in cages with varying depth of water

Series [1]	Water depth (m)	Fish per cubic meter	Average CV	Mortality (percent)	Fighting injury (percent) [2]	Food conversion
1	0.6	150	0.22	8.3	13.1	2.3
2	.6	250	.23	6.6	5.6	2.0
3	1.1	150	.31	2.0	.0	1.5
4	1.5	150	.36	1.3	.0	1.6

[1] Each series three cages.
[2] Percent of surviving fish.

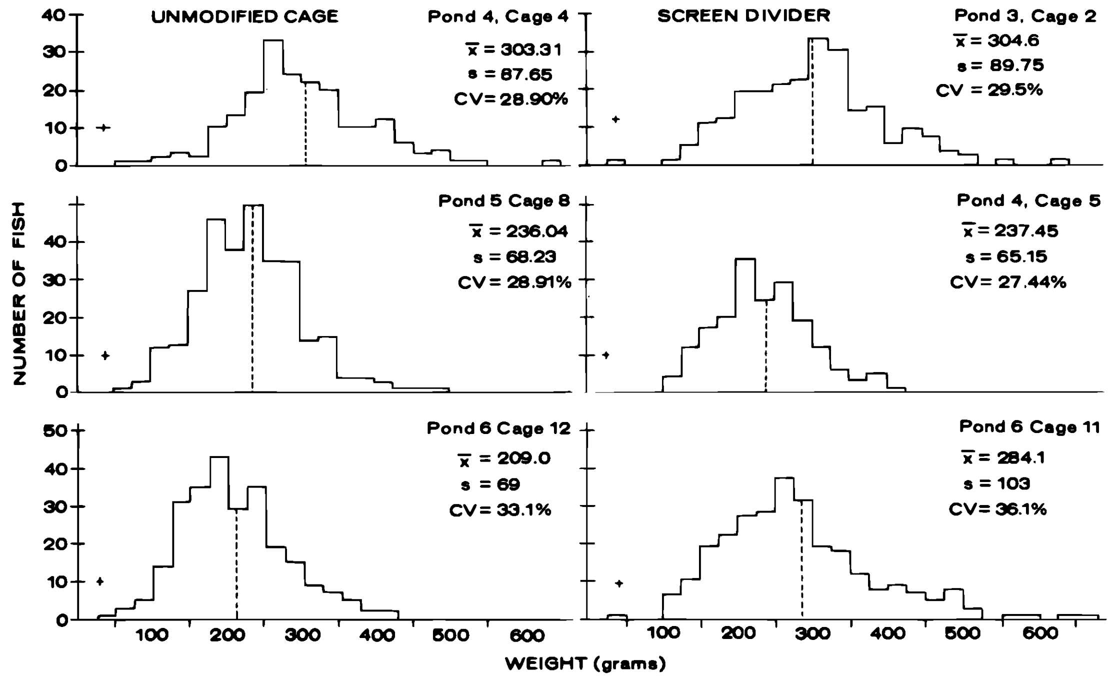

Figure 1.—Weight-frequency of channel catfish grown in unmodified cages and cages with a dividing screen (+ = size at stocking).

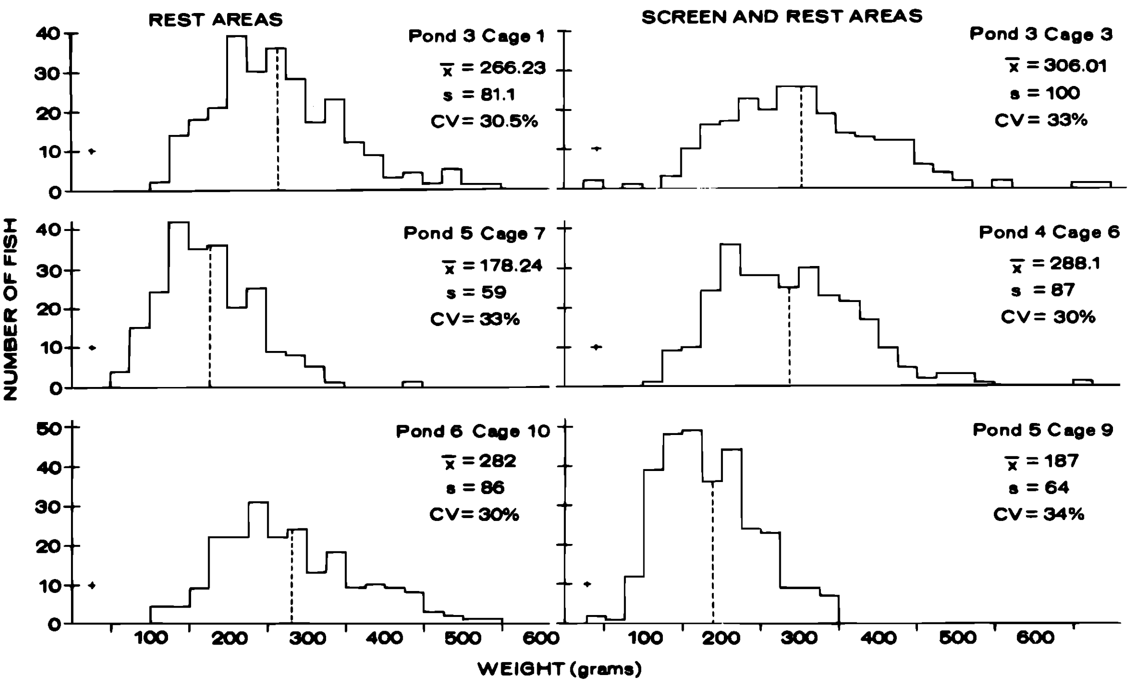

Figure 2.—Weight-frequency distribution of channel catfish grown in cages with rest areas and a combination of rest areas and dividing screen (+ = size at stocking).

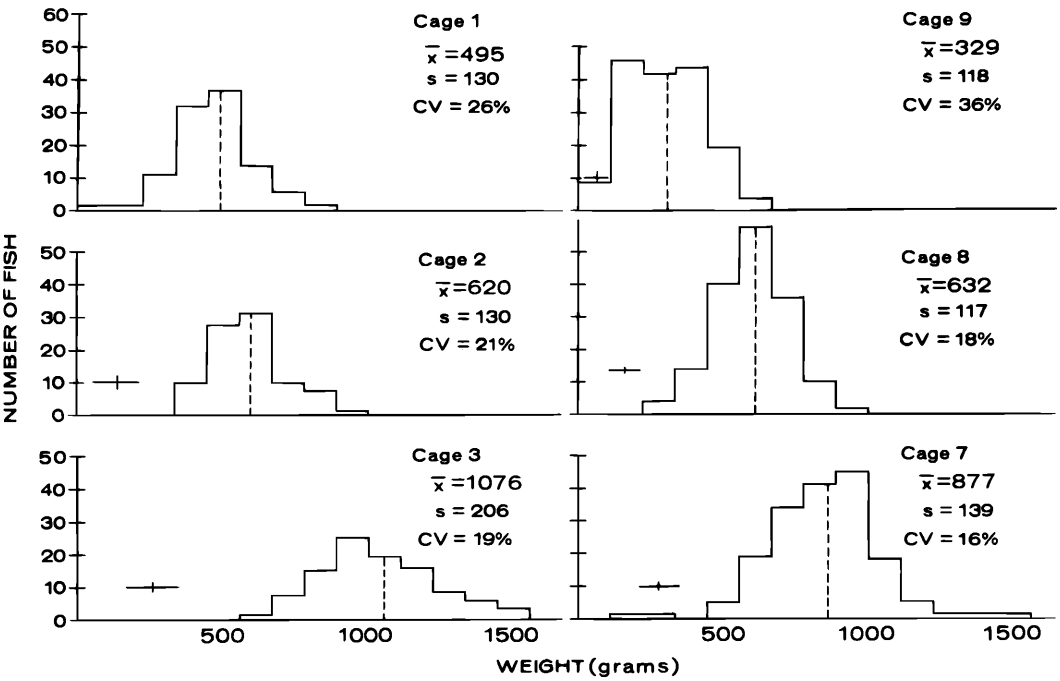

Figure 3.—Weight-frequency distribution of populations of channel catfish produced in shallow (0.6–meter) cages (+ = weight at stocking).

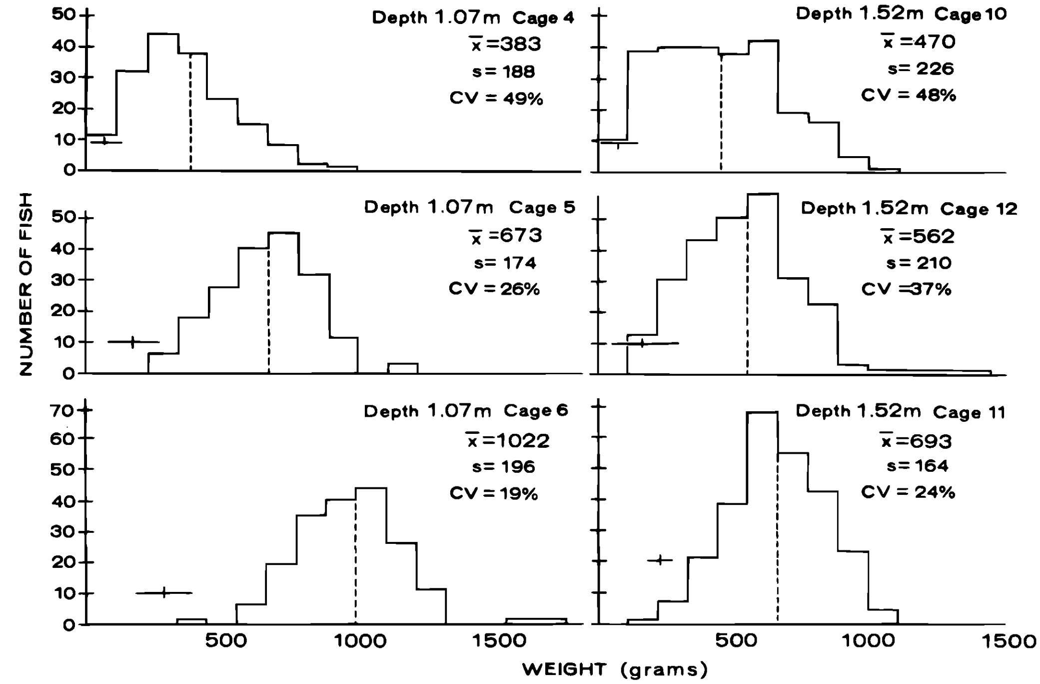

Figure 4.—Weight-frequency distribution of populations of channel catfish produced in relatively deep cages (+ = weight at stocking).

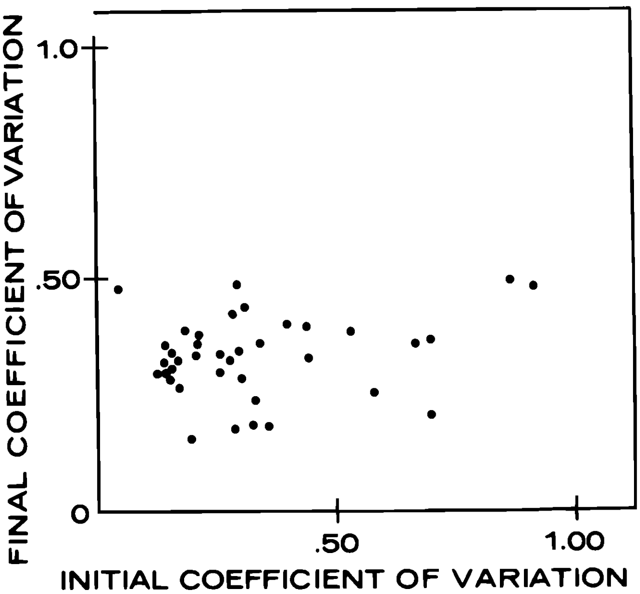

Figure 5.—Relationship between initial and final coefficient of variation in cage-reared channel catfish.

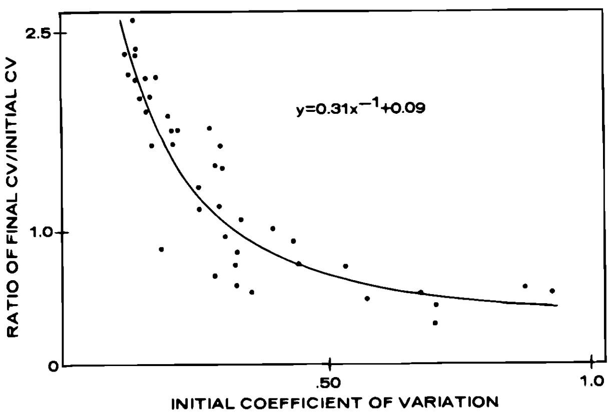

Figure 6.—Change in variation in weight as related to initial variation in cage-reared channel catfish.

greater than 4 percent, and six had mortality of 2 percent or less. Those populations having increased variation all had mortality greater than 7 percent and most greater than 10 percent.

DISCUSSION

In an earlier study we fed nonfloating Kansas formula to caged catfish. The weight-frequency of these populations exhibited a skewed distribution (fig. 7). In the present study all populations were fed Purina Trout Chow (floating) and the resulting weight distributions were reasonably normal (figs. 1 and 2). We are of the opinion that a bimodal or strongly skewed distribution should be designated as *differential growth,* while a basically normal distribution should be designated *growth variation.* The distinction is important in that the cause for the two types of variation may be different. We suggest that *differential growth* results when one part of a population utilizes a substantially different diet than does another portion of the population. This could have occurred when we used the nonfloating Kansas formula, but we do not have proof that some of the fish were feeding while others were not. In a study involving training largemouth bass to utilize artificial feed, Lewis et al. [*2*], it was concluded that a percent of the bass did not feed, and that this resulted in a bimodal distribution or *differential growth.* Nikolsky [*3*, p. 206] suggests a difference in growth rate related to inadequate food supply. Thus he states: "When the feeding conditions are impoverished there occurs not only a reduction of the total growth of the fishes of a population, but also an increase in the variability of growth, which leads to the existence of individuals of very different sizes but in the same age group."

In designing the present study, we speculated that antagonism between fish might produce differential growth. Rest areas and varying water depth were used in the supposition that these environmental changes would affect any attempts by the fish to develop a hierarchy. If the antagonistic behavior associated with attempts to develop a hierarchy were affected, any impact of this activity on growth, especially resulting in the occurrence of differential growth, should indicate whether or not behavior is important in producing either differential growth or growth variation.

Growth variation (weight-frequency curve normal) is probably an expression of genetic difference among the fish. Despite the fact that most of the variation in growth is probably genetic, other variables can be expected to cause differences. Again, behavioral differences as well as environmental variations may be involved. Thus, in the present study we have

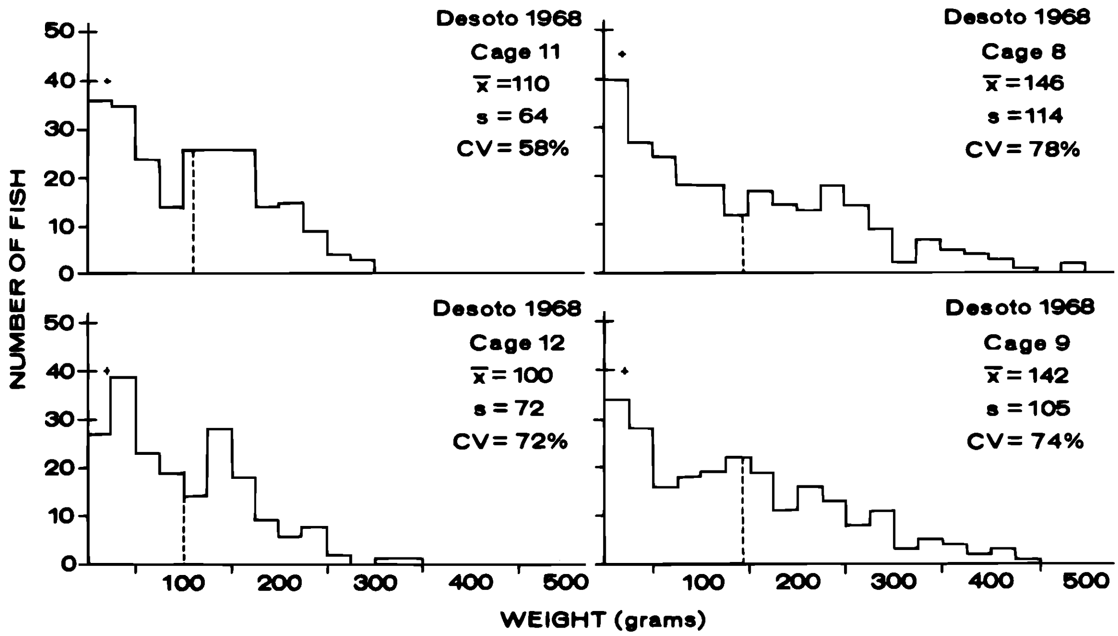

Figure 7.—Skewed weight-frequency distributions of channel catfish populations resulting from an inadequate or poorly utilized feed.

investigated differences in depth of cage, the presence of rest areas, and the relationship of variation in size at stocking to variation in size at harvest.

Increased fighting and poor feed conversion were associated with limited water depth (0.6 meter) as compared to greater water depth (1.1 and 1.5 meters). At least three of the deeper cages (figs. 3 and 4) contained a few disproportionately large fish. These results suggest that hierarchy functioned more successfully in the deeper cages than in the shallow cages. Fighting occurred in the shallow cages where limited vertical space prevented successful development of hierarchy. Stress associated with fighting may explain the poor feed conversions in the more shallow cages.

The failure of rest areas (sections of 10-cm pipe stacked in the cages) to affect variation in growth suggests that either the observed growth variation was not related to behavior or that the retirement areas did not reduce stress associated with any attempt of the fish to establish a hierarchy. If fish were stocked at densities of less than 60 fish per cubic meter, the effects of the retirement areas might have been significant. This is suggested on the basis of our findings in an earlier study (National Marine Fisheries Service Project 4-32-R), in which we concluded that fighting was very evident at low densities (less than 60 fish per m^3), but was infrequent at high densities (above 125 fish per m^3).

Does a high initial variation in size lead to an ever increasing difference up to the time of harvest? This is a reasonable assumption on the basis that the larger fish might be more aggressive and might intimidate the smaller fish, and if this occurs, it is a significant problem. The fact that the results of the present study indicate that this phenomenon does not occur means that there need be less concern about variation in size of fingerlings at stocking. Moreover, cage populations having a high initial variation exhibited a decrease in relative variation at harvest. This decrease can be attributed to either faster growth of small fish, or differential mortality between large and small fish.

Knable [*1*] found that large channel catfish did not alter the food intake of small fish when two sizes were confined in a cage. Thus both the mortality data and Knable's findings suggest that the observed decrease in relative variation is a result of faster growth by the smaller fish.

The significance of the tendency of weight-frequency distributions to be skewed to the right and the occurrence of a few exceptionally large fish in a number of the populations is not known. In caged populations of only 100 or 200 fish, it is not unreasonable to expect one or two large fish to be able to dominate the rest of the population.

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Toxicity of the Synthetic Pyrethroid SBP-1382 to Fish

Antimcyin (Fintrol®) and rotenone have been used effectively for lake, pond, and stream reclamation. Their limitations, however, justify the search for other toxicants: both are much less effective in high than in low pH water, neither is completely satisfactory for killing *Ictalurus* spp.; both are toxic to some important fish-food organisms; and rotenone can be detected and avoided by some species of fish. Recently, structures closely related to naturally occurring pyrethrins have been synthesized. One of these experimental insecticides, SBP-1382® (5-benzyl-3-furyl ester of chrysanthemate), is particularly toxic to fish. This pyrethroid is uniformly toxic to coldwater and warmwater fish of fingerling size in standard, static, laboratory tests. The 96-hour LC50's (concentrations producing 50-percent mortality) ranged from 1 to 5 micrograms per liter (parts per billion) for coho salmon (*Oncorhynchus kisutch*, chinook salmon (*Oncorhynchus tshawytscha*), rainbow trout (*Salmo gairdneri*), lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), carp (*Cyprinus carpio*), white sucker (*Catostomus commersoni*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), and yellow perch (*Perca flavescens*). The 96-hour LC50 for channel catfish (*Ictalurus punctatus*) was 15 µg/*l*. The pyrethrin was significantly more toxic at low than at high water temperatures, as shown by the following 96-hour LC50's (µg/*l*) derived in tests with rainbow trout: 7°C, 1.22; 12°C, 1.90; and 17°C, 3.49. Similar temperature effects were noted in exposures of green sunfish and bluegill. The compound was equally toxic to rainbow trout, green sunfish, and bluegill in waters of different hardness (12, 44, 170, and 300 milligrams per liter as CaCO) and of different pH (6.5, 7.5, 8.5, and 9.5).

Although the chemical shows potential as a fish toxicant, registration would require extensive study of its effects on nontarget organisms—particularly fish-food organisms—and on various life stages of fish.

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