USE OF DORSAL FIN MEASUREMENTS IN THE IDENTIFICATION OF HATCHERY STEELHEAD IN HIGH SEAS CATCHES

by

Jeffrey T. Light

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Fisheries Research Institute
College of Ocean and Fishery Sciences
University of Washington
Seattle, Washington 98195

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INTRODUCTION

An estimated eighteen million steelhead smolts are released annually by production facilities along the Pacific coast of North America (Wahle and Smith 1979, Washington Dept. of Game 1982, 1983, and individual agency records). Recoveries of tagged fish in the central and western North Pacific Ocean indicate that some of these hatchery-reared fish migrate into areas fished by Japanese landbased and mothership commercial salmon fleets (Dahlberg and Fowler 1985). At present there is insufficient information on the relative contribution of North American hatchery steelhead to the mixed stocks of *Salmo* species (*S. gairdneri* and *S. mykiss*) that inhabit the North Pacific Ocean (Okazaki 1986). This has mainly been due to the difficulty of identifying the origins of ocean caught steelhead.

Several inshore sportfish management agencies in the United States have used dorsal fin height as a hatchery-wild stock separation tool for steelhead. Since 1984, Fisheries Research Institute scientists have routinely measured the dorsal fins of steelhead sampled on Japanese motherships and salmon research vessels, with the intention of distinguishing hatchery from wild fish in the mixed-stock samples. At the annual meeting of the Ad Hoc Salmon Research Coordination Group in early March, 1986, the Japanese National Section inquired about the history and details of this stock separation technique.

This report is presented in response to that inquiry, and also to provide an assessment of the usefulness of the dorsal fin height criterion in separating hatchery- and wild-origin steelhead in 1984 and 1985 high seas samples.

DESCRIPTION OF DORSAL FIN HEIGHT CRITERION

Dorsal fin height has been used as a tool by management agencies in Washington (Washington Dept. of Game), Oregon (Oregon Dept. of Fish and Wildlife), and Idaho (Idaho Dept. of Fish and Game) to identify steelhead of hatchery origin in stream systems where both hatchery and wild stocks coexist (DeShazo 1985, Thurow 1982). Artificially reared steelhead usually exhibit stubbing or deformation of the dorsal fin, and the degree of deformation depends upon a number of environmental factors including water chemistry, density loading and the type of rearing environment (concrete raceway, gravel raceway, circular concrete pond, etc.) (DeShazo 1985). A comparison of fin heights among hatchery and wild steelhead of several stream systems showed that the majority of adult hatchery steelhead had dorsal fins less than two inches (50 mm) in height, whereas most adult wild steelhead had dorsal fins that exceeded two inches (DeShazo 1985). Fin height is used to protect wild stocks from overharvest in streams where both hatchery and wild fish exist by

requiring fishermen to release fish with dorsal fins above certain size limits. A 57 mm cutoff point was the original criterion used by Idaho Dept. of Fish and Game for fish of upper Snake River tributaries (Reingold 1980, Thurow 1982). However, this was considered to be too large for many of the stocks outside the Snake River system, and so a 50 mm cutoff was adopted in 1984 to protect a larger proportion of wild fish from harvest by sport fisheries (DeShazo 1985).

METHODS

Steelhead caught incidentally to salmon during fishing operations of Japanese salmon mothership fleets in 1984 and 1985 and Japanese salmon research vessels in 1985 were frozen and returned to the United States for further analyses. As part of these analyses, the anterior (maximum) height of the dorsal fin of each fish was measured to the nearest mm, and the data were grouped into four categories based on fin height: 1) less than or equal to 50 mm, 2) greater than 50 mm, 3) less than or equal to 57 mm, and 4) greater than 57 mm.

The fin height data were grouped according to ocean age[1] to account for differences in fin size due to age (size) of the fish. The data were also grouped by freshwater age[1] because I expected that most of the steelhead spending one year in freshwater were hatchery fish (Sheppard 1972), and this subgroup might have a larger proportion of fish with stubbed dorsal fins.

Several fish in the samples had visibly deformed dorsal fins or clipped fins that indicated they were of hatchery origins. In addition, some fish carried a coded-wire microtag that allowed for positive identification of the origins of these fish. Fish with clipped fins, worn dorsals, or coded-wire tags were grouped and analyzed separately.

RESULTS

Overall, few fish in the samples had dorsal fins less than 57 mm. Of the 1,226 fish in the combined sample (1984 and 1985 mothership, 1985 research vessel), 958 (78%) had measurable (unbroken) dorsal fins. Of these, only 51 (5%) had fins ≤ 50 mm, and 149 (16%) had fins ≤ 57 mm (Table 1, Figure 1). The proportion of stubbed dorsals (fin height ≤ 57 mm) was highest in the 1984 mothership samples, and lowest in the 1985 research vessel samples.

A weak but significant ($P < .001$) positive linear relationship was found between fin height and fork length (Figure 2), and the relationship is described by the regression equation:

$$\text{Fin Height} = .072\ \text{Length} + 21.245 \quad (r^2 = .249)$$

[1] Ages were determined by analysis of scales and otoliths.

Dorsal fin heights of fish in ocean age groups .1, .2, and .3 are presented in Figure 3.[2] The greatest number of fish with small dorsals were the younger (smaller) fish, and this may as much reflect the natural relationship of fin height to length among wild fish as it suggests the presence of fish with deformed dorsals. Note that in Figure 2 the fin size of most of the smaller fish was already above the 50 mm cutoff point.

To examine fin heights on the basis of freshwater age of the sampled fish, the data were grouped into two categories: fish that had spent one year in freshwater, and all older fish (Table 2, Figure 4). Surprisingly, few fish of freshwater age 1. had small dorsal fins. Nineteen percent of the total sample were freshwater age 1. fish (range among the three samples was 15% - 24%), but only 18% of these had fins smaller than 57 mm, and 8% had fins less than 50 mm. These values were somewhat higher than for the total sample (all ages combined), suggesting that more age 1. fish (presumed hatchery fish) had worn dorsals, but the values were not as high as might be expected if the majority of freshwater age 1. fish were from hatcheries and had fins ≤ 50 mm.

The results of the analysis of fish that were either known to be hatchery fish (coded-wire tagged fish) or where there was a high degree of certainty of their hatchery origins (deformed dorsals or clipped fins), are presented in Figures 5 and 6. Once again a surprising number of these fish had dorsal fins well beyond the 50 mm hatchery/wild separation criterion. When grouped by freshwater age, however, most of these fish fell within the one-year age category expected of hatchery fish (Figure 6). Some of the known-age hatchery fish spent two years in freshwater.

DISCUSSION

While dorsal fin measurements may be useful in the identification of hatchery fish from particular stocks or stream systems, the use of this criterion alone for identifying hatchery fish in mixed-stock samples of steelhead collected on the high seas is limited. Data compiled by DeShazo (1985) comparing the dorsal fin heights of hatchery and wild steelhead from several stream systems in the Columbia River Basin and Puget Sound suggest that fin height varies considerably from stock to stock and region to region. The percentage of hatchery fish with dorsal fins below the 50 mm cutoff point varied between 14% and 80%, and averaged 41% overall (Table 3). The proportion of hatchery fish with fins less than 57 mm was higher (68% overall), but still varied greatly (from 33% to 96%). Fish from rearing facilities around Puget Sound appear to be less prone to dorsal fin deformation, and this may be due to the Washington State Department of Game's use of natural rearing ponds to raise steelhead (DeShazo 1985). A substantial number of adult wild fish also had dorsal fins smaller than 57 mm (28%) or 50 mm (8%).

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[2] Ocean age .4 fish not included due to small sample size.

The high degree of overlap in dorsal fin measurements among hatchery and wild fish in the above study, coupled with a lack of fin height information for fish from other areas such as coastal Oregon, British Columbia, and Alaska that may contribute a large number of fish to the mixed population in the North Pacific Ocean, severely reduces the usefulness of this technique for use with ocean-caught steelhead. Combining this method with freshwater age analysis did not greatly improve the results, and this may be partially due to problems inherent with age designations (Davis and Light 1985).

Fisheries management agencies are well aware of the limitations of fin height analysis as a means of separating hatchery and wild fish, and have responded by adopting the adipose fin clip as the mark for hatchery fish. Prior to 1983 the adipose fin clip was reserved exclusively for steelhead that carried coded-wire tags. In 1983 procedures were changed to allow the use of the adipose clip as a mark for hatchery fish (Johnson 1983), and since that time an increasing number of hatchery-reared steelhead have been marked with clipped adipose fins. Conceivably, 100% of hatchery releases may someday be identifiable by a missing adipose fin. This will allow for a much more accurate estimate of the relative contribution of hatchery steelhead to ocean populations of Salmo in the North Pacific. As information becomes available on the proportions of hatchery and wild steelhead in streams along the Pacific coast of North America, an estimate of the total abundance of North American steelhead in the North Pacific Ocean will be possible.

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Table 1. Dorsal fin height analysis for steelhead caught in the North Pacific Ocean during fishing operations of Japanese salmon motherships and research vessels in 1984 and 1985.

Source	Sample Size		No.(%) with dorsal fin height			
	Total	No.(%) with measureable fins	≤50mm	>50mm	≤57mm	>57mm
Mother-ship						
1984	396	363 (92)	31 (9)	332 (91)	84 (23)	279 (77)
1985	383	308 (80)	17 (5)	291 (95)	35 (11)	273 (89)
Research Vessel						
1985	447	287 (64)	3 (1)	284 (99)	30 (10)	257 (90)
All Samples Combined						
	1,226	958 (78)	51 (5)	907 (95)	149 (16)	809 (84)

Table 2. Analysis of dorsal fin height for freshwater age 1 steelhead caught in the North Pacific Ocean during fishing operations of Japanese salmon mothership and research vessels in 1985 and 1986.

Source	Sample Size		No.(%) of FW age 1. fish with dorsal fin height			
	No. with measureable fins	No.(%) with FW age = one year	≤50mm	>50mm	≤57mm	>57mm
Mother-ship						
1984	363	53 (15)	8 (15)	45 (85)	11 (21)	42 (79)
1985	308	63 (20)	5 (8)	58 (92)	9 (14)	54 (86)
Research Vessel						
1985	287	69 (24)	1 (1)	68 (99)	14 (20)	55 (80)
All Samples Combined						
	958	185 (19)	14 (8)	171 (92)	34 (18)	151 (82)

Table 3. Dorsal fin height measurements of steelhead from streams in Washington, Oregon, and Idaho (modified from DeShazo 1985).

	Wild Steelhead				Hatchery Steelhead			
			Number (%) with dorsal fin height:				Number (%) with dorsal fin height:	
River System	Year	Sample Size	<2.0" (50 mm)	<2.25" (57 mm)	Year	Sample Size	<2.0" (50 mm)	<2.25" (57 mm)
Salmon (Idaho)	1981	91	2 (2)	3 (3)	1980	N/A	N/A	-- (96)
Salmon (Idaho)	1982	146	0	3 (2)	----	---	---	---
Deschutes (Oregon)[1]	1982-83	130	13 (10)	44 (34)	1982-83	41	37 (90)	39 (95)
Imnaha (Oregon)[1]	1983-84	53	13 (25)	36 (68)	----	---	---	---
Snow Creek (Wash.)	1983	82	6 (7)	17 (21)	1983-84	24	12 (50)	19 (79)
Kalama R. (Wash.)	1983-84	54	N/A	11 (20)	1983	110	N/A	61 (55)
Green R. (Wash.)	1983-84	6	0	1 (17)	1983-84	43	6 (14)	25 (58)
Skagit R. (Wash.)	1983-84	59	1 (2)	11 (19)	1983-84	179	62 (35)	119 (67)
Snohomish R. (Wash.)	1983-84	9	0	2 (22)	1983-84	133	53 (40)	90 (68)
Columbia R. (Lower river sport fishery)	1983	66	N/A	56 (85)	1983	220	N/A	211 (96)
	1984	104	18 (17)	42 (40)	1984	171	69 (40)	56 (33)
Columbia R. (Zone #6 treaty fishery-July)	1984	45	6 (13)	13 (29)	1984	117	52 (44)	88 (75)
Totals		845	59 (8)	239 (28)		1038	291 (41)	708 (68)

[1]Assignment of hatchery-wild classifications by dorsal fin deformation only; all other river systems based on scale analysis.

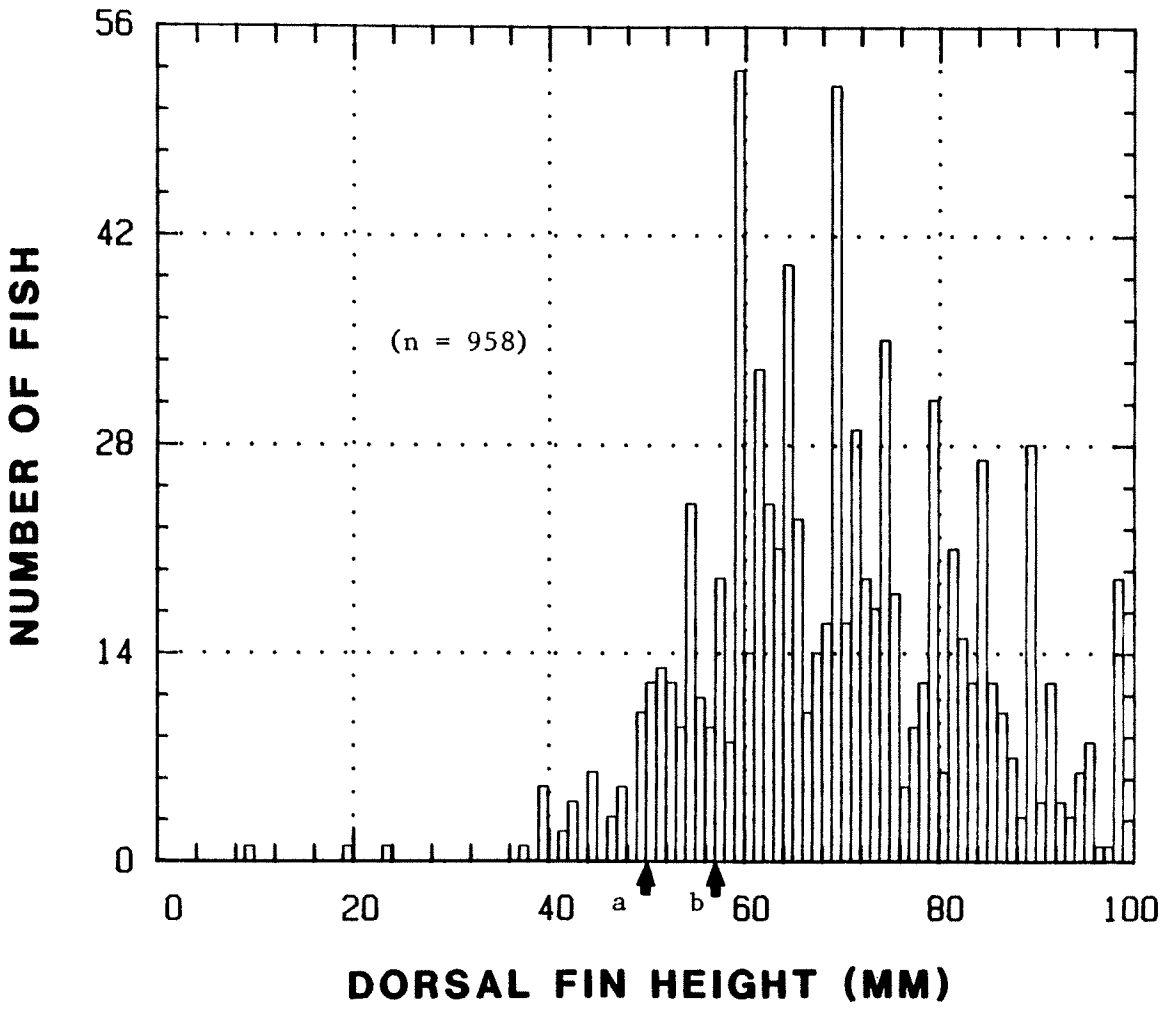

Figure 1. Frequency distribution of dorsal fin heights of steelhead caught in the North Pacific Ocean in 1984 and 1985. Arrows indicate (a) 50 mm and (b) 57 mm cutoff points used as selection criteria in identifying origins (hatchery or wild) of adult fish. All data for fins larger than 99 mm were pooled into the last category (the largest fin size was 102 mm).

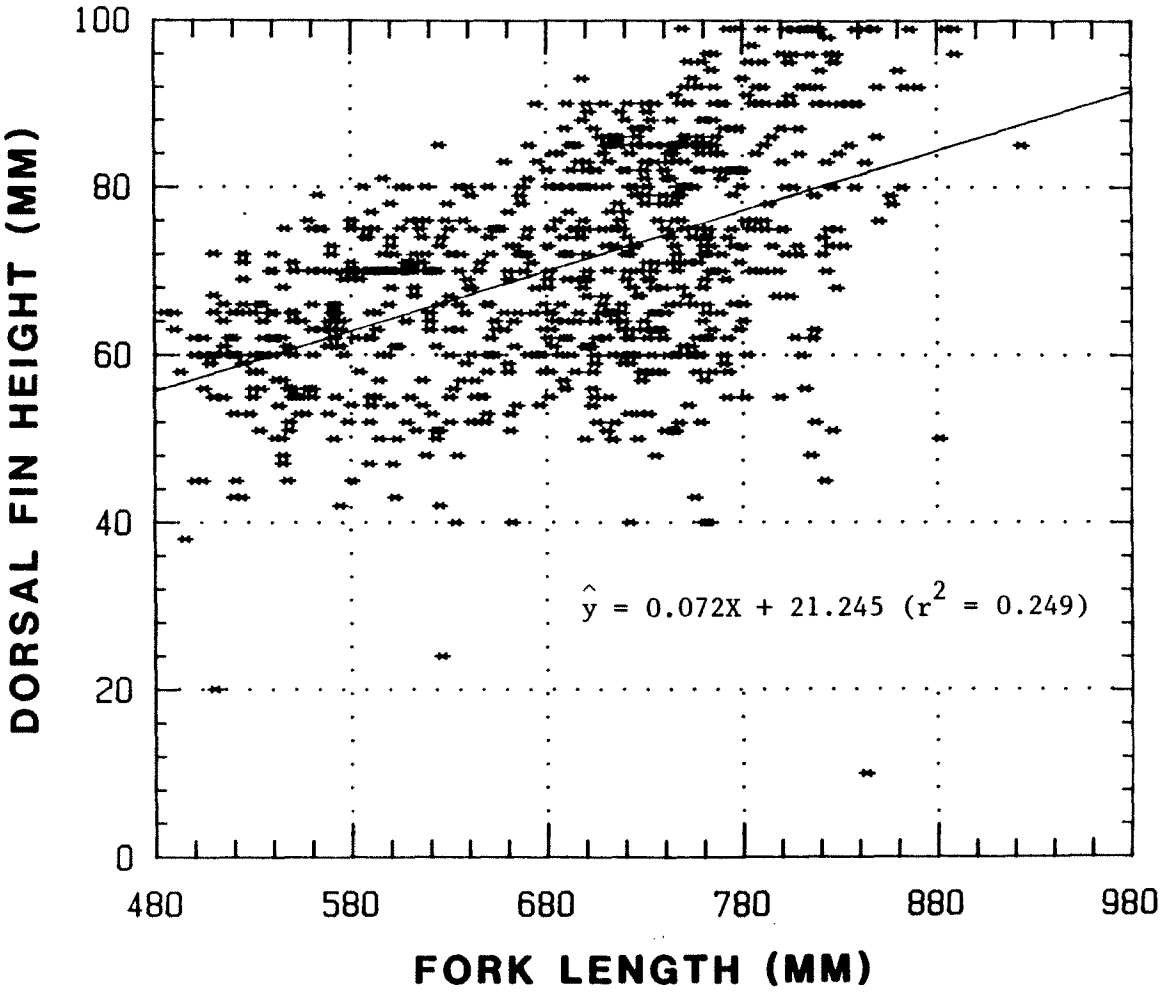

Figure 2. Relationship between dorsal fin height and fork length of steelhead caught in the North Pacific Ocean in 1984 and 1985. Only fins less than 100 mm were included in the plot (the largest fin size was 102 mm).

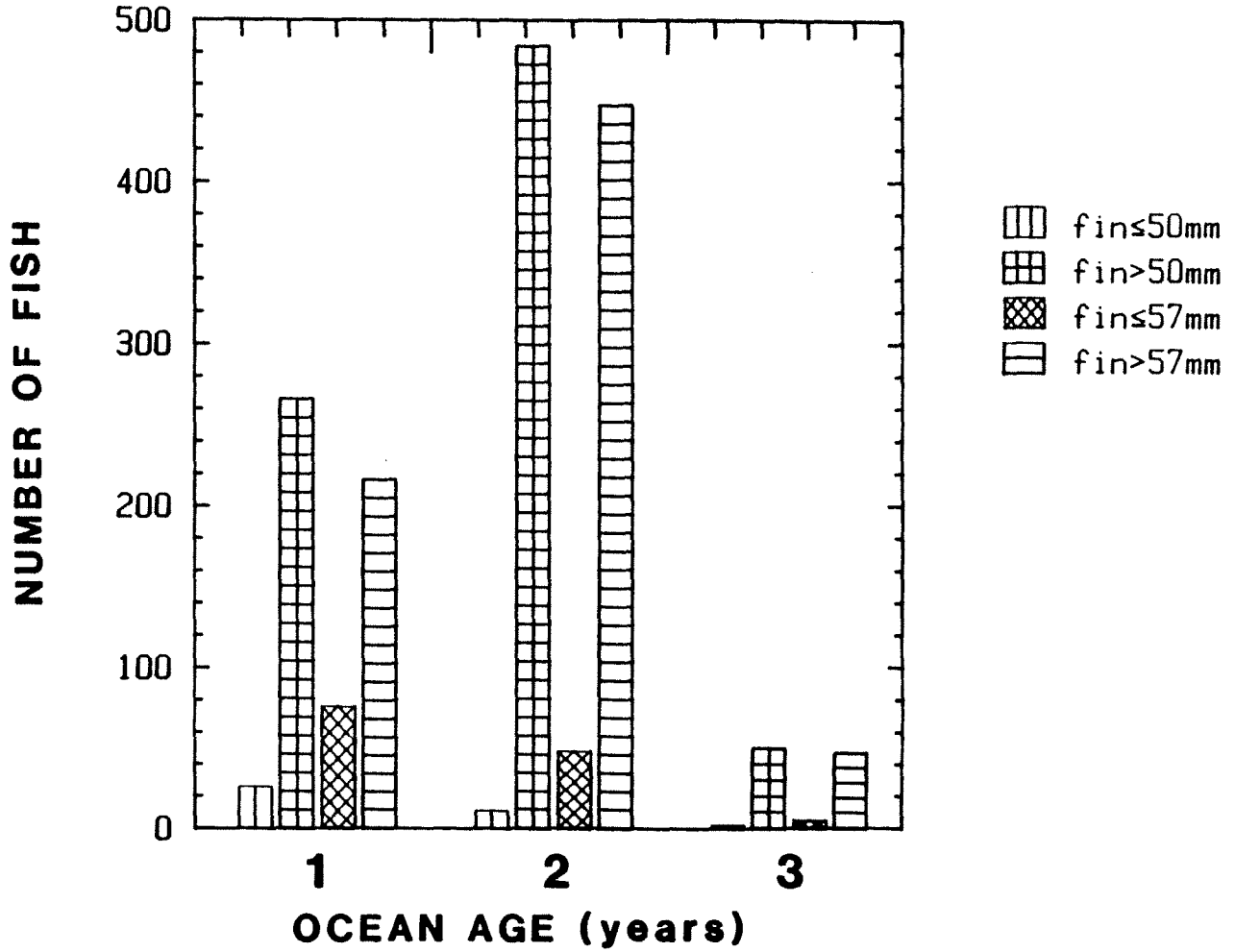

Figure 3. Frequency distribution of dorsal fin height by ocean age for steelhead caught in the North Pacific Ocean in 1984 and 1985.

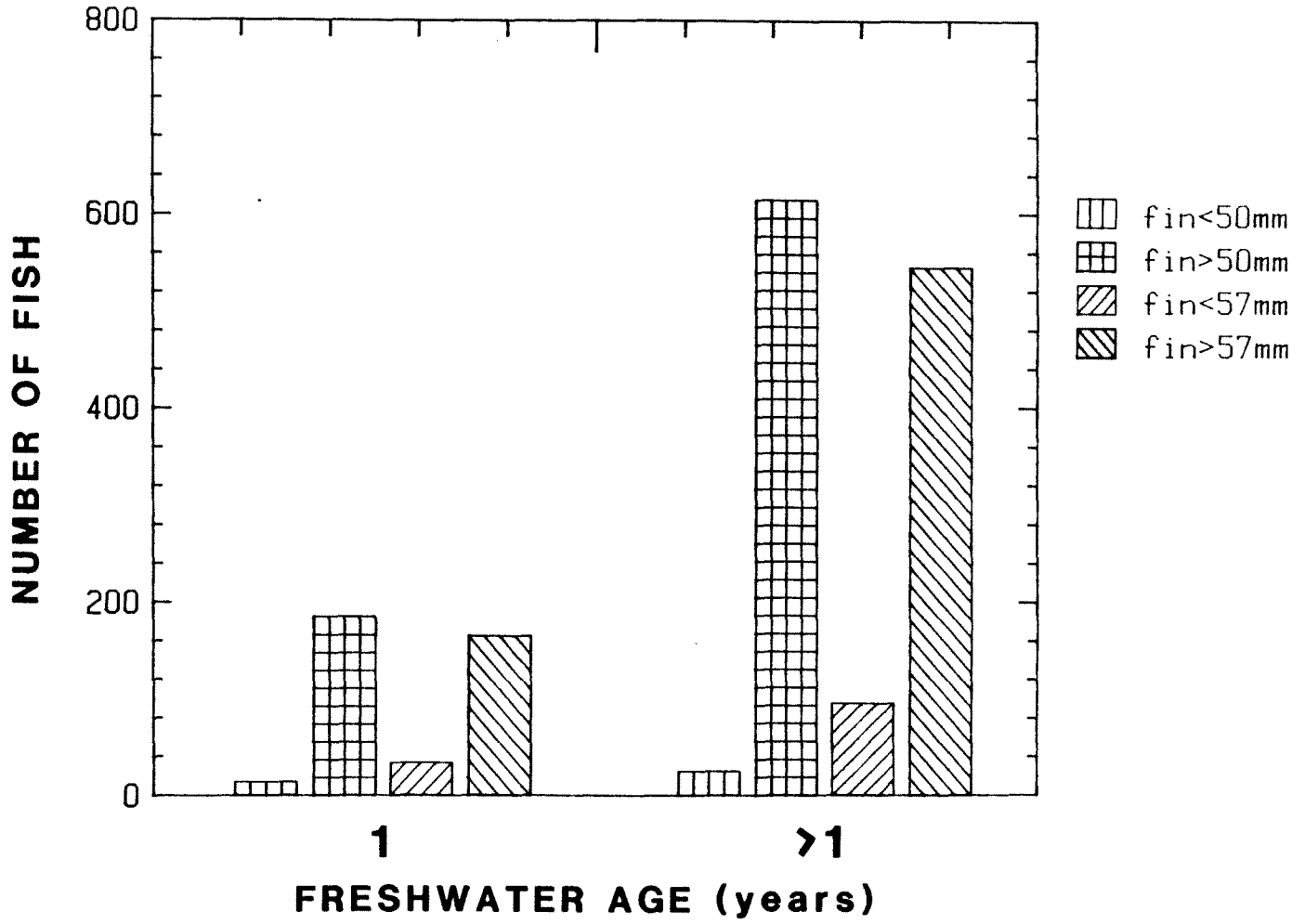

Figure 4. Frequency distribution of dorsal fin height by freshwater age for steelhead caught in the North Pacific Ocean in 1984 and 1985.

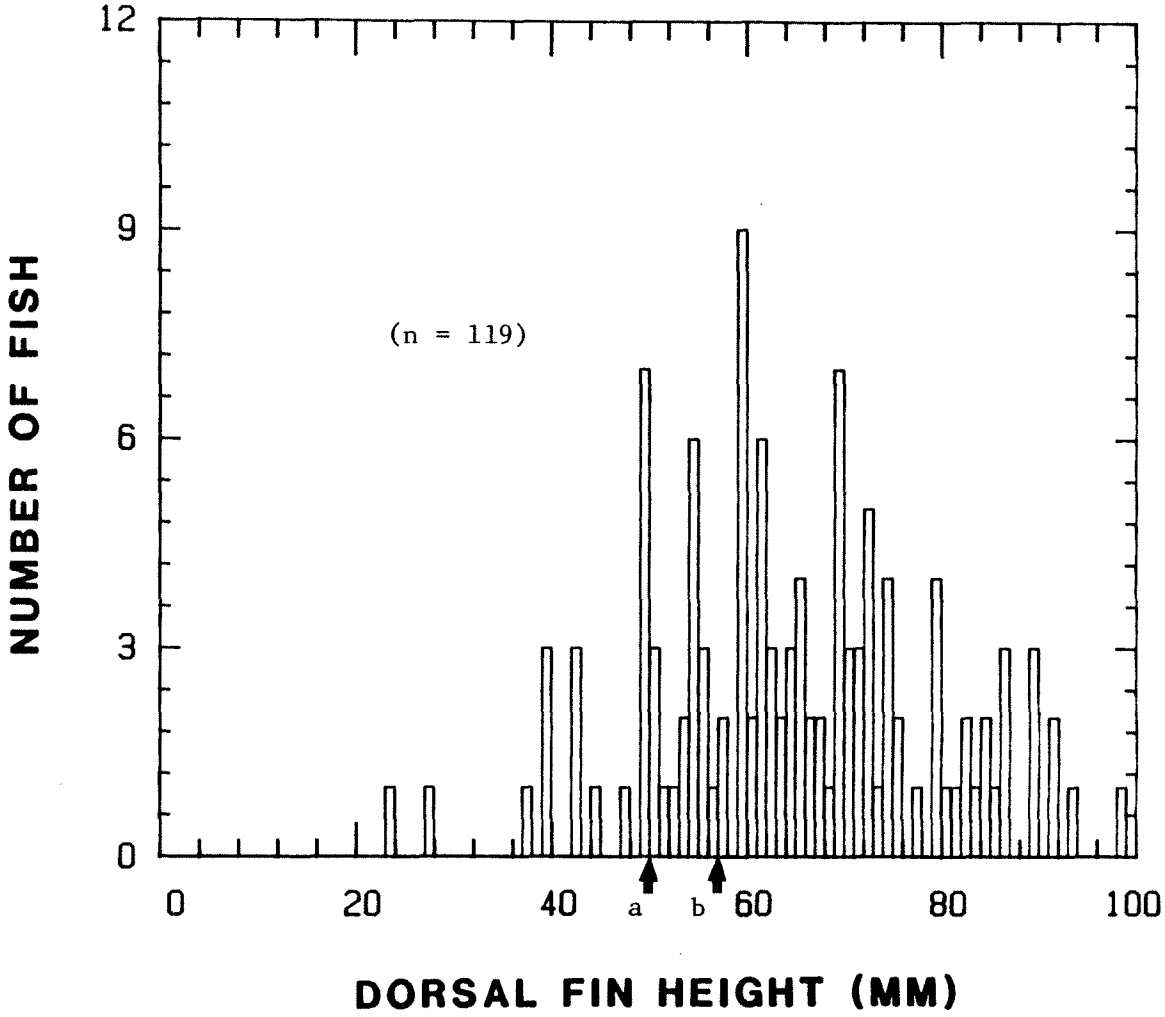

Figure 5. Distribution of dorsal fin heights of steelhead caught in the North Pacific Ocean in 1984 and 1985 that had clipped fins, a deformed dorsal, or carried a coded-wire tag. Arrows indicate (a) 50 mm and (b) 57 mm cutoff points used as selection criteria in identifying origins (hatchery or wild) of adult fish. All data for fins larger than 99 mm were pooled into the last category (the largest fin size was 102 mm).

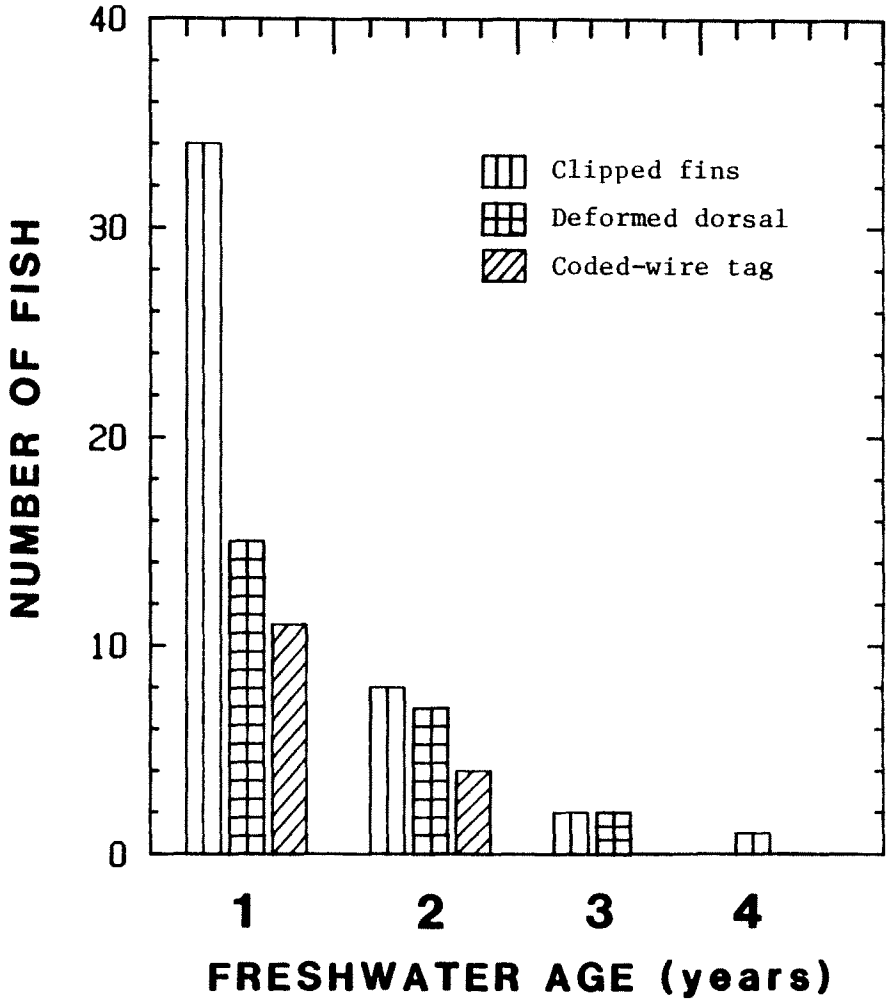

Figure 6. Freshwater age distribution of steelhead caught in the North North Pacific Ocean in 1984 and 1985 that had clipped fins, a deformed dorsal, or carried a coded-wire tag.