

VERMONT YANKEE/CONNECTICUT RIVER SYSTEM  
ANALYTICAL BULLETIN 72

**Composition of Adult American Shad at the Vernon  
Hydroelectric Dam Fishway During Spring 1998**

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## ABSTRACT

Eighty-six adult American shad were collected from the Vernon Dam Fishway on 29 and 30 May and 2 and 4 June 1998. Males dominated the collections from each of the four samples collected, and overall, constituted 69% of the fish sampled. Ninety-four percent of the adults sampled at the Vernon Fishway were age IV and V (56% and 38%, respectively). Male shad composition was dominated (61%) by age IV fish, and females at age V were more abundant (52%) than other age classes in the sample. Repeat spawning was evident in 30% of the age V adults and 2% of the age IV adults. In general, the sexual condition of sampled shad was mostly ripe on the first three sampling dates, and of the four fish processed from the last sample, one fish was green, one was ripe, and two were spent. The 1998 results are consistent with surveys conducted at the Vernon Fishway between 1990 and 1995 and 1997. There were no adult shad sampled at Vernon in 1996. The slight annual differences seen in age and sex ratios are typical of the characteristics of natural fish populations.

## INTRODUCTION

One of the stated objectives by the Shad Studies Subcommittee of the Connecticut River Atlantic Salmon Commission in "A Management Plan for American Shad in the Connecticut River Basin" (prepared February 1992) is that population monitoring is required to support the achievement of the management goal of sustaining 1.5 to 2 million shad in the Connecticut River system. Vermont Yankee has participated in the long-term population monitoring in past years (e.g., Vermont Yankee Analytical Bulletin Nos. 36, 40, 41, and 70), and agreed to continue monitoring adult American shad during the 1998 spawning migration.

As part of the 1998 objective-specific studies of the Vermont Yankee Nuclear Power Corporation's NPDES Permit (NPDES No. VT0000264), life history data were collected from a sample of adult American shad (*Alosa sapidissima*) that used the Vernon Dam Fishway during the spring 1998 spawning run. We determined the size, sex ratios, sexual condition, and age structure for a sample of American shad collected during the 1998 spawning run to contribute to a long term database for evaluating the impacts, if any, of the Vermont Yankee Plant on American shad.

## METHODS

The Fishway at Vernon Dam (river km 230, Vernon, Vermont) (Figure 1) is located on the Connecticut River, less than one mile downstream of the Vermont Yankee Nuclear Power Plant. The Fishway operated between 14 May and 23 July 1998. Beginning on 20 May through 28 June, fish passage monitoring was conducted by Vermont Department of Fish and Wildlife employees daily between 0700 and 1900 hours. American shad were sampled on 29 and 30 May, and 2 and 4 June 1998 at the Fishway. American shad were randomly trapped by Vermont Department of Fish and Wildlife employees and processed by Normandeau Associates, Inc. (NAI) biologists. After 2 June 1998, the number of shad utilizing the Fishway was too sporadic to effectively trap more than a few at a time. Captured shad were weighed to the nearest gram and total length was measured to the nearest millimeter. The sex was determined for 84 of the 86 shad processed, by applying pressure ventrally and posterior to the pelvic fins and observing the release of eggs or milt from the vent. Two shad escaped prior to sex determination. The quantity and appearance of the milt or eggs extruded was used to estimate sexual condition. Sexual condition was divided into six categories: green, ripe, running ripe, partially spent,

spent, and undetermined. Male and female shad were classified into one of five sexual condition categories by observing the release (or not), and appearance of milt or eggs. If it was early in the run and no milt or eggs were released upon application of gentle pressure, that individual would be considered "green" or not yet ready to spawn. Some "green" females release eggs when pressure is applied, but they are clearly undeveloped. There is a general fullness to the ventral portion of shad that contain milt or eggs but are not ready to spawn. If upon application of pressure, milt or eggs are expelled with ease and volume and there is no blood in the eggs or milt, the fish would be categorized as being sexually "ripe". If upon picking up a shad and the milt or eggs were freely released with little or no pressure, that individual would be considered "running ripe". A "partially spent" male shad exhibits similar characteristics as "ripe" shad except that it takes more pressure to achieve the release of milt, a smaller volume usually results, and there is usually a small amount of blood in the milt. A "partially spent" female shad generally releases a small volume of eggs and there is often a small amount of blood present. The eggs also tend to lack the color relative to eggs released from a ripe or running ripe female. For a shad to be considered "spent", it would be difficult to get milt or eggs from the vent, blood is generally released, and the appearance of the fish suggest they have already spawned. This is usually observed late in the spawning run. Undetermined sexual condition generally resulted from fish escaping before the sexual condition could be determined.

Water temperature in the Fishway was continuously recorded during the sampling period. Scales were taken from each processed shad from above the lateral line near the insertion of the dorsal fin. After processing, those individuals that were stressed beyond recovery were sacrificed. All others were released back into the Fishway.

Shad scales were prepared for age determination in the laboratory. Age and repeat spawning status was determined following the method outlined by Cating (1953). Each scale was soaked in water and gently scrubbed with a soft bristled brush. Three to five scales from each fish were mounted between two microscope slides. Annuli enumeration was conducted by two Normandeau biologists. One biologist independently examined the scales with a Nikon microprojector with 10 - 20X magnification. A second biologist examined the scales utilizing a Bausch and Lomb microprojector with 20 - 40X magnification. The second biologist also determined repeat "spawning checks" on scales to identify previously spawned shad. As described in Cating (1953), spawning marks are scar-like rings extending around the anterior portion of the scale similar to the annuli, but unlike the annuli, they extend only a short distance into the posterior portion of the scale. These marks are caused by absorption or erosion of the scale during the spawning migration into freshwater when little or no food is eaten by the adult shad.

## RESULTS

Eighty-eight adult American shad were sampled and processed from the four sampling events (Table 1). This represents 1.3% of the total shad passed at Vernon in 1998. Vernon Fishway passed 65% of the total American shad estimated to have passed the Turner's Falls Fishway. The age and sex of 86/88 of the adult shad processed was determined. The sexual condition of 79/86 adults was determined.

Water temperature in the Fishway ranged from 19.2 – 21.6°C over the four sampling events. The Fishway maintained a continuous flow of 65 cfs during the period of operation. Attraction flow of an additional 135 cfs was supplied to the Fishway during the daytime period of operation (0600 – 2000 DST). Total River flow at Vernon Dam ranged from 1,735 – 9,204 cfs over the four sampling dates

Males dominated the collections from each of the four sample dates, constituting 69% of all collected shad for which sex was determined (i.e.,  $n = 86$ ) (Figure 2). On three of the four sample dates, males constituted more than 60% of the catch and on 30 May, males constituted 84% of the catch. Of the males for which sexual condition was determined ( $N = 52$  males) over the four dates, 85% were sexually ripe, 12% running ripe, and 4% green (Table 2). Male shad ranged in weight from 500 – 1600 g and in length from 391 – 560 mm (Figure 3). Male shad were generally smaller in length and weight than females (Figure 3). Female shad ranged in weight from 800 – 2200g and in length from 457 – 558 mm (Figure 3). The sexual condition of the females sampled over the four dates, was 41% ripe, 26% green, 15% partially spent, 11% spent, and 7% running ripe (Table 2). The sexual condition of the sampled fish (sexes combined) showed "ripe" individuals dominating on the first three sample dates (79%, 96%, and 46%, respectively) (Table 2).

Fifty-six percent of the 85 adult shad for which age was determined (one shad on 2 June was not aged, scales collected had all been regenerated and therefore not used for aging) from the Vernon Fishway were age IV, followed by 38% that were age V and 6% that were age III (Table 3).

The age composition of males processed at the Vernon Fishway was dominated (61%) by four-year olds followed by 30% age V males (Table 3). The remaining 9% comprised age III males (Table 3). Fifty-two percent of the female adult shad were age V and the remaining 48% were age IV (Table 3). Thirteen percent of sampled shad were repeat spawners. Repeat spawning was evident in 30.3% of the age V adults and 2.1% of the age IV adults (Table 3). Repeat spawning was evident in 28.6% of age V females and 35.3% of age V males (Table 3). Repeat spawning was evident in 2.9% of age IV males (Table 3). There was no evidence of spawning checks on the scales of age III males or age III and IV females.

## DISCUSSION

Historically, the sex ratio of adult American shad sampled at the Vernon Fishway has favored males at least in the early part of the spring immigration, and usually overall (Smith and Downey 1995). This trend continued in 1997 (Normandeau Associates 1998) and in 1998. Males were also most abundant, particularly during the early and middle stage of spawning runs in the Susquehanna River (Susquehanna River Anadromous Fish Restoration Committee 1993 - 1996) and at the Holyoke fish passage facility downstream from the Vernon Dam on the Connecticut River (Mather 1997).

Whereas 80% of the adult American shad that passed Turners Falls in 1997 passed Vernon Dam, only 65% of the total passed at Turners Falls also passed Vernon Dam in 1998 (Ken Cox, personal communication). Total river flow at Vernon Dam during Fishway operation was considerably lower in 1998 (1,735 – 9,204 cfs) than 1997 (4,470 – 11,600 cfs). Comparisons of total adult shad passed at Holyoke, Turners Falls, and Vernon Fishways from 1995 - 1998 show a noticeable drop in the number of shad immigrating from Holyoke to Turners Falls in 1998 compared to the three previous years (Table 4). In 1997 a large majority (80%) of the shad that passed Turners Falls also passed Vernon. The percentage dropped to 65% in 1998 (Table 4).

The percentage of male adult American shad sampled at the Vernon Fishway in 1998 was slightly higher (69%) than that reported in 1997 (63.1%) and similar to the percentage of males reported during 1990-1995. The range during 1990-1998 was 63 - 91% males; the mean was 78% (Table 5).

Between 1990 and 1998, the 322 adult female shad aged at the Vernon Dam Fishway have been age IV and V, with the exception of two age VI females collected in 1997 (Table 5).

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TABLE 1. Listing of all adult American shad processed at the Vernon Fishway, Spring 1998.

DATE												
29MAY98						30MAY98						
Fish_ID	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition
1	M	1000	456	4		Ripe	M	500	391	3		Ripe
2	U	1200	478	5		U	M	700	425	4		Ripe
3	F	1500	533	5		Spent	F	1500	529	4		Ripe
4	M	1300	482	4		Ripe	M	1000	466	5		Ripe
5	M	1000	453	4		Ripe	M	600	420	4		Ripe
6	U	2200	560	5		U	M	1000	472	5		Ripe
7	F	2000	558	5		Running Ripe	M	1000	475	4		Ripe
8	F	2200	558	4		Running Ripe	M	600	425	5	1	Ripe
9	M	1200	463	3		Ripe	M	800	456	5		Ripe
10	M	1200	482	5	1	Ripe	M	1000	482	5		Ripe
11	M	900	424	3		Ripe	M	600	426	4		Ripe
12	M	1200	460	4		Ripe	F	1100	480	4		Partially Spent
13	M	1000	422	4		Ripe	F	1500	535	5		Partially Spent
14	F	2100	558	5		Green	M	900	465			Ripe
15	M	1000	427	4		Ripe	F	1000	474	4		Ripe
16	M	1000	429	4		Ripe	M	900	458	5		Ripe
17	M	1300	463	4		Ripe	F	1700	535	5		Ripe
18	F	1300	496	4		Ripe	M	1100	463	5		Ripe
19	F	1100	457	5	1	Ripe	M	800	440	4		Ripe
20	M	1100	438	5	1	Ripe	M	700	453	4		Ripe
21	M	900	403	4		Ripe	M	600	407	4		Ripe
22	M	900	453	4		Ripe	M	1100	489	5	1	Ripe
23	F	1700	507	4		Ripe	M	600	398	4		Ripe
24	F	1400	476	5	1	Ripe	M	800	455	4		Ripe
25	M	1100	463	4		Ripe	M	900	454	5		Ripe
26	M	900	425	4		Ripe	M	700	450	4		Ripe

02JUN98						04JUN98						
Fish_ID	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition
1	M	1600	523	5	1	Green	F	800	480	4		Green
2	F	1550	541	5	1	Ripe	M	700	456	4		
3	M	850	479	4		Ripe	M	700	414	3		
4	F	1500	533	5		Ripe	F	1100	465	4		Ripe
5	M	1000	485	4		Ripe	M	800	456	4		
6	M	800	447	4		Ripe	M	900	462	5		
7	M	850	494	5		Ripe	M	800	430	5		
8	F	550	468	4		Ripe	F	1600	528	5		Spent
9	F	700	472	5	1	Green	M	800	432	4		
10	F	1300	515	4		Green	M	700	450	5		
11	M	150	453	4		Ripe	F	300	480	4		Spent
12	F	1250	515	4		Partially Spent						
13	M	750	468	4		Ripe						
14	M	800	446	4	1	Running Ripe						
15	F	1050	477	4		Green						
16	M	1050	466	4		Running Ripe						
17	M	950	495	5	1	Ripe						
18	F	1550	544	5		Green						
19	M	750	410	3		Running Ripe						
20	F	1600	538	5		Green						
21	M	550	412	4		Running Ripe						
22	M	950	450	4		Running Ripe						
23	F	1150	495	5		Partially Spent						
24	M	950	445	4		Running Ripe						
25	M	950	464			Ripe						

NOTE: SC = Spawning Check: 1 = Number of spawning checks present  
blank = no spawning checks observed  
U = undetermined; fish escaped prior to sex determination





Table 3. Age and percent repeat spawners (% RS) for all adult American shad processed at the Vernon Dam Fishway, Spring 1998.

	AGE CLASS						
	III		IV		V		III - V
	Total N	% RS	Total N	% RS	Total N	% RS	Total by Sex
Males	5	0.0	35	2.9	17	35.3	57
Females	0	0.0	13	0	14	28.6	27
Sex unknown					2		2
Total	5		48		33		86
overall percent repeat spawners		0.0		2.1		30.3	

Table 4. Comparison of adult American shad that passed the Holyoke, Turners Falls, and Vernon Fishways during 1995 - 1998. (Ken Cox VT. Dept. Fish and Wildlife - personal communication).

Year	Approximate number of shad passed at Holyoke	Approximate number of shad passed at Turners Falls	Approximate number of shad passed at Vernon
1995	190,000	18,912	15,771
1996	276,289	18,485	18,884
1997	298,000	9,216	7,384
1998	311,704	10,527	8,151

Table 5. Summary of sex composition, sex ratio, dominant age classes and total number of adult American shad passed at Turners Falls and Vernon Dam Fishway's from 1990 - 1995 and at Vernon Dam Fishway during 1997 - 1998.

Total Number Passed				Total Number Sampled		Sex Ratio		Dominant Age Classes																		
						Male : Female		Turners Falls Fishway						Vernon Dam Fishway												
Year	Turners Falls	Vernon Dam	Turners Falls	Vernon Dam	Turners Falls	Vernon Dam	No. Males/age class	III	IV	V	VI	No. Females/age class	III	IV	V	VI	No. males/age class	III	IV	V	VI	No. Females/age class	III	IV	V	VI
1990	27908	10894	314	465	86.0 : 14.0	90.5 : 9.5	43	123	59		20	10	43	141	42		14	22								
1991	54656	37197	192	395	87.0 : 13.0	87.1 : 12.9	65	69			8	9	123	120			13	23								
1992	60089	31155	192	275	73.4 : 26.6	78.9 : 21.1	42	89			24	26	75	128			37	14								
1993	10221	3651	179	190	53.6 : 46.4	71.1 : 28.9	34	53			42	32	48	68			30	22								
1994	3729	2681	112	168	69.6 : 30.4	77.2 : 22.8	30	35			10	22	47	70			10	22								
1995	18369	15771	100	334	80.5 : 19.5	85.8 : 14.2	41	38			10	4	116	122			29	28								
1997	9216	7384		85		63.1 : 36.9	**						9	33	10	1	11	18								2
1998	10527	8151		86		68.6 : 31.4				**			5	35	17		13	14								
Total	194715	116884	1089	1998	75.0:25.0	80.0:20.0	255	407	59		0	94	113	10	466	717	69	1	0	157	163					2
Avg.	24339	14611	136	250	75.0:25.0	78.0:22.0		3.6				4.7			3.9		4.6									

No Data collected in 1996 at Vernon Dam Fishway

\*(1 shad sex unknown)

\*\*Age of adult shad sampled at Turners Falls in 1998 not completed as of 4/15/99 (C. Slater personal communication).

Note: Data for 1990 - 1995 taken from Vermont Yankee/Connecticut River System Analytical Bulletin 57, although the total and average values appear to have been calculated wrong in Bulletin 57, and are re-calculated here.

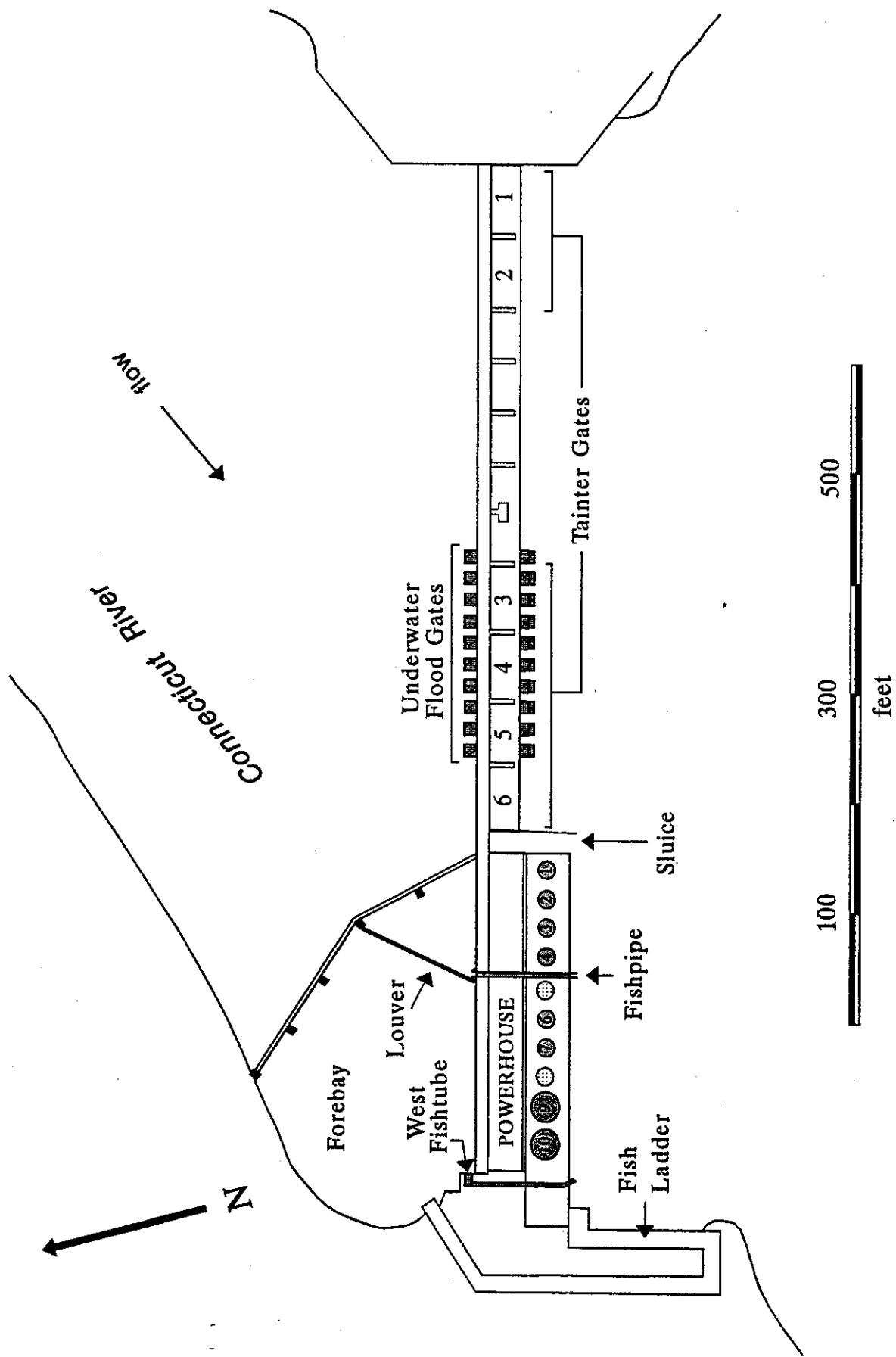


Figure 1. Plan view of the Vernon Project.

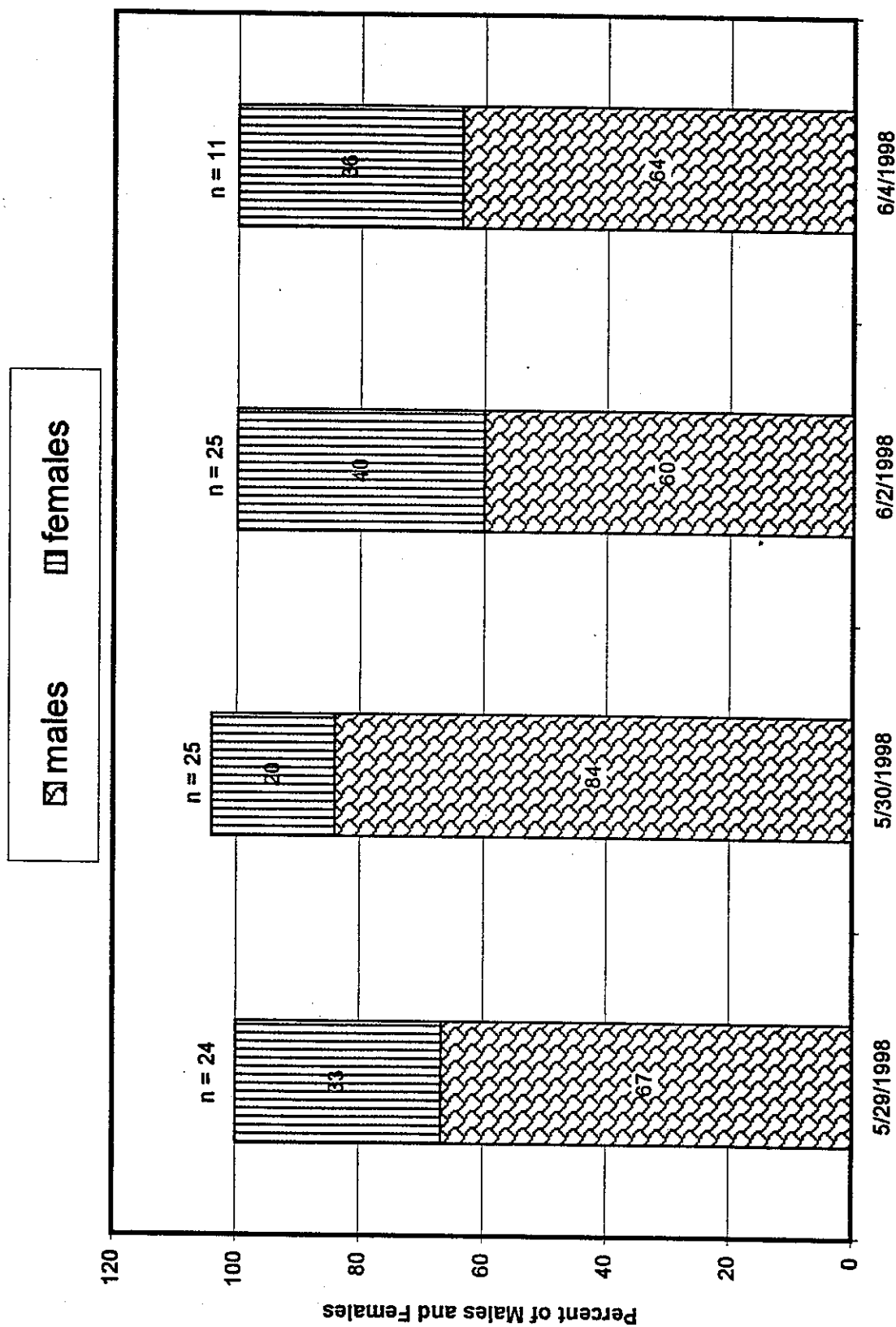


Figure 2. Percent sex composition by date, for all adult American shad processed at the Vernon Fishway, Spring 1998.

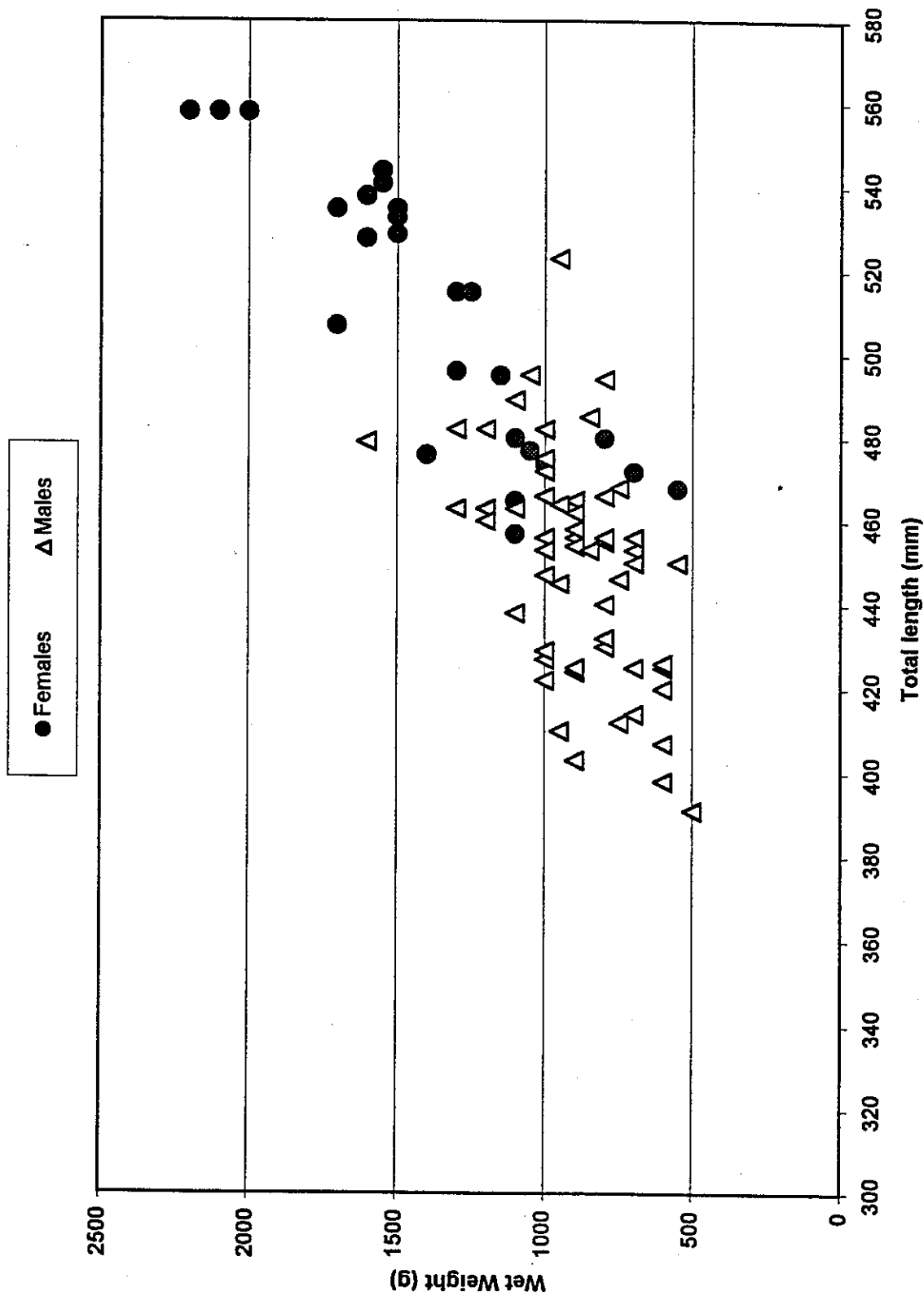


Figure 3. Length-weight plot of male and female adult American shad processed at the Vernon Fishway, Spring 1988.