

VERMONT YANKEE/CONNECTICUT RIVER SYSTEM  
ANALYTICAL BULLETIN 74

**Composition of Adult American Shad at the Vernon  
Hydroelectric Dam Fishway During Spring 1999**

NORMANDEAU ASSOCIATES, INC.  
224 OLD FERRY ROAD  
BRATTLEBORO, VT &  
25 NASHUA ROAD  
BEDFORD, NH

DRAFT BULLETIN PREPARED  
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## ABSTRACT

Two hundred twelve adult American shad (out of a total of 5,083 passed) were collected from the Vernon Dam Fishway on 27 and 28 May, 1 through 4 June, and 7 and 8 June 1999. Males dominated the collections from each of the eight samples collected, and overall, constituted 75% of the fish sampled. Ninety-three percent of the adults sampled at the Vernon Fishway were age III, IV, and V (20%, 46%, and 27%, respectively). Male shad composition was dominated (49%) by age IV fish, and females at age V were more abundant (40%) followed by age IV females (37%). Repeat spawning was evident in 5.32% of the age IV adults, 31.58% of the age V adults, and 62.5% of the age VI adults sampled at the Vernon Fishway. The 1999 results are consistent with surveys conducted at the Vernon Fishway between 1990 and 1995, as well as 1997 and 1998. There were no adult shad sampled at Vernon in 1996. The slight inter-annual differences seen among American shad age and sex ratios are typical of natural variation in 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, 70, and 72), and agreed to continue monitoring adult American shad during the 1999 spawning migration.

As part of the 1999 objective-specific studies of the Vermont Yankee Nuclear Power Station'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 1999 spawning run. We determined the size, sex ratios, sexual condition, and age structure for a sample of American shad collected during the 1999 spawning run to contribute to a long term database for evaluating the impacts, if any, of the Vermont Yankee Station 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 Station. The Fishway operated between 14 May and 30 June 1999. Beginning on 19 May through 30 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 27 and 28 May, and 1 through 4 June and 7 and 8 June 1999 at the Fishway. American shad were randomly trapped by Vermont Department of Fish and Wildlife employees and processed by Normandeau Associates, Inc. (Normandeau) biologists. After 8 June 1999, 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 by applying pressure ventrally and posterior to the pelvic fins and observing the release of eggs or milt from the

vent.

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.

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. Annulus enumeration was conducted independently by two Normandeau biologists, utilizing a Bausch and Lomb microprojector with 20 - 40X magnification. Both biologists determined age and repeat "spawning checks" on scales to identify previously spawned shad. In cases where the biologists disagreed on age or repeat spawning status, the scale in question was reviewed by both biologists together. 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.

Water temperature in the Fishway was continuously recorded (at 15-min intervals) during the sampling period by a WaDaR™ temperature logger.

## RESULTS

Two hundred twelve (4.2%) of the 5,083 total adult American shad passed at the Vernon Fishway in 1999 were sampled and processed during the eight sampling events (Table 1). The Vernon Fishway passed 75% of the total American shad estimated to have passed the Turner's Falls Fishway.

Water temperature in the Fishway ranged from 15.2 – 24.3°C over the eight sampling events. The Fishway maintained a continuous flow of 65 cfs during the period of operation. Attraction flow of an additional 200 cfs was supplied to the Fishway from the forebay during the daytime period of operation (0600 – 2000 DST, Earl Brissette PG&E Generating, personal communication). Total river flow at Vernon Dam ranged from 3,595 – 9,321 cubic feet per second over the eight sampling dates.

The sexual condition of 211/212 adults was determined. The scale samples collected from six shad included all regenerated scales, from which age could not be determined. Males dominated the collections from each of the eight sample dates, constituting 75% of all collected shad for which sex was determined (i.e.,  $n = 211$ , Figure 2). On all sample dates, males constituted more than 67% of the catch and on 3 June, males constituted 88% of the catch. Of the males for which sexual condition was determined ( $N = 141$  males), 49% were sexually running ripe, 41% ripe, 3.5% partially spent, and the remainder were green or spent (Table 2). Male shad ranged in weight from 400 – 1300 g and in length from 357 - 497 mm (Figure 3). Male shad were generally smaller in length and weight than females (Figure 3). Female shad ranged in weight from 800 – 1900g and in length from 448 – 543 mm (Figure 3). The sexual condition of the females sampled ( $N = 51$ ) over the eight dates, was 57% green, 25% partially spent, 7.8% ripe, 7.8% spent, and 2.4% running ripe (Table 2).

The age of 206 of the 212 adult shad processed was determined. Forty-six percent of the 206 adult shad from the Vernon Fishway were age IV, followed by 27% that were age V, and 20% that were age III (Table 3).

The age composition of males processed at the Vernon Fishway was dominated (49%) by age IV, followed by 25% age III and 23% age V males (Table 3). The remaining 2% comprised age VI males (Table 3). Forty percent of the female adult shad were age V followed by 37% age IV, 12% age VI, 8% age III, and 2% age VII (Table 3).

Fourteen percent (28/206) of sampled shad for which age was determined were repeat spawners. Repeat spawning was evident in 5% of the age IV adults, 32% of the age V adults, and 44% of age VI adults (Table 3). Repeat spawning was evident in 5% of age IV females and 3.8% of age IV males (Table 3). There was no evidence of spawning checks on the scales of age III males or 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 during 1997, 1998, and 1999 (Normandeau 1998, 1999, and 2000, respectively). 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 and 75% of the total

passed at Turners Falls also passed Vernon Dam in 1999. Comparisons of total adult shad passed at Holyoke, Turners Falls, and Vernon Fishways from 1995 - 1999 show a noticeable drop in the number of shad immigrating from Holyoke to Turners Falls (Table 4). In 1999 and 1997 a large majority (75 and 80%, respectively) of the shad that passed Turners Falls also passed Vernon Dam. The percentage was slightly lower (65%) in 1998 (Table 4).

The percentage of male adult American shad sampled at the Vernon Fishway in 1999 was slightly higher (75%) than that reported in 1998 and 1997 (69% and 63.1%, respectively) and similar to the percentage of males reported during 1990-1995. The range during 1990-1999 was 63 - 91 % males; the mean was 77% (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). During 1999 forty females were age IV and V, four females were age III, six were age VI, and one female was age VII.

The 1999 adult shad data appear to be consistent with previous years summarized data with respect to number of adults passed, sex ratios, age, repeat spawning, and the general trends seen in passage between Holyoke and Vernon Dams.

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Table 1. Listing of all adult American shad processed at the Vernon Fishway, spring 1999.

DATE												
27MAY99							28MAY99					
Fish ID	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition
1	M	600	400	3		Ripe	M	850	468	3		Ripe
2	M	850	456	5	1	Ripe	M	700	447			Running Ripe
3	F	1900	515	3		Partially Spent	M	650	416	3		Green
4	M	900	456	4		Partially Spent	F	1200	496	5		Partially Spent
5	M	1500	530	4		Partially Spent	F	1400	524	4	1	Partially Spent
6	M	900	468	4		Ripe	M	800	457	4		Running Ripe
7	M	1050	472	4		Ripe	M	600	449	4		Running Ripe
8	M	900	471	4		Ripe	M	850	462	3		Running Ripe
9	M	800	439	4		Ripe	M	700	440	4		Running Ripe
10	M	1100	477	5	1	Ripe	F	1000	474	4		Green
11	M	900	411	3		Ripe	M	950	441	3		Ripe
12	M	800	461	5	1	Ripe	M	1000	468	4		Ripe
13	M	900	430	4		Ripe	M	800	426	3		Running Ripe
14	F	1100	485	4		Partially Spent						
15	M	800	431	5		Ripe						
16	M	1250	476	5		Ripe						
17	F	1100	482	5	1	Green						
18	F	1500	522	6	1	Ripe						
19	M	950	456	4		Ripe						
20	F	1000	473	5		Partially Spent						
21	F	1100	460	4		Partially Spent						
22	M	900	461	4		Ripe						
23	M	800	422	5		Ripe						

(CONTINUED)

NOTE: SC = Spawning Check: 1=Number of spawning checks present, blank = no spawning checks observed.

Table 1. Listing of all adult American shad processed at the Vernon Fishway, Spring 1999.

DATE												
01JUN99						02JUN99						
Fish ID	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition
1	M	600	435	3		Running Ripe	F	1100	513	5		Green
2	M	750	446	4		Running Ripe	M	1000	470	4		Ripe
3	F	1100	489	3		Partially Spent	F	900	476	4		Green
4	M	500	433	4		Ripe	M	800	433	3		Ripe
5	F	1100	490	5		Green	M	900	442	4		Ripe
6	M	850	456	4		Running Ripe	M	900	448	3		Ripe
7	M	700	445	4		Ripe	F	1500	497	4		Green
8	F	1450	511	5		Green	F	1400	513	5		Green
9	M	950	460	4		Ripe	M	800	427	4		Ripe
10	M	950	496	5	1	Ripe	M	1100	492	5		Running Ripe
11	M	600	444	3		Running Ripe	M	800	434	3		Ripe
12	F	1100	503	5		Green	F	1100	494	4		Green
13	M		475	3		Running Ripe	M	1000	478			Running Ripe
14	M	750	461	4		Running Ripe	M	900	453	4		Ripe
15	M	850	450	4		Running Ripe	M	1100	493	5		Running Ripe
16	F	1450	509	6	1	Green	M	900	447	4		Ripe
17	M	750	435	3		Running Ripe	F	1400	513	5		Green
18	M	1000	466	4		Ripe	F	1400	510	6	1	Green
19	M	800	450	5	1	Ripe	M	800	433	3		Running Ripe
20	M	1000	470	5		Ripe	M	900	446	4		Running Ripe
21	F	1400	514	4		Green	F	1400	485	6		Green
22	M	850	451	5		Ripe	M	600	370	3		Running Ripe
23	M	500	371	3		Ripe	M	1100	481	5		Running Ripe
24	M	1000	476	4		Ripe	M	800	433	4		Running Ripe
25	M	1000	449	5		Ripe	M	900	436	4		Ripe
26	M	800	453	4		Ripe	M	1000	460	5	1	Running Ripe
27	M	900	460	4		Ripe	F	1500	471	5		Green
28							M	700	426	5		Running Ripe
29							M		450	4		Running Ripe
30							M	900	461	3		Running Ripe
31							F	1600	517	5	1	Ripe
32							M	900	431	5		Running Ripe
33							M	1000	451	4		Ripe
34							M	1100	453	5		Running Ripe
35							F	1400	485	4		Green
36							M	1100	483	4		Running Ripe
37							M	800	431	5		Ripe
38							M	1000	447	4		Ripe
39							M	800	457	4		Ripe
40							M	1000	452	6		Ripe
41							M	800	425	4		Ripe
42							M	1100	461	4		Ripe
43							M	800	417	5	1	Ripe
44							M	900	438	3		Ripe
45							M	900	462	5	1	Ripe
46							M	900	457	5		Ripe
47							F	1200	500	5	1	Partially Spent
48							M	800	437	4		Ripe
49							M	900	447	4		Ripe
50							M	800	426	4		Ripe
51							M	700	402	3		Ripe
52							M	800	456	4		Ripe

(CONTINUED)

NOTE: SC = Spawning Check: 1=Number of spawning checks present, blank = no spawning checks observed.

Table 1. Listing of all adult American shad processed at the Vernon Fishway, Spring 1999.

DATE												
03JUN99						04JUN99						
Fish ID	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition
1	M	800	446	4	1		F	1100	490	4		Green
2	F	1500	523			Green	M	700	446	3		Running Ripe
3	M	900	457	4			M	1000	486	5		Running Ripe
4	M	1200	465	5	1	Green	M	600	416	3		Running Ripe
5	M	800	441	4			M	1000	456	4		Running Ripe
6	M	900	478	3			F	900	459	4		Partially Spent
7	M	700	407	4			F	1200	514	4		Green
8	M	900	434	4			F	1500	519	5		Green
9	M	900	448	4			M	800	461	4		Running Ripe
10	M	900	474	4			F	1100	486	5	1	Green
11	M	1000	462	4			M	900	463	5		Running Ripe
12	M	800	447	4			M	1000	463	4		Running Ripe
13	M	800	436	4			F	900	463	3		Green
14	F	1400	492	5		Green	M	800	451	3		Running Ripe
15	M	800	423	3			M	1000	461	4		Running Ripe
16	M	1100	451	5			M	800	435	4	1	Running Ripe
17	M	1000	453	5			M	1000	471	4		Running Ripe
18	M	1300	497	5			F	900	472	3		Partially Spent
19	F	1500	512	5	1	Green	M	700	444	3		Running Ripe
20	M	1000	453	5	1		M	800	439	5		Running Ripe
21	M	800	423	3			F	1000	484	5		Partially Spent
22	M	800	450	5			M	1100	485	4		Running Ripe
23	M	1100	453	4			M	700	421	3		Running Ripe
24	M	800	424	4			M	800	437	3		Running Ripe
25							F	1000	506	4		Partially Spent
26							M	800	435	3		Running Ripe
27							M	700	426	3		Running Ripe

07JUN99						08JUN99						
Fish ID	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition	Sex	Weight (g)	Length (mm)	Age	SC	Sexual Condition
1	F	1400	520	6	1	Green	M	600	451	5	1	Running Ripe
2	F	1200	489	4		Green	M	800	486	4		Running Ripe
3	F	1100	490	4		Spent	F	1300	535	5	1	Ripe
4	M	1100	460	5	1	Running Ripe	F	900	484	4		Spent
5	M	900	460	3		Running Ripe	M	400	384	3		Running Ripe
6	M	700	423	4		Running Ripe	M	600	444	4		Running Ripe
7	F	1100	464	5		Ripe	M	900	497			Partially Spent
8	M	400	357	3		Running Ripe	M	700	442	5		Ripe
9	M	1100	478	6	1	Running Ripe	M	800	447	4		Ripe
10	F	1600	515	6		Green	F	1700	543	5		Spent
11	M	1100	463	4		Spent	M	700	440	4		Running Ripe
12	M	1000	488	4		Running Ripe	M	900	490	4	1	Running Ripe
13	M	800	430	4		Spent	F	800	463	4		Spent
14	M	900	469	4		Running Ripe	M	800	468	4	1	
15	M	900	454			Running Ripe	M	900	440	5		Running Ripe
16	M	900	457	4		Spent	M	900	455			Running Ripe
17	F	1900	542	7		Partially Spent	M	800	430	3		Running Ripe
18	M	800	453	3		Running Ripe	M	800	457	4		Spent
19	M	1000	462	4		Running Ripe	M	700	420	3		Partially Spent
20	F	1500	448	4		Green	F	1700	524	5		Running Ripe
21	M	900	454	4		Spent	M	800	430	4		Running Ripe
22	M	800	421	3		Running Ripe	M	1000	475	5		Partially Spent
23	M	900	464	3		Spent	M	700	414	4		Running Ripe

NOTE: SC = Spawning Check: 1=Number of spawning checks present, blank = no spawning checks observed.

Table 2. Summary of adult American shad sexual condition over four sampling dates at the Vernon Fishway, May -- June 1999.

	SAMPLING DATE											
	27-May-99				28-May-99				1-Jun-99			
Sexual Condition	N	N	Sample	Percent	N	N	Sample	Percent	N	N	Sample	Percent
	males	females	Total	of sample	males	females	Total	of sample	males	females	Total	of sample
Green	0	1	1	4.3	1	1	2	15.4	0	5	5	18.5
Ripe	15	1	16	69.6	3	0	3	23.1	13	0	13	48.1
Running Ripe	0	0	0	0.0	6	0	6	46.2	8	0	8	29.6
Partially Spent	2	4	6	26.1	0	2	2	15.4	0	1	1	3.7
Spent	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0

	SAMPLING DATE											
	3-Jun-99				4-Jun-99				7-Jun-99			
Sexual Condition	N	N	Sample	Percent	N	N	Sample	Percent	N	N	Sample	Percent
	males	females	Total	of sample	males	females	Total	of sample	males	females	Total	of sample
Green	1	3	4	100.0	0	5	5	18.5	0	4	4	17.4
Ripe	0	0	0	0.0	0	0	0	0.0	0	1	1	4.3
Running Ripe	0	0	0	0.0	18	0	18	66.7	11	0	11	47.8
Partially Spent	0	0	0	0.0	0	4	4	14.8	0	1	1	4.3
Spent	0	0	0	0.0	0	0	0	0.0	5	1	6	26.1

Table 3. Age and percent repeat spawners (% RS) for all adult American shad processed at the Vernon Dam Fishway, May - June 1999.

	AGE CLASS									
	III		IV		V		VI		VII	
	Total N	% RS	Total N	% RS	Total N	% RS	Total N	% RS	Total N	Total by Sex
Males	39	0.0	74	4.1	36	33.3	2	50.0	0	151
Females	4	0.0	19	5.3	21	28.6	6	66.7	1	51
Sex undetermined			1	100.0						1
Total	43		94		57		8		1	203
overall percent repeat spawners		0.0		5.3		31.6		62.5		0.0

Table 4. Comparison of adult American shad that passed the Holyoke, Turners Falls, and Vernon Fishways during 1995 through 1999. (Ken Cox VT. Dept. Fish and Wildlife, and Jan Rowan USFWS - 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
1999	193,782	6,756	5,083

Table 5. Summary of sex composition, sex ratios, dominant age classes, and total number of adult American shad passed at Turners Falls from 1990 through 1995 and passed at Vernon Dam from 1990 through 1999. Biocharacteristics data from the American shad passing at the Turners Falls Dam was not available after 1995 (Caleb Slater, personal communication).

Year	Total Number		Sex Ratio		Dominant Age Classes													
	Passed		Male : Female		Turners Falls Fishway							Vernon Dam Fishway						
	Sampled				No. Males/age class				No. Females/age class			No. males/age class				No. Females/age class		
	Turners Falls	Vernon Dam	Turners Falls	Vernon Dam	III	IV	V	VI	III	IV	V	VI	III	IV	V	VI	VII	
1990	27908	10894	314	465		43	123	59				20	10	43	141	42		
1991	54656	37197	192	395		65	69					8	9	123	120		14	22
1992	60089	31155	192	275		42	89					24	26	75	128		13	23
1993	10221	3651	179	190		34	53					42	32	48	68		37	14
1994	3729	2681	112	168		30	35					10	22	47	70		30	22
1995	18369	15771	100	334		41	38					10	4	116	122		10	22
1997	9216	7384	0	85										9	33	10	29	28
1998	10527	8151	0	86										5	35	17	11	18
1999	6756	5083	0	212										39	74	36	13	14
Total	201471	121967	1089	2210	75.0:25.0	255	407	59	0	94	113	10	10	505	791	105	4	176
Avg	22386	13552	121	246	75.0:25.0	3.6				4.7				4.0				4.7

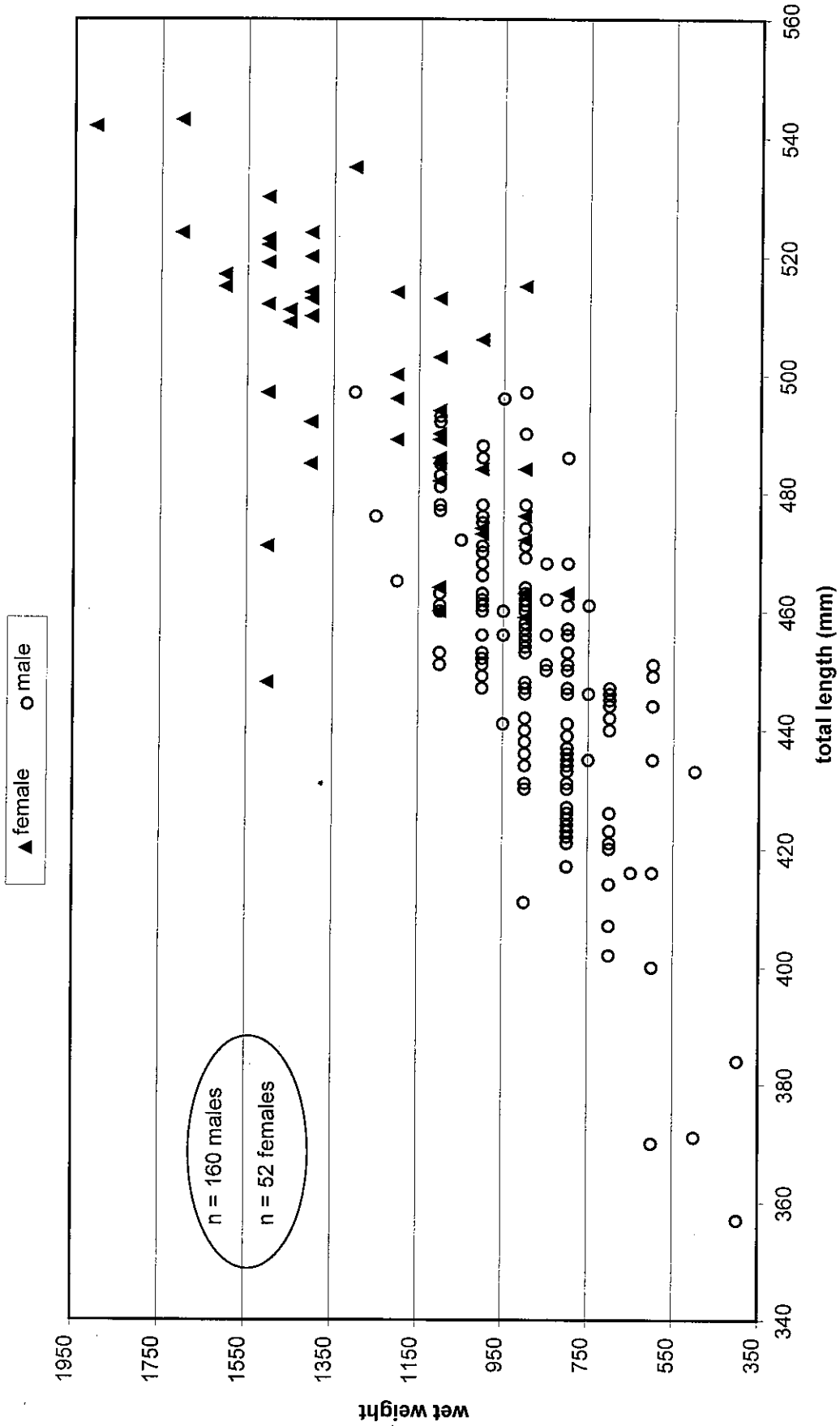


Figure 3. Length-weight plot of male and female adult American shad processed at the Vernon Fishway, May - June 1999.



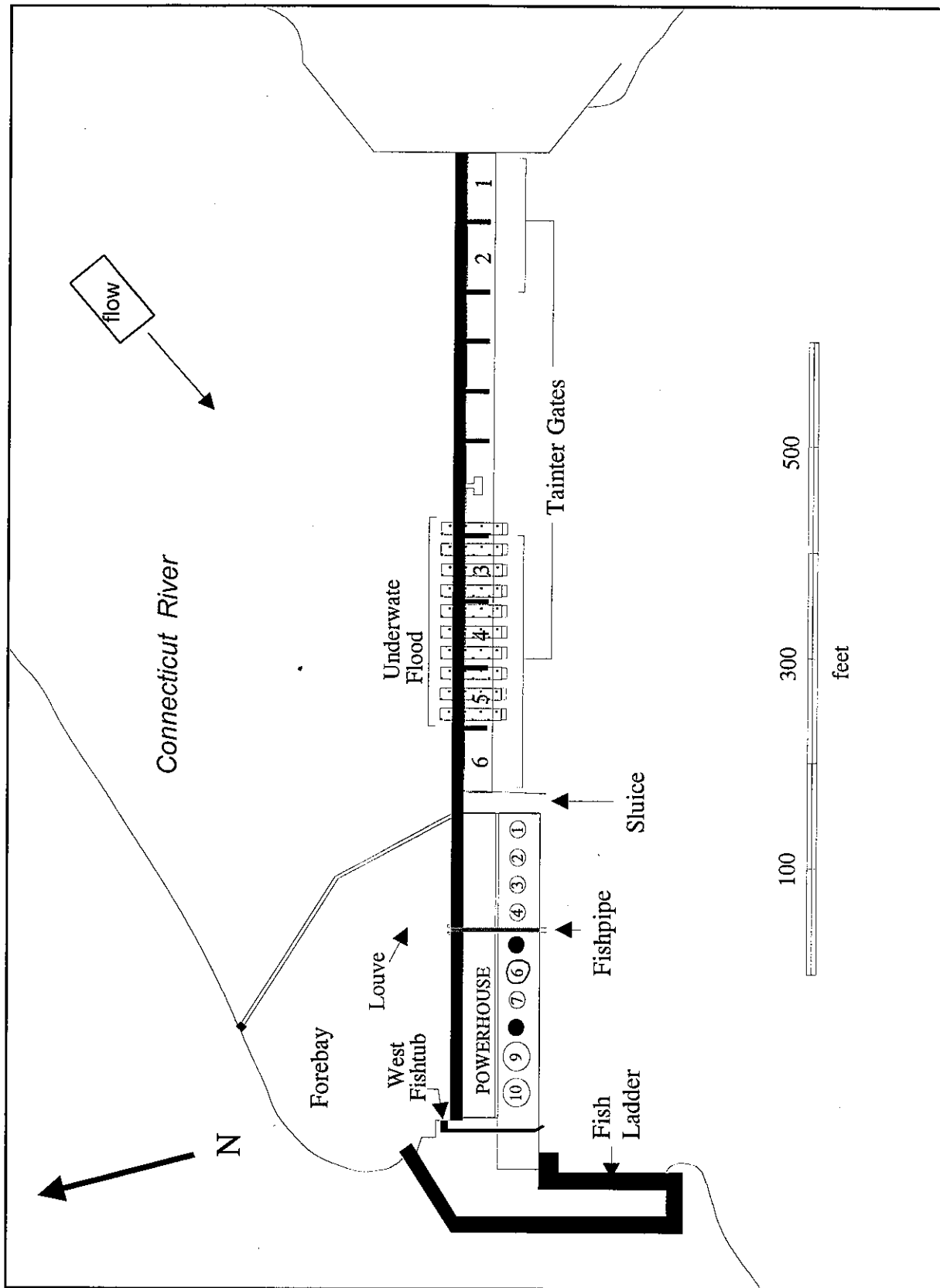
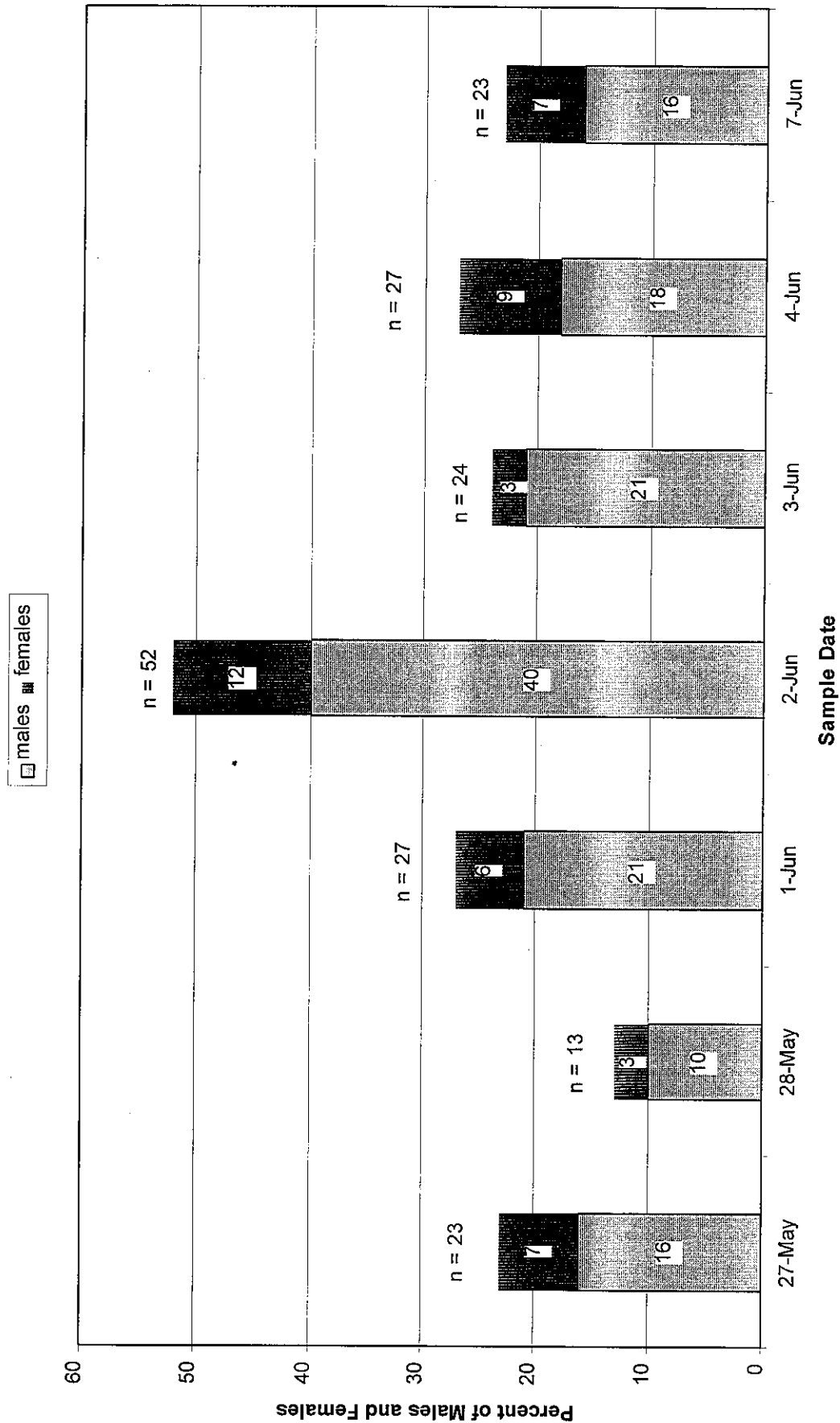


Figure 1. Plan view of the Vernon Project.



**Figure 2. Percent sex composition by date, for all adult American shad processed at the Vernon Fishway, Spring 1999.**