Texas Water Resources Institute
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Aquatic Studies at the Proposed George Parkhouse I Reservoir Site on the South Sulphur River in Northeast Texas

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P.O. Box 13231, Capitol Station
1700 N Congress Avenue
Austin, Texas 78711-3231

By

Frances P. Gelwick
Christine C. Burgess

Department of Wildlife and Fisheries Sciences
Texas A&M University

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1.0 INTRODUCTION

George Parkhouse I was identified as a potential reservoir site by the Texas Water Development Board (1997) for construction on the South Sulphur River in northeast Texas. This aquatic survey of a future reservoir site is designed to provide information about the stream fishes upstream and downstream of the proposed dam for instream flow assessment. In addition, this information will be used to identify the fish assemblages and habitat associations in the unchannelized as well as the presently channelized and diverted South Sulphur River for consideration of mitigation. The instream flow assessment is habitat oriented to determine the relationship between habitat availability and habitat utilization at different flows within the normal flow regime of the stream. Published studies of fish surveys of the Sulphur River can be found in Bonn and Inman (1955), Carroll et al. (1977), and Turner (1978). A comprehensive list of fish species known from museum records for the Sulphur River basin can be found in Travis et al. (1994).

The goals of this study were: 1) map, photograph, and assess habitats, 2) measure ambient water quality parameters, 3) report the abundance of fishes of each species collected in each habitat at each of three sample sites upstream (unchannelized reach) and three sample sites downstream (channelized reach) of the proposed reservoir, 4) evaluate the relative health of sites using an Index of Biotic Integrity (Karr et al. 1986) that was regionalized for use in Texas streams (Linam and Kleinsasser 2002), and 5) identify instream habitats based on the relative abundance of fishes sampled using an indicator species analysis (Dufrêne and Legendre 1997).

2.0 STUDY AREA

The Sulphur River Basin is located in northeast Texas and covers approximately 9100 km^2. The river starts as three forks, the North, Middle, and South Sulphur Rivers, which eventually all come together to form the main stem of the Sulphur River. Jim Chapman Lake (formerly known as Cooper Lake) was impounded on the South Sulphur River, and Wright Patman Lake was impounded on the main stem just west of the Texas-Arkansas border. The Sulphur River flows eastward into Arkansas, where it enters the Red River. The western half of the basin comprises the Texas Blackland Prairie ecoregion consisting of clay and semipermeable soils. The eastern half comprises the South Central Plains ecoregion, consisting primarily of sandy soils (Omernik 1987). The basin is located in a rural area comprised primarily of farmland and pastures. Crops grown include cotton, soybeans, grain sorghum, corn, wheat, peanuts, alfalfa, and hay. Livestock raised are generally cattle and poultry (Ressel 1979).

The upper half of the Sulphur River Basin was extensively channelized in an attempt to alleviate frequent flooding of the surrounding farmland. The entire North Sulphur River and a small section of the upper main stem were channelized in the 1930's. In the 1950's the lower third of the South Sulphur River was channelized, straightened, and redirected north of its original location. The old channel of the South Sulphur River still exists, but it is dry for much of the year with a levee currently blocking any connection to the new channel.

Unchannelized areas of this stream typically contain spatially heterogeneous habitats varying in width, depth, and velocity that generate habitats such as pools, riffles, runs, and backwaters. Unchannelized areas without levees contain tributaries and oxbow lakes, which provide habitats for different life-history stages of many riverine fishes. In contrast, channelized reaches of the South Sulphur River have straighter channels and relatively uniform depth and velocity countours contributing to fairly homogenous habitat characteristics. At low flows these areas consist primarily of pool habitats, and at higher flows mainly run habitats. Levees constructed along the channelized reach have cut off several connections between the main stem and its tributaries, as well as reduced the frequency of natural floods needed to inundate oxbow lakes and maintain floodplain habitats that once were common landscape features of this drainage.

Six sites were chosen (figure 1a) based on their accessibility and characteristics representative of the river reach. Habitats within each site were categorized based on hydraulic characteristics into one of 4 mesohabitat types (pools, runs, riffles, and backwater areas). Definitions for mesohabitats are as follows: pools may vary in depth and be flowing, but have a smooth surface; runs vary in depth but generally up to 50% of their water surface is turbulent, or wavy, whereas in riffles >50% of the surface is turbulent (Jowett 1993); and backwaters have little or no flow, and are still connected, but adjacent to the main channel. Site length was equivalent to 20 times the wetted stream width at base flow, which encompassed the variety of habitat types within each reach.

Sites 1-3 were selected in the unchannelized reach upstream of the proposed dam. The site lengths for this reach ranged from 140 to 160 m, and the mesohabitat types included pools, riffles, runs, and backwater areas. Access to sites within the unchannelized reach was from the bridge crossing of State Highway 19 over the South Sulphur River near Cooper, Texas, where USGS gage station #07342500, used for discharge measurements, was located.

Sites 4-6 were selected in the channelized reach downstream of the proposed dam. The site lengths for this reach range from 170 to 190 m, and the habitat types were pools with a few runs. Access to the channelized reach was from the bridge crossing of State Highway 37 over the main stem of the Sulphur River near Hagansport, Texas.

3.0 METHODS AND MATERIALS

3.1 Seasons and flows

Two seasonal intervals were selected for sampling; a summer season (April-October) with lower flows and warmer water temperatures, and a winter season (November-March) with higher flows and cooler water temperatures. Fish community assessment was distributed across the normal to low flow conditions in the river based on percentile flows provided by the Texas Water Development Board. Sampling was targeted for the following three flow regimes in each season: 50th-30th percentile (high), 30th-15th percentile (middle), and < 15th percentile (low). Summer season target flow ranges were 200-20 cfs (high), 11-20 cfs (middle), and < 11 cfs (low). Winter season target flow ranges were 600-200 cfs (high), 200-20 cfs (middle), and < 20 cfs (low).

3.2 Habitat assessment and identification

Latitude and longitude for each site was recorded using a Global Positioning System (GPS) (Table 1). Maps were sketched and representative microhabitats were photographed for each site during the study. Four mesohabitats and seven microhabitat types were distinguished during the study period. Mesohabitats were pools, riffles, runs, and backwaters. Microhabitats were bank snags, channel snags, snag complexes, undercut banks, rootwads, rip rap, and debris dams. Typically, only woody habitats that appeared to be permanent were selected for repeated sampling and mapping.

3.3 Fish collection

All representative mesohabitat and microhabitat types present at a site were sampled for fish, using a variety of gear types, including seines, gillnets, and electrofishers. All sampling was conducted during daylight hours, except for gill nets left overnight. Straight seines of 5-mm mesh were 1.2 m deep and 2.4 m, 3.0 m, or 6.1 m long, as appropriate for the habitat sampled. One 38.1-m long experimental gillnet (five panels, each 7.6 m long x 1.8 m deep with 2.5, 3.8, 5.1, 6.3, and 7.6 cm bar mesh) was set at each site in deeper pools diagonally from bank to bank in an effort to maximize use of all panels. Pools for gill nets were chosen to be deep enough to permit the fullest possible extension of the net. Nets were fished for a minimum of 4 hours and a maximum of 22 hours. A 4.1 m aluminum jon boat powered by a 15 horsepower outboard motor was equipped for electrofishing with a Coffelt control box and a handheld probe, powered by a 3000 watt Honda generator. Direct current (DC) output was set at 200-350 V to achieve 3-5 A depending on conductivity. Electrofishing was conducted in an upstream direction.

Total fishing effort at a site continued until at least 20% of each available mesohabitat type was sampled (Vadas and Orth 1998), each microhabitat type present was sampled, and no new species were collected in 3 consecutive seine hauls or 3 consecutive 5 minute periods of electrofishing. Fishes greater than 100 mm were identified, counted, weighed (nearest 1 g), total length recorded (nearest 1 mm), and released in the field. Voucher specimens, and small or uncommon fishes were preserved in 10% formalin, transported to the lab for identification, and counted. Specimens transported to the lab were washed out of formalin, preserved in 70% ethyl alcohol, and deposited in the Texas Cooperative Wildlife Collection at Texas A&M University. Fish abundance was standardized by area (number of individuals per m^2) for all gear types.

3.4 Physicochemical parameters

At each study site on each collection date Temperature, conductivity, dissolved oxygen, and percent oxygen saturation were measured approximately 15 to 30 cm below the water's surface with a YSI Model 85 multiparameter meter. Mean daily discharges were obtained from USGS gage number 07342500 (South Sulphur River near Cooper, TX). Depths and velocities were measured just upstream of each microhabitat type present within a site during each sampling period. Depth (nearest 0.1 m) was measured using either a graduated wading rod or a Speedtech digital depth sounder (depth > 2 m). Velocity was measured at 0.6 depth with a Marsh-McBirney Model 2000 digital flowmeter. Coordinates for upstream and downstream boundaries were recorded for each site using a Garmin Etrex Global Positioning System.

3.5 Index of Biotic Integrity

To assess stream health Karr et al. (1986) proposed an Index of Biotic Integrity (IBI) based on fish community attributes. Because watershed characteristics and fish communities from the Sulphur River differ from those for midwestern headwater streams originally used by Karr et al. (1986), a regionalized adaptation was developed (Linam and Kleinsasser 2002). The IBI is used to determine the relative biological "health" of a stream by examining particular characteristics of a fish assemblage (Karr et al. 1986). Metrics used in the IBI analysis for representative streams in this ecoregion are in Linam and Kleinsasser (2002). Assignment of trophic status and intolerance/tolerance was based on Linam and Kleinsasser (1993). Gill net samples were eliminated from the IBI analysis because they were not used in the construction of the regionalized IBI metrics. Only those samples collected in July 2002 and August 2001 were used to compute the IBI because only samples made during June through September were used in creation of the regionalized metrics.

3.6 Habitat groups and indicator species

Data were standardized by calculating densities (# individuals per m^2 sampled) for each mesohabitat and an indicator species analysis was run using the software package PC-ORD (McCune and Mefford 1997). Indicator species analysis (Dufrêne and Legendre 1997) calculates the probablility that a species could indicate predetermined mesohabitat types (pool, riffle, run, backwater). It is based on the proportional abundance of the species in each habitat type and its proportional occurrence in all collections in each habitat type.

4.0 RESULTS AND DISCUSSION

4.1 Seasons and flows

Mean daily discharges measured at the USGS gage during the study period ranged from a low of 0.47 cfs to a high of 5760 cfs (Figure 1b). During summer season (May- October) sampling periods actual flow ranges were 521-114 cfs (high), 0.50-24 cfs (middle), and 8-9 cfs (low). During winter season (November-April) sampling periods actual flow ranges were 470-453 cfs (high), 106-22 cfs (middle), and 17-11 cfs (low). Due to high river discharges, the winter high flow sample had to be obtained in April, which was originally considered a summer flow. However, this allowed us the opportunity to sample fish during the beginning of spawning season.

4.2 Physicochemical parameters

Ambient water quality parameters for the summer season are given in Table 2 and for the winter season in Table 3. For all sites, water temperature ranged from 5.7 to 34.4 °C. Conductivity ranged from 103 to 629 µS/cm. Dissolved oxygen ranged from 5.0 to 13.0 mg/L, and the corresponding percent oxygen saturation ranged from 62.7 to 108.0 %. Part of the variation in oxygen and temperature measurements depended on cloud cover and time of day during sampling. Depths ranged from 0.04 to 2.3 m and velocities ranged from -0.08 to 0.69 m/s upstream from the microhabitats (Tables 4-9). Negative velocities indicate flow in an upstream direction. Generally, velocities associated with pools and backwater mesohabitats were slower than those associated with riffle and run mesohabitats. Pools averaged 0.04 m/s and backwaters -0.01 m/s, while riffles averaged 0.29 m/s and runs 0.21 m/s. The velocity measurements in this report reflect the value at the time for a representative microhabitat type in which fish were collected during a particular flow condition and season. This should be taken into consideration when interpreting our results and the flow models developed from measurements taken at a later time by the Texas Water Development Board.

Sketch maps of sample sites (Figures 2, 12, 23, 37, 48, and 54) are accompanied by photographs of individual microhabitats (Figures 3-11, 13-22, 24-36, 38-47, 49-53, and 55-65). The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat. Tables 4-9 display attributes associated with each individual microhabitat for each sampling period.

4.3 Fish species and microhabitat utilization

Table 10 lists the species and mesohabitat codes used in bubble graphs of fish species collected by mesohabitat type. Figures 66-101 are individual bubble graphs which display the total number of individuals for a site sampled during a particular season and a particular flow range. Figures 102-107 are composite bubble graphs for George Parkhouse I. Codes for species names and mesohabitat types are indicated on the axes. A total of 10,962 individuals representing 42 species and 13 families were collected from 4 mesohabitat types and 7 microhabitat types. Red shiners were most abundant (59%) followed by mosquitofish (10%) and bullhead minnows (9%).

4.4 Index of Biotic Integrity

Results for the 11 IBI metrics for the six sites are given in Table 11. The range of the possible total value for IBI metrics was that for the possible sum of the ranks (11-55). Sites 5 and 6 were tied for the highest overall score (50) and therefore the highest percentage (91%) of the maximum score. Site 3 had the lowest overall score (44) and therefore the lowest percentage (80%) of the maximum score. The overall scores for sites 1, 2, 3, and 4 fell within the high range for an overall rating, and sites 5 and 6 fell within the exceptional range.

The mean of the overall scores for the upstream sites 1, 2, and 3 (within the unchannelized reach) was 45.3 or 82.4% of the maximum score. The mean of scores for the downstream sites 4, 5, and 6 (within the channelized reach) was 48.3 or 87.9% of the maximum score. This is an interesting result given that the habitat of the downstream sites would appear to be degraded by channelization. Thus, the metrics which were most sensitive to generally recognized biological criteria (e.g., percentage of tolerant species) might not necessarily be correlated with those of habitat degradation. However, the difference between scores for the two groups of sites was small and not statistically significant (ANOVA, $F = 2.531$, $P = 0.187$).

4.5 Habitat groups and fish species indicators

Table 12 gives indicator values for fish species associated with each mesohabitat group.

42 species were entered for analysis as indicators of habitat types. Only five of those species were significant indicators. Bluegill indicated backwater areas. This is reasonable given that backwater areas are generally low velocity habitats frequently having large woody debris to provide cover, which this species prefers. Freckled madtoms indicated riffle mesohabitats. This species was collected at site 1 where a large amount of riffle habitat was present, and was usually absent at all other sites. River carpsuckers indicated pool mesohabitats. Longnose gar indicated pool mesohabitats. However, longnose gar were caught primarily by gill nets, which were set only in pools. Ghost shiners were indicated pool mesohabitat and were found exclusively in the downstream channelized reach. Pools were the most commonly encountered mesohabitat type. Very few species were indicators of a particular mesohabitat type, but the South Sulphur River contains mostly generalist species that use a variety of habitats.

4.6 Fish kills

Three fish kills were observed during the study period. The first occurred in May 2001 below Cooper Dam three months prior to the first sampling period. The primary species affected were stripped bass, white bass, buffalo, common carp, and gizzard shad. However, the cause and number of fish lost was unable to be determined (A. Whisenant, Texas Parks and Wildlife, personal communication). The second occurred in September 2001 between sampling periods. The primary species affected were reported to be bottom feeders including suckers (catastomidae) and freshwater drum. The source of the September kill was determined to be chemicals washed into the North Sulphur River during a storm and was estimated at 8,000 fishes (A. Whisenant, Texas Parks and Wildlife, personal communication). During our November 2001 samples, we caught very few of the affected species, particularly in sites 4, 5, and 6 that were near the confluence of the north and south forks of the Sulphur River. The last observed kill occurred in May 2002 when Cooper Dam was closed for maintenance. This caused the stilling pond to dry out, killed most of the fish in the area, and the carcasses were washed downstream (John Rael, U.S. Army Corps of Engineers – Cooper Dam, personal communication). Dead fish were observed only at the upstream sites (1-3). A wide range of species were affected including catfish, freshwater drum, white bass, stripped bass, bigmouth buffalo, smallmouth buffalo, gizzard shad, and white crappie (personal observation).

Table 1. Latitude and longitude coordinates for sampling sites on the South Sulphur River.

Site	River Reach	Upstream boundary	Downstream boundary
1	Unchannelized	N 33° 21.341'	N 33° 21.382'
		W 95° 35.661'	W 95° 35.520'
2	Unchannelized	N 33° 22.418'	N 33° 21.475'
		W 95° 35.382'	W 95° 35.284'
3	Unchannelized	N 33° 21.523'	N 33° 21.470'
		W 95° 35.209'	W 95° 35.103'
4	Channelized	N 33° 23.642'	N 33° 23.714'
		W 95° 22.889'	W 95° 22.721'
5	Channelized	N 33° 23.650'	N 33° 23.630'
		W 95° 21.927'	W 95° 21.808'
6	Channelized	N 33° 23.550'	N 33° 23.477'
		W 95° 21.664'	W 95° 21.439'

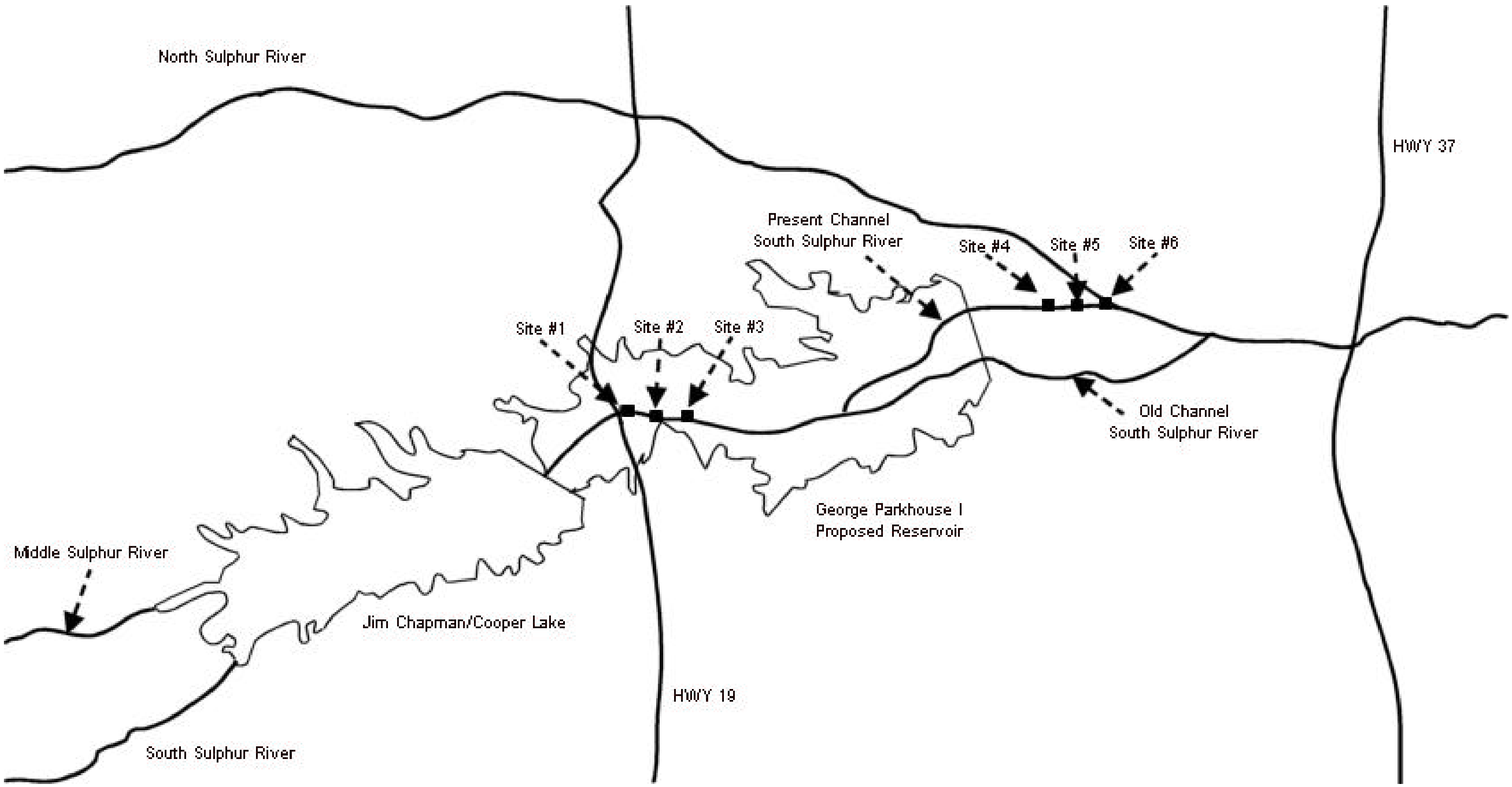

Figure 1a. Study area showing approximate locations of study sites in the South Sulphur River, TX.

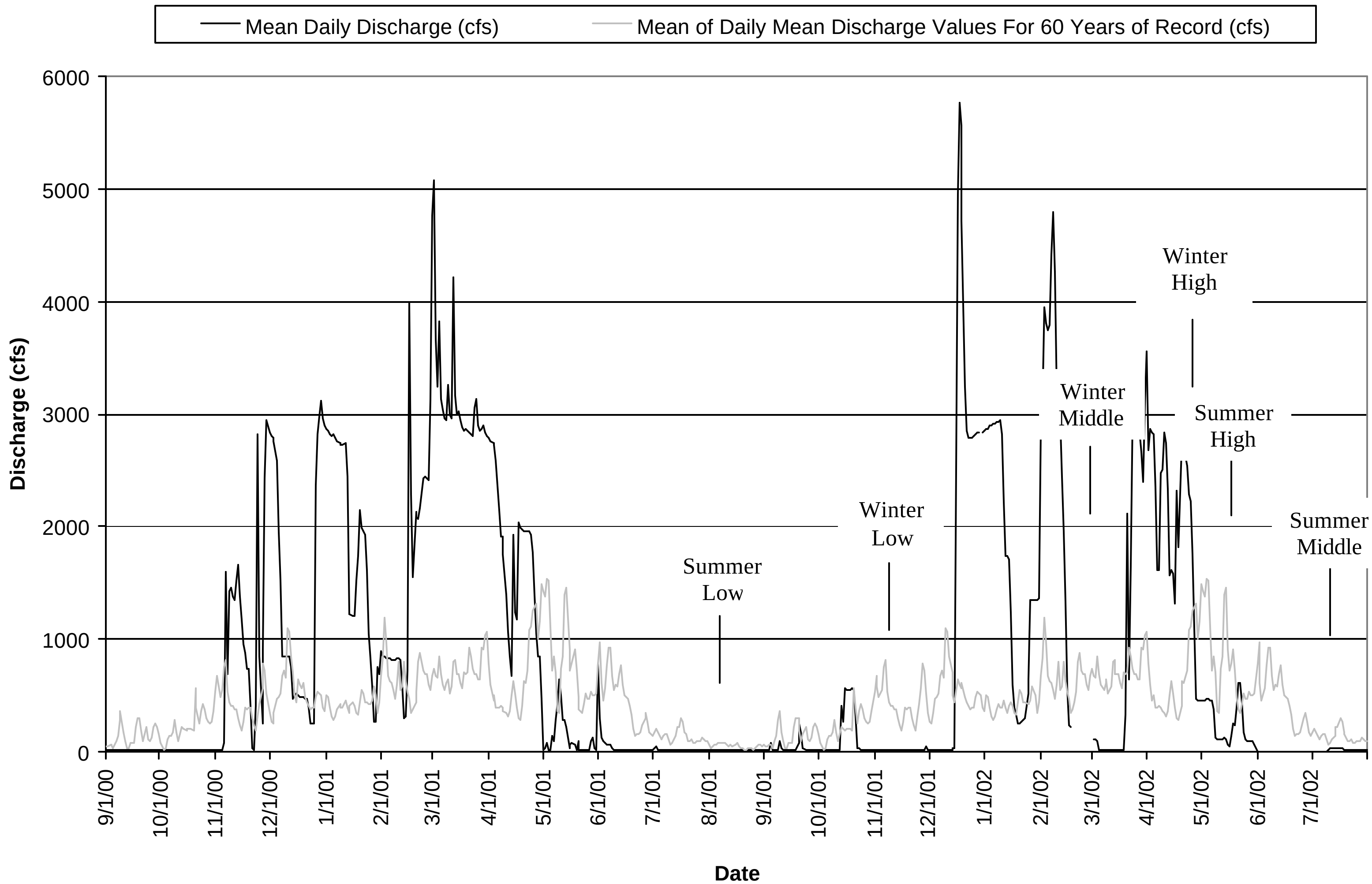

Figure 1b. Mean daily discharge recorded during the study period, 1 September 2000 – 31 July 2002, at USGS gauge 07342500 on the South Sulphur River near Cooper, TX.

Table 2. Physicochemical parameters for sites in the South Sulphur River during the summer season, May - October.

Site	Date	Mean Daily Discharge (cfs)	Temperature (EC)	Conductivity (ΦS/cm)	DO (mg/L)	% O_2 Saturation
1	4 Aug 2001	6.60	N/A[a]	N/A[a]	N/A[a]	N/A[a]
	18 May 2002	242	23.1	162	8.8	103.5
	9 Jul 2002	0.47	29.6	238	5.9	77.0
2	4 Aug 2001	6.60	N/A[a]	N/A[a]	N/A[a]	N/A[a]
	18 May 2002	242	23.4	165	8.9	105.1
	9 Jul 2002	0.47	31.1	243	6.1	82.5
3	4 Aug 2001	6.60	N/A[a]	N/A[a]	N/A[a]	N/A[a]
	18 May 2002	242	23.3	167	8.4	99.2
	9 Jul 2002	0.47	31.3	247	6.6	89.5
4	6 Aug 2001	6.10	34.4	384	5.7	69.1
	20 May 2002	392	22.5	167	8.4	96.4
	11 Jul 2002	22.0	31.5	556	5.0	62.7

Table 2. Continued.

Site	Date	Mean Daily Discharge (cfs)	Temperature (EC)	Conductivity (ΦS/cm)	DO (mg/L)	% O_2 Saturation
5	6 Aug 2001	6.10	N/A[a]	N/A[a]	N/A[a]	N/A[a]
	20 May 2002	392	22.8	171	8.9	97.6
	11 Jul 2002	22.0	31.7	619	5.2	72.1
6	6 Aug 2001	6.10	N/A[a]	N/A[a]	N/A[a]	N/A[a]
	20 May 2002	392	23.3	170.6	8.8	103.3
	11 Jul 2002	22.0	32.1	629	5.8	77.4

[a] Not measured due to instrument malfunction.

Table 3. Physicochemical parameters for sites in the South Sulphur River during the winter season, November - April.

Site	Date	Mean Daily Discharge (cfs)	Temperature (EC)	Conductivity (ΦS/cm)	DO (mg/L)	% O_2 Saturation
1	10 Nov 2001	9.60	17.5	164	8.1	84.9
	1 Mar 2002	N/A[a]	9.4	137	11.8	106.4
	28 Apr 2002	456	22.1	145	9.4	111.1
2	10 Nov 2001	9.60	17.8	191	8.7	92.5
	1 Mar 2002	N/A[a]	8.3	103	11.1	93.4
	28 Apr 2002	456	21.6	146	9.8	105.1
3	10 Nov 2001	9.60	18.1	166	9.0	96.8
	1 Mar 2002	N/A[a]	8.2	104	12.0	101.9
	27 Apr 2002	464	20.2	142	9.3	102.2
4	11 Nov 2001	8.60	16.4	216	8.7	89.4
	3 Mar 2002	101	5.9	116	12.7	98.2
	29 Apr 2002	451	21.6	154	9.0	102.1

Table 3. Continued.

Site	Date	Mean Daily Discharge (cfs)	Temperature (EC)	Conductivity (ΦS/cm)	DO (mg/L)	% O_2 Saturation
5	11 Nov 2001	8.60	17.2	229	8.8	86.4
	3 Mar 2002	101	5.9	121	13.0	108.0
	29 Apr 2002	451	21.9	157	8.8	103.2
6	11 Nov 2001	8.60	17.0	271	8.0	84.3
	3 Mar 2002	101	5.7	122	12.2	90.8
	29 Apr 2002	451	22.2	158	8.4	96.6

[a] No estimate available from USGS gage.

Table 4. Mesohabitats, microhabitats, estimated areas (m^2), depths (m), and velocities (m/s) for individual habitats located within the South Sulphur River during the summer high flow sampling period, 17-20 May 2002.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
1	N/A[a]	N/A[a]	N/A[a]	N/A[a]	N/A[a]	N/A[a]
2	2-B	run	rootwad	1	0.34	0.16
2	2-C	run	bank snag	4	0.32	0.11
2	2-O	run	rootwad	3	0.86	-0.08
3	3-L	backwater	bank snag	5	1.54	0.06
3	3-F	run	bank snag	8	0.49	-0.07
3	3-Q	run	bank snag	4	0.80	-0.05
3	3-C	run	rootwad	6	0.70	0.46
3	3-S	run	rootwad	5	1.20	0.03
3	3-B	run	rootwad	7	1.33	0.44
3	3-O	run	bank snag	10	0.59	0.20
3	3-G	run	bank snag	3	0.59	0.21
4	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]
5	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]
6	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]	N/A[b]

[a] No permanent structure encountered due to high flows.
[b] Not sampled due to equipment difficulties.

Table 5. Mesohabitats, microhabitats, estimated areas (m^2), depths (m), and velocities (m/s) for individual habitats located within the South Sulphur River during the summer middle flow sampling period, 8-12 July 2002.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
1	1-B	riffle	bank snag	3	0.18	0.20
1	1-C	riffle	bank snag	1	0.08	-0.06
1	1-D	riffle	bank snag	2	0.16	0.10
1	1-E	riffle	channel snag	16	0.21	0.37
1	1-G	riffle	bank snag	5	0.36	0.40
1	1-I	run	channel snag	5	0.20	0.23
1	1-J	run	bank snag	2	0.12	0.16
1	1-K	run	debris dam	7	0.18	0.05
1	1-M	pool	channel snag	4	1.31	0.07
2	2-B	pool	bank snag	3	0.68	0.03
2	2-D	run	bank snag	5	0.24	0.26
2	2-E	run	bank snag	16	0.08	0.11
2	2-F	run	bank snag	4	0.22	0.03
2	2-H	pool	bank snag	4	0.49	0.08
2	2-I	pool	bank snag	4	0.18	0.11
2	2-K	pool	bank snag	6	0.18	0.02
2	2-L	pool	bank snag	8	0.42	0.01
2	2-N	pool	bank snag	3	0.22	-0.01
3	3-B	pool	rootwad	4	0.54	0.04
3	3-D	run	bank snag	10	0.22	0.00
3	3-E	pool	bank snag	10	0.54	0.01
3	3-G	pool	bank snag	12	0.78	-0.01
3	3-H	pool	channel snag	4	0.54	0.05
3	3-I	pool	bank snag	1	0.30	-0.03
3	3-J	pool	bank snag	6	0.58	0.00
3	3-M	pool	bank snag	16	0.52	0.02

Table 5. Continued.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
3	3-N	run	bank snag	4	0.26	0.18
3	3-O	run	channel snag	9	0.24	0.12
4	4-A	pool	bank snag	16	1.28	0.03
4	4-B	pool	channel snag	4	1.21	-0.01
4	4-D	pool	undercut bank	1	0.48	0.02
4	4-J	run	rootwad	12	0.30	0.34
5	5-B	pool	rip rap	10	0.52	0.09
5	5-D	pool	rip rap	6	0.32	-0.04
5	5-F	pool	bank snag	7	0.88	0.19
5	5-K	pool	bank snag	10	0.70	0.04
5	5-L	pool	bank snag	7	0.30	0.04
5	5-M	pool	rootwad	2	0.38	0.10
5	5-N	pool	channel snag	6	1.00	0.06
5	5-R	pool	bank snag	8	0.31	0.14
5	5-S	pool	bank snag	4	0.32	0.16
6	6-A	pool	bank snag	2	0.34	0.02
6	6-B	pool	bank snag	6	0.24	-0.02
6	6-E	pool	bank snag	2	0.51	-0.04
6	6-H	pool	rootwad	6	0.43	0.04
6	6-K	pool	channel snag	8	0.82	-0.04
6	6-M	pool	bank snag	12	0.73	-0.02
6	6-O	pool	channel snag	3	0.62	-0.02
6	6-P	pool	bank snag	20	0.55	0.00

Table 6. Mesohabitats, microhabitats, estimated areas (m^2), depths (m), and velocities (m/s) for individual habitats located within the South Sulphur River during the summer low flow sampling period, 3-8 August 2001.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
1	1-C	riffle	bank snag	4	0.04	0.36
1	1-G	run	bank snag	7	0.19	-0.01
1	1-H	pool	channel snag	9	0.48	0.03
1	1-I	pool	channel snag	4	0.28	0.14
1	1-J	run	bank snag	2	0.20	0.03
1	1-K	run	debris dam	7	0.14	0.10
2	2-A	pool	bank snag	1	1.07	0.05
2	2-B	pool	bank snag	3	0.24	0.00
2	2-C	run	bank snag	5	0.22	0.16
2	2-D	run	bank snag	5	0.14	0.01
2	2-E	run	bank snag	16	0.15	0.12
2	2-H	pool	bank snag	3	0.37	0.02
2	2-I	pool	bank snag	5	0.15	0.15
2	2-J	pool	bank snag	7	0.04	0.04
2	2-K	pool	bank snag	5	0.16	0.05
2	2-L	pool	bank snag	3	0.44	0.04
3	3-D	pool	bank snag	4	0.22	-0.05
3	3-E	pool	bank snag	2	0.40	0.10
3	3-G	pool	bank snag	15	0.31	-0.02
3	3-H	pool	channel snag	4	0.73	0.07
3	3-I	pool	bank snag	8	0.32	-0.02
3	3-J	pool	bank snag	10	0.49	0.04
3	3-K	backwater	bank snag	4	0.52	-0.01
3	3-L	backwater	bank snag	4	0.58	0.04
3	3-M	pool	bank snag	5	0.38	-0.01
3	3-N	run	bank snag	15	0.55	0.14

Table 6. Continued.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
3	3-O	riffle	channel snag	8	0.35	0.20
4	4-A	pool	bank snag	2	0.76	0.02
4	4-B	pool	channel snag	3	0.68	0.02
4	4-C	pool	rootwad	3	0.23	-0.06
4	4-D	pool	undercut bank	1	0.23	-0.01
4	4-E	pool	channel snag	4	0.48	-0.06
4	4-F	pool	channel snag	2	0.29	-0.03
4	4-G	pool	bank snag	4	0.31	-0.01
4	4-H	pool	snag complex	6	0.61	0.03
4	4-I	pool	snag complex	4	0.22	0.00
5	5-A	pool	bank snag	10	0.14	0.05
5	5-B	pool	bank snag	6	0.29	0.04
5	5-D	pool	bank snag	8	0.18	0.00
5	5-E	pool	channel snag	5	0.81	0.04
5	5-F	pool	bank snag	4	0.42	0.04
5	5-G	pool	bank snag	1	0.32	0.05
5	5-H	pool	undercut bank	1	0.21	0.02
5	5-I	pool	undercut bank	1	0.21	0.04
5	5-J	pool	bank snag	1	0.21	0.04
5	5-K	pool	bank snag	8	0.19	0.02
5	5-L	pool	bank snag	2	0.08	0.03
5	5-M	pool	rootwad	2	0.22	0.01
5	5-N	pool	channel snag	5	0.77	0.08
5	5-O	pool	bank snag	6	0.44	0.00
6	6-A	pool	bank snag	2	0.32	0.02
6	6-B	pool	bank snag	4	0.30	0.00
6	6-D	pool	rootwad	2	0.35	0.01

Table 6. Continued.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
6	6-I	pool	rootwad	2	0.27	0.06
6	6-K	pool	channel snag	2	0.72	0.03
6	6-M	pool	bank snag	3	0.64	0.01

Table 7. Mesohabitats, microhabitats, estimated areas (m^2), depths (m), and velocities (m/s) for individual habitats located within the South Sulphur River during the winter high flow sampling period, 26-29 April 2002.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
1	1-M	run	bank snag	1	1.55	0.26
2	2-L	run	bank snag	7	1.5	0.13
2	2-M	run	channel snag	2	1.8	0.23
3	3-B	run	rootwad	7	1.37	0.36
3	3-C	run	rootwad	5	1.3	0.51
3	3-E	run	rootwad	4	0.76	0.14
3	3-L	backwater	bank snag	8	1.5	-0.08
3	3-Q	run	rootwad	10	1.7	0.60
3	3-R	run	bank snag	12	0.71	0.54
4	N/A[a]	N/A[a]	N/A[a]	N/A[a]	N/A[a]	N/A[a]
5	N/A[a]	N/A[a]	N/A[a]	N/A[a]	N/A[a]	N/A[a]
6	6-H	run	bank snag	6	2.0	0.67
6	6-L	run	rootwad/bank snag	5	1.55	0.26
6	6-M	run	channel snag	20	2.3	0.69
6	6-O	run	channel snag	8	1.8	0.37

[a] Not sampled due to equipment malfunction

Table 8. Mesohabitats, microhabitats, estimated areas (m^2), depths (m), and velocities (m/s) for individual habitats located within the South Sulphur River during the winter middle flow sampling period, 1-5 March 2002.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
1	1-A	riffle	snag complex	2	0.40	0.41
1	1-B	riffle	bank snag	5	0.18	0.02
1	1-C	riffle	bank snag	4	0.18	0.28
1	1-D	riffle	snag complex	3	0.35	0.41
1	1-E	riffle	channel snag	12	0.30	0.41
1	1-F	run	bank snag	25	0.19	0.37
1	1-G	run	bank snag	5	0.10	0.35
1	1-I	pool	channel snag	5	0.53	0.08
1	1-J	pool	bank snag	1	0.45	0.09
1	1-K	pool	debris dam	4	0.52	0.10
1	1-L	pool	bank snag	3	0.39	0.07
2	2-I	run	bank snag	6	0.56	0.20
2	2-K	run	bank snag	4	0.54	0.11
2	2-L	run	channel snag	3	1.60	0.28
3	3-B	pool	rootwad	12	0.70	0.21
3	3-D	pool	bank snag	4	0.68	0.10
3	3-E	pool	bank snag	3	0.94	0.09
3	3-G	pool	bank snag	6	1.04	0.03
3	3-I	pool	bank snag	4	1.02	0.02
3	3-J	pool	bank snag	20	0.45	0.09
3	3-O	run	channel snag	8	0.89	0.39
3	3-P	riffle	bank snag	6	0.98	0.50
4	4-B	pool	snag complex	10	1.51	0.08
5	5-E	pool	bank snag	6	1.10	0.11
5	5-F	pool	bank snag	3	0.70	0.04
5	5-H	pool	bank snag/rootwad	1/1	0.30	0.05

Table 8. Continued.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
5	5-K	pool	bank snag	8	0.79	0.09
5	5-P	pool	bank snag	4	0.52	0.06
5	5-Q	pool	rootwad	7	0.76	0.07
6	6-A	pool	channel snag	2	0.98	0.07
6	6-C	pool	bank snag	6	0.68	0.14
6	6-H	pool	bank snag	4	1.21	0.15
6	6-M	pool	bank snag	3	0.78	0.12

Table 9. Mesohabitats, microhabitats, estimated areas (m^2), depths (m), and velocities (m/s) for individual habitats located within the South Sulphur River during the winter low flow sampling period, 8-11 November 2001.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
1	1-B	riffle	Rip Rap	9	0.27	0.29
1	1-C	riffle	bank snag	3	0.24	0.22
1	1-D	riffle	Rip Rap	12	0.33	0.37
1	1-E	riffle	Rip Rap	5	0.23	0.18
1	1-F	riffle	Rip Rap	3	0.20	0.47
1	1-G	run	bank snag	5	0.65	0.24
1	1-H	pool	channel snag	9	1.36	0.03
1	1-J	pool	bank snag	1	0.30	-0.08
1	1-K	pool	debris dam	5	0.24	0.09
2	2-B	pool	bank snag	4	0.29	0.08
2	2-B	run	bank snag	1	0.44	0.14
2	2-E	run	debris dam	12	0.20	0.08
2	2-F	run	bank snag	1	0.33	0.09
2	2-G	run	bank snag	5	0.45	0.17
2	2-H	pool	bank snag	2	0.45	0.01
2	2-I	pool	bank snag	5	0.55	0.19
2	2-J	pool	bank snag	16	0.30	0.03
3	3-E	run	snag complex	15	0.29	0.20
3	3-F	pool	snag complex	20	0.41	0.03
3	3-H	run	channel snag	4	0.66	0.21
3	3-I	pool	bank snag	2	0.24	0.06
3	3-J	run	bank snag	3	0.53	0.21
3	3-K	backwater	bank snag	4	0.59	-0.06
3	3-L	backwater	bank snag	4	0.60	0.00
3	3-M	run	bank snag	4	0.35	0.08
4	4-A	pool	rootwad	3	0.48	0.04

Table 9. Continued.

Site	ID	Mesohabitat	Microhabitat	Estimated Area (m^2)	Depth (m)	Velocity (m/s)
4	4-E	pool	channel snag	8	0.58	0.07
4	4-F	pool	bank snag	1	0.36	0.04
4	4-G	pool	bank snag	4	0.42	0.06
4	4-I	pool	bank snag	3	0.34	0.15
5	5-B	pool	Rip Rap	3	0.44	0.05
5	5-C	pool	bank snag	4	0.34	0.03
5	5-E	pool	bank snag	7	0.62	0.05
5	5-K	pool	bank snag	4	0.65	0.07
6	6-A	pool	bank snag	1	0.25	0.08
6	6-B	pool	channel snag	2	0.26	0.01
6	6-C	pool	bank snag	8	0.28	0.02
6	6-D	pool	channel snag	5	0.25	0.02
6	6-E	pool	channel snag	1	0.39	0.01
6	6-G	pool	bank snag	12	0.29	0.06
6	6-H	pool	rootwad	3	0.29	0.05
6	6-I	pool	rootwad	2	0.35	0.03
6	6-J	pool	bank snag	3	0.27	0.01
6	6-K	pool	channel snag	2	0.67	0.14
6	6-L	pool	bank snag	3	0.27	0.03

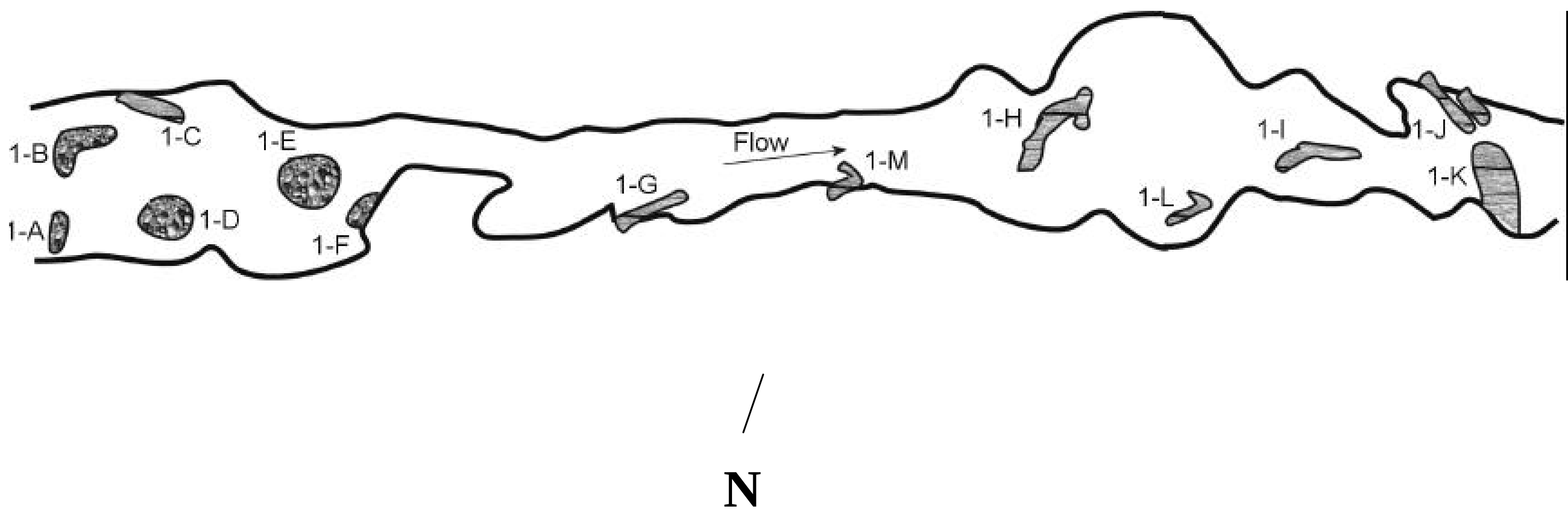

Figure 2. Sketch map of site 1. The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat.

Figure 3. Site 1. 1-A (against bank) and 1-B (in foreground). 3-8 August 2001, 6.4-10 cfs.

Figure 4. Site 1. 1-C. 3-8 August 2001, 6.4-10 cfs.

Figure 5. Site 1. 1-D. 8-11 November 2001, 11-19 cfs.

Figure 6. Site 1. 1-E. 8-11 November 2001, 11-19 cfs.

Figure 7. Site 1. 1-G. 8-11 November 2001, 11-19 cfs.

Figure 8. Site 1. 1-H. 8-11 November 2001, 11-19 cfs.

Figure 9. Site 1. 1-I. 3-8 August 2001, 6.4-10 cfs.

Figure 10. Site 1. 1-J. 3-8 August 2001, 6.4-10 cfs.

Figure 11. Site 1. 1-K. 8-11 November 2001, 11-19 cfs.

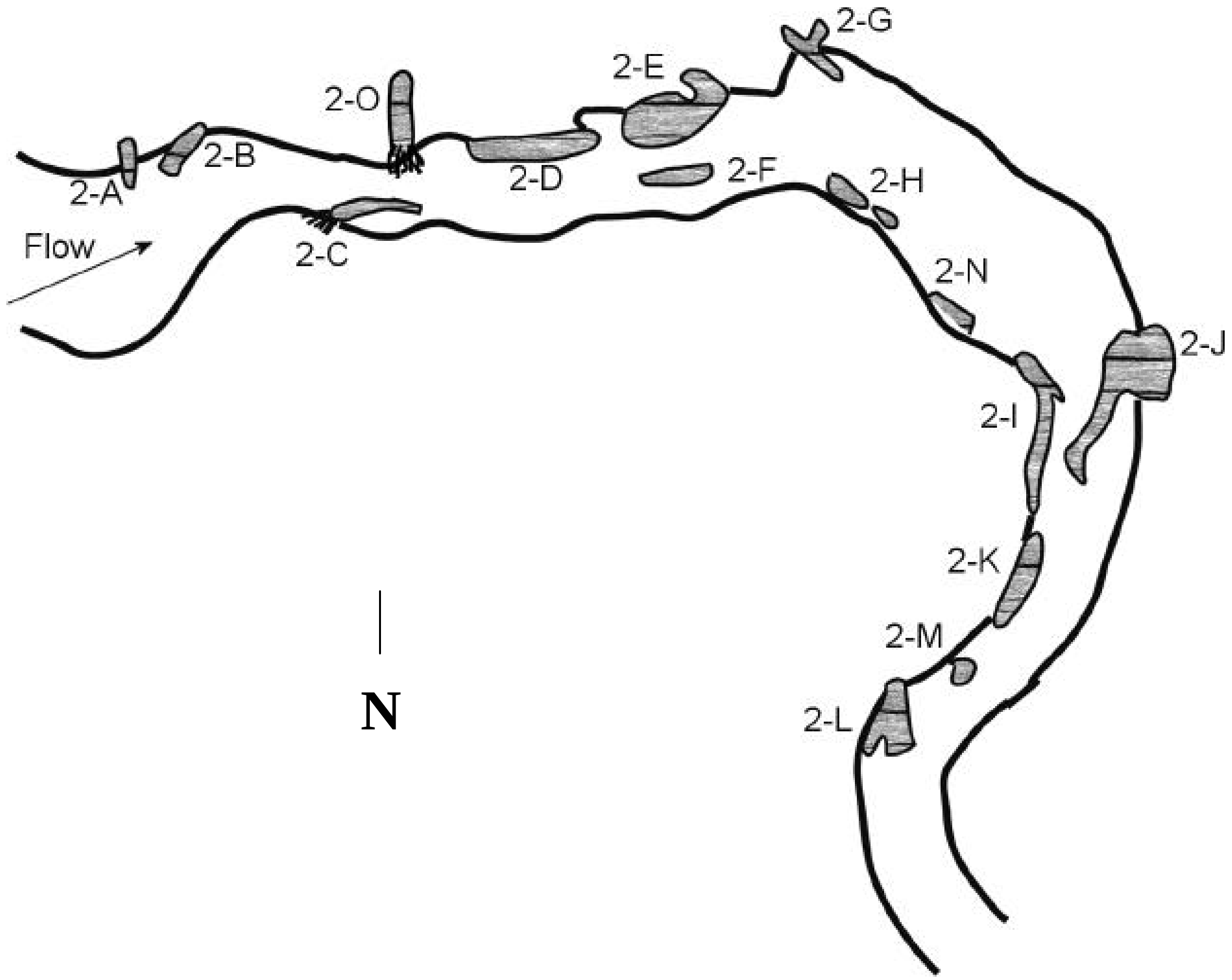

Figure 12. Sketch map of site 2. The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat.

Figure 13. Site 2. 2-A. 3-8 August 2001, 6.4-10 cfs.

Figure 14. Site 2. 2-B. 3-8 August 2001, 6.4-10 cfs.

Figure 15. Site 2. 2-C. 3-8 August 2001, 6.4-10 cfs.

Figure 16. Site 2. 2-D. 3-8 August 2001, 6.4-10 cfs.

Figure 17. Site 2. 2-E. 3-8 August 2001, 6.4-10 cfs.

Figure 18. Site 2. 2-H. 3-8 August 2001, 6.4-10 cfs.

Figure 19. Site 2. 2-I. 3-8 August 2001, 6.4-10 cfs.

Figure 20. Site 2. 2-J. 3-8 August 2001, 6.4-10 cfs.

Figure 21. Site 2. 2-K. 3-8 August 2001, 6.4-10 cfs.

Figure 22. Site 2. 2-L. 3-8 August 2001, 6.4-10 cfs.

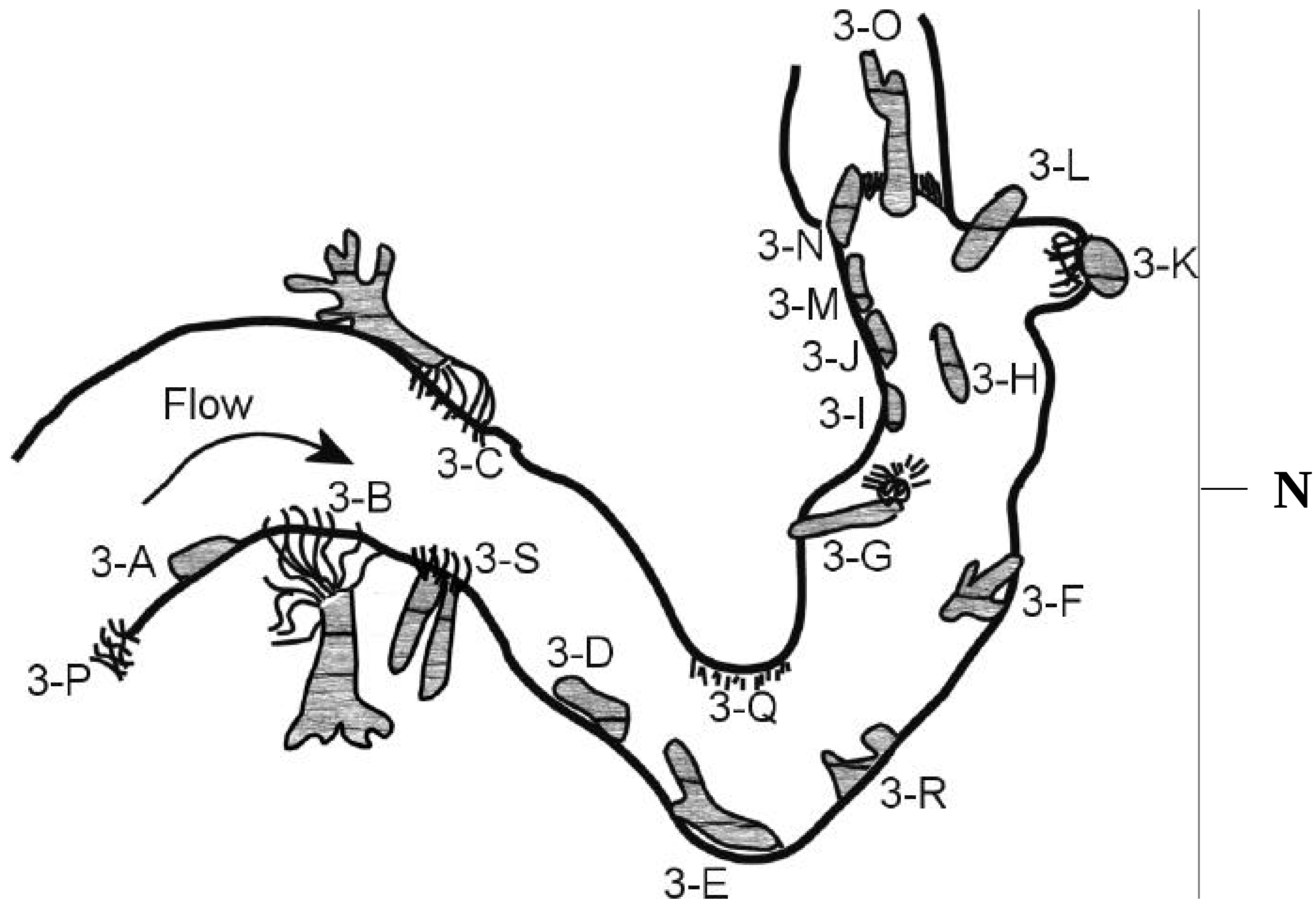

Figure 23. Sketch map of site 3. The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat.

Figure 24. Site 3. 3-C. 3-8 August 2001, 6.4-10 cfs.

Figure 25. Site 3. 3-S. 3-8 August 2001, 6.4-10 cfs.

Figure 26. Site 3. 3-D. 3-8 August 2001, 6.4-10 cfs.

Figure 27. Site 3. 3-E. 3-8 August 2001, 6.4-10 cfs.

Figure 28. Site 3. 3-G. 3-8 August 2001, 6.4-10 cfs.

Figure 29. Site 3. 3-H. 3-8 August 2001, 6.4-10 cfs.

Figure 30. Site 3. 3-I. 3-8 August 2001, 6.4-10 cfs.

Figure 31. Site 3. 3-J. 3-8 August 2001, 6.4-10 cfs.

Figure 32. Site 3. 3-K. 8-11 November 2001, 11-19 cfs.

Figure 33. Site 3. 3-L. 8-11 November 2001, 11-19 cfs.

Figure 34. Site 3. 3-M. 3-8 August 2001, 6.4-10 cfs.

Figure 35. Site 3. 3-N. 3-8 August 2001, 6.4-10 cfs.

Figure 36. Site 3. 3-O. 3-8 August 2001, 6.4-10 cfs.

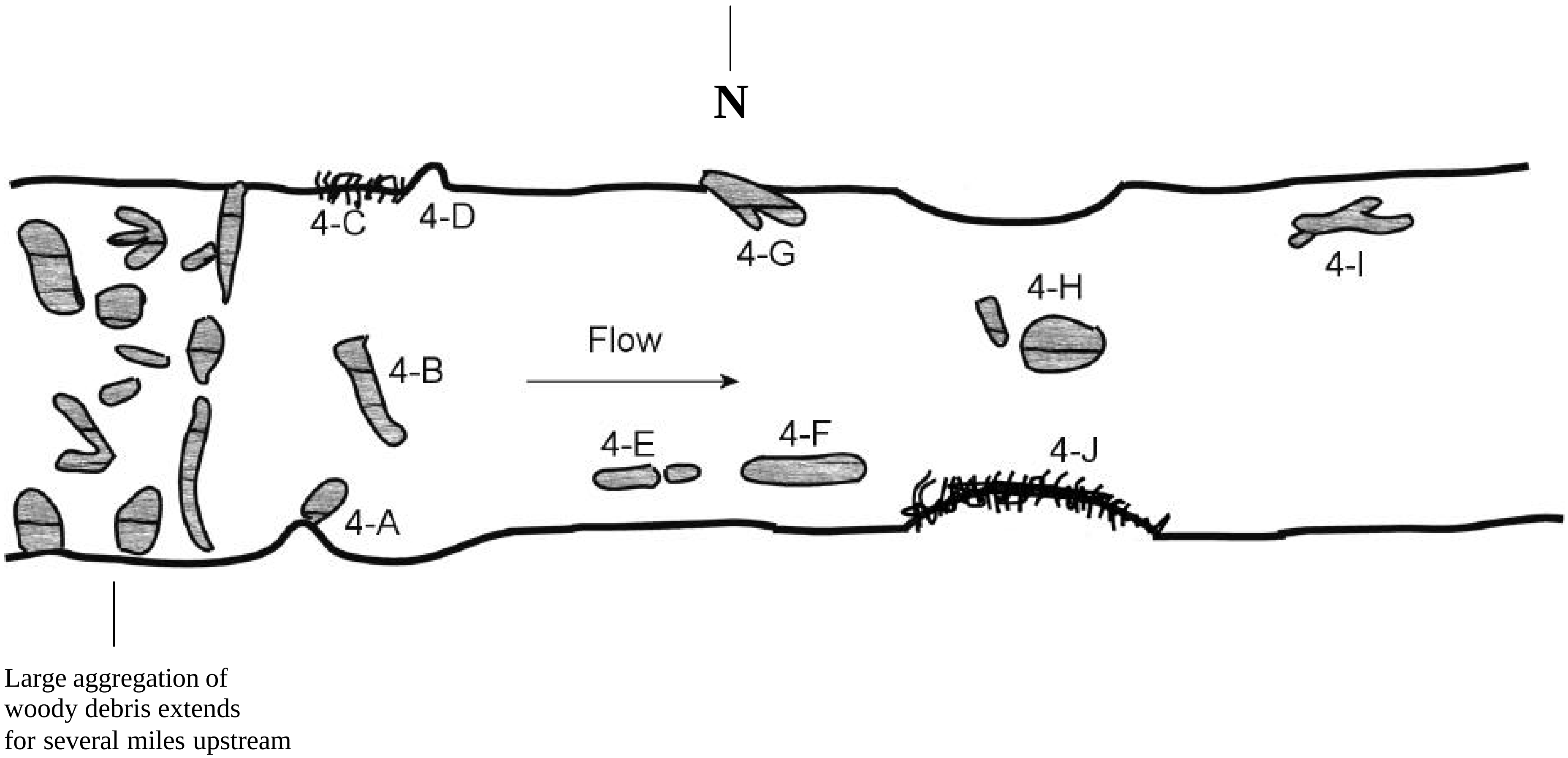

Figure 37. Sketch map of site 4. The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat.

Figure 38. Site 4. Large aggregation of wood. 3-8 August 2001, 6.4-10 cfs.

Figure 39. Site 4. 4-A. 3-8 August 2001, 6.4-10 cfs.

Figure 40. Site 4. 4-B. 3-8 August 2001, 6.4-10 cfs.

Figure 41. Site 4. 4-C. 3-8 August 2001, 6.4-10 cfs.

Figure 42. Site 4. 4-D. 3-8 August 2001, 6.4-10 cfs.

Figure 43. Site 4. 4-E. 3-8 August 2001, 6.4-10 cfs.

Figure 44. Site 4. 4-F. 3-8 August 2001, 6.4-10 cfs.

Figure 45. Site 4. 4-G. 3-8 August 2001, 6.4-10 cfs.

Figure 46. Site 4. 4-H. 3-8 August 2001, 6.4-10 cfs.

Figure 47. Site 4. 4-I. 3-8 August 2001, 6.4-10 cfs.

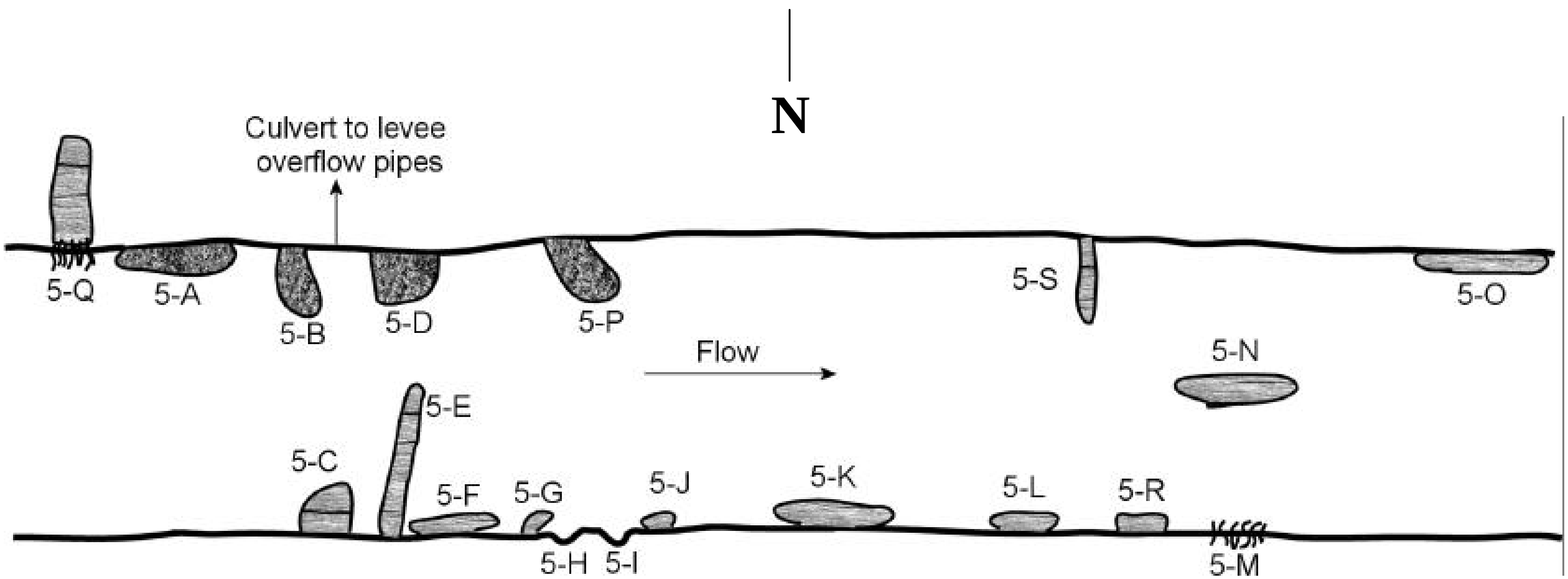

Figure 48. Sketch map of site 5. The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat.

Figure 49. Site 5. 5-B. 8-11 November 2001, 11-19 cfs.

Figure 50. Site 5. 5-C. 8-11 November 2001, 11-19 cfs.

Figure 51. Site 5. 5-D. 8-11 November 2001, 11-19 cfs.

Figure 52. Site 5. 5-E. 8-11 November 2001, 11-19 cfs.

Figure 53. Site 5. 5-K. 8-11 November 2001, 11-19 cfs.

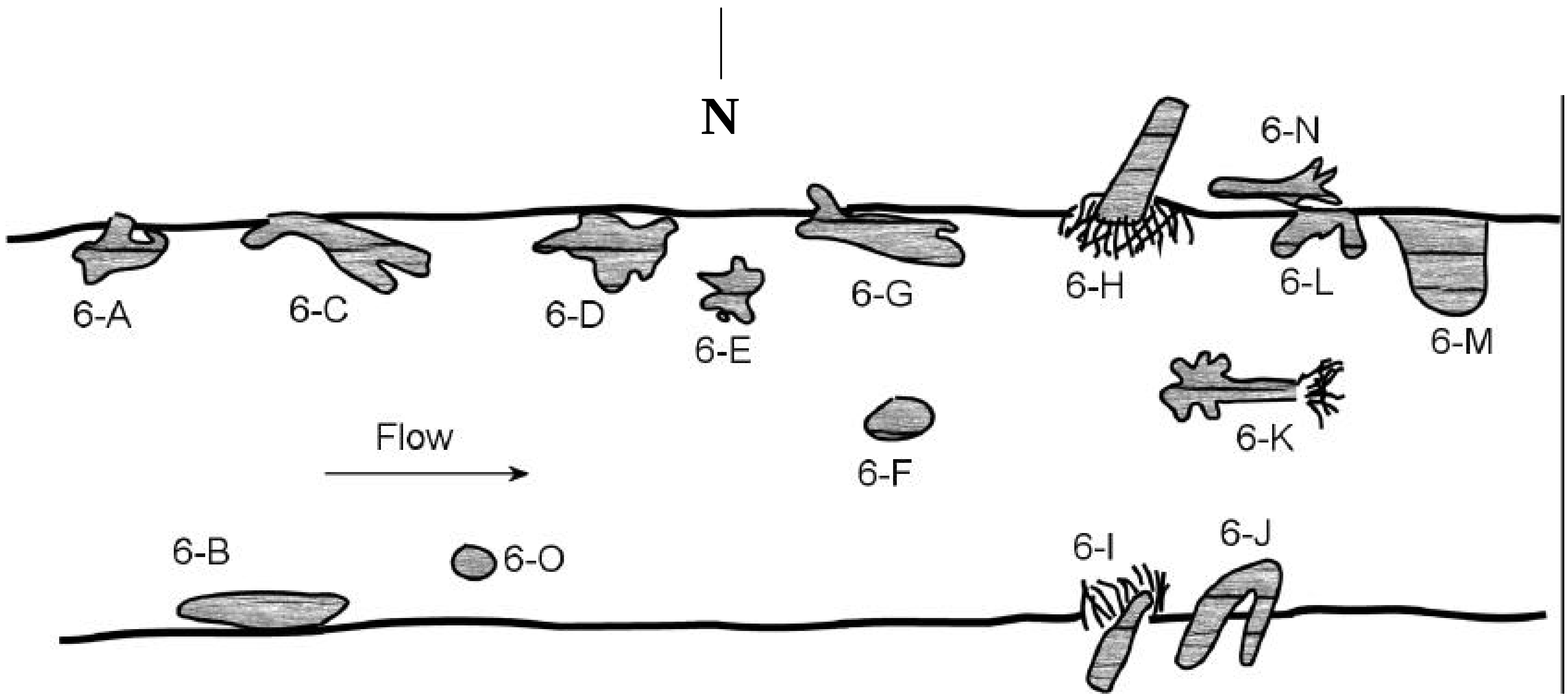

Figure 54. Sketch map of site 6. The alpha-numeric code for each microhabitat identified includes a number that designates the site and a letter that identifies an individual microhabitat.

Figure 55. Site 6. 6-A. 8-11 November 2001, 11-19 cfs.

Figure 56. Site 6. 6-C. 8-11 November 2001, 11-19 cfs.

Figure 57. Site 6. 6-D. 8-11 November 2001, 11-19 cfs.

Figure 58. Site 6. 6-E. 8-11 November 2001, 11-19 cfs.

Figure 59. Site 6. 6-G. 8-11 November 2001, 11-19 cfs.

Figure 60. Site 6. 6-H. 8-11 November 2001, 11-19 cfs.

Figure 61. Site 6. 6-I. 8-11 November 2001, 11-19 cfs.

Figure 62. Site 6. 6-J. 8-11 November 2001, 11-19 cfs.

Figure 63. Site 6. 6-K. 8-11 November 2001, 11-19 cfs.

Figure 64. Site 6. 6-L. 8-11 November 2001, 11-19 cfs.

Figure 65. Site 6. 6-M. 8-11 November 2001, 11-19 cfs.

Table 10. Species and habitat codes for bubble graphs.

Code	Species	Common name	Habitat
1	*Lepisosteus oculatus*	Spotted gar	Pool
2	*Lepisosteus osseus*	Longnose gar	Riffle
3	*Lepisosteus platostomus*	Shortnose gar	Run
4	*Dorosoma cepedianum*	Gizzard shad	Backwater
5	*Dorosoma petenense*	Threadfin shad	
6	*Cyprinella lutrensis*	Red shiner	
7	*Cyprinus carpio*	Common carp	
8	*Hybognathus nuchalis*	Mississippi silvery minnow	
9	*Lythrurus fumeus*	Ribbon shiner	
10	*Lythrurus umbratilis*	Redfin shiner	
11	*Notropis atherinoides*	Emerald shiner	
12	*Notropis buchananai*	Ghost shiner	
13	*Notropis shumardi*	Silverband shiner	
14	*Notropis volucellus*	Mimic shiner	
15	*Pimephales vigilax*	Bullhead minnow	
16	*Carpoides carpio*	River carpsucker	
17	*Ictiobus bubalus*	Smallmouth buffalo	
18	*Ictiobus cyprinellus*	Bigmouth buffalo	
19	*Ictalurus furcatus*	Blue catfish	
20	*Ictalurus punctatus*	Channel catfish	
21	*Noturus gyrinus*	Tadpole madtom	
22	*Noturus nocturnus*	Freckled madtom	
23	*Pylodictis olivaris*	Flathead catfish	
24	*Aphredoderus sayanus*	Pirate perch	
25	*Fundulus notatus*	Blackstripe topminnow	

Table 10. Continued.

Code	Species	Common name	Habitat
26	*Fundulus olivaceus*	Blackspotted topminnow	
27	*Gambusia affinis*	Western mosquitofish	
28	*Menidia beryllina*	Inland silverside	
29	*Morone sp.*	Temperate bass	
30	*Lepomis cyanellus*	Green sunfish	
31	*Lepomis gulosus*	Warmouth	
32	*Lepomis humilis*	Orangespotted sunfish	
33	*Lepomis macrochirus*	Bluegill	
34	*Lepomis marginatus*	Dollar sunfish	
35	*Lepomis megalotis*	Longear sunfish	
36	*Lepomis microlophus*	Redear sunfish	
37	*Lepomis sp.*[a]	Sunfish	
38	*Micropterus salmoides*	Largemouth bass	
39	*Pomoxis annularis*	White crappie	
40	*Pomoxis nigromaculatus*	Black crappie	
41	*Etheostoma gracile*	Slough darter	
42	*Aplodinotus grunniens*	Freshwater drum	

[a] Fish < 20 mm total length.

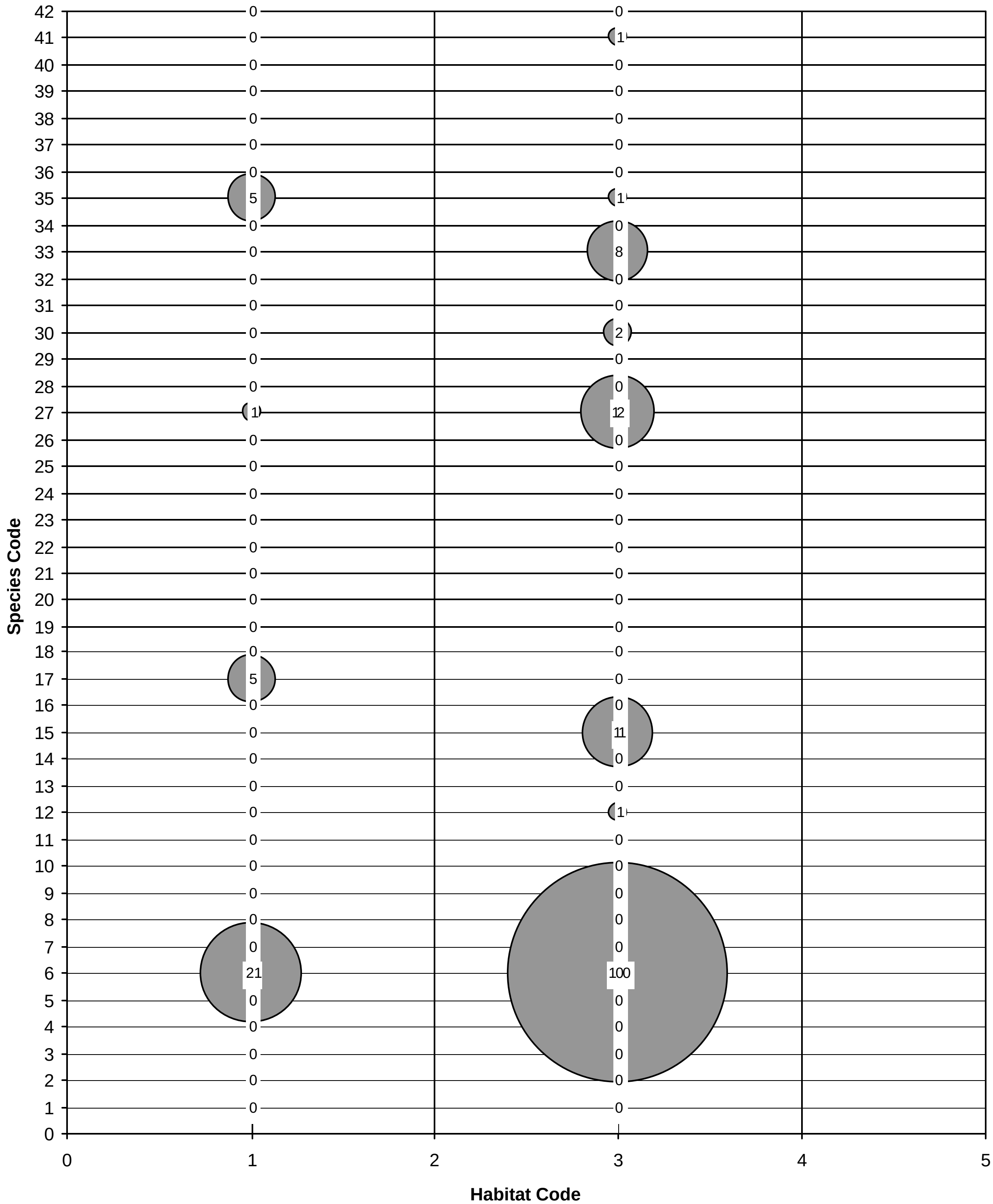

Figure 66. Total number of fishes collected from site 1 in the South Sulphur River on 18 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

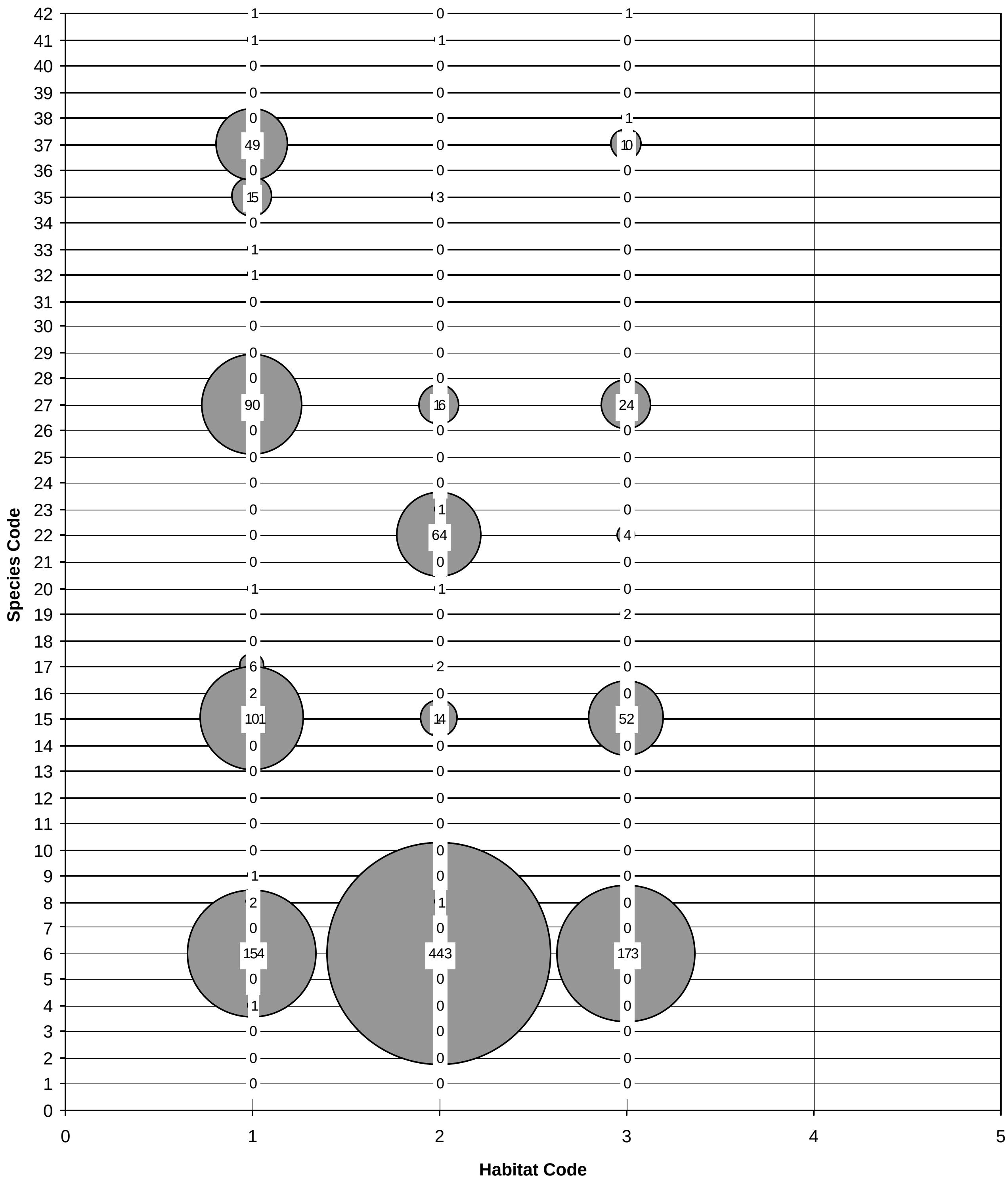

Figure 67. Total number of fishes collected from site 1 in the South Sulphur River on 9-10 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

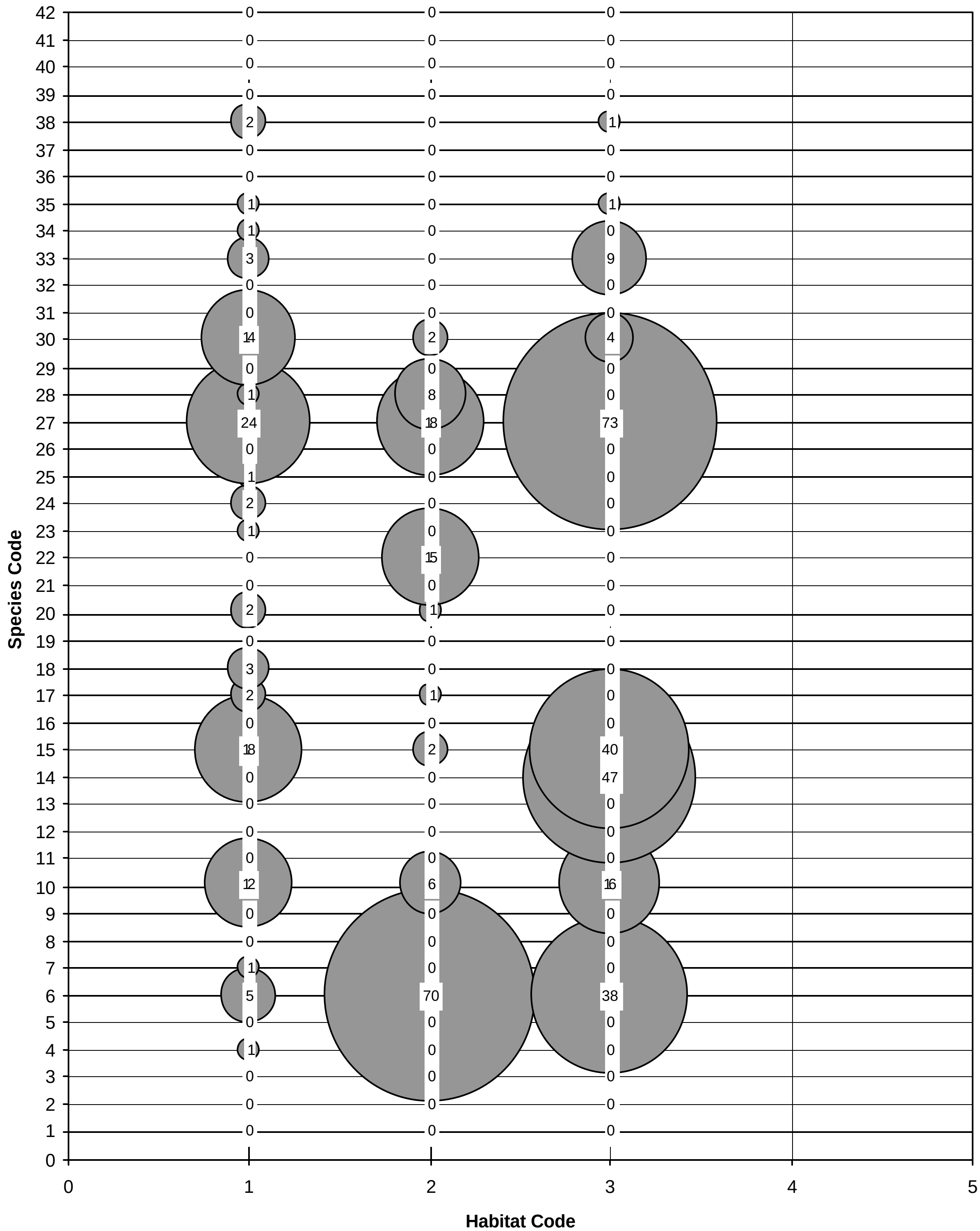

Figure 68. Total number of fishes collected from site 1 in the South Sulphur River on 6-7 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

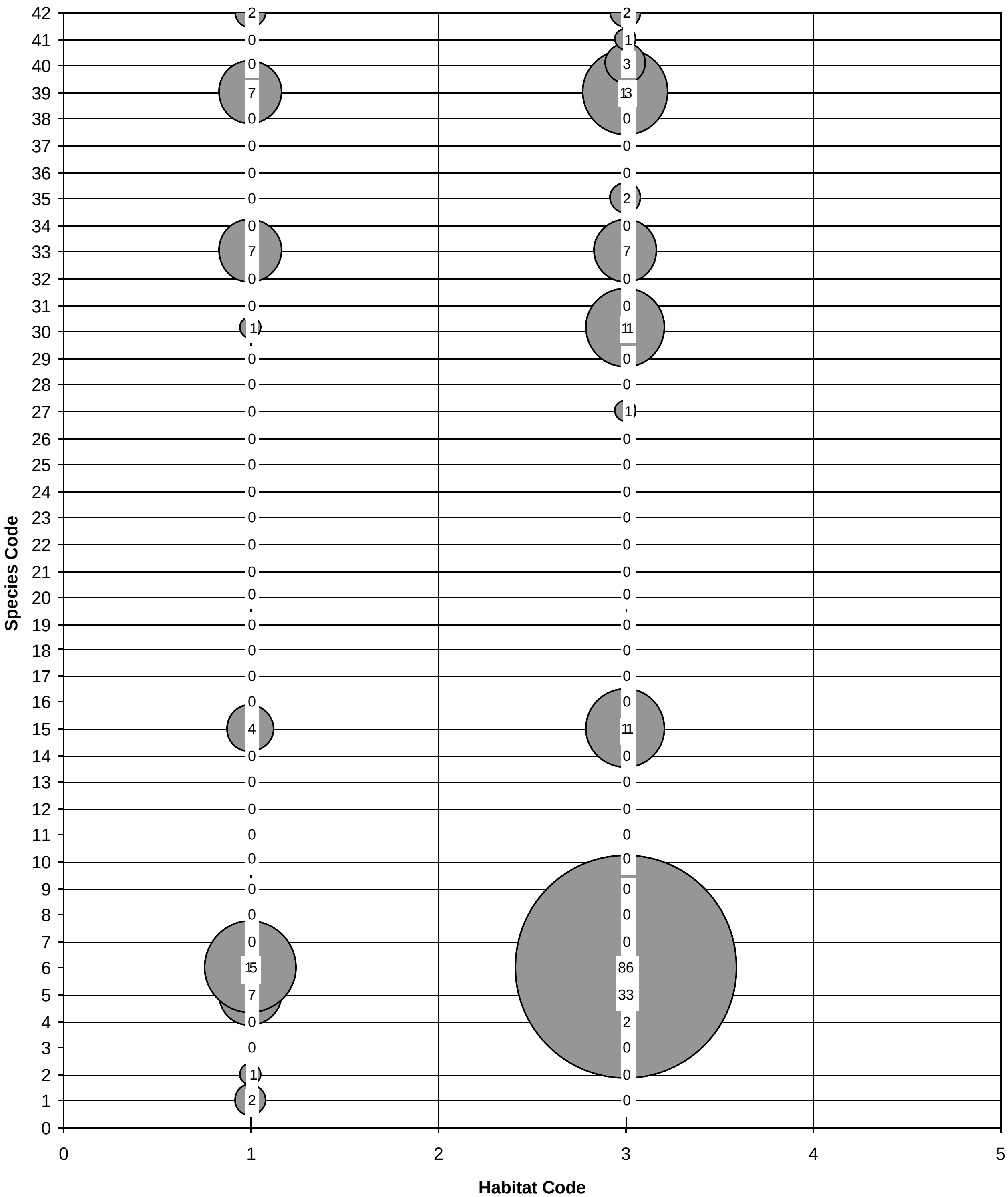

Figure 69. Total number of fishes collected from site 1 in the South Sulphur River on 27-28 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

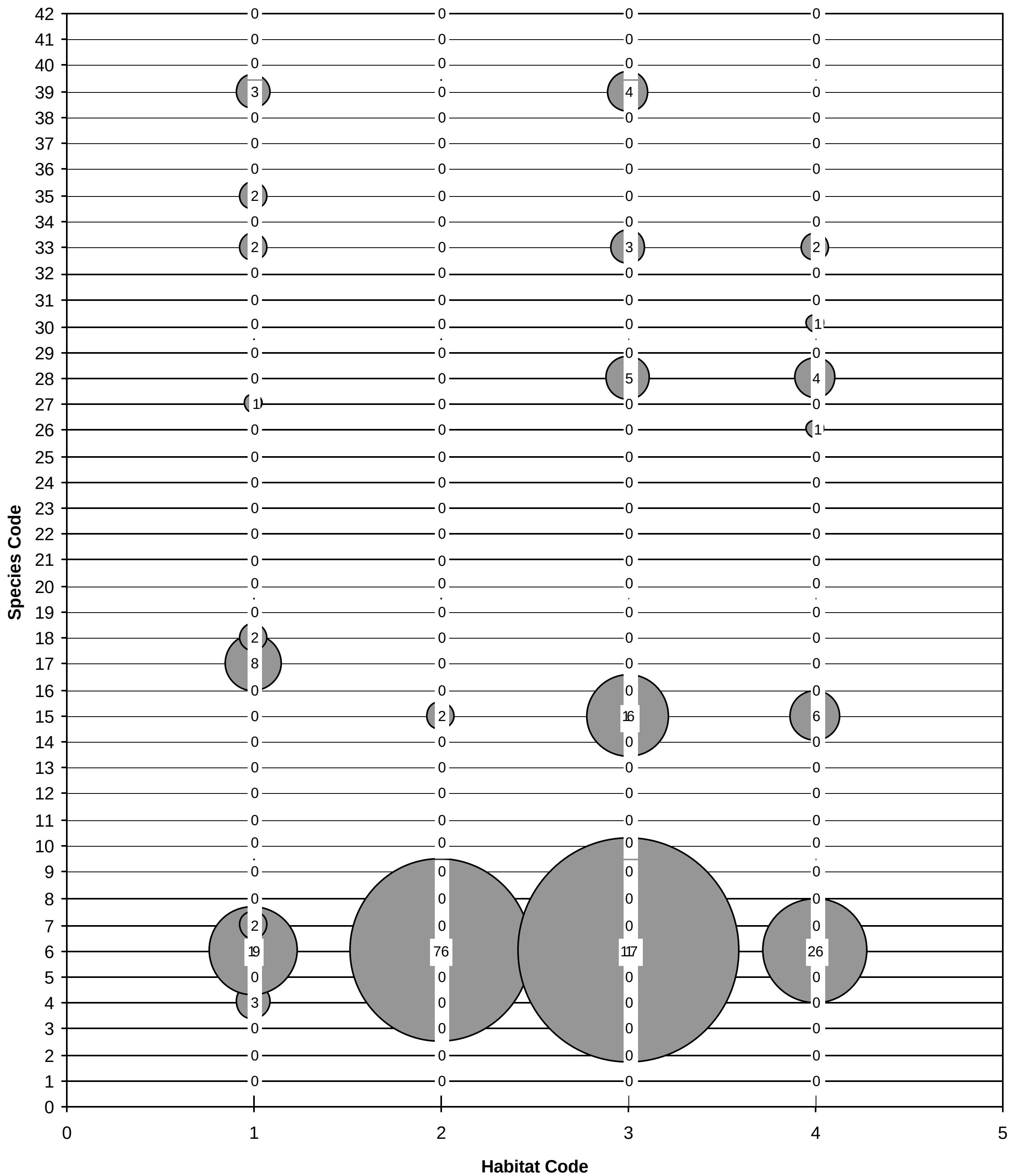

Figure 70. Total number of fishes collected from site 1 in the South Sulphur River on 2-3 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

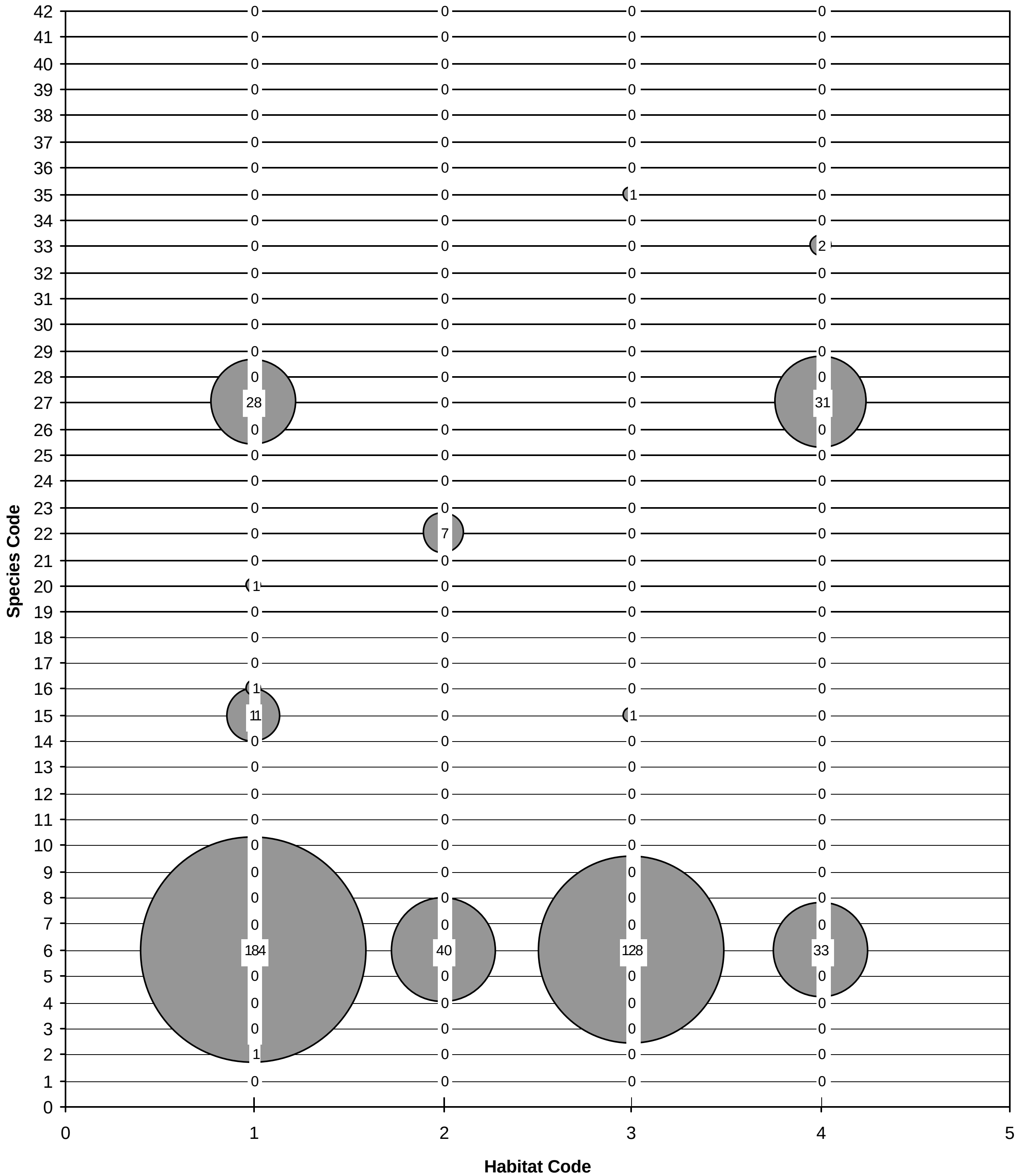

Figure 71. Total number of fishes collected from site 1 in the South Sulphur River on 10 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

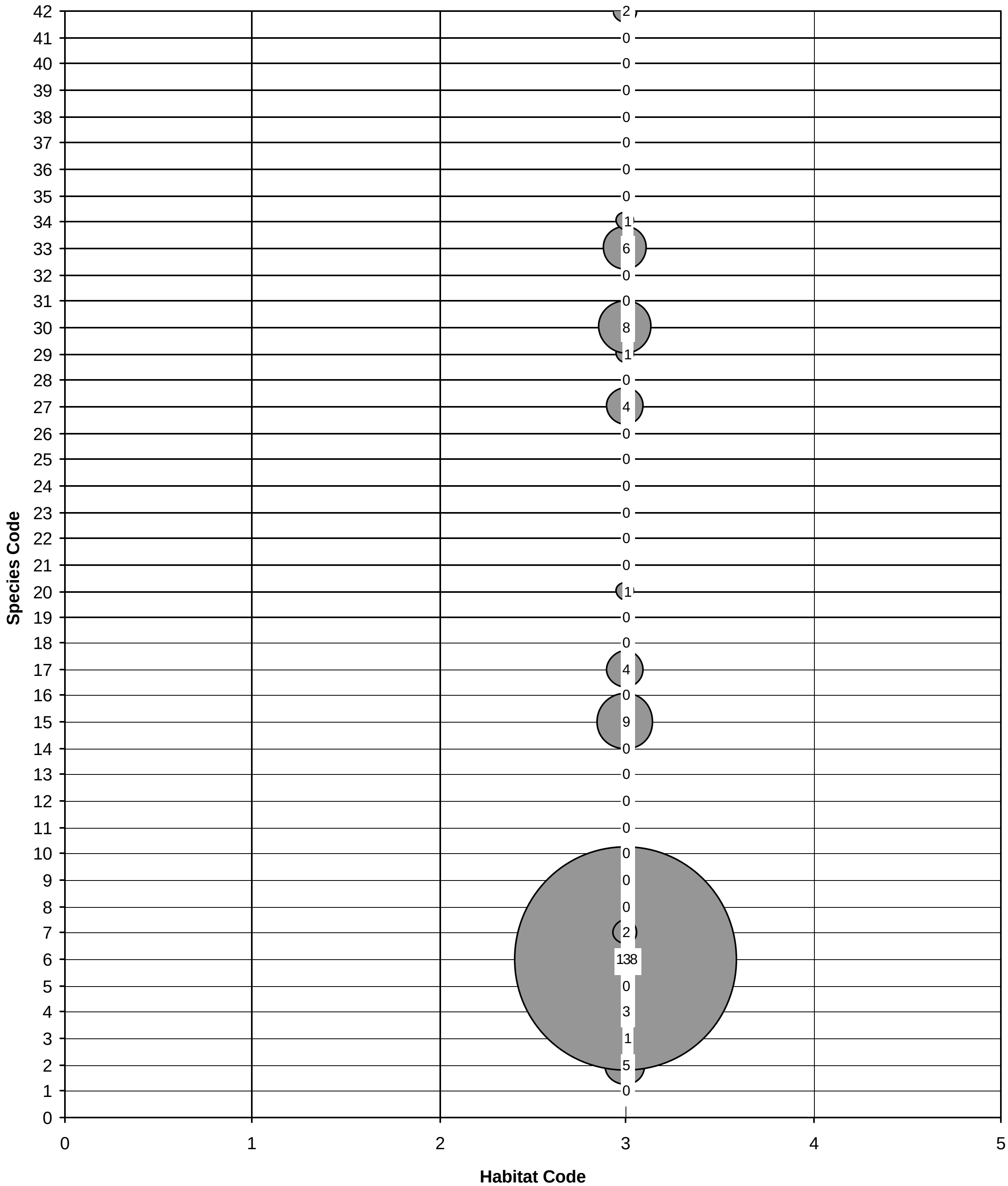

Figure 72. Total number of fishes collected from site 2 in the South Sulphur River on 18 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

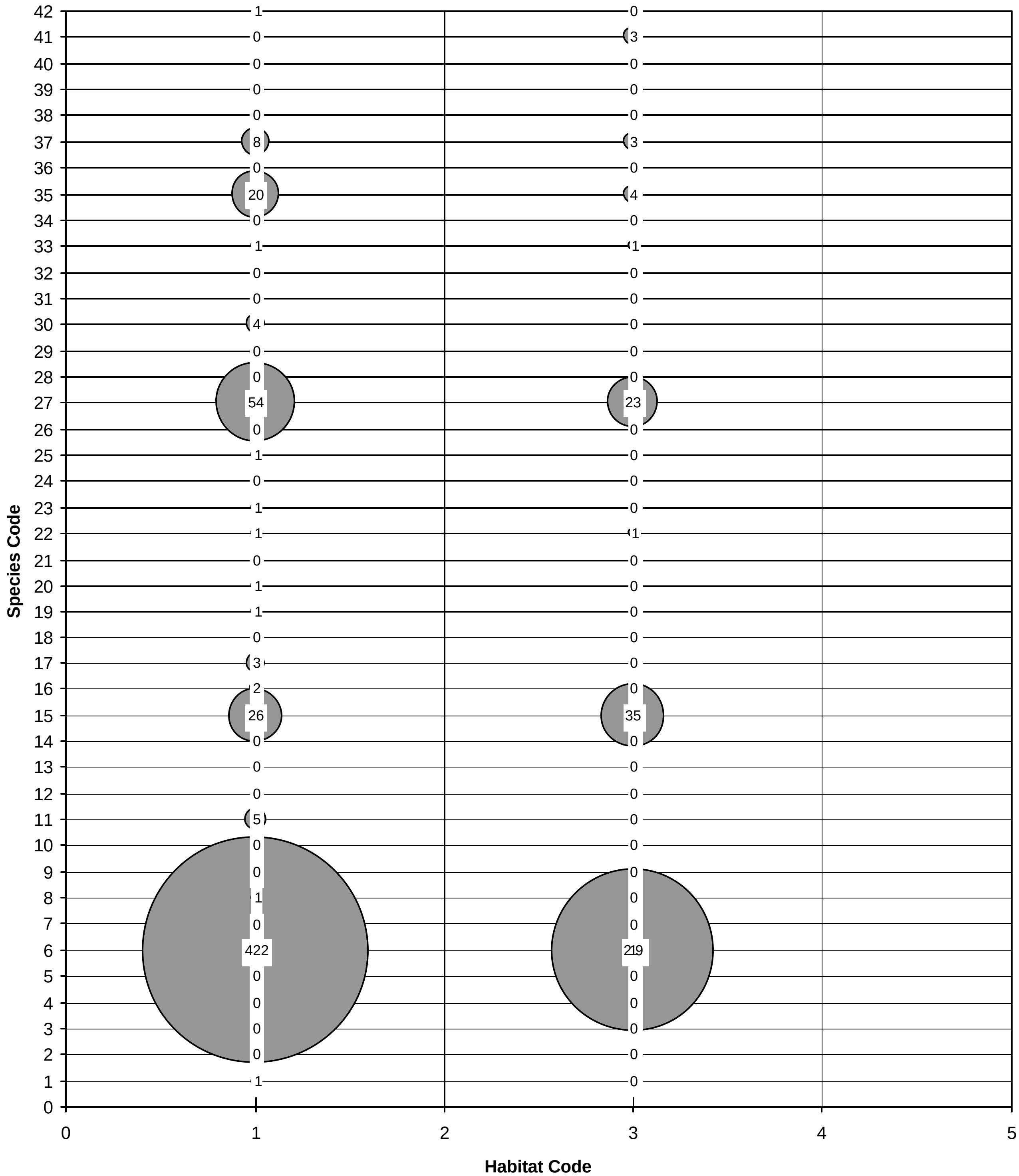

Figure 73. Total number of fishes collected from site 2 in the South Sulphur River on 9-10 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

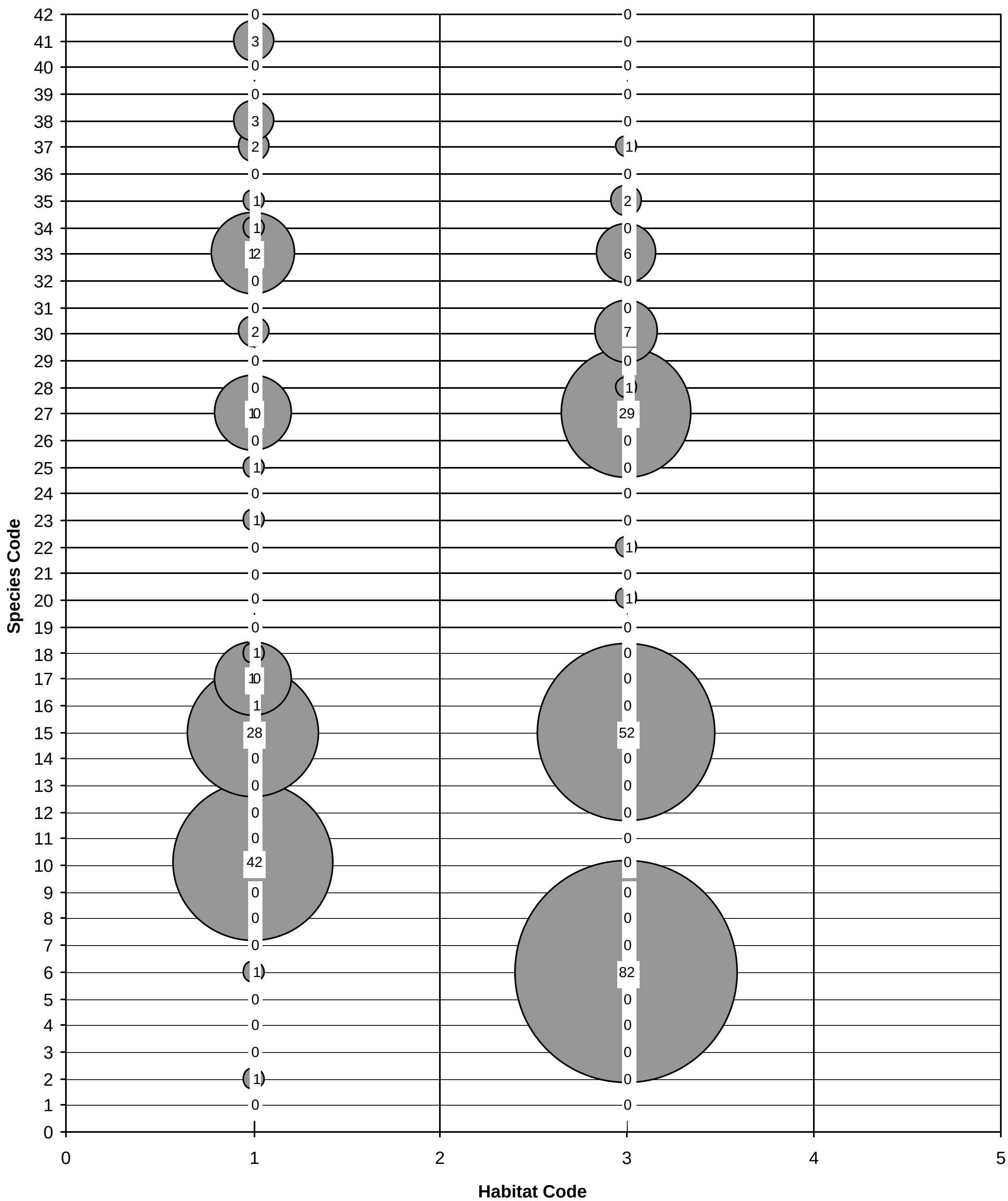

Figure 74. Total number of fishes collected from site 2 in the South Sulphur River on 6-7 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

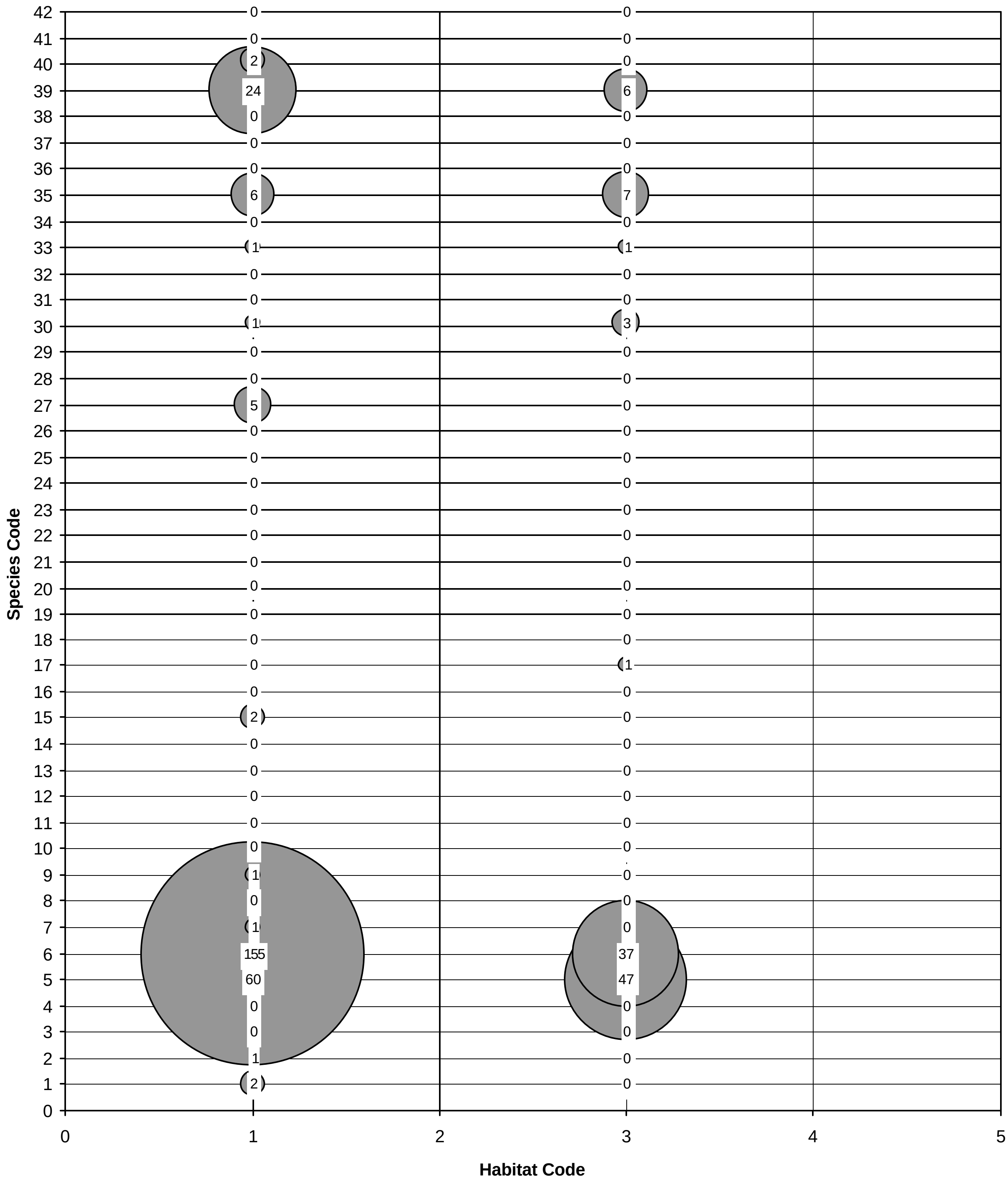

Figure 75. Total number of fishes collected from site 2 in the South Sulphur River on 27-28 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

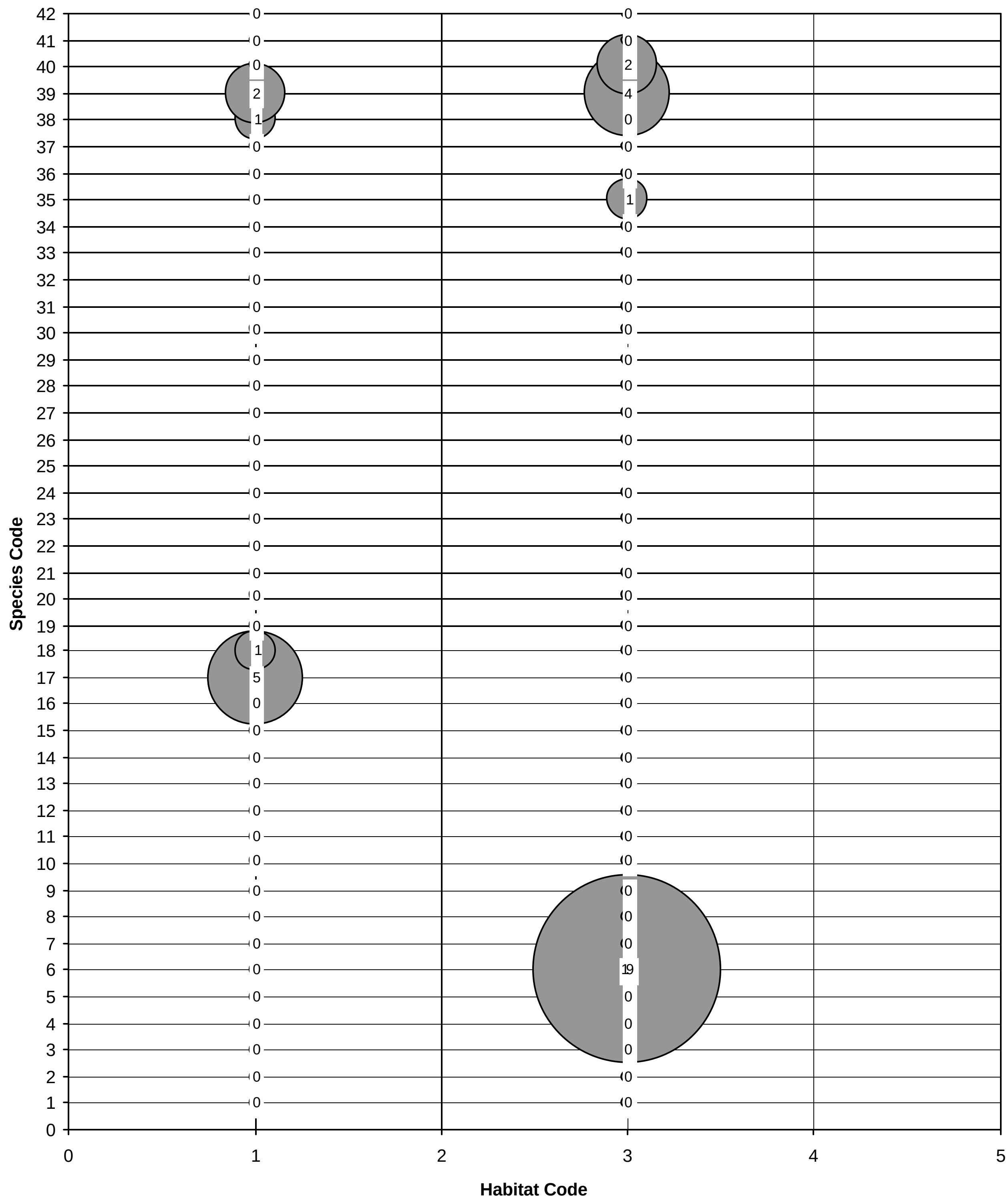

Figure 76. Total number of fishes collected from site2 in the South Sulphur River on 2-3 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

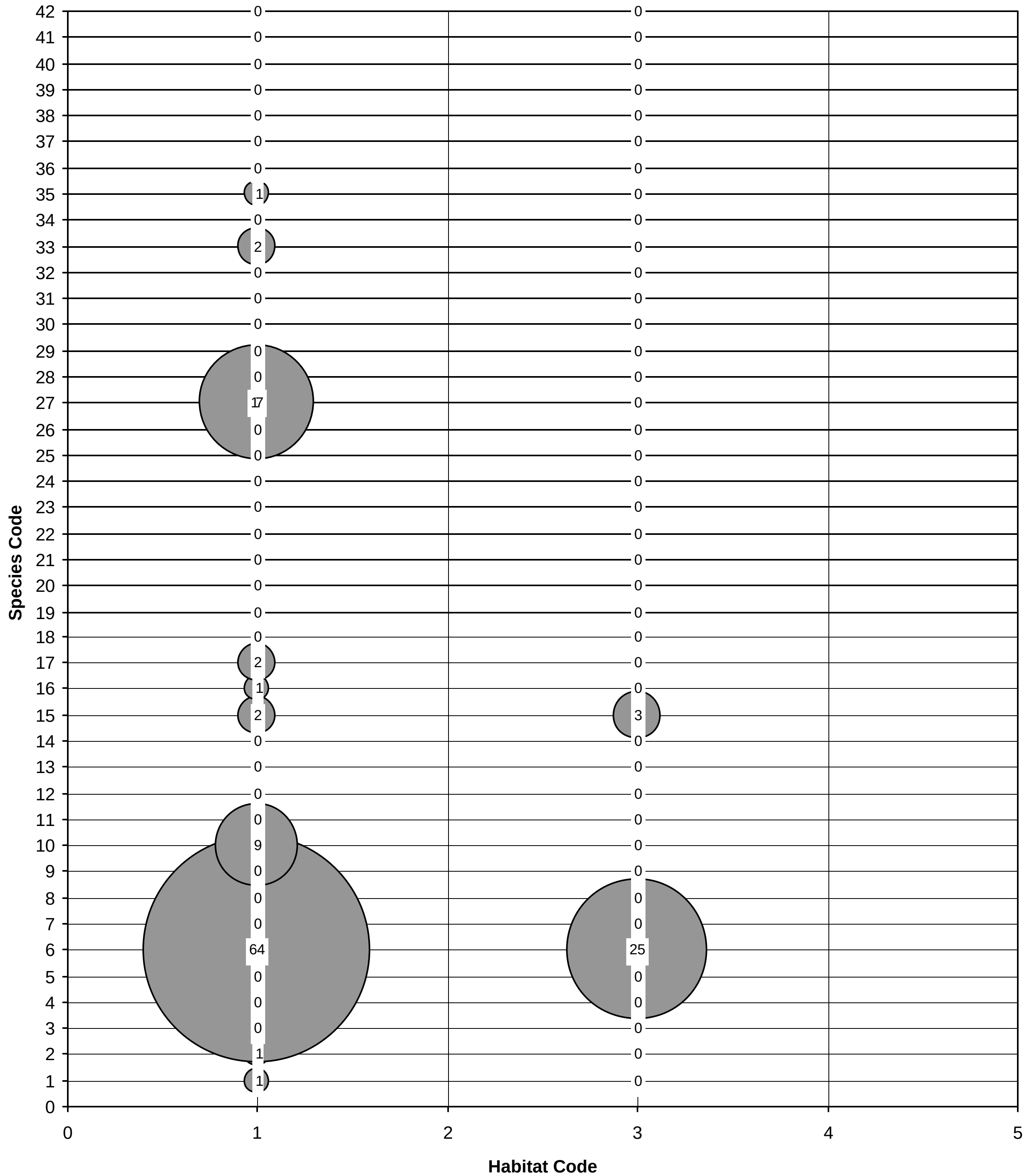

Figure 77. Total number of fishes collected from site 2 in the South Sulphur River on 10 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

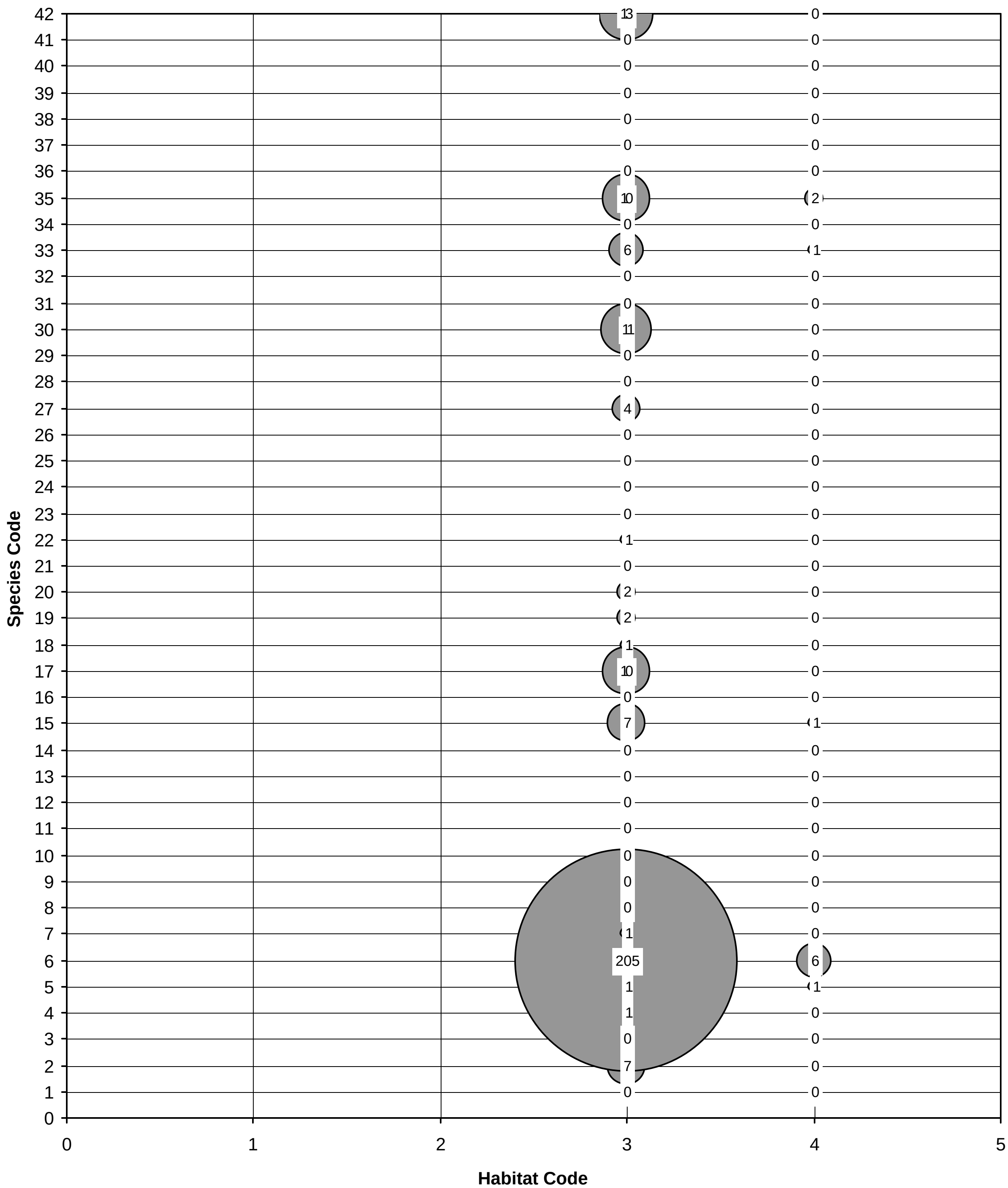

Figure 78. Total number of fishes collected from site 3 in the South Sulphur River on 18 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

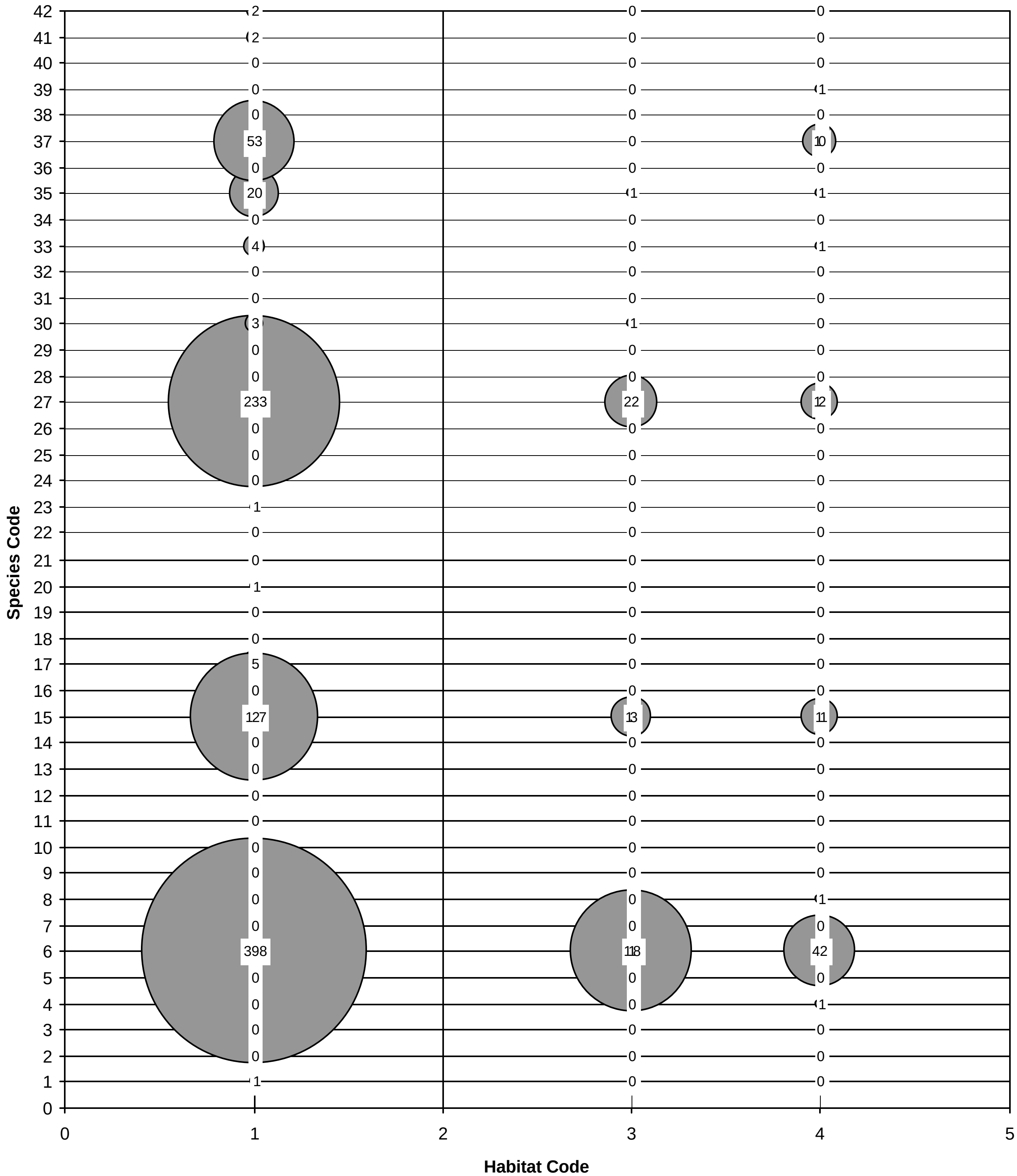

Figure 79. Total number of fishes collected from site 3 in the South Sulphur River on 9-10 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

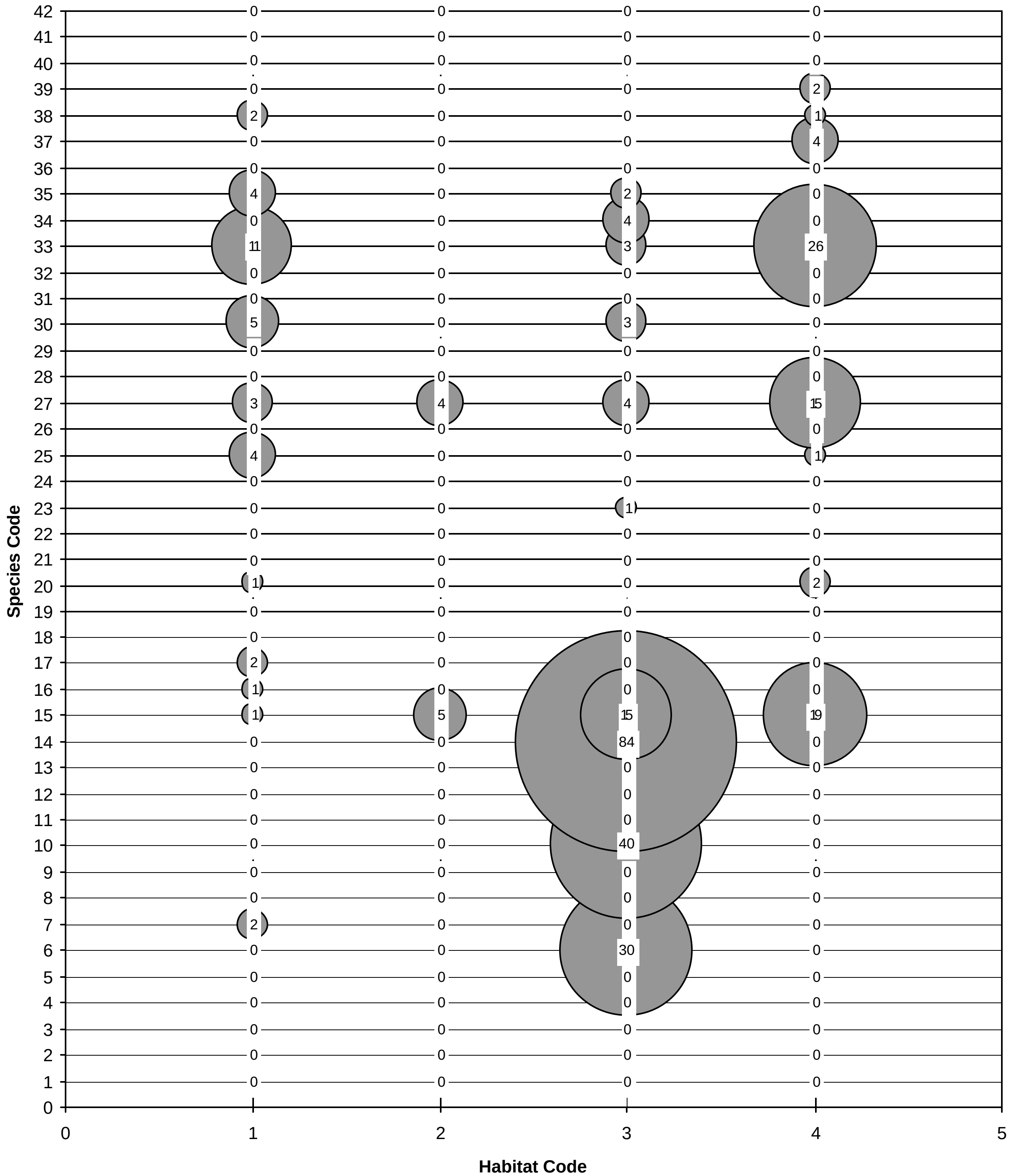

Figure 80. Total number of fishes collected from site 3 in the South Sulphur River 6-7 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

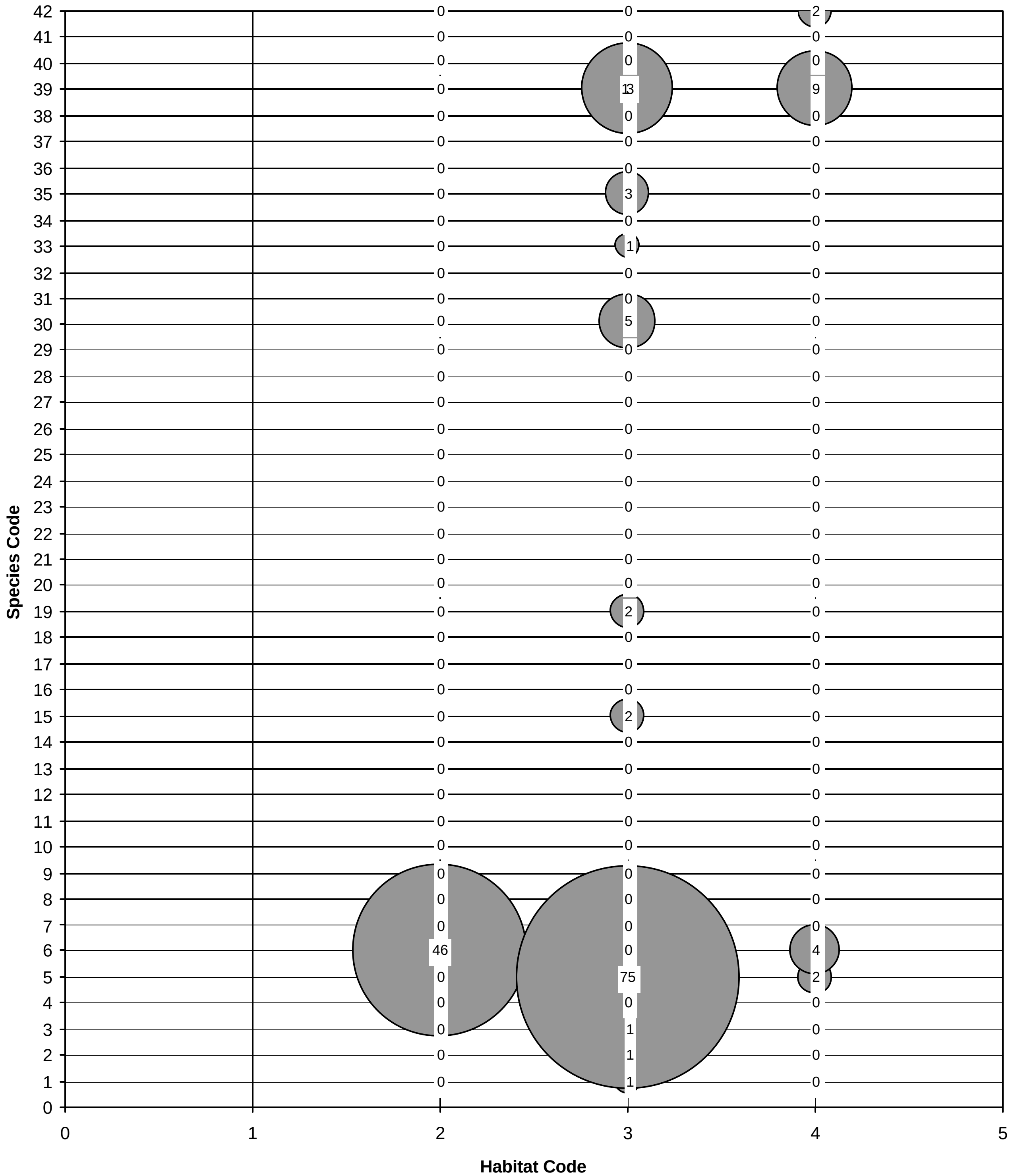

Figure 81. Total number of fishes collected from site 3 in the South Sulphur River on 27-28 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

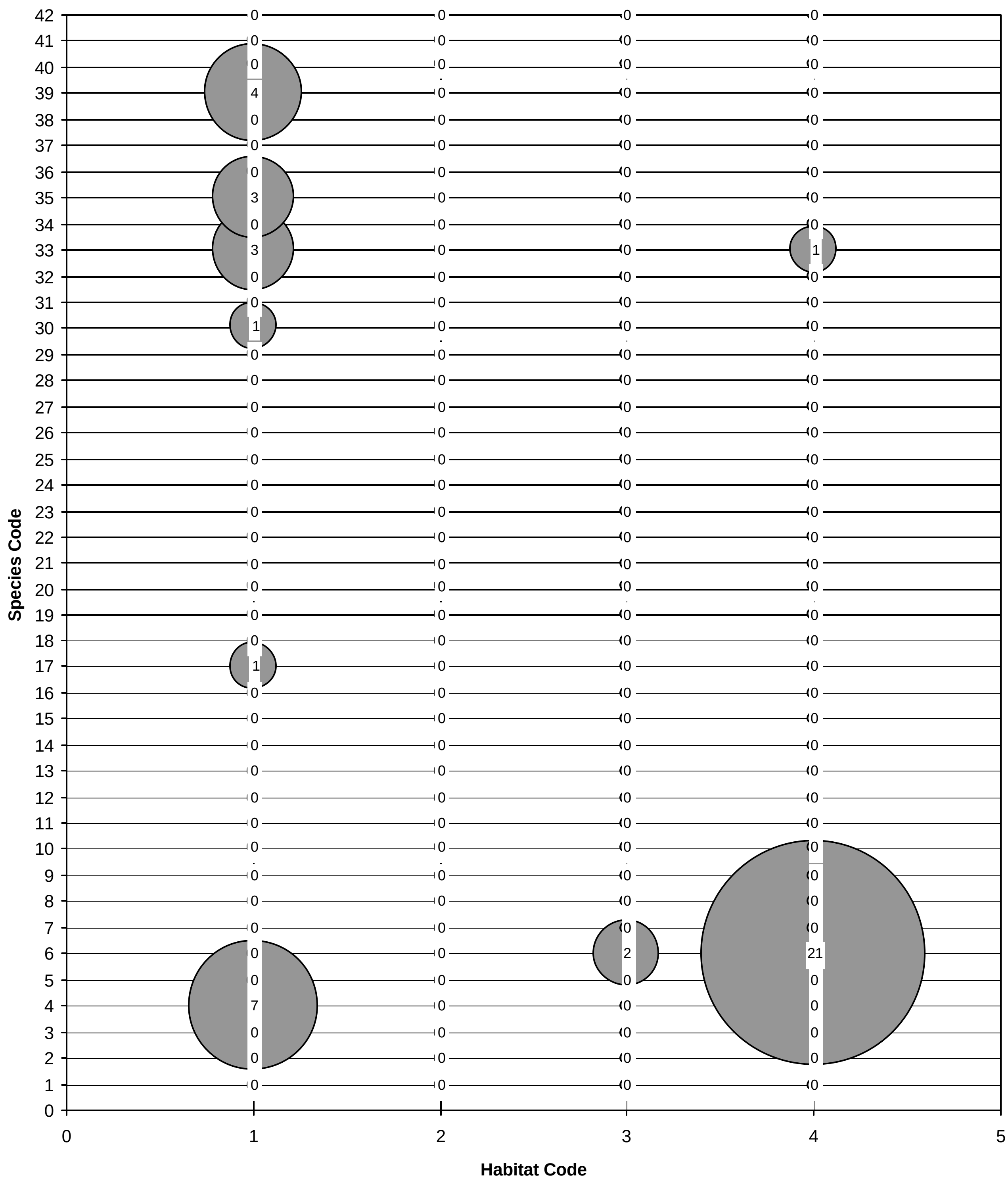

Figure 82. Total number of fishes collected from site 3 in the South Sulphur River on 2-3 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

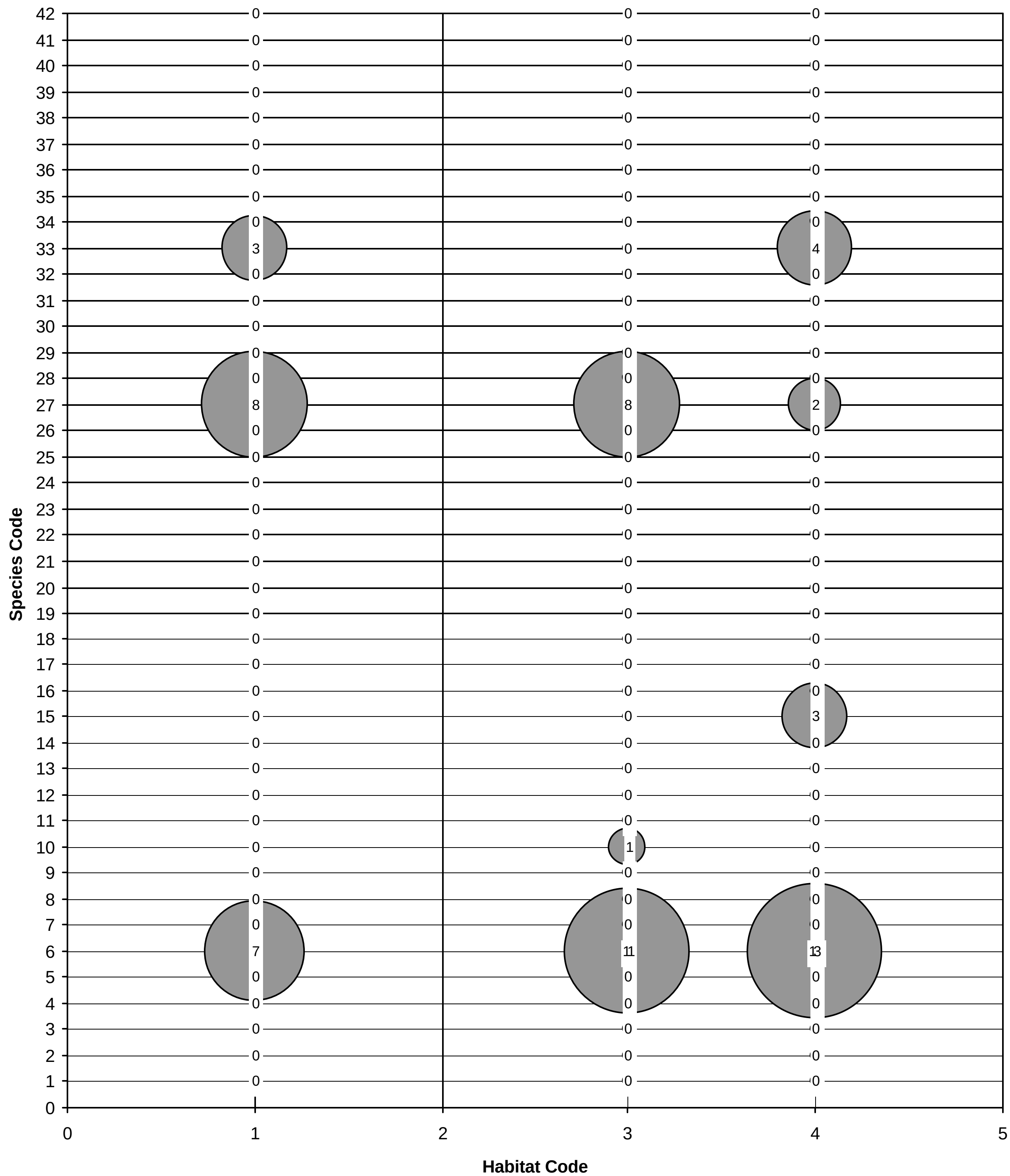

Figure 83. Total number of fishes collected from site 3 in the South Sulphur River on 10 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

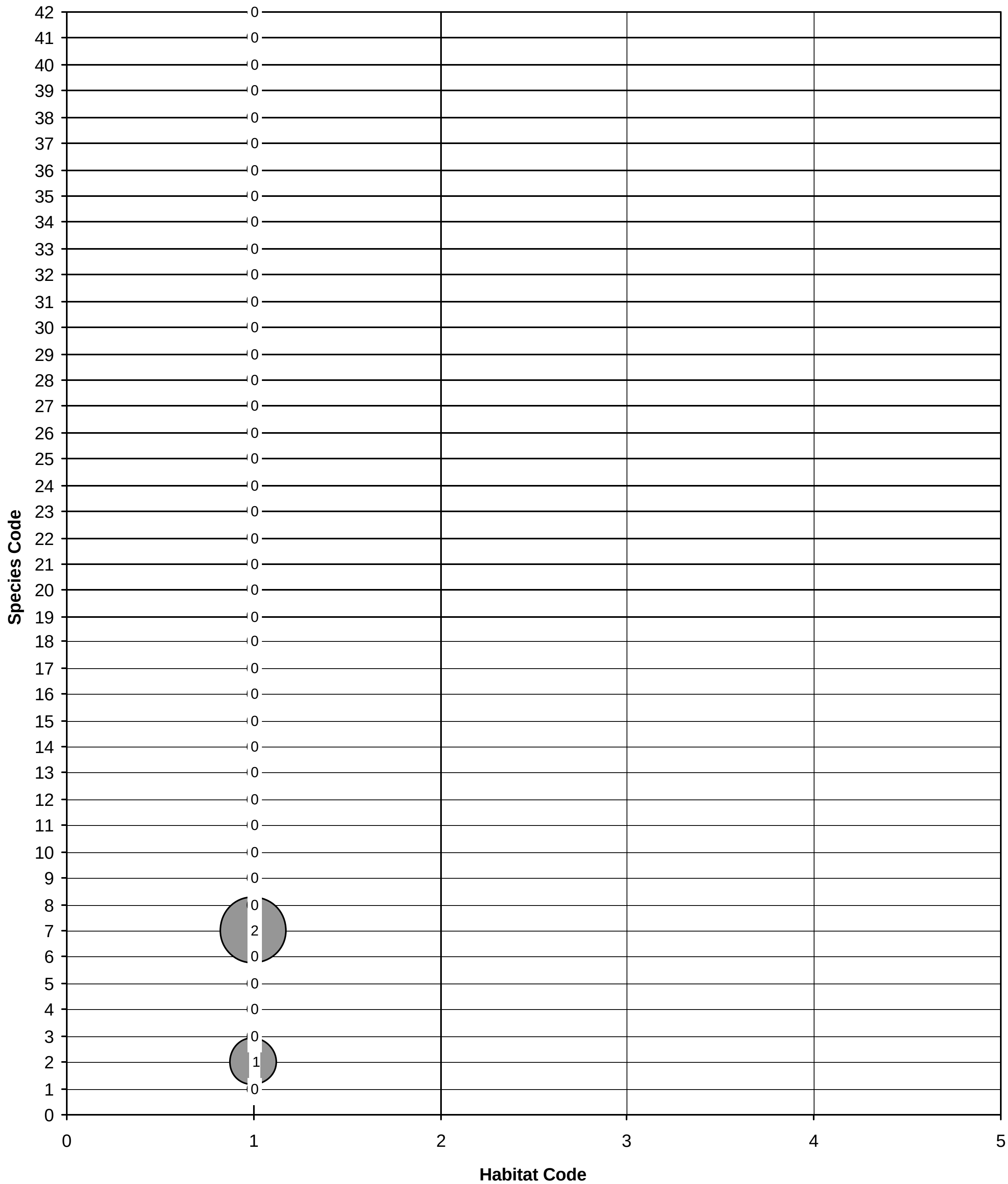

Figure 84. Total number of fishes collected from site 4 in the South Sulphur River on 19-20 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

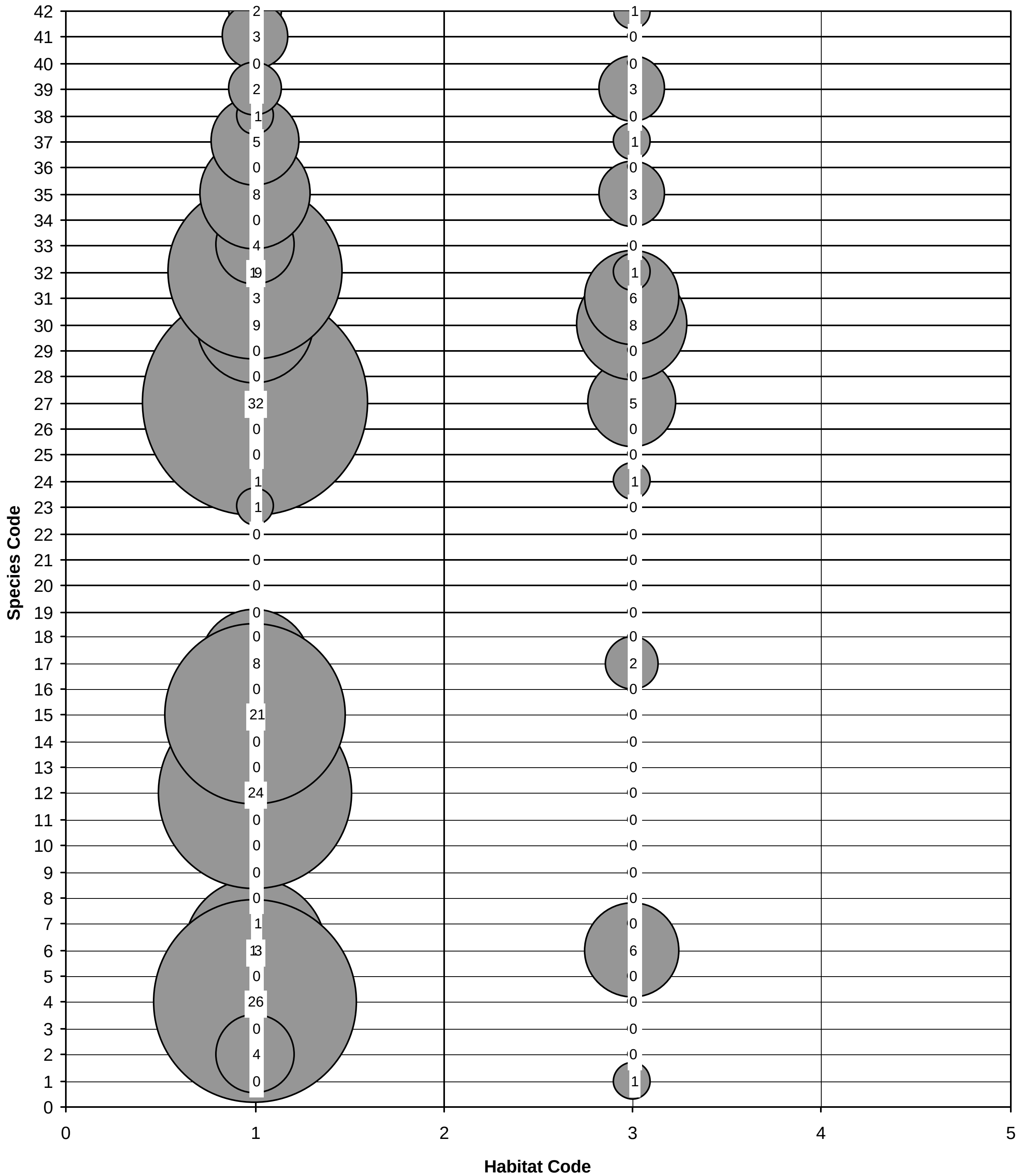

Figure 85. Total number of fishes collected from site 4 in the South Sulphur River on 11-12 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

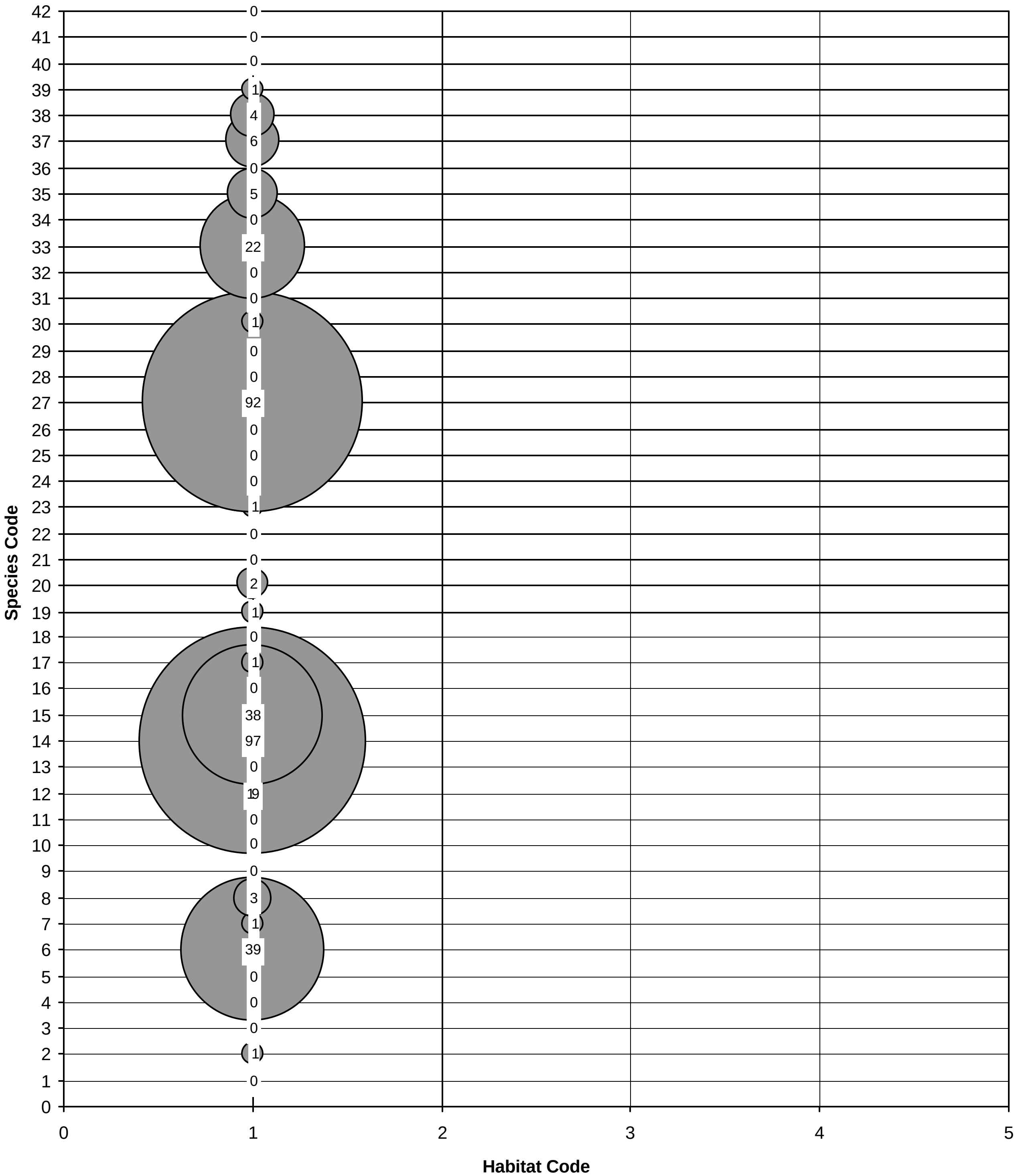

Figure 86. Total number of fishes collected from site 4 in the South Sulphur River on 4-6 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

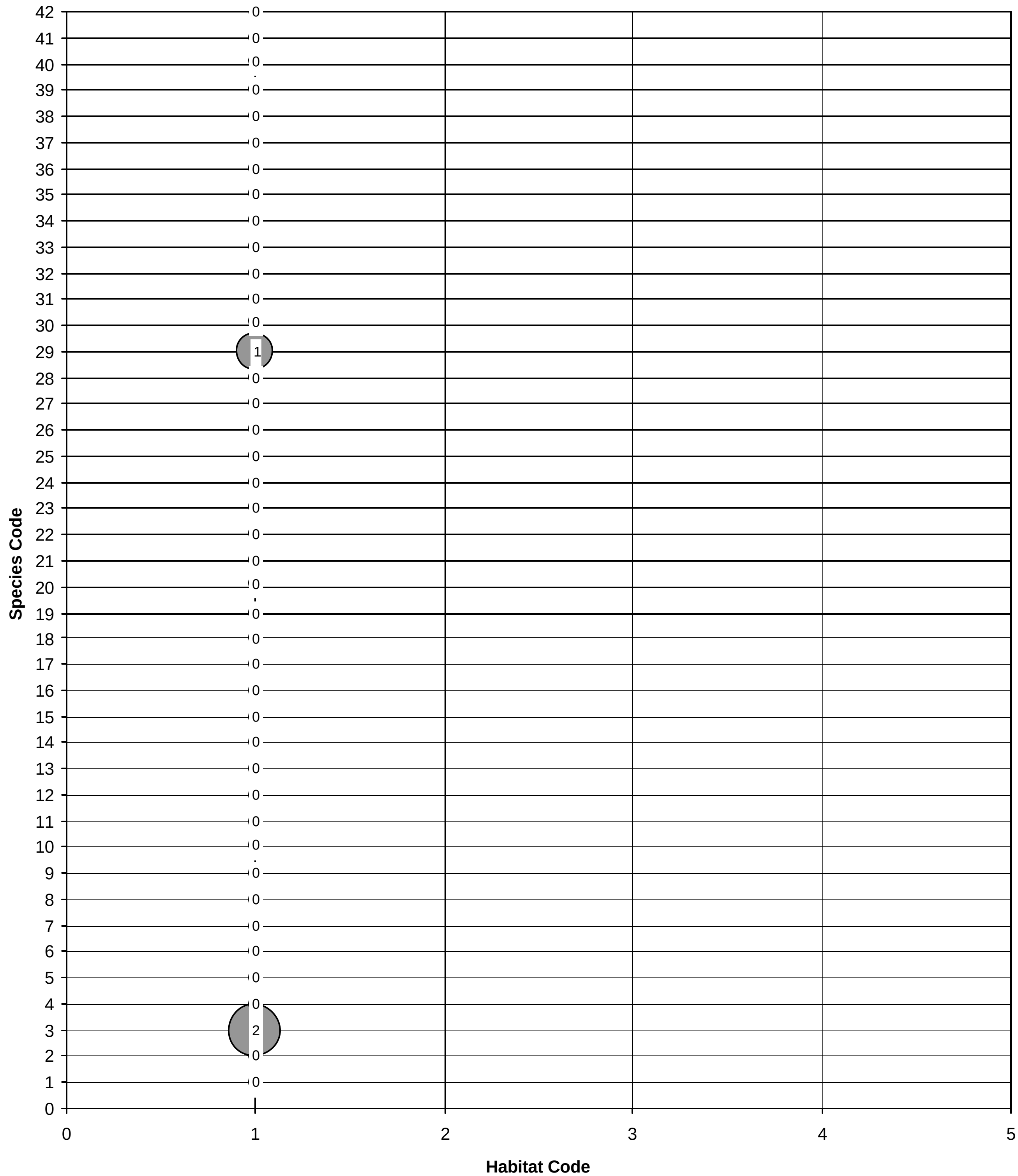

Figure 87. Total number of fishes collected from site 4 in the South Sulphur River on 29 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

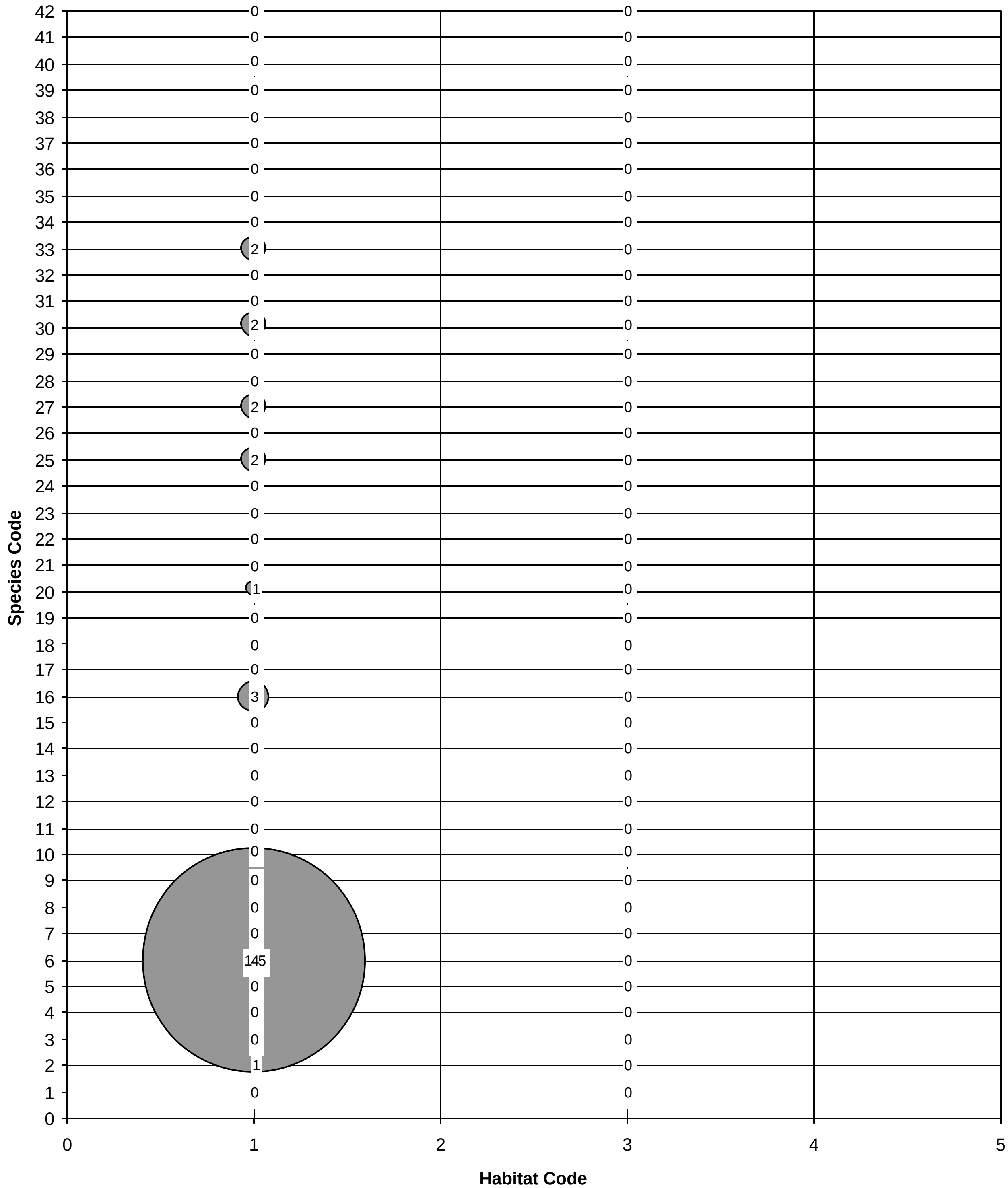

Figure 88. Total number of fishes collected from site 4 in the South Sulphur River on 3-4 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

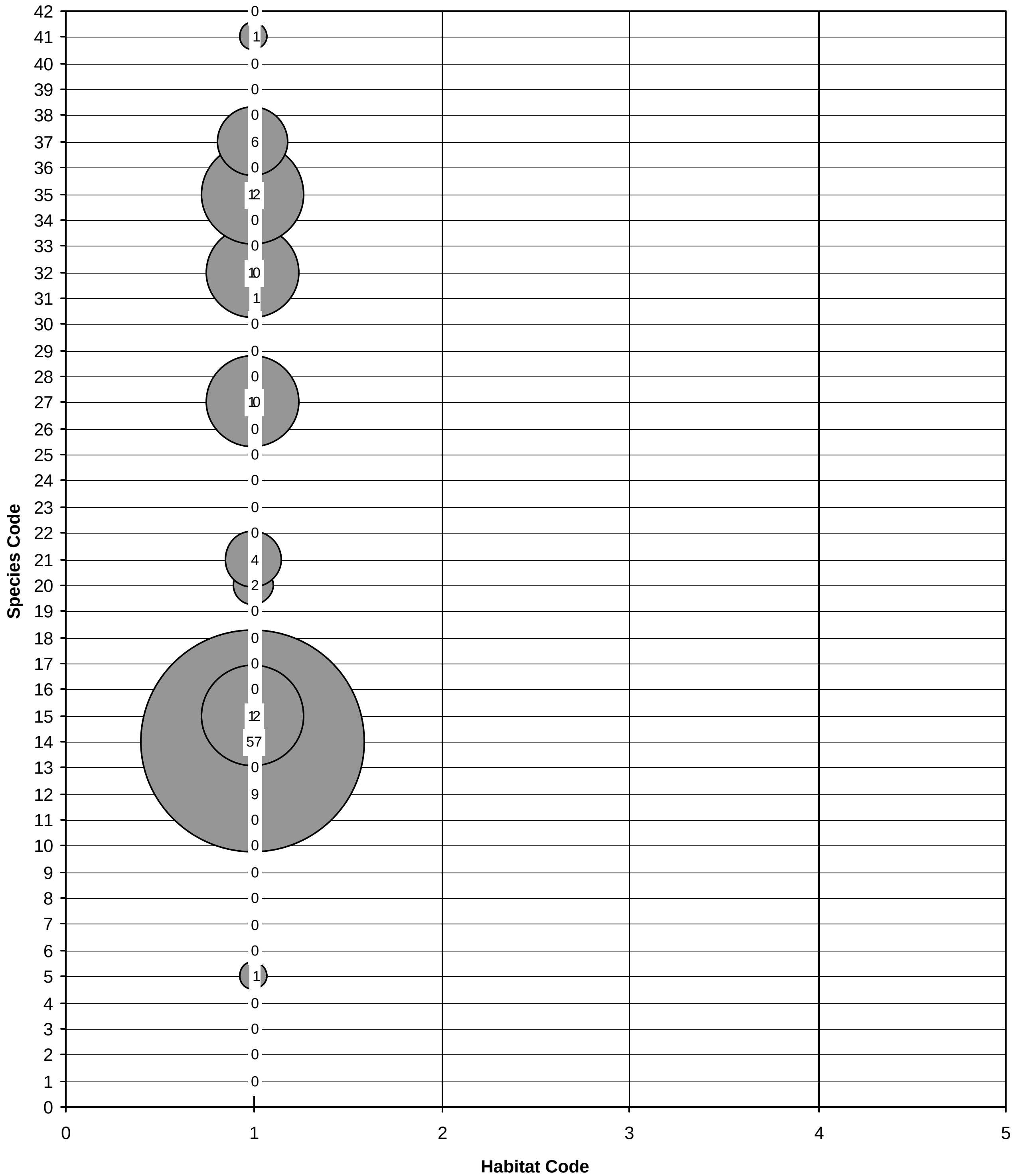

Figure 89. Total number of fishes collected from site 4 in the South Sulphur River on 11 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

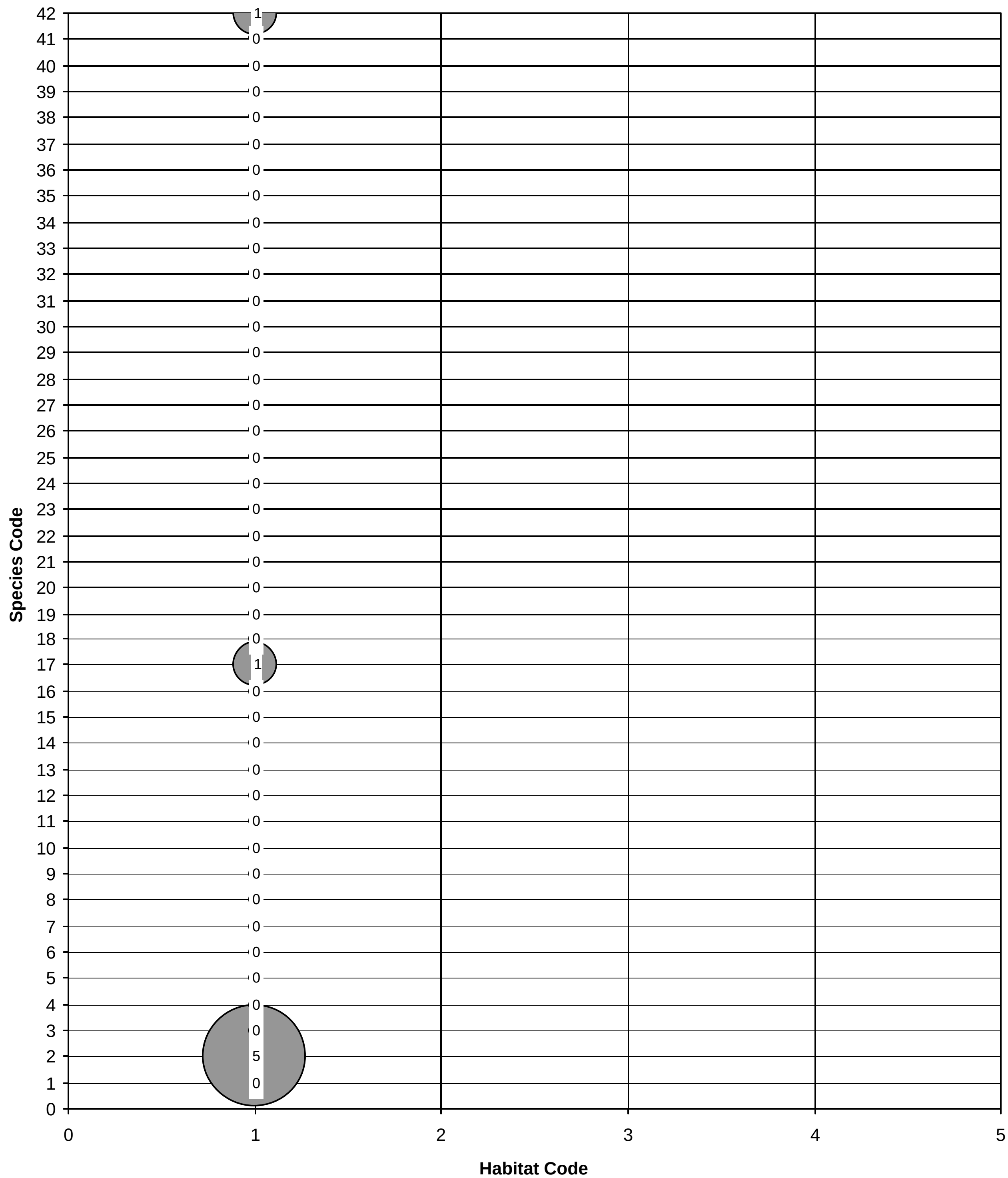

Figure 90. Total number of fishes collected from site 5 in the South Sulphur River 19-20 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

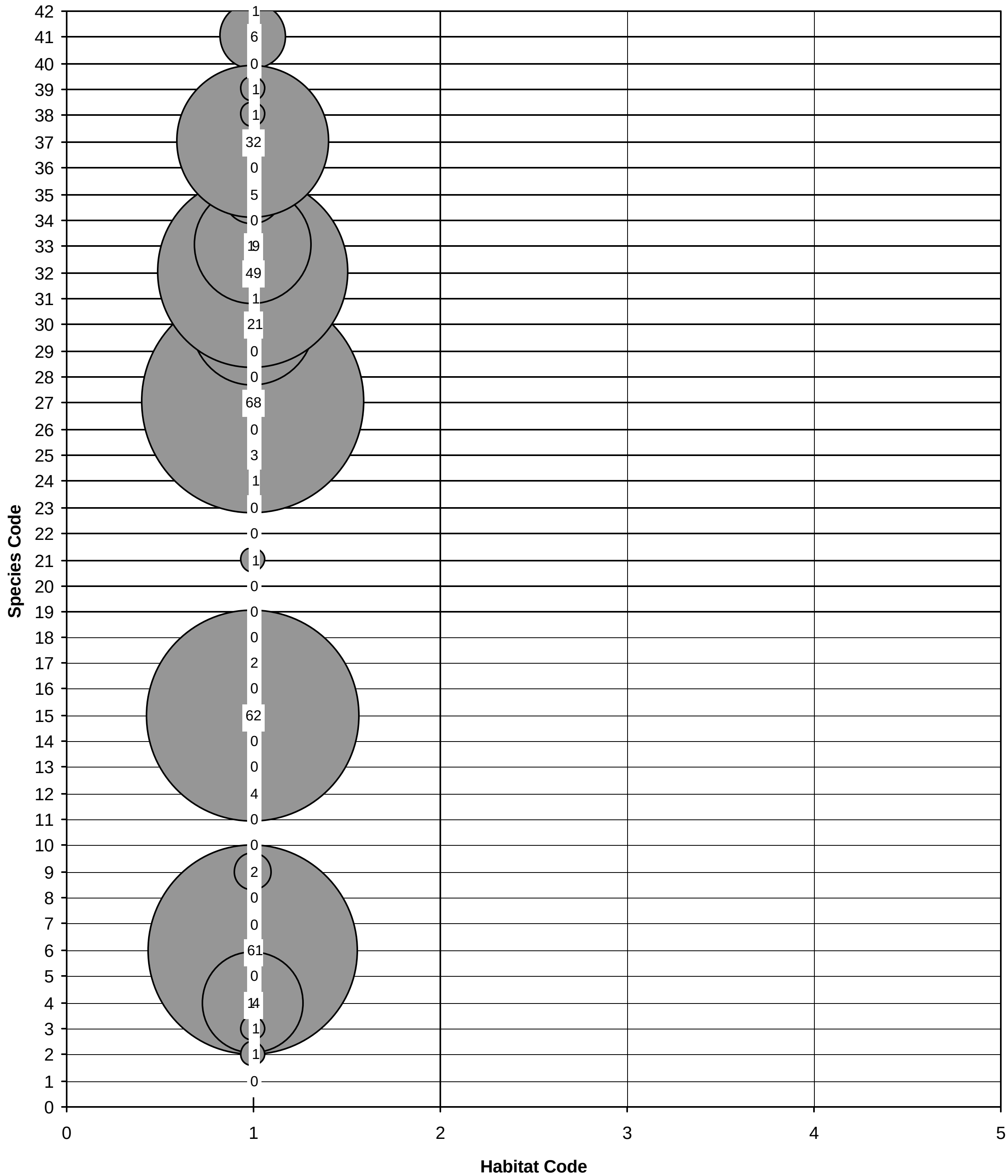

Figure 91. Total number of fishes collected from site 5 in the South Sulphur River on 11-12 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

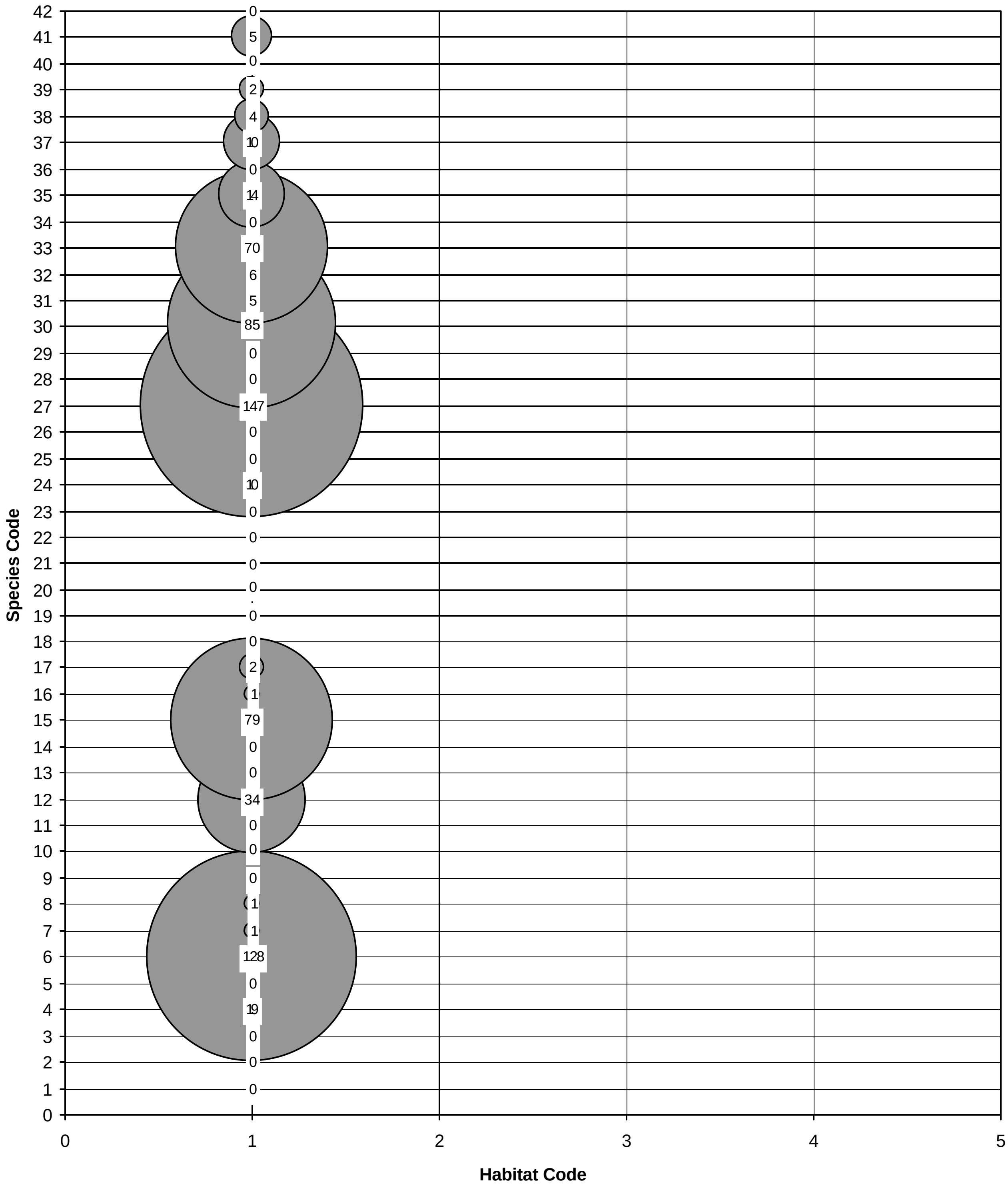

Figure 92. Total number of fishes collected from site 5 in the South Sulphur River on 4-6 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

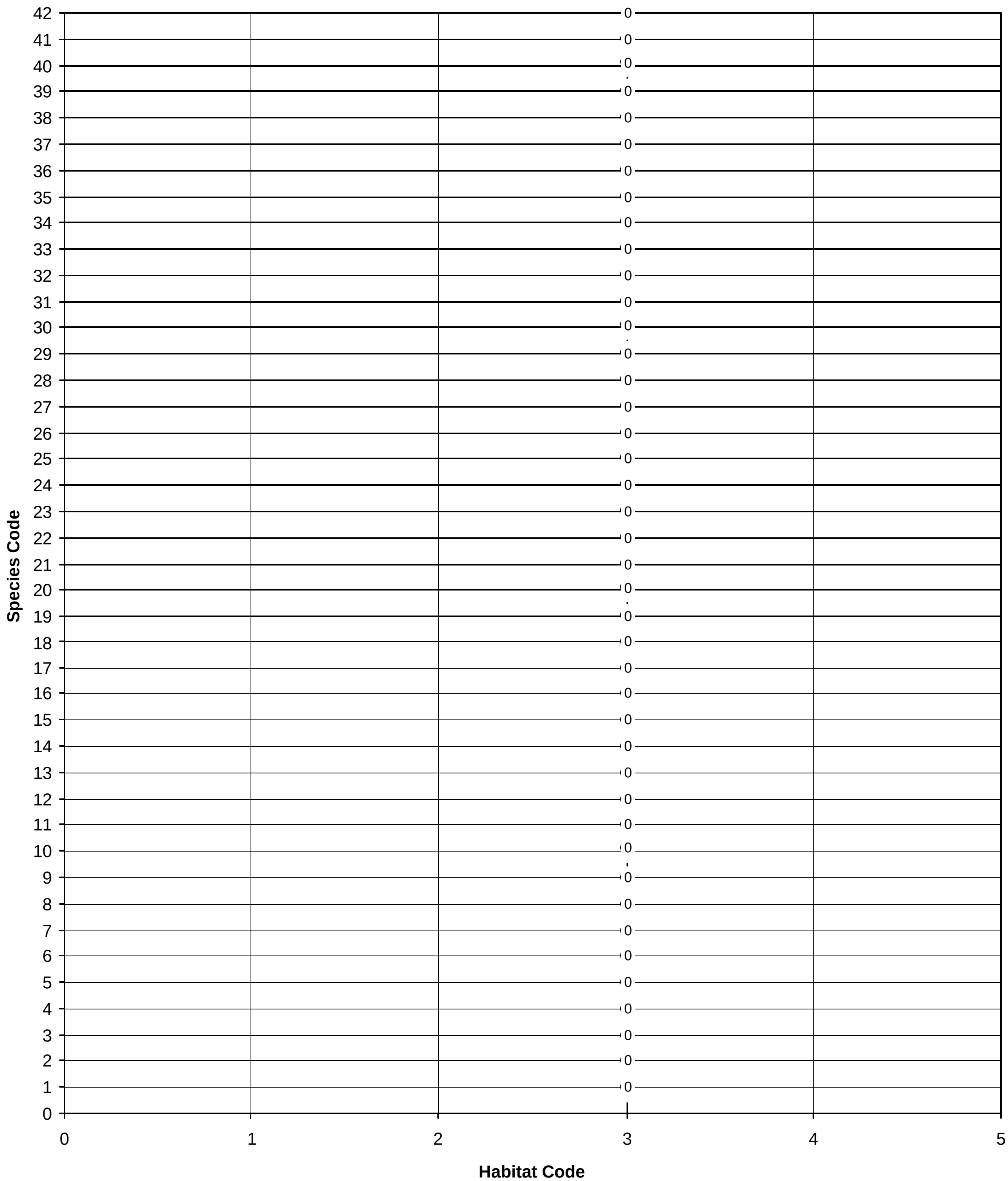

Figure 93. Total number of fishes collected from site 5 in the South Sulphur River on 29 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

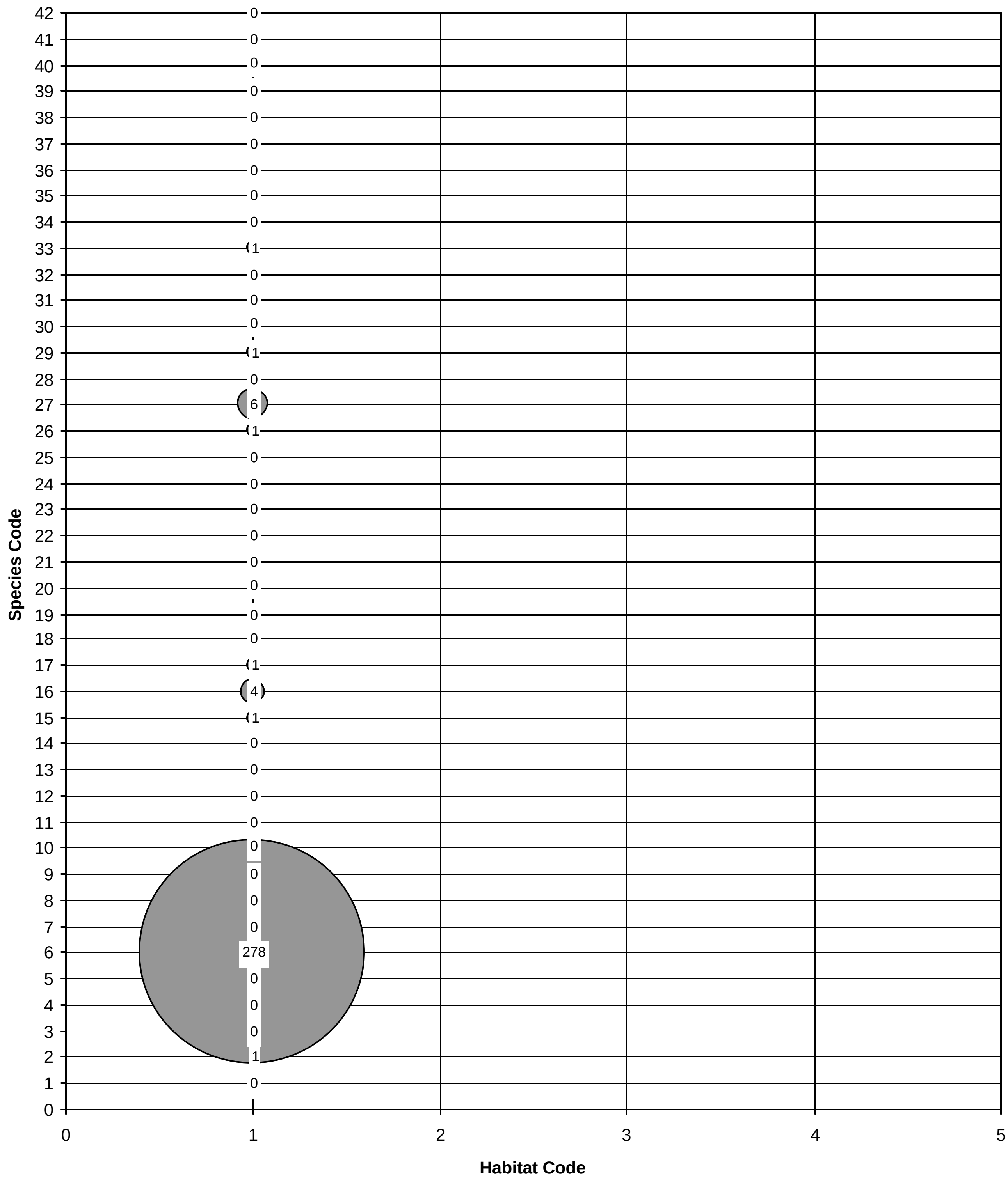

Figure 94. Total number of fishes collected from site 5 in the South Sulphur River on 3-4 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

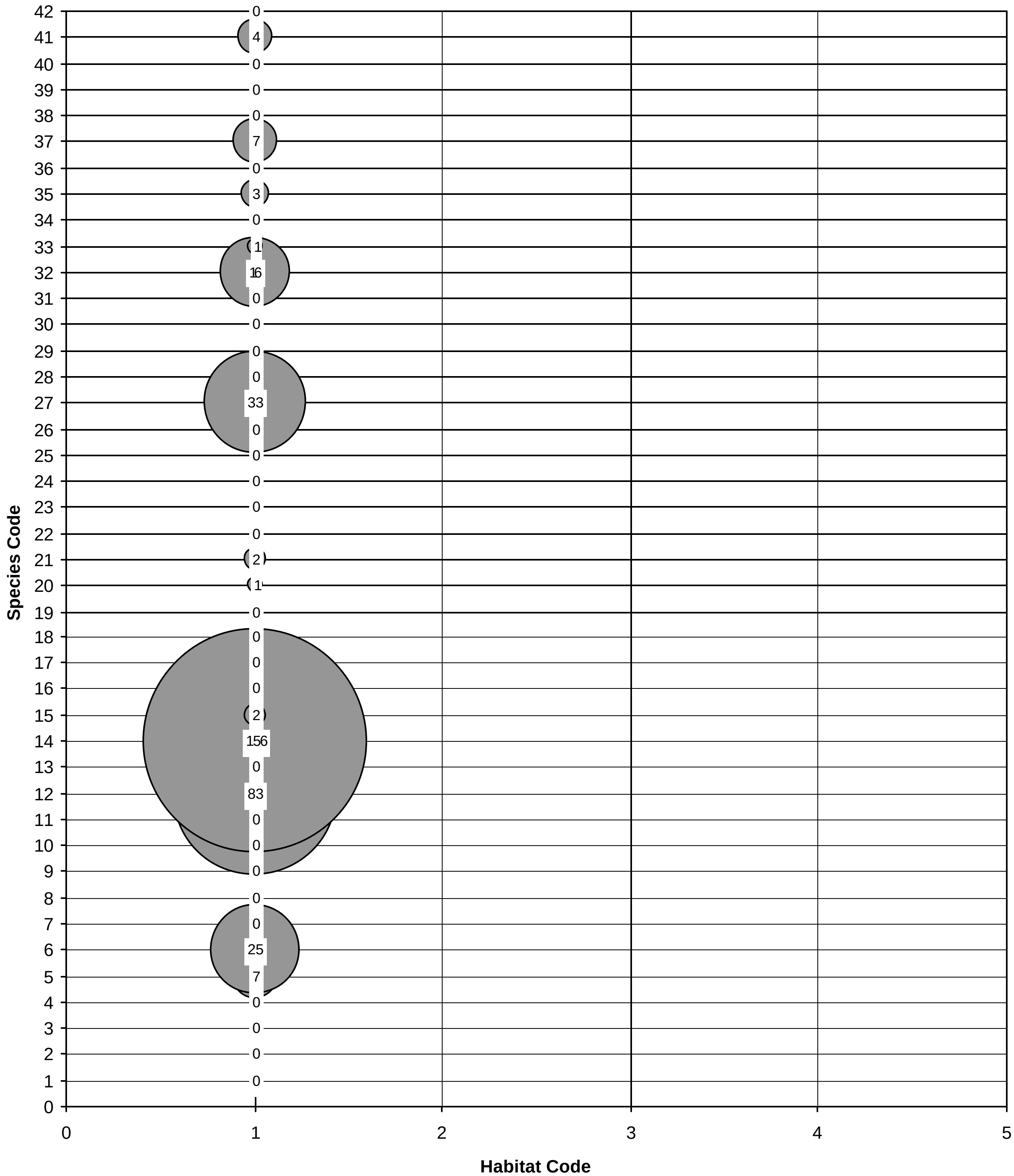

Figure 95. Total number of fishes collected from site 5 in the South Sulphur River on 11 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

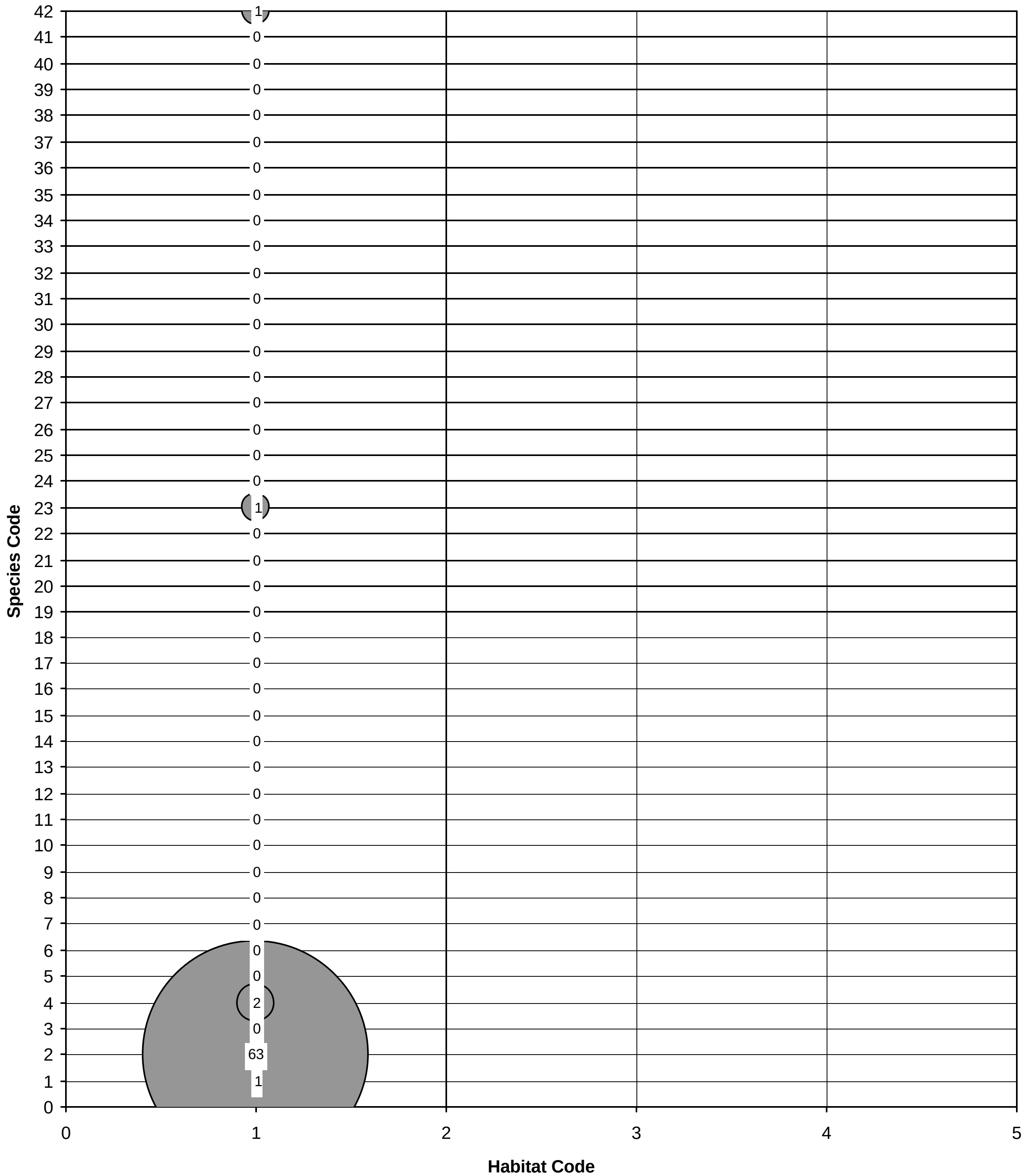

Figure 96. Total number of fishes collected from site 6 in the South Sulphur River on 19-20 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

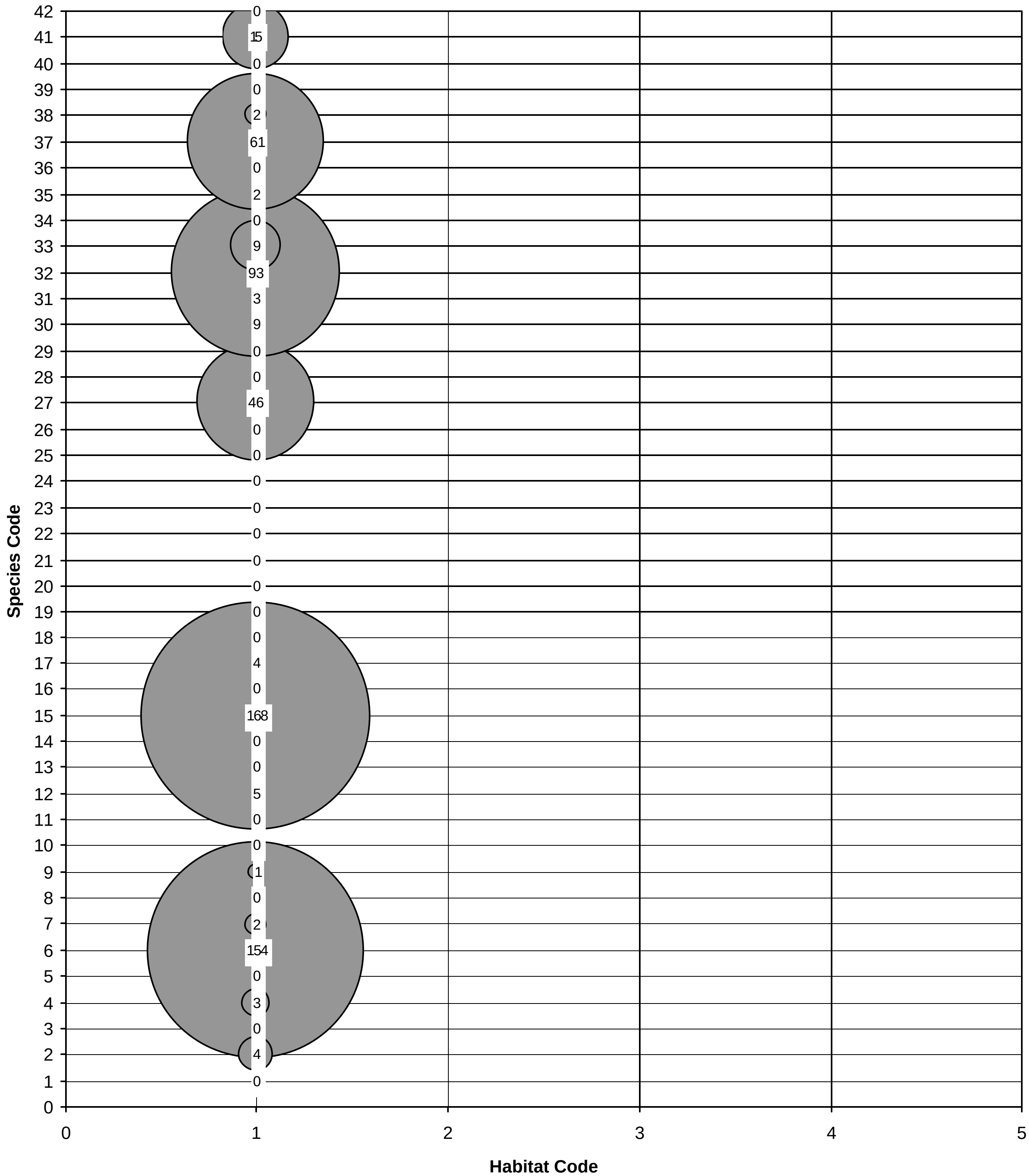

Figure 97. Total number of fishes collected from site 6 in the South Sulphur River on 11-12 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

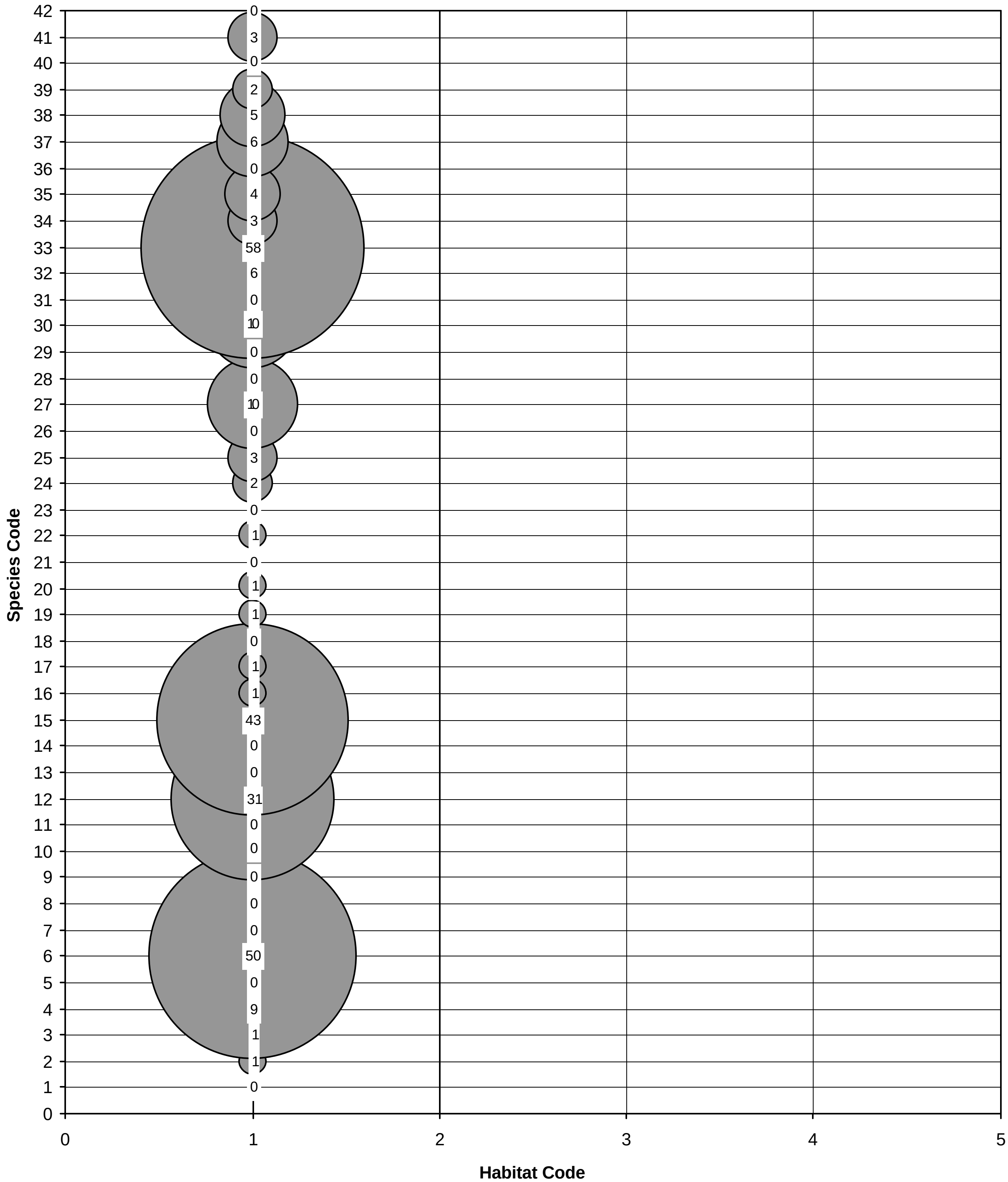

Figure 98. Total number of fishes collected from site 6 in the South Sulphur River on 4-6 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

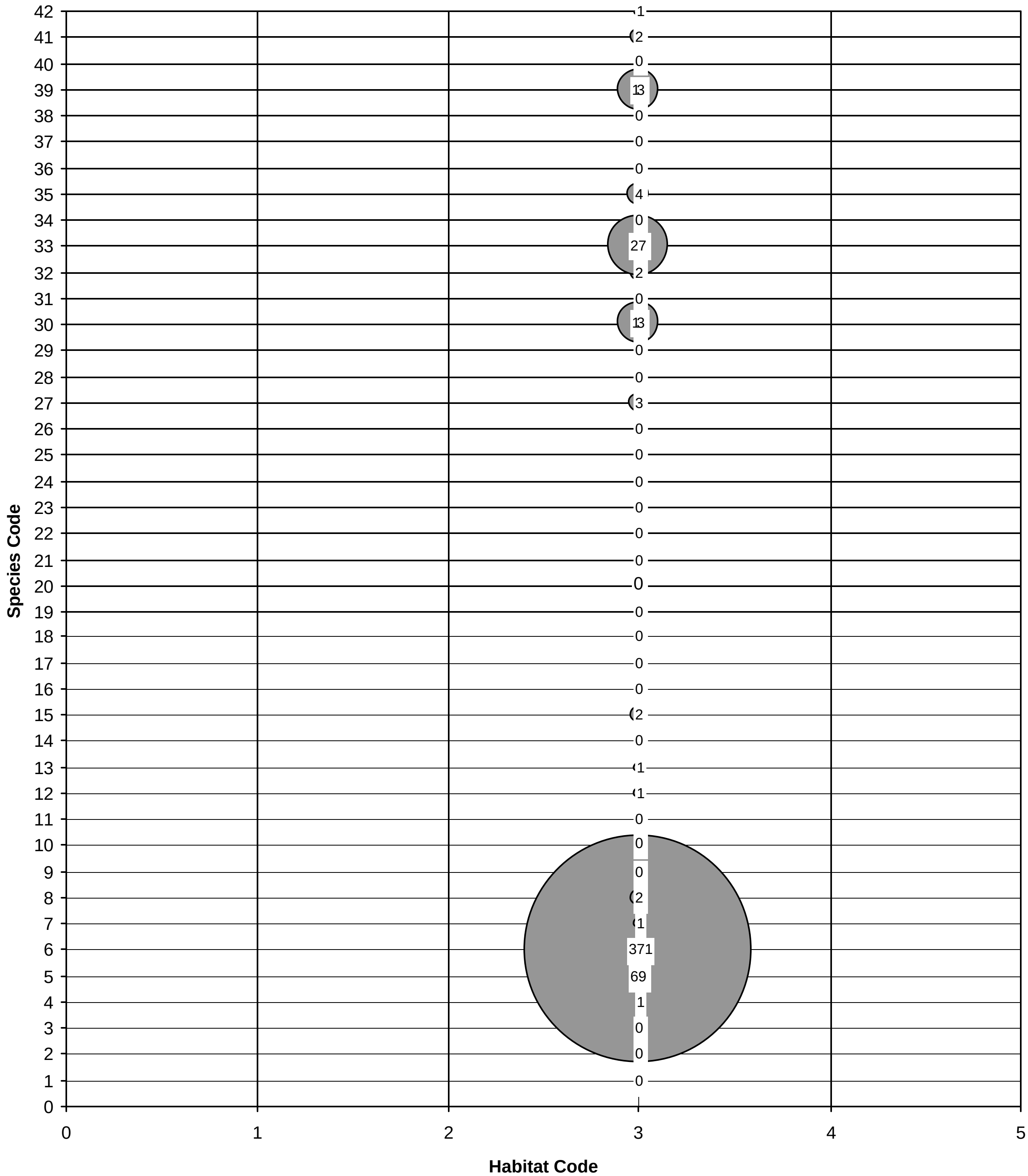

Figure 99. Total number of fishes collected from site 6 in the South Sulphur River on 29 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

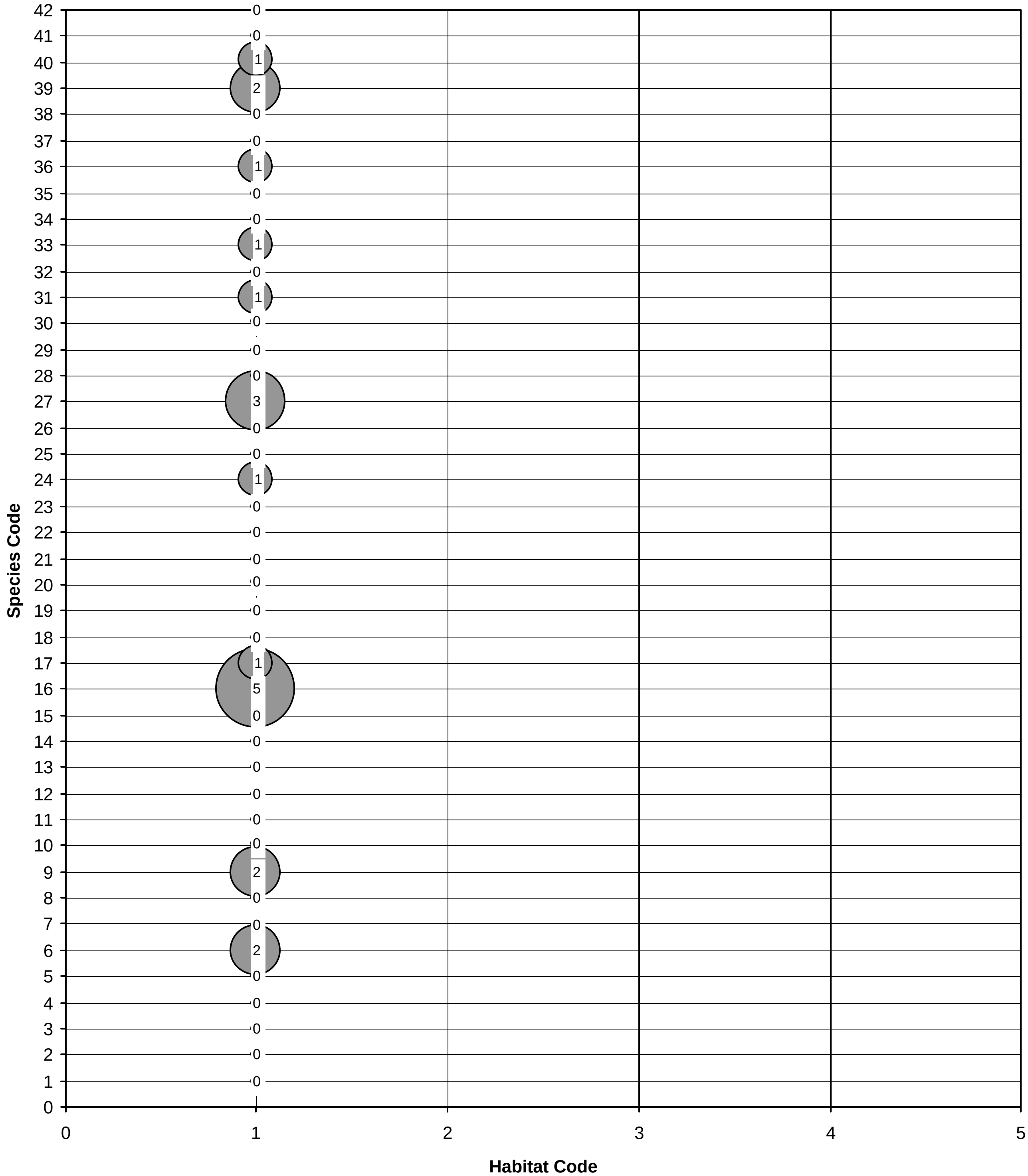

Figure 100. Total number of fishes collected from site 6 in the South Sulphur River on 3-4 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

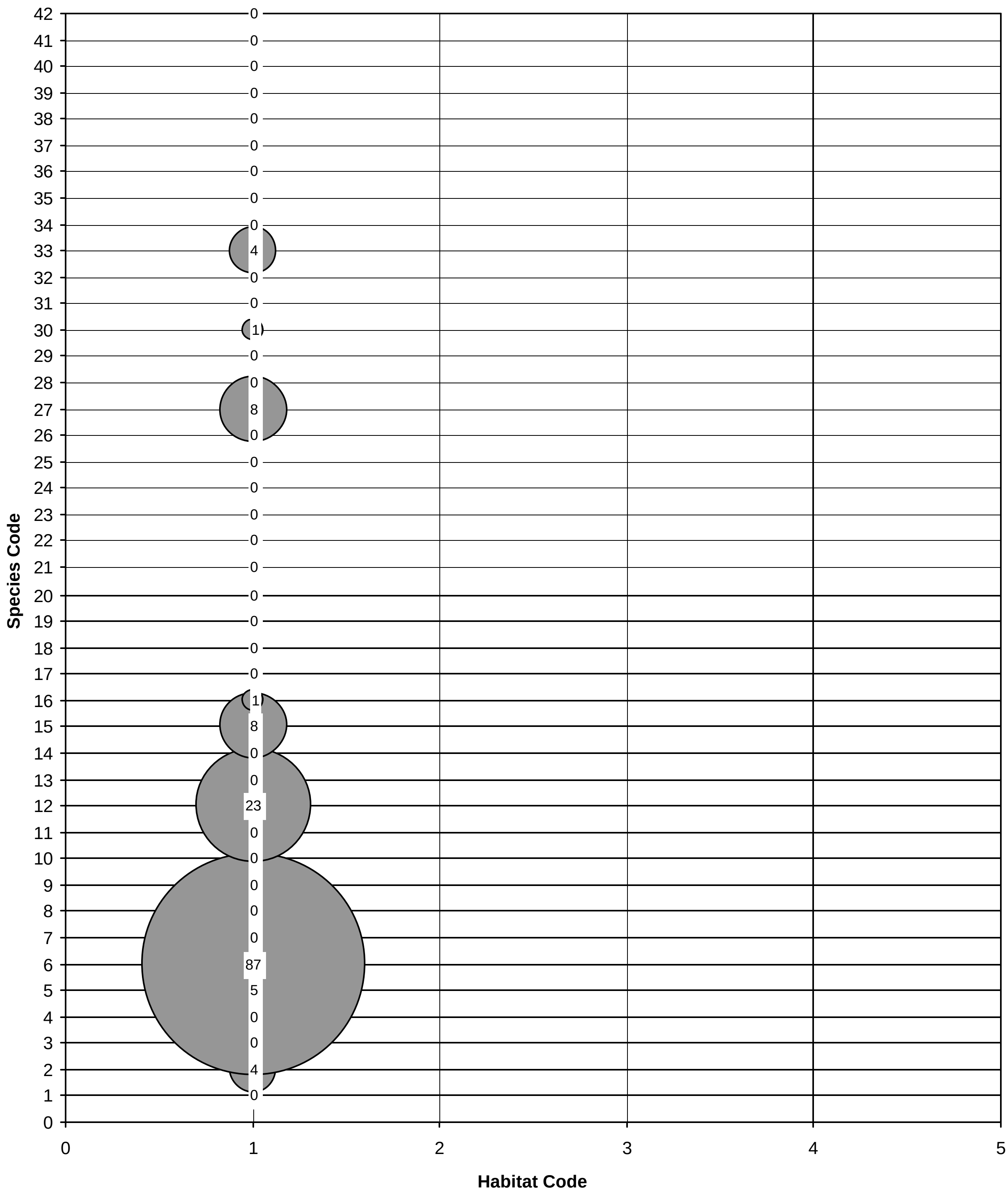

Figure 101. Total number of fishes collected from site 6 in the South Sulphur River on 11 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. Species and habitat codes are in Table 10.

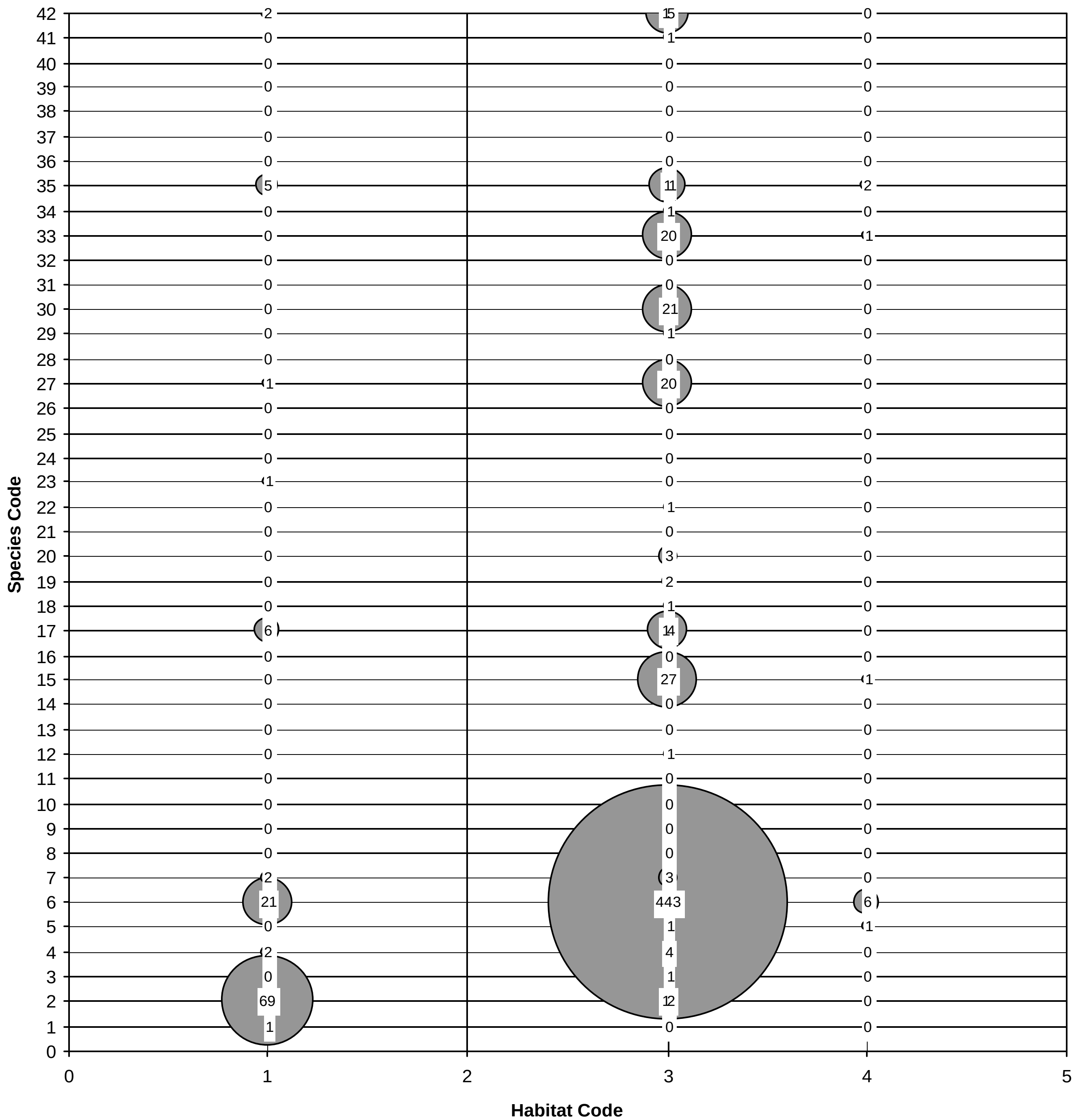

Figure 102. Total number of fishes collected in the proposed George Parkhouse I Reservoir study sites on 18-20 May 2002 during the summer-high flow range (114-521 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. No number at an intersection indicates the habitat was absent. Species and habitat codes are in Table 10.

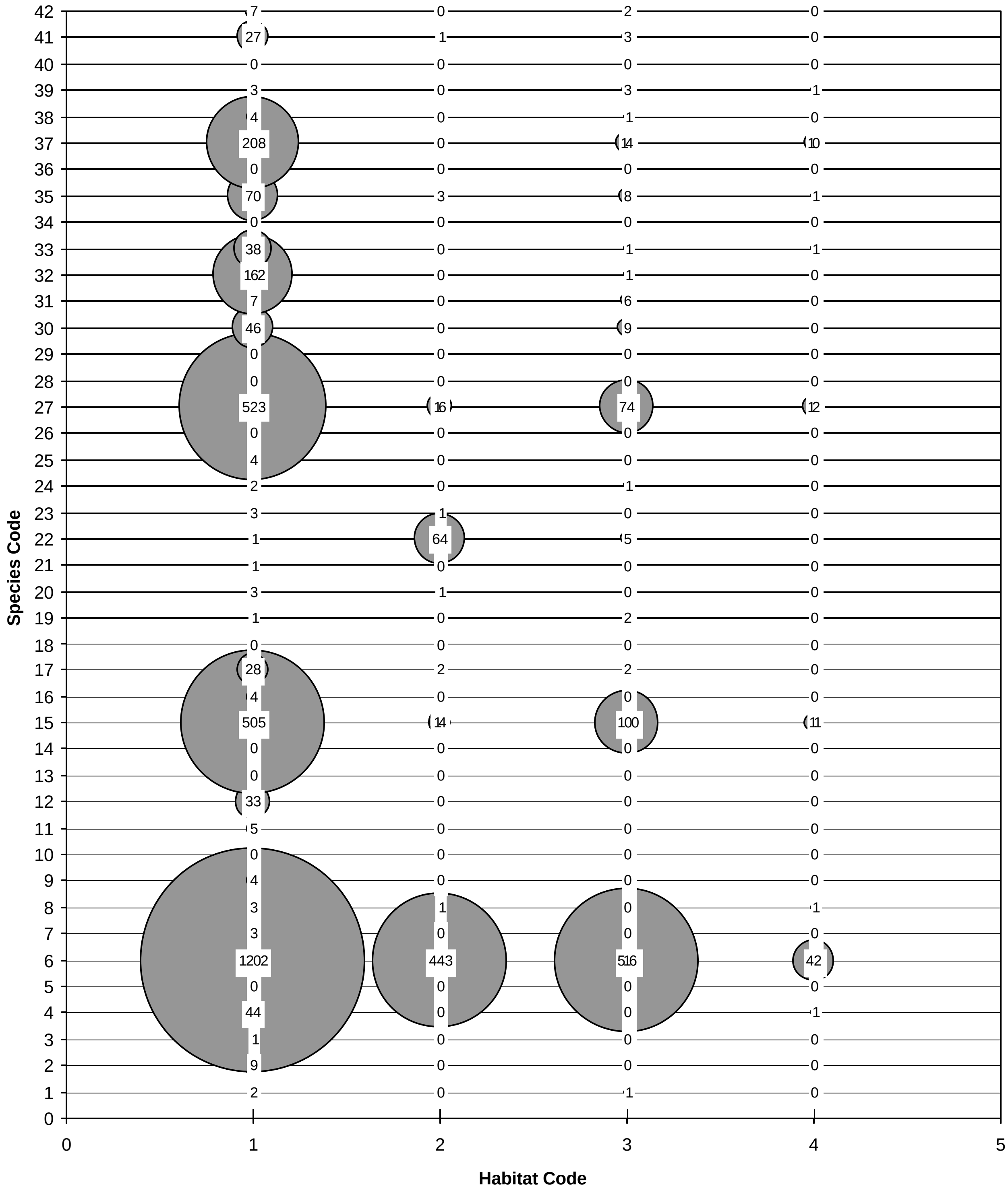

Figure 103. Total number of fishes collected in the proposed George Parkhouse I Reservoir study sites on 9-12 July 2002 during the summer-middle flow range (0.50-24 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. No number at an intersection indicates the habitat was absent. Species and habitat codes are in Table 10.

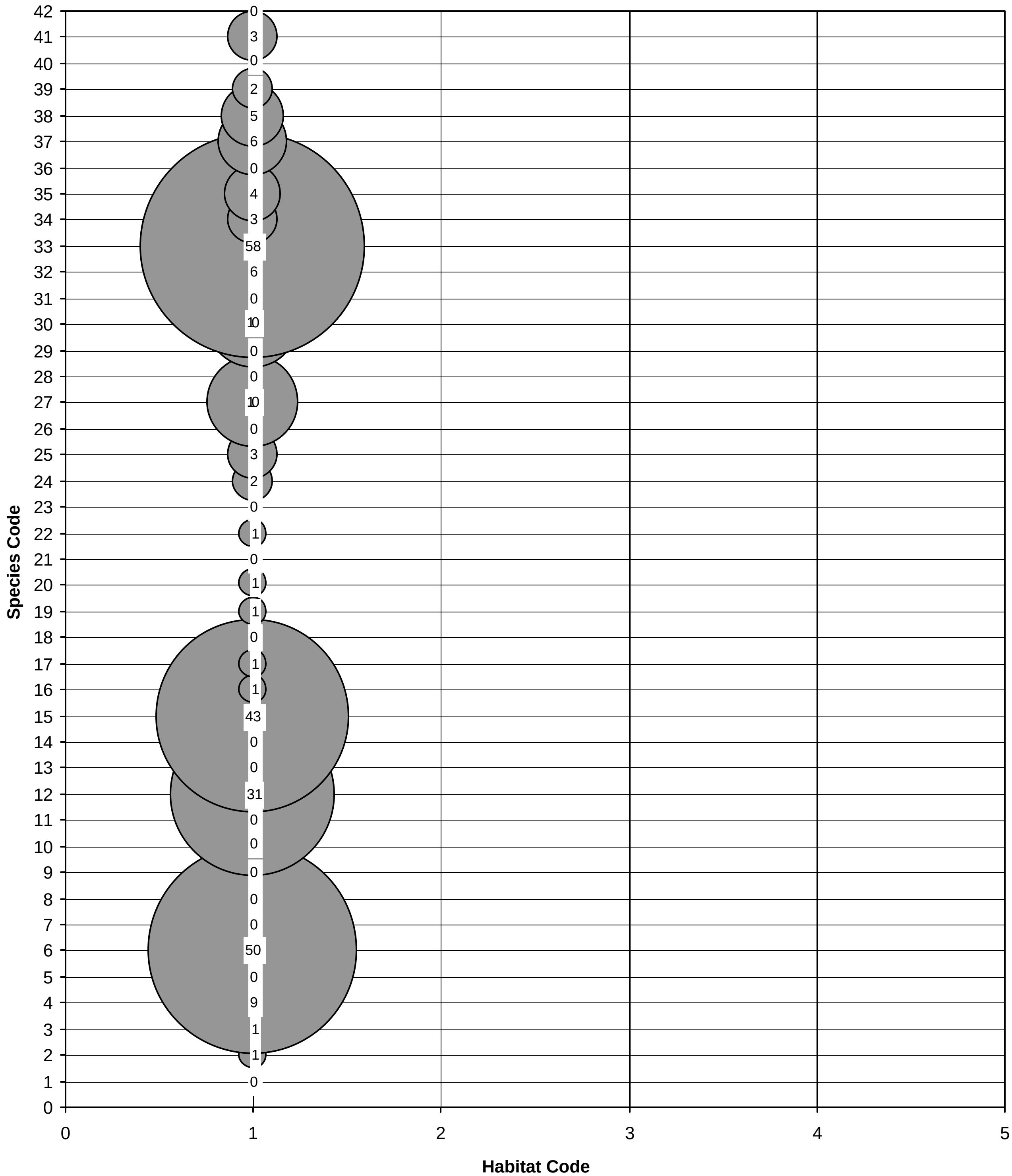

Figure 104. Total number of fishes collected in the proposed George Parkhouse I Reservoir study sites on 4-8 August 2001 during the summer-low flow range (8-9 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. No number at an intersection indicates the habitat was absent. Species and habitat codes are in Table 10.

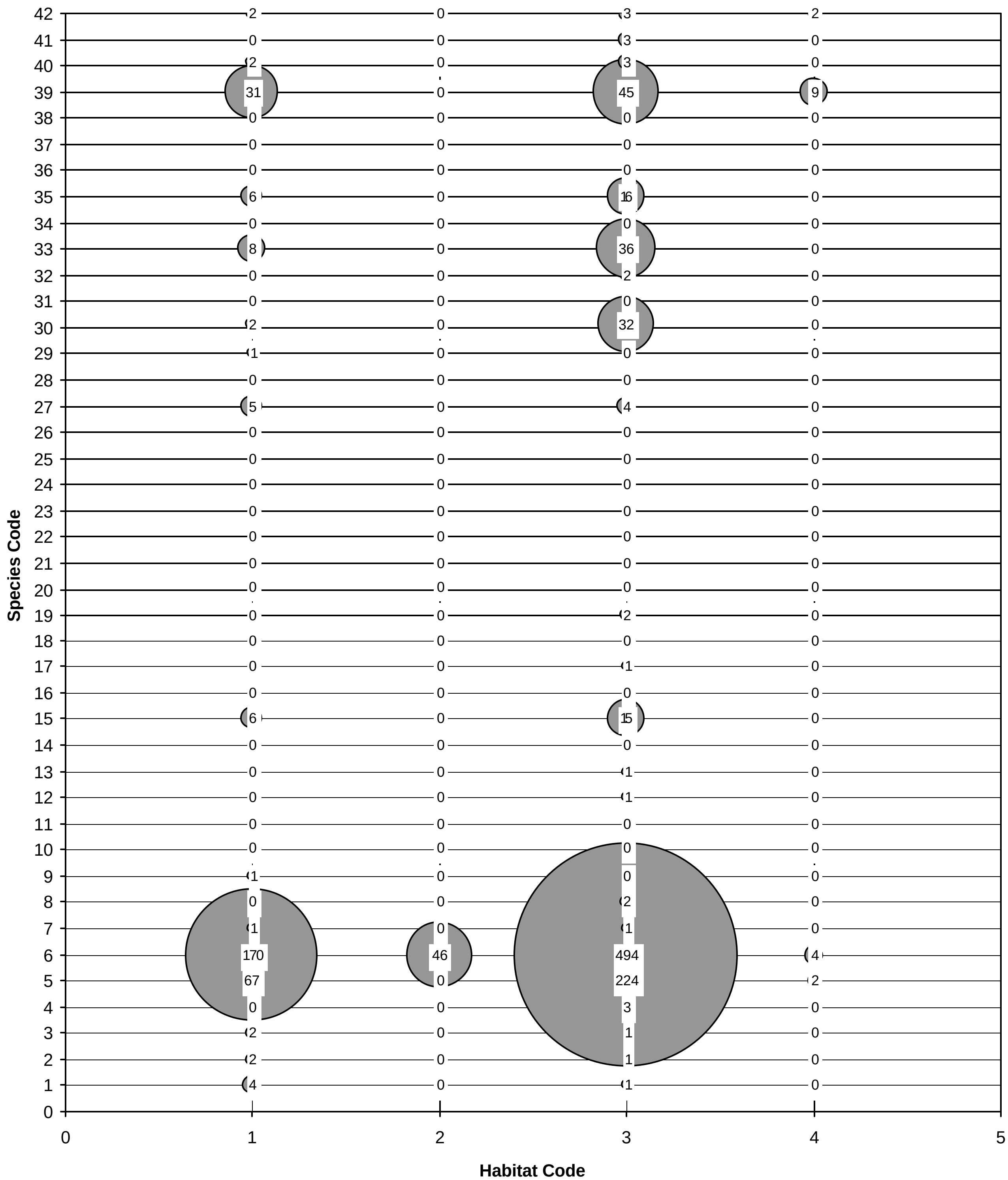

Figure 105. Total number of fishes collected in the proposed George Parkhouse I Reservoir study sites on 27-29 April 2002 during the winter-high flow range (453-470 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. No number at an intersection indicates the habitat was absent. Species and habitat codes are in Table 10.

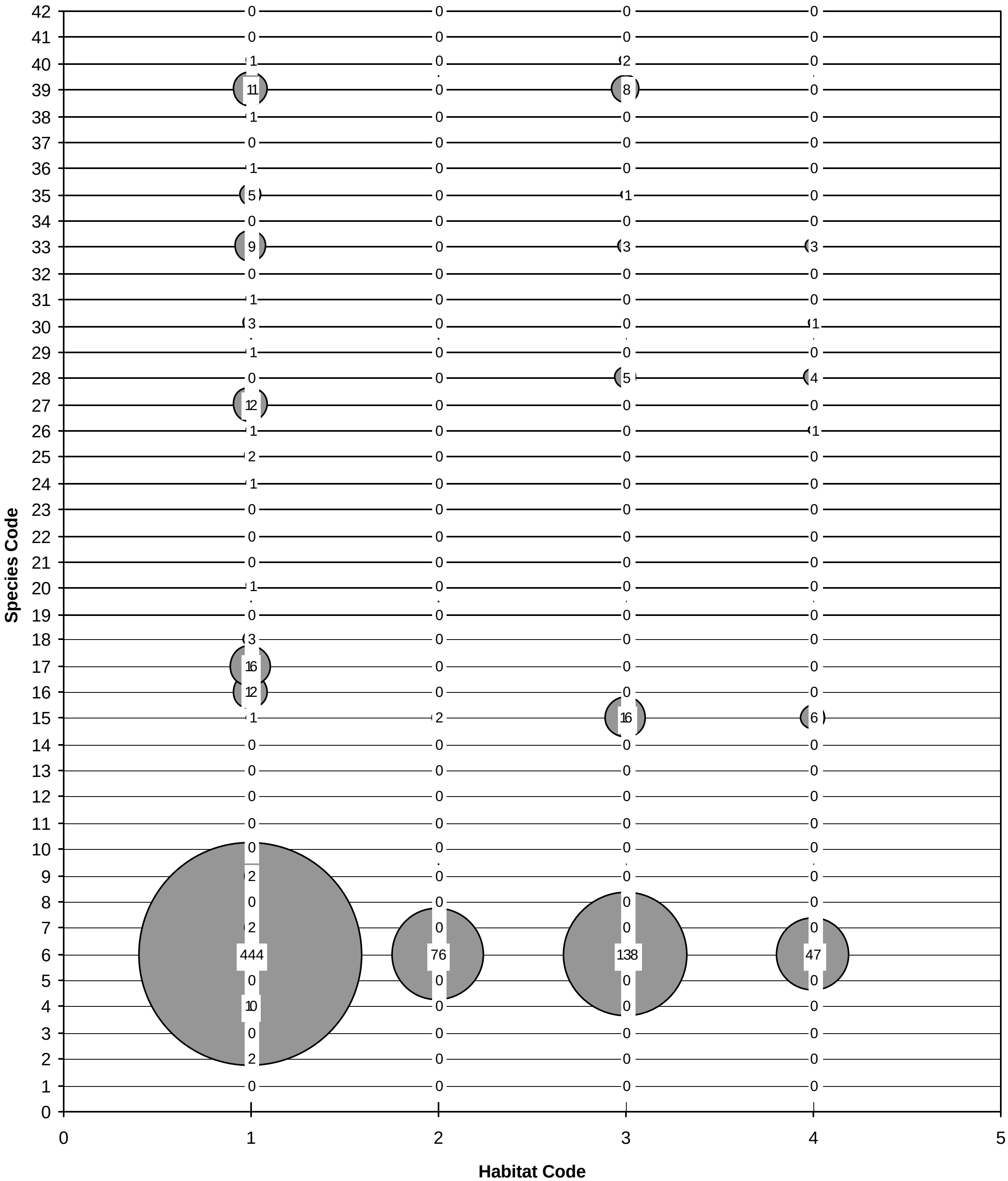

Figure 106. Total number of fishes collected in the proposed George Parkhouse I Reservoir study sites on 2-4 March 2002 during the winter-middle flow range (22-106 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. No number at an intersection indicates the habitat was absent. Species and habitat codes are in Table 10.

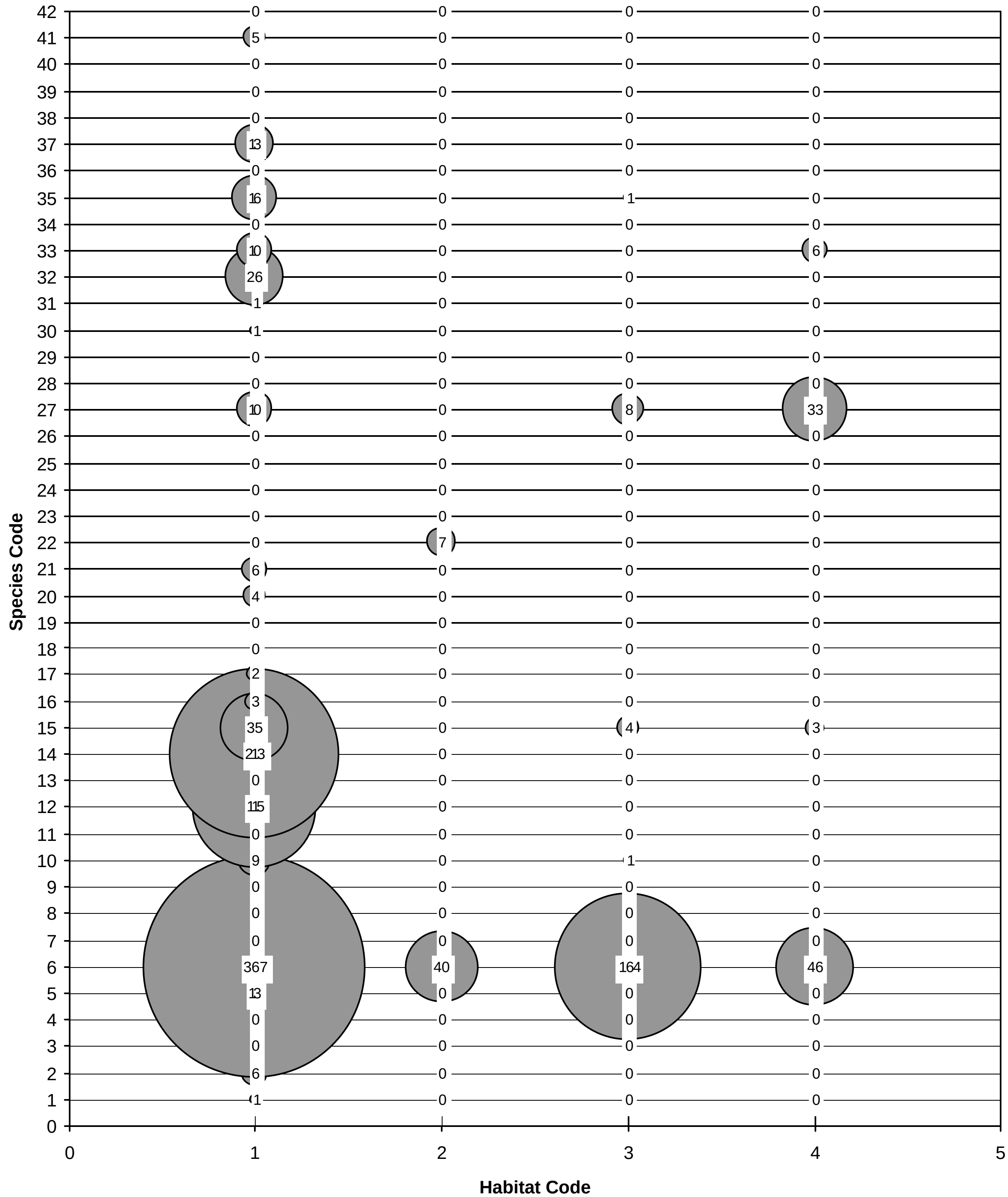

Figure 107. Total number of fishes collected in the proposed George Parkhouse I Reservoir study sites on 10-11 November 2001 during the winter-low flow range (11-17 cfs). Number of fish is indicated at the intersections of species and habitat codes and also by relative size of bubbles centered at the intersections. Zeros indicate the species was not collected from the habitat. No number at an intersection indicates the habitat was absent. Species and habitat codes are in Table 10.

Table 11. IBI metrics and sum ranks for the South Sulphur River.

		Ranks					
		Site					
	Metric	1	2	3	4	5	6
1.	Total number of fish species	5	5	5	5	5	5
2.	Number of native cyprinid species	5	5	5	5	5	5
3.	Number of benthic invertivore species (Catastomidae, Ictaluridae, or Percidae)	5	5	3	3	5	5
4.	Number of sunfish species	5	5	5	5	5	5
5.	% of individuals as tolerant species (excluding western mosquitofish)	1	1	3	3	3	3
6.	% of individuals as omnivores	5	5	5	5	5	5
7.	% of individuals as invertivores	5	5	5	5	5	5
8.	% of individuals as piscivores	1	1	1	3	5	5
9.	Number of individuals in sample a. Number of individuals/seine haul b. Number of individuals/min electrofishing	5	3	2	1	2	2
10.	% of individuals as non-native species	5	5	5	5	5	5
11.	% of individuals with disease or other anomaly	5	5	5	5	5	5
	Overall Score	47	45	44	45	50	50
	Overall Rating	high	high	high	high	exceptional	exceptional
	% of possible score	85	82	80	82	91	91

	Overall Rating	Overall Score
1	Exceptional	= 49
2	High	41-48
3	Intermediate	35-40
4	Limited	< 35

Table 12. Indicator values for fish based on relative abundance and frequency of occurrence in Sulphur River habitat groups. *P* is the proportion of Monte Carlo randomized trials (1000) with indicator values equal to or exceeding the observed indicator value. Bold numbers indicate the value that is highest for each species.

		Habitat Groups			
Species	*P*	Pool	Riffle	Run	Backwater
Bluegill	0.000	7	0	7	**68**
Freckled Madtom	0.006	0	**41**	1	0
River Carpsucker	0.006	**39**	0	0	0
Longnose Gar	0.030	**49**	0	1	0
Ghost Shiner	0.045	**28**	0	0	0
Smallmouth Buffalo	0.052	**34**	7	4	0
Orangespotted Sunfish	0.075	**23**	0	1	0
Gizzard Shad	0.078	**25**	0	2	1
Common Carp	0.093	**24**	0	3	0
Ribbon Shiner	0.159	**16**	0	0	0
Blackspotted Topminnow	0.168	0	0	0	**12**
White Crappie	0.188	2	0	5	**29**
Green Sunfish	0.210	10	1	**28**	3
Blue Catfish	0.223	1	0	**13**	0
Bigmouth Buffalo	0.230	**12**	0	0	0
Longear Sunfish	0.246	18	1	**27**	5

Table 12. Continued.

Species	*P*	Habitat Groups			
		Pool	Riffle	Run	Backwater
Red Shiner	0.248	4	**39**	19	16
Tadpole Madtom	0.317	**10**	0	0	0
Pirate Perch	0.409	**10**	0	2	0
Spotted Gar	0.428	**11**	0	4	0
Inland Silverside	0.434	0	3	1	**9**
Threadfin Shad	0.456	2	0	**13**	7
Redfin Shiner	0.509	1	2	**10**	0
Silverband Shiner	0.546	0	0	**5**	0
Black Crappie	0.547	1	0	**8**	0
Mimic Shiner	0.550	2	0	**8**	0
Bullhead Minnow	0.558	7	9	**27**	22
Dollar Sunfish	0.566	1	0	**8**	0
Slough Darter	0.568	**13**	3	7	0
Blackstriped Topminnow	0.592	7	0	0	**9**
Shortnose Gar	0.619	**7**	0	2	0
Morone sp.	0.690	**5**	0	1	0
Mississippi Silvery Minnow	0.748	3	**6**	0	4

Table 12. Continued.

		Habitat Groups			
Species	*P*	Pool	Riffle	Run	Backwater
Lepomis sp.	0.761	**12**	0	5	11
Largemouth Bass	0.765	**9**	0	2	6
Flathead Catfish	0.772	**7**	6	1	0
Western Mosquitofish	0.802	9	6	15	**24**
Freshwater Drum	0.930	2	0	5	**9**
Warmouth	0.980	2	0	**4**	0
Channel Catfish	0.999	4	**7**	1	**7**
Emerald Shiner	0.999	**3**	0	0	0
Redear Sunfish	0.999	**3**	0	0	0

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