INTERNAL REPORT 32

DEVELOPMENT OF A SYSTEMATIC SAMPLING SCHEME FOR THE LAKE WASHINGTON DRAINAGE

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To determine productivity of fish, we will require an estmate of relative abundance that can be expanded later into estimates of biomass. Our work has shown that much of the fish production in Lake Washington is in the form of nonsalmonid and nongame species, such as peamouth and northern squawfish. As the title of our proposal indicates, we are attempting to develop a systematic sampling scheme that eventually will allow us to estimate the relative abundance of the key species, or perhaps all 35 species, of fish that inhabit the drainage and to expand these estimates into terms of biomass or energy.

All sampling gear is selective in capturing fish. Therefore, a combination of types of gear must be used to study the fish populations. We have chosen to use gill nets with nine mesh sizes, horizontal nets to sample the benthic and littoral zones, vertical nets to sample the pelagic and benthic zones, and fyke nets in the shallow bays. This equipment can be used throughout the lake and the selectivity of the nets can be determined.

We see our studies developing into three phases: (1) development of a sampling scheme to determine relative abundance and biomass, (2) determining food habits to follow energy transfer, and (3) developing models that will allow us to understand the biological bases of fish productivity and predict the specific changes in a given situation. We have discussed above our approach and examples of data for Phase 1. We are beginning to study Phase 2 as personnel and budgets allow. The end result will be the development of a model, Phase 3.

Our studies will complement those of Burgner and Thorne that include estimation of juvenile sockeye salmondabundance using an echo integrator and a midwater trawl. The echo integrator provides information on the location of fish in the water column. The midwater trawl is adequate to sample sockeye fry and smaller juveniles. Our vertical gill nets with nine mesh sizes will provide a breakdown of species composition and the size composition in the pelagic as well as the benthic zones. From the Mathisen and Burgner study, we may be able to use the estimates of the abundance of juvenile sockeye as a base line for our estimates of relative abundance of their competitors and predators, such as the squawfish.

Although we need a full year of data from our sampling to make an adequate analysis of our progress to date, the following information will provide some insight into how the data will be used.

A statistically sound sampling scheme has been devised, and random samples are being taken in the different strata. Thirty-eight vertical gill net sets have been made since January in Lake Washington. Figure 1 shows the location of the sets. The sets are made over a 24-hour period and the nets lifted after 12 hours so that catches can be separated by time of day (day or night). We will continue to sample once or twice weekly until the end of December. All data are punched on IBM cards from the summary sheet in Figure 2.

A summary of the vertical gill net samples from Lake Washington that include the catch-per-unit-of-effort is given in Table 1. Figure 3 shows the availability of fish to our vertical gill nets as indicated by the catch-per-unit-of-effort. By knowing where and when to sample, we can produce better estimates of relative abundance.

Table 2 summarizes the catch-per-unit-of-effort for various species during the winter season. These data show the relative abundance of species in the various strata. For example, it shows that juvenile sockeye fry are most plentiful in the deepest water and least plentiful in the shallow water. It also shows that yellow perch are found in bays rather than open water in winter. Similar summaries will be prepared for different seasons.

Figures 4 through 6 show the vertical distribution of three species of fish during both day and night conditions in the winter. A significant difference appeared in the distribution of peamouth (Figure 6) during the day and night. Peamouth tend to move up in the water column at night.

Two research assistantships are being provided through the IBP. Norman Bartoo (M.S. candidate) is studying the vertical and horizontal distribution of the fishes in Lake Washington. This information is necessary in estimating the overall fish productivity of the lake. Randall Hansen (M.S. candidate) will analyze the selectivity of gill nets in sampling warm and cold water fish. His data will be necessary to make adjustments in the catches so that we can account for the bias produced through gear selectivity.

Three unsupported M.S. candidates also are working on species that appear to play an important role in the productivity of Lake Washington. Kenneth Imamura is studying the life history and movements of the brown bullhead, Ictalurus nebulosus. This species is not captured readily in gill nets, because of its behavior and habitat preference. Fyke nets are being used to study this species that inhabits shallow water. At the same time, information is being gathered on other species that inhabit shallow bays. Michael Nishimoto is studying the life history of the peamouth, Mylocheilus caurinus. He will gather samples from the vertical gill nets being fished by Bartoo and Hansen. He will also supplement our data on fish distribution in the benthic and littoral zones by using sinking horizontal gill nets. Fred Olney will investigate the role of the northern squawfish, Ptychocheilus oregonensis, in the ecology of the lake.

The life history studies will provide data on the age and growth, age composition, length-weight relations, size and age at maturity, and food habits of the important species. These data will be necessary to develop a model of energy transfer and productivity of the system.

The distribution of fish will be influenced by physical variables of the water, particularly temperature, dissolved oxygen, and light. The distribution of food organisms no doubt also will be an important influence on fish distribution. We will coordinate closely with others who will be measuring these variables.

Table 3 summarizes the catch of yellow perch from vertical gill nets that were used in Lake Washington. We are working with Dr. McCaughran of the Quantitative Science Center to produce a model that will allow us to understand the selectivity of these nets. Each species will have to be considered separately, because factors such as their shape and swimming strength will affect the selectivity of the nets. In the Comments section of the data summary sheet (Figure 2) we are recording the girth of the fish at the nape (columns 56-60) and maximum girths (columns 61-65). Girths are related more closely to the mesh perimeter that will govern the selectivity of the nets.

Ultimately, we hope to understand the ways in which the fish species interact with one another in Lake Washington and the other lakes. We have produced some preliminary sketches that model what we now know about the positions of the species in the system. An example of the approach we are following is shown in Figure 7. This illustration of the food utilization of squawfish provides some insight into the energy flow in the aquatic environment.

If we can develop such a description of the major species in the lakes and couple that with estimates of biomass for each species, we can develop a working model of the fish systems. The first step will be in terms of biomass, but it could be expressed secondarily in terms of energy flow with some additional information.

A manuscript has been prepared that describes the portable vertical gill net system being used in our studies. Our present plan is to release this as a Biome publication.

Table 1. Summary of vertical gill net samples from Lake Washington which includes catch per unit of effort.

Date	Reference number	Number of strata	Fish with sockeye	Fish without sockeye	Season	C/E[a] without sockeye	C/E[a] sockeye
1/4/71	001	1	36	7	Winter	59.82	307.69
1/6/71	002	1	82	19	Winter	4.69	20.24
2/3/71	006	1	86	36	Winter	22.95	54.84
3/9/71	009	1	23	21	Winter	9.46	10.37
4/12/71	013	1	99	4	Spring	0.94	23.5
4/27/71	015	1	29	29	Spring	12.2	12.2
5/24/71	019	1	9	9	Spring	5.86	5.86
6/18/71	023	1	9	9	Spring	2.26	2.26
7/15/71	027	1	10	4		1.089	2.723
7/28/71	031	1	37	7		2.181	11.531
8/26/71	034	1	44	25		16.53	79.10
1/12/71	003	2	4	4	Winter	17.77	17.77
3/1/71	008	2	0	0	Winter	0	0
3/23/71	012	2	1	1	Winter	4.62	4.62
5/10/71	018	2	17	17	Spring	131.17	131.17
6/11/71	022	2	45	44	Spring	407.40	416.66
6/24/71	024	2	21	21	Spring	64.81	64.81
7/22/71	029	2	84	84		51.742	51.742
8/10/71	032	2	53	53		245.370	245.370
9/13/71	036	2	51	51		236.11	236.11
1/26/71	005	3	1	0	Winter	0	3.56
3/23/71	011	3	0	0	Winter	0	0
5/6/71	017	3	42	41	Spring	158.17	162.03
5/25/71	020	3	18	18	Spring	46.29	46.29
6/30/71	025	3	26	25	Spring	96.51	100.31
7/17/71	028	3	21	19		73.30	81.01
8/30/71	035	3	10	10		38.58	38.58
9/20/71	038	3	10	9		34.72	38.58
1/19/71	004	4	15	0	Winter	0	17.14
3/18/71	010	4	6	3	Winter	3.40	6.80
4/21/71	014	4	40	26	Spring	26.74	41.15
4/29/71	016	4	48	35	Spring	36.00	49.38
6/2/71	021	4	18	18	Spring	18.51	18.51
7/7/71	026	4	24	4	Spring	3.08	18.51
7/26/71	030	4	23	12		15.873	30.423
8/23/71	033	4	31	31		44.84	44.84
9/14/71	037	4	9	9		11.26	11.26

[a]Catch per effort is defined as the catch for 1 vertical foot of net that is 6 ft. wide per hour of fishing by 10^4.

Table 2. Horizontal distribution of fish in Lake Washington as measured by the catch-per-unit-of-effort for vertical gill nets.

Species	Catch per effort[a] by strata			
	60+ feet deep	18-60 feet deep	0-18 feet deep	Selected bays
Squawfish	4.527	0	0	0
Peamouth	5.030	0	0	0
Sockeye	17.353	10.781	1.781	0
Smelt	1.132	0	0	4.679
Cottids	.125	0	0	0
Steelhead	0	0	0	1.559[b]
Chinook	.126	0	0	1.708[b]
Perch	.377	0	0	1.559

[a]Effort is defined as the catch for 1 vertical foot of net that is 6 feet wide per hour of fishing by 10^4.

[b]Possible spawning catch.

Table 3. Size frequency of yellow perch (*Perca flavescens*) from Lake Washington taken in vertical gill nets of different mesh sizes (January-September, 1971).

Fork length	Mesh size (stretched)									Total
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	
cm	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
80-89	2									2
90-99	19		1							20
100-109	10	2								12
110-119			2							2
120-129			1							1
130-139	2	1	1	2						6
140-149			1		1					2
150-159		4	1		1					6
160-169	2	3		1						6
170-179	1	4	2	2						9
180-189		3	1							4
190-199	2		2	2						6
200-209		1	5	3						9
210-219	1		4	1						6
220-229			3	9						12
230-239			3	6	1					10
240-249		2	2	5	3					12
250-259		1	2	4	2					9
260-269				3	5					8
270-279			1	1	4					6
280-289			1	2	6	1				10
290-299				1	3					4
300-309					3					3
310-319						1				1
320-329					1	1				2
330-339							1			1
340-349					1					1
350-359										0
360-369					2					2
370-379				1						1
380-389					1					1
390-399										0
400-409										0
410-419										0
420-429			1							1
430-439										0
440-449										0
450-459										0
460-469										0
470-479										0
480-489					1					1
490-499				1						1
500-509										0
510-519					1					1
520-529										0
Total	39	21	34	44	36	3	1			178

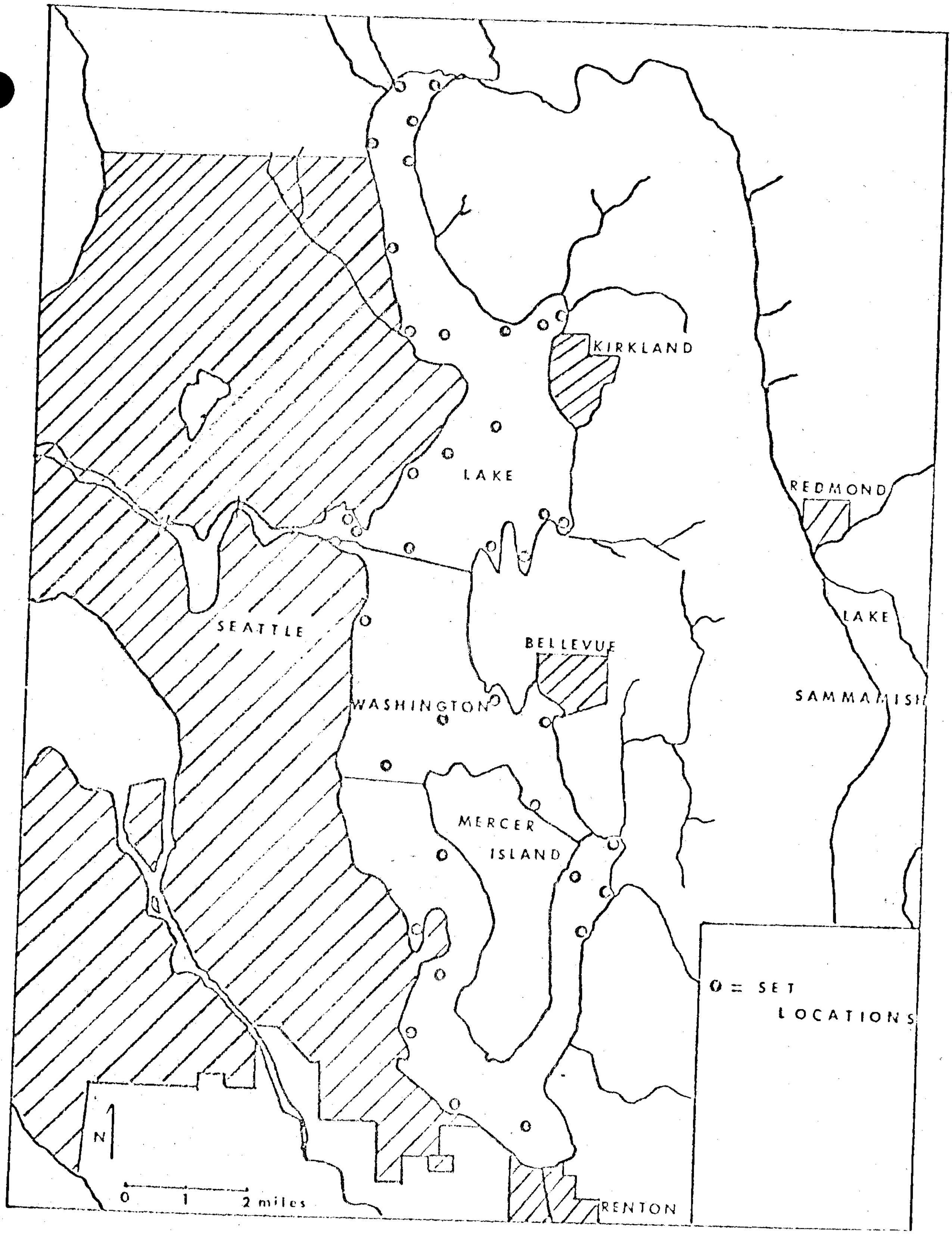

Figure 1. Randomized sampling locations in Lake Washington between January and September 1971.

LAKE WASHINGTON GILLNETTING

WCFU

SEX
1 - ♂
2 - ♀

MAT.
1 - IMMAT
2 - PRESPAWN
3 - SPENT

REF. NO.	STRATA	DATE			SET TIME	PICK TIME	MESH	MAX DEPTH	SPECIES	FISH HT. FT	FORK LENGTH	WEIGHT	SEX	MAT.	AGE	COMMENTS
		DAY	MO	YR												

Figure 2. Summary sheet for vertical gill net sampling.

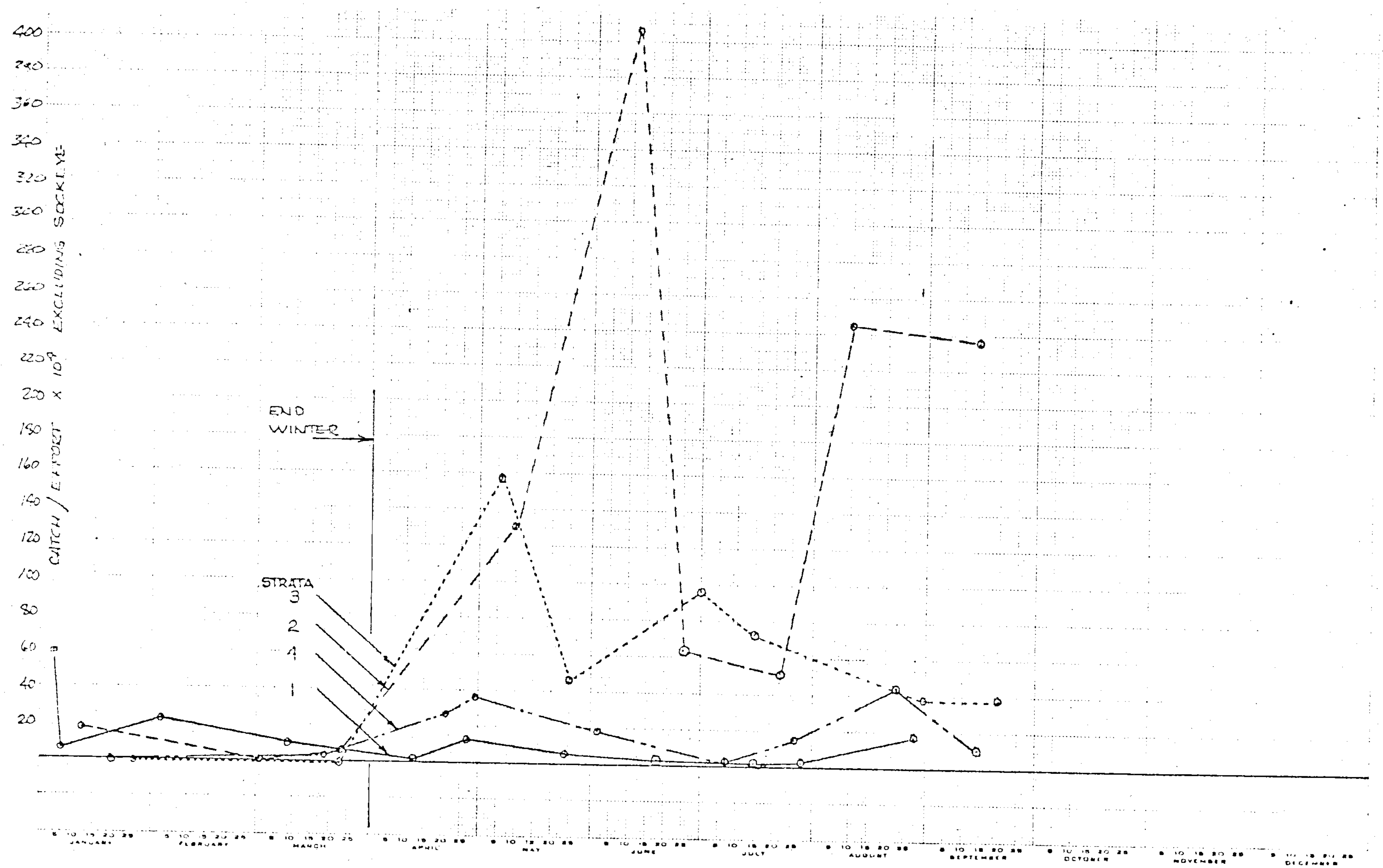

Figure 3. The catch per unit-of-effort for four strata in Lake Washington between January and September 1971. (Strata 1, greater than 60 feet; 2, 0-18 feet in bays; 3, 0-18 feet in open shore areas; and 4, 18-60 feet in depths.

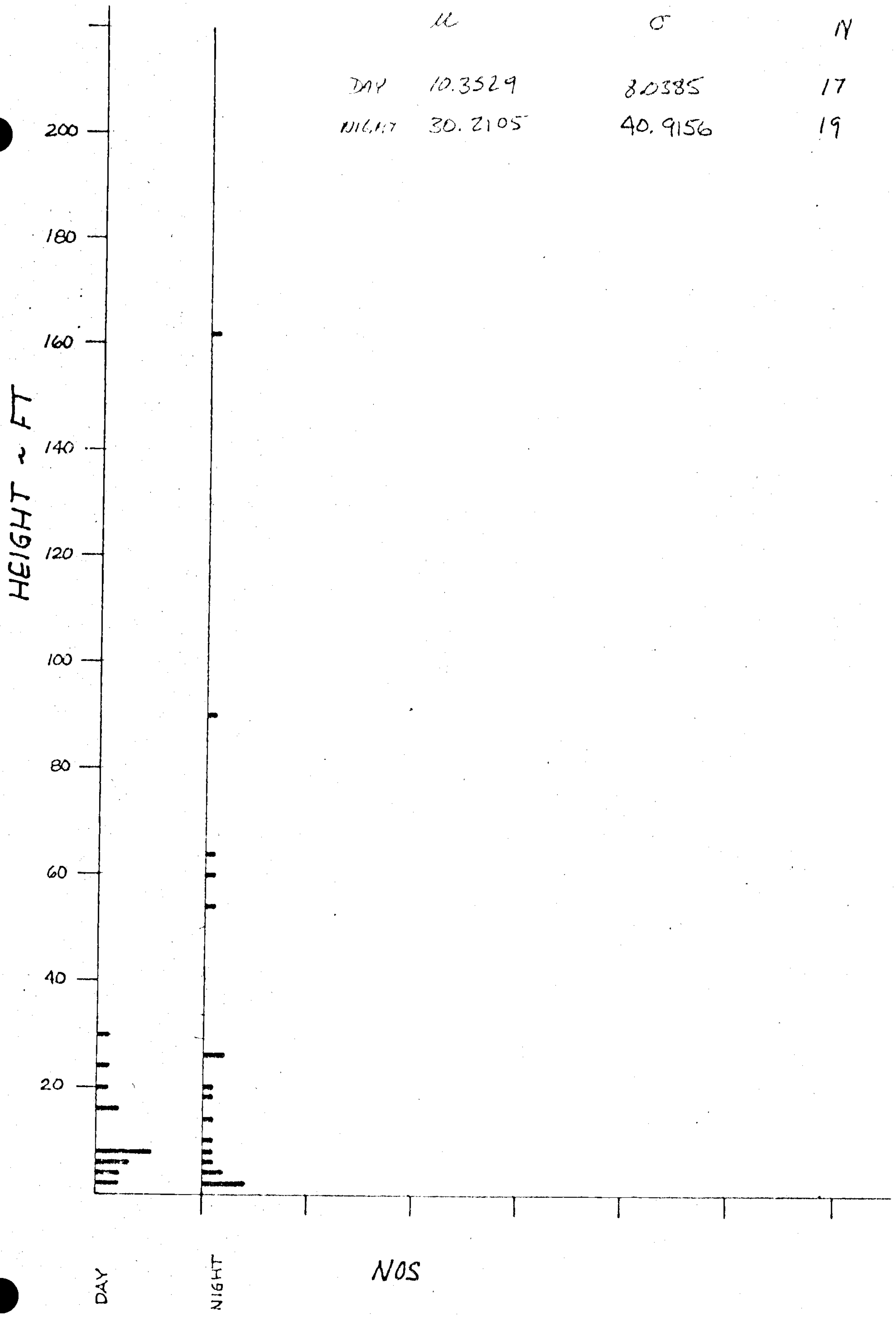

Figure 4. The day and night distribution of squawfish in Lake Washington during the winter of 1971. (u indicates the mean distance of fish from the bottom of the lake, α indicates standard deviation, and ν indicates number of fish).

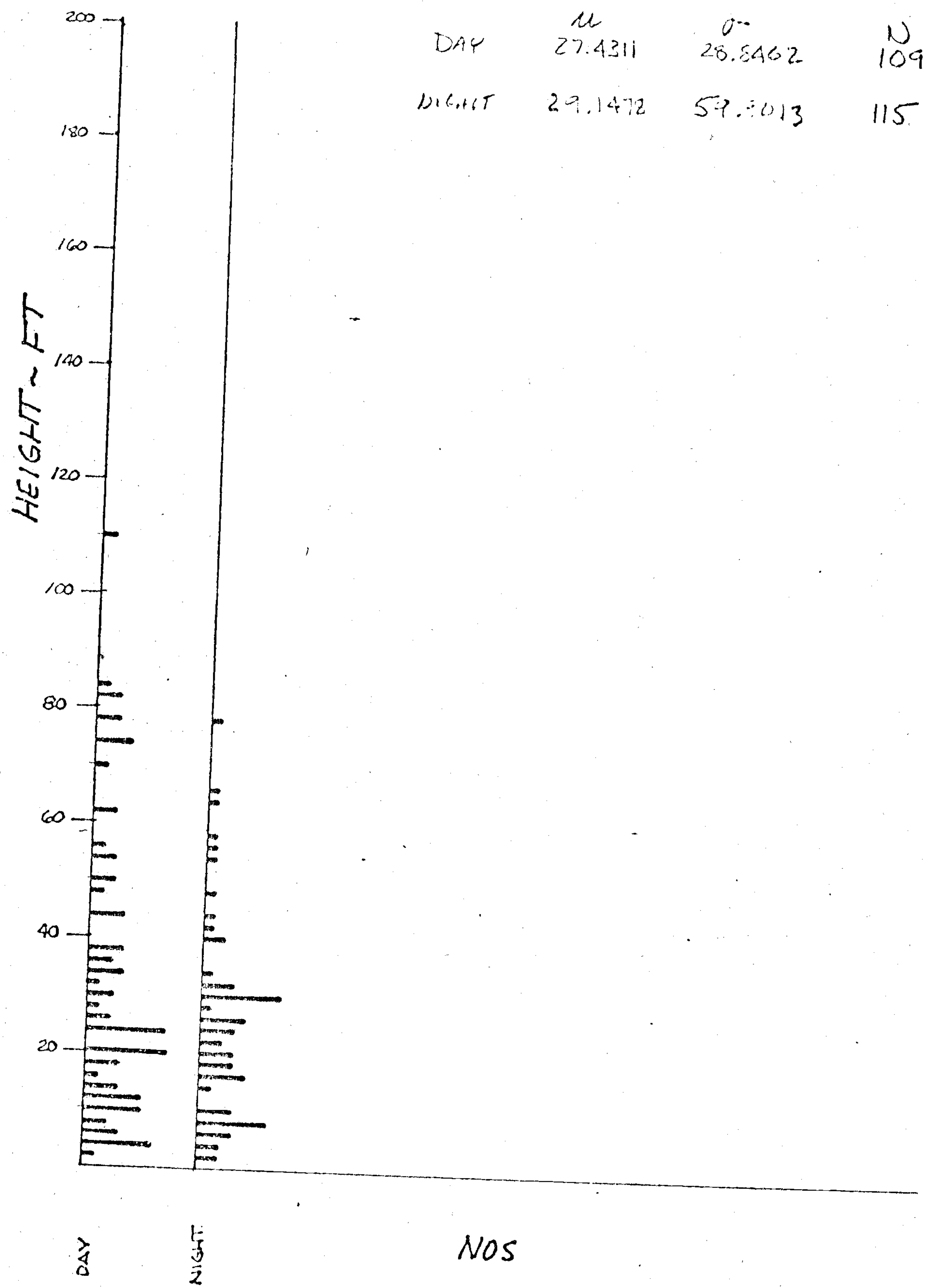

Figure 5. The day and night distribution of juvenile sockeye salmon in Lake Washington during the winter of 1971.

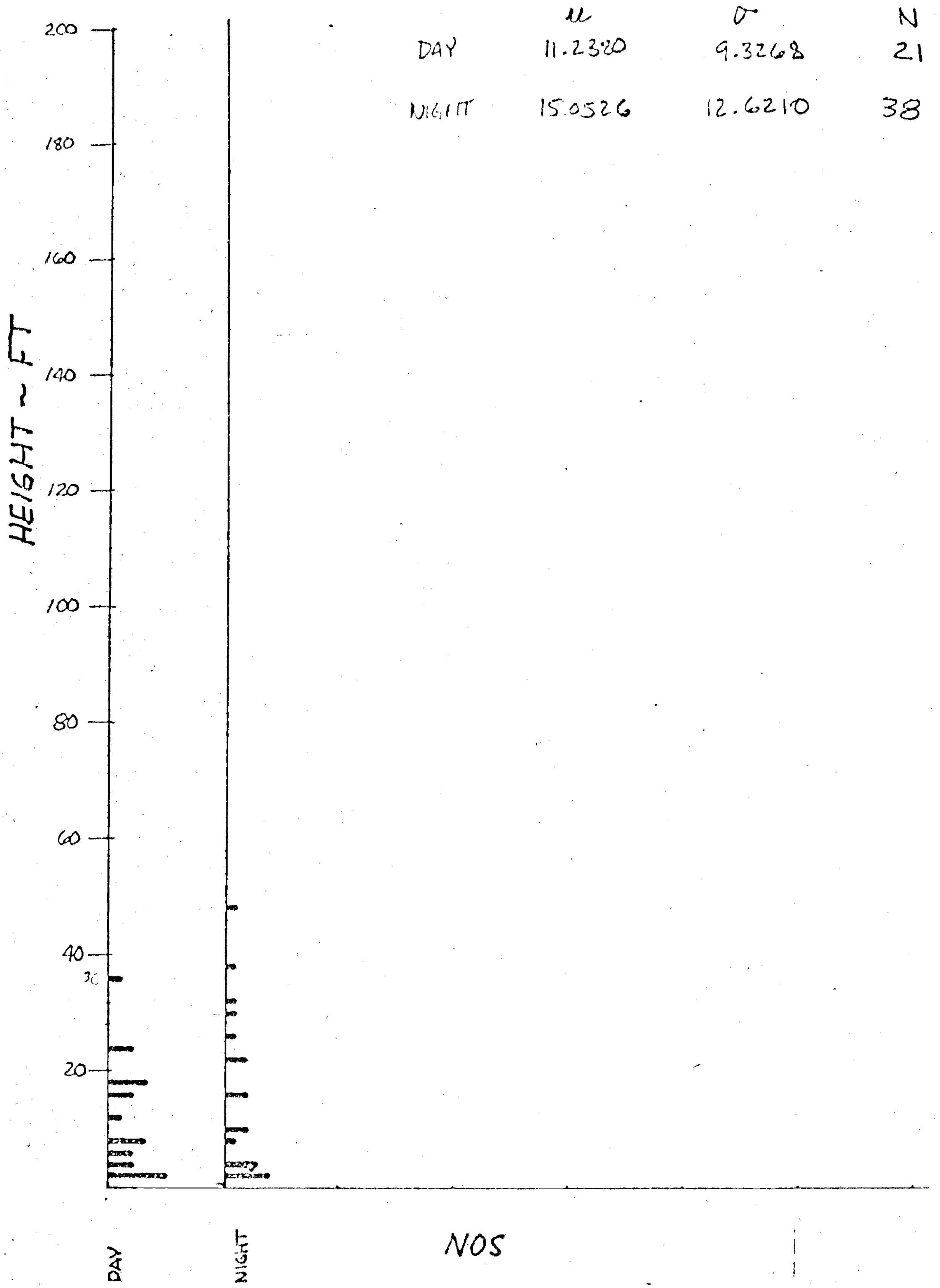

Figure 6. The day and night distribution of peamouth in Lake Washington during winter of 1971.

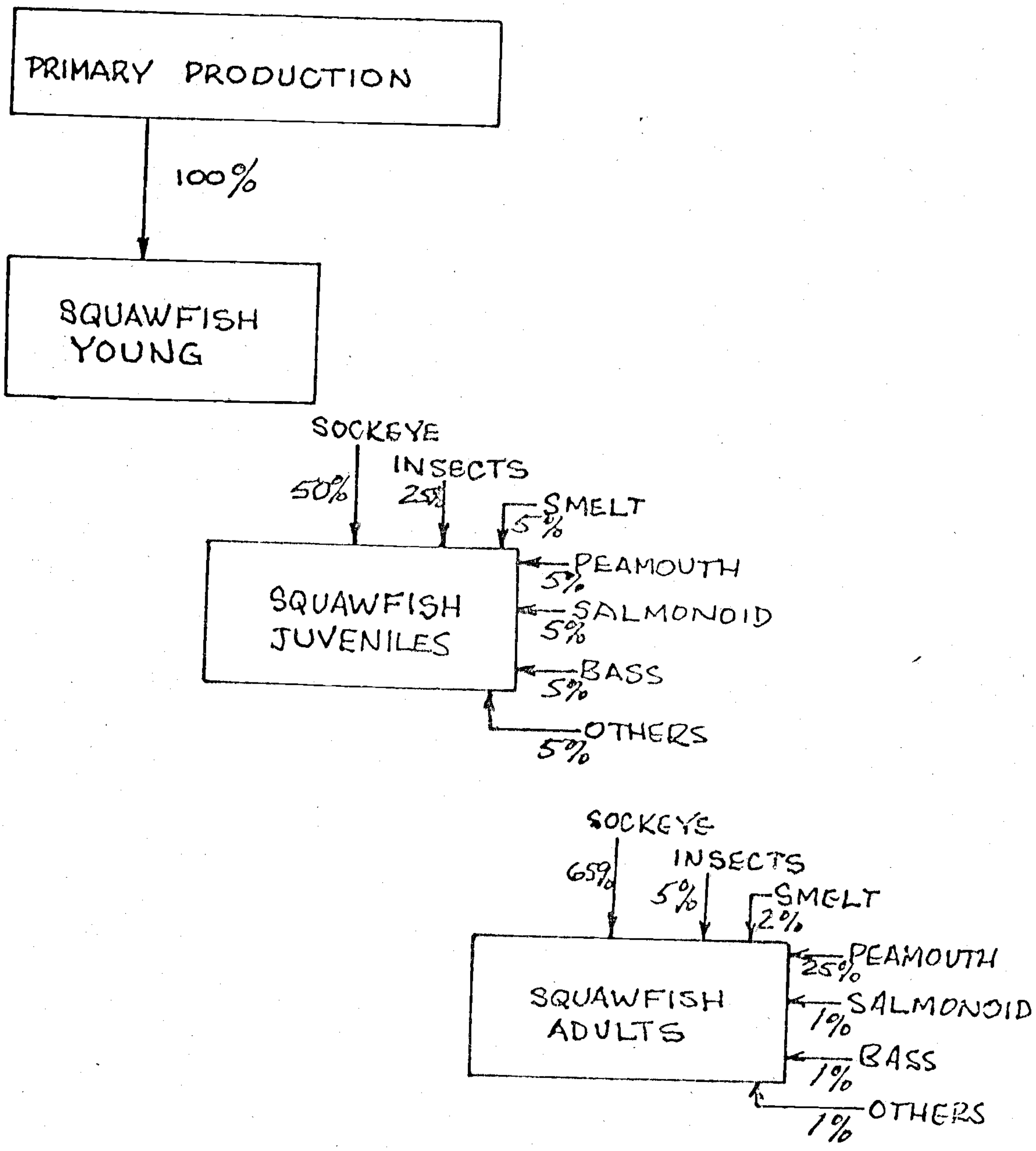

Figure 7. Preliminary outline of food utilization by northern squawfish in Lake Washington.