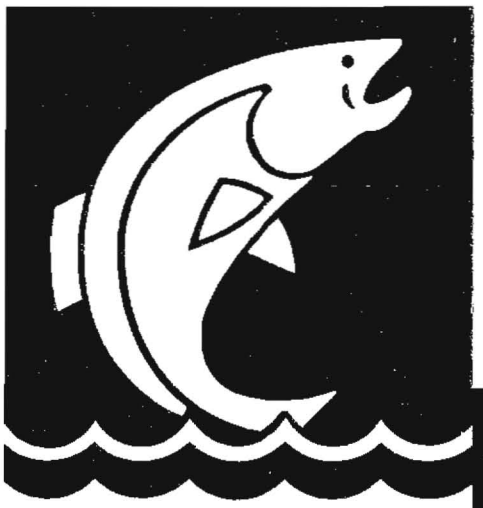
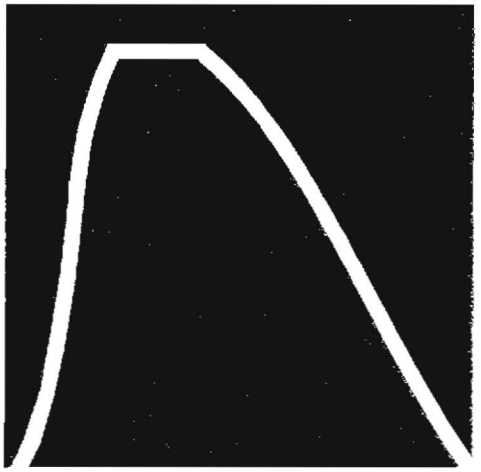


Probability Of Use Criteria For The Family Salmonidae.

COOPERATIVE
INSTREAM FLOW
SERVICE GROUP

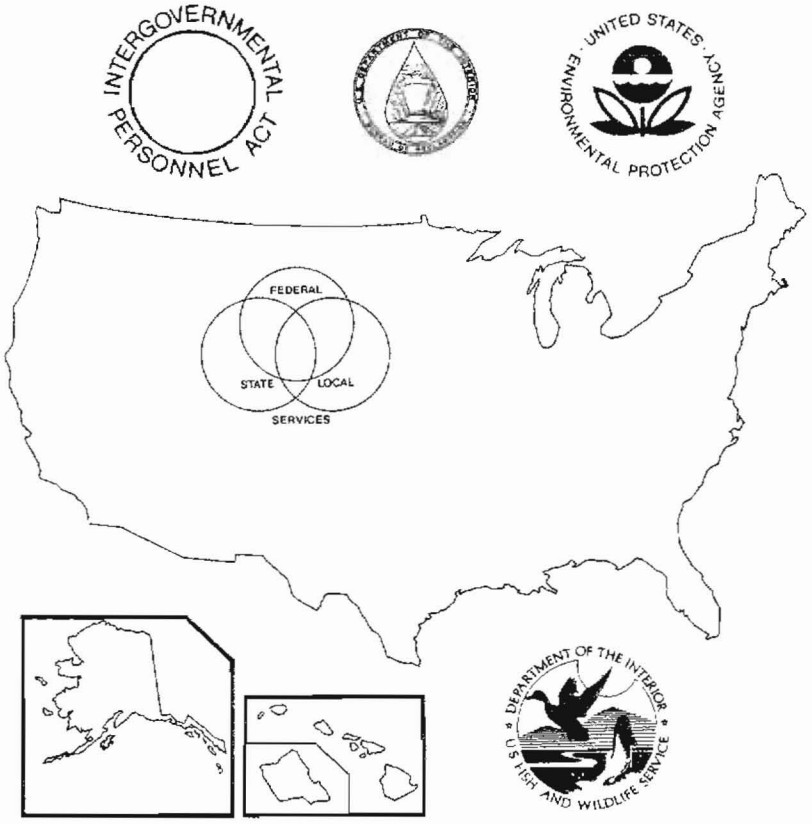
INSTREAM FLOW INFORMATION PAPER: NO. 4

FWS/OBS-78/07
JANUARY 1978



Cooperating Agencies:

Fish and Wildlife Service
Environmental Protection Agency
Heritage Conservation and Recreation Service
Bureau of Reclamation



COOPERATIVE INSTREAM FLOW SERVICE GROUP

The Cooperative Instream Flow Service Group was formed in 1976 under the sponsorship of the U.S. Fish and Wildlife Service. Primary funding was provided by the U.S. Environmental Protection Agency. The group operates as a satellite of the Western Energy and Land Use Team. It is a part of the Western Water Allocation Project, Office of Biological Services.

Cooperative Instream Flow
Service Group
333 West Drake Road
Fort Collins, Colorado 80521
(303) 493-4275 FTS 323-5231

While the Fish and Wildlife Service is providing the initiative and leadership, the IFG is conceived as a multi-agency, multi-disciplinary program which is to become a "center of activity," providing a focus for the increasing importance of instream flow assessments.

The multi-agency, multi-disciplinary nature of the group is provided through the Intergovernmental Personnel Act transfer of state personnel, and details from other Federal agencies.

Interagency Energy-Environment
Research and Development Program
Office of Research and Development
U.S. Environmental Protection Agency

FWS/OBS-78/07
January 1978

PROBABILITY-OF-USE CRITERIA FOR THE FAMILY SALMONIDAE

Instream Flow Information Paper No. 4

by

Ken D. Bovee[1]
Cooperative Instream Flow Service Group
333 West Drake Road
Fort Collins, Colorado 80521

This study was conducted
as part of the Federal
Interagency Energy/Environment
Research and Development Program
Office of Research and Development
U.S. Environmental Protection Agency

Cooperative Instream Flow Service Group
Western Energy and Land Use Team
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

[1] Hydrologist, Geology Department, University of Montana, Missoula, MT on IPA Assignment from December 1976 - December 1977, to Cooperative Instream Flow Service Group.

PREFACE

This document gives probability-of-use criteria for the hydraulic parameters of depth, velocity, substrate, and temperature, for the family Salmonidae. It is intended as a companion document to Instream Flow Information Paper No. 3, Development and Evaluation of Weighted Criteria, Probability-of-Use Curves for Instream Flow Assessments: Fisheries, which describes the techniques used to construct and criteria used to evaluate each set. The user is urged to keep both volumes together for cross-reference.

Except for egg incubation, a curve set for each life stage consists of four curves; one each for velocity, depth, substrate, and temperature. The criteria selected for egg incubation is a function of the channel slope and sediment concentration. Incubation is usually represented by six curve sets, with different combinations of slope and sediment concentration. The user should select the curve set which most closely resembles the conditions at each study area.

A curve maintenance program has been developed by the Instream Flow Group to store a digitized file of these curves on magnetic tape. This program will be utilized by IFG to store new curves and update old ones. Updated versions of curves and curves for species not included in this

publication will be released by IFG periodically as new data becomes available. Any comments or questions involving these curves, or any additional data on the family Salmonidae, may be directed to:

Cooperative Instream Flow Service Group
U.S. Fish and Wildlife Service
Room 206, Federal Building
Fort Collins, Colorado 80521

We extend our gratitude to those individuals who have submitted unpublished data on various species of fish. Without their cooperation the development of probability criteria would have been virtually impossible. Contributing individuals and organizations are listed below:

Mr. Liter Spence
Montana Department of Fish and Game

Mr. Tim Cochnauer
Idaho Department of Fish and Game

Messrs. Jeff Gosse, R. S. Wydoski, and W. T. Helm
Utah Cooperative Fishery Research Unit
Utah State University

Mr. D. L. Hanson
Washington Department of Game

Oregon State Game Commission
Oregon State Fish Commission

The following list of substrate codes will be useful in the reading and interpretation of the probability curves for substrate.

SUBSTRATE	CODE NUMBER
Plant detritus/ organic material	1
Mud/Soft Clay	2
Silt	3
Sand	4
Gravel	5
Cobble/Rubble	6
Boulder	7
Bedrock	8

NOTE: Gradations between code numbers refer to a rough proportion between one substrate type and another. For example, a 5.5 substrate code would indicate a gravel/cobble mixture with approximately equal portions of each particle size. A code of 4.8 would indicate a mix of approximately 80% gravel and 20% sand, whereas a code of 5.2 would mean 80% gravel and 20% cobble.

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COHO SALMON

Oncorhynchus kisutch

Catalog No.	10010 Spawning				Adult				Juvenile				10000 Fry				10021-10026 Egg Incubation			
SPECIES: Coho	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	G	G	F	R									E	E	E	G	F	F	F	R
REFERENCE	1	1	1	1									15	15	15	5	9,10	9,10	10	5
ANALYSIS	FA	FA	FA	RO									FA	FA	FA	RO	IN	IN	IN	PO
			7	31												15	24	24	36	10
			RO	RO												FA	29	29	IN	RO
																	IN	IN		
																	38	38	38	31
																	IN	IN	IN	PO
																	36	36		
																	IN	IN		
COMMENTS																				

Key to IFG Evaluation Matrix

IFG Evaluation:
- E - Excellent
- G - Good
- F - Fair
- R - Reconnaissance Grade

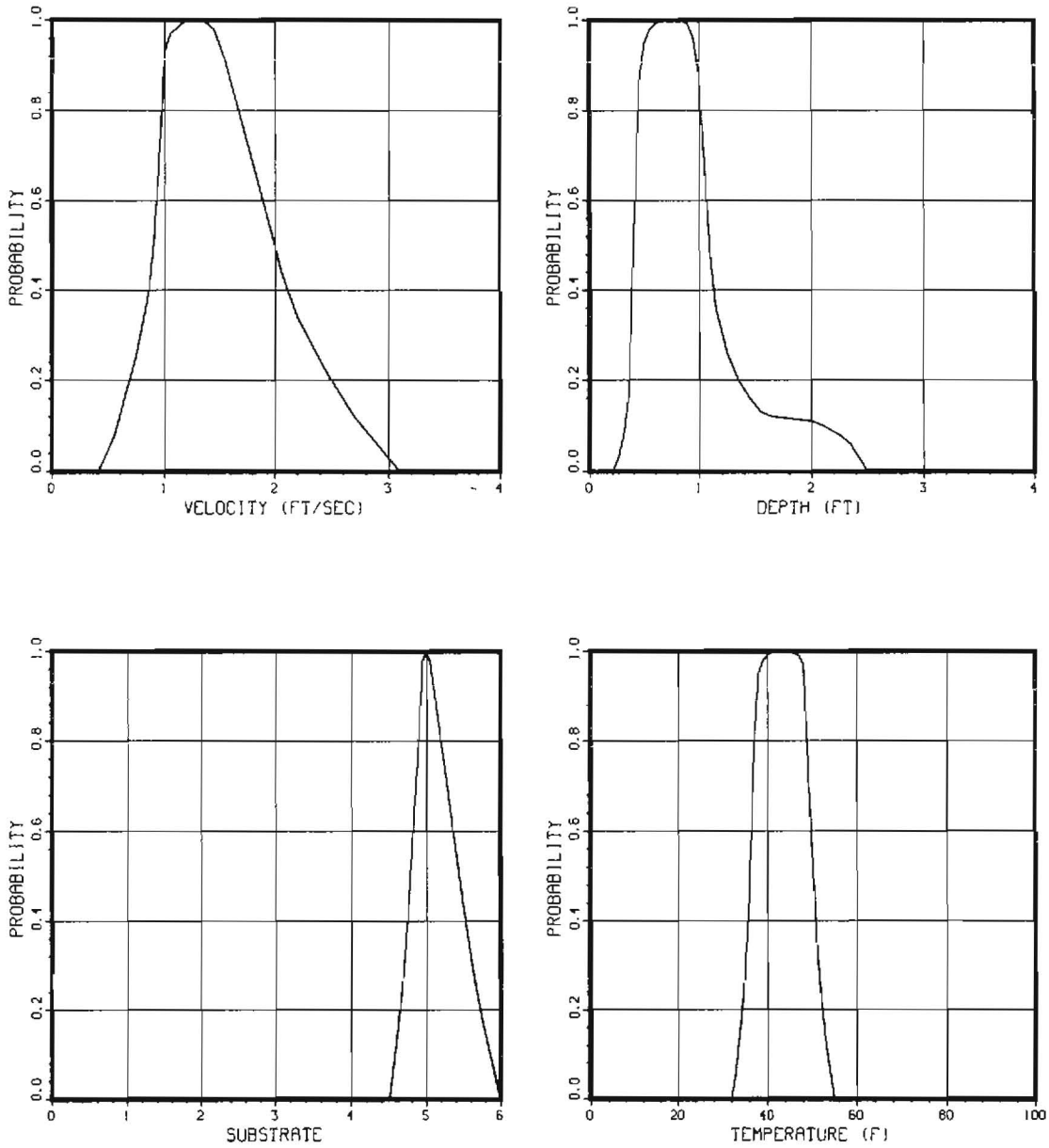
Analysis:
- FA - frequency analysis
- RO - range and optimum
- PO - Parameter overlap
- IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

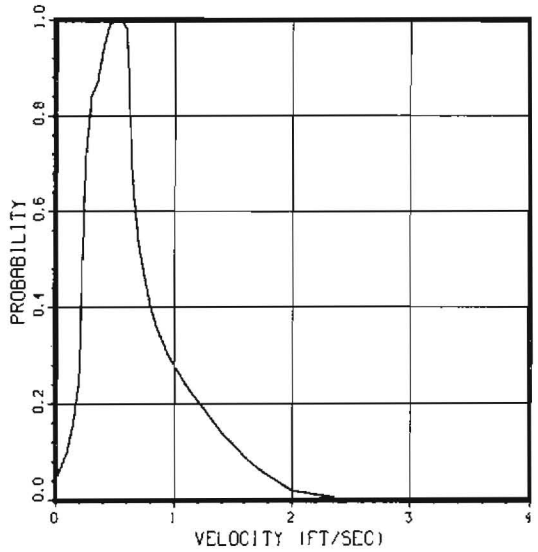
COHO SALMON

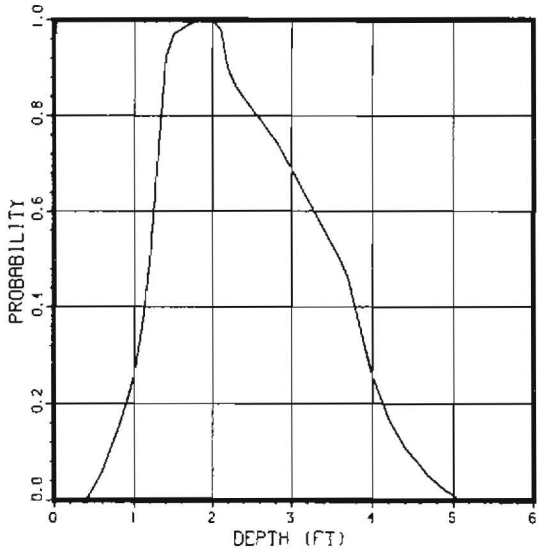
10010 SPAWNING 78/01/24.

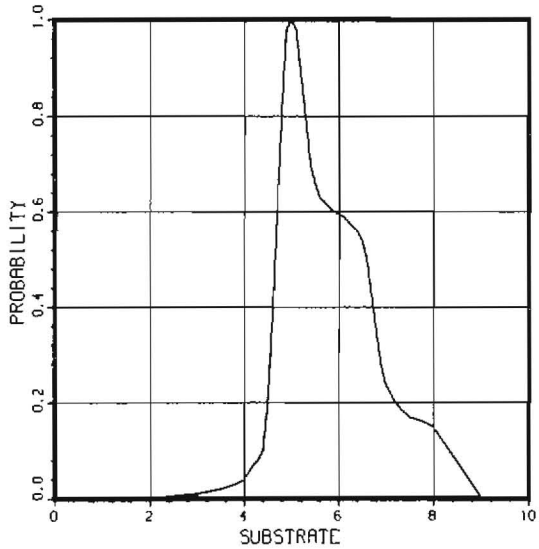


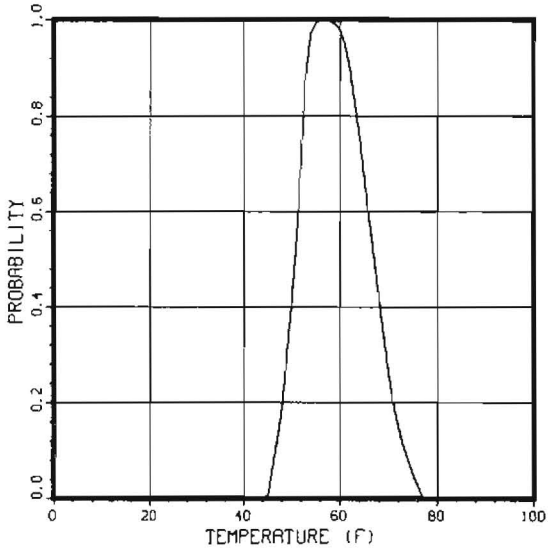
COHO SALMON

10000 FRY 78/01/24.



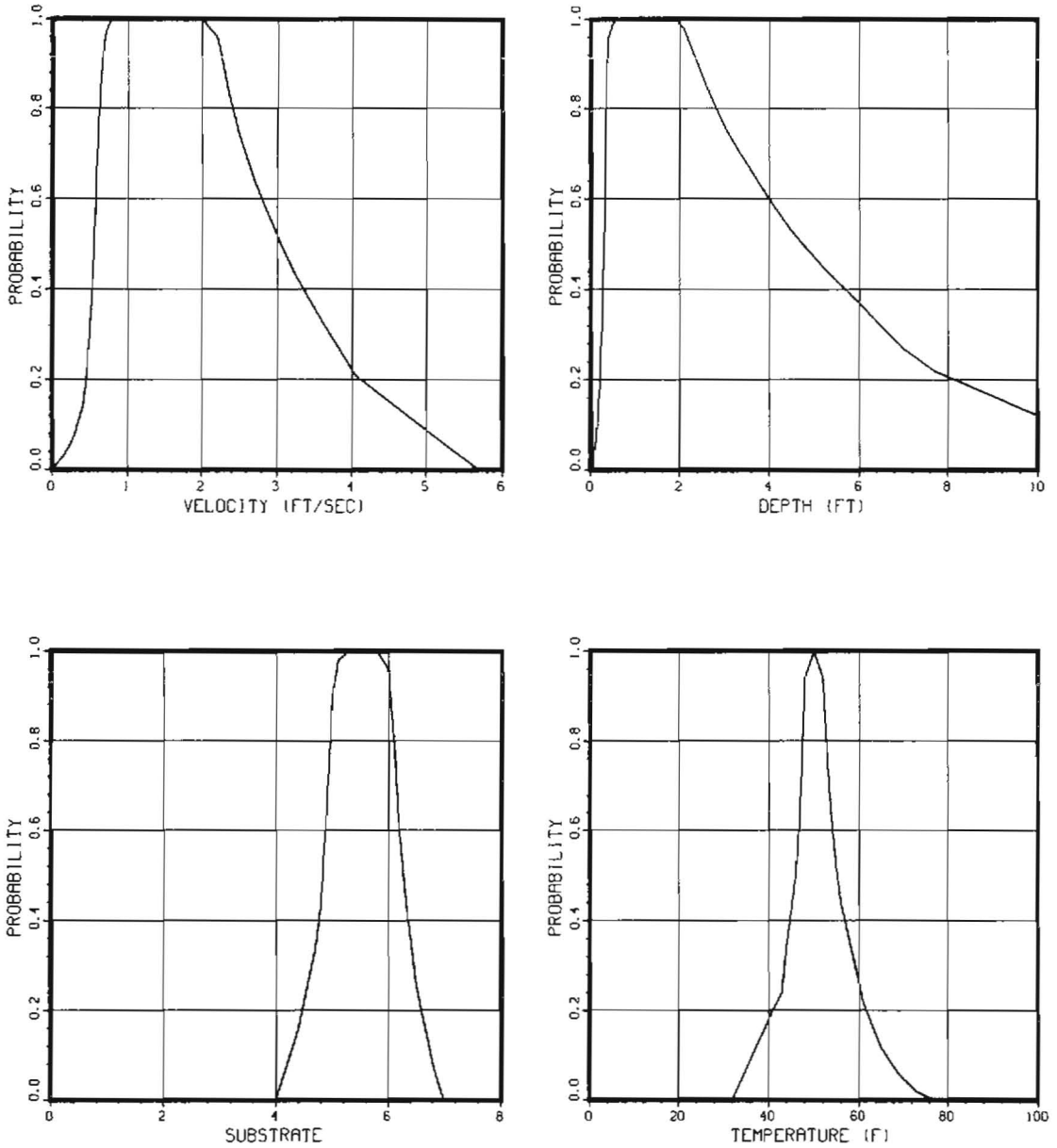






COHO SALMON (CLEAR WATER, S=.001)

10021 INCUBATION 78/01/24.



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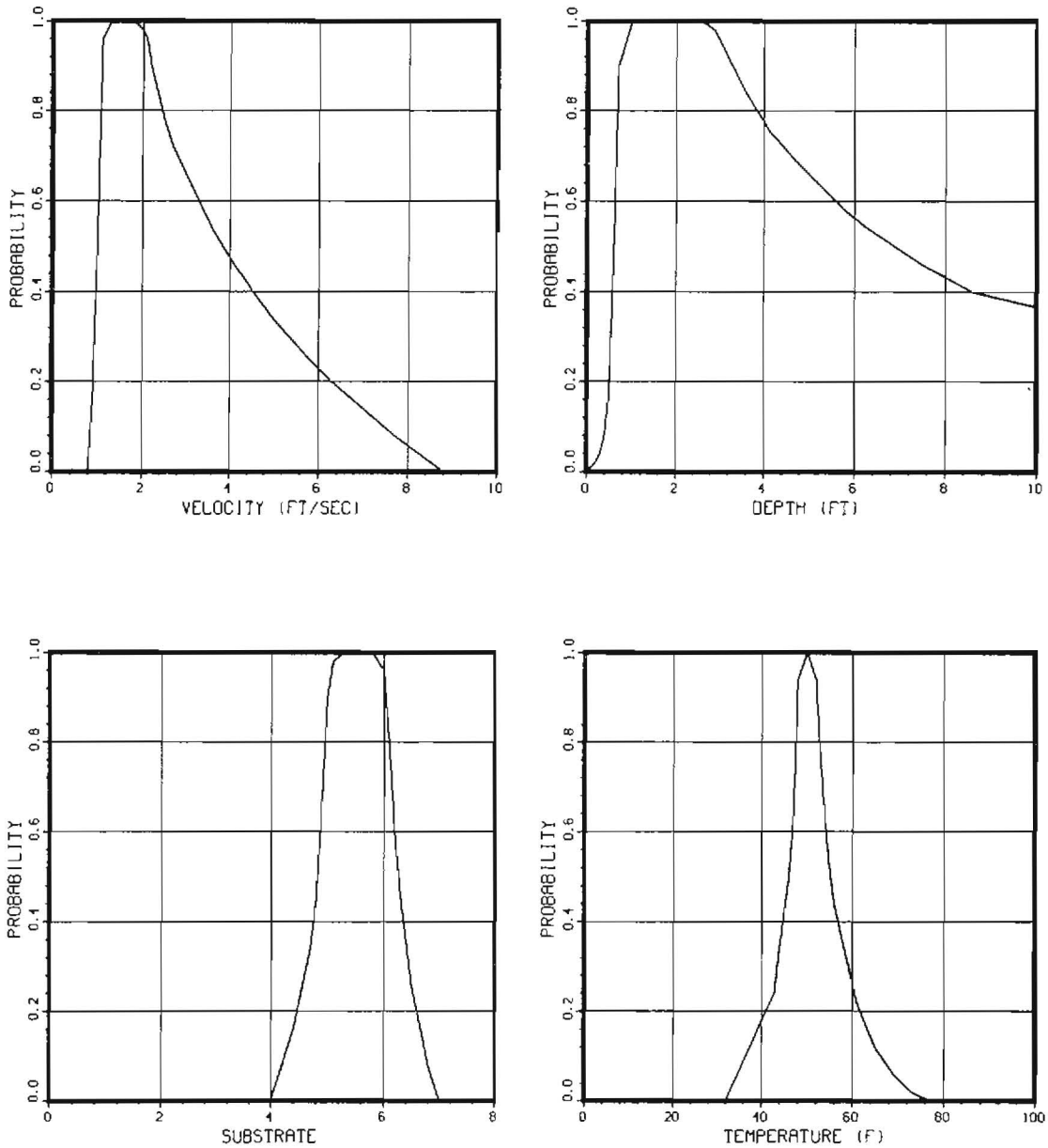

COHO SALMON (CLEAR WATER, S=.0025)

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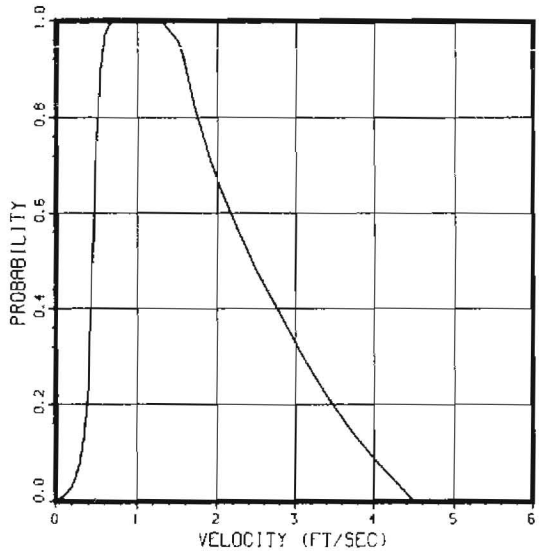

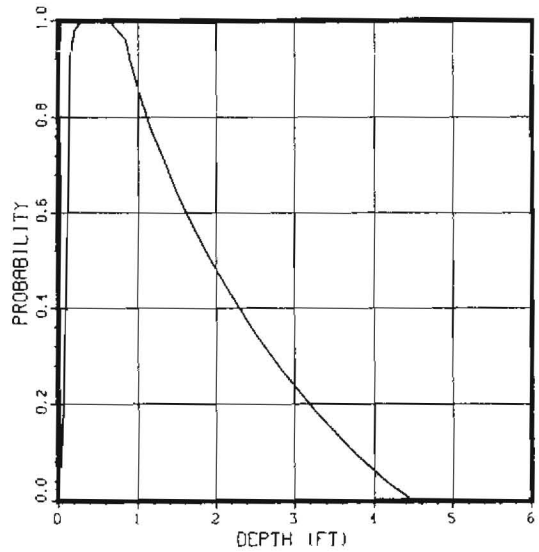

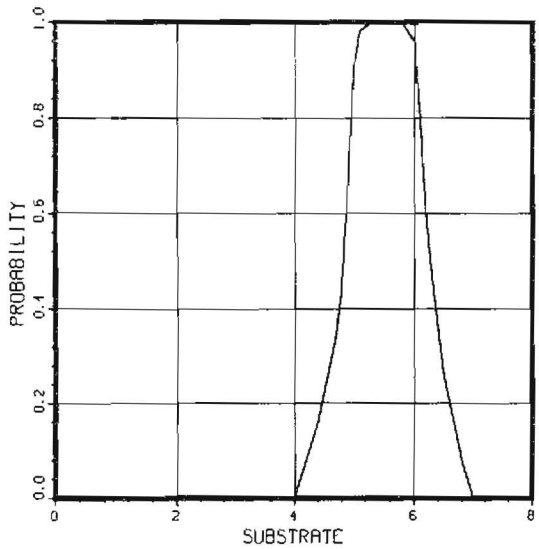

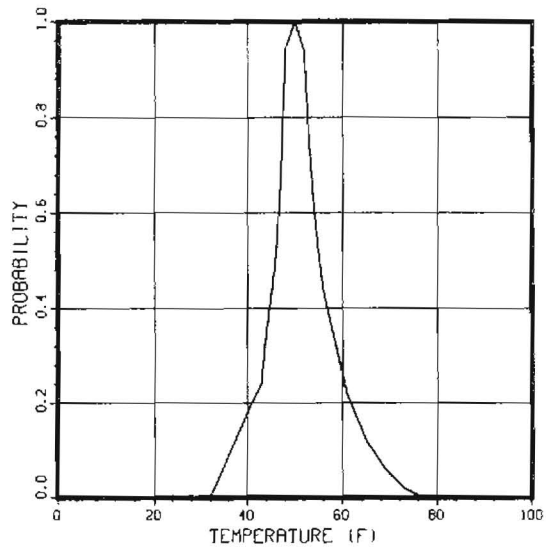

COHO SALMON (TURBID WATER, S=.0025)

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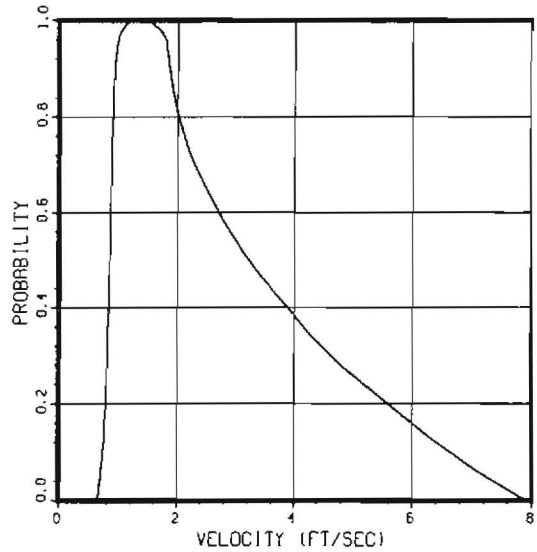
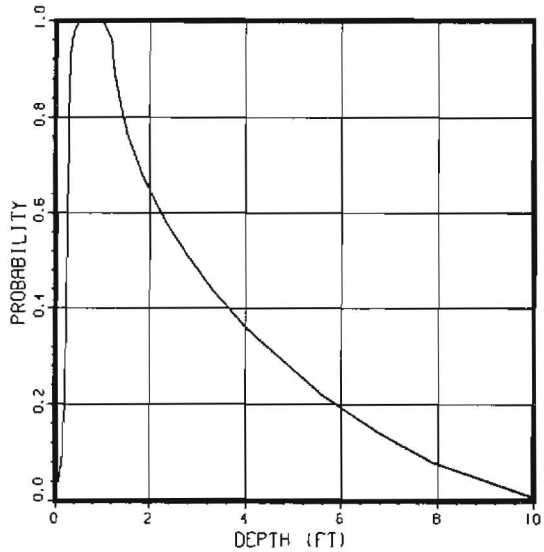
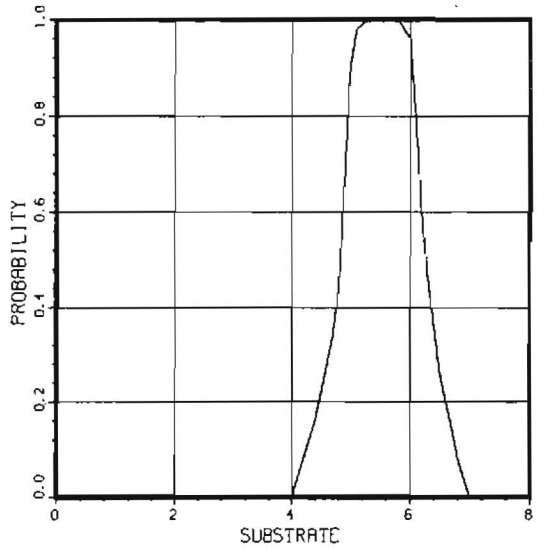
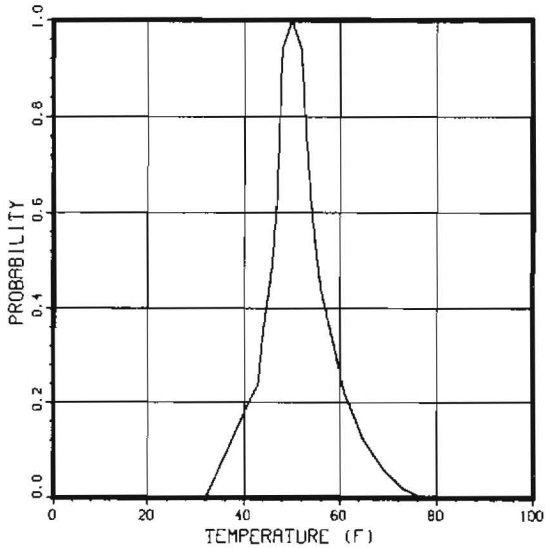


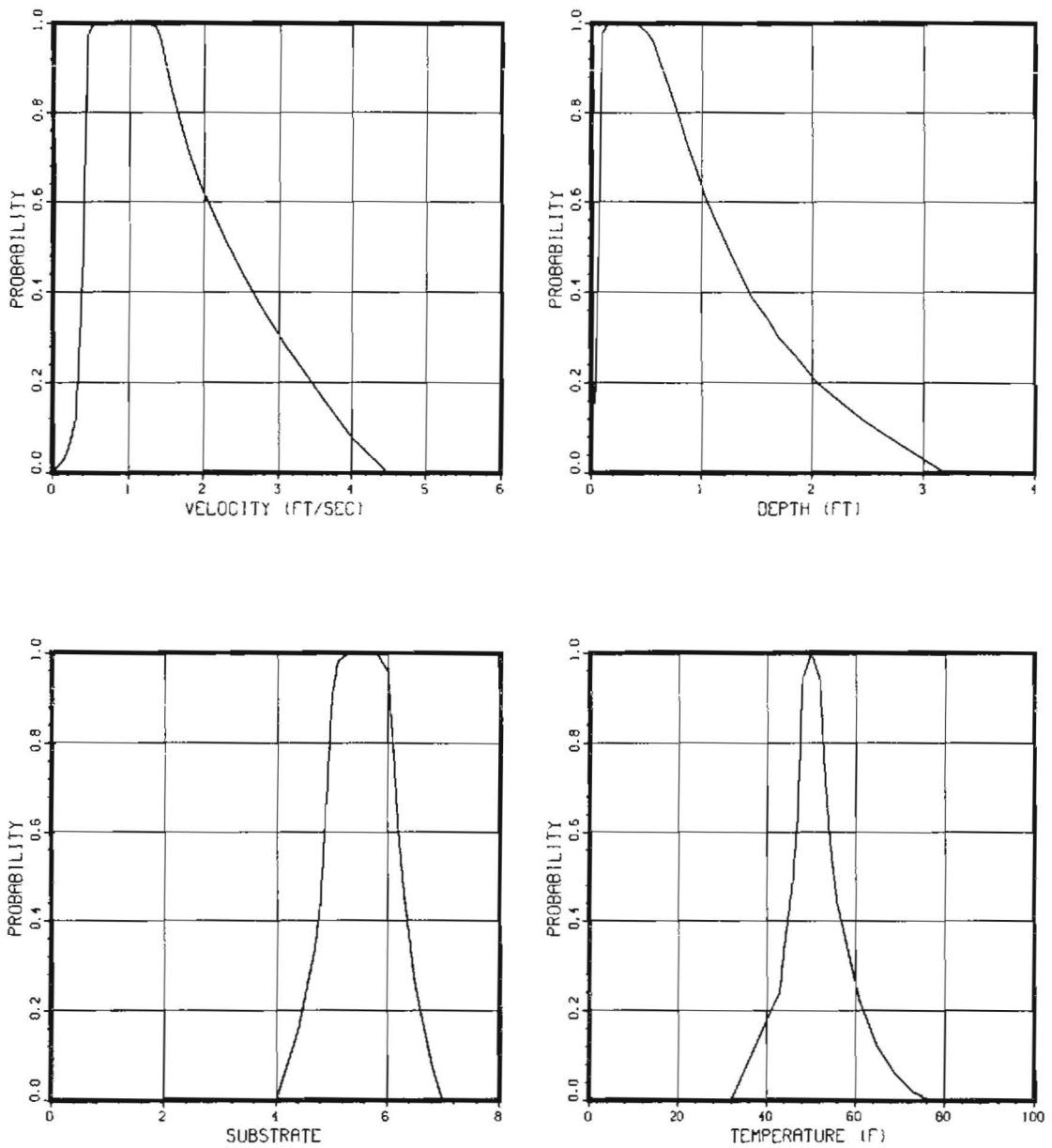






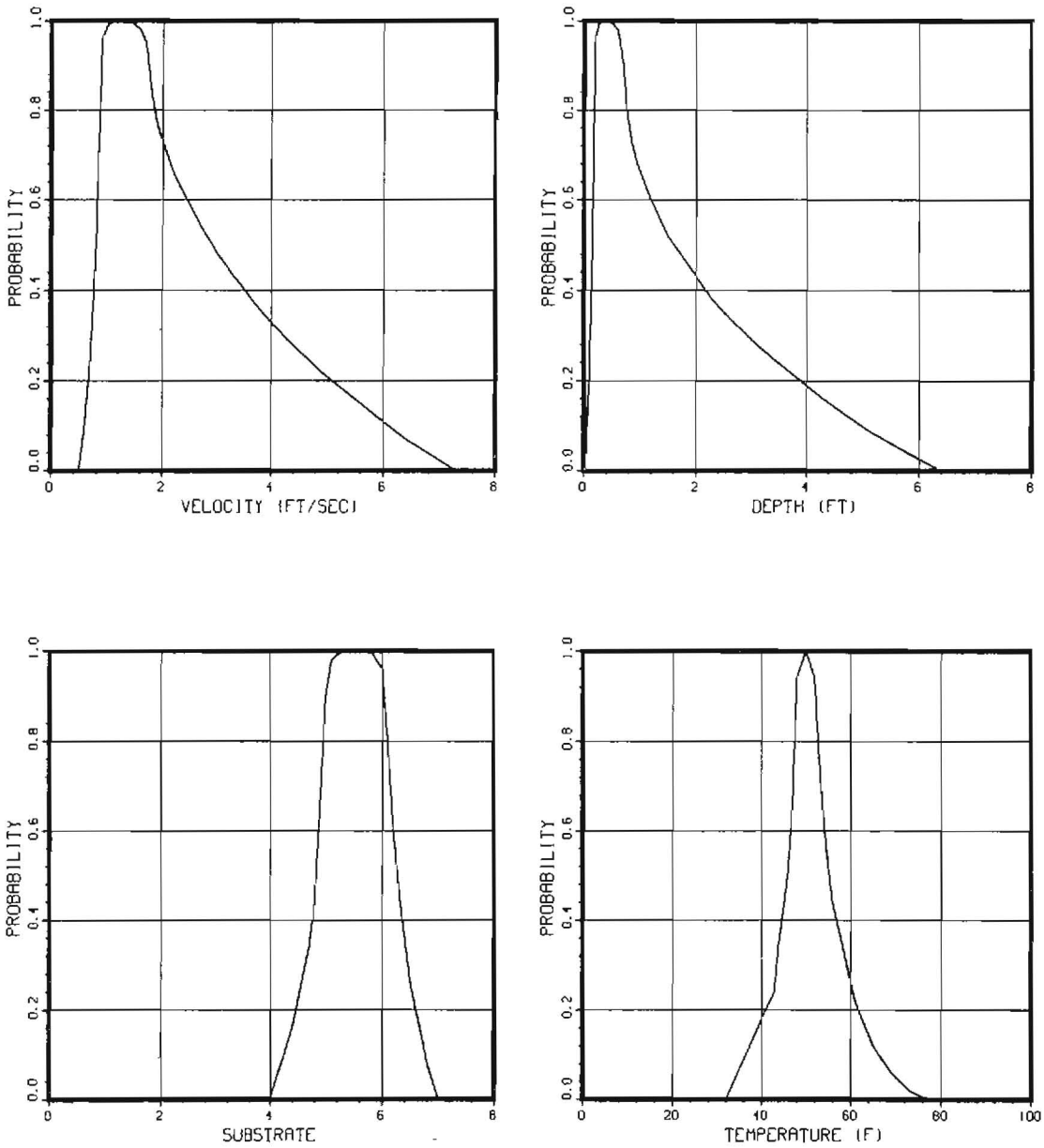
COHO SALMON (CLEAR WATER, S=.004)

10025 INCUBATION 78/01/24.



COHO SALMON (TURBID WATER, S=.004)

10026 INCUBATION 78/01/24.



SOCKEYE SALMON

Oncorhynchus nerka

Catalog No.	10310 Spawning				Adult				Juvenile				Fry				Egg Incubation			
SPECIES: Sockeye	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	F	F	F	R																
REFERENCE	7	7	21	31																
	RO	RO	RO	RO																
	21	21	7																	
	RO	RO	RO																	
ANALYSIS																				
COMMENTS																				

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

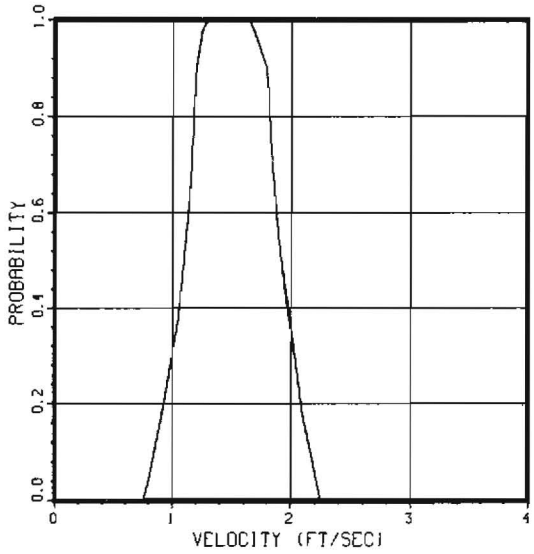
Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IR - indirect analysis

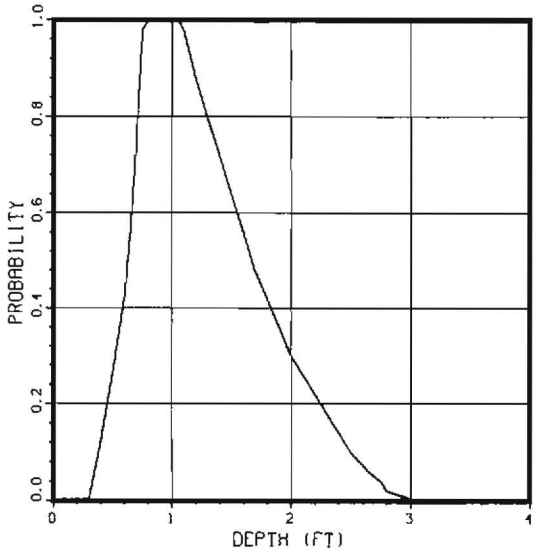
Reference: Refer to listed number in bibliography.

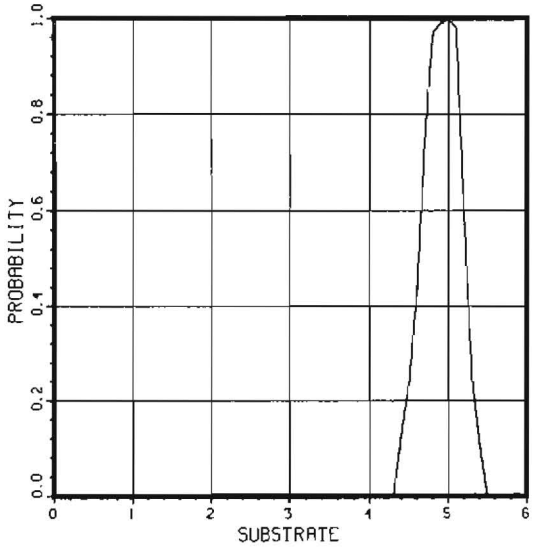
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

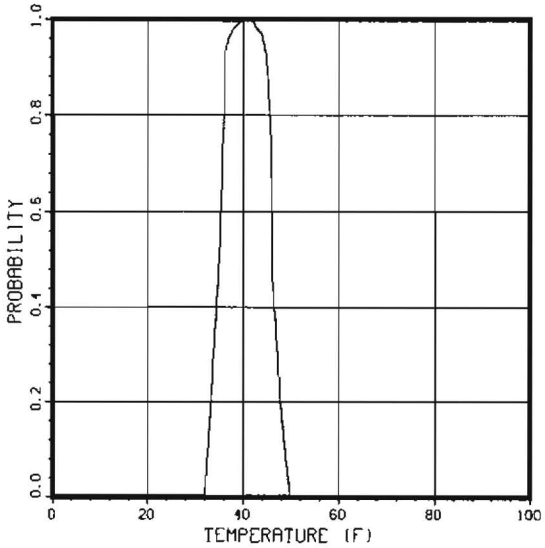
SOCKEYE SALMON

10310 SPAWNING 78/01/24.









KOKANEE

Oncorhynchus nerka

Catalog No.	10210 Spawning				Adult				Juvenile				Fry				Egg Incubation			
SPECIES: Kokanee	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	G	G	F	F																
REFERENCE	22	22	21	22																
ANALTSIS	FA	FA	RO	PO																
				31																
				PO																
COMMENTS																				

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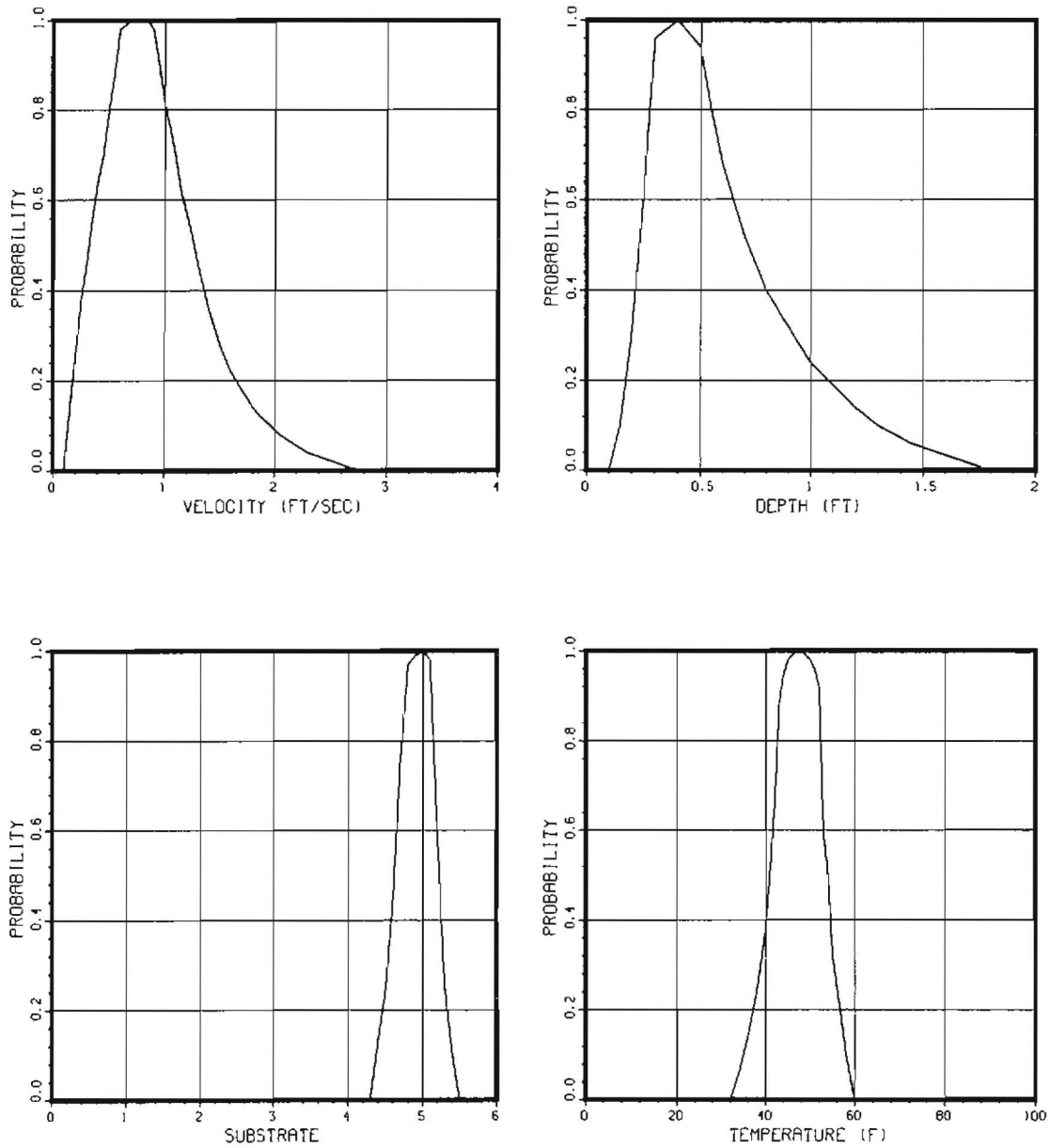
Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

KOKANEE SALMON

10210 SPAWNING 78/01/24.



CHINOOK SALMON

Oncorhynchus tshawytscha

Catalog No.	10111 Spring Spawning				10112 Fall Spawning Adult				10101 Juvenile				Fry				10121-10126 Egg Incubation			
SPECIES: Chinook Salmon	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	E	E	G	F	G	G	F	F	G	G	E	G					F	F	F	
REFERENCE / ANALYSIS	1 FA	1 FA	1 FA	1 PO	1 FA	1 FA	1 FA	1 RO	14 FA	14 FA	15 FA	5 FA					1 IN	1 IN	36 IN	
	32 RO	32 RO			23 FA	23 FA			15 FA	15 FA		15 FA					9,24 IN	9,24 IN	38 IN	
					30 FA	30 FA											36 IN	36 IN		
					32 RO	32 RO											38 IN	38 IN		
COMMENTS																				

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

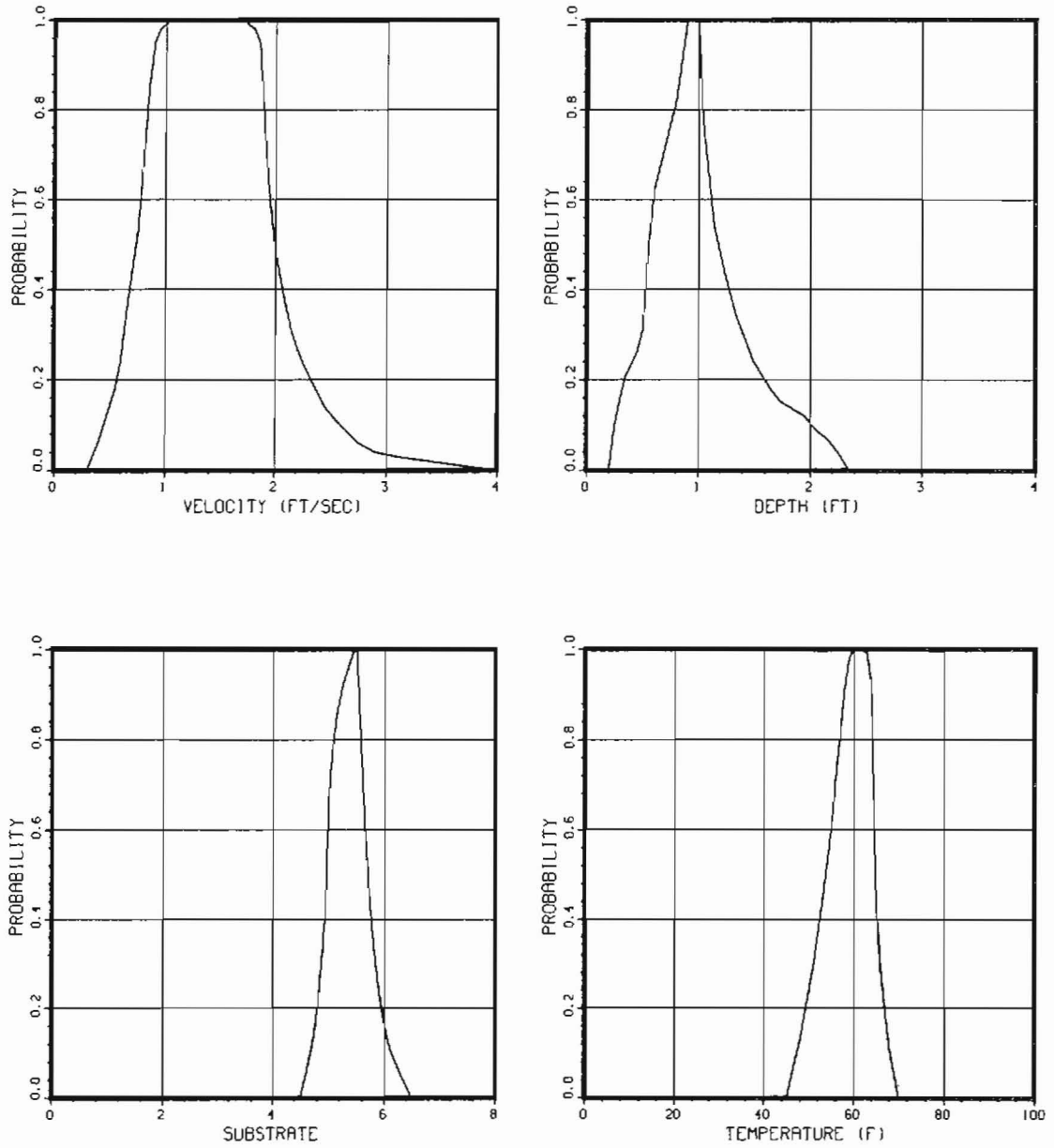
Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

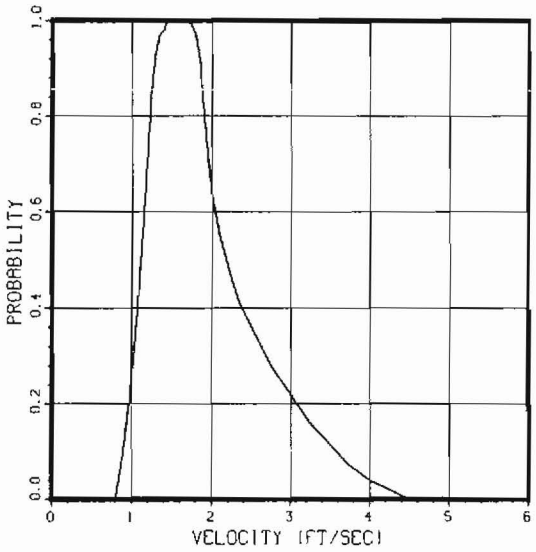
SPRING CHINOOK

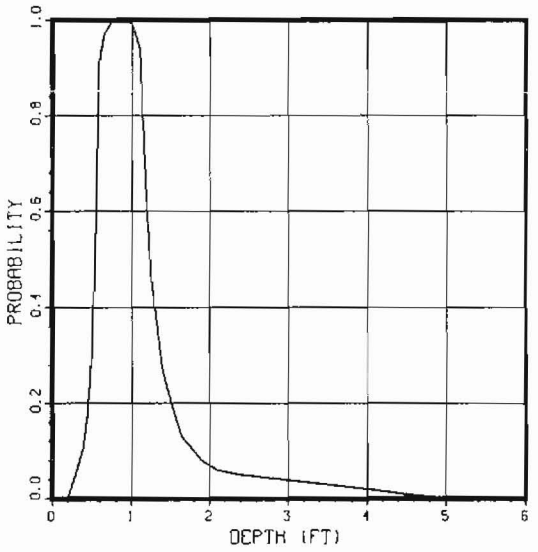
10111 SPAWNING 78/01/24.

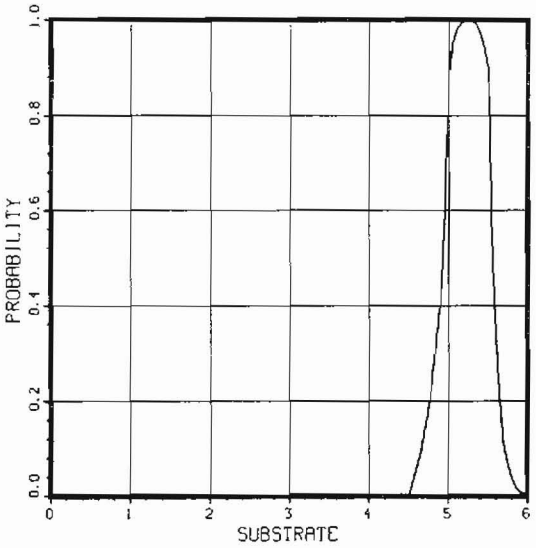


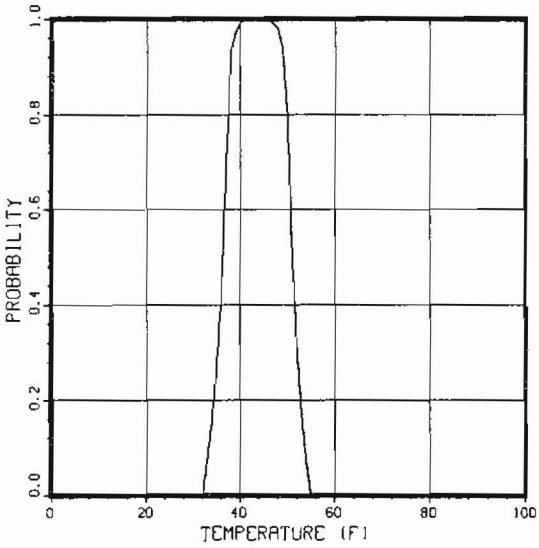
FALL CHINOOK

10112 SPAWNING 78/01/24.



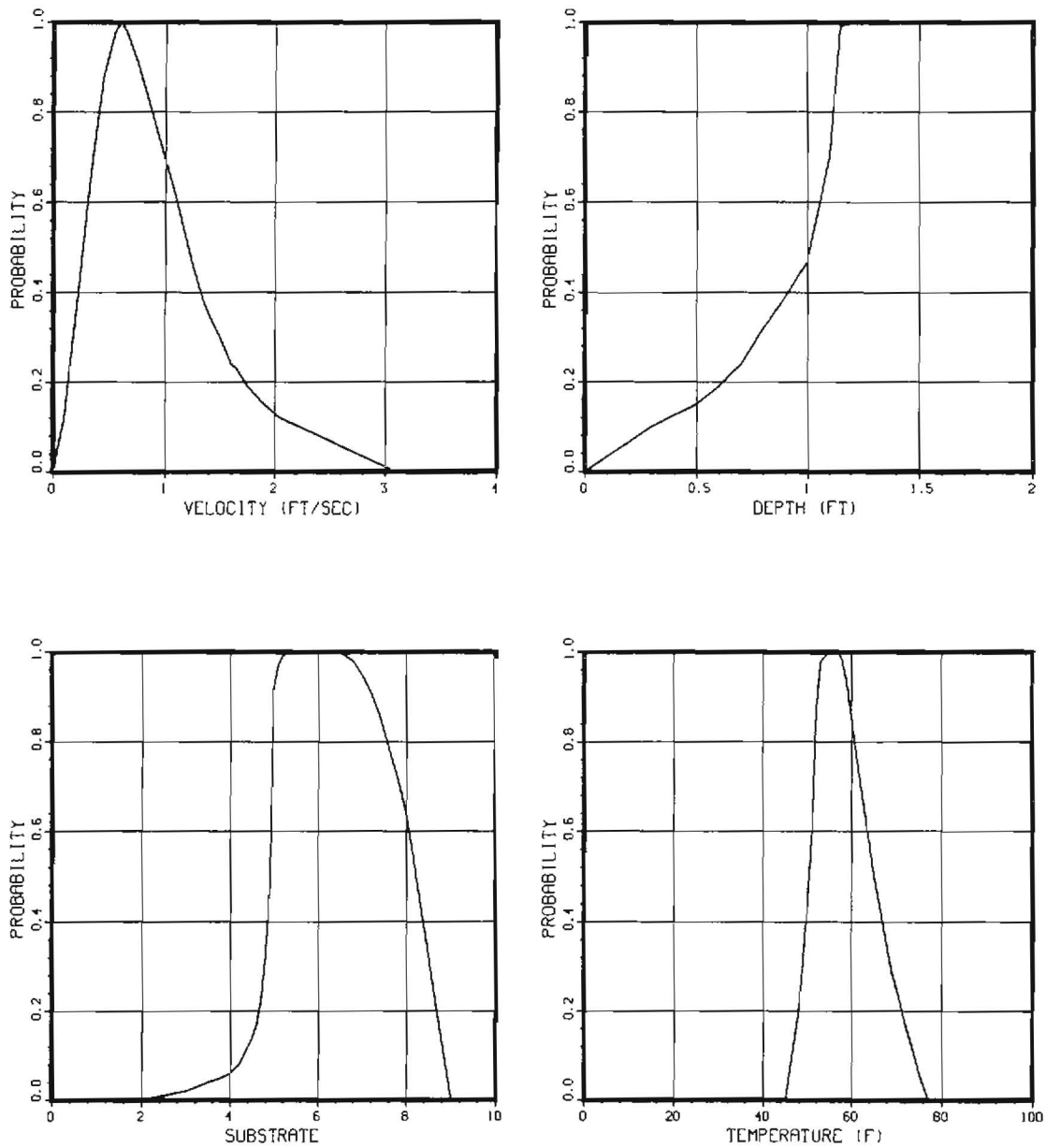






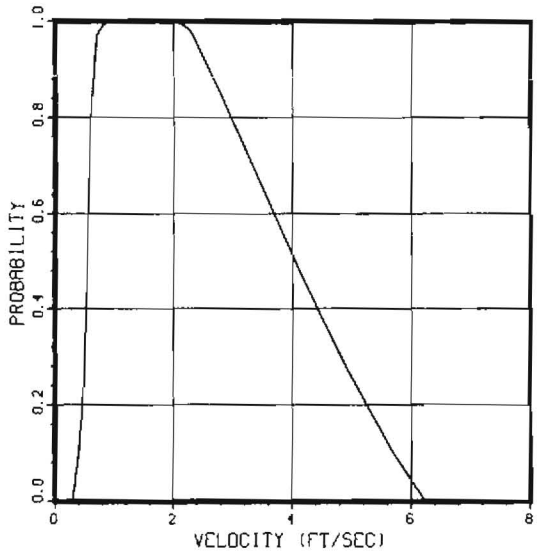
CHINOOK SALMON

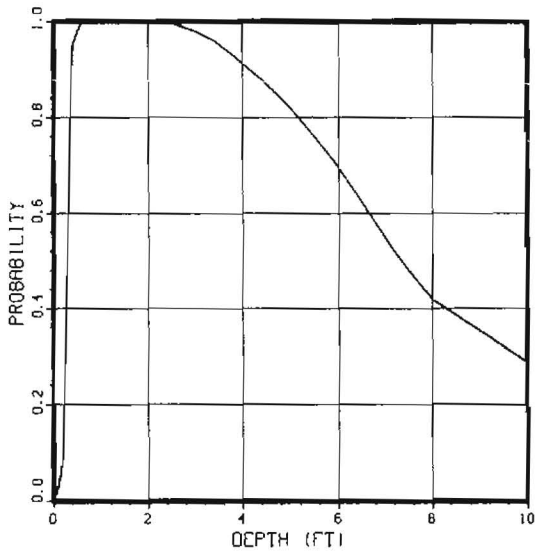
10101 JUVENILE 78/01/24.

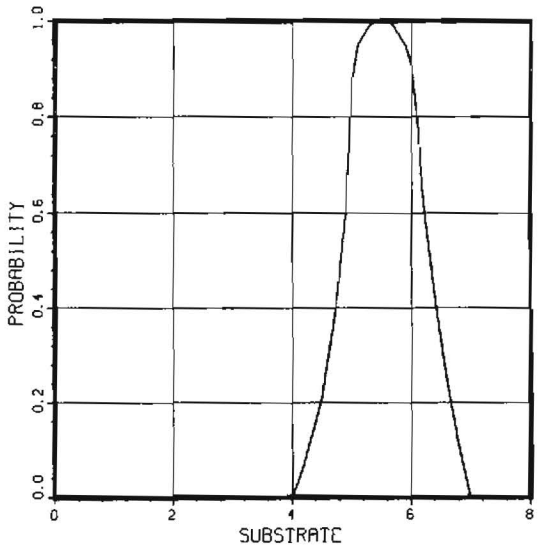


CHINOOK SALMON (CLEAR WATER, S=.001)

10121 INCUBATION 78/01/24.

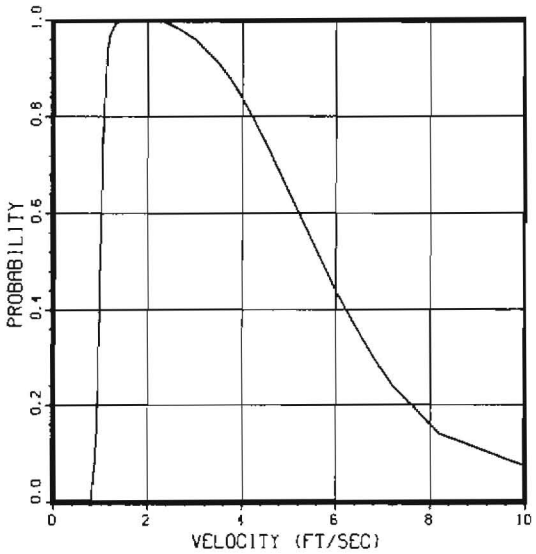


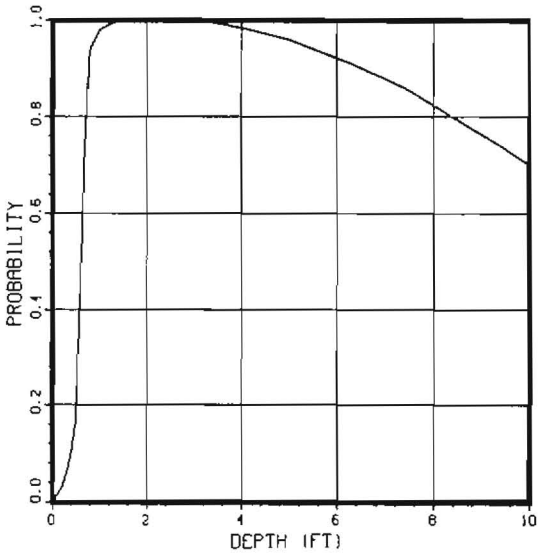


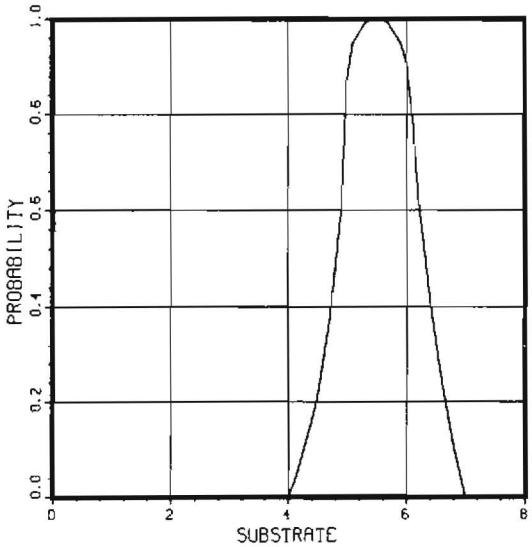


CHINOOK SALMON (TURBID WATER, S=.001)

10122 INCUBATION 78/01/24.

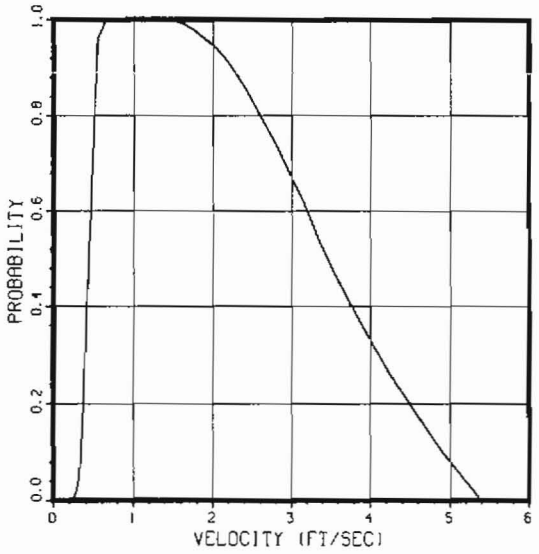


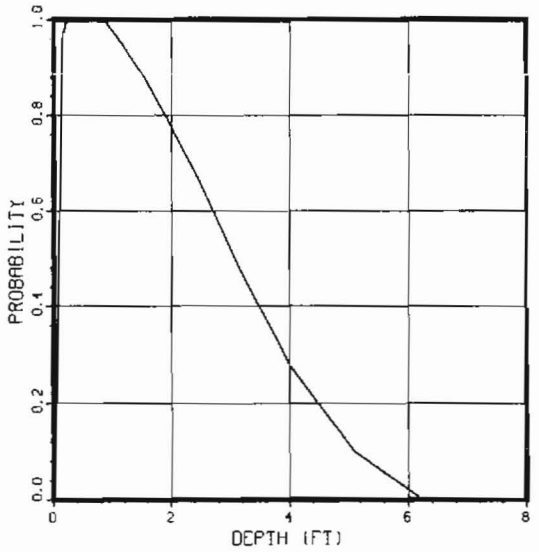


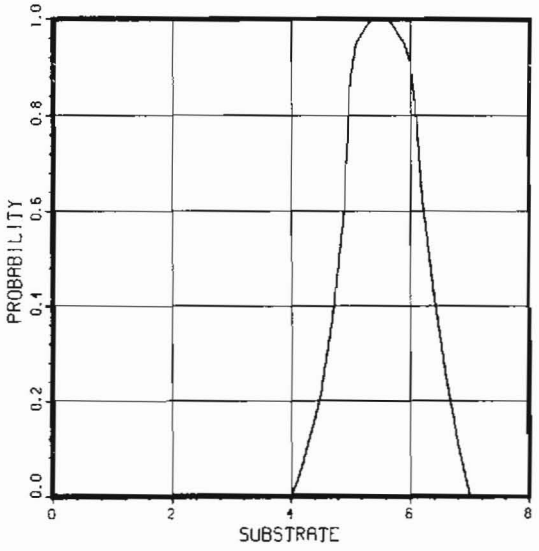


CHINOOK SALMON (CLEAR WATER, S=.0025)

10123 INCUBATION 78/01/24.







CHINOOK SALMON (TURBID WATER, S=.0025)

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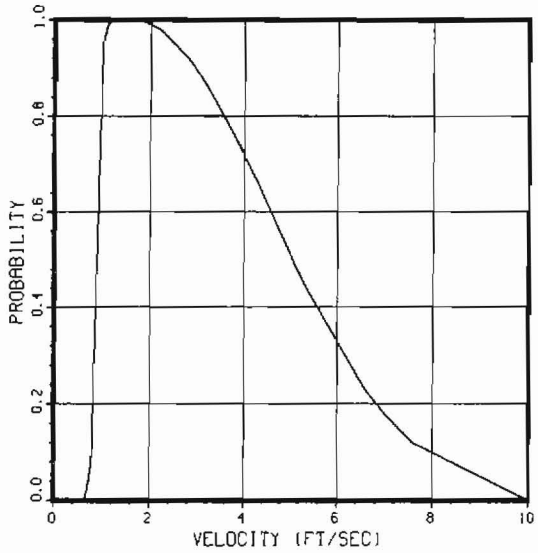

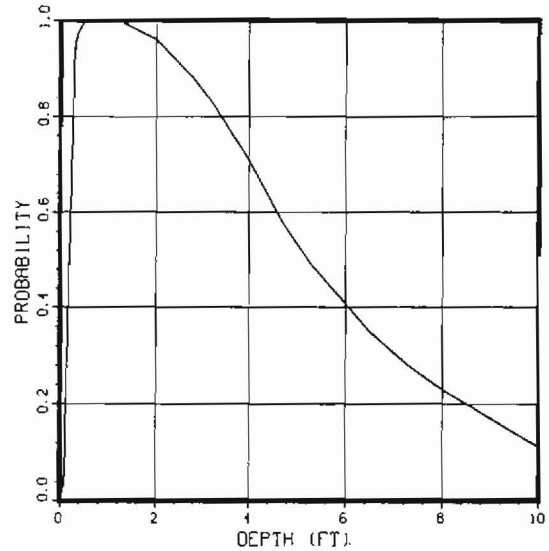

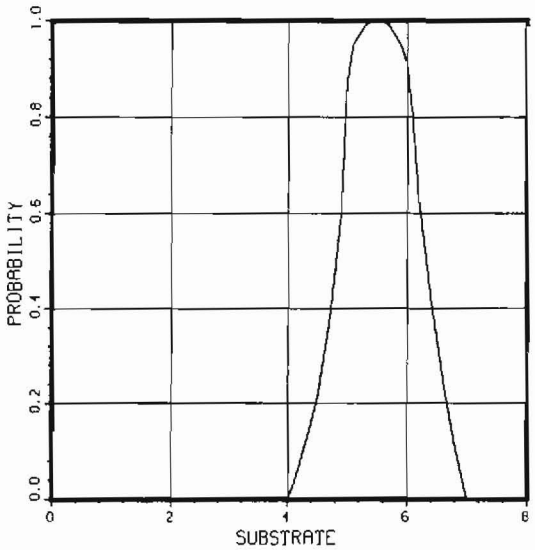

CHINOOK SALMON (CLEAR WATER, S=.004)

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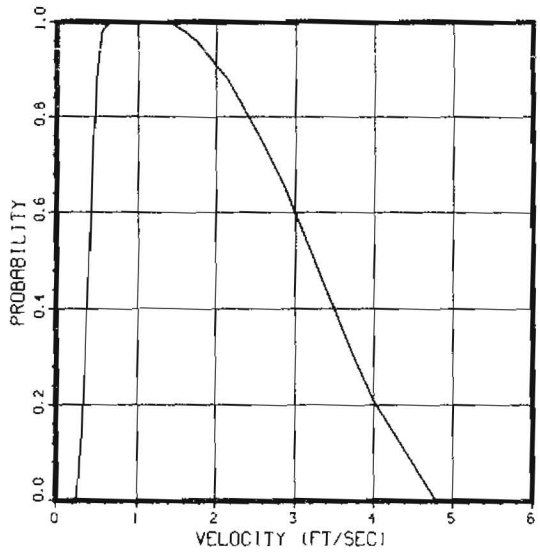
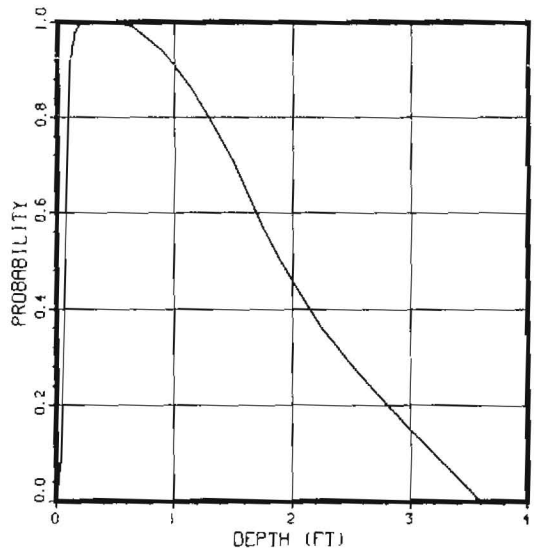
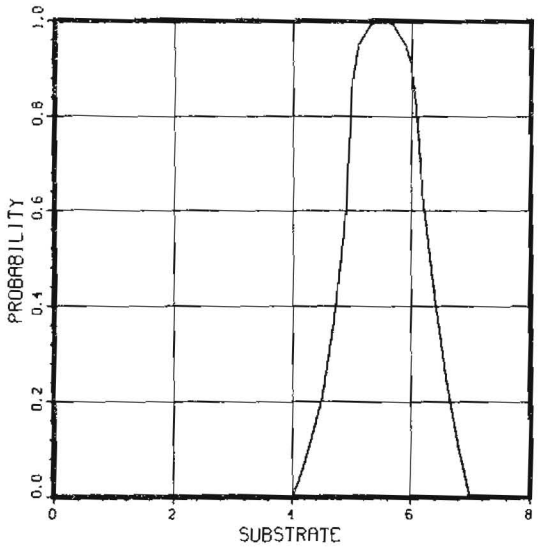
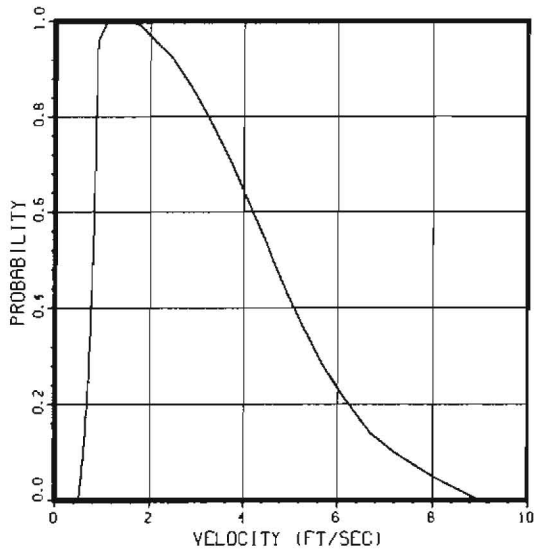


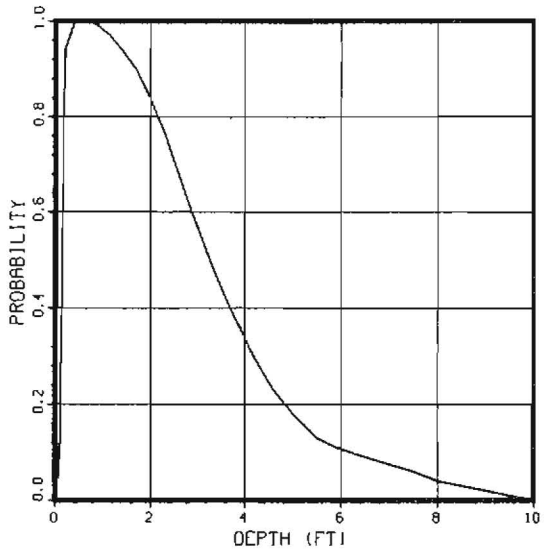


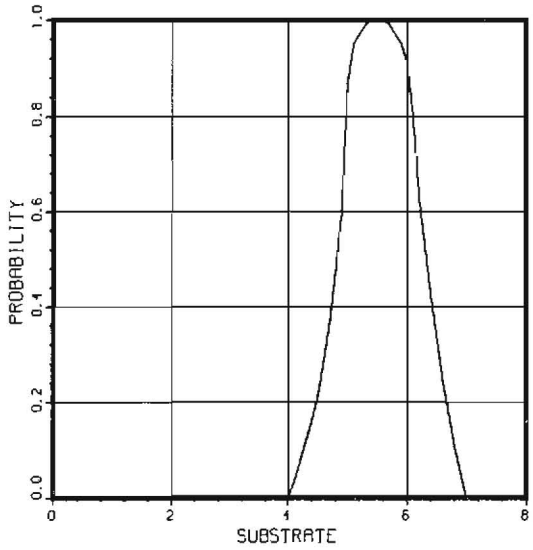


CHINOOK SALMON (TURBID WATER,S=.004)

10126 INCUBATION 78/01/24.







CUTTHROAT TROUT

Salmo clarki

	11210 Spawning				11202 Adult				11201 Juvenile				11200 Fry				11221-11226 Egg Incubation			
SPECIES: Cutthroat trout	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	F	F	F	F	F	F	F	R	G	G	G	R	F	F	G	R	F	F	F	R
REFERENCE	22 FA	22 FA		20 RO	15 FA	15 FA	15 FA		15 FA	15 FA	15 FA		15 FA	15 FA	15 FA		9 IN	9 IN	11 IN	
				31 RO													25 IN	25 IN	36 IN	
																	36 IN	36 IN		
ANALYSIS																				
COMMENTS	1	1	1 2	1	1	1	1	1 2	1	1	1	1 2	1	1	1	1 2	1 2	1 2	1 2	1 2

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

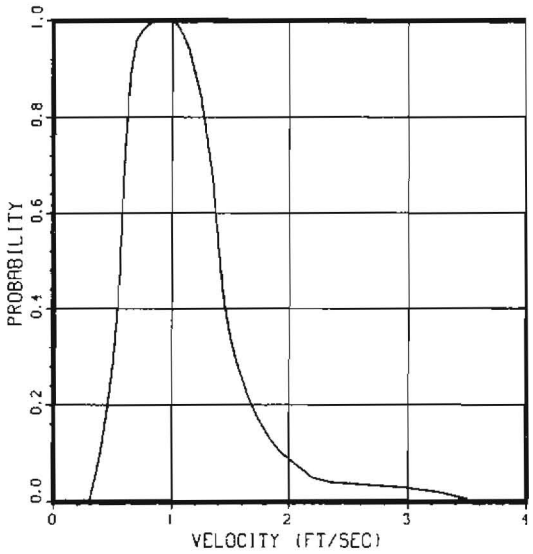
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

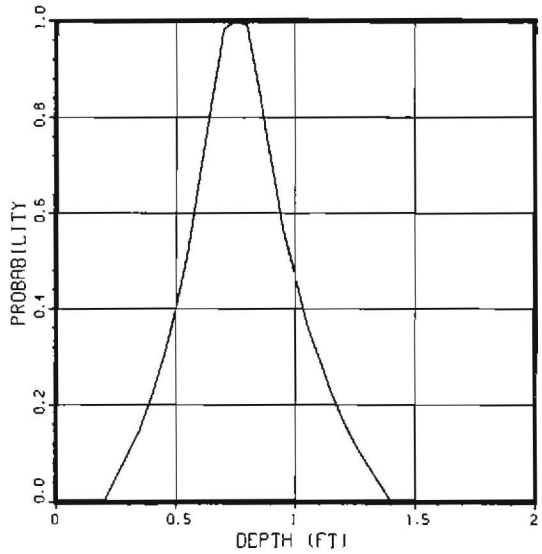
Comments - Cutthroat Trout

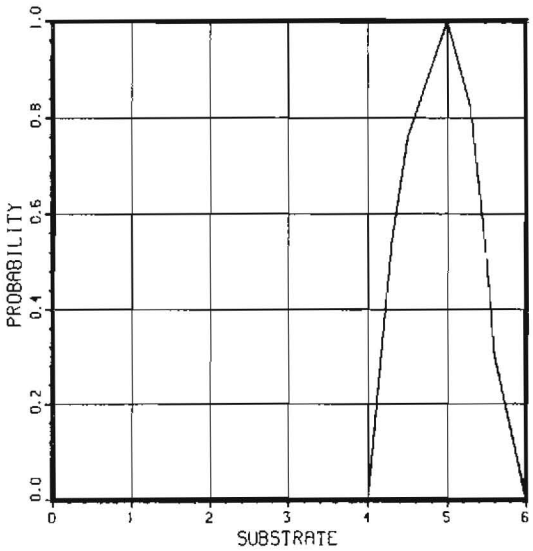
1. These curves represent the composite cutthroat trout. There are so many races and sub-species of cutthroat trout that the criteria for any single race may deviate somewhat from these criteria.
2. Assumed same as rainbow trout.

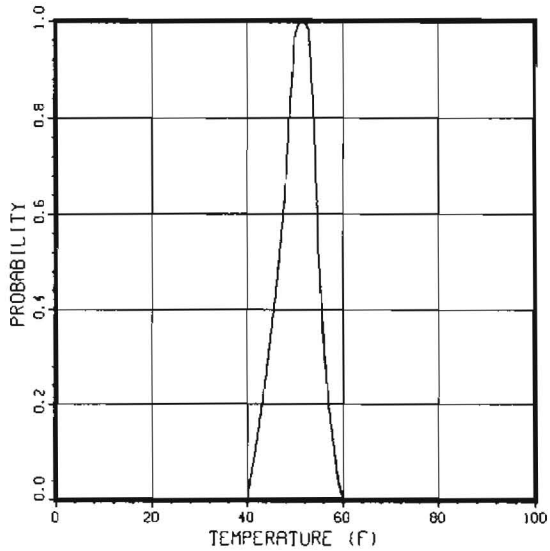
CUTTHROAT TROUT

11210 SPAWNING 78/01/24.



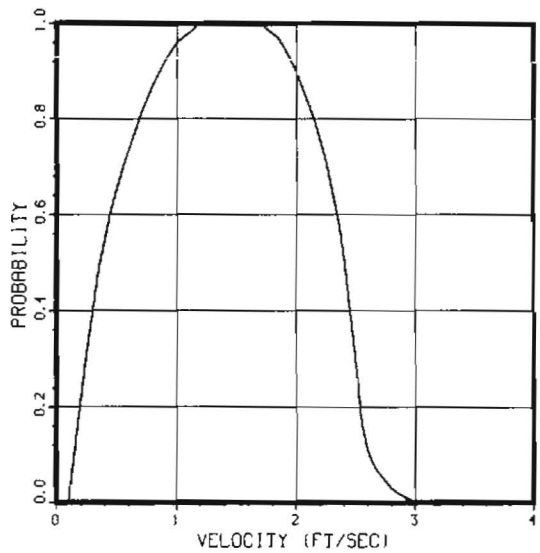


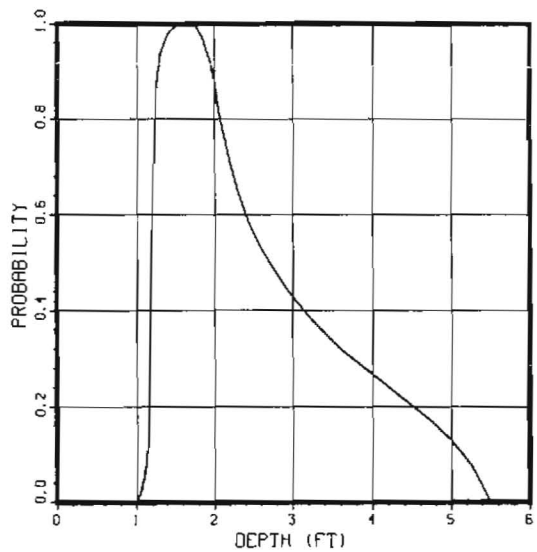


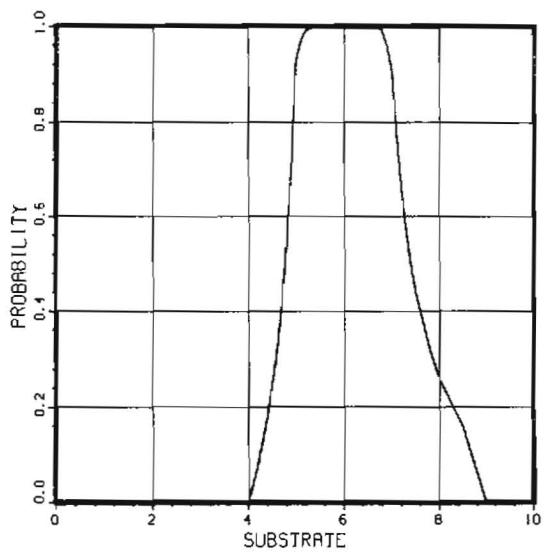


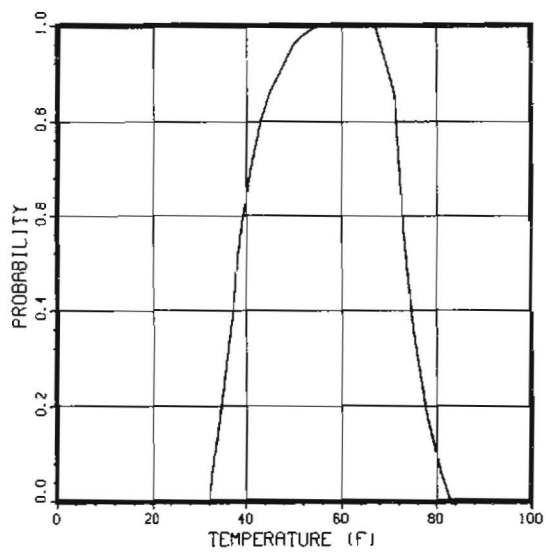
CUTTHROAT TROUT

11202 ADULTS 78/01/24.



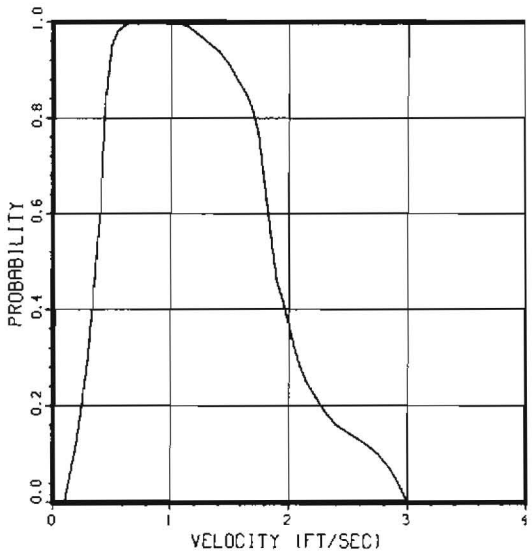


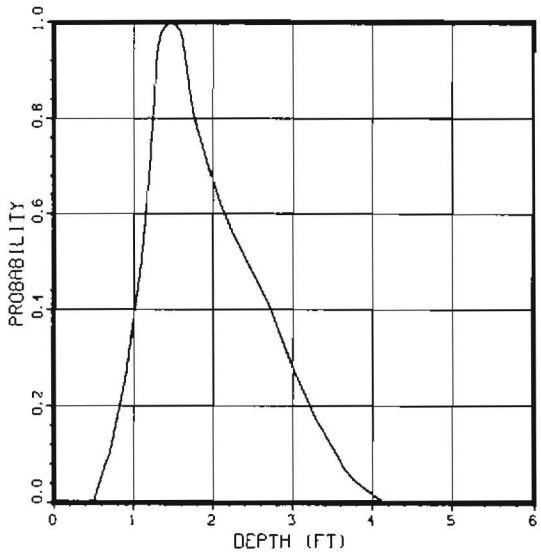


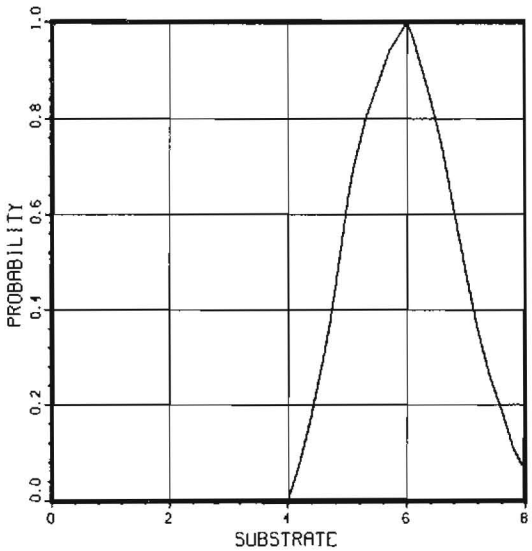


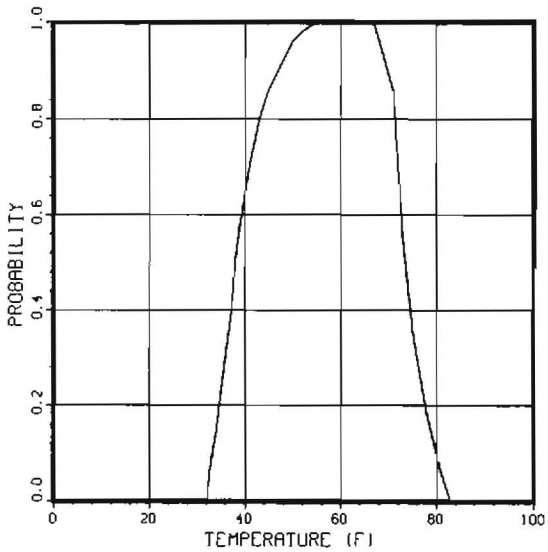
CUTTHROAT TROUT

11201 JUVENILE 78/01/24.



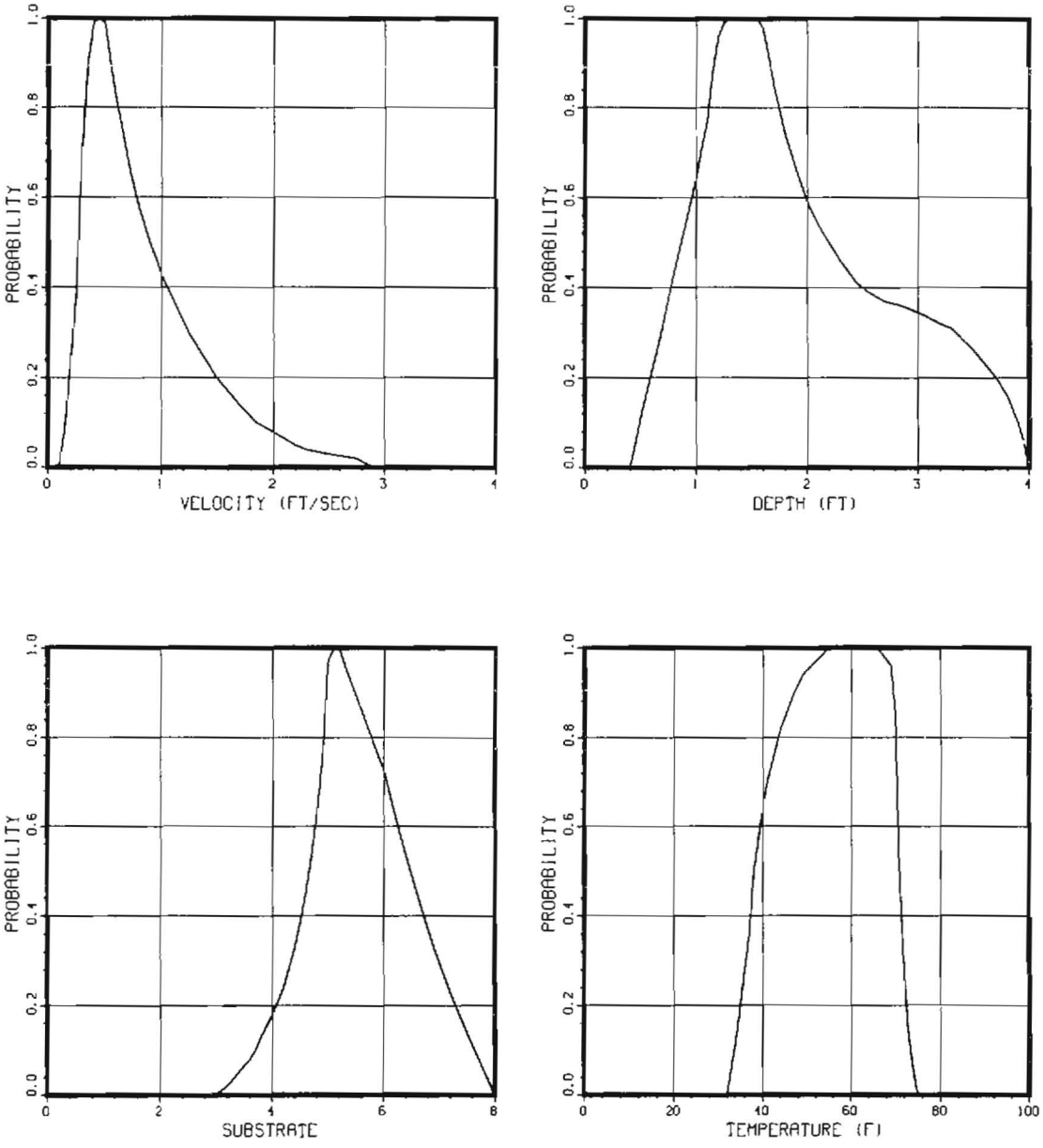






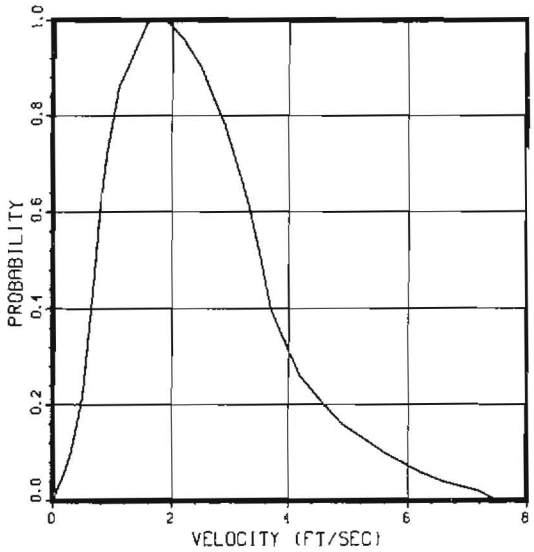
CUTTHROAT TROUT

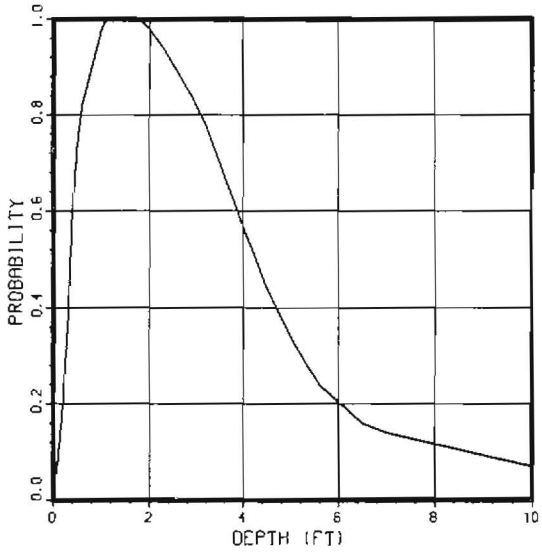
11200 FRY 78/01/24.

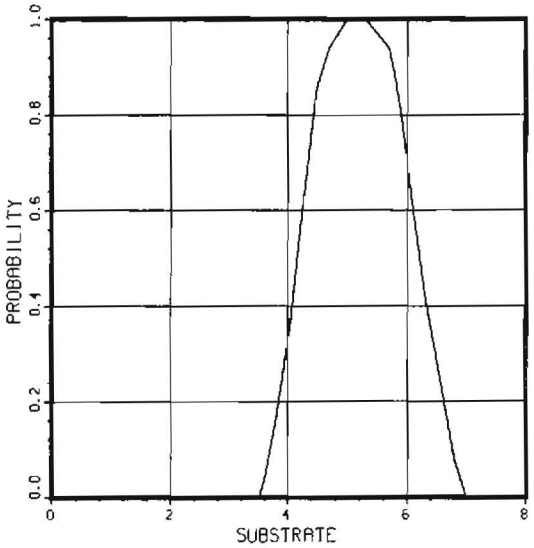


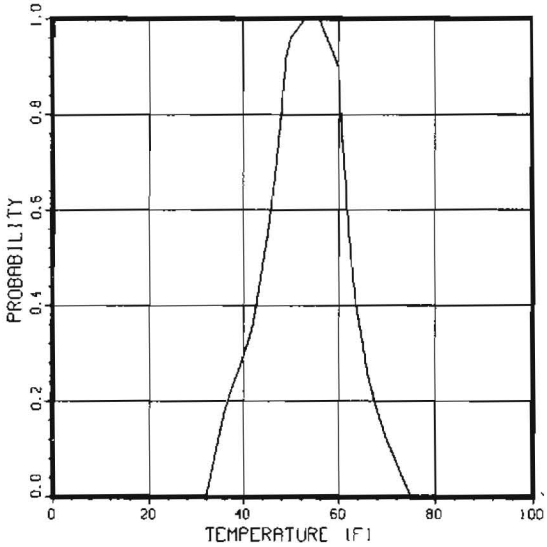
CUTTHROAT TROUT (CLEAR WATER, S=.001)

11221 INCUBATION 78/01/24.



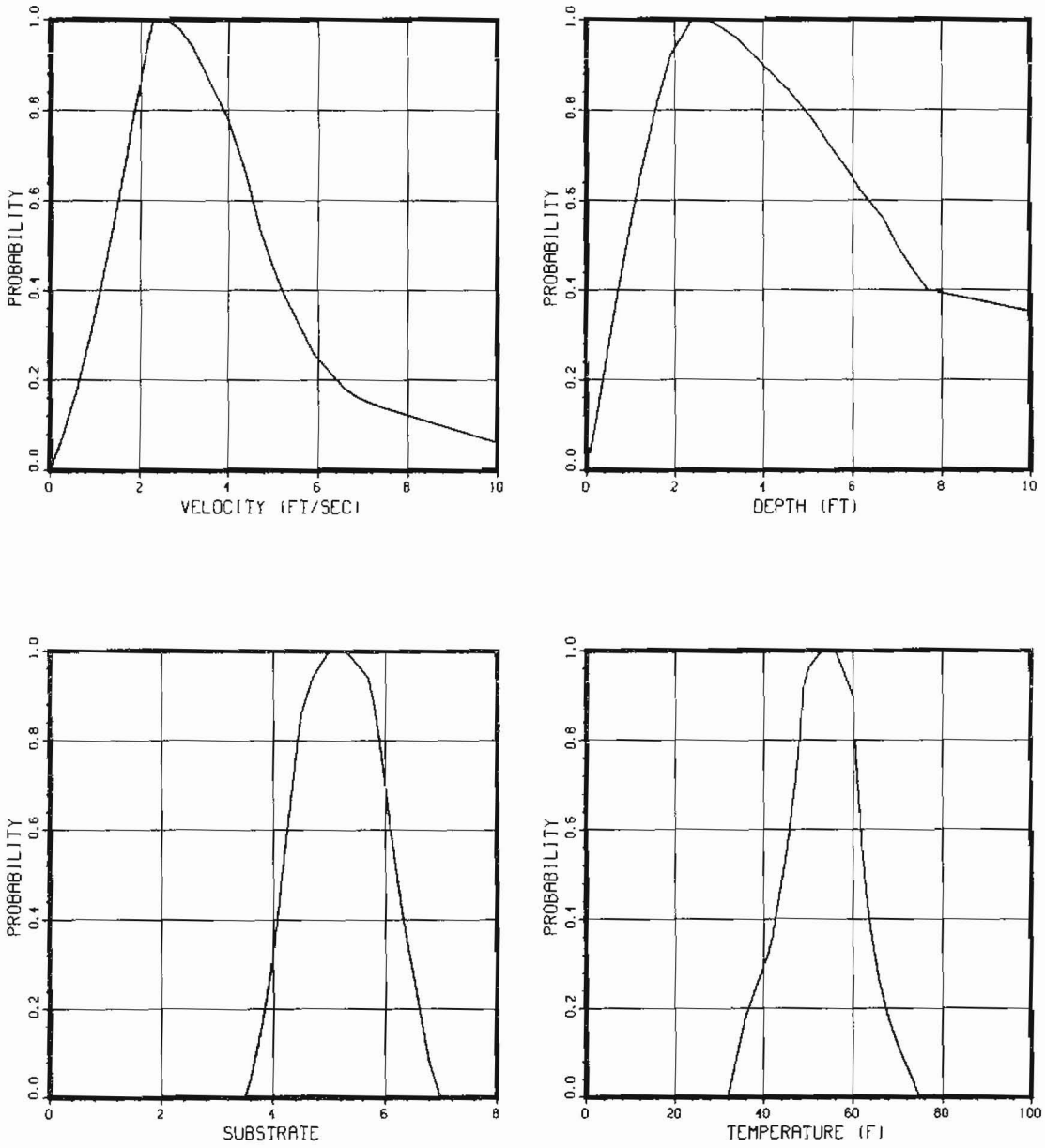






CUTTHROAT TROUT (TURBID WATER, S=.001)

11222 INCUBATION 78/01/24.



CUTTHROAT TROUT (CLEAR WATER, S=.0025)

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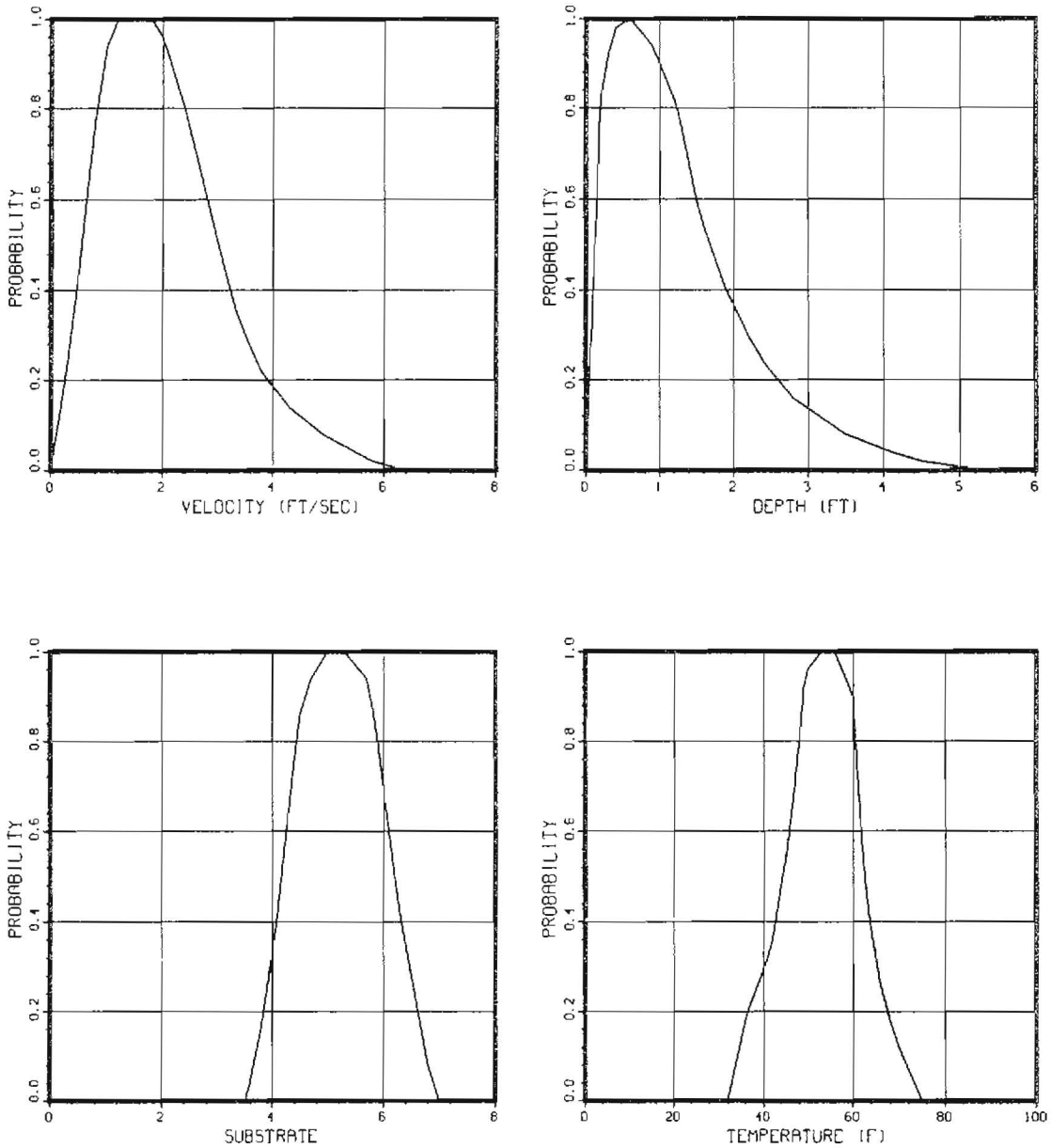

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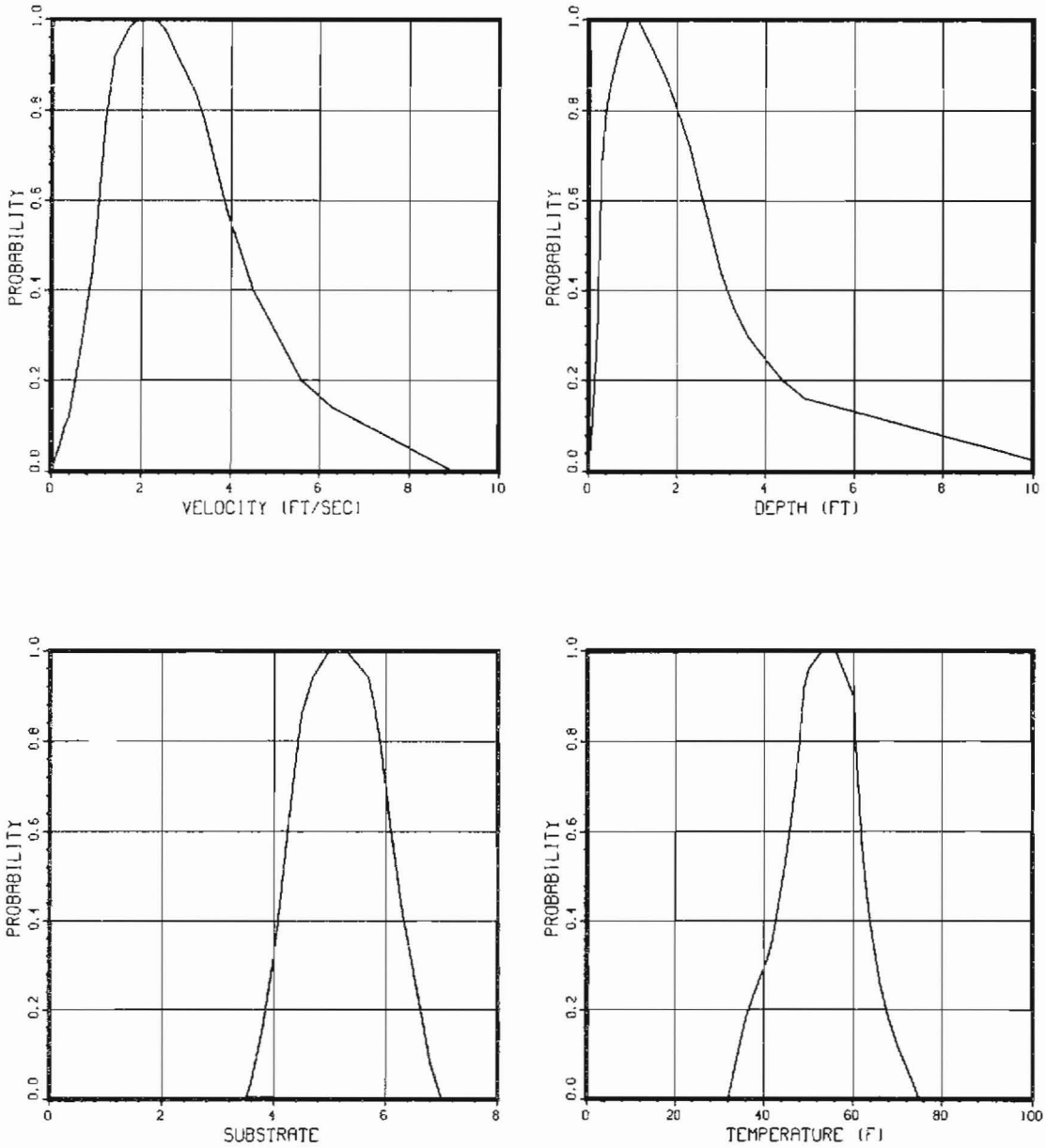

CUTTHROAT TROUT (CLEAR WATER, S=.004)

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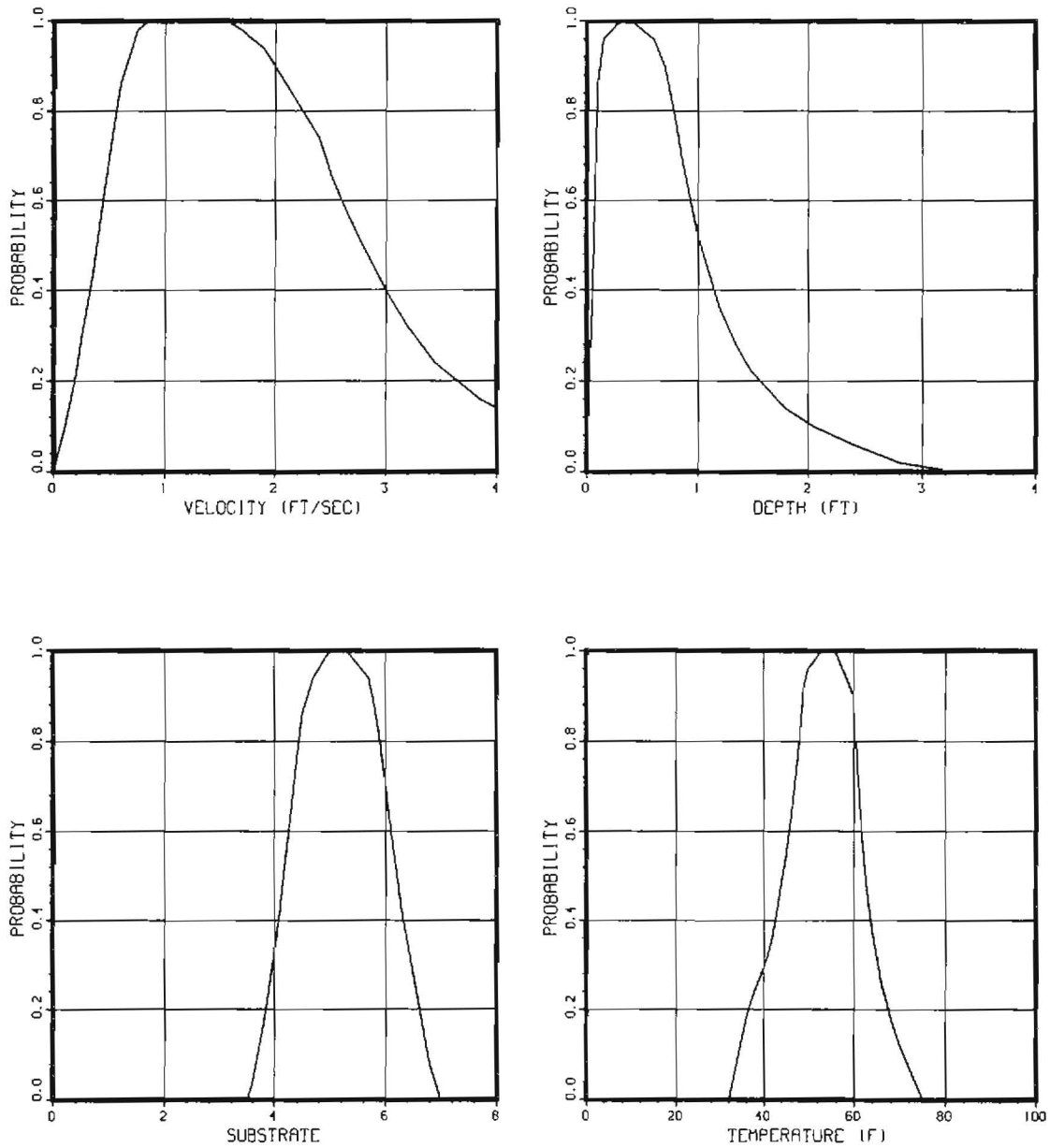

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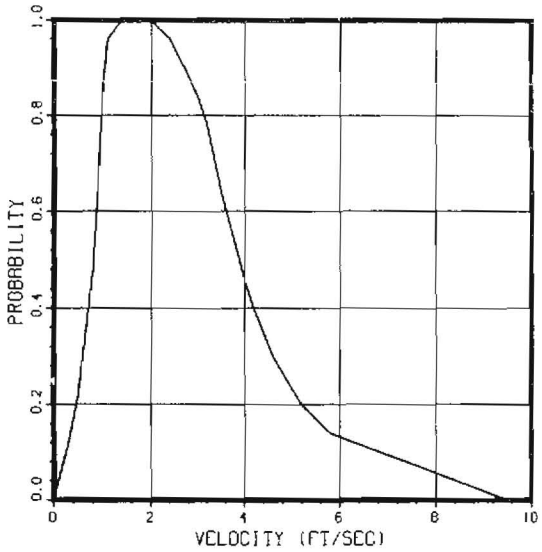
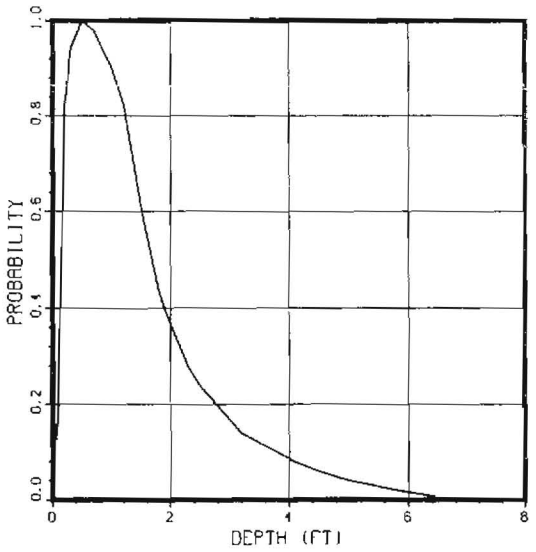
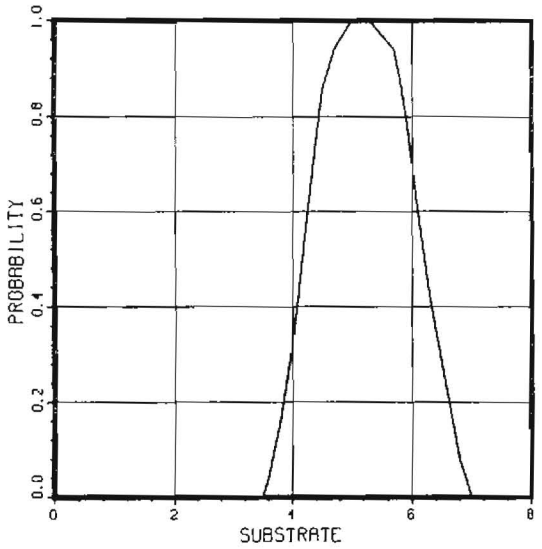
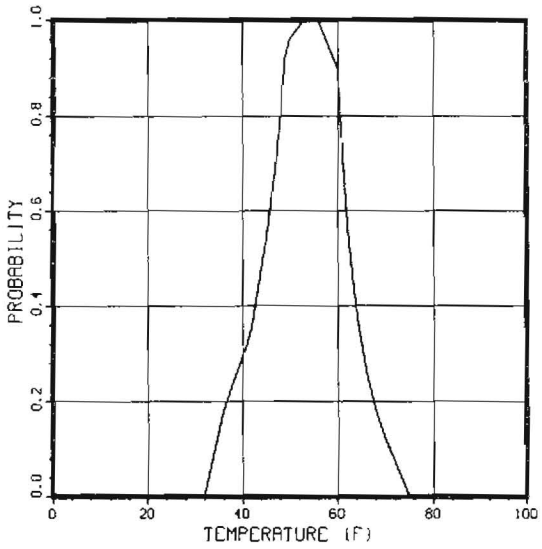








RAINBOW TROUT

Salmo gairdneri

Catalog No.	011110 Spawning				011102 Adult				011101 Juvenile				011100 Fry				01121-011126 Egg Incubation			
SPECIES: Rainbow Trout	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	E	E	G	G	F	F	F	G	E	E	E	G	G	E	E	G	F	F	G	G
REFERENCE	19 RO	19 RO	19 RO	2 PO	15 FA	15 FA	15 FA	27 PO	15 FA	15 FA	15 FA	27 PO	15 FA	15 FA	15 FA	4 FA	11 IN	11 IN	11 IN	8 IN
	23 FA	23 FA	20 RO	8 PO	18 FA	18 FA	18 FA	2 PO	18 FA	18 FA	18 FA	2 PO	18 FA	18 FA	18 FA	8 PO	9 IN	9 IN	35 IN	8 IN
	28 FA	28 FA		20 RO				31 PO				31 PO				31 PO	25 IN	25 IN	29 IN	
ANALYSIS				31 PO				8 PO				8 PO					36 IN	36 IN		
COMMENTS								2				2	1		2 3					4

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
N - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

Comments - Rainbow Trout Curves

1. Multiple modes in data. Variance not removed by clustering of adjacent velocity classes. Because fry tend to school, it is possible to observe a large number of fish in relatively few types of areas; therefore, the actual sample size here is smaller than would be indicated by the number of observations (n = 524).

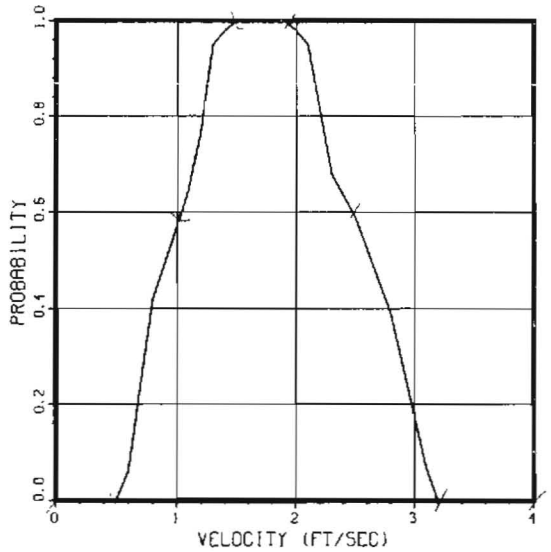
2. Digestion is poor at temperatures lower than 38°F.

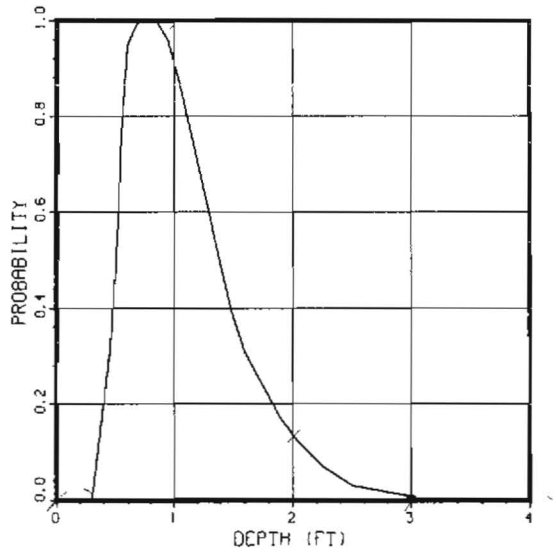
3. Fry exhibit downstream drift at temperatures less than 55°F.

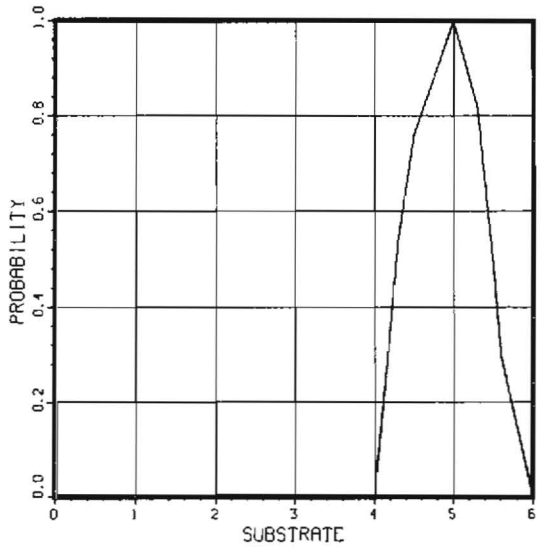
4. Probabilities of survival based on time required for hatching at different temperatures.

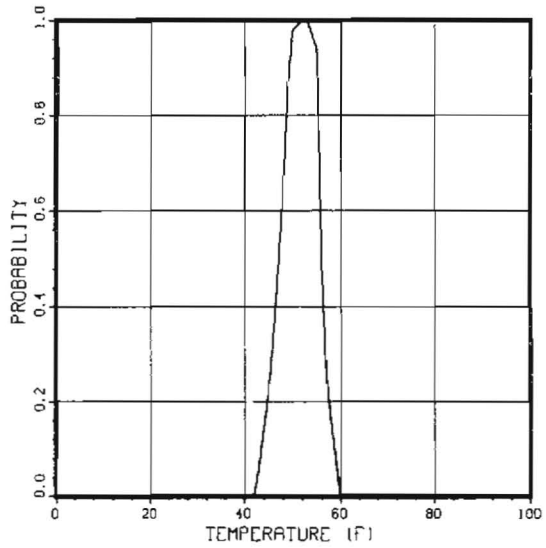
RAINBOW TROUT

11110 SPAWNING 78/01/24.



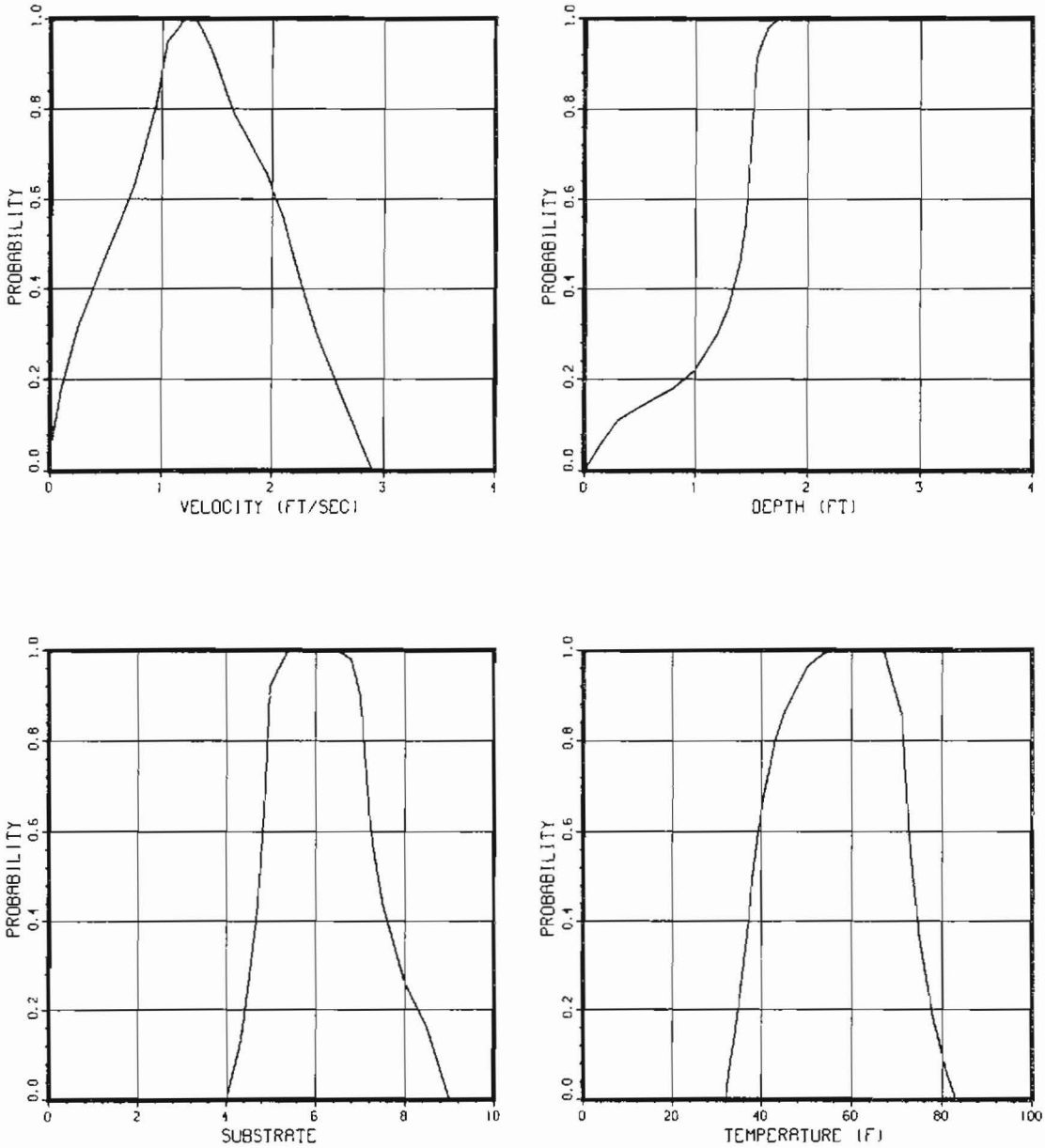






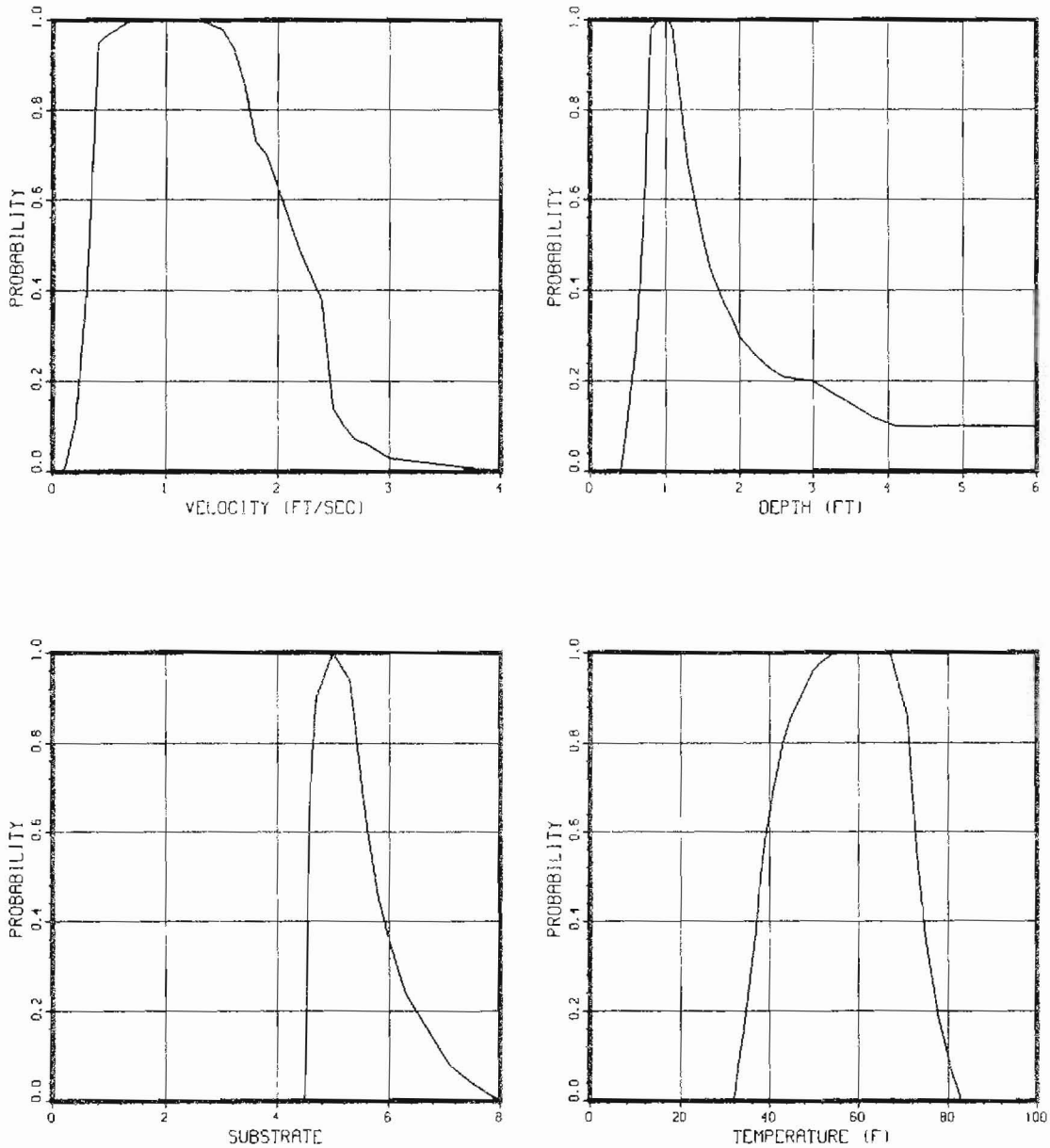
RAINBOW TROUT

11102 ADULT 78/01/24.



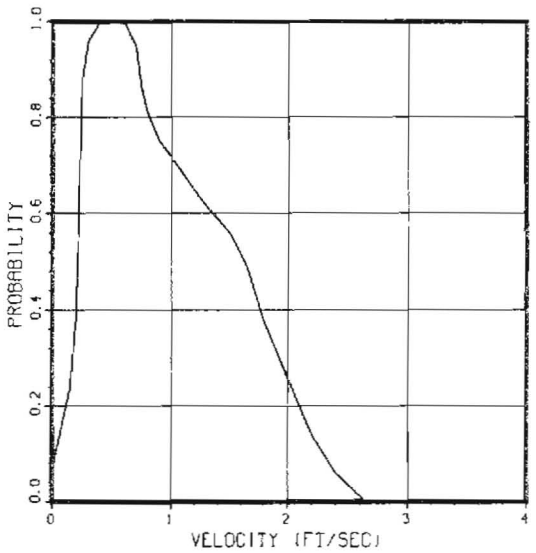
RAINBOW TROUT

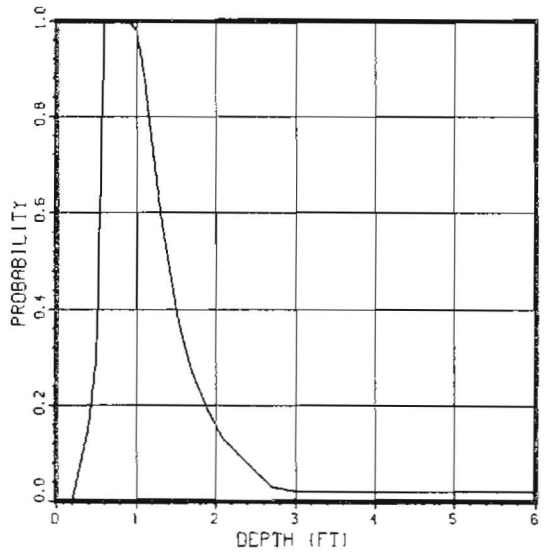
11101 JUVENILES 78/01/24.

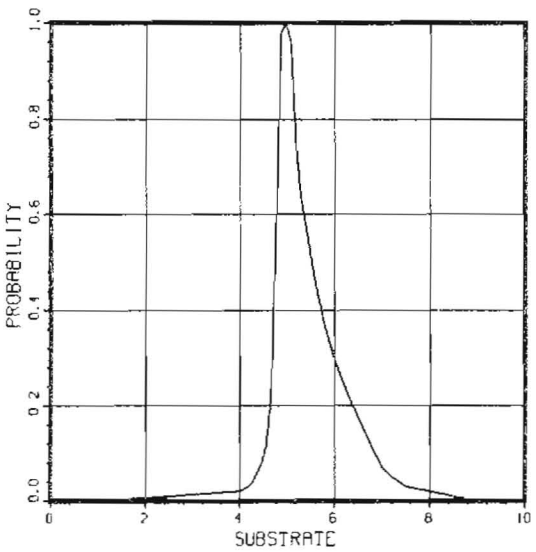


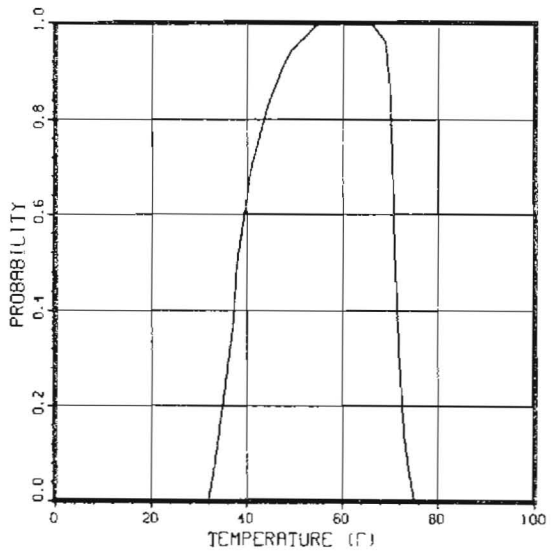
RAINBOW TROUT

11100 FRY 78/01/24.



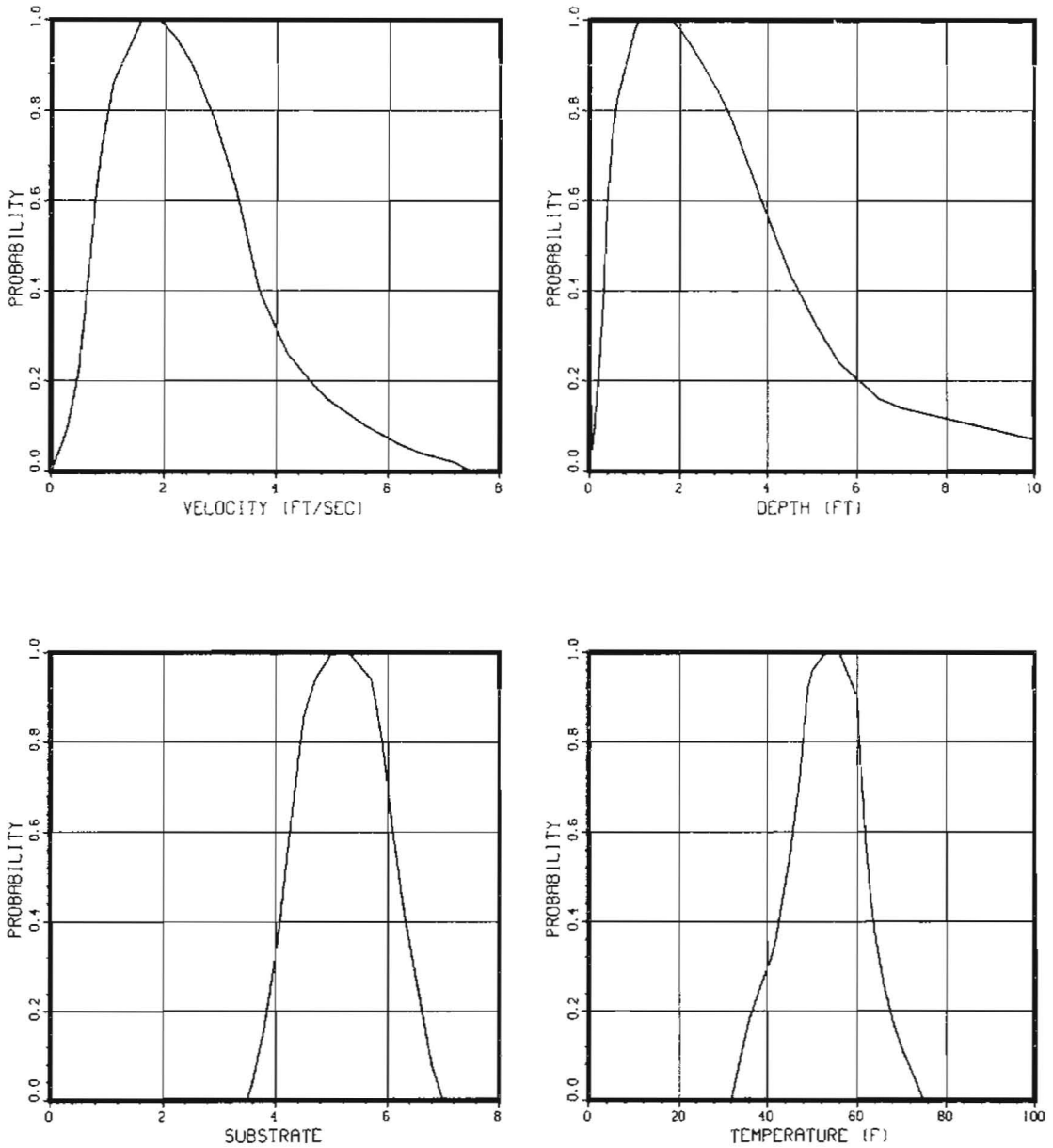






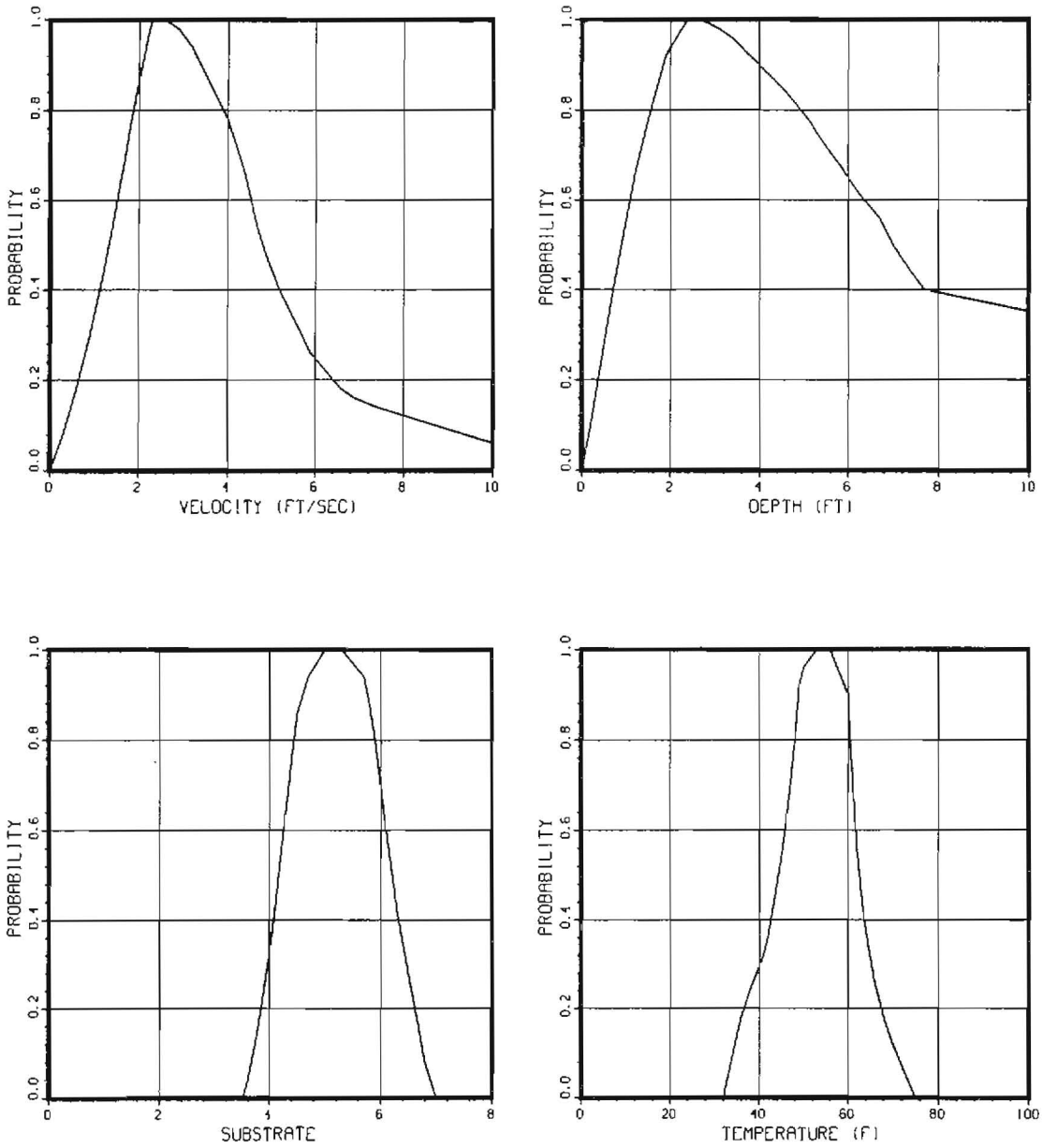
RAINBOW TROUT (CLEAR WATER, S=.001)

11121 INCUBATION 78/01/24.



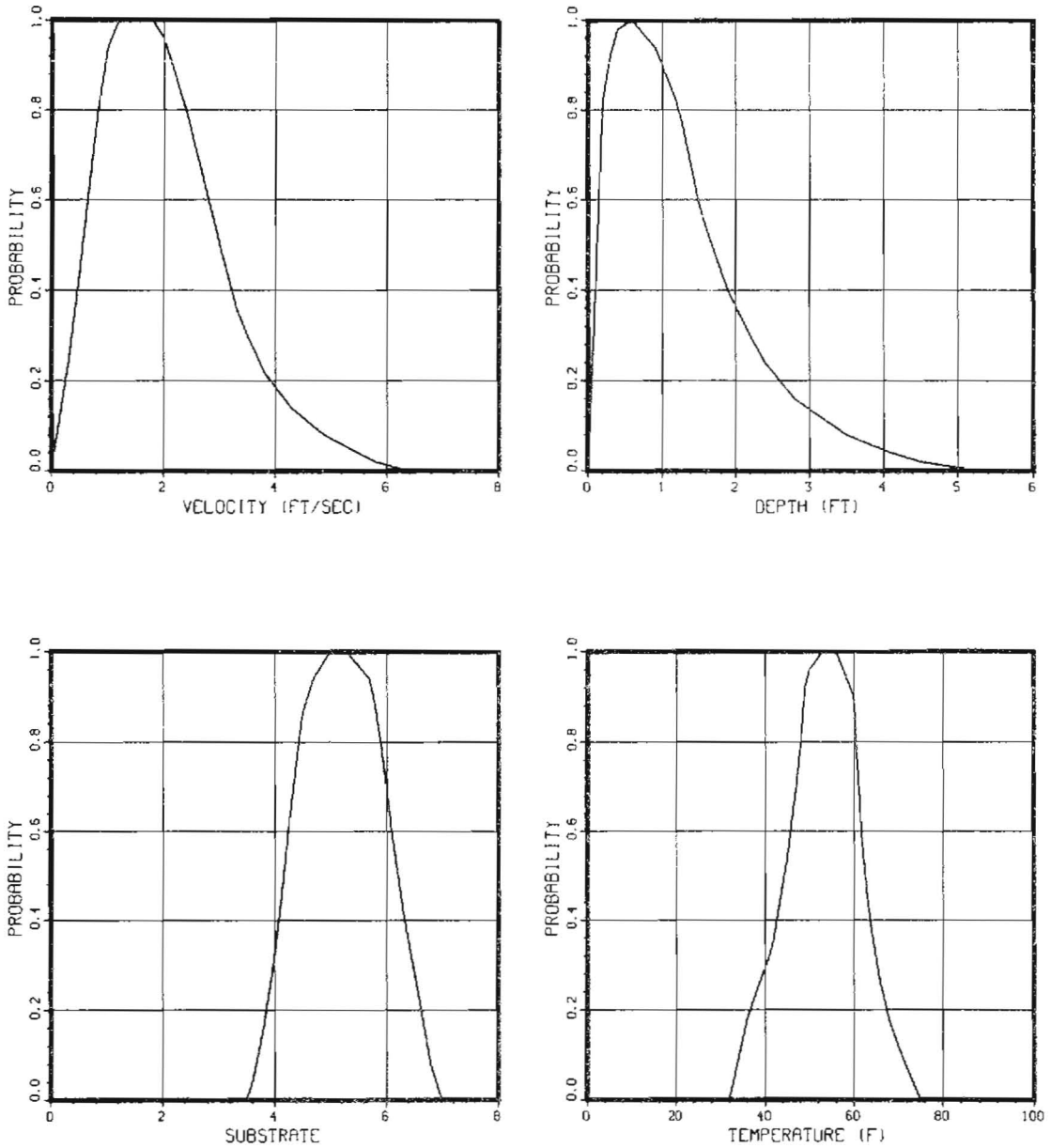
RAINBOW TROUT (TURBID WATER, S=.001)

11122 INCUBATION 78/01/24.



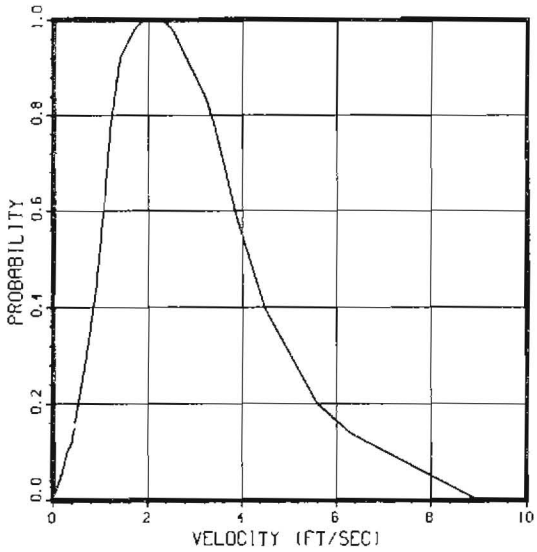
RAINBOW TROUT (CLEAR WATER, S=.0025)

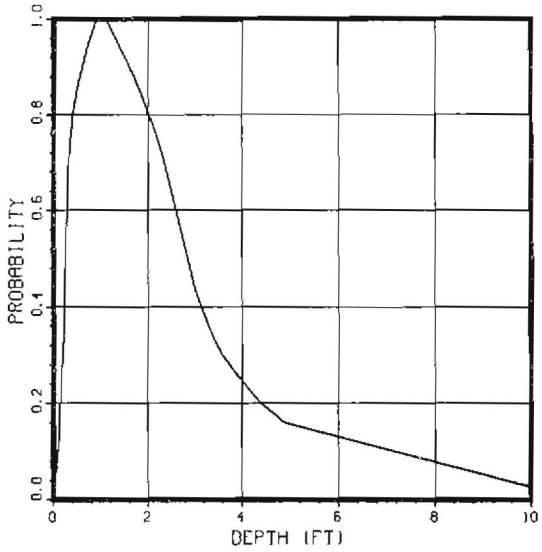
11123 INCUBATION 78/C1/24.

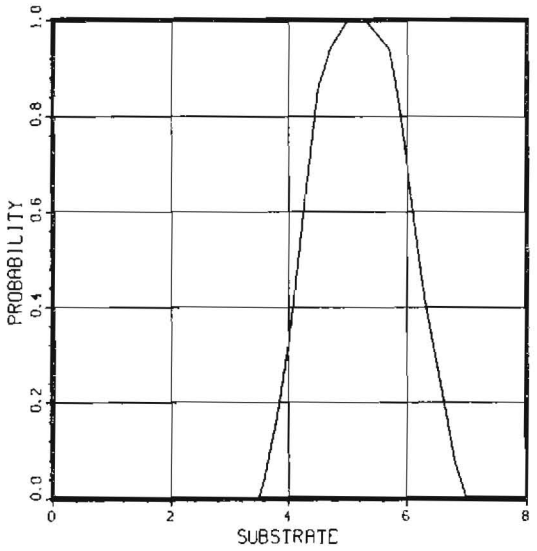


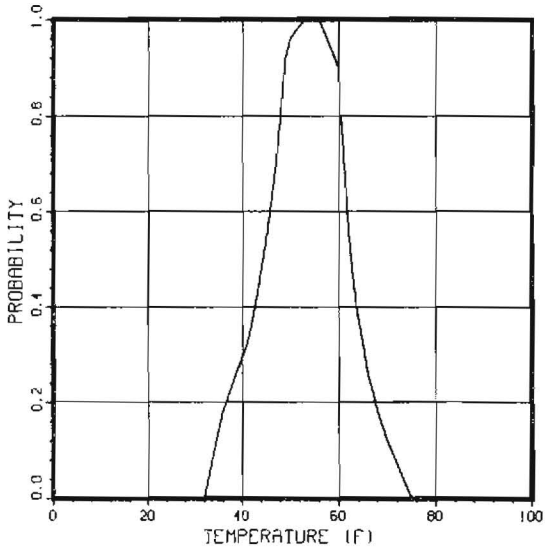
RAINBOW TROUT (TURBID WATER, S=.0025)

11124 INCUBATION 78/01/24.



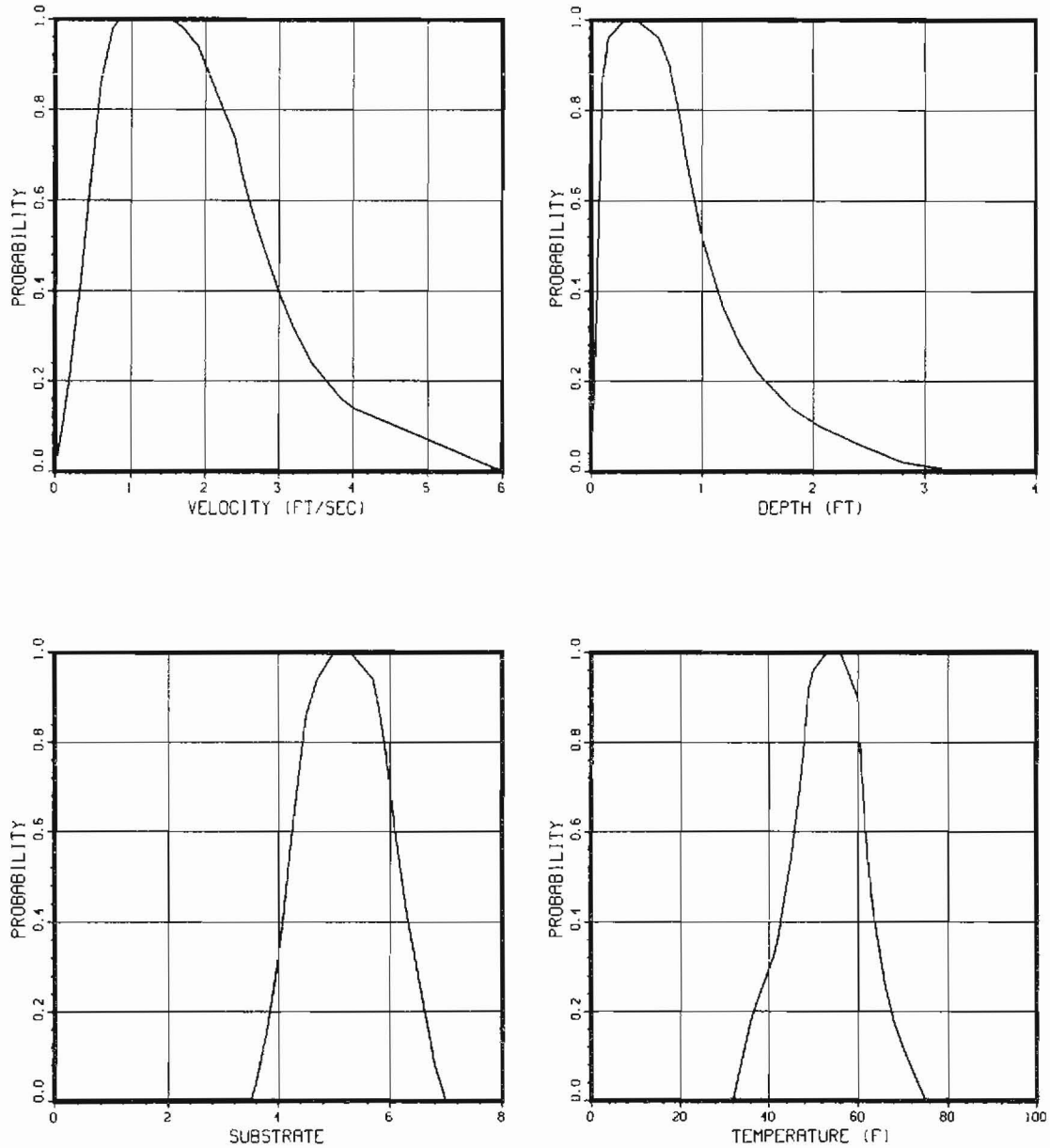






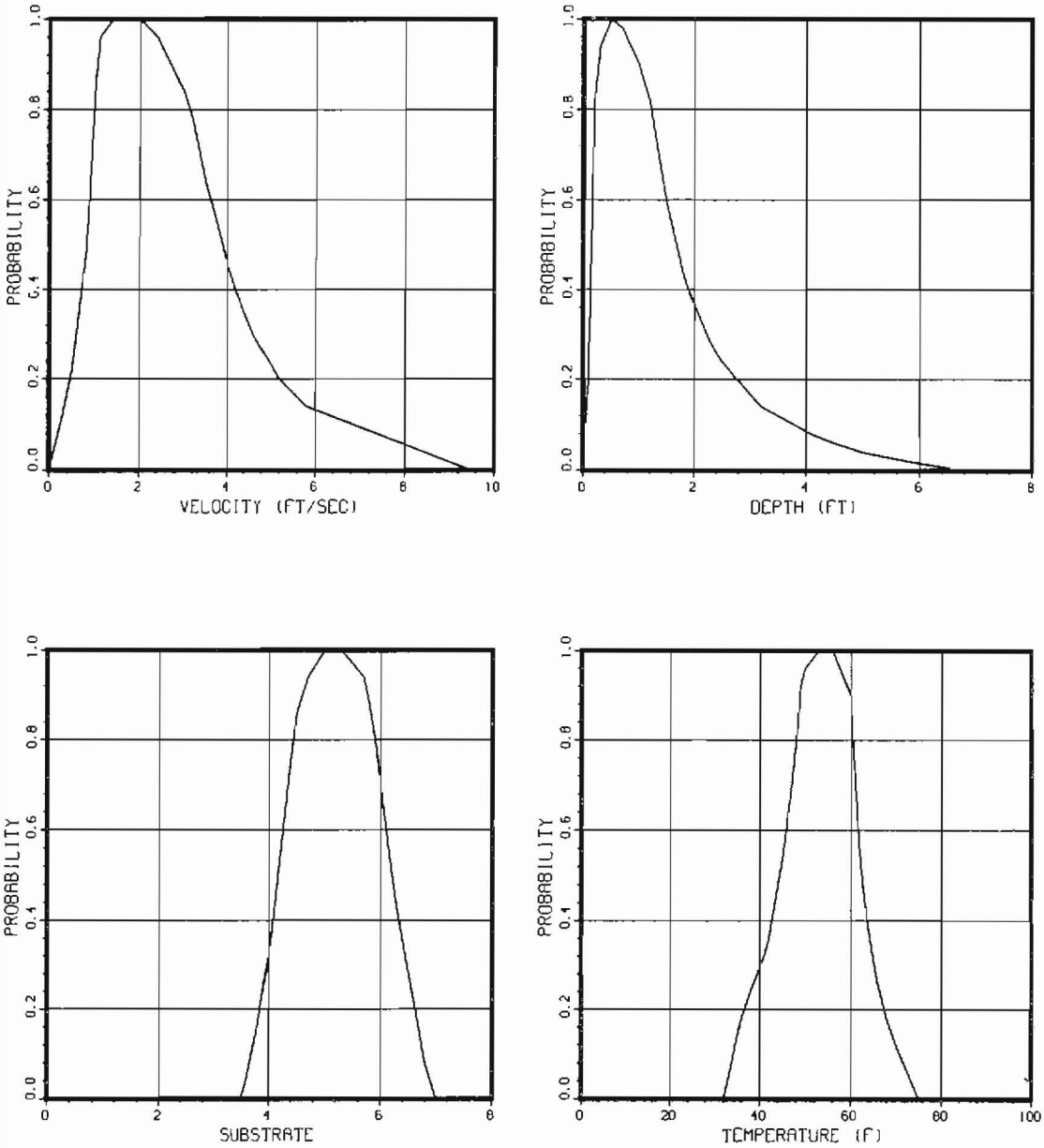
RAINBOW TROUT (CLEAR WATER, S=.004)

11125 INCUBATION 78/01/24.



RAINBOW TROUT (TURBID WATER, S=.004)

11126 INCUBATION 78/01/24.



STEELHEAD

Salmo gairdneri

Catalog No.	11013 Spawning				11002 Adult				11001 Juvenile				11000 Fry				11021-11026 Egg Incubation			
SPECIES: Steelhead	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	E	E	G	G	F	F	F	F	G	G	G	F	G	G	G	F	F	G	F	R
REFERENCE	22 FA	22 FA	28 FA	22 PO	18 FA	18 FA	18 FA	15 PO	14 FA	14 FA	14 FA	15 PO	14 FA	14 FA	14 FA	15 PO	9 IN	9 IN	11 IN	21 RO
	28 FA	28 FA							17 RO	17 RO	17 RO		17 RO	17 RO	17 RO		11 IN	11 IN	36 IN	
									18 FA	18 FA	18 FA		18 FA	18 FA	18 FA		25 IN	25 IN		
ANALYSIS																	36 IN	36 IN		
COMMENTS									1	1	2		1	1						

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

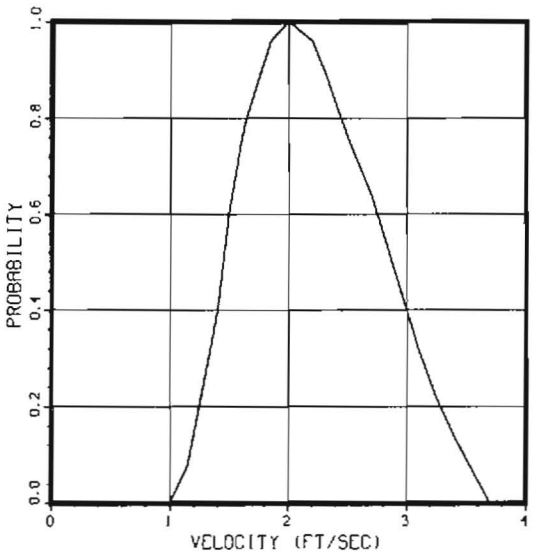
Comments - Winter Steelhead

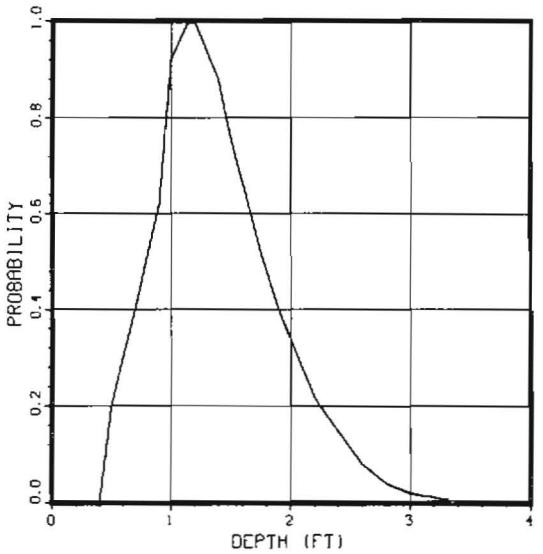
1. Frequency Analysis from Everest and Chapman utilized density rather than frequency of observation. Sample size unknown.

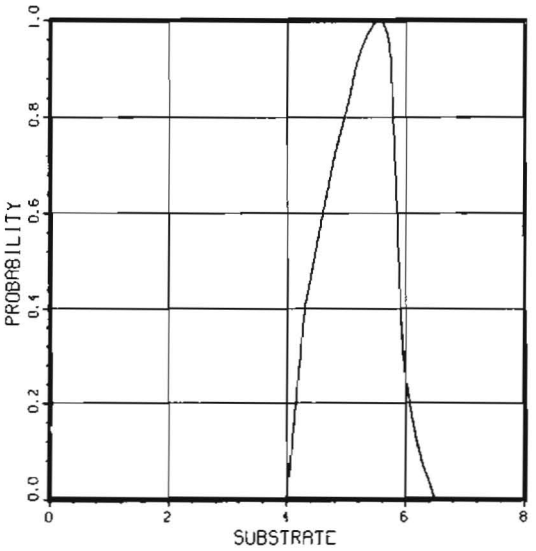
2. Everest and Chapman show conflicting data. In one study section they found steelhead pre-smolts over a silt bottom, but not so in two others. These two agreed well with the data provided by Hanson. Data from the conflicting stream reach was not used in the analysis.

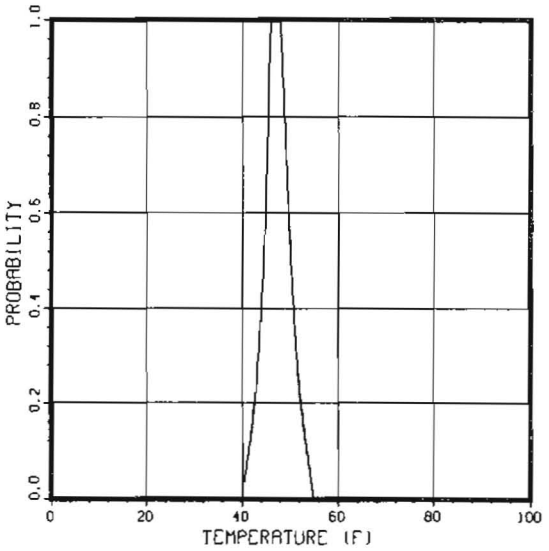
WINTER STEELHEAD

11010 SPAWNING 78/01/24.



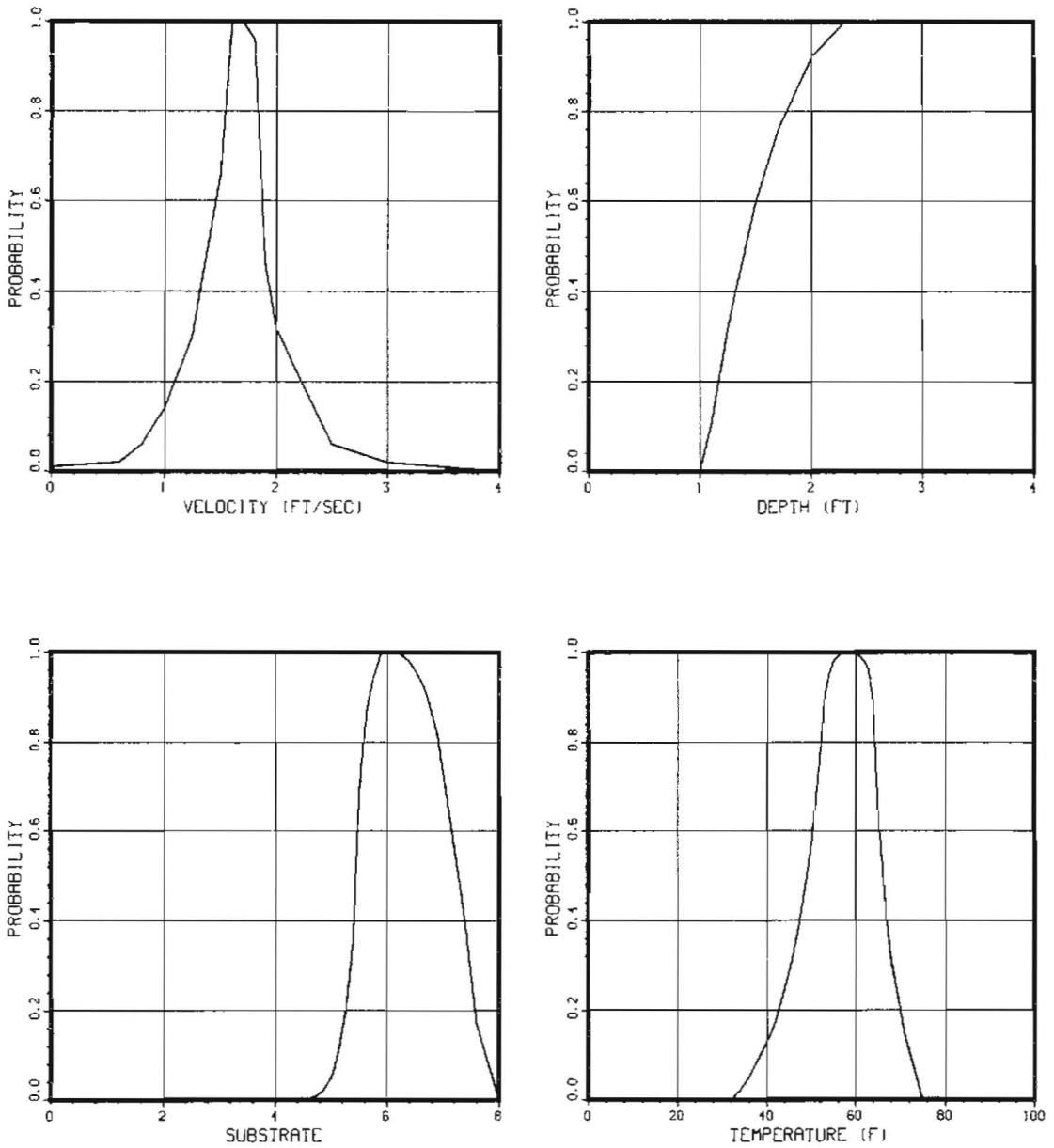






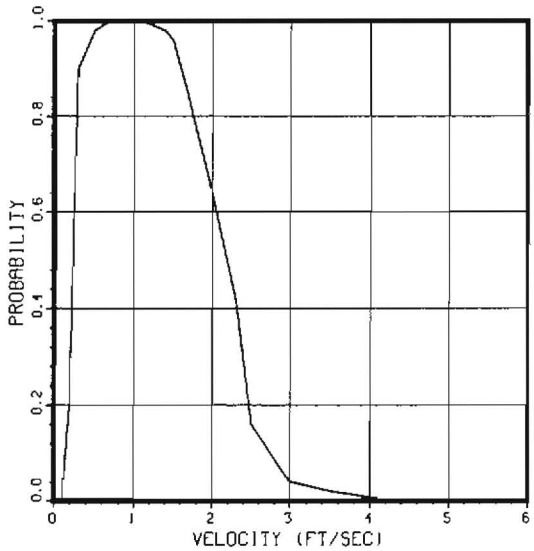
WINTER STEELHEAD

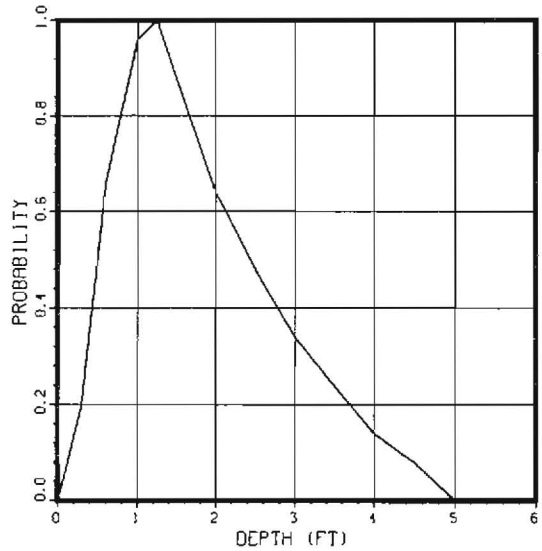
11002 ADULT 78/01/24.

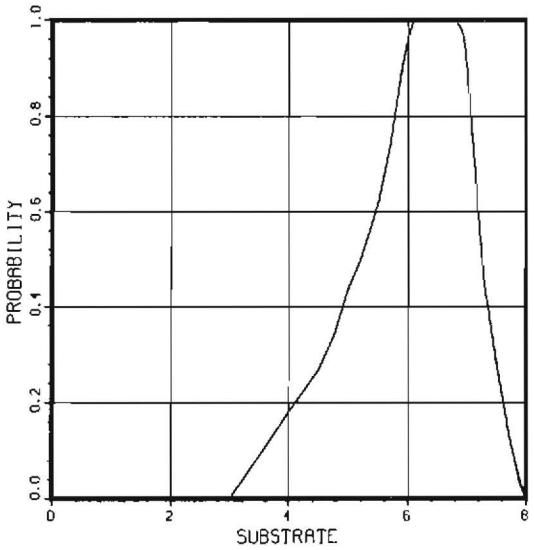


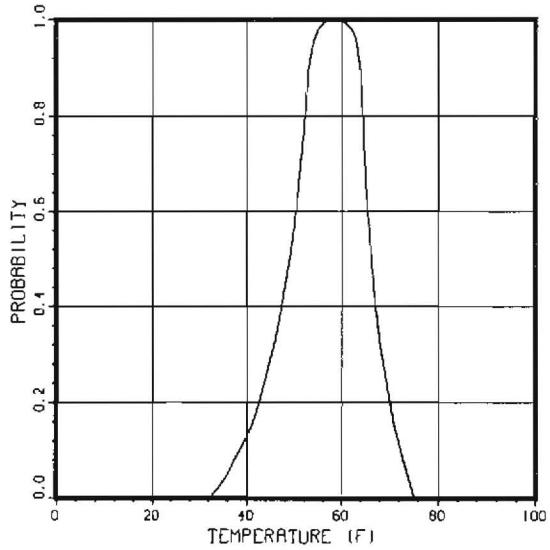
WINTER STEELHEAD

11001 JUVENILE 78/01/24.



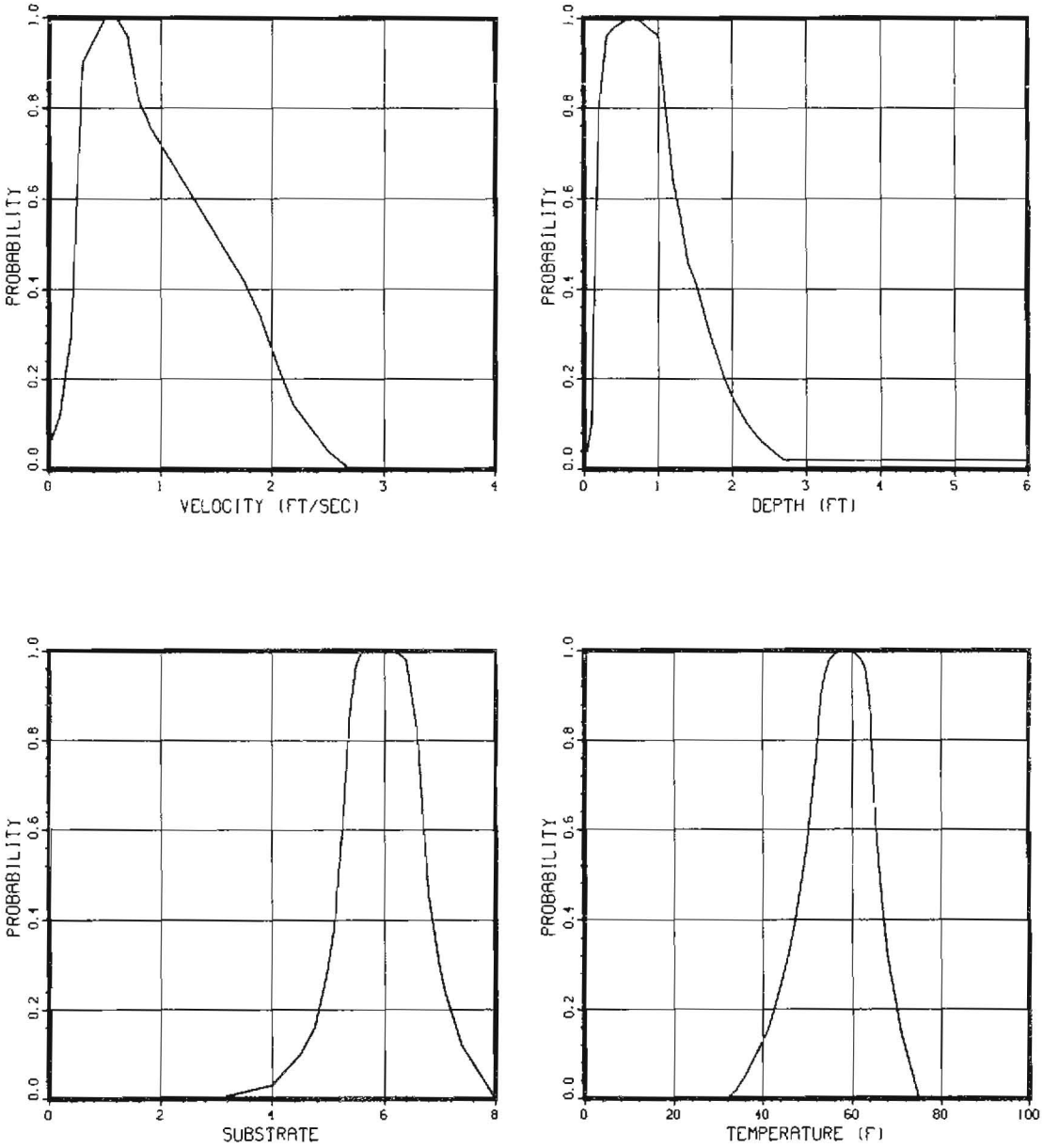






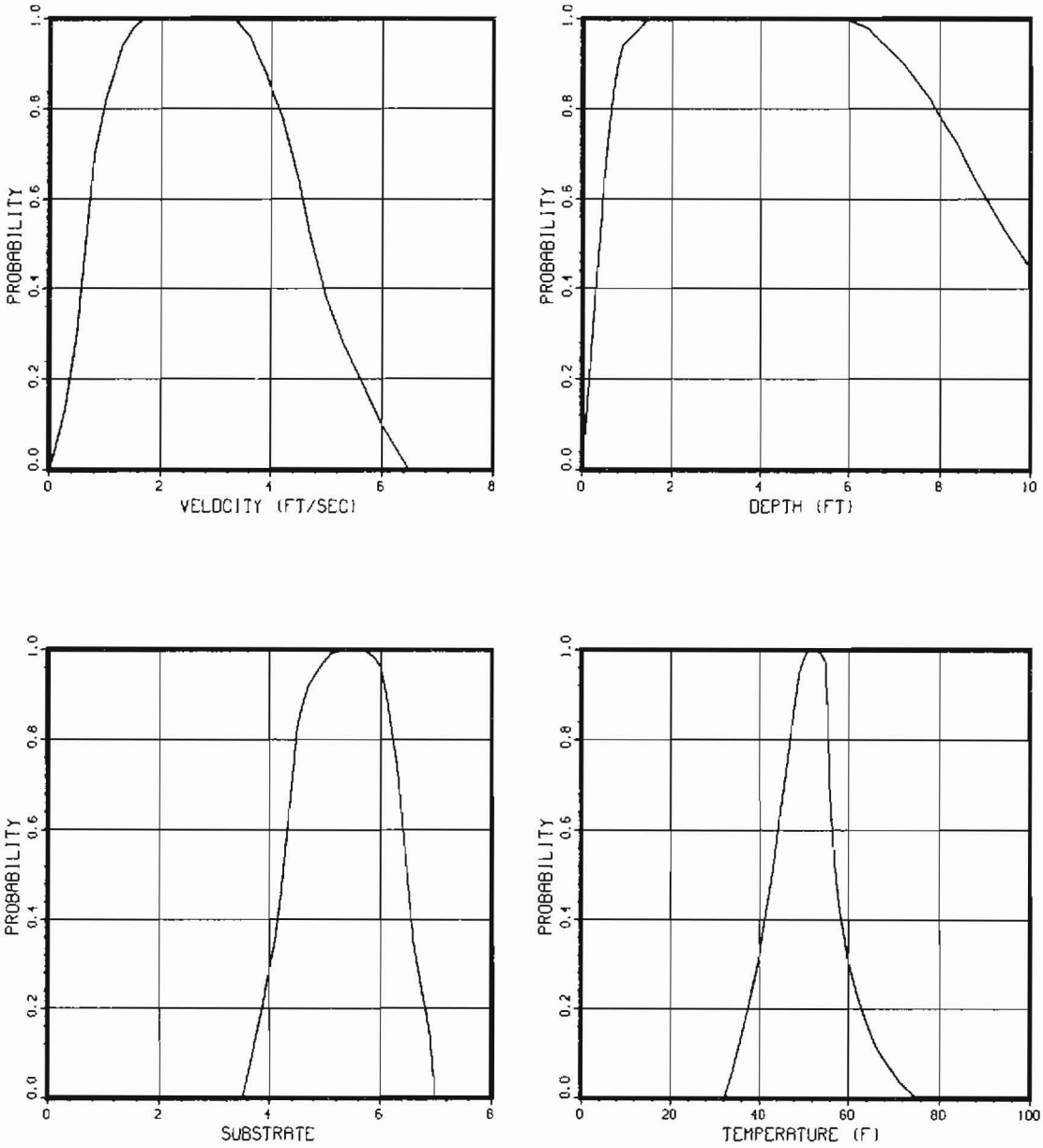
WINTER STEELHEAD

11000 FRY 78/01/24.



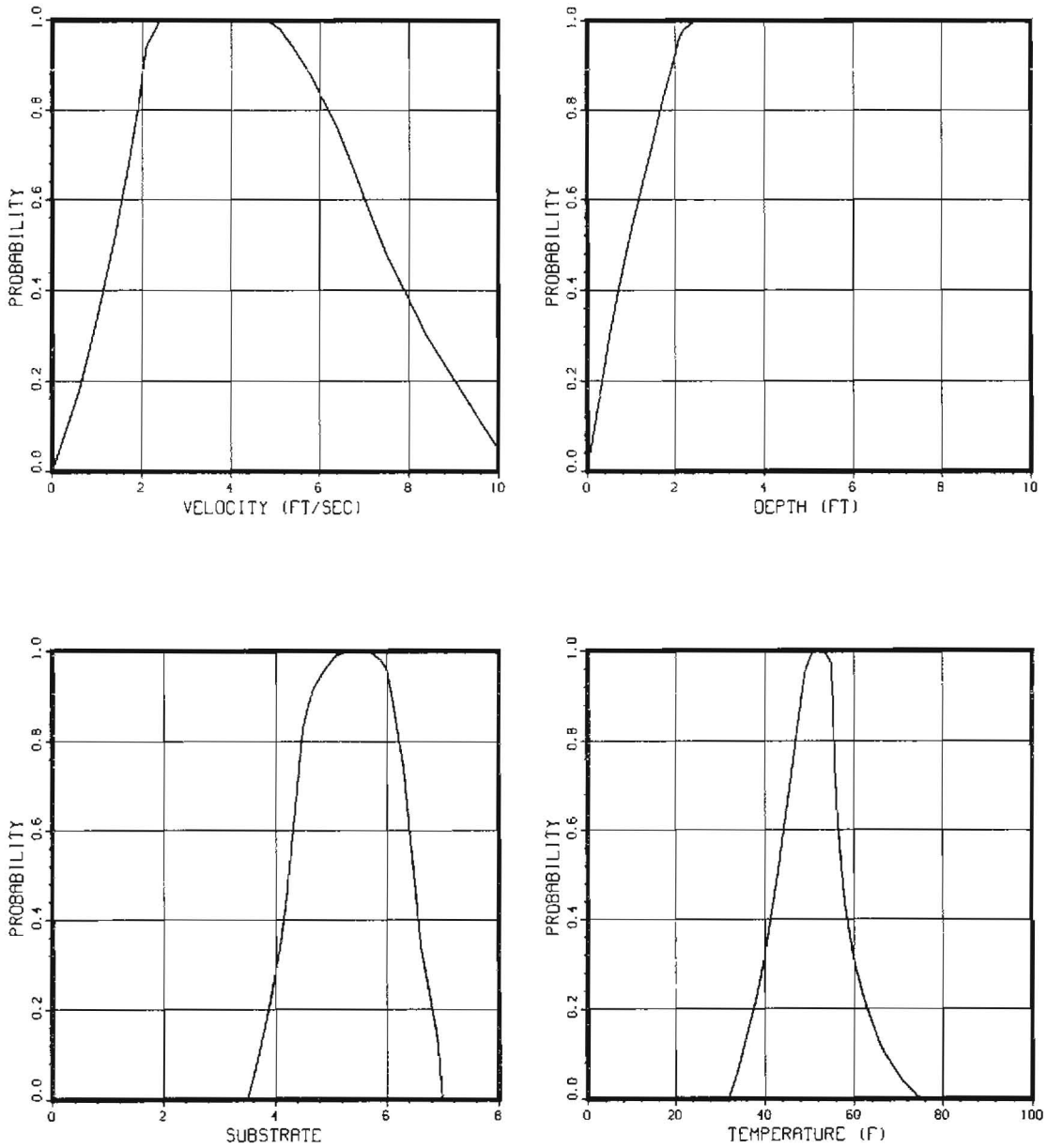
WINTER STEELHEAD (CLEAR WATER, S=.001)

11021 INCUBATION 78/01/24.



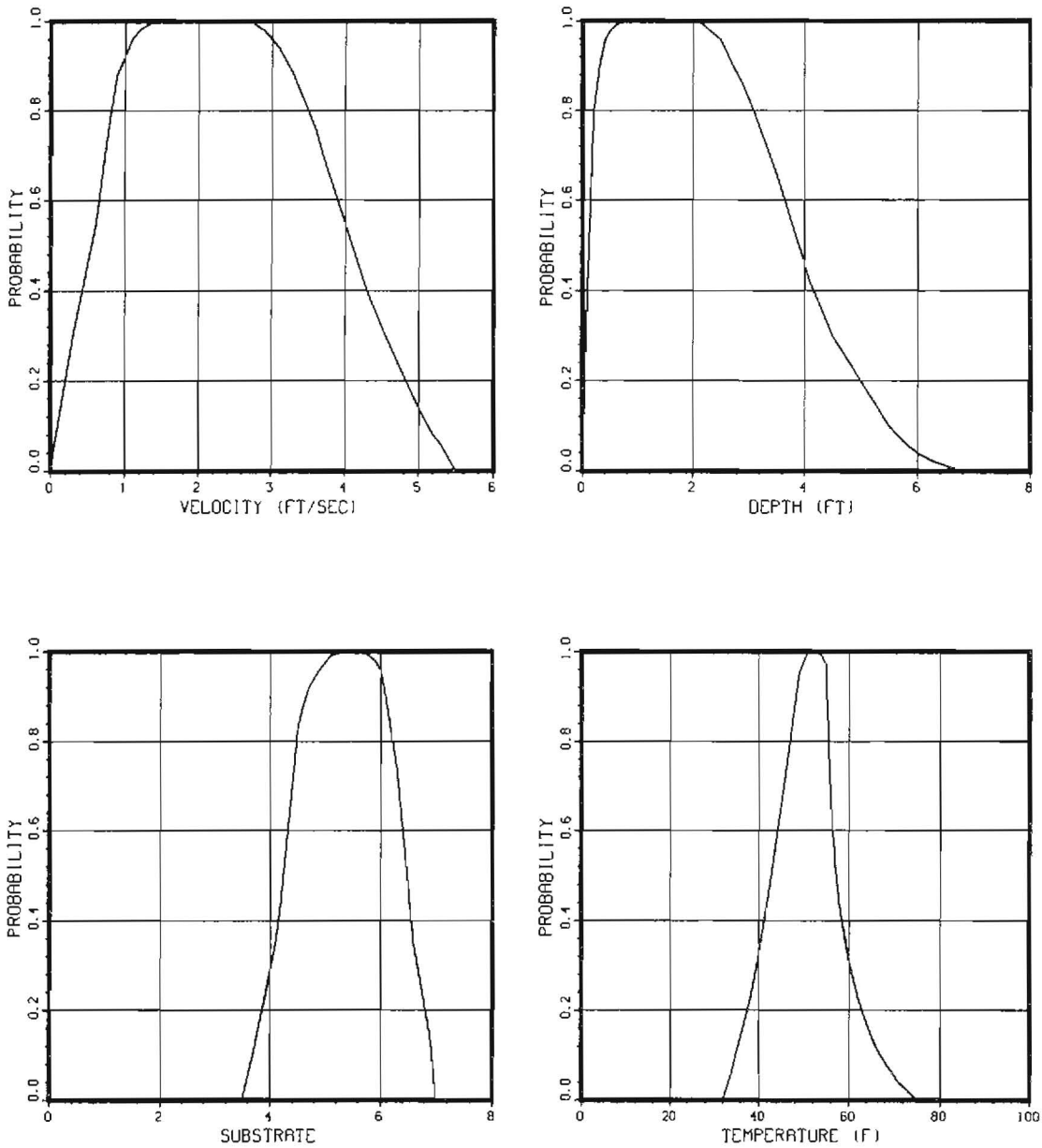
WINTER STEELHEAD (TURBID WATER,S=.001)

11022 INCUBATION 78/01/24.



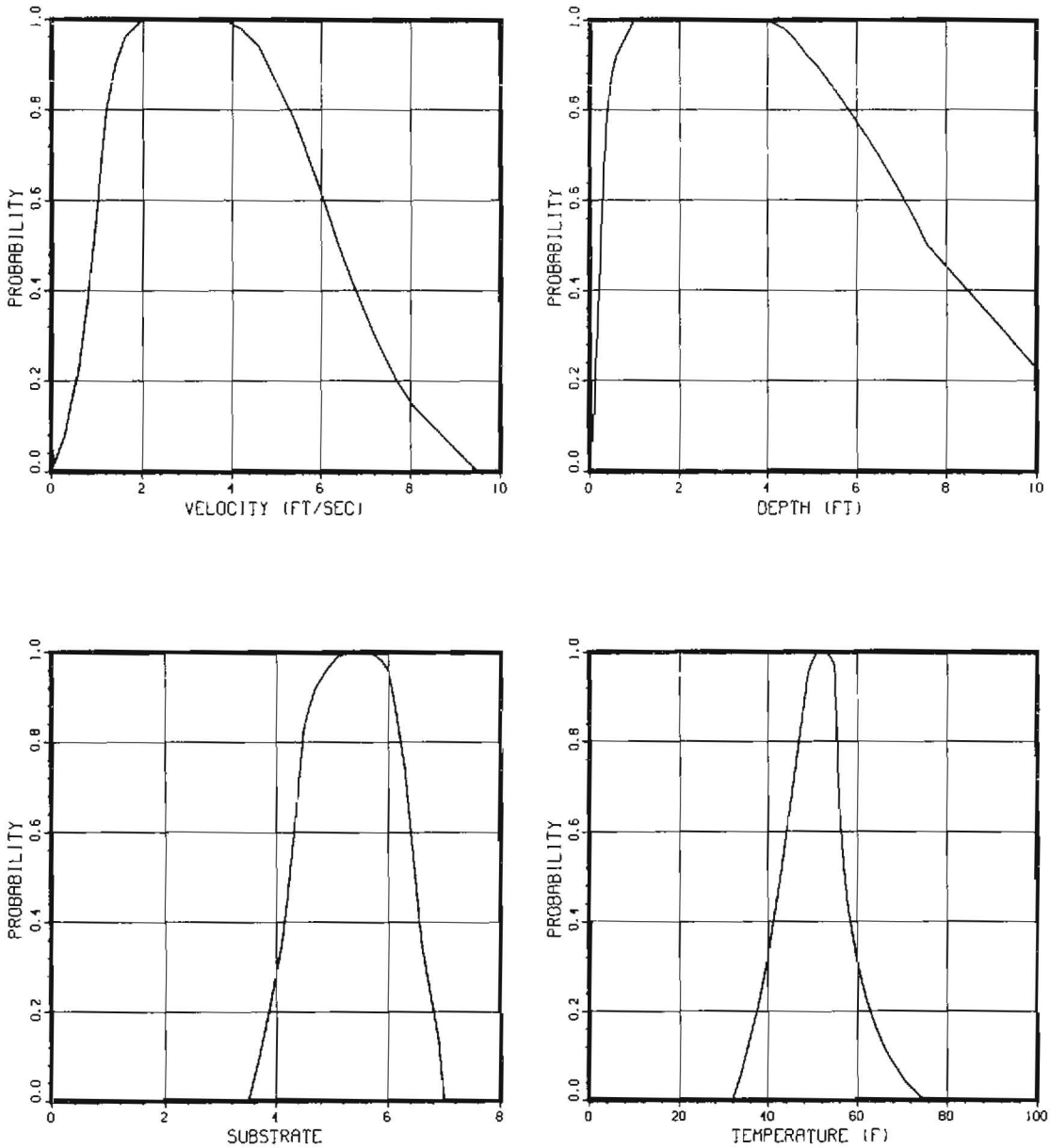
WINTER STEELHEAD (CLEAR WATER, S=.0025)

11023 INCUBATION 78/01/24.



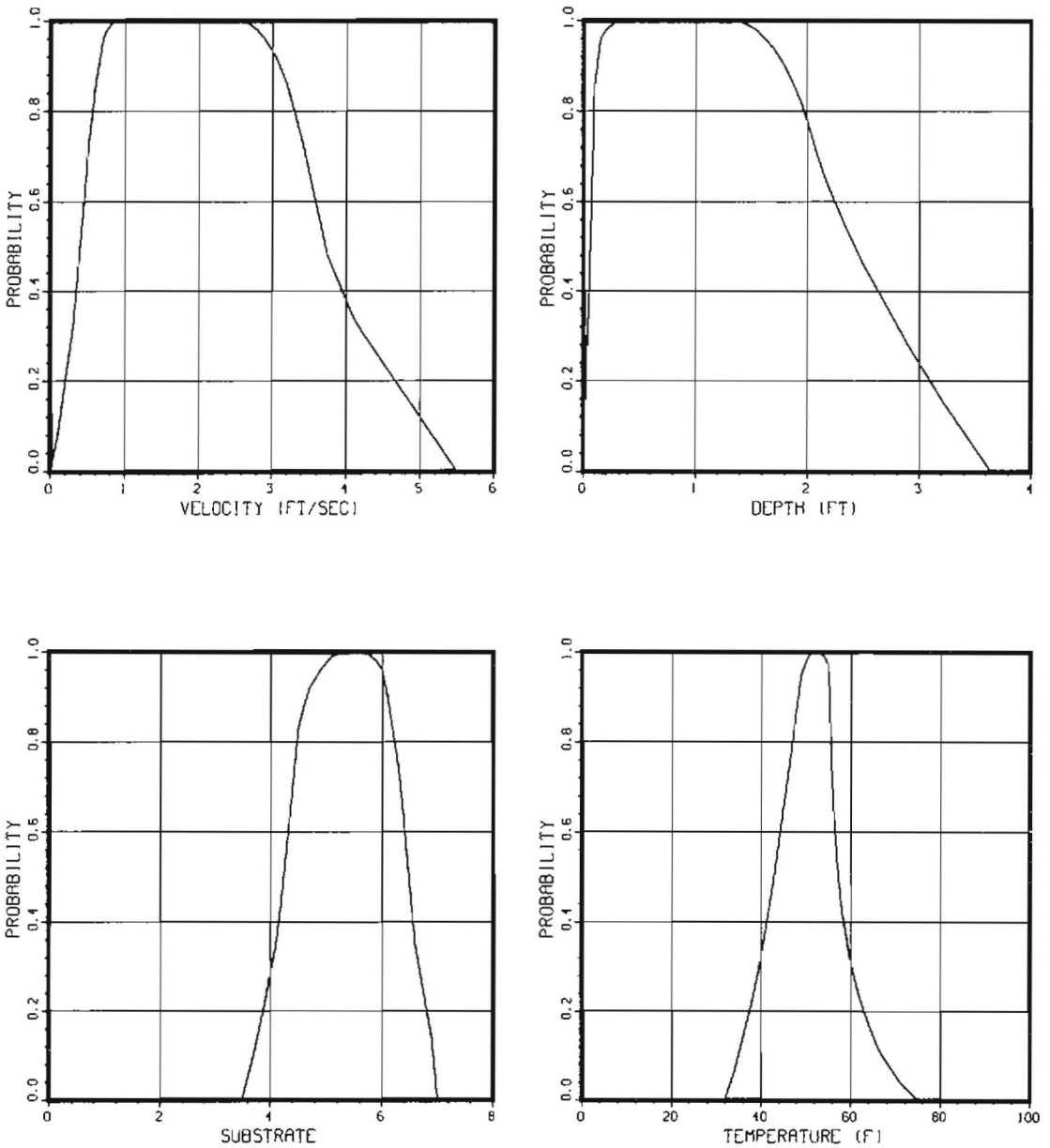
WINTER STEELHEAD (TURBID WATER, S=.0025)

11024 INCUBATION 78/01/24.



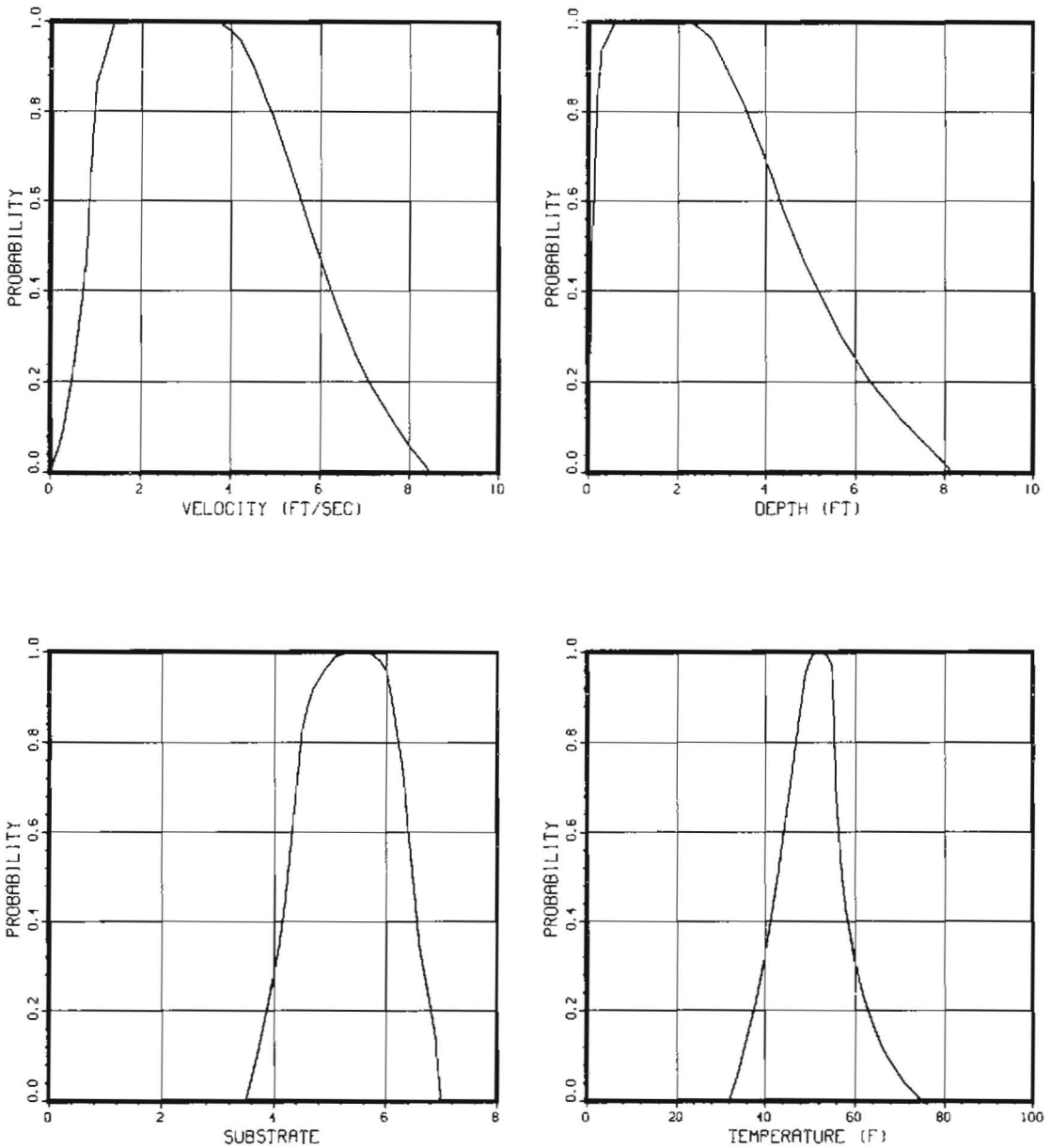
WINTER STEELHEAD (CLEAR WATER, S=.004)

11025 INCUBATION 78/01/24.



WINTER STEELHEAD (TURBID WATER,S=.004)

11026 INCUBATION 78/01/24.



BROWN TROUT

Salmo trutta

Catalog No.	11310 Spawning				11302 Adult				11301 Juvenile				11300 Fry				11321-11326 Egg Incubation			
SPECIES: Brown Trout	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	E	E	G	G	G	G	E	G	F	F	E	G	F	G	G	G	F	F	G	F
REFERENCE	29 FA	29 FA	29 FA	20 RO	12 FA	12 FA	12 FA	2 RO	12 FA	12 FA	12 FA	2 RO	12 FA	12 FA	12 FA	2 RO	9 IN	9 IN	11 IN	2 IN
	33 FA	33 FA	33 FA	31 RO	16 FA	16 FA	16 FA	13 RO	16 FA	16 FA	16 FA	13 RO	16 FA	16 FA	16 FA	8 RO	11 IN	11 IN	29 IN	8 IN
ANALYSIS					3 RO			31 PO				31 PO				13 RP	25 IN	25 IN	36 IN	30 IN
								8 RO				8 RO					36 IN	36 IN		
COMMENTS										1			2							3

Key to IFG Evaluation Matrix

IFG Evaluation:
- E - Excellent
- G - Good
- F - Fair
- R - Reconnaissance Grade

Analysis:
- FA - frequency analysis
- RO - range and optimum
- PO - Parameter overlap
- IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

Comments - Brown Trout Curves

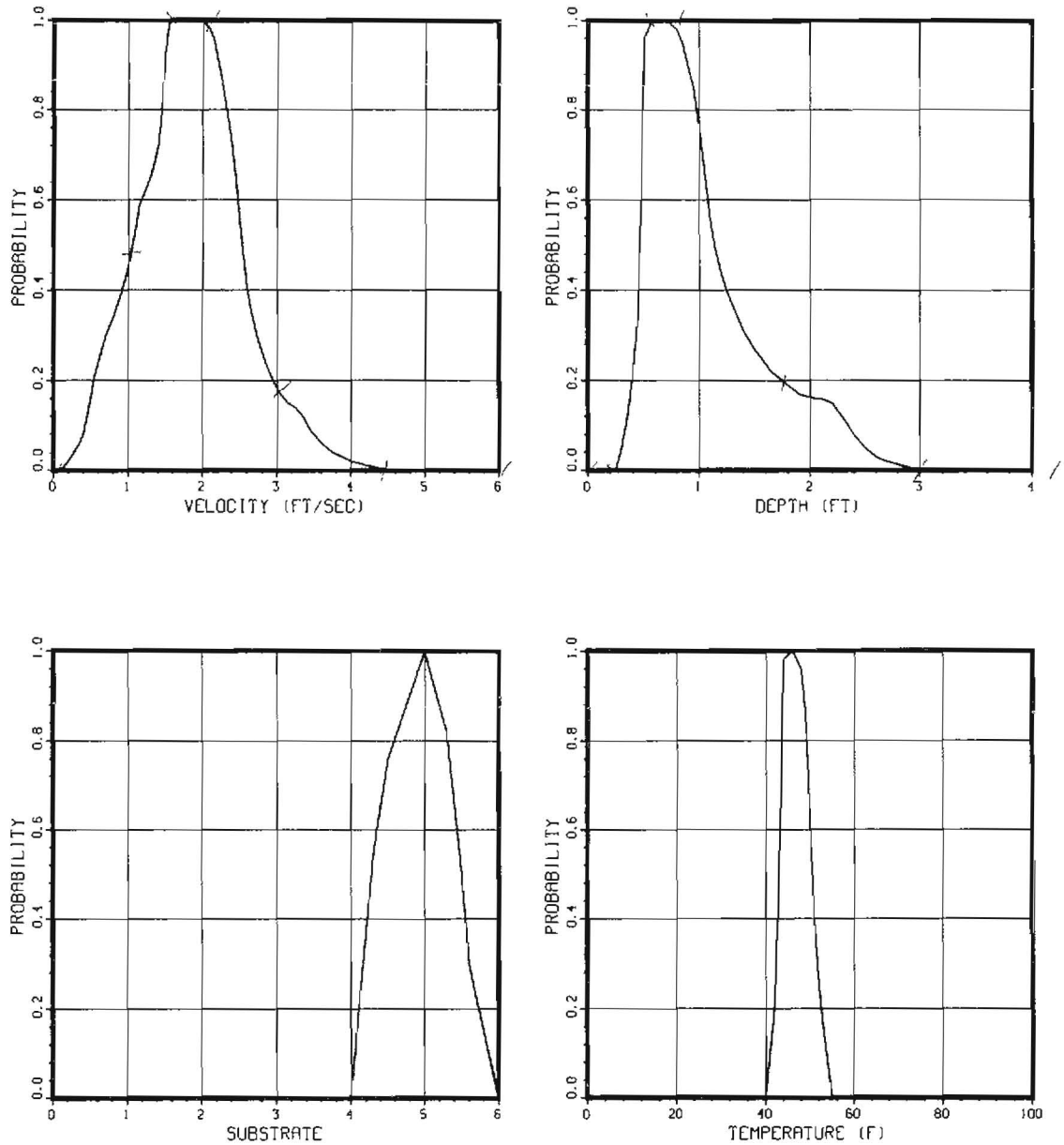
1. The mode for Wesche's data was from .5 to 1.25 feet in depth. Cochnauer's data showed no difference between 1.0 and 3.0 feet. Gosse, et. al., showed a very distinct peak at 2.9 to 3.1 feet. The optimum on this curve incorporates these differences, which may be due to availability of different conditions rather than differential preferences.

2. At the time of year that these collections were made, young of the year brown trout were fairly large. For fry recently emerged from the redds, this curve would be compacted toward the zero velocity axis somewhat.

3. Survival rates were calculated from time-to-hatching data, based on a standard hatching time of 4 to 6 weeks. It was assumed that an extended incubation period would increase the probability of egg mortality. This assumption applies only to the lower temperature limb of the curve.

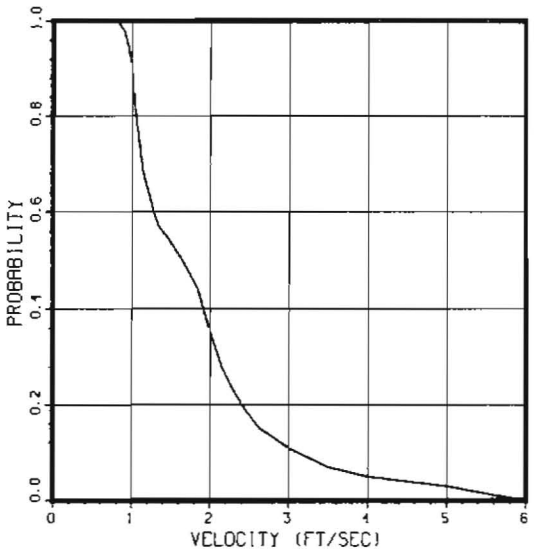
BROWN TROUT

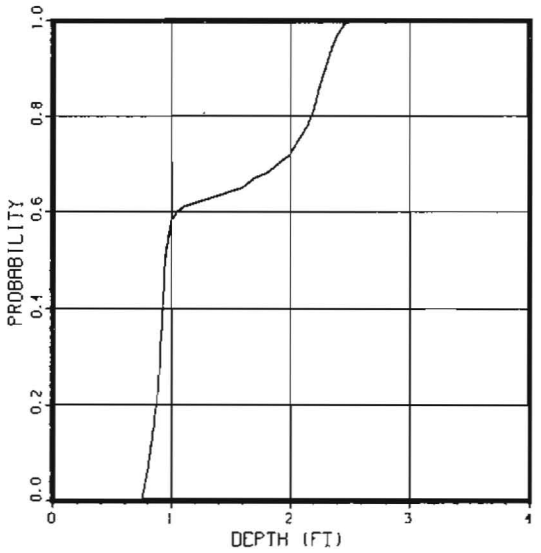
11310 SPAWNING 78/01/24.

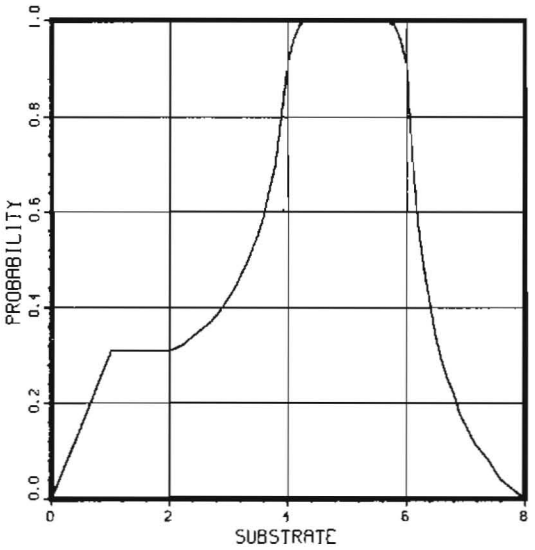


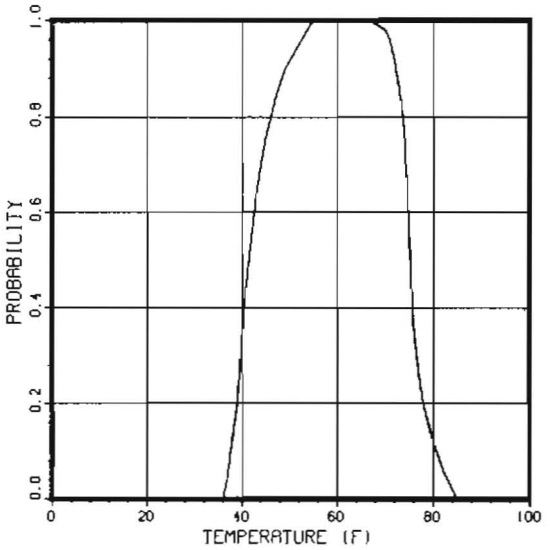
BROWN TROUT

11302 ADULTS 78/01/24.



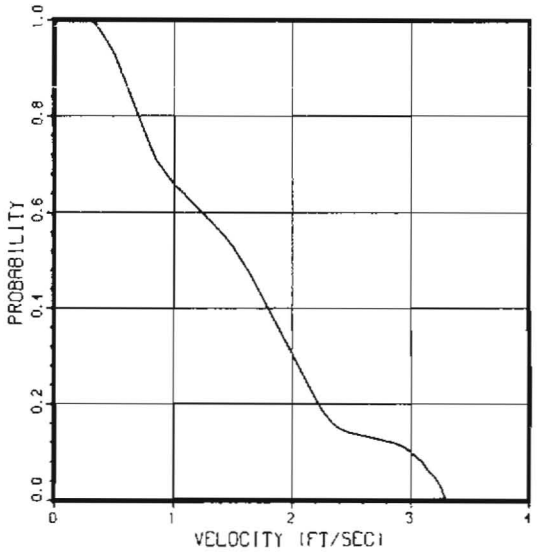


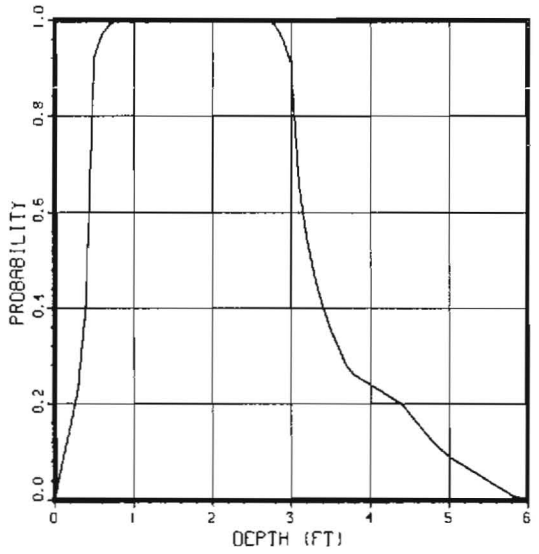


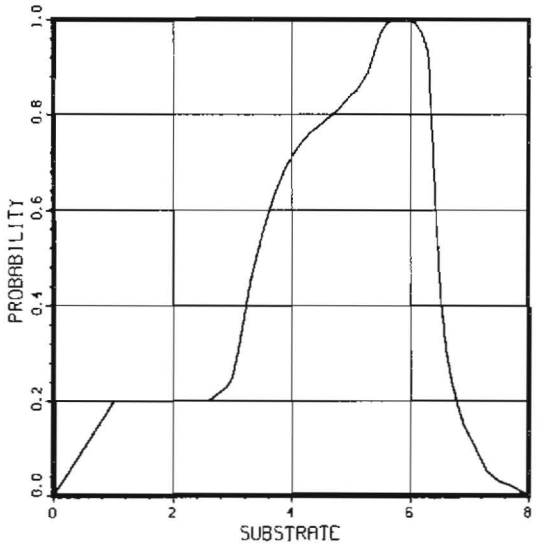


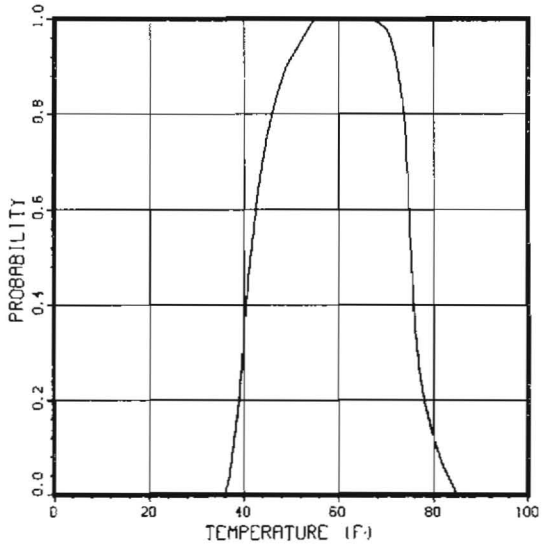
BROWN TROUT

11301 JUVENILE 78/01/24.



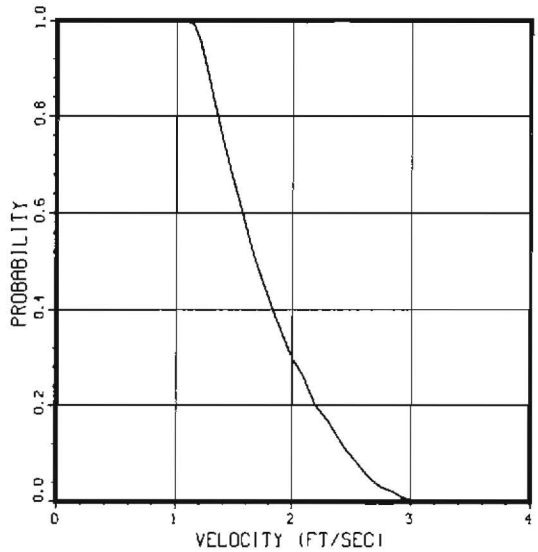


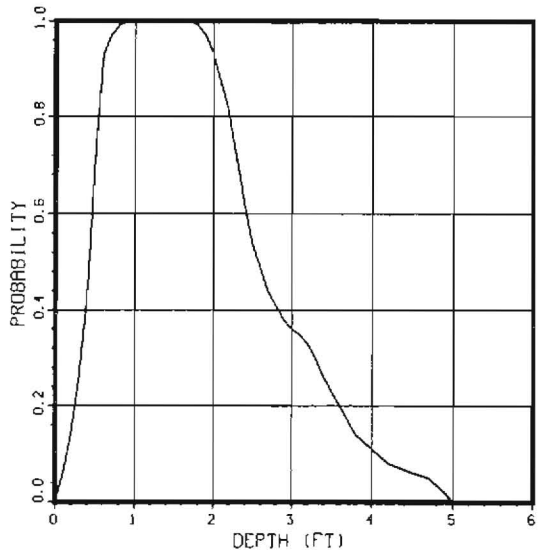


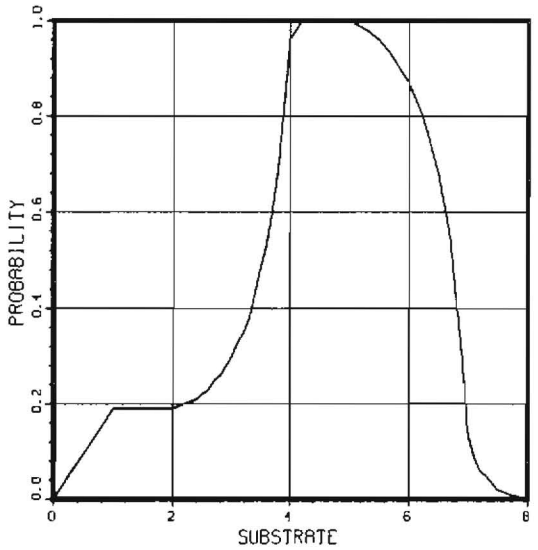


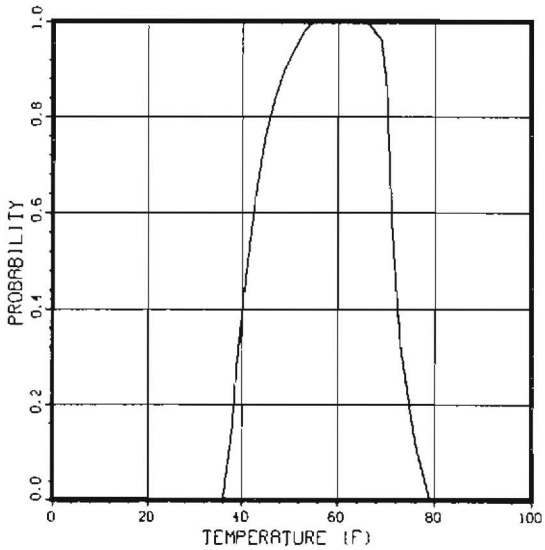
BROWN TROUT

11300 FRY 78/01/24.



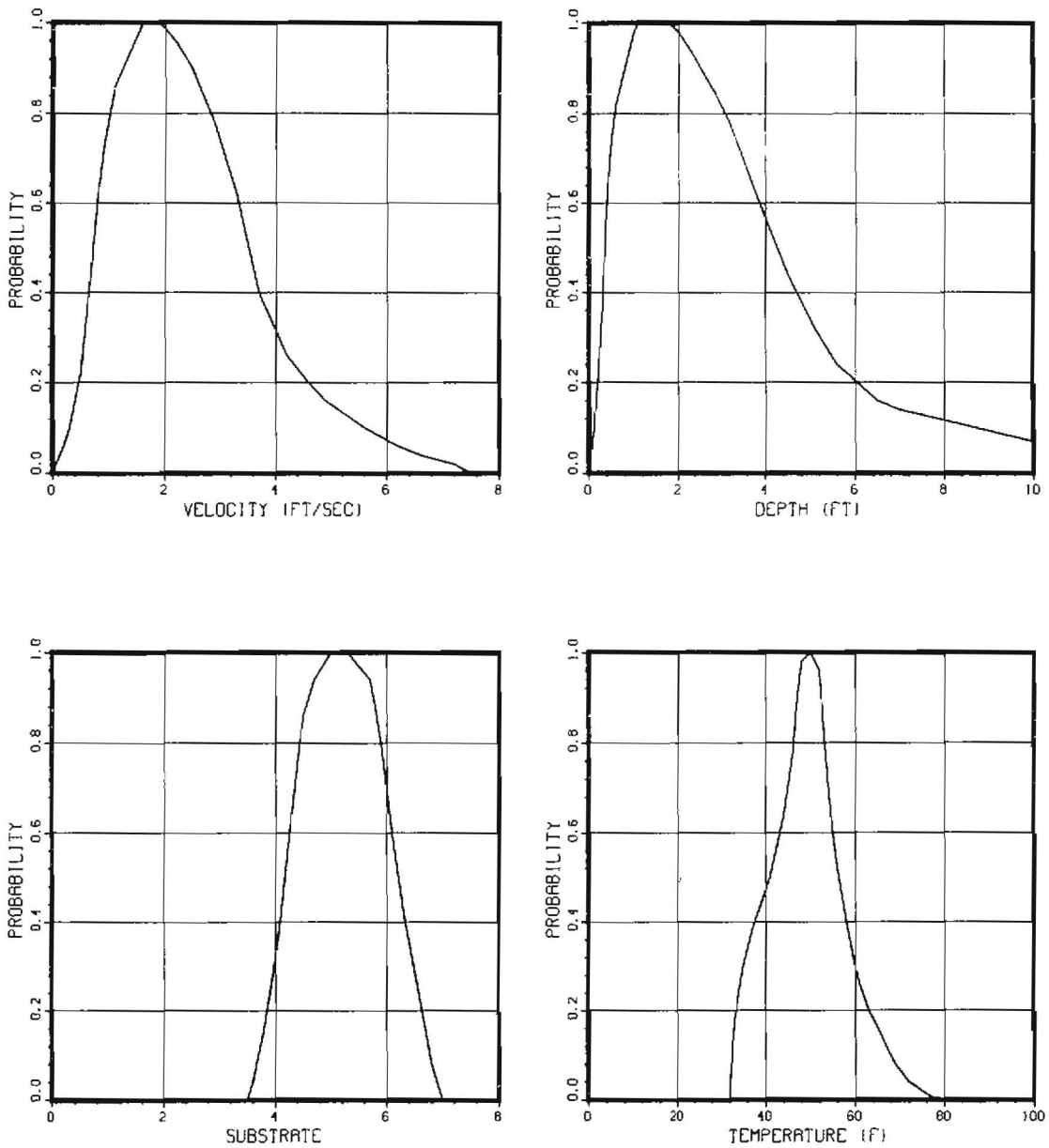






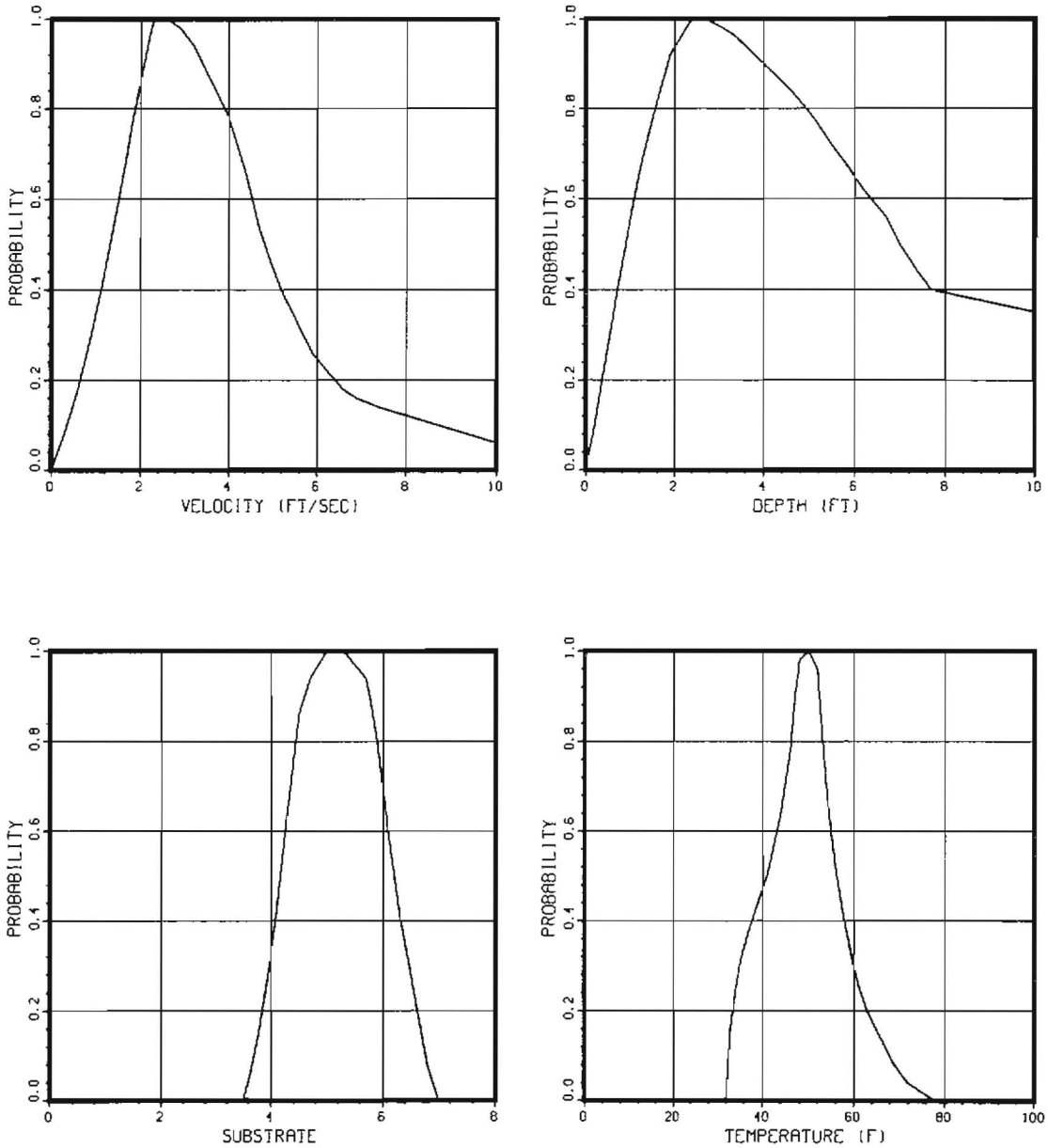
BROWN TROUT (CLEAR WATER, S=.001)

11321 INCUBATION 78/01/24.



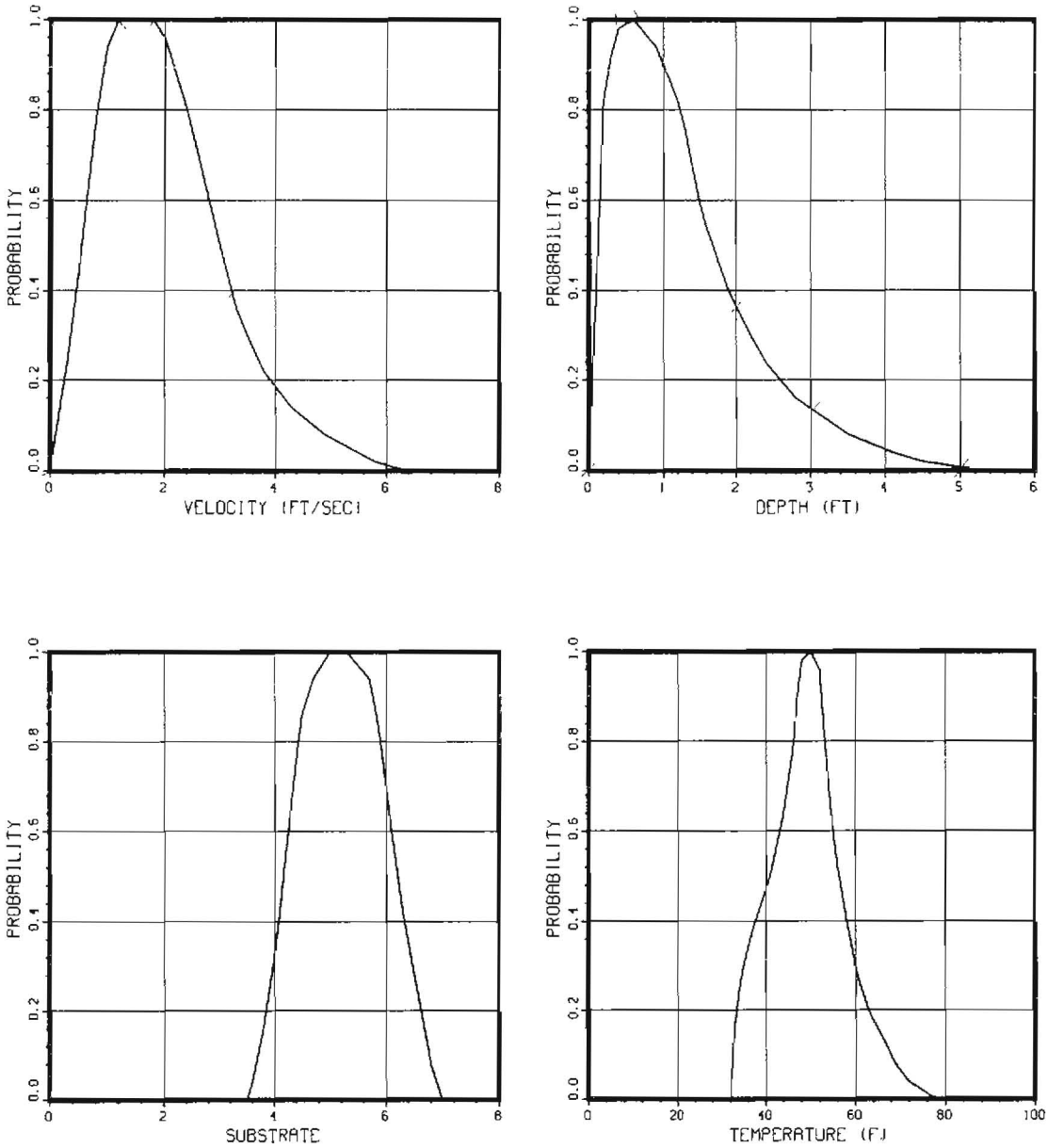
BROWN TROUT (TURBID WATER, S=.001)

11322 INCUBATION 78/01/24.



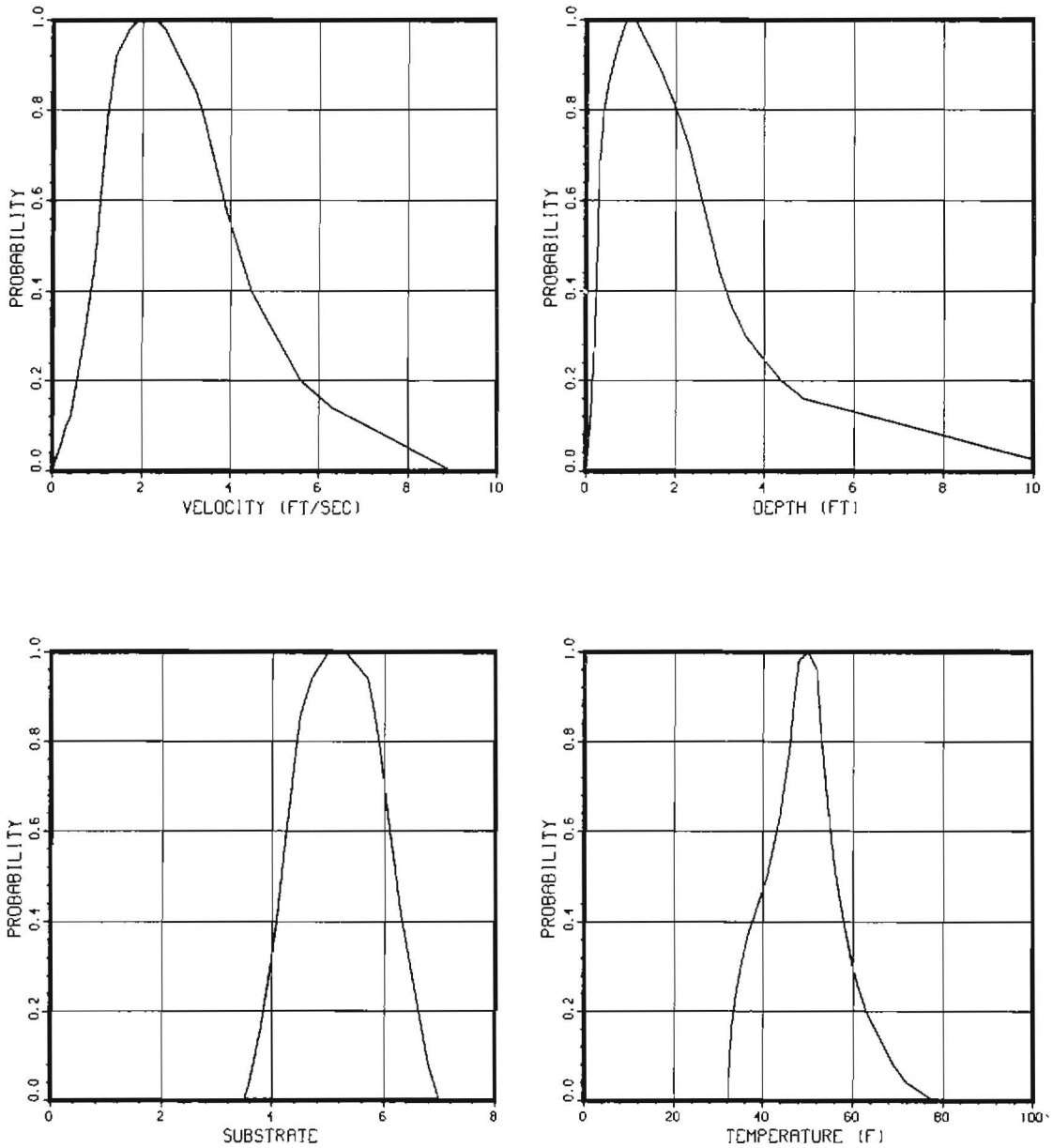
BROWN TROUT (CLEAR WATER, S=.0025)

11323 INCUBATION 78/01/24.



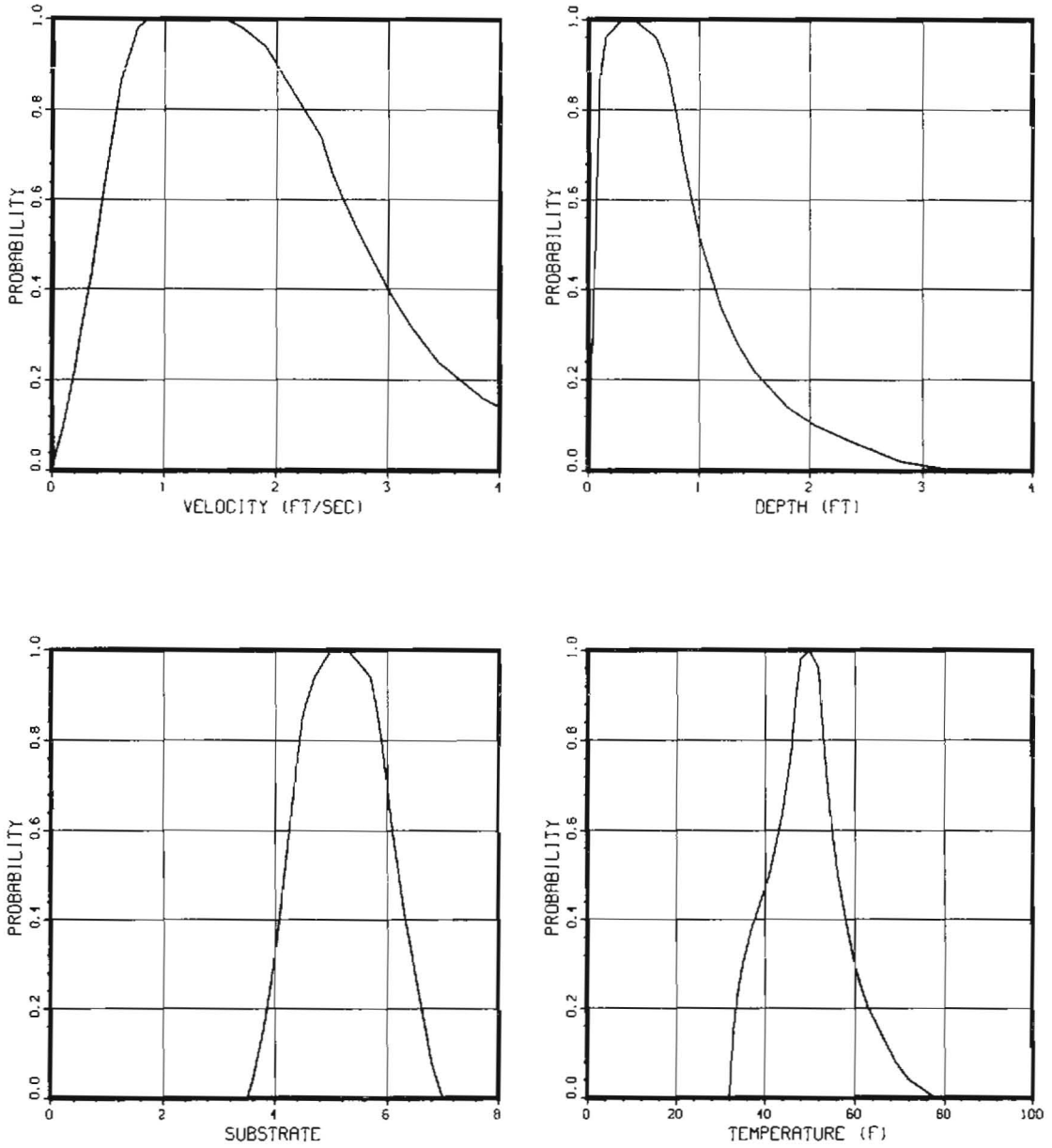
BROWN TROUT (TURBID WATER, S=.0025)

11324 INCUBATION 78/01/24.



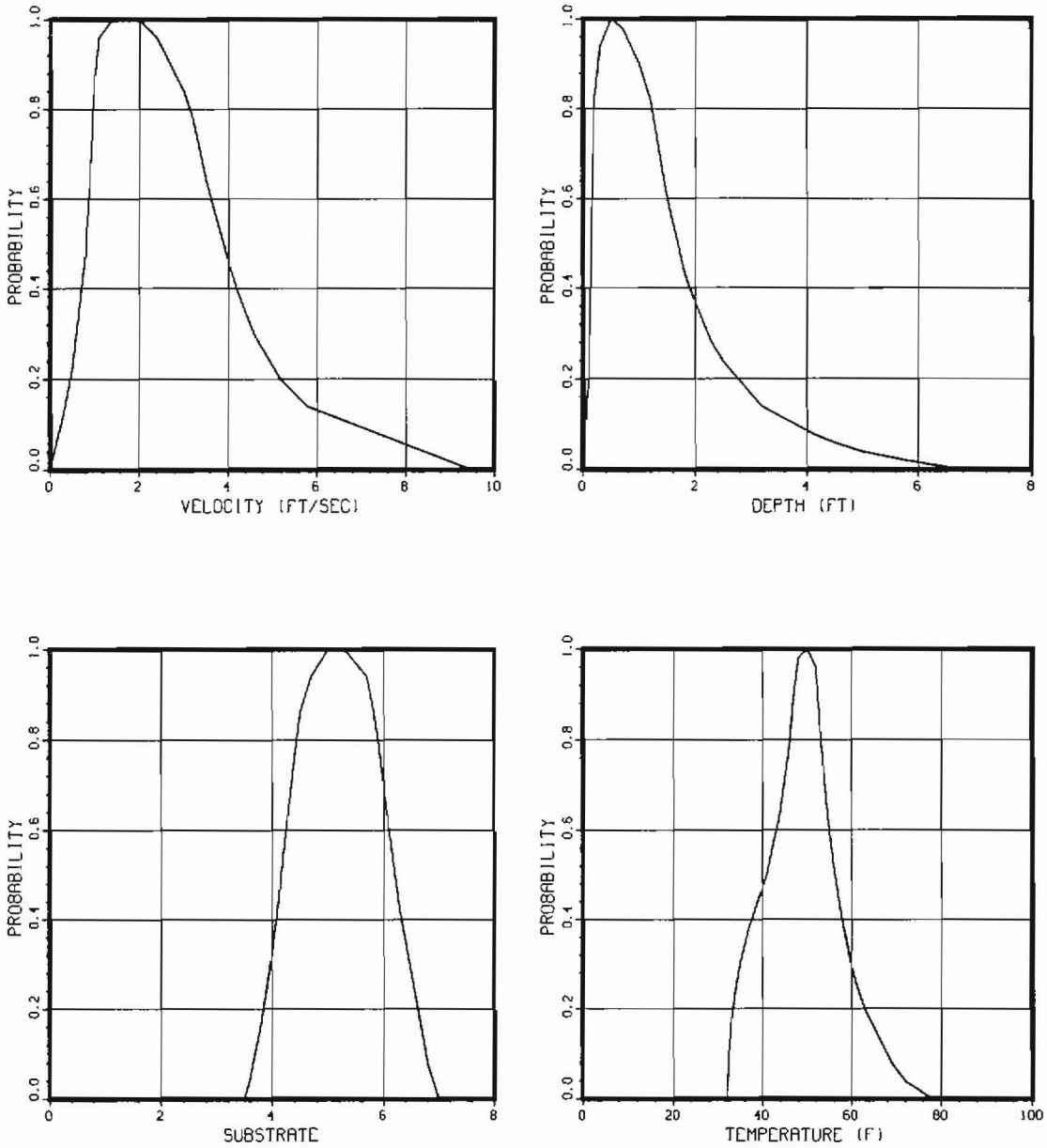
BROWN TROUT (CLEAR WATER, S=.004)

11325 INCUBATION 78/01/24.



BROWN TROUT (TURBID WATER, S=.004)

11326 INCUBATION 78/01/24.



BROOK TROUT

Salvelinus fontinalis

Catalog No.	011410				011402															
	Spawning				Adult				Juvenile				Fry				Egg Incubation			
SPECIES: Brook Trout	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	G	G	G	F	R	R	R	F												
REFERENCE	22 FA	22 FA	20 RO	12 RO	12 FA	12 FA	12 RO	2 RO												
	29 FA	29 FA	22 RO	22 RO	35 FA	35 FA		22 RO												
ANALYSIS			29 FA																	
COMMENTS	1	1			2	2														

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

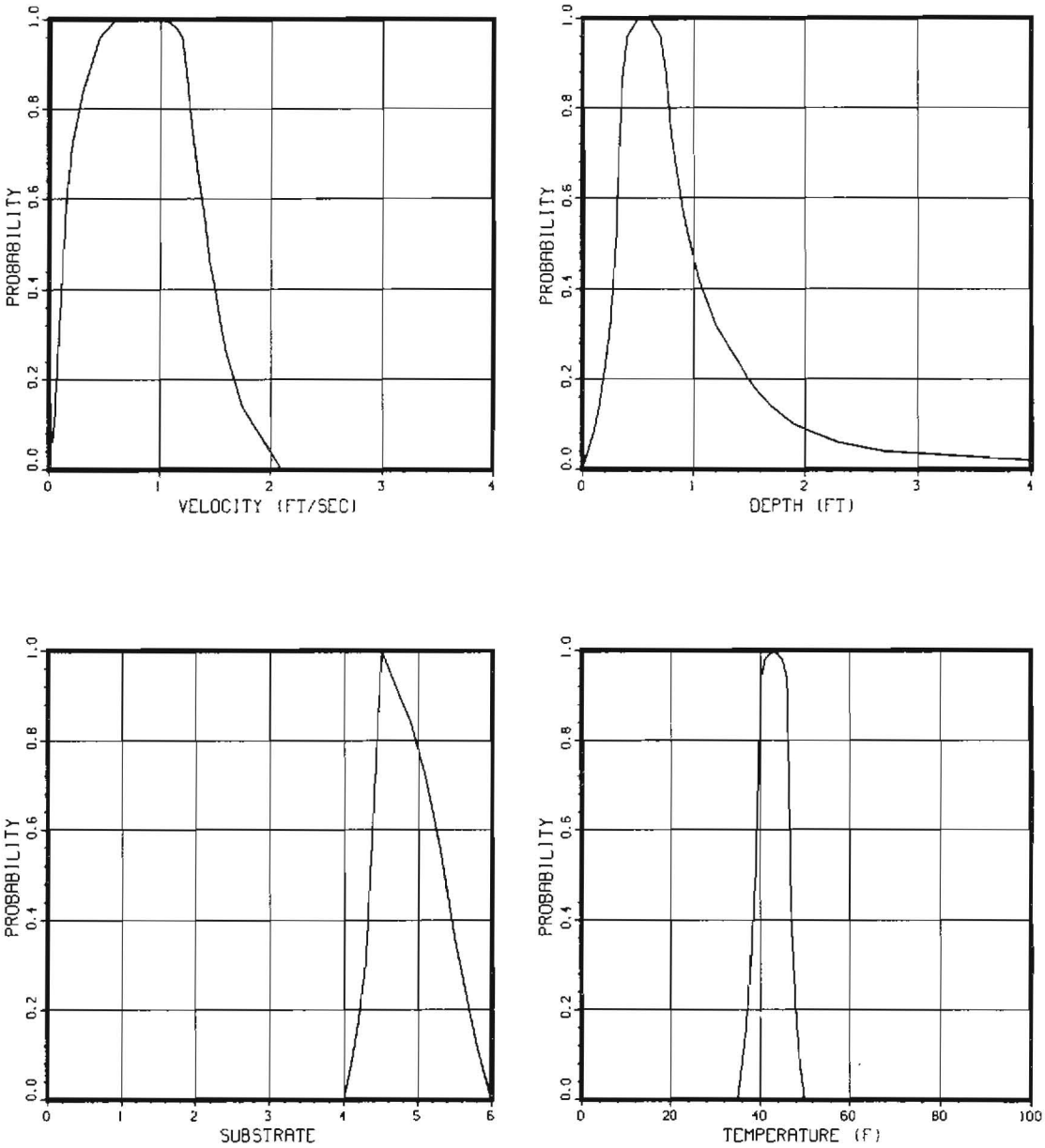
Comments - Brook Trout Curves

1. Data from Reiser & Wesche (1977) were taken in small streams for 7 to 9" brook trout. Hunter's (1973) data came from a wider range of conditions and was given double weighting in the frequency analysis. These curves represent a composite of large and small spawners and would be skewed to the left for small spawners alone.

2. The depths and velocities in Stewart's study were measured the year prior to his population sampling. Therefore, there is no way of knowing that the flow conditions measured were those actually inhabited by the fish.

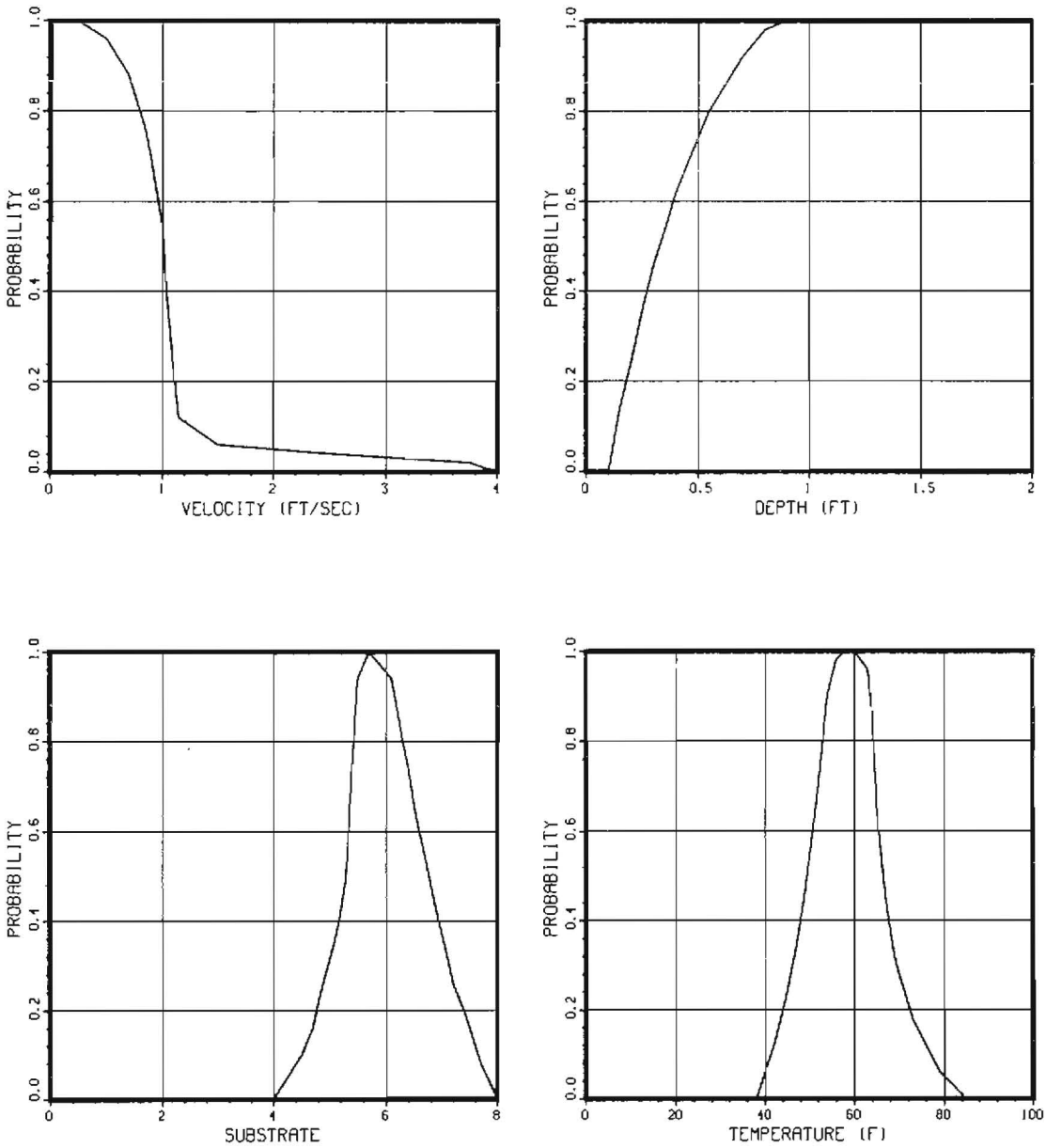
BROOK TROUT

11410 SPAWNING 78/01/24.



BROOK TROUT

11402 ADULT 78/01/24.



MOUNTAIN WHITEFISH

Prosopium williamsoni

Catalog No.	12010 Spawning				12002 Adult				12001 Juvenile				12000 Fry				Egg Incubation			
SPECIES: Mountain Whitefish	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature	Velocity	Depth	Substrate	Temperature
IFG EVALUATION	F	F	F	F	G	E	G	F	G	G	E	F	G	G	G	F				
REFERENCE	33 FA	6 RO	6 RO	6 RO	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA	12 FA				
	34 RO	33 FA	33 FA		16 FA	16 FA	16 FA	26 PO	16 FA	16 FA	16 FA	26 PO	16 FA	16 FA	16 FA	26 PO				
		34 RO	34 RO			6 RO		31 PO				31 PO				31 PO				
ANALYSIS																				
COMMENTS						1														

Key to IFG Evaluation Matrix

IFG Evaluation: E - Excellent
G - Good
F - Fair
R - Reconnaissance Grade

Analysis: FA - frequency analysis
RO - range and optimum
PO - Parameter overlap
IN - indirect analysis

Reference: Refer to listed number in bibliography.

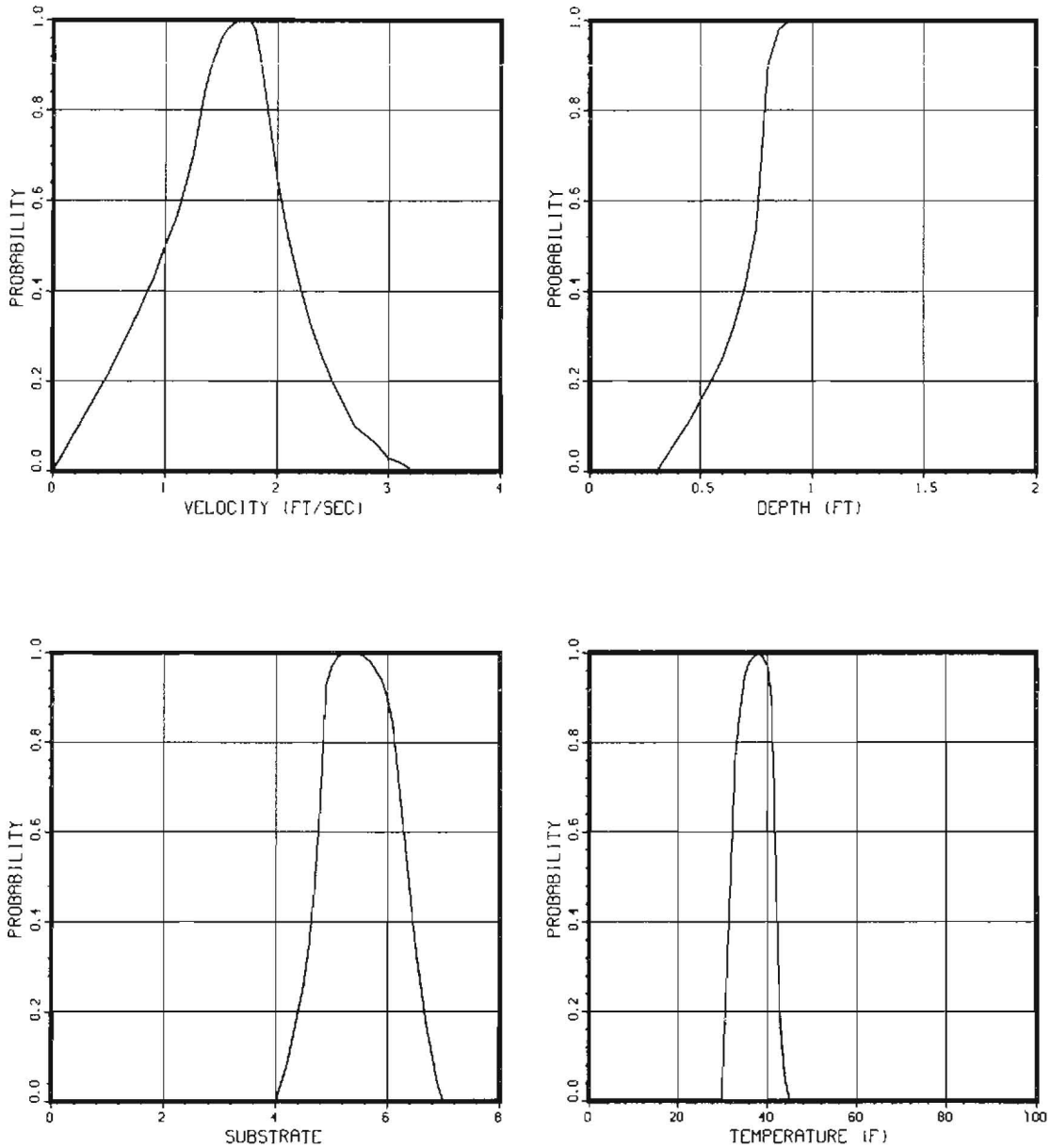
Comments: Refer to listed number on comment sheet (following IFG Evaluation Matrix).

Comments - Mountain Whitefish

1. Despite the large sample size, the optimum could not be tested beyond 2.5 ft in depth due (probably) to lack of habitat in the greater depth ranges. Optimum line continued by observations from Brown (1952).

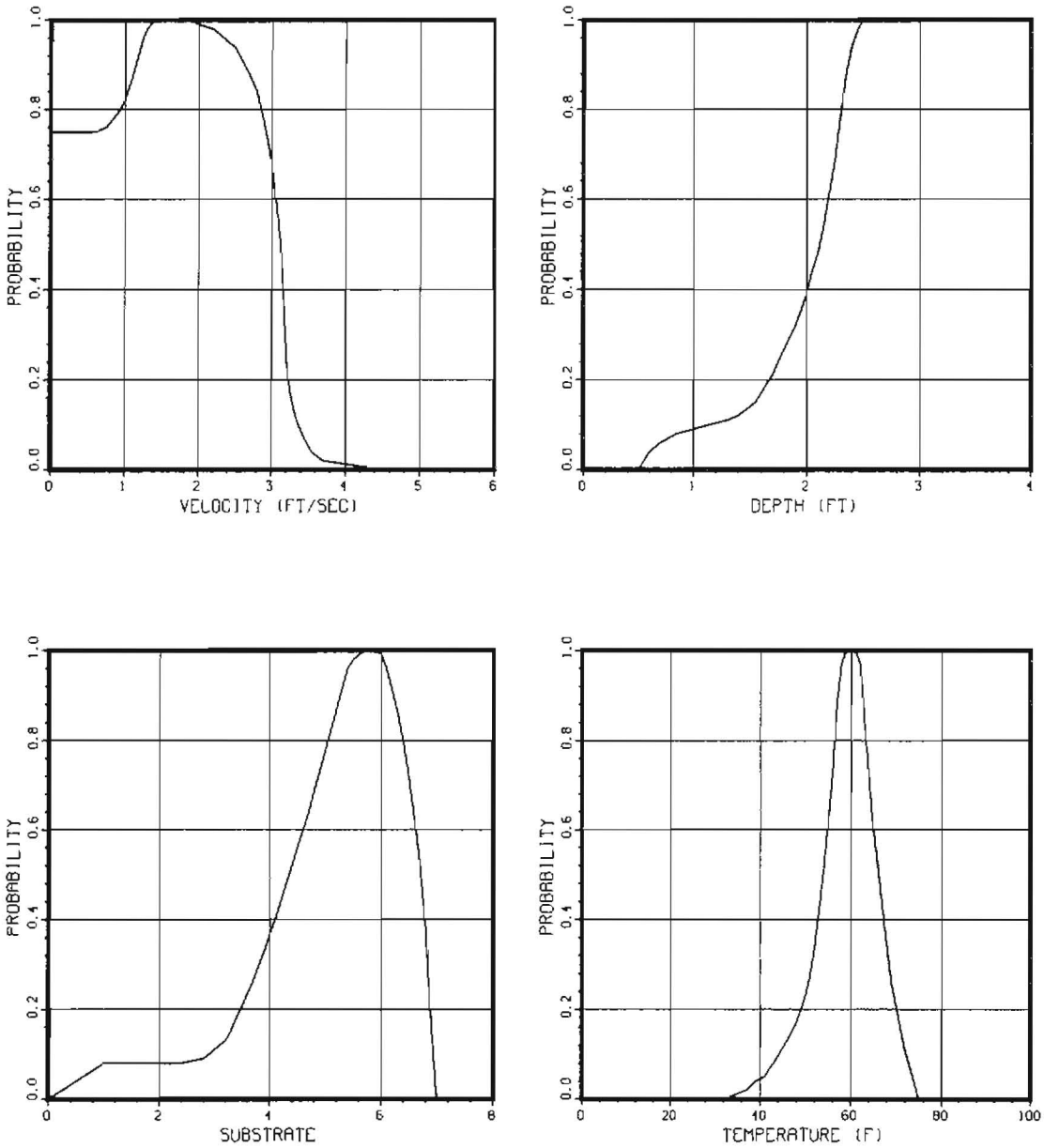
MOUNTAIN WHITEFISH

12010 SPAWNING 78/01/24.



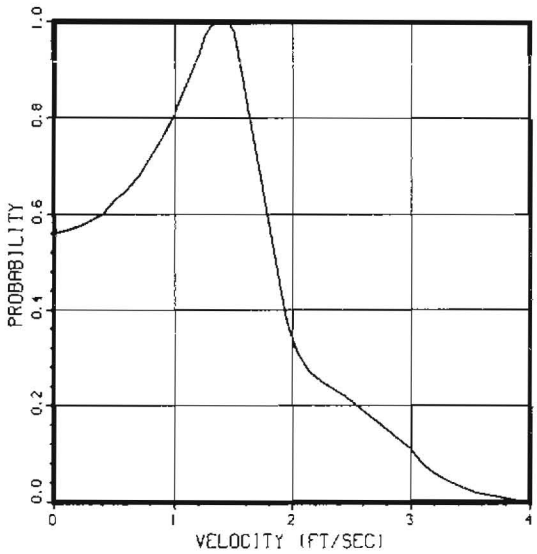
MOUNTAIN WHITEFISH

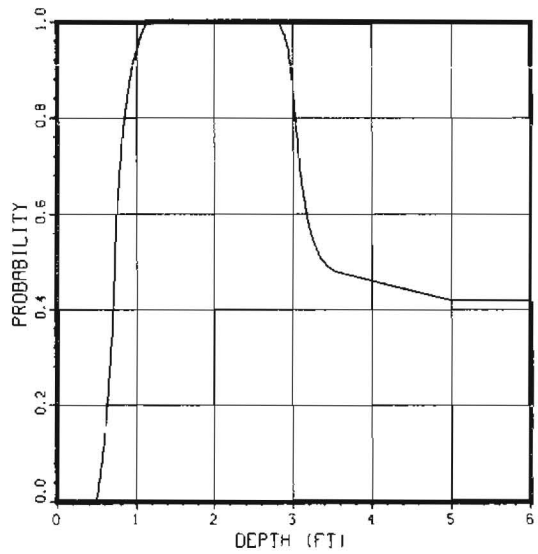
12002 ADULT 78/01/24.

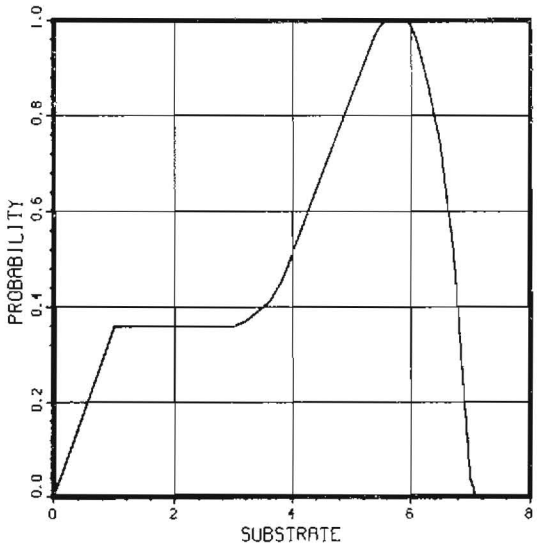


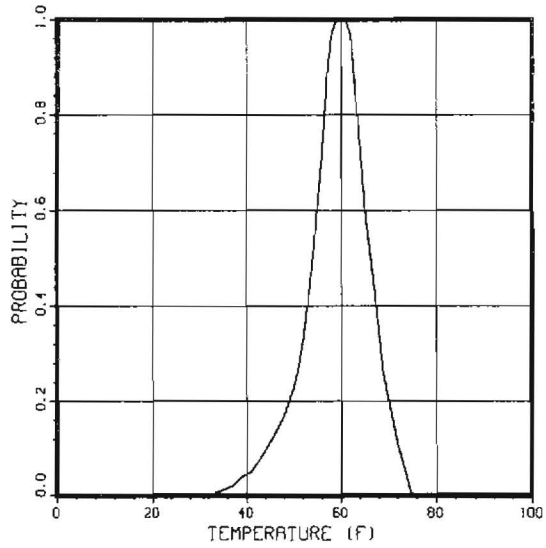
MOUNTAIN WHITEFISH

12001 JUVENILE 78/01/24.









MOUNTAIN WHITEFISH

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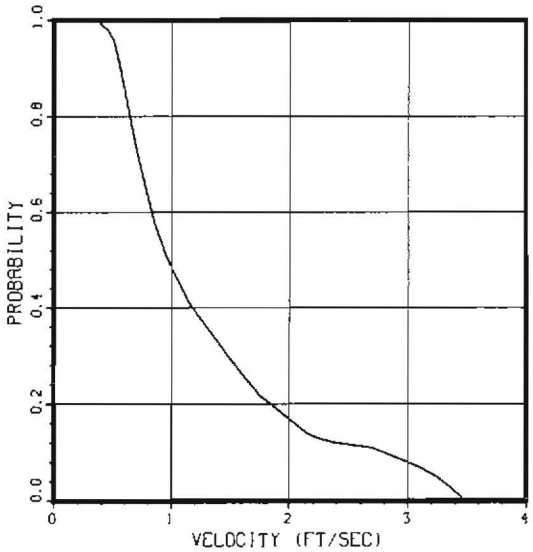

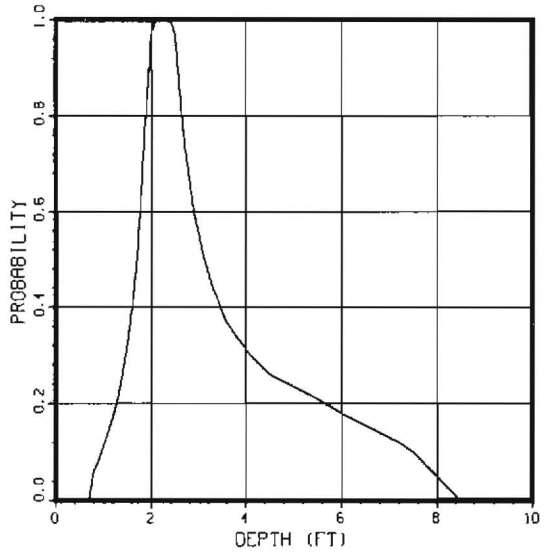

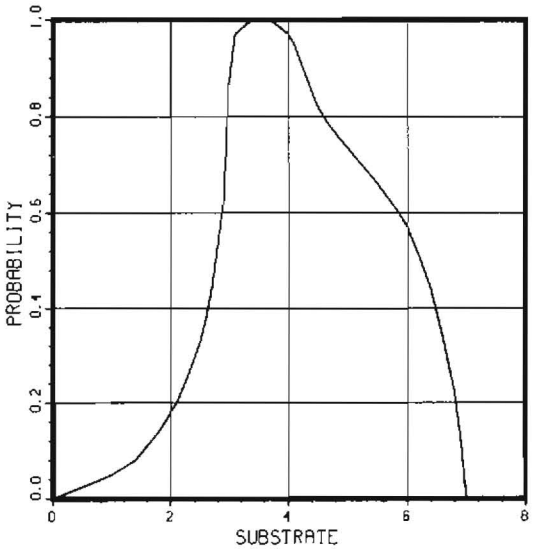

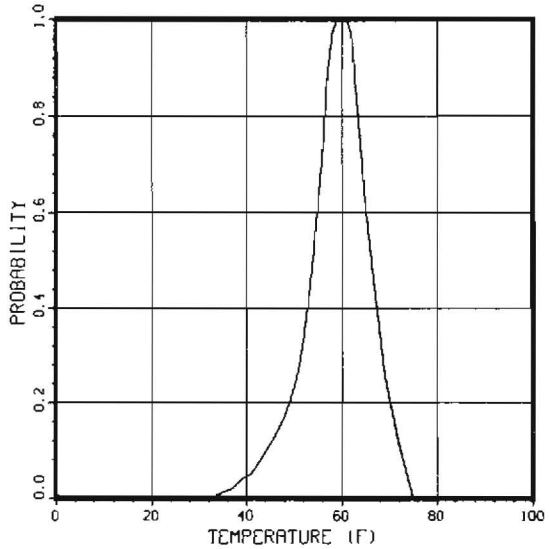

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INSTREAM FLOW INFORMATION PAPERS ISSUED

1. Lamb, Berton Lee, Editor. Guidelines for Preparing Expert Testimony in Water Management Decisions Related to Instream Flow Issues. Fort Collins, Colorado, Cooperative Instream Flow Service Group, July 1977, 30 pages. (NTIS Accession Number: PB 268 597; Library of Congress Catalog Card No. 77-83281).

2. Lamb, Berton Lee, Editor. Protecting Instream Flows Under Western Water Law: Selected Papers. Fort Collins, Colorado, Cooperative Instream Flow Service Group, September 1977, 60 pages. (NTIS Accession Number: PB 272 993; Library of Congress Catalog Card No. 77-15286).

3. Bovee, Ken D., and Cochnauer, Tim. Development and Evaluation of Weighted Criteria , Probability-of-Use Curves for Instream Flow Assessments; Fisheries. Fort Collins, Colorado, Cooperative Instream Flow Service Group, December 1977, 49 pages. (NTIS Accession Number: PB ; Library of Congress Catalog Card No. -).

4. Bovee, Ken D. Probability-of-Use Criteria for the Family Salmonidae. Fort Collins, Colorado, Cooperative Instream Flow Service Group, January 1978, 88 pages. (NTIS Accession Number: PB : Library of Congress Catalog Card No. -).

BIBLIOGRAPHIC DATA SHEET	1. Report No. FWS/OBS-78/07	2.	3. Recipient's Accession No.

4. Title and Subtitle

Probability-of-Use Criteria for the Family Salmonidae

5. Report Date

January 1978

6.

7. Author(s)

Ken D. Bovee

8. Performing Organization Rept. No. IFIP-4

9. Performing Organization Name and Address

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

Cooperative Instream Flow Service Group; Western Energy and Land Use Team; Office of Biological Services; Rm. 206, Federal Bldg., 301 S. Howes St., Fort Collins, Colorado 80521

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

The report gives the probability-of-use criteria for the hydraulic parameters of depth, velocity, substrate and temperature for the family Salmonidae. It is intended as a companion document to Instream Flow Information Paper No. 3, "Development and Evaluation of Weighted Criteria, Probability-of-Use Curves for Instream Flow Assessments: Fisheries," which describes the techniques used to construct and criteria used to evaluate each set.

17. Key Words and Document Analysis. 17a. Descriptors

probability curves
weighted criteria
data collection
stream hydraulics
Salmonidae

17b. Identifiers/Open-Ended Terms

Cooperative Instream Flow Service Group

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	UNCLASSIFIED	90
	20. Security Class (This Page) UNCLASSIFIED	22. Price

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2. To gather, analyze, and present information that will aid decisionmakers in the identification and resolution of problems associated with major land and water use changes.

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