Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Pragmatic use of the trout habitat score

Using the trout habitat score in forecasting parr habitat suitability

Retrout workshop, 26-28 June 2018, in Klaipeda, Lithuania

Katarina Magnusson, SLU

Content

1. **Background**
2. **Trout habitat score (THS) – additive model**
3. **How to measure and calculate THS**
4. **Recruitment status and trend analysis**
5. **Work in progress, model development**
6. **Field protocol**

Trout habitat score THS - Background

A tool to estimate habitat suitability for trout at electrofishing sites

- Developed by ICES SGBALANST (Pedersen & Degerman, 2011)

Number of young salmonids in a given area of streambed, related to:

- **number of spawners**
- **survival of offspring, which depend on habitat quality**

Monitoring of parr density from electrofishing available from many countries across the Baltic, together with habitat variables

- Using already collected data, for low cost and time-series of data

- Electrofishing survey densities can be compared between sites

Example, data in Sweden

-ca 800 streams along the coast with sea-run brown trout

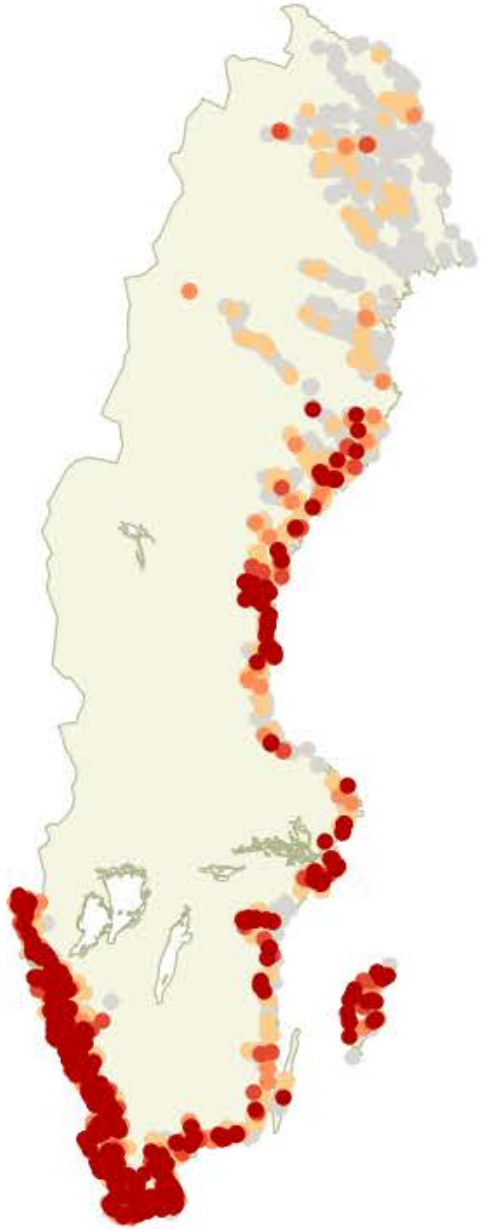
-extremely few with data on smolt production and age

-scattered data on sea survival of wild trout

-But data available on recruitment from many streams

Electrofishing and habitat quality

Salmon is in focus for sampling programmes



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Trout habitat score, THS

Additive model:

THS = width + depth + slope + shade + substrate + velocity

Scores = 0, 1, 2

Max = 12

THS = 0 (poor)

THS = 12 (best)

(Pedersen, Degerman, Debowski, and Peteriet, 2017)

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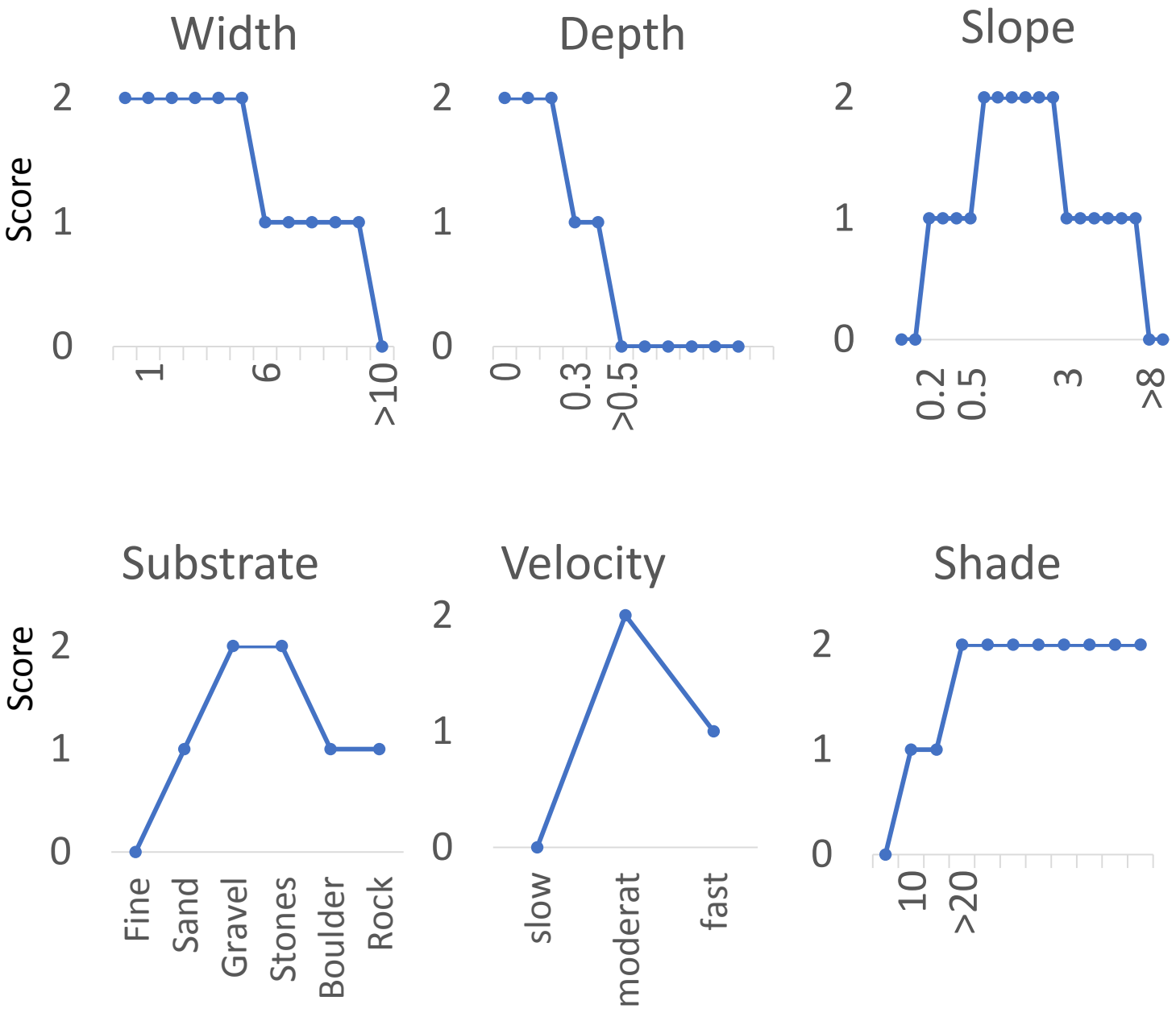
THS = width + depth + slope + shade + substrate + velocity (Max = 12)

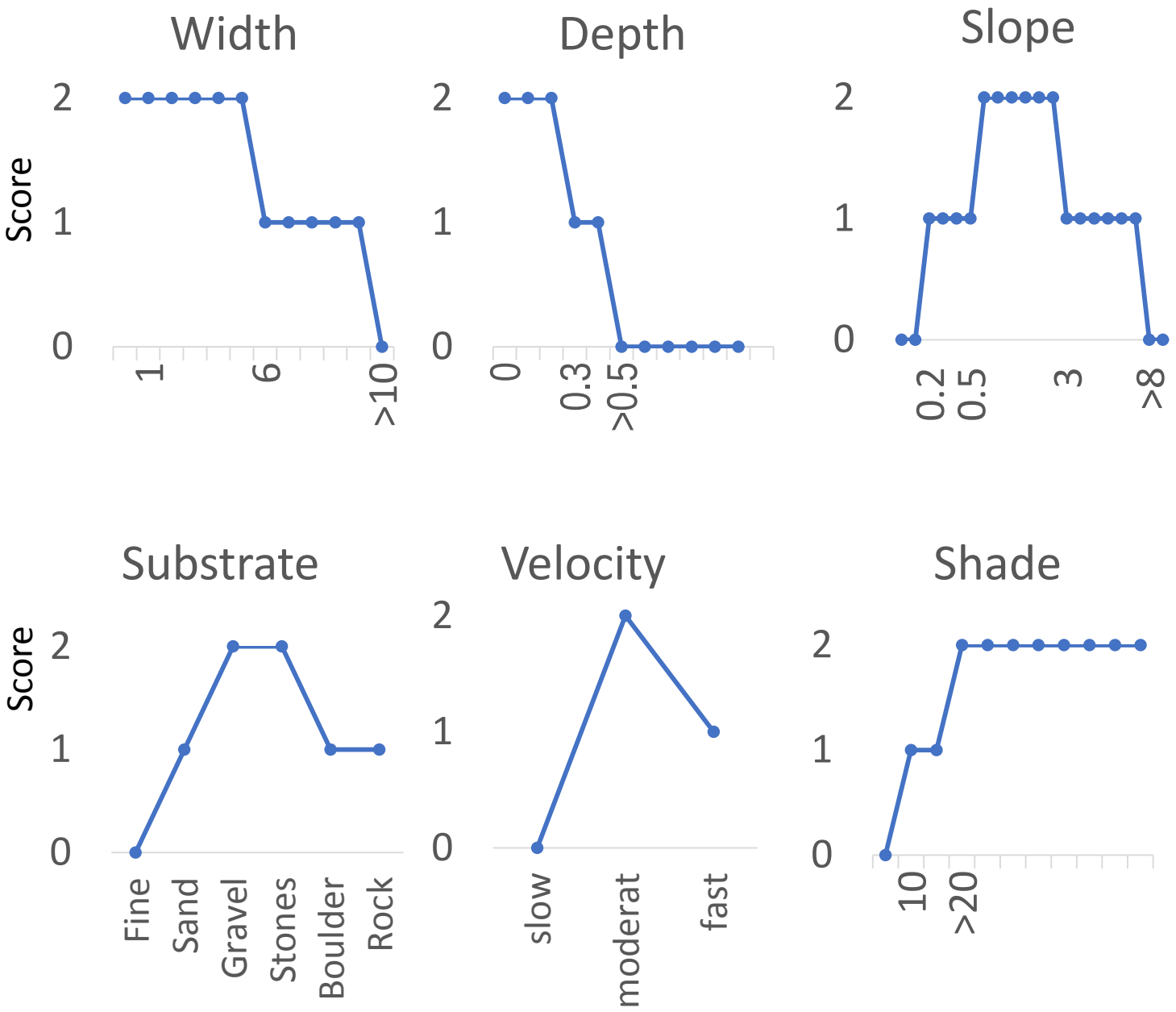
Electrofishing sites, 5 m transects at ¼ m ½, and ¾ m	
Stream width (m)	Average stream width at site (measuring tape, one decimal)
Depth (m)	Average depth at site (3 points at each transect)
Slope (%)	Terrain map 1:50 000 (height per length)
Velocity (m/sec)	Average velocity at surface, 3 classes
Substratum (mm)	Dominating substrate (0.5 x 0.5 m at 3 points per transect)
Shade (%)	Shade on water surface (not crown cover) at 10 am to 14 pm

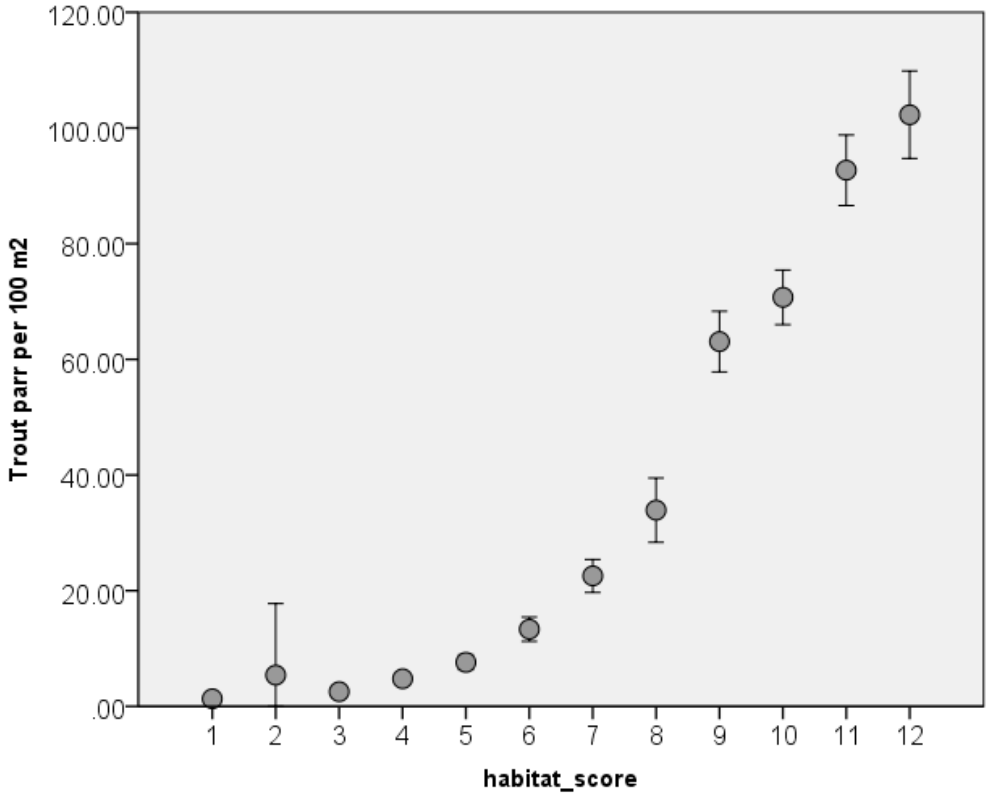
THS = width + depth + slope + shade + substrate + velocity (Max = 12)

	Habitat score		
	0	1	2
Stream width (m)	**>10**	**6-10**	**<6**
Depth (m)	**>0.5**	**0.3-0.5**	**<0.3**
Slope (%)	**<0.2 & >8**	**0.2-0.5 & 3-8**	**>0.5-<3**
Velocity (m/sec)	**Slow/still <0.2**	**Fast >0.7**	**Moderate 0.2-0.7**
Substratum (mm)	**Fine <0.2**	**Sand or Large stones, boulders 0.2-2 or >200**	**Gravel-Stone 2-200**
Shade (%)	**<10%**	**10-20**	**>20**



	Habitat score		
	0	1	2
Stream width (m)	>10	6-10	<6
Depth (m)	>0.5	0.3-0.5	<0.3
Slope (%)	<0.2 & >8	0.2-0.5 & 3-8	>0.5-<3
Velocity (m/sec)	Slow/still <0.2	Fast >0.7	Moderate 0.2-0.7
Substratum (mm)	Fine <0.2	Sand or Large stones, boulders 0.2-2 or >200	Gravel-Stone 2-200
Shade (%)	<10%	10-20	>20


Width
Depth
Slope
Substrate
Velocity
Shade
Score
Score
2
1
0
1
6
>10
0
0.3
>0.5
0.2
0.5
3
>8
Fine
Sand
Gravel
Stones
Boulder
Rock
slow
moderat
fast
10
>20


Trout parr per 100 m2
120.00
100.00
80.00
60.00
40.00
20.00
.00
1
2
3
4
5
6
7
8
9
10
11
12
habitat_score

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Recruitment status and trend analysis

Recruitment status = (observed recruitment / potential maximum recruitment) * 100

Maximum recruitment from undisturbed sites

Recruitment status and trend analysis

Recruitment status = (observed recruitment / potential maximum recruitment) * 100

Maximum recruitment from undisturbed sites

- **multiple linear regression on maximum (n=3) observed densities at a given THS vs. climatic parameters and stream magnitude**

WGBAST, and Pedersen, Degerman, Debowski, and Peteriet 2017

Recruitment status and trend analysis

Recruitment status = (observed recruitment / potential maximum recruitment) * 100

Maximum recruitment from undisturbed sites

- **multiple linear regression on maximum (n=3) observed densities at a given THS vs. climatic parameters and stream magnitude**

Maximum recruitment = C + a*Climate + b*Wetted width + c*THS

Climate

Maximum recruitment = C + a*Climate + b*Wetted width + c*THS

- Longitude
- Latitude
- Air temperature (annual average from environmental agency, or WorldClim)

Climate and THS

Maximum recruitment = C + a*Climate + b*Wetted width + c*THS

- Longitude
- Latitude
- Air temperature (annual average from environmental agency, or WorldClim)
- THS class (0-3)

THS class

THS = width + slope + shade + depth + substrate + velocity

THS Class	Maximum THS	
	10	12
0	THS < 5	THS < 6
1	THS = 5 - 6	THS = 6 - 8
2	THS = 7 - 8	THS = 9 - 10
3	THS = 9 - 10	THS = 11 - 12

Maximum recruitment

Maximum recruitment = C + a*Climate + b*Wetted width + c*THS

Log10 (0+ density) = 0.963 +

0.45*airtemp – 0.037*longitude + 0.027*latitude +

(-0.906)*log(Wetted width) +

0.033*THS

(R2 = 0.5, Anova; F2,254 = 51.8, P<0.001)

Why such a simple approach?

Handles data from different sampling protocols,
a least common denominator.

Doesn’t require elaborate measurements in the field,
i.e. more of old data can be used.

Easy to use and understand

Recruitment status

Trend analysis

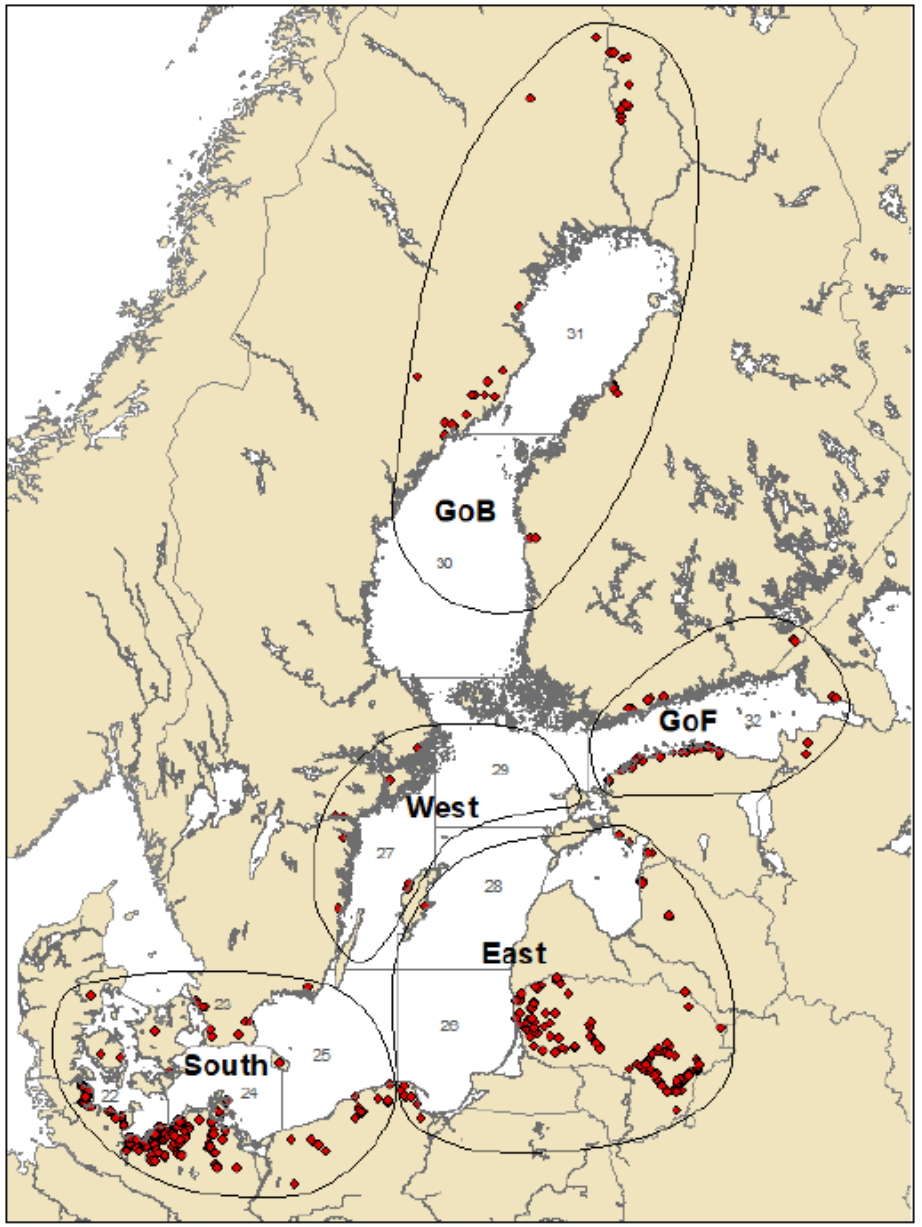

Figure 5.3.2.1. Electrofishing site is subdivisions 22–32 used for assessment of sea trout recruitment status (2018).

WGBAST 2018

Recruitment status – assessment area

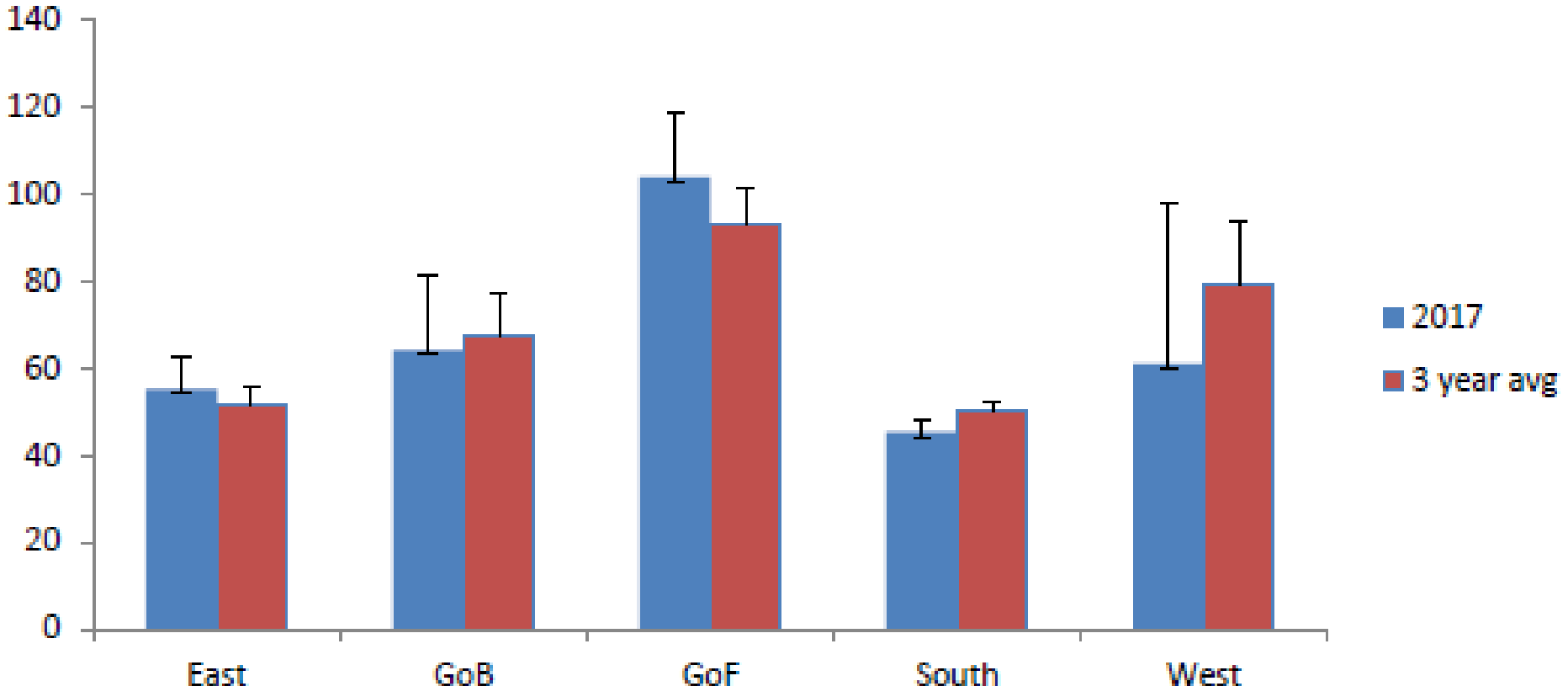

Figure 5.5.1. Recruitment status for 0+ trout by Assessment Area Division (95% CL, only positive value displayed) in 2017 and the last three years (2015–2017).

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Recruitment status - subdivisions

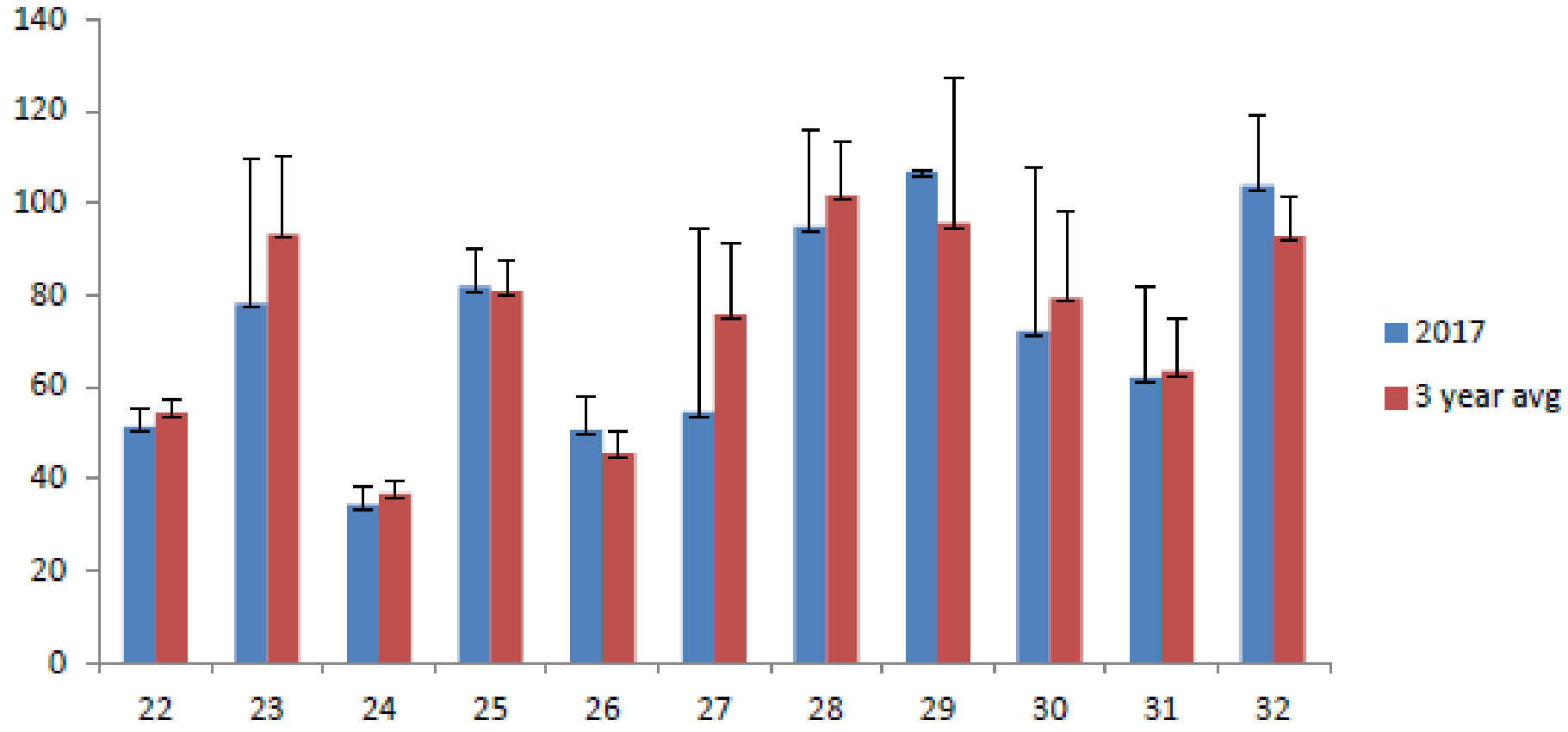

Figure 5.5.2. Recruitment status for 0+ trout by ICES SD (95% CL, only positive value displayed) in 2017 and the last three years (2015–2017).

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Recruitment status - country

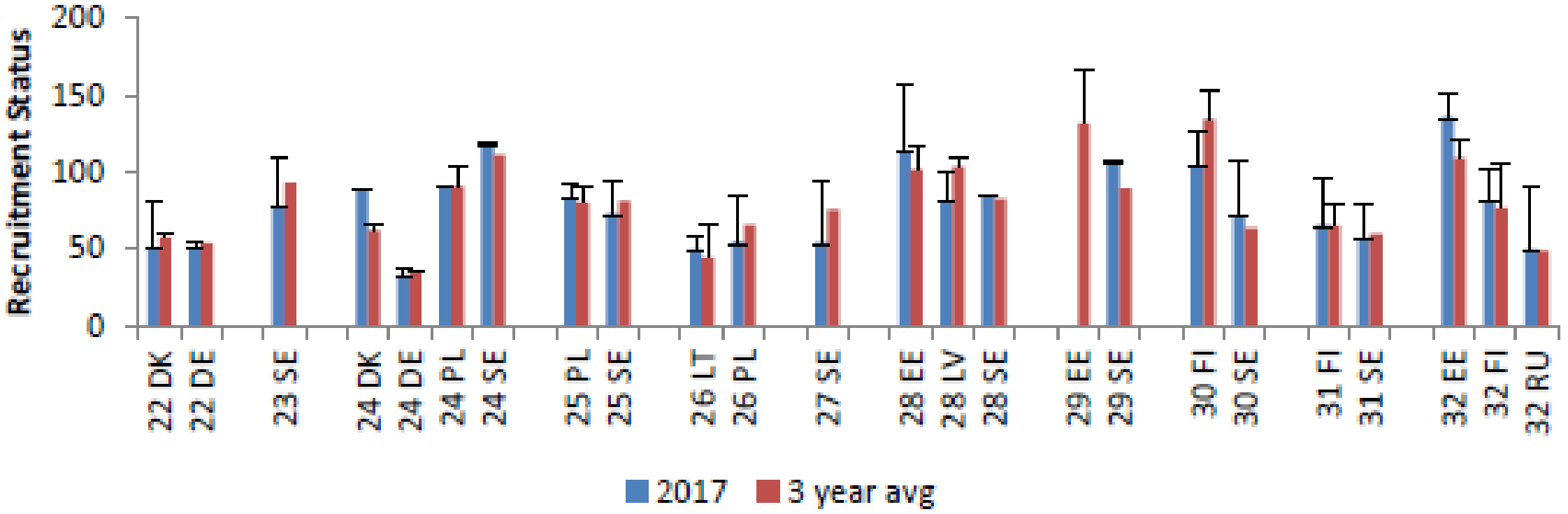

Figure 5.5.3. Recruitment status for 0+ trout by ICES SD and individual countries within SD (95% CL, only positive value displayed) in 2017 and the last three years (2015–2017).

WGBAST 2018

Recruitment status

Trend analysis

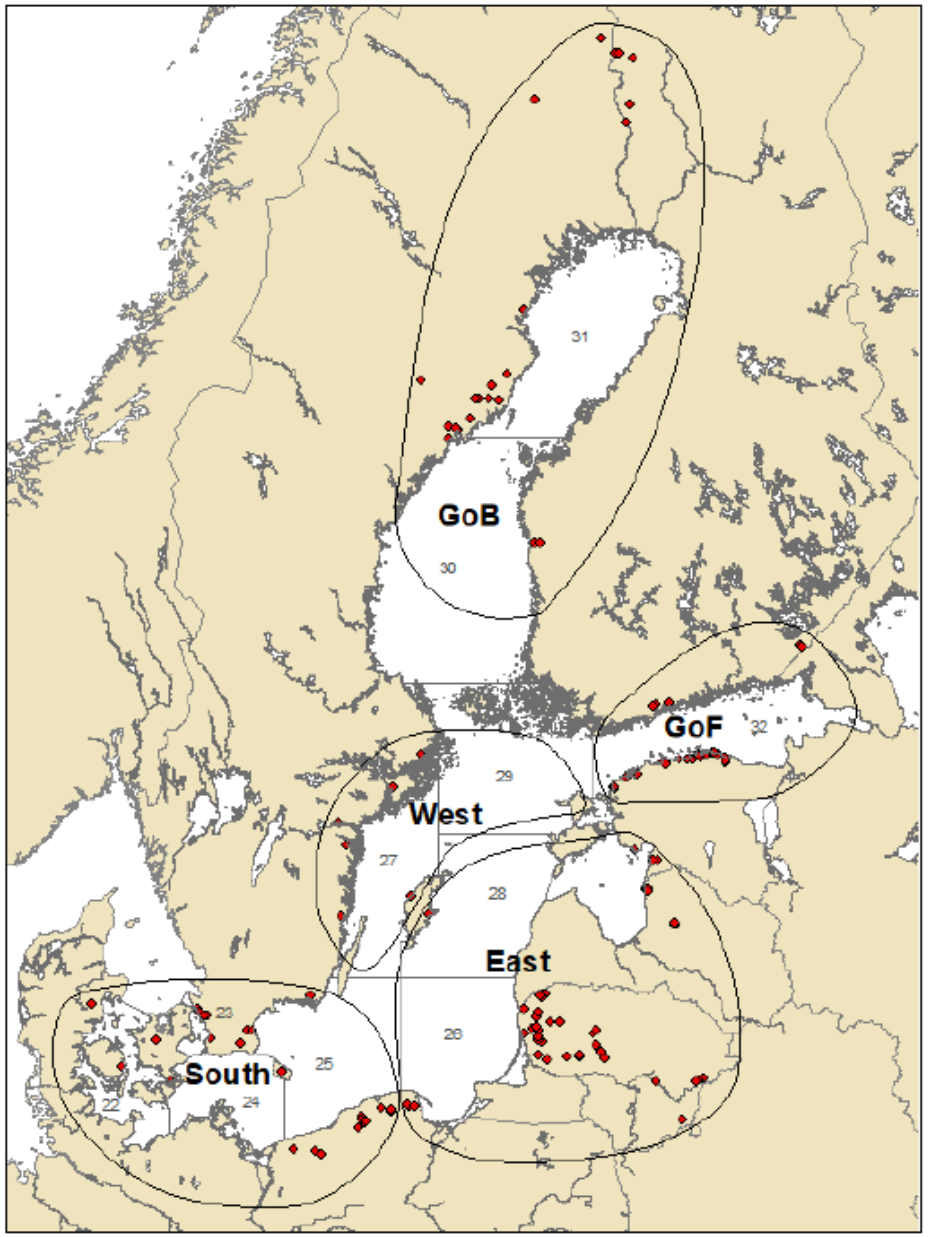

Figure 5.3.2.2. Electrofishing site is subdivisions 22–32 used for trend analysis of sea trout recruitment status (2018).

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Recruitment 5 year trend – assessment area

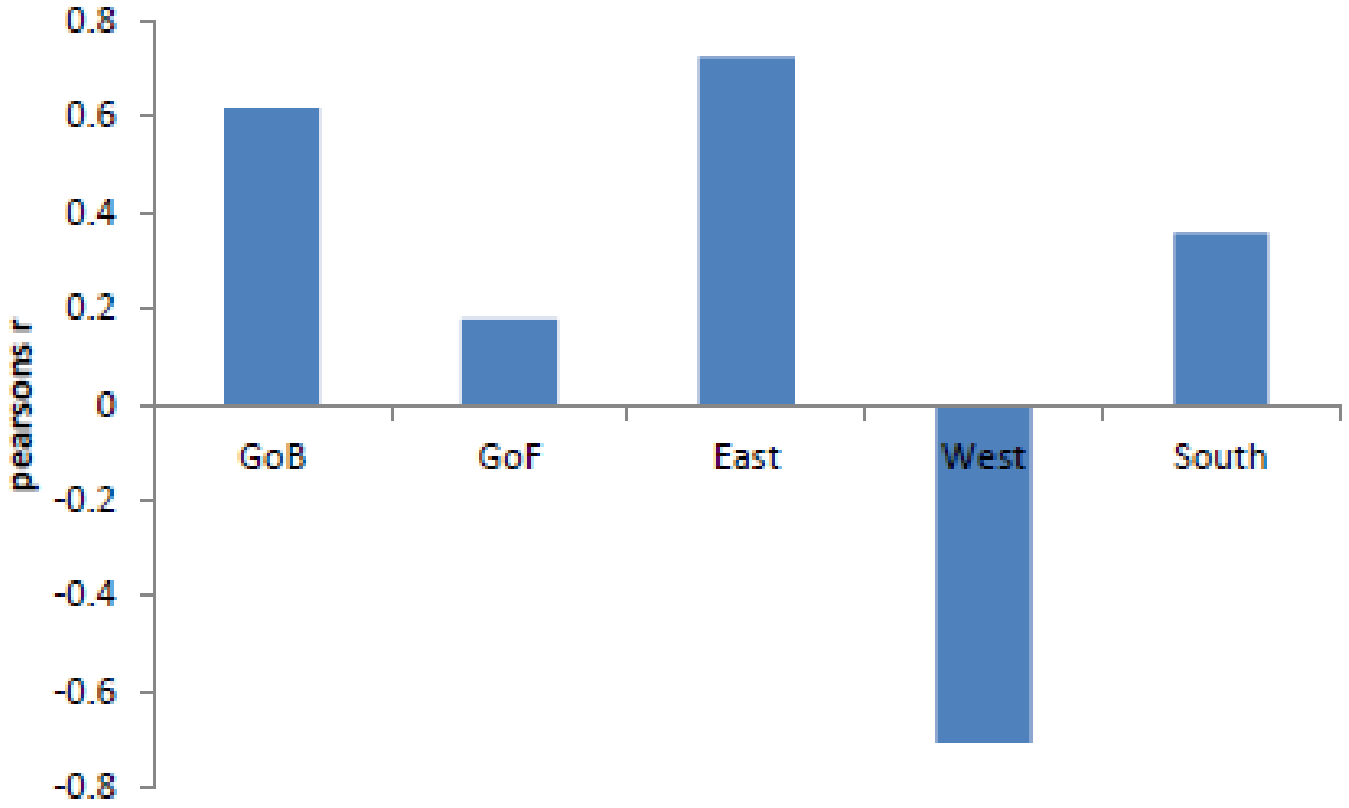

Figure 5.5.4. Average trend (Pearsons r) in 0+ trout recruitment status in the last five years by Assessment Area Division.

WGBAST 2018

Recruitment 5 year trend - subdivisions

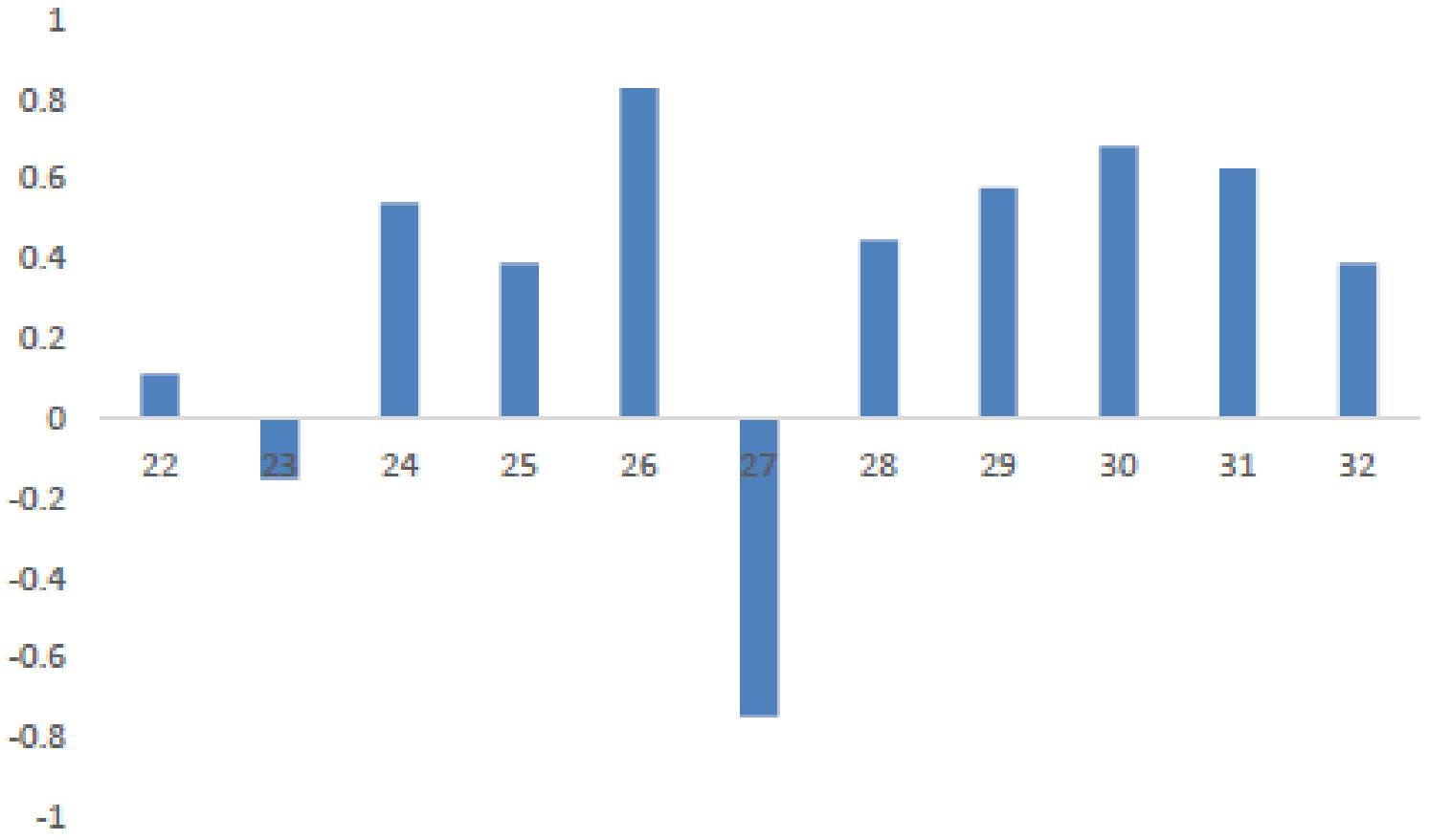

Figure 5.5.5. Average trend (Pearsons r) in 0+ trout recruitment status in the last five years by ICES SD.

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Recruitment 5 year trend - country

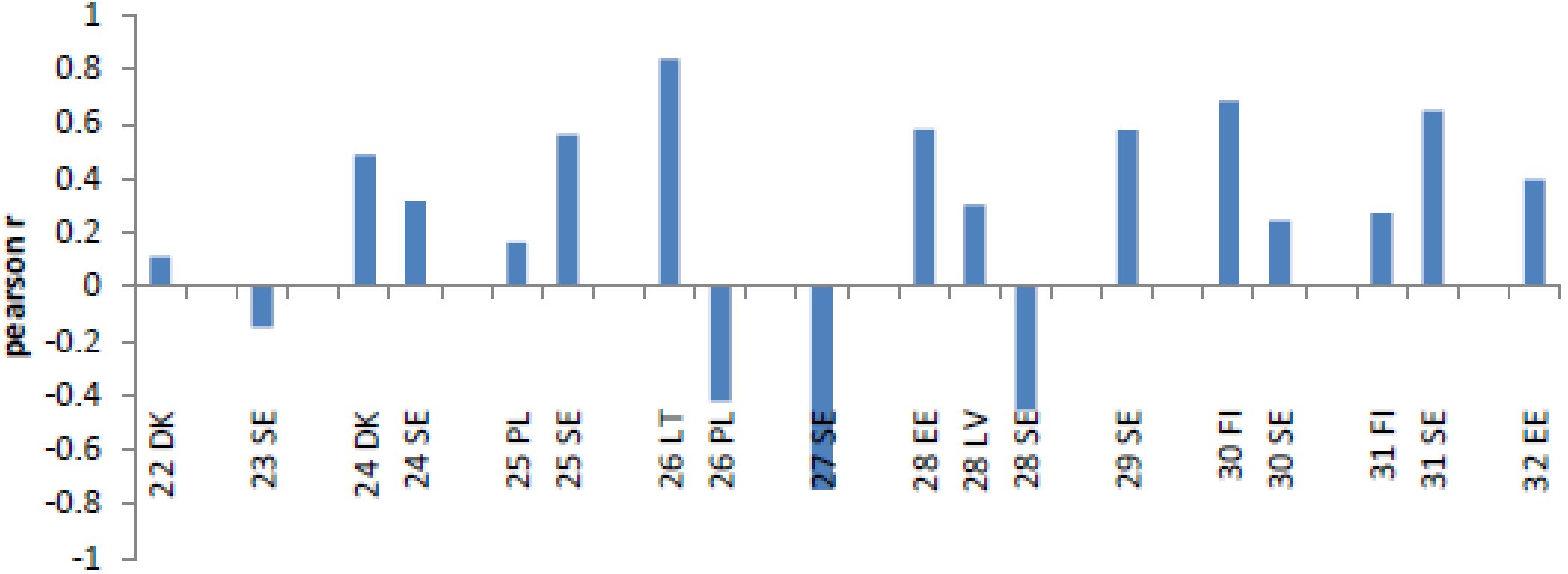

Figure 5.5.6. Average trend (Pearsons r) in 0+ trout recruitment status in the last five years by ICES SD and country (within SD:s shared by several countries).

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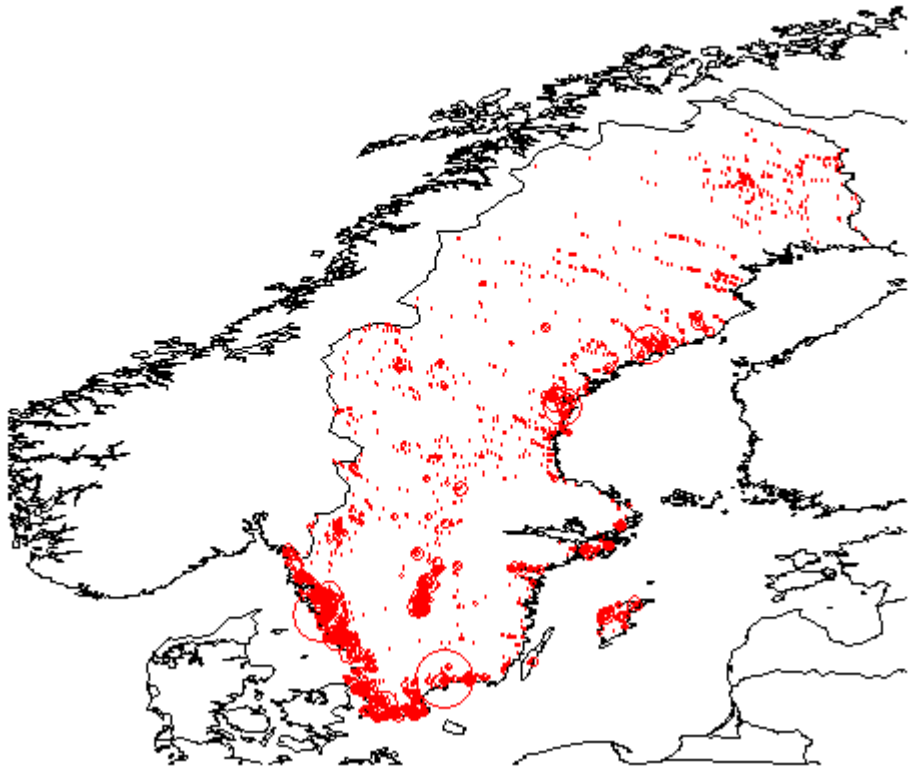
Work in progress - Model development

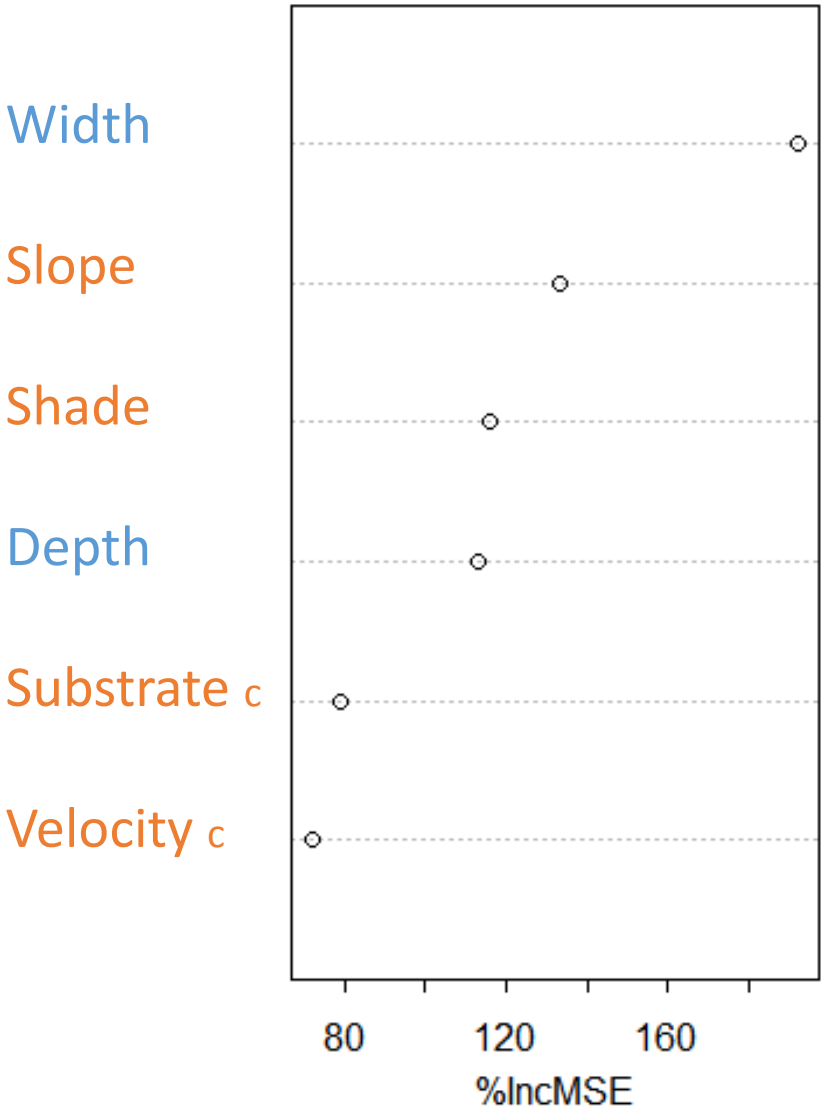
THS – variables and weights

Swedish observations 2000-2016 (n = 16 151)



Method: Random forest regression

Fry + Parr: R2 = 62% (75% with covariables)



THS = width + slope + shade + depth + substrate + velocity

Max = 12

Method: Random forest regression

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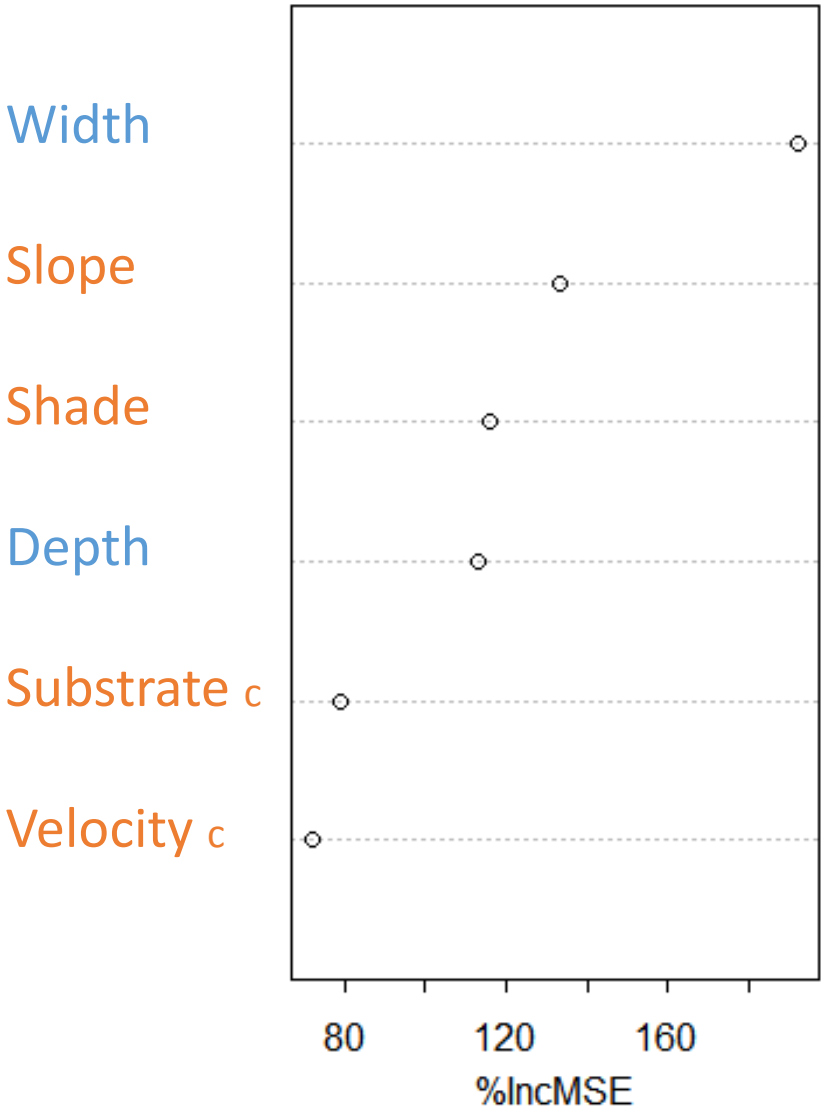


THS = width + slope + shade + depth + substrate + velocity

Max = 12

THS new = slope + shade + 0.5 * substrate + 0.5 * velocity

(width and depth continuous variables)

Max = 6

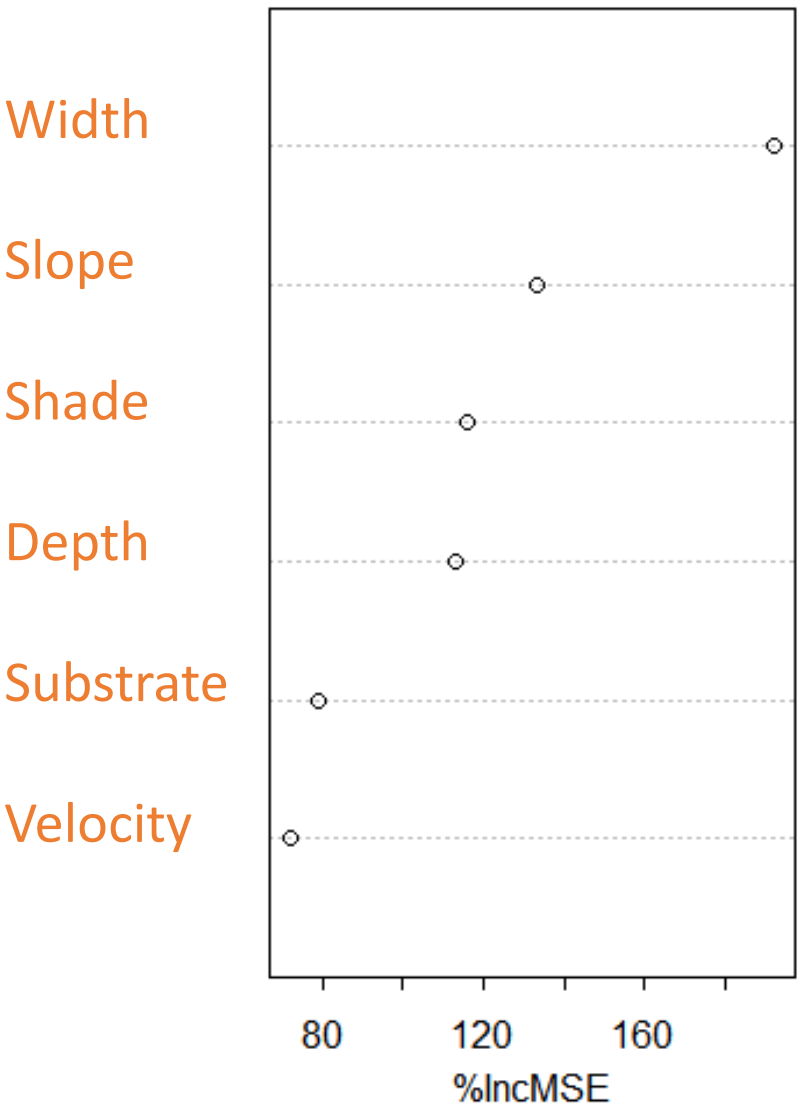
Model development

- **THS – variables and weights**
- **Geographical scale – local and regional models**
- **Other relevant factors:**
  - **- Water quality**
  - **- Environmental impact**
    - **Sediment transport**
    - **Extreme water temperatures**
    - **Habitat access (fish paths, natural obstacles that are partly passable, road tunnels)**

Potential relevant factors

Second dominant substrate type (most important included)
Water level (affect catchability)
Productivity (Conducitivty, phosphorous, salinity, alkalinity
Predator densities
North atlantic oscillation, Baltic sea index
Water quality
River quality
Residents
Spawning grounds (<200 m, 200-1000 m, >1 km)
Spawning previous fall (accessability, water related)
Stocking
Vegetation, bank vegetation, cover, hiding places
Number of downstream barriers
Impacts
Diseases

Fry + Parr: R2 = 62%



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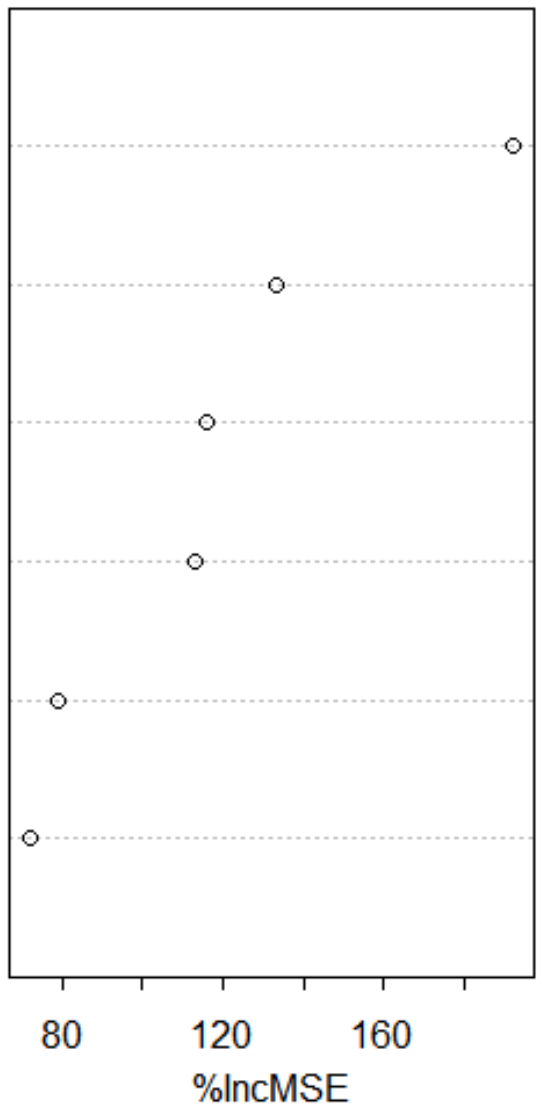
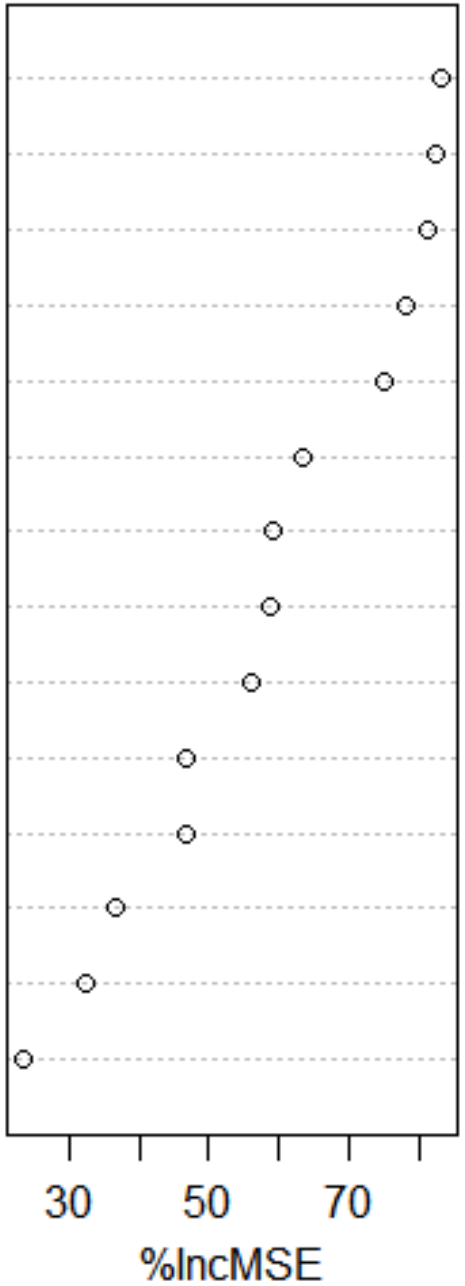


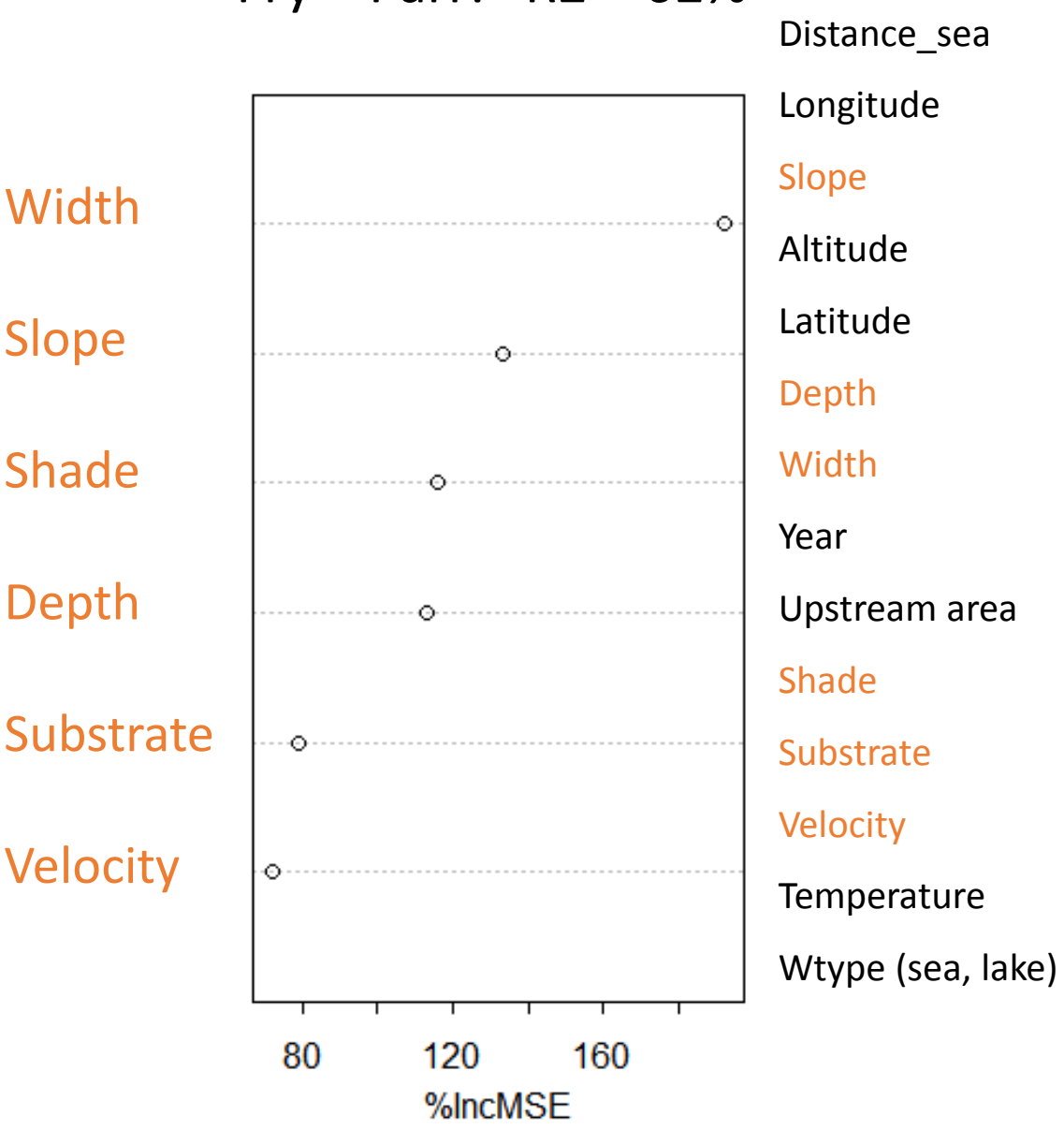
Width
Slope
Shade
Depth
Substrate
Velocity

Distance_sea
Longitude
Slope
Altitude
Latitude
Depth
Width
Year
Upstream area
Shade
Substrate
Velocity
Temperature
Wtype (sea, lake)

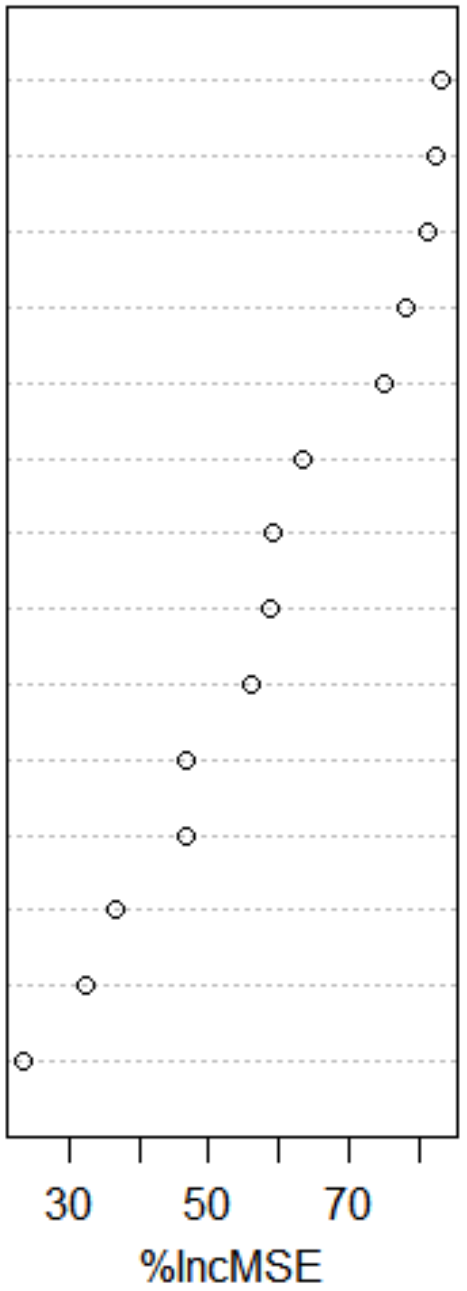
Fry + Parr: R2 = 75%

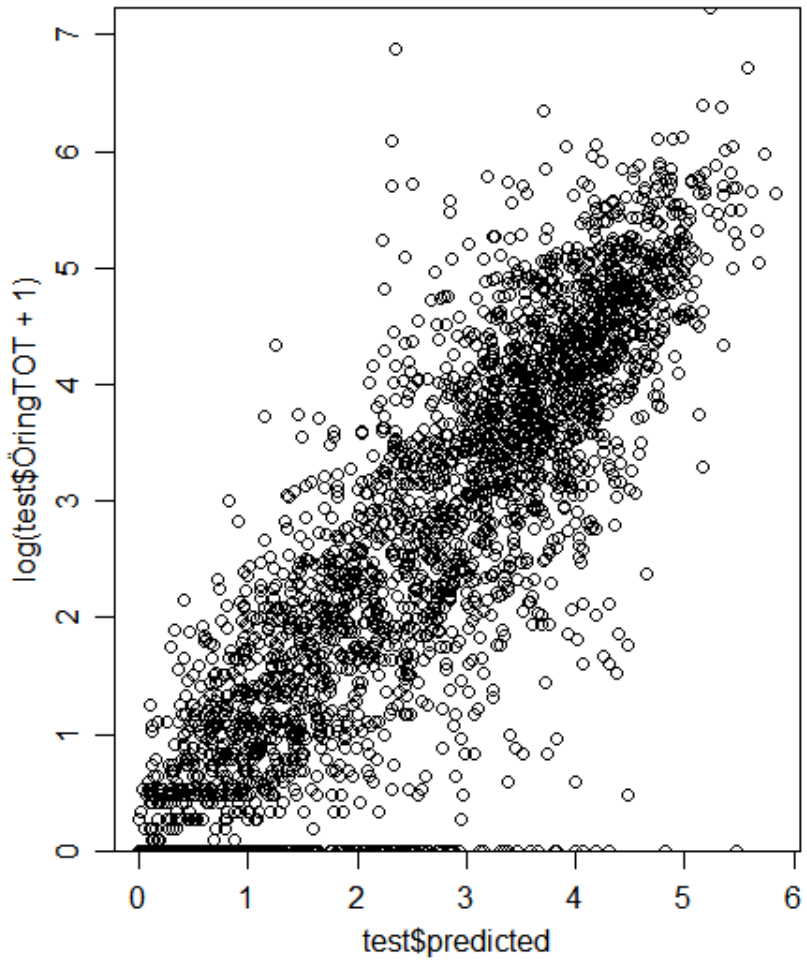


Fry + Parr: R2 = 62%

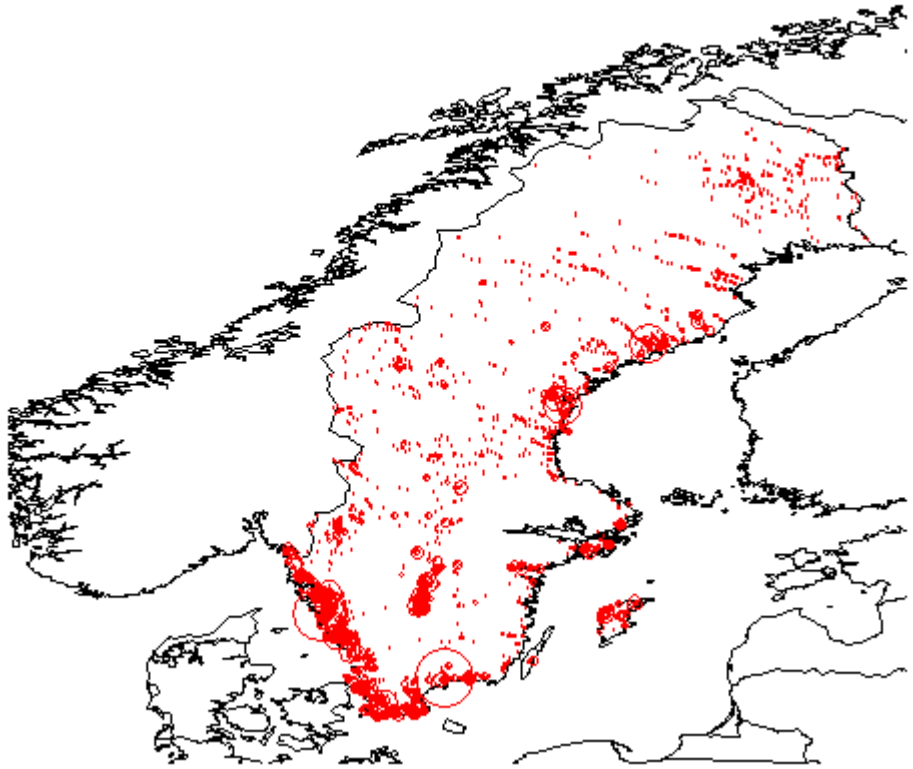


Fry + Parr: R2 = 75%



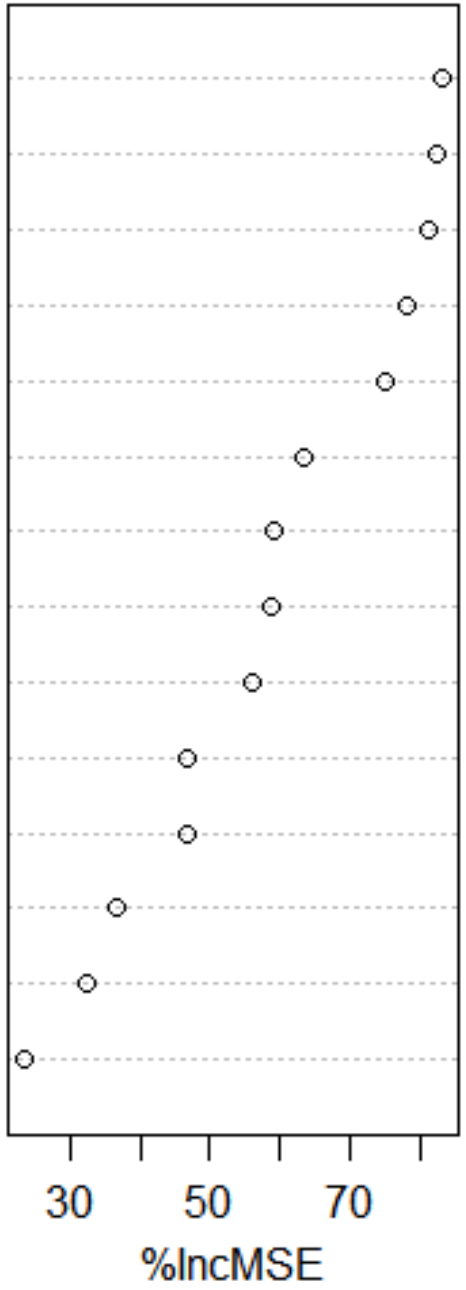


Swedish observations 2000-2016 (n = 16 151)



Distance_sea
Longitude
Slope
Altitude
Latitude
Depth
Width
Year
Upstream area
Shade
Substrate c
Velocity c
Temperature
Wtype (sea, lake)

Fry + Parr: R2 = 75%



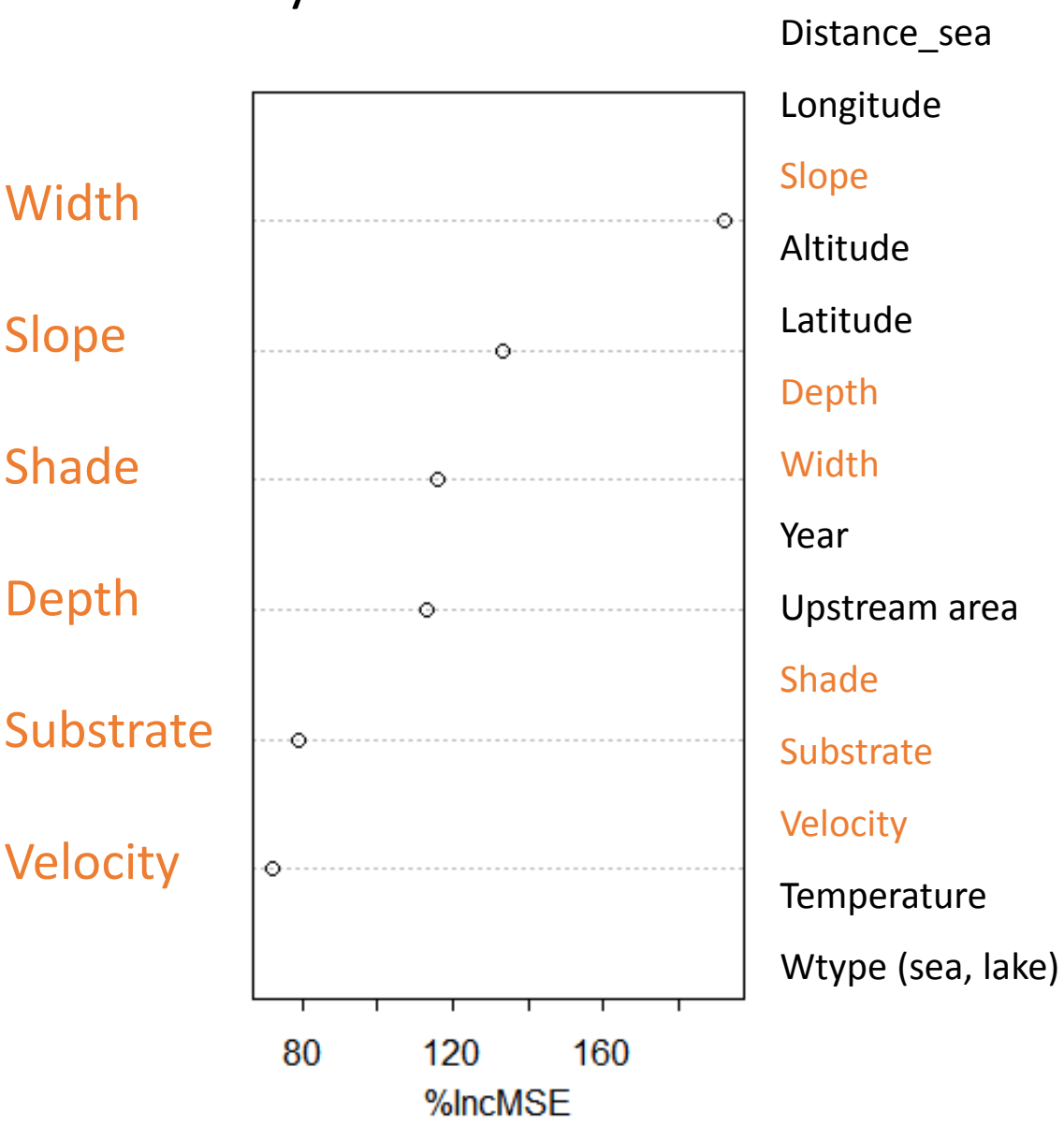
Variable importance

1. Geography

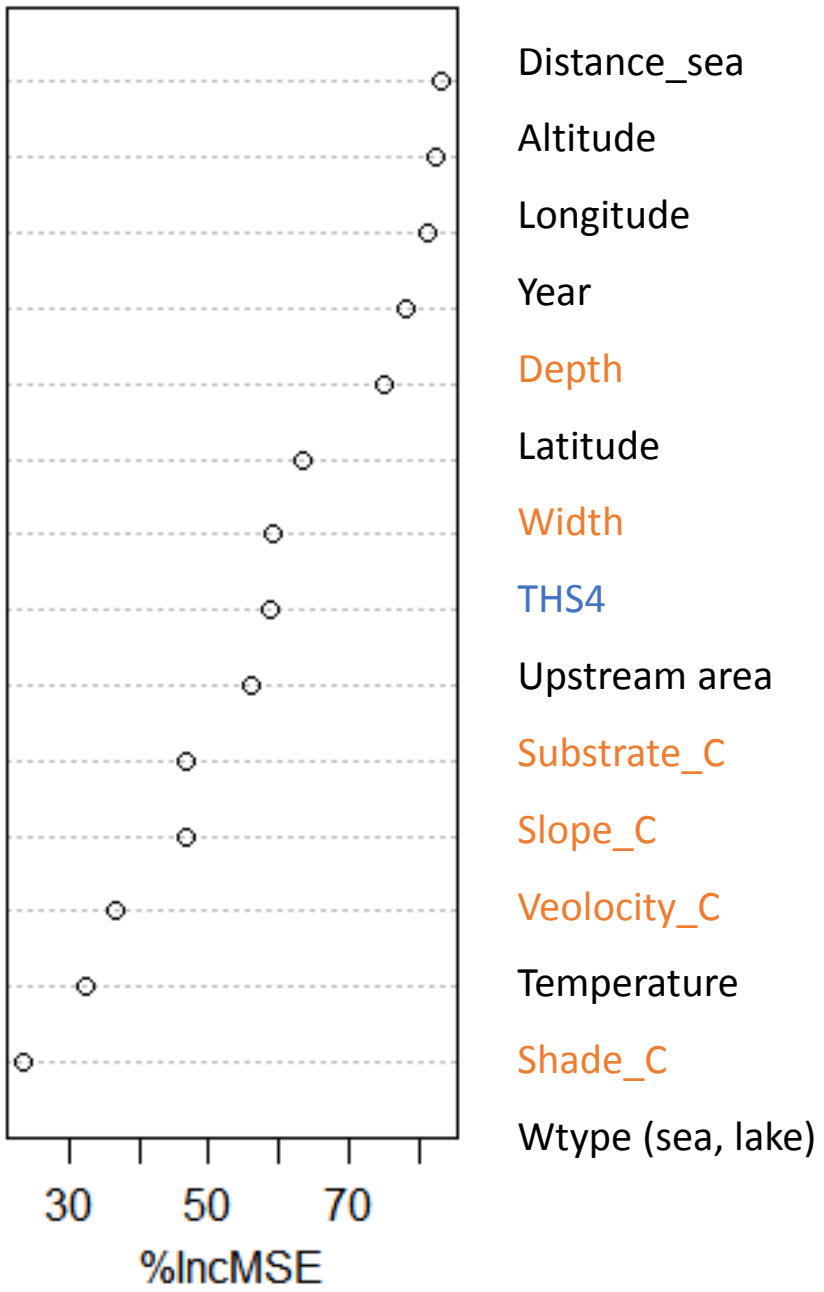
2. Stream characteristics

3. Local habitat characteristics

Fry + Parr: R2 = 62%



Fry + Parr: R2 = 75%



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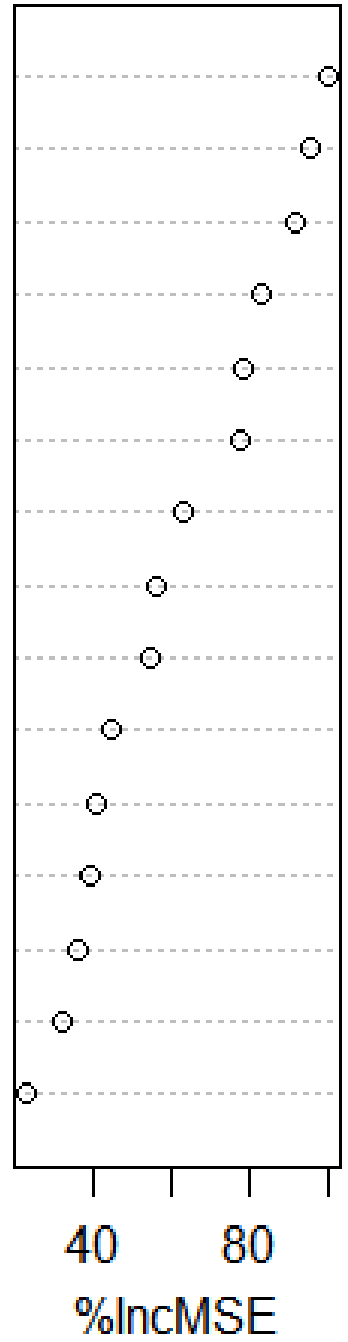

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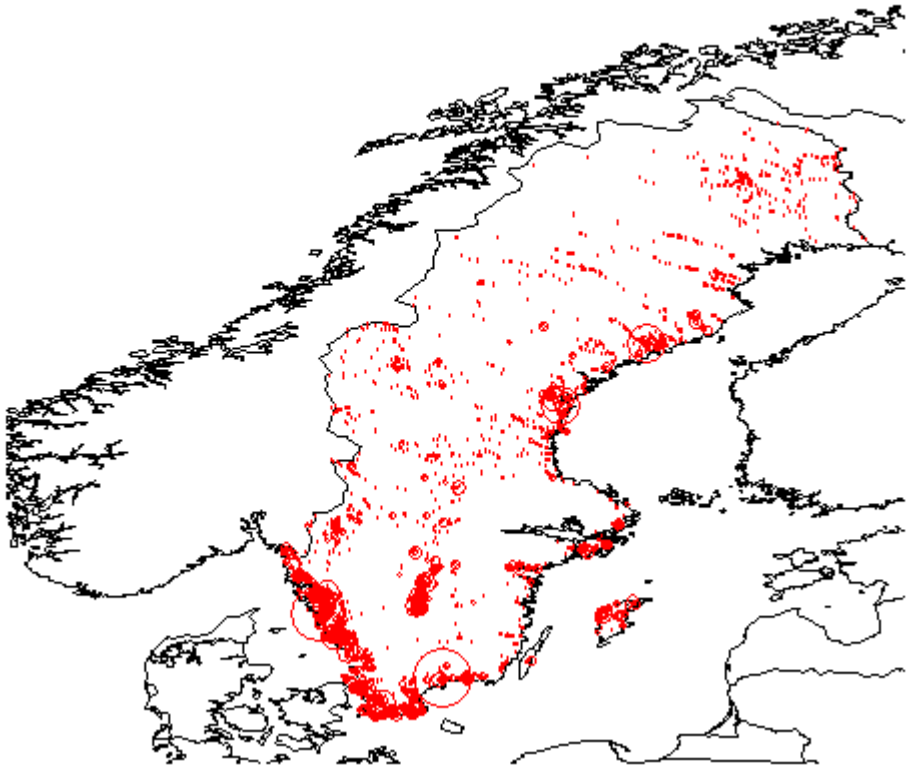
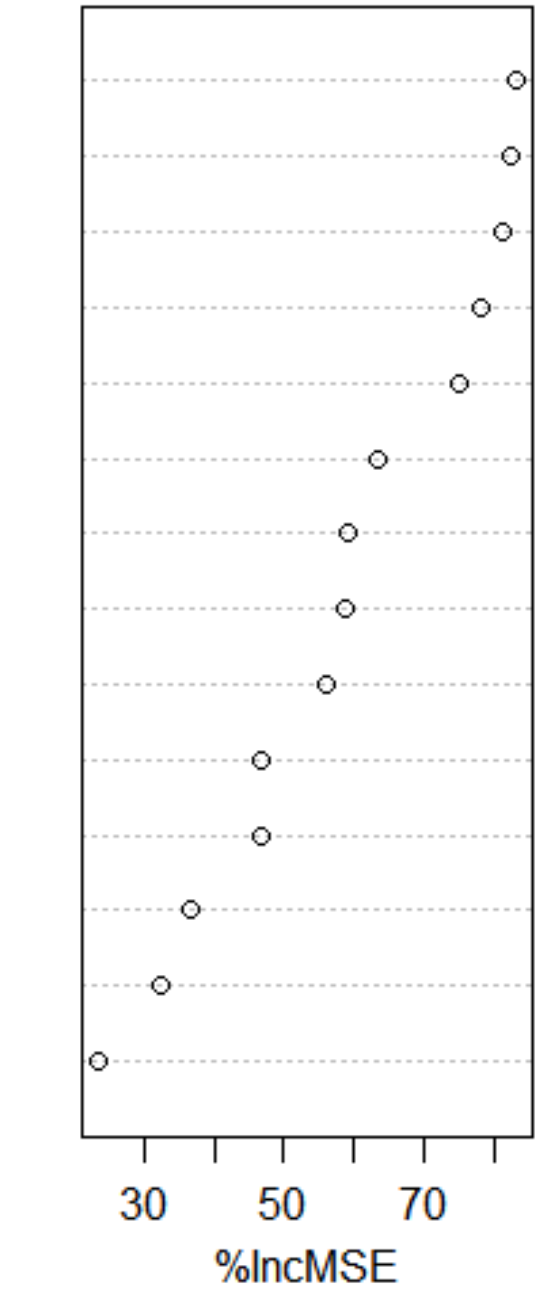
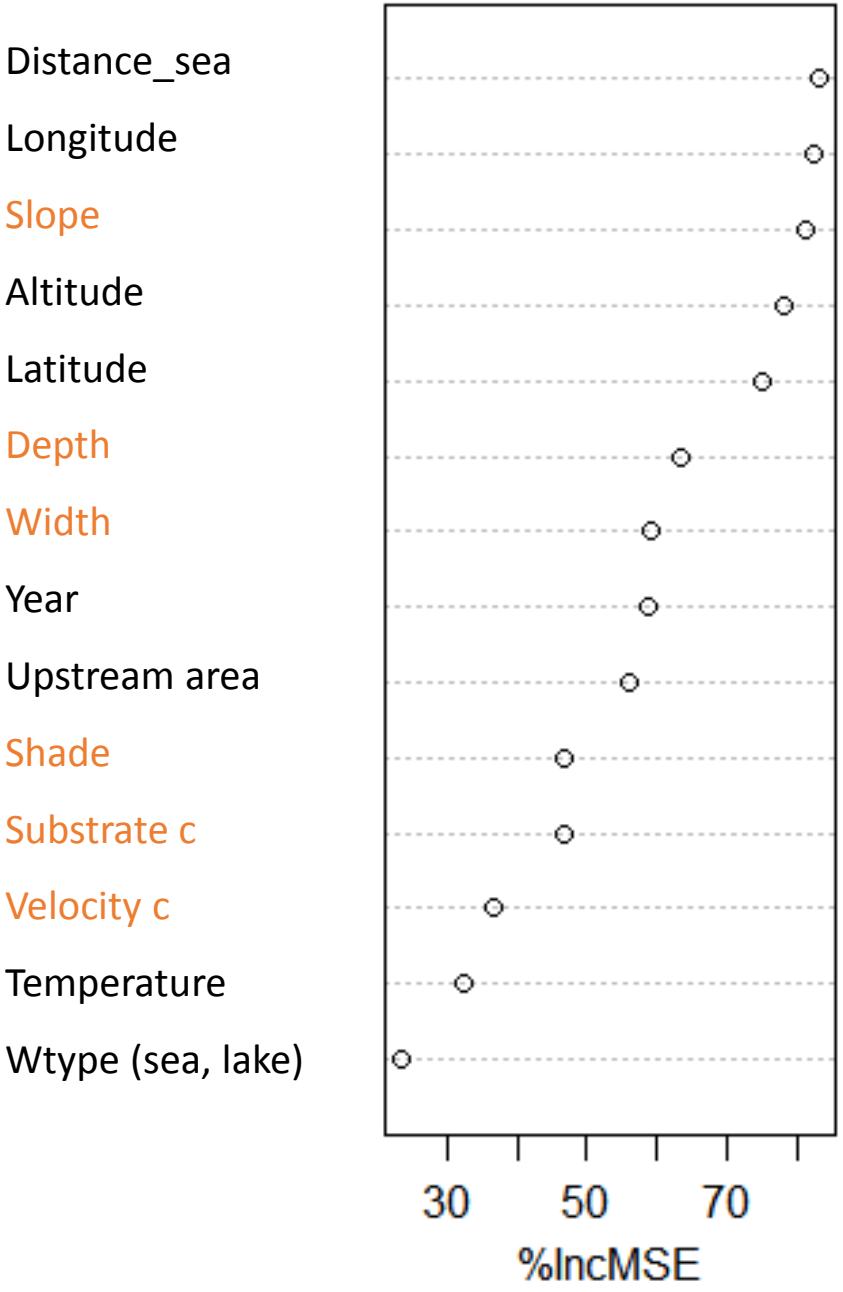


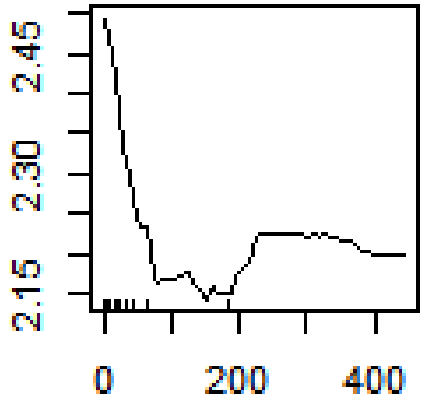
Fry + Parr: R2 = 75%

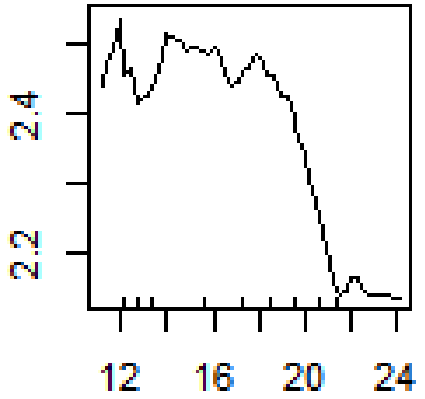


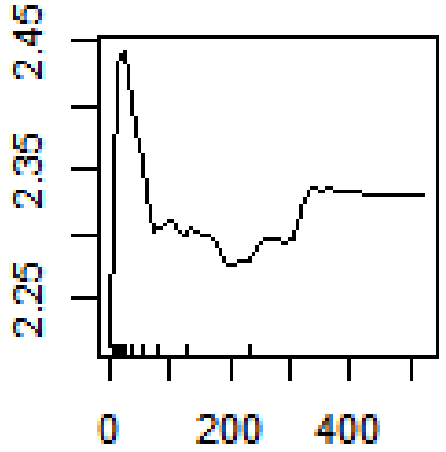
Fry + Parr: R2 = 75%

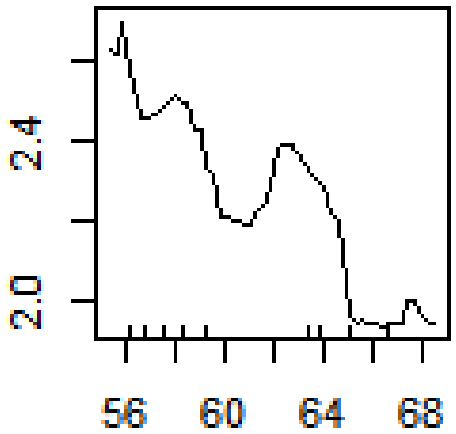


1. Geography



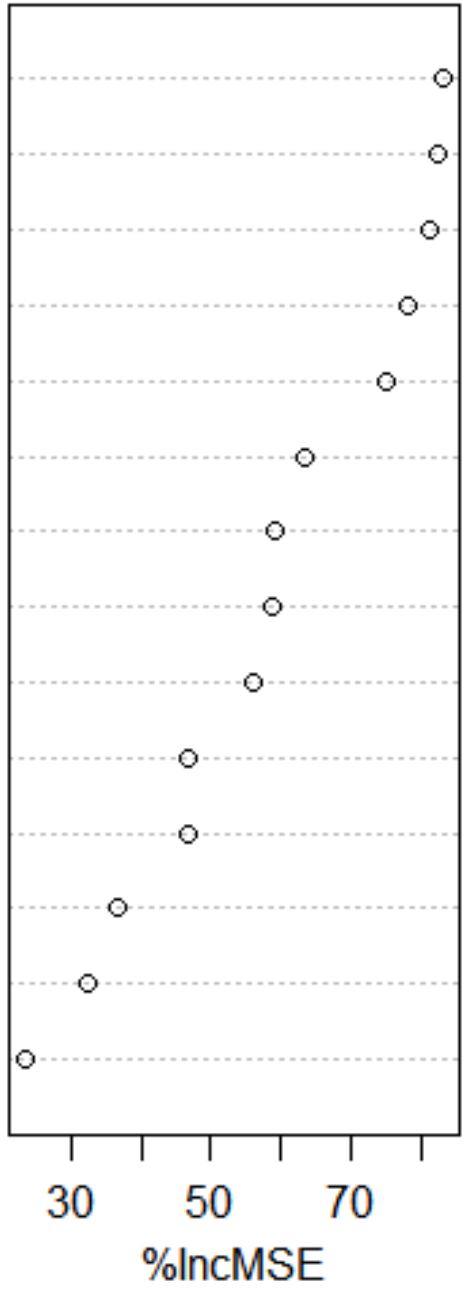




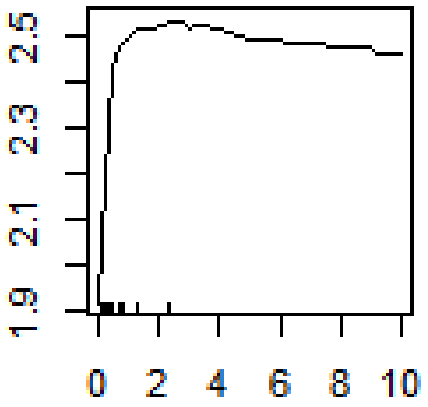


Fry + Parr: R2 = 75%

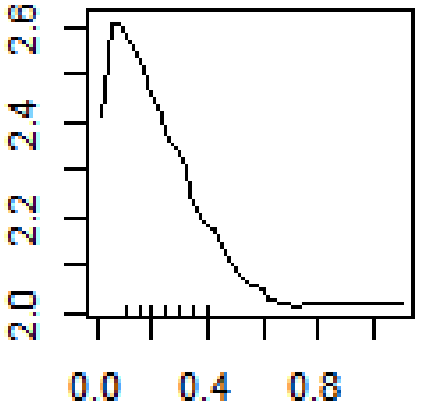
Distance_sea
Longitude
Slope
Altitude
Latitude
Depth
Width
Year
Upstream area
Shade
Substrate c
Velocity c
Temperature
Wtype (sea, lake)



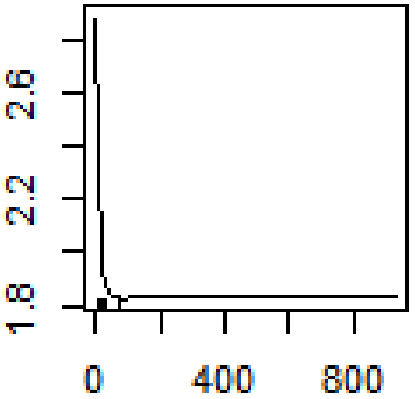
2. Stream characteristics



Slope (%)

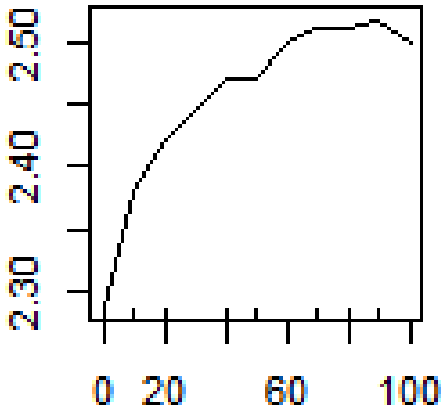


Depth (m)

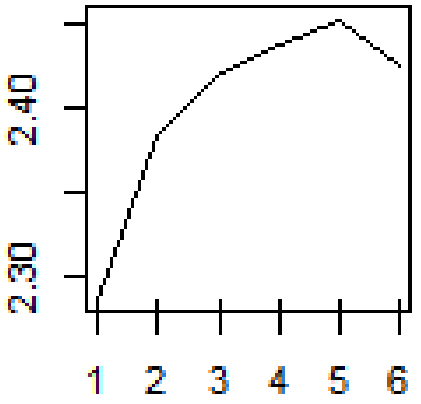


Width (m)

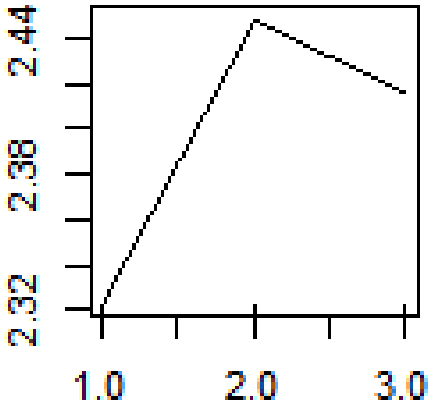
3. Local habitat



Shade (%)

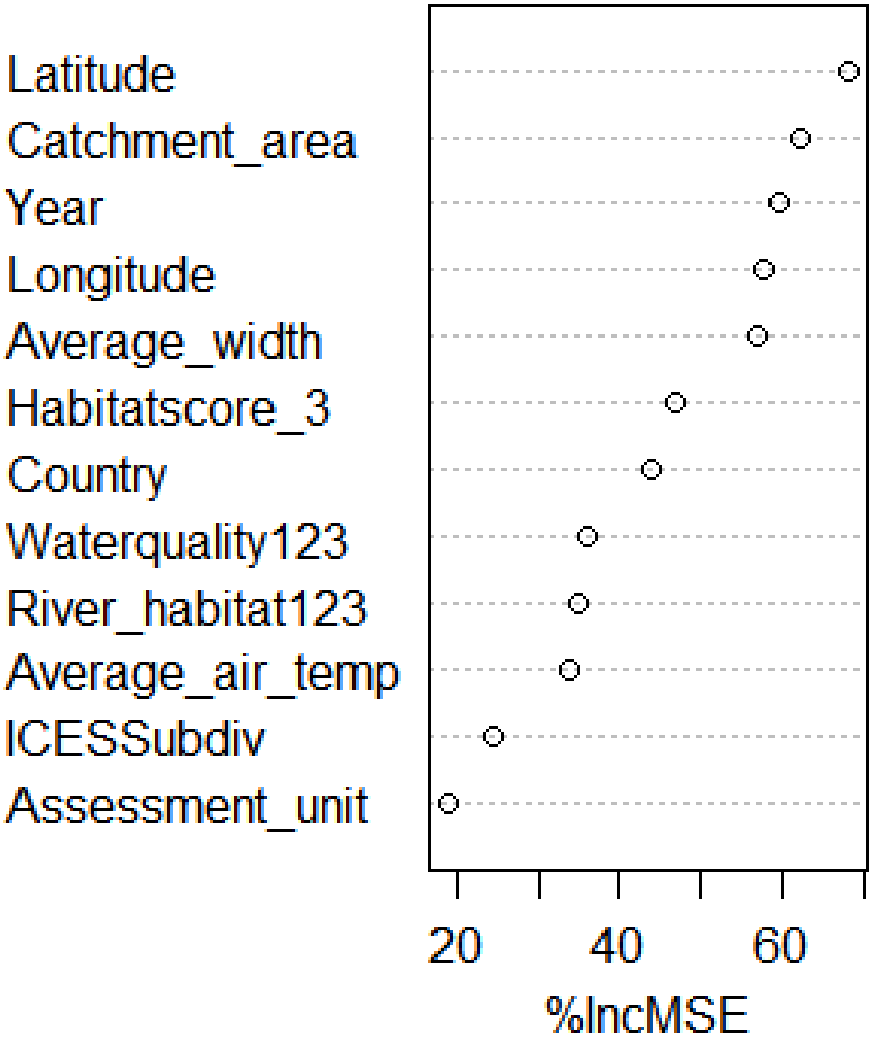


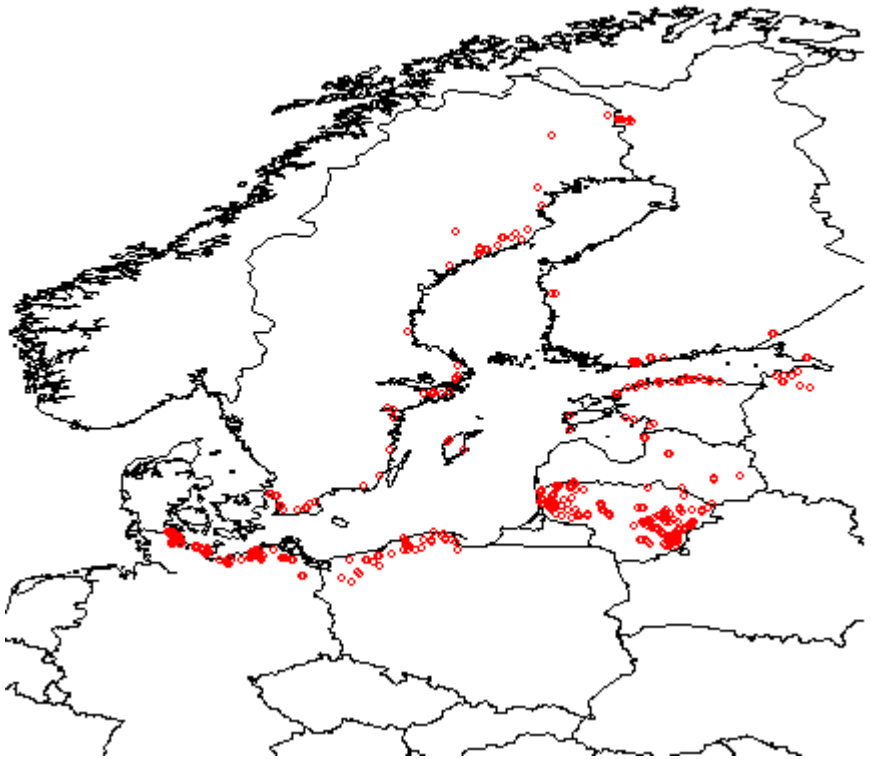
Substrate

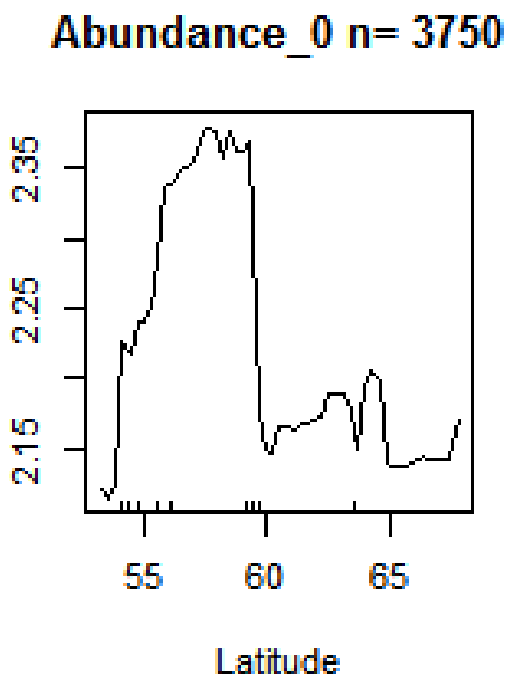


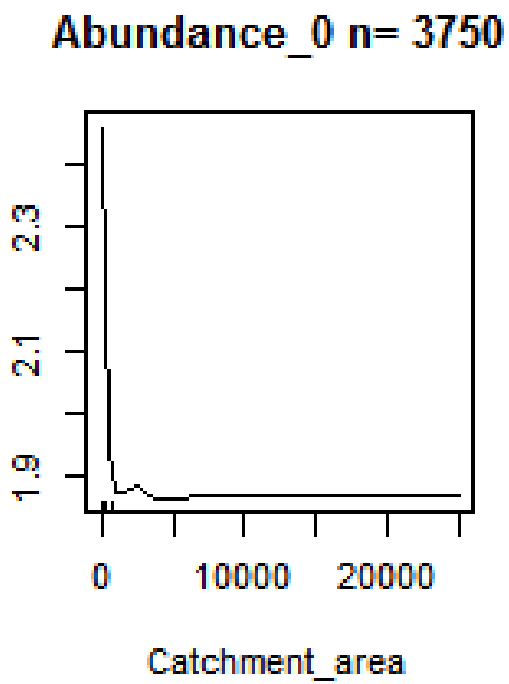
Velocity

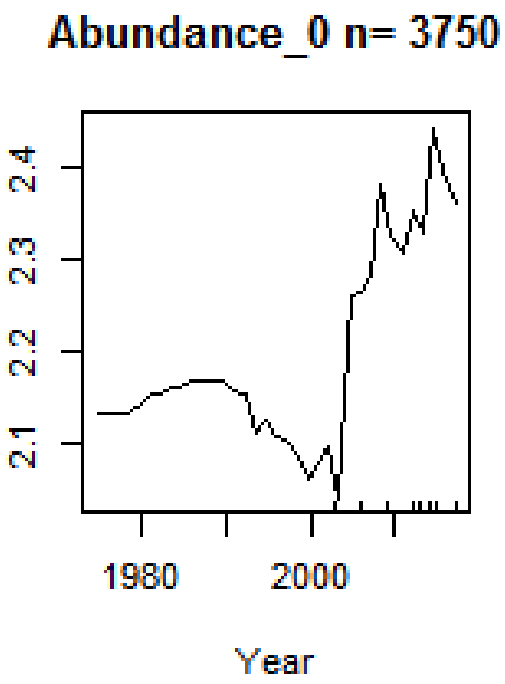
R2 = 65% (n= 3750)

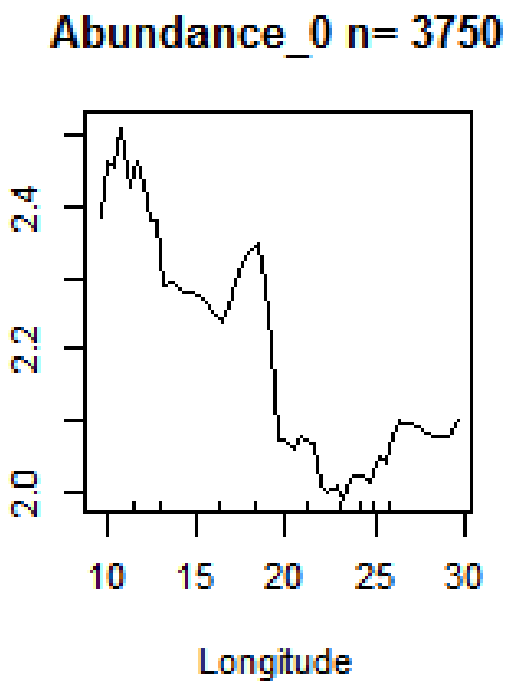

Latitude
Catchment_area
Year
Longitude
Average_width
Habitatscore_3
Country
Waterquality123
River_habitat123
Average_air_temp
ICESSubdiv
Assessment_unit
20
40
60
%IncMSE

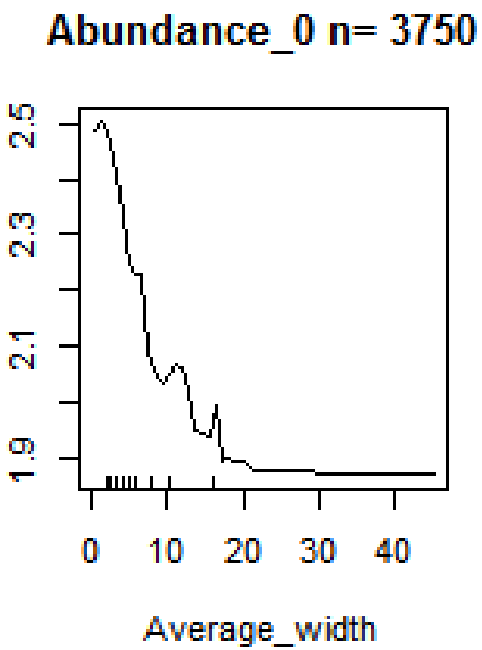


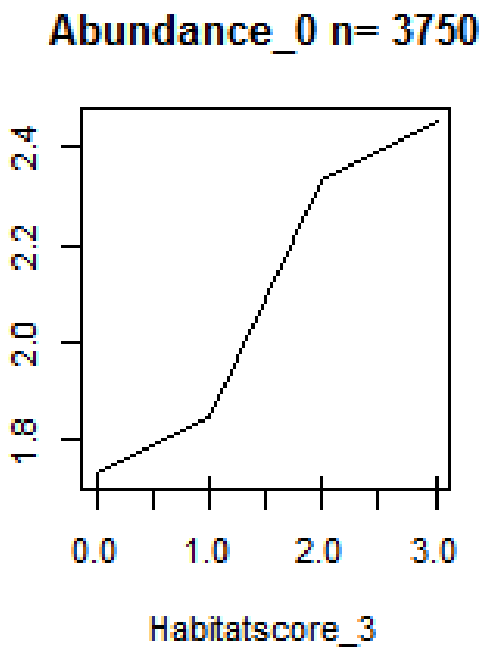

Abundance_0 n= 3750
2.35
2.25
2.15
55
60
65
Latitude


Abundance_0 n= 3750
2.3
2.1
1.9
0
10000
20000
Catchment_area


Abundance_0 n= 3750
2.4
2.3
2.2
2.1
1980
2000
Year


Abundance_0 n= 3750
2.4
2.2
2.0
10
15
20
25
30
Longitude


Abundance_0 n= 3750
2.5
2.3
2.1
1.9
0
10
20
30
40
Average_width


Abundance_0 n= 3750
2.4
2.2
2.0
1.8
0.0
1.0
2.0
3.0
Habitatscore_3

Model development (cont.)

Predicted maximum density

- **Reference sites or other measure?**
- **Definition of undisturbed sites**

Future development?

- Combine THS with GIS to quantify available habitats?

- **Quantify habitat from maps**
- **Verify with field visits using a simple protocol for sampling habitat quality**

- Include THS in Bayesian life history model

Content

1. **Background**
2. **Trout habitat score (THS) – additive model**
3. **How to measure and calculate THS**
4. **Recruitment status and trend analysis**
5. **Work in progress, model development**
6. **Field protocol**

THS field protocol – site information

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Field protocol for Trout habitat score**													
2														
3	River				River coordinates X:				Y:			Date:		
4	Site name/nr				Site coordinates X:				Y:					
5														
6	Site length (m):				Alkalinity:							Personel (Name):		
7	Water level (Low/Medium/High):				Conductivity:									
8	Slope %				Phosphorous:									
9	Distance to sea:				Salinity:									
10	Altitude:				Water temperature:									
11	Catchment area:				Air temperature:									
12					Water colour:									
13					Turbidity:									

THS field protocol – THS parameters

A minimum of 6 transects

Transect number	Distance (m) from downstream corner of site	Width (m)	Water depth (x.xx m) 1/4 width	1/2 width	3/4 width	Velocity code or m/s	Shade %	Dominating bottom substrate (code 1/4 width	1/2 width	3/4 bredd
1	0									
2	5									
3	10									
4	15									
5	20									
6	25									
7	30									
8	35									
9	40									
10	45									
11	50									
12	55									
13	60									
14	65									
15	70									
16	75									
17	80									
18	85									
19	90									
20	95									
21	100									
Average										

SUBSTRATE		
CODE		FREQUENCE
1	FINE	
2	SAND	
3	GRAVEL	
4	STONE1	
5	STONE2	
6	BOULDER1	
7	BOULDER2	
8	BOULDER3	
9	FLAT	

Instruction for Substrate table
Dominating substrate: =D1
Subdominating substratate1: =D2
Subdominating substrate2: =D3
% cover (0-3) classes
***0** = missing **1** < = 5% **2** =5-50% **3** >=50%*

VELOCITY	
Code	Velocity
Slow	<0,2 m/s
Moderate	0,2-0,7
Fast	>0,7 m/s

SHADE (WATERSURFACE)	
Code	Shade
0	0-4%
10	5-14%
20	15-24%
30	25-34%
40	35-44%
50	45-54%
60	55-64%
70	65-74%
80	75-84%
90	85-94%
100	95-100%

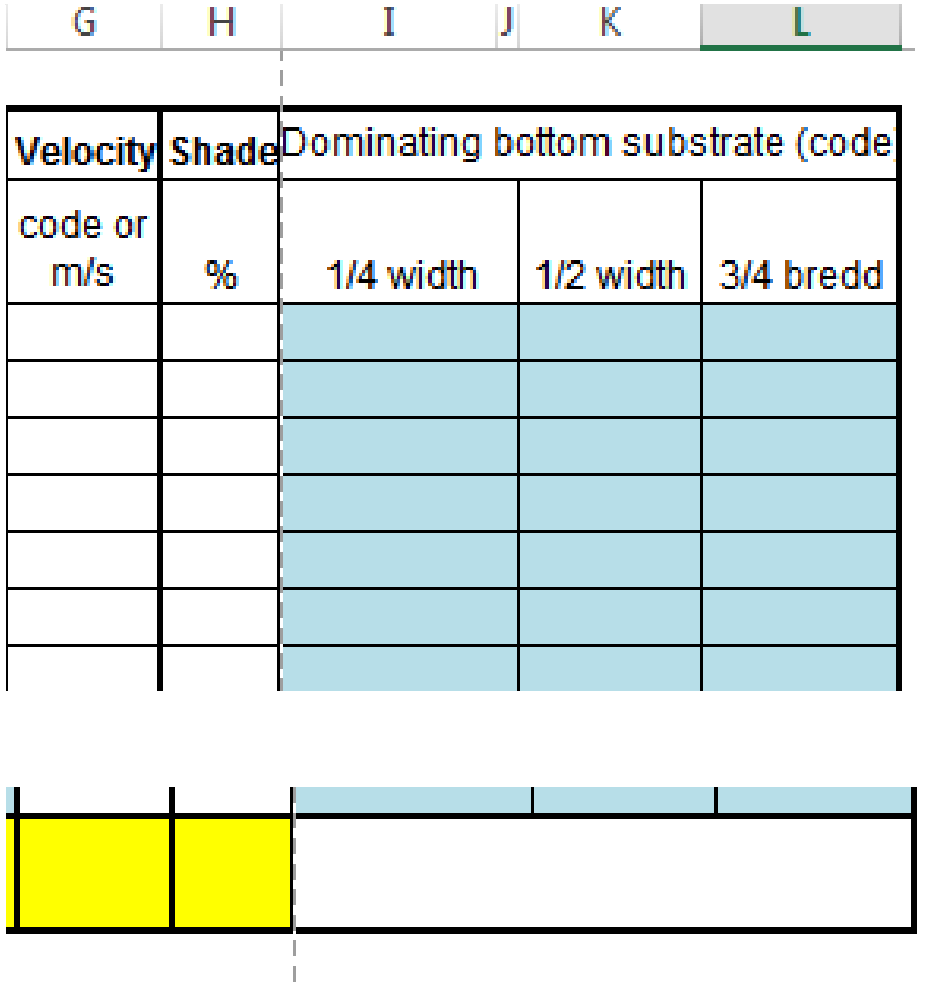
SUBSTRATE (explanation)	Fine sediment	Sand	Gravel	Smaller stones	Larger stones	Smaller boulders	Medium boulders	Large boulders	Flat
Particle size (cm)	<0,02	0,02 - 0,2	0,2 - 2	2 - 10	10 - 20	20 - 30	30 - 40	40 - 200	>200
Code	FINE	SAND	GRAVEL	STONE1	STONE2	BOULDER1	BOULDER2	BOULDER3	FLAT
Dominating substrate (D1 - D3)									
% cover (0 - 3)									

THS field protocol

	A	B	C	D	E	F	G	H	I	J	K	L
14	A minimum of 6 transects											
15				Water depth (x.xx m)			Velocity	Shade	Dominating bottom substrate (code			
16	Transect number	Distance (m) from downstream corner of site	Width (m)	1/4 width	1/2 width	3/4 width	code or m/s	%	1/4 width		1/2 width	3/4 bredd
17	1	0										
18	2	5										
19	3	10										
20	4	15										
21	5	20										
22	6	25										
23	7	30										
37	21	100										
38												
39	Average											
40												

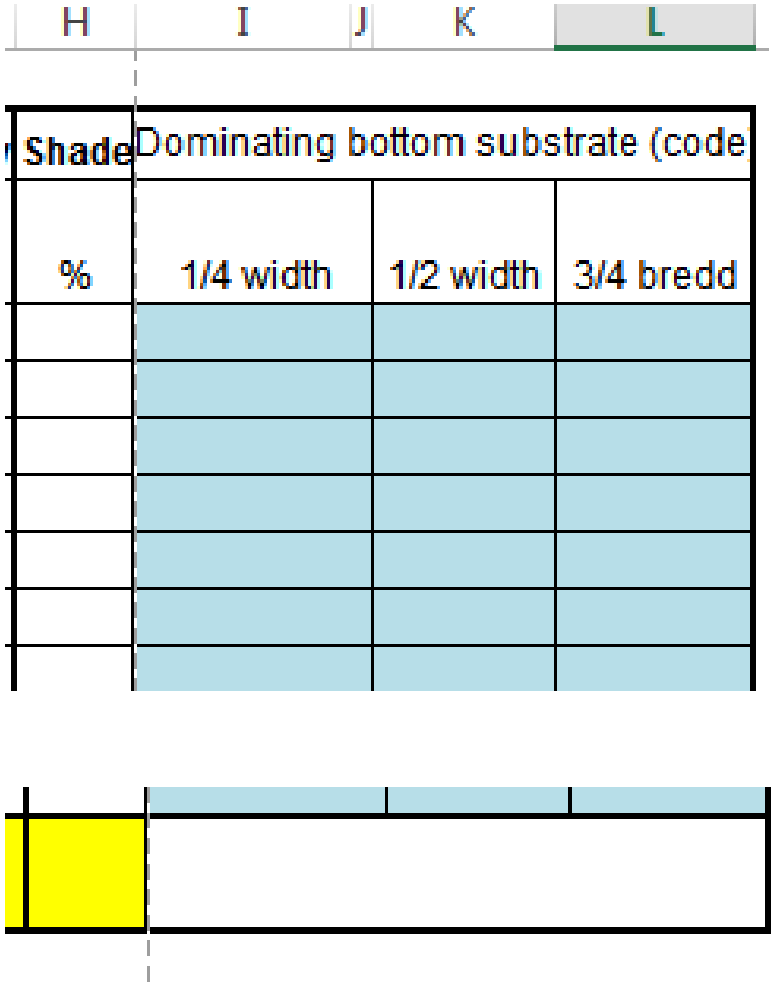
THS field protocol - velocity

VELOCITY	
Code	Velocity
Slow	<0,2 m/s
Moderate	0,2-0,7
Fast	>0,7 m/s



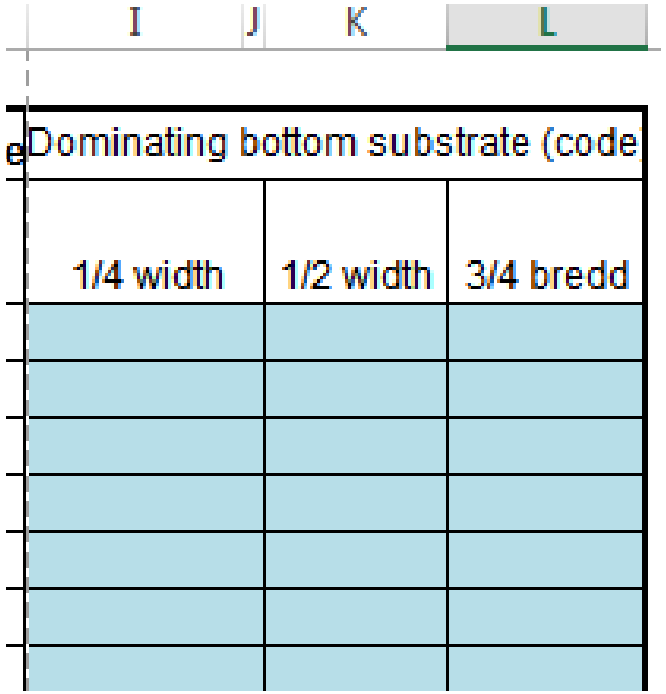
THS field protocol - shade

SHADE (WATERSURFACE)	
Code	Shade
0	0-4%
10	5-14%
20	15-24%
30	25-34%
40	35-44%
50	45-54%
60	55-64%
70	65-74%
80	75-84%
90	85-94%
100	95-100%



THS field protocol - substrate

SUBSTRATE		
CODE		FREQUENCE
1	FINE	
2	SAND	
3	GRAVEL	
4	STONE1	
5	STONE2	
6	BOULDER1	
7	BOULDER2	
8	BOULDER3	
9	FLAT	



	I	J	K	L
e	Dominating bottom substrate (code			
	1/4 width		1/2 width	3/4 bredd

THS field protocol– substrate (cont.)

SUBSTRATE		
CODE		FREQUENCE
1	FINE	
2	SAND	
3	GRAVEL	
4	STONE1	
5	STONE2	
6	BOULDER1	
7	BOULDER2	
8	BOULDER3	
9	FLAT	

I	J	K	L
e	Dominating bottom substrate (code		
	1/4 width	1/2 width	3/4 bredd

41										
42	SUBSTRATE (explanation)	Fine sediment	Sand	Gravel	Smaller stones	Larger stones	Smaller boulders	Medium boulders	Large boulders	Flat
43	Particle size (cm)	<0,02	0,02 - 0,2	0,2 - 2	2 - 10	10 - 20	20 - 30	30 - 40	40 - 200	>200
44	Code	FINE	SAND	GRAVEL	STONE1	STONE2	BOULDER1	BOULDER2	BOULDER3	FLAT
45	**Dominating substrate (D1 - D3)**									
46	**% cover (0 - 3)**									

THS field protocol - substrate (cont..)

SUBSTRATE		
CODE		FREQUENCE
1	FINE	
2	SAND	
3	GRAVEL	
4	STONE1	
5	STONE2	
6	BOULDER1	
7	BOULDER2	
8	BOULDER3	
9	FLAT	

Instruction for Substrate table
Dominating substrate: =D1
Subdominating substratate1: =D2
Subdominating substrate2: =D3
% cover (0-3) classes
***0** = missing **1** < = 5% **2** =5-50% **3** >=50%*

I	J	K	L
e	Dominating bottom substrate (code		
	1/4 width	1/2 width	3/4 bredd

41

42	SUBSTRATE (explanation)	Fine sediment	Sand	Gravel	Smaller stones	Larger stones	Smaller boulders	Medium boulders	Large boulders	Flat
43	Particle size (cm)	<0,02	0,02 - 0,2	0,2 - 2	2 - 10	10 - 20	20 - 30	30 - 40	40 - 200	>200
44	Code	FINE	SAND	GRAVEL	STONE1	STONE2	BOULDER1	BOULDER2	BOULDER3	FLAT
45	**Dominating substrate (D1 - D3)**									
46	**% cover (0 - 3)**									

THS field protocol

– site description

	A	B	C	D	E
1	SITE DESCRIPTION; NOT IN THS BUT MAY ALSO BE OF IMPORTANCE				
2	**Vegetation:**				
3		**In water**		**On bank**	
4		Type	% cover	Type	% cover
5	- type 1				
6	- type 2				
7	- type 3				
8					
9	**Surrounding area:**				
10			Type		
11	most common				
12	second common				
13	third common				
14					
15	**Impacts (e.g., climate, forestry, agriculture,**				
16		type	Code		
17	**None (=0)**			Code	
18	**- impact 1**			1	medium
19	**- impact 2**			2	strong
20	**- impact 3**			3	very strong
21					
22	**Number of downstream lakes:**				
23	**- upstream**				
24	**- downstream**				
25					

THS field protocol

– site description

25	
26	Type of trout population (migrating to sea, migrating to lake, stationary)
27	Stocked trout (Yes or No):
28	
29	Spawning grounds (<200 m, 200-1000 m, > 1 km)
30	- at site
31	
32	Cover, hiding places (<25%, 25-75%, >75%):
33	
34	Wood in water (number per 100 m2):
35	
36	Number of migration barriers:
37	- upstream
38	- downstream
39	
40	Predator density (mammals, fish, birds)
41	Diseases:
42	

Thank you!

Questions?