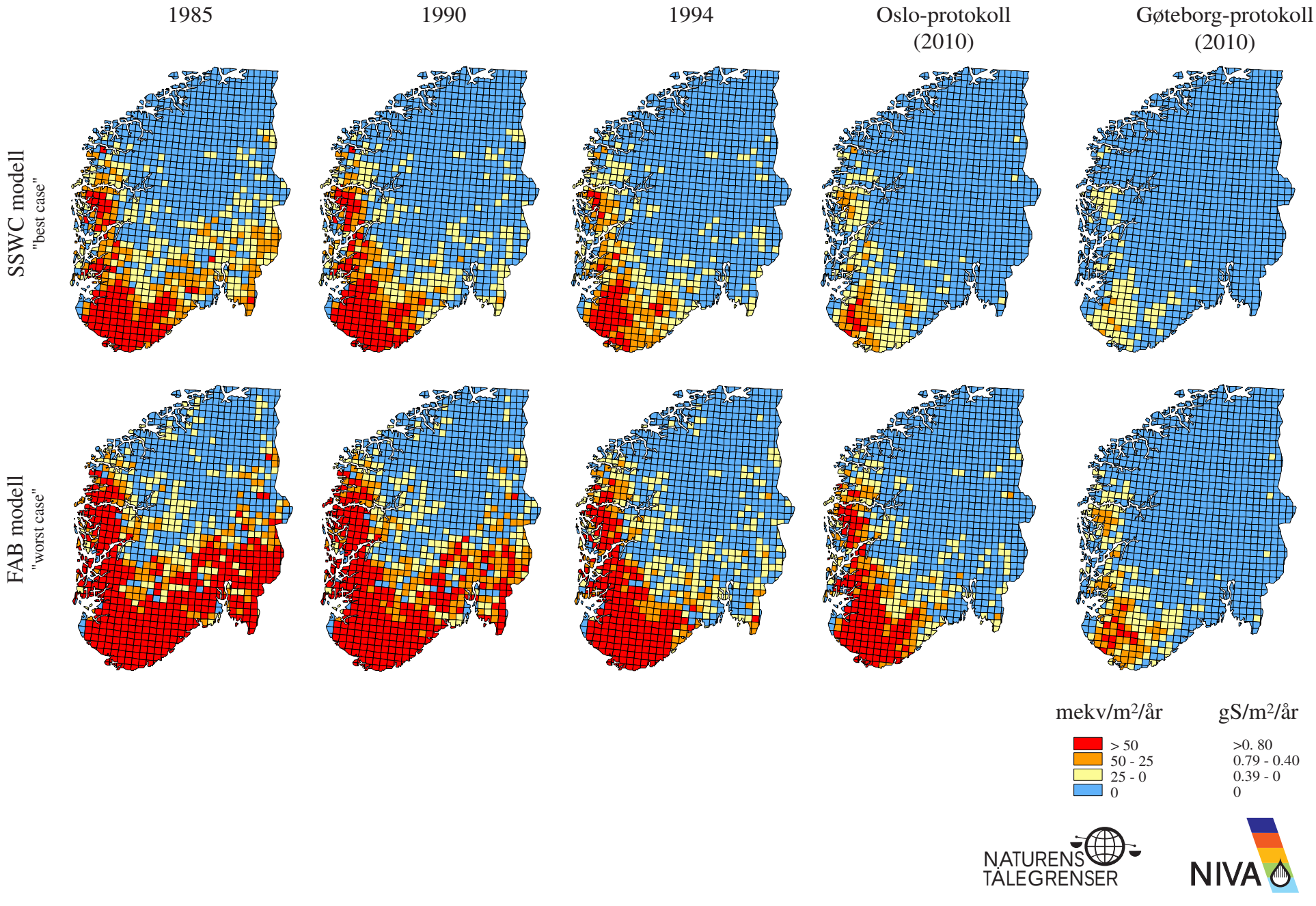
Effekter av forsuring og kalking på fisk og krepsdyr i innsjøer i Enningdalsvassdraget.

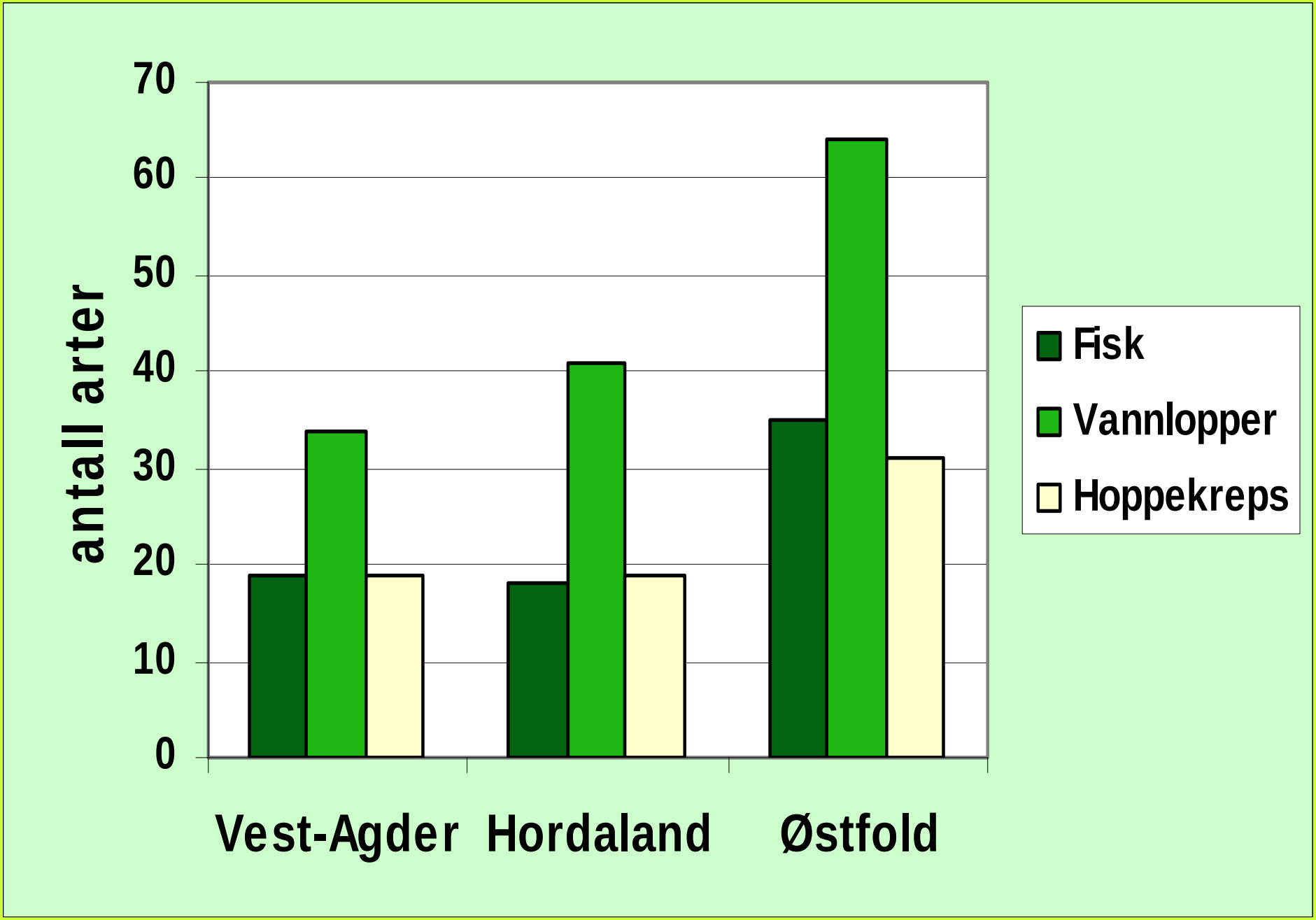
Trygve Hesthagen & Bjørn Walseng,
NINA
Leif Roger Karlsen, Fylkesmannen i Østfold,
Fredrik Nilsson og Andreas Bäckstrand,
Ländsstyrelsen i Västra Götaland



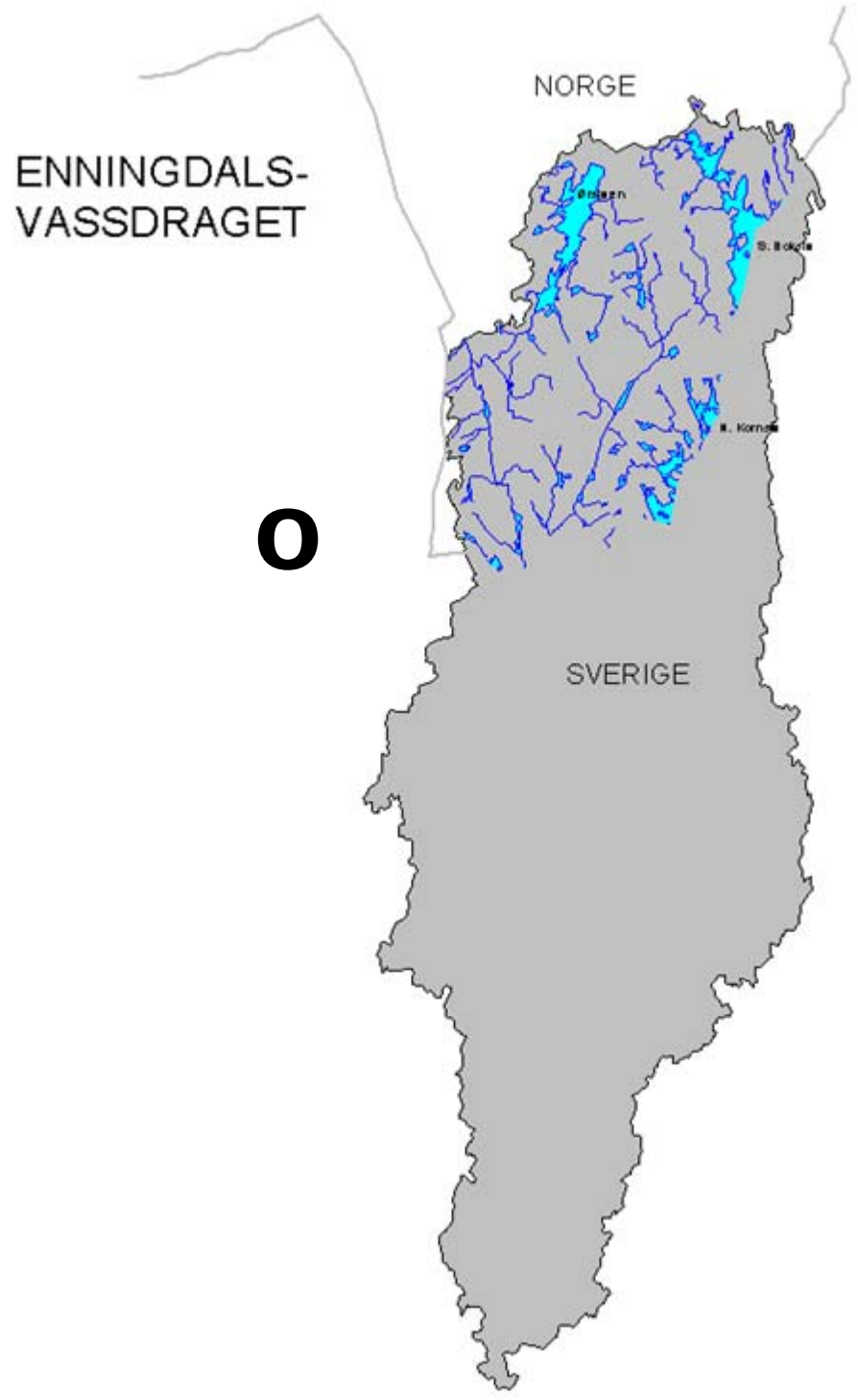


Overskridelse av tålegrenser for sur nedbør i Norge




70
60
50
40
30
20
10
0
antall arter
Vest-Agder
Hordaland
Østfold
Fisk
Vannlopper
Hoppekreps


NORDFJORD
LUSTER
HAMAR
SERNA
BERGENHUS
AKERSHUS
HARDANGER
Bergen
BRUNLA
Oslo
BRATSBERG
TØNS-
BERG
SMÅ-
LENENE
Enningdals-
vassdraget
STAVANGER
BRUNLA
RÅBYGGE-
LAGET
NEDENES
BÅHUS
LISTER
MAN-
DAL

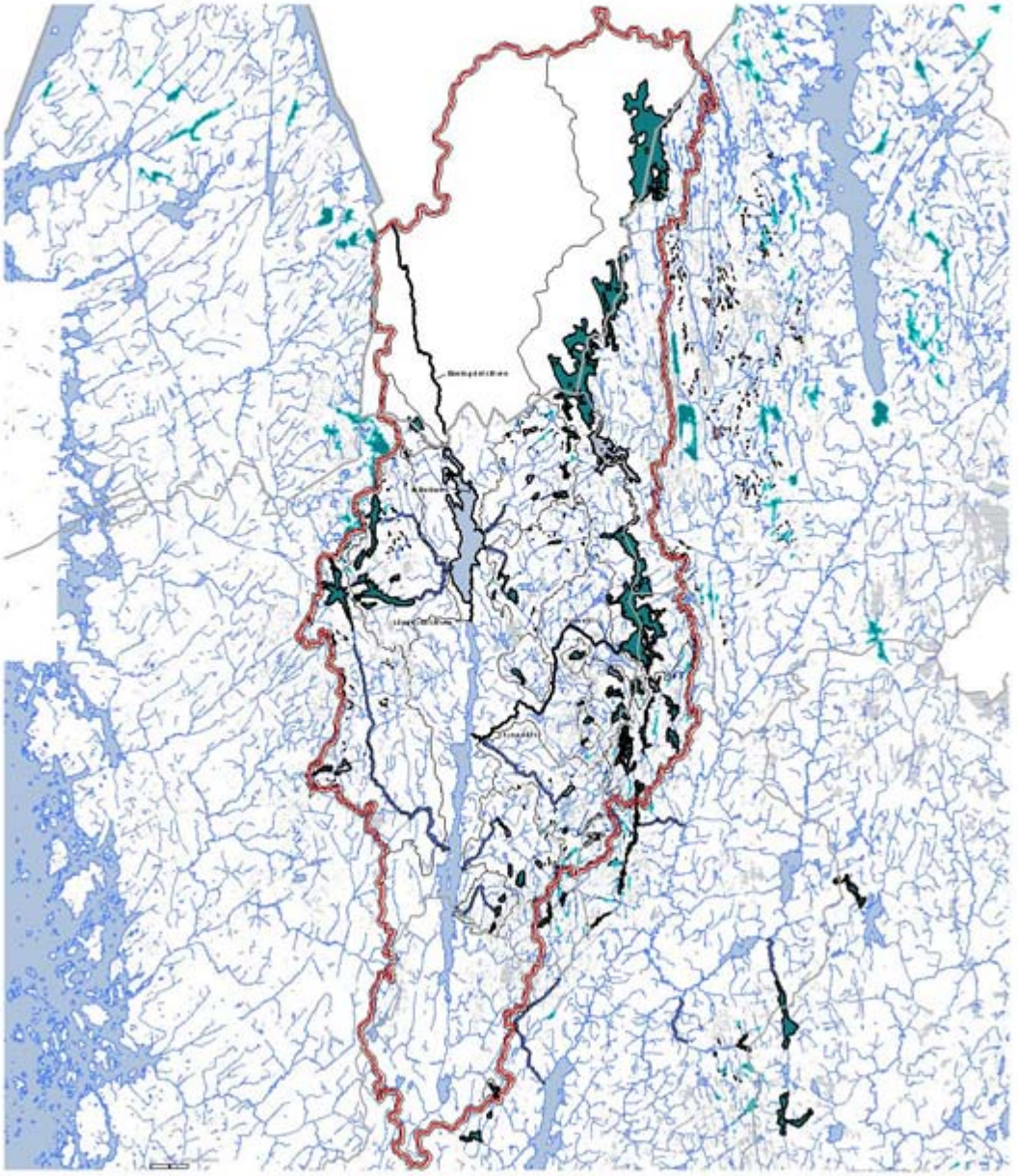

NORGE
ENNINGDALS-
VASSDRAGET
SVERIGE



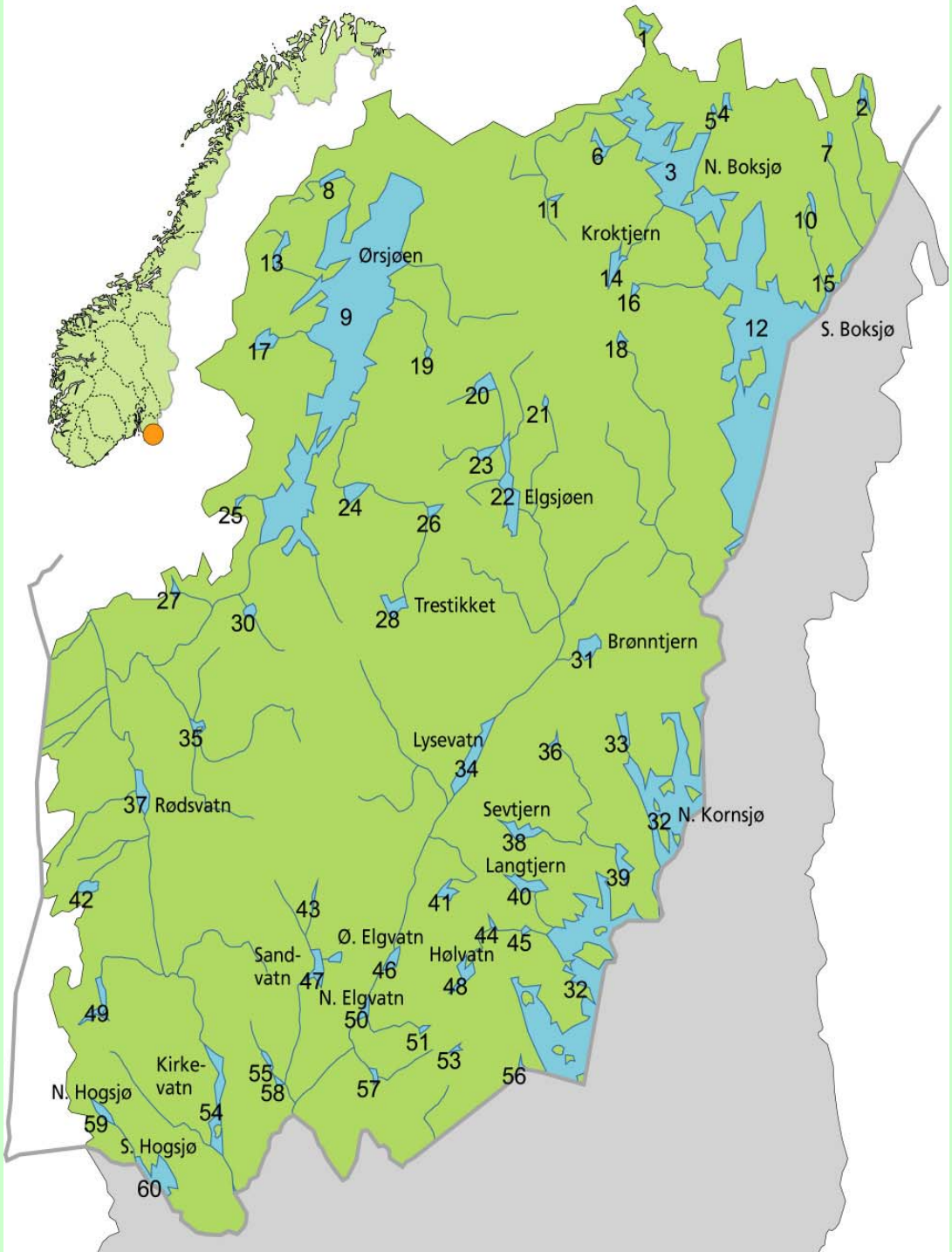
Regional åtgärdsplan för kalkning i sjöar och vattendrag 2003-2007

ENNINGDALSÄLVEN
Enningdalsälvens avrinningsområde





Enningdal catchment area



- Forsura vann pH<5,0
- Ukalkede, svakt forsura vann pH 5,5-6,0
- Kalkede vann 6,0-7,0



Historiske data på fisk

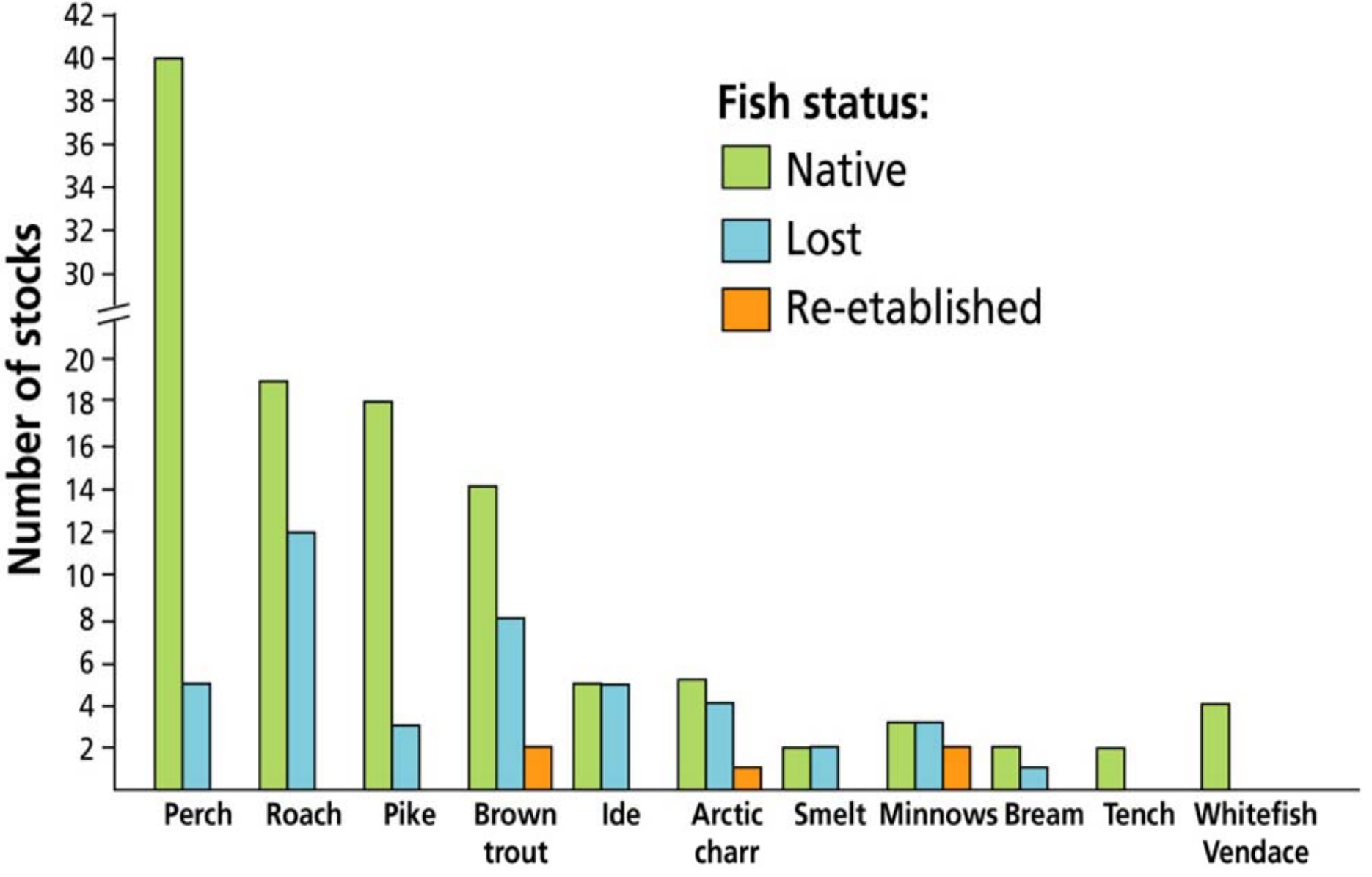
- Huitfeldt-Kaas 1918
- Vasshaug & Vøllestad 1990:

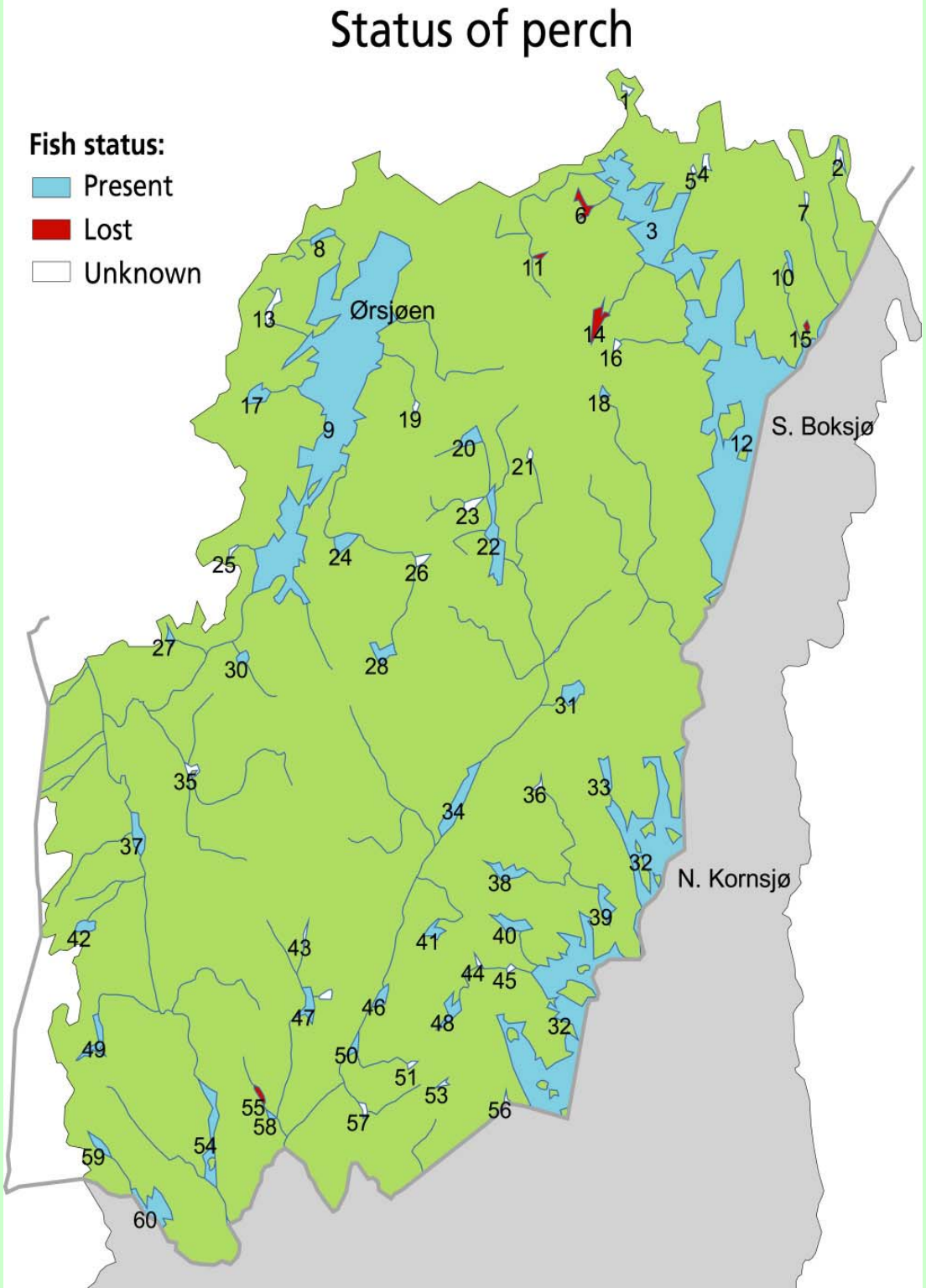
  Vasshaug kartla fiskestatus i 150 fiskevann på 1950-tallet

- Intervju-undersøkelse 2000/2001:

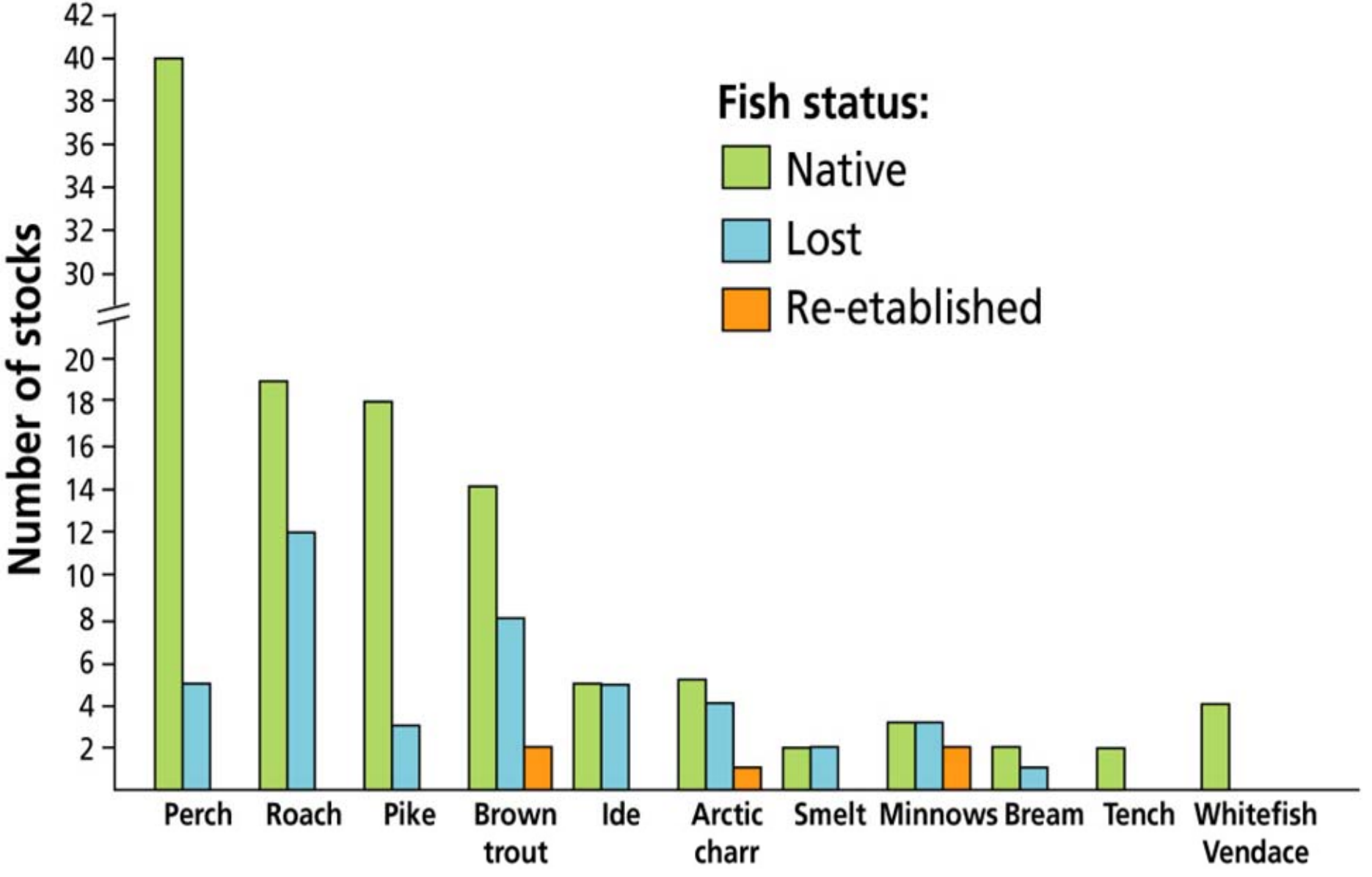
- 42 vann
- 114 bestander
- > 42 bestander tapt (sur nedbør?)

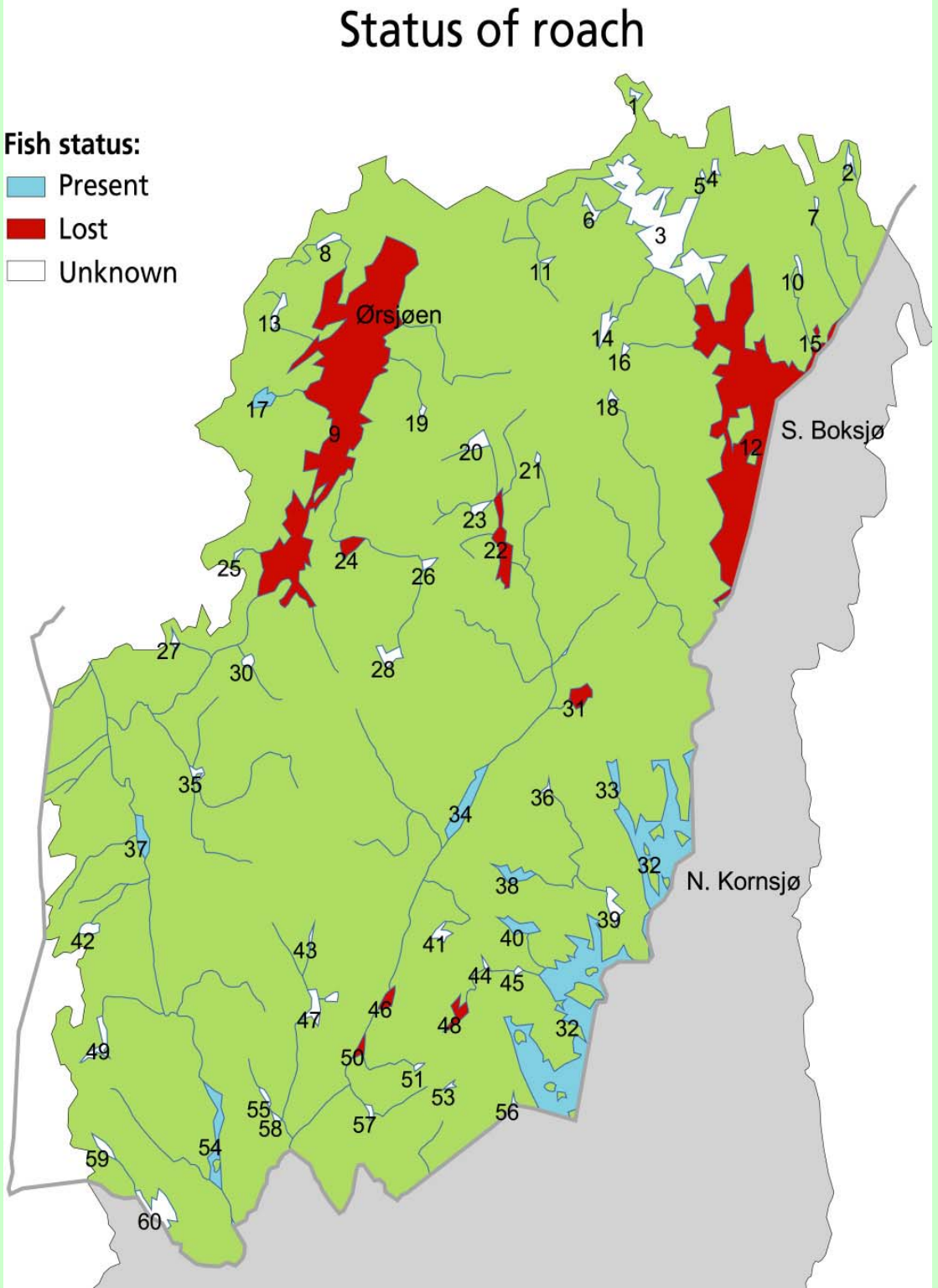



Number of stocks
42
40
38
36
34
32
30
20
18
16
14
12
10
8
6
4
2
Fish status:
Native
Lost
Re-established
Perch
Roach
Pike
Brown trout
Ide
Arctic charr
Smelt
Minnows
Bream
Tench
Whitefish
Vendace

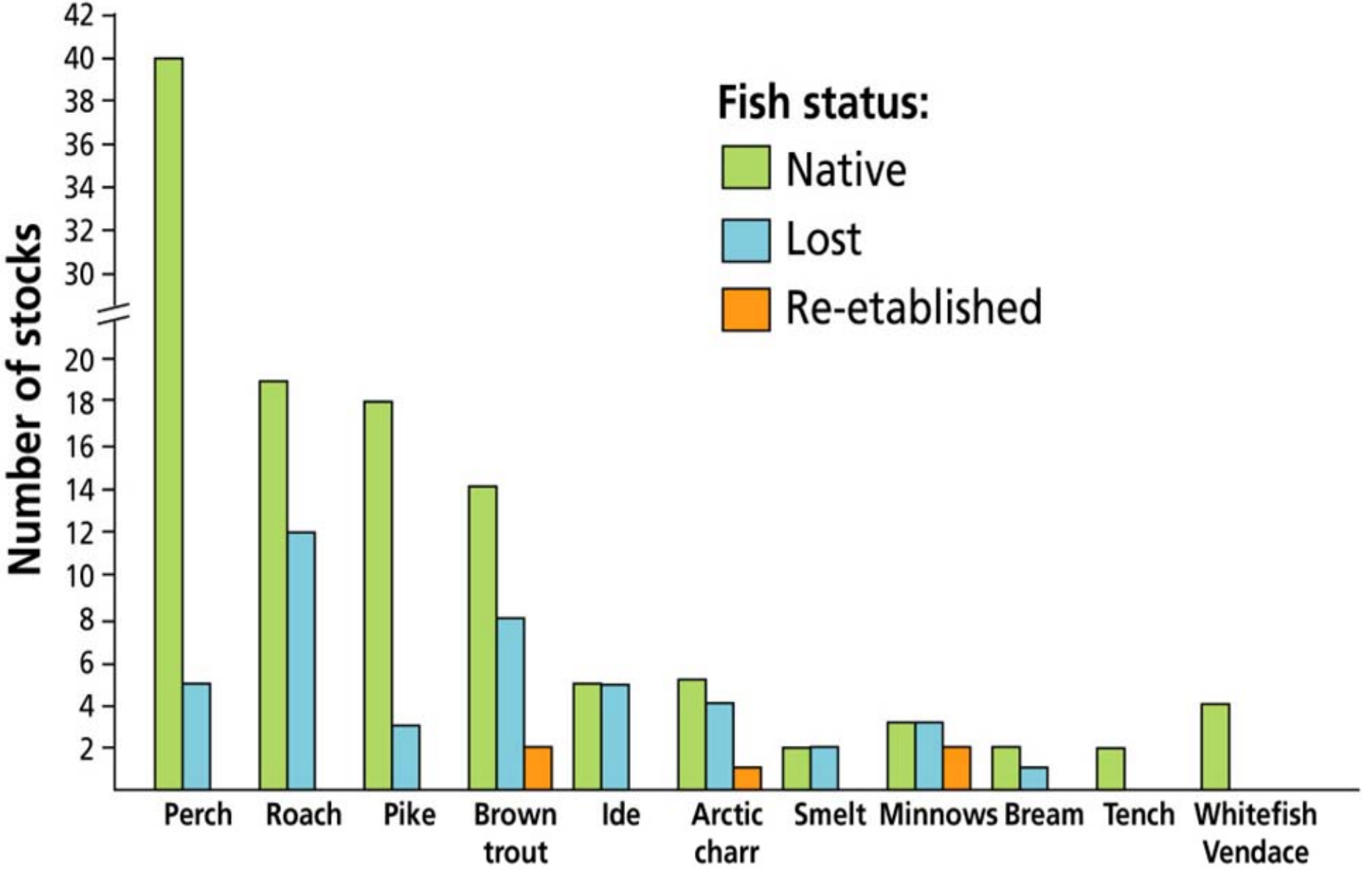

Status of perch
Fish status:
Present
Lost
Unknown
Ørsjøen
S. Boksjø
N. Kornsjø
1
2
3
54
6
7
8
11
10
13
14
15
16
17
18
9
19
20
12
21
23
22
25
24
26
27
30
28
31
35
36
33
34
37
32
38
39
42
43
41
40
44
45
46
47
48
32
49
50
51
53
55
58
57
56
54
59
60

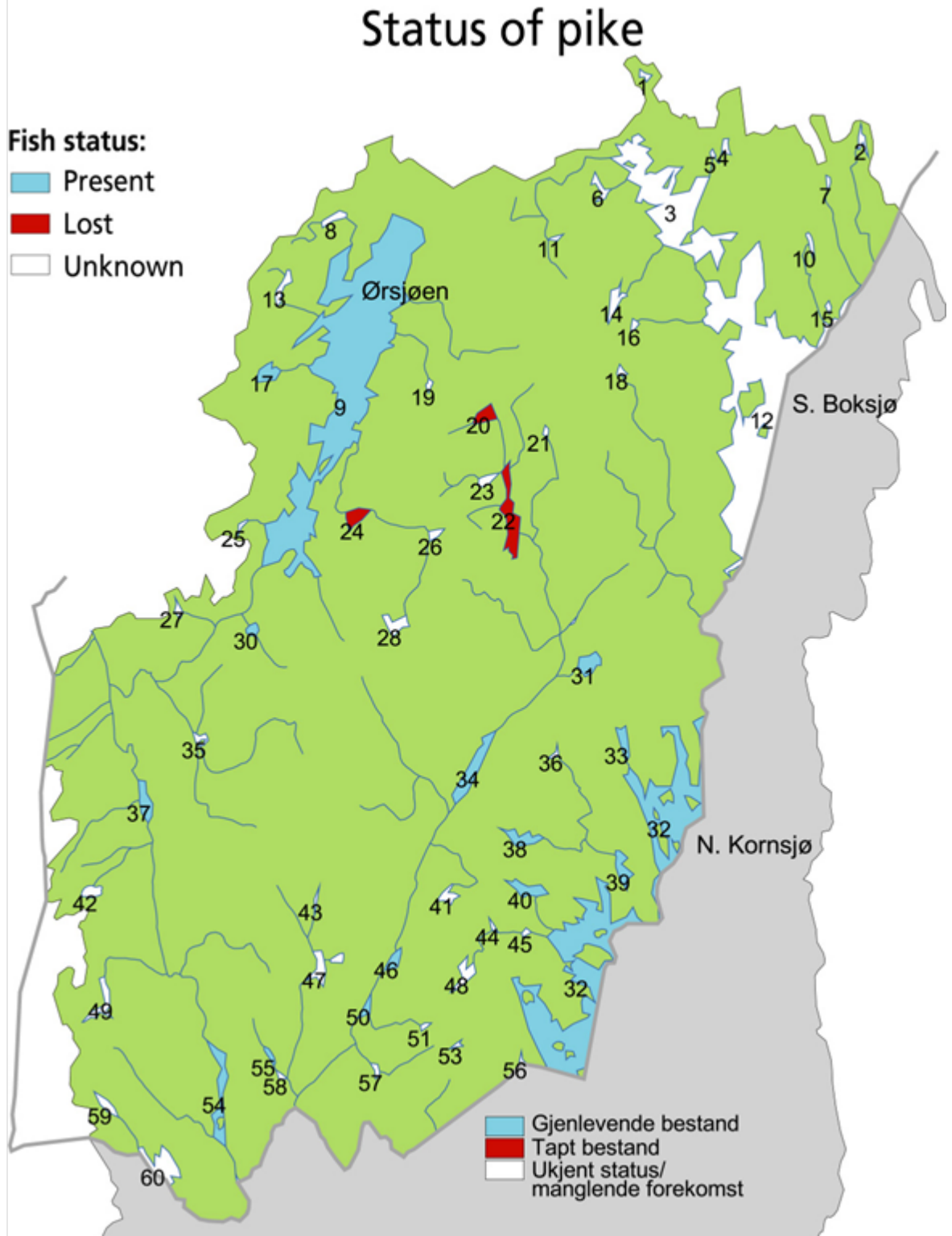



Number of stocks
42
40
38
36
34
32
30
20
18
16
14
12
10
8
6
4
2
Fish status:
Native
Lost
Re-established
Perch
Roach
Pike
Brown trout
Ide
Arctic charr
Smelt
Minnows
Bream
Tench
Whitefish
Vendace


Status of roach
Fish status:
Present
Lost
Unknown
Ørsjøen
S. Boksjø
N. Kornsjø
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
53
54
55
56
57
58
59
60




Number of stocks
42
40
38
36
34
32
30
20
18
16
14
12
10
8
6
4
2
Fish status:
Native
Lost
Re-established
Perch
Roach
Pike
Brown trout
Ide
Arctic charr
Smelt
Minnows
Bream
Tench
Whitefish
Vendace


Status of pike
Fish status:
Present
Lost
Unknown
Ørsjøen
S. Boksjø
N. Kornsjø
Gjenlevende bestand
Tapt bestand
Ukjent status/
manglende forekomst


Feltstasjon
Prøvefiske fra 2002
8 vann årlig



2002-2007:
Prøvefisket og prøvetatt for krepsdyr:

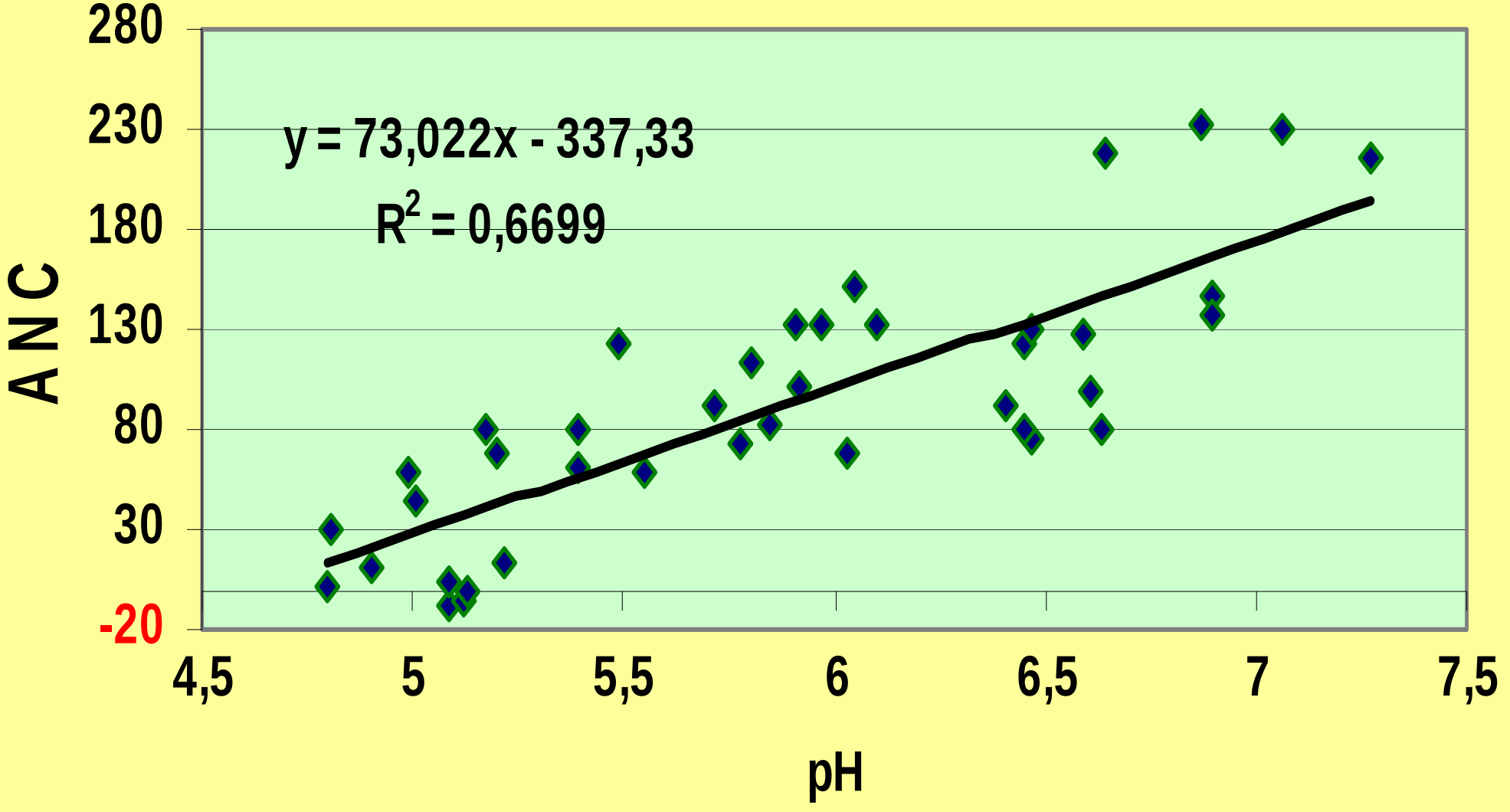
Norge: 48 vann
Sverige: 18 vann

22 arter
> 10 000 individer

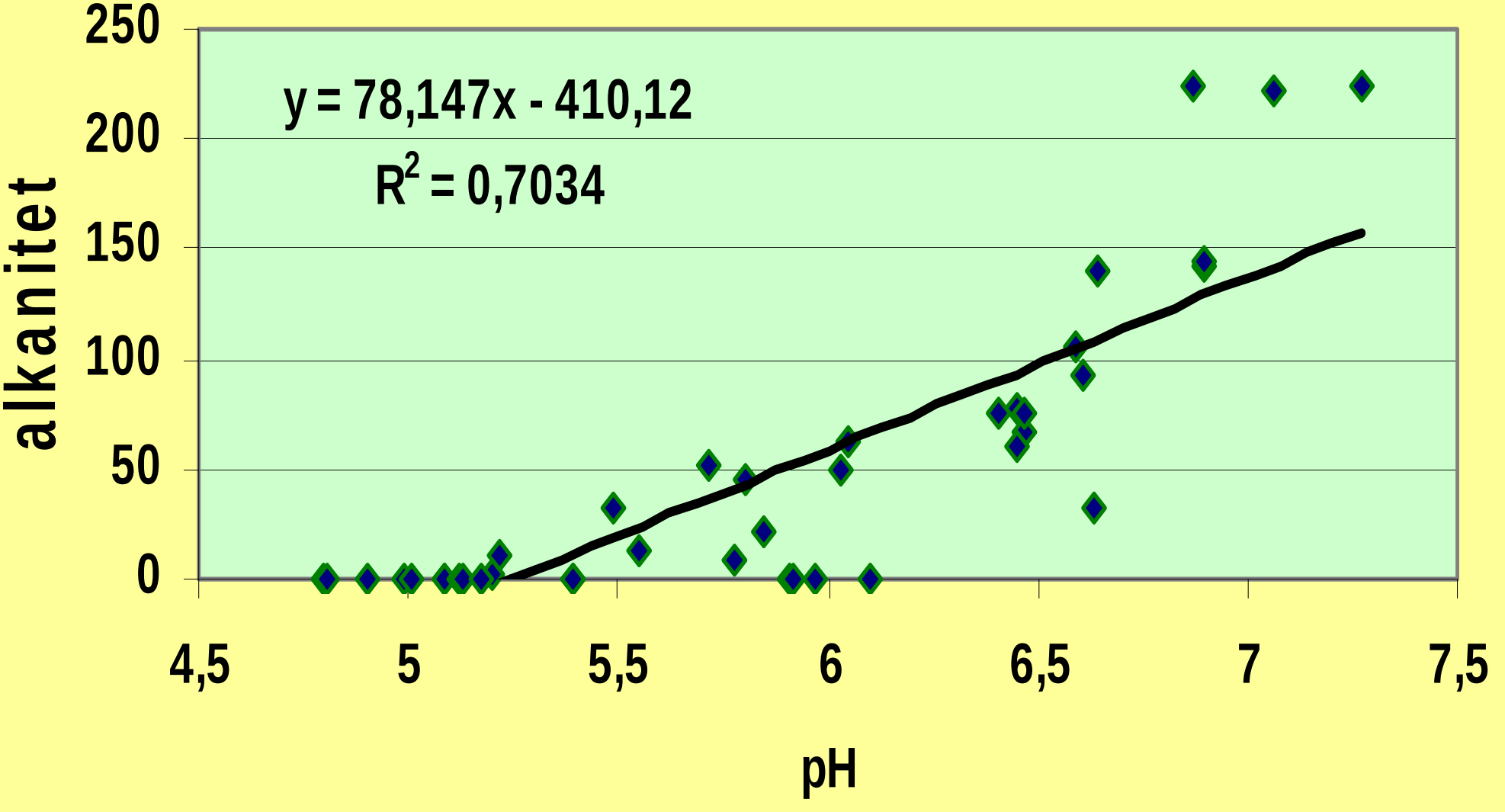
Gjennomsnittlige verdier for noen vannkjemiske parametre i ikke-kalka og kalka innsjøer

	pH	Labilt Al	ANC
Ikke-kalka	5.25	37 µg/L	38 µekv/L
Kalka	6.61	3 µg/L	142 µekv/L

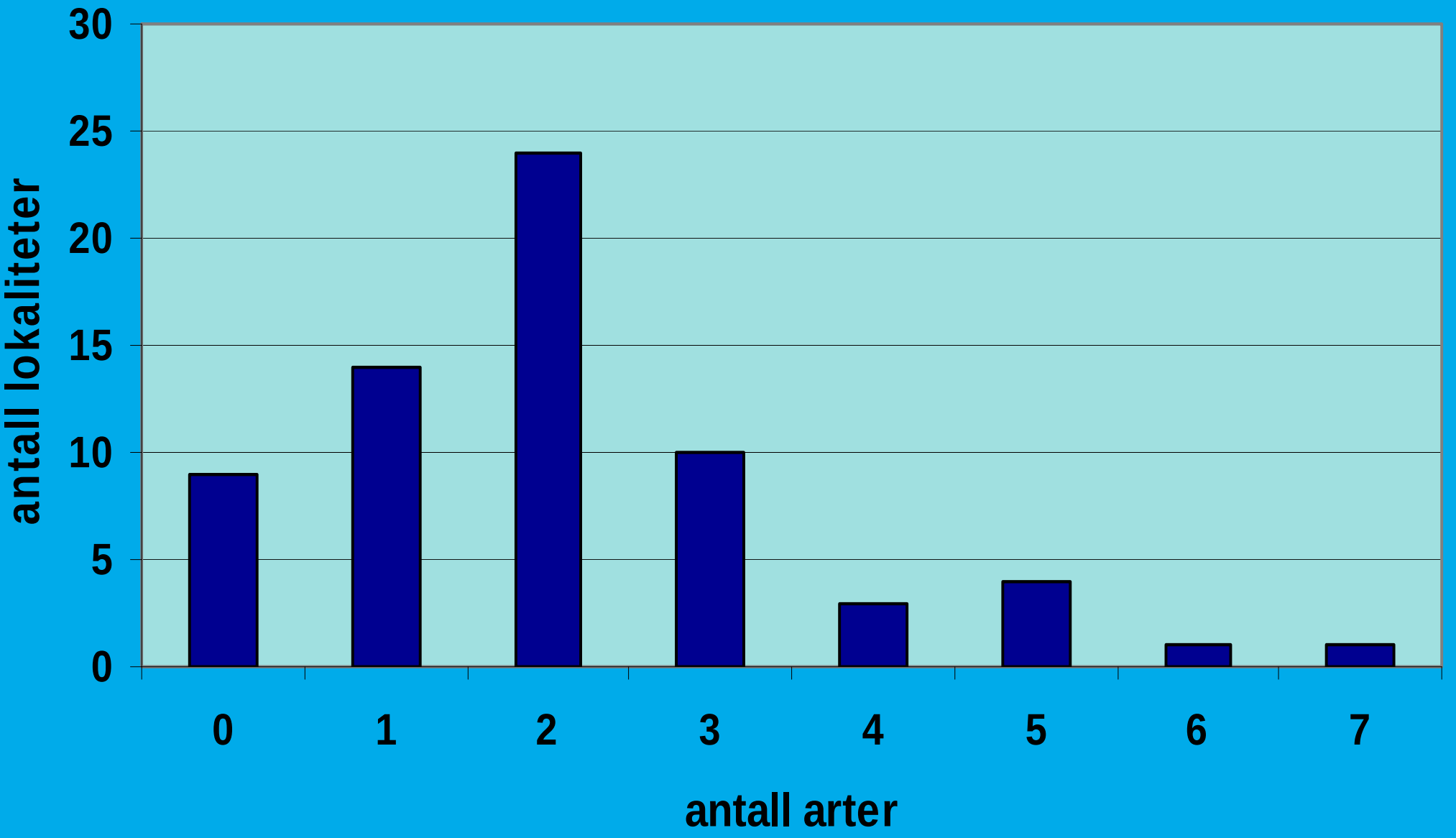
Enningdalsvassdraget

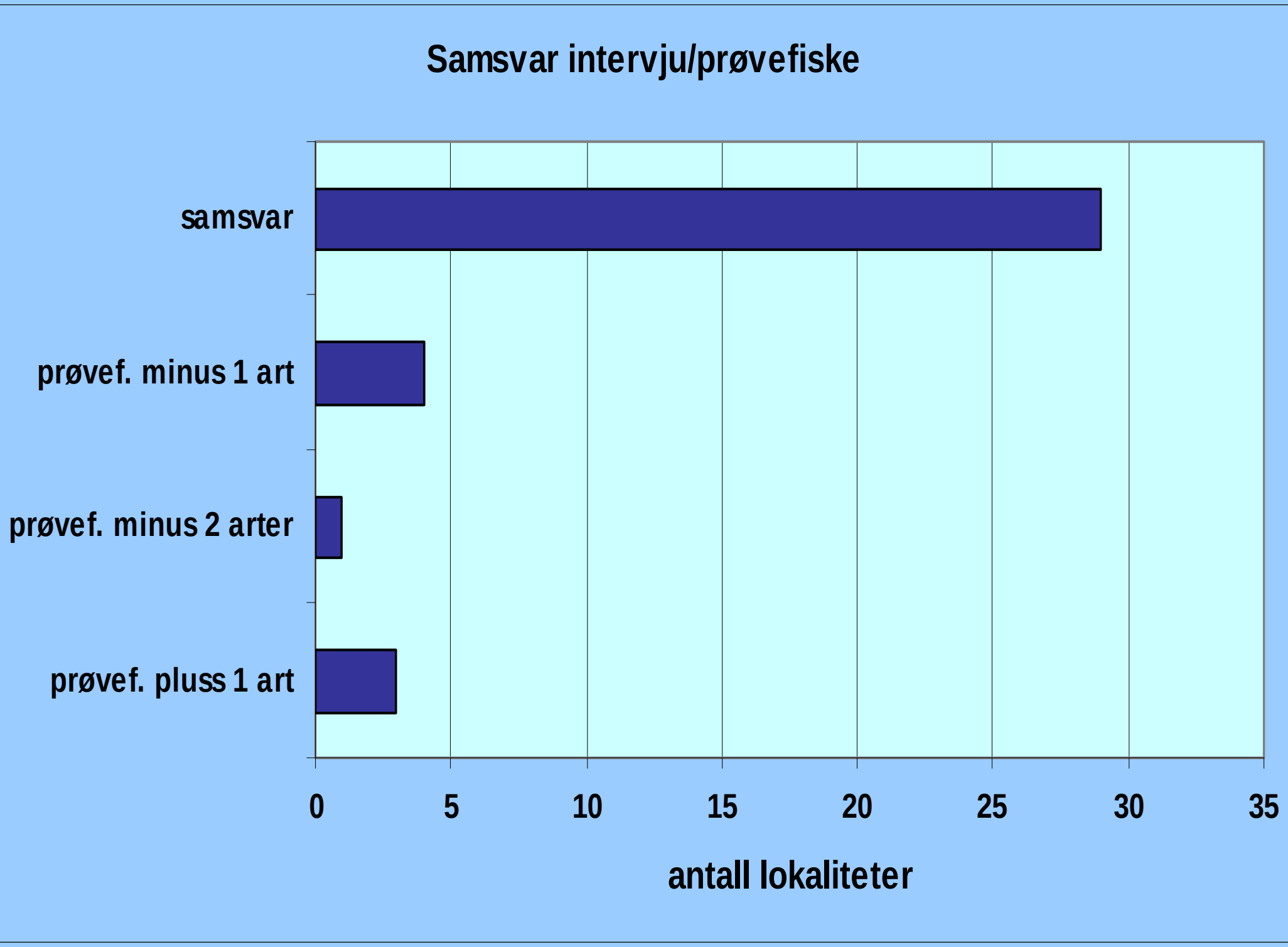


Enningdalsvassdraget



Enningdalsvassdraget 2002-2007 (n=66)

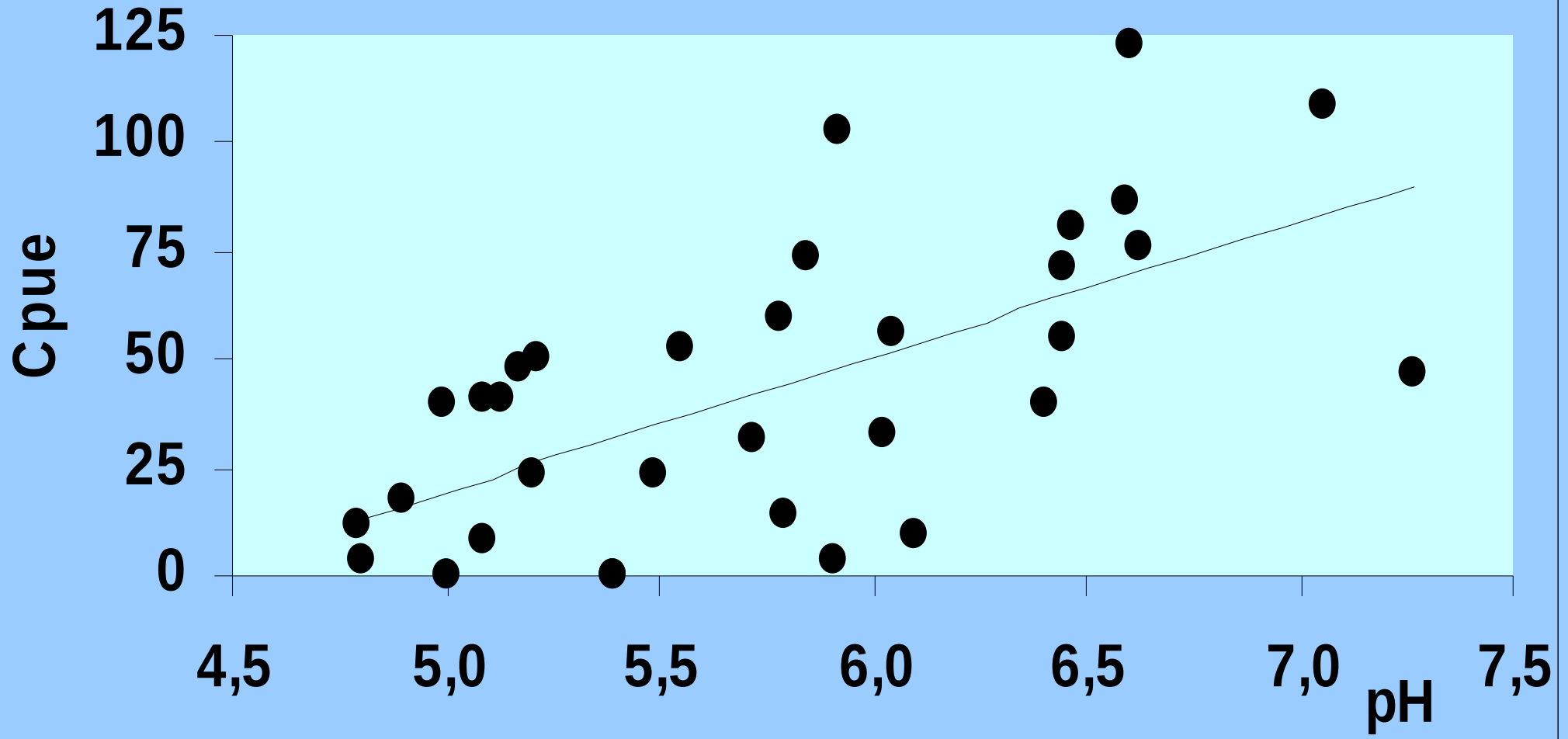



Samsvar intervju/prøvefiske
samsvar
prøvef. minus 1 art
prøvef. minus 2 arter
prøvef. pluss 1 art
0
5
10
15
20
25
30
35
antall lokaliteter

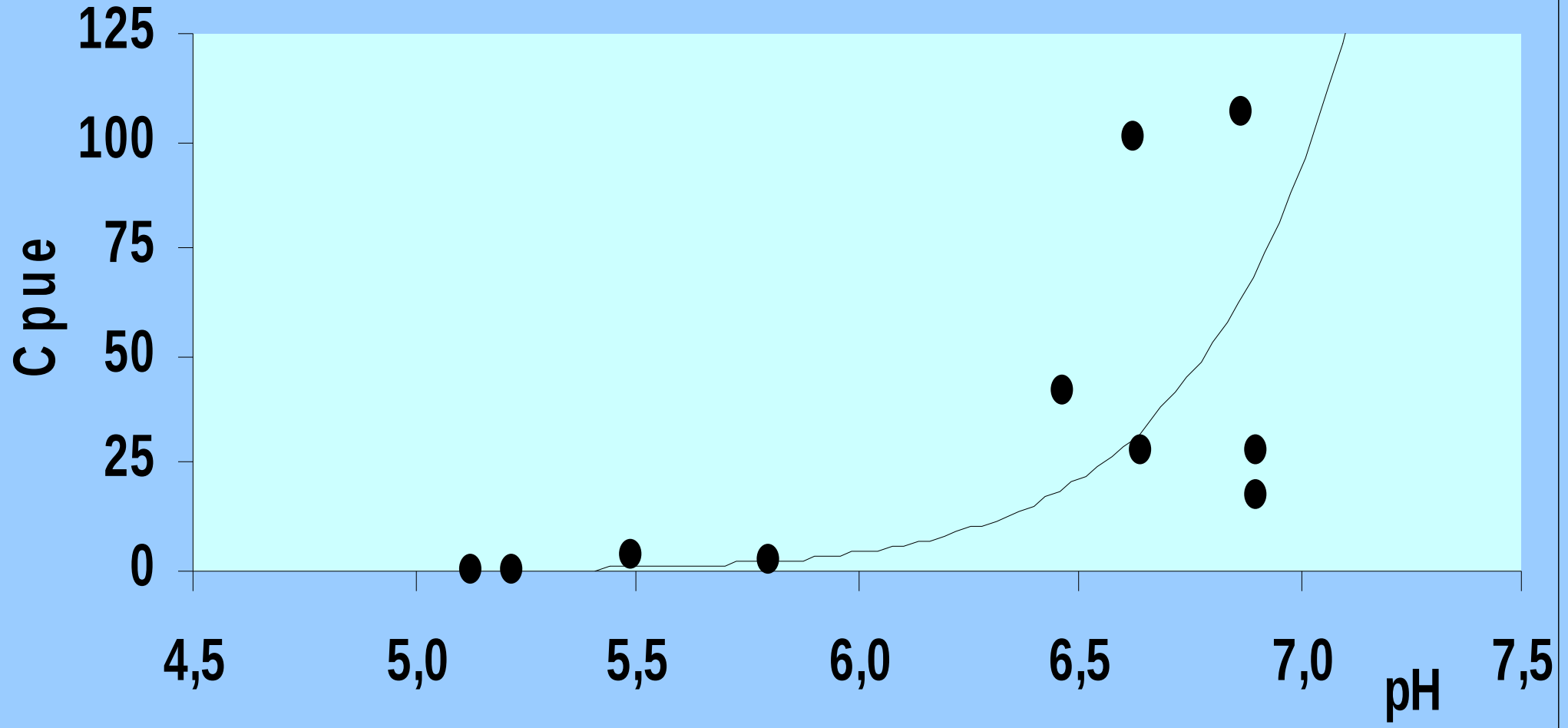

Hjelpestikker



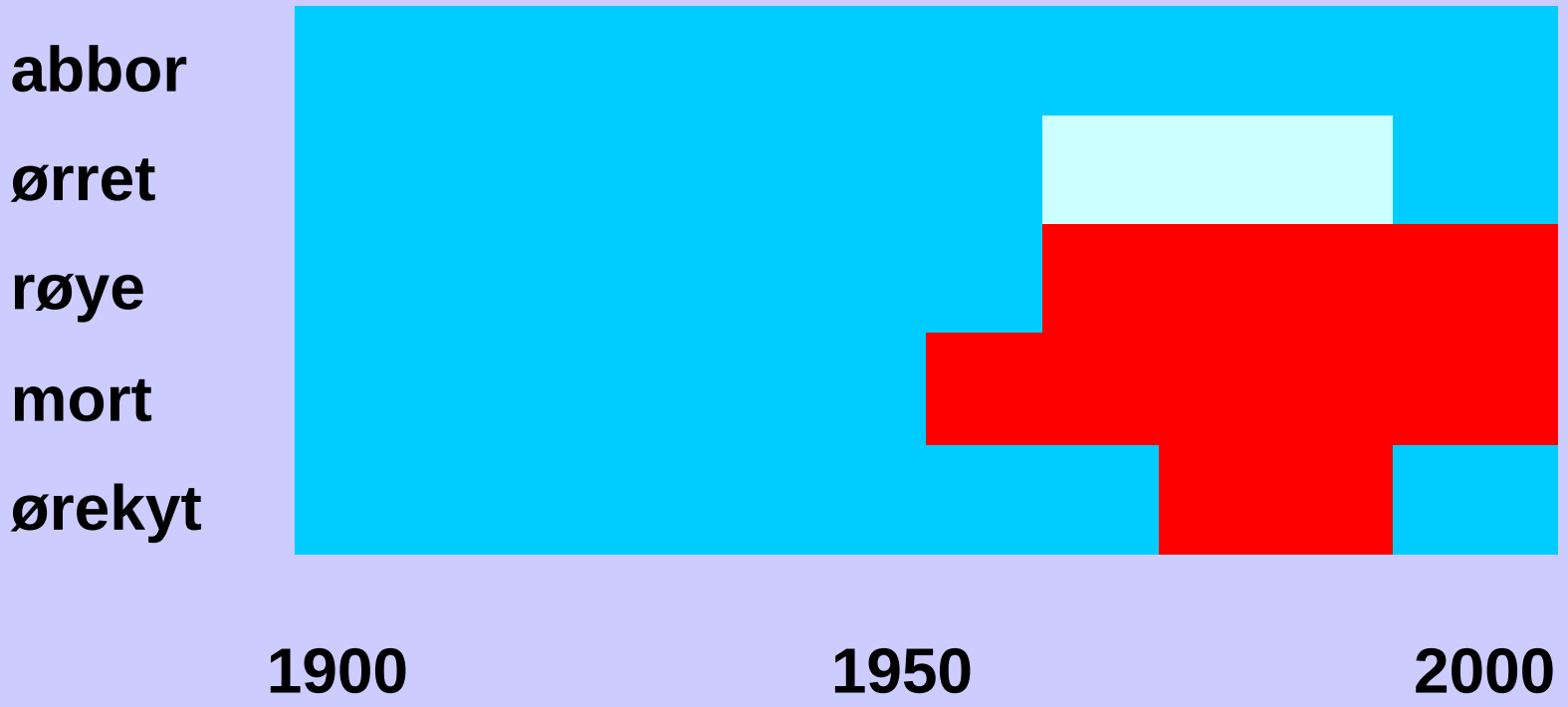
Abbor



Mort



Nordre Boksjø

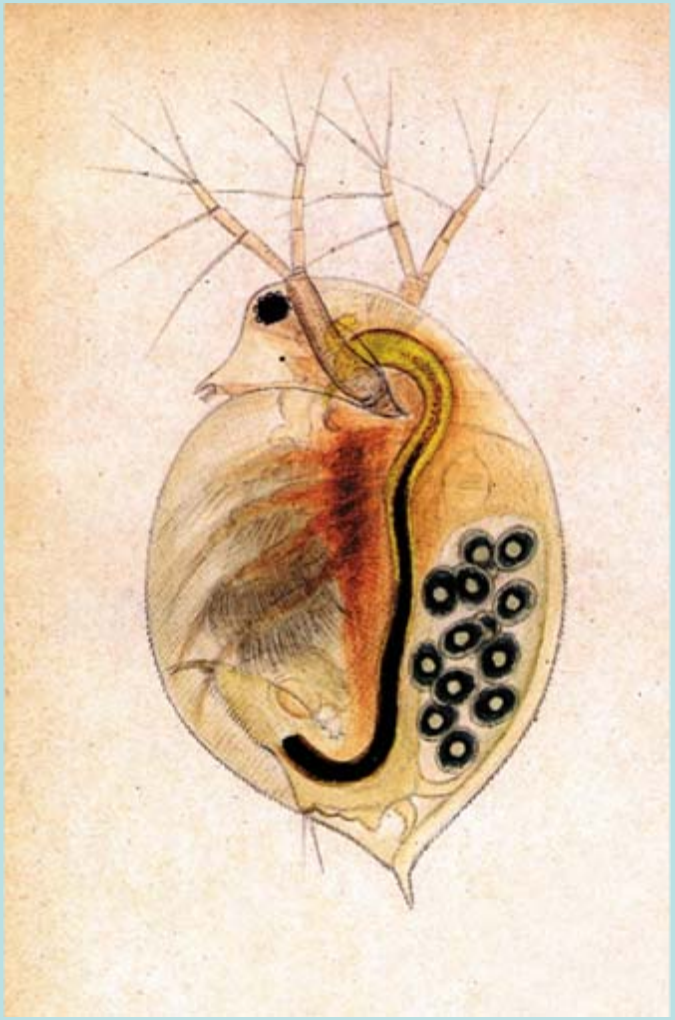



FISKING
FORBUDT

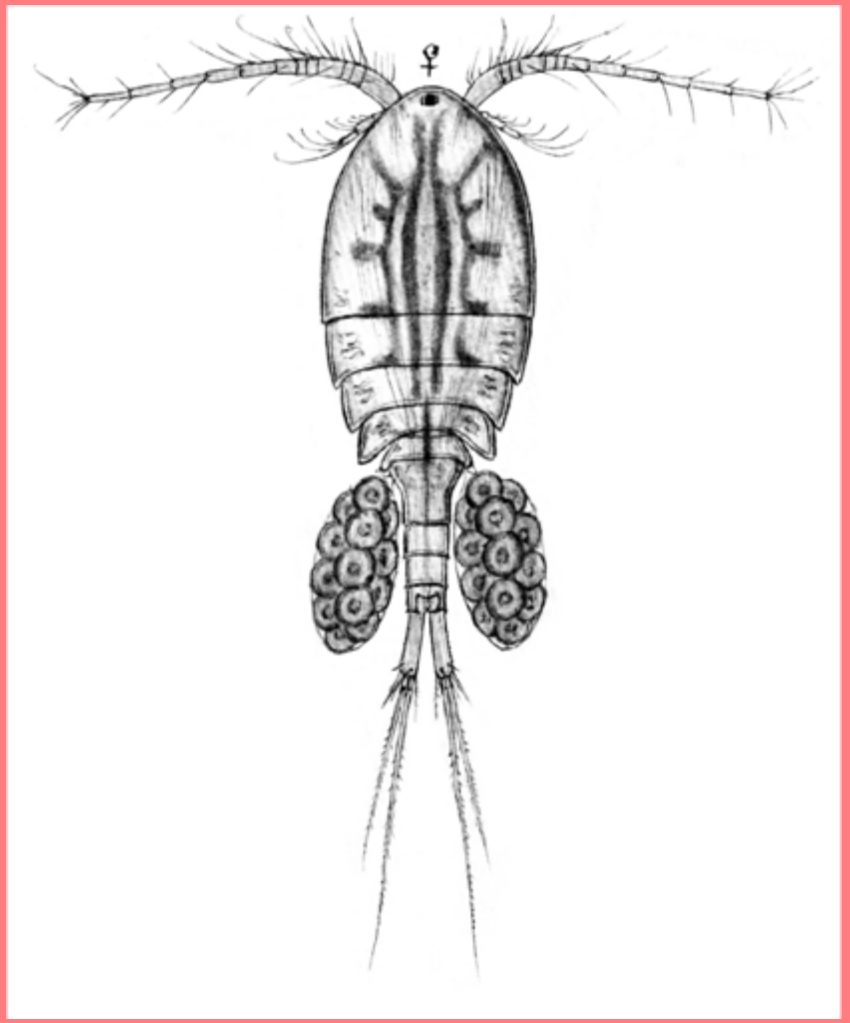
G.O. SARS



Vannlopper: 85 arter



Hoppekreps: 50 arter



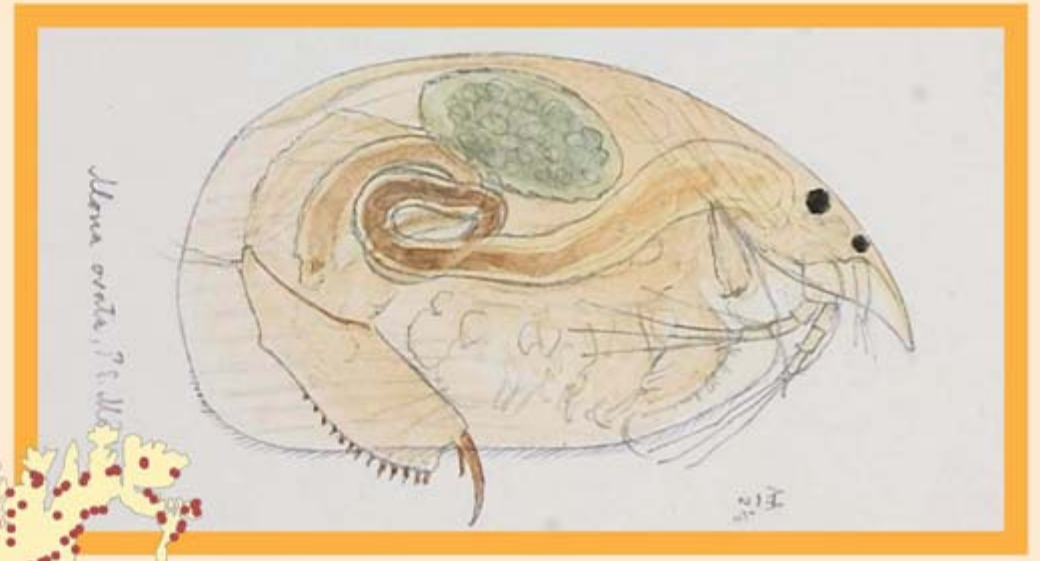
Også informasjon om:

- innsjø areal
- høyde over havet
- pH
- ledningsevne

Alona affinis (Leydig 1860)

Family chydoridae, Stebbing

Genus Alona, Baird 1843



Key characteristics:

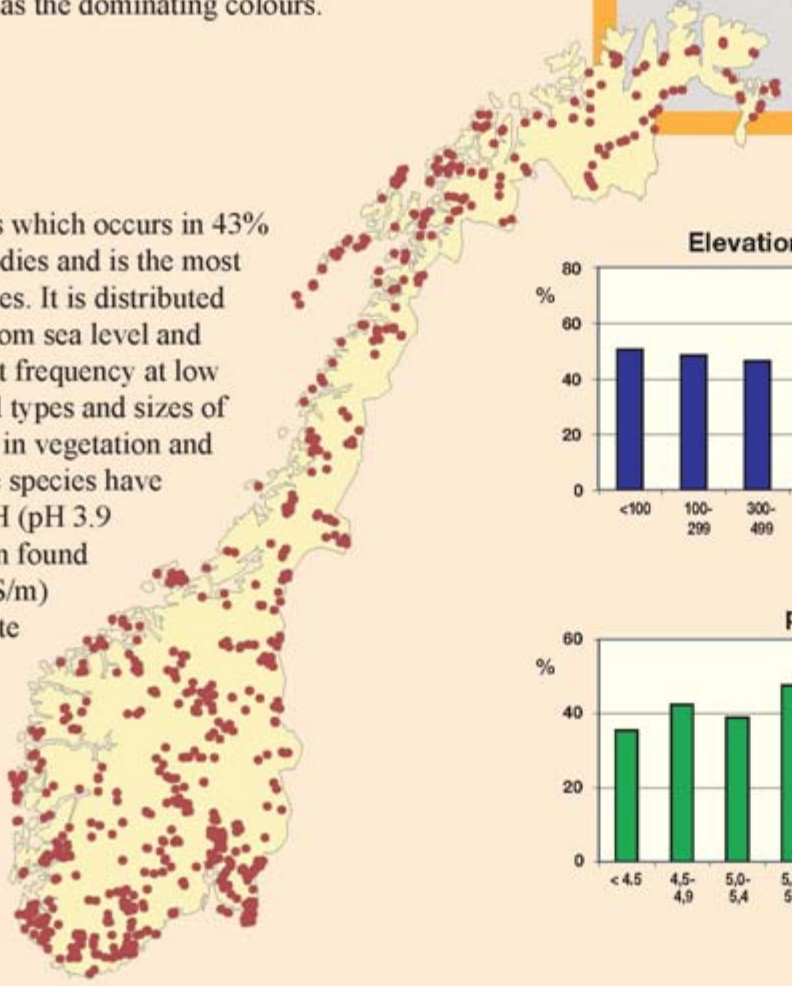
A. affinis is the largest species in the genus *Alona*. Its postabdomen has an oval form and is similar to the postabdomen of *A. quadrangularis* with altogether 14-18 teeth. It differs from the latter species having 4-6 fine spinules on the basal spine close to the base. In contrast to *A. quadrangularis*, *A. affinis* have two instead of three head pores. Its colour varies with brown and read as the dominating colours.

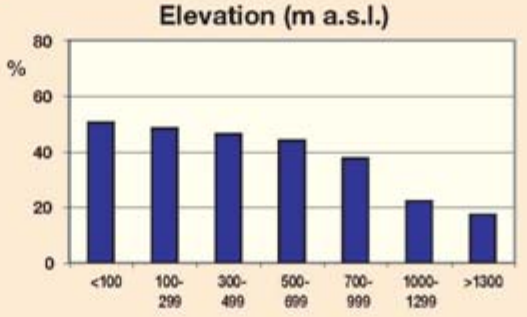
Female: 0.6 - 1.3 mm.

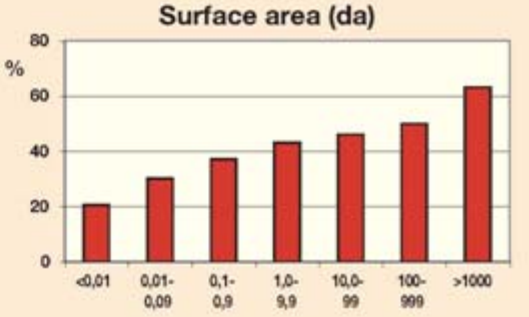
Male: 0.7 - 0.9 mm.

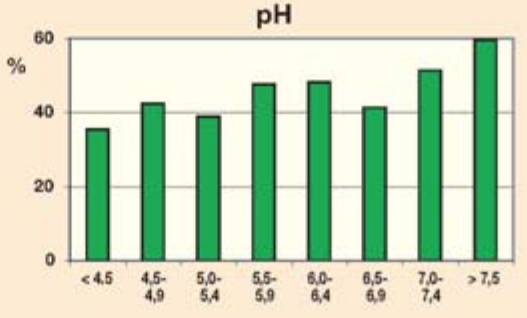
Distribution:

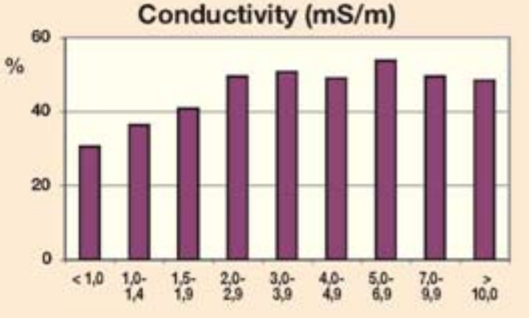
A. affinis is a littoral species which occurs in 43% of the investigated water bodies and is the most common of the *Alona*-species. It is distributed in all parts of the country from sea level and to 1396 m a.s.l. with highest frequency at low altitudes. It's common in all types and sizes of water bodies and lives both in vegetation and on stony/sandy bottom. The species have a wide tolerance towards pH (pH 3.9 - pH 9.1). *A. affinis* has been found in brackish water (957.0 mS/m) and occurs also in very dilute mountain waters (0.4 mS/m).





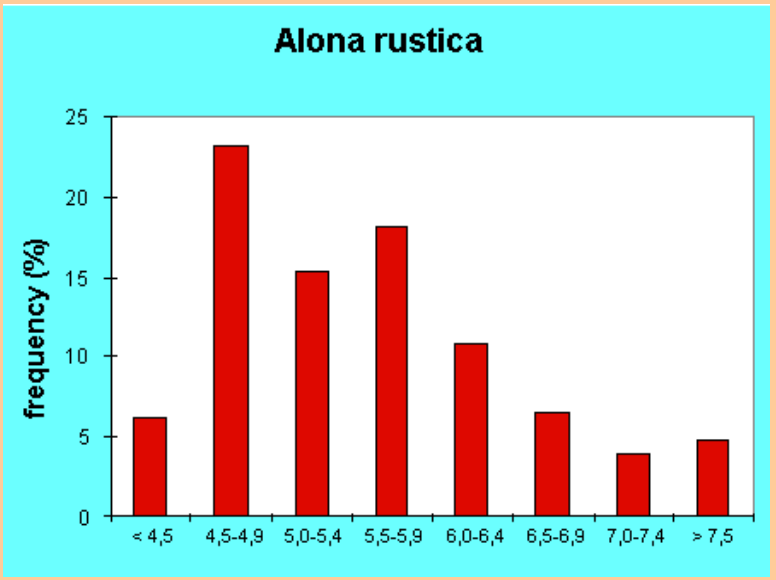


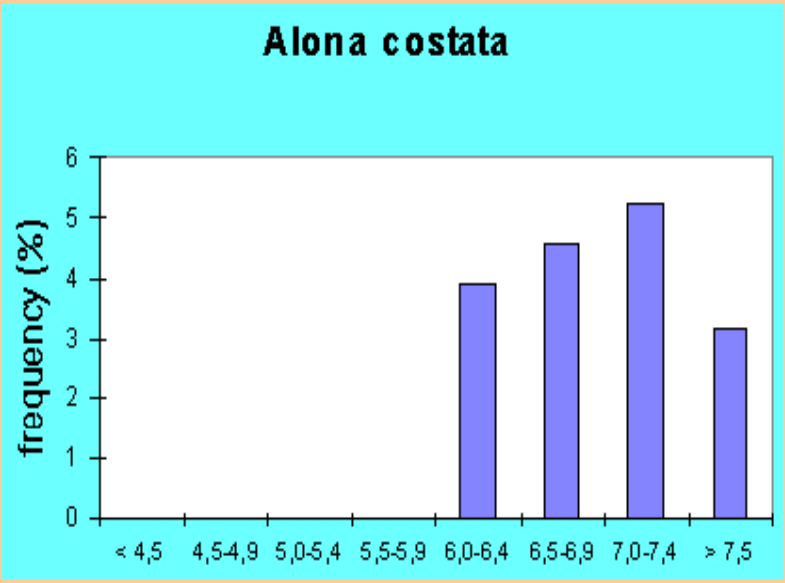




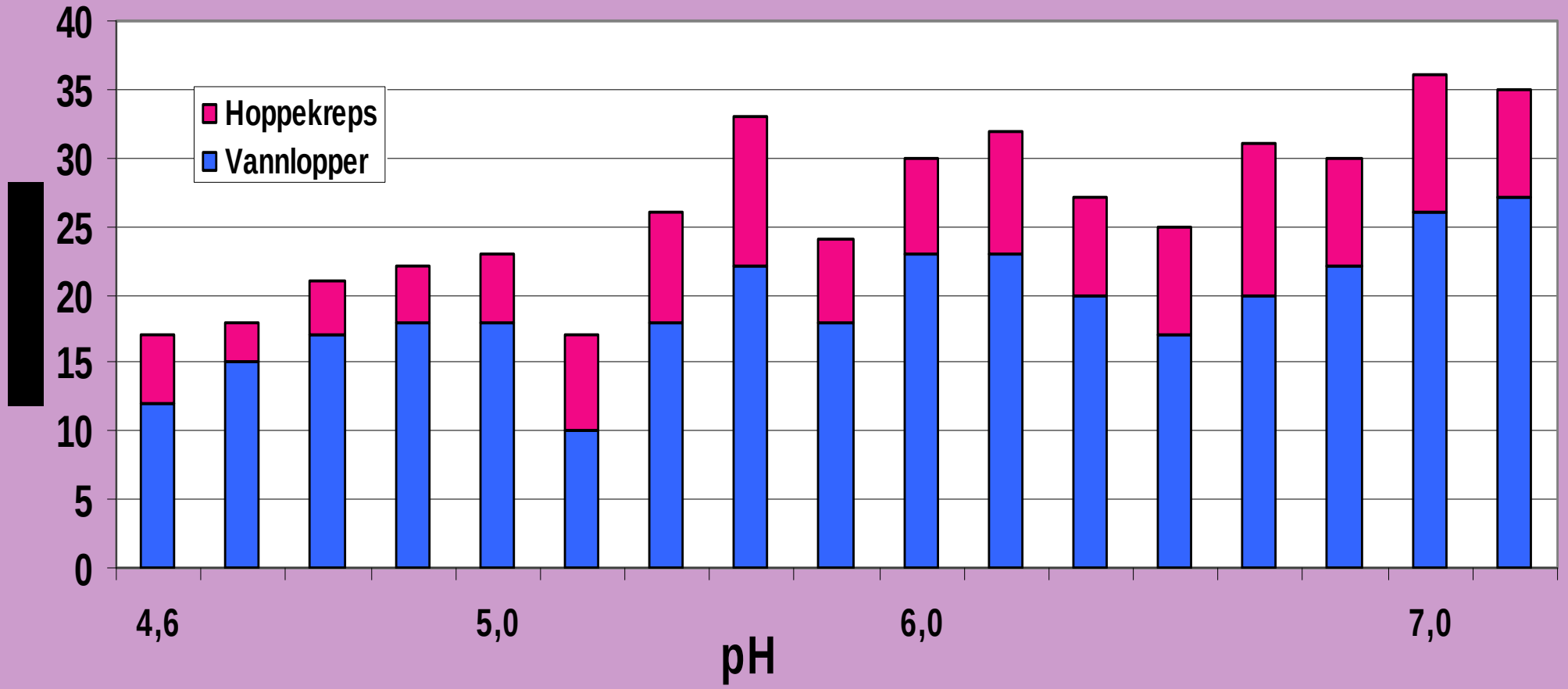
The occurence of two Alona sp. due to pH

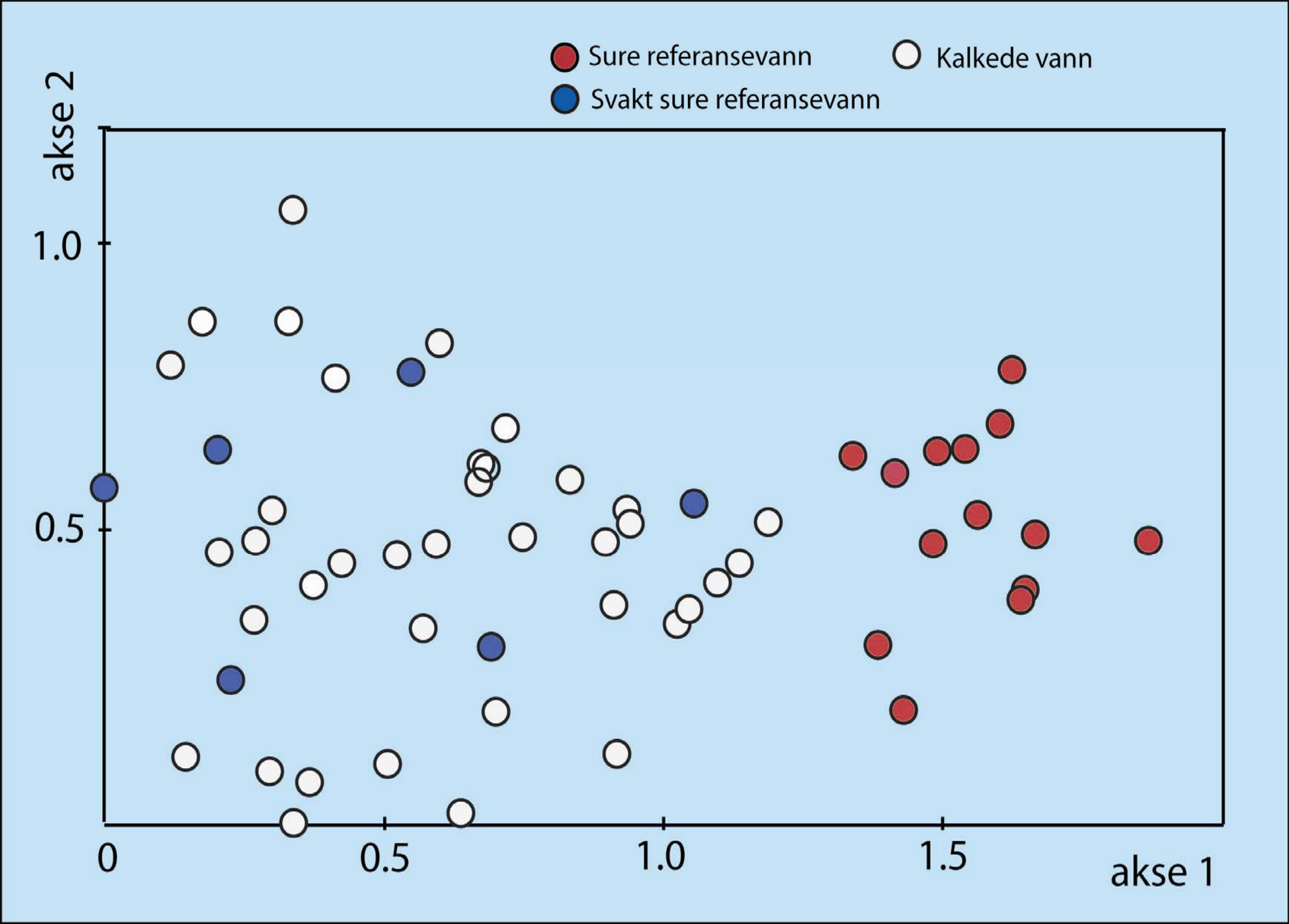


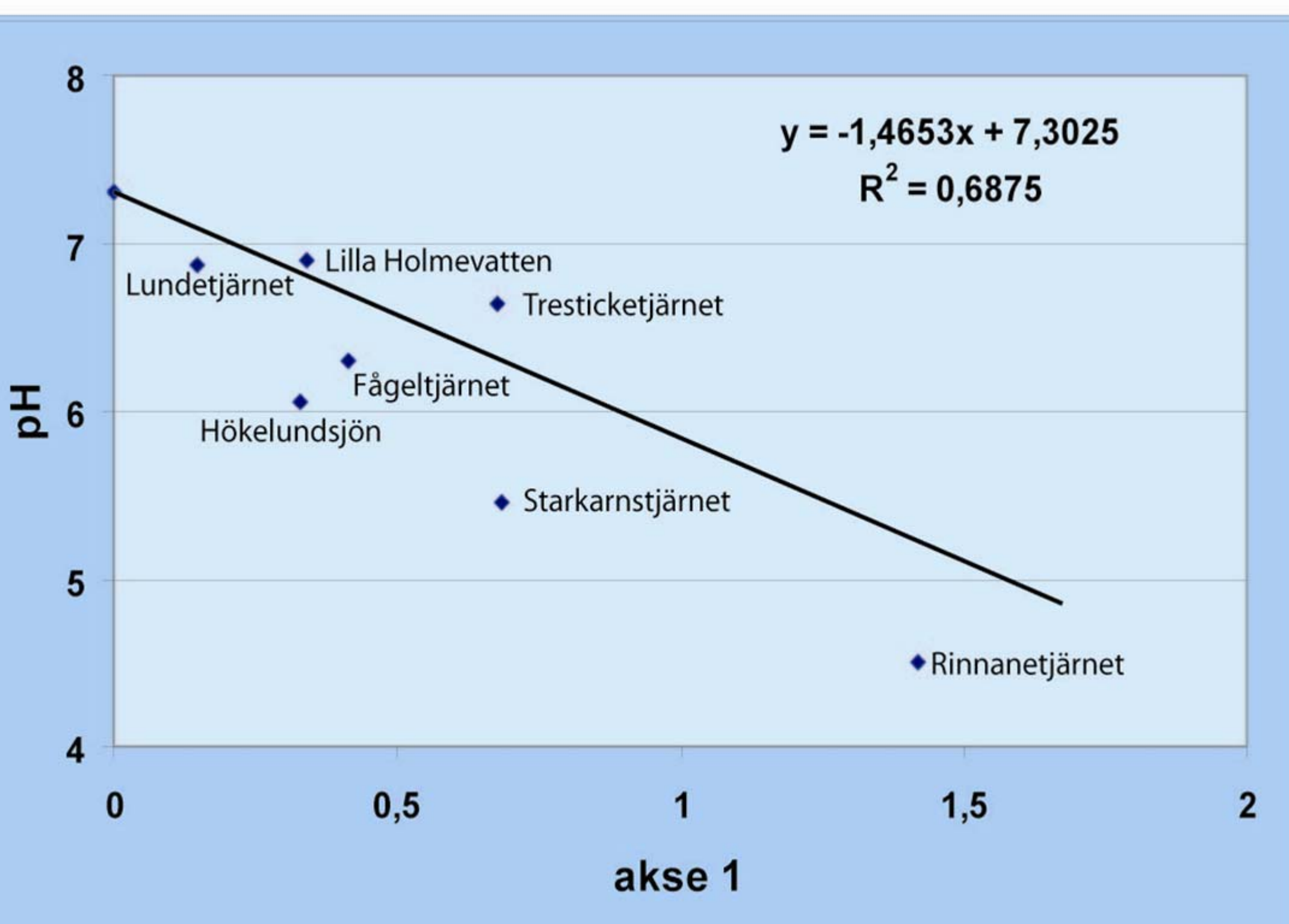


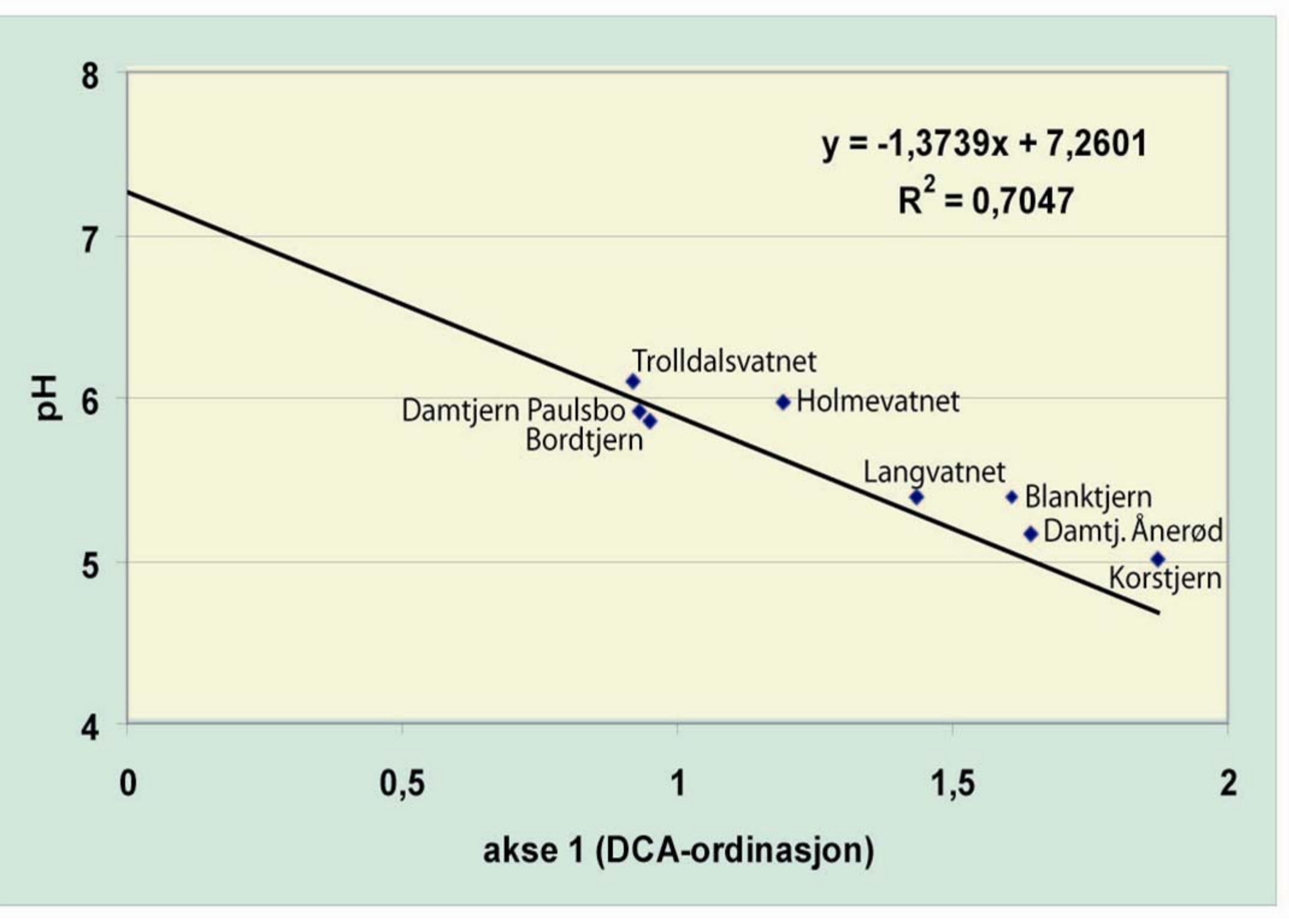


Enningdalsvassdraget 2001

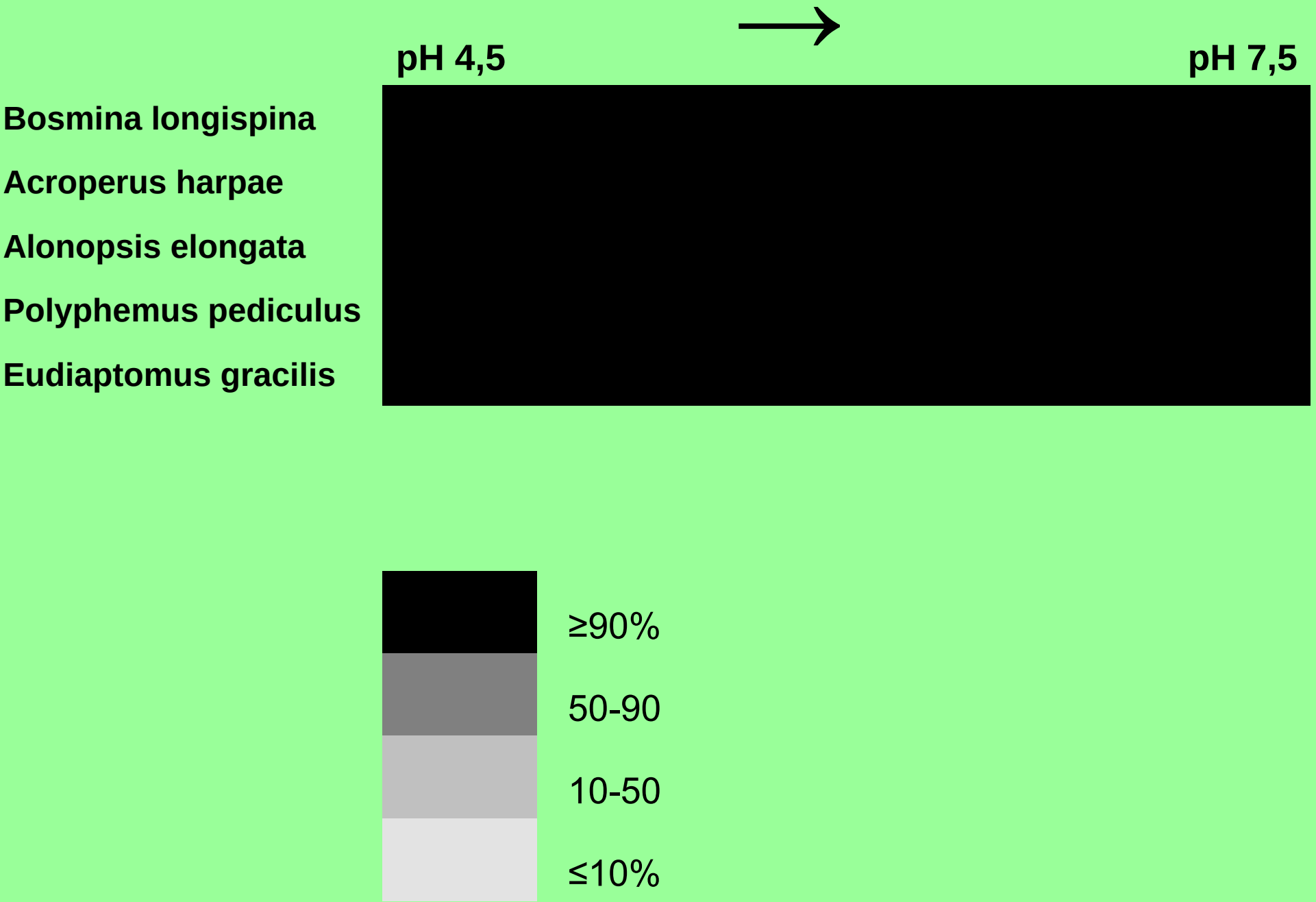


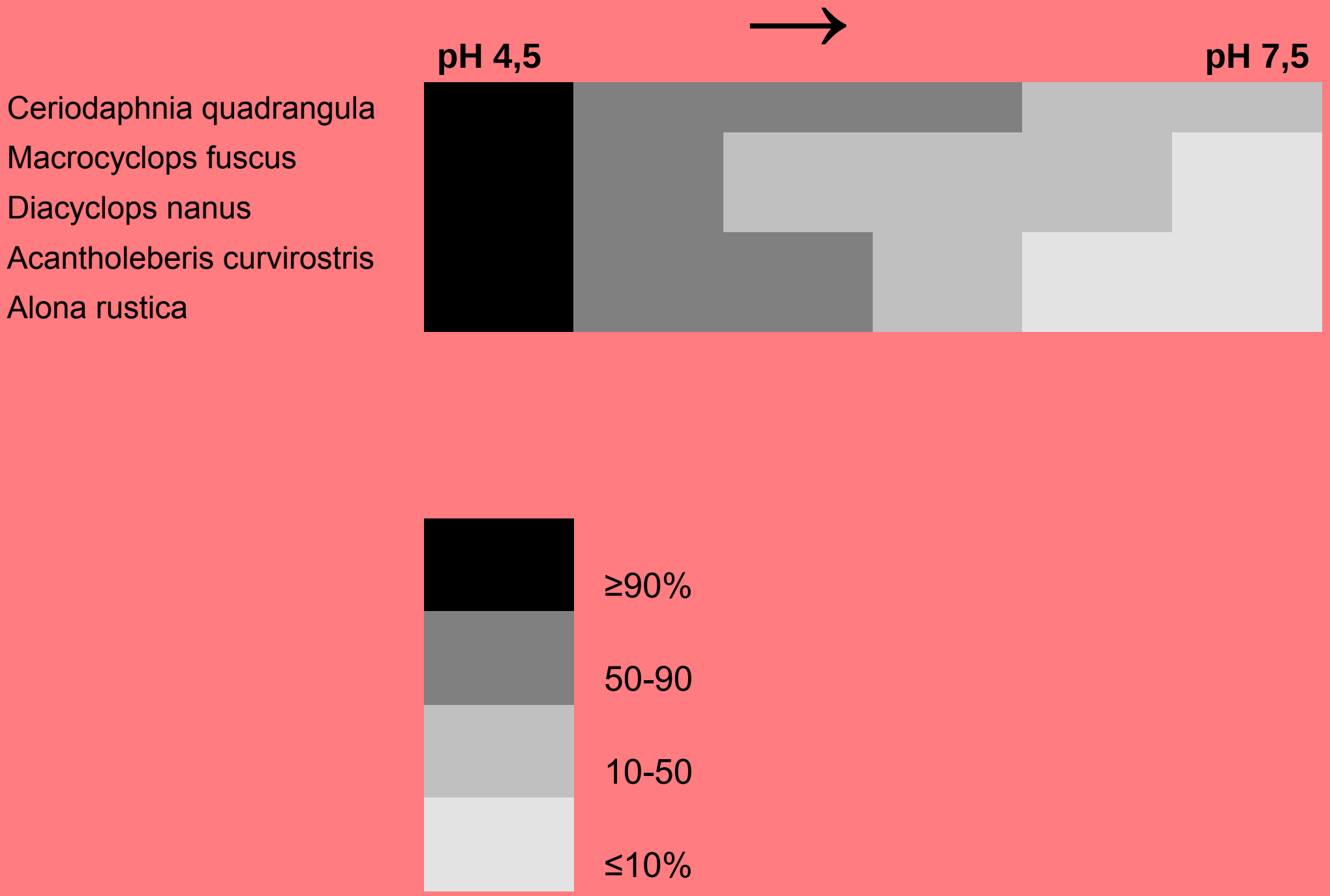

Sure referansevann
Kalkede vann
Svakt sure referansevann
akse 2
1.0
0.5
0
0.5
1.0
1.5
akse 1


y = -1,4653x + 7,3025
R2 = 0,6875
Lundetjärnet
Lilla Holmevatten
Tresticketjärnet
Fågeltjärnet
Hökelundsjön
Starkarnstjärnet
Rinnanetjärnet
pH
akse 1
8
7
6
5
4
0
0,5
1
1,5
2


y = -1,3739x + 7,2601
R2 = 0,7047
pH
8
7
6
5
4
0
0,5
1
1,5
2
akse 1 (DCA-ordinasjon)
Trolldalsvatnet
Holmevatnet
Damtjern Paulsbo
Bordtjern
Langvatnet
Blanktjern
Damtj. Ånerød
Korstjern

	Akse 1		Akse 2		Akse 3		Akse 4
artsantall	0,359	*	0,240		0,011		-0,085
Turb	-0,033		0,367	*	-0,163		-0,040
Farge	-0,007		0,377	**	-0,029		0,043
Kond-25	0,616	***	-0,043		0,014		0,188
pH	0,547	***	-0,073		0,080		0,212
Alk-3	0,561	***	-0,037		0,030		0,229
Ca	0,500	**	0,014		-0,014		0,159
Mg	0,570	***	0,200		-0,156		0,069
Na	0,449	**	0,109		0,007		0,152
K	0,465	**	0,182		-0,349	*	0,051
SSS	0,406	**	-0,123		0,022		0,036
SO4	0,362	*	-0,094		-0,123		-0,065
Cl	0,309	*	-0,083		0,004		0,098
NO3	0,237		-0,089		-0,074		0,007
Si	0,098		0,149		0,127		0,178
Al	-0,174		0,370	*	-0,065		0,036
Tm-Al	-0,477	**	0,098		-0,026		-0,062
Om-Al	-0,318		0,238		-0,026		-0,040
Um-Al	-0,546	***	-0,083		0,053		-0,076
Pk-Al	-0,080		0,420	**	-0,116		0,014
Tot-P	0,014		0,283		-0,036		0,036
ANC	0,616	***	0,072		-0,058		0,246


pH 4,5
pH 7,5
Bosmina longispina
Acroperus harpae
Alonopsis elongata
Polyphemus pediculus
Eudiaptomus gracilis
≥90%
50-90
10-50
≤10%


pH 4,5
pH 7,5
Ceriodaphnia quadrangula
Macrocyclops fuscus
Diacyclops nanus
Acantholeberis curvirostris
Alona rustica
≥90%
50-90
10-50
≤10%

Achantoleberis curvirostris

(O.F. Müller 1776)

Family Macrothricidae Norman et Brady

Genus Achantoleberis Lilljeborg 1853



Key characteristics:

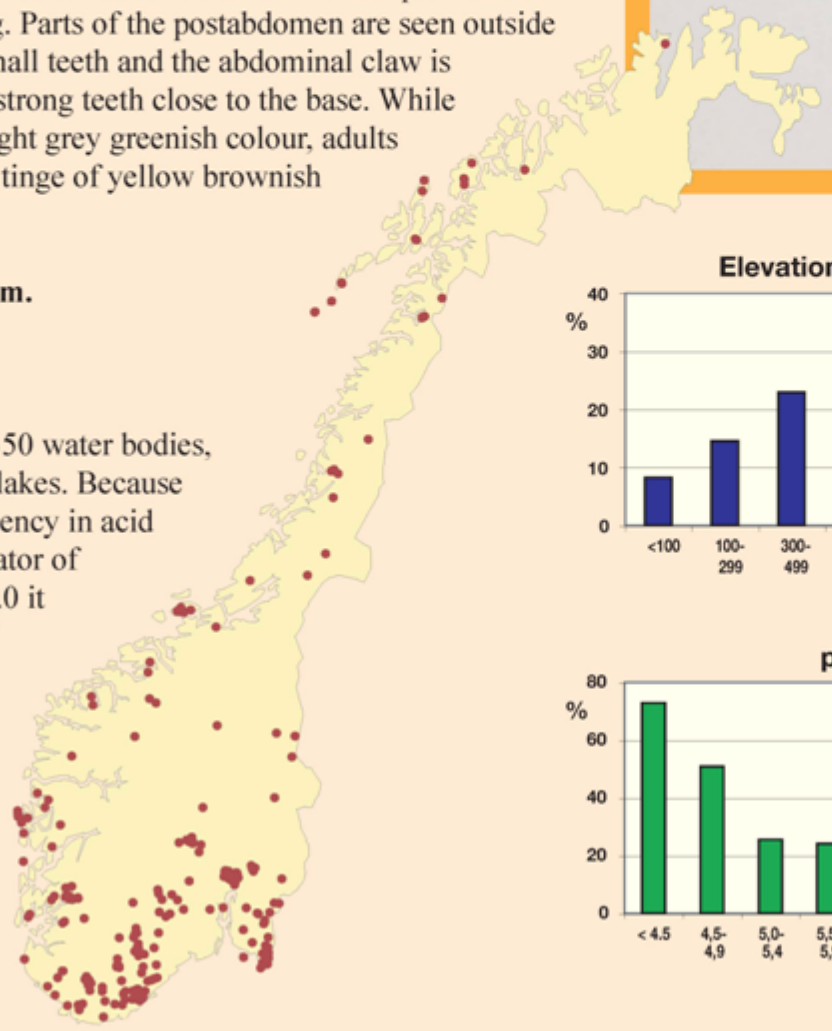
Because of its characteristic look, this species is easy to separate from other species. Its head which constitutes about one third of the entire animal is dorsally curved and ends up in a pointed tip. Here the long and spectacular antennae bend backwards towards the carapace which is about as high as it is long. Parts of the postabdomen are seen outside carapace. It has a row of small teeth and the abdominal claw is relatively short wearing to strong teeth close to the base. While young individuals has a bright grey greenish colour, adults are dark green often with a tinge of yellow brownish colour

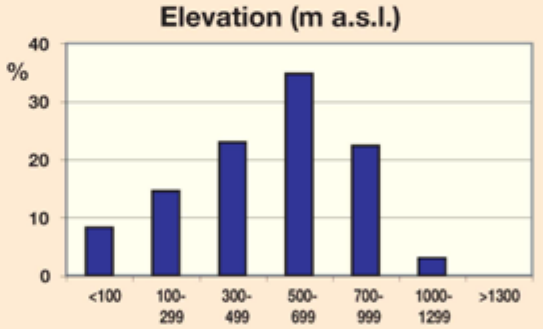
Female: Length 0.9-2.0 mm.

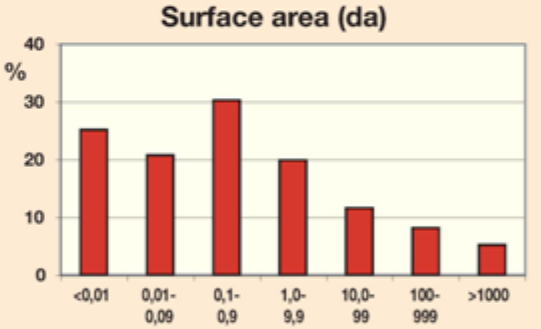
Male: Length 0.6-1.2 mm.

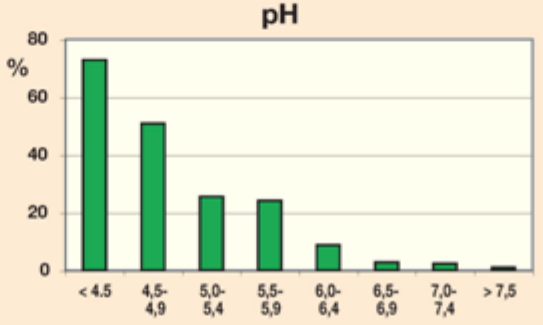
Distribution:

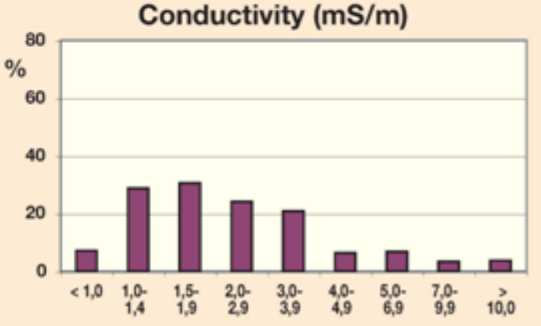
A. curvirostris is found in 350 water bodies, or 16% of the investigated lakes. Because it occurs with highest frequency in acid water, it is used as an indicator of acid water. I.e. when pH<5.0 it occurs in more than half of the investigated localities. Most of these are situated between 300 and 1000 m. a.s.l. It is most common in ponds and small lakes, often with a high content of humus.







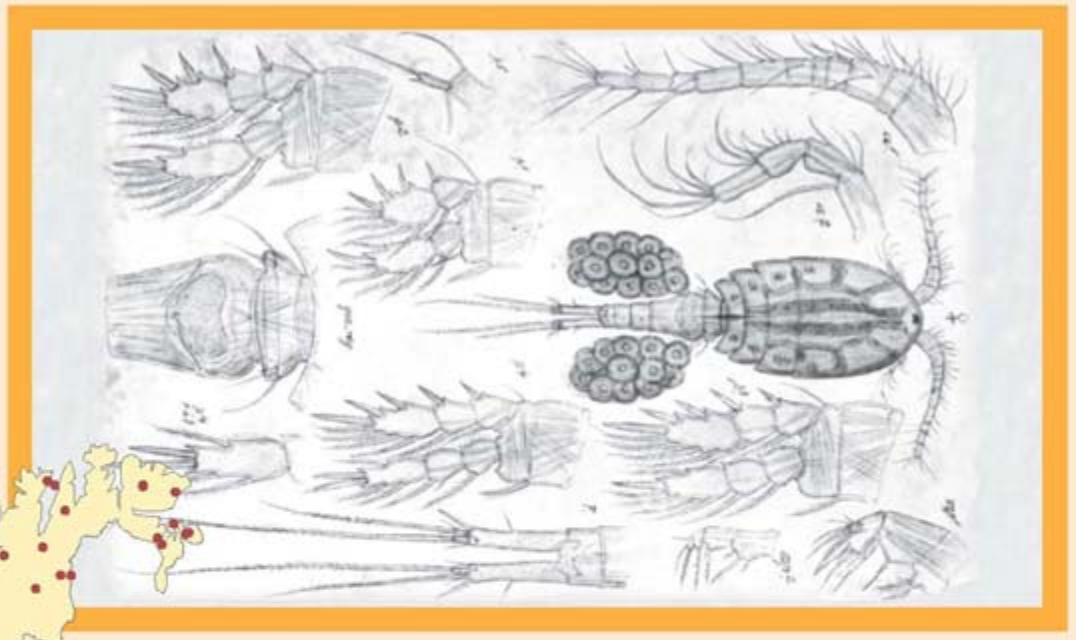




Diacyclops nanus (Sars 1863)

Family Cyclopidae, G.O. Sars

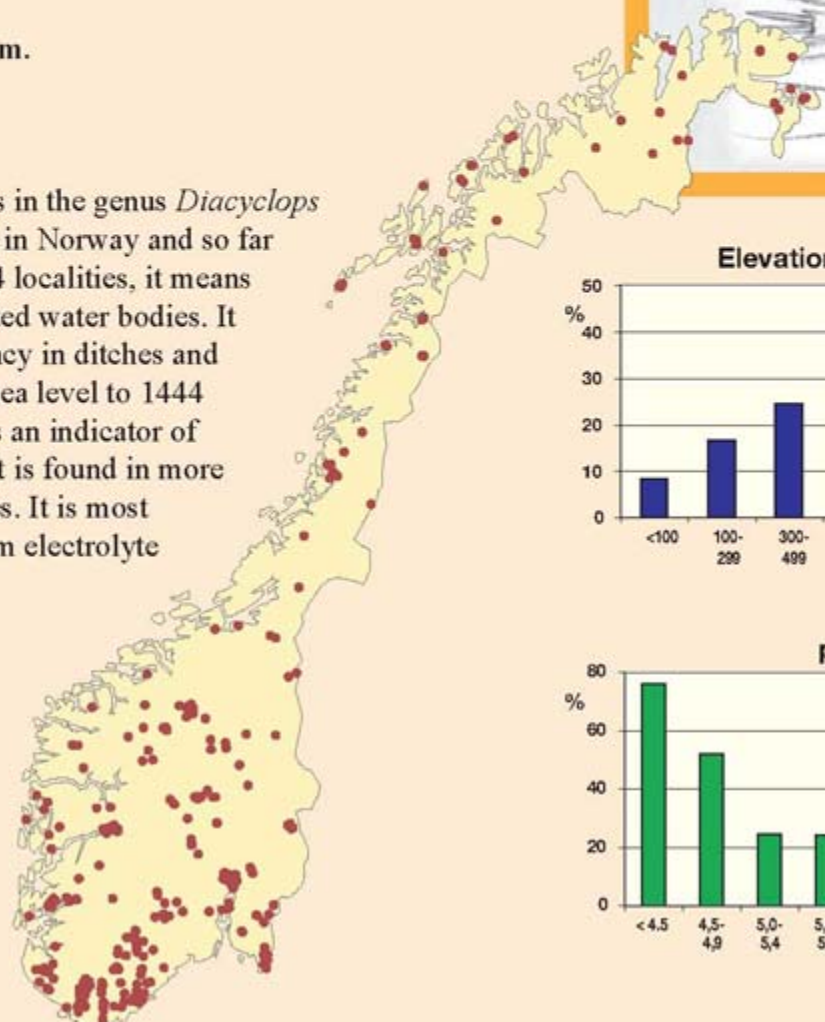
Genus Diacyclops, Kiefer 1927

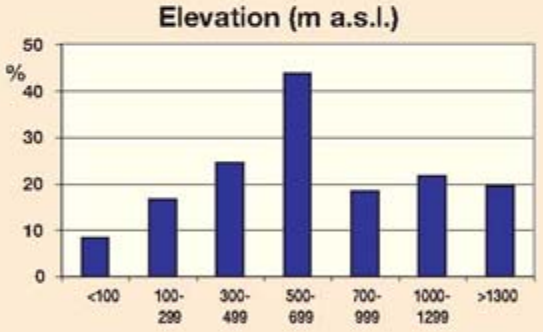


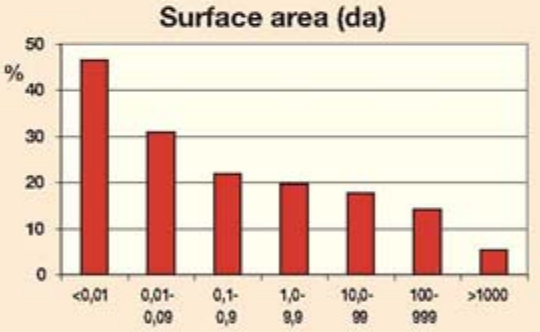
Key characteristics:
This species may resemble *D. bicuspidatus* having a relatively long tail with the outer edge seta attached close to the middle. However *D. nanus* is much smaller, its body is less slender, and the antenna is composed of 11 joints compared with 17 joints in *D. bicuspidatus*. The body of *D. nanus* is rather pellucid, with a faint yellow or reddish tinge.

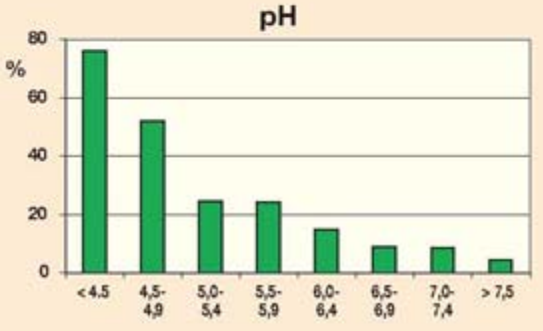
Female: Length 0.7-0.9 mm.
Male: Length 0.6-0.7 mm.

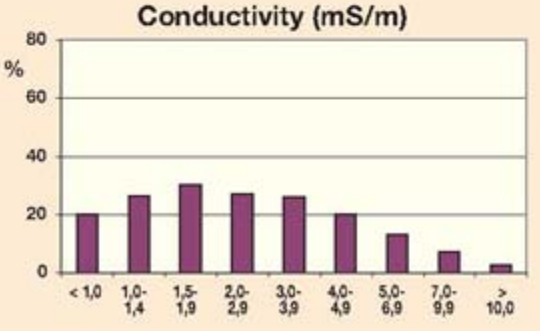
Distribution:
D. nanus is the only species in the genus *Diacyclops* which is widely distributed in Norway and so far has been recorded from 444 localities, it means about 20% of the investigated water bodies. It occurs with highest frequency in ditches and small ponds situated from sea level to 1444 m.a.s.l. *D. nanus* is used as an indicator of acidity and when pH<5.0, it is found in more than half of the water bodies. It is most common in low and medium electrolyte rich water (<5.0 mS/m).

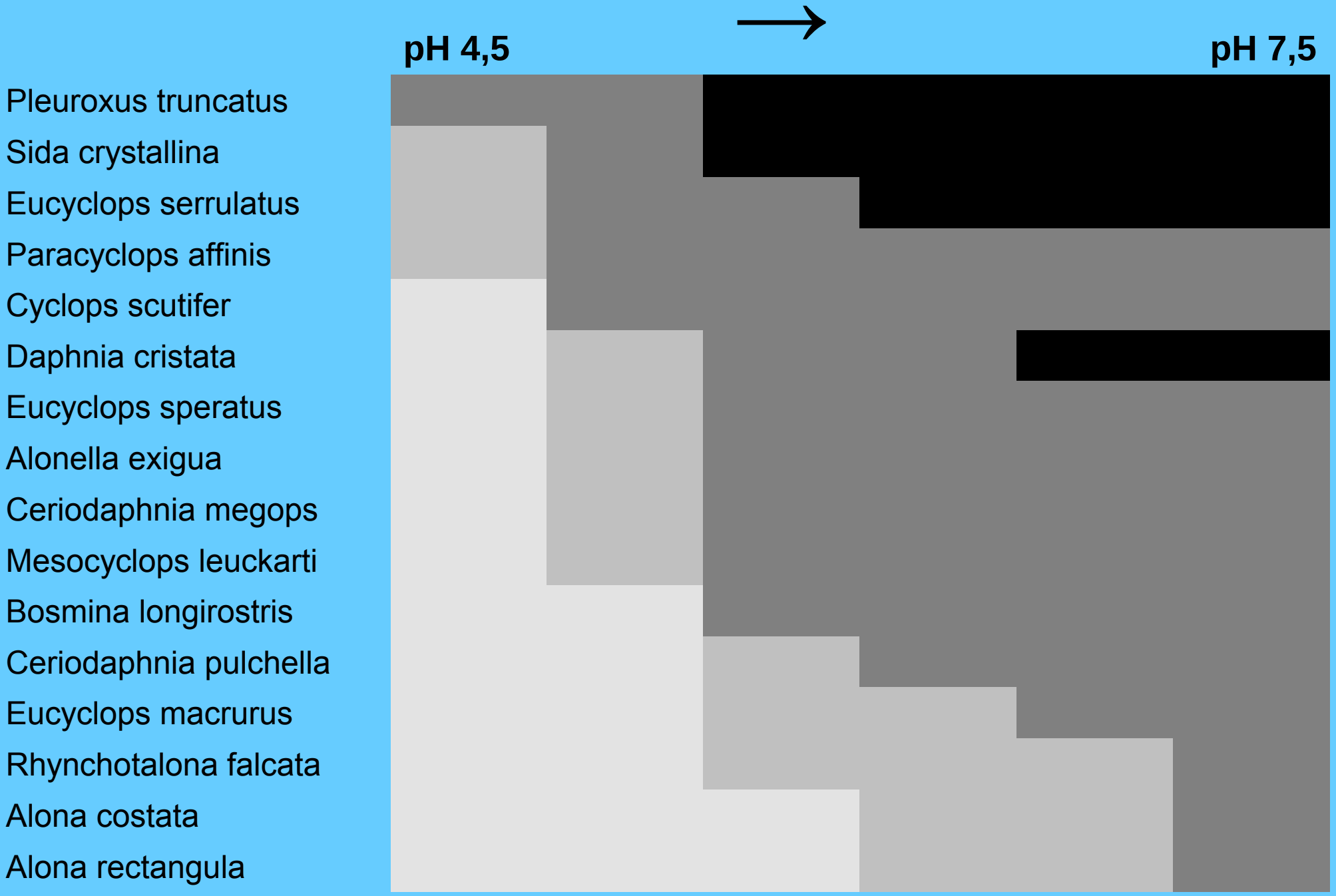











pH 4,5
pH 7,5
Pleuroxus truncatus
Sida crystallina
Eucyclops serrulatus
Paracyclops affinis
Cyclops scutifer
Daphnia cristata
Eucyclops speratus
Alonella exigua
Ceriodaphnia megops
Mesocyclops leuckarti
Bosmina longirostris
Ceriodaphnia pulchella
Eucyclops macrurus
Rhynchotalona falcata
Alona costata
Alona rectangula

Daphnia cristata (Sars 1861)

Family Daphniidae

Genus Daphnia O.F. Müller 1785



Key characteristics:

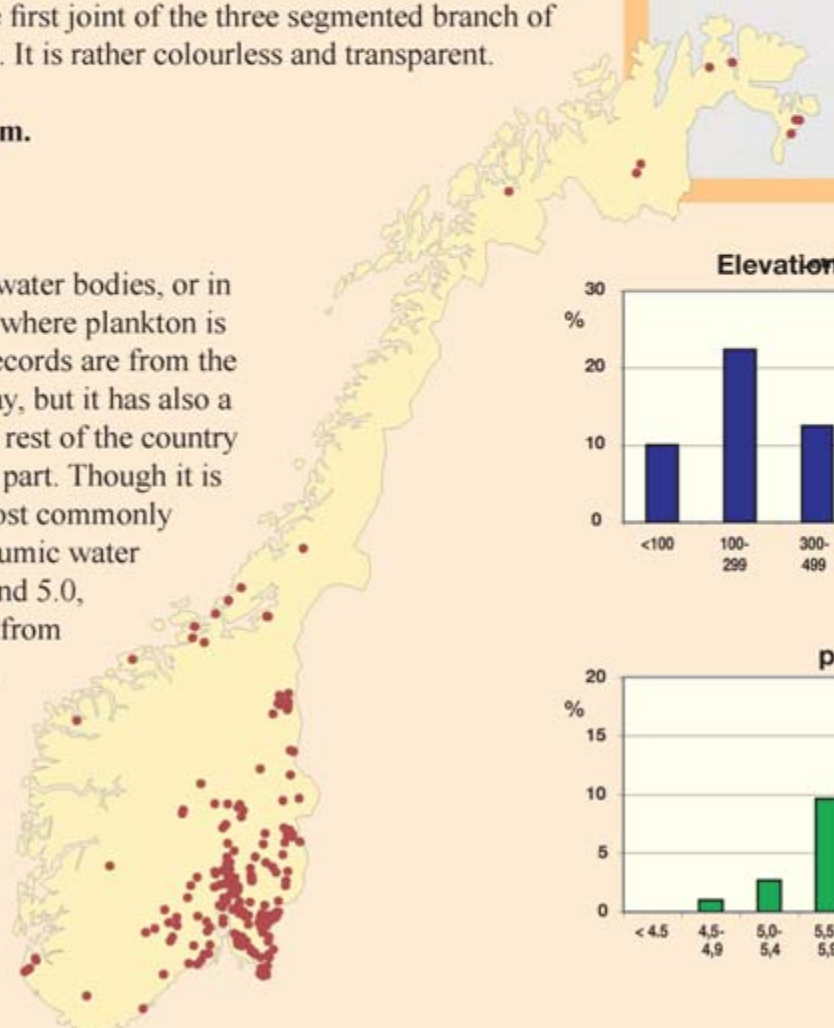
Though it may vary in size, *D. cristata* is one of the smallest daphniids.It is characterised by the crista which continues around the whole perimeter of the head, tarting from the rostrum. The head is large and makes up about 1/3 of the whole animal which has the greatest width ine middle of carapace. The species is easily separated from other Daphnids because it do not has the bristle on the first joint of the three segmented branch of the second pair of antennae. It is rather colourless and transparent.

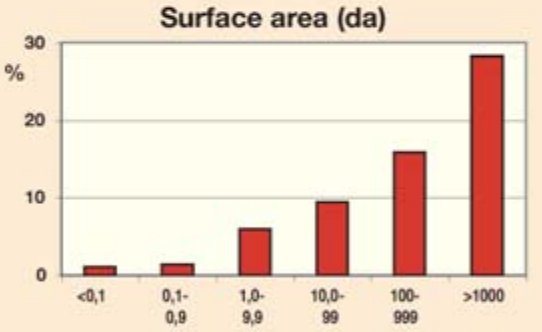
Female: Length 0.9-1.8 mm.

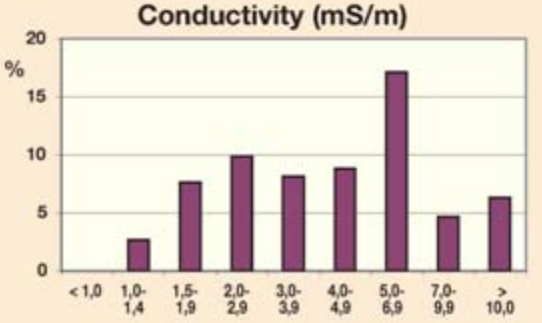
Male: Length 0.6-1.0 mm.

Distribution:

D. cristata is found in 224 water bodies, or in about 10% of the localities where plankton is sampled. The majority of records are from the eastern part of south Norway, but it has also a scattered distribution in the rest of the country including the northernmost part. Though it is found 1244 m a.s.l., it is most commonly found 100-300 m a.s.l. In humic water it is found when pH is around 5.0, otherwise most records are from water bodies having pH>5. *D. cristata* is found in a relatively high frequency in electrolyte poor water (>1.5 mS/m), though highest frequency is found between 2 and 7 mS/m.



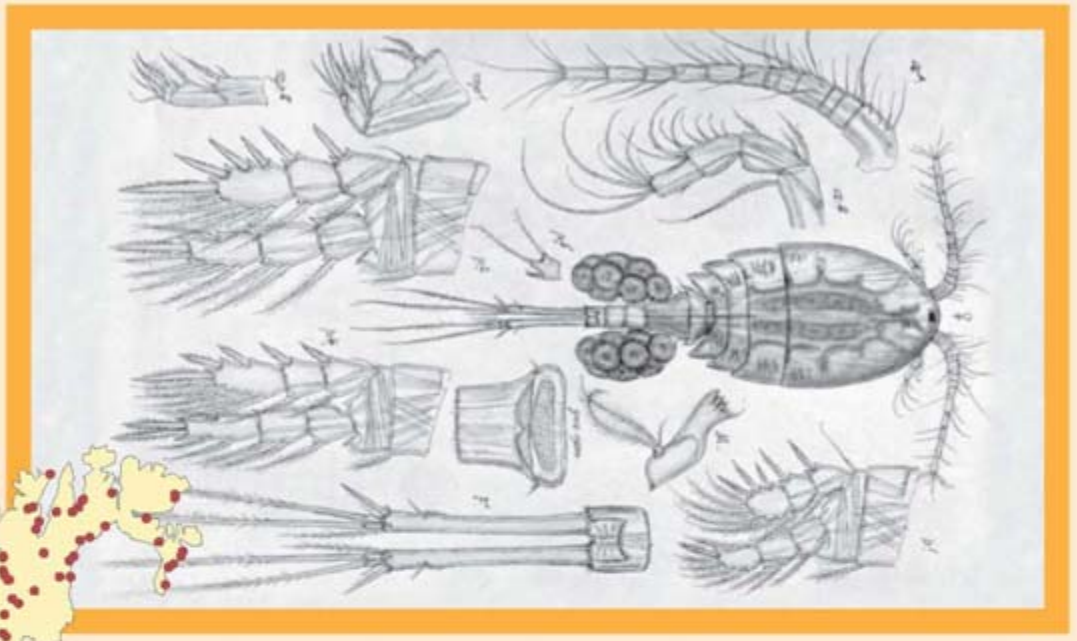




Eucyclops macrurus (G.O. Sars 1863)

Family Cyclopidae, G.O. Sars

Genus Eucyclops, Claus 1893



Key characteristics:

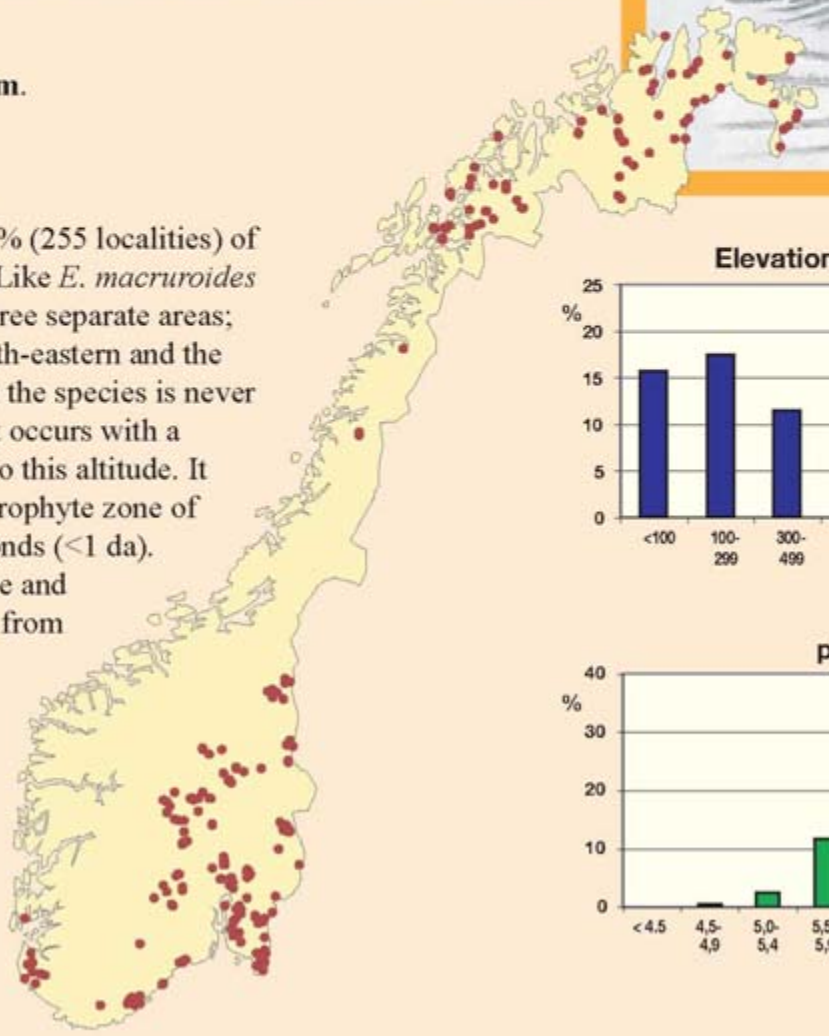
E. macrurus has a body which is rather slender and with the tail much produced (more than 10 times as long as wide). Outer margins of the branches have no rows of teeth. The anterior antennae are shorter than in the other *Eucyclops* species and there are no teeth on the proximal part of the last joint. Its colour is light yellowish grey, with a faint of olivaceous tinge.

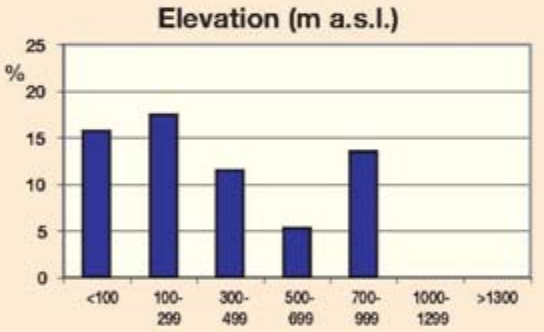
Female: Length 1.1-1.4 mm.

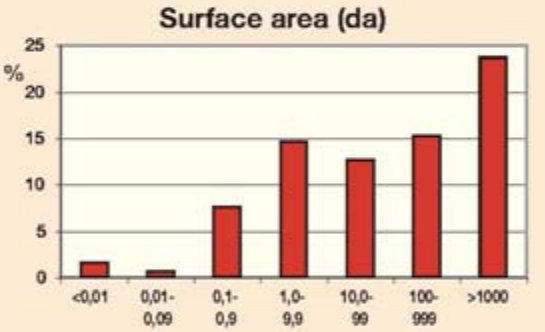
Male: Length 0.7-0.9 mm.

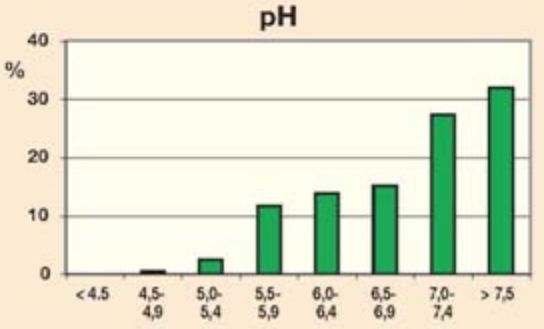
Distribution:

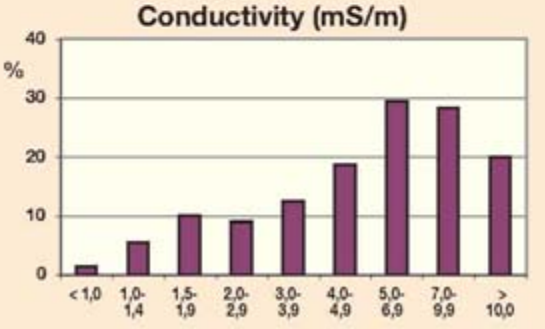
E. macrurus is found in 12 % (255 localities) of the surveyed water bodies. Like *E. macruroides* it is mainly distributed in three separate areas; south-western lowland, south-eastern and the northernmost parts. Though the species is never found above 1000 m a.s.l, it occurs with a relative high frequency up to this altitude. It is most common in the macrophyte zone of lakes and is rare in small ponds (<1 da). *E. macrurus* is acid sensitive and there are only three records from lakes having pH<5.5. It is one of the most common copepods in electrolyte-rich lakes with pH> 7.0.

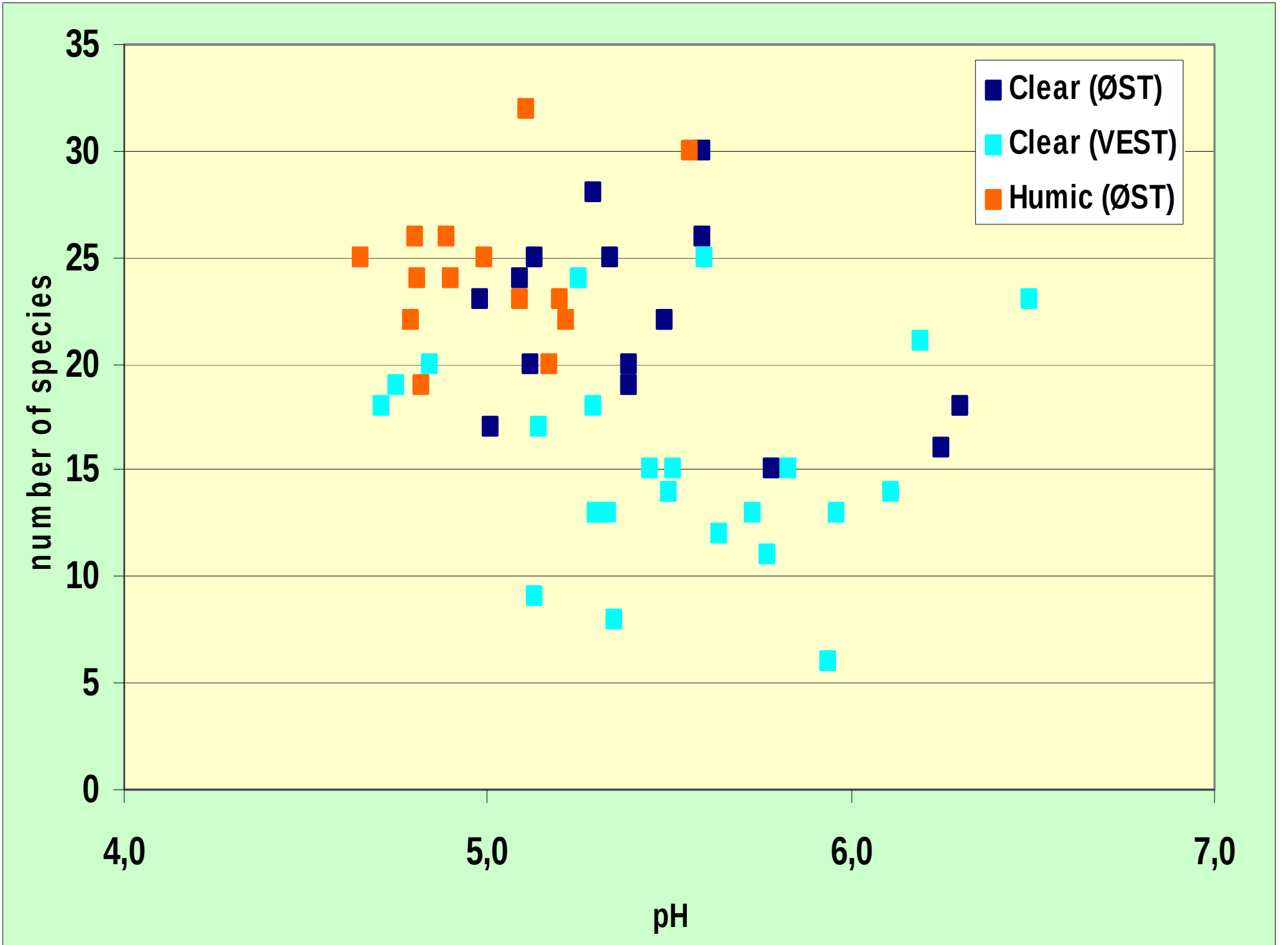




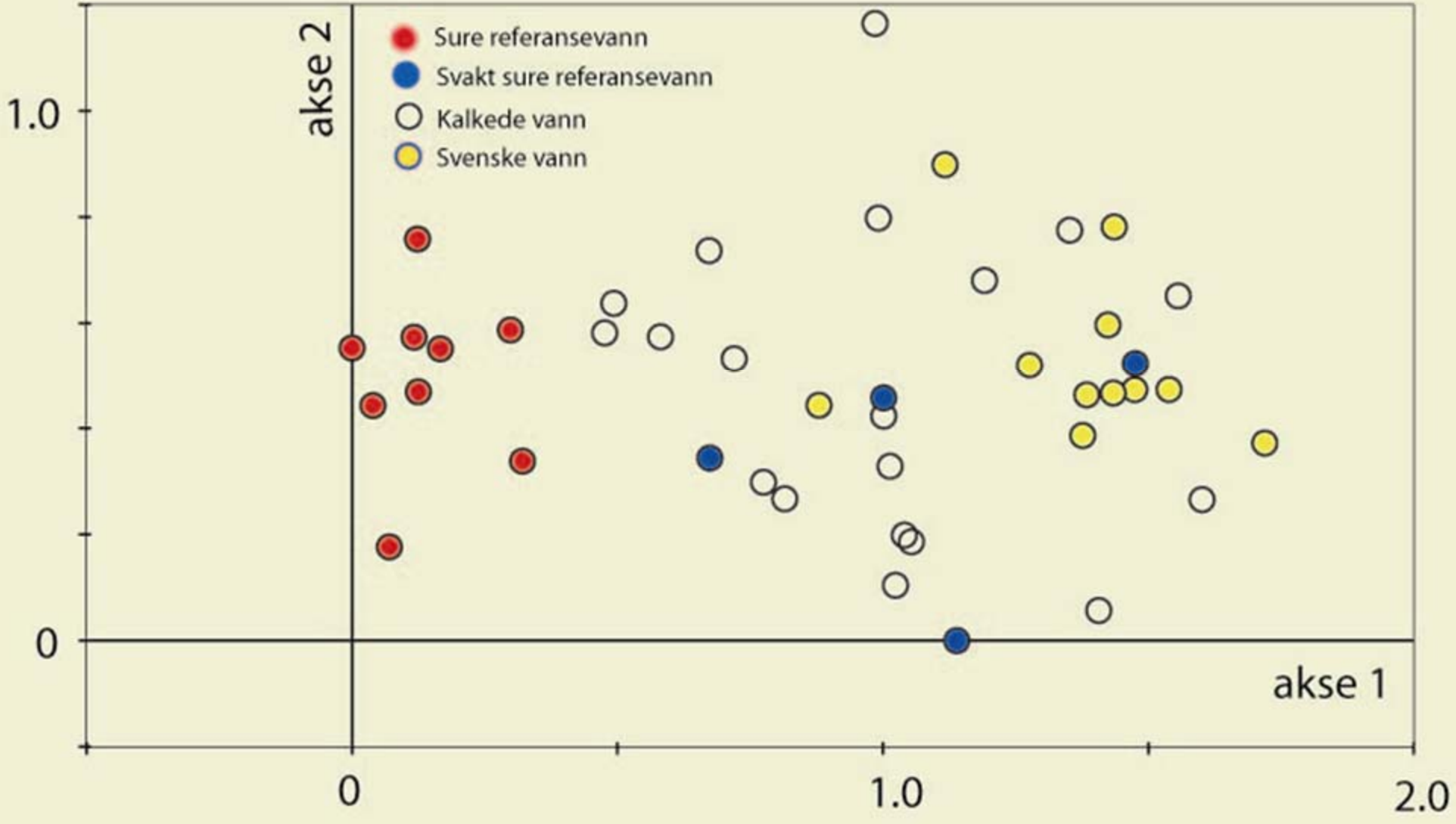


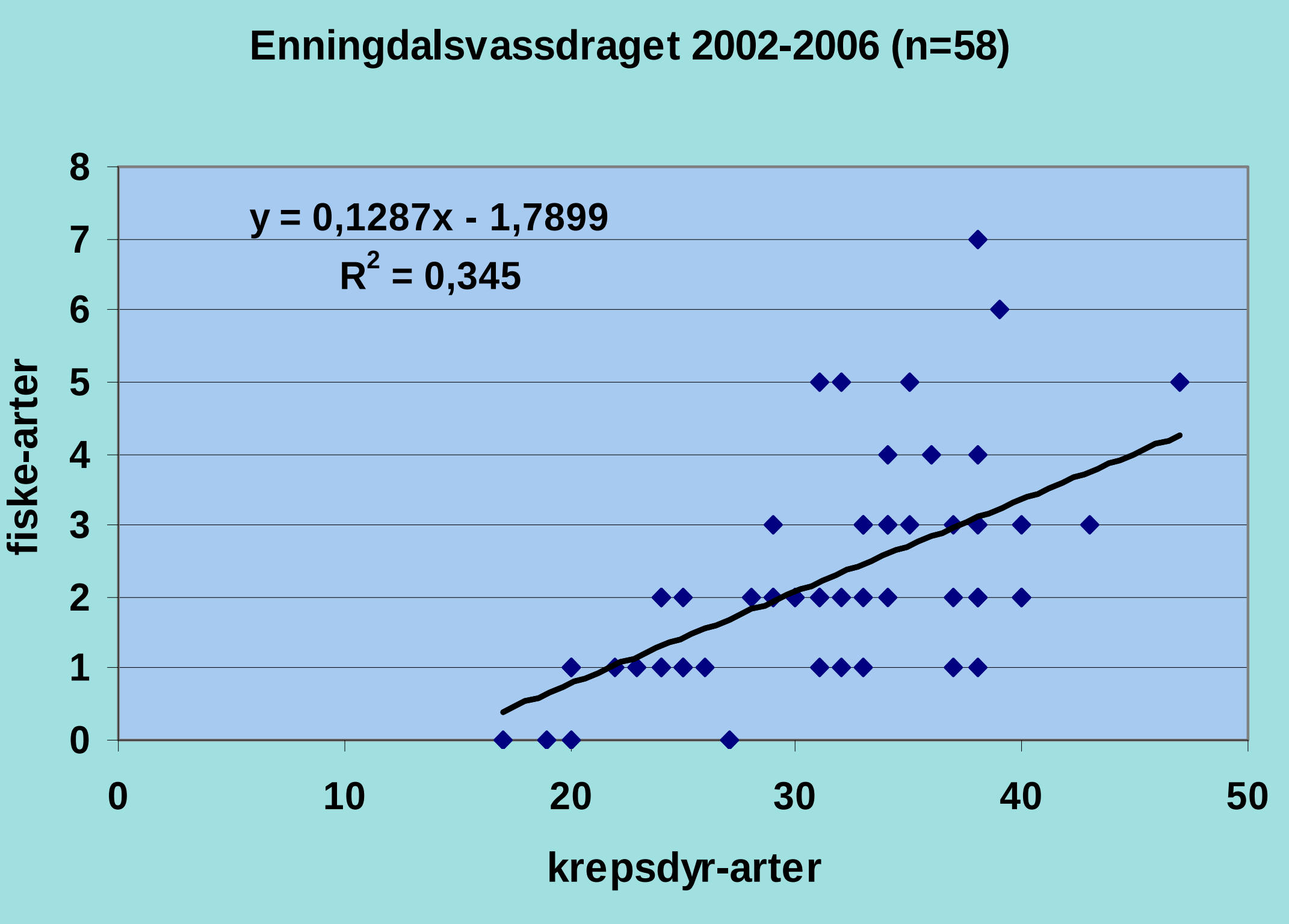





35
30
25
20
15
10
5
0
number of species
4,0
5,0
6,0
7,0
pH
Clear (ØST)
Clear (VEST)
Humic (ØST)

DCA-ordinasjon - fisk og krepsdyr




Enningdalsvassdraget 2002-2006 (n=58)
y = 0,1287x - 1,7899
R2 = 0,345
fiske-arter
krepsdyr-arter
0
1
2
3
4
5
6
7
8
0
10
20
30
40
50

- Konklusjoner
- 5 bestander av fisk er reetablert (Homo sapiens)
- forsuringsfølsomme krepsdyr er tilbake i de kalkede vannene
- avstand til refugier er viktig
- erfaring fra Canada: reetablering av arter i sterkt forsurede lokaliteter går tregt til tross for at pH er blitt akseptabel
- med redusert tilførsel av sur nedbør har vi all grunn til å være optimister

Fish and crustaceans

Do they respond differently to improved water quality due to liming?

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N-0105 Oslo, Norway

Leif Roger Karlsen
Dept. of Environmental Affairs,
P.O. Box 325, N-1502 Moss, Norway

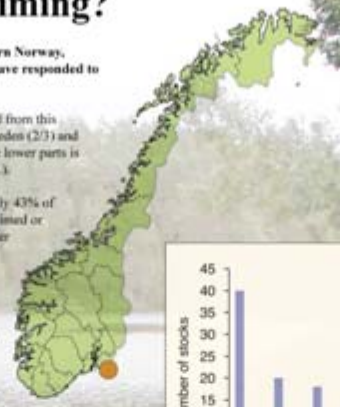
Roy M. Langåker
DN, Tungasletta 2
N-7485 Trondheim, Norway

The present study from Enningdal watershed in southeastern Norway, shows that crustaceans to a much greater extent than fish have responded to improved water quality from liming.

The highest diversity of aquatic biota in Norway is documented from this region. The watershed is shared between Norway (1/3) and Sweden (2/3) and includes 60 lakes in Norway (>1.0 ha). The water quality in the lower parts is influenced by marine sediments (transgression line: 174 m a.s.l.).

The liming was mainly initiated in the early 1980s, and presently 43% of the lakes, covering 93% of the total lake area, are either being limed or are affected by liming. The liming has caused an improved water quality in formerly acidic lakes (pH: 6.5-7.2 and labile Al: 1-4 µg/L).

Based on earlier studies and inquires, historical data of fish community status was obtained from 42 lakes. In addition, test-fishing and sampling of crustaceans have been conducted in 24 lakes in recent years (2003-2004). Six of these lakes were acidic not limed, three were weakly acid not limed and 15 were limed.



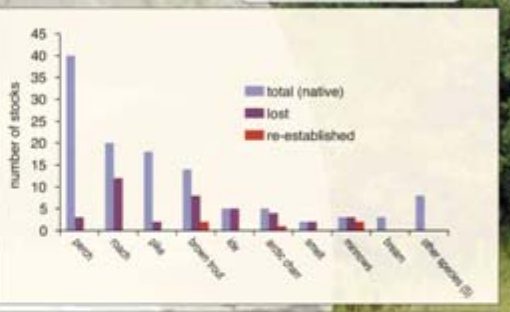


Figure 1
Perch (Perca fluviatilis) is the dominant (3 species in lakes in Enningdal watershed. A total of 14 different species of fish (either extant or last previously extinct) in the study lakes (n=42). Roach (Rhodus rhodus) has suffered most due to acidification in the study area.

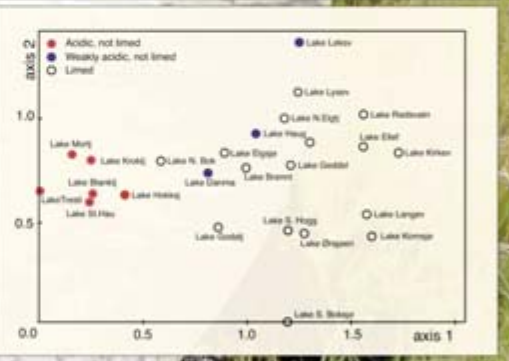


Figure 2
DCA ordination based on crustacean species found in Enningdal (presence/absence). Axis1 is correlated to conductivity, pH, alkalinity, Mg, labile Al, ANC, Ca. Axis 2, correlated to colour, Pb-A, turbidity and tot Al.

RESULTS

Fish

- Of a total of 14 species and 120 fish populations, 42 populations (35%) have gone extinct (*figure 1*).
- Only five of the formerly lost fish populations (12 %) have been re-established, all by means of man's introductions.
- The mean number of fish species prior to acidification was 2.9±1.9, as opposed to 1.9±1.2 at present.
- The majority of the lakes are now inhabited by only one species: perch.

Crustaceans

- A mean of 23 species in six acidic not limed lakes
- A mean of 36 species in both weakly acidic not limed lakes and in limed lakes
- Acid tolerant species (i.e. *Acantholeberis curvirostris, Diacyclops nanus*) dominate in the acidic lakes, while 20 acid sensitive species (i.e. *Limnosida frontosa, Ceriodaphnia pulchella, Daphnia cristata, Bosmina longirostris, Opbryoxus gracilis, Alona costata, Alonella exigua, Disparalona rostrata, Heterocope appendiculata, Eucyclops macrurus, E. speratus*) were found in lakes when pH>5.5.

CONCLUSIONS

Physical barriers are considered to be the main factor preventing fish from re-establishing populations after liming. Thus, to restore the original fish fauna in the near future, re-stocking by man is needed. In contrast, crustaceans have to a much greater extent, responded to improved water quality. This is mainly due to their spreading capacity, but also by survival both in refuges within the watershed and as resting-eggs in the sediment.










INTERREG
www.interreg-sverige-norge.com

Enningdalsvassdraget

Svensk side: ”Vatenkraft samt vattenregulering eller vattenöverledning får inte utföras”

Norsk side: Med unntak av Mjølnerødfossen er vassdraget varig vernet mot utbygging.

Nasjonalt laksevassdrag

Målsetning:

Og utarbeide en permanent svensk/norsk forvaltningsplan for Enningdalselva og dens utløpsområde i Iddefjorden

Viktig!:

”Gränshinder” må fjernes

F.eks digitale kartsystem må samkjøres

Bedømningsgrunnlag for vannkvalitet må samkjøres

Laks og sjøørret
ål
elveperlemusling
kalkingsstrategier
re-introduksjon av fiskearter

friluftliv (kano)
tilrettelegging for fiske i både innsjøer og i Iddefjorden (i tillegg til laks og sjøørret, fiske etter ørret, abbor, gjedde og karpefisk)

Norsk Side:

Norsk institutt for vannforskning (NIVA)
v/Atle Hindar, sekretær
Fylkesmannen i Østfold
v/Leif Roger Karlsen og Håvard Hornes
Norsk institutt for naturforskning (NINA)
v/Bjørn Walseng og Trygve Hesthagen
Direktoratet for naturforvaltning (DN) v/Roy Langåker

Andre som har vist interesse:
Halden kommune
Norges vassdrags- og energiverk (NVE)
Statens forurensningstilsyn (SFT)

Svensk side:

Vattenmyndigheten for Västerhavsdistriktet
Länsstyrelsen i Västra Götaland
v/Hans Oscarsson, sekretær
Tanum kommun v/Ingvar Olofsson
Göteborgs Universitet/Högskolan i Borås
v/Jan Erik Svensson

Medvirket så langt:
IVL i Göteborg v/Filip Moldan

Startsida
Om programmet
Programdokument
Populärversion
Vilka kan söka
Budget
Karta
Kontakta oss
Personal
Vanliga frågor
Så här ansöker du
Blanketter och råd
Logotyp/EU-flagga
Publikationer
Pressinformation
Projektbank
Länkar
Short in English
Interreg IIIA 2000-2006

Genomförare av programmet >>

Förvaltande myndighet
Länsstyrelsen Jämtlands län
interreg@z.lst.se

Logga in >>

Om programmet

EU-programmet Interreg Sverige-Norge ingår i det nya målet "Territoriellt samarbete" som ska stärka samarbete över gränser i EU och angränsande länder. Målet bygger på det tidigare gemenskapsinitiativet Interreg. Det finns tre former av samarbeten inom Territoriellt samarbete: gränsöverskridande samarbete, transnationellt samarbete och interregionalt samarbete. Interreg Sverige-Norge är ett gränsöverskridande samarbete.

Sverige-Norge-programmet stödjer projektverksamhet mellan länderna för att stärka regionens attraktivitet och konkurrenskraft. Området sträcker sig på båda sidor om riksgränsen från nordligaste Jämtland/Trøndelag till Västra Götalandsregionen (Fyrbodalområdet)/Østfold fylke. Se karta

Programmets innehåll

Programmet ska stärka innovativa projekt, kunskapshöjning och konkurrenskraft inom näringsliv, teknik och samhällsutveckling. Den ekonomiska tillväxten ska främjas genom satsningar på infrastruktur och undanröjande av gränshinder. Den attraktiva livsmiljön ska förstärkas genom att skapa en region där människor vill bo, verka och vistas.

Stödmottagare

Stöd kan utgå till universitet, högskolor, forskningsinstitutioner, gymnasier, grundskolor, yrkes- och lärlingsutbildningar, folkhögskolor, folkbildningsorganisationer, näringslivsorganisationer, bransch- och intresseorganisationer, kommuner, landsting, fylkeskommuner, statliga myndigheter, kulturinstitutioner samt kooperativ.

Budget och beslut

Programmet har som mål att under sju års tid förverkliga projekt för 1,3 miljarder kronor varav 335 miljoner är EU-stöd. Budgeten är gemensam för hela programområdet längs den svensk-norska gränsen.