The influence of plankton- and fish-eating seabird colonies on the Arctic tundra ecosystem of Spitsbergen

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The importance of seabirds in Arctic

- conditions on land: very harsh, deficiency of nutrients
- inhabiting two environments ► transport of organic matter from sea to land
- feaces deposition ► guano decay ► ecosystem enrichment
- nutrient components depending on the birds diet
- plankton-eaters and fish-eatres ► different impact on tundra ecosystem

Stempniewicz L., Błachowiak-Samołyk K., Węsławski J.M. 2007. Impact of climate change on zooplankton communities, seabird populations and arctic terrestrial ecosystem — A scenario. *Deep Sea Research Part II* 54: 2934-2945

Comparison of plankton-eating and fish-eating seabird colonies:

- guano deposition

Impact on:

- physicochemical properties of soil
- tundra vegetation structure

Study area

Hornsund, Spitsbergen
Two different seabird colonies:

PLANKTON-EATING (**P**)

little auks *(Alle alle)*

Ariekammen

FISH-EATING (**F**)

Brünich's guilemots *(Uria lomvia)*

black-legged kittiwakes *(Rissa tridactyla)*

Gnålberget

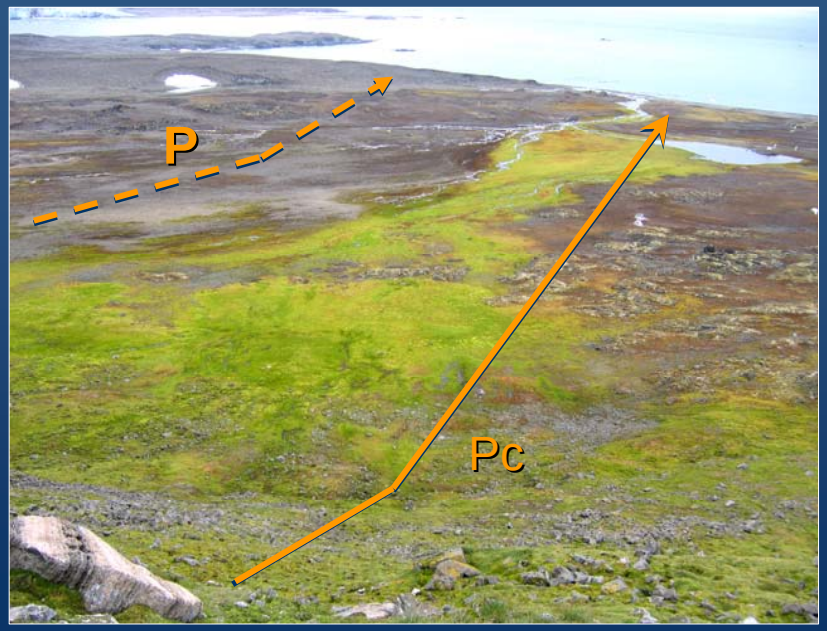
Methods

2 proper transects + 2 control transects

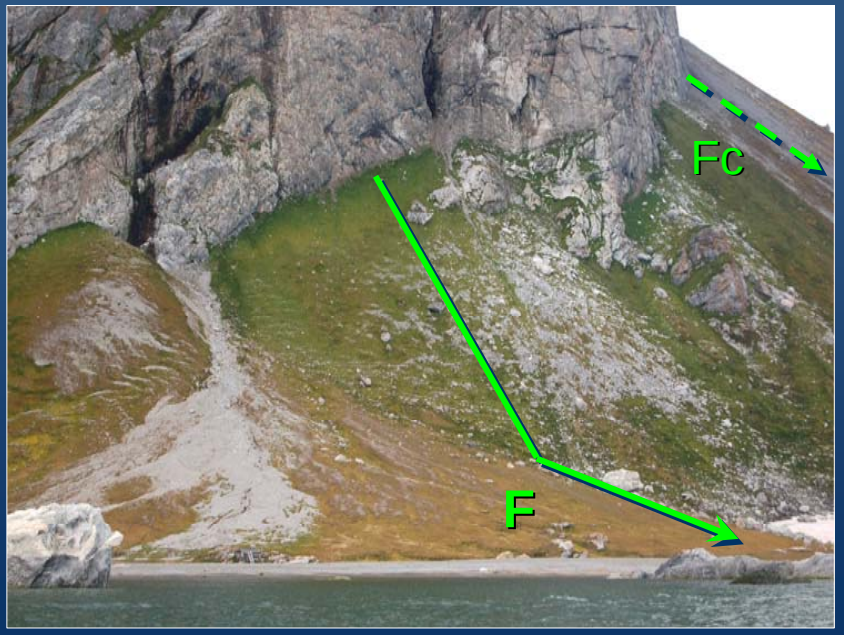
Each contains:

- 10-12 sample plots (160×160 cm)
- 10-12 plastic sheets (150×150 cm)

Plankton-eaters (**P**) + control (Pc)



Fish-eaters (**F**) + control (Fc)



Collecting data

Guano deposition [$g \cdot m^{-2} \cdot day$]
(plastic sheets + computer analysis with SigmaScan Pro 5.0)

Physicochemical properties of soil:
N, P, K content, conductivity,
pH, dry mass
(3 soil samples per square)

Plant species' cover [%]

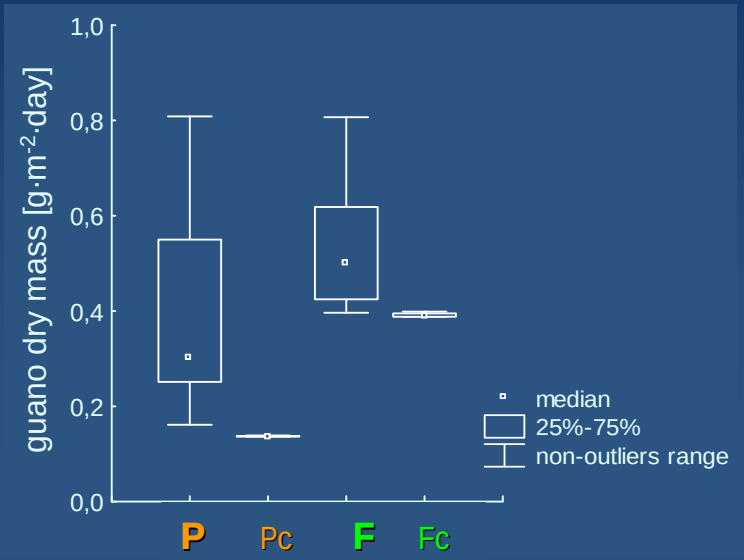
Biomass of plants
(5 samples [20×20 cm] per square)

Results

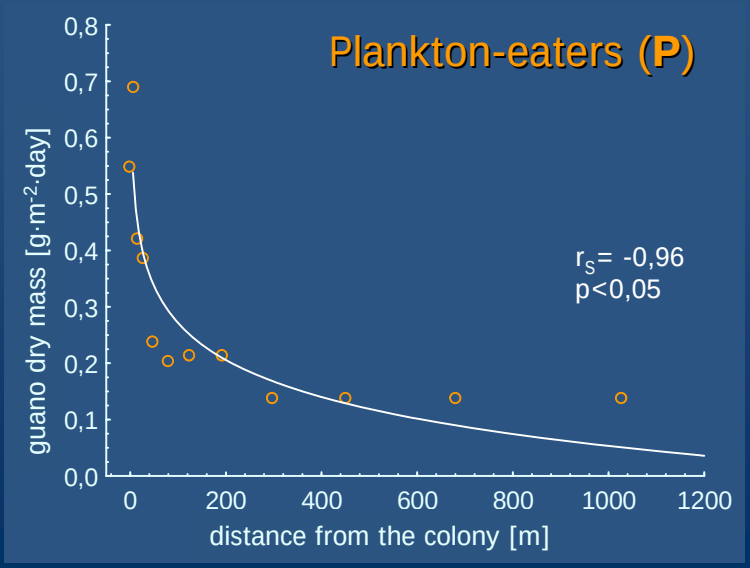
Guano deposition

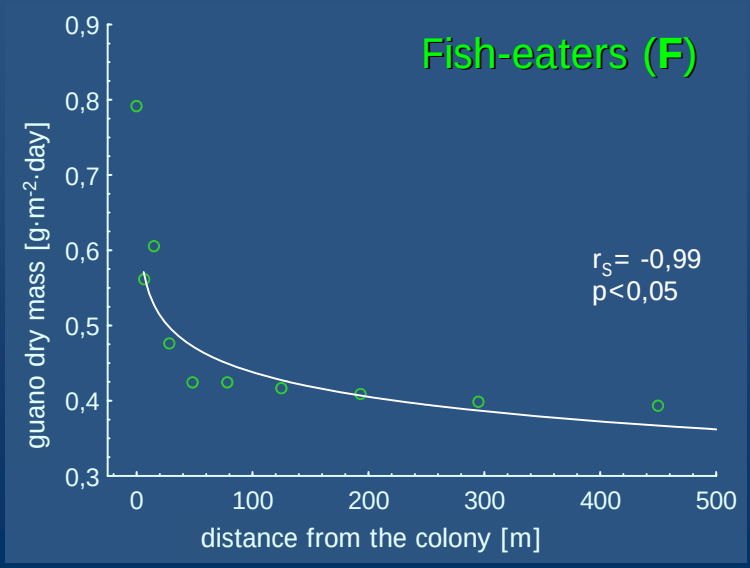
In plots close to colonies (1 – 6):

- higher amount of guano near both colonies vs. control areas
- higher amount of guano near fish-eaters (**F**) vs. plankton-eaters (**P**)



Strong correlation with distance:



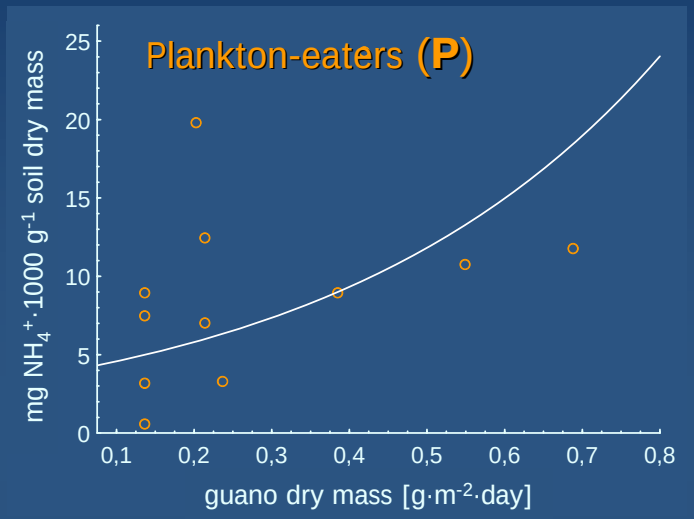


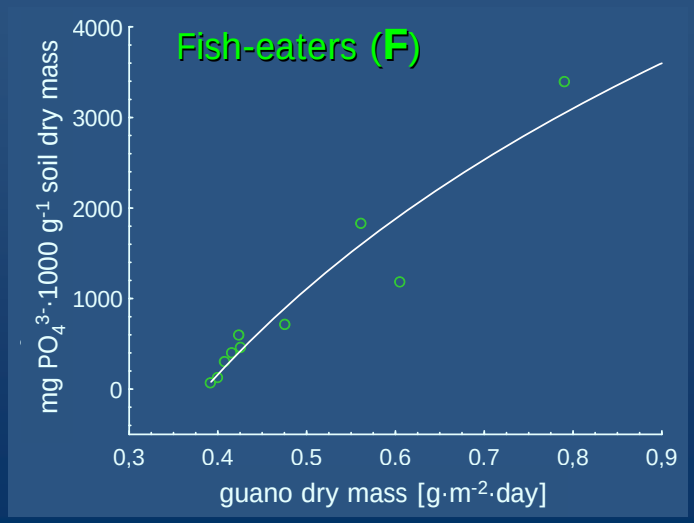
Results

Guano deposition – correlation with soil physicochemical parameters

Spearman's coefficient, p <0,05

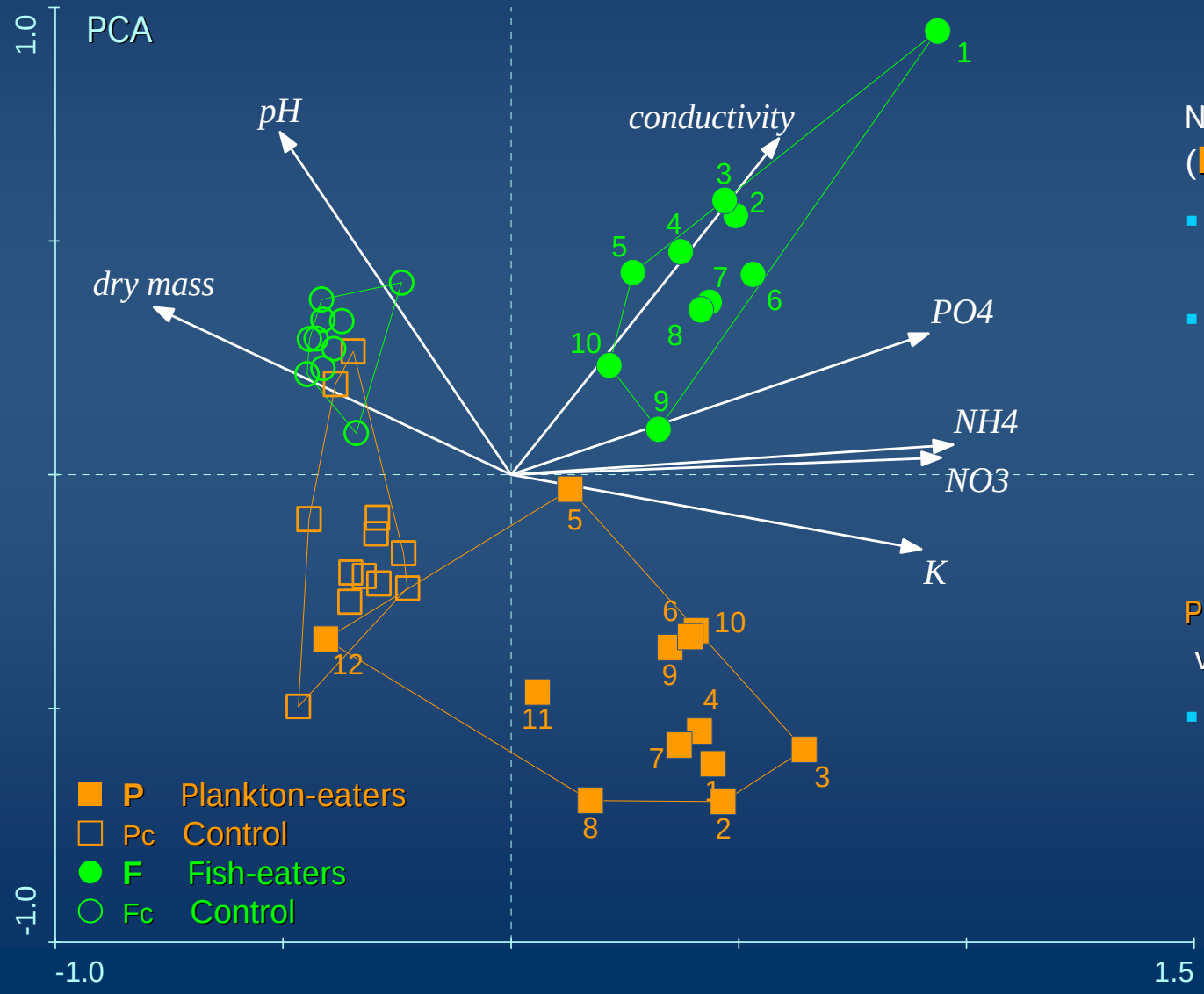
	P	Pc	F	Fc
NH_4^+ [mg·1000g^{-1} soil dry mass]	0,61	ns	ns	ns
NO_3^-	0,64	-0,67	0,85	ns
K^+	ns	ns	0,67	ns
PO_4^{3-}	ns	ns	0,98	-0,82
conductivity [mS·cm^{-1}]	0,86	ns	0,75	0,89
pH	-0,71	ns	-0,66	ns
soil dry mass [%]	ns	ns	0,87	ns





Results

Physicochemical parameters of soil – sample plots ordination



Near both seabird colonies (**P** and **F**) vs. controls (...):

- higher nutrient content and lower pH
- higher variability of soil parameters

Plankton-eaters' (**P**) vs. Fish-eaters' (**F**) colonies:

- different soil properties

Results

Soil physicochemical parameters – a comparison

Kruskal-Wallis' test, *post-hoc* Dunn's test ($p < 0,05$)

	P ↔ Pc	F ↔ Fc	P ↔ F	Pc ↔ Fc
NH_4^+ [mg·1000g^{-1} soil dry mass]	>	>	ns	ns
NO_3^- [mg·1000g^{-1} soil dry mass]	>	>	ns	ns
K^+ [mg·1000g^{-1} soil dry mass]	>	>	ns	ns
PO_4^{3-} [mg·1000g^{-1} soil dry mass]	>	>	<	ns
pH	<	ns	<	<
conductivity [mS·cm^{-1}]	>	>	<	<
soil dry mass [%]	<	<	>	ns

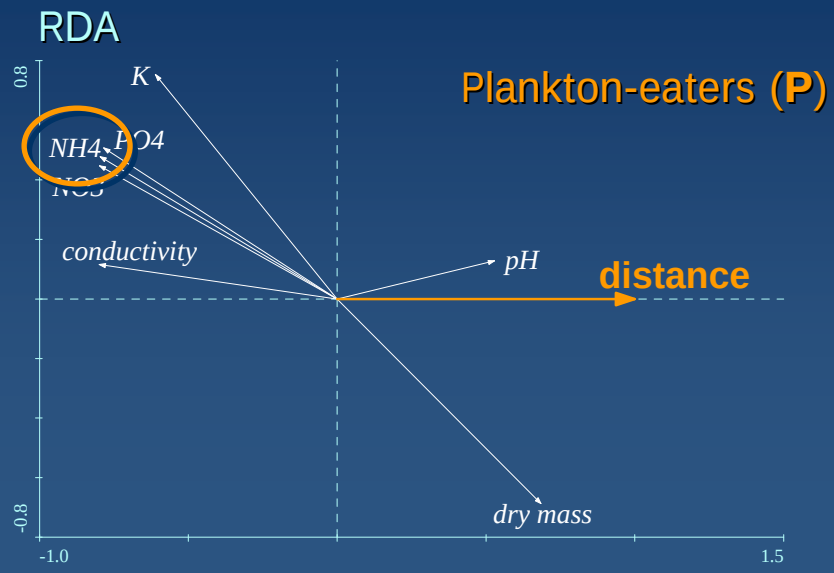
Difference between plankton-eaters and fish-eaters:

- phosphates content

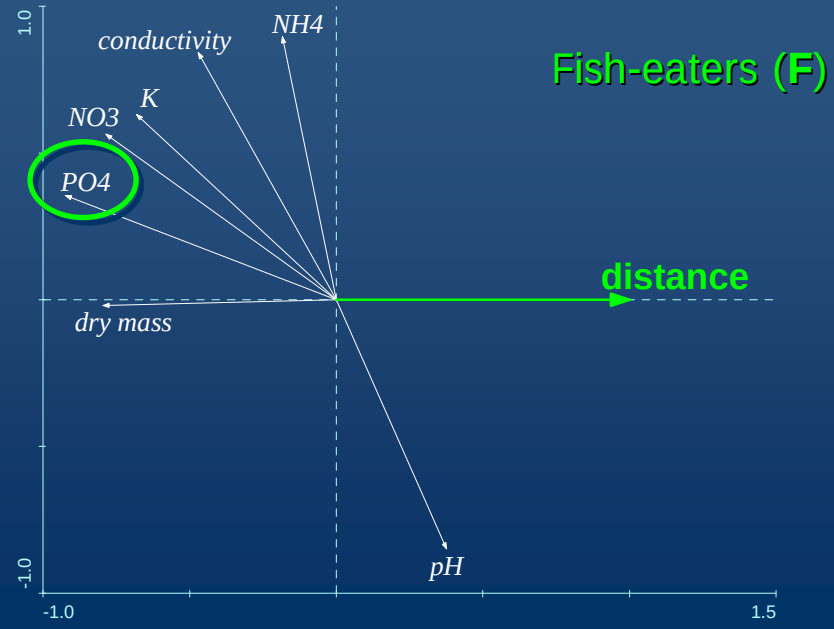
P Plankton-eaters
Pc Control
F Fish-eaters
Fc Control

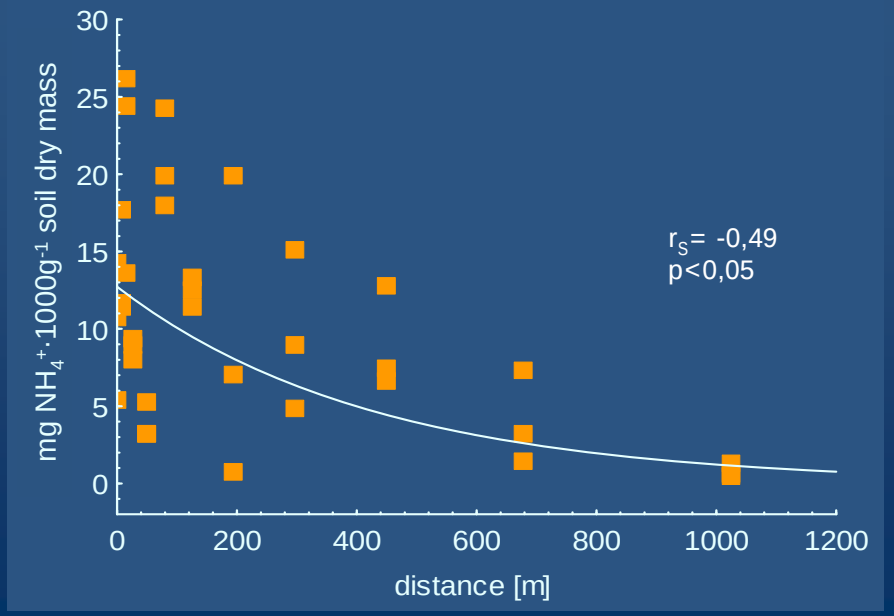
Results

Gradient of soil physicochemical parameters



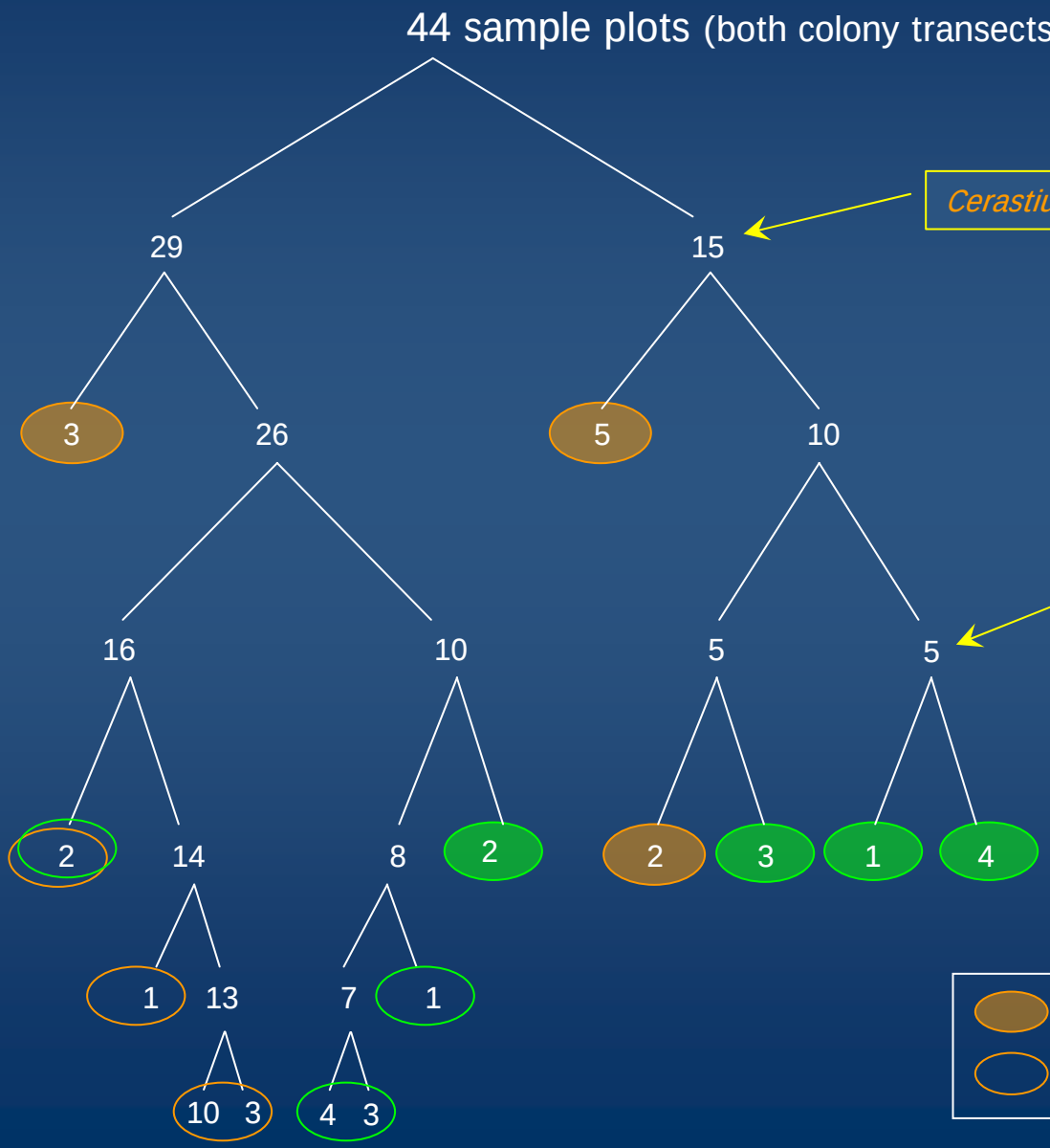
	variability [%]	MonteCarlo [F]	p
P	52,2	10,9	0,006
Pc	---	---	ns
F	42,2	5,9	0,032
Fc	---	---	ns





Results

Vegetation classification (TwinSpan)



Cerastium arcticum

- distinguishes transects near both seabird colonies (**P** and **F**)
- distinguishes plankton-eaters (**P**)

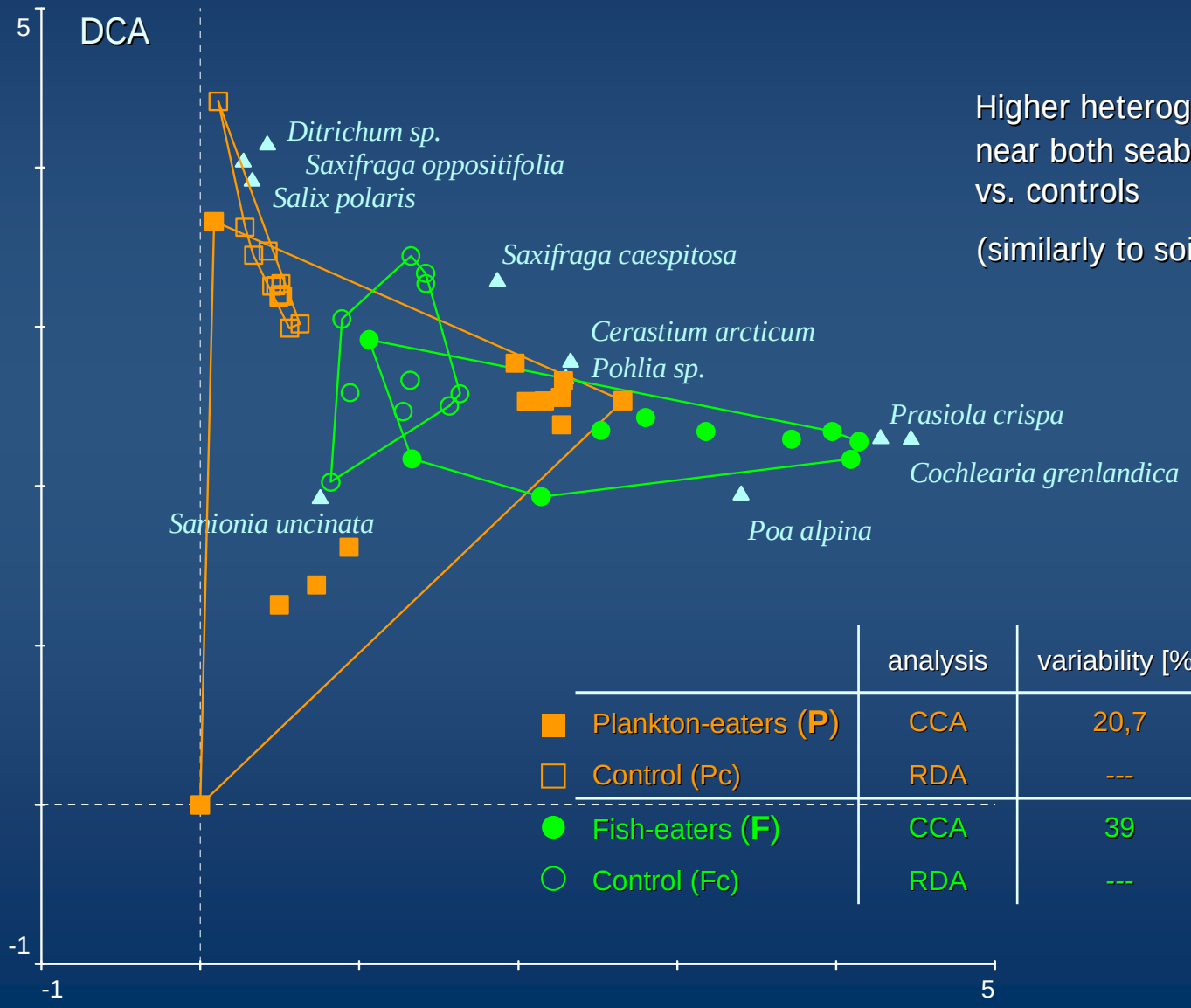
Cochlearia groenlandica

- distinguishes fish-eaters (**F**)

P Plankton-eaters
F Fish-eaters
Pc Control
Fc Control

Results

Plant species composition – sample plots ordination



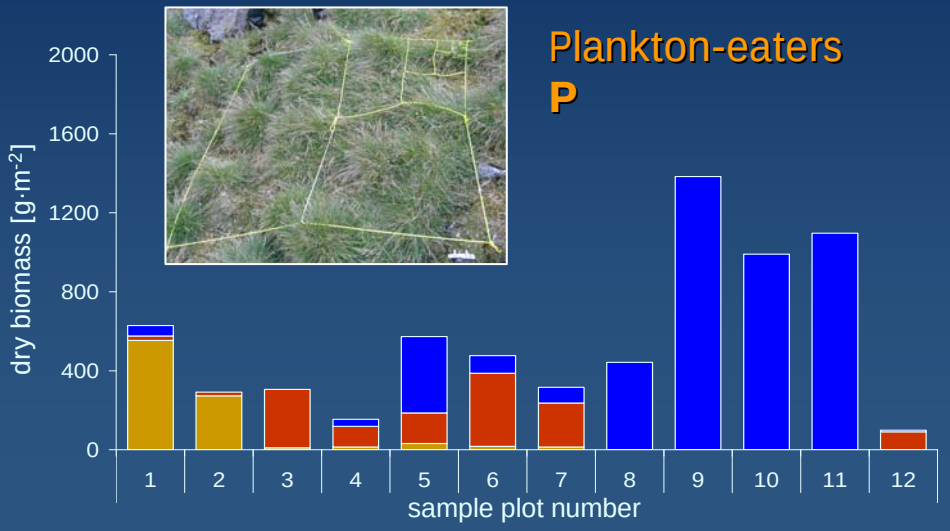
Higher heterogeneity of vegetation near both seabird colonies (**P** and **F**) vs. controls

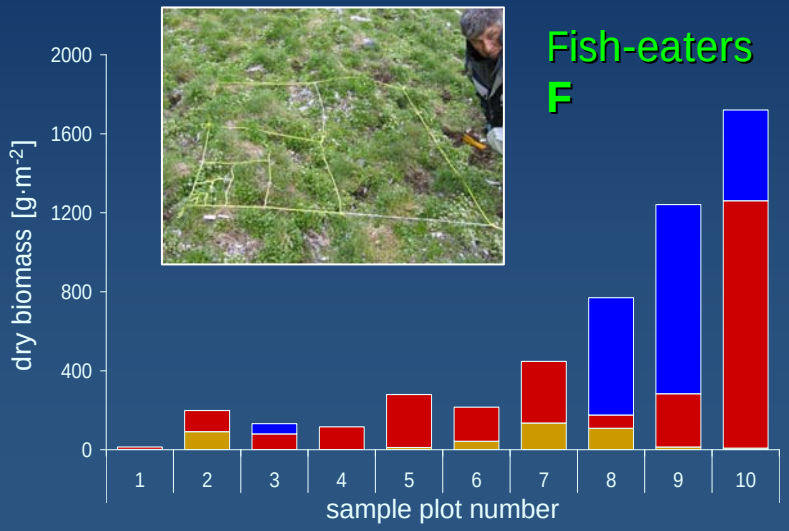
(similarly to soil samples ordination)

	analysis	variability [%]	MonteCarlo [F]	p
■ Plankton-eaters (**P**)	CCA	20,7	2,58	0,028
□ Control (Pc)	RDA	---	---	ns
● Fish-eaters (**F**)	CCA	39	5,25	0,034
○ Control (Fc)	RDA	---	---	ns

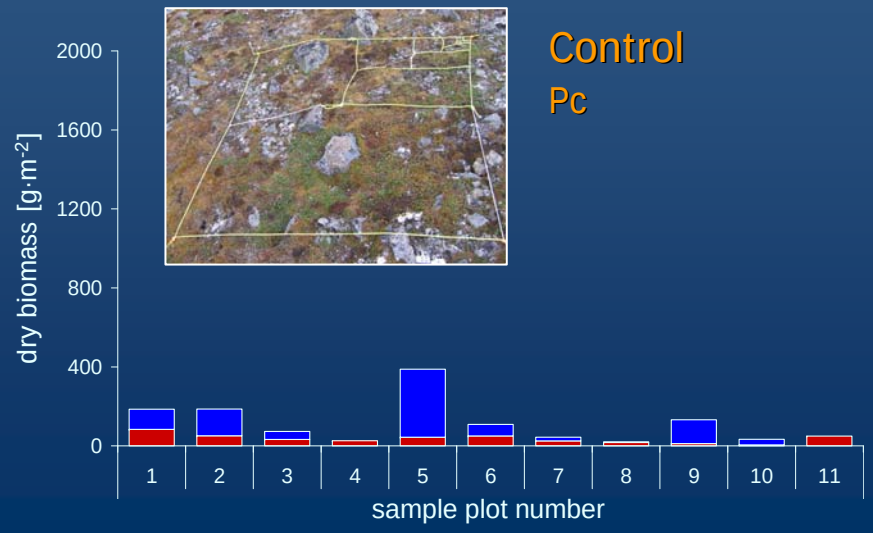
Results

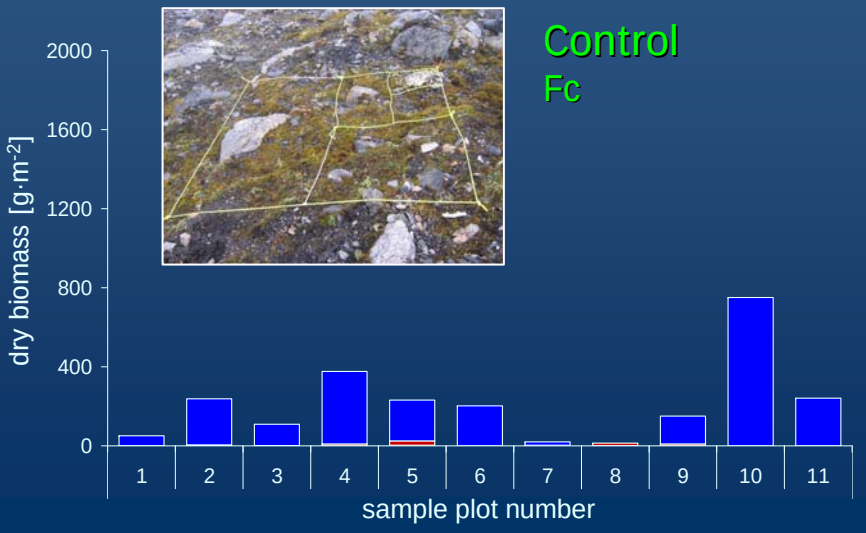
Vegetation biomass





Eudicots Monocots Mosses





Summary

Vicinity of seabird colonies:

- higher guano deposition
- higher soil ion's content: NO_3^-, NH_4^+, PO_4^{3-}, K^+ and lower pH
- gradual decrease of soil nutrient contents along the colony-sea axis
- higher heterogeneity of tundra plant communities
- *Cerastium arcticum* discriminating ornithogenic tundra plant communities
- higher biomass of plants

Summary

Fish-eaters' colony:

- higher guano deposition
- higher content of phosphates
- dominance of *Cochlearia groenlandica*

Plankton-eaters' colony:

- higher biomass of vascular plants, particularly grasses
- dominance of *Cerastium arcticum*

Thank you