The impact of different hydrographic conditions on food web traits of the west Spitsbergen fjords ecosystems:

A comparison between Kongsfjorden and Hornsund (West Spitsbergen Shelf)

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The main objectives of this study were to investigate and compare ecosystem structure, mass-flow patterns and keystoneness patterns (with emphasis on plankton, benthos and fish) in two closely situated fjord ecosystems influenced by different hydrographic conditions, by using the ECOPATH approach.

Our main hypothesis: Arctic marine ecosystem is growing up in the course of global Warming

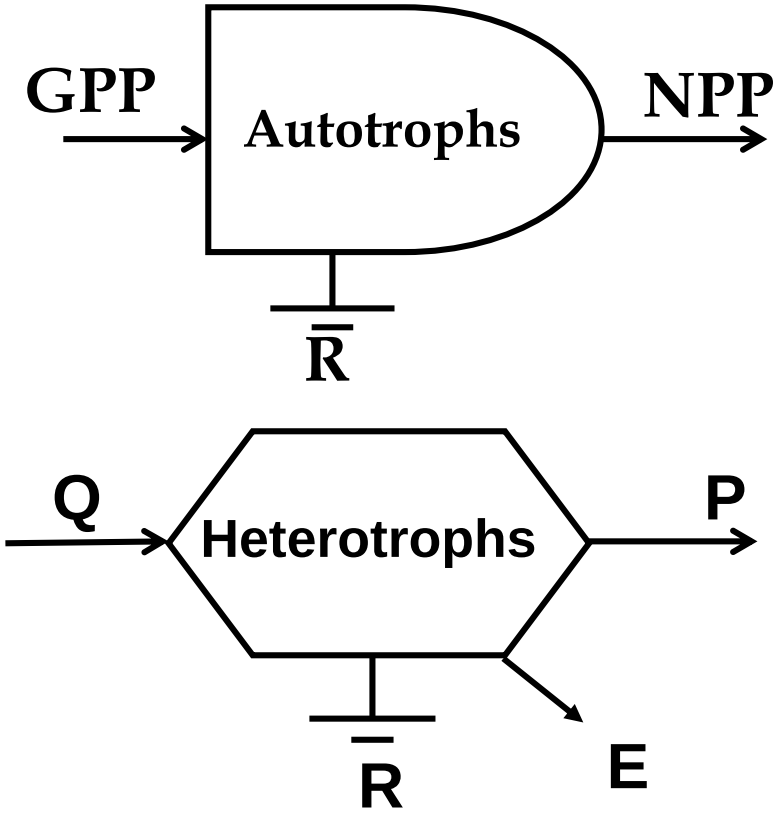
Coastal waters of European Arctic: world youngest large marine ecosystem,
released from ice sheet 12 thousands years ago

Growing up theory: The physical environment determines the pattern, the rate of change, and often sets limits as to how far development can go

Ecopath master equations:

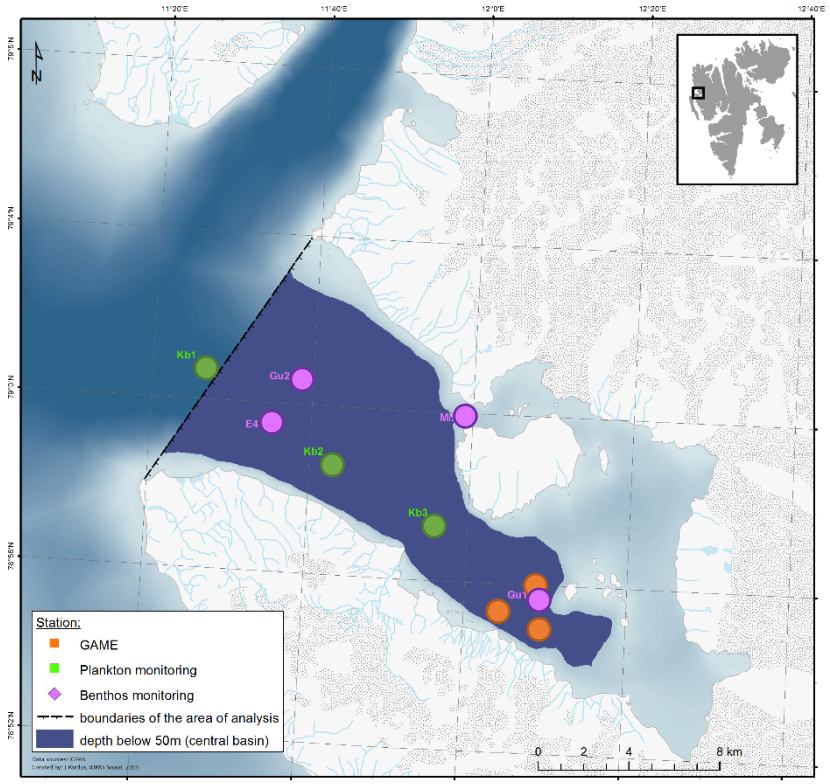
Production = Predation + Catches + Net migration + Biomass Accumulation + Other mortality

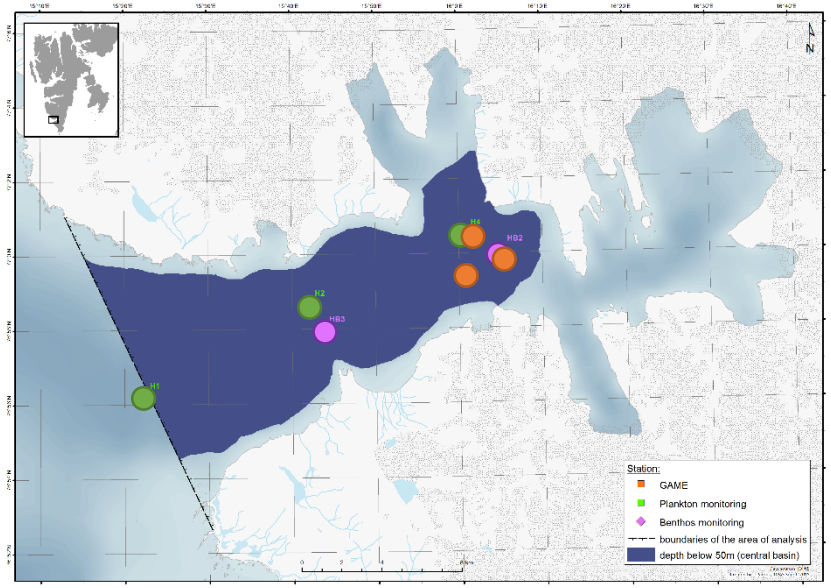
Consumption = Production + Unassimilated food + Respiration



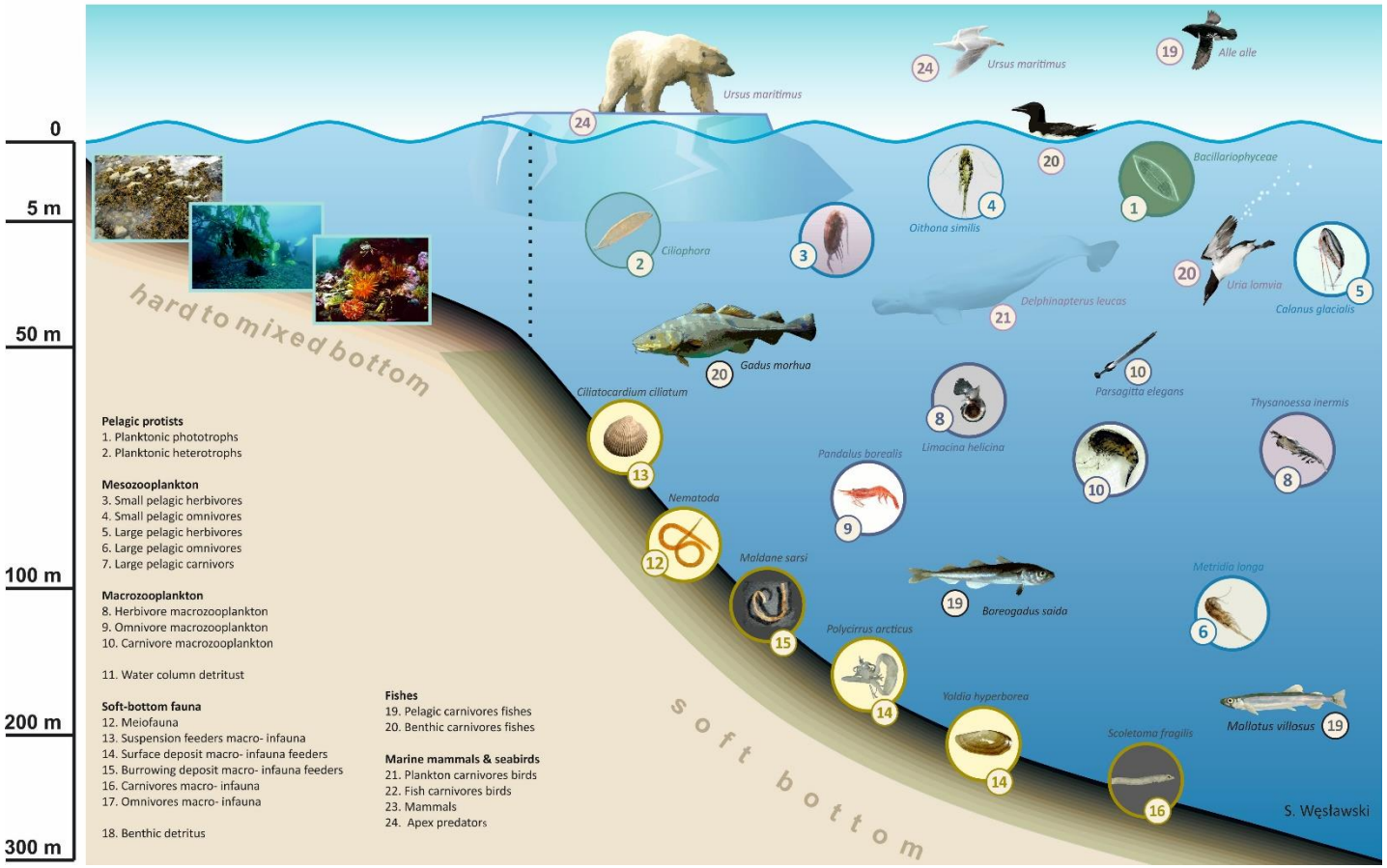
Ecopath data requirements:

B	Biomass	$t.km^{-2}$
P/B	Production/Biomass	$year^{-1}$
Q/B	Consumption/Biomass	$year^{-1}$
EE	Other mortality	Proportion
Diets		Proportion
Catches		$t.km^{-2}.year^{-1}$





Structure of the soft-bottom „GAME" model



Pelagic protists
1. Planktonic phototrophs
2. Planktonic heterotrophs

Mesozooplankton
3. Small pelagic herbivores
4. Small pelagic omnivores
5. Large pelagic herbivores
6. Large pelagic omnivores
7. Large pelagic carnivors

Macrozooplankton
8. Herbivore macrozooplankton
9. Omnivore macrozooplankton
10. Carnivore macrozooplankton

11. Water column detritust

Soft-bottom fauna
12. Meiofauna
13. Suspension feeders macro- infauna
14. Surface deposit macro- infauna feeders
15. Burrowing deposit macro- infauna feeders
16. Carnivores macro- infauna
17. Omnivores macro- infauna

18. Benthic detritus

Fishes
19. Pelagic carnivores fishes
20. Benthic carnivores fishes

Marine mammals & seabirds
21. Plankton carnivores birds
22. Fish carnivores birds
23. Mammals
24. Apex predators

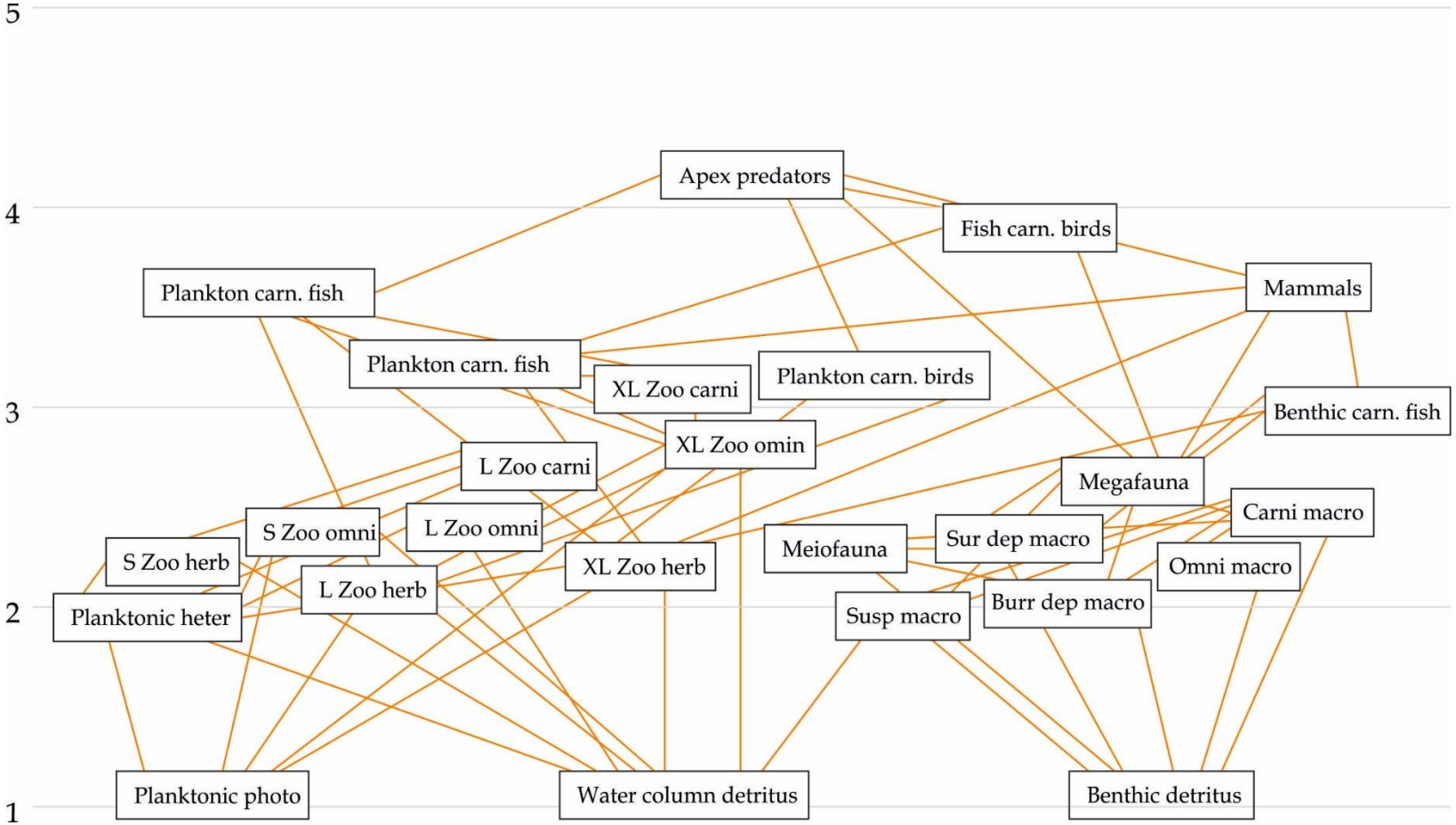
Model group structure - the 25 ecological groups

Pelagic protist	1. Planktonic phototrophs 2. Planktonic heterotrophs	Kubiszyn, Smoła, Wiktor et al. 2002-2006-2012-2013
Mesozooplankton	3. Small pelagic herbivores 4. Small pelagic omnivores 5. Large pelagic herbivores 6. Large pelagic omnivores 7. Large pelagic carnivors	Kwasniewski, Walkusz, Gluchowska, Ormanczyk, Trudnowska, et al. 2002-2007-2012-2013
Macrozooplankton	8. Herbivore macrozooplankton 9. Omnivore macrozooplankton 10. Carnivore macrozooplankton	
Meiofauna	11. Meiofauna	Grzelak, Włodarska et al. 2010-2013
Macrofauna	12. Suspension feeders macro- infauna 13. Surface deposit macro- infauna feeders 14. Burrowing deposit macro- infauna feeders 15. Carnivores macro- infauna 16. Omnivores macro- infauna	Wlodarska-Kowalczuk, Gorska, Deja et al. 2010-2013
Mobile megafauna	17. Megafauna	Szczucka et al. 2013
Fish	18. Pelagic carnivores fish 19. Benthic carnivores fish	
Marine mammals &seabirds	20. Plankton carnivores birds 21. Fish carnivores birds 22. Mammals 23. Apex predators	Stempniewicz et al. archival data
Detritus	24. Water column detritus 25. Benthic detritus	

Table
Summary of basics parameters inputs of the Ecopath models. B-biomass; P/B – Production/Biomass ratio; Q/B – Consumption/Biomass ratio

Group				Hornsund		Kongsfjorden	
	Trophic level	P/B (year^{-1})	Q/B (year^{-1})	EE	Biomass (g m^2)	EE	Biomass (g m^2)
Planktonic phototrophs	1,00	100		0,12	2,48	0,42	1,48
Planktonic heterotrophs	2,09	36	120	0,85	0,60	0,98	1,06
Small pelagic herbivores	2,22	13	25	0,79	0,20	0,40	0,34
Small pelagic omnivores	2,22	11	25	0,74	0,18	0,22	0,54
Large pelagic herbivores	2,11	6,5	26	0,61	3,26	0,32	6,68
Large pelagic omnivores	2,41	4,5	12	0,48	0,50	0,76	0,37
Large pelagic carnivors	2,70	3	17	0,50	0,14	0,71	0,12
Herbivore macrozooplankton	2,22	4,9	16,7	0,62	0,32	0,14	1,31
Omnivore macrozooplankton	2,87	2	13,3	0,74	0,19	0,74	0,18
Carnivore macrozooplankton	3,15	0,2	17	0,74	0,62	0,56	0,75
Meiofauna	2,25	19	47,5	0,80	1,15	0,90	1,75
Suspension feeders macro- infauna	2,00	1,5	9,75	0,46	2,48	0,43	3,26
Surface deposit macro- infauna feeders	2,25	1,5	9,75	0,50	2,23	0,29	4,51
Burrowing deposit macro- infauna feeders	2,06	1,5	9,75	0,47	1,69	0,44	2,48
Omnivores macro- infauna	2,31	1,5	9,78	0,35	0,08	0,07	0,61
Carnivores macro- infauna	2,42	1,5	9,75	0,28	0,85	0,21	1,27
Megafauna	2,64	1,25	5	0,90	14,51	0,90	15,60
Pelagic carnivores fish	3,22	1	3	0,90	1,52	0,90	1,90
Benthic carnivores fish	2,72	0,3	6	0,90	1,73	0,90	1,87
Plankton carnivores birds	3,11	1	110	0,05	0,01	0,60	0,00
Fish carnivores birds	3,90	1	125	0,03	0,02	0,04	0,02
Mammals	3,60	0,1	32	0,41	0,07	0,38	0,08
Apex predators	4,15	0,1	12	0,00	0,00	0,00	0,00
Water column detritus & bacteria	1,00			0,24	60,00	0,99	30,00
Benthic detritus & bacteria	1,00			0,98	60,00	0,95	30,00

Trophic levels and corresponding net productions



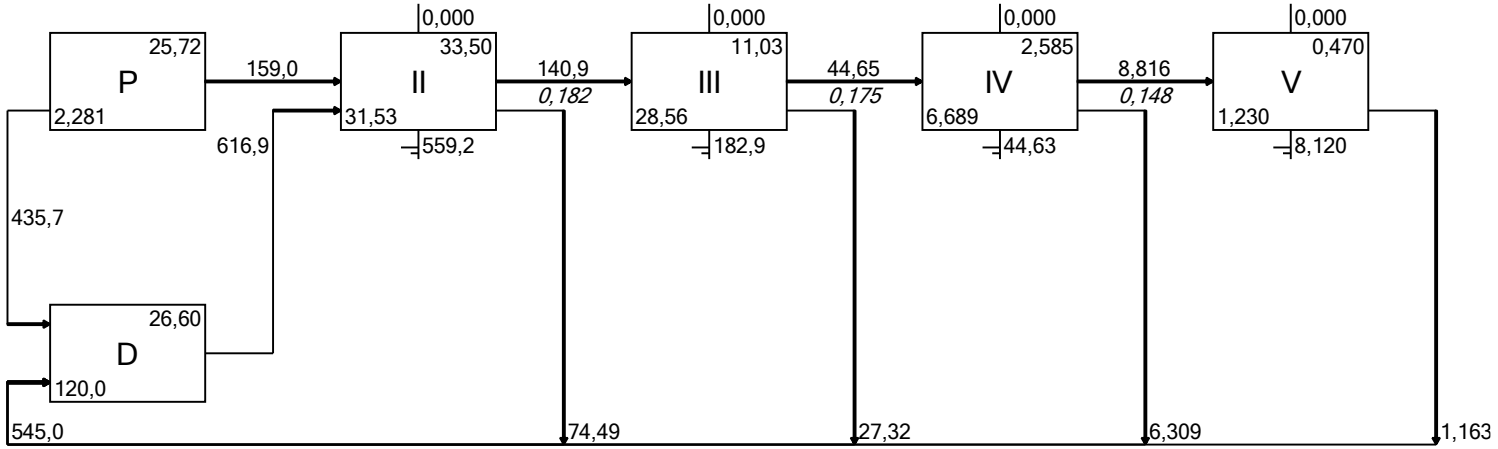
Net production ($gC\ m^{-2}\ year^{-1}$)

	Hornsund	Konsgfjorden
> 4th TL:	0.7	0.6
3th - 4th TL:	3.0	3.8
2nd - 3th TL:	17.6	46.9
PP:	435.7	170.5

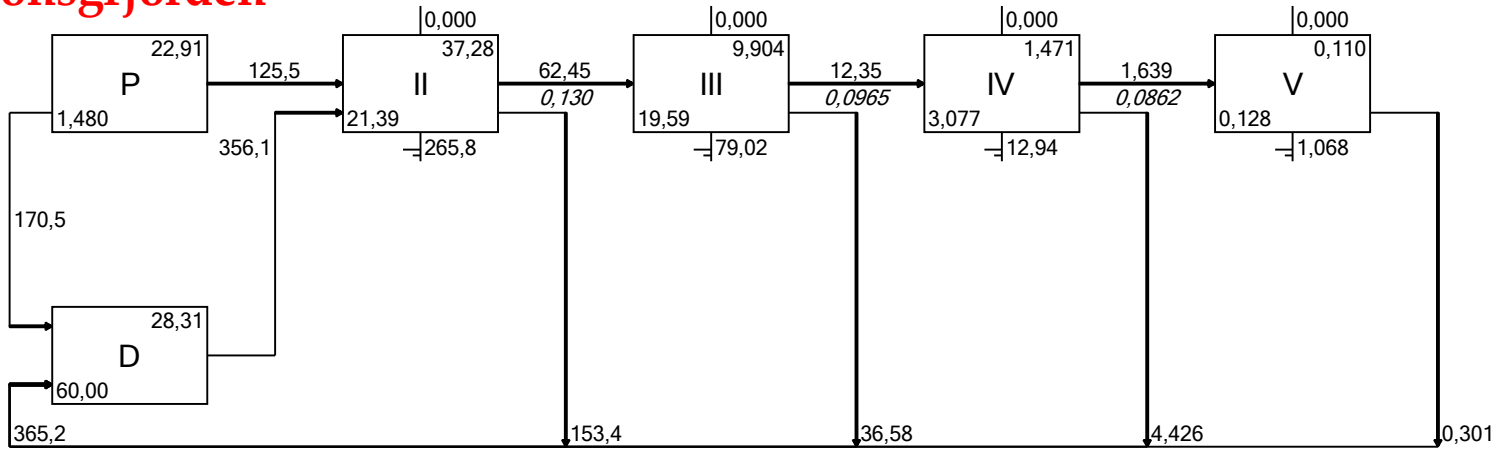
Table
Summary statistics comparing the Ecopath models

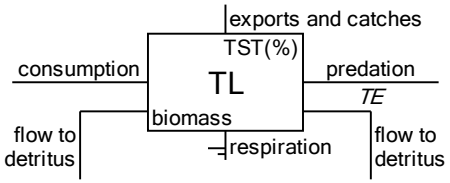
Ecosystem theory indices	**Hornsund**	**Konsgfjorden**	
Sum of all consumption (gC m^{-2} $year^{-1}$)	412,71	665,85	
Sum of all exports (gC m^{-2} $year^{-1}$)	2,06	9,08	
Sum of all respiratory flows (gC m^{-2} $year^{-1}$)	225,16	358,86	
Sum of all flows into detritus (gC m^{-2} $year^{-1}$)	545,27	365,74	
Total system throughput (TST, gC m^{-2} $year^{-1}$)	1185,20	1399,53	→ size of the entire system in terms of flow (Ulanowicz, 1986)
Sum of all production (gC m^{-2} $year^{-1}$)	600,61	469,82	
Calculated total net primary production (gC m^{-2} $year^{-1}$)	495,60	296,00	
Total primary production/total respiration (TPR/TR)	4,20	1,42	→ Indicating maturity of an ecosystem, close to 1 – mature ecosystem (Odum, 1971)
Net system production (PP-TP) (gC m^{-2} $year^{-1}$)	270,44	12,86	
Total primary production/total biomass (TPP/TB)	14,23	5,48	→ Indicating maturity of an ecosystem (Odum, 1971; Christensen, 1995)
Total biomass/total throughput (TB/TST)	0,03	0,03	
Total biomass (excluding detritus) (TB) (gC m^{-2} $year^{-1}$)	34,83	45,67	

Hornsund



Konsgfjorden





- the highest TE occured between II and III TL
- biomass associated with all trophic levels were higher in Hornsund
- higher flow to detritus in Hornsund

Summary

Relative contribution (%) of major components to total biomass and total production

	Biomass		Production	
	Hornsund	Kongsfjord	Hornsund	Kongsfjord
Plankton	0,39	0,41	0,94	0,88
Benthos	0,46	0,49	0,06	0,12
Nekton	0,15	0,10	0,00	0,00
Mammals & Seabirds	0,01	0,00	0,00	0,00

Both ecosystems are dominated by bethos

	Hornsund		Konsgfjorden
Biomass:		<	
Production:		>	
Consumption:		<	
Maturity:		<	

Hornsund – development stage

Kongsfjorden – more mature ecosystem, characterized by the high transfer efficienty, high carbon recycling, Energy conservation and stability