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Patterns in macrozooplankton and micronekton biomass distribution across four north Atlantic ocean basins

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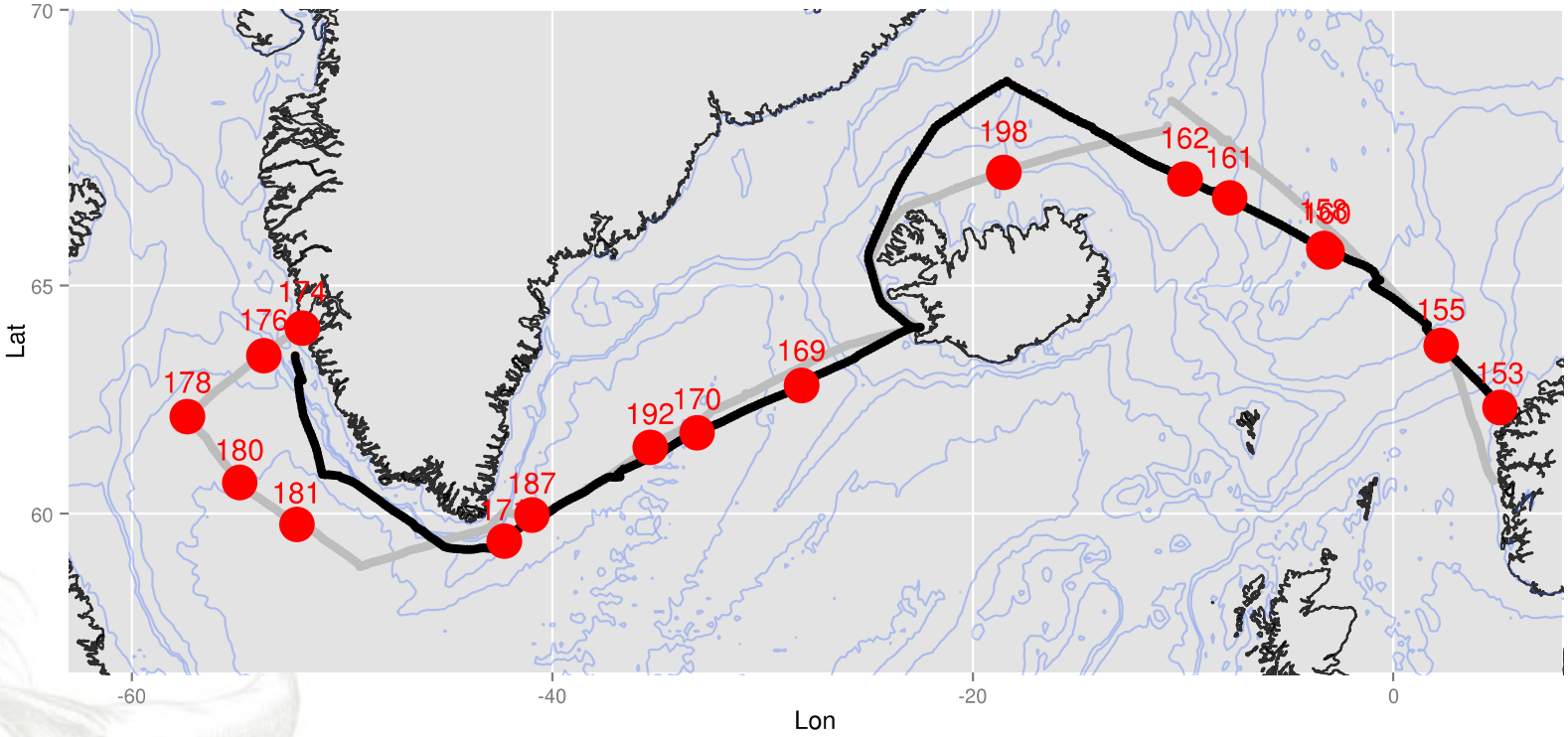
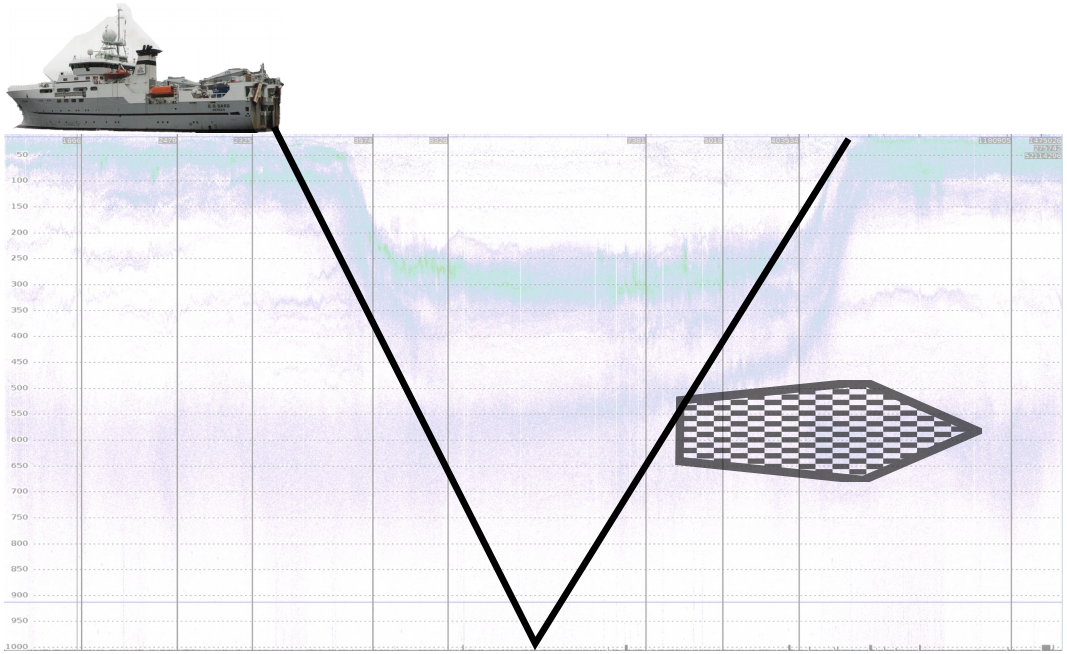
Patterns in micronekton biomass



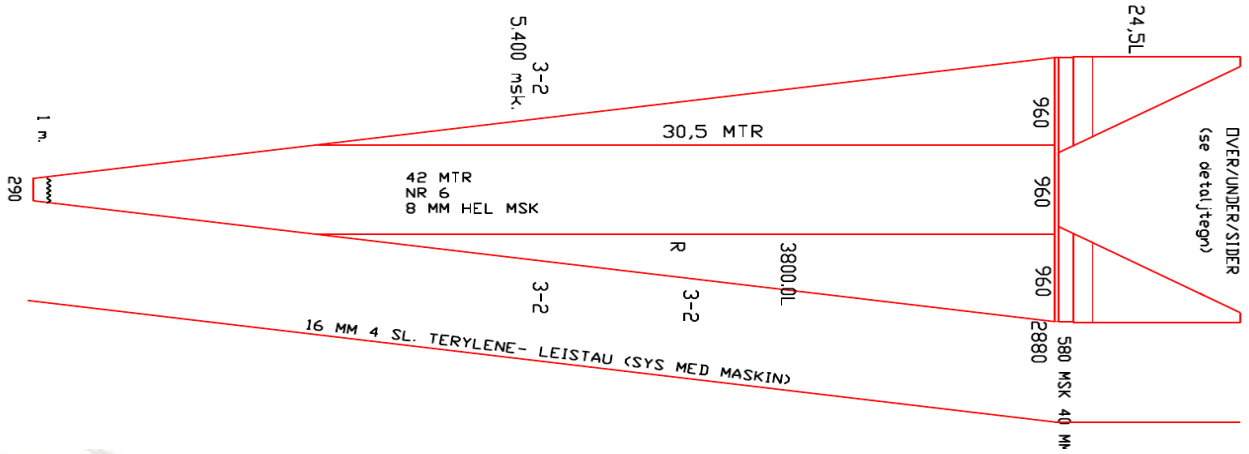
Patterns in micronekton biomass

- Primary data from oblique hauls 0 -1000 m during Euro BASIN



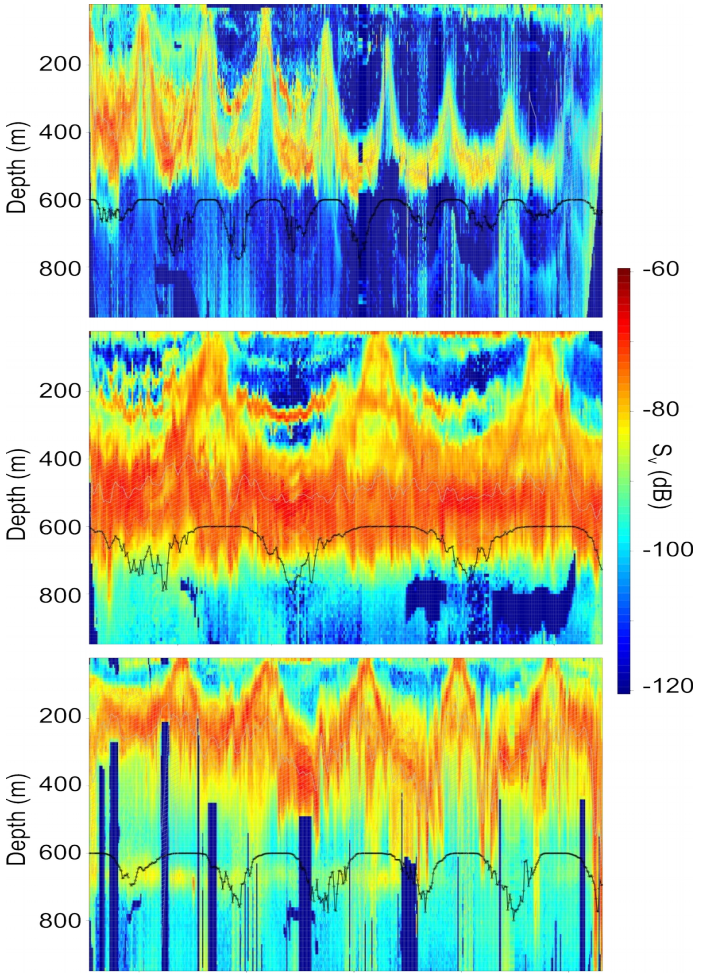
Patterns in micronekton biomass

- Macroplankton trawl: 6x6 m opening
- 3x3 mm mesh along entire length
- 45 m long



Patterns in micronekton biomass

- Additional data from acoustics, both hull mounted and towed body



Patterns in micronekton biomass

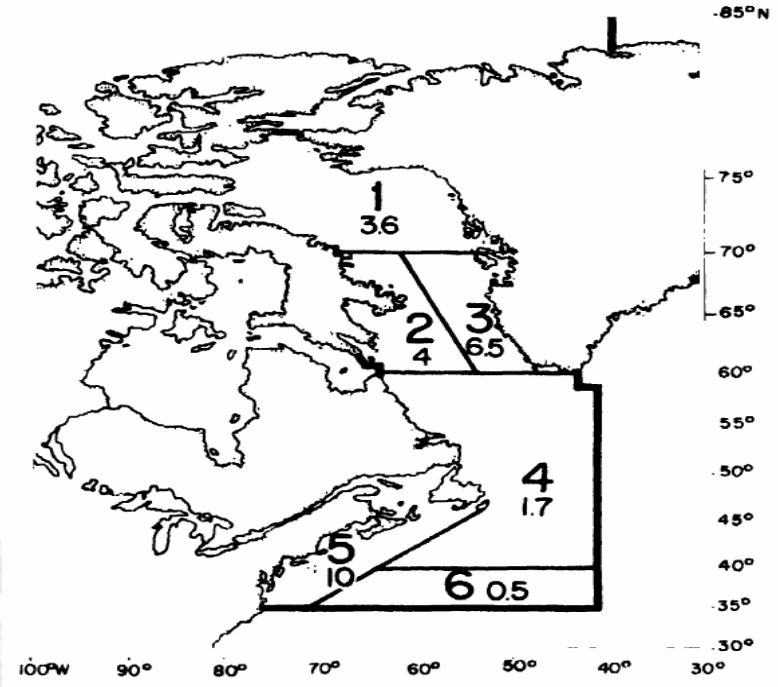
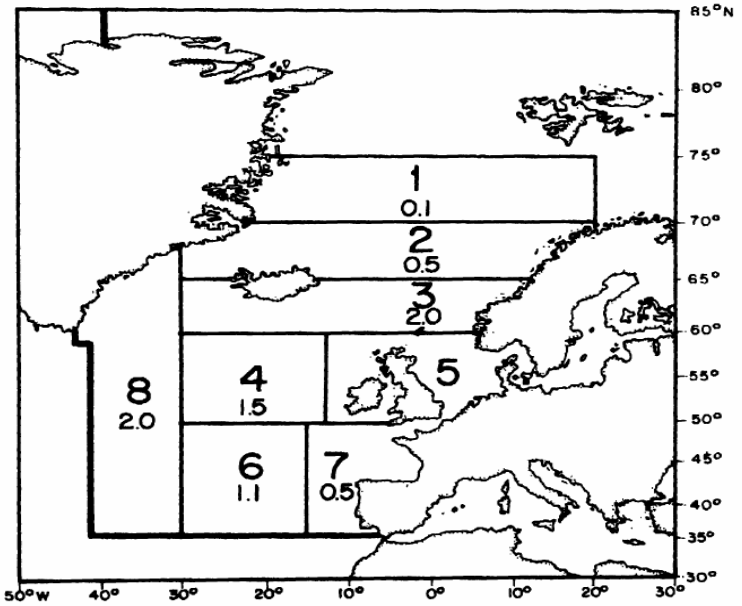


Fig. 6.2 Subareas of the Northwest Atlantic used in the biomass assessment (Table 6.2). The smaller figures indicate mean biomass in g/m^2



g. 5.2 Subareas of the Northeast Atlantic used in the biomass assessment (Table 5.3). The smaller figures indicate mean biomass in g/m^2

FAO Fisheries Technical Paper No. 193

A REVIEW OF THE WORLD RESOURCES OF MESOPELAGIC FISH

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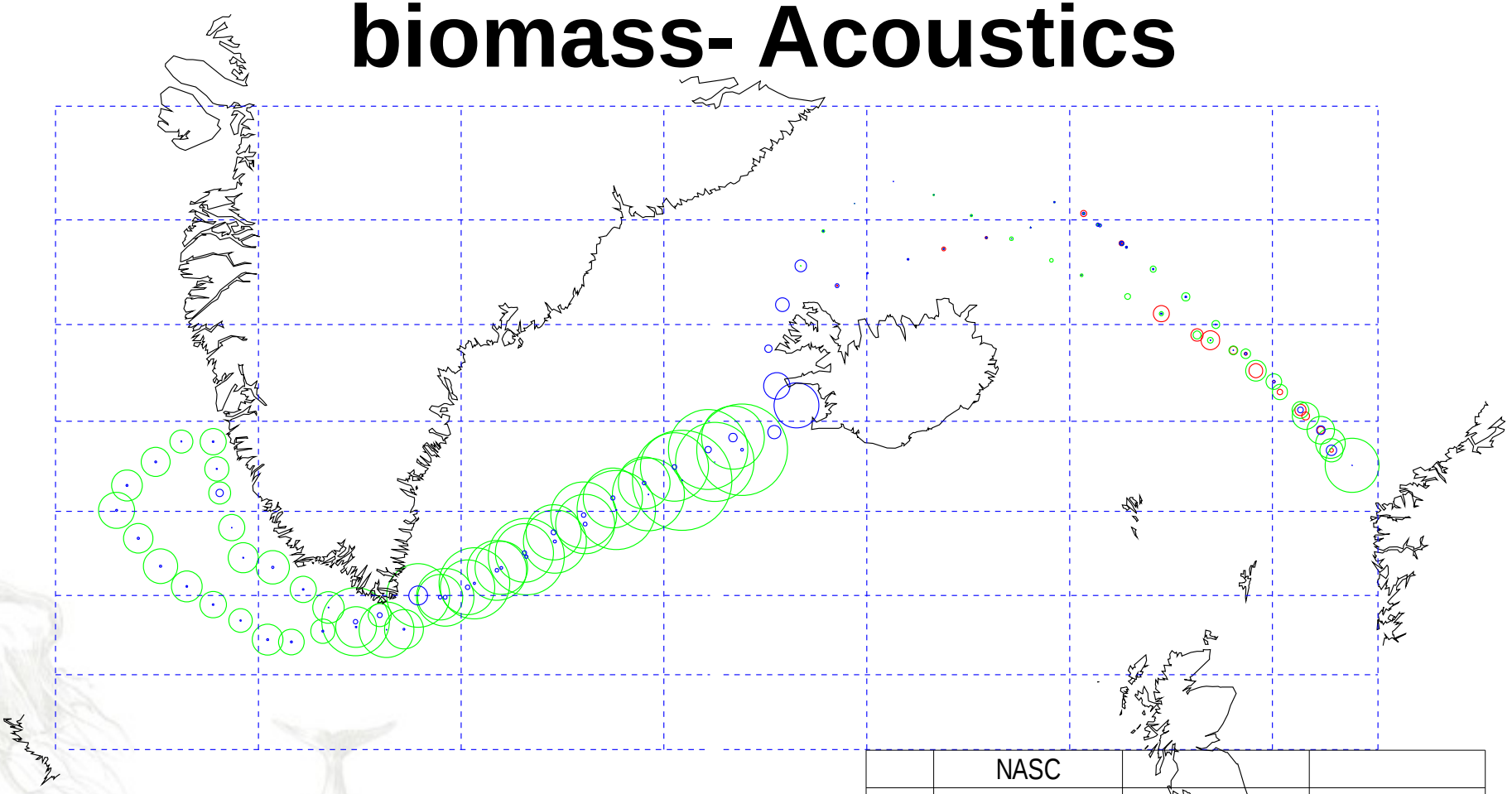
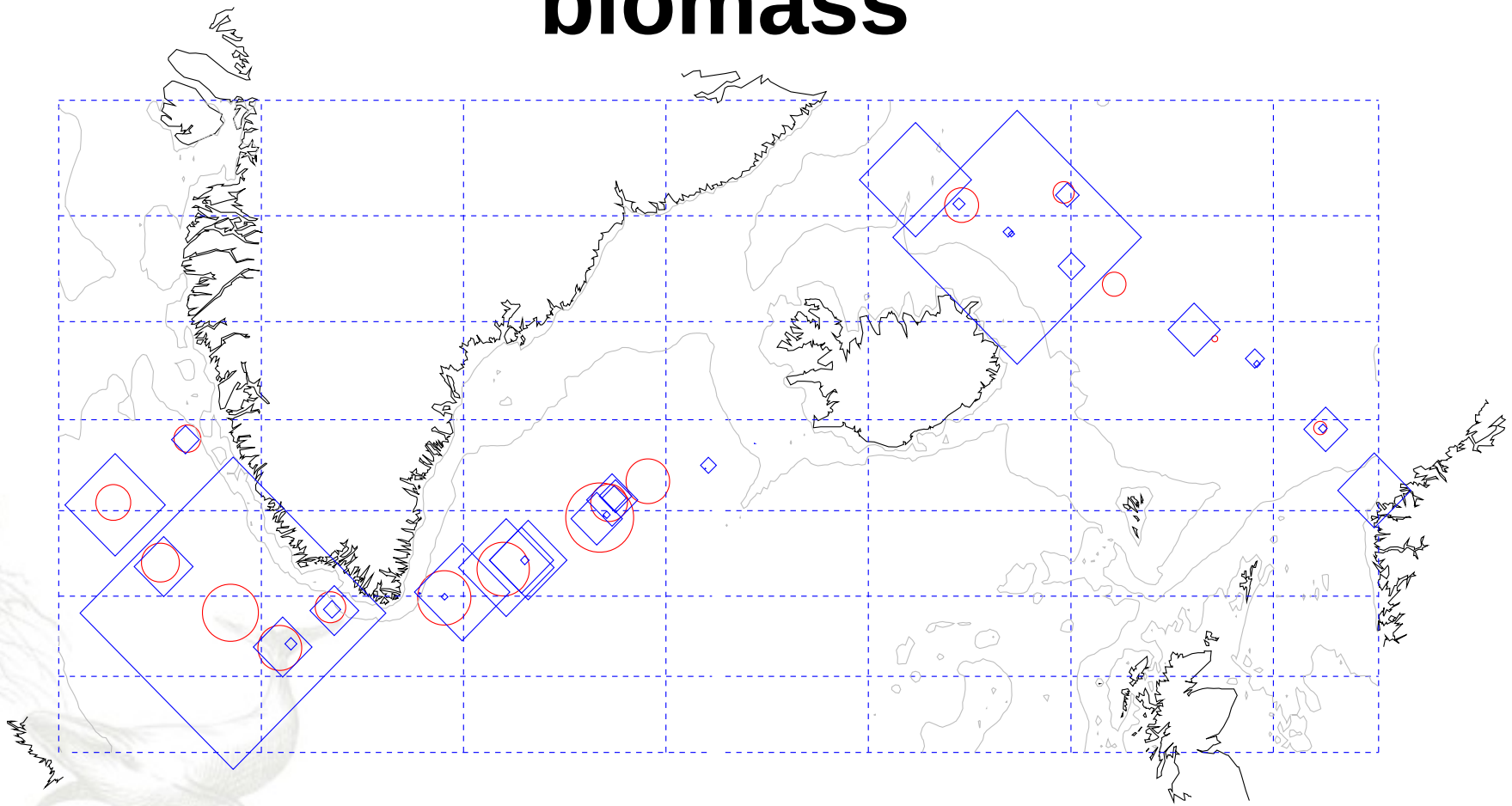
Patterns in micronekton biomass- Acoustics



	NASC		
Area	Large_fish	Mesopelagic	Crustacean
Ice	19	29	23
Irm	0	962	44
Lab	0	591	27
Nor	155	325	26

- Relative scales, not comparable between groups.
  Green: Mesopelagic backscatter, red: larger pelagic fishes, blue: crustacean backscatter.

Patterns in micronekton biomass



Patterns in micronekton biomass- Biomass (g WW m-2)

	Krill	Amphipoda	Shrimp	Myctophidae	Bathylagidae	Gonostomatidae	Nemichthyidae
Ice	0.6	1.7	3.8	0.8	-	-	-
Irm	0.5	0.1	6.6	5.5	4.4	7.5	1.8
Lab	1.5	0.2	4.6	7.4	4.5	2.1	0.5
Nor	1.2	0.2	1.7	0.7	-	-	-
Nor-HIST	2.0	0.3	0.4	0.7	-	0.0	-

	Stomiidae	Other fish	Cephalopoda	Jelly	Total	TotCrust	TotFish
Ice	-	0.1	4.3	6.3	11.2	6.1	0.8
Irm	1.8	0.5	1.2	70.6	29.8	7.3	21.4
Lab	0.6	0.3	1.2	55.5	22.9	6.4	15.4
Nor	-	0.3	2.4	3.7	6.5	3.1	1.0
Nor-HIST	-	0.3	0.6	1.9	4.4	2.7	1.1

- Total weight is excluding larger fishes and groups with low prevalence (e.g. Barracudinas)
- Other fish: other fish groups in micronekton size-range pooled (Barracudinas excluded)
- Gelatinous group dominated by Periphylla & Atolla

Patterns in micronekton biomass- Relative Biomass

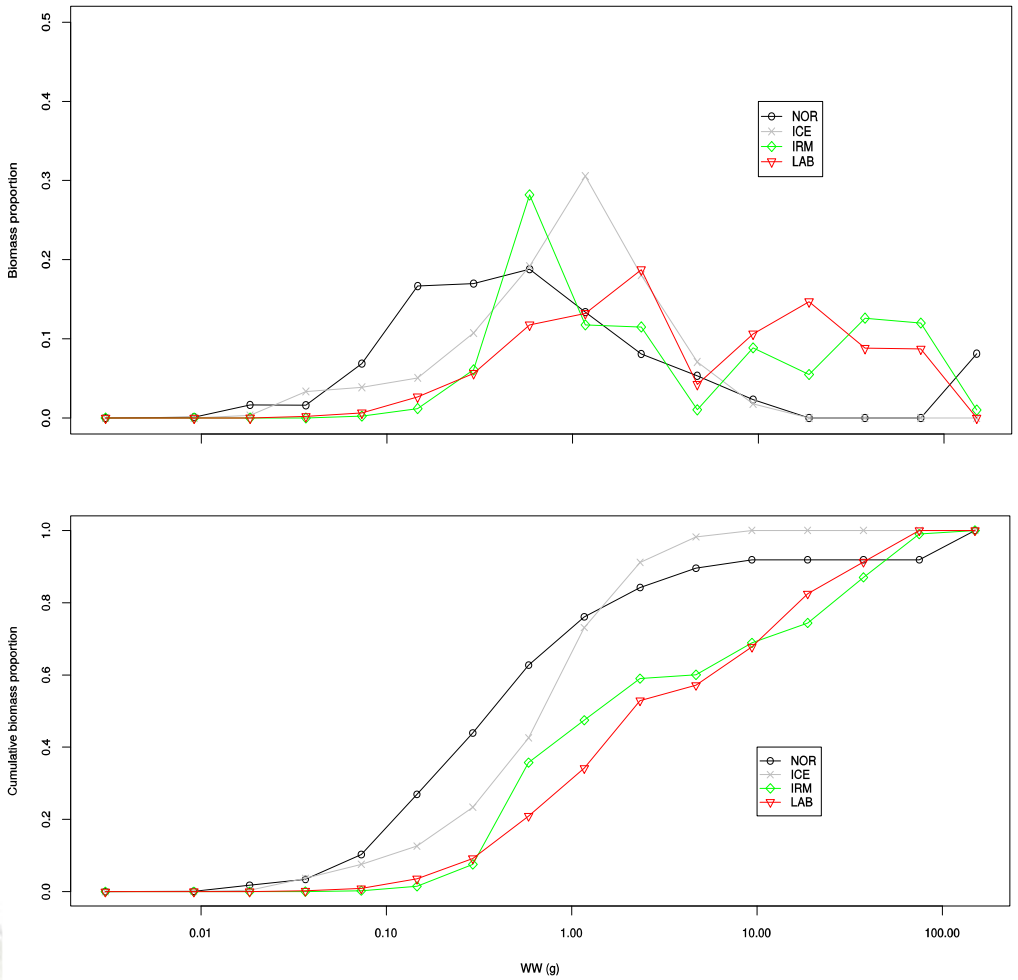
	Krill	Amphipoda	Shrimp	Myctophidae	Bathylagidae	Gonostomatidae	Nemichthyidae
Ice	6	15	34	7	-	-	-
Irm	2	0	22	18	15	25	6
Lab	7	1	20	32	20	9	2
Nor	19	2	27	11	-	-	-
Nor-HIST	47	6	10	16	-	1	-

	Stomiidae	Other fish	Cephalopoda	Jelly	TotCrust	TotFish	N
Ice	-	1	38	0.6	54	7	3
Irm	6	2	4	2.4	24	72	5
Lab	2	1	5	2.4	28	67	6
Nor	-	5	36	0.6	48	16	2
Nor-HIST	-	7	13	0.4	62	25	51

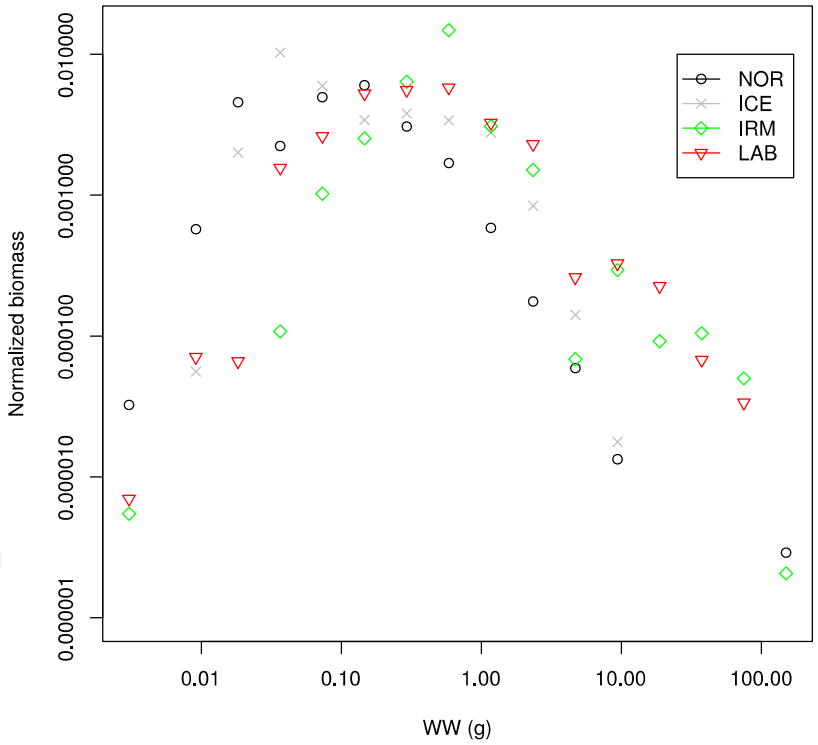
- Numbers in percentage of non-gelationous catch
- Gelatinous numbers fraction relative total non-gelatinous

Patterns in micronekton biomass: Size spectra

- Individual weights estimated from length measurements
- Only non-gelatinous organisms



Patterns in micronekton biomass: Normalized biomass size spectra



Patterns in micronekton biomass- comparable measures

- Conversions: DW 20 % of WW

C 40% of DW (all groups except jelly)

Jelly: WW2C 0.0058 (avg for P.periphylla Kiørboe et al. 2013)

- In comparison: Overwintering Calanus (data from Jonasdottir et al. 2015)

Patterns in micronekton biomass- carbon mg C m^{-2}

	Krill	Amphipoda	Shrimp	Myctophidae	Bathylagidae	Gonostomatidae	Nemichthyidae
Ice	254	135	302	62	NA	NA	NA
Irm	38	11	532	440	349	598	141
Lab	121	15	372	594	359	168	41
Nor	99	12	140	59	NA	NA	NA
Nor-HIST	164	20	33	57	NA	4	NA

	Stomiidae	Other fish	Cephalopoda	Jelly	Total	TotCrust	TotFish	Overwintering Calanus
Ice	NA	5	343	37	897	488	66	4716
Irm	145	40	93	409	2387	581	1712	1635
Lab	45	25	95	322	1835	508	1232	4266
Nor	NA	24	188	22	522	251	83	2280
Nor-HIST	NA	24	46	11	348	217	85	

- Total weight is excluding larger fishes and groups with low prevalence (e.g. Barracudinas)
- Other fish: other fish groups in micronekton size-range pooled (Barracudinas excluded)
- Gelatinous group dominated by Periphylla & Atolla

Patterns in micronekton biomass- relative Calanus owb

	Krill	Amphipoda	Shrimp	Myctophidae	Bathylagidae	Gonostomatidae	Nemichthyidae
Ice	0.05	0.03	0.06	0.01	NA	NA	NA
Irm	0.02	0.01	0.33	0.27	0.21	0.37	0.09
Lab	0.03	0.00	0.09	0.14	0.08	0.04	0.01
Nor	0.04	0.01	0.06	0.03	NA	NA	NA
Nor-HIST	0.07	0.01	0.01	0.03	NA	0.00	NA

	Stomiidae	Other fish	Cephalopoda	Jelly	Total	TotCrust	TotFish
Ice	NA	0.00	0.07	0.01	0.19	0.10	0.01
Irm	0.09	0.02	0.06	0.25	1.46	0.36	1.05
Lab	0.01	0.01	0.02	0.08	0.43	0.12	0.29
Nor	NA	0.01	0.08	0.01	0.23	0.11	0.04
Nor-HIST	NA	0.01	0.02	0.00	0.15	0.10	0.04

- Total weight is excluding larger fishes and groups with low prevalence (e.g. Barracudinas)
- Other fish: other fish groups in micronekton size-range pooled (Barracudinas excluded)
- Gelatinous group dominated by Periphylla & Atolla

Patterns in micronekton biomass- Biomass summary

- More diverse assemblage of micronektonic fishes in LAB and IRM
- ~50 % of non-gelatinous macroplankton/micronekton biomass in crustaceans in NOR/ICE
- ~70 % of non-gelatinous macroplankton/micronekton in mesopelagic fishes in IRM/LAB
- Gelatinous macroplankton 1 order of magnitude more abundant in LAB/IRM
- Schooling epipelagic fish restricted to ICE/NOR
- Cephalopods?

Patterns in micronekton biomass- Biomass summary

- Wrt. FAO 1980 comparable biomass levels in NOR and ICE
- ~1 order of magnitude higher biomass found in IRM, more than 2x in LAB
- However, Euro-BASIN with low N

Patterns in micronekton biomass- QA

- Poor coverage (N and western NOR)
- Avoidance
- Extrusion
- Swarming organisms

Patterns in micronekton biomass- Prevalence

	Krill	Amphipoda	Shrimp	Myctophidae	Bathylagidae	Gonostomatidae	Nemichthyidae	Stomiidae	Other fish	Cephalopoda	Jelly
Ice (3)	1	1	1	1	0	0	0	0	0.33	1	1
Irm (5)	1	1	1	1	1	1	1	1	1	1	1
Lab (6)	1	1	1	1	1	1	0.83	1	0.83	1	1
Nor (2)	1	1	1	1	0	0	0	0	1	1	1
Nor-HIST (51)	0.94	0.94	0.88	1	0	0.04	0	0	0.12	0.55	0.82

Patterns in micronekton biomass- Variability

Biomass CV

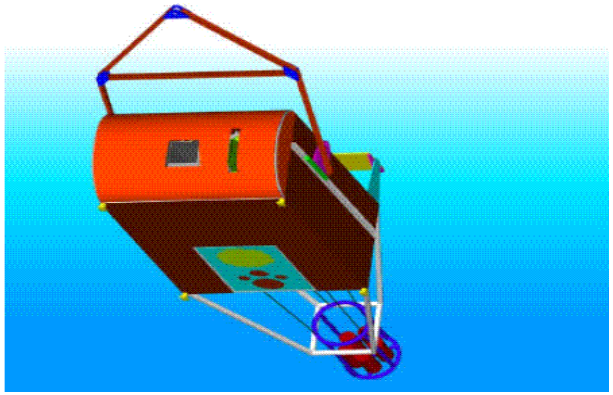
	Krill	Amphipoda	Shrimp	Myctophidae	Cephalopoda	Jelly	Total non-gelat:
Ice	0.65	0.99	0.56	0.87	0.67	0.47	0.3
Irm	0.70	0.47	0.41	0.42	0.88	0.40	0.3
Lab	0.56	0.72	0.29	0.35	1.96	0.49	0.3
Nor	0.99	0.57	0.19	0.94	0.49	1.04	0.6
Nor-HIST	1.32	1.87	1.31	1.16	2.34	1.19	

	CV NASC		
Area	Large_fish	Mesopelagic	Crustacean
Ice	10.0	1.0	2.5
Irm	NA	0.7	1.2
Lab	NA	0.6	1.0
Nor	2.5	0.9	2.0

Patterns in micronekton biomass

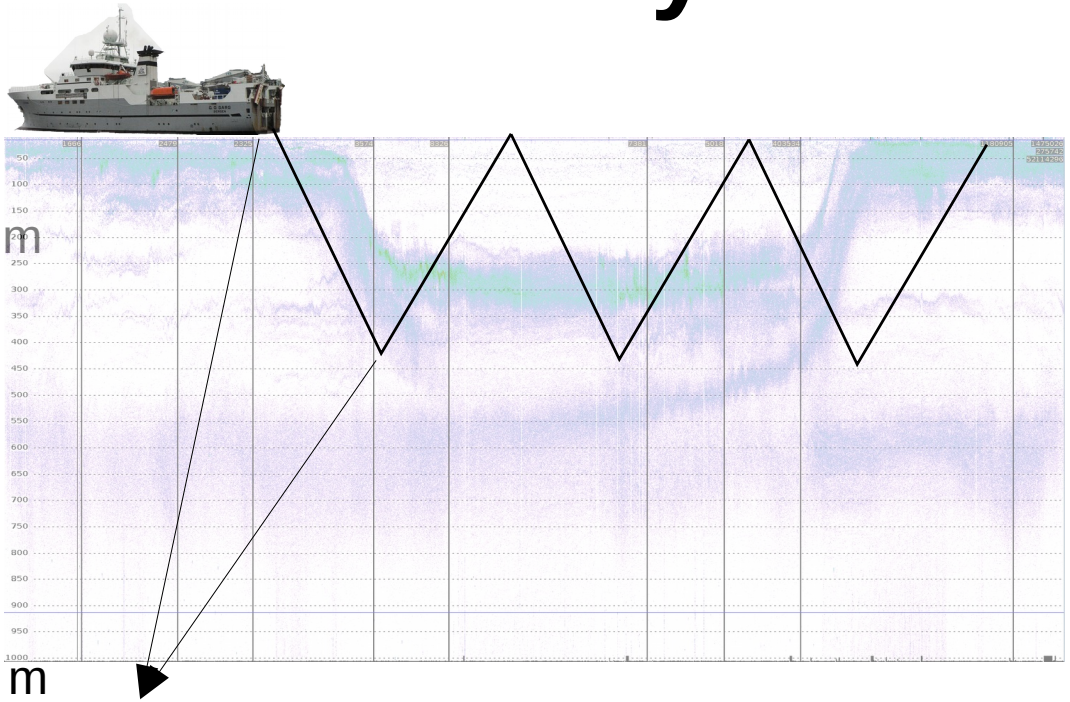
- Total estimated volumes for trawls ~ 190 000 m^3 (range 93 000 – 243 000)
- While total non-gelatinous catch CV was relatively low?, differences between max and min densities in trawl estimates of biomass densities in the different areas ranged from ~5 g WW m^{-2} (Nor) to ~ 14 g WW m^{-2} (Lab)
- What are the causes of these variations? Sampling error or natural variation?

Patterns in micronekton biomass- Variability in backscatter seen from a towed body



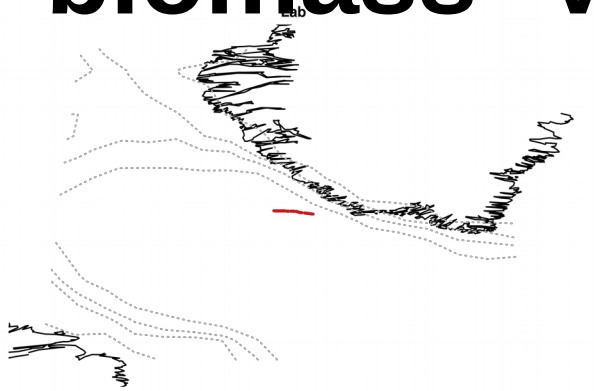
- Deployed from 0-400 m, undulating fashion.
- Acoustic sampling ranges 20 – 50 m
- Hull-mounted transducers with very large observation volumes at these depths

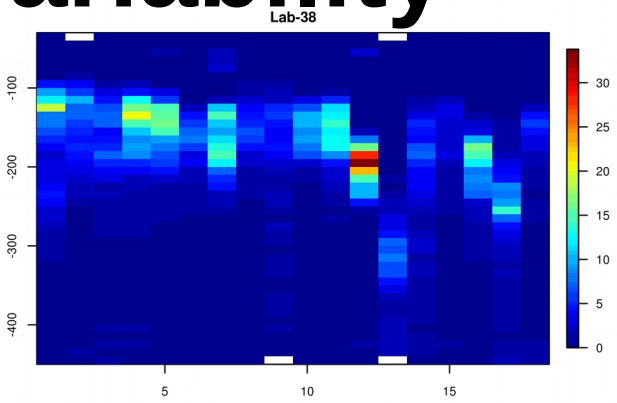
Patterns in micronekton biomass- Variability

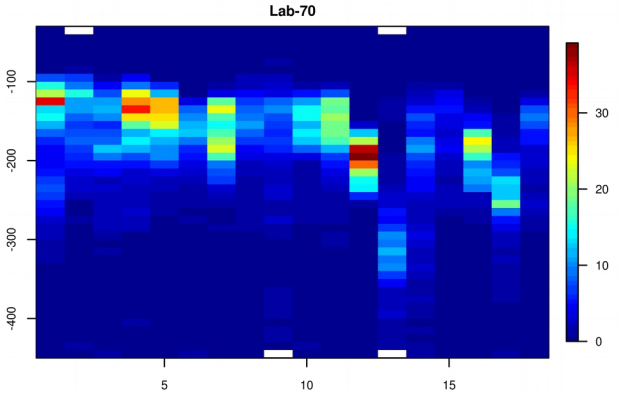


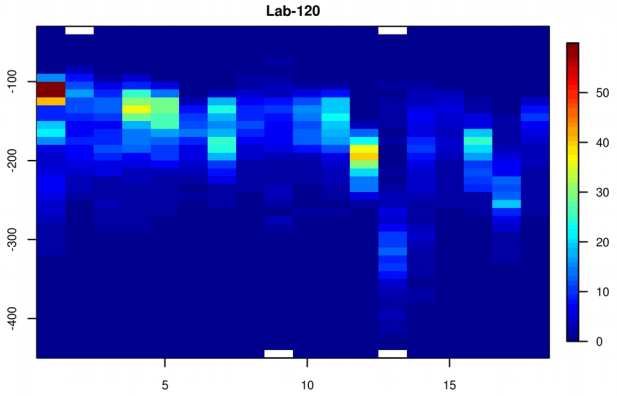
- MESSOR undulating 0-400 m
- Acoustic data from each upcast/downcast treated as a “virtual trawl”
- Means and CV computed based on “virtual trawls”
- Acoustic data from 20 to 50 m range, total coverage 20 - 450 m (with all 5 frequencies)

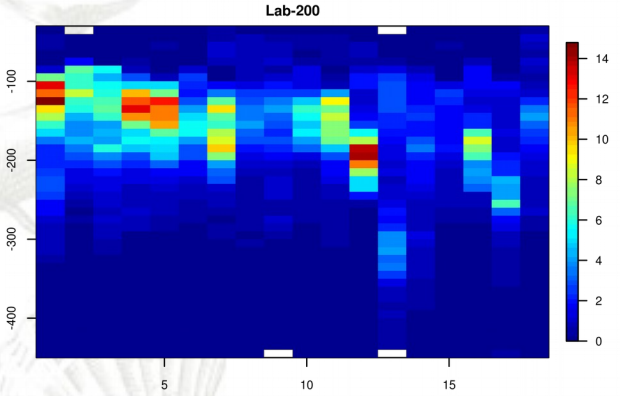
Patterns in micronekton biomass- Variability

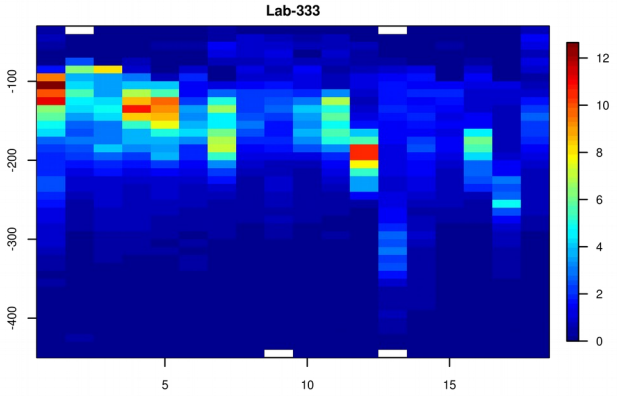




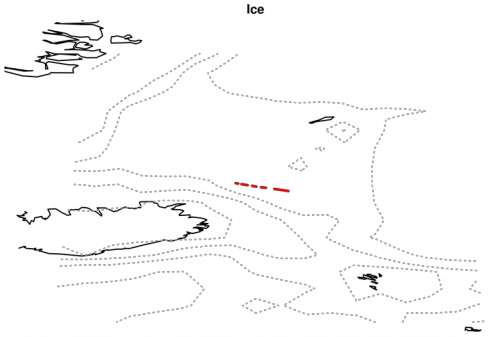


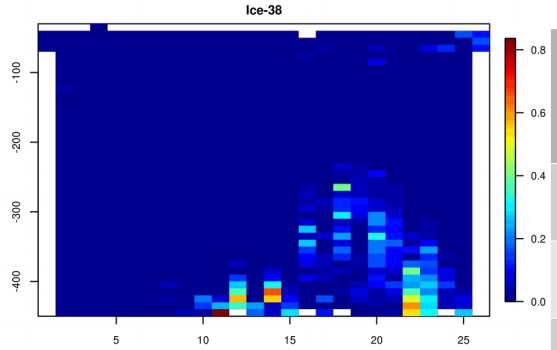


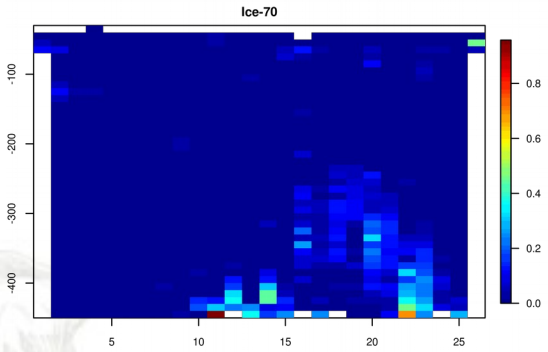


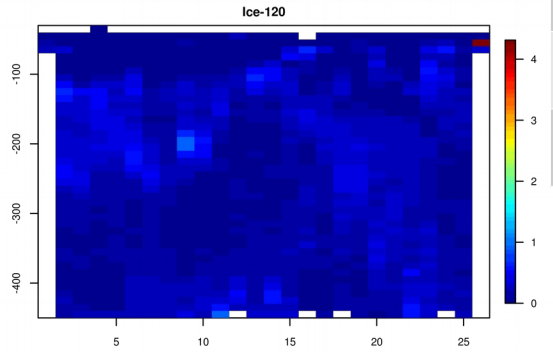


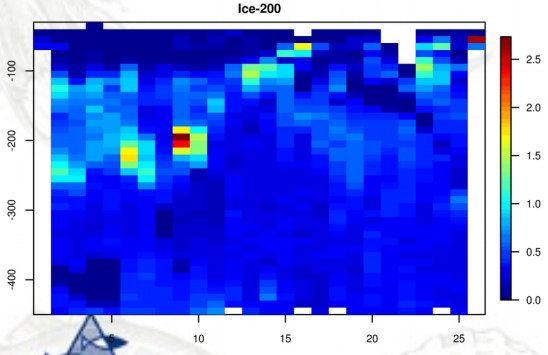
Patterns in micronekton biomass- Variability

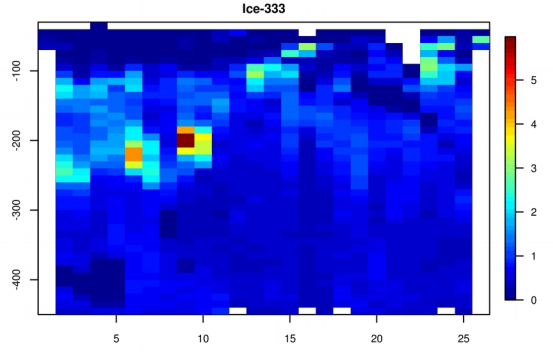












sA	Ar	CV 38	CV 70	CV 120	CV 200
0.08	Ice	0.9	0.9	0.4	0.3
1.83	Lab	0.4	0.3	0.4	0.3
2.03	Lab	0.7	0.6	0.6	0.7
2.09	Irm	0.9	0.8	1	1
0.20	Nor	0.6	0.5	0.3	0.2

Jelly	Total non-gelat:
0.47	0.3
0.40	0.3
0.49	0.3
1.04	0.6

Patterns in micronekton biomass- Jellyfish budget

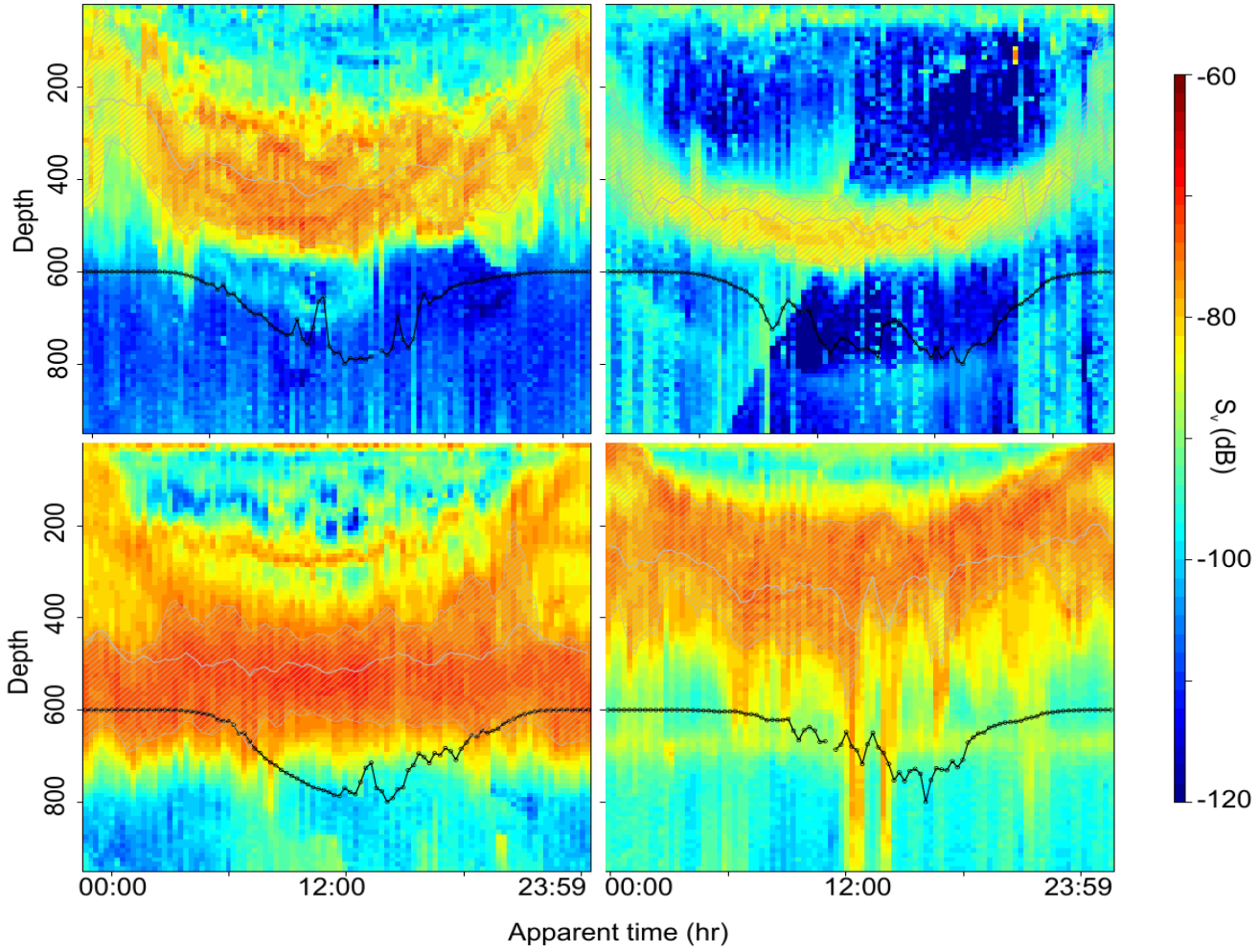
- Respiration data from Youngbluth and Båmstedt (2001): Periphylla 0.4 – 5.6 µl 0_2 mg C^{-1} h^{-1}

- Assume fat-based metabolism (e.g. RQ = 0.7)

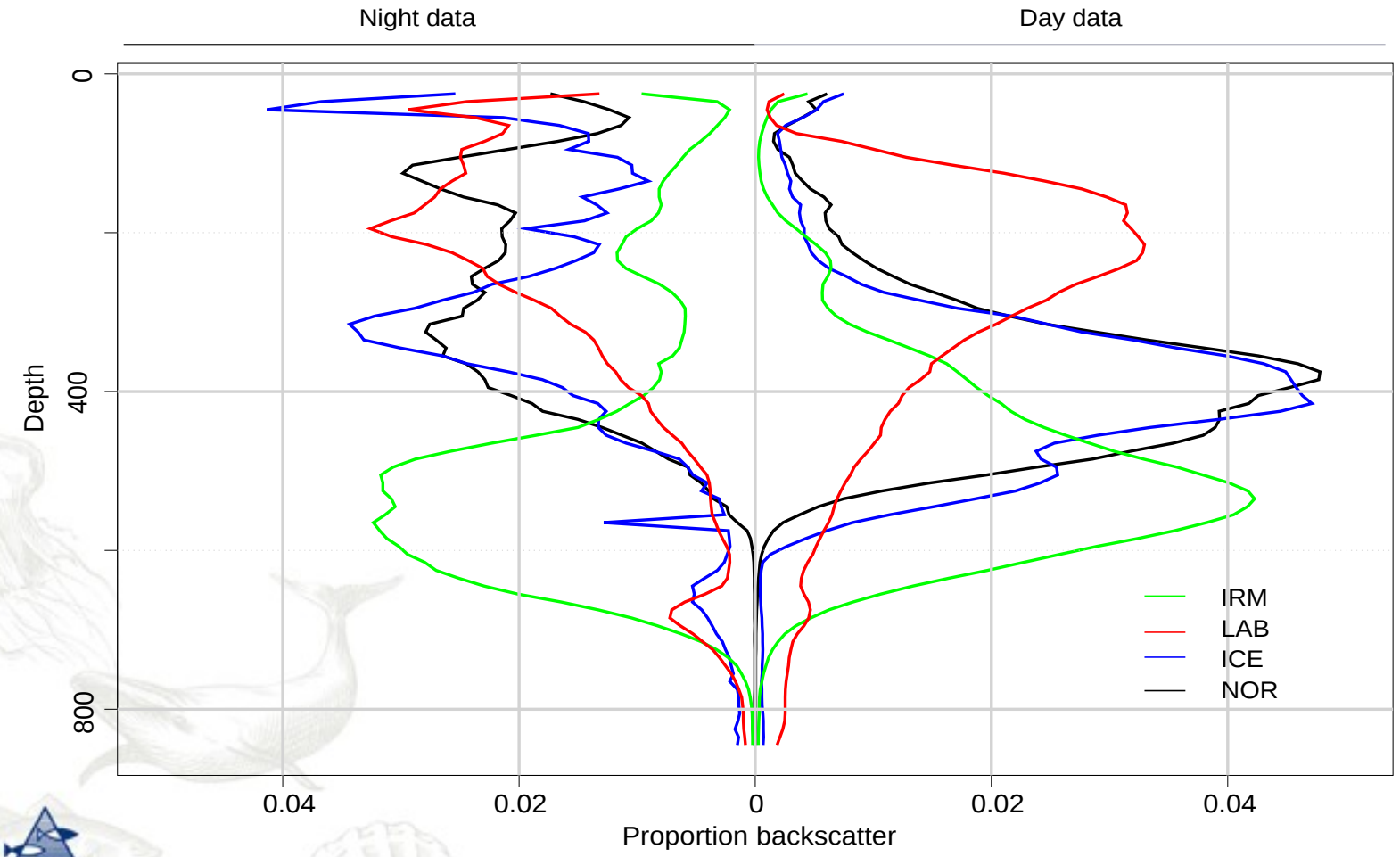
- Assume assimilation efficiency 0.9

Area	Carbon demand (mg C m^{-2} d^{-1})	"Crustacea" demand (mg WW m^{-2} d^{-1})	Resp rate (µl 0_2 mg C^{-1} h^{-1})	Relative Calanus owb
Ice	0.2	2	0.4	0.003 %
Irm	1.6	21	0.4	0.1 %
Lab	1.3	16	0.4	0.03 %
Nor	0.1	1	0.4	0.004 %
Ice	2.1	25	5.6	0.04 %
Irm	23	287	5.6	1.4 %
Lab	18	226	5.6	0.4 %
Nor	1.2	15	5.6	0.05 %

Patterns in micronekton biomass



Patterns in micronekton biomass- Acoustics



Micronekton-acoustic results

- Estimated migrating proportion based on loss of backscatter at 38 kHz from mesopelagic zone during night
- Ice: 79%, Irm: 11 %, Lab: 39 %, Nor: 68 %
- If we assume that “fish” are the main components of acoustic signal, then we get the following migrating biomasses:

Patterns in micronekton biomass- DVM

- Estimated migrating proportion based on loss of backscatter at 38 kHz from mesopelagic zone during night
- If we assume that “fish” are the main components of acoustic DVM signal, then we get the following migrating biomasses:

	Acoustic estimate migration	Migrating Fish (in mg C m-2)	Migrating Fish (in g WW m-2)
Ice	0.79	52	0.7
Irm	0.11	188	2.4
Lab	0.39	481	6.0
Nor	0.68	56	0.7

Patterns in micronekton biomass- DVM carbon ingestion

- Daily ration?
- Migrators eat epipelagic production?
- For simplicity assuming WW 2 Carbon ratio same in fish as in crustaceans (i.e. 8 %)

	Migration est	Total Fish ingestion (mg C m-2 d-1)	Migrating Fish carbon ingestion (mg C m-2 d-1)	Daily ration %	Total fish relative Calanus overwintering stock	Migrating fish relative Calanus overwintering stock
Ice	0.79	0.7	0.5	1	0.01%	0.01%
Irm	0.11	17.1	1.9	1	1.05%	0.12%
Lab	0.39	12.3	4.8	1	0.29%	0.11%
Nor	0.68	0.8	0.6	1	0.04%	0.02%
Ice	0.79	3.3	2.6	5	0.07%	0.06%
Irm	0.11	85.6	9.4	5	5.24%	0.58%
Lab	0.39	61.6	24.0	5	1.44%	0.56%
Nor	0.68	4.1	2.8	5	0.18%	0.12%

Patterns in micronekton biomass- comparable measures

- Conversions: DW 20 % of WW

C 40% of DW (all groups except jelly)

Jelly: WW2C 0.0058 (avg for P.periphylla Kiørboe et al. 2013)

- In comparison: Overwintering Calanus (data from Jonasdottir et al. 2015)

Patterns in micronekton biomass- Jellyfish budget

- Respiration data from Youngbluth and Båmstedt (2001): Periphylla 0.4 – 5.6 µl 0_2 mg C^{-1} h^{-1}
- Assume fat-based metabolism (e.g. RQ = 0.7)
- Assume assimilation efficiency 0.9

Area	Carbon demand (mg C m^{-2} d^{-1})	"Crustacea" demand (mg WW m^{-2} d^{-1})	Resp rate (µl 0_2 mg C^{-1} h^{-1})	Relative Calanus owb
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BASIN- BASIC hydrography