

*The following supplements accompany the article*

# **Carbon transfer in herbivore- and microbial loop-dominated pelagic food webs in the southern Barents Sea during spring and summer**

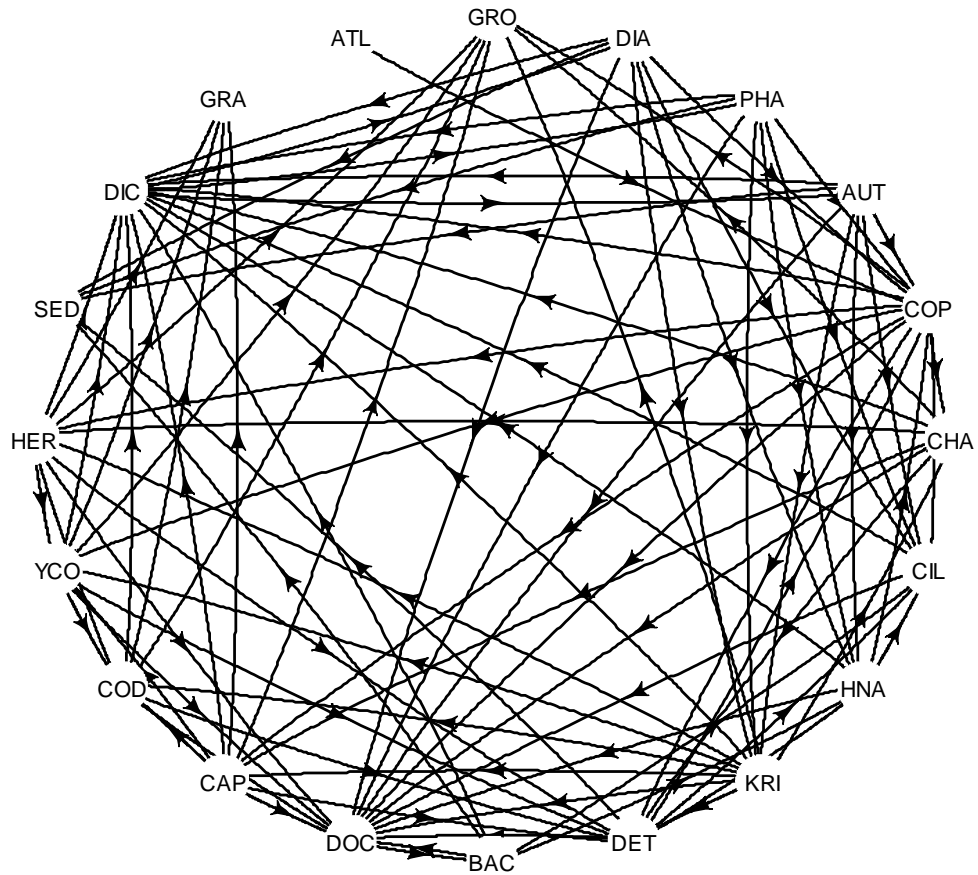
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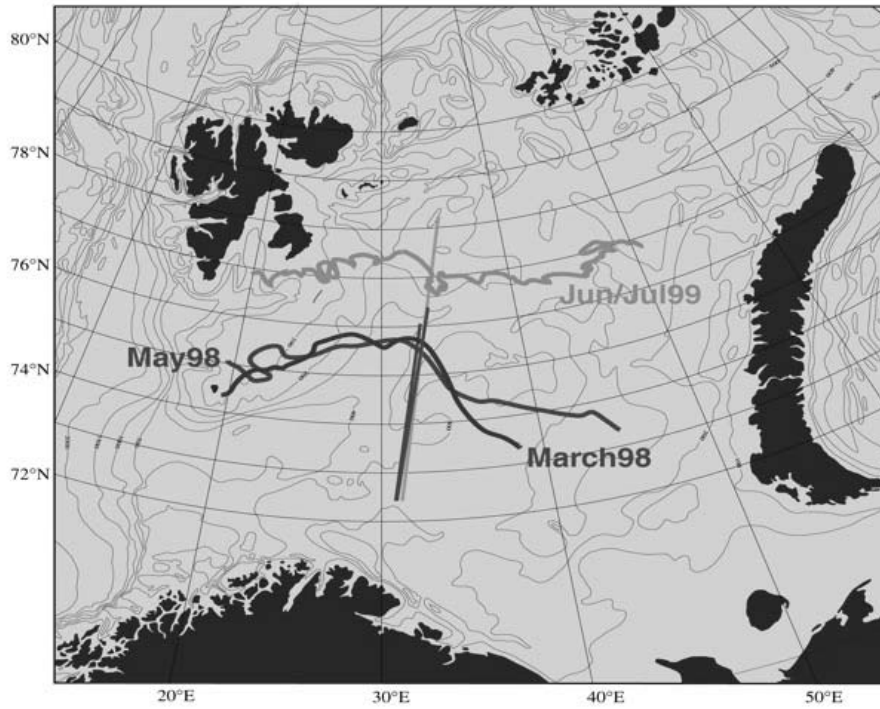
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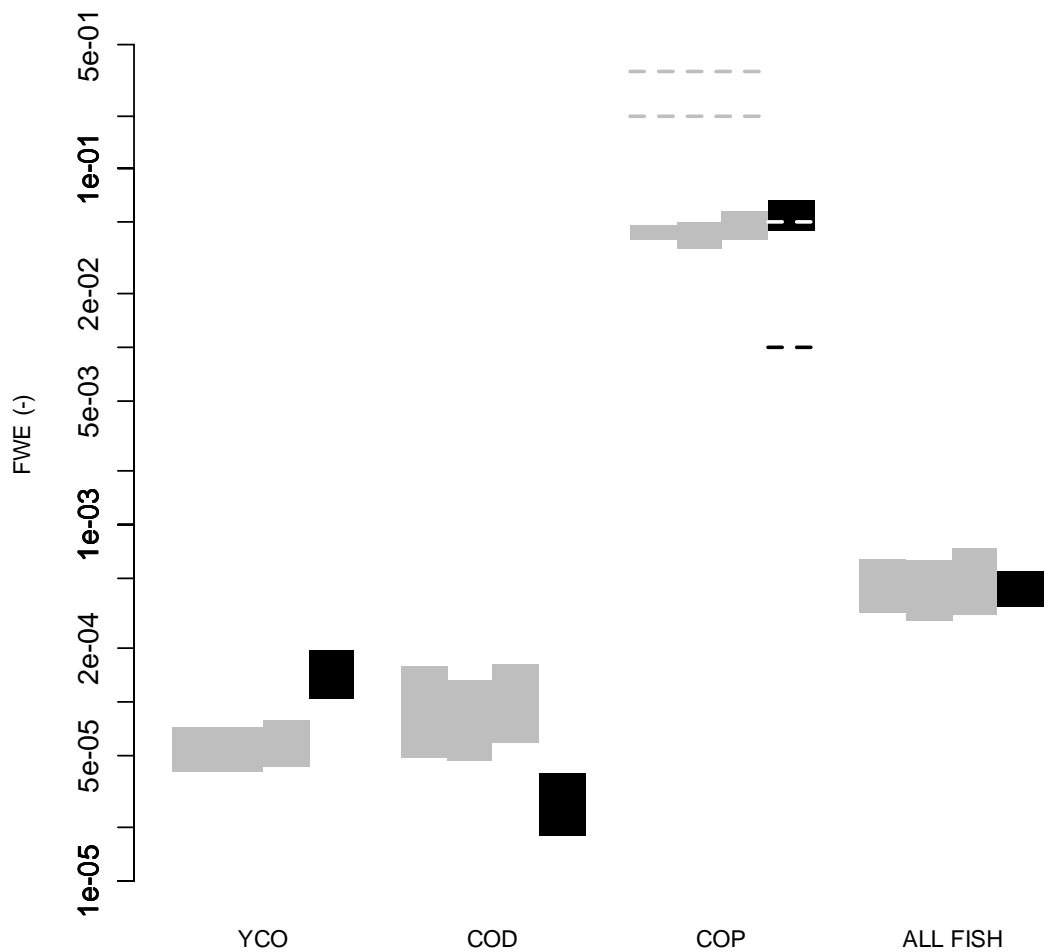
**Supplement 1. Additional figures and tables**



**Fig. S1. Compartments, externals and flows (arrows) of the southern Barents Sea food web. Externals are Atlantic current (ATL), growth (GRO), sedimentation (SED), dissolved inorganic carbon (DIC), grazing by higher trophic levels, including man (GRA). Compartments are diatoms (DIA), *Phaeocystis* sp. (PHA), autotrophic pico- and nanoplankton (AUT), copepods (COP), chaetognaths (CHA), ciliates (CIL), heterotrophic flagellates (HNA), krill (KRI), detritus (DET), bacteria (BAC), dissolved organic carbon (DOC), capelin (CAP), adult cod (COD), young cod (YCO), herring (HER)**



**Fig. S2.** The Barents Sea, with horizontal lines denoting the maximal seasonal extent of the ice cover and vertical lines representing the transects along which the data in Wassmann (2002) were sampled. Only data were considered from those parts of the transects that were never covered by ice



**Fig. S3.** Food web efficiency (FWE, expressed as a proportion) calculated as the production of young cod (YCO), adult cod (COD), copepods (COP) and all fish (ALL FISH), divided by the sum of net primary production and input of copepod biomass by the Atlantic current minus sedimentation losses. Dashed lines are FWEs for copepod production found by Berglund et al. (2007)



**Table S2. *lp* ranges for the carbon flows in the four food web structures: minima and maxima (g C m<sup>-2</sup> d<sup>-1</sup>).**

	spring HF0		spring HF50		spring HF100		summer	
	min	max	min	max	min	max	min	max
DIC->PHA	7.22E-01	4.12E+00	7.22E-01	4.48E+00	7.22E-01	4.85E+00	1.32E-01	2.06E+00
PHA->COP	0.00E+00	2.50E-01	0.00E+00	2.47E-01	0.00E+00	2.44E-01	0.00E+00	1.99E-01
PHA->CIL	0.00E+00	2.99E-01	0.00E+00	3.02E-01	0.00E+00	3.02E-01	0.00E+00	5.76E-01
PHA->HNA	0.00E+00	0.00E+00	0.00E+00	6.56E-01	0.00E+00	7.58E-01	0.00E+00	5.76E-01
PHA->KRI	0.00E+00	1.20E-03	0.00E+00	1.20E-03	0.00E+00	1.20E-03	0.00E+00	7.52E-04
PHA->SED	6.00E-01	8.00E-01	6.00E-01	8.00E-01	6.00E-01	8.00E-01	0.00E+00	2.36E-01
PHA->DIC	3.61E-02	1.24E+00	3.61E-02	1.35E+00	3.61E-02	1.46E+00	6.58E-03	6.17E-01
PHA->DOC	8.57E-02	1.73E+00	8.57E-02	1.88E+00	8.57E-02	2.04E+00	6.79E-02	8.64E-01
DIC->DIA	3.47E-01	2.37E+00	3.47E-01	2.81E+00	3.47E-01	3.18E+00	1.58E-01	2.09E+00
DIA->COP	0.00E+00	2.50E-01	0.00E+00	2.47E-01	0.00E+00	2.44E-01	0.00E+00	1.99E-01
DIA->CIL	0.00E+00	3.01E-01	0.00E+00	3.02E-01	0.00E+00	3.02E-01	0.00E+00	5.86E-01
DIA->HNA	0.00E+00	0.00E+00	0.00E+00	7.38E-01	0.00E+00	8.40E-01	0.00E+00	5.86E-01
DIA->KRI	0.00E+00	1.20E-03	0.00E+00	1.20E-03	0.00E+00	1.20E-03	0.00E+00	7.52E-04
DIA->SED	5.00E-02	1.50E-01	5.00E-02	1.50E-01	5.00E-02	1.50E-01	0.00E+00	2.36E-01
DIA->DIC	1.74E-02	7.11E-01	1.74E-02	8.44E-01	1.74E-02	9.54E-01	7.89E-03	6.28E-01
DIA->DOC	4.13E-02	9.95E-01	4.13E-02	1.18E+00	4.13E-02	1.34E+00	8.29E-02	8.79E-01
DIC->AUT	5.66E-01	2.74E+00	2.96E-01	2.74E+00	2.54E-02	6.89E-01	4.32E-01	2.46E+00
AUT->COP	0.00E+00	2.50E-01	0.00E+00	2.47E-01	0.00E+00	2.44E-01	0.00E+00	1.99E-01
AUT->CIL	0.00E+00	3.01E-01	0.00E+00	3.02E-01	0.00E+00	3.02E-01	0.00E+00	6.90E-01
AUT->HNA	0.00E+00	0.00E+00	0.00E+00	7.68E-01	0.00E+00	4.22E-01	0.00E+00	6.90E-01
AUT->KRI	0.00E+00	1.20E-03	0.00E+00	1.20E-03	0.00E+00	1.20E-03	0.00E+00	7.52E-04
AUT->SED	0.00E+00	7.68E-01	0.00E+00	7.68E-01	0.00E+00	4.22E-01	0.00E+00	2.36E-01
AUT->DIC	2.83E-02	8.23E-01	1.48E-02	8.23E-01	1.27E-03	2.07E-01	2.16E-02	7.39E-01
AUT->DOC	6.72E-02	1.15E+00	3.51E-02	1.15E+00	3.01E-03	2.89E-01	2.39E-01	1.04E+00
HNA->COP	0.00E+00	0.00E+00	0.00E+00	2.50E-01	0.00E+00	2.50E-01	0.00E+00	4.15E-01
HNA->CIL	0.00E+00	0.00E+00	0.00E+00	3.02E-01	0.00E+00	3.02E-01	0.00E+00	1.91E+00
HNA->DIC	0.00E+00	0.00E+00	2.02E-01	1.71E+00	4.05E-01	1.71E+00	2.56E-01	1.39E+00
HNA->DOC	0.00E+00	0.00E+00	6.68E-02	1.35E+00	1.34E-01	1.35E+00	2.56E-01	1.39E+00
CHA->CAP	0.00E+00	2.20E-03	0.00E+00	2.20E-03	0.00E+00	2.20E-03	0.00E+00	0.00E+00
CHA->HER	0.00E+00	1.39E-03	0.00E+00	1.39E-03	0.00E+00	1.39E-03	0.00E+00	1.39E-03
CHA->DIC	1.38E-02	1.76E-02	1.38E-02	1.76E-02	1.38E-02	1.76E-02	1.77E-03	2.26E-03
CHA->DOC	9.96E-03	1.76E-02	9.96E-03	1.76E-02	9.96E-03	1.76E-02	1.28E-03	2.26E-03
CHA->DET	1.20E-02	2.67E-02	1.20E-02	2.67E-02	1.20E-02	2.67E-02	1.54E-03	3.43E-03
CHA->GRO	1.01E-02	2.71E-02	1.01E-02	2.71E-02	1.01E-02	2.71E-02	3.66E-04	3.49E-03
ATL->COP	0.00E+00	1.18E-01	0.00E+00	1.18E-01	0.00E+00	1.18E-01	0.00E+00	7.87E-02
COP->CHA	6.92E-02	8.89E-02	6.92E-02	8.89E-02	6.92E-02	8.89E-02	8.90E-03	1.14E-02
COP->CAP	0.00E+00	2.20E-03	0.00E+00	2.20E-03	0.00E+00	2.20E-03	0.00E+00	0.00E+00
COP->HER	0.00E+00	1.39E-03	0.00E+00	1.39E-03	0.00E+00	1.39E-03	0.00E+00	1.39E-03
COP->YCO	0.00E+00	1.76E-03	0.00E+00	1.76E-03	0.00E+00	1.76E-03	1.99E-04	9.45E-04
COP->DET	8.36E-02	1.25E-01	8.36E-02	1.25E-01	8.36E-02	1.25E-01	1.75E-01	2.10E-01
COP->DIC	2.68E-02	6.80E-02	2.68E-02	6.80E-02	2.68E-02	6.80E-02	3.91E-02	5.68E-02
COP->DOC	8.86E-03	6.80E-02	8.86E-03	6.80E-02	8.86E-03	6.80E-02	3.91E-02	5.68E-02

<b>COP-&gt;GRO</b>	0.00E+00	3.07E-02	0.00E+00	3.07E-02	0.00E+00	3.07E-02	4.75E-02	1.58E-01
<b>CIL-&gt;COP</b>	5.24E-04	1.81E-01	5.24E-04	1.81E-01	5.24E-04	1.81E-01	3.87E-03	4.21E-01
<b>CIL-&gt;DIC</b>	3.55E-03	2.05E-01	3.55E-03	2.05E-01	3.55E-03	2.05E-01	2.68E-02	1.14E+00
<b>CIL-&gt;DOC</b>	1.17E-03	1.36E-01	1.17E-03	1.36E-01	1.17E-03	1.36E-01	8.04E-03	1.12E+00
<b>KRI-&gt;CHA</b>	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	6.80E-05
<b>KRI-&gt;CAP</b>	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	0.00E+00
<b>KRI-&gt;COD</b>	2.09E-05	4.80E-04	2.09E-05	4.80E-04	2.09E-05	4.80E-04	2.33E-04	3.01E-04
<b>KRI-&gt;HER</b>	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	6.80E-05
<b>KRI-&gt;YCO</b>	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	6.80E-05
<b>KRI-&gt;DET</b>	1.49E-05	6.00E-04	1.49E-05	6.00E-04	1.49E-05	6.00E-04	5.82E-05	3.76E-04
<b>KRI-&gt;DIC</b>	8.49E-05	7.96E-04	8.49E-05	7.96E-04	8.49E-05	7.96E-04	5.90E-05	3.42E-04
<b>KRI-&gt;DOC</b>	2.80E-05	5.30E-04	2.80E-05	5.30E-04	2.80E-05	5.30E-04	1.77E-05	2.22E-04
<b>KRI-&gt;GRO</b>	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	4.59E-04	0.00E+00	6.80E-05
<b>DET-&gt;CIL</b>	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.66E-01
<b>DET-&gt;COP</b>	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.66E-01
<b>DET-&gt;HNA</b>	0.00E+00	0.00E+00	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.66E-01
<b>DET-&gt;SED</b>	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.63E-01
<b>DET-&gt;DOC</b>	0.00E+00	1.54E-01	0.00E+00	1.54E-01	0.00E+00	1.54E-01	1.39E-02	4.95E-02
<b>BAC-&gt;CIL</b>	1.51E-03	3.02E-01	0.00E+00	3.02E-01	0.00E+00	3.02E-01	0.00E+00	2.43E+00
<b>BAC-&gt;HNA</b>	0.00E+00	0.00E+00	0.00E+00	2.20E+00	0.00E+00	2.20E+00	0.00E+00	2.43E+00
<b>BAC-&gt;DIC</b>	9.54E-02	2.61E+00	1.05E-01	2.71E+00	1.39E-01	2.56E+00	1.77E+00	1.79E+00
<b>BAC-&gt;DOC</b>	1.91E-04	1.21E-01	2.23E-04	7.58E-01	3.17E-04	7.58E-01	2.42E-01	2.68E-01
<b>BAC-&gt;SED</b>	0.00E+00	6.05E-03	0.00E+00	4.32E-02	0.00E+00	4.32E-02	0.00E+00	1.52E-02
<b>DOC-&gt;BAC</b>	2.14E-01	2.75E+00	2.50E-01	4.42E+00	3.47E-01	4.42E+00	4.43E+00	4.48E+00
<b>CAP-&gt;COD</b>	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	0.00E+00
<b>CAP-&gt;YCO</b>	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	0.00E+00
<b>CAP-&gt;DIC</b>	1.00E-03	1.61E-03	1.00E-03	1.61E-03	1.00E-03	1.61E-03	0.00E+00	0.00E+00
<b>CAP-&gt;DOC</b>	0.00E+00	6.15E-04	0.00E+00	6.15E-04	0.00E+00	6.15E-04	0.00E+00	0.00E+00
<b>CAP-&gt;DET</b>	1.52E-04	6.60E-04	1.52E-04	6.60E-04	1.52E-04	6.60E-04	0.00E+00	0.00E+00
<b>CAP-&gt;GRA</b>	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	0.00E+00
<b>CAP-&gt;GRO</b>	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	7.31E-04	0.00E+00	0.00E+00
<b>HER-&gt;COD</b>	2.37E-06	6.11E-05	2.37E-06	6.11E-05	2.37E-06	6.11E-05	2.64E-05	4.30E-05
<b>HER-&gt;YCO</b>	0.00E+00	5.49E-05	0.00E+00	5.49E-05	0.00E+00	5.49E-05	0.00E+00	3.47E-05
<b>HER-&gt;DIC</b>	3.63E-04	7.88E-04	3.63E-04	7.88E-04	3.63E-04	7.88E-04	3.64E-04	7.88E-04
<b>HER-&gt;DOC</b>	2.27E-05	2.09E-04	2.27E-05	2.09E-04	2.27E-05	2.09E-04	2.35E-05	2.09E-04
<b>HER-&gt;DET</b>	3.63E-05	3.34E-04	3.63E-05	3.34E-04	3.63E-05	3.34E-04	3.75E-05	3.34E-04
<b>HER-&gt;GRA</b>	0.00E+00	5.87E-05	0.00E+00	5.87E-05	0.00E+00	5.87E-05	0.00E+00	3.47E-05
<b>HER-&gt;GRO</b>	0.00E+00	5.87E-05	0.00E+00	5.87E-05	0.00E+00	5.87E-05	0.00E+00	3.47E-05
<b>YCO-&gt;COD</b>	6.18E-06	2.40E-04	6.18E-06	2.40E-04	6.18E-06	2.40E-04	6.87E-05	1.50E-04
<b>YCO-&gt;DIC</b>	5.83E-05	1.33E-03	5.83E-05	1.33E-03	5.83E-05	1.33E-03	3.14E-05	7.18E-04
<b>YCO-&gt;DOC</b>	1.74E-05	2.13E-04	1.74E-05	2.13E-04	1.74E-05	2.13E-04	9.37E-06	1.15E-04
<b>YCO-&gt;DET</b>	5.53E-05	5.27E-04	5.53E-05	5.27E-04	5.53E-05	5.27E-04	2.98E-05	2.84E-04
<b>YCO-&gt;GRA</b>	0.00E+00	8.71E-04	0.00E+00	8.71E-04	0.00E+00	8.71E-04	0.00E+00	4.04E-04
<b>YCO-&gt;GRO</b>	0.00E+00	8.71E-04	0.00E+00	8.71E-04	0.00E+00	8.71E-04	0.00E+00	4.04E-04
<b>COD-&gt;DIC</b>	3.10E-04	1.28E-03	3.10E-04	1.28E-03	3.10E-04	1.28E-03	1.55E-04	4.20E-04
<b>COD-&gt;DOC</b>	2.41E-05	1.84E-04	2.41E-05	1.84E-04	2.41E-05	1.84E-04	1.20E-05	6.00E-05

<b>COD-&gt;DET</b>	7.65E-05	4.53E-04	7.65E-05	4.53E-04	7.65E-05	4.53E-04	3.83E-05	1.48E-04
<b>COD-&gt;GRA</b>	0.00E+00	3.02E-04	0.00E+00	3.02E-04	0.00E+00	3.02E-04	0.00E+00	9.88E-05
<b>COD-&gt;GRO</b>	0.00E+00	3.02E-04	0.00E+00	3.02E-04	0.00E+00	3.02E-04	0.00E+00	9.88E-05



**Supplement 2. Equalities and inequalities for the spring food web model HF0, where  $A \rightarrow B$  denotes a food web flow from A to B ( $\text{g C m}^{-2} \text{d}^{-1}$ ) and  $SS\_X$  denotes the standing stock of X ( $\text{g C m}^{-2}$ ). Abbreviations as in Fig S1.**

### **Phytoplankton**

Net particulate primary production is between 1 and  $1.5 \text{ gC m}^{-2} \text{d}^{-1}$ .

$$DIC \rightarrow AUT + DIC \rightarrow DIA + DIC \rightarrow PHA$$

$$- (AUT \rightarrow DIC + DIA \rightarrow DIC + PHA \rightarrow DIC)$$

$$- (AUT \rightarrow DOC + DIA \rightarrow DOC + PHA \rightarrow DOC) > 1$$

$$DIC \rightarrow AUT + DIC \rightarrow DIA + DIC \rightarrow PHA$$

$$- (AUT \rightarrow DIC + DIA \rightarrow DIC + PHA \rightarrow DIC)$$

$$- (AUT \rightarrow DOC + DIA \rightarrow DOC + PHA \rightarrow DOC) < 1.5$$

Sedimentation is between 0.5 and  $1.8 \text{ gC m}^{-2} \text{d}^{-1}$ .

$$AUT \rightarrow SED + DIA \rightarrow SED + PHA \rightarrow SED > 0.5$$

$$AUT \rightarrow SED + DIA \rightarrow SED + PHA \rightarrow SED < 1.8$$

Respiration is between 5 and 30% of the gross primary production

$$PHA \rightarrow DIC > 0.05 \cdot DIC \rightarrow PHA$$

$$PHA \rightarrow DIC < 0.3 \cdot DIC \rightarrow PHA$$

$$DIA \rightarrow DIC > 0.05 \cdot DIC \rightarrow DIA$$

$$DIA \rightarrow DIC < 0.3 \cdot DIC \rightarrow DIA$$

$$AUT \rightarrow DIC > 0.05 \cdot DIC \rightarrow AUT$$

$$AUT \rightarrow DIC < 0.3 \cdot DIC \rightarrow AUT$$

Excretion is between 5 and 60% of the net primary production

$$PHA \rightarrow DOC > 0.05 \cdot (DIC \rightarrow PHA - PHA \rightarrow DIC)$$

$$PHA \rightarrow DOC < 0.6 \cdot (DIC \rightarrow PHA - PHA \rightarrow DIC)$$

$$DIA \rightarrow DOC > 0.05 \cdot (DIC \rightarrow DIA - DIA \rightarrow DIC)$$

$$\text{DIA} \rightarrow \text{DOC} < 0.6 \cdot (\text{DIC} \rightarrow \text{DIA} - \text{DIA} \rightarrow \text{DIC})$$

$$\text{AUT} \rightarrow \text{DOC} > 0.05 \cdot (\text{DIC} \rightarrow \text{AUT} - \text{AUT} \rightarrow \text{DIC})$$

$$\text{AUT} \rightarrow \text{DOC} < 0.6 \cdot (\text{DIC} \rightarrow \text{AUT} - \text{AUT} \rightarrow \text{DIC})$$

Sedimentation is between 0.6 and 0.8 gC m<sup>-2</sup> d<sup>-1</sup> for *Phaeocystis sp.*, between 0.05 and 0.15 gC m<sup>-2</sup> d<sup>-1</sup> for diatoms and between 0.5 and 1.8 for phytoplankton in total

$$\text{PHA} \rightarrow \text{SED} > 0.6$$

$$\text{PHA} \rightarrow \text{SED} < 0.8$$

$$\text{DIA} \rightarrow \text{SED} > 0.05$$

$$\text{DIA} \rightarrow \text{SED} < 0.15$$

$$\text{PHA} \rightarrow \text{SED} + \text{DIA} \rightarrow \text{SED} + \text{AUT} \rightarrow \text{SED} > 0.5$$

$$\text{PHA} \rightarrow \text{SED} + \text{DIA} \rightarrow \text{SED} + \text{AUT} \rightarrow \text{SED} < 1.8$$

Net primary production is between 0.5 and 1.5 d<sup>-1</sup>

$$\text{DIC} \rightarrow \text{PHA} - \text{PHA} \rightarrow \text{DIC} > 0.5 \cdot \text{SS\_PHA}$$

$$\text{DIC} \rightarrow \text{PHA} - \text{PHA} \rightarrow \text{DIC} < 1.5 \cdot \text{SS\_PHA}$$

$$\text{DIC} \rightarrow \text{DIA} - \text{DIA} \rightarrow \text{DIC} > 0.5 \cdot \text{SS\_DIA}$$

$$\text{DIC} \rightarrow \text{DIA} - \text{DIA} \rightarrow \text{DIC} < 1.5 \cdot \text{SS\_DIA}$$

$$\text{DIC} \rightarrow \text{AUT} - \text{AUT} \rightarrow \text{DIC} > 0.5 \cdot \text{SS\_AUT}$$

$$\text{DIC} \rightarrow \text{AUT} - \text{AUT} \rightarrow \text{DIC} < 1.5 \cdot \text{SS\_AUT}$$

### **Protozoa**

Respiration is higher than 0.08 d<sup>-1</sup>

$$\text{CIL} \rightarrow \text{DIC} > 0.08 \cdot \text{SS\_CIL}$$

$$\text{HNA} \rightarrow \text{DIC} > 0.08 \cdot \text{SS\_HNA}$$

Excretion is between 33 and 100% of respiration

$$\text{CIL} \rightarrow \text{DOC} > 0.33 \cdot \text{CIL} \rightarrow \text{DIC}$$

$$\text{CIL} \rightarrow \text{DOC} < 1 \cdot \text{CIL} \rightarrow \text{DIC}$$

$$\text{HNA} \rightarrow \text{DOC} > 0.33 \cdot \text{HNA} \rightarrow \text{DIC}$$

$$\text{HNA} \rightarrow \text{DOC} < 1 \cdot \text{HNA} \rightarrow \text{DIC}$$

Ingestion is smaller than  $7 \text{ d}^{-1}$

$$\text{BAC} \rightarrow \text{CIL} + \text{DET} \rightarrow \text{CIL} + \text{DIA} \rightarrow \text{CIL} + \text{PHA} \rightarrow \text{CIL} + \text{HNA} \rightarrow \text{CIL} + \text{AUT} \rightarrow \text{CIL} < 7 \cdot \text{SS\_CIL}$$

$$\text{DET} \rightarrow \text{HNA} + \text{PHA} \rightarrow \text{HNA} + \text{DIA} \rightarrow \text{HNA} + \text{AUT} \rightarrow \text{HNA} + \text{BAC} \rightarrow \text{HNA} < 7 \cdot \text{SS\_CIL}$$

Gross growth efficiency is between 0.1 and 0.6

$$\text{CIL} \rightarrow \text{COP} > 0.1 \cdot (\text{BAC} \rightarrow \text{CIL} + \text{DET} \rightarrow \text{CIL} + \text{DIA} \rightarrow \text{CIL} + \text{PHA} \rightarrow \text{CIL} + \text{HNA} \rightarrow \text{CIL} + \text{AUT} \rightarrow \text{CIL})$$

$$\text{CIL} \rightarrow \text{COP} < 0.6 \cdot (\text{BAC} \rightarrow \text{CIL} + \text{DET} \rightarrow \text{CIL} + \text{DIA} \rightarrow \text{CIL} + \text{PHA} \rightarrow \text{CIL} + \text{HNA} \rightarrow \text{CIL} + \text{AUT} \rightarrow \text{CIL})$$

$$\text{HNA} \rightarrow \text{COP} + \text{HNA} \rightarrow \text{CIL} > 0.1 \cdot (\text{DET} \rightarrow \text{HNA} + \text{PHA} \rightarrow \text{HNA} + \text{DIA} \rightarrow \text{HNA} + \text{AUT} \rightarrow \text{HNA} + \text{BAC} \rightarrow \text{HNA})$$

$$\text{HNA} \rightarrow \text{COP} + \text{HNA} \rightarrow \text{CIL} < 0.6 \cdot (\text{DET} \rightarrow \text{HNA} + \text{PHA} \rightarrow \text{HNA} + \text{DIA} \rightarrow \text{HNA} + \text{AUT} \rightarrow \text{HNA} + \text{BAC} \rightarrow \text{HNA})$$

### **Copepods**

Ingestion is between  $0.008$  and  $0.14 \text{ d}^{-1}$

$$\text{DET} \rightarrow \text{COP} + \text{DIA} \rightarrow \text{COP} + \text{PHA} \rightarrow \text{COP} + \text{AUT} \rightarrow \text{COP} + \text{HNA} \rightarrow \text{COP} + \text{CIL} \rightarrow \text{COP} > 0.008 \cdot \text{SS\_COP}$$

$$\text{DET} \rightarrow \text{COP} + \text{DIA} \rightarrow \text{COP} + \text{PHA} \rightarrow \text{COP} + \text{AUT} \rightarrow \text{COP} + \text{HNA} \rightarrow \text{COP} + \text{CIL} \rightarrow \text{COP} < 0.14 \cdot \text{SS\_COP}$$

Respiration is between  $0.015$  and  $0.038 \text{ d}^{-1}$

$$\text{COP} \rightarrow \text{DIC} > 0.015 \cdot \text{SS\_COP}$$

$$\text{COP} \rightarrow \text{DIC} < 0.038 \cdot \text{SS\_COP}$$

Assimilation efficiency is between 0.5 and 0.9

$$\text{DET} \rightarrow \text{COP} + \text{DIA} \rightarrow \text{COP} + \text{PHA} \rightarrow \text{COP} + \text{AUT} \rightarrow \text{COP} + \text{HNA} \rightarrow \text{COP} + \text{CIL} \rightarrow \text{COP} - \text{COP} \rightarrow \text{DET} > 0.5 \cdot \text{DET} \rightarrow \text{COP} + \text{DIA} \rightarrow \text{COP} + \text{PHA} \rightarrow \text{COP} + \text{AUT} \rightarrow \text{COP} + \text{HNA} \rightarrow \text{COP} + \text{CIL} \rightarrow \text{COP}$$

$DET \rightarrow COP + DIA \rightarrow COP + PHA \rightarrow COP + AUT \rightarrow COP + HNA \rightarrow COP + CIL \rightarrow COP - COP \rightarrow DET$   
 $< 0.9 \cdot DET \rightarrow COP + DIA \rightarrow COP + PHA \rightarrow COP + AUT \rightarrow COP + HNA \rightarrow COP + CIL \rightarrow COP$

Gross growth efficiency is lower than 0.4

$COP \rightarrow CHA + COP \rightarrow CAP + COP \rightarrow HER + COP \rightarrow YCO + COP \rightarrow GRO < 0.1 \cdot DET \rightarrow COP +$   
 $DIA \rightarrow COP + PHA \rightarrow COP + AUT \rightarrow COP + HNA \rightarrow COP + CIL \rightarrow COP$

Excretion is between 33 and 100% of respiration

$COP \rightarrow DOC > 0.33 \cdot COP \rightarrow DIC$

$COP \rightarrow DOC < 1 \cdot COP \rightarrow DIC$

Advection of copepod biomass is smaller than  $0.23 \text{ gC m}^{-2} \text{ d}^{-1}$

$ATL \rightarrow COP < 0.23$

## **Krill**

Ingestion is below  $0.4 \text{ d}^{-1}$

$DIA \rightarrow KRI + PHA \rightarrow KRI + AUT \rightarrow KRI < 0.4 \cdot SS\_KRI$

Respiration is higher than  $0.03 \text{ d}^{-1}$

$KRI \rightarrow DIC > 0.03 \cdot SS\_KRI$

Gross growth efficiency is below 0.4

$KRI \rightarrow CAP + KRI \rightarrow COD + KRI \rightarrow HER + KRI \rightarrow YCO + KRI \rightarrow CHA + KRI \rightarrow GRO < 0.4 \cdot$   
 $DIA \rightarrow KRI + PHA \rightarrow KRI + AUT \rightarrow KRI$

Production over biomass ratio is higher than  $0.0058 \text{ d}^{-1}$

$KRI \rightarrow CAP + KRI \rightarrow COD + KRI \rightarrow HER + KRI \rightarrow YCO + KRI \rightarrow CHA + KRI \rightarrow GRO > 0.0058 \cdot$   
 $SS\_KRI$

Excretion is between 33 and 100% of respiration

$KRI \rightarrow DOC > 0.33 \cdot KRI \rightarrow DIC$

$$\text{KRI} \rightarrow \text{DOC} < 1 \cdot \text{KRI} \rightarrow \text{DIC}$$

Assimilation efficiency is between 0.5 and 0.9

$$\text{DIA} \rightarrow \text{KRI} + \text{PHA} \rightarrow \text{KRI} + \text{AUT} \rightarrow \text{KRI} - \text{KRI} \rightarrow \text{DET} > 0.5 \cdot \text{DIA} \rightarrow \text{KRI} + \text{PHA} \rightarrow \text{KRI} + \text{AUT} \rightarrow \text{KRI}$$

$$\text{DIA} \rightarrow \text{KRI} + \text{PHA} \rightarrow \text{KRI} + \text{AUT} \rightarrow \text{KRI} - \text{KRI} \rightarrow \text{DET} < 0.9 \cdot \text{DIA} \rightarrow \text{KRI} + \text{PHA} \rightarrow \text{KRI} + \text{AUT} \rightarrow \text{KRI}$$

### **Chaetognaths**

Ingestion is between 0.1 and 0.3 d<sup>-1</sup>

$$\text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA} > 0.1 \cdot \text{SS\_CHA}$$

$$\text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA} < 0.3 \cdot \text{SS\_CHA}$$

Net growth efficiency is between 0.15 and 0.35

$$\text{CHA} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{HER} + \text{CHA} \rightarrow \text{GRO} > 0.15 \cdot \text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA} - 0.35 \cdot \text{CHA} \rightarrow \text{DET}$$

$$\text{CHA} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{HER} + \text{CHA} \rightarrow \text{GRO} < 0.35 \cdot \text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA} - 0.15 \cdot \text{CHA} \rightarrow \text{DET}$$

Assimilation efficiency is between 0.7 and 0.9

$$\text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA} - \text{CHA} \rightarrow \text{DET} > 0.7 \cdot \text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA}$$

$$\text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA} - \text{CHA} \rightarrow \text{DET} < 0.9 \cdot \text{COP} \rightarrow \text{CHA} + \text{KRI} \rightarrow \text{CHA}$$

Excretion is between 33 and 100% of respiration

$$\text{CHA} \rightarrow \text{DOC} > 0.33 \cdot \text{CHA} \rightarrow \text{DIC}$$

$$\text{CHA} \rightarrow \text{DOC} < 1 \cdot \text{CHA} \rightarrow \text{DIC}$$

Respiration is between 0.0072 - 0.0252 d<sup>-1</sup>

$$\text{CHA} \rightarrow \text{DIC} > 0.0072 \cdot \text{SS\_CHA}$$

$$\text{CHA} \rightarrow \text{DIC} < 0.0252 \cdot \text{SS\_CHA}$$

### **Detritus**

Dissolution is lower than  $0.02 \text{ d}^{-1}$

$$\text{DET} \rightarrow \text{DOC} < 0.02 \cdot \text{SS\_DET}$$

### **Bacteria**

Gross growth efficiency is between 0.01 and 0.6

$$\text{BAC} \rightarrow \text{DIC} > \text{DOC} \rightarrow \text{BAC} - 0.6 \cdot \text{DOC} \rightarrow \text{BAC}$$

$$\text{BAC} \rightarrow \text{DIC} < \text{DOC} \rightarrow \text{BAC} - 0.01 \cdot \text{DOC} \rightarrow \text{BAC}$$

Sedimentation is below 2% of bacterial production per day

$$\text{BAC} \rightarrow \text{SED} < 0.02 \cdot (\text{BAC} \rightarrow \text{CIL} + \text{BAC} \rightarrow \text{HNA})$$

viral feedback rate is 10 to 40% of bacterial production rate

$$\text{BAC} \rightarrow \text{DOC} > 0.1 \cdot (\text{BAC} \rightarrow \text{CIL} + \text{BAC} \rightarrow \text{HNA})$$

### **All zooplankton**

Fecal pellet production rate is higher than  $0.11 \text{ gC m}^{-2} \text{ d}^{-1}$

$$\text{COP} \rightarrow \text{DET} + \text{CHA} \rightarrow \text{DET} + \text{KRI} \rightarrow \text{DET} > 0.11$$

### **Particulate organic carbon**

Sedimentation is between  $0.8$  and  $1.7 \text{ gC m}^{-2} \text{ d}^{-1}$

$$\text{PHA} \rightarrow \text{SED} + \text{DIA} \rightarrow \text{SED} + \text{AUT} \rightarrow \text{SED} + \text{DET} \rightarrow \text{SED} + \text{BAC} \rightarrow \text{SED} > 0.8$$

$$\text{PHA} \rightarrow \text{SED} + \text{DIA} \rightarrow \text{SED} + \text{AUT} \rightarrow \text{SED} + \text{DET} \rightarrow \text{SED} + \text{BAC} \rightarrow \text{SED} < 1.7$$

### **Capelin**

Ingestion is between  $0.013$  and  $0.022 \text{ d}^{-1}$

$$\text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP} > 0.013 \cdot \text{SS\_CAP}$$

$$\text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP} < 0.022 \cdot \text{SS\_CAP}$$

Production over biomass is between  $0.0036$  and  $0.0073 \text{ d}^{-1}$

$$\text{CAP} \rightarrow \text{GRA} + \text{CAP} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{COD} + \text{CAP} \rightarrow \text{GRO} > 0.0036 \cdot \text{SS\_CAP}$$

$$\text{CAP} \rightarrow \text{GRA} + \text{CAP} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{COD} + \text{CAP} \rightarrow \text{GRO} < 0.0073 \cdot \text{SS\_CAP}$$

Assimilation efficiency is between 0.7 and 0.9

$$\text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP} - \text{CAPE}_{\text{gest}} > 0.7 \cdot \text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP}$$

$$\text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP} - \text{CAPE}_{\text{gest}} < 0.9 \cdot \text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP}$$

Respiration is between 0.01 and 0.04 d<sup>-1</sup>

$$\text{CAP} \rightarrow \text{DIC} > 0.01 \cdot \text{SS\_CAP}$$

$$\text{CAP} \rightarrow \text{DIC} < 0.04 \cdot \text{SS\_CAP}$$

## **Herring**

Ingestion is between 0.01 and 0.1 d<sup>-1</sup>

$$\text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} > 0.01 \cdot \text{SS\_HER}$$

$$\text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} < 0.1 \cdot \text{SS\_HER}$$

Maintenance respiration is between 0.019 and 0.024 d<sup>-1</sup>; growth respiration is between 0.0875 - 0.263 d<sup>-1</sup>

$$\text{HER} \rightarrow \text{DIC} > 0.019 \cdot \text{SS\_HER} + 0.0875 \cdot \text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} - 0.263 \cdot \text{HER} \rightarrow \text{DET}$$

$$\text{HER} \rightarrow \text{DIC} < 0.024 \cdot \text{SS\_HER} + 0.263 \cdot \text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} - 0.0875 \cdot \text{HER} \rightarrow \text{DET}$$

Assimilation efficiency is between 0.76 and 0.92

$$\text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} - \text{CAP} \rightarrow \text{DET} > 0.76 \cdot \text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP}$$

$$\text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} - \text{CAP} \rightarrow \text{DET} < 0.92 \cdot \text{COP} \rightarrow \text{CAP} + \text{KRI} \rightarrow \text{CAP} + \text{CHA} \rightarrow \text{CAP}$$

Excretion is between 0.05 and 0.15 of the ingestion

$$\text{HER} \rightarrow \text{DOC} > 0.05 \cdot \text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} - \text{CAP} \rightarrow \text{DET}$$

$$\text{HER} \rightarrow \text{DOC} < 0.15 \cdot \text{CHA} \rightarrow \text{HER} + \text{COP} \rightarrow \text{HER} + \text{KRI} \rightarrow \text{HER} - \text{CAP} \rightarrow \text{DET}$$

### **Adult cod**

Ingestion is between 0.017 and 0.054 d<sup>-1</sup>

$$\text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD} > 0.017 \cdot \text{SS\_COD}$$

$$\text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD} < 0.054 \cdot \text{SS\_COD}$$

Gross growth efficiency is between 0.2 and 0.5

$$\text{COD} \rightarrow \text{GRA} + \text{COD} \rightarrow \text{GRO} > 0.2 \cdot \text{CODUptake}$$

$$\text{COD} \rightarrow \text{GRA} + \text{COD} \rightarrow \text{GRO} < 0.5 \cdot \text{CODUptake}$$

Assimilation efficiency is between 0.7 and 0.9

$$\text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD} - \text{COD} \rightarrow \text{DET} > 0.7 \cdot \text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD}$$

$$\text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD} - \text{COD} \rightarrow \text{DET} < 0.9 \cdot \text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD}$$

Excretion is between 0.045 and 0.135 of assimilation

$$\text{COD} \rightarrow \text{DOC} > 0.045 \cdot (\text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD} - \text{COD} \rightarrow \text{DET})$$

$$\text{COD} \rightarrow \text{DOC} < 0.135 \cdot (\text{CAP} \rightarrow \text{COD} + \text{KRI} \rightarrow \text{COD} + \text{HER} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{COD} - \text{COD} \rightarrow \text{DET})$$

Krill ingestion by cod is 7 to 9 times herring ingestion by cod

$$\text{KRI} \rightarrow \text{COD} > 7 \cdot \text{HER} \rightarrow \text{COD}$$

$$\text{KRI} \rightarrow \text{COD} < 9 \cdot \text{HER} \rightarrow \text{COD}$$

Krill ingestion by cod is 2 to 4 times young cod ingestion by cod

$$\text{KRI} \rightarrow \text{COD} > 2 \cdot \text{YCO} \rightarrow \text{COD}$$



$$\text{KRI} \rightarrow \text{COD} < 4 \cdot \text{YCO} \rightarrow \text{COD}$$

### Young cod

Ingestion is between 0.017 and 0.054 d<sup>-1</sup>

$$\text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO} > 0.017 \cdot \text{SS\_YCO}$$

$$\text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO} < 0.054 \cdot \text{SS\_YCO}$$

Gross growth efficiency is between 0.2 and 0.5

$$\text{YCO} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{GRA} + \text{YCO} \rightarrow \text{GRO} > 0.2 \cdot \text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO}$$

$$\text{YCO} \rightarrow \text{COD} + \text{YCO} \rightarrow \text{GRA} + \text{YCO} \rightarrow \text{GRO} < 0.5 \cdot \text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO}$$

Assimilation efficiency is between 0.7 and 0.9

$$\text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO} - \text{YCO} \rightarrow \text{DET} > 0.7 \cdot \text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO}$$

$$\text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO} - \text{YCO} \rightarrow \text{DET} < 0.9 \cdot \text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO}$$

Excretion is between 0.045 and 0.135 of assimilation

$$\text{YCO} \rightarrow \text{DOC} > 0.045 \cdot (\text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO} - \text{YCO} \rightarrow \text{DET})$$

$$\text{YCO} \rightarrow \text{DOC} < 0.135 \cdot (\text{COP} \rightarrow \text{YCO} + \text{KRI} \rightarrow \text{YCO} + \text{HER} \rightarrow \text{YCO} + \text{CAP} \rightarrow \text{YCO} - \text{YCO} \rightarrow \text{DET})$$

Feeding on herring is less important than feeding on copepods, krill or capelin

$$\text{HER} \rightarrow \text{YCO} < \text{COP} \rightarrow \text{YCO}$$

$$\text{HER} \rightarrow \text{YCO} < \text{KRI} \rightarrow \text{YCO}$$

$$\text{HER} \rightarrow \text{YCO} < \text{CAP} \rightarrow \text{YCO}$$