Temporal Succession of Ecosystem Structure in the Kuroshio Extension Region: Are Gelatinous Zooplankton Species Indicators of Ecosystem Status?

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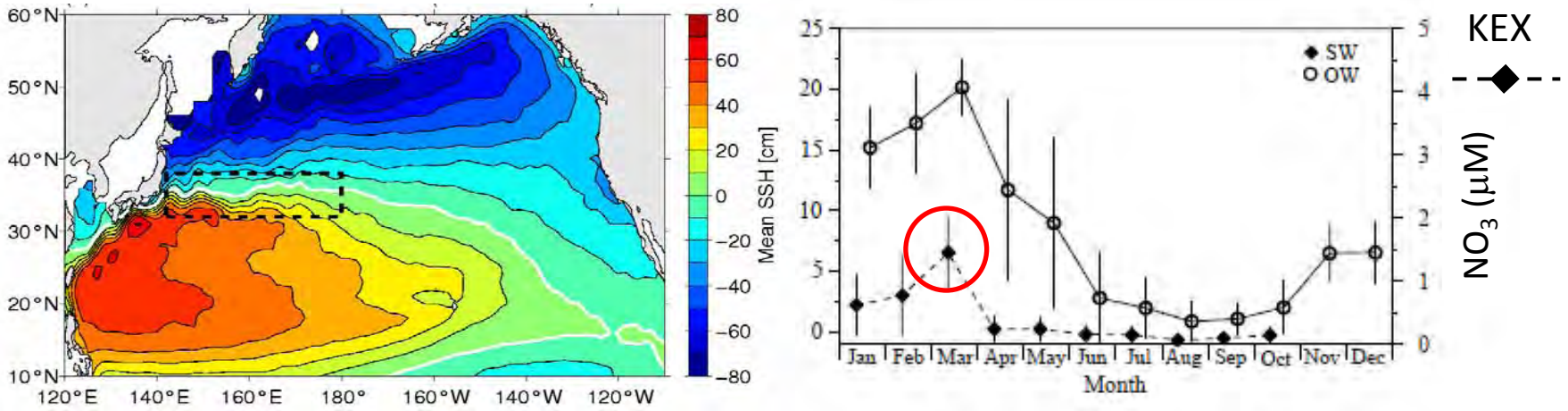
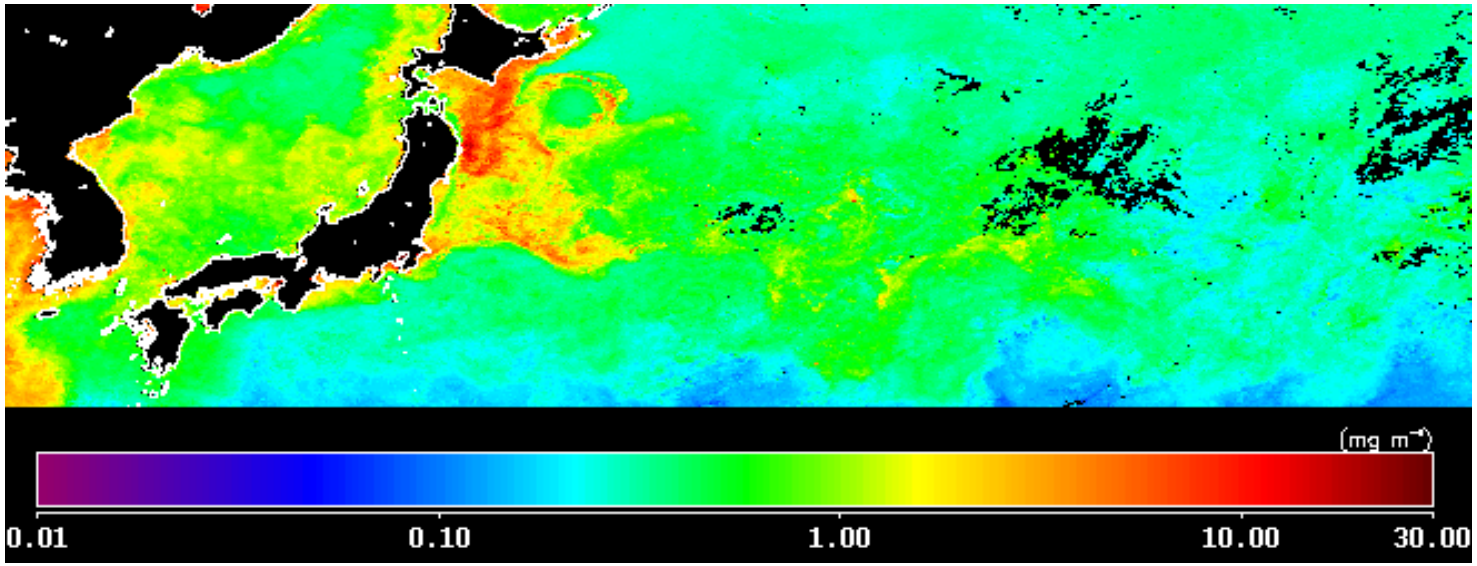
Kuroshio Extension Region (KEX)

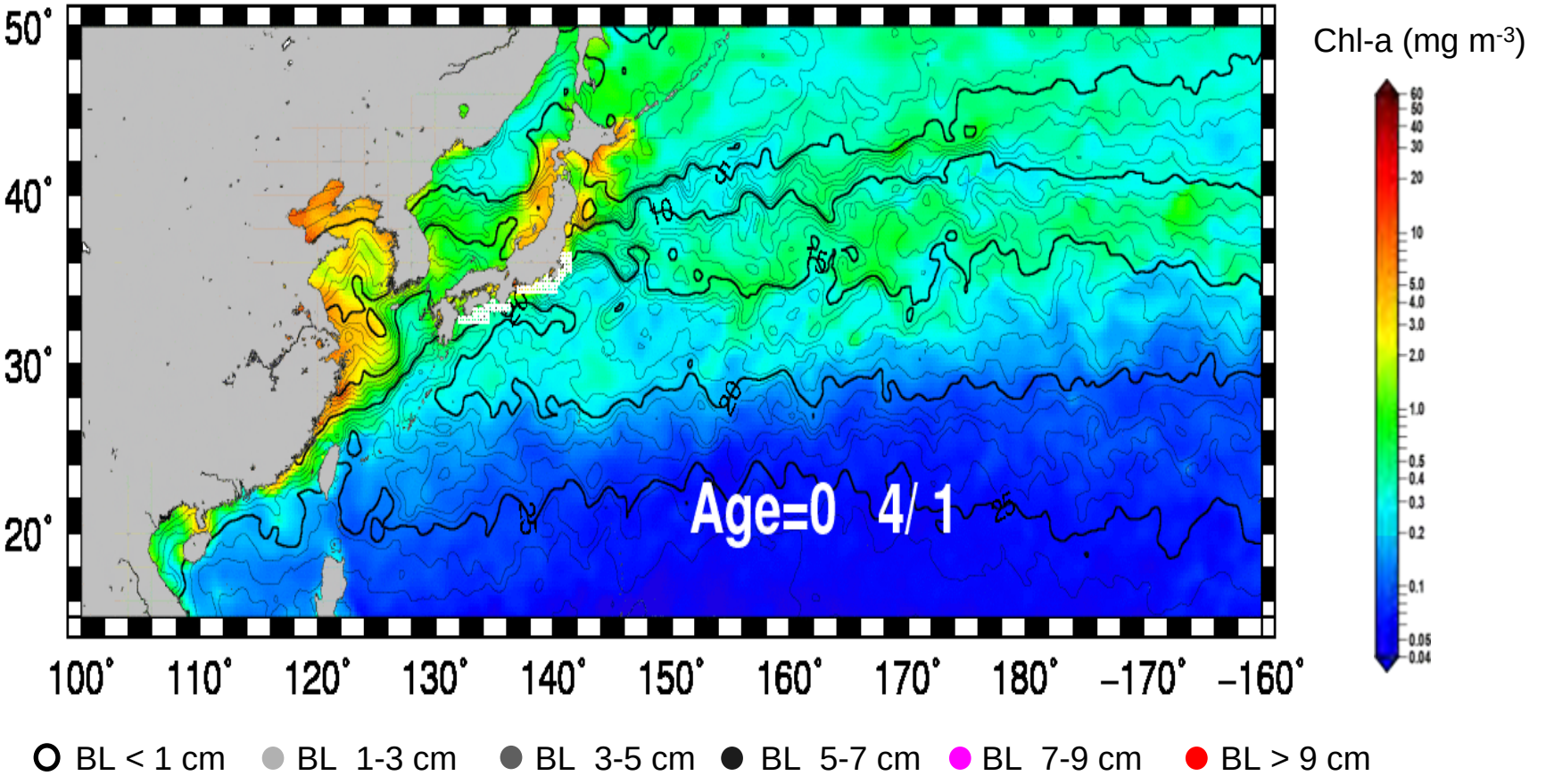




Nursery ground of small epipelagic fish

Okunishi et al., in prep

April-spawned cohort in 2006



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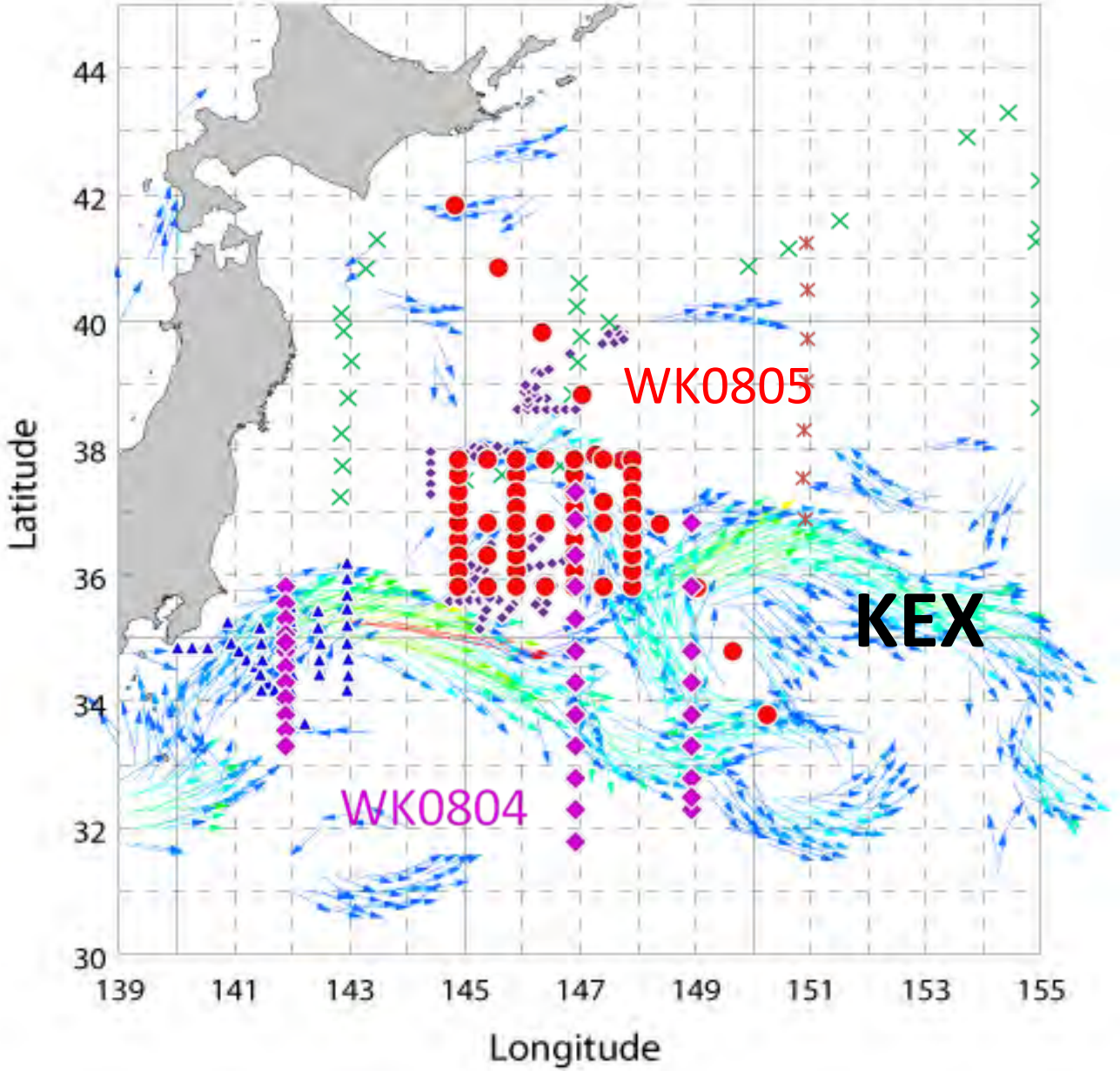
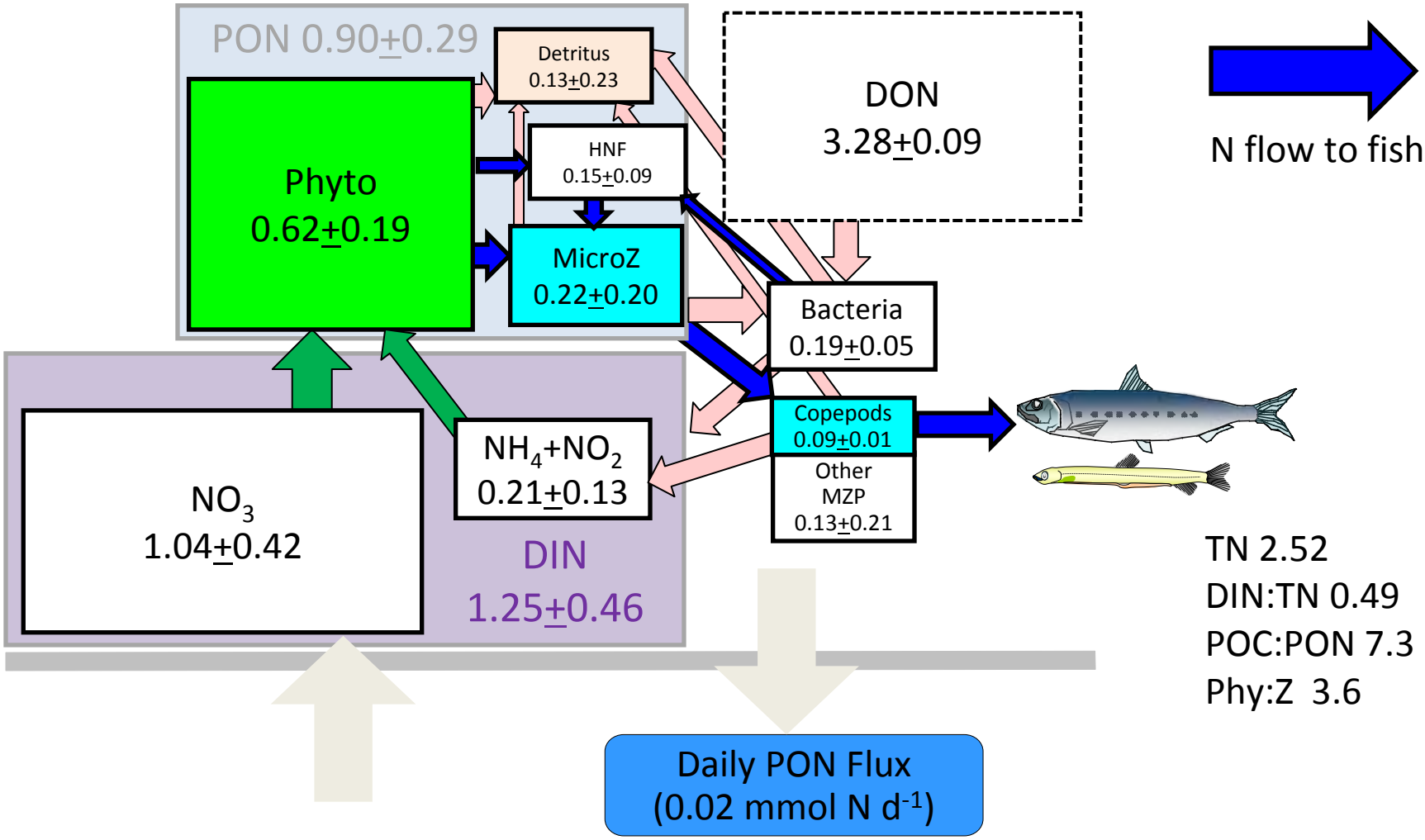
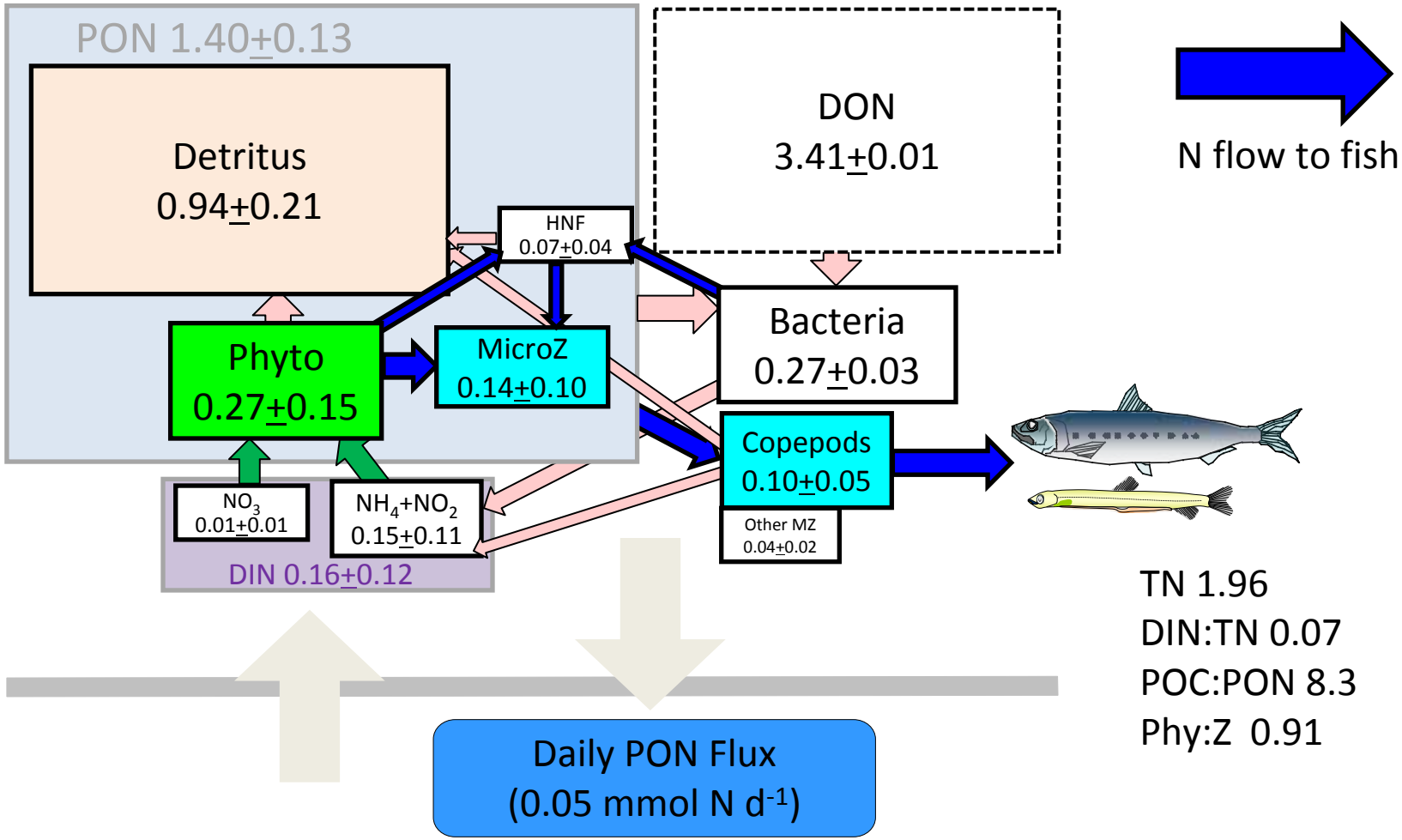
Field Campaign 2008



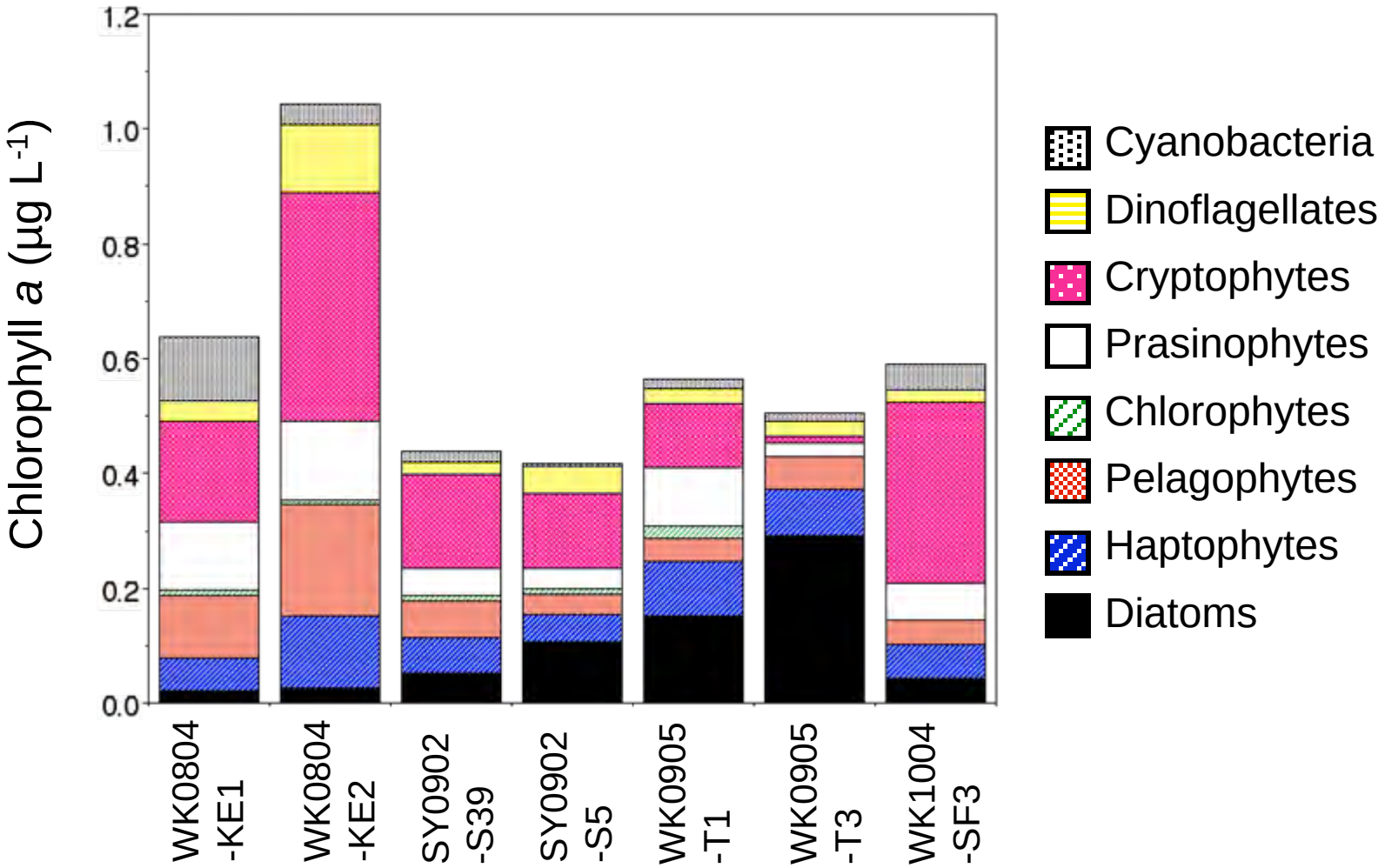
N Inventory (April 10 m, mmol m^{-3})



N Inventory (May 10 m, mmol m^{-3})



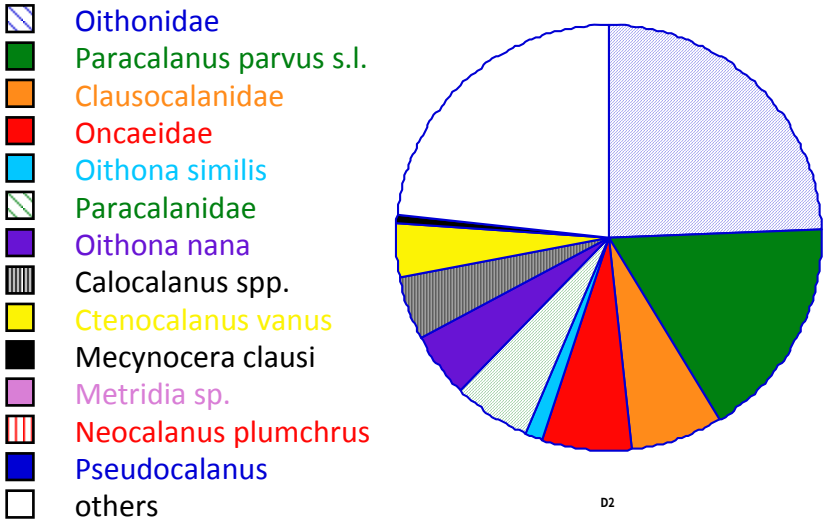
Phytoplankton species composition in the KEX (HPLC)



Primary production

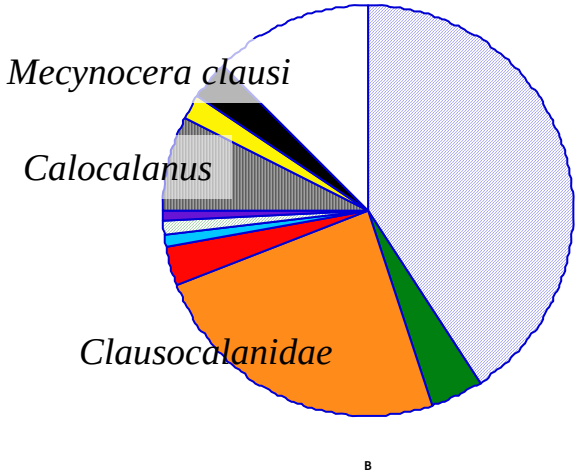
Cruise	Station	Primary production (mgC m^{-2} d^{-1})		
		<10 um	>10 um	Total
WK08-04	KE1-11	324 (73%)	119 (27%)	444
	KE1-12	244 (69%)	112 (31%)	356
	KE2-13	307 (64%)	176 (36%)	483
	KE3-7	99 (68%)	47 (32%)	146
	KE3-8	449 (71%)	181 (29%)	630
WK08-05	F1	201 (86%)	33 (14%)	234
	F2	238 (82%)	54 (18%)	292

KEX Copepods Community in spring

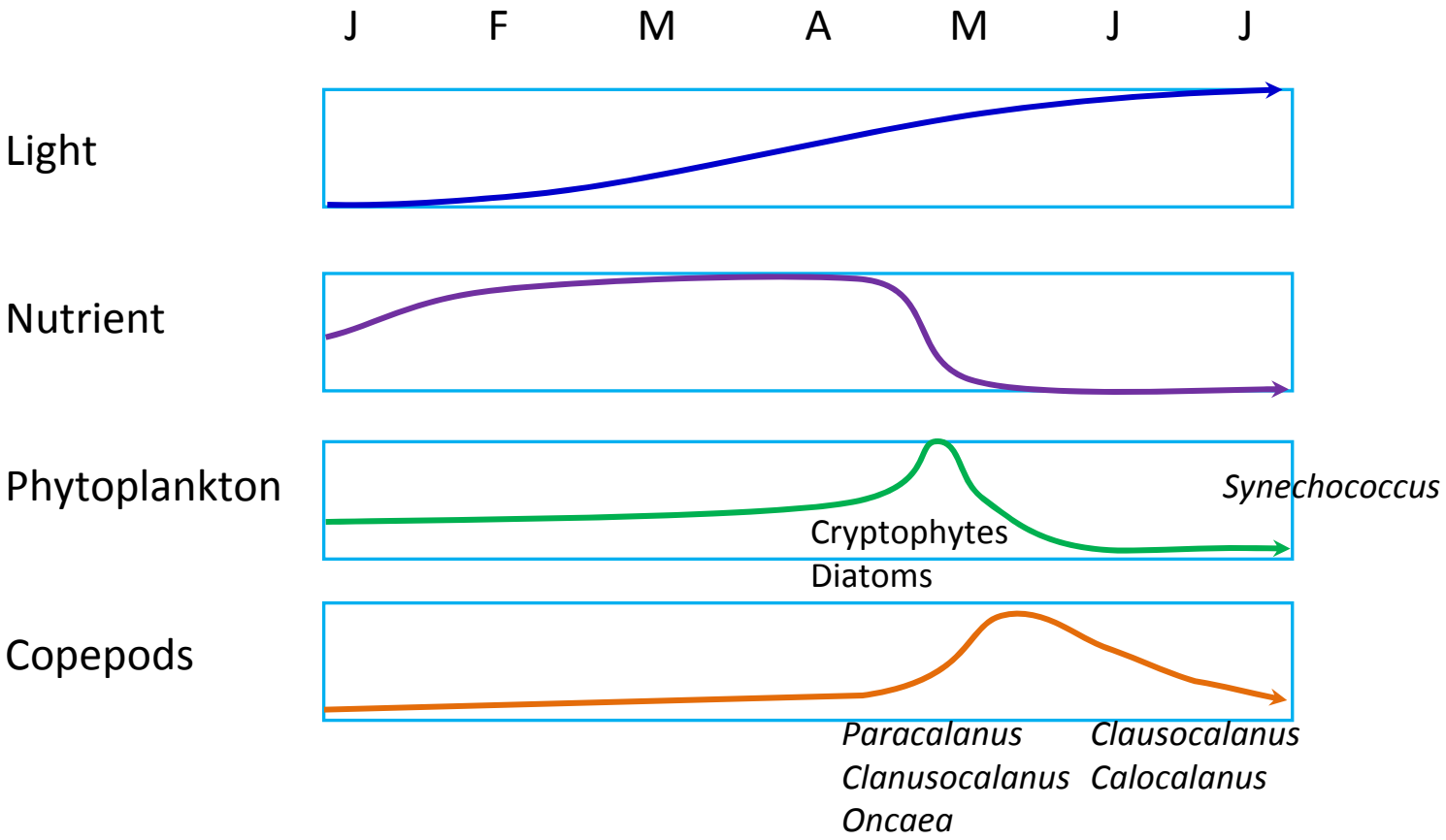


Paracalanidae
Clanusocalanidae
Oncaea

After nutrient depletion

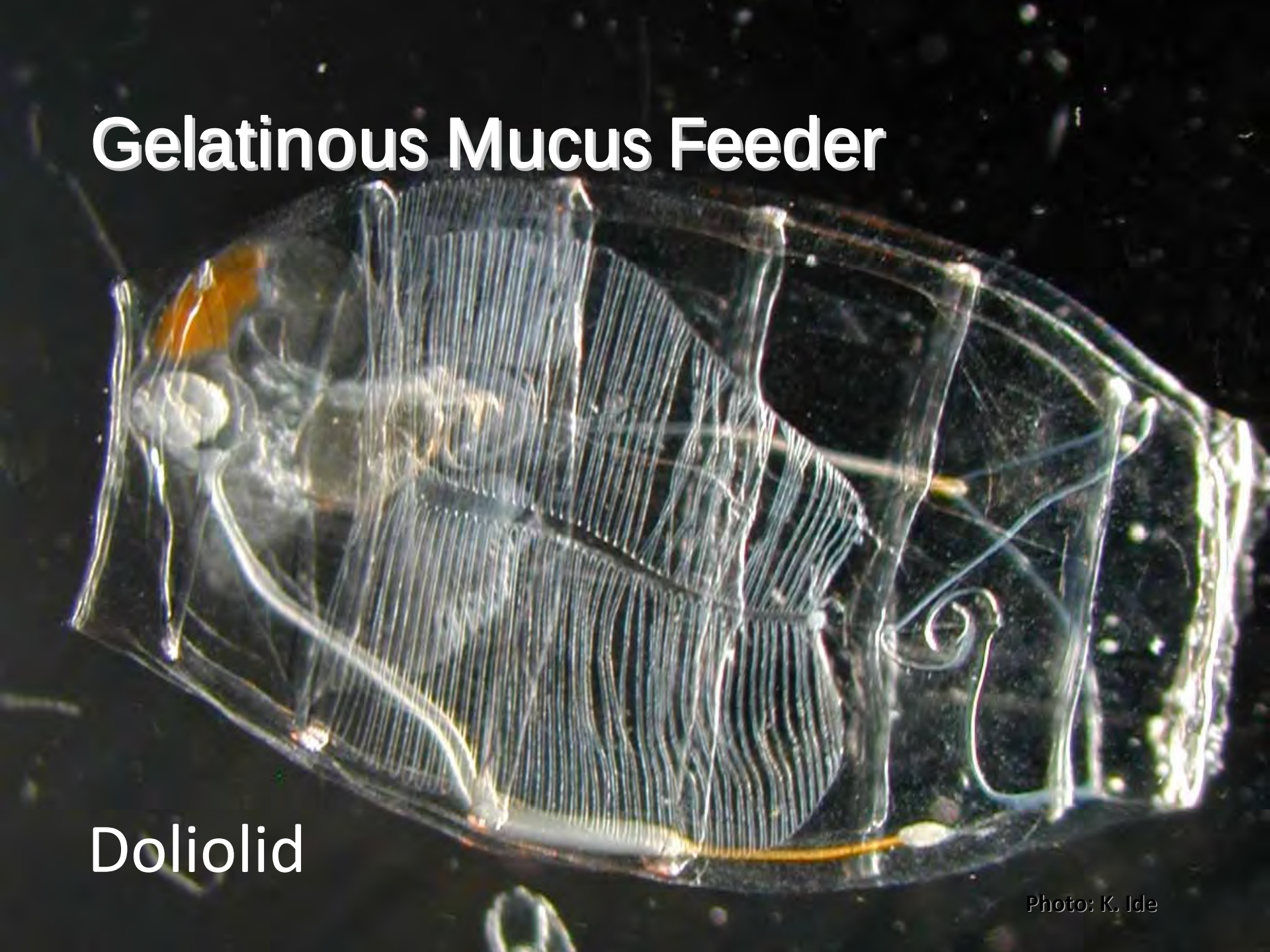


Ecosystem succession in the KEX



Bottom-up control of the ecosystem succession

Gelatinous Mucus Feeder

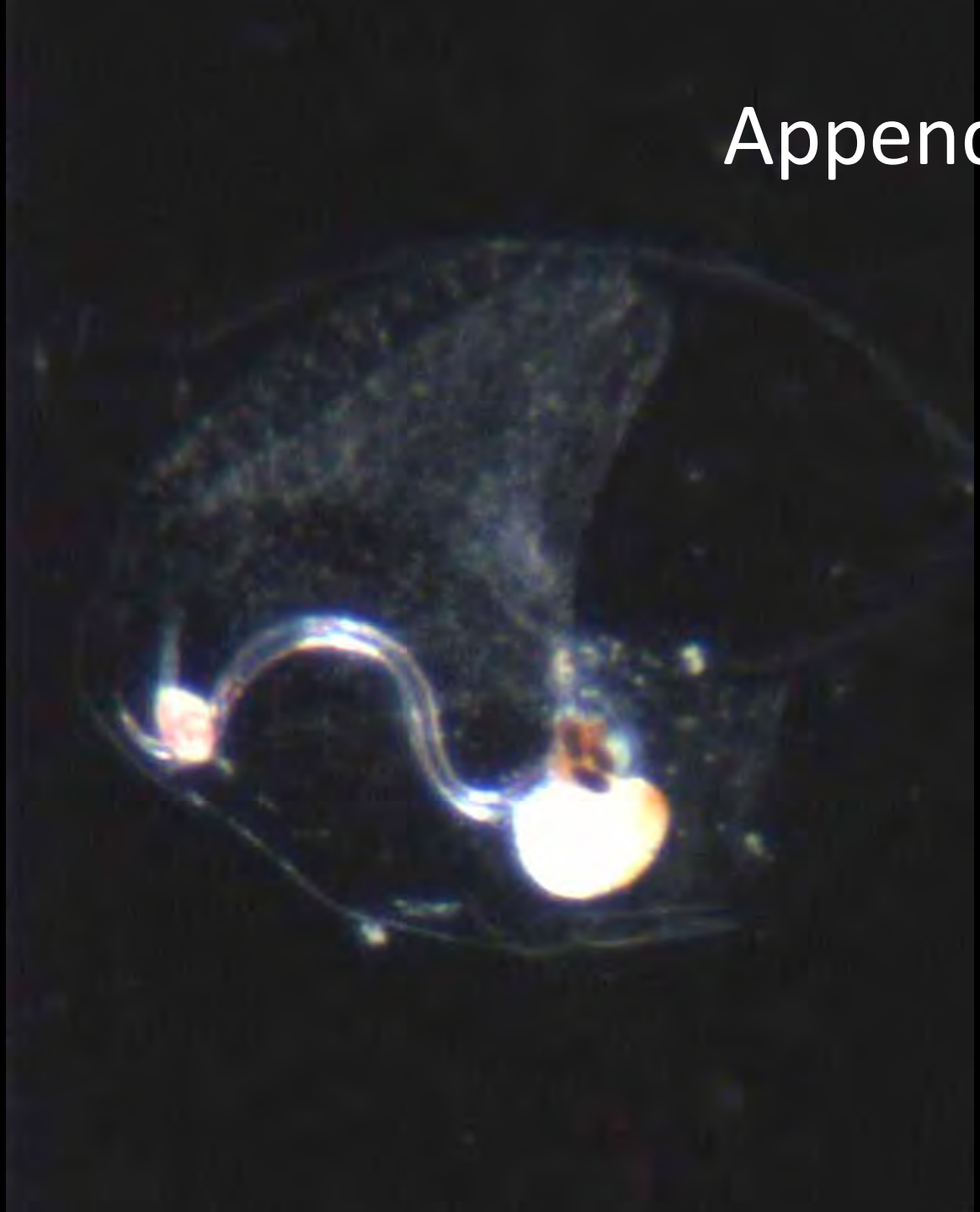


Doliolid

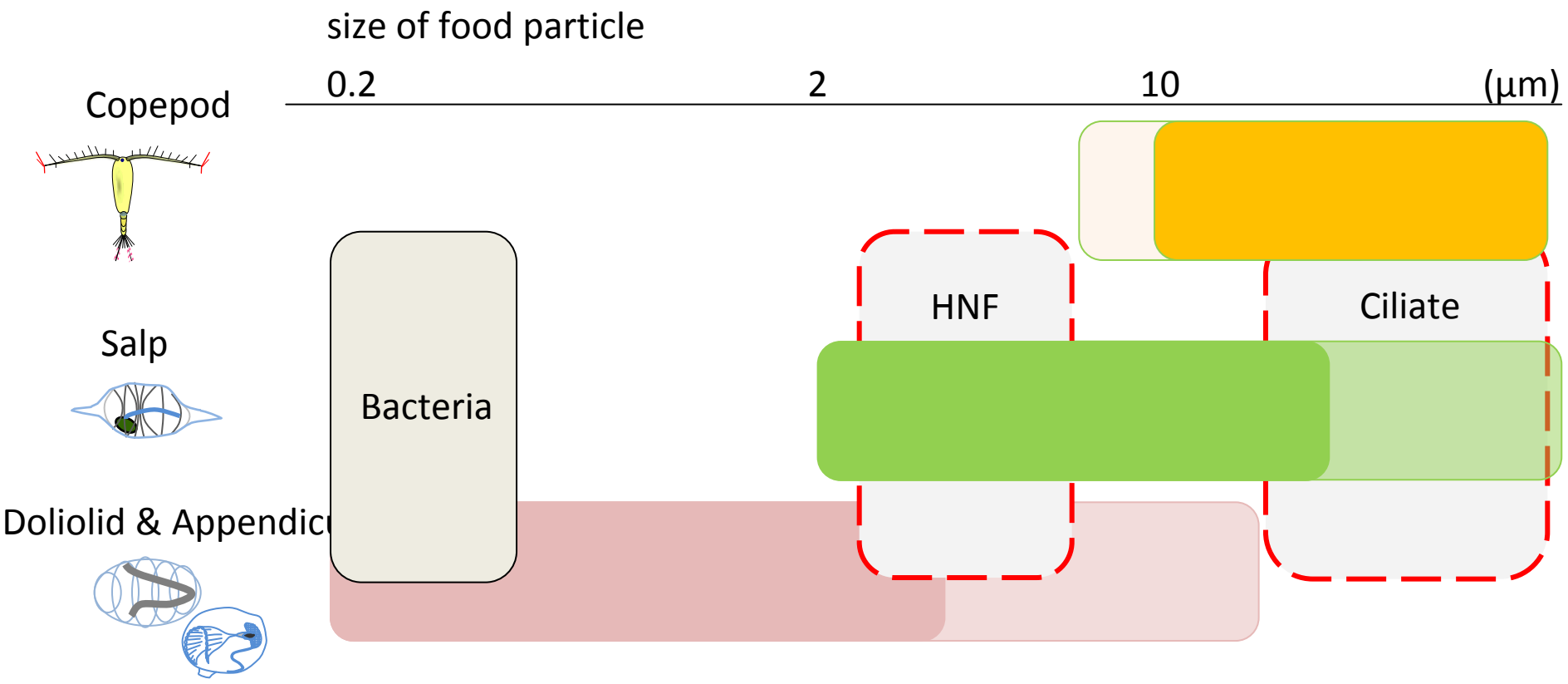
Photo: K. Ide


Salp

Appendicularian



Prey size of Tunicates & Copepod

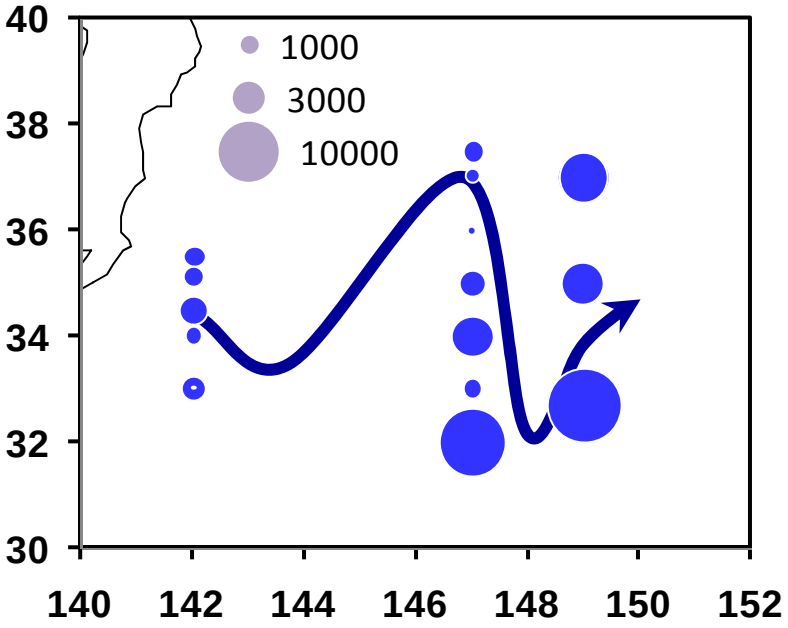


Tunicates can grow in the absence of microphytoplankton
(in which herbivorous copepods such as *Paracalanus* can not grow).

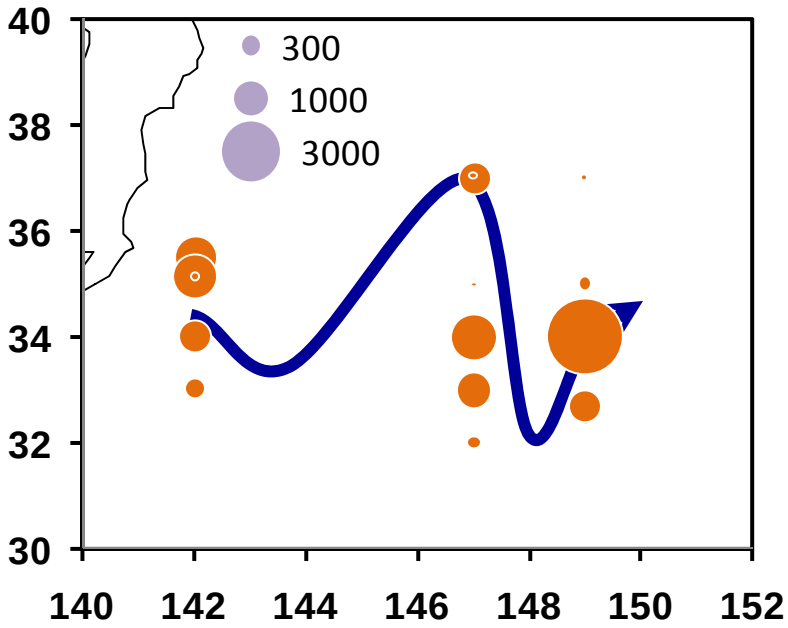
Doliolids and Salps (ind. m^{-2}, 0-50m)

April 2008

Doliolids



Salps



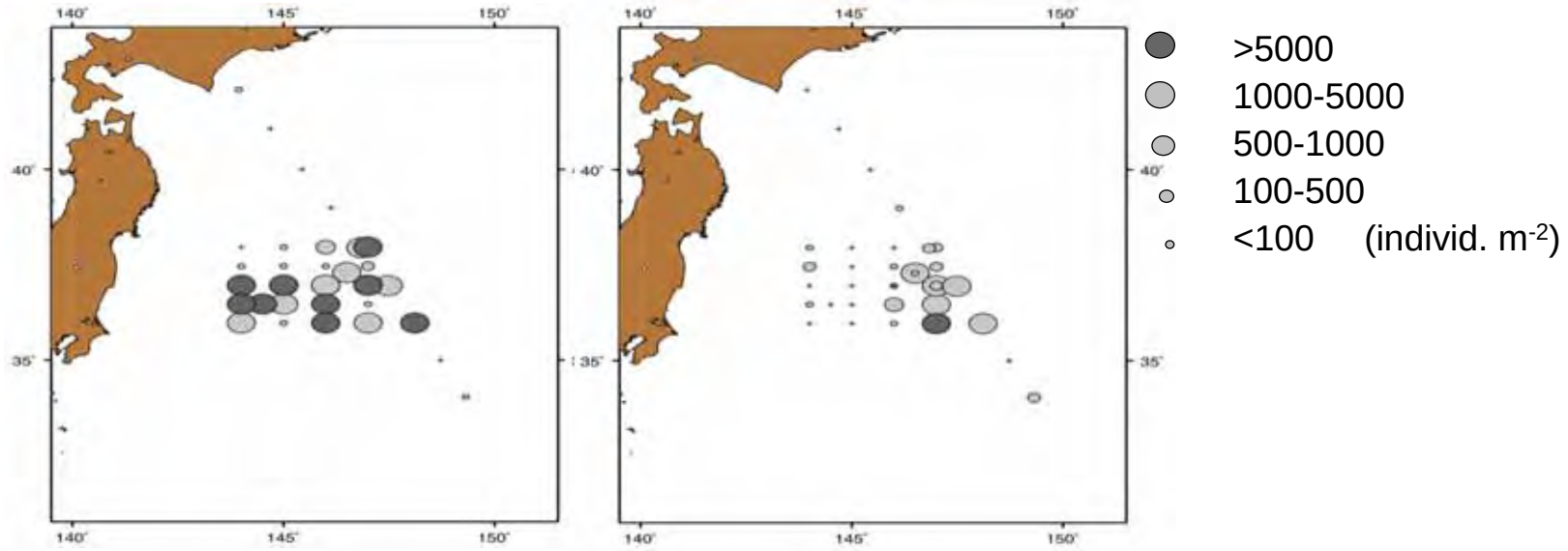
>4 order of magnitude in abundance (copepods<1 order)

Doliolids and Salps (ind. m^{-2}, 0-50m)

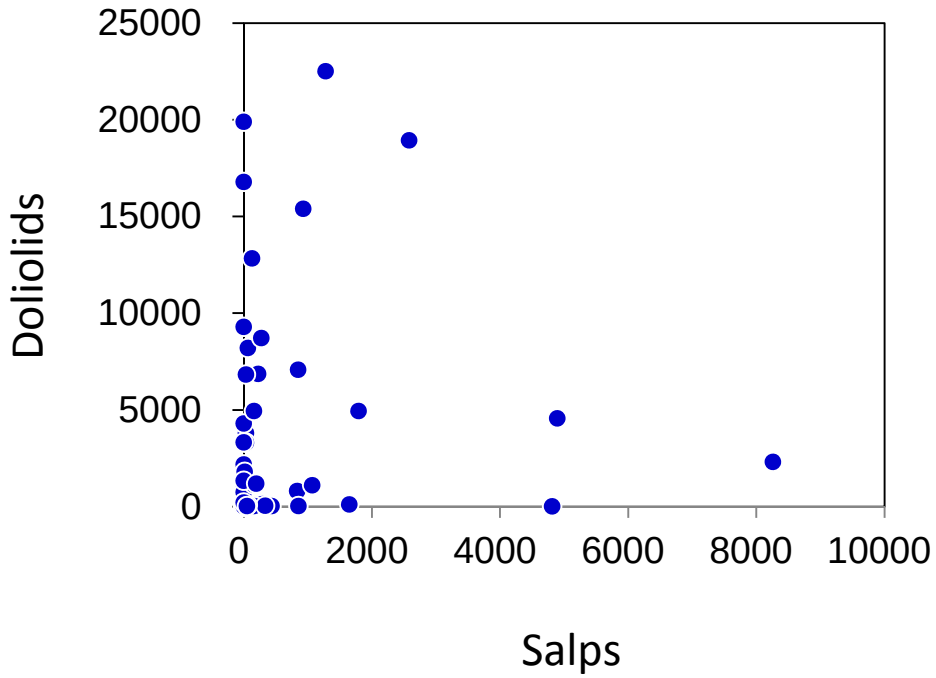
May 2008

Doliolids

Salps



Abundance of doliolids vs salps (ind m^{-2})



Indicating the contribution of salps and doliolids on ecosystem dynamics is highly variable by stations.

Doliolids are more adaptive at oligotrophic-picoplankton dominated environments than salps

Clearance rate and daily ration

Hidaka in prep.

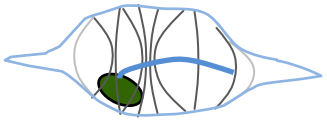
	Length (mm)	Weight (mg C ind^{-1})	Clearance rate (l ind $^{-1}$ d^{-1})	Daily ration (%)
Salps				
aggregate	10.9±3.3	0.5±0.3	0.9±1.5	6.9-62.2
solitary	24.0±2.3	2.9±0.6	2.2±1.5	1.8-7.6
Doliolids				
oozoid	6.9±0.2	0.04±0.003	0.5±0.08	46.5-91.8

	Length (mm)	Weight (mg C ind^{-1})	Clearance rate (l ind $^{-1}$ d^{-1})	Source
Salps				
S. fusiformis	17.0	1.3	6.0	Anderson (1985)
P. confederata	13	0.7	3.6	Harbinson & Gilmer (1976)
T. democratica	2.7	0.02	0.1	Deibel (1982)
Doliolids				
D gegenbauri	6.5	35.0	0.6	Gibson & Paffenhoffer (2000)
	3.4	10.5	0.3	Deibel (1982)

Grazing pressure (% d^{-1})

	Avg	Max
Salps	1.1±2.6	14.9
Doliolids	3.6±5.2	19.8

Ecological function of salps



Producing strong feeding current
Feeding on not only micro- and nanophytoplankton but also protozoa microzooplankton, copepod nauplius, HNF (grazer of nano- and picophytoplankton)

Salps may accelerate phytoplankton succession from nanoplankton dominant assemblage to picophytoplankton dominant assemblage (driving trophic cascading).

Egestion of fast sinking faecal pellet prevent regeneration of nitrogen and accelerate "oligotrophication" on the KEX

The role of salps on transferring primary production to higher trophic levels is low, rather decreasing the ecological transfer efficiency of primary productoin.

Ecological function of doliolids

Weak feeding current
Fine mesh (- 0.2 μm)
Grazer for pico- and nanophytoplankton
Asexual reproduction , high growth rate (g>1 d^{-1})
Sapphirina spp. feed on doliolids

Doliolids adapt to picoplankton dominated oligotrophic environment.

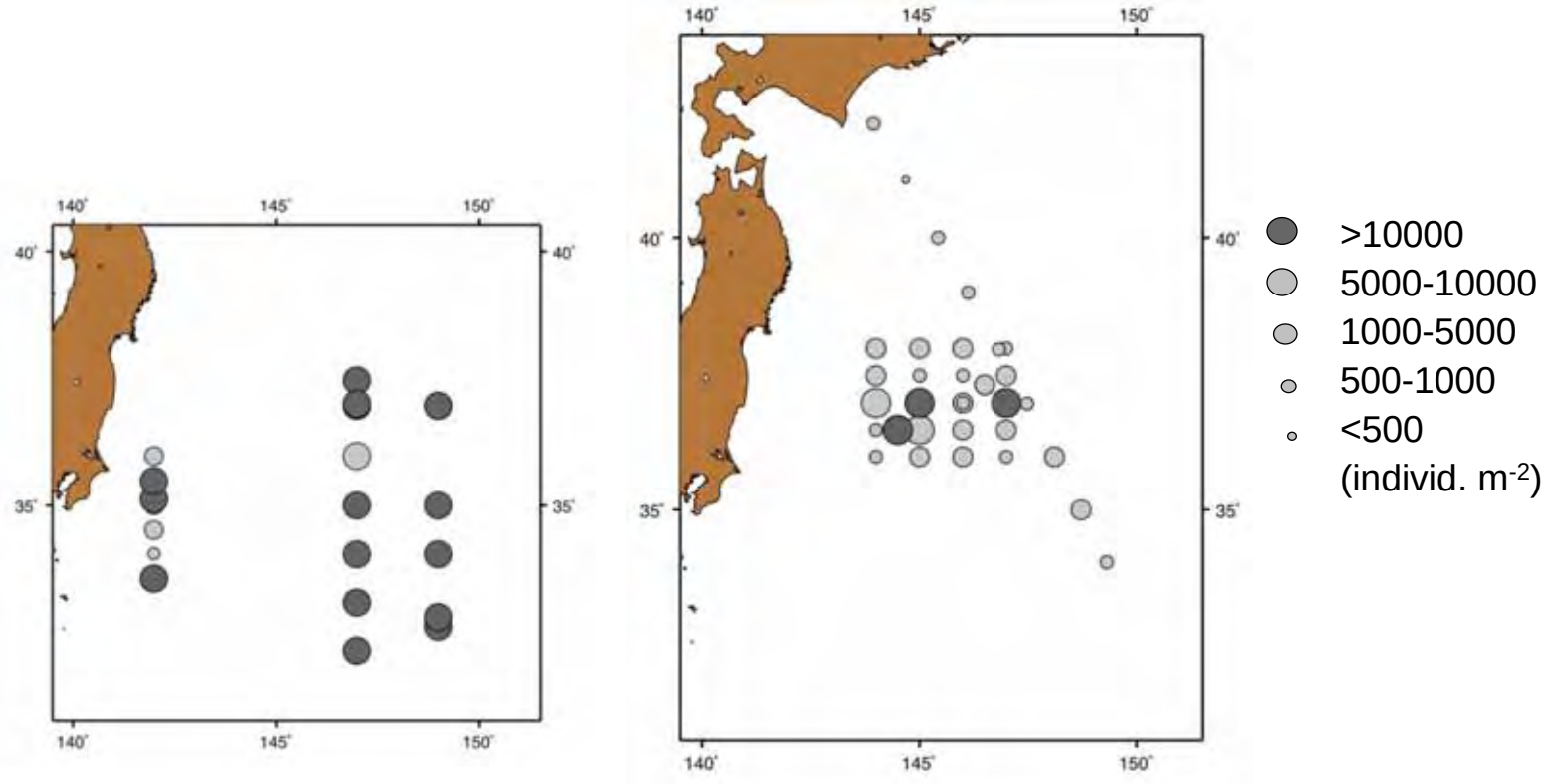
Transferring picophytoplankton production to Sapphirina *spp. and then juvenile fish.*

It is suggested the dominancy of doliolids in zooplankton assemblage occur after salp retreatment.

Horizontal distribution of appendicularians

April

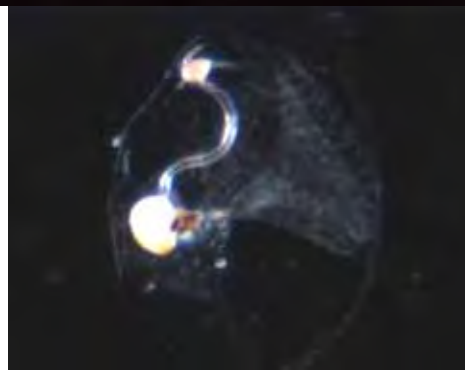
May



Grazing pressure of appendicularians (gut pigment method)

Station	Ingestion (µg chl ind-1 d-1)	abundance (inds. m-2)	comm. ingestion (mg chl m-2 d-1)	0-50m Chl. a (mg m-2)	% ingestion
KE1-11	0.17	15208	2.62	37.09	7.1
KE1-12	0.15	20000	3.08	28.40	10.8
KE2-13	0.64	45440	29.30	30.83	95.0
KE3-7	0.17	79272	13.31	37.85	35.2
KE3-8	0.39	20275	7.86	37.61	20.9

Oncaea spp are dependent on sinking particles, esp. for discarded appendicularian houses.



Ecological function of appendicularian

High grazing pressure on phytoplankton and production of sticky houses indicate the role of appendicularians is repackaging and gathering small non-sinking particles

Supporting the production of Oncaea *spp., important prey for juvenile fish in the KEX.*

Appendicularians enhance the feeding ground for juvenile fish by transferring nano-picophytoplankton production to Oncaea. Increasing the ecological transfer efficiency in pico-nanophytoplankton dominant environment.

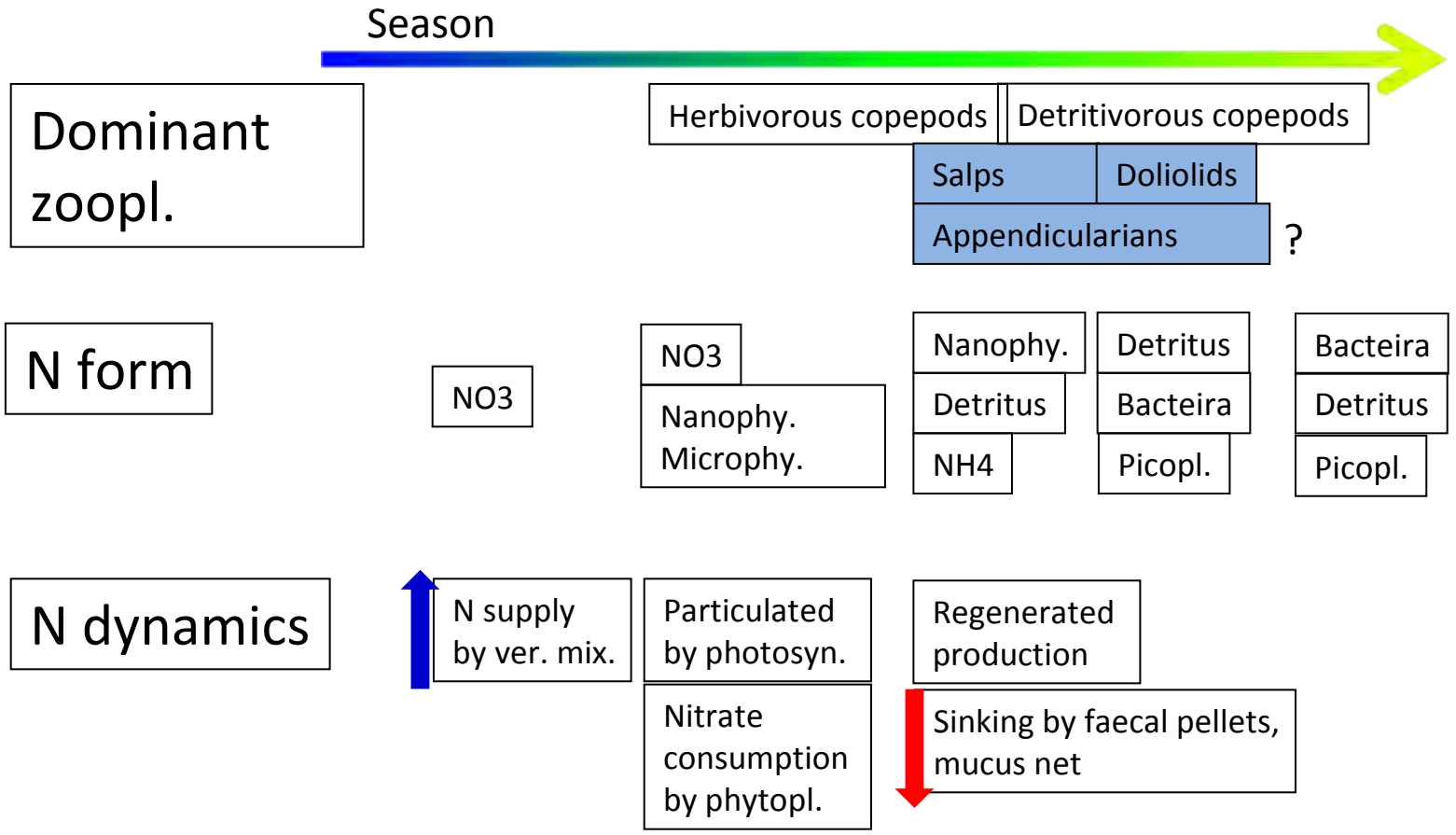
Outburst of tunicates indicates the status of KEX ecosystem seasonal succession.

Salp outburst: Driving the ecosystem from micro- and nanophytoplankton dominated to picophytoplankton dominated status. Driving the ecosystem to more oligotrophic condition by activating biological pump (preventing regenerated production)

Doliolid outburst: Indicating picophytoplankton dominated oligotrophic status of the ecosystem.

Appendicularian outburst: Indicating ecosystem succession period from herbivorous copepod dominated condition to detritivore dominated condition. Driving the ecosystem to detritus PON dominated condition.

Seasonal ecosystem succession in the KEX



Remainign issue:

Control factor(s) of the dominancy between appendicularians and salps/doliolids.
Control factor(s) of the dominancy between copepods and tunicates

This is due to limited understanding on the biology and ecology of tunicates. Most zooplanktologists (including myself) have been avoided to study gelatinous zooplankton…..

Thank you!