Using fatty acids as physiological and ecological indicator of zooplankton in the Yellow Sea: with implications in relationships of biochemical indices and biodiversity

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Marine ecosystem dynamics and degradation in coastal oceans

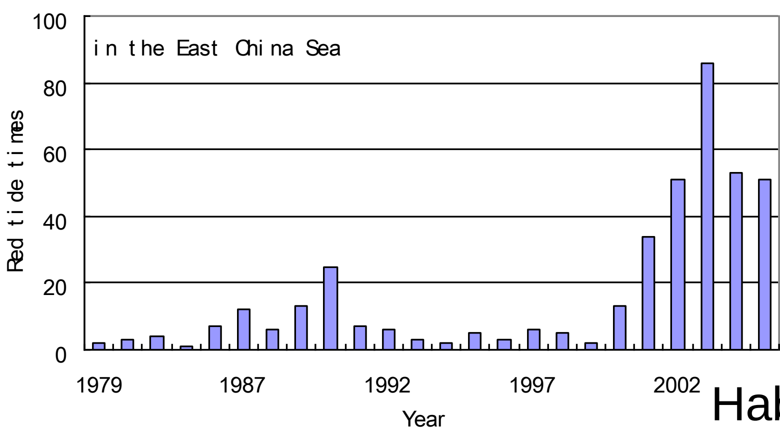
Harmful algal blooms

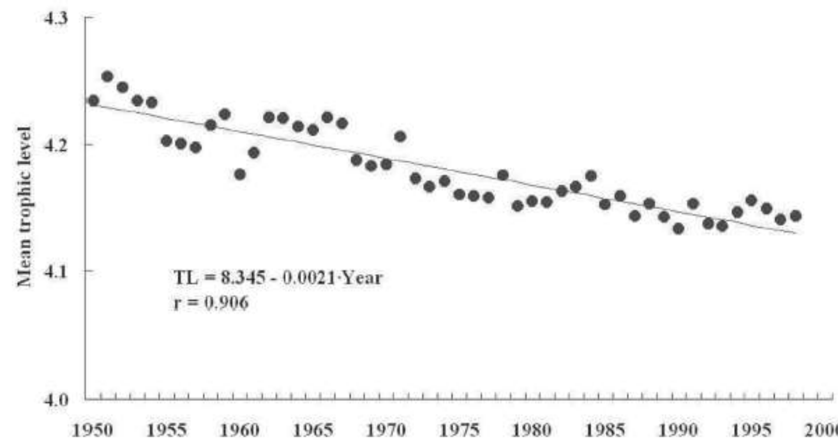
Phytoplankton species succession

Toxic algae

Decrease of fish stocks

Mean trophic level of global fisheries declined





Habitat dustruction

SOA

Pauly et al, 1998

Aquaculture

Climate change

zooplankton

- Quantity

Biomass

VS

- Quality

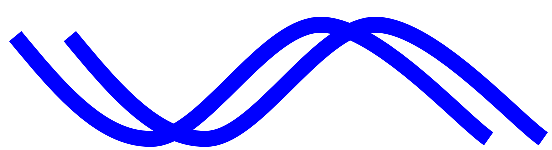
Biodiversity

Nutritional value (or biochemical contents)

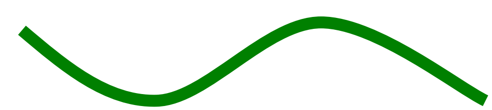
Jellyfish vs copepod

Biochemical fingerprints in zooplankton

- Proteins
- Carbohydrates
- Lipids
- **Nucleic Acids**



DNA



RNA

Proteins

Many functions: the embodiment of life

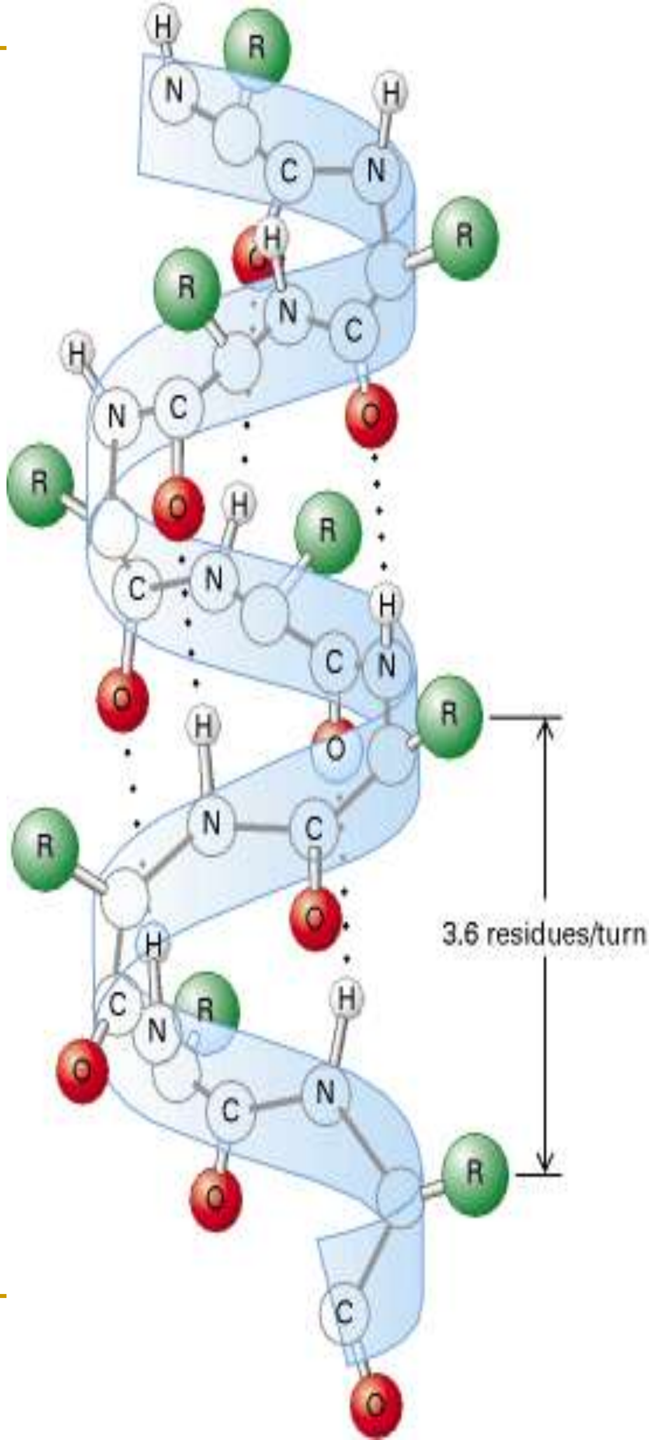
Total protein content

Amino acids

Enzymes

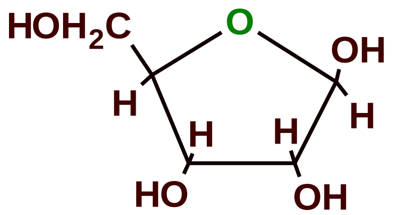
Protein content is a good indicator of the nutritive state of the animals and, also, it is a good tool for elucidating food-competitive capacities among species. The amino acid composition of the species is a good indicator of the trophic niche and the adaptations of the species to abiotic factors.

(Cástor Guisande, 2006)

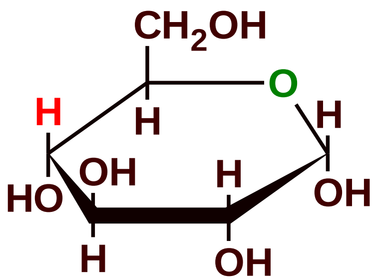


Carbohydrates

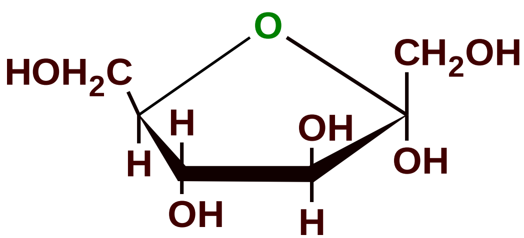
Energy supply for metabolism



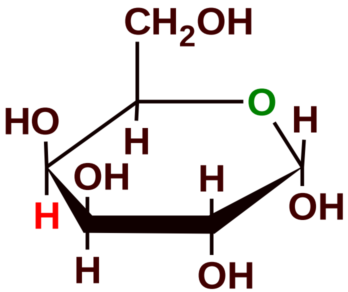
ribose



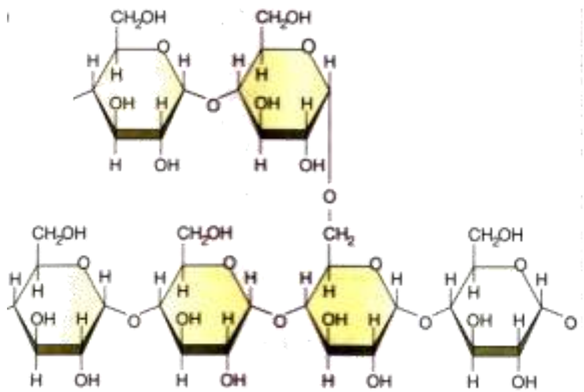
glucose



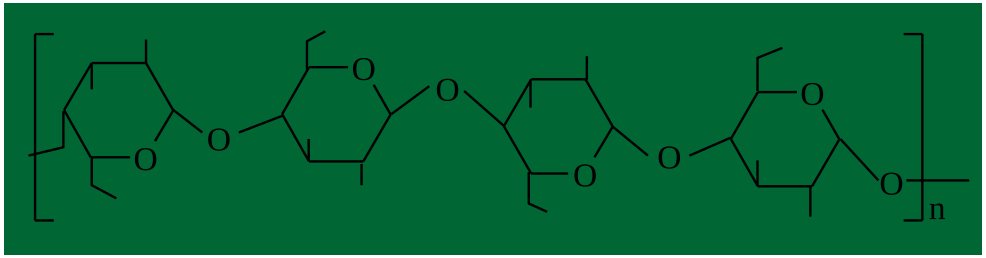
fructose



galactose



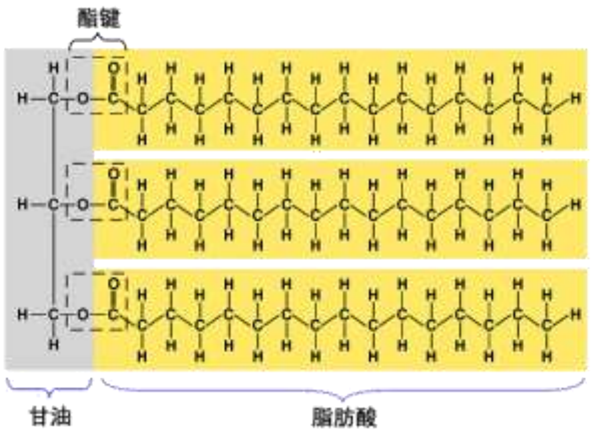
starch



cellulose

Lipid

- Triacylglycerol
- Phospholipid
- Wax esters …



- Fatty acids

Essential Fatty Acid (EFA)

e.g. EPA C20:5(n-3), DHA C22:6(n-3)

Litzow et al(2006) EFA limitation hypothesis during ecosystem regime shift

Good indicator for feeding relationships, trophic position, and physiology of a species.

General biochemical composition of zooplankton

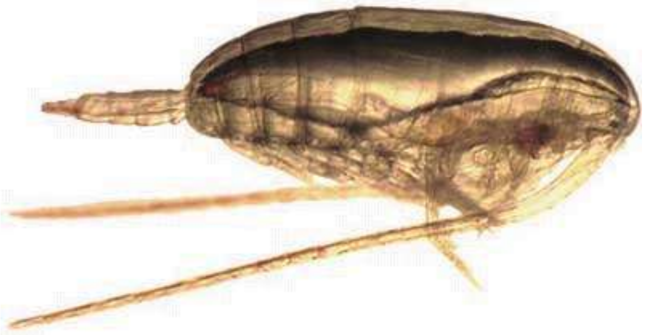
- Comparison of the biochemical composition of 182 freshwater and marine species (**Ventura, 2006)**

(b) Marine	Mysiids			Euphausiids			Calanoid copepods		
	Mean ± SD	Range	n	Mean ± SD	Range	n	Mean ± SD	Range	n
ATP	0.62 ± 0.17	0.69 – 0.35	2	0.37 ± 0.29	0.85 – 0.08	1	0.67 ± 0.02	1.70 – 0.39	13
ADP	0.33 ± 0.11	0.73 – 0.03	2	0.73 ± 0.31	1.34 – 0.11	1	0.27 ± 0.07	1.47 – 0.00	9
AMP	0.19 ± 0.10	0.60 – 0.00	2	0.09 ± 0.50	1.10 – 0.00	1	0.16 ± 0.04	0.71 – 0.00	9
DNA				0.33 ± 0.59	1.60 – 0.07	1	0.67 ± 1.09	3.92 – 0.06	5
RNA				0.53 ± 0.57	2.13 – 0.18	1	2.14 ± 0.57	6.80 – 0.31	7
Chitin	7.10 ± 0.65	8.40 – 5.80	1	4.83 ± 3.82	10.66 – 2.30	1	4.94 ± 2.12	9.30 – 2.10	13
Carbohydrate	3.20 ± 1.14	5.40 – 2.40	1	2.18 ± 0.09	2.36 – 2.01	1	2.82 ± 2.04	8.50 – 0.20	19
Protein	37.41 ± 20.64	66.66 – 39.14	3	43.90 ± 7.69	69.21 – 30.00	15	38.74 ± 11.20	64.34 – 23.94	37
Free amino acids	9.68 ± 1.90	13.60 – 5.94	3	5.26 ± 4.04	10.70 – 2.00	2	10.89 ± 4.08	19.35 – 5.06	5
Total lipids	13.67 ± 3.82	24.00 – 8.20	3	12.09 ± 9.26	59.70 – 0.43	20	25.08 ± 15.72	73.00 – 1.90	93
Phospholipids	41.56 ± 15.82	51.00 – 23.30	2	59.89 ± 17.76	84.68 – 35.18	8	41.54 ± 24.92	84.55 – 1.00	74
Triacylglycerol	39.04 ± 23.85	56.29 – 11.82	3	29.79 ± 12.00	51.03 – 15.32	8	18.31 ± 17.23	76.50 – 0.00	74
Wax esters	19.41 ± 18.92	37.81 – 0.00	3	10.32 ± 15.97	40.77 – 0.00	8	40.15 ± 32.51	94.13 – 0.00	74

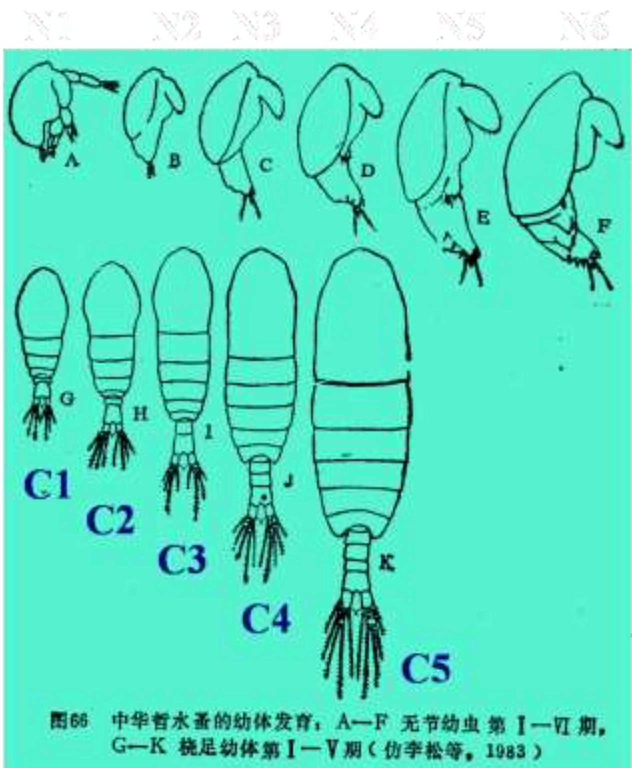
- Among these compounds, lipids are those which have received the highest research effort (140 species were found with data on lipid content, which was more than twice the number of species for which data on protein were found).
- Lipids also exhibited the highest variability in minimum-maximum ranges, most significantly so for copepods.

(Ventura, 2006)

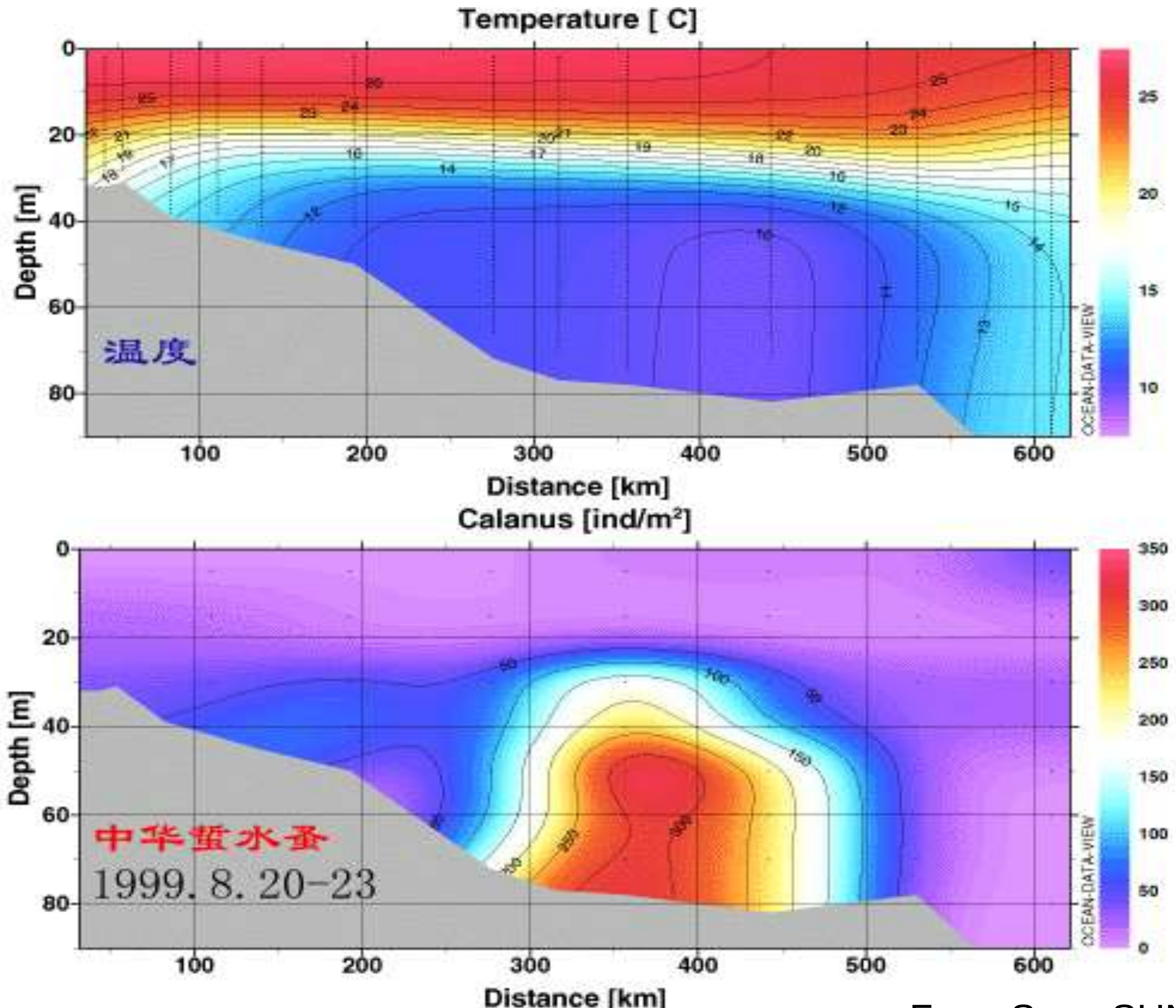
Using fatty acids in Population dynamics study of key zooplankton species in YSCWM– Calanus Sinicus



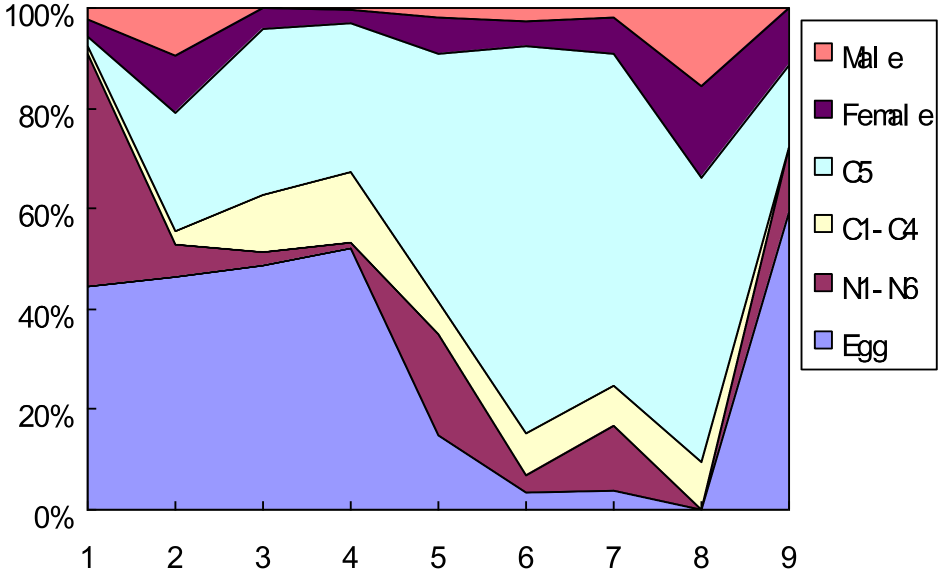
Calanus sinicus



- The most dominant zooplankton species in the Yellow Sea
- Great importance in trophic transfer from phytoplankton to fish
- Tight linkage with YSCWM during summer time



From Song SUN



Diapause in YSCWM

Development pause at C5

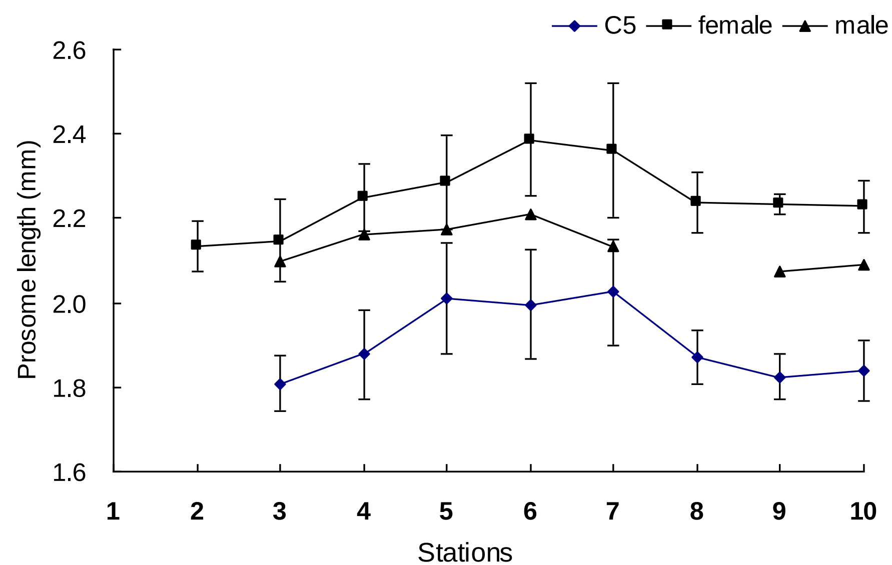
Longer body length

Heavier body weight

Limited DVM

Non-active feeding

Aug 2001



Fatty acid?

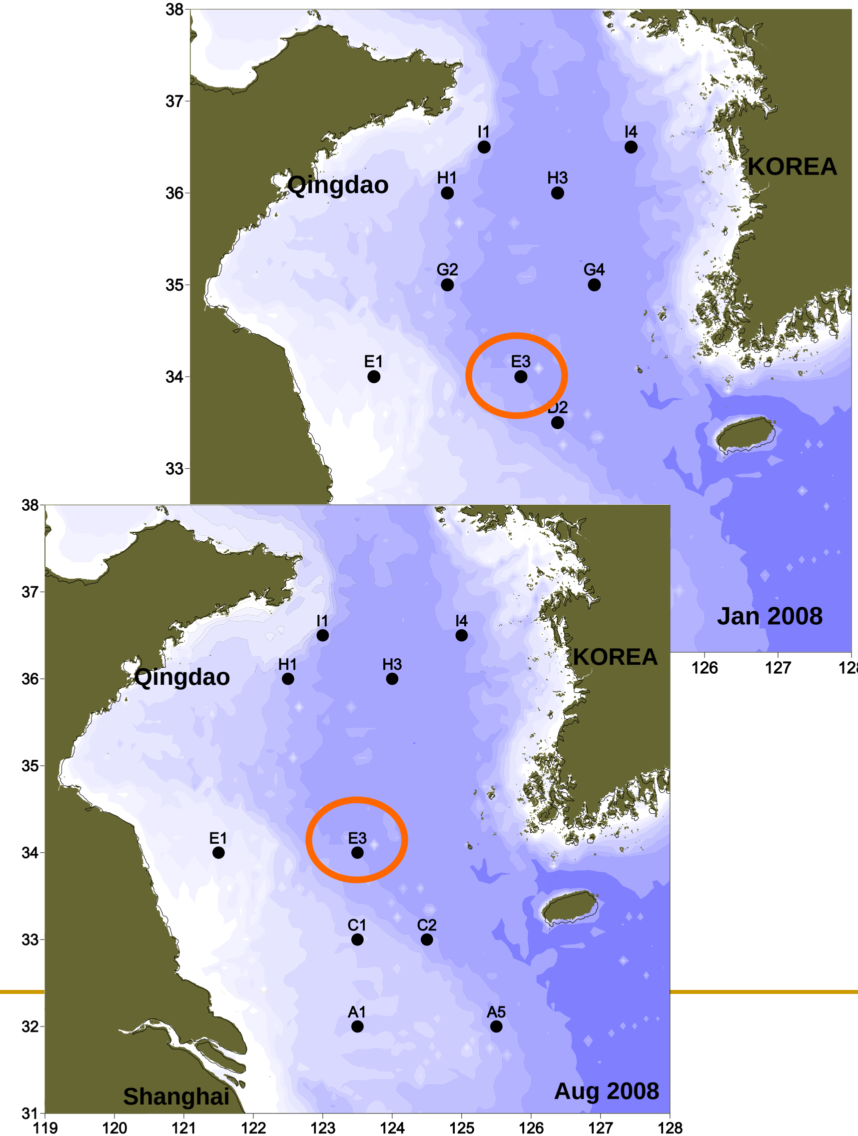
Fatty acid composition of some dominant zooplankton species in the Yellow Sea

Methods:

Besides traditional net-sampling and microscopic counting,

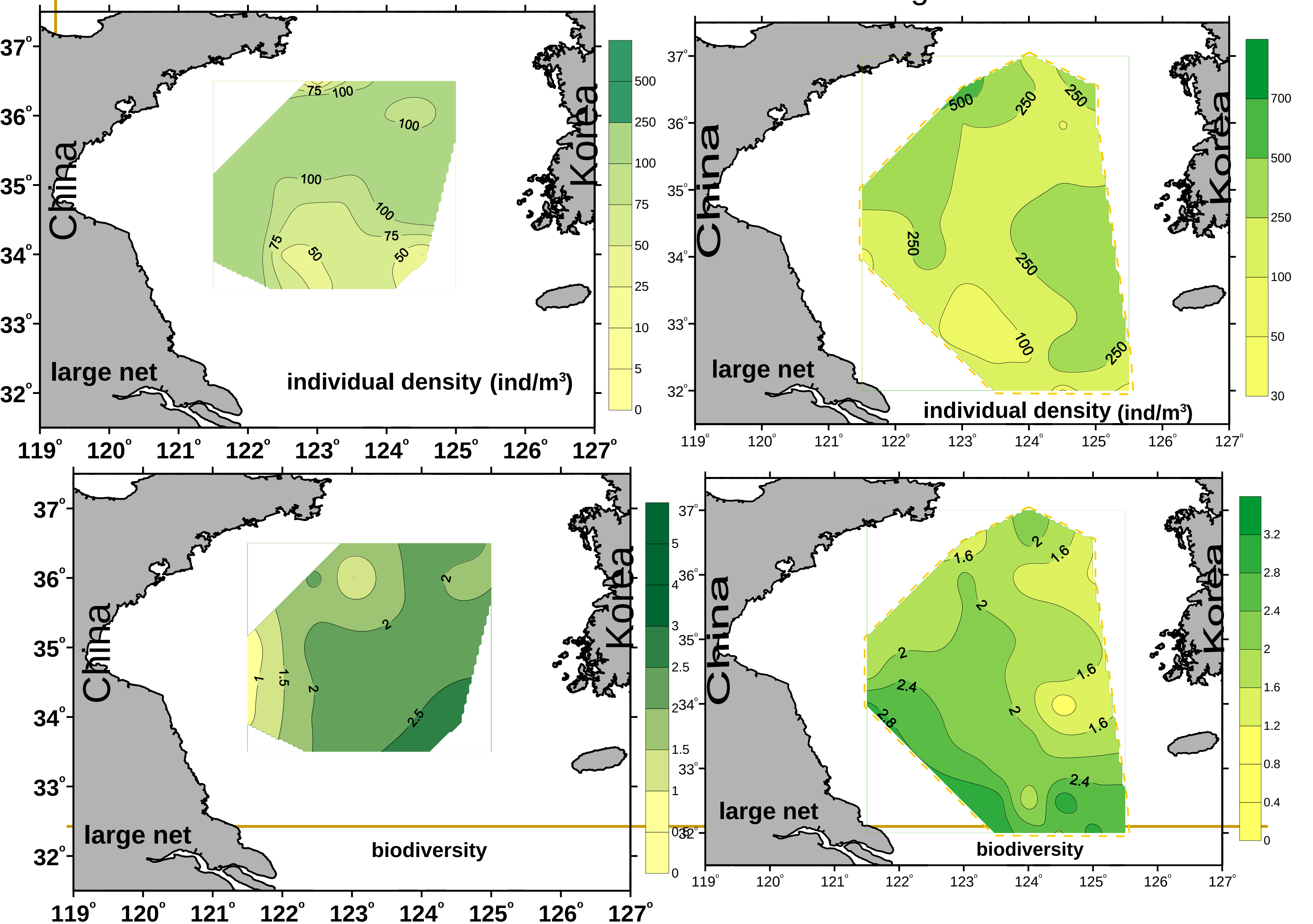
Zooplankton assemblage samples by vertically towing a net (500 um in mesh size and 0.5 m^2 in mesh mouth). Dominant species such as *Calanus sinicus* were picked out for further analysis.

Samples were freeze-dried. Fatty acids were extracted and analyzed with GC-MS.



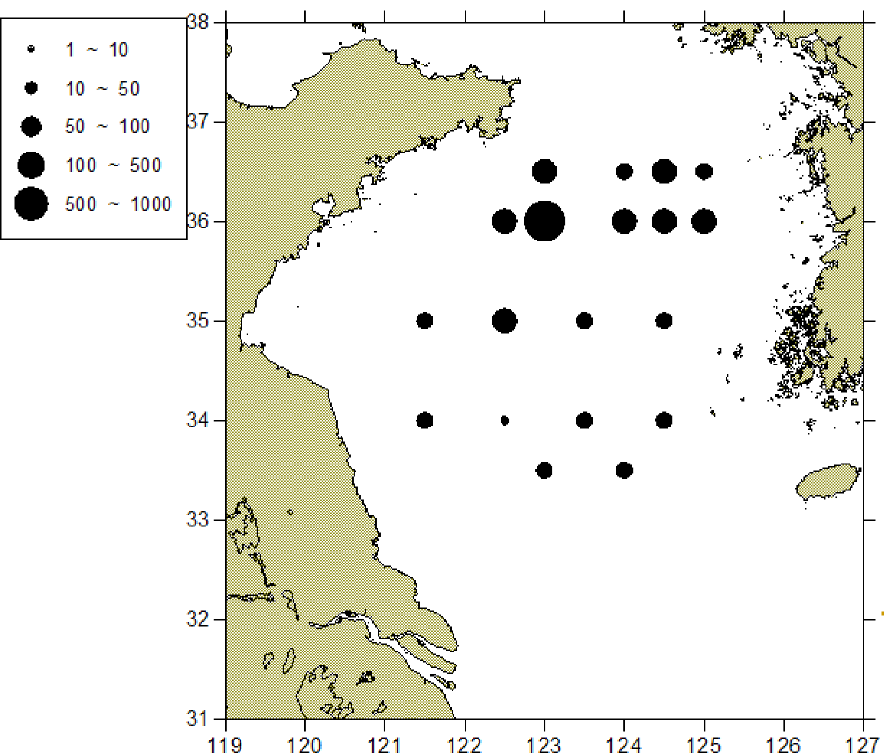
Jan 2008

Aug 2008

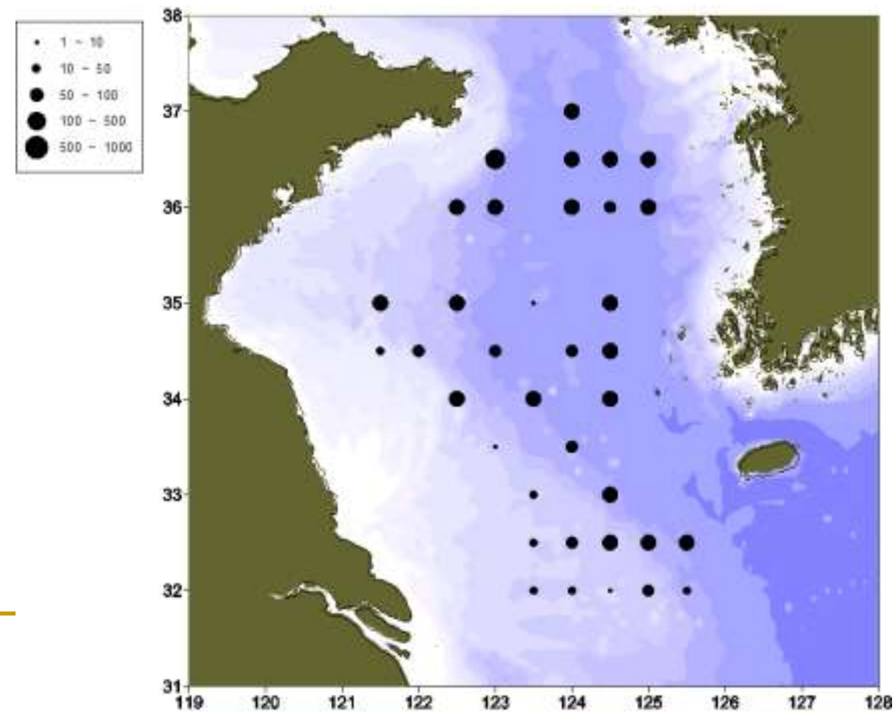


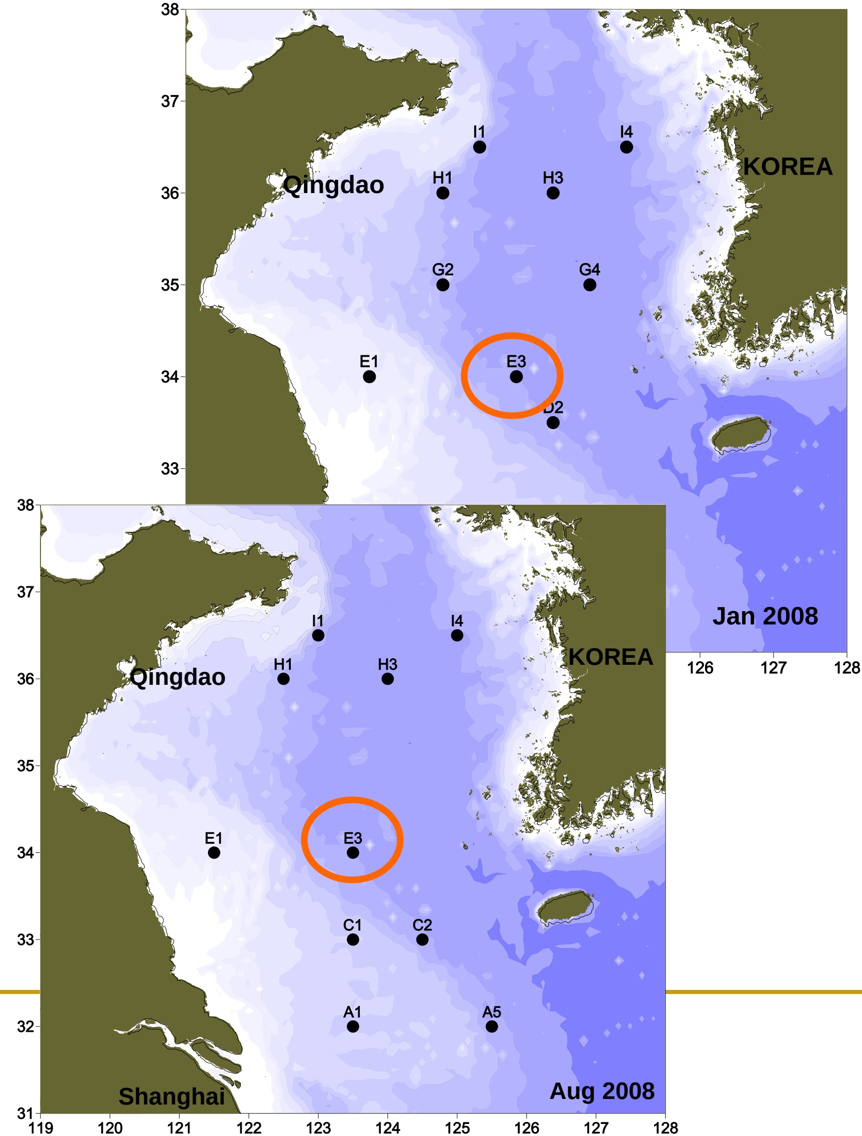
Abundance *of C.sinicus* (ind./m^3) in 2008

Jan 36.5



Aug 109.9




Qingdao
KOREA
Jan 2008
I1
I4
H1
H3
G2
G4
E1
E3
D2
Qingdao
KOREA
Shanghai
Aug 2008
I1
I4
H1
H3
E1
E3
C1
C2
A1
A5
38
37
36
35
34
33
32
31
119
120
121
122
123
124
125
126
127
128

Fatty acids %

Stn: E3 in Jan

PG: Parathemisto gaudichardi

EP:*Euphausia pacifica*

CS: Calanus sinicus

	PG	EP	C3-C4	C5	♀	♂
C12:0	0.62	0.16	0.24	0.44	0.59	0.41
C14:0	3.63	10.73	7.10	9.88	8.16	9.85
C16:0	67.39	22.72	39.41	26.64	58.18	47.35
C18:0	17.73	2.46	10.41	6.16	14.33	8.89
C14:1	0.09	0.07	0.00	0.24	0.17	—
C16:1n-7	1.90	9.63	4.26	8.04	4.76	6.81
C18:1n9	1.87	7.71	1.90	3.97	1.20	3.05
C20:1	0.40	1.42	2.37	3.42	2.60	3.30
C22:1n11	0.05	0.44	1.07	1.86	1.21	1.75
C18:3n6	0.26	10.19	2.60	5.09	0.59	1.43
C18:2n6	0.15	0.99	0.24	0.75	0.14	0.30
C20:4n6	—	1.09	—	0.27	—	—
C20:5n3	2.69	11.21	10.53	11.74	3.61	6.33
C22:6n3	2.62	16.46	18.93	20.11	4.01	10.40
SFAs	89.90	39.62	57.87	44.08	81.72	66.63
MUFAs	4.38	20.25	9.82	17.96	9.93	14.91
PUFAs	5.72	40.13	32.31	36.30	8.35	18.46
TFA/DW%	3.89	8.44	0.96	3.67	5.51	4.20

Stn: E3 in Aug

EP: *Euphausia pacifica*

CS: Calanus sinicus

	EP	CV	♀
C12:0	0.84	1.40	1.18
C14:0	10.68	13.92	12.62
C16:0	35.36	28.01	29.97
C18:0	5.06	6.58	6.66
C14:1	0.14	0.16	0.20
C16:1（n-7）	3.97	7.60	0.65
C18:1（n-9）	4.84	2.57	3.66
C20:1	0.89	11.47	3.69
C22:1（n-11）	0.25	7.60	1.65
C18:3（n-6）	9.62	4.87	6.87
C18:2（n-6）	1.19	0.68	1.02
C20:4（n-6）	0.63	—	0.46
C20:5（n-3）	9.74	5.99	9.45
C22:6（n-3）	12.26	6.67	17.46
SFAs	53.62	51.54	53.01
MUFAs	12.94	30.25	11.74
PUFAs	33.44	18.21	35.25
16:1(n-7)/16:0	0.11	0.27	0.02
20:5 (n–3)/22:6 (n–3)	0.79	0.90	0.54
TFA/DW %	5.4	10.61	5.24

The results indicate

- CV in the cold water during summer accumulate lipids.
- Mono-unsaturated fatty acids was much higher than that in winter and higher than female adults
- A biochemical support for the summer diapause of *C.sinicus*
- A useful tool for life history studies.

Prospects for future works

- Biochemical data will not be used solely for species taxonomy. However, adding biochemical parameters to traditional taxa data will give us more information on the biology and ecology of zooplankton.

- Proteins and lipids are the two largest biochemical component of marine zooplankton. Amino acids and fatty acids can be used as biochemical fingerprint for understanding biology and ecology of target zooplankton species. ^{15}N in amino acids, much more difficult.

- Biochemical data should be collected along with taxonomic data, and corresponding databases be constructed.

- Data comparison and analysis: geographic differences, chronically changes for zooplankton community and/or some key species.

- From biodiversity to functional biodiversity (processes, multidisciplinary)

Thank you