Seasonal changes in food quantity and quality for the development and egg production of the common North Sea copepods *Temora longicornis* and *Pseudocalanus elongatus*

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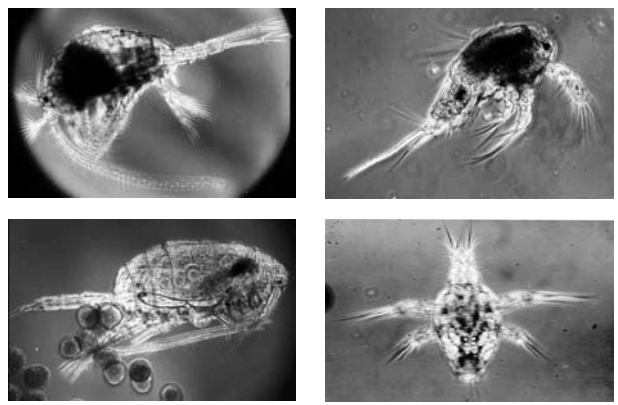


Photos: Wim Klein Breteler; www.nioz.nl

Background and objectives

The control of secondary production in seasonal environments?

Reproduction:
- Temperature and body size?
- Food concentration?
- Food quality?
  - Taxonomic composition?
  - Mineral nutrients?
  - Biochemical composition?
- Maternal factors

Juvenile growth:
- Temperature?
- Food quantity?
- Food quality?
- Maternal effects?

Bioassay approach to study the effect of food **only**

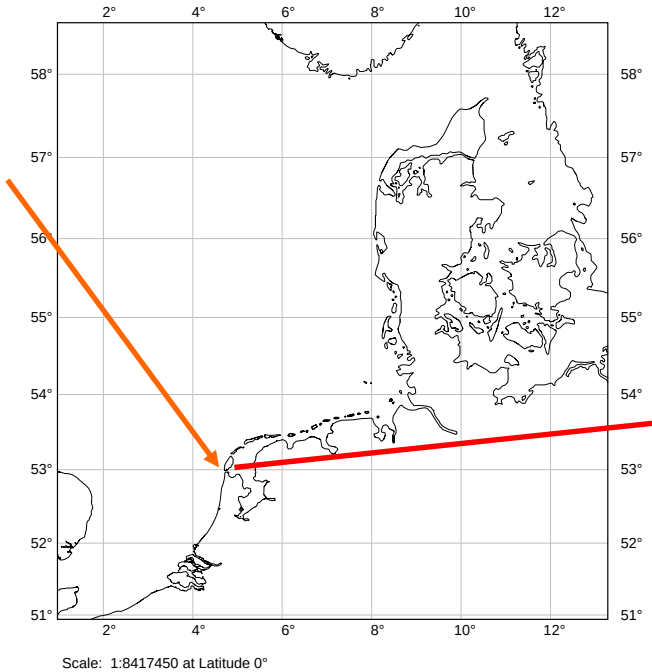
→ Biochemical measurements (sterols) included

Juvenile development over a seasonal cycle

Methods

- Monthly sampling from December to September from a well-mixed tidal inlet, coastal North Sea

- Water transferred to laboratory and fed to <u>cultured</u> copepods at a <u>constant temperature</u> (15 °C)



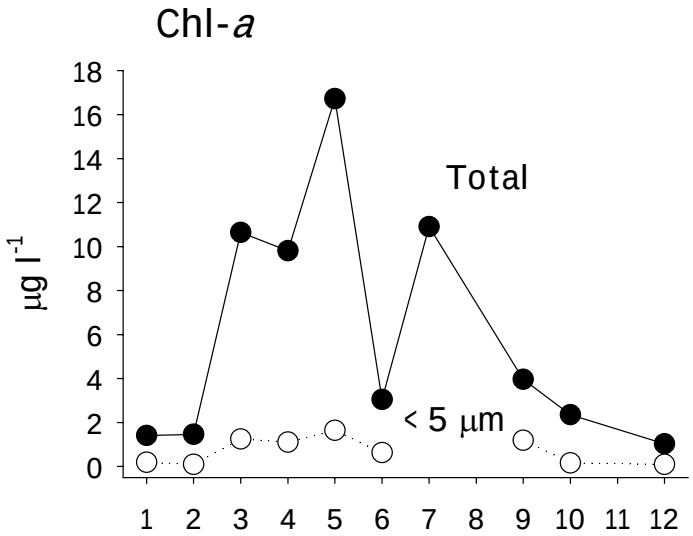
Chl-*a* (total, < 5 µm)
Pigments
POC, PON
FA, sterols

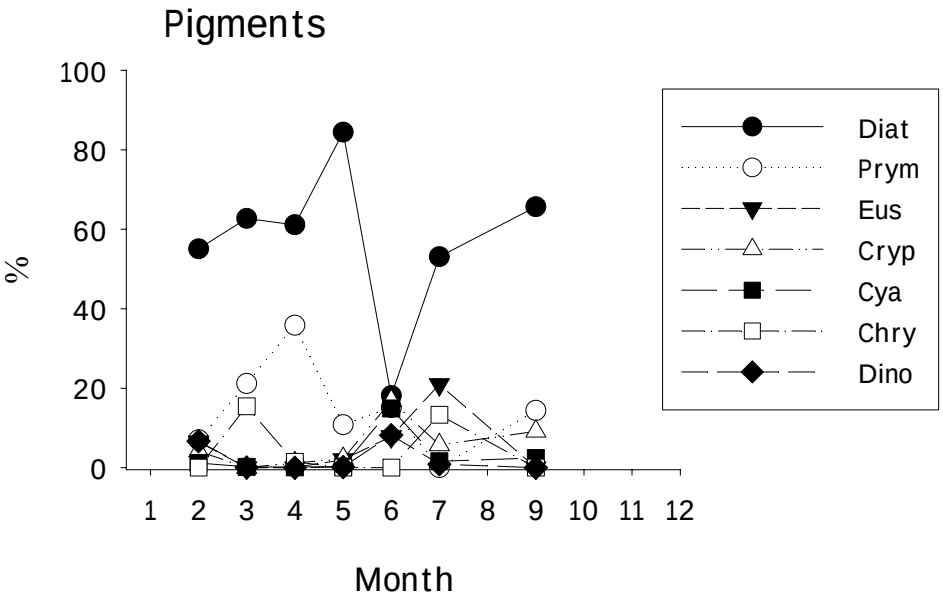
Temora longicornis
Pseudocalanus elongatus

Egg production
Development (growth)
Juvenile mortality

Results

Seasonal development of food quantity and quality: Phytoplankton





- High biomass
- Diatoms dominate (50-80%), except in June
- Prymnesiophytes in March-May
- Diverse in June

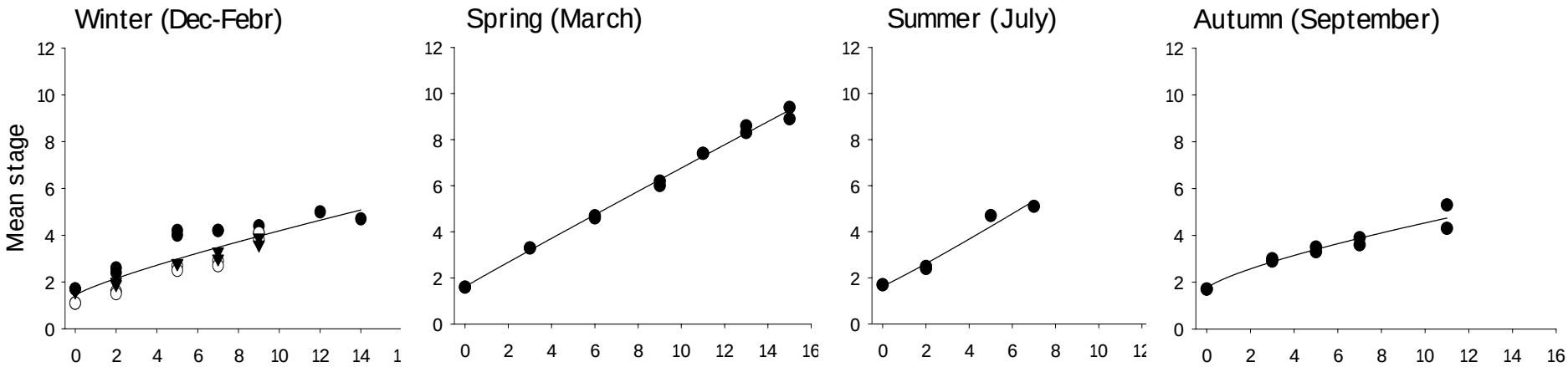
Seasonal development of food quantity and quality: POC, PON, FA; sterols

Month	*Minerals (µg l^{-1})*		*Ratios (weight)*		*Biochemistry (µg l^{-1})*		
	POC	PON	POC:PON	POC: Chl-*a*	PUFA	EPA + DHA	Sterols
December	535	78	6.9	520	2.7 (10)	1.2	2.3
January	406	58	7.0	290	-	-	-
February	492	64	7.7	340	0.3 (0.9)	0	3.0
March	971	173	5.6	91	58 (7.4)	25.8	49.6
April	916	169	5.4	93	6.5 (13)	1.0	5.2
May	1111	192	5.8	66	13.4 (14)	10.3	7.3
June	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-
September	713	119	6.0	180	0.2 (1.8)	0	1.2
October	1352	188	7.2	580	1.9 (0.7)	1.9	18.5

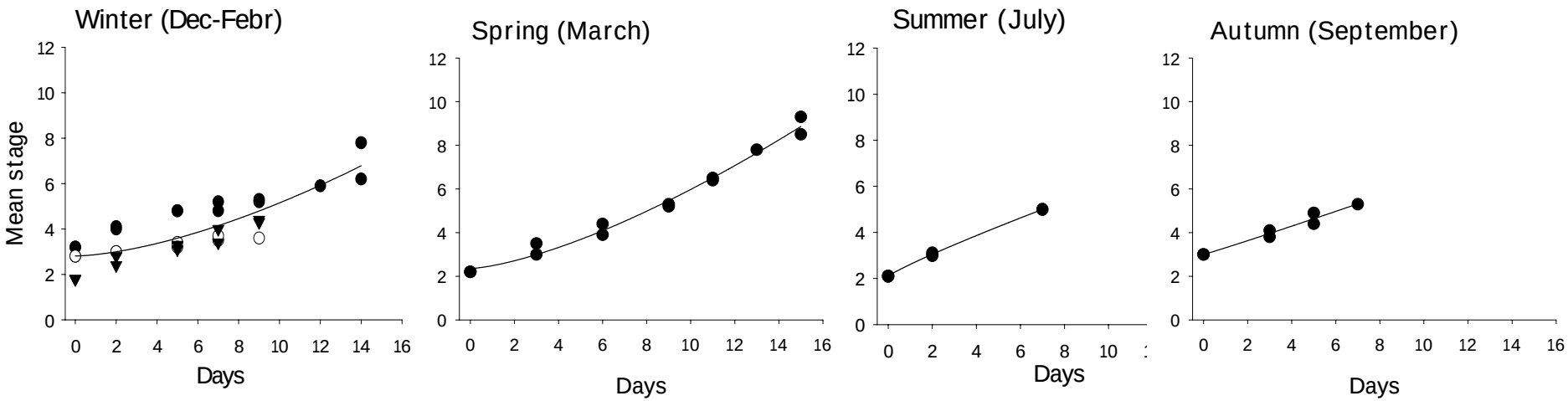
- High concentration of POC the year round
- Lot of detritus during the winter months (POC: Chl-*a* 300-500)
- High concentration and quality of seston during the spring bloom

Results: Juvenile development

Temora longicornis



Pseudocalanus elongatus



Juvenile growth and mortality

	Growth (% d^{-1})		*Mortality (% d^{-1})*	
	T. longicornis	*P. elongatus*	*T. longicornis*	*P. elongatus*
Winter	8-10	4-11	14-21	11-40
Spring	17	18	13	16
Summer	18	17	***48***	***61***
Autumn	9	14	26	47

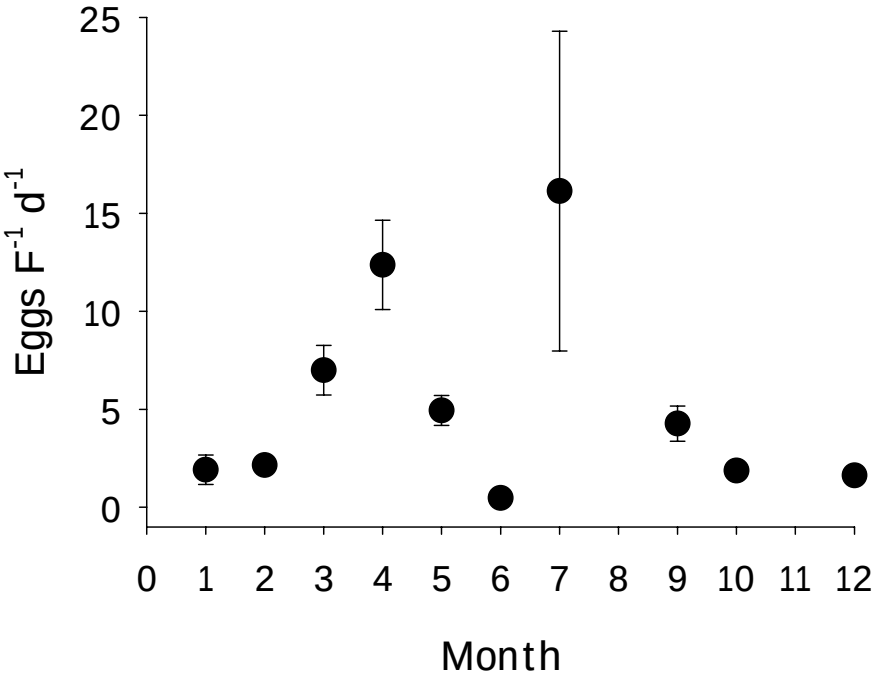
- The only time of the year when development could be completed was March (early spring bloom)

- Equally high growth, but very high mortality in July

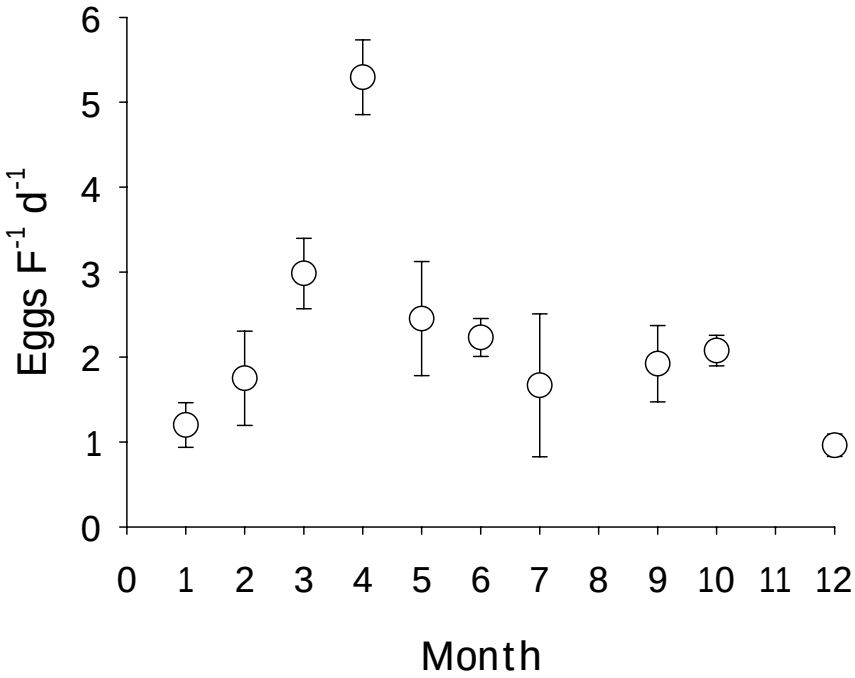
- In winter and autumn generally low growth and moderate to high mortality

Results: Egg production

Temora longicornis



Pseudocalanus elongatus



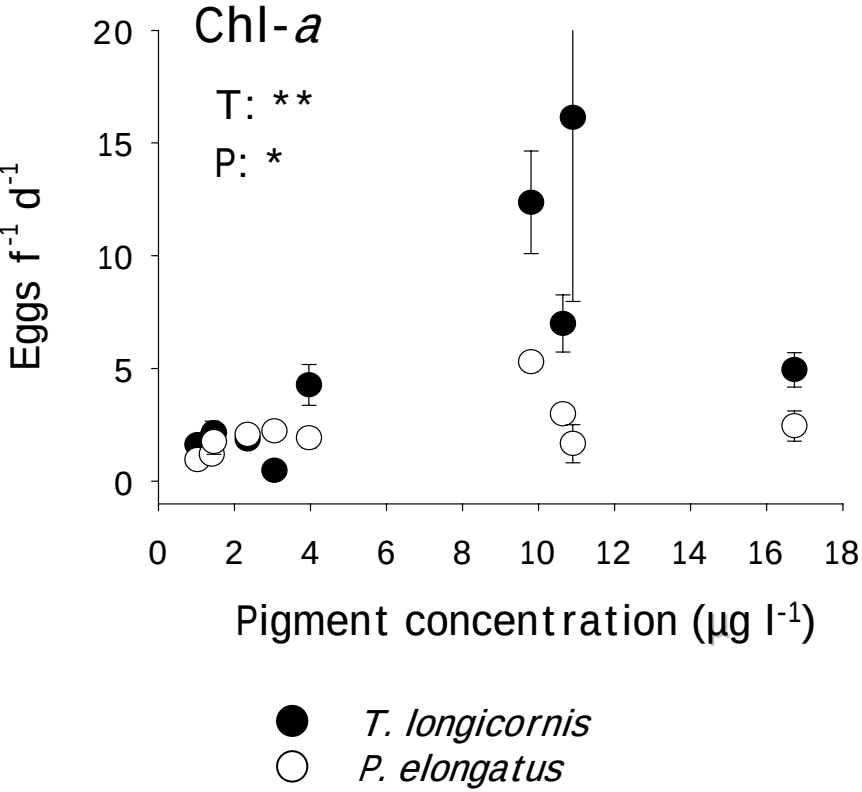
- > 5 fold variation in egg production of both species between months

- Peak in April; for *Temora* also high in July, other months low

- With the exception of July, similar seasonal trends in both species

Effect of food on egg production

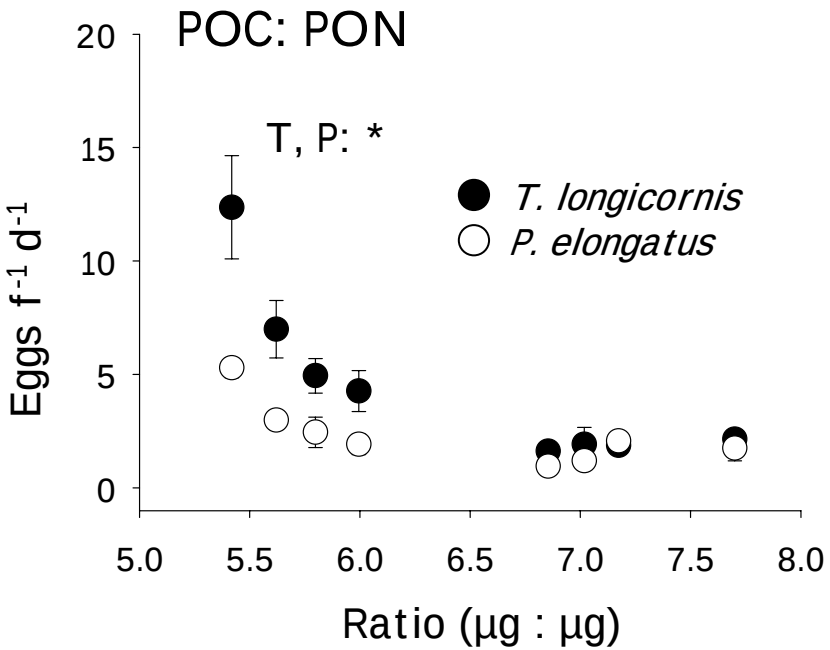
Pigments



	Significance of correlation (Spearman rank)	
Algae group	***T. longicornis***	***P. elongatus***
Diatoms (fucoxanthin)	* (< 0.05)	* (< 0.05)
Prymnesiophytes (Chl Ch2+3)	** (< 0.01)	** (< 0.01)
Dinoflagellates (peridin)	Ns	** (< 0.01)
Cyanobacteria (zeaxanthin)	Ns	Ns
Chlorophytes (Chl-*b*)	Ns	Ns
Cryptophytes (alloxanthin)	Ns	Ns
Chl-*a*: POC	** (< 0.01)	Ns

- Egg production connected to phytoplankton biomass, Chl-*a*: POC ratio and concentration of diatoms, prymnesiophytes and dinoflagellates

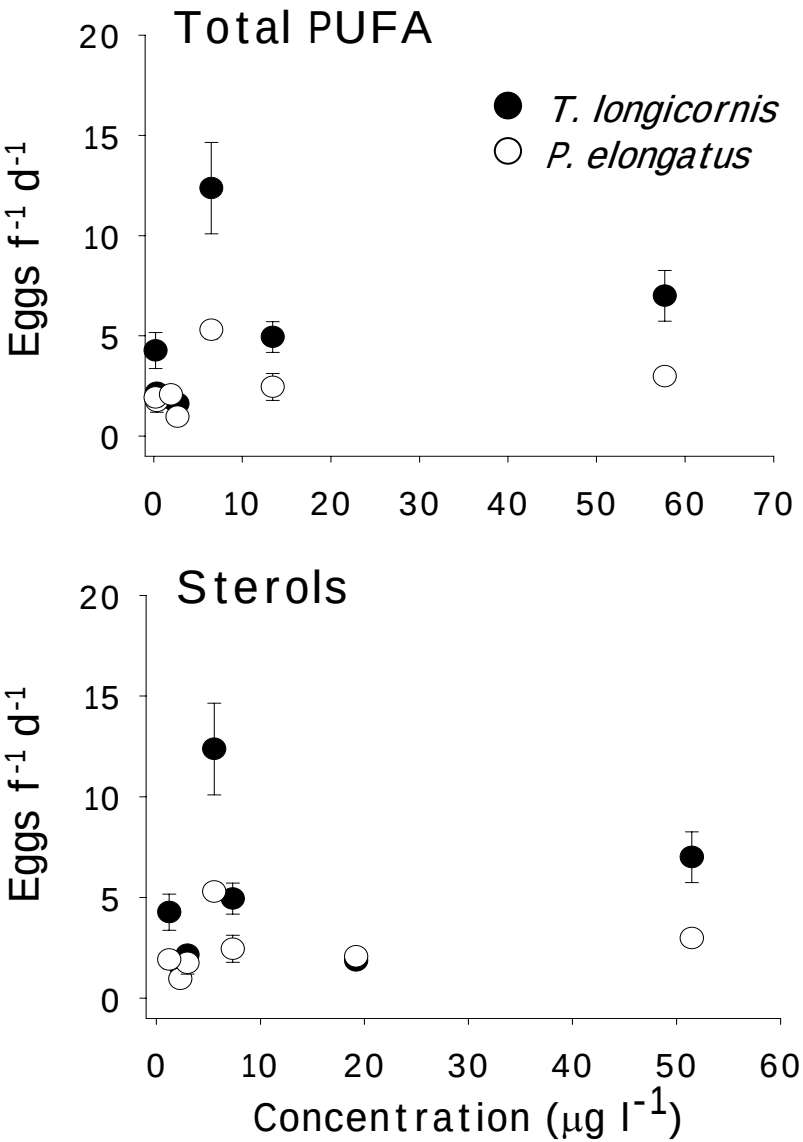
POC and PON



	Significance of correlation (Spearman rank)	
	T. longicornis	***P. elongatus***
POC	Ns	* (< 0.05)
PON	Ns	* (< 0.05)
POC: PON	- * (< 0.05)	- * (< 0.05)

- Egg production *P. elongatus* related to POC and PON, egg production of both species negatively related to POC: PON ratio

Biochemistry



	Significance of correlation (Spearman rank)	
Biochemical compound	***T. longicornis***	***P. elongatus***
Total FA	Ns	Ns
MUFA + SAFA	Ns	Ns
Total PUFA	Ns	Ns
DHA + EPA	Ns	Ns
Sterols	Ns	Ns

- No connection to any of the measured biochemical parameters

The effect of food on juvenile growth and mortality

-Significant connection between growth and
    * chl-*a*, diatoms, dinoflagellates, prymnesiophytes
    * POC and PON
    * Chl-*a*: POC ratio

-Significant positive correlation between survival and
    * PUFA concentration

Conclusions:

Despite potential limitations (ingestion / selective feeding / ciliate concentration / potential changes in food during incubations):

1) Up to 5 fold differences in egg production and growth based on food only

2) Only spring bloom generation has a potential to develop into adults

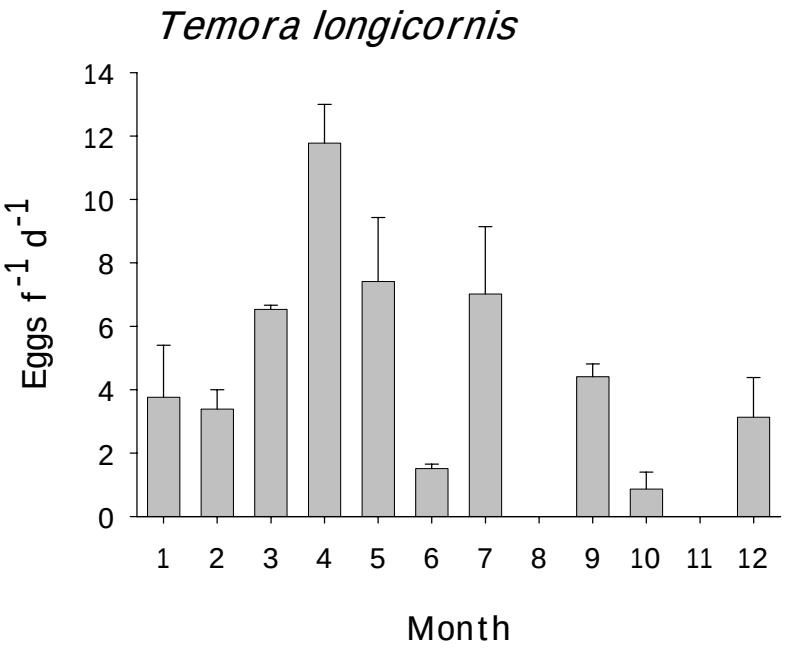
3) Both egg production and juvenile development seem to follow phytoplankton development: Phytoplankton concentration alone explains most of the annual variation in egg production and growth

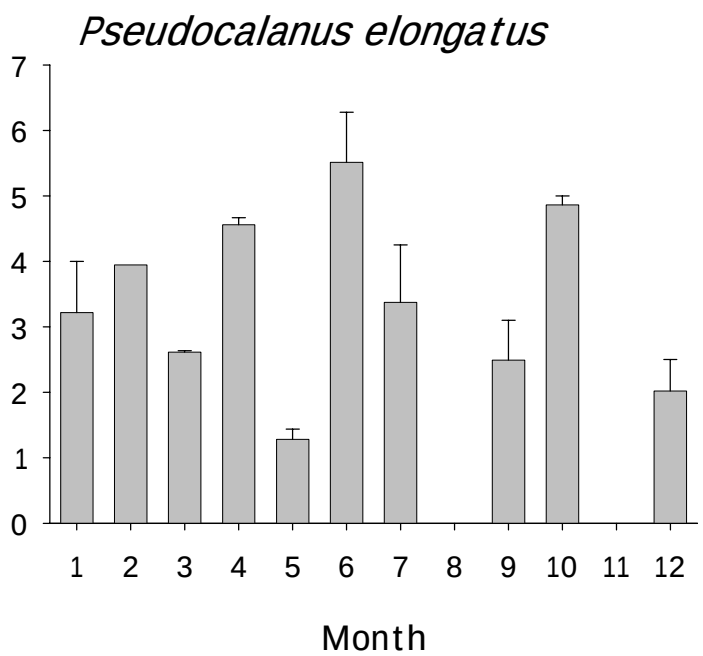
4) Biochemical components of the food do not seem to be limiting, while nitrogen might be more important

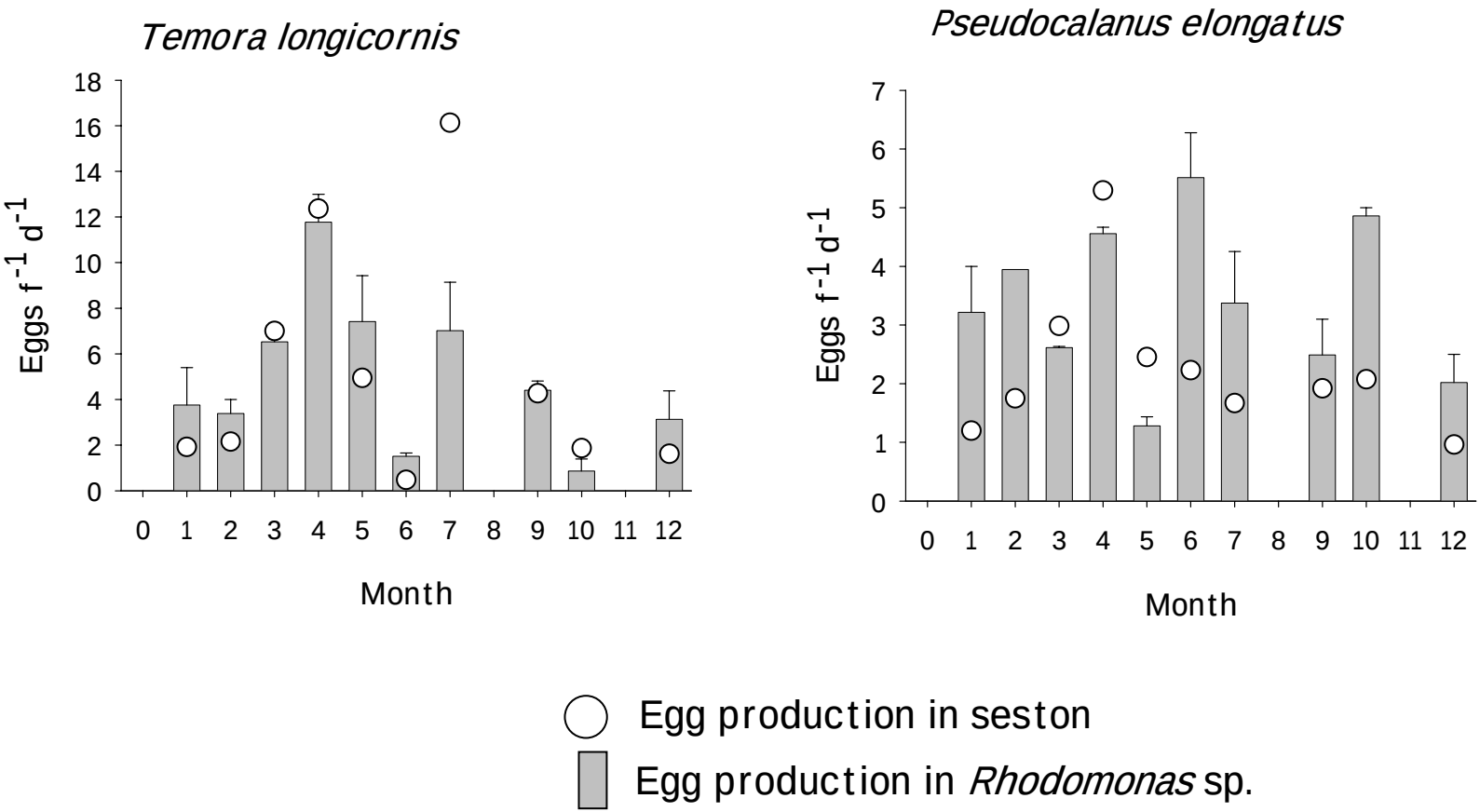
5) Diatoms and prymnesiophytes (spring bloom composition) seem to be acceptable food both for egg production and growth

Seasonal rhythm of cultured copepods:

Monthly egg production of **cultured copepods fed *Rhodomonas* sp.** :







- A seasonal rhythm in egg production of standard copepods feeding on a standard diet; resembling the seasonal development of egg production in natural seston

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