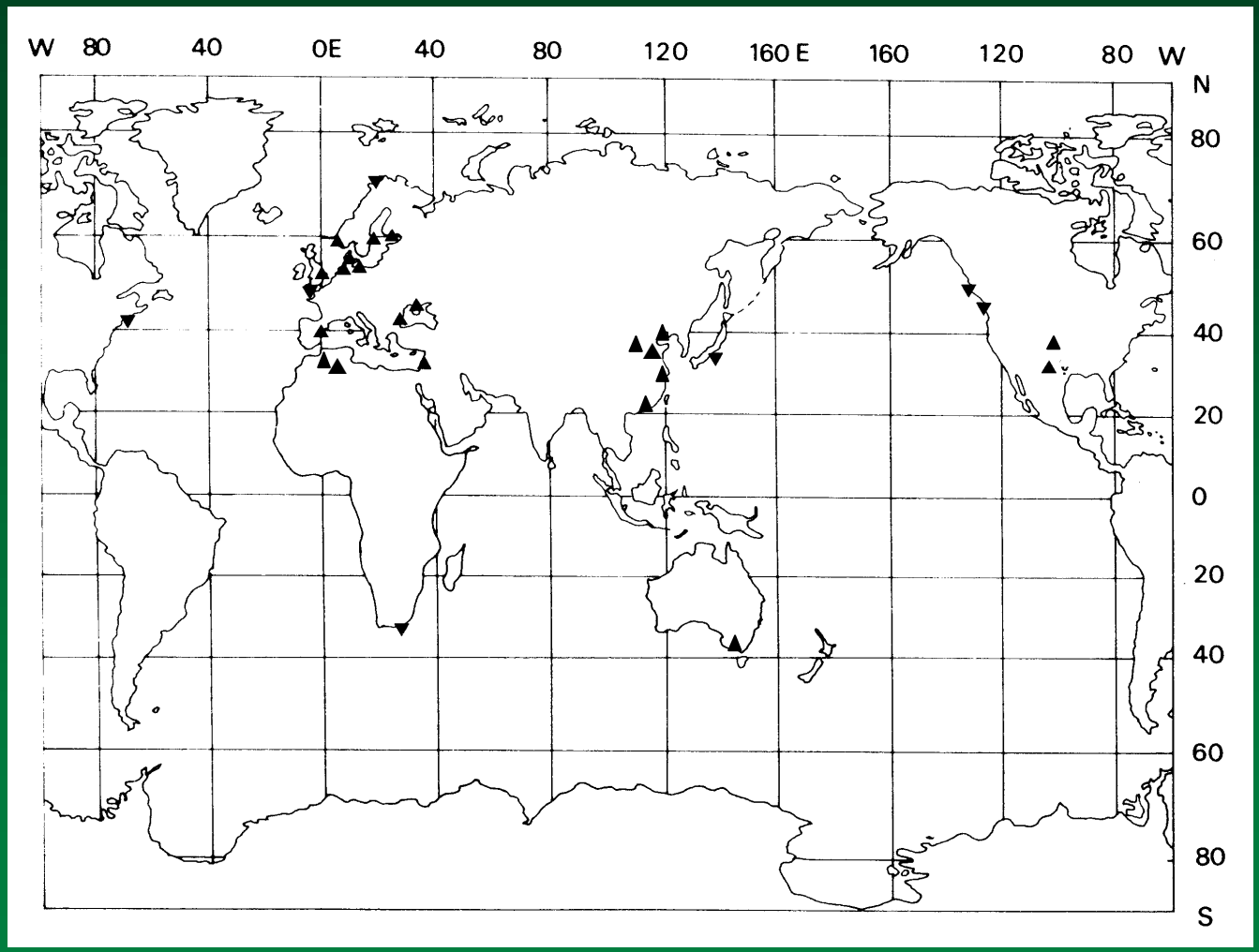
Phylogeny, life history, autecology and toxicity of *Prymnesium parvum*

Bente Edvardsen[1,2] and Aud Larsen[3]

1 University of Oslo, Norway, 2 NIVA, Norway

3 University of Bergen, Norway

Distribution of *Prymnesium parvum*

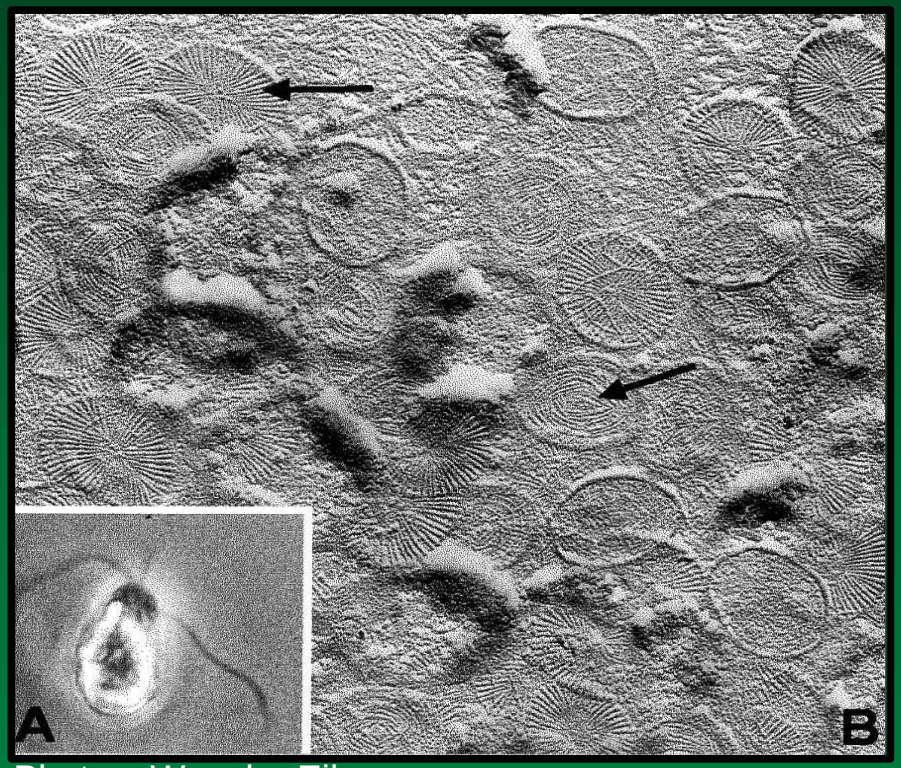


Overview

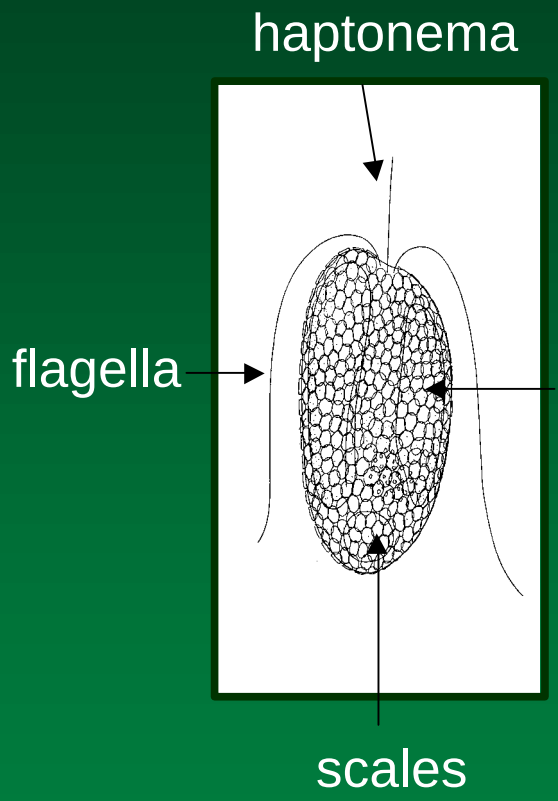
- morphology - what it looks like
- phylogeny - how is *P. parvum* related to other organisms
- life cycle – with alternating cell types
- physiology - nutrition and toxicity
- autecology - growth as a function of environmental factors
- occurrence of *P. parvum* - interpreting environmental conditions that cause blooms
- how can we reduce the risk for harmful blooms?

Division: **Haptophyta**
Class: **Prymnesiophyceae**
Species: ***Prymnesium parvum***
forms: **f. *parvum* and f. *patelliferum***

Morphology of *P. parvum*



Photos: Wenche Eikrem



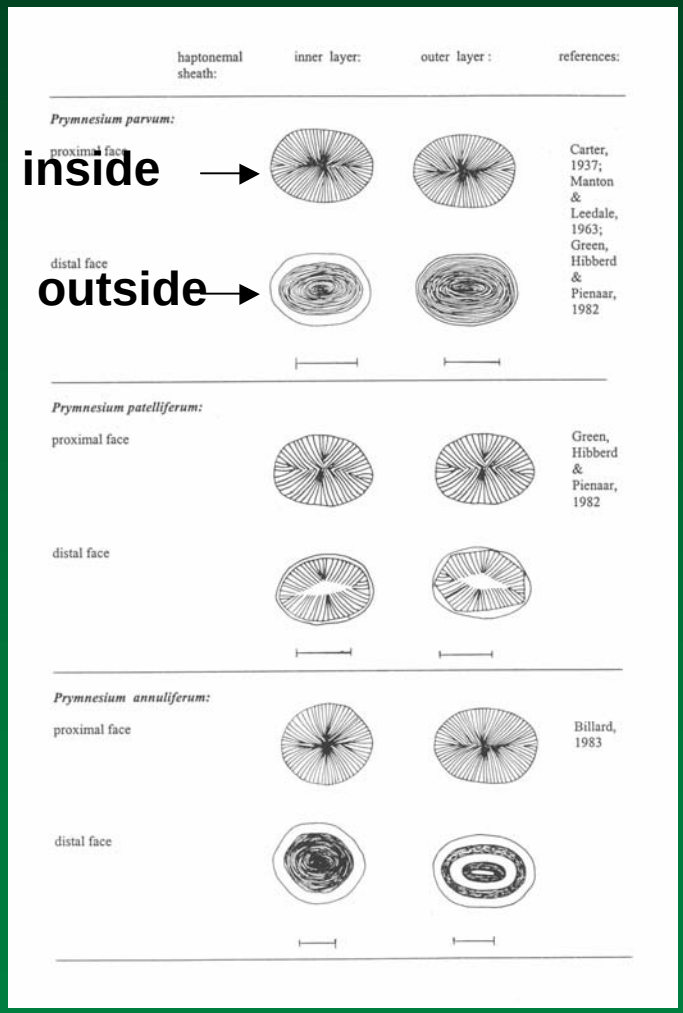
Ill.: Jahn Thronds

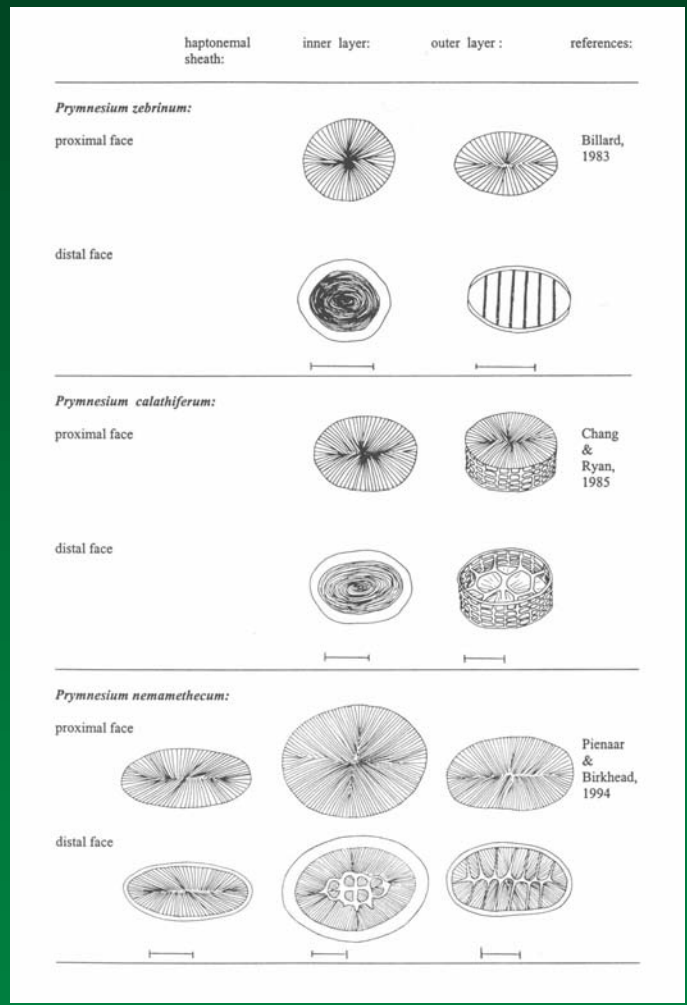
A Light micrograph of cell

B Electron micrograph of scales

Organic scales covering the cells

- character for species identification





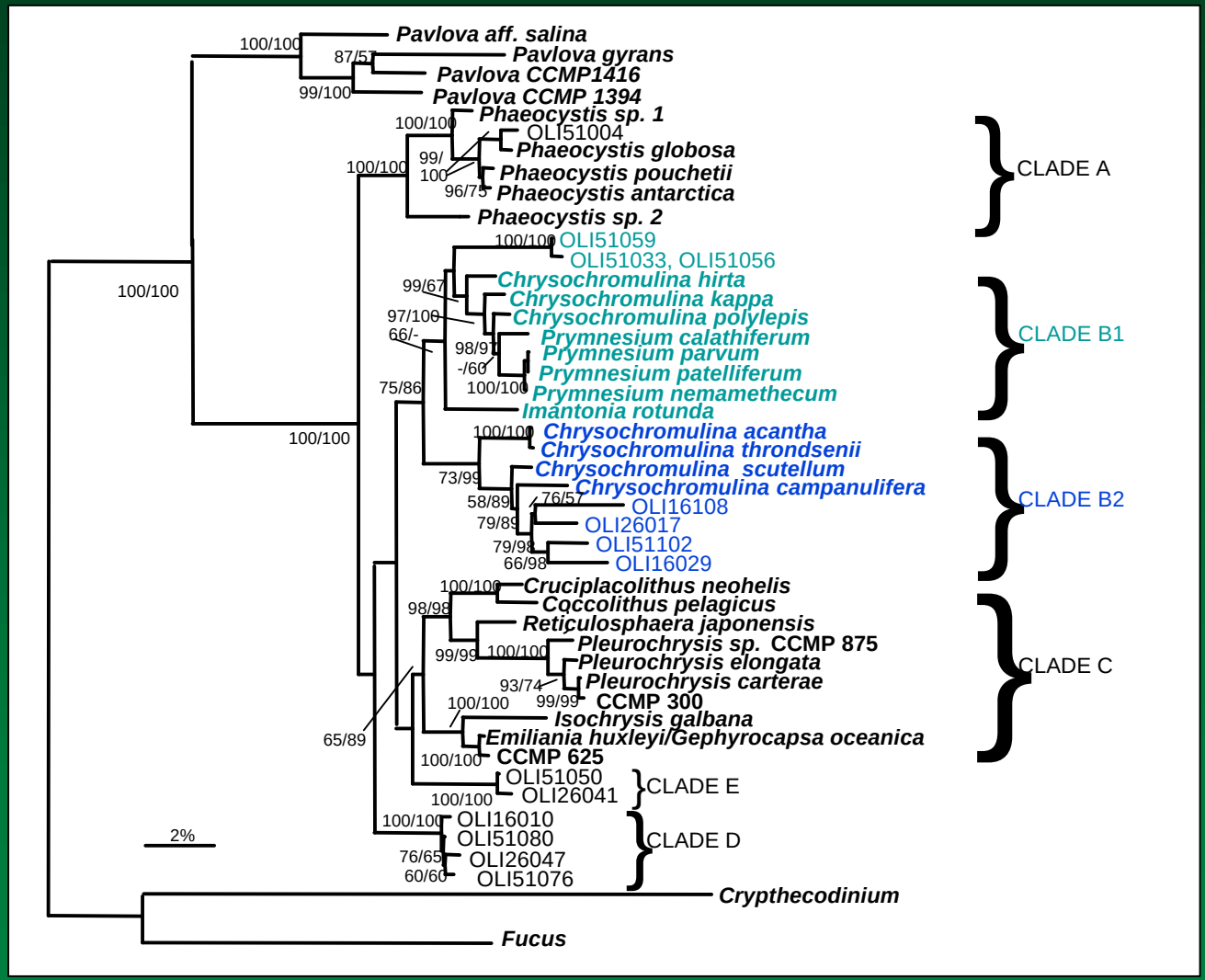
(Larsen 1998)

Prymnesium species

Species	Habitat	Distribution	Toxic
P. parvum	brackish	worldwide, temperate zone	yes
P. annuliferum	marine	France (Med. Sea)	unknown
P. calathiferum	marine	New Zealand	yes
P. faveolatum	marine	France, Spain	yes
P. nemamethecum	marine	S Africa, Australia	unknown
P. zebrinum	marine	France (Med. Sea)	unknown

P. czosnowskii, P. gladiociliatum, P. minutum, P.papillarum and *P. saltans* have uncertain status

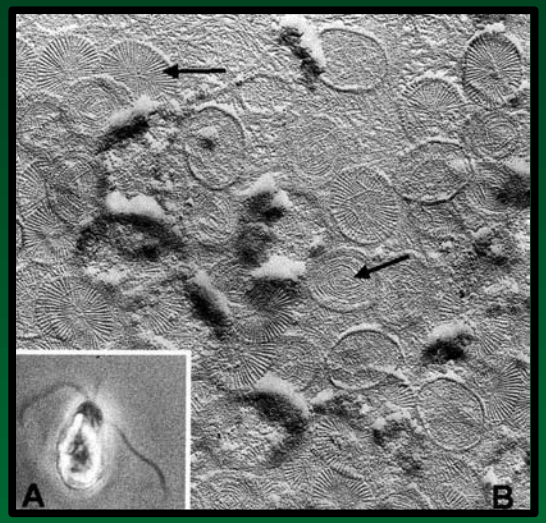
Haptophyte phylogeny



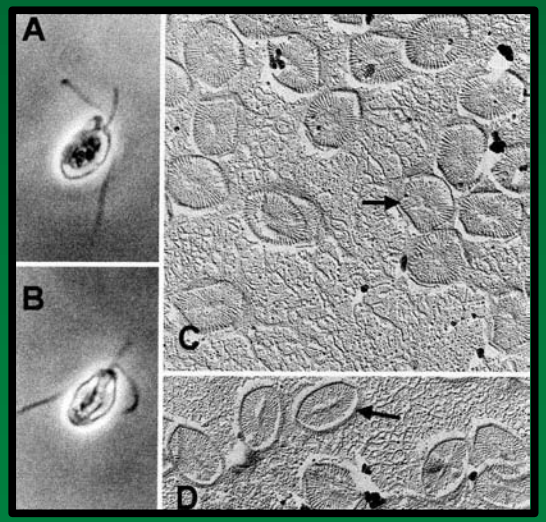
(Edvardsen et al. 2000)

Haplo-diploid life cycle

P. parvum f. *parvum*

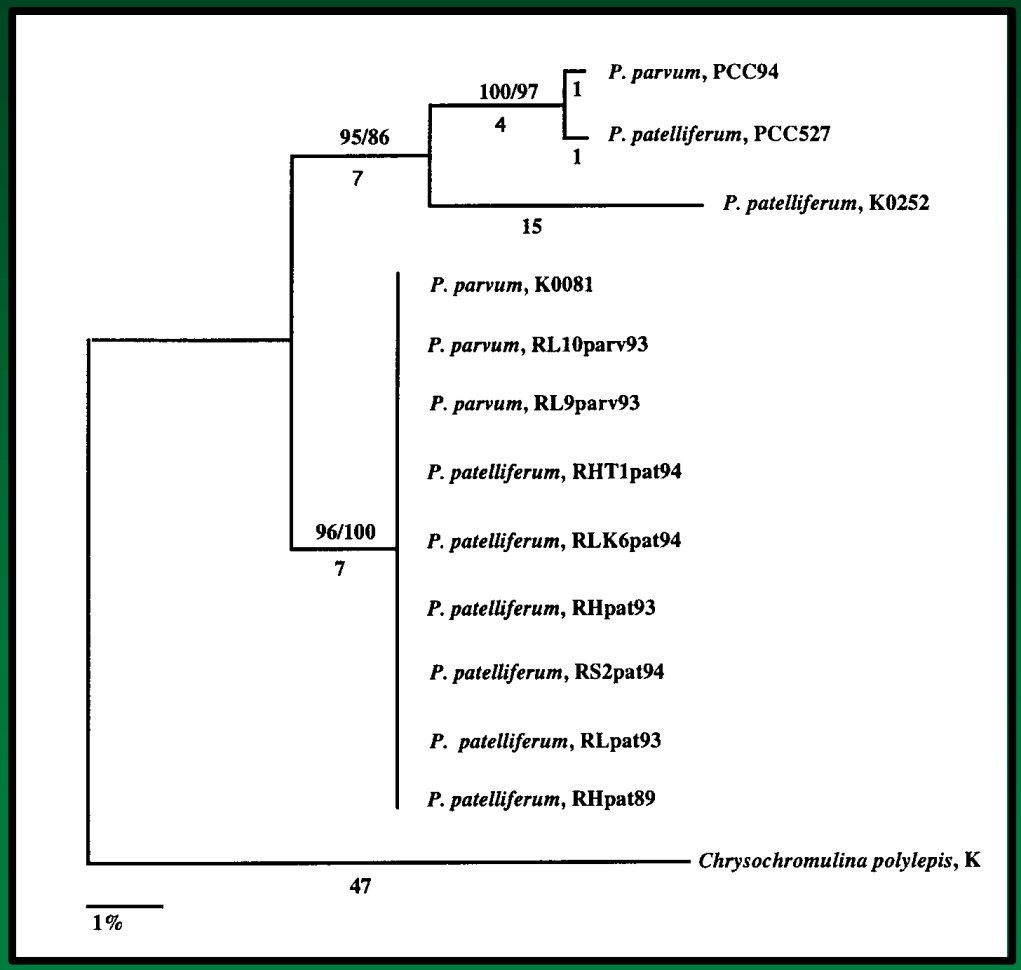


P. parvum f. *patelliferum*



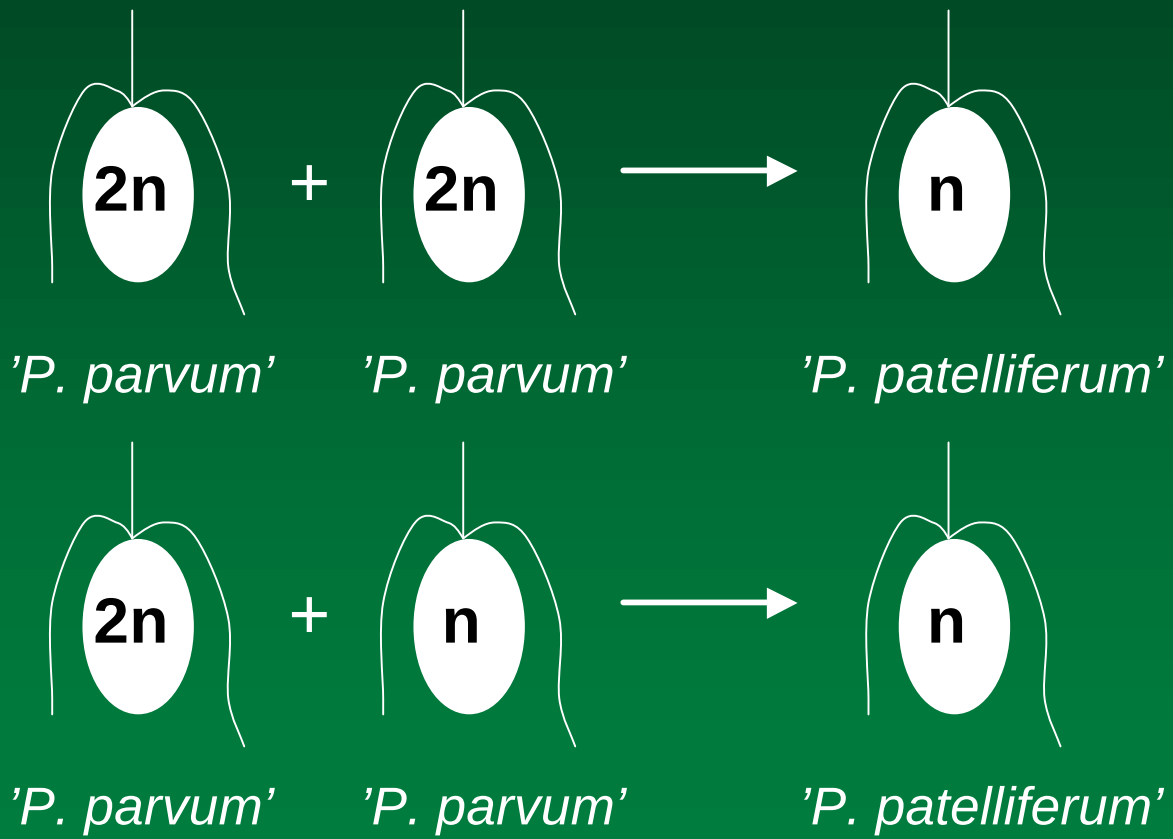
Photos: Wenche Eikrem

ITS rDNA phylogeny of *P. parvum* strains



(Larsen & Medlin 1997)

Life cycle: mating experiment

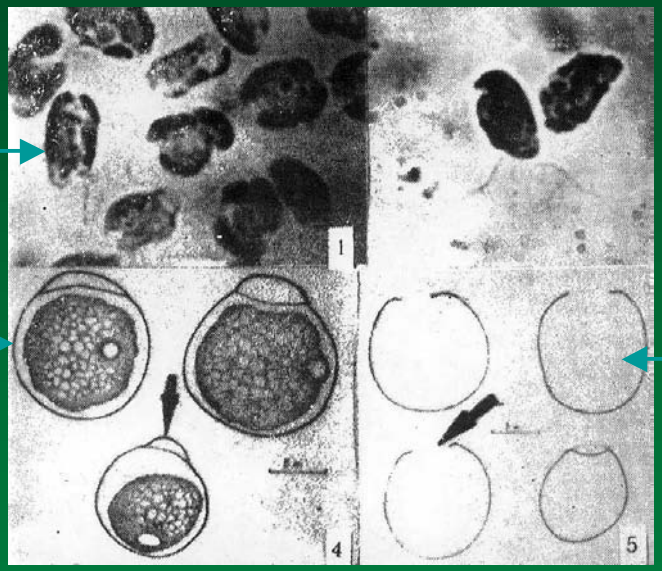


(Larsen & Edvardsen 1998)

Cyst: a possible resting stage

motile cells

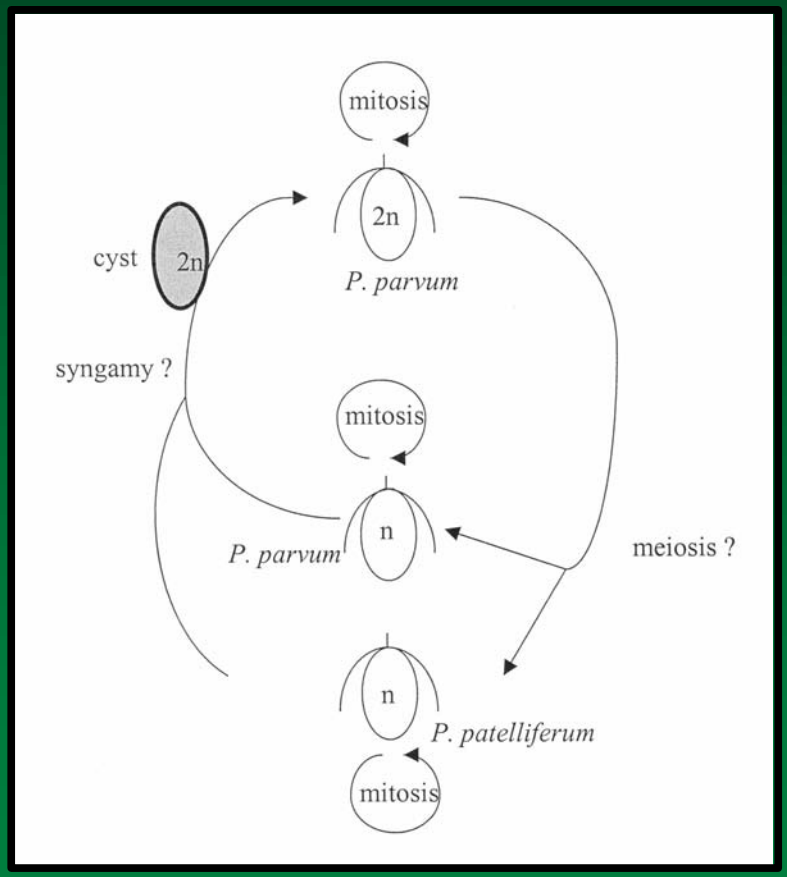
cyst



empty cyst

P. saltans (Wang & Wang 1992)

Possible life cycle for *P. parvum*

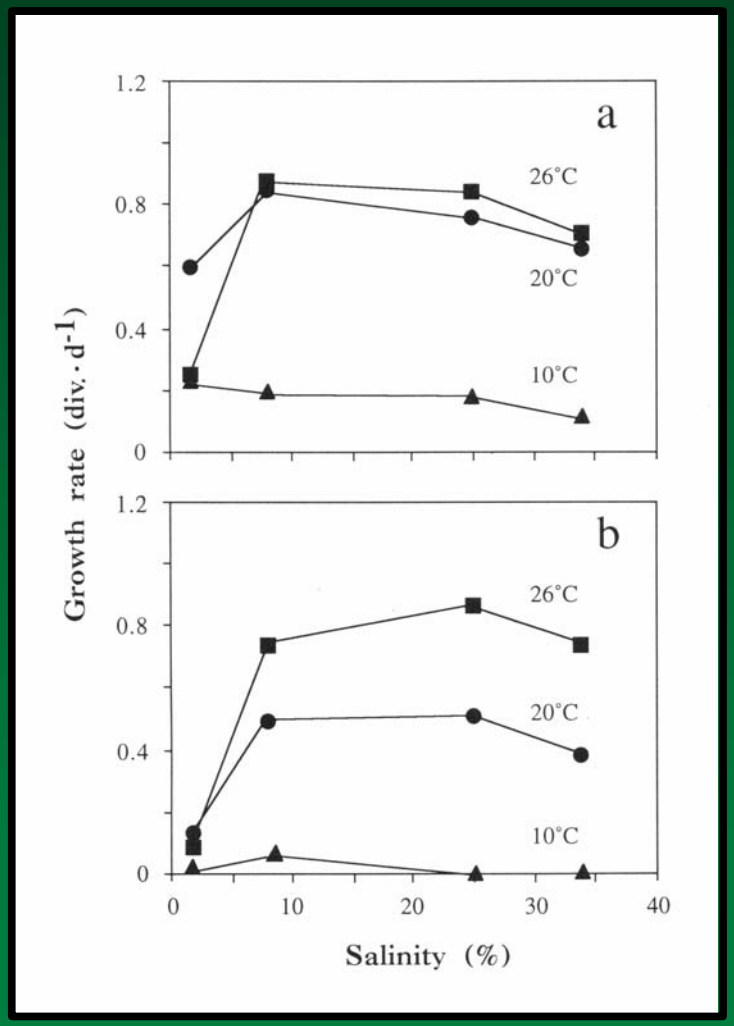


(Larsen & Edvardsen 1998)

Haplo-diploid life cycle

- 4 cell types:
  - f. *parvum* 2n
  - f. *parvum* n
  - f. *patelliferum* n
  - cyst
- all flagellates can grow vegetatively
- meiosis or syngamy have not been seen

Growth optimum and tolerance



a *P. parvum* f. *patelliferum* Norway

b *P. parvum* f. *parvum* Norway

- No differences in growth pattern between the two forms from Norway

(Larsen et al. 1993)

Optimum and tolerance for growth

Parameter	Optimum	Tolerance
Temperature (°C)	21-26 (15-30)	5 - 30
Salinity	10-20 (3-50)	0.8 - 45 (100)
Irradiance (µmol $m^{-2}s^{-1}$)	200	<25 - >500

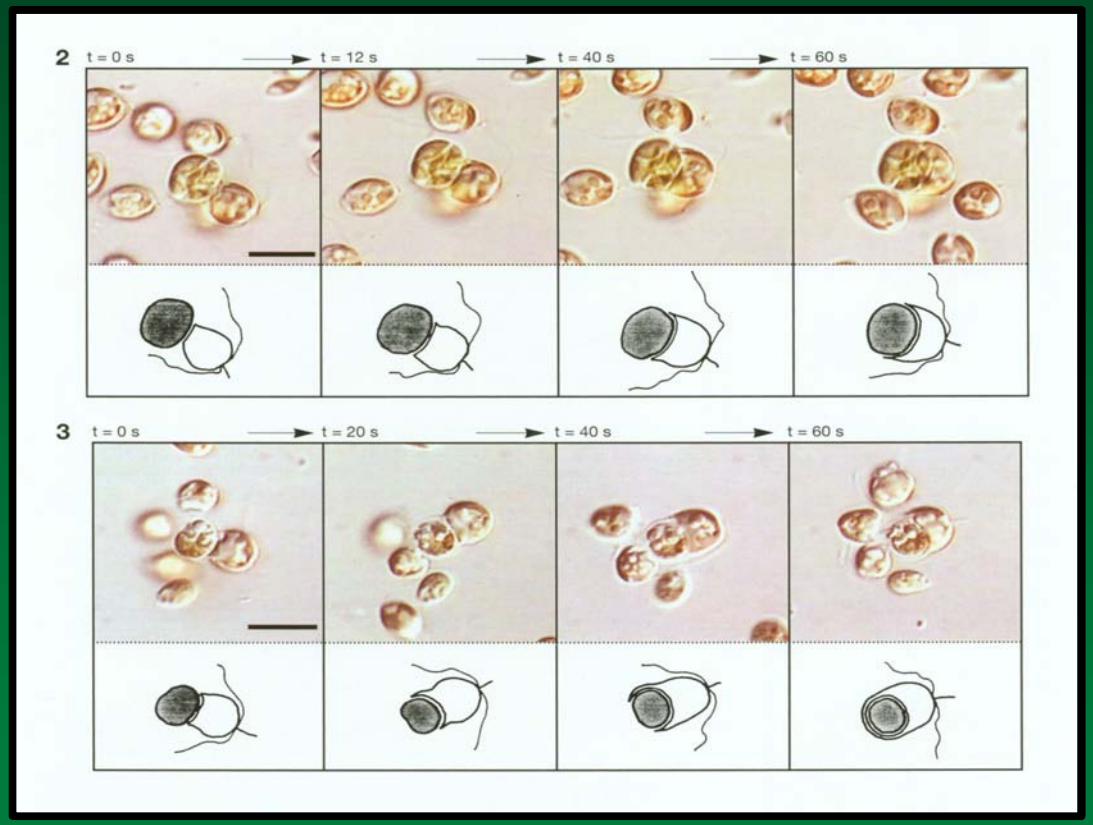
- *P. parvum* is extremely euryhaline and very eurytherm
- Maximum growth rate 0.3-1.4 divisions per day
- Large strain differences

Nutrition

- Autotrophic organisms need only inorganic nutrients (N, P and trace elements), CO_2 and light for growth
- Auxotrophic: *P. parvum* also needs vitamin B_{12} and B_1
- It can utilise organic nutrients in darkness
- Phagotrophic: it can ingest particles

P. parvum is mixotrophic

Mixotrophy



***P. parvum* f. *patelliferum* ingesting green algae**

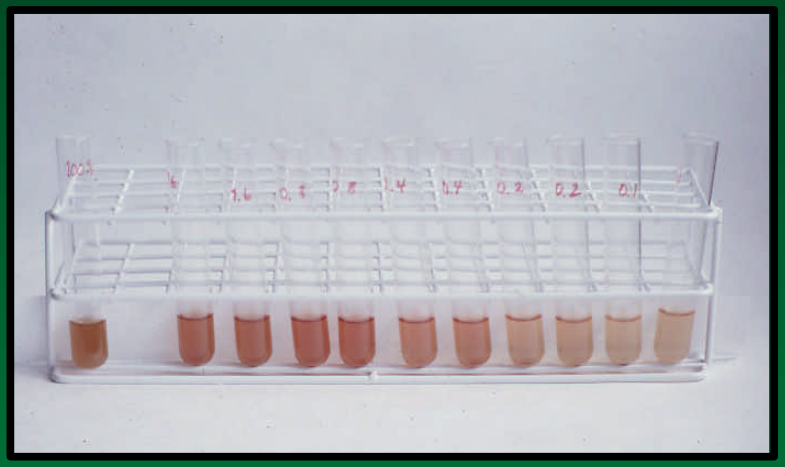
(Tillmann 1998)

- *P. parvum* can ingest and assimilate food particles such as microalgae and bacteria
- Toxins may be used to immobilise or kill the prey

Toxicity

Toxic effects:

- ichthyotoxic
- cytotoxic
- hemolytic
- hepatotoxic
- neurotoxic
- antibacterial
- allelopatic

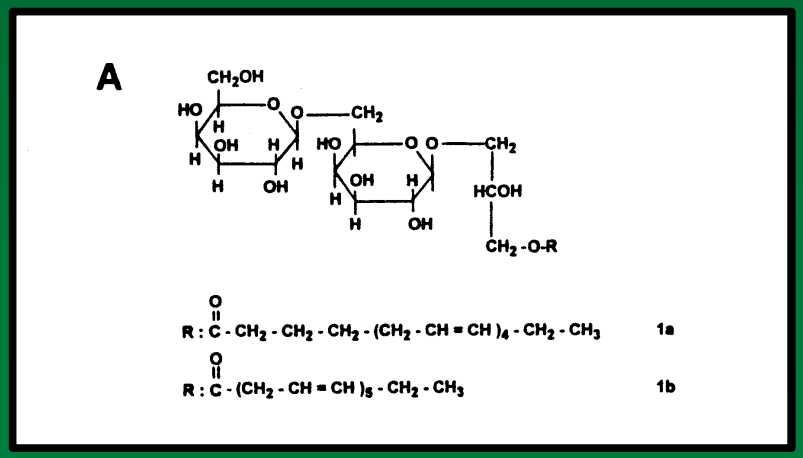


Mode of action:

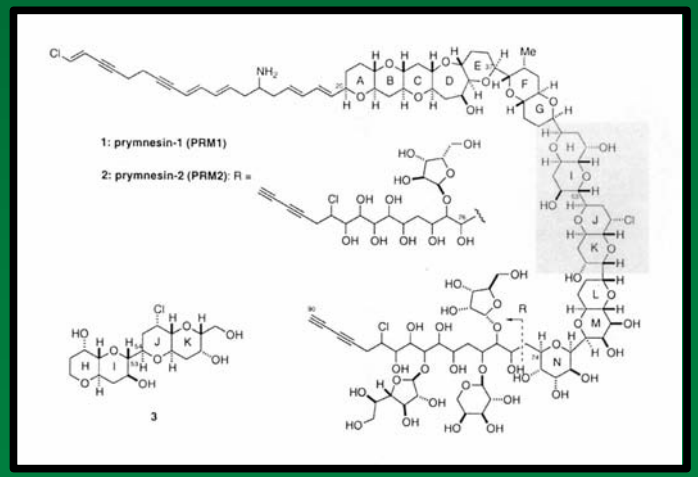
- act on cell membranes
- loss of selective permeability
- disrupt ion regulation in gills

Toxins

- proteolipids (Ulizur & Shilo 1970)
- lipopoly-saccharide (Paster 1968)
- galactoglycerolipid (Kozakai et al. 1982)
- polyene polyethers (Igarashi et a. 1995)



hemolysin (Kozakai et al. 1982)



prymnesin-1 and -2

Toxicity varies with growth conditions

- P- and N-deficiency
- cationic substances
- pH
- aeration
- growth phase
- salinity
- temperature

- There are also strain differences

Occurrence of harmful *Prymnesium* blooms

Typical habitat:

- Low salinity : 1-12
- Limited in area: ponds, lakes, river systems, fjords, lagoons
- Nutrient rich (high N and P levels)
- Moderate to high temperature: 10-25°C

Conclusions from previous blooms

- Fish kills usually only occur at algal concentrations >50-100 million cells per L
- Considerable amounts of nutrients are usually needed
- Many of the affected waters are clearly eutrophic due to cultivation of fish, discharge of sewage or run-off from agricultural land

What can be done?

- Establish a monitoring programme for water quality including measurements on:
  - physics (T, S, conductivity, light, $O_{2,}$)
  - chemistry (dissolved and particulate nutrients)
  - phytoplankton (composition and concentrations)
- Sampling of affected and non-affected localities at least every month
- It can possibly be recommended to reduce **both** N and P, and when possible the salinity
- Avoid conditions which increase toxicity

References

Edvardsen, B., Eikrem, W., Green, J.C., Andersen, R.A., Moon-van der Staay, S.Y. & Medlin, L.K. 2000. Phylogenetic reconstructions of the Haptophyta inferred from 18S ribosomal DNA sequences and available morphological data. Phycologia 39 (1), 19-35.

Igarashi, T. Satake, M.& Yasumoto, T. 1996. Prymnesin-2: a potent ichthyotoxic and hemolytic glycoside isolated from the red tide algae *Prymnesium parvum*. J. Am. Chem. Soc. 118: 479-480.

Kozakai, H., Oshima, Y.& Yasumoto, T. 1982. Isolation and structural elucidation of hemolysin from the phytoflagellate *Prymnesium parvum*. Agric. Biol. Chem. 46: 233-236.

Larsen, A. 1998. Autecology, toxicity, genetics and life history of *Prymnesium parvum* and *Prymnesium patelliferum* (Haptophyta): is a species separation warranted? Dr. Scient. thesis, University of Bergen, Norway.

Larsen, A. 1999. *Prymnesium parvum* and *P. patelliferum* (Haptophyta) - one species. Phycologia 38:541-543.

Larsen, A. & Edvardsen, B. 1998. A study of relative ploidy levels *in Prymnesium parvum* and *P. patelliferum* (Haptophyta) analysed by flow cytometry. Phycologia 37(6), 412-424

Larsen, A. Eikrem, W. & Paasche, E. 1993. Growth and toxicity in *Prymnesium patelliferum* (Haptophyta) isolated from Norwegian waters. Can. J. Bot. 71: 1357-1362.

Larsen, A. & Medlin, L.K. 1997. Inter- and intraspecific genetic variation in twelve *Prymnesium* (Haptophyta) clones. J. Phycol. 33:1007-1015.

Tillmann, U. 1998. Phagotrophy by a plastidic haptophyte, *Prymnesium patelliferum*. Aquat. Microb. Ecol. 14: 155-160.

Wang, Y.& Wang, Y. 1992. Biology and classification of *Prymnesium saltans*. Acta Hydrobiol. Sin. 16: 193-199.