TAXONOMIC SURVEY OF NANOPLANKTON IN SAANICH INLET, B.C.

by

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We accept this thesis as conforming to the required standards

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Absract

Nanoplankton collected from April 1990 to April 1991 from surface water of Saanich Inlet, British Columbia was examined with transmission and scanning electron microscopy. Eighty species were identified. These belonged to the algal Classes Pedinophyceae, Prasinophyceae, Prymnesiophyceae and Chrysophyceae and the protistan Order Choanoflagellida and Class Heliozoea. Fifty of these are new published records for the west coast of North America. New taxonomic findings were a variation of *Triparma columacea*, a new scale type from *Cymbomonas*, two undescribed prasinophyte scale types and an unusual number of lorica costae in *Polyfibula stipitata*.

Summer nanoplankton was characterized by high species numbers of autotrophic Prasinophyceae and Prymnesiophyceae. Prasinophytes were almost entirely absent in winter months. Winter nanoplankton populations varied between translocated freshwater species and marine and brackish species, most of which were heterotrophic chrysophytes and choanoflagellates. Low species numbers with similar species composition was seen in April of both years. Speculations on causes of species succession are made.

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INTRODUCTION

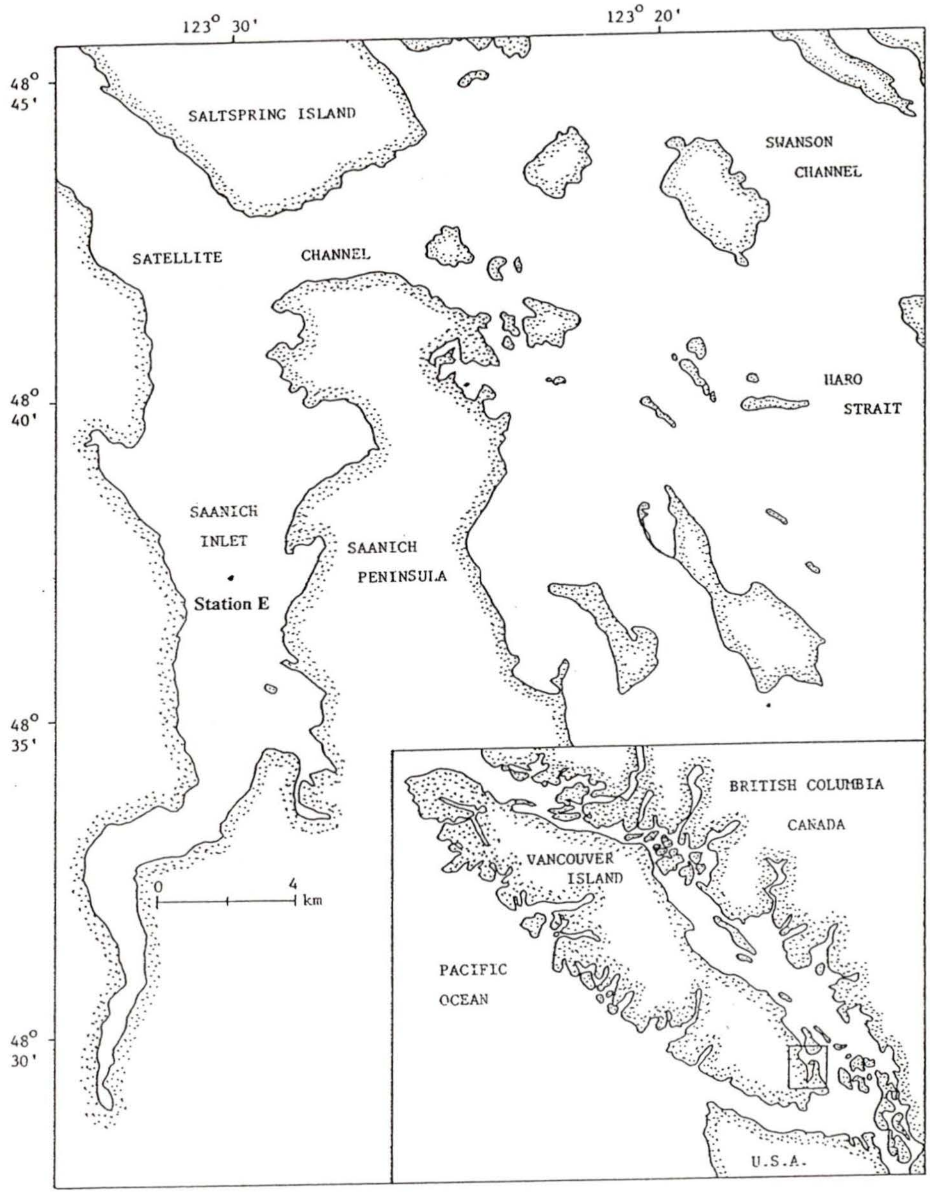
The term nanoplankton was introduced at the turn of the century to describe small organisms which passed through a plankton net. In 1978, Sieburth *et al.* designated nanoplankton as plankton in the 2-20 μm size range. Generally these organisms remained unidentified until techniques for electron microscopy were developed in the 1950's which allowed examination of cultured material. This led to the description of many new species (Parke *et al.*, 1955, 1956, 1958). Freshly collected wild material from Norway was examined for the first time using the electron microscope by Leadbeater (1972a) giving an indication of the diverse taxonomic composition of nanoplankton. Nanoplanktonic organisms commonly belong to the algal Classes Prasinophyceae, Prymnesiophyceae, Chrysophyceae and Cryptophyceae as well as the protistan Order Choanoflagellida (Leadbeater, 1972a; Moestrup, 1979).

As studies on natural plankton communities began to include nanoplankton its importance was realized. Nanoplankton often dominates phytoplankton assemblages both numerically and by biomass in neritic (Takahashi *et al.*, 1978; Hallegraeff, 1981) and oceanic (Beers *et al.*, 1975; Booth *et al.*, 1982) communities. Also nanoplankton can be responsible for 90-98 % of primary productivity (Hannah and Boney, 1983). Heterotrophic nanoflagellates appear to be the major consumers of bacteria in plankton communities (Fenchel, 1982), thereby repackaging bacterial biomass to cells accessible to zooplankton. Some nanoflagellates consume phytoplankton nearly their own size which reduces primary productivity available to higher trophic levels (Goldman and Caron, 1985). Several nanoplanktonic species are capable of autotrophic as well as heterotrophic growth. To understand trophic levels within planktonic communities it is necessary to determine species present in the nanoplankton.

Studies on wild nanoplankton populations from Norway (Leadbeater, 1972a), Denmark (Leadbeater, 1972b), Jugoslavia and Bay of Algiers (Leadbeater, 1974), New Zealand (Moestrup, 1979), Australia (Hallegraeff, 1983), South Africa (Norris, 1984), Antarctica (Buck and Garrison, 1983), the North Atlantic Ocean (Estep *et al.*, 1984) and the North Pacific Ocean (Hoepffner and Haas, 1990) have shown that most nanoplanktonic species are cosmopolitan. Although it is known that the chlorophyll *a* concentration of the nanoplanktonic fraction of phytoplankton in coastal waters remains fairly constant year round compared to the dramatic fluctuations seen with microplanktonic blooms (Hallegraeff, 1981; Hannah and Boney, 1983) seasonal species composition of nanoplankton hasn't been well studied. Most studies on nanoplankton have had short sampling periods (Leadbeater, 1972a,b, 1974; Moestrup, 1979), have involved one group of nanoplankton (Reid, 1980) or have relied on light microscopy for species identification (Hallegraeff, 1981; Hannah and Bony, 1983). To date no extensive examination of marine nanoplankton with the electron microscope has been conducted on wild populations on the west coast of North America. The objective of this study was to use the electron microscope to do a taxonomic survey of nanoplankton in Saanich Inlet, B.C. Sampling was done at monthly intervals for one year to determine seasonal variations in taxonomic composition. By conducting this survey in a well studied area, it was hoped that speculations could be made to correlate findings with physical, chemical and biological factors.

Chemical and physical oceanographic features of Saanich Inlet, British Columbia, a temperate fjord on the south-east coast of Vancouver Island (Figure 1) have been studied extensively (Herlinveaux, 1962; Takahashi *et al.*, 1978; Hobson, 1985). Taxonomy and succession of microphytoplankton in Saanich Inlet is well

Figure 1. Chart of Saanich Inlet and surrounding area.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123° 20'
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48° 40'
48° 35'
48° 30'
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SWANSON
CHANNEL
SATELLITE
CHANNEL
HARO
STRAIT
SAANICH
INLET
Station E
SAANICH
PENINSULA
0
4
km
BRITISH COLUMBIA
CANADA
VANCOUVER
ISLAND
PACIFIC
OCEAN
U.S.A.

Figure 1

documented (Hobson, 1981, 1983; Takahashi *et al.*, 1977, 1978). Several studies have looked at the dynamics of grazing herbivorous zooplankton (Huntley and Hobson, 1978; Takahashi and Hoskins, 1978). Also bacterial productivity in Saanich Inlet has been examined (Hobson, 1983). However, despite nanoplankton being present year round and dominating the phytoplankton during winter months (Takahashi *et al.*, 1978), nanoplankton has generally been referred to as a uniform group of unidentified flagellates.

Many nanoplanktonic organisms can be identified with certainty only by electron microscopy because their taxonomic features are indiscernible with a light microscope. Electron microscopy allows examination of external structures such as plate-like or spined scales which can be composed of silica, calcium or organic material depending on the Class of the organism. One of the earliest techniques used to identify nanoplankton was shadow-cast whole mounts examined in the transmission electron microscope (TEM). This technique which enhances contrast and produces a three dimensional impression is useful in showing external structures such as flagellar appendages and body scales. Negative staining, in which a solution of heavy metal is applied to whole mounts, aids in outlining delicate structures such as thin prasinophyte scales. Scanning electron microscopy (SEM), with its three dimensional image, allows study of the surface characteristics of cells but does not give as high resolution as the TEM. A spectrum of elements present in a sample is provided by energy dispersive X-ray (EDX) analysis in the scanning transmission electron microscope (STEM). The majority of the material in this study was examined using shadow-casting. Negative staining, SEM and EDX analysis were used to examine selected material.

METHODS AND MATERIALS

Samples were taken from surface waters at Station E (48° 37.5'N; 123° 30.0'W) in Saanich Inlet, B.C. (Figure 1) at approximately monthly intervals from April 1990 to April 1991 (Table 1). From April 1990 to July 1990 collections were made with Niskin bottles from the MSSV *John Strickland*. The remainder of the samples were collected by bucket from a small motor vessel. Water samples (20 l) were passed through 20 μm Nitex mesh to remove large plankton. Plankton less than 20 μm was concentrated using a continuous flow centrifuge (6000 rpm).

For transmission electron microscopy, drops of concentrated cells were pipetted onto formvar coated copper grids and fixed with osmium tetroxide vapor for 30 seconds. Cells were air-dried, rinsed with distilled water and air-dried again. Most grids were shadow cast with gold at approximately 30° in an Edwards vacuum evaporator (Moestrup and Thomsen, 1980). A few grids were negatively stained with 1 % phosphotungstic acid for 30 seconds and air dried (Gantt, 1980). Grids were examined in a Philips 300 transmission electron microscope. A total of 250 grids were viewed, most at 60 kV but a few at 40 kV to increase contrast.

For scanning electron microscopy, seawater samples were fixed with Lugol's solution (1 % final concentration) for 20 minutes. Fixed samples were collected on 0.45 μm Millipore filters in a Swinnex filter holder. The filter was dehydrated with increasing concentrations of ethanol (30-100 %) and critical point dried from liquid CO_2. Small pieces of filter were mounted with silver paste on copper stubs and sputter coated with a thin layer of gold before examination in the JEOL 1200 EX electron microscope (Booth *et al.*, 1982).

Energy dispersive X-ray (EDX) microanalysis was carried out using a Tracor Northern X-ray spectrometer with a Tracor Northern 5500 multichannel analyzer and display system. Analyses were performed at 40 kV (Hayat, 1980).

Three aliquots (50-200 ml) were taken from each water sample before and after the water had been passed through the 20 μm Nitex mesh. These aliquots were filtered through 0.4 μm Nucleopore filters which were dissolved in 90 % acetone to extract chlorophyll. Chlorophyll *a* concentration was determined spectrophotometrically (Parsons *et al.*, 1984).

Similarity of samples was determined by computing association coefficients based on either the presence or the absence of each species. This analysis was plotted as a phenogram. Software used for cluster analysis was Numerical Taxonomy and Multivariate Analysis System (NTSYS-pc) version 1.50 (Rohlf, 1988).

Table 1. Dates water was collected from surface water of Saanich Inlet, B.C.

Sample number	Date
1	April 20, 1990
2	May 17, 1990
3	June 28, 1990
4	July 18, 1990
5	August 14, 1990
6	September 18, 1990
7	October 16, 1990
8	November 16, 1990
9	December 17, 1990
10	January 16, 1991
11	February 12, 1991
12	March 12, 1991
13	April 15, 1991

RESULTS

Taxonomy

Eighty nanoplanktonic species belonging to the algal Classes Pedinophyceae, Prasinophyceae, Chrysophyceae and Prymnesiophyceae as well as the protistan Order Choanoflagellida and Class Heliozoea and a genus of uncertain taxonomy were identified from Saanich Inlet (Table 2). These are listed below with higher taxa arranged phylogenetically and species within taxa arranged alphabetically. Descriptions were taken from the literature. Unless otherwise indicated photographs are of transmission electronmicrographs of shadow-cast whole mounts.

Division Chlorophyta

Algae in this division share the features of containing chlorophylls *a* and *b*. Chloroplasts are double membrane-bounded organelles with thylakoids in stacks of two to six. Chloroplasts contain pigmented organelles called stigma or eyespots. Storage material is starch (Bold and Wynne, 1985).

Class Pedinophyceae Moestrup 1991

Organisms in this newly erected class contain the most primitive green algae which are unicellular and without cell walls or scales. Cells are biflagellated but one flagellum is reduced to a short basal body. Mitosis is closed and the mitotic spindle is persistent (Moestrup, 1991).

Order Pedinomonadales Moestrup 1991

Family Pedinomonadaceae Korshikov 1938

Resultor mikron (Throndsen) Moestrup 1991

(=*Pedinomonas mikron* Throndsen 1969)

Table 2. Species identified from Saanich Inlet.

Class Pedinophyceae
Resultor mikron

Class Prasinophyceae
Dolichomastix nummulifera
Mamiella sp.
Micromonas pusilla
Pseudoscourfieldia marina
Cymbomonas sp.
Pterosperma cristatum
Pyramimonas grossii
P. amylifera
P. orientalis
Pyramimonas sp. 1

Classs Chrysophyceae
Paraphysomonas butcheri
P. capreolata
P. foraminifera
P. gladiata
P. punctata punctata
P. vestita truncata
P. vestita vestita
Mallomonas akrokomos
M. caudata
M. crassisquama
Synura petersenii
Calycomonas ovalis
C. wulfii
Kephyrion sp. 1
Kephyrion sp. 2
Kephyrion sp. 3
Dinobryon balticum
D. borgei
Apedinella spinifera
Triparma cf. *columacea*
Meringosphaera mediterranea
Dictyocha fibula

Incertae sedis
Thaumatomastix bipartita
T. salina
T. tripus

Class Prymnesiophyceae
Chrysochromulina adriatica
C. brachycylindra
C. brevifilum
C. ephippium
C. ericina
C. hirta
C. leadbeateri
C. mantoniae
C. megacylindra
C. minor
C. parkeae
C. polylepis
C. simplex
Corymbellus aureus
Phaeocystis pouchetii
Dicrateria inornata
Imantonia rotunda
Balaniger balticus
Calcidiscus leptoporus
Emilania huxleyi
Pappomonas virgulosa
Papposphaera sagittifera
Quaternariella obscura
Trigonaspis sp.
Wigwamma annulifera
W. artica

Order Choanoflagellida
Acanthocorbis apoda
Acanthoeca spectabilis
Bicosta minor
Calliacantha natans
C. simplex
Cosmoeca norvegica
C. ventricosa
C. ventricosa Form B
Crinolina isefiordensis
Diaphanoeca grandis
D. pedicellata
D. sphaerica
Parvicorbicula quadricosta
P. socialis
Polyfibula stipitata
Savillea parva

Class Heliozoea
Pinaciophora denticulata
P. reticulata
Raphidiophrys elegans

Figures 2 and 3.

Description: Cell is 3.0 x 2.0 x 1.0 μm with a single emergent flagellum (7.0-12.0 μm) which is characteristically curved around the cell. The flagellum is inserted laterally near one end of the cell. No flagellar or body scales are present (Moestrup, 1991).

Observed in Saanich Inlet: Cells were 1.2-1.4 x 2.0 μm with curved flagellum 8.5-8.6 μm. Found in samples 3, 4 and 5 (June, July and Aug).

Previous records: Norway (Throndsen, 1969), North Atlantic Ocean (Estep *et al.*, 1984), Denmark and Australia (Moestrup, 1991).

Class Prasinophyceae Moestrup and Throndsen 1988

Cells are unicellular or colony forming and can have 1, 2, 4 or 8 flagella. Flagellar transitional region varies with flagella number. Flagella and cell body are covered with several types of organic scales. One flagellar scale is hair-shaped and partly tubular. Basal bodies are very long. Mitosis is open (Moestrup and Throndsen, 1988).

Order Mamiellales Moestrup 1984

Flagella and cell covered by scales with concentric and often radiating ribs. Inner layer of small square or diamond-shaped scales on body and flagella are lacking.

Family Mamiellaceae Moestrup 1984

Dolichomastix nummulifera Manton 1977

Figures 4-7.

Description: Cell is 3.0-4.5 x 4.0-5.0 μm with two equal or subequal flagella up to 30 μm long. The cell body is covered with round (0.4 μm) rimmed scales with a

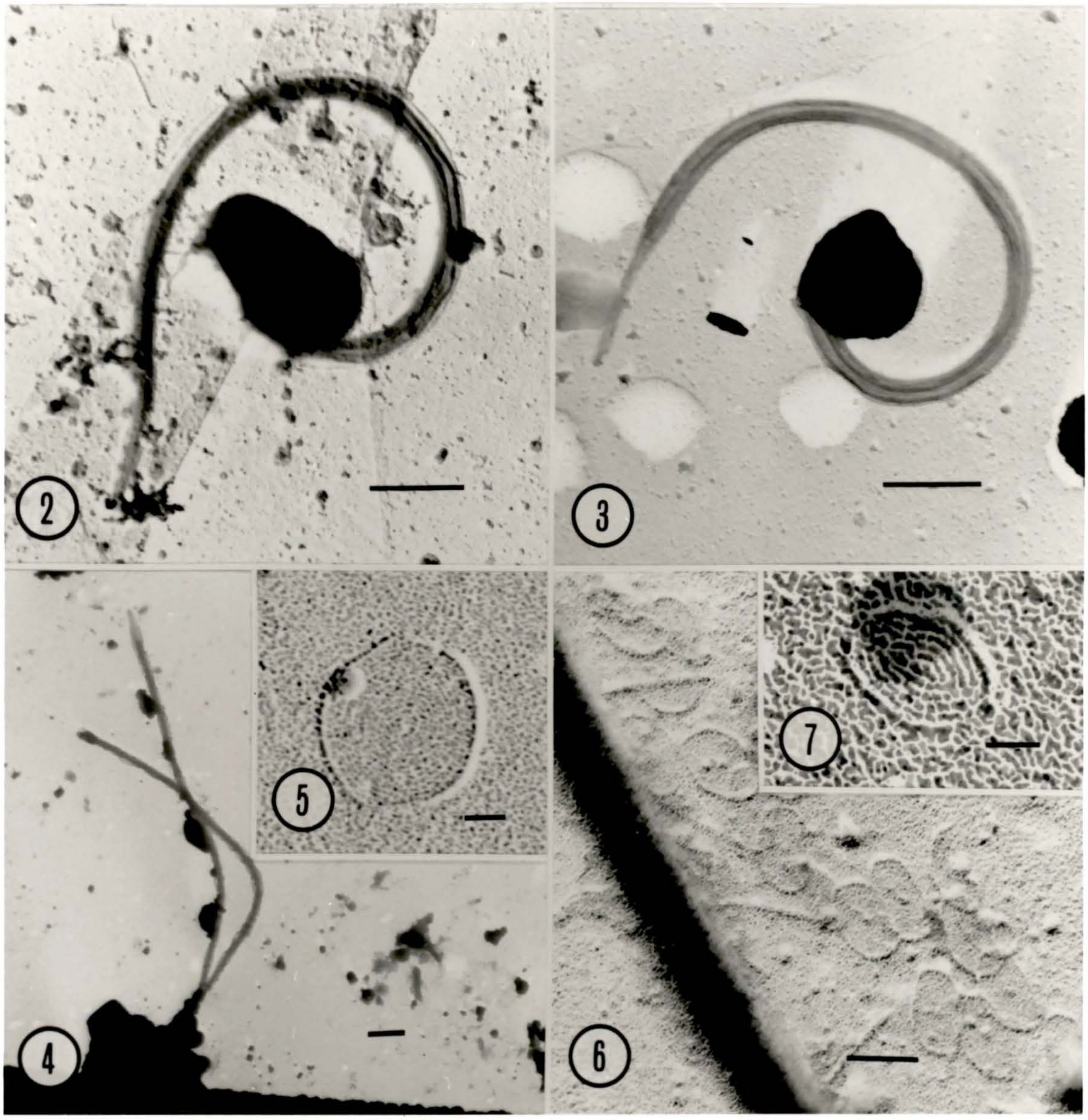
Figures 2 and 3. *Resultor mikron*. Whole cell with characteristically curved flagellum. Scale bar = 1.0 μm.

Figure 4. *Dolichomastix nummulifera*. Whole cell with two equal flagella. Scale bar = 1.0 μm.

Figure 5. *D. nummulifera*. Round body scale with concentric ridges. Scale bar = 0.1 μm.

Figure 6. *D. nummulifera*. Flagellum with oval flagellar scales. Scale bar = 0.3 μm.

Figure 7. *D. nummulifera*. Flagellar scale showing concentric ridges. Scale bar = 0.1 μm.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pattern of concentric ridges. The flagella have oval (0.3 x 0.2 μm) scales with similar concentric markings. Hair scales are also found on the flagella (Manton, 1977).

Observed in Saanich Inlet: Cells were 4.5-4.6 x 4.5-4.6 μm. Flagellar length ranged from 19.6-24.0 μm. Large round body scales were 0.44 x 0.44 μm and oval flagellar scales were 0.33 x 0.21 μm. Found in samples 3, 4 and 5 (June, July and Aug).

Previous records: Arctic Canada, Alaska and South Africa (Manton, 1977) and Greenland (Thomsen, 1982).

Mamiella sp.

Figures 8-12.

Description: Although this species has long been recognized as unique it has not been described and named. Cell is biflagellated, with flagellar scales (0.22 μm diameter) showing concentric and radial ridges and a narrow central spine. Two types of scale cover the cell, the largest is square with an elaborate surface pattern and the smaller one is oval with concentric and radiating ridges (Leadbeater, 1974).

Observed in Saanich Inlet: Cells had diameters of 4.3-4.5 μm with flagella of 17.0-17.5 μm. Flagellar scales were 0.22 μm wide and 0.35 μm long. Large square body scales were 0.32-0.37 μm and smaller oval scales were 0.17 x 0.12 μm. Found in samples 3, 4 and 5.

Previous records: Jugoslavia and Bay of Algiers (Leadbeater, 1974) and Norway (Espeland and Throndsen, 1986).

Incertae sedis

Micromonas pusilla (Butcher) Manton and Parke 1960

(=*Chromulina pusilla* Butcher 1952)

Figures 13 and 14.

Figure 8. *Mamiella* sp. Whole cell. Scale bar = 3.0 μm.

Figure 9. *Mamiella* sp. Oval body scale showing concentric and radiating ridges. Scale bar = 0.1 μm.

Figure 10. *Mamiella* sp. Flagellum with flagellar scales. Scales have concentric and radiating ridges with a central spine. Scale bar = 0.1 μm.

Figure 11. *Mamiella* sp. Field of square body scales and smaller oval body scales (arrow). Scale bar = 0.5 μm.

Figure 12. *Mamiella* sp. Large square body scale with patterning of concentric and radiating ridges. Scale bar = 0.1 μm.

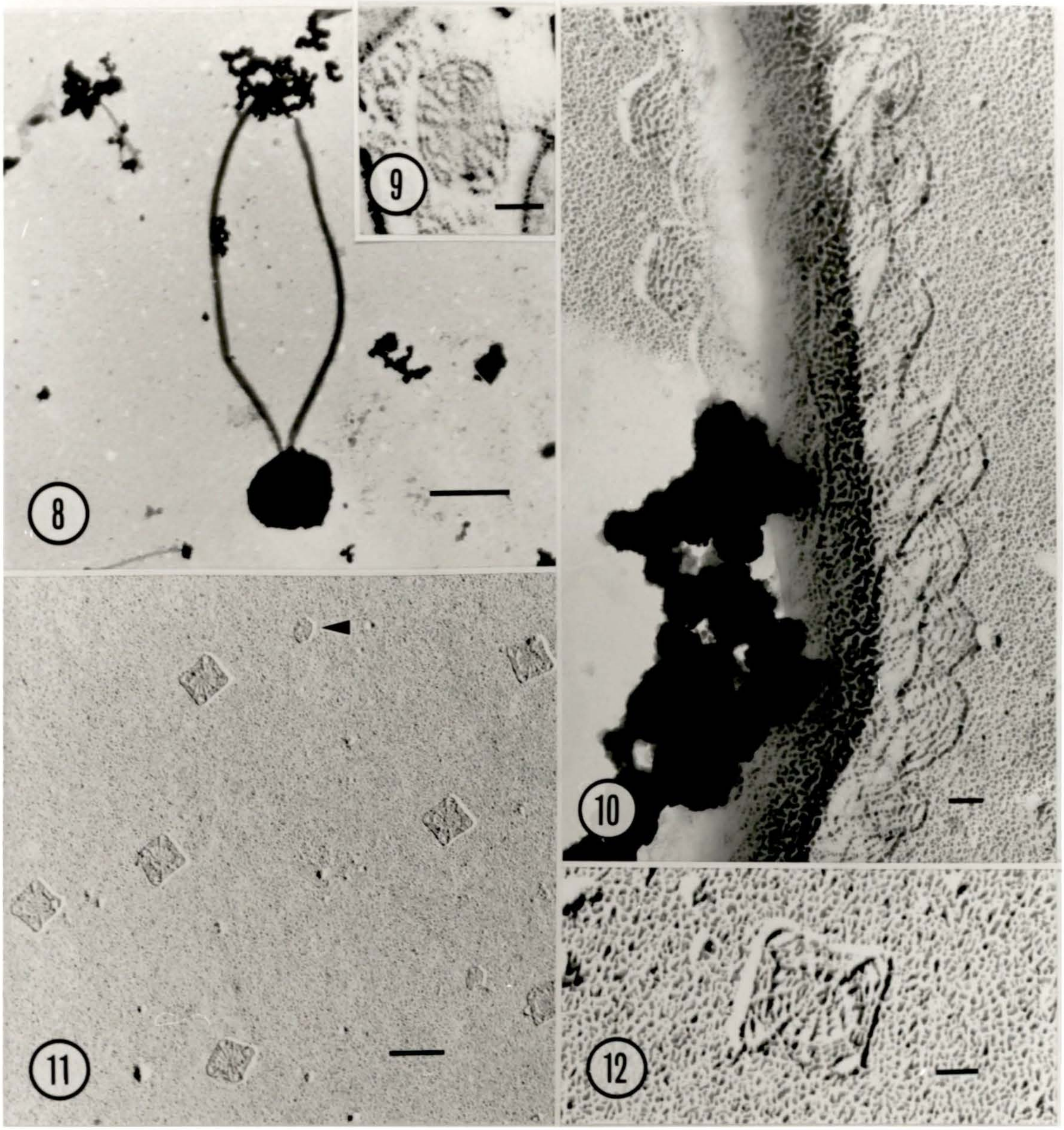
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Figure 13. *Micromonas pusilla*. Negatively stained specimen. Negative staining outlines the distal flagellum which consists of only two microtubules. Scale bar = 0.6 μm.

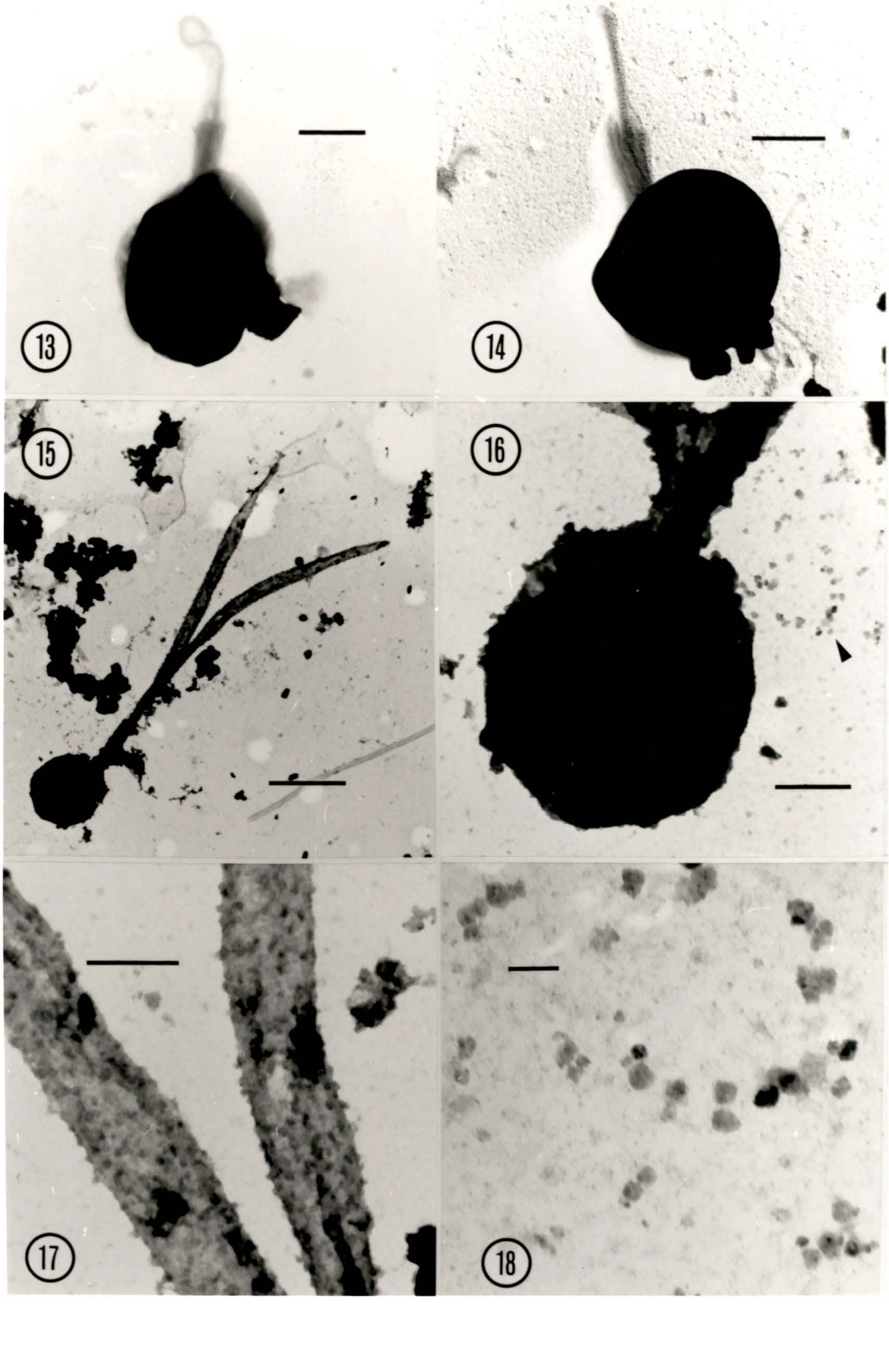
Figure 14. *M. pusilla*. Whole cell with unique flagellum as it appears with shadow casting. Scale bar = 0.5 μm.

Figure 15. *Pseudoscourfieldia marina*. Whole cell with two parallel flagella. Scale bar = 2.0 μm.

Figure 16. *P. marina*. Cell body with tiny body scales beside cell (arrow). Scale bar = 0.5 μm.

Figure 17. *P. marina*. Flagella with covering of tiny square and rod-shaped scales. Scale bar = 0.5 μm.

Figure 18. *P. marina*. Body scales. Scale bar = 0.5 μm.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Description: The taxonomic classification of this small (1.0-3.0 x 0.7-1.0 μm) flagellate is uncertain. It has no body or flagellar scales, the distal 3 μm of its 4 μm flagellum is a slender hairpoint which contains only a central pair of microtubules and it has a very short basal body. It has been placed in the primitive Prasinophycean Order Mamiellales and not in Pedinophyceae because it contains prasinoxanthin and magnesium 2,4-divinyl pheoporphyrin a_5 monomethyl ester, both pigments seen in prasinophytes. The lack of scales and short flagellum may be a secondary reduction due to its small size (Manton and Parke, 1960; Moestrup, 1991).

Observed in Saanich Inlet: Cells were 1.0-1.5 μm. Flagella were 0.6-1.0 μm which is shorter than the type material. Found in samples 3, 4, 5, 11 and 12 (June, July, Aug., Feb. and Mar.)

Previous records: England (Manton and Parke, 1960), North Pacific Ocean (Booth *et al.*, 1978; Hoepffner and Haas, 1990), Australia (Hallegraeff, 1983), Scotland (Hannah and Boney, 1983), Norway (Throndsen, 1969; Espeland and Throndsen, 1986), Greenland (Thomsen, 1982), Denmark (Manton and Leadbeater, 1974) and New Zealand (Moestrup, 1979).

Order Chlorodendrales Fritsch 1918

Flagella and usually cell body covered by scales of which the inner layer are square or diamond shaped. On the flagella these are arranged in 24 rows.

Family Chlorodendraceae Oltmanns 1904

Flagellar underlayer scales covered by small, usually rod-shaped scales, in 24 rows.

Pseudoscourfieldia marina (Throndsen) Manton 1975

(=*Scourfieldia marina* Throndsen 1969)

Figures 15-18.

Description: Cell is 3.0-3.5 x 2.5-3.0 x 1.5 μm with two unequal flagella with lengths of 8.0-14.0 μm and 10.0-23.0 μm. Flagella are unusual in their parallel insertion. The flagella are covered with an inner layer of square and pentagonal scales and an outer layer of rod-shaped scales as well as short hair scales (0.2 μm). On the cell body small square scales form an inner layer and flat scales composed of two identical parts make up an outer layer (Manton, 1975; Moestrup and Throndsen, 1988).

Observed in Saanich Inlet: Cells were 1.8-2.0 μm with flagella ranging from 8.8-10.0 μm and 8.4-9.0 μm. Small rod-shaped and square flagellar scales and square body scales were visible. Found in sample 3 (June).

Previous records: Norway (Throndsen, 1969), South Africa and Denmark (Manton, 1975) and North Atlantic Ocean (Estep *et al.*, 1984).

Family Halosphaeraceae Haeckel 1894

The underlayer scales on the flagella are covered by asymmetrical spine-bearing (= limuloid) scales in 9 longitudinal rows.

Cymbomonas Schiller 1913

Figures 19-25.

Description: *Cymbomonas tetramitiformes* was described by Schiller in 1913 from the Adriatic Sea and in 1925 two more species were described by him. Few records of this genus were recorded until Throndsen (1988) isolated specimens from the Gulf of Naples. *Cymbomonas* has four flagella, and its cells and flagella are covered with organic scales. A species examined by Throndsen (1988) had an inner layer of

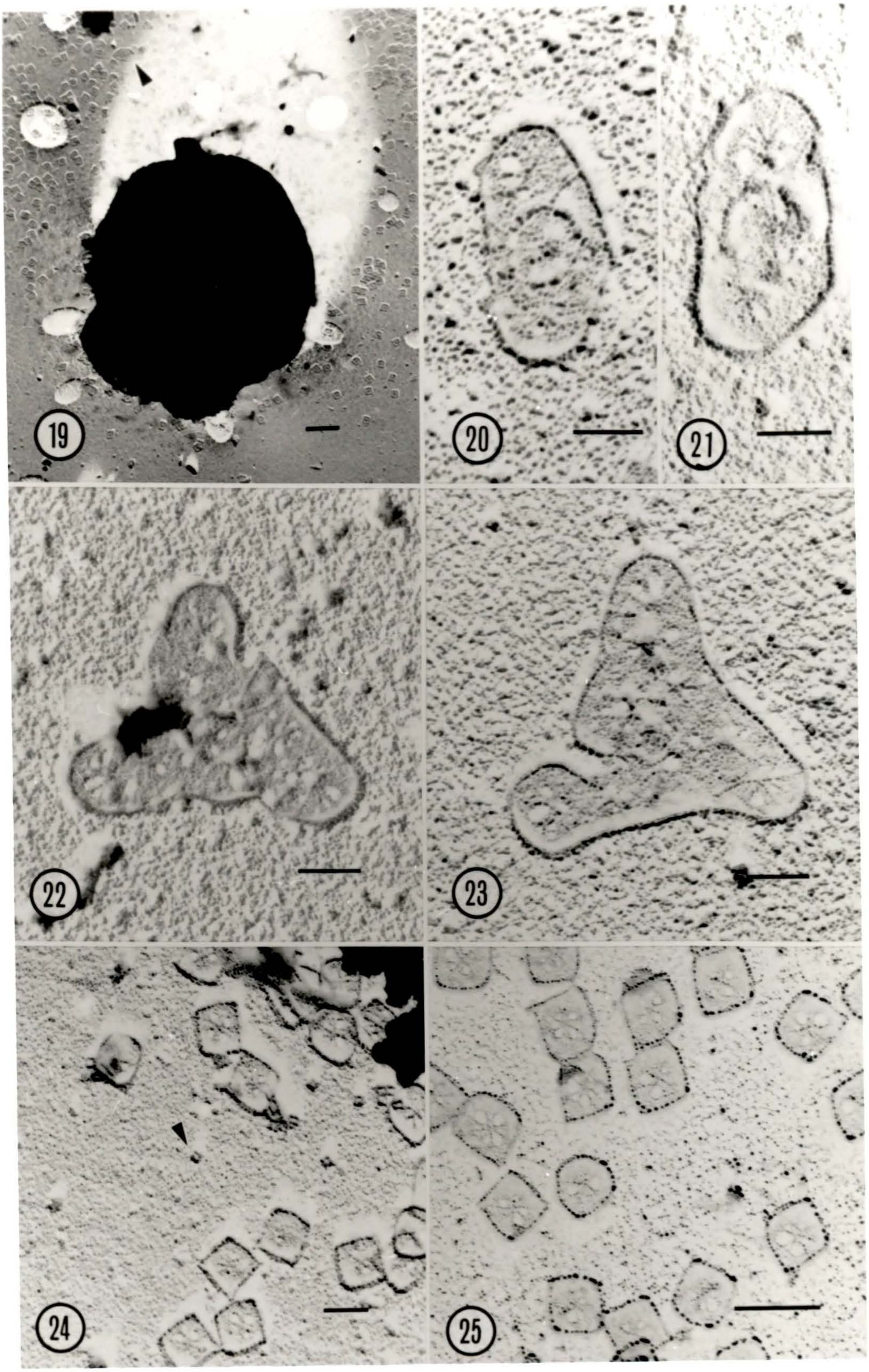
Figure 19. *Cymbomonas* sp. Cell body surrounded by square body scales and an oval scale (arrow). Flagella have fallen off during processing. Scale bar = 1.0 μm.

Figures 20 and 21. *Cymbomonas* sp. Thin, oval scales showing perforations and raised central ring. Scale bar = 0.2 μm.

Figures 22 and 23. *Cymbomonas* sp. Large, three sided scales with perforations. Scale bar = 0.2 μm.

Figure 24. *Cymbomonas* sp. Field of scales with large and small square body scales (arrow). Scale bar = 0.2 μm.

Figure 25. *Cymbomonas* sp. Field of square body scales, some with rounded edges, showing perforations which vary in size. Scale bar = 0.2 μm.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small square scales (0.5 x 0.5 μm) covering the entire cell. Outer layer thin square scales (0.22 x 0.22 μν) with lines dividing the scale into eight sections had perforations of varying sizes. Large oval scales (0.75 x 0.26 μm) with up to four merging concentric patterns were found in the apical depression. The flagella had small pentagonal underlayer scales and an outer layer of spined limuloid scales. Hair scales were lacking. *Cymbomonas* sp. isolated from Georgia Strait (R. Waters, personal communication) was 9.0-11.0 μm in diameter with square to rounded body scales and larger oval scales.

Observed in Saanich Inlet: A species which seemed to belong to the genus *Cymbomonas* was common during the summer. Cell body (8.0-10.5 x 8.0-10.5 μm) was covered with an inner layer of small square scales (0.04 x 0.04 μm) and a middle layer of thin square to rounded scales (0.22 x 0.22 μm) with radiating lines and perforations of varying sizes. Large oval scales (0.7 x 0.3-0.4 μm) had perforations around central points at each end and a round raised ring in the center. ccasionally large three sided scales (0.9 x 0.9 x 0.9 μm) with a pattern of perforations around central points were seen. This scale type was not seen by Throndsen (1988). Found in samples 3, 4 and 5 (June, July and Aug.).

Pterosperma cristatum Schiller 1926

Figures 26-29.

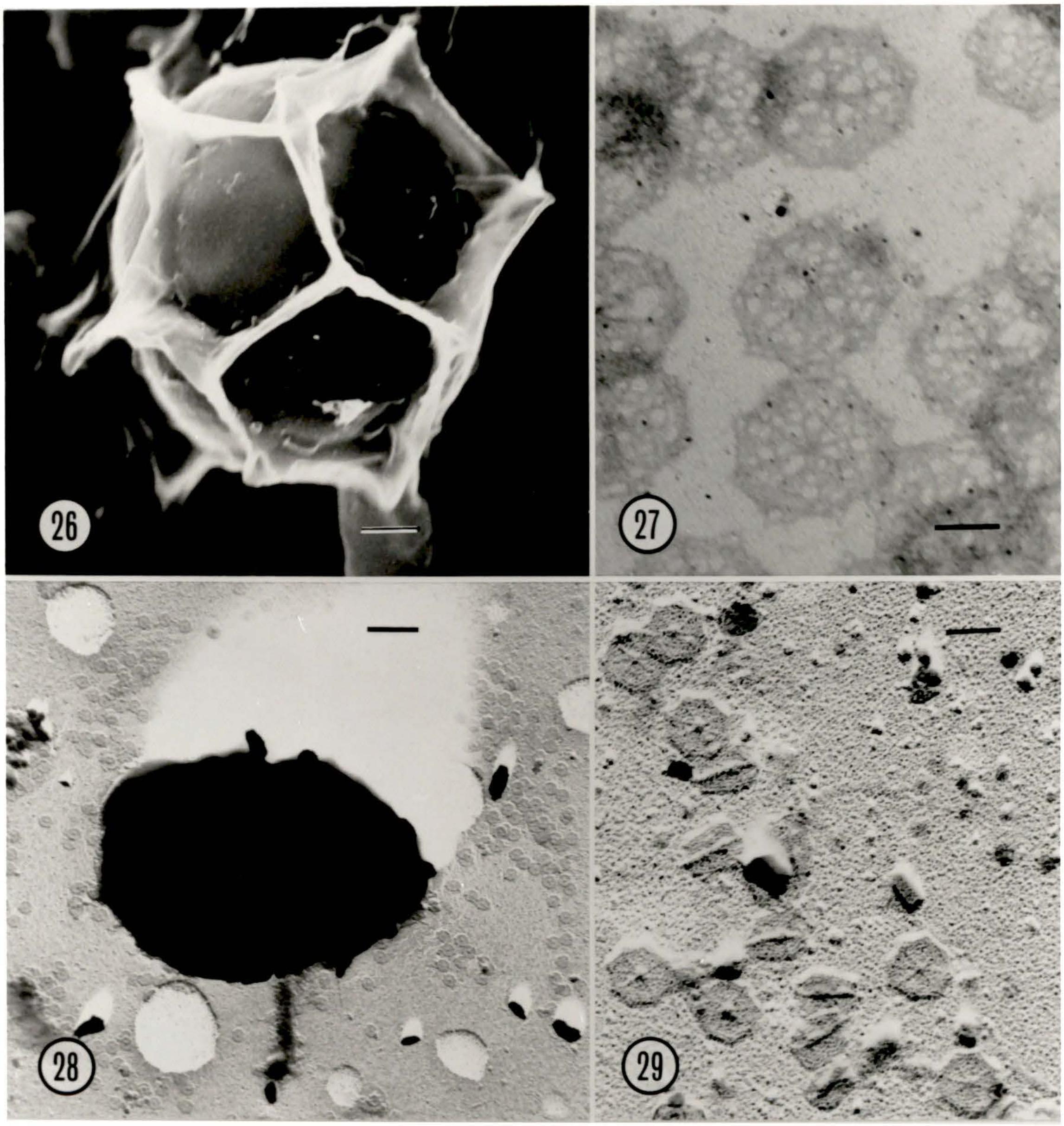
Description: Two phases are present in the life cycle of this species. One is a non-motile pelagic phycoma phase and the other a motile flagellate. The round phycomata (7.0-25 μm) have multiple wings (=alae) on their surface which form square, pentagonal or hexagonal compartments. Motile cells are 5.0-6.0 x 7.5-11.0 μm with four flagella 5-10 times the length of the cell. Flagella and cell body are covered with an underlayer of small (0.45 μm) diamond-shaped scales. Outer

Figure 26. *Pterosperma cristatum*. Scanning electron micrograph of phycoma stage. Multiple alae form pentagonal compartments on the surface. Scale bar = 1.0 μm.

Figure 27. *P. cristatum*. Negatively stained body scales with concentric and radiating ribs forming a spider's web pattern. Scale bar = 0.1 μm.

Figure 28. *P. cristatum*. Cell body of motile stage. Flagella have fallen off during processing. Cell is surrounded by octagonal scales. Scale bar = 1.0 μm.

Figure 29. *P. cristatum*. Octagonal body scales and flagellar scales (arrow) which have a central spine and longitudinal striations. Scale bar = 0.2 μm.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limuloid flagellar scales (0.22-0.26 x 0.16-0.18 μm) have an adnate spine and longitudinal striations. Octagonal body scales with either 8 or 9 ribs and 4 striae at the periphery forming an inner corolla are found in two sizes, 0.21-0.22 μm and 0.26-0.27 μm. Body scales (0.21-0.23 μm) with 8 ribs and 5 striae form a spider's web pattern (Inouye *et al.*, 1990).

Observed in Saanich Inlet: Both phycomata and motile forms were found. Phycomata were 7.4-8.0 μm with pentagonal compartments. Cells of the motile phase were 4.4-5.1 x 6.4-7.0 μm. No specimens with attached flagella were found. Octagonal body scales with spider's web patterns (0.23 μm) were seen. Flagellar scales were 0.22 x 0.17 μm. Found in samples 3, 4 and 5 (June, July and Aug.).

Previous records: Adriatic Sea and Japan (Inouye *et al.*, 1990).

Pyramimonas Schmarda 1850

This large genus has 70 species of which less than half have been examined with the electron microscope. Cells have 4 or occasionally 8 flagella inserted in an invagination at the anterior end of the cell. Cells and flagella are covered with up to 7 types of organic scales which are arranged in ordered tiers. On the flagella are tubular hair scales, small underlayer square or pentagonal scales and limuloid scales. Cell body has an underlayer of small square or pentagonal scales and a middle layer of square scales and an outer layer of crown scales. This genus has been further divided into subgenera on the basis of periplast, ultrastructural and biochemical characteristics (Pennick, 1984; McFadden et al, 1986).

Subgenus Trichocystis McFadden 1986

Species have trichocysts. Pyrenoid structure is variable. Underlayer scales are smooth square scales (McFadden *et al.*, 1986).

P. grossii Parke 1949 emended Manton 1969

Figures 30-35.

Description: Cells are 4.0-8.0 x 4.0-6.0 μm with four flagella slightly longer than the cell. Seven types of scales cover the cell and flagella. Inner layer body scales are smooth square scales (0.45 x 0.45 μm). Middle layer body scales are square (0.25 x 0.25 μm) with low rims. The face of this scale has 8 central perforations surrounded by 8 larger perforations which are surrounded by 20 perforations. Outer layer body scales have an octagonal base (0.22 μm) with spined struts arising and arching to the center where they meet. The limuloid flagellar scale (0.35 μm) has two perforations at the proximal end. Cells discharge tubular trichocysts which are 0.1 μm wide and up to 35 μm long with pointed tips (Pennick and Clarke, 1976; Manton, 1969).

Observed in Saanich Inlet: Cells had diameters of 2.5-4.4 x 3.2-5.1 μm with flagella ranging from 5.8-9.6 μm. Limuloid flagellar scales were 0.26-0.30 μm which is smaller than the type material. Middle layer square body scales were 0.22-0.28 μm across and crown scales measured 0.26 μm. Trichocysts were common and were up to 30 μm long. Found in samples 1, 3, 4, 5, 6, 9, 11, 12 and 13 (Apr., June, July, Aug., Sept., Dec., Feb. and Apr.). This species was very common in samples July and August.

Previous records: England (Pennick and Clarke, 1976), Norway (Throndsen, 1969; Leadbeater, 1972c), New Zealand (Norris, 1964; Moestrup, 1979), Jugoslavia and Bay of Algiers (Leadbeater, 1974), Denmark (Manton and Leadbeater, 1974), Japan (Inouye and Hori, 1982a) and Australia (McFadden *et al.*, 1986).

Subgenus Pyramimonas McFadden 1986

Underlayer scales have high rims, 8 subunits and a central boss. Pyrenoids are

Figure 30. *Pyramimonas grossii.* Scanning electron micrograph of cell body showing flagella emerging from characteristic anterior invagination. Scale bar = 1.0 μm.

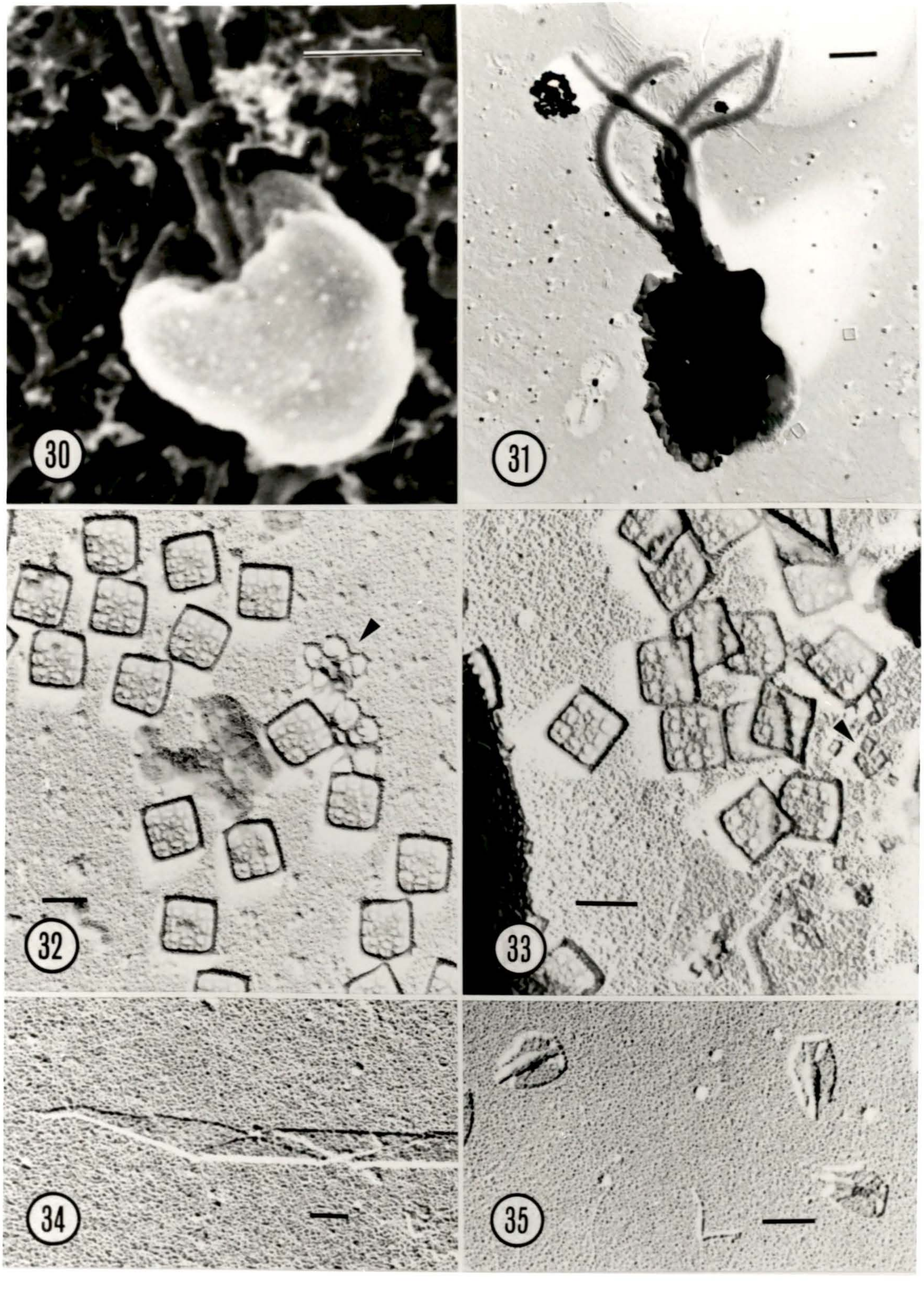
Figure 31. *P. grossii.* Whole cell showing four equal flagella, hairs and scales are visible on flagella. Scale bar = 1.0 μm.

Figure 32. *P. grossii.* Field of scales with square middle layer scales with characteristically arranged perforations as well as three dimensional crown scales (arrow). Scale bar = 0.2 μm.

Figure 33. *P. grossii.* Field of scales with middle layer square scales and small, inner layer square scales (arrow). Scale bar = 0.2 μm.

Figure 34. *P. grossii.* Trichocyst tip. Scale bar = 0.2 μm.

Figure 35. *P. grossii.* Flagellar scales with spine and two anterior perforations. Scale bar = 0.2 μm.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penetrated by convoluted thylakoids and surrounded by numerous starch grains (McFadden *et al.*, 1986).

P. amylifera Conrad 1939

(=*Asteromonas amylifera* (Conrad) Butcher 1959)

(=*Asteromonas propulsum* Butcher 1959)

(=*Polybepharides amylifera* (Conrad) Ettl 1981)

Figure 36.

Description: Cells are 18.0-31.0 x 12.0-20.0 μm with 4 or 8 flagella which are 1.5 times the cell length. Cell and flagella are covered with 6 types of scales. Square middle layer body scales are 0.28 x 0.28 μm with 8 ribs radiating from the center, between each of which is a perforation. Large flagellar limuloid scales have elongated perforations (Pennick, 1978).

Observed in Saanich Inlet: No whole cells of *P. amylifera* were found but scales were common. The large cells were likely removed when water sample was passed through the 20 μm mesh. The characteristic middle layer body scale measured 0.26 x 0.26 μm. Found in samples 3, 4 and 5 (June, July and Aug.).

Previous records: England (Manton *et al.*, 1963), San Juan Islands, Washington (Norris and Pienaar, 1978), Massachusetts (Hulbert, 1965), Japan (Inouye and Horiguchi, 1982b), South Africa, Norway and Australia (McFadden *et al.*, 1986).

Subgenus Vestigiferae McFadden 1986

Cells have an excentric pyrenoid invaded by a few thylakoids and two bi-layered stigmata. Square underlayer scales have a central boss and are limited to the flagellar pit, footprint shaped underlayer scales cover the rest of the cell (McFadden et al, 1986).

P. orientalis Butcher 1959

Figure 36. *P. amylifera*. Square, middle layer body scales showing eight perforations separated by ribs. Scale bar = 0.2 μm.

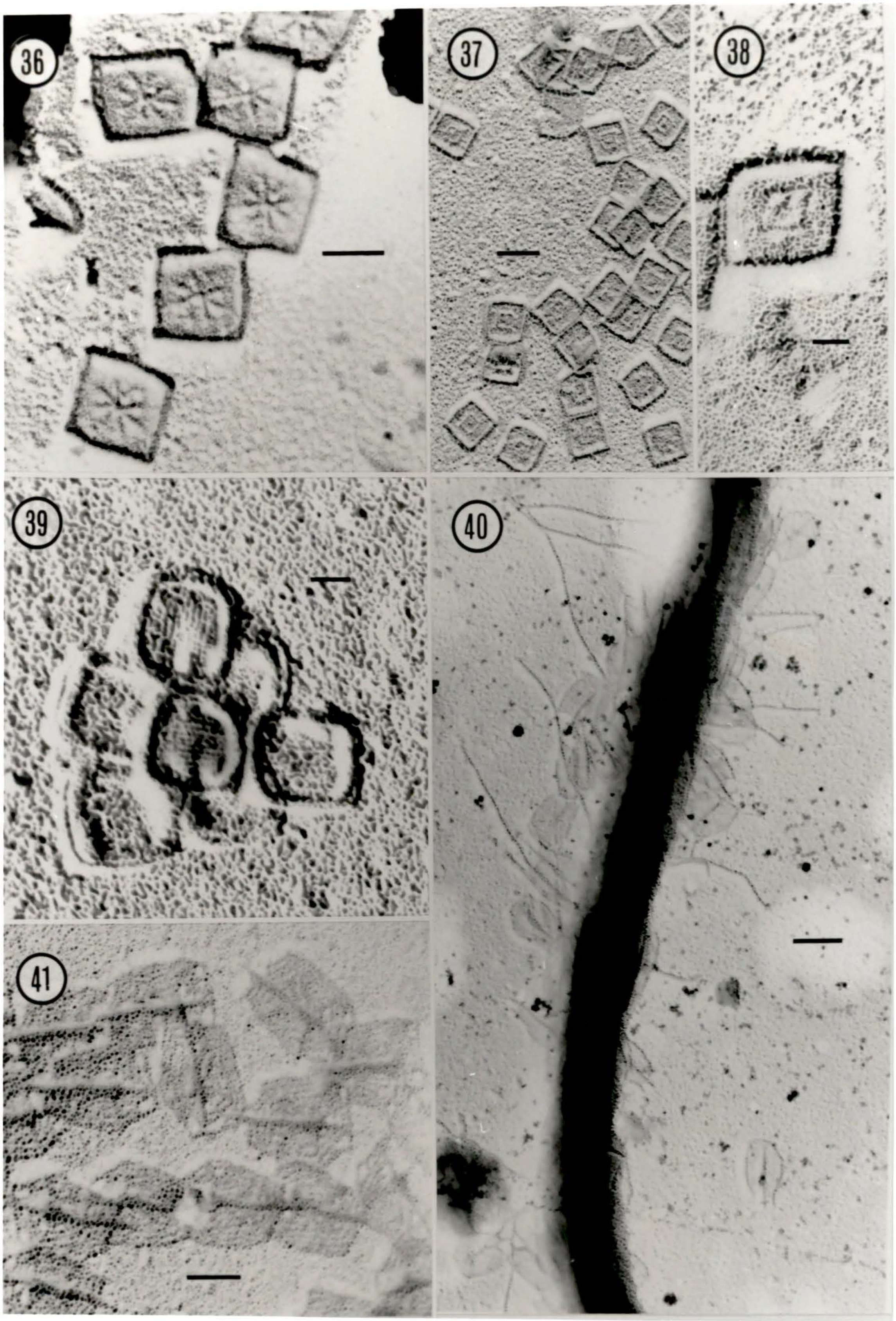
Figure 37. *Pyramimonas* sp. 1. Square middle layer body scales with raised central, square boss. Scale bar = 0.3 μm.

Figure 38. *Pyramimonas* sp. 1. Square middle layer body scale showing faint striations around the central square area. Scale bar = 0.1 μm.

Figure 39. *P. orientalis*. Square middle layer body scales with longitudinal striations. Scale bar = 0.1 μm.

Figure 40. *P. orientalis*. Flagellum with hairs and limuloid scales. Scale bar = 0.3 μm.

Figure 41. *P. orientalis*. Flagellar scales with longitudinal striations, proximal perforations and anterior spines. Scale bar = 0.1 μm.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(=*P. plurioculata* Butcher 1959)

Figures 39-41.

Description: Cell is 4.0-6.0 x 6.0-8.0 μm with four flagella the same length as the cell. Five types of scale cover the cell and flagella and can show considerable morphological variation The typical form has a square middle layer body scale (0.2 x 0.2 μm) with longitudinal striations and no radiating pattern. Limuloid flagellar scales (0.25 x 0.25 μm) have longitudinal striations and proximal perforations (Pennick et al, 1978).

Observed in Saanich Inlet: Cells were 4.0 x 5.0 μm with flagella of 5.0-6.0 μm . Square body scales measured 0.26 x 0.26 μm and limuloid flagellar scales were 0.25 x 0.17 μm. Found in samples 3, 4 and 5 (June, July and Aug.).

Previous records: England (Pennick et al, 1978), Norway (Leadbeater, 1972c), Arctic (Throndsen, 1970b), Denmark (Moestrup and Thomsen, 1974), Jugoslavia and Bay of Algiers, (Leadbeater, 1974), San Juan Islands, Washington (Norris and Pienaar, 1978), New Zealand (Moestrup, 1979), Israel (Thomsen, 1978a) and Greenland (Thomsen, 1982).

Pyramimonas sp. 1

Figures 37 and 38.

Description: This species was described from the San Juan Islands, Washington as *P.* aff. *plurioculata* by Norris and Pienaar (1978). Square middle layer body scales have a raised square and a square central boss. Morphology of the flagellar limuloid scale is unknown. Since this description McFadden *et al.* (1986) have designated *P. plurioculata* a synonym to *P. orientalis*, leaving this species unnamed. Because this species has two bi-layered stigmata (Norris and Pienaar, 1978) I have included it in the subgenus Vestigiferae.

Observed in Saanich Inlet: Cells were 5.0 x 6.0 μm. Square scales were 0.3 x 0.3 μm, faint striations were visible around the raised square area. No specimens with attached flagella were found. Found in sample 3 (June).

Previous records: San Juan Islands, Washington (Norris and Pienaar, 1978).

Uncertain taxomonic position (=*Incertae sedis*)

Figures 42-47.

Observed in Saanich Inlet: Large numbers of what appeared to be two scale types from an undescribed species were found in samples 4 and 5. One scale type was radially symmetric, with a finely perforate three sided base plate, each side measured 1.2 μm. Arising from the base plate, at 0.9 μm intervals, were short perpendicular rods (0.9 μm) which were linked distally to form another ring. Arising from this ring at 0.18-0.22 μm intervals were longer perpendicular rods (0.20 μm) which were also linked distally forming a ring. The perpendicular rod at the midpoint of each side of the scale extended beyond the distal ring and joined the extended rods from the other two sides at a spot 0.5 μm above the center of the scale. From this central meeting place a rod extended down to the center of the scale. Three rods from the scale center to the scale edge divided the base plate into three sections. The other scale type was oval (0.8-1.0 x 0.5-0.7 μm) with a finely perforate base divided into two sections by a thickened area extending across it. A rim projecting around the periphery of the scale seemed to be a meshwork of rods however most specimens had collapsed during processing, making it impossible to determine the exact structure of this rim. No cells were found.

EDX microanalysis of these scales (Figure 48) indicated that they were made of organic material. Elemental composition of scales (top spectrum) did not differ from areas on the grids which had no specimens (bottom spectrum). Copper peaks

Figure 42. Three sided undescribed scale. Negatively stained specimen showing three dimensional structure. Scale bar = 0.3 μm.

Figures 43-45. Various shadow cast views of three sided scale to show perforations on base plate, radial symmetry and structure of sides. Scale bar = 0.3 μm.

Figures 46 and 47. Undescribed oval scale which has a perforated base plate divided in two by thickened area and sides which have crumpled during processing of specimen. Scale bar = 0.3 μm.

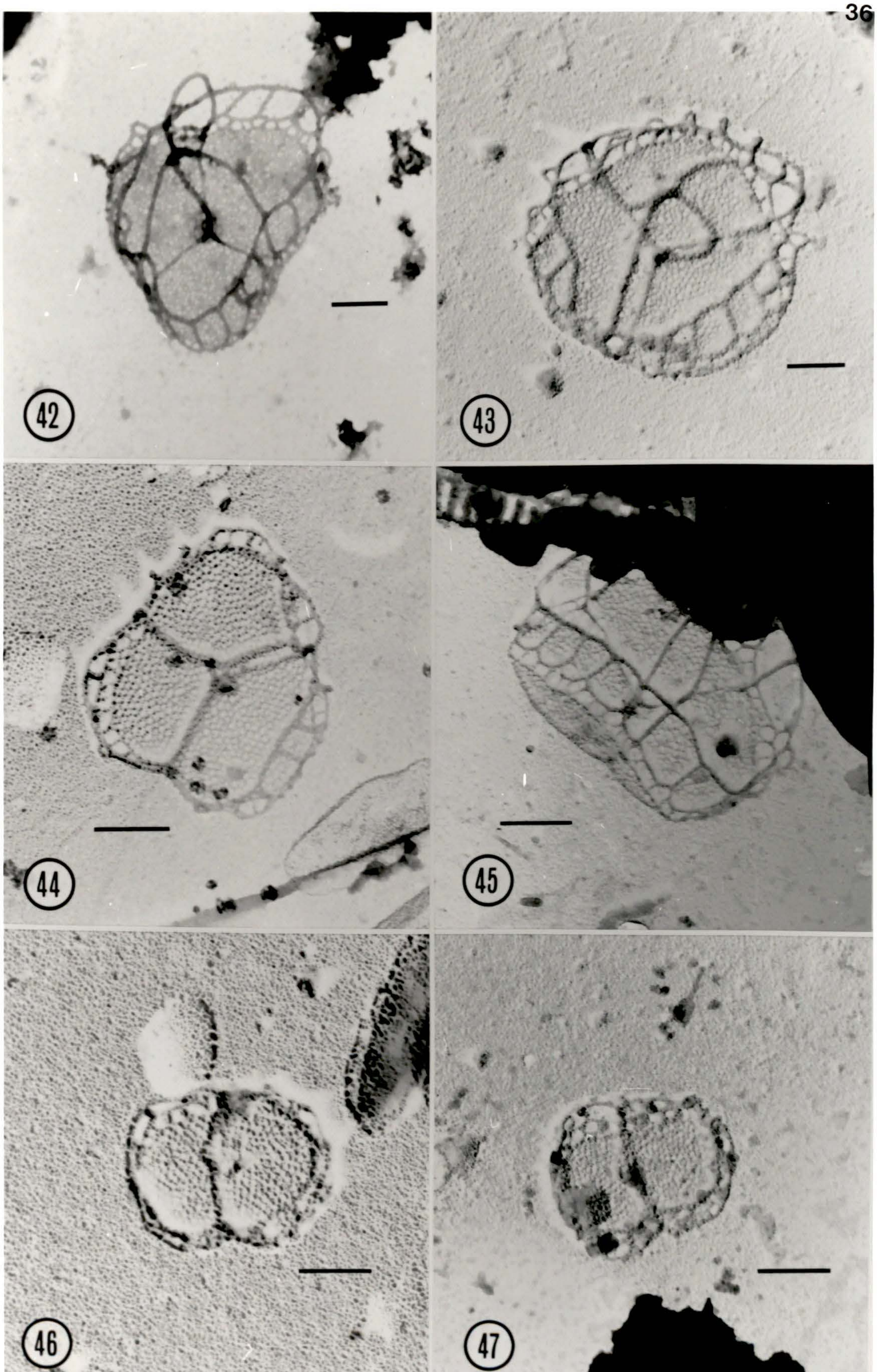
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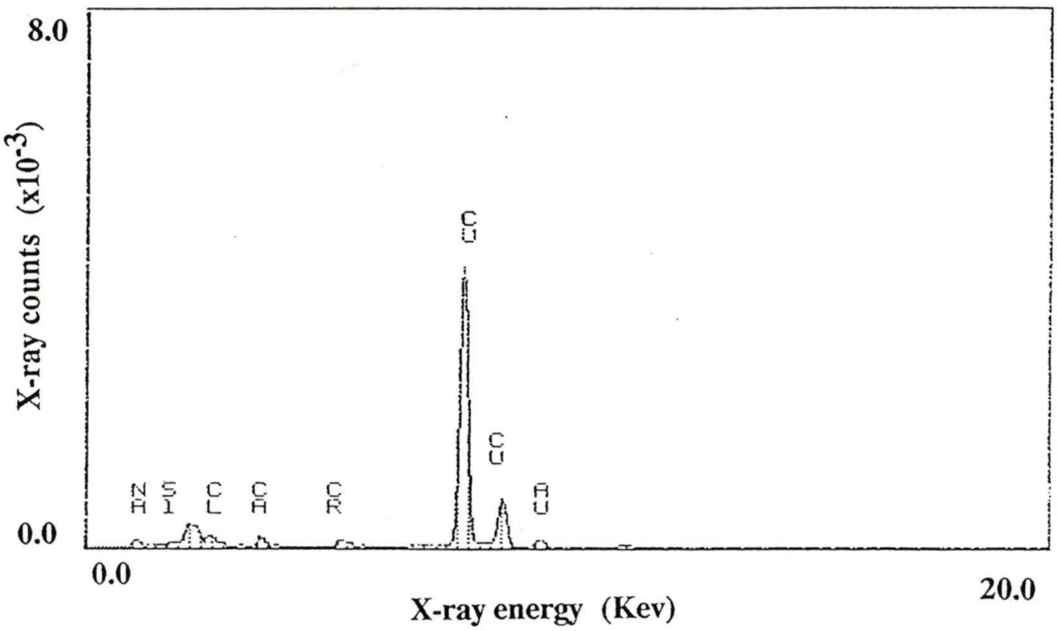
Figure 48. EDX microanalysis of undescribed scales. Top spectrum is from a scale and the bottom spectrum is from an area on the grid where there was no specimen. Copper peaks are from the grids. Scales appear to be composed of organic material.


8.0
X-ray counts (x10-3)
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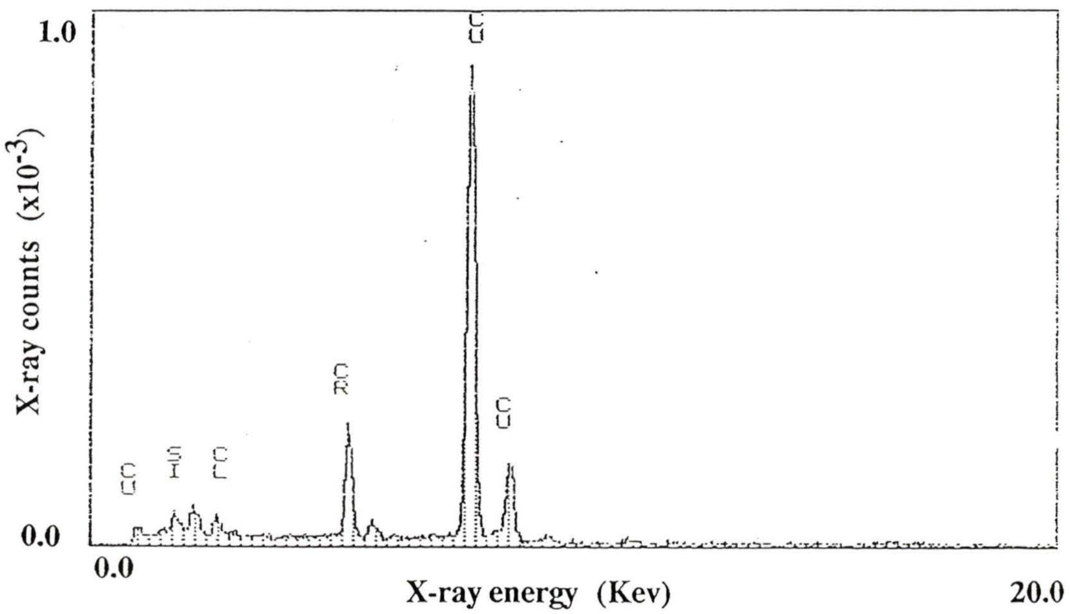
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X-ray energy (Kev)
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Figure 48

are from the copper grids. Organic scales with a similar perforate three dimensional structure are seen in *Pyramimonas longicauda* (Inouye *et al.*, 1984) suggesting these scales belong to an undescribed species of *Pyramimonas*. *P. longicauda* scales are of similar size (1.0-1.2 μm) and the cell body is large (12.5-20.5 μm) therefore the cells of these unknown scales might have been large enough to be retained by the 20-μm mesh used to filter water samples.

Division Chrysophyta

Although this division contains a diversified group of algae they share the features of containing predominantly carotenoids along with chlorophylls *a* and *c* but not chlorophyll *b*. Endoplasmic reticulum surrounds the chloroplasts in all Chrysophyta and is continuous with the outer membrane of the nuclear envelope except in the Raphidophyceae. Chrysolaminarin is the food reserve. Arguments for raising the classes within Chrysophyta to division status or combining Chrysophyta, Cryptophyta and Phaeophyta in the division Chromophyta are ongoing (Bold and Wynne, 1985).

Class Prymnesiophyceae Hibberd 1976

This class was established in 1962 by Christensen as the Haptophyceae but is now referred to by the typified name Prymnesiophyceae. Most prymnesiophytes are unicellular planktonic organisms which have a flagellated stage in their life cycle. They have two equal, subequal or unequal flagella which, except in the Order Pavlovales, lack scales or hairs. The majority of prymnesiophytes have a haptonema arising between the two flagella. Haptonema are flagellum-like appendages composed of 6 or 7 single microtubules in a ring which differs from flagellar ultrastructure of 9 microtubule pairs surrounding 1 central pair of microtubules. Flagellar transition region has two widely spaced cross partitions. Microtubular flagellar roots are present. Cells are covered by unmineralized scales or calcified coccoliths. Resting cysts, if present, are produced exogenously (Hibberd, 1980).

Order Prymnesiales

Organisms within this order have a definite haptonema in their motile stage (Bold and Wynne, 1985).

Family Prymnesiaceae Motile phase is dominant (Boney, 1970).

Chrysochromulina Lackey 1939

Cells have two flagella and a haptonema which exhibits different movement than the flagella and is usually coiled. Haptonema can be longer or shorter than the flagella. Structure of the elaborately sculptured scales, composed of cellulose and pectic polysaccaride, is the major taxonomic character used to distinguish species. Scales on a single species may be from one to four types. *Chrysochromulina*, a cosmopolitan genus with 47 described species, is primarily autotrophic but some species are capable of heterotrophic growth (Allen and Northcote, 1975; Estep and MacIntyre, 1989).

Chrysochromulina adriatica Leadbeater 1974

Figures 49-52.

Description: Cells are 5.0-8.0 x 6.0-9.0 μm with two equal flagella (8.0-10.0 μm) and haptonema 6.0-10.0 μm. Two types of scales cover the cell. Oval scales (1.8-2.5 x 1.2-1.5 μm) have curved and radiating ridges and a thickened margin on the distal surface. Circular scales (diameter 1.8-2.5 μm) have similar markings but no thickened margin (Leadbeater, 1974).

Observed in Saanich Inlet: Only one cell was seen. Cell size was 5.0 x 3.3 μm with flagellar length of 9.8 μm. Haptonema was folded preventing measurement. Oval scales with thickened margins were 1.6 x 1.2 μm. Found in sample 3 (June).

Previous records: Jugoslavia and Bay of Algiers (Leadbeater, 1974).

C. brachycylindra Hallfors and Thomsen 1985

Figures 53-60.

Description: Cells are 3.9-6.7 μm in diameter, with two subequal flagella (8.0-

Figure 49. *Chrysochromulina adriatica*. Whole cell with two flagella and central haptonema which is looped back. Scale bar = 2.0 μm.

Figures 50-52. *C. adriatica*. Scales adjacent to cell body. Scales are not well preserved but the distinctive pattern of curved and radiating ridges is visible. Thickened margins are visible on some of the scales. Scale bar = 0.5 μm.

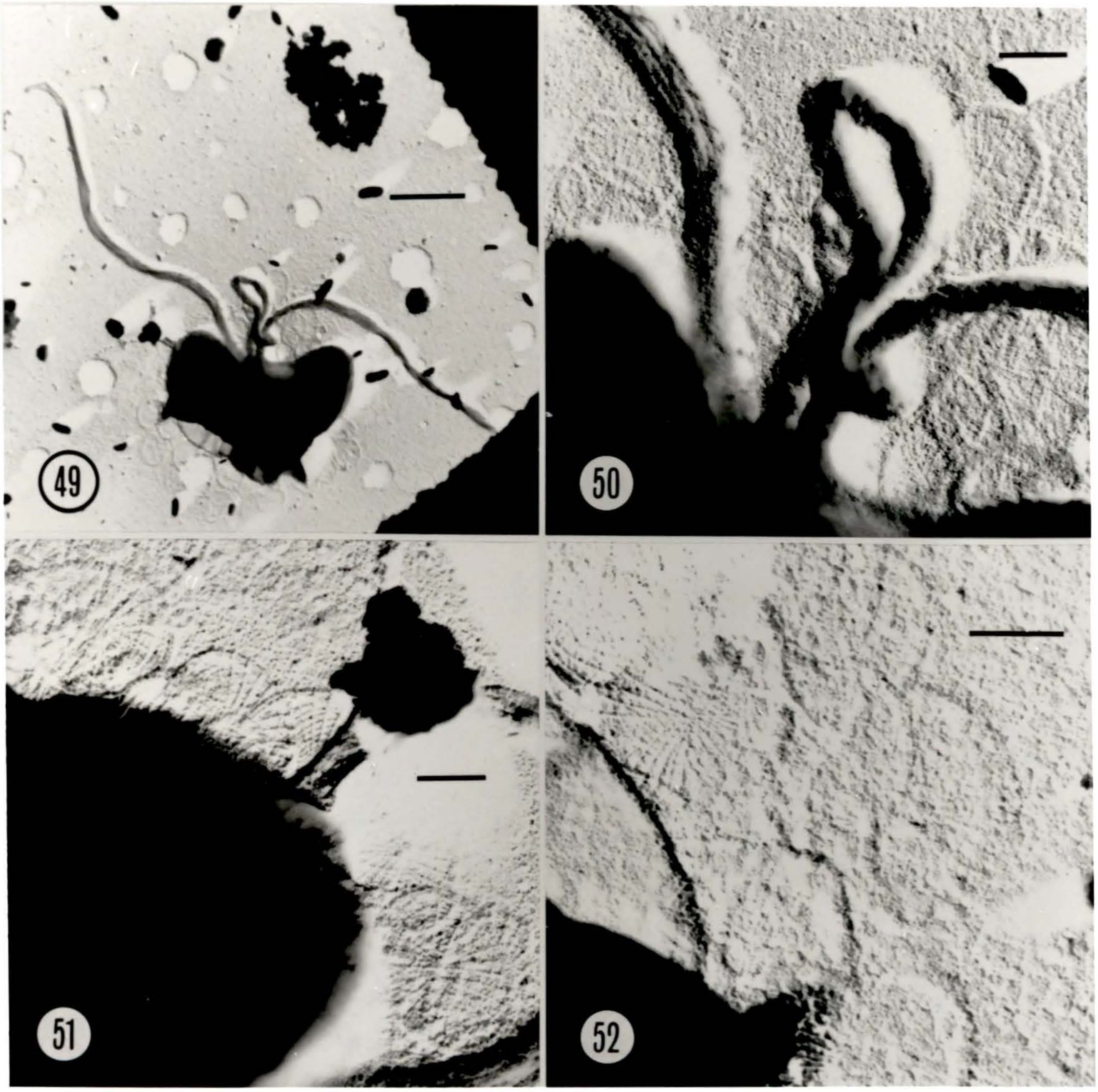
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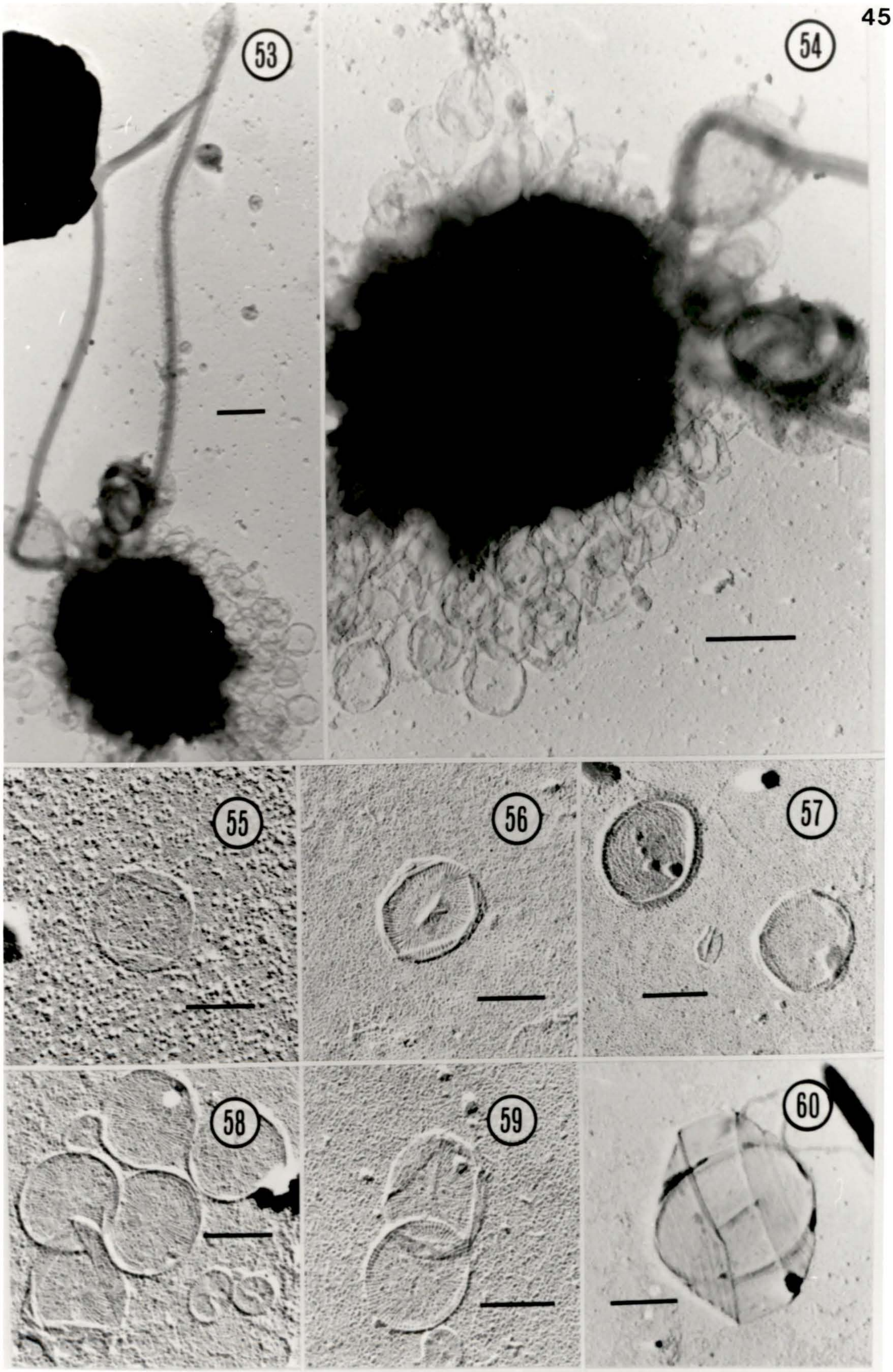
Figure 53. *C. brachycylindra.* Whole cell with two subequal flagella and central coiled haptonema. Scales are visible around the cell. Scale bar = 1.0 μm.

Figure 54. *C. brachycylindra.* Cell body with field of round scales. Scale bar = 1.0 μm.

Figures 55-59. *C. brachycylindra.* Scales of the small type. Distal face of cylinder scale with cylinder walls folded onto scale (Fig. 55); proximal face of cylinder scale with oblong central thickening and radial ridges (Fig. 56); distal face of plate scale with inframarginal ridge and concentric markings; proximal face of cylinder scale (Fig. 57); field of scales with four scales showing proximal face of plate scale with radial ridges and one scale showing distal side of cylinder scale (Fig. 58); proximal side of plate scale and distal side of cylinder scale (Fig. 59). Scale bar = 0.5 μm.

Figure 60. *C. brachycylindra.* Distal face of large sized cylinder scale, with larger cylinder wall folded onto scale and central oblong thickening visible. Scale bar = 0.5 μm.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13.0 μm) and a haptonema of approximately the same length. Two types of scales are present. An oval plate scale, 0.9-1.5 x 0.7-1.2 μm, has a distal surface of faint concentric markings and a distinct inframarginal ridge. The proximal surface has radial ridges and an oblong central thickening. The other scale is cylindrical with an oval base-plate (1-1.6 x .6-1.2 μm) and an upright, concentrically marked cylinder (0.4-0.8 μm) attached to the margin. This scale also has concentric distal markings and radial proximal markings and an oblong central thickening. *C. brachycylindra* of smaller dimensions have also been recorded. These have plate scales of 0.8 x 0.6-0.7 μm and cylinder scales with bases of 0.7-1.0 x 0.5-0.8 μm with cylinder heights of 0.2 μm (Hallfors and Thomsen, 1985).

Observed in Saanich Inlet: Cell size ranged from 3.8-5.1 μm diameter. Flagellar lengths of 7.9-11.3 μm were seen. All haptonema were coiled preventing measurement. Most scales seen were of the smaller type with plate scales of 0.6-0.7 x 0.7 μm. Cylinder scales had base plates of 0.7 x 0.7 μm and cylinder heights of 0.2 μm. A few larger cylinder scales with diameters of 0.9 x 1.3 μm with cylinder height of 0.5 μm were seen. No size overlap was seen between the large and small scale types. Scales had typical markings. Found in samples 2, 3, 4 and 5 (May, June, Aug. and Sept.).

Previous records: Finland and Thailand (Hallfors and Thomsen, 1985).

C. brevifilum Parke and Manton 1955

Figures 61 and 62.

Description: Cells are 3.5-11.5 μm in diameter with two equal flagella 2.5-3.5 times body length and a haptonema 2-2.5 times body length. Ellipsoid scales, approximately 0.7 μm across with a central spine (0.7 μm) attached by four decurrent ridges, cover the cell. The distal face of the scale, is covered with

Figure 61. *C. brevifilum.* Whole cell with flagella partially obscured. Spines visible protruding around cell body. Scale body = 1.0 μm.

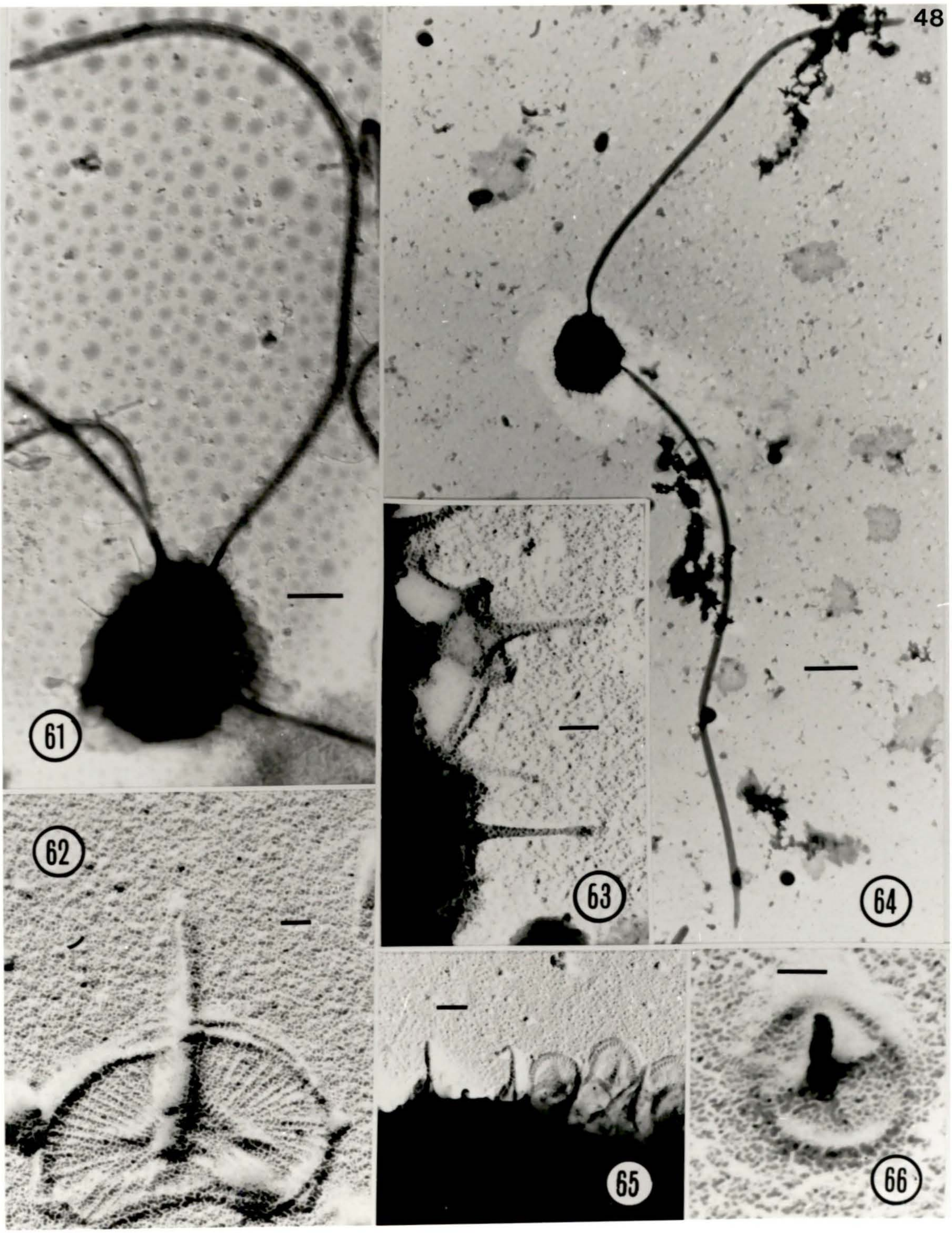
Figure 62. *C. brevifilum.* Spined scale, with radiating lines on base. Scale bar = 0.1 μm.

Figure 63. *C. ephippium.* Side view of spined scales. Scale bar = 0.1 μm.

Figure 64. *C. ephippium.* Whole cell with two unequal flagella, haptonema is missing. Scale bar = 1.0 μm.

Figure 65. *C. ephippium.* Spine scales and plate scales showing proximal surface with radiating ridges. Scale bar = 0.2 μm.

Figure 66. *C. ephippium.* Spine scale with four decurrent ridges. Scale bar = 0.1 μm.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radiating lines (Parke *et al.*, 1955).

Observed in Saanich Inlet: Cell diameters were 3.0-4.0 μm with a flagellar length of 17.5 μm. No specimens with haptonema were found. Spine lengths were 0.68-0.74 μm. Found in sample 5 (Aug.).

Previous records: England (Parke *et al.*, 1955), Norway (Leadbeater, 1972c), Denmark (Manton and Leadbeater, 1974) and Australia (Hallegraeff, 1983).

C. ephippium Parke and Manton 1956

Figures 63-66.

Description: Cells are 4-12 μm in diameter with two equal flagella 3-4 times body length and a long haptonema 1-2 times body length. The cell is covered with two types of scale. One, a plate scale (0.5-0.7 μm diameter) has radiating ridges on the proximal surface and crossed striations within a raised rim on the distal surface. The other scale (0.3-0.6 μm diameter) carries a spine (0.3-0.4 μm) attached by four decurrent ridges on its distal surface. The distal surface is marked with concentric lines (Parke *et al.*, 1956).

Observed in Saanich Inlet: Cells were 4.0-5.0 μm in diameter, with flagellar lengths of 15-24 μm. Flagella were unequal. Plate scales were 0.3 μm across and spines were 0.3-0.4 μm. Found in samples 2 and 5 (May and Aug.).

Previous records: England (Parke *et al.*, 1956), Norway (Leadbeater, 1972c), Jugoslavia and Bay of Algiers (Leadbeater, 1974), North Atlantic (Estep *et al.*, 1984), New Zealand (Moestrup, 1979), Denmark, South Africa, and Greenland (Thomsen, 1978) and Gulf of Elat (Thomsen, 1978).

Leadbeater (1972c) showed scale size and morphology in *C. ephippium* and *C. brevifilum* to be very constant therefore the length of spines and the patterning on the distal surface of the spined scale distinguishes the two species in Saanich Inlet.

Length of haptonema also distinguishes these species however neither species was found with a haptonema.

C. ericina Parke and Manton 1956

Figures 67-71.

Description: Cells 5-12 μm in length, 4-8 μm in width. Two equal flagella are 2-2.5 times body length, haptonema is 4-5 times body length. Oval scales, 0.5-0.7 x 0.6-0.9 μm, have radiating ridges on their proximal side and a raised rim surrounding irregular striations on the distal side. Spines, 9-15 μm in length, arise from flared bases 1.0-1.4 μm wide (Parke *et al.*, 1956).

Observed in Saanich Inlet: Cells were within the range of the species description (4.0 x 5.0 μm) but the plate scales were slightly larger (0.7 x 1.1 μm). However this is within the range of scale size seen by Leadbeater (1972c) who found scale size of *C. ericina* to be extremely variable. Spine lengths were 9.5 - 10.0 μm with bases of 1.2 - 1.3 μm. No specimens with haptonema were found. Found in samples 1, 3 and 4 (Apr., June and July).

Previous records: England (Parke *et al.*, 1956), Norway (Throndsen, 1969; Leadbeater, 1972c), Denmark (Manton and Leadbeater, 1974), Jugoslavia and Bay of Algiers (Leadbeater, 1974), New Zealand (Moestrup, 1979), Firth of Clyde (Hannah and Boney, 1983) and Greenland (Thomsen, 1982).

C. hirta Manton 1978

Figures 72-75.

Description: Cells are 6.0 μm with two equal flagella up to 20 μm in length, and a haptonema slightly longer. Spines of two sizes are attached to the center of concave scales with radial markings arranged in quadrants on the distal surface and radially

Figures 67 and 68. *C. ericina*. Whole cells surrounded by spines and scales. One flagellum is visible in each photograph. The cells in Fig. 67 appear to be in the process of dividing. Scale bar = 2.0 μm.

Figure 69. *C. ericina*. Scales showing the proximal face with radiating ridges and rimless edge. Scale bar = 0.2 μm.

Figure 70. *C. ericina*. Distal face of scale with irregular striations and rimmed edge. Base of spine with flared base. Scale bar = 0.2 μm.

Figure 71. *C. ericina*. Collection of scales and spines. Scale bar = 0.5 μm.

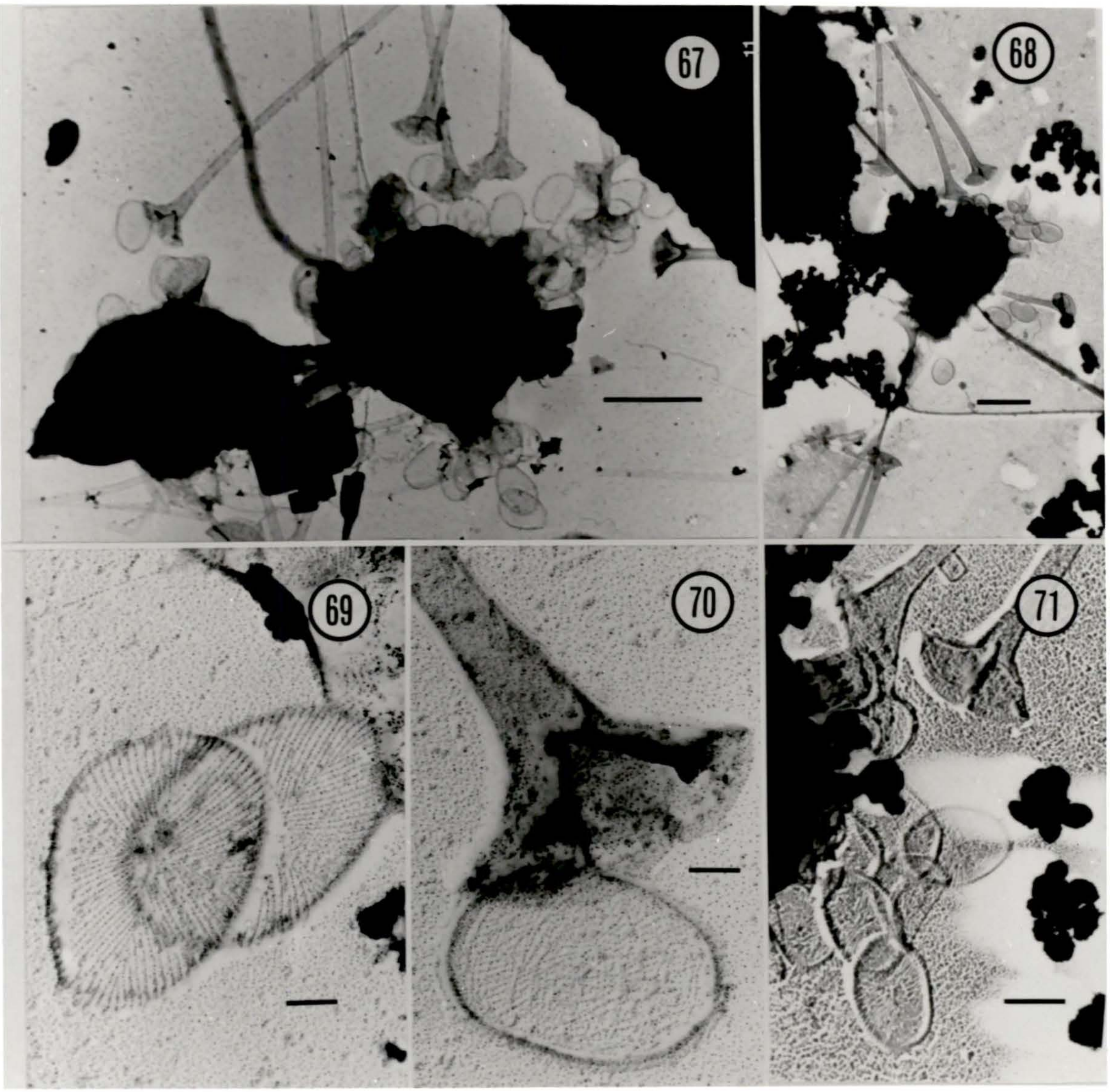
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Figure 72. *C. hirta*. Whole cell with two equal flagella and folded back haptonema (arrow). Spines are visible protruding from cell. Scale bar = 5.0 μm.

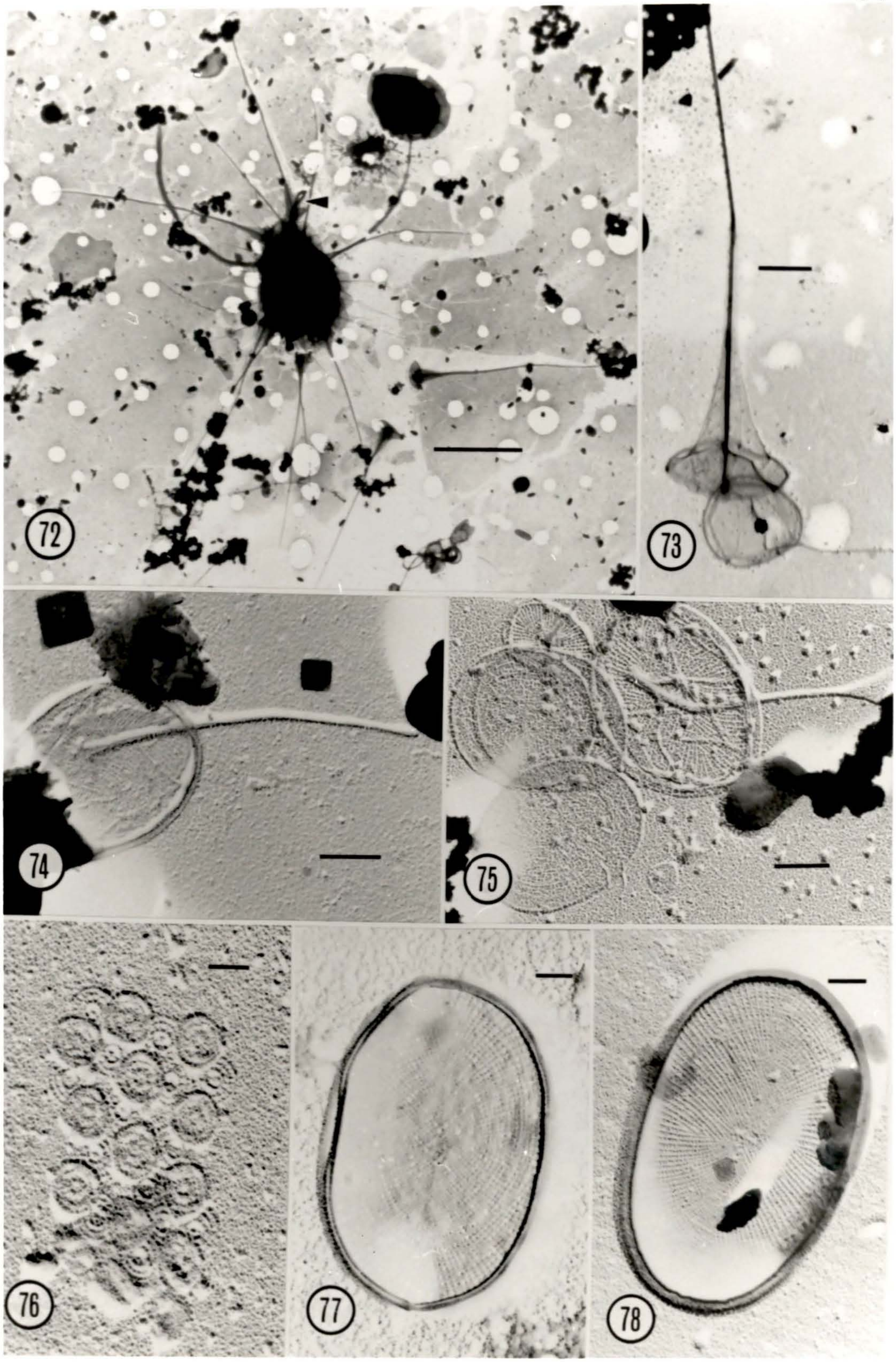
Figure 73. *C. hirta*. Long and short spines. Long spine has buttress ridges at base. Scale bar = 1.0 μm.

Figures 74 and 75. *C. hirta*. Short whiplike spines showing radial striations in quadrants on the distal face of the base plate. Distal face of plate scales with faint concentric and radial markings. Scale bar = 0.5 μm.

Figure 76. *C. leadbeateri*. Field of scales with central and peripheral rings and radial striations. Scale bar = 0.2 μm.

Figure 77. *C. mantoniae*. Proximal face of large oval scale, with radiating ridges and concentric markings visible. Tiny perforations are visible between the radial ridges. Rim is projecting. Scale bar = 0.2 μm.

Figure 78. *C. mantoniae*. Distal face of large oval scale. Rim is projected away. Radial and concentric marking are visible but perforations not obvious. Scale bar = 0.2 μm.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oriented threads on the proximal surface. The large spine, 20-30 μm long, has four buttress-like ridges with thread covered surfaces, attached proximally. The diameter of the scale is 2.0-2.5 μm. The smaller whiplike scales, up to 5.0 μm in length, are attached to scales 1.5 x 2.0 μm with support struts much reduced. Rimless plate scales, 1.3 x 1.6 μm, have radiating ridges in quadrants on the proximal face and an indistinct arrangement of concentric and radial threads on the distal face (Manton, 1978).

Observed in Saanich Inlet: Cells were 5.5 μm in diameter with flagella 10.0-10.5 μm. No specimens with extended haptonema were found. Long spines were smaller (12.0-19.6 μm) than that of the type specimen. Small spines ranged from 1.7 - 4.1 μm. Plate scales were 1.1 x 1.4 μm . Found in samples 2, 3, 4, 5, 7, 8, 9, 12 and 13 (May, June, July, Aug., Oct., Nov., Dec., Mar. and Apr.).

Previous records: South Africa, Alaska, Arctic Canada (Manton, 1978), Greenland (Thomsen, 1982) and Norway (Espeland and Throndsen, 1986).

C. leadbeateri Estep *et al.*, 1984

Figure 76.

Description: Cells are 1.5-4.0 μm in diameter with two subequal flagella. Haptonema is longer than the flagella. Two types of scale cover the cell. Both types are circular (0.2-0.4 μm in diameter) with a cruciform center surrounded by a central ring. One scale has another ring near the periphery and radiating striations. The other scale has a raised rim and no radial striations (Estep *et al.*, 1984).

Observed in Saanich Inlet: Only scales were found. Scales with diameters of 0.26 μm showed central and peripheral rings and radial striations. Found in sample 3 (June).

Previous records: North Atlantic Ocean, Florida, Australia and Norway (Estep et al, 1984) and North Pacific Ocean (Hoepffner and Haas, 1990).

C. mantoniae Leadbeater 1972

Figures 77 and 78.

Description: Cells are 3.0 x 6.0 μm with two equal flagella (18.0-20.0 μm) and a shorter haptonema (10.0 μm). Spines are present at both ends of the cell. Two types of plate scales cover the cell. Small oval scales (0.4 x 0.5 μm) have radiating ridges proximally and irregular fibrillar markings distally. Larger oval scales (1.1 x 1.5 μm) have radiating ridges superimposed on concentric markings. Tiny perforations are present between the radiating ridges. A rim projects proximally (Leadbeater, 1972d).

Observed in Saanich Inlet: Although no whole cells were found several distinctive large oval scales were seen. These were 1.3 x 1.8-2.1 μm which is larger than the type material. Proximal and distal surfaces were distinguishable by the proximally projecting rim. Found in samples 7 and 12 (Oct. and Mar.).

Previous records: Norway (Leadbeater, 1972d), Denmark, South Africa and Adriatic Sea (Manton and Leadbeater, 1974).

C. megacylindra Leadbeater 1972

Figures 79-84.

Description: Cell is conical, 4.0 x 5.0 μm, with two equal flagella of 20.0 μm and a haptonema of 18.0 μm. Scales of two types cover the cell. Large subcircular plate scale (1.0 μm diameter) has radiating ridges on both proximal and distal surfaces. These ridges extend to the rimless edge on the proximal surface; the distal surface has a peripheral band of concentric striations. The cylinder scale has a thin, straight sided cylinder of 1.0 μm length attached submarginally to a circular base plate of 0.7

Figure 79. *C. megacylindra.* Field of scales with cylinder scales as well as plate scales. Scale bar = 0.2 μm.

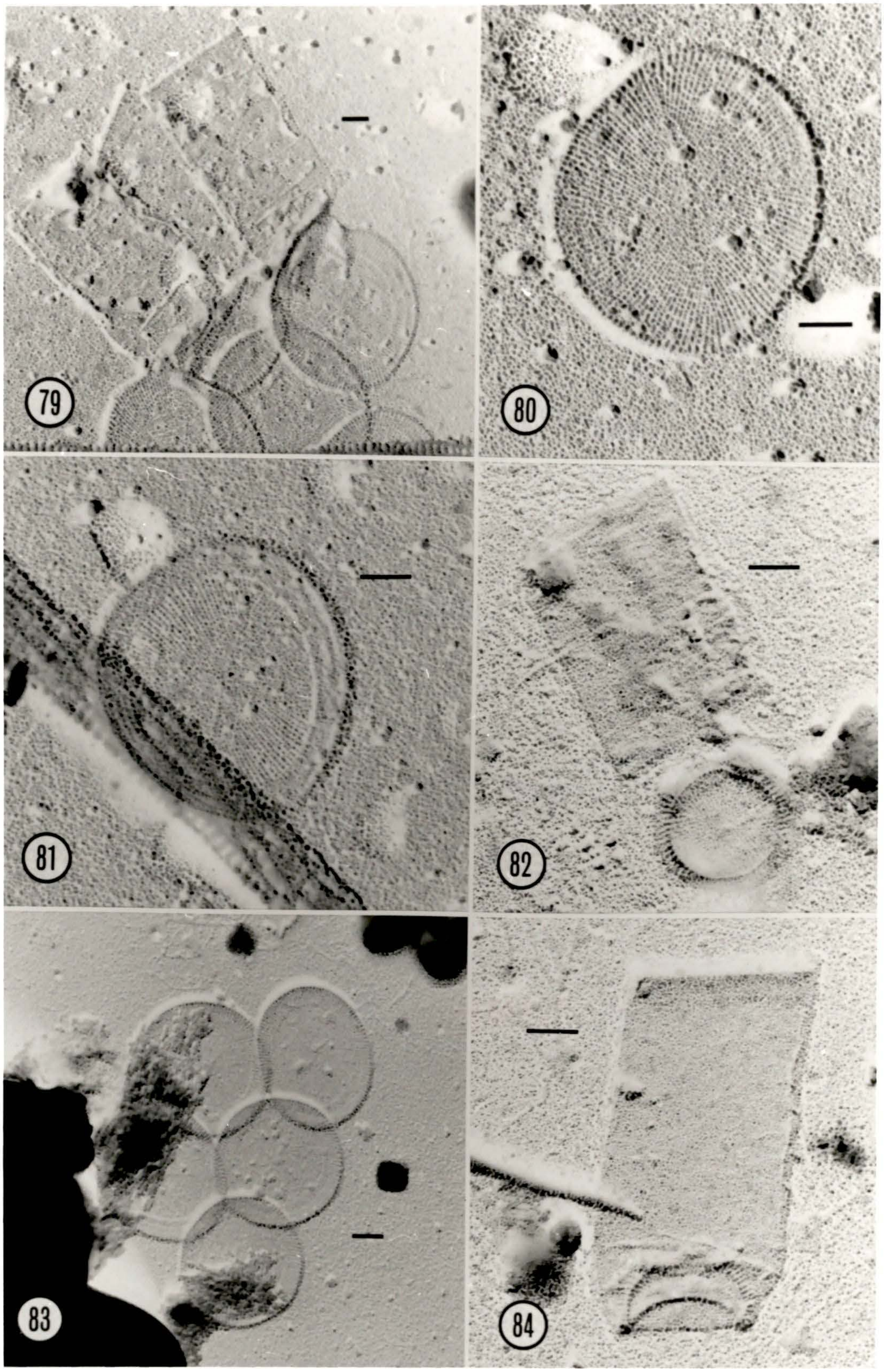
Figure 80. *C. megacylindra.* Proximal surface of plate scale with radial striations extending to rimless edge. Scale bar = 0.2 μm.

Figure 81. *C. megacylindra.* Distal surface of plate scale with radial striations extending to peripheral band of concentric striations. Scale bar = 0.2 μm.

Figure 82. *C. megacylindra.* Cylinder scale. Cylinder is collapsed. Circular base plate shows radial striations which are more evident beyond peripheral ring. Scale bar = 0.2 μm.

Figure 83. *C. megacylindra.* Field of plate scales showing round and oval forms. Scale bar = 0.2 μm.

Figure 84. *C. megacylindra.* Cylinder scale. Scale bar = 0.2 μm.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μm diameter. The proximal surface of this base plate has faint radial markings centrally and a peripheral ridge, beyond which the radiating ridges are more evident (Leadbeater, 1972d).

Observed in Saanich Inlet: No cells were found but large numbers of the distinctive scales were seen. Plate scales were round to oval, 1.0-1.1 μm in diameter with typical proximal and distal markings. The cylinders ranged in height from 0.9 - 1.3 μm with base plates of 0.6-0.7 μm diameter. Radial markings were evident on the cylinder base plate. Found in samples 4, 5 and 6 (July, Aug. and Sept.).

Previous records: Norway (Leadbeater, 1972d), Jugoslavia and Bay of Algiers (Leadbeater, 1974) and Denmark (Manton and Leadbeater, 1974).

C. minor Parke and Manton 1955

Figures 85-91.

Description: Cells are 3-5 μm in diameter. Two equal flagella are 2-3 times the cell diameter. The haptonema is slightly shorter than the flagella. Cells are covered with scales, circular to ellipsoid, sometimes hexagonal to octagonal 0.2 x 0.3-0.5 x 0.7 μm in size (Parke *et al.*, 1955).

Observed in Saanich Inet: Cells were 3.0-5.0 μm in diameter with some haptonema shorter than the flagella and some slightly longer than the flagella. Flagellar length ranged from 10.0-14.5 μm. Scales were circular (0.2-0.3 μm), oval (0.3 x 0.4 μm) and oval to octagonal (0.3-0.4 x 0.4-0.5 μm) bearing radial lines. Octagonal scales had projecting rims. Found in sample 5 (Aug.) where it was very abundant.

Previous records: England (Parke *et al.*, 1955), Norway (Throndsen, 1969; Leadbeater, 1972c), Jugoslavia and Bay of Algiers (Leadbeater, 1974), Denmark (Manton and Leadbeater, 1974) and Australia (Hallegraeff, 1983).

Figure 85. *C. minor.* Whole cell with two equal flagella and central haptonema longer than flagella. Scale bar = 2.0 μm.

Figure 86. *C. minor.* Whole cell with two equal flagella and haptonema shorter than flagella. Scale bar = 0.2 μm.

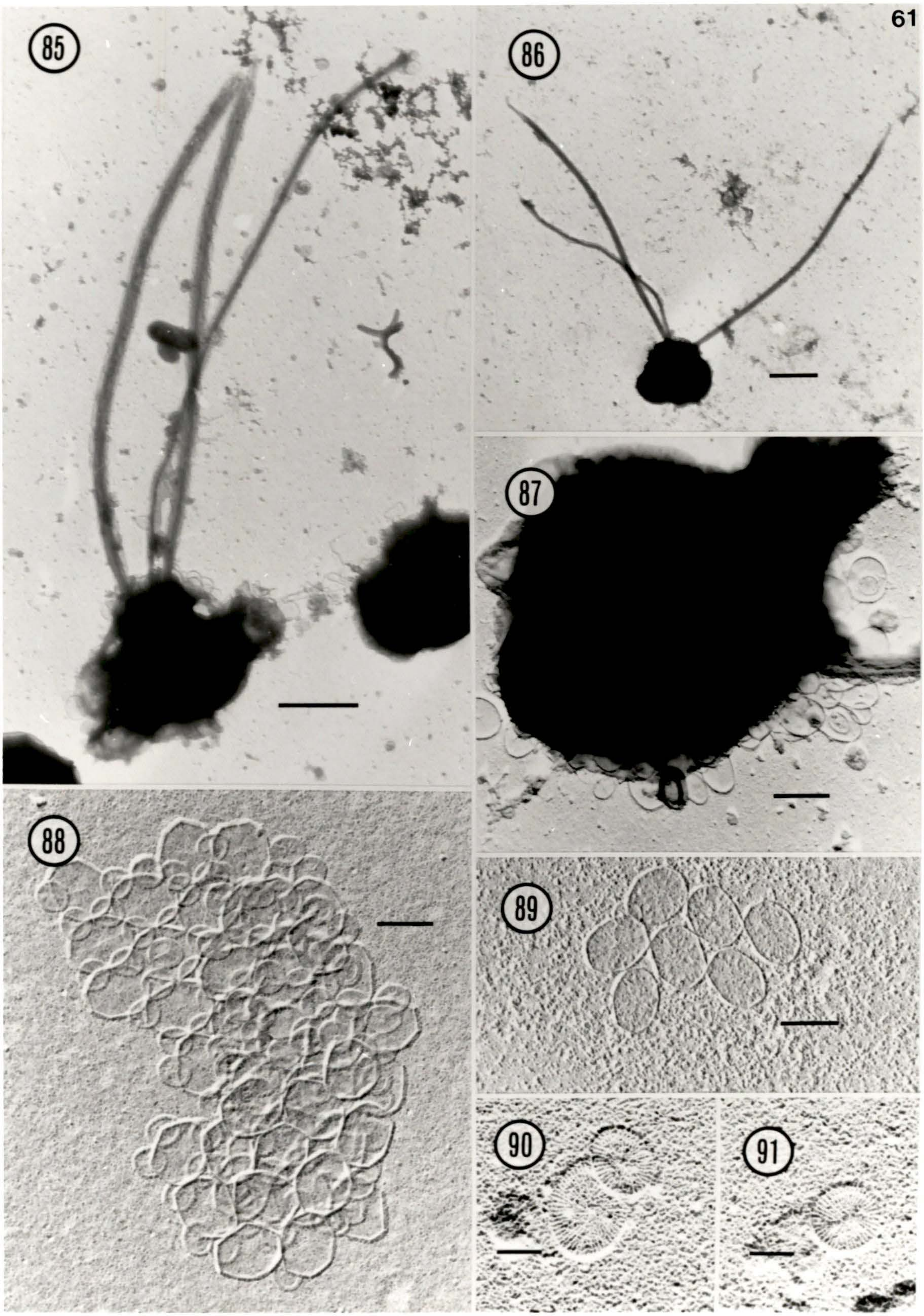
Figure 87. *C. minor.* Cell body with scales around cell.

Scale bar = 0.5 μm.

Figure 88. *C. minor.* Field of scales showing octagonal, round and oval scales. Octagonal scale has two sides, one with rims projecting up, the other with rims projecting away. Scale bar = 0.5 μm.

Figure 89. *C. minor.* Field of octagonal scales all with rims projecting up. Scale bar = 0.5 μm.

Figures 90 and 91. *C. minor.* Oval and circular rimless scales with radial markings. Scale bar = 0.2 μm.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C. parkeae Green and Leadbeater 1972

Figures 92-99.

Description: Cells are elongate, 10.0-26.0 μm long and 5.0-10.0 μm wide, with two equal flagella 8-20 μm long. The haptonema is 2.5-4.5 μm. Four types of scale cover the cell. Large elliptical scales (2.2-5.0 x 1.3-3.5 μm) have radiating and crescentric ridges on their proximal surface and a raised peripheral flap and irregular fibrillar markings on their distal surface. Another elliptical scale (1.3-4.1 x 0.7-2.8 μm) resembles the larger scale with curved and straight ridges proximally and irregular fibrils distally. This scale has marginal pores. Small elliptical scales (1.3- on their distal surface and radiating ridges proximally. Spines are 20-30 μm long with a cross banded shaft and spoon shaped base (Green and Leadbeater, 1972).

Observed in Saanich Inlet: Cells were 5.0-6.0 x 9.0-18.0 μm with flagella of 10.0-12.0 μm. No intact haptonema were found. Large elliptical scales were 2.0-2.5 x 1.3-1.9 μm. Medium scales ranged from 1.6-1.9 x 0.9-1.3 μm. Small scales were 1.3-1.8 x 0.6-0.7 μm. All scales had typical markings. Found in samples 3 and 4 (June and July); it was very common in June.

Previous records: England and Norway (Green and Leadbeater, 1972), Jugoslavia and Bay of Algiers (Leadbeater, 1972), Denmark (Manton and Leadbeater, 1974), New Zealand (Moestrup, 1979), Australia (Hallegraeff, 1983) and the North Atlantic Ocean (Estep *et al.*, 1984).

C. polylepis Manton and Parke 1962

Figures 100 and 101.

Description: Cells are 6-12 μm, with flagella equal or subequal, 2-3 times body length with a haptonema shorter than the flagella (1-1.5 times body length). Four scale types cover the cell. Large oval scales (1.4 x 1.2 μm) with rims projecting

Figure 92. *C. parkeae*. Whole cell showing elongated shape and scales and spines surrounding cell body. Scale bar = 5.0 μm.

Figure 93. *C. parkeae*. Distal face of small elliptical scale with cross-striated peripheral border. Scale bar = 0.5 μm.

Figure 94. *C. parkeae*. Proximal face of large elliptical scale with radiating and crescentric markings. Scale bar = 0.5 μm.

Figure 95. *C. parkeae*. Distal face of large elliptical scale showing fibrillar markings and a projecting peripheral rim. Scale bar = 0.5 μm.

Figure 96. *C. parkeae*. Whole cell showing cells and two equal flagella. Scale bar = 5.0 μm.

Figure 97. *C. parkeae*. Medium elliptical scales showing proximal face with curved and radial striations and small peripheral pores. Scale bar = 0.5 μm.

Figure 98. *C. parkeae*. Base of spine showing spoon shape. Scale bar = 0.5 μm.

Figure 99. *C. parkeae*. Field of scales with large, medium and small elliptical scales. Scale bar = 0.5 μm.

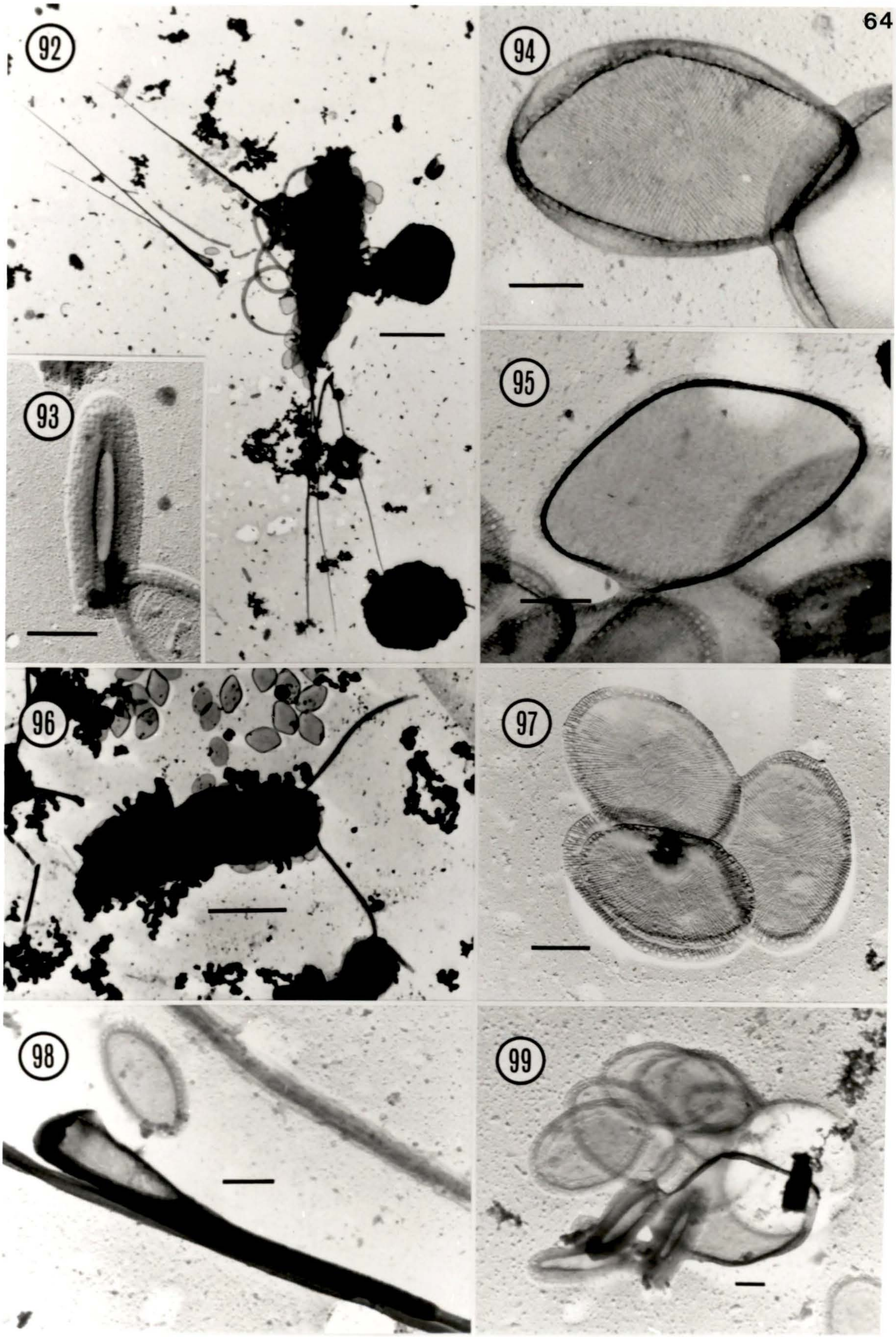
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Figure 100. *C. polylepis*. Whole cell with two flagella and coiled haptonema. Scale bar = 5.0 μm.

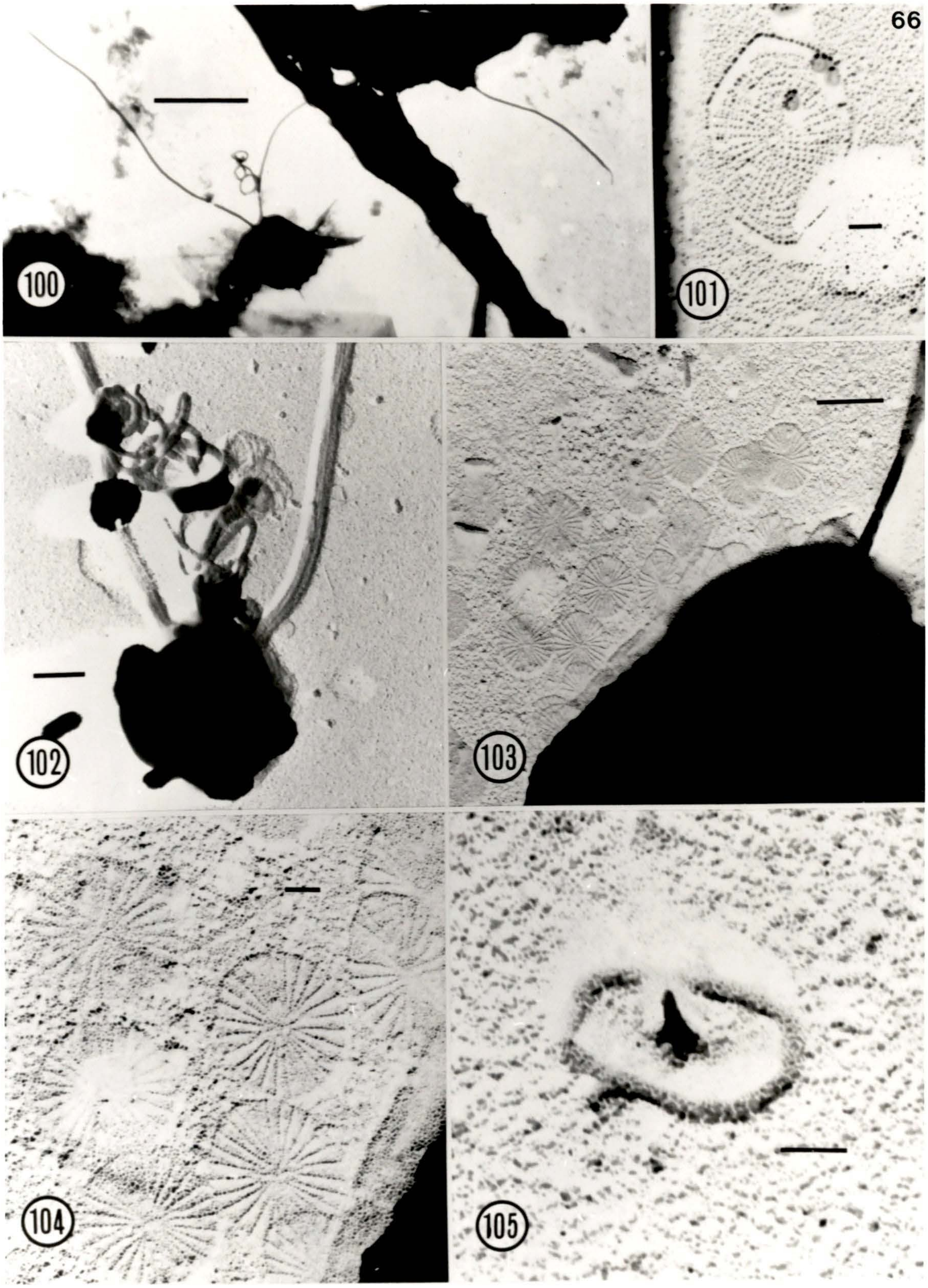
Figure 101. *C. polylepis*. Proximal face of large oval scale; collapsed rim gives scale an angular shape. Radial and concentric striations are visible. Scale bar = 0.1 μm.

Figure 102. *C. simplex*. Whole cell with two flagella and long coiling haptonema. Scale bar = 1.0 μm.

Figure 103. *C. simplex*. Cell body with adjacent field of scales. Scale bar = 0.5 μm.

Figure 104. *C. simplex*. Scales showing proximal side with rimless margin and radial striations. Scale bar = 0.1 μm.

Figure 105. *Corymbellus aureus*. Spine scale with oval base plate and raised rim. Scale bar = 0.1 μm.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distally have a ribbed pattern with a meshwork of holes on both surfaces. Large elongated scales (2.5 x 0.9 μm), which are relatively rare, have a similar ribbed pattern and meshwork of holes as well as forked projections at one end. Small rounded scales (0.8 x 0.6 μm) have a meshwork of holes and a ribbed pattern proximally and a patternless rim distally as well as two central bulbosities. Small elongated scales (1.2 x 0.6 μm) have a relatively patternless distal surface and a strong ridged proximal surface. A wide rim is flexed toward the distal surface.

Observed in Saanich Inlet: Cells were 4.0 x 4.0 μm in diameter with equal flagella (17.0 μm) and haptonema shorter than flagella. Several damaged specimens with poorly preserved scales were seen. Large oval scales (0.8-1.3 x 1.1-1.3 μm) were the most distinguishable with obvious ribbing and evidence of a meshwork of holes. An angular outline due to the collapsed rim is characteristic of this scale. Found in samples 5 and 9 (Aug. and Dec.).

Previous records: England (Manton and Parke, 1962), Norway (Leadbeater, 1972) and Denmark (Manton and Leadbeater, 1974).

C. simplex Estep *et al.* 1984

Figures 102-104.

Description: Cells are 2.0-6.0 μm in diameter, with two equal flagella 9-27 μm in length and a haptonema much longer than the flagella. Cell is covered with circular scales which vary in size (0.4-1.0 μm in diameter). The proximal face of the rimless scale has a radial pattern, the distal face has concentric markings. Some scales have two ovate dimples near the center (Estep *et al.*, 1984).

Observed in Saanich Inlet: Cells ranged from 2.7-4.0 μm in diameter with flagella from 7.0-12.6 μm. Scale size was 0.4-0.5 μm. Found in samples 2, 3, 4 and 5 (May, June, July and Aug.).

Previous records: New Zealand (Moestrup, 1979) and Australia as "Plymouth 384" (Hallegraeff, 1983), North Atlantic Ocean (Estep *et al.*, 1984) and North Pacific Ocean (Hoepffner and Haas, 1990).

Corymbellus aureus Green 1976

Figure 105.

Description: Cells are 8.0-11.0 x 7.5-10.0 μm in diameter with two subequal flagella and a short haptonema (3.9 μm). Cells aggregate to form motile colonies up to 200 μm in diameter. Oval body scales, 0.3-0.35 x 0.21-0.25 μm, with raised rims have a pattern of radiating ridges and a short four-strutted spine. There are also smaller oval scales without spines (0.2-0.24 x 0.10-0.15 μm) (Green, 1976).

Observed in Saanich Inlet: No cells were identified but several scales were seen. This is not surprising as the large colonies would be removed by initial filtering of samples. Size of scales was 0.37 x 0.22 μm in diameter with spine length of 0.15 μm. Found in sample 3 (June).

Previous records: England (Green, 1976), New Zealand (Moestrup, 1979), Australia (Hallegraeff, 1983), North Atlantic Ocean (Estep *et al.*, 1984), North Sea (Gieskes and Kraay, 1986) and North Pacific Ocean (Hoepffner and Haas, 1990).

Phaeocystis pouchetii (Hariot) Lagerheim

(= *Tetraspora pouchetii* Hariot in Pouchet 1892)

Figures 106-110.

Description: This species has at least two life forms, one a motile flagellate and the other a non-motile colony. The flagellated form is spherical with diameter 3.0-10.0 μm, two equal flagella with tapered ends and a short haptonema with a distal swelling. Two types of scale cover the cell. Circular flat scales (0.18 x 0.19 μm) have

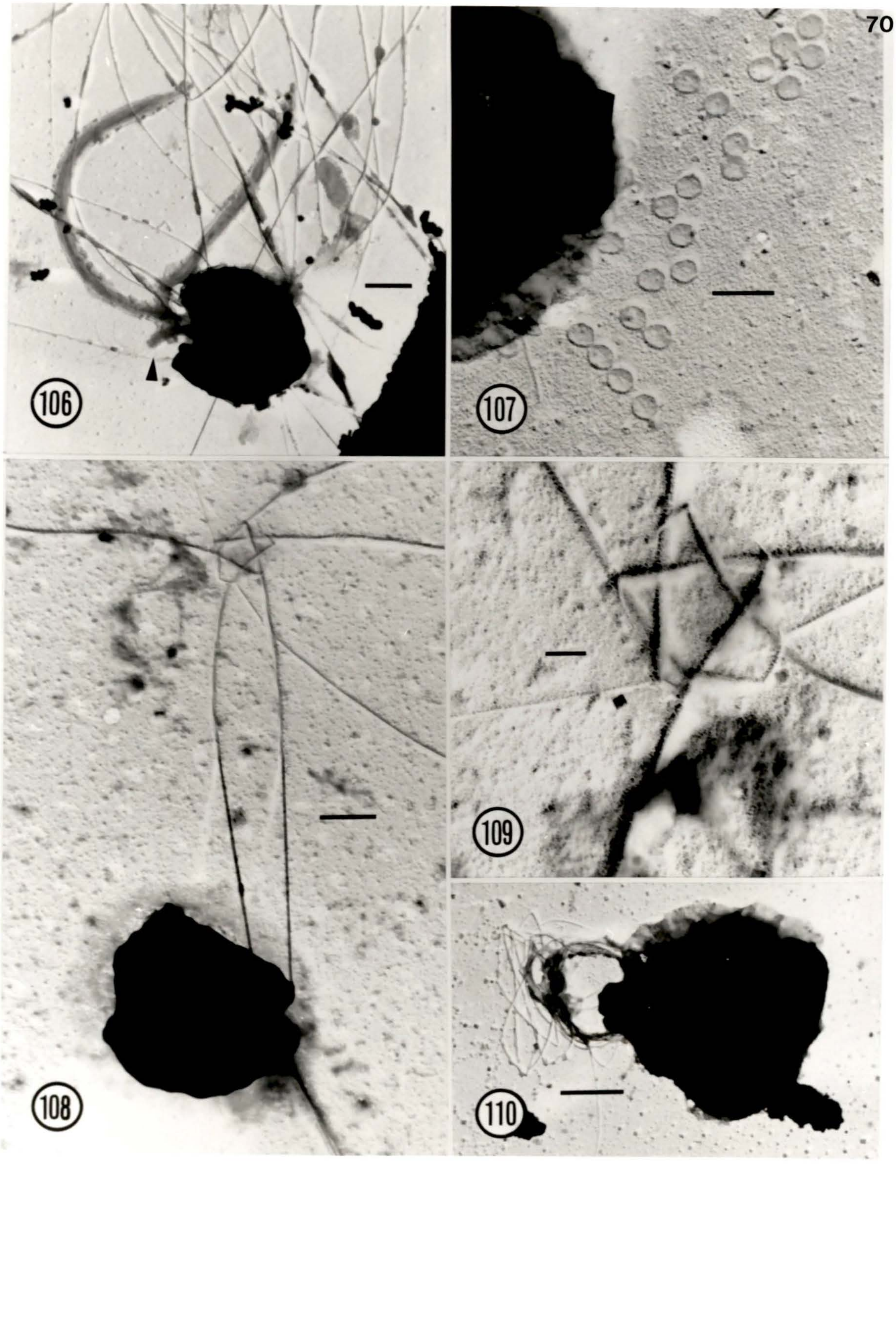
Figure 106. *Phaeocystis pouchetii*. Whole cell with two equal flagella with tapered ends and a short haptonema (arrow). Cell is surround by threads. Scale bar = 1.0 μm.

Figure 107. *P. pouchetii*. Field of round body scales adjacent to cell body. Scale bar = 0.5 μm.

Figure 108. *P. pouchetii*. Cell body without flagella or haptonema with attached threads arranged in pentagon. Scale bar = 1.0 μm.

Figure 109. *P. pouchetii*. Threadlike filaments in pentagonal pattern. Scale bar = 0.2 μm.

Figure 110. *P. pouchetii*. Cell body without appendages but recognizable by the coiled threads attached to it. Scale bar = 1 μm.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upstanding rims and radiating ridges on both surfaces. Smaller, oval scales (0.10 x 0.13 μm) have a radiating pattern and inflexed rims. Often threadlike filaments with a diameter of 0.05 μm and lengths up to 50 μm surround cells. These threads are arranged in groups of five with proximal ends held together in a pentagonal pattern (Parke *et al.*, 1975). Colonies consist of cells (7.0-8.0 μm), without flagella or scales, entrapped in a gelatinous matrix forming spherical or ellipsoid colonies up to 20 mm in size (Chang, 1983).

Observed in Saanich Inlet: The motile form of *P. pouchetii* had diameters of 3.0-5.4 μm and flagellar length of 5.9-7.0 μm. Haptonema were 1.0-1.5 μm. Scales, which were difficult to find, were 0.23 x 0.23 μm and 0.14 x 0.14 μm. Colonial forms were not seen but colonies would be filtered out of sample before examination and individual cells from colonies are not identifiable with shadow casting. Found in all samples.

Previous records: England (Parke *et al.*, 1971), Gulf of Elat (Thomsen, 1978), Greenland (Thomsen, 1982), Antarctica (Buck and Garrison, 1983), North Atlantic Ocean (Lagerheim, 1896; Estep *et al.*, 1984), Australia (Hallegraeff, 1983), New Zealand (Moestrup, 1979; Chang, 1983), North Pacific Ocean (Booth *et al.*, 1982; Hoepffner and Haas, 1990), Firth of Clyde (Hannah and Boney, 1983), Norway (Leadbeater, 1972c), Denmark, (Manton and Leadbeater, 1974), Jugoslavia and Bay of Algiers (Leadbeater, 1974).

Order Isochrysidales

Organisms in this order either lack a haptonema or if one is present it is rudimentary and undetectable with the light microscope. Motile cells have two smooth flagella of equal or subequal length (Green and Parke, 1975).

Family Prinsiaceae

Organisms in which the vestigial haptonema lacks microtubules (Norris, 1982).

Dicrateria inornata Parke 1949

Figures 111 and 112.

Description: Cells are spherical or ovate (3.0-5.5 μm) with two smooth, unequal flagella (7.0-9.0 μm) which are shortly tapered distally. Haptonema absent. Neither flagellar scales nor body scales have been recorded (Green and Pienaar, 1977).

Observed in Saanich Inlet: Cells were slightly smaller than the species description with dimensions of 2.2-2.6 x 2.8-3.2 μm. Short flagellar lengths were 5.2-5.8 μm; large flagella were 7.0-7.5 μm. Found in samples 2, 3, 4 and 5 (May, June, July and Aug.).

Previous records: England and Friday Harbor, Washington (Green and Pienaar, 1977), Norway (Leadbeater, 1972; Throndsen, 1970), Indian Arm, B.C. (Buchanan, 1966). *Dicrateria* sp. recorded from Saanich Inlet (Takahashi *et al.*, 1978; Watanabe, 1978).

Imantonia rotunda Reynolds 1974

Figures 113-116.

Description: Cells are spherical, 2.0-4.0 μm in diameter, with two widely divergent flagella (3.0-7.0 μm) with tapered ends. Haptonema is absent. A delicate subcircular scale, 0.45-0.68 μm in diameter has radiating ridges and a thickened rim. A second scale type, 0.72-0.8 μm in diameter, with broad upturned rims and radiating ridges is sometimes present (Reynolds, 1974; Green and Pienaar, 1977).

Observed in Saanich Inlet: Cells had diameters ranging from 2.8-3.5 μm. Flagella were both equal and subequal and ranged from 3.0-5.2 μm. Flagella had hairpoints rather than the tapered ends seen in the type material. Scales of only one

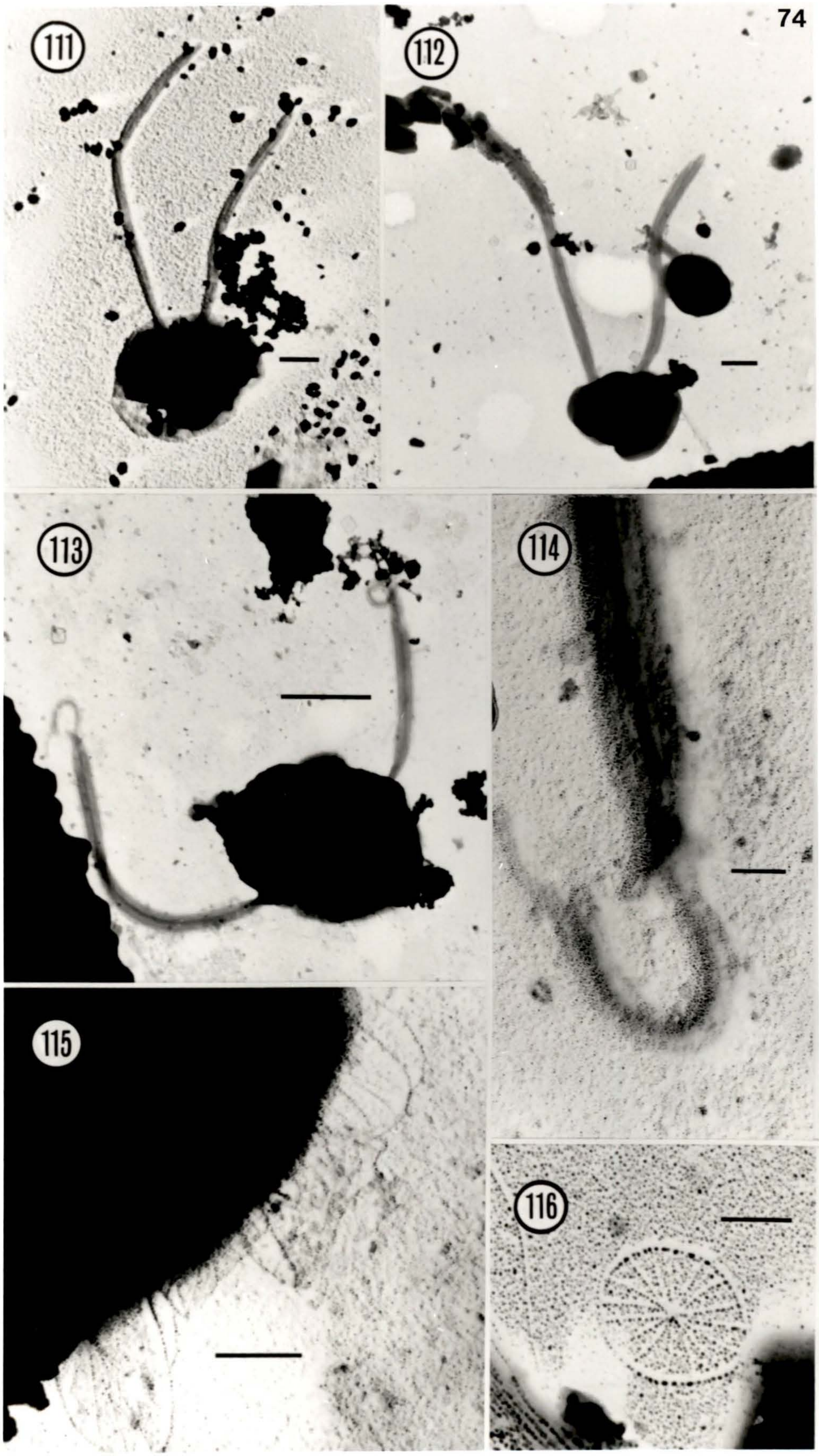
Figures 111 and 112. *Dicrateria inornata.* Whole cells with two unequal flagella. Cells have no haptonema or body scales. Scale bar = 1.0 μm.

Figure 113. *Imantonia rotunda.* Whole cell with two equal flagella with hairpoint tips. Scale bar = 1.0 μm.

Figure 114. *I. rotunda.* Flagellum with hairpoint tip. Scale bar = 0.3 μm.

Figure 115. *I. rotunda.* Cell body with delicate scales protruding. Scale bar = 0.3 μm.

Figure 116. *I. rotunda.* Scale showing radiating ridges and thickened rim. Scale bar = 0.3 μm.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type were seen, which is consistent with specimens found at Friday Harbor, Washington (Green and Pienaar, 1977). Round scales (diameters from 0.55-0.6 x 0.6-0.7 μm) were delicate, with radial striations and rims. Found in samples 3, 5, 11 and 12 (June, Aug., Feb. and Mar.).

Previous records: Ireland (Reynolds, 1974), England and Washington (Green and Pienaar, 1977) and Australia (Hallegraeff, 1983).

Order Coccosphaerales

Coccolith forming organisms many of which are known only from their coccoliths on which taxonomy is based (Bold and Wynne, 1985).

Family Hymenomonadaceae

Wigwamma Manton, Sutherland and Oates 1977

Coccolithophores with two equal flagella and a short haptonema. Calcification is limited to rims of plates. Rims carry a superstructure of rod crystallites converging to a point distally. Rectangular rim crystallites are joined end to end. Patterning on the rest of plate is irregular fibrils. Rimless, unmineralized plates are also present (Manton *et al.*, 1977).

W. annulifera Manton, Sutherland and Oates 1977

Figures 117-120.

Description: Cell is circular (5 μm diameter). Coccoliths are oval (0.9-1.1 x 1.2-1.5 μm) without superstructures except at the flagellar pole. Superstructure composed of 2 or 4 slender rods, 1.5-2.0 μm long converging distally. Each rod has a thin lamina (0.4-0.6 μm) attached to it. Rim crystallites are either rectangular (outer) or rod shaped (inner). Coccoliths without superstructures have two rows of rectangular rim crystallites (Manton *et al.*, 1977).

Figures 117 and 118. *Wigwamma annulifera.* Whole cells showing pyramidal coccolith superstructure (arrow) near flagella and oval coccoliths without superstructures surrounding the rest of cell. Scale bar = 1.0 μm.

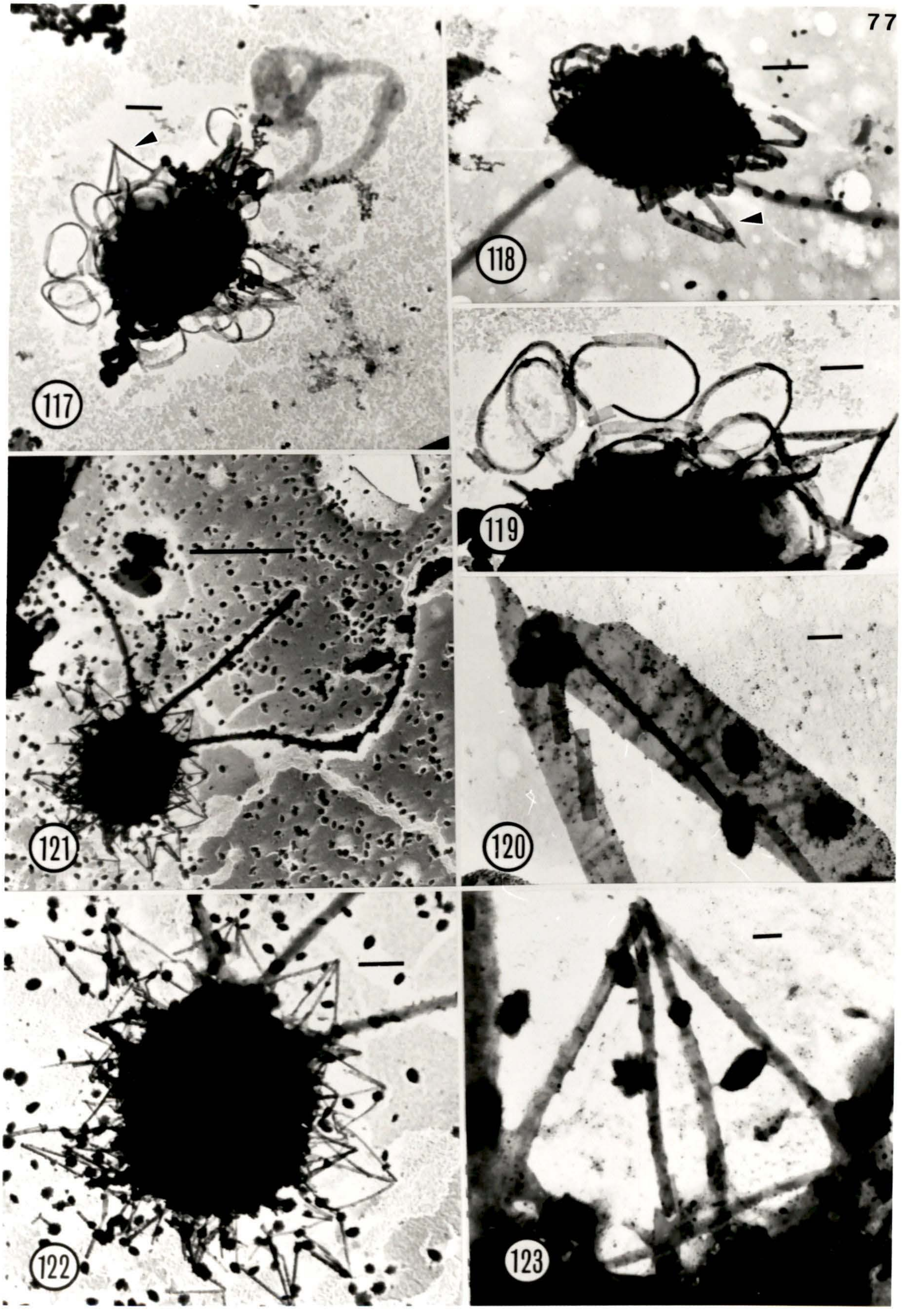
Figure 119. *W. annulifera.* Oval coccoliths with rectangular rim crystallites. Scale bar = 0.5 μm.

Figure 120. *W. annulifera.* Coccolith superstructure composed of rod shaped crystallites joined end to end converging to a point. Rods have lamina attached. Scale bar = 0.1 μm.

Figure 121. *W. arctica.* Whole cell with coccolith superstructures around entire cell. Two flagella and central, straight haptonema are visible. Scale bar = 5.0 μm.

Figure 122. *W. arctica.* Cell body with surrounding coccolith superstructures. Scale bar = 1.0 μm.

Figure 123. *W. arctica.* Coccolith superstructure of four rods converging in a conical pattern. Scale bar = 0.1 μm.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Observed in Saanich Inlet: Cell diameters ranged from 3.2-3.5 x 3.5-4.4 μm. Length of rods in superstructure was 0.9-1.4 μm and width of lamina 0.2-0.3 μm. Oval coccoliths were 1.3-1.5 x 1.0 μm. Found in samples 1 and 13 (April of both years).

Previous records: South Africa and Alaska (Manton *et al.*, 1977), Greenland (Thomsen, 1981) and the Weddell Sea, Antarctica (Thomsen *et al.*, 1988).

W. arctica Manton, Sutherland and Oates 1977

Figures 121-123.

Description: Cells are round with flagella up to 24 μm and a shorter haptonema. Coccoliths are round (1.5-2.0 μm) with rod shaped rim crystallites. Superstructures, which are present over entire cell, are 1.5 μm long rods joining distally in a conical group of four. Unmineralized plates with threadlike patterning are also present (Manton *et al.*, 1977).

Observed in Saanich Inlet: Diameter of cells was 4.5 μm with flagellar length of at least 14 μm and haptonema length of 7.4 μm. Crystallites of superstructures were 1.4 μm long and 0.07 μm wide. Found in sample 1 (Aril, 1990)

Previous records: Greenland (Manton *et al.*, 1977; Thomsen, 1981), Arctic Canada (Manton *et al.*, 1977), Denmark (Thomsen, 1981) and the Weddell Sea, Antarctica (Thomsen *et al.*, 1988).

Family Deflandriaceae

Cells covered with thinly calcified scales in which crystallites (square, rectangular or pentagonal) are arranged in two basal peripheral cycles with little or no overlapping. Some coccoliths have a buttressed central process (Norris, 1983).

Pappomonas virgulosa Manton and Sutherland 1975

Figures 124-128.

Description: Cells are round (5.0 μm) with two flagella (20 μm in length) and a short haptonema. Coccoliths are of two types. Calcified plate scales (1.0 x 0.6 μm) have loosely arranged crystallites on plate surface and erect blunt ended rim crystallites as well as smaller, flat rim crystallites. Coccoliths with appendages have similar rim crystallites and a central shaft (1.0 μm in length) ending distally in a tuft of 2, 3 or 4 rods (0.5 μm in length) (Manton and Sutherland, 1975).

Observed in Saanich Inlet: Cells had diameters ranging from 3.2-8.4 μm with flagellar length of 21.0 μm and a haptonema of 7.5 μm. Plate scales without appendages were 1.0 x 0.5 μm with erect, blunt rim crystallites. Smaller, flat crystallites were not obvious. Coccoliths (0.9 x 0.5 μm) with appendages (0.6 μm) had end tufts of 2 and 3. Found in samples 1 and 3 (Apr. and June).

Previous records: Greenland (Manton and Sutherland; Thomsen, 1981), Alaska (Manton *et al.*, 1976), Denmark (Thomsen, 1981), Finland (Thomsen, 1979) and Norway (Espeland and Throndsen, 1986).

Papposphaera sagittifera Manton, Sutherland and McCully 1976

Figures 129-131.

Description: Cells are circular, 4.0-8.0 μm in diameter with two flagella and a short haptonema. One type of coccolith covers the cell. Appendage of coccolith is composed of several crystallites arranged in four rows. The quadripartite appendage head is composed of four crystallites with unequal sides, the longest side directed outwards. Anterior appendages are longer (2.7-3.4 μm) than posterior appendages (1.8-2.0 μm). Base plate of coccolith is composed of parallel rod shaped crystallites and erect rim crystallites which are roughly pentagonal (0.25 μm)

Figure 124. *Pappomonas virgulosa*. Whole cell with surrounding coccoliths. Scale bar = 0.5 μm.

Figure 125. *P. virgulosa*. Coccolith with appendage of two rods and peripheral blunt sided rim crystallites. Scale without appendage also shows blunt sided rim crystallites. Scale bar = 0.3 μm.

Figure 126. *P. virgulosa*. Whole cell showing two flagella and central haptonema. Coccolith appendages protrude around cell and loose crystallites are lying adjacent to cell. Scale bar = 2.0 μm.

Figures 127 and 128. *P. virgulosa*. Coccolith appendages ending in tufts of two and three rods. Scale bar = 0.3 μm.

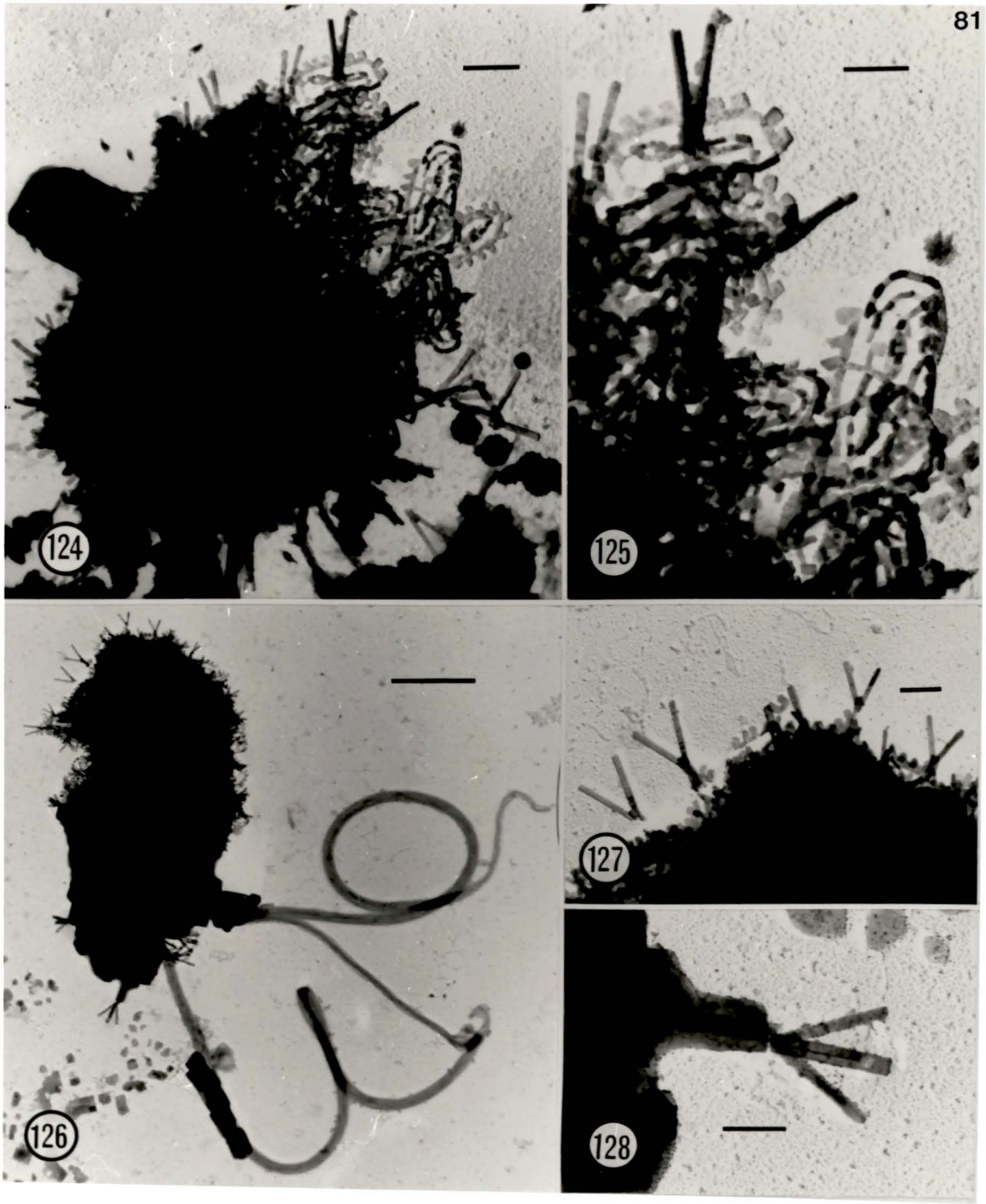
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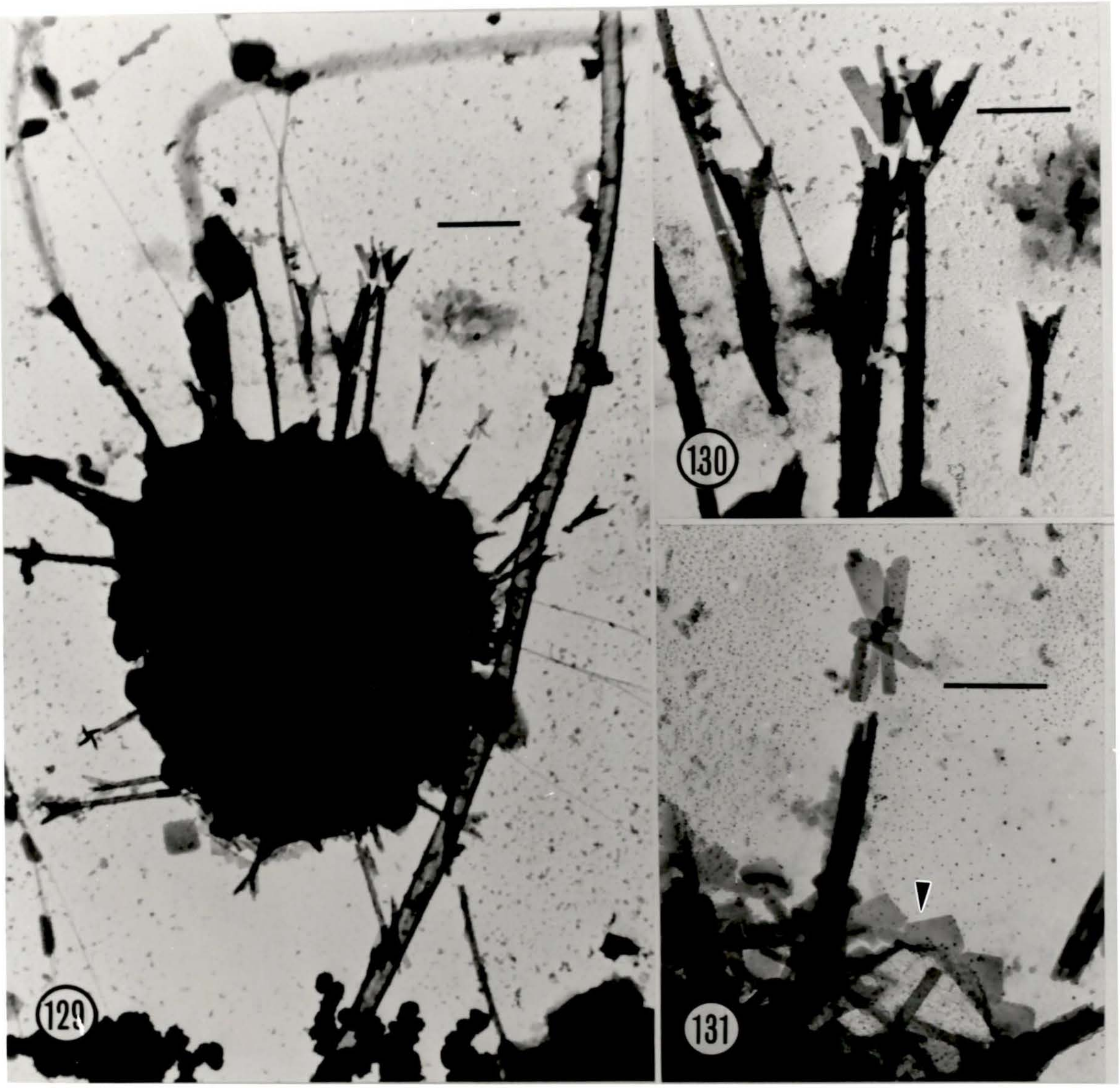
Figure 129. *Papposphaera sagittifera*. Whole cell has coccoliths with long appendages near flagella and shorter appendages at posterior end. Scale bar = 1.0 μm.

Figure 130. *P. sagittifera*. Longer anterior coccolith consisting of several crystallites supporting quadripartite appendage head. Scale bar = 0.3 μm.

Figure 131. *P. sagittifera*. Shorter posterior coccolith showing base plate with peripheral rim crystallites with pointed edge and pentagonal shape (arrow). Scale bar = 0.3 μm.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(Manton *et al.*, 1976; Thomsen, 1981).

Observed in Saanich Inlet: Cells had diameters of 5.0-5.2 μm with anterior coccolith appendages of 2.2 μm and posterior appendages of 1.2 μm. Pentagonal crystallites were 0.20 μm. Found in sample 1 (April, 1990).

Previous records: Alaska (Manton *et al.*, 1976), Greenland (Thomsen, 1981), and the Weddell Sea, Antarctica (Thomsen, *et al.*, 1988).

Family Zygosphaeraceae

Coccoliths are built up entirely of microcrystals with regular crystallographic features.

Balaniger balticus Thomsen and Oates 1978

Figures 132 and 133.

Description: Cells are saddle shaped, 3.1-4.7 x 3.8-6.0 μm, with two unequal flagella (20-26 μm) and a haptonema (7.0-8.8 μm) arising close together. Cell is covered with oval, rimmed organic scales (0.4-0.5 x 0.3-0.35 μm) with radiating ridges proximally and concentric ridges distally. Distal surfaces of scales bear small, calcified pyramidal structures 0.10-0.15 μm high and 0.10-0.15 μm wide at base. There are about ten pyramids per scale. Cells contain no functional chloroplasts; this is the first known completely heterotrophic prymnesiophyte (Thomsen and Oates, 1978; Thomsen, 1987).

Observed in Saanich Inlet: Only one specimen was found (diameter = 2.9 x 3.1 μm) which seemed to be dividing as there were two sets of flagella and haptonema. The two haptonema measured 8.1 and 4.6 μm. Measurement of the flagella was impossible because they were obscured by a grid bar. Pyramids resembled those described by Thomsen and Oates (1978) as having drawn out distal ends and were

Figure 132. *Balaniger balticus*. Whole cell with two sets of flagella and haptonema, probably a dividing cell. Scale bar = 2.0 μm.

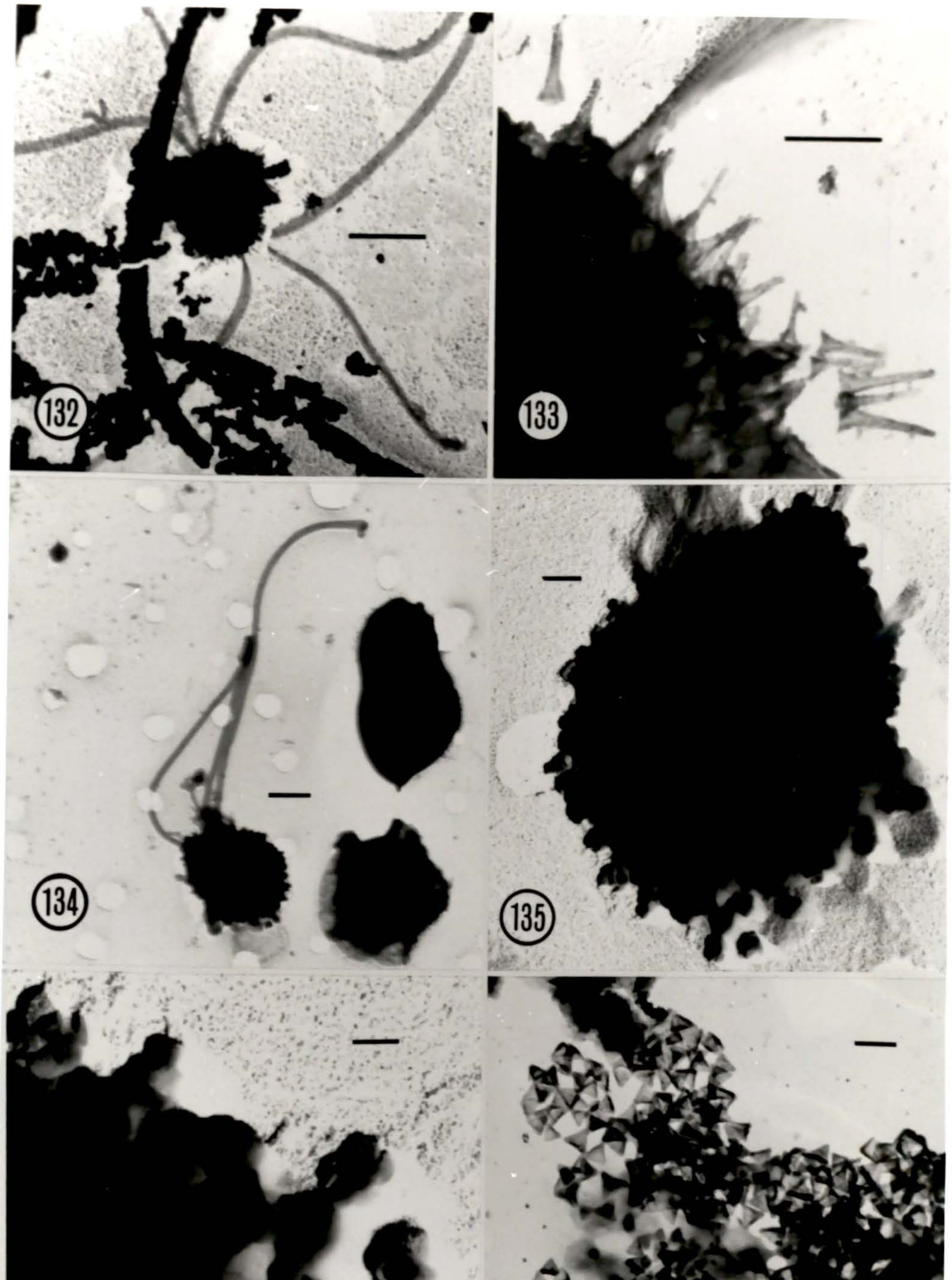
Figure 133. *B. balticus*. Pyramidal coccoliths on cell surface. Scale bar = 0.3 μm.

Figure 134. *Quaternariella obscura*. Whole cell with two flagella and haptonema. Scale bar = 2.0 μm.

Figure 135. *Q. obscura*. Cell body covered with four sided coccoliths. Scale bar = 0.5 μm.

Figure 136. *Q. obscura*. Coccoliths composed of rhombohedric crystallites arranged in fours. Scale bar = 0.2 μm.

Figure 137. *Trigonapsis* sp. Triangular crystallites which make up tower-like coccoliths. Scale bar = 0.2 μm.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taller (0.25-0.35 μm) than the type material. Bases of pyramids were 0.10-0.11 μm. No organic scales were seen. Found in sample 8 (Nov.).

Previous records: Denmark (Thomsen and Oates, 1978), Finland (Thomsen, 1979) and Greenland (Thomsen, 1980).

Quaternariella obscura Thomsen 1980

Figures 134-136.

Description: Cell body is 3.1-5.0 x 3.3-4.6 μm with two flagella (13.3-25.6 μm) and a shorter haptonema (7.5-14.6 μm). Subcircular coccolith base-plates (0.63-0.69 x 0.54-0.63 μm) are rimmed. Rhombohedric crystals (0.08-0.16 μm) are arranged in fours to form squares (0.18-0.28 μm) on the base plates. Cells appear as a dark spot with an irregular outline (Thomsen, 1980b).

Observed in Saanich Inlet: Cell size was 4.5 x 4.8 μm. Flagellar lengths were 13.1-13.5 μm with shorter haptonema. Crystals were 0.12 μm. Found in sample 3 (June).

Previous records: Greenland (Thomsen, 1980b).

Trigonaspis sp. Thomsen 1980

Figure 137.

Description: Biflagellate coccolithophorids with a short haptonema. Coccolith crystallites are small triangular plates composed of three subunits. Coccoliths are tower-like structures near the flagella (Thomsen, 1980c).

Observed in Saanich Inlet: One damaged cell with tower-like coccoliths made of triangular crystallites was seen. The shape of the coccolith could not be determined. Crystallites measured 0.13 μm. Found in sample 8 (Nov.).

Previous records: species belonging to the genus *Trigonaspis* have been found in Greenland, Norway, Denmark and Antarctica (Thomsen *et al.*, 1988).

Family Coccolithaceae Kamptner

Calcidiscus leptoporus (Murray and Blackman) Loeblich and Tappan

(=*Coccosphaera leptopora* Murray and Blackman 1898)

(=*Coccolithophora leptopora* (Murray and Blackman) Lohmann 1902)

(=*Coccolithus leptoporus* (Murray and Blackman) Schiller 1930)

(=*Cyclococcolithus leptoporus* (Murray and Blackman) Kamptner 1954)

Figure 138.

Description: Coccolith type is a placolith, which is a coccolith of two layers (=shields) separated by a cylindrical or tubular central piece. Placolith is circular with a circular pore. Distal surfaces of both shields have petaloid elements with curved suture lines with dextral imbrication distally and sinistral imbrication proximally. The proximal surfaces of both shields have straight suture lines radiating from the central column. The diameter of the distal shield ranges from 6.3-7.2 μm and the proximal shield ranges from 4.4-5.9 μm (McIntyre and Be, 1967).

Observed in Saanich Inlet: No complete coccospheres were found but coccoliths were seen. Diameter of the distal shield was 6.2 μm. Found in sample 11 (Feb.).

Previous records: Atlantic Ocean (tropical to subarctic and antarctic) (McIntyre and Be, 1967), Gulf of Mexico (Gaarder and Hasle, 1971) and Australia (Hallegraeff, 1984).

Emilania huxleyi (Lohmann) Hay and Mohler 1967

(=*Pontosphaera huxleyi* Lohmann 1902)

(=*Hymenomonas huxleyi* (Lohmann) Kamptner 1930)

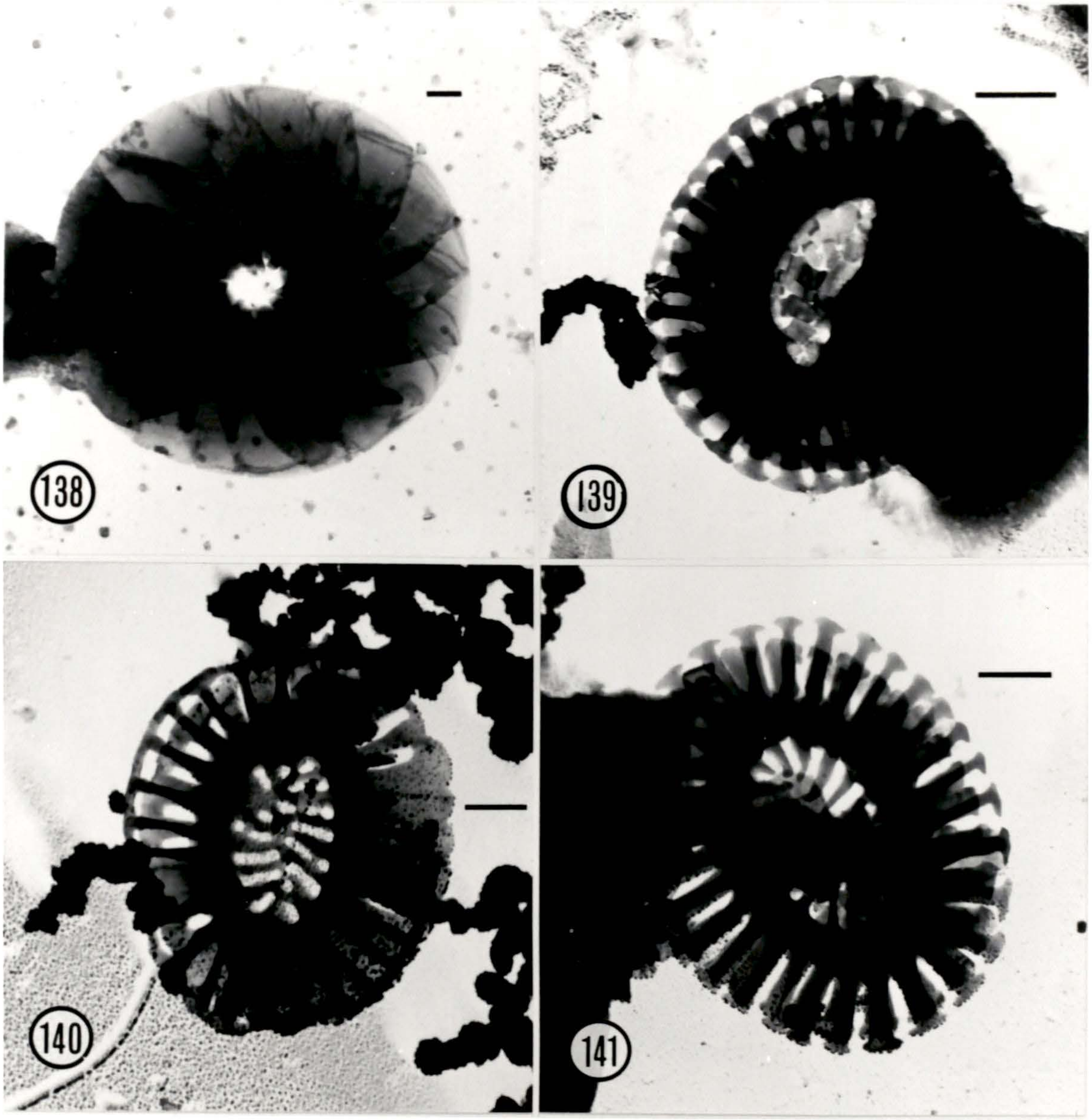
(=*Coccolithus huxleyi* (Lohmann) Kamptner 1943)

Figures: 139-141.

Description: Placolith is oval with an elliptical pore. Distal shield is made of "T"

Figure 138. *Calcidiscus leptoporus*. Distal shield of coccolith showing petaloid elements with curved suture lines around a circular pore. Scale bar = 0.5 μm

Figures 139-141. *Emilania huxleyi*. Coccoliths consist of two shields and an elliptical pore. Morphology varies. Fig. 139 has the pore covered by a plate of interlocking elements and "T" shaped peripheral elements. Fig. 140 has peripheral elements on the proximal shield flattened to a blunt shape, elliptical pore is covered by rods forming a grill. Fig. 141. has a grill covered pore and peripheral elements on both shields "T" shaped. Scale bar = 0.5 μm.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shaped elements which interlock at the margin. In warm water the proximal shield resembles the distal and the pore is covered by rods forming a grill. In cold water the elements of the proximal shield are flattened with blunt or slightly pointed margins and the pore is completely covered by a thin plate of interlocking elements. Also element number is less (23-33) in cold water than in warm water (30-40). Gradations between the two types are found. Shield dimensions range from 2.0-3.1 x 2.9-3.3 μm.

Observed in Saanich Inlet: No complete coccospheres were seen; coccoliths ranged from 2.0-2.9 x 2.5-3.3 μm. Most placoliths had proximal shields with at least some elements flattened. Pores with grills as well as those covered with interlocking plates were seen. Found in samples 8, 9, 10 and 11 (Nov., Dec., Jan. and Feb.).

Previous records: Atlantic Ocean (tropical to subarctic and subantarctic) McIntyre and Be, 1967), Gulf of Mexico (Gaarder and Hasle, 1971), Caribbean Sea (Throndsen, 1972), Pacific Ocean (Okada and Honjo, 1973; Hoepffner and Haas, 1990), Norway (Throndsen and Espeland, 1986), New Zealand (Moestrup, 1979; Norris, 1964), Australia (Hallegraeff, 1984) and Denmark (Manton and Leadbeater, 1974).

Class Chrysophyceae Pascher 1914

Bilaterally symmetrical cells with two unequal flagella inserted at oblique angles to each other. Long flagellum bears tripartite hairs and shorter flagellum is naked. Tripartite hairs have a short base, a long narrow tubular shaft and one or more tubular filaments. Flagellar transition region contains a transitional helix. One or two chloroplasts with regularly arranged three thylakoid lamellae are present in each cell. Cells form endogenous resting cysts. Orders defined by organizational level of the vegetative state (Hibberd, 1986).

Order Ochromonadales

Dominant vegetative state is motile, unicellular or colonial.

Family Paraphysomonadaceae Preisig and Hibberd 1983

Cells spherical, solitary or colonial, free swimming with two unequal flagella inserted approximately perpendicular to each other. Cells covered by siliceous scales or spines. There are no flagellar scales (Preisig and Hibberd, 1983).

Paraphysomonas Stokes 1885

Colorless genus with leucoplasts in place of chloroplasts. Two subapical flagella have perpendicular insertion. One flagellum is smooth and short and the other is longer and covered with hairs. Cell is covered with siliceous spines or scales which show variety in form, upon which the systematics of the genus is based.

Paraphysomonas butcheri Pennick and Clarke 1972

Figures 142-144.

Description: Cells are spherical, 2.4-3.0 μm in diameter. Long flagellum is 7.0-10.0 μm, short flagellum is 2.4-3.0 μm. Scales of two types cover the cell. One is an elliptical plate-scale (0.5-1.1 x 0.4-0.8 μm) with perforations arranged in rings. The

Figure 142. *Paraphysomonas butcheri*. Whole cell showing long hair covered flagellum and scales surrounding cell body. Scale bar = 2.0 μm.

Figure 143. *P. butcheri*. Cell body with surrounding scales. Arrow indicates apical ring of crown scales. Scale bar = 0.5 μm.

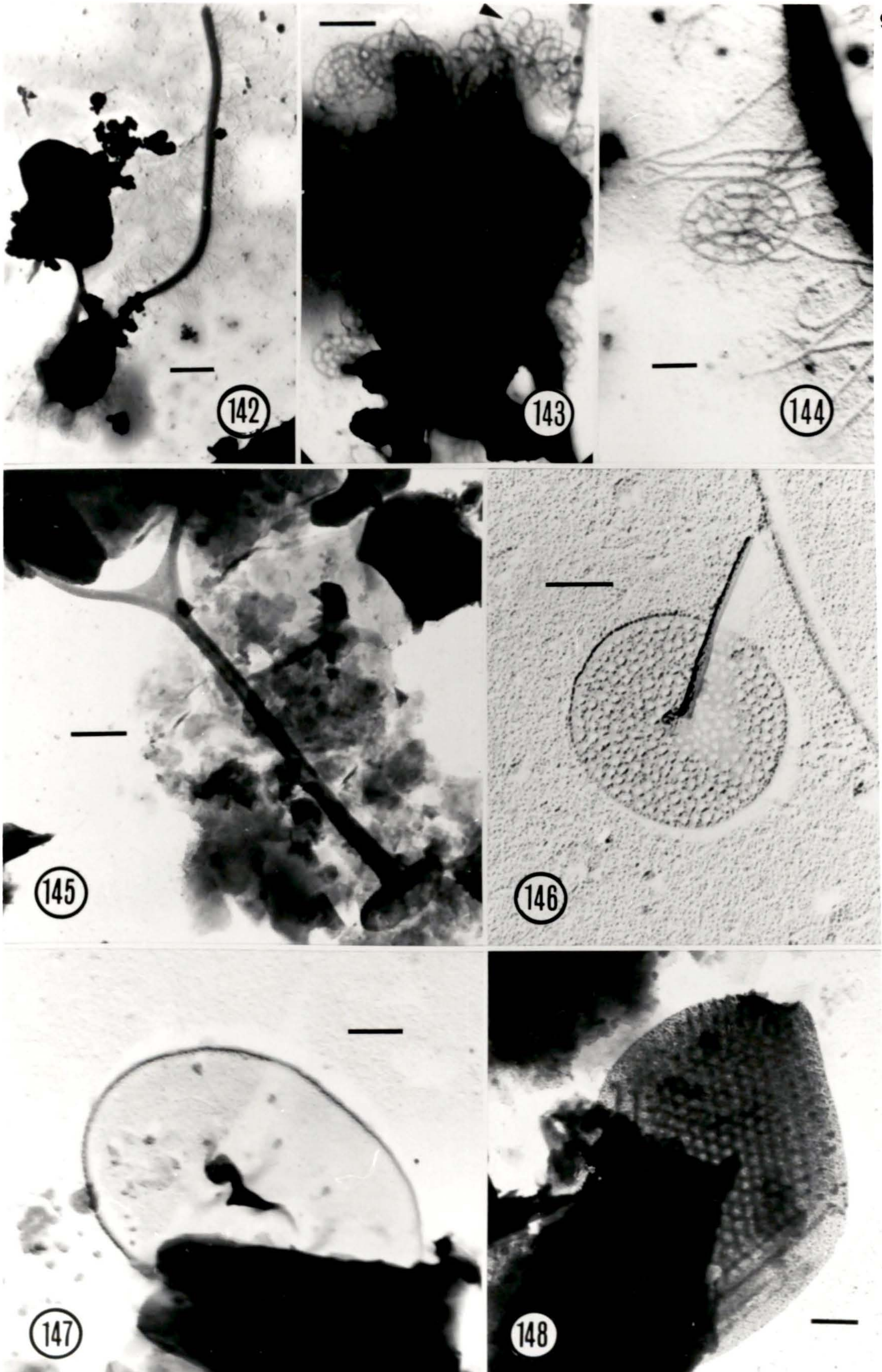
Figure 144. *P. butcheri*. Flagellum with tubular hairs and perforated plate scale. Scale bar = 0.3 μm.

Figure 145. *P. capreolata*. Spine scale showing flared base and bifurcated tips which are obscured with debris. Scale bar = 0.3 μm.

Figure 146. *P. foraminifera*. Spined scale with perforated base plate. Scale bar = 0.3 μm.

Figure 147. *P. gladiata*. Elliptical scale with upturned margin and short sharp spine. Scale bar = 0.3 μm.

Figure 148. *P. punctata punctata*. Proximal side of scale with small holes arranged in lines surrounded by a plain border. Scale bar = 0.3 μm.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other is a crown scale with basal and apical rings of 0.5-1.1 μm diameter connected by 5 or 6 perpendicular rods. The apical ring encloses an area of perforations. There is a tendency for one type of scale to predominate in any one cell (Pennick and Clarke, 1972).

Observed in Saanich Inlet: Cells were 2.2-3.2 μm in diameter with flagellar lengths of 12.0-12.8 and 1.7-2.0 μm. Plate scales, which measured 0.7-0.8 x 0.4-0.5 μm, appeared to dominate in most cells. Crown scales were 0.7-0.8 μm in diameter. Found in samples 5 and 12 (Aug. and Mar.).

Previous records: England (Pennick and Clarke, 1972), Norway (Leadbeater, 1972), Jugoslavia and Bay of Algiers (Leadbeater, 1974) and Denmark (Manton and Leadbeater, 1974; Thomsen, 1985).

P. capreolata Preisig and Hibberd 1982

Figure 145.

Description: Cell is 3.0-6.5 μm. Long flagellum is 15-28 μm and short flagellum is 1.2-1.6 μm. Spine scales and plate scales cover the cell. Spines have flared elliptical bases (2.0-2.0 x 1.5-2.0 μm) with thickened rims supporting a hollow tube which broadens and bifurcates forming two long (0.4-0.8 μm) pointed tips. Total length of spines is 1.4-5.3 μm. Plate scales are flat and elliptical ranging in size from 1.8-3.0 x 1.3-2.4 μm (Preisig and Hibberd, 1982a).

Observed in Saanich Inlet: Spines measured 2.1-2.5 μm with bifurcated tips of 0.8-0.9 μm. Found in sample 10 (Jan.).

Previous records: from freshwater in England (Preisig and Hibberd, 1982a).

P. foraminifera Lucas 1967

Figure 146.

Description: Cells are 3.1-4.4 μm with long flagellum 3-5 times body length and short flagellum equal to body length. Scales are 1.5-1.6 μm with a tapered end supported by a circular base plate (1.0-1.5 μm) perforated with concentric rings of pores (Lucas, 1967).

Observed in Saanich Inlet: Scales had base plates of 1.0 μm and spine lengths of 0.9 μm. This spine is shorter than the type material however Thomsen (1975) found a large variation in spine length (0.8-4.2 μm) in this species. Found in samples 10 and 11 (Jan. and Feb.).

Previous records: Italy (Lucas, 1967), Norway (Leadbeater, 1972e) and Denmark (Thomsen, 1985).

P gladiata Preisig and Hibberd 1982

Figure 147.

Description: Cells have diameters of 3.0-8.0 μm with a long flagellum of 11.0-33.0 μm and a short flagellum of 2.0-6.0 μm. Cells are covered with two types of scales. Both have unperforated elliptical base plates (1.3-4.4 x 1.2-3.8 μm) with an upturned margin. One scale has a long tapering spine (9.0 μm) whereas the other has a very short sharp spine (Preisig and Hibberd, 1982a).

Observed in Saanich Inlet: Scales with short spines measured 1.8-1.9 x 1.4 μm with spines of 0.2-0.3 μm. Found in samples 8 and 10 (Nov. and Jan.).

Previous records: from freshwater in England (Preisig and Hibberd, 1982a).

P. punctata Zimmerman ssp. *punctata* Preisig and Hibberd 1982

(=*Paraphysomonas punctata* Zimmerman 1981)

Figure 148.

Description: Cells are 3.0-7.0 μm in diameter with a long flagellum of 13.0-24.0

μm and a short flagellum of 2.5-4.0 μm. Cells are covered with oval plate scales (1.3-2.7 x 1.0-1.9 μm) with a plain border (0.1-0.2 μm). Central area of distal side of scale has small knobs arranged in lines, the proximal side is perforated with small holes arranged in lines (Thomsen *et al.*, 1981; Preisig and Hibberd, 1982b).

Observed in Saanich Inlet: Scales measured 1.0-1.8 x 1.6-2.4 μm with 0.2 μm borders around the perforations. Found in samples 8 and 10 (Nov. and Jan.).

Previous records: from freshwater in England (Preisig and Hibberd, 1982b), Denmark (Thomsen *et al.*, 1981) and Finland (Hallfors and Hallfors, 1988).

P. vestita ssp. *truncata* Preisig and Hibberd 1982
Figures 149-151.

Description: Cell is 4.0-6.0 μm in diameter with a long flagellum of 9.0-15.0 μm and a short flagellum of 2.0-3.0 μm. Cell is covered with spines with transverse striations and truncate ends. Length of spines ranges from 1.0-1.4 μm on a circular base plate of diameter 0.7-0.9 μm (Preisig and Hibberd, 1982a).

Observed in Saanich Inlet: Cells had diameters ranging from 2.2-4.0 μm and flagellar lengths of 14.5-14.7 μm and 1.5-2.2 μm. Spine length varied from 0.7-1.3 μm and base plate diameter from 0.6-0.8 μm. This is slightly smaller than the type material. Found in samples 3, 4, 5, 8, 10, 11 and 12 (June, July, Aug., Nov., Jan., Feb. and Mar.)

Previous records: from freshwater in England (Preisig and Hibberd, 1982a) and Denmark (Vors *et al.*, 1990).

P. vestita (Stokes) De Saedeleer spp. *vestita* Preisig and Hibberd 1982
(=*Paraphysomonas vestita* (Stokes) De Saedeleer 1929)
(=*Physomonas vestita* Stokes 1885)

Figure 149. *P. vestita truncata*. Whole cell with hair covered long flagellum, short flagellum is not visible. Scales are protruding around cell body. Scale bar = 2.0 μm.

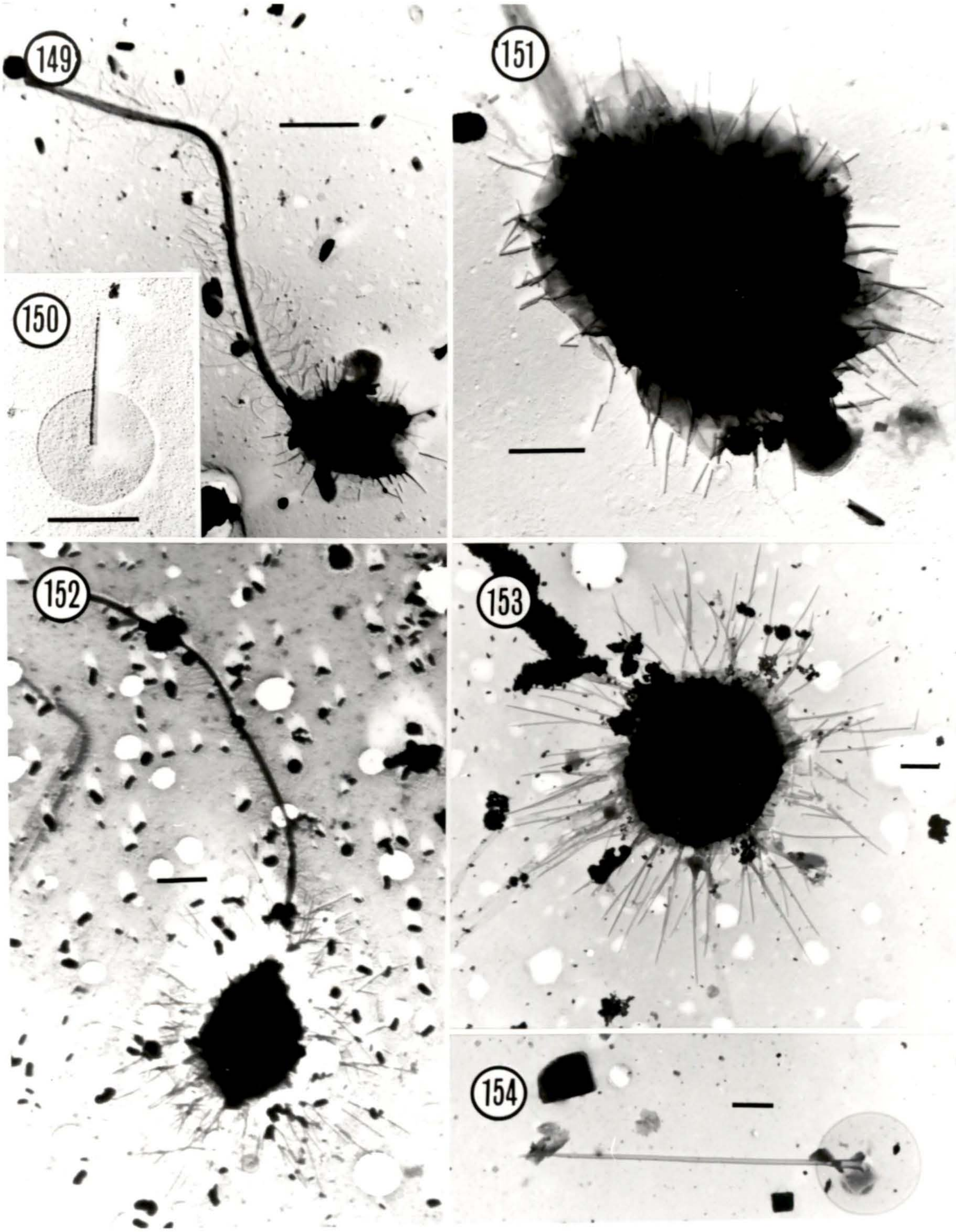
Figure 150. *P. vestita truncata*. Spined scale with short blunt ended spine. Transverse striations are visible on spine. Scale bar = 0.5 μm.

Figure 151. *P. vestita truncata*. Cell body with spines protruding around cell. Scale bar = 1.0 μm.

Figure 152. *P. vestita vestita*. Whole cell with long hair covered flagellum and spines protruding around cell. Scale bar = 2.0 μm.

Figure 153. *P. vestita vestita*. Cell body with long spines protruding. Scale bar = 1.0 μm.

Figure 154. *P. vestita vestita*. Spined scale with long tapering spine, base plate has thickened rim. Scale bar = 0.5 μm.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Figures 152-154.

Description: This subspecies differs from *P. vestita truncata* in having longer spines (1.3-12.5 μm) with tapering ends. Unperforated base plate of spine is circular (0.4-4.3 μm) with a thickened rim. Cells have diameters of 5.0-26.0 μm, with long flagellum from 15.0-54.0 μm and short flagellum 3.0-10.0 μm.

Observed in Saanich Inlet: Cells had diameters ranging from 5.2-6.9 μm. Spine length varied from 2.2-7.5 μm; base plate diameter ranged from 1.0-3.2 μm. Found in samples 3, 4, 8, 9 and 10 (June, July, Nov., Dec. and Jan.).

Previous records: Denmark (Thomsen, 1975), Norway (Leadbeater, 1972c), Jugoslavia and Bay of Algiers (Leadbeater, 1974) and Finland (Thomsen, 1979).

Family Mallomonadaceae Diesing 1866

Cells are solitary or colonial. Some species with one emergent and one vestigial flagellum, others with two equal flagella with parallel, apical insertion. Flagellar scales may be present. Cells are covered with silica scales (Preisig and Hibberd, 1983).

Mallomonas Perty 1851

This is a biflagellated freshwater genus, with one flagellum reduced to a peduncle. Cell membrane is covered with siliceous scales which often have needle like projections. Taxonomy is based on the structure of the scales.

Mallomonas akrokomos Ruttner in Pascher 1913 emended Bourrelly 1957

(=*Mallomonas pauciseta naumann* 1924)

Figures 155 and 156.

Description: Cell is pointed posteriorly (5-15 x 15-50 μm) with a tuft of bristles anteriorly. Three types of scale cover the cell. All scales have an oval area of close

Figure 155. *Mallomonas akrokomos*. Body scale with toothed anterior margin and central area of close perforations. Posterior end is thickened and has a single row of perforations. Scale bar = 0.5 μm.

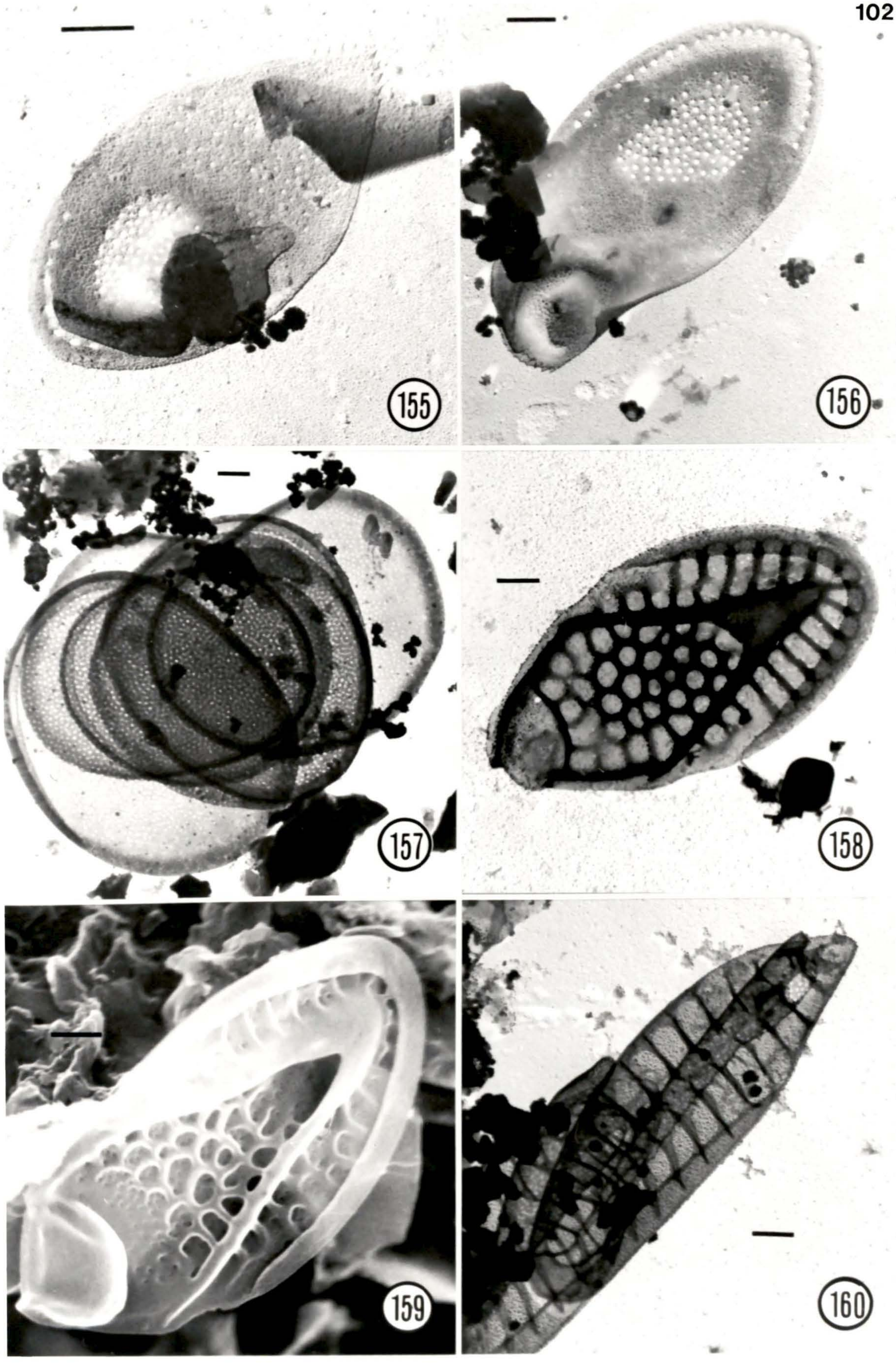
Figure 156. *M. akrokomos*. Anterior scale is asymmetric with a posterior dome for bristle attachment, central area of close perforations and peripheral row of perforations. Scale bar = 0.5 μm.

Figure 157. *M. caudata*. Subcircular body scales with upturned rims and small perforations. Scale bar = 1.0 μm.

Figure 158. *M. crassisquama*. Body scale with anterior dome for bristle attachment and characteristic network of perforations, ribs and struts. Scale bar = 0.5 μm.

Figure 159. *M. crassisquama*. Scanning electron micrograph of domed body scale showing three dimensional structure of scale. Scale bar = 0.5 μm.

Figure 160. *Synura petersenii*. Scale with perforated base plate, transverse ribs and inflexed rims. Scale bar = 0.5 μm.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perforations near the posterior end and a toothed anterior margin. Posterior scales are slender and tapered toward the thickened posterior end. Body scales are rhombic with a thickened posterior margin inside of which is a single row of perforations. Asymmetric anterior scales have a dome for attachment of bristles and a peripheral row of perforations. Number of toothed bristles (8-35 μm) varies from 3 to 6 (Harris, 1958).

Observed in Saanich Inlet: Anterior scales ranged from 2.3-2.4 x 4.1-4.9 μm, body scales were 3.1 x 2.0 μm and elongated posterior scales were 1.7-1.9 x 3.2-3.4 μm. Found in samples 10 and 11 (Jan. and Feb.).

Previous records (Canadian): from freshwater Otter Lake, B.C. (Green, 1980), Lower Fraser Valley (Donaldson and Stein, 1984), Linnet Lake, Alberta (Kristiansen, 1975), Ontario (Nicholls, 1982) and MacKenzie Delta, NWT (McKenzie and Kling, 1989).

M. caudata Iwanov 1899 emended Krieger 1930

Figure 157.

Description: Cell is covered with large, subcircular scales with upturned rims and numerous uniformly arranged small holes. Bristles are long, curved and distally have conspicuous teeth (Kristiansen, 1980).

Observed in Saanich Inlet: Scales were numerous and measured 6.1-6.2 x 7.1 μm. Found in sample 11 (Feb.).

Previous records (Canadian): from freshwater Otter Lake, B.C. (Green, 1980), northern Manitoba (Kling and Kristiansen, 1983), Lower Fraser Valley, B.C. (Donaldson and Stein, 1986) and Ontario (Nicholls, 1982).

M. crassisquama (Asmund) Fott 1962

(=*Mallomonas acaroides* Perty em. Iwanov var. *crassisquama* Asmund 1959)
Figures 158 and 159.

Description: Ovoid cells are 10.0-29.0 x 6.0-18.0 µm with siliceous scales and bristles. Four types of scale cover the cell; asymmetric anterior domed scales, asymmetric body scales with domes, symmetric body scales without domes and posterior spined scales. All scales have a network of ribs and struts and a pronounced mesh. Scales range from 2.7-6.0 x 1.9-3.8 µm. Bristles are 8-30 µm (Siver and Skogstad, 1988).

Observed in Saanich Inlet: A large number of domed body scales were seen. Sizes ranged from 3.8-3.9 x 6.4-6.7 µm. Found in samples 10 and 11 (Jan. and Feb.).

Previous records (Canadian): from freshwater Otter Lake, B.C. (Green, 1980), Hobiton, Kichha and Tsusiak lakes, B.C. (Green, 1979), interior B.C. (Kristiansen, 1975), Lower Fraser Valley, B.C. (Donaldson and Stein, 1984), northern Manitoba (Kling and Kristiansen, 1983), Ontario (Nicholls, 1982) and MacKenzie Delta, NWT (McKenzie and Kling, 1989).

Synura petersenii Korshikov
(=*Synura glabra* Korshikov 1929)
(=*Synura petersenii* v. *glabra* (Korshikov) Huber-Pestalozzi 1941)
Figure 160.

Description: Cells which are arranged in spherical colonies have two unequal flagella. Scales are oval to elliptical and have forward and upward projecting spines mounted on a median fold. Base plate is perforated and transverse ribs extend to scale border. Rim of scale is upturned. Scales toward the posterior end of the cell are more elongated and spines are not as raised as the anterior end. Morphology of scales can vary (Kristiansen, 1980).

Observed in Saanich Inlet: Scales were 1.8-2.0 x 6.6 μm. Found in samples 10 and 11 (Jan. and Feb.).

Previous records (Canadian): from freshwater interior B.C. lakes (Kristiansen, 1975), northern Manitoba (Kling and Kristiansen, 1983), MacKenzie Delta, NWT (MacKenzie and Kling, 1989), Lower Fraser Valley, B.C. (Donaldson and Stein, 1984) and Ontario (Nicholls, 1982).

Family Dinobryaceae

Cells are surrounded with a lorica.

Calycomonas Lohmann 1908

Non-pigmented monad within a thick walled lorica, one obvious flagellum. Loricae are often impregnated with minerals.

C. ovalis Wulff 1919

Figure 161.

Description: Lorica is round to oval with a small opening. On the outside there are 7-8 annular thickenings which appear as bumps separated by furrows. Lorica length is 3.7-5.0 μm and width is 2.3-3.0 μm (Wulff, 1919; Espeland and Throndsen, 1986).

Observed in Saanich Inlet: Loricae were 3.5 x 4.5 μm. Found in samples 4, 5, 10, 11 and 13 (July, Aug., Jan., Feb. and Apr.).

Previous records: Germany and the North Sea (Wulff, 1919), Norway (Espeland and Throndsen, 1986; Throndsen, 1969), Massachusetts (Hulbert, 1965) and New Zealand (Norris, 1964).

C. wulfii Conrad and Kufferath 1954

Figure 161. *Calycomonas ovalis*. Thick, oval lorica with anterior opening and annular thickenings. Scale bar = 0.5 μm.

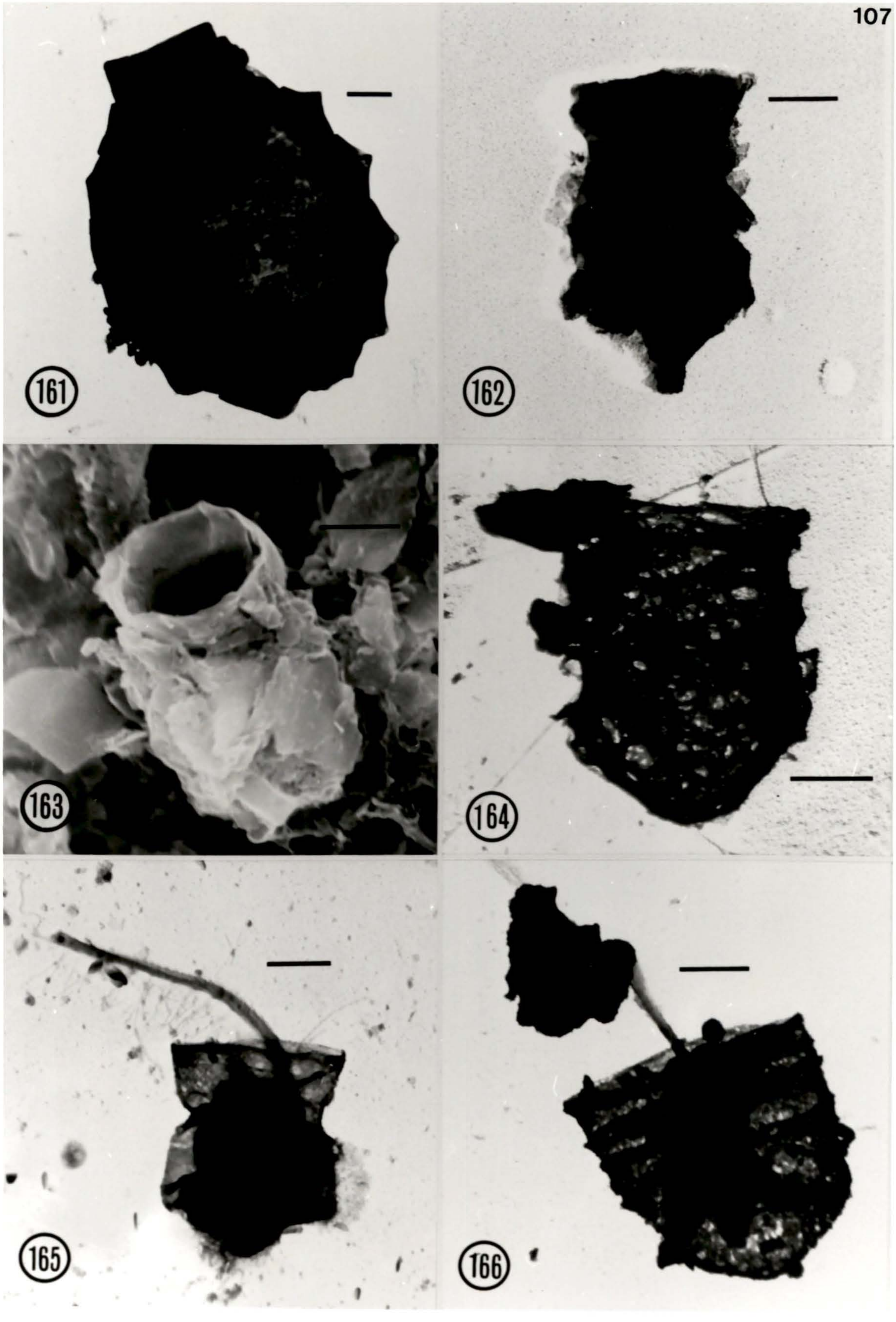
Figure 162. *C. wulfii*. Lorica with large anterior opening, is cylinder shaped anteriorly and pointed posteriorly. Annular thickenings are present. Scale bar = 1.0 μm.

Figure 163. *C. wulfii*. Scanning electron micrograph of lorica showing wide anterior opening and thick walls. Scale bar = 1.0 μm.

Figure 164. *Kephyrion* sp. 1. Fibrillar lorica which is tall relative to its width. Scale bar = 1.0 μm.

Figure 165. *Kephyrion* sp. 2. Lorica with distinctive fibrillar structure. Cell body almost fills lorica, hair covered flagellum is visible. Scale bar = 1.0 μm.

Figure 166. *Kephyrion* sp. 3. Lorica with fibrils arranged in annular rings. Cell doesn't fill lorica. Long flagellum extends beyond lorica. Scale bar = 1.0 μm.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(=*Calycomonas gracilis* Lohmann 1908)

Figures 162 and 163.

Description: Lorica is thimble shaped with a large opening at one end and pointed at the other end. Lorica has 3-4 annular thickenings which are difficult to see. Length of lorica is 4.0-7.0 μm and width is 3.0-4.0 μm (Wulff, 1919).

Observed in Saanich Inlet: Loricae were 3.0-3.2 x 5.2-5.6 μm. Structure of lorica was difficult to discern with shadow casting however with SEM the thickness of the wall was obvious. Found in samples 10 and 11 (Jan. and Feb.).

Previous records: Indian Arm B.C. (Buchanan, 1966), Norway (Throndsen, 1969), Germany, Baltic Sea, North Sea and Barents Sea (Wulff, 1919) and Massachusetts (Hulbert, 1965).

Kephyrion Pacher 1911

Biflagellated cell within a fibrillar lorica. One hair covered flagellum, one smooth. Considered a freshwater species but often found in brackish waters.

Kephyrion sp. 1

Figure 164.

Observed in Saanich Inlet: Lorica height of 4.1 μm and width 2.7 μm. Found in samples 3 and 11 (June and Feb.).

Previous records: As Kephyrion Type A from Jugoslavia and Bay of Algiers (Leadbeater, 1974) and Firth of Clyde, Scotland (Hinton and Boney, 1979).

Kephyrion sp. 2.

Figure 165.

Observed in Saanich Inlet: Lorica height was 3.8 μm and width was 3.3 μm. Cell bodies almost filled loricae. Flagellar length was 5.8 μm. Cell size was 2.6 x 2.6 μm. Found in sample 5 (Aug.).

Kephyrion sp. 3.

Figure 166.

Observed in Saanich Inlet: Lorica height of 3.4-3.8 μm. Width was 3.0-3.5 μm. Cells did not fill loricae. Cell size was 1.6-1.7 x 2.0-2.5 μm. Flagellar length was 5.5 μm. Found in samples 3 and 13 (June and Apr.).

Previous records: As Kephyrion Type B from Jugoslavia and Bay of Algiers (Leadbeater, 1974).

Dinobryon Ehrenberg 1835

This genus consists of free swimming, usually colonial organisms encased within cellulose loricae. Cells have two unequal flagella, one with hair and one smooth. Some species are solitary. Loricae are vase shaped with large openings. Taxonomy of genus is based on morphology of loricae. This is a freshwater genus but is often found in brackish water (Franke and Herth, 1973).

Dinobryon balticum (Schutt) Lemmerman

(=*Dinodendron balticum* Schutt)

(=*Dinobryon pellucidum* Levander)

Figures 167 and 168.

Description: Consists of colonies of noncrenate loricae with a slightly flared lorica of length 32-66 μm and width 3-5 μm.

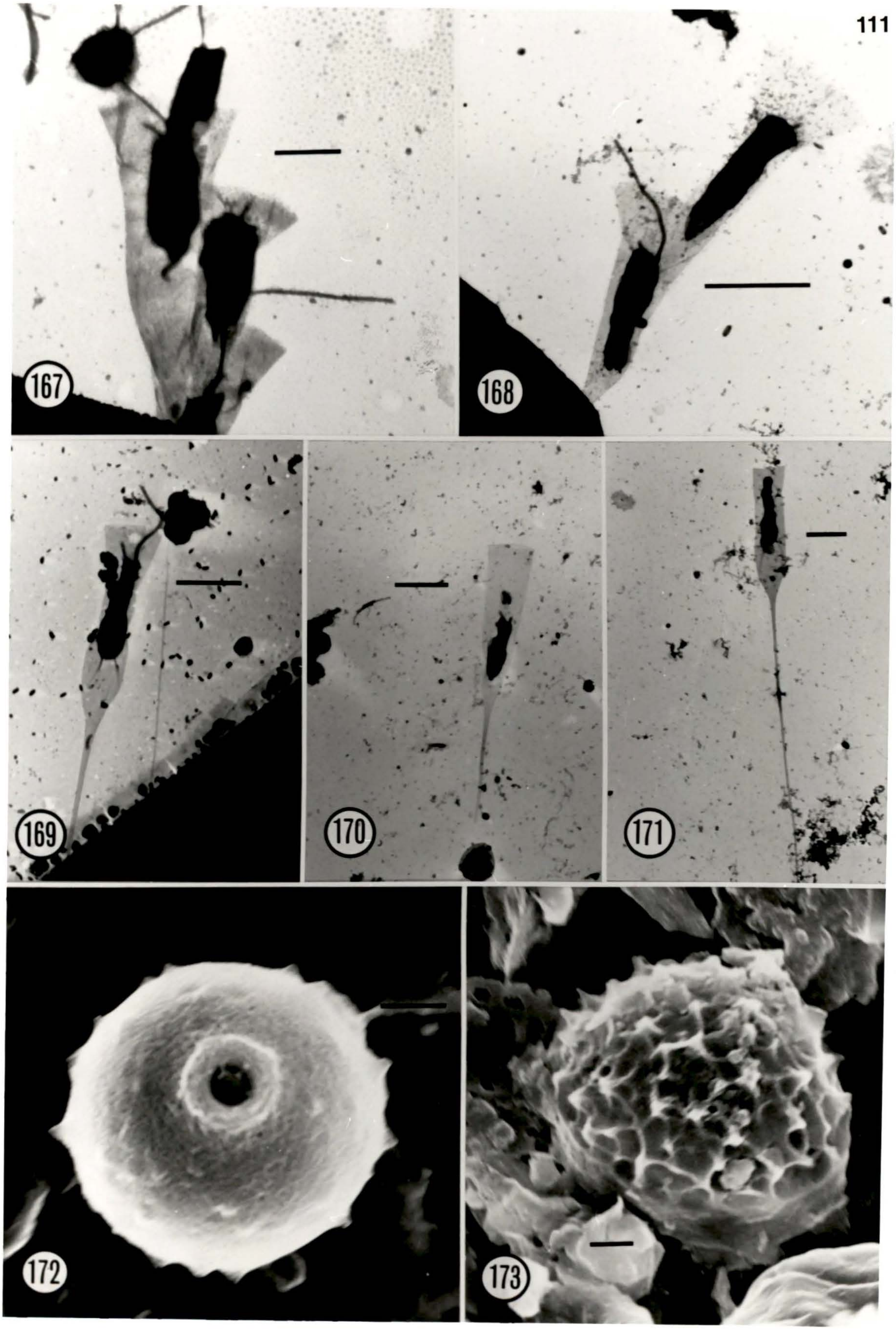
Observed in Saanich Inlet: Shape of the lorica agreed with the description given by Huber-Pestalozzi (1941) however loricae were shorter, ranging from 18.6-21.3

Figures 167-168. *Dinobryon balticum*. Colonies consist of cells encased in cellulose loricae which are joined. Long hair covered flagellum protrudes beyond lorica. Scale bar = 5.0 μm.

Figures 169-171. *Dinobryon borgei*. Solitary lorica surrounds cell. Loricae have posterior spines of various lengths. Long flagellum protrudes beyond lorica but short flagellum does not. Scale bar = 5.0 μm.

Figure 172. Statospore. Wall is granulated and has a few spines. Pore with surrounding collar is visible. Scale bar = 1.0 μm.

Figure 173. Statospore. Wall is covered with projecting spines. Pore is not visible. Scale bar = 1.0 μm.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μm. This is similar to *D. balticum* seen by Moestrup (1979). Loricae widths were 4.6-7.5 μm. Both asymmetric and symmetric loricae were seen. Cell size was from 2.5-3.2 x 5.7-13.1 μm and flagellar lengths ranged from 9.6-17.4 μm for long flagellum and 1.6-2.3 μm for short, smooth flagellum. Found in sample 5 (Aug.).

Previous records: North Atlantic Ocean and Baltic Sea (Huber-Pestalozzi, 1941), Indian Arm, B.C. (Buchanan, 1966), Lower Fraser Valley, B.C. (Stein, 1975), New Zealand (Moestrup, 1979), Denmark (Manton and Leadbeater, 1974) and Greenland (Thomsen, 1982).

Dinobryon borgei Lemmerman 1904

Figure 169-171.

Description: Solitary lorica which is cylindrical with basal portion drawn out into a spine. Walls of lorica have a spiral band. Total length ranges from 20-50 μm with spine length from 2-30 μm. Lorica width is 2.0-3.0 μm. Length of cell body varies from 17.0-22.0 μm (Hilliard, 1968).

Observed in Saanich Inlet: Total lorica lengths ranged from 30.8-59.0 μm with spine lengths of 13.5-44.2 μm. Loricae were 4.1-5.3 μm wide at the mouth, which is larger than values seen in the literature. Cell sizes were 2.0-2.5 x 7.0-8.6 μm with short flagellar lengths of 1.5 μm and long flagellar lengths of 8.1 μm. Found in sample 3 (June).

Previous records: Alaska (Hilliard, 1968), Greenland (Nygaard, 1979) and Indian Arm (Buchanan, 1966).

Chrysophycean cysts

Figures 172 and 173.

The production of endogenously formed siliceous resting cysts called statospores or stomatocysts is a feature unique to Chrysophytes. Statospores, which are species specific, may be smooth or ornamented. A collar usually surrounds a small pore which is closed by a plug. In order to assign a statospore to a species, culturing is necessary to see cyst formation therefore many statospores seen in the wild have not been classified.

Observed in Saanich Inlet: In samples 3 (June) and 5 (Aug.) several spherical statospores (Figure 172) with surface granulations and a few short spines were seen. Diameter of these cysts was 5.0 μm with pore diameter 0.7 μm and collar width of 0.5 μm. In samples 10 and 11 a statospore (Figure 173) covered with projecting spines (0.4 μm) was seen. Diameter of this cyst was 6.7 μm. Biological affinity of both these statospores is unknown.

Order Pedinalles Zimmerman, Moestrup and Hallfors 1984

Although retained in the Chrysophyceae for now this group will likely be segregated into a separate algal Class. These are radially symmetric cells with one flagellum with tripartite hairs. Flagellum has its membrane expanded into a fin usually supported by a paraxial rod. A second basal body parallel to the flagellar base is likely a vestigial flagellum. No flagellar roots are present. Cells have triads of microtubules which can extend from the cell as tentacles. Several chloroplasts are regularly arranged. Statospore production has not been observed. Cells are capable of capturing bacteria for ingestion (Zimmerman *et al.*, 1984; Hibberd, 1986).

Family Pedinellaceae Christiansen 1962

Apedinella spinifera Throndsen 1971

(=*Pseudopedinella spinifera* Throndsen 1969)

Figures 174-178.

Description: Cells rounded (6.5-10.0 x 7.0-10.5 μm) with one emergent flagellum 1-2 times body length. Flagellum has hairs and a wing with a strengthening band. Second flagellum reduced to a basal body. Microtubules in triads terminate near the cell surface therefore do not form tentacles. Scales and spines of cellulose cover the cell. Oval and round plate scales, which vary in size (0.5-1.0 x 1.0-1.5 μm) have rims and irregular fibrillar markings. Spines have a triangular base and a tapering spine of length 12-34 μm (Throndsen, 1971).

Observed in Saanich Inlet: Cell size ranged from 5.6-6.6 x 6.1-9.3 μm with scale size from 0.6-1.6 x 1.0-2.5 μm. These scales are larger than the type material but agree with scale sizes seen by Moestrup (1979) and Hallegraeff (1983). Spine length ranged from 10.3-28.5 μm. No cells with the unique flagellum were found. Found in all samples.

Previous records: Saanich Inlet (Takahashi *et al.*, 1978), Norway (Leadbeater, 1972c; Throndsen, 1971; Espeland and Throndsen, 1986), Denmark (Manton and Leadbeater, 1975), New Zealand (Moestrup, 1979), Gulf of Elat (Thomsen, 1978), Jugoslavia and Bay of Algiers (Leadbeater, 1974), Australia (Hallegraeff, 1983) and Firth of Clyde (Hannah and Boney, 1983). Also as *Pseudopedinella* sp. 1 from Indian Arm, B. C. (Buchanan, 1966).

Order Parmales Booth and Marchant 1987

Nanoplanktonic cyst-like organisms made of round and triradiate siliceous plates, with or without oblong girdle plates. Each arm of triradiate plate fits between two round plates. Cells contain a large chloroplast and very little storage material suggesting they are not a resting stage (Booth and Marchant, 1986).

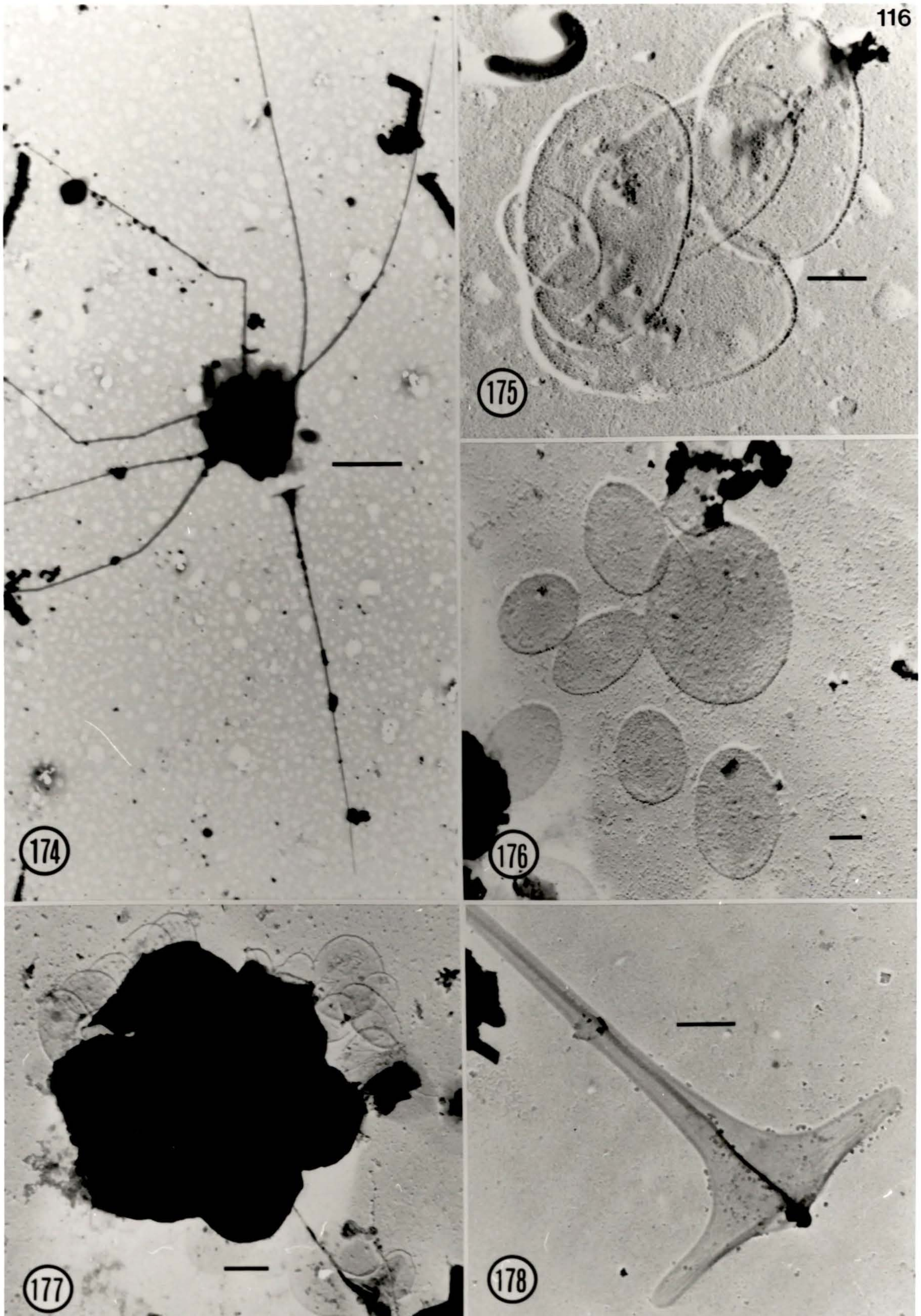
Family Triparmaceae Booth and Marchant 1988

Figure 174. *Apedinella spinifera.* Whole cell. Spines are visible around cell. Flagellum is missing. Scale bar = 5.0 μm.

Figures 175 and 176. *A. spinifera.* Body scales of varying sizes and shapes showing fibrillar markings. Scale bar = 0.5 μm.

Figure 177. *A. spinifera.* Cell body with scales surrounding cell. Scale bar = 1.0 μm.

Figure 178. *A. spinifera.* Base of spine showing characteristic triangular shape. Scale bar = 0.5 μm.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Cell wall is composed of 8 plates, four are round, fitting edge to edge (Booth and Marchant, 1988).

Triparma cf. *columacea* Booth 1987

Figures 179 and 180.

Description: Cells are spherical or subspherical (2.3-4.7 μm) with one round plate (2.0-3.0 μm) larger than the other three plates (1.0-1.8 μm). One triradiate plate fits between the three smaller round plates and three oblong plates fit end to end surrounding the large round plate. Small round plates are convex with a central umbo and large plate is rounded. Plates have coarse venation and areolae. Edges of girdle plates and triradiate plates are thickened.

Observed in Saanich Inlet: A large number of cells which appeared to be a variation of *T. columacea* were seen. Diameters were 2.4-2.7 μm with small round plates 1.3 μm across. Arms of triradiate plates were 1.0 μm. Measurement of large round plates was not possible because of orientation of cells. The cells had much less ornamentation than *T. columacea* with areolae present in the center of round plates and the center of triradiate plates. Edges of triradiate plates were thickened. EDX microanalysis (Figure 181) showed a pronounced silicon peak. Found in samples 10, 11 and 12 (Jan., Feb. and Mar.).

Previous records: Subarctic Pacific Ocean (Booth *et al.*, 1981) as Cyst VI: Nishida 1979 and Bay of Bothnia (Booth and Marchant, 1987)

Incertae sedis

Meringosphaera mediterranea Lohmann 1902

Figures 182-185.

Description: This easily identified species has an uncertain systematic position.

Figures 179 and 180. *Triparma* cf. *columacea*. Three small round plates are visible, separated by triradiate plate, with thickened edges. Areolae are visible on the center of round plates and the center of the tripartite plate. Scale bar = 0.5 μm.

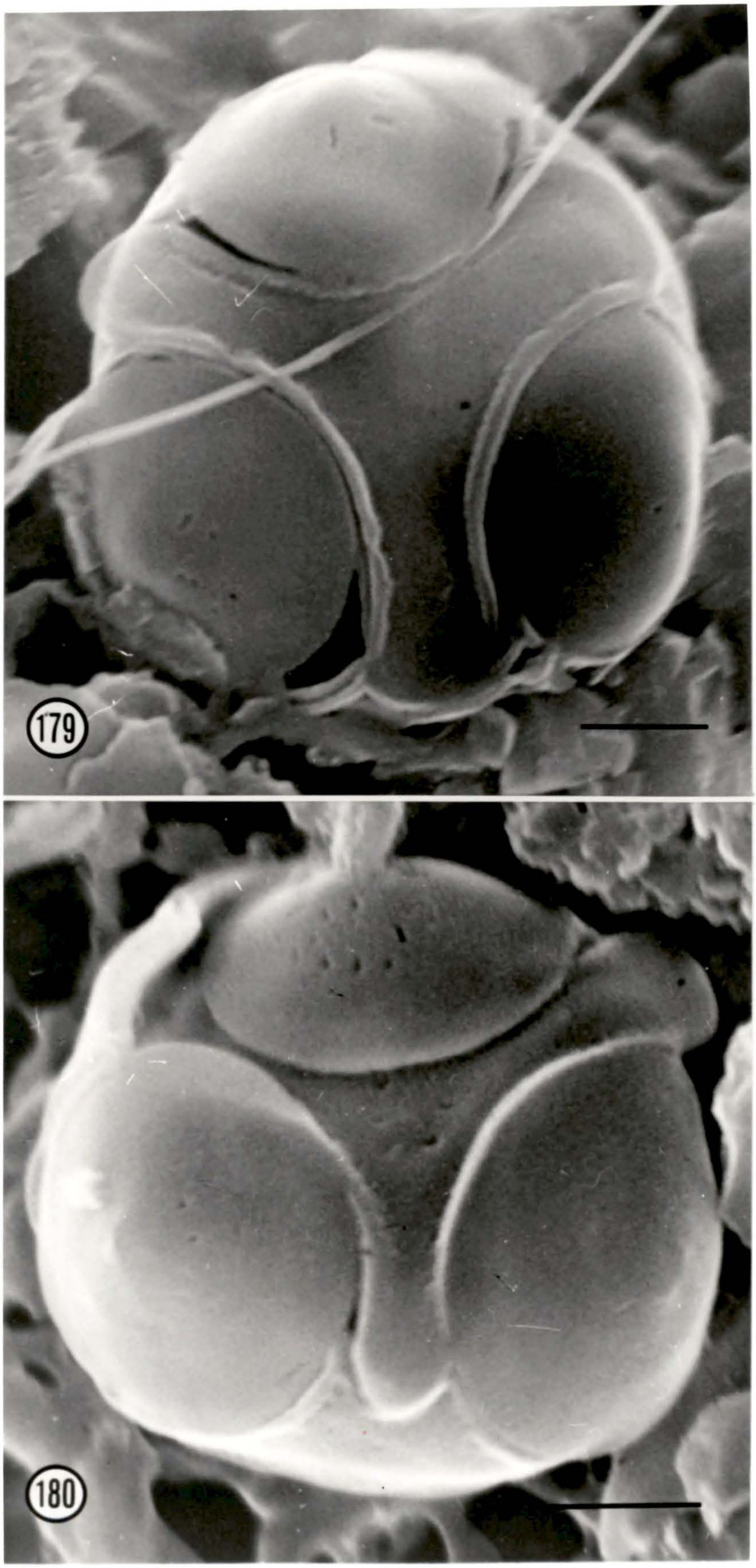
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Figure 181. EDX microanalysis of *Triparma* cf. *columacea*. Large silica peak indicates cysts are made of silica.

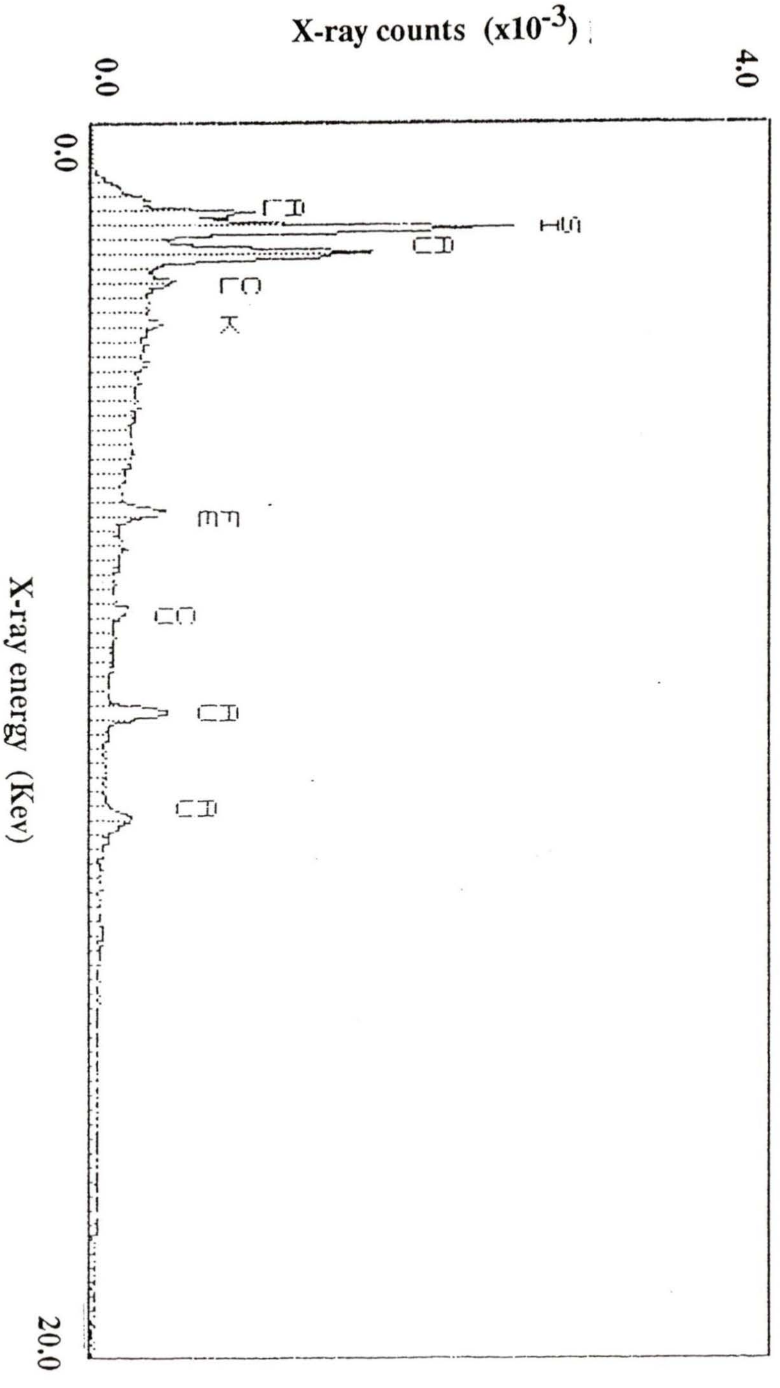


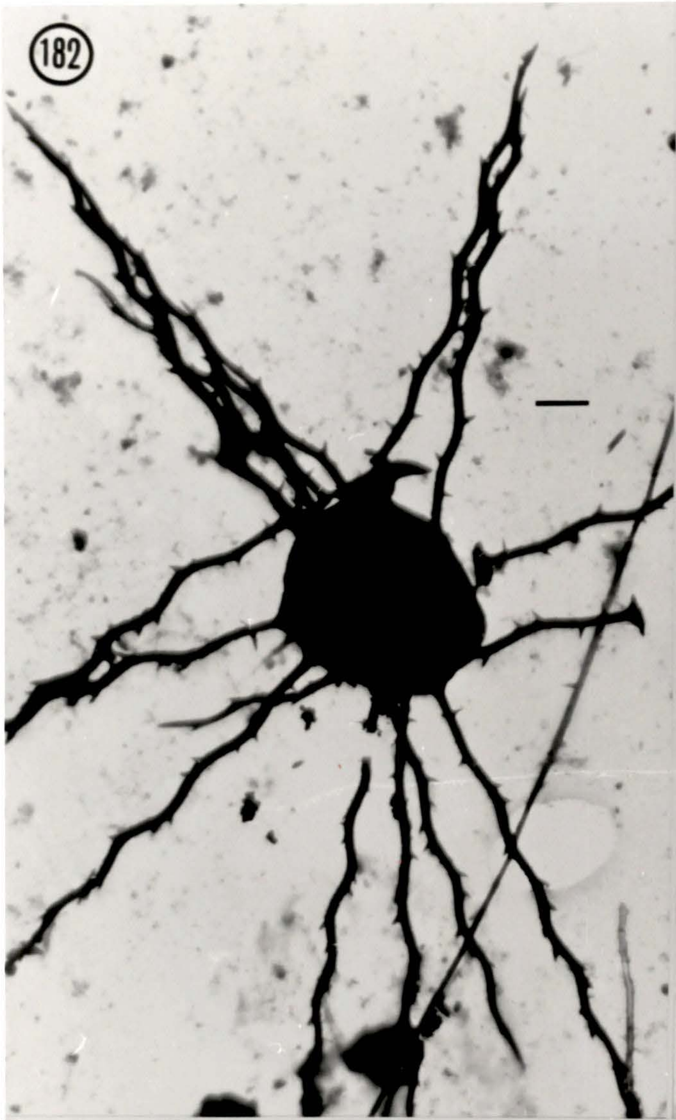
Figure 181

Figure 182. *Meringosphaera mediterranea*. Whole cell with undulated, barbed spines protruding. Scale bar = 2.0 μm.

Figure 183. *M. mediterranea*. Spines, showing barbs and bases with serrated edges. Scale bar = 1.0 μm.

Figure 184. *M. mediterranea*. Base of spines. Scale bar = 0.5 μm.

Figure 185. *M. mediterranea*. Body scale with patternless surface and narrow central thickened area. Scale bar = 0.5 μm.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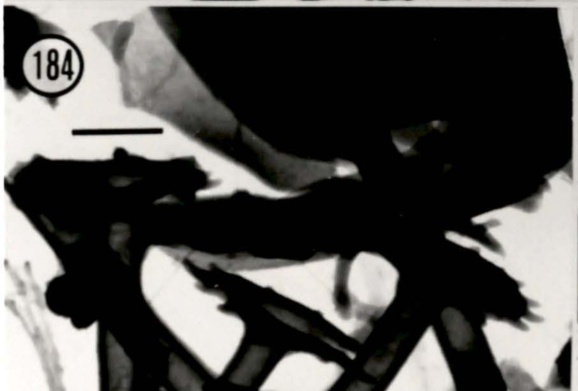
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Because of its pigments, reserve products and siliceous scales it has been placed in the Class Chrysophyceae, however ultrastructural studies are necessary to further classify it. The spherical cell (5.0 x 5.0 μm) is covered with siliceous scales and spines. Oval plate scales (0.4 x 0.8 μm) are patternless and have a narrow central thickening. Long undulated, barbed spines (15.0-40.0 μm) have a base with serrated edges (Leadbeater, 1974; Hallegraeff, 1983).

Observed in Saanich Inlet: Cells had diameters ranging from 3.4-7.5 μm. Spine lengths were from 10.0-14.0 μm and the base of spines was from 1.4-1.6 μm. Scales were 1.5-1.7 x 1.8-2.0 μm which is larger than other values in the literature. Found in samples 1, 3, 4, 7, 8, 11, 12 and 13 (Apr., June, July, Oct., Nov., Feb., Mar. and Apr.).

Previous records: Indian Arm, B.C. (Buchanan, 1966), Great Britain (Parke and Dixon, 1968), Gulf of Elat (Thomsen, 1978), Denmark (Manton and Leadbeater, 1974), Mediterranean and Adriatic Seas (Leadbeater, 1974), New Zealand (Moestrup, 1979), Gulf of Alaska (Booth *et al.*, 1982), Australia (Hallegraeff, 1983), Antarctic (Buck and Garrison, 1983), Benguela Current (Norris, 1984), North Atlantic Ocean (Estep *et al.*, 1984) and North Pacific Ocean (Hoepffner and Haas, 1990).

Order Dictyochales

This group, commonly called the silicoflagellates, has been assigned Class rank by some researchers (Hibberd, 1986) because of the absence of statospores and an internal skeleton. Others feel that the skeleton is external and that chrysophycean pigmentation, mitochondrial and chloroplast structure and the deposition of biological silica make these organisms chrysophytes (Van Valkenburg, 1980). Silicoflagellates have one flagellum and a siliceous skeleton composed of a network of tubular elements. The cell body has a central dense endoplasm containing the nucleus and dictyosomes and a peripheral frothy appearing ectoplasm with chloroplasts and mitochondria. Extensive pseudopodia are present. Taxonomy is based on the configuration of the skeleton (Van Valkenburg, 1980).

Dictyocha fibula Ehrenberg

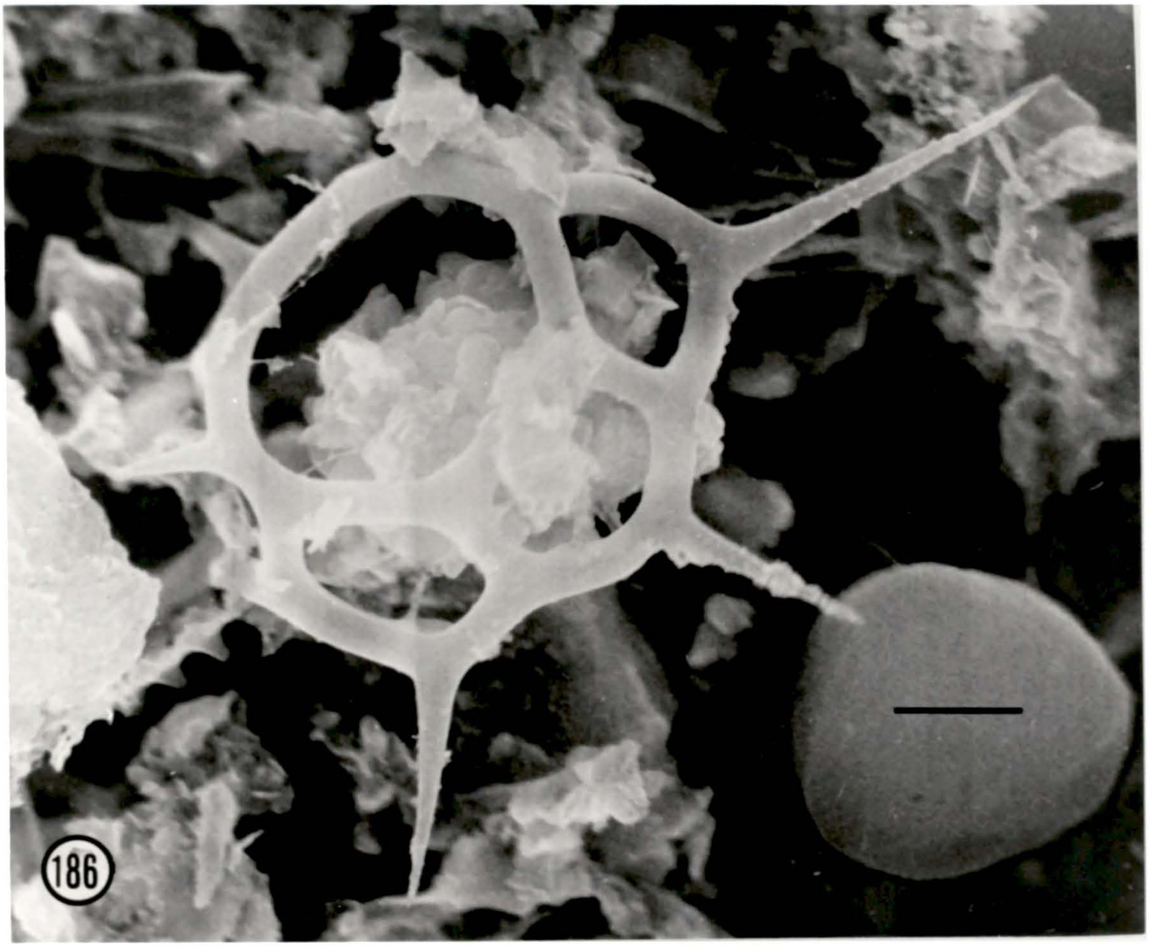
Figure 186.

Description: The skeleton in cultured specimens shows much plasticity suggesting this is not a good taxonomic character. The skeleton is a basal ring with projecting spines and elements that divide up the interior of the ring. The number of spines on the basal ring can be 4, 5, 6 or 7. The skeleton may or may not have open spaces that are not in contact with the basal ring. Cultured specimens have an average diameter for the long axis of the skeleton of 39 μm and an average diameter for the short skeletal axis of 15 μm. Spinelets are common, as are open rings (Van Valkenburg and Norris, 1970).

Observed in Saanich Inlet: One specimen was found. It had a closed basal ring with 4 open spaces but none without contact with the basal ring. Diameter of the ring was 18.9 μm. The ring had 4 spines with the longest spine 16.7 μm. The size of this organism might have caused it to be filtered out of sample when water was passed through the 20 μm mesh. Found in sample 11 (Feb.).

Previous records: Saanich Inlet, B.C. (Hobson, 1981), Washington (Van Valkenburg and Norris, 1970), Jugoslavia and Bay of Algiers (Leadbeater, 1974), Denmark (Manton and Leadbeater, 1974), North Atlantic Ocean (Estep *et al.*, 1984) and North Pacific Ocean (Taylor and Waters, 1982; Hoepffner and Haas, 1990).

Figure 186. *Dictyocha fibula*. Siliceous skeleton. Basal ring is asymmetric with four spines. Scale bar = 5.0 μm.



Incertae sedis

Thaumatomastix (Lauterborn) Lemmerman

(=*Thaumatonema* Lauterborn 1899)

(=*Reckertia* Conrad 1920)

The taxonomic position of this genus is uncertain. It is nonpigmented with a short, scale covered front flagellum and a long trailing naked flagellum. Neither flagellum has hairs. Cells are flattened and have a median furrow; pseudopodia can be present. Siliceous scales and spines can cover the cell (Beech and Moestrup, 1986).

Thaumatomastix bipartita Beech and Moestrup 1986

Figure 187.

Description: This species is considered rare. Cell is 10.0 x 5.0 µm with long naked flagellum of 10.0 µm. A short flagellum has not been seen. Two types of scale cover the cell. Spine scales (2.5-3.0 µm) have a triangular base plate (0.5 µm in diameter) with three struts which join to form the spine. Distal to this fusion is a collar (0.1 µm) which surrounds the spine. A bifurcation of the spine occurs 1/2-3/4 of the way along its length but the two branches remain connected. Body scales are composed of two fused elliptical plates (1.7-2.0 x 0.9-1.1 µm), with the distal plate depressed to form two semi-elliptical areas separated by a band. Perforations are present around the perimeter of the semi-elliptical areas (Beech and Moestrup, 1986).

Observed in Saanich Inlet: One spine scale from this species was found. Diameter of spine base was 0.35 µm and spine length was 1.1 µm which is smaller than the type material. Collar distal to spine base was 0.1 µm. The tip was obscured by debris making measurement difficult. Found in sample 10 (Jan.).

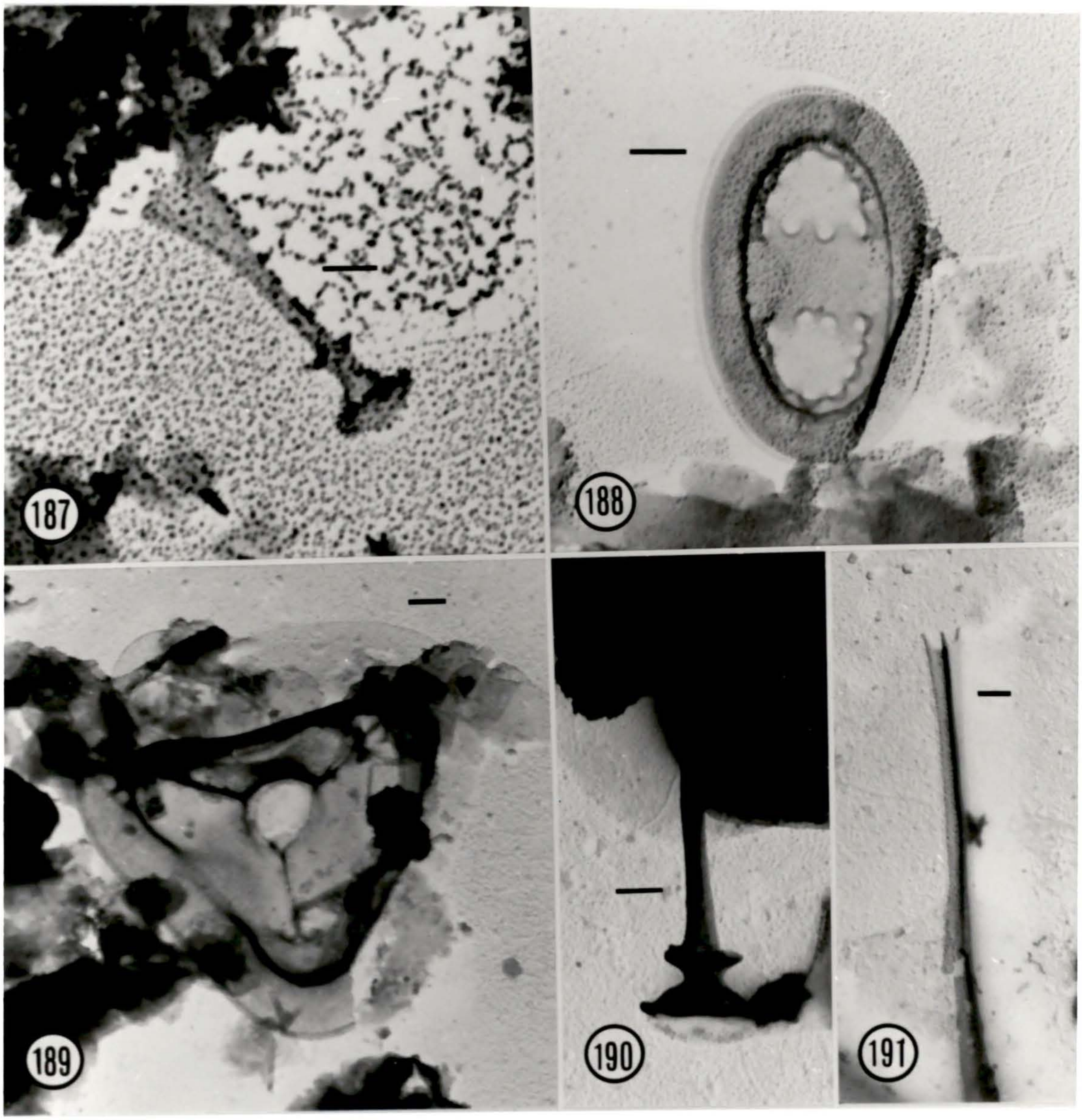
Figure 187. *Thaumatomastix bipartita.* Spined scale with characteristic collar distal to base and bifurcated tip. Scale bar = 0.2 μm.

Figure 188. *T. salina.* Body scale which is made of two appressed plates. Perforations are visible around the semi-elliptical areas. Scale bar = 0.2 μm.

Figure 189. *T. tripus.* Triangular dish shaped body scale partially obscured by debris. Scale bar = 0.2 μm.

Figure 190. *T. tripus.* Base of spine with characteristic collar distal to base. Scale bar = 0.2 μm.

Figure 191. *T. tripus.* Tip of spine with three points. Scale bar = 0.2 μm.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Previous records: Denmark (Beech and Moestrup, 1986).

T. salina (Birch-Anderson) Beech and Moestrup 1984

(=*Chrysosphaerella salina* Birch-Anderson 1973)

(=*Spiniferomonas salina* (Birch-Anderson) Nicholls 1984)

Figure 188.

Description: Cells are ovoid (7.0-12.0 x 8.0-15.0 μm). Long naked flagellum is 3/4-5/4 length of the cell. Short flagellum is covered with small ovoid scales (0.6-0.75 x 0.2-0.3 μm). Two types of scale cover the cell. Base plate of the spine scale has three struts which project upwards and fuse, continuing as a straight spine (2.0-10.0 μm). Distal to the fusion is a collar which is 2/3 the size of the base plate. The proximal end of the spine has three divergent projections. Body scales are formed of two fused, oval plates (0.9-1.6 x 0.6-1.2 μm), with the distal plate depressed forming two semi-elliptical areas separated by a patternless band. The depressed areas are perforated (Beech and Moestrup, 1986).

Observed in Saanich Inlet: Scales were 0.7 x 1.2-1.3 μm with a variable amount of perforation. Found in samples 8, 10 and 11 (Nov., Jan. and Feb.).

Previous records: Denmark (Birch-Anderson, 1973), Finland (Thomsen, 1979), New Zealand (Moestrup, 1979), Japan (Takahashi and Hara, 1984) and Australia (Beech and Moestrup, 1986).

T. tripus (Takahashi and Hara) Beech and Moestrup 1986

(=*Chrysosphaerella tripus* Takahashi and Hara 1984)

(=*Spiniferomonas tripus* (Takahashi and Hara) Nicholls 1984)

Figures 189-191.

Description: Cells are ovoid (14.0-24.0 x 12.0-21.0 μm) with a long flagellum slightly longer than the cell and a short flagellum, both without hairs. Spines (7.0-19.0 μm) and scales cover the cell. Slightly curved spines have a triangular base plate (0.8-1.4 μm) with projecting struts which unite to form the spine. A collar (0.3-0.6 μm) surrounds the spine distal to this fusion. The distal end of the spine has three points. Body scales have a triangular base with a broad margin (1.8-2.5 μm) fused to a distal triangular dish plate (Takahashi and Hara, 1984; Beech and Moestrup, 1986).

Observed in Saanich Inlet: Scales were 2.3 μm across. Many were obscured by debris and difficult to measure. Spines were 6.8-7.0 μm in length with bases of 0.5 μm and collar width of 0.35 μm. Tips were three toothed. Found in sample 8 (Nov.).

Previous records: Japan (Takahashi and Hara, 1984), Australia, Denmark and South Africa (Beech and Moestrup, 1986).

Unidentified Scales

Figures 192-195.

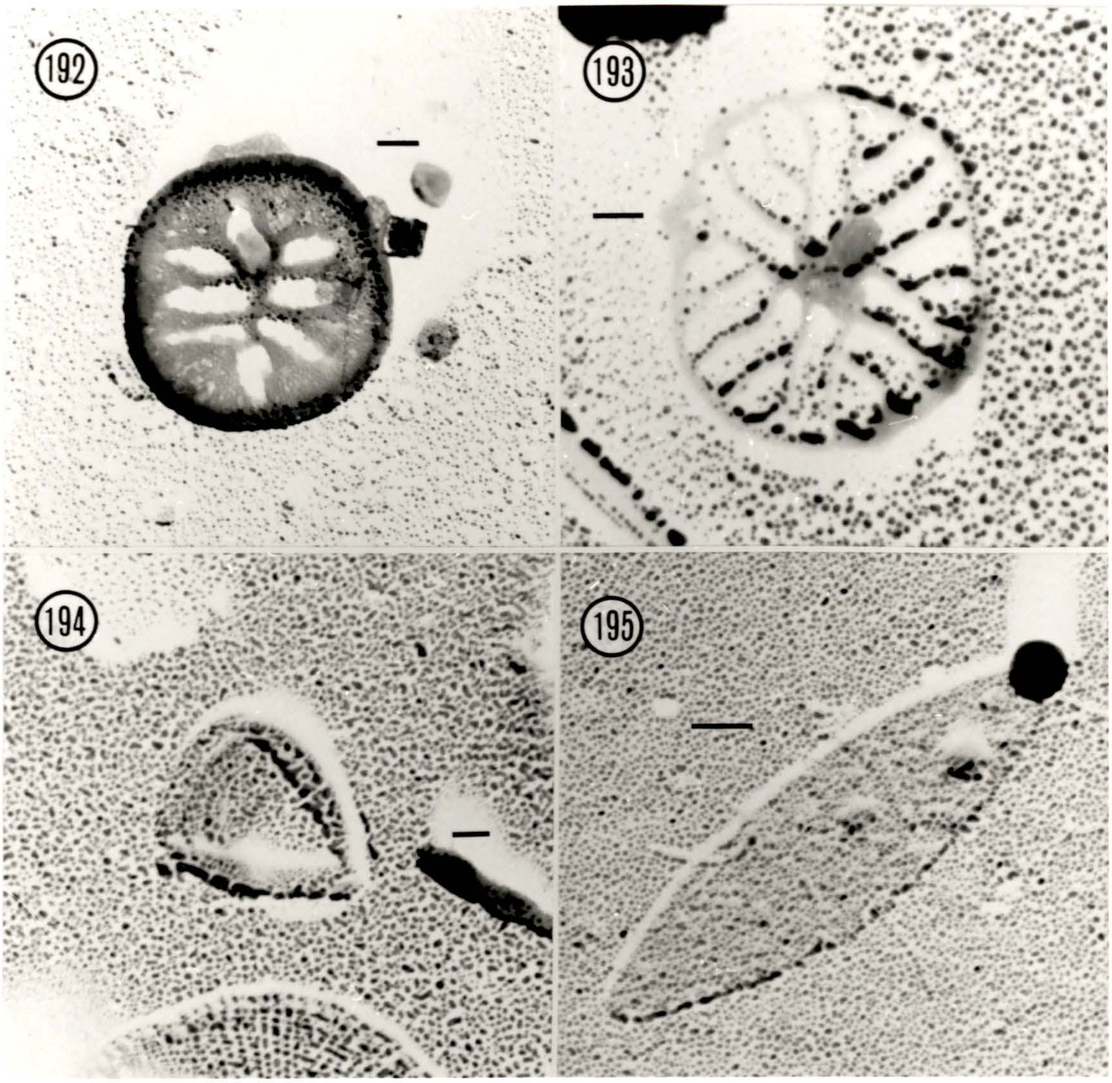
Some scale types not associated with cells could not be identified. The scale in Figure 192 was found in sample 9. It was 0.7 μm across with a thickened rim and 8 regularly arranged perforations. The scale in Figure 193, found in sample 11 (Feb.), was 0.7 x 0.8 μm, bilaterally symmetric with radial striations. The small (0.03 x 0.03 x 0.02 μm) patternless three sided scale with a raised margin (Figure 194) resembled a scale from *Chrysochromulina novae-zealandiae* (Moestrup, 1979), however it lacked the tiny spines seen on that scale. It was abundant in samples 3 (June) and 4 (July). The fusiform scale in Figure 195 was found in sample 9 (Dec.). It was was 0.9 μm long and 0.3 μm wide.

Figure 192. Unidentified scale. Rimmed scale has eight regularly arranged perforations. Scale bar = 0.1 μm.

Figure 193. Unidentified scale. Scale is oval with a bilaterally symmetric arrangement of striations. Scale bar = 0.1 μm.

Figure 194. Unidentified scale. Patternless triangular scale has a raised margin. Scale bar = 0.1 μm.

Figure 195. Unidentified scale. Patternless, rimless fusiform scale. Scale bar = 0.1 μm.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Kingdom Protista

Subkingdom Protozoa

Phylum Sarcomastigophora Honigberg and Balamuth 1963

Subphylum Mastigophora Diesing 1866

One or more flagella typically present.

Class Zoomastigophorea Calkins 1909

Choroplasts absent; one to many flagella.

Order Choanoflagellida Kent 1880

One flagellum, inserted apically, with proximal part surrounded by a ring of tentacles (=collar). Cell body is surrounded by a membranous sheath or a basket-like lorica composed of rod-shaped silicified bars (=costae). Free-swimming or stalked (Levine *et al.*, 1980).

Family Acanthoecidae

Cell body is surrounded by a lorica composed of interconnected siliceous costae. Costae are composed of costal strips.

Acanthocorbis apoda (Leadbeater) Hara and Takahashi 1984

(=*Acanthoecopis apoda* Leadbeater 1972)

Figure 196.

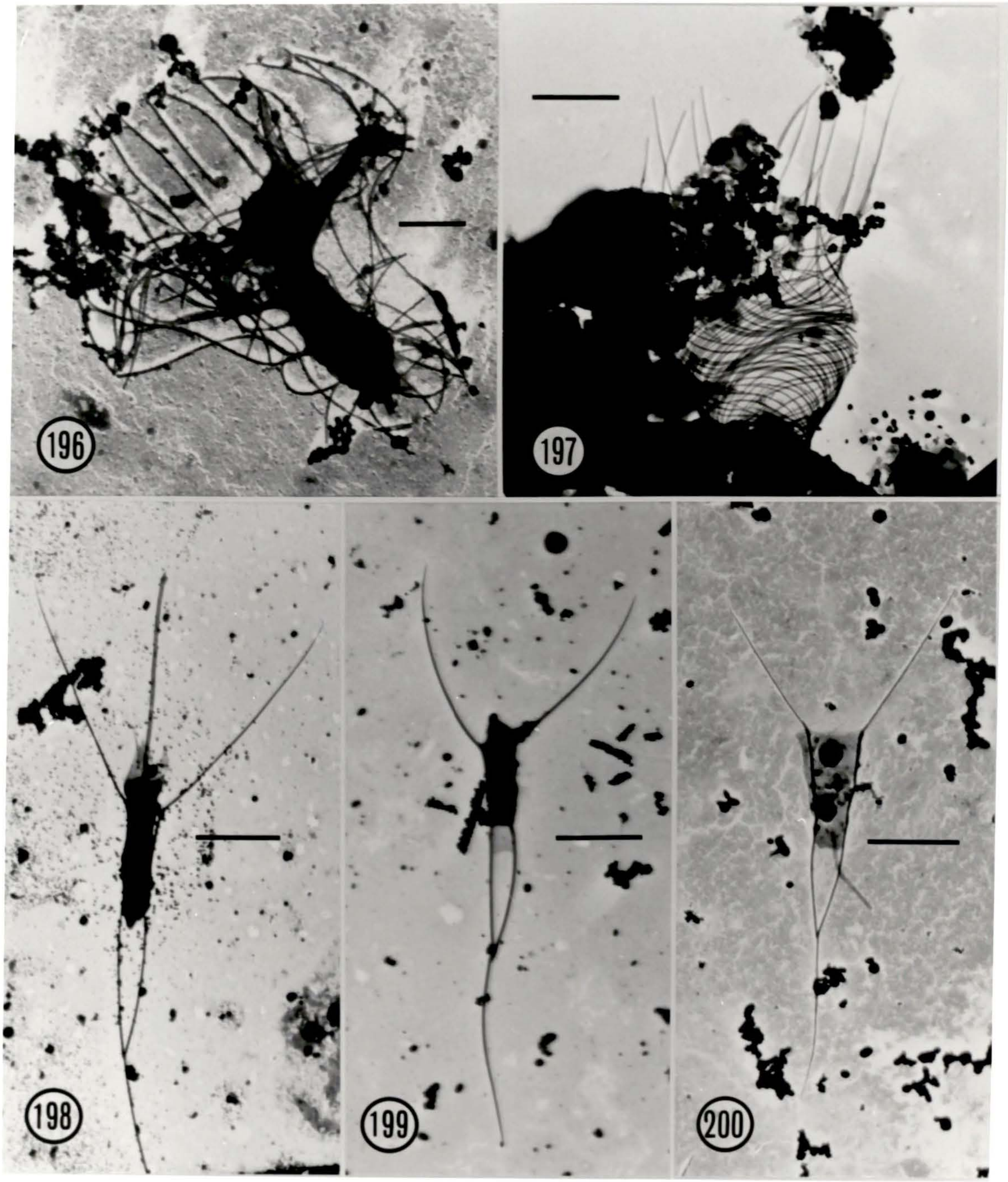
Description: Lorica is composed of 13-15 longitudinal costae which converge at the posterior end of the lorica and project as spines at the anterior end. Three transverse costae encircle the lorica. Cell body is spherical (4.0 x 4.0 μm), flagellum is 8.0 μm, collar is composed of 15-20 tentacles. Lorica is 16.0 μm high, 14.0 μm wide at the anterior end and 5.0 μm wide at the posterior end (Leadbeater, 1972a).

Observed in Saanich Inlet. Loricae had 15 longitudinal costae with heights of

Figure 196. *Acanthocorbis apoda.* Cell body is visible within lorica. Costae project as anterior spines. Scale bar = 2.0 μm.

Figure 197. *Acanthoeca spectabilis.* Lorica is made of spiral costae which project as anterior spines. Lorica is empty. Scale bar = 2.0 μm.

Figures 198-200. *Bicosta minor.* Lorica is made of two longitudinal costae which join posteriorly to form a spine and project anteriorly as spines. Cell body and flagellum are visible in Fig. 198, flagellum is missing from Fig. 199, flagellum and cell body are missing from Fig 200 allowing a clear view of lorica structure. Scale bar = 5.0 μm.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13.0-14.5 μm. Anterior lorica width ranged from 12.0-14.0 μm and posterior width was 5.2 μm. Found in samples 3, 5 and 8 (June, Aug. and Nov.).

Previous records: Norway (Leadbeater, 1972a; Throndsen, 1974), Denmark (Thomsen, 1977), Greenland (Thomsen, 1982), Jugoslavia and Bay of Algiers (Leadbeater, 1974).

Acanthoeca spectabilis Ellis 1930

Figure 197.

Description: Lorica is formed of loosely overlapping costae, which spiral from the base forming a chamber housing the cell body. Spiralling is steep at the lorica base but flattens near the anterior end giving rise to spines that project anteriorly for 5-18 μm. Each spine consists of two costal strips. Spine number varies from 9-17. Lorica height is 8.0-35.0 μm and width is 3.2-5.0 μm. A stalk (4.0-25.0 μm) extends from the base and is often attached to detritus. Cell body is 4.0-8.0 x 3.0-6.0 μm with flagellum of 7.0-10.0 μm surrounded by 20-35 tentacles (Leadbeater and Morton, 1974; Leadbeater, 1979).

Observed in Saanich Inlet: Several specimens were seen but they were often obscured by debris making measurement difficult, however the distinctive lorica allowed identification. Lorica height was at least 10.0 μm and widths ranged from 4.0-5.0 μm. Spine number was usually 11. Found in sample 10 (Jan.).

Previous records: San Juan Islands, Washington (Norris, 1965), Norway (Leadbeater, 1972a), England (Leadbeater and Morton, 1974), Denmark (Thomsen, 1973), Japan (Hara and Takahashi, 1984) and the North Pacific Ocean (Booth, 1990).

Bicosta minor (Reynolds) Leadbeater 1978

(=*Salpingoeca minor* Reynolds 1976)

Figures 198-200.

Description: Lorica is composed of 2 longitudinal costae joined posteriorly and a posterior spine. There are no transverse costae. Longitudinal costae, which are made of three costal strips, form spines anteriorly. Total length of lorica is 20-30 μm with anterior spines slightly longer than the posterior spine (5.0-11.0 μm). Cell body is 5.0-8.0 x 2.0-3.0 μm and flagellum length can be less or more than the anterior spines (Reynolds, 1978; Manton *et al.*, 1980).

Observed in Saanich Inlet: Total lorica lengths were 21.0-39.3 μm. Anterior spine lengths were 6.9-16.8 μm with posterior spines of 6.9-22.4 μm. Cell body size was 5.0-6.5 x 1.9-2.3 μm and flagellar lengths ranged from 5.5-13.7 μm. Found in samples 3, 4, 7, 8, 11, 12 and 13 (June, July, Oct., Nov., Feb., Mar., and Apr.).

Previous records: Barents Sea (Reynolds, 1976), Norway (Espeland and Throndsen, 1986), Greenland (Thomsen, 1982), Denmark (Thomsen, 1973), New Zealand (Moestrup, 1979), Arctic Canada, Alaska, South Africa, Galapagos (Manton *et al.*, 1980), Antarctic (Buck and Garrison, 1983) and the North Pacific Ocean (Booth, 1990).

Calliacantha Leadbeater 1978

Lorica is conical with few longitudinal costae converging posteriorly and projecting anteriorly as spines (Leadbeater, 1978).

C. simplex Manton and Oates 1979

Figures 201-202.

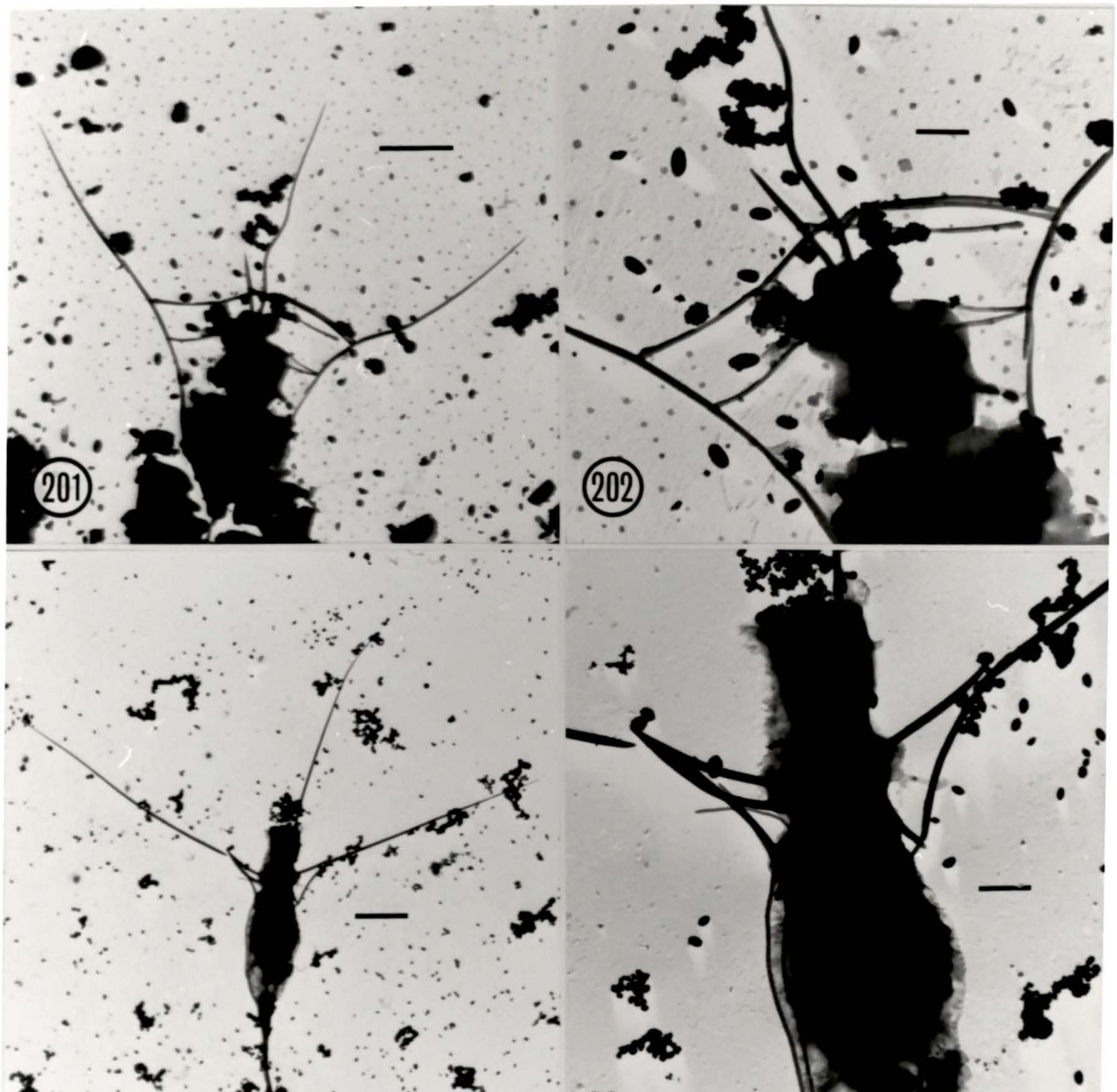
Description: Conical lorica is 25-45 μm long but can vary with water temperature. Four anterior spines are continuous with four longitudinal costae

Figure 201. *Calliacantha simplex*. Lorica consists of two transverse costae and four longitudinal costae which project anteriorly as spines and converge posteriorly. Scale bar = 3.0 μm.

Figure 202. *C. simplex*. Cell body held within lorica. Anterior spines are continuous with longitudinal costae. Scale bar = 1.0 μm.

Figure 203. *C. natans*. Long, narrow lorica has three anterior spines and one posterior spine. Scale bar = 3.0 μm.

Figure 204. *C. natans*. Lorica chamber which contains cell body and is made of six longitudinal costae, is lined with a delicate membrane. Longitudinal costae are not continuous with anterior spines. Scale bar = 1.0 μm.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which converge posteriorly without decreasing in number. Longitudinal costae are made of 3 costal strips united by overlapping joints. Two transverse costae are attached to the middle longitudinal costal strips. Anterior spine length is 10.0-20.0 μm and posterior spine length is 6.0-14.0 μm. Flagellar length varies (Manton and Oates, 1979).

Observed in Saanich Inlet: Loricae were 27.6-30.0 μm with anterior spines of 8.4 μm. Debris in samples prevented measurement of anterior spines. Found in samples 8 and 12 (Nov. and Mar.).

Previous records: England, Galapagos Islands, South Africa and Arctic (Manton and Oates, 1979), Greenland (Thomsen, 1982) and North Pacific Ocean (Hoepffner and Haas, 1990; Booth, 1990).

C. natans (Grontved) Leadbeater 1978
(=*Salpingoeca natans* Grontved 1956)
Figures 203 and 204.

Description: Lorica is 17-60 μm high and 4-8 μm wide with one posterior spine (4.0-25.0 μm) and 3 anterior spines (6.0-25.0 μm). Size varies with water temperature. Six longitudinal costae and 2 transverse costae enclose the cell body (9.0-22.0 x 4.0-5.0 μm). Longitudinal costae number decreases as lorica tapers posteriorly. Anterior spines are not continuous with the longitudinal costae. Flagellum is 1-3 times the cell body length and is surrounded by 15-30 tentacles. A delicate membrane lines the lorica chamber.

Observed in Saanich Inlet: Loricae ranged from 35.6-41.0 x 3.5-4.7 μm. Anterior spines were 15.1-16.6 μm and posterior spines were 12.0-14.9 μm. Found in samples 1, 2, 7, 8 and 12 (Apr., May, Oct., Nov., and Mar.).

Previous records: Denmark (Grontved, 1956; Leadbeater, 1972b; Thomsen, 1973), Arctic (Bursa, 1961), Indian Arm, B.C. (Buchanan, 1961), Gulf of Elat, Israel (Thomsen, 1978a), Finland (Thomsen, 1979), Greenland (Thomsen, 1982) Alaska (Manton and Leadbeater, 1978), Antarctic (Buck and Garrison, 1983; Takahashi, 1981) and the North Pacific Ocean (Booth, 1990).

Cosmoeca Thomsen 1984

Conical or barrel-shaped lorica composed of 9-12 longitudinal costae and 2-3 transverse costae located at right angles to each other. Longitudinal costae, which converge posteriorly, cross transverse costal strips at joints between costal strips. Anterior transverse costa and longitudinal costae form a characteristic three point intersection (Thomsen and Boonruang, 1984).

C. norvegica Thomsen 1984

Figures 205 and 206.

Description: Cup shaped lorica is 15.0-17.0 μm high and 12.5-15.0 μm wide anteriorly with 10 longitudinal costae and 3 transverse costae. Anterior transverse costa is at anterior lorica end and middle transverse costa is just posterior to the joints between the first and second longitudinal costal strips. Posterior transverse costa is at the level of third and fourth longitudinal costal joints. Below this, the number of longitudinal costae is reduced. Cell (3.0-6.0 x 3.0-5.0 μm) is at posterior end of lorica and flagellum (15.0-25.0 μm) extends beyond the lorica (Thomsen and Boonruang, 1984).

Observed in Saanich Inlet: Loricae measured 9.0-16.7 μm high and 13.6-17.9 μm wide. Cell body sizes ranged from 3.2-4.6 x 3.2-6.6 μm with flagellar lengths of 15.2-17.8 μm. Found in samples 7, 8, 10, 11 and 12 (Oct., Nov., Jan., Feb. and Mar.).

Previous records: Denmark and Thailand (Thomsen and Boonruang, 1984),

Figure 205. *Cosmoeca norvegica*. Lorica, which is made of 10 longitudinal costae and 3 transverse costae, contains cell body. Tentacles are visible anterior to cell. Flagellum projects beyond lorica. Scale bar = 2.0 μm.

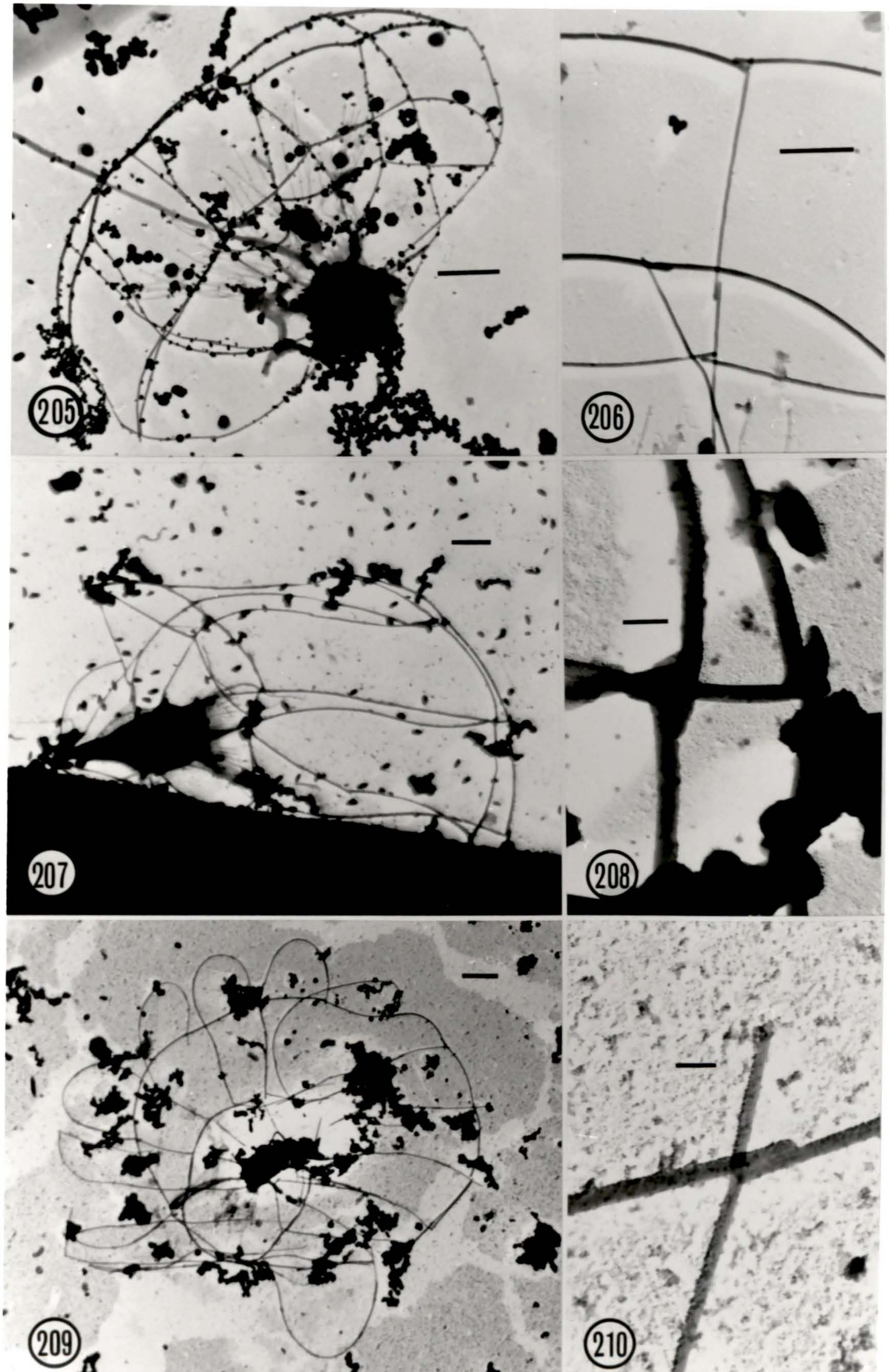
Figure 206. *C. norvegica*. Characteristic three point joint at anterior end of lorica and middle transverse costa just posterior to the joint between first and second longitudinal strips. Scale bar = 1.0 μm.

Figure 207. *C. ventricosa*. Lorica against a grid bar obscuring some of the 9 longitudinal costae. Cell body and tentacles are visible within lorica. Scale bar = 2.0 μm.

Figure 208. *C. ventricosa*. Anterior end of lorica showing three point joint with longitudinal strips not projecting as spines. Scale bar = 0.2 μm.

Figure 209. *C. ventricosa* Form B. Flattened lorica with 12 longitudinal costae which project as spines. Scale bar = 2.0 μm.

Figure 210. *C. ventricosa* Form B. Anterior end of lorica showing the three point joint and the longitudinal costa projecting as a spine. Scale bar = 0.2 μm.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Norway (Leadbeater, 1972a; Espeland and Throndsen, 1986), North Pacific Ocean (Booth, 1990), New Zealand (Moestrup, 1979) and Antarctic (Takahashi, 1981); the last two as sp. N.

C. ventricosa Thomsen 1984

Figures 207 and 208.

Description: Barrel-shaped lorica (23.0-31.0 μm high) is composed of 9-12 longitudinal costae and 3 transverse costae. Anterior transverse costa is at anterior end of the lorica and middle transverse costa is at the level of the joints between the second and third longitudinal costal strips. The third transverse costal strip is at the level of the joints between the third and fourth longitudinal strips. Below this, longitudinal costae number is reduced. Cell body (6.7-7.5 x 2.5-4.0 μm) is located at posterior end of lorica. Flagellum extends beyond lorica (Thomsen and Boonruang, 1984).

Observed in Saanich Inlet: Loricae had 9 longitudinal costae and were 23.0-23.2 μm high. Cell body sizes were 3.3 x 6.2. Found in samples 9 and 12 (Dec. and Mar.).

Previous records: Greenland (Thomsen,1982), Denmark, Thailand, Finland (Thomsen and Boonruang, 1984), Norway (Espeland and Throndsen, 1986) and North Pacific Ocean (Hoepffner and Haas, 1990; Booth, 1990).

C. ventricosa Form B Thomsen and Boonruang 1984

Figures 209 and 210.

Description: Almost identical to *C. ventricosa* but slightly smaller and longitudinal costal strips project as spines beyond anterior costa. Lorica dimensions are 16.0-20.0 μm high and 12.7-15.9 μm wide.

Observed in Saanich Inlet: Loricae had 12 longitudinal costae with heights of 14.4-15.0 μm and projecting spines of 0.8 μm. Found in samples 8 and 9 (Nov. and Dec.).

Previous records: Thailand (Thomsen and Boonruang, 1984), Australia (Hallegraeff, 1983) and North Pacific Ocean (Hoepffner and Haas, 1990; Booth, 1990).

Crinolina isefiordensis Thomsen 1976

Figure 211.

Description: Lorica is skirt-shaped, not closed anteriorly or posteriorly. Lorica which is 25.0-30.0 μm high with maximum diameter of 20.0-30.0 μm, is composed of 15-16 longitudinal costae and 2 transverse costae. Anterior transverse costa is located at the junction of second and third longitudinal costal strips with 2 costal strips projecting as anterior spines. The posterior transverse costa forms the posterior end of the lorica, longitudinal costal strips project slightly beyond the transverse costa. Cell body (8.0 x 5.0 μm) is suspended in the middle of the lorica, the flagellum (2-3 times body length) is often coiled (Thomsen, 1976).

Observed in Saanich Inlet: One specimen was found. It had a lorica height of 30.8 μm and maximum diameter of 22.4 μm. Damage to the lorica prevented counting longitudinal costae. Flagellum showed the characteristic loop. Found in sample 9 (Dec.).

Previous records: Denmark (Thomsen, 1976), Greenland (Thomsen, 1982), New Zealand (Moestrup, 1979) and Norway (Espeland and Throndsen, 1986).

Diaphanoeca Ellis 1930

D. grandis Ellis 1930

Figure 211. *Crinolina isefiordensis*. Damaged lorica showing open anterior and posterior ends with anterior spines. Cell body and characteristically looped flagellum (arrow) are visible. Scale bar = 5.0 μm.

Figure 212. *Diaphanoeca grandis*. Lorica, which has a damaged posterior end, shows longitudinal costae projecting as spines. Cell body is suspended in the middle of the lorica, tentacles are visible anterior to the cell. Scale bar = 5.0 μm.

Figure 213. *D. pedicellata*. Large lorica, with 14 longitudinal costae which project anteriorly as spines, has a posterior stalk. Cell body and flagellum are visible within the lorica. Scale bar = 5.0 μm.

Figure 214. *D. pedicellata*. Characteristic overlapping joining pattern of anterior costal strips. Scale bar = 0.5 μm.

Figure 215. *D. sphaerica*. Bell shaped lorica with 12 longitudinal strips projecting as anterior spines. Cell body is visible within lorica. Scale bar = 5.0 μm.

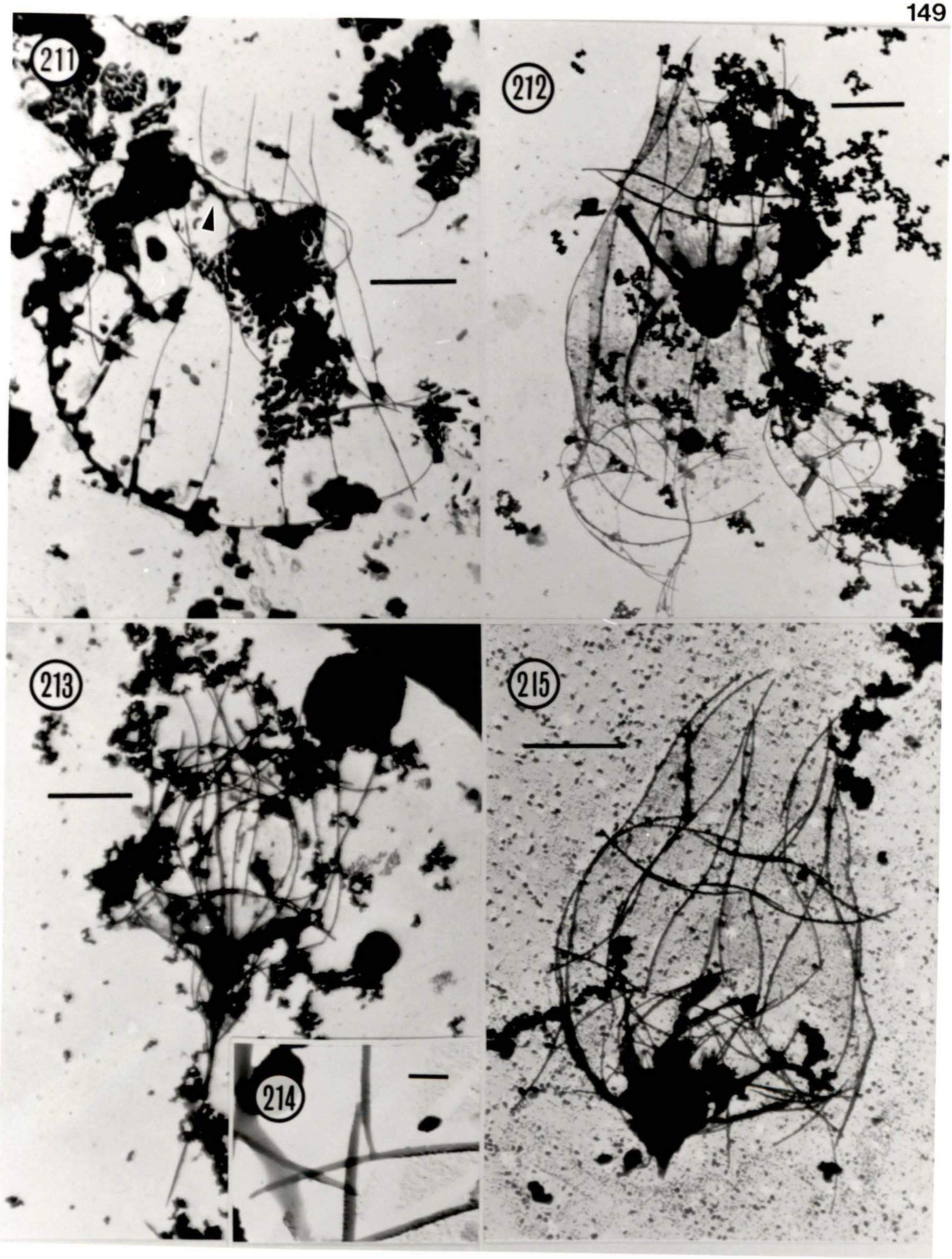
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Figure 212.

Description: Large lorica with height of 30.0-40.0 μm is composed of 12-14 longitudinal costae and 2-4 transverse costae. Transverse costal strips overlap giving the appearance of two costae. Anterior transverse costa is located at the joint of the second and third longitudinal costal strips with 2 costal strips projecting as anterior spines. The middle transverse costa is located at the joint of the fifth and sixth longitudinal costal strips. Details of posterior end of lorica are not well defined. Cell body (4.0-5.0 x 5.0-10.0 μm) is suspended in the middle of the lorica and flagellum does not project beyond the lorica (Manton *et al.*, 1980; Thomsen, 1982).

Observed in Saanich Inlet: Although several specimens were found most were damaged which is a common problem with this species. Lorica heights ranged from 33.0-35.0 μm and the number of longitudinal costae appeared to be 12. Cell sizes of 4.7 x 5.0 μm and flagellar lengths of 3.7-4.0 μm were seen. Found in samples 3 and 12 (June and Mar.).

Previous records: Jugoslavia and Bay of Algiers (Leadbeater, 1973), Denmark (Manton and Leadbeater, 1974; Thomsen, 1973), Norway (Leadbeater, 1972a, Throndsen, 1970), Finland (Thomsen, 1979), San Juan Island, Washington (Norris, 1965) and North Atlantic Ocean (Throndsen, 1974).

D. pedicellata Leadbeater 1972

Figures 213 and 214.

Description: Lorica is composed of a chamber of 25.0-35.0 μm and a stalk (11.0-40.0 μm). Lorica chamber has 12-14 longitudinal costae and 3 transverse costae. The anterior transverse costa is located at the joint of the first and second longitudinal costal strips with one costal strip projecting as anterior spines. Anterior costal strips join in characteristic overlapping pattern. The middle transverse costa is located anterior to the joint between the third and fourth costal strips. Posteriorly, longitudinal costae converge and form a stalk. Cell body (4.0-5.0 x 4.0-5.0 μm) is located at the posterior end of the lorica (Leadbeater, 1972b; Thomsen, 1982).

Observed in Saanich Inlet: Loricae had 14 longitudinal costae with chambers measuring 24.4-28.8 μm. Stalk lengths ranged from 10.8-14.0 μm. Cell body sizes were 3.0-4.2 x 3.2-6.2 μm. Found in samples 11 and 12 (Feb. and Mar.).

Previous records: Denmark (Leadbeater, 1972b), Adriatic Sea (Leadbeater, 1973), Greenland (Thomsen, 1982) and North Pacific Ocean (Hoepffner and Haas, 1990; Booth, 1990).

D. sphaerica Thomsen 1982

Figure 215.

Description: Bell-shaped lorica which is 22.5-30.0 μm high with a maximum diameter of 16.0-17.5 μm is composed of 13-15 longitudinal costae and 3 transverse costae. The anterior transverse costa is located at the junction of the second and third longitudinal costal strips with 2 costal strips projecting as anterior spines. The middle transverse costa attaches at the joints between the fifth and sixth longitudinal costal strips. Posterior lorica is triangular due to converging longitudinal costae. Cell body (7.0 x 4.0 μm) is located at the posterior end of the lorica. Flagellum (10.0-12.0 μm) does not project beyond the lorica. Cells often unite into spherical colonies (Thomsen, 1982).

Observed in Saanich Inlet: One specimen was found. This might be due to colonial forms being filtered out with initial treatment of water sample. This specimen had 12 longitudinal costae with a lorica height of 21.6 μm and maximum diameter of 15.0 μm which is slightly smaller than the type material. Cell body size was 6.6 x 4.3 μm. Found in sample 7 (Oct.).

Previous record: Denmark (Thomsen, 1982).

Parvicorbicula Deflandre 1960

P. quadricostata Throndsen 1970

Figures 216-218.

Description: Conical lorica which is 24.0-32.0 μm high with a diameter of 30.0-32.0 μm has 4 longitudinal costae and 2 transverse costae. The anterior transverse costa forms the anterior end of the lorica. Longitudinal costal strips join the anterior ring at the midpoint of alternate costal strips. Longitudinal costal strips have an end dilation and form a T shaped joint with transverse costal strips. Posterior transverse costa is located at the joints of the first and second longitudinal costal strips. Posteriorly longitudinal costae converge to a blunt point, often additional longitudinal costae are found at the base. Cell body (5.0 x 8.0 μm) is located at the posterior end of the lorica. Flagellum (1.5-2 times cell length) projects beyond the lorica (Throndsen, 1970; Manton *et al.*, 1976).

Observed in Saanich Inlet: Loricae diameters ranged from 30.0-31.5 μm. Cell body sizes were 7.0-7.5 x 4.0-4.3 μm and flagellar lengths were 13.0-13.3 μm. Found in samples 8 and 12 (Nov. and Mar.).

Previous records: Arctic (Throndsen, 1979; Manton *et al.*, 1976), Greenland (Thomsen, 1982), Denmark (Thomsen, 1976) and the North Pacific Ocean (Booth, 1990).

P. socialis (Meunier) Deflandre 1960

(=*Corbicula socialis* Meunier 1910)

Figures 219-221.

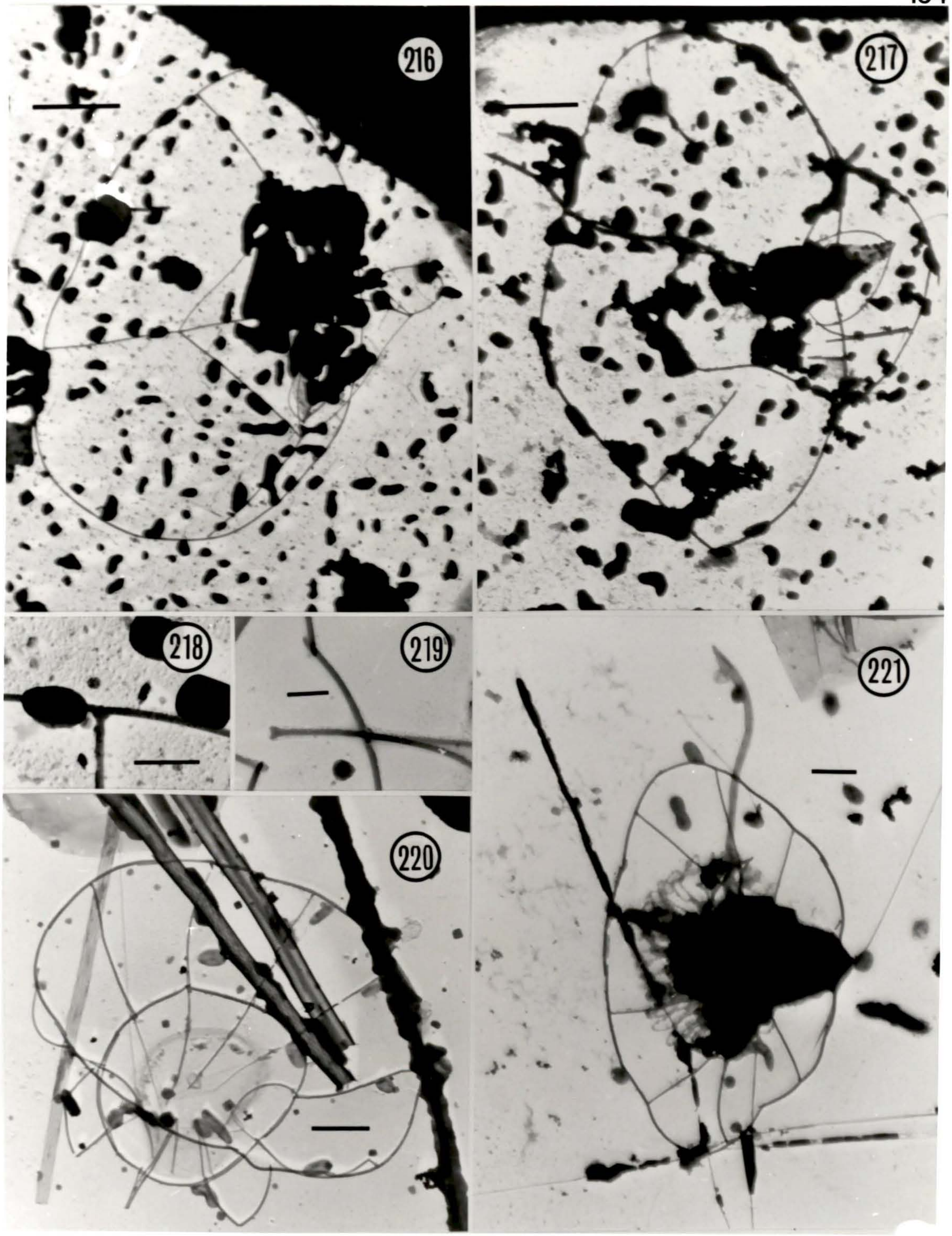
Figures 216 and 217. *Parvicorbicula quadricostata*. Conical loricae with four longitudinal costae, two transverse costae and no anterior spines. Flagellum projects beyond the lorica. Scale bar = 5.0 μm.

Figure 218. *P. quadricostata*. Joint at anterior end of lorica with dilated end of longitudinal costa meeting midpoint of transverse costa. Scale bar = 1.0 μm.

Figure 219. *P. socialis*. Dilated tip of longitudinal costa, which is characteristic for this genus. Scale bar = 1.0 μm.

Figure 220. *P. socialis*. Empty lorica showing two transverse costae and ten longitudinal costae which converge posteriorly. Scale bar = 2.0 μm.

Figure 221. *P. socialis*. Lorica containing cell body. Flagellum projects beyond lorica, tentacles are visible at anterior end of cell. Scale body = 2.0 μm.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Description: Conical lorica which can be solitary or colonial has heights ranging from 10.0-23.0 μm and diameters ranging from 11.0-17.0 μm. Lorica is composed of 10 longitudinal costae and 2 transverse costae. The anterior transverse costa forms the anterior end of the lorica. Longitudinal costal strips form a T joint at the midpoint of each anterior transverse costal strip. Longitudinal costae converge posteriorly and number of costae is reduced. Cell body (5.0-8.0 x 4.0-5.0 μm) is located posteriorly and is held in the lorica by a membrane. Flagellum (15.0-20.0 μm) projects beyond the lorica (Manton *et al.*, 1976).

Observed in Saanich Inlet: Common, only in solitary form. Colonial forms, if present, would be filtered out of sample. Loricae ranged from 9.3-9.8 μm with diameters of 13.6-14.8 μm. Cell body sizes were 6.5-9.0 x 4.2-5.8 μm. Flagellar lengths were 8.3-9.3 which is shorter than the type material. Found in samples 1, 4, 8, 11, 12 and 13 (Apr., July, Nov., Feb., Mar. and Apr.).

Previous records: Norway (Throndsen, 1970; Leadbeater, 1972a), Denmark (Thomsen, 1973), Arctic (Manton *et al.*, 1976), Gulf of Elat, Israel (Thomsen, 1978), North Pacific Ocean (Booth, 1982), Greenland (Thomsen, 1982), Antarctic (Buck and Garrison, 1983; Silver *et al.*, 1980; Takahashi, 1981).

Polyfibula stipitata Manton 1981

Figures 222-225.

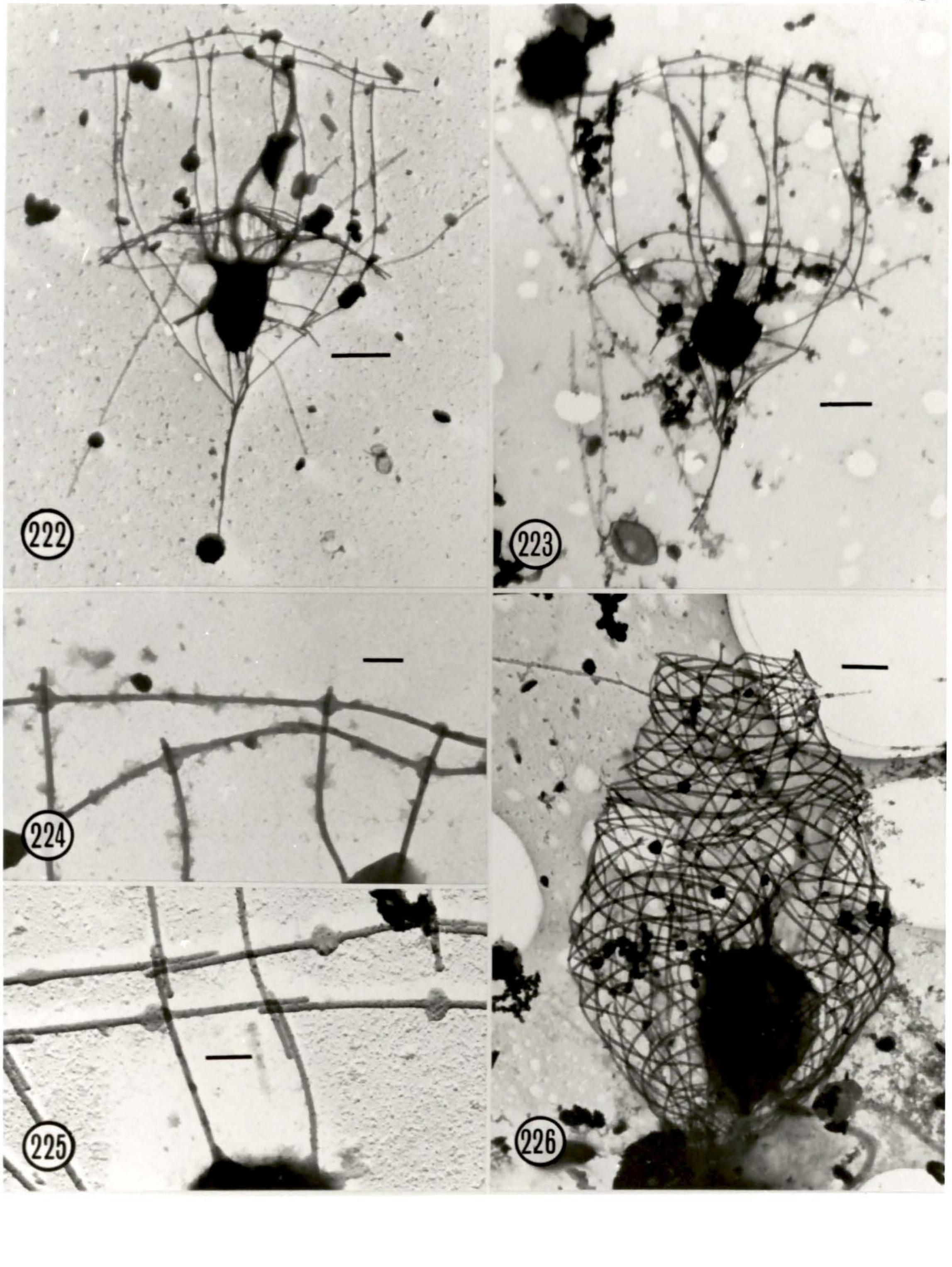
Description: Barrel-shaped lorica, which is less than 15 μm high, has a posterior stalk. Lorica is composed of 7 longitudinal costae and 3 transverse costae. The anterior and middle transverse costal strips have widened regions (=facets) at their midpoints. These serve as attachment sites on the anterior costa but not on the middle costa. The anterior transverse costa forms the anterior end of the lorica with some longitudinal costae projecting slightly. Longitudinal costae converge

Figures 222 and 223. *Polyfibula stipitata*. Both specimens show eight longitudinal costae and three transverse costae, as well as a posterior stalk. Cell body, tentacles and flagella are visible within the loricae. Scale bar = 2.0 μm.

Figure 224. *P. stipitata*. Anterior end of lorica showing widened areas on transverse costa. Longitudinal strips join to these widenings. Scale bar = 0.5 μm.

Figure 225. *P. stipitata*. Lorica at the level of the middle transverse costa. Widened areas on transverse costa do not serve as attachment sites. Scale bar = 0.5 μm.

Figure 226. *Savillea parva*. Lorica showing spirally arranged costae. Cell body and flagellum are visible within the lorica. Scale bar = 2.0 μm.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posteriorly. The posterior stalk is usually 1 costal strip but sometimes 2. Flagellum is equal to the lorica chamber in length (Manton and Bremer, 1981).

Observed in Saanich Inlet: Specimens agreed with the species description in all respects except the number of longitudinal costae. All specimens of this abundant species had 8 instead of 7 longitudinal costae. Since other species in this genus can have variable longitudinal costae number these specimens are considered to be *P. stipitata*. Loricae sizes were 10.9-15.3 μm high and 8.3-13.7 μm wide. Cell body sizes ranged from 2.0-2.8 x 3.2 -3.9 μm. Found in sample 3 (June).

Previous records: Alaska and Canadian Arctic (Manton and Bremer, 1981) and the North Pacific Ocean (Booth, 1990).

Savillea parva (Ellis) Loeblich 1967

(=*Diaphanoeca parva* Ellis 1930)

(=*Ellisiella parva* Norris 1965)

Figure 226.

Description: Two groups of spirally arranged costae form the lorica. One group of costal strips form a shallow spiral which flattens to form the anterior ring of the lorica. A steeper spiral is formed by other costal strips which terminate at the anterior ring. The lorica height is 10.0-12.0 μm with a maximum diameter of 6.0-6.5 μm and a diameter at the anterior end of 1.6-3.0 μm. Cell body (2.0-4.0 μm) is suspended within the lorica and flagellum (7.0-8.0 μm) does not extend beyond the lorica (Norris, 1965; Leadbeater, 1972b).

Observed in Saanich Inlet: Loricae heights were 11.0-11.2 μm, maximum width was 7.0-7.2 μm and anterior orifice diameters were 3.3-3.4 μm. This is slightly wider than the type material. Cell body sizes ranged from 2.6-2.7 x 3.8-4.0 μm. Flagellar lengths were 5.0-7.2 μm. Found in sample 3 (June).

Previous records: San Juan Islands, Washington (Norris, 1965) and Denmark (Leadbeater, 1972b; Thomsen, 1973; Manton and Leadbeater, 1974).

Phylum Sarcomastigophora Honigberg and Balamuth 1963

Subphylum Sarcodina Schmarda 1871

Pseudopodia or locomotive protoplasmic flow; chloroplasts lacking (Levine *et al.*, 1980).

Class Heliozoea Haeckel 1866

Order Centrohelida Kuhn 1926

Frequently have a skeleton of siliceous plates and scales. Radiating axopodia. Axonemes insert on centroplast. Most are freshwater (Levine *et al.*, 1980).

Pinaciophora Gerloff 1873

Spherical cells covered with siliceous spines and three-layered perforated plates. Axopodia are present. Many species described from plates and spines only (Thomsen, 1978b).

P. denticulata Thomsen 1978

Figures 227 and 229.

Description: Protoplast unknown. Plate scales circular to oval, 3.0-4.0 μm in diameter. The distal surface of plate scale has 6 (sometimes 5) large perforations surrounding a central perforation. Small hexagonally arranged perforations surround these large perforations. Lower scale plate has small hexagonally arranged perforations. Rim of scale is patternless. Spines (0.8-1.8 μm) are tubular with a diameter of 0.3 μm. Distally spines flare (0.5-0.8 μm) and have a row of teeth (Thomsen, 1978b).

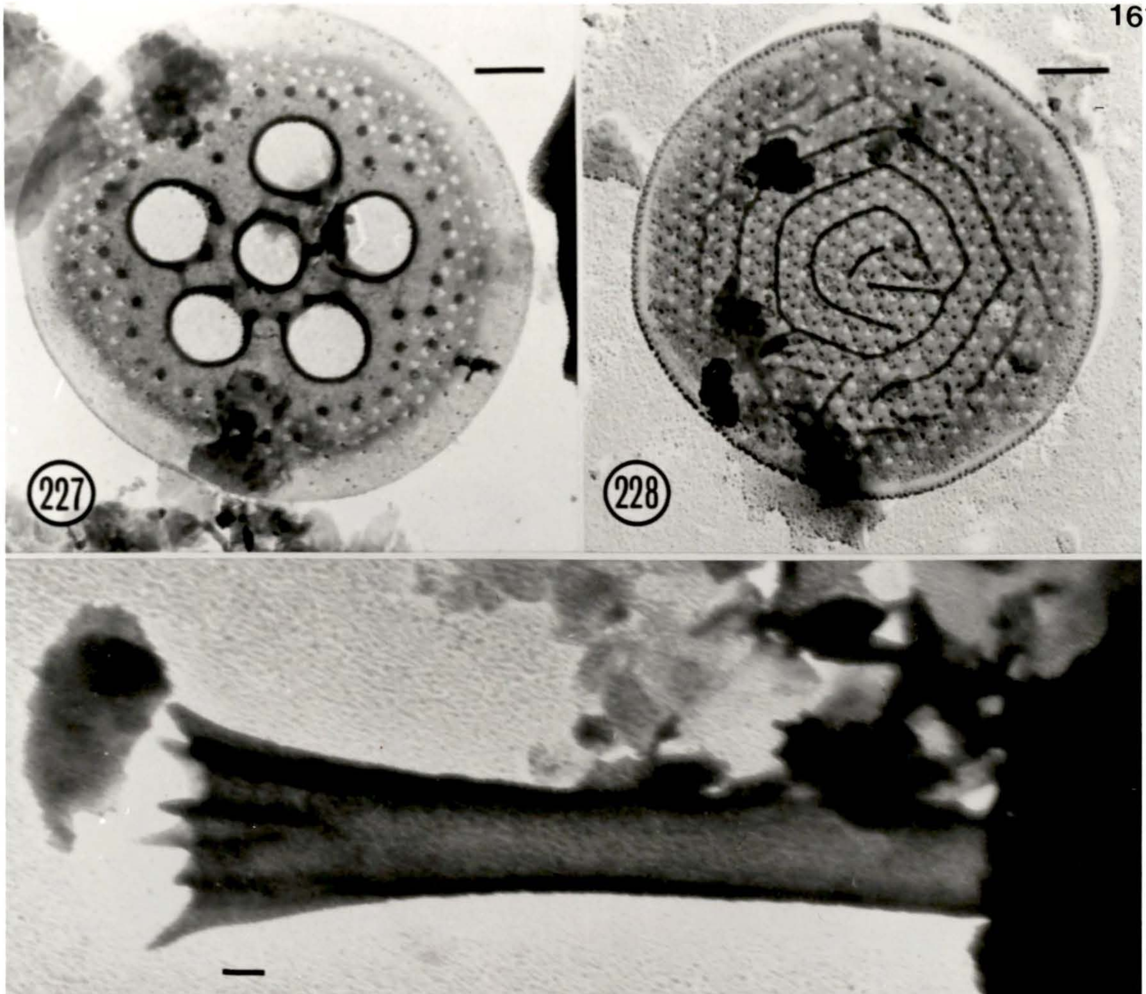
Observed in Saanich Inlet: Scales were round with a diameter of 3.9 μm. All had

Figure 227. *Pinaciophora denticulata.* Circular plate scale showing five perforations surround a central perforation on the top layer of plate. Scale bar = 0.5 μm.

Figure 229. *P. denticulata.* End of spine which is flared and has a row of six teeth. Scale bar = 0.1 μm.

Figure 228. *P. reticulata.* Circular plate scale with small perforations arranged hexagonally. A reticulate pattern of heavily silicified material is visible on plate surface. Scale bar = 0.5 μm.

Figures 230 and 231. *Raphidiophrys elegans.* Plate scales with radial striations and varying degrees of inflexed rims. Scale bar = 1.0 μm.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5 perforations surrounding the central perforation. Spines were 0.3 μm wide flaring to 0.6 μm, with ends extended into a row of 6 teeth. Debris on samples prevented length measurement of spines. Found in sample 10 (Jan.).

Previous records: Denmark and Peru (Thomsen, 1978b), Canadian Arctic and Alaska (Manton and Sutherland, 1979).

P. reticulata Thomsen 1979

Figure 228.

Description: Protoplast unknown. Plate scales 2.7-3.3 μm, with small perforations arranged hexagonally. A ribbon-like or reticulate pattern of heavily silicified material covers the scale. The rim of the scale is patternless; the edge of the scale is finely dotted. Spine (4.0 x 3.0 μm) flares distally (0.9 μm) and is drawn out into small spines (Thomsen, 1979).

Observed in Saanich Inlet: Plate scales were 2.7-3.3 μm in diameter. No spines were seen. Found in sample 11 (Feb.).

Previous records: Finland and Denmark (Thomsen, 1979).

Raphidiophrys elegans Hertwig and Lesser 1874

Figures 230 and 231.

Description: Cells (17-67 μm) are covered with silicified plate scales (4.0-14.0 x 2.0-3.0 μm) which are boat shaped with rounded or widened ends but can have aberrant shapes. Scales which are thin with radial striations are convex with inflexed rims. There are no spines (Nicholls and Durrschmidt, 1985).

Observed in Saanich Inlet: Scales were oval to boat shaped (5.5-8.4 x 3.4-3.4 μm) with varying degrees of inflexed rims. Radial striations were obvious. Found in samples 8 and 11 (Nov. and Feb.).

Previous records: from freshwater in Ontario, Canada and worldwide distribution (Nicholls and Durrschmidt, 1985).

Succession

Total chlorophyll *a* concentration of surface water at Station E and chlorophyll *a* concentration of nanoplanktonic fraction is shown in Figure 232. Unfortunately values for June, September and October are not available because the water sample used for chlorophyll analysis was too small. During summer months nanoplankton contributed 5-80 % of the total chlorophyll *a* while during the winter these organisms are responsible for almost all the chlorophyll *a*. During winter chlorophyll *a* values were 1.2-1.5 μgl^{-1}. The highest values seen were in April 1991 (22 μgl^{-1}) for total chlorophyll *a* concentration. Chlorophyll *a* concentration of organisms less than 20 μm was 1.5 μgl^{-1} at this time indicating that a bloom of larger organisms was occurring.

Temporal distribution of species during the sampling period is given in Tables 3-5. Figure 233 shows the number of species per Class present in each sample. A phenogram (Figure 234) illustrating a similarity matrix (Appendix I) shows how samples cluster based on either the presence or absence of each species.

Similarity analysis showed that samples 3, 4 and 5 (June, July and August) were similar to each other but quite different from the rest of the samples. These three samples had high total species numbers (24-35) with large numbers of Prasinophyceae and Prymnesiophyceae, less Chrysophyceae and relatively few choanoflagellates. Other than *P. grossii* and *M. pusilla*, prasinophytes were absent from the rest of the samples. Samples 1 and 13 (April 1990 and 1991) showed 90 % similarity according to cluster analysis. They both had low species numbers (9 and 11) with coccolithophores present as well as species which were present in several

Figure 232. Chlorophyll *a* concentration of total phytoplankton and nanoplanktonic fraction of surface water from Station E, Saanich Inlet from April 1990-April 1991.

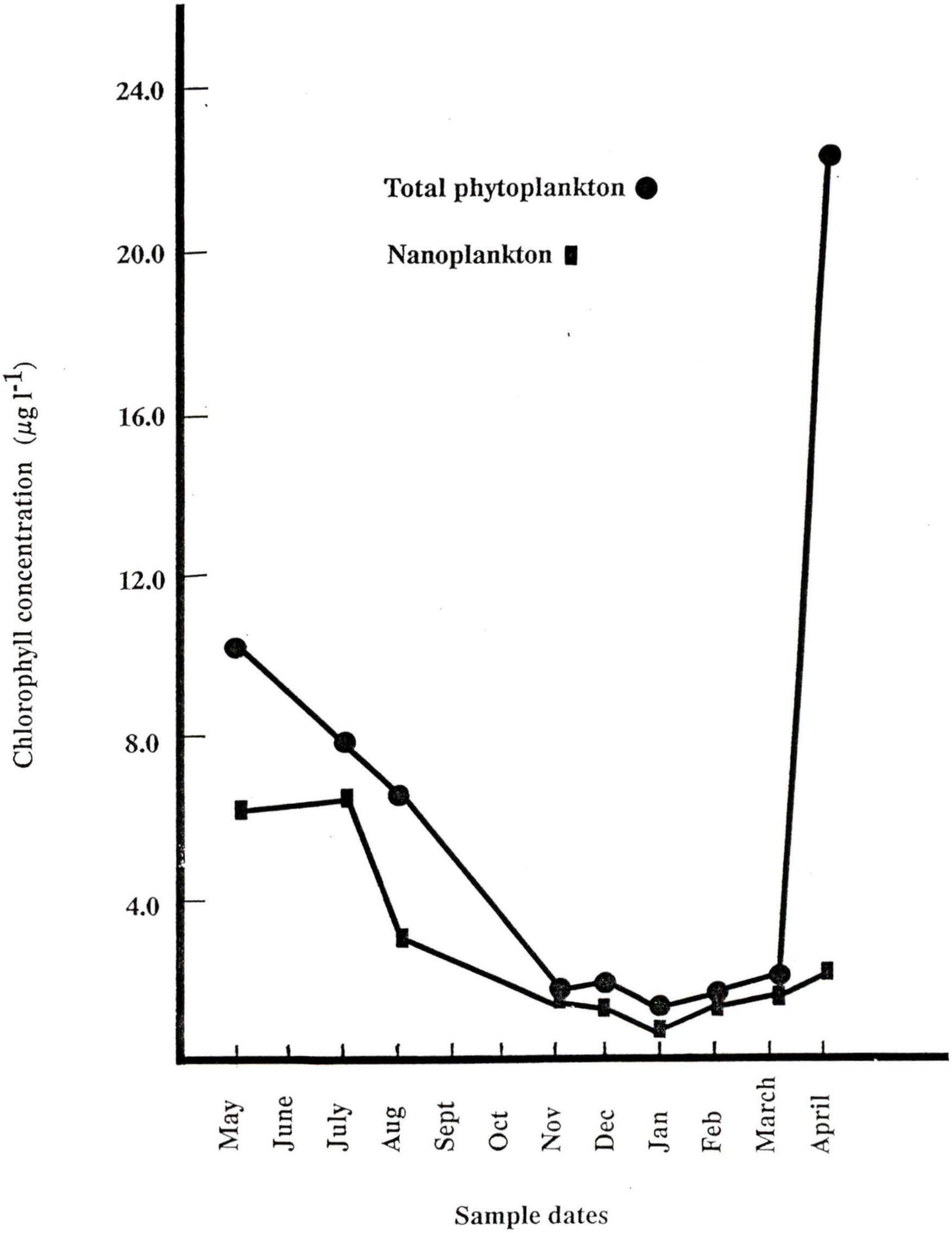
Total phytoplankton
Nanoplankton
Chlorophyll concentration (μg l-1)
24.0
20.0
16.0
12.0
8.0
4.0
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
April
Sample dates

Figure 232.

Table 3. Temporal distribution of Pedinophyceae, Prasinophyceae and Prymnesiophyceae.
• = presence of species, · = absence of species.

Species	Sample number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Pedinophyceae													
Resultor mikron	·	·	•	•	•	·	·	·	·	·	·	·	·
Prasinophyceae													
Dolichomastix nummulifera	·	·	•	•	•	·	·	·	·	·	·	·	·
Mamiella sp.	·	·	•	•	•	·	·	·	·	·	·	·	·
Micromonas pusilla	·	·	•	•	•	·	·	·	·	·	•	•	·
Pseudoscourfieldia marina	·	·	•	·	·	·	·	·	·	·	·	·	·
Cymbomonas sp.	·	·	•	•	•	·	·	·	·	·	·	·	·
Pterosperma cristatum	·	·	•	•	•	·	·	·	·	·	·	·	·
Pyrmimonas grossii	•	·	•	•	•	•	·	·	•	·	•	•	•
P. amylifera	·	·	•	•	•	·	·	·	·	·	·	·	·
P. orientalis	·	·	•	•	•	·	·	·	·	·	·	·	·
Prymnesiophyceae													
Chrysochromulina adriatica	·	·	•	·	·	·	·	·	·	·	·	·	·
C. brachycylindra	·	•	•	•	•	·	·	·	·	·	·	·	·
C. brevifilum	·	·	·	·	•	·	·	·	·	·	·	·	·
C. ephippium	·	•	·	·	•	·	·	·	·	·	·	·	·
C. ericina	•	·	•	•	·	·	·	·	·	·	·	·	·
C. hirta	·	•	•	•	•	·	•	•	•	·	·	•	•
C. leadbeateri	·	·	•	·	·	·	·	·	·	·	·	·	·
C. mantoniae	·	·	·	·	·	·	•	·	·	·	·	•	·
C. megacylindra	·	·	·	•	•	•	·	·	·	·	·	·	·
C. minor	·	·	·	·	•	·	·	·	·	·	·	·	·
C. parkeae	·	·	•	•	·	·	·	·	·	·	·	·	·
C. polylepis	·	·	·	·	•	·	·	·	•	·	·	·	·
C. simplex	·	•	•	•	•	·	·	·	·	·	·	·	·
Corymbellus aureus	·	·	•	·	·	·	·	·	·	·	·	·	·
Phaeocystis pouchetii	•	•	•	•	•	•	•	•	•	•	•	•	•
Dicrateria inornata	·	•	•	•	•	·	·	·	·	·	·	·	·
Imantonia rotunda	·	·	•	·	•	·	·	·	·	·	•	•	·
Wigwamma annulifera	•	·	·	·	·	·	·	·	·	·	·	·	•
W. arctica	•	·	·	·	·	·	·	·	·	·	·	·	·
Pappomonas virgulosa	•	·	•	·	·	·	·	·	·	·	·	·	·
Papposphaera sagittifera	•	·	·	·	·	·	·	·	·	·	·	·	·
Balaniger balticus	·	·	·	·	·	·	·	•	·	·	·	·	·
Quaternariella obscura	·	·	•	·	·	·	·	·	·	·	·	·	·
Trigonaspis sp.	·	·	·	·	·	·	·	•	·	·	·	·	·
Calcidiscus leptoporus	·	·	·	·	·	·	·	·	·	·	•	·	·
Emilania huxleyi	·	·	·	·	·	·	·	•	•	•	•	·	·

Table 4. Temporal distribution of Chrysophyceae and *Thaumatomastix*

Species	Sample number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Chrysophyceae													
Paraphysomonas butcheri	·	·	·	·	•	·	·	·	·	·	·	·	·
P. capreolata	·	·	·	·	·	·	·	·	·	•	·	·	·
P. foraminifera	·	·	·	·	·	·	·	·	·	•	•	·	·
P. gladiata	·	·	·	·	·	·	·	•	·	•	·	·	·
P. punctata punctata	·	·	·	·	·	·	·	•	·	•	·	·	·
P. vestita truncata	·	·	•	•	•	·	·	•	·	•	•	•	·
P. vestita vestita	·	·	•	•	·	·	·	•	•	•	·	·	·
Mallomonas akrokomos	·	·	·	·	·	·	·	·	·	•	•	·	·
M. caudata	·	·	·	·	·	·	·	·	·	·	•	·	·
M. crassisquama	·	·	·	·	·	·	·	·	·	•	•	·	·
Synura petersenii	·	·	·	·	·	·	·	·	·	•	•	·	·
Calycomonas ovalis	·	·	·	•	•	·	·	·	·	•	•	·	•
C. wulfii	·	·	·	·	·	·	·	·	·	•	•	·	·
Kephyrion sp. 1	·	·	•	·	·	·	·	·	·	·	•	·	·
Kephyrion sp. 2	·	·	·	·	•	·	·	·	·	·	·	·	·
Kephyrion sp. 3	·	·	•	·	·	·	·	·	·	·	•	·	·
Dinobryon balticum	·	·	·	·	•	·	·	·	·	·	·	·	·
D. borgei	·	·	•	·	·	·	·	·	·	·	·	·	·
Apedinella spinifera	•	•	•	•	•	•	•	•	•	•	•	•	•
Triparma cf. *columacea.*	·	·	·	·	·	·	·	·	·	•	•	•	·
Meringosphaera mediterranea	•	·	•	•	·	·	•	•	·	·	•	•	•
Dictyocha fibula	·	·	·	·	·	·	·	·	·	·	•	·	·
Incertae sedis													
Thaumatomastix bipartita	·	·	·	·	·	·	·	·	·	•	·	·	·
T. salina	·	·	·	·	·	·	·	•	·	•	·	·	·
T. tripus	·	·	·	·	·	·	·	•	·	·	·	·	·

Table 5. Temporal distribution of Choanoflagellida and Heliozoea

Species	Sample number 1	2	3	4	5	6	7	8	9	10	11	12	13
Choanoflagellida													
Acanthocorbis apoda	·	·	●	·	●	·	·	●	·	·	·	·	·
Acanthoeca spectabilis	·	·	·	·	·	·	·	·	·	●	·	·	·
Bicosta minor	·	·	●	●	·	·	●	●	·	·	●	●	●
Calliacantha natans	●	●	·	·	·	·	●	●	·	·	·	·	·
C. simplex	·	·	·	·	·	·	·	●	·	·	·	●	·
Cosmoeca norvegica	·	·	·	·	·	·	●	●	·	●	●	●	·
C. ventricosa	·	·	·	·	·	·	·	·	●	·	·	●	·
C. ventricosa Form B	·	·	·	·	·	·	·	●	●	·	·	·	·
Crinolina isefiordensis	·	·	·	·	·	·	·	·	●	·	·	·	·
Diaphanoeca grandis	·	·	●	·	·	·	·	·	·	·	·	●	·
D. pedicellata	·	·	·	·	·	·	·	·	·	·	●	●	·
D. sphaerica	·	·	·	·	·	·	●	·	·	·	·	·	·
Parvicorbicula quadricostata	·	·	·	·	·	·	·	●	·	·	·	●	·
P. socialis	●	·	·	●	·	·	·	●	·	·	●	●	●

Figure 233. Number of species identified in Saanich Inlet each month, placed into higher taxonomic categories.

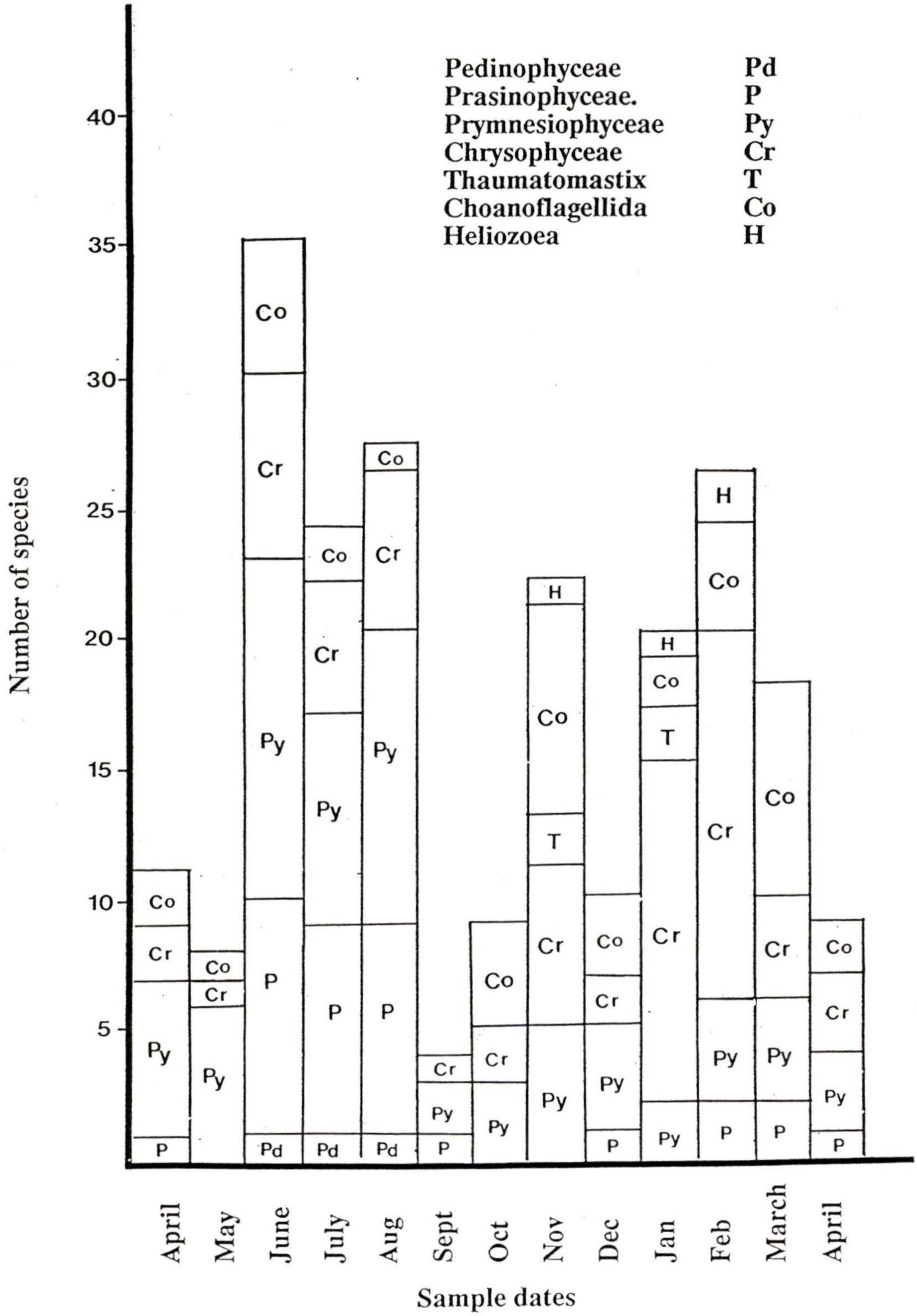
Pedinophyceae Pd
Prasinophyceae. P
Prymnesiophyceae Py
Chrysophyceae Cr
Thaumatomastix T
Choanoflagellida Co
Heliozoea H
Number of species
Sample dates
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
March
April

Figure 233.

Figure 234. Phenogram produced from similarity matrix based on either the presence or absence of each species.

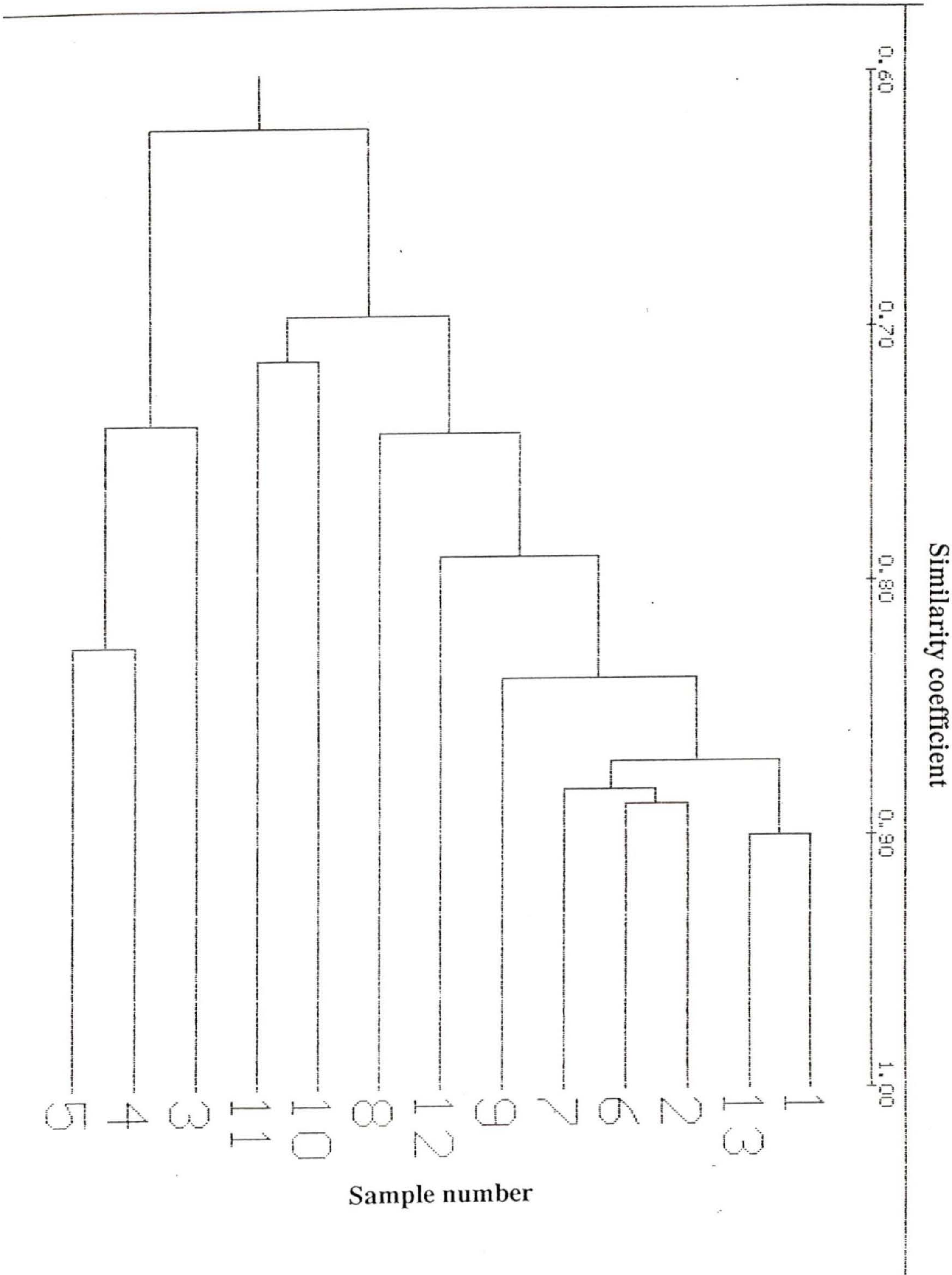
Similarity coefficient
0.60
0.70
0.80
0.90
1.00
1
13
2
6
7
9
12
8
10
11
3
4
5
Sample number

Figure 234.

samples (*P. grossii* and *M. mediterranea*) and *A. spinifera* and *P. pouchetii* which were present in all samples. Samples 2, 6 and 7 (May, September and October) clustered together. They had low total species (4-9) counts with few or no prasinophytes, no coccolithophores and a fairly equal distribution of species among the Prymnesiophyceae, Chrysophyceae and Choanoflagellida. Samples 10 and 11 (January and February) were more similar to each other than they were to any other samples. They both had high total species numbers (20 and 26) and several freshwater chrysophyte species. Many of these species were heterotrophic. Also heterotrophic heliozoans and a few species of choanoflagellates were present. Sample 8 (November) was different from other winter samples in that it contained several heterotrophic freshwater species as well as heliozoans along with a large number of choanoflagellates and two coccolithophores (*B. balticus* and *Trigonaspis* sp.) which were not found in any other samples. The non-pigmented genus *Thaumatomastix* was represented by three species seen in samples 8 and 10. Sample 8 had a high total species count. Sample 9 (December) had a low total species count, no freshwater species and was not dominated by any Class. Sample 12 (March) had a relatively high number of species, with no freshwater species. Choanoflagellates made up the largest group.

DISCUSSION

Taxonomy

Identification of 80 nanoplanktonic species from Saanich Inlet is slightly higher than species numbers found in neritic waters from other parts of the world. Moestrup (1979) identified 50 species from New Zealand, Hallegraeff (1983) found 44 species in an Australian study and Leadbeater (1972c; 1974) found 48 and 60 species from Norway and the Mediterranean Sea respectively. Systematic groups represented in Saanich Inlet are consistent with other studies. The algal Classes Prymnesiophyceae, Prasinophyceae and Chrysophyceae and the protistan Order Choanoflagellida dominate nanoplanktonic communities world wide (Leadbeater, 1972a,b, 1974; Moestrup, 1979, Espeland and Throndsen, 1986). The newly erected Class Pedinophyceae is represented in Saanich Inlet by a species previously included in Prasinophyceae. Heliozoans seen are species which have been recorded from antarctic, arctic and temperate neritic waters. Most nanoplanktonic species are cosmopolitan. Similar species composition occurs in the southern (Moestrup, 1979) and northern (Leadbeater, 1972c) hemispheres as well as neritic (Hallegraeff, 1983) and oceanic (Hoepffner and Haas, 1990) communities. This study has expanded the previously identified nanoplanktonic organisms in Saanich Inlet from *Dictyocha fibula* , *A. spinifera*, *Dicrateria* sp., *Chrysochromulina* sp., and *Pyramimonas* sp. as well as some cryptophytes (Takahashi *et al.*, 1978; Hobson, 1981). New findings include two undescribed organic scales perhaps belonging to *Pyramimonas* (Figures 42-47), a new scale type from *Cymbomonas* sp. (Figures 19-25), *Polyfibula stipitata* specimens with an unusual number of longitudinal costae (Figures 222-225) and a variation of *Triparma columacea* (Figures 179 and 180) as well as 50 new published records of species on the west coast of North America.

The three dimensional perforate scales composed of organic material (Figures

42-47) illustrate several aspects of this study; the difficulty in identifying solitary scales without other cell characteristics, the convergence of morphology seen in phylogenetically distant organisms and the need to use more than one technique. With shadow-casting these scales resemble those seen in the a-chloroplastic chrysophyte genus *Paraphysomonas* (Preisig and Hibberd, 1982) as well as those seen in the prasinophyte genus *Pyramimonas* (Inouye *et al.*, 1984). With complete cells differentiating between these two is possible because chrysophytes have two unequal flagella, one smooth and one with tripartitie hairs whereas prasinophytes have 1, 2, 4 or 8 equal, usually scaly flagella which all have partly tubular hairs. Without whole cells other characteristics must be used. Scales in *Paraphysomonas* are made of silica while those of *Pyramimonas* are organic. EDX microanalysis was necessary to rule out the presence of silica. These scales are considered to be from a prasinophyte, likely belonging to the genus *Pyramimonas*. Morphologically similar spines are also seen in unrelated taxa, for instance the chrysophyte *A. spinifera* (Figures 174-178) and the prymnesiophyte *C. hirta* (Figures 72-75) suggesting these structures increase the likelihood of survival in the nanoplankton.

Although there are no published records of *Cymbomonas* sp. from Saanich Inlet it has been seen in samples examined with a light microscope (R. Waters, personal communication). Also *Cymbomonas* sp. from Georgia Strait (R. Waters, personal communication) and the Adriatic Sea (Throndsen, 1988) have scale types which agree with those seen in this study. However the unique three sided scale has not been described before suggesting this is either an undescribed species of *Cymbomonas* or a species that has not been examined with the EM.

Specimens of *Polyfibula stipitata*, which were abundant in sample 3, all had 8 longitudinal costae instead of 7 as given in the species description. The number of longitudinal costae is an infra-generic character used for distinguishing species or subspecies in *Polyfibula*, however at least one species, *P. elatensis*, has 7 or 8 longitudinal costae (Manton and Bremer, 1981). Therefore instead of excessive splitting of taxa to create a subspecies of *P. stipitata* with 8 longitudinal costae, I suggest that the species description be emended to include 7 or 8 longitudinal costae.

The newly described Order Parmales have walls constructed of siliceous plates. These organisms were originally thought to be a stage in the lifecyle of choanoflagellates however ultrastructural examination has revealed chloroplasts with three thylakoid lamellae and a chloroplast endoplasmic reticulum. Therefore Parmales has been placed in the Chrysophyceae although nothing is known about pigmentation or life cycles. Although specimens from Saanich Inlet are quite distinct from *Triparma columacea* with respect to ornamentation, they have the same plate formation which is the basis for distinguishing species. Therefore Saanich Inlet specimens are considered a variation of *T. columacea*. This is the first observation of any Parmales species in abundance in inshore waters (B. Booth, personal communication). They were found in Saanich Inlet at a time (January-March) when most of the nanoplankton were freshwater species.

The taxonomic position of most species in this survey is stable however a few are uncertain. *Micromonas pusilla* has prasinophycean pigmentation with pedinophycean features such as absence of either body or flagellar scales and flagellar hairs (Moestrup, 1991). For now *M. pusilla* is retained in Prasinophyceae. *Meringospheara mediterranea* has been placed in the Class Chrysophyceae because of its pigmentation and siliceous spines but nothing is known about the ultrastructure of this organism with its unusual barbed spines (Leadbeater, 1974). Pedinalles, considered to be an Order in the Class Chrysophyceae has non-chrysophyte traits including radial symmetry, several chloroplasts per cell, one emergent flagellum with a second basal body parallel to the flagellar base, paraxial rod supporting expanded flagellar membrane, no microtubular flagellar roots, tentacles and no statospores. Some have suggested Pedinalles should occupy a position between chrysophytes and heliozoans (Hibberd, 1986). The taxonomic position of *Thaumatomastix* is unknown. It is unpigmented, which is not unusual in algal Classes, but its flagellation is not seen in any Class. It has one short, scale covered flagellum and one long flagellum. Neither one has hairs. Further ultrastructural studies are necessary to classify this organism.

Seasonal Succession of the Nanoplankton

Due to limitations caused by examination of large water samples with electron microscopy, the absence of a species from a sample does not rule out its presence in Saanich Inlet. However, some trends in succession were indicated by this study. During June, July and August a large number of autotrophic prasinophytes and prymnesiophytes were seen with low numbers of heterotrophic choanoflagellates. This is known to be the period in Saanich Inlet when diatom biomass decreases and numbers of flagellated cells are maximal (Hobson, 1981,1983). Prasinophytes were almost entirely absent during the rest of the year. Another obvious trend in species composition was the presence of many freshwater species in January and February and a few in November but none in December. Winter is the period of maximum freshwater runoff in Saanich Inlet (Appendix II). All winter samples showed few autotrophs and increased numbers of heterotrophs. Indications of nanoplanktonic species succession were seen by Hallegraeff (1981) who found *Pyramimonas* spp. common in winter and absent in summer and *Micromonas* sp. and coccolithophores more common in summer than in winter in Australian waters.

Chlorophyll *a* concentrations of nanoplankton in Saanich Inlet was higher in summer than in winter but did not show the amount of variation seen in the total phytoplankton fraction. This agrees with other studies of coastal phytoplankton (Hallegraeff, 1981). The number of species as well as higher taxa was not constant over the year. This indicates that at various times of the year chlorophyll *a* in the water is not due to the same organisms. Because chlorophyll analysis did not consider degraded pigments and counts of organisms were not done, it is not possible to determine how much of this chlorophyll was involved in primary production and what percentage each species was contributing. The large number of heterotrophic species present shows that chlorophyll concentration is not a true estimate of nanoplankton biomass. Changes in higher taxa are significant because within Classes common nutritional modes are usually present. Therefore a shift from a population dominated by autotrophic prasinophytes to one that is dominated by heterotrophic choanoflagellates means a major change in trophic organization. If changes in species composition were merely substitutions of one prasinophyte for another prasinophyte of similar size, trophic level restructuring would not be seen.

Succession of nanoplanktonic species is due to complex interactions of many factors. These include water stability, temperature, salinity, photoperiod and light intensity, nutrient concentration, interaction with microphytoplankton, presence of grazers and availability of prey for heterotrophs. Although none of these parameters were measured in this study much information is available from previous Saanich Inlet studies allowing speculations on the causes of nanoplankton species succession.

Nanoplankton and Planktonic Ecosystems

Saanich Inlet is a fjord, 24 km long and 7.2 km wide at its widest point. The major freshwater contributor is the Cowichan River which flows into Cowichan Bay 6 km north of Saanich Inlet. Discharge of this river depends on precipitation which on average is highest in December and lowest in July (Appendix II). This causes variation in surface salinity from 14 in winter to 29 in summer (Herlinveaux, 1962). Large variations in surface salinities can occur in short periods. Seasonal changes in air temperature from maxima in July and August to minima in December, January and February (Appendix II) result in a maximum surface water temperature of 19°C in July and a minimum of 5°C in December and January (Herlinveaux, 1962; Takahashi *et al.*, 1978). Hours of daylight and light intensity are at a maximum in June and July and a minimum in December (Herlinveaux, 1962; Takahashi *et al.*, 1978). Surface water in Saanich Inlet is stable due to a sharp pycnocline associated with a thermocline in summer and a halocline in winter (Herlinveaux, 1962). In general, concentrations of nitrate, silicate and phosphate are high in surface water during the winter months and low in summer months (Hobson, 1985; Takahashi *et al.*, 1978). A spring bloom dominated by diatoms generally begins in April, diatoms remain abundant throughout the summer although not at bloom levels. A second bloom can occur in the fall. Dinoflagellates increase in June and July. Nanoflagellates dominate surface water from October to March (Hobson, 1981, 1983; Takahashi *et al.*, 1977, 1978). Winter populations of zooplankton are primarily small copepods and ciliates (microzooplankton) at relatively low levels. After the onset of the spring diatom bloom, microzooplankton numbers increase but the grazers at this time are mainly larger copepods and euphasiids (macrozooplankton) (Harrison *et al.*, 1983; Takahashi and Hoskins, 1978). Bacterial activity of water 0-25 m was high in April to mid-June and from mid-July to mid-September in 1981. Surface water had high bacterial activity in December of that year. Values were not determined for December to April (Hobson, 1983). In Georgia Strait increased bacterial production occurs in plume areas, a region where river water mixes with seawater (Valdes and Albright, 1981).

The sampling site for this study (Station E) is in the center of Saanich Inlet approximately half way between the head and the mouth. Although patchiness of salinity, temperature and density occur in the surface water of Saanich Inlet (Herlinveaux, 1962), Takahashi *et al.*, (1978) found that at two stations no major differences in general trends existed. Chlorophyll *a* concentration between the two stations varied less than +/- 50% and other variables had less variation than this. Therefore this station should be representative of the Inlet. The study period (April 1990-1991) appears to have been typical with respect to chlorophyll *a* concentration. Total winter chlorophyll *a* concentration of < 1 μgl^{-1} in 1975-76 (Takahashi *et al.*, 1978) and 0.1-1.3 μgl^{-1} in 1981 (Hobson, 1983) agreed with the values seen (1.2-1.5 μgl^{-1}). Also values of 22 ugl^{-1} in the top 10 m in May 1975 (Takahashi *et al.*, 1977) and 30 μgl^{-1} in April 1976 (Hobson, 1983) corresponds to the values seen in April 1991 (22 μgl^{-1}). The fraction of total chlorophyll *a* due to nanoplankton is consistent with findings of Takahashi *et al.* (1977, 1978) who found that during the summer the nanoplanktonic contribution was 5-50 % whereas during the winter often 90 % of the chlorophyll was from nanoplankton. Average monthly air temperatures and precipitation for the study period (Appendix II) indicate that conditions were fairly typical with cooler temperatures than normal during December and winter precipitation both higher (November and December) and lower (January) than normal during various months.

Assuming that the period April 1990-1991 was typical, the water conditions during June, July and August included high temperature, high salinity, low nutrient concentration, increased photoperiod and light intensity and high numbers of grazing zooplankton. It seems logical that the high number of autotrophic prasinophytes seen at this time is due to either high temperature or long photoperiod with increased light intensity. Also the ability of nanoflagellates to move vertically in the water column might allow them to place themselves temporarily in areas of higher nutrient concentrations (below the thermocline) . Reduced choanoflagellate numbers might result from competition with other predatory organisms. It is also possible that choanoflagellates move to deeper water to take advantage of increased bacterial activity which extends to 25 m during summer (Hobson, 1983). During this period when surface water is thermally stratified and nutrient concentrations are low, trophic organization is predominantly autotrophic nanoplankton being grazed by microzooplankton, which are food for the macrozooplankton.

The presence of many freshwater species in January and February and a few in November but none in December is likely due to fluctuations in the amount of river runoff, which depends on precipitation. Nanoplanktonic communities in the surface water vary between translocated freshwater species and brackish or marine species. River runoff increases nutrient concentration as well as organic material (Albright, 1983). Both of these enhance bacterial growth. Since the increased number of heterotrophs seen in the winter are primarily bacteriverous this would favor heterotrophy. The reduced photoperiod at this time should also encourage heterotrophy. I believe that the winter trophic organization is caused by the presence of autotrophic bacteria, which may be augmented in the Inlet by freshwater runoff, being consumed by the nanoplankton.

Similar nanoplanktonic communities of low species number were seen in April of 1990 and 1991 suggesting conditions are repeated seasonally. Late April and early May is the period during or immediately following the spring diatom bloom, indicating that large numbers of diatoms depresses nanoplankton species diversity perhaps by competing for nutrients. Hobson (1989) has suggested that increased pH in surface water at this time gives diatoms an advantage in carbon uptake. Of the few nanoplanktonic species seen during this time, four were coccolithophorids previously seen in arctic and antarctic waters. These are considered to be cold adapted (Thomsen *et al.*, 1988). It is possible these organisms were present in Saanich Inlet during winter months but remained at deeper depths because of reduced salinity of surface water. *Balaniger balticus*, a coccolithophorid seen during November, differs from other coccolithophorids in its capability of surviving in low salinities and has been seen only in brackish water (Thomsen *et al.*, 1988). Therefore salinity and temperature seem to control the appearance of these coccolithophores.

Future Considerations

Although this study identified many species some organisms were unidentifiable. Cryptophytes, which are known to inhabit Saanich Inlet (Takahashi *et al.*, 1978), were not identifiable beyond Class level. Their characteristic bean shaped body and two flagella +/- hairs emerging from a furrow, recognizable with shadow-casting, was seen in several samples. For further identification cell surface features must be examined with freeze fracture techniques or high resolution SEM (Hill, 1991). Processing necessary to concentrate and preserve organisms often damaged cells which lost flagella and haptonema, and therefore some organisms could not be identified. Also, species present in low numbers might have been missed because of the small amount of material that can be examined with electron microscopy.

Further taxonomic studies on Saanich Inlet nanoplankton should involve isolation and culturing of organisms. This would allow life cycle studies as well as provide high cell numbers necessary for sectioning of material for ultrastructural examination. Combining light microscopy, SEM, EDX, freeze fracture and TEM techniques would alleviate some limitations realized in this study. Determination of taxonomic compositon of nanoplankton is necessary to understand the role these organisms play in plankton communities.

In order to fully explain nanoplanktonic species succession, simultaneous records of species presence and other factors are necessary. Quantitative analyses of species in the surface water as well as at other depths are also part of a complete successional study.

Conclusions

Examination of surface nanoplankton from Saanich Inlet with transmission and scanning electron microscopy has identified eighty species. Fifty of these are new published records for the west coast of North America. These organisms belong to the algal Classes Pedinophyceae, Prasinophyceae, Prymnesiophyceae and Chrysophyceae and the protistan Order Choanoflagellida and Class Heliozoea. The species seen in Saanich Inlet are the same as those seen in other parts of the world, which reflects the cosmopolitan nature of nanoplankton.

New taxonomic findings include a variation of *Triparma columaceae*, a new scale type from *Cymbomonas*, two undescribed prasinophyte scale types, and an unusual number of lorica costae in *Polyfibula stipitata*.

There is evidence of seasonal species succession with high numbers of autotrophic prasinophytes and prymnesiophytes during summer months and very few in winter months. Winter nanoplankton populations varied between translocated freshwater species and marine and brackish species, many of which were heterotrophic chrysophytes and choanoflagellates. Low species number with similar species composition was seen in April of both years. Species succession is possibly caused by differences in photoperiod and light intensity, river runoff and bacterial activity.

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Appendix I

Similarity matrix based on presence or absence of each species.

SIMQUAL

1 1.000
2 0.838 1.000
3 0.575 0.613 1.000
4 0.713 0.750 0.787 1.000
5 0.613 0.750 0.688 0.825 1.000
6 0.875 0.887 0.575 0.738 0.713 1.000
7 0.850 0.887 0.575 0.713 0.637 0.875 1.000
8 0.713 0.725 0.487 0.625 0.525 0.713 0.787 1.000
9 0.000 0.838 0.550 0.688 0.662 0.875 0.825 0.738 1.000
10 0.662 0.700 0.412 0.575 0.525 0.738 0.713 0.700 0.738 1.000
11 0.675 0.637 0.500 0.613 0.537 0.700 0.700 0.637 0.650 0.713 1.000
12 0.762 0.750 0.588 0.700 0.625 0.787 0.838 0.838 0.750 0.762 0.650 0.762 1.000
13 0.900 0.863 0.60 0.787 0.688 0.900 0.900 0.762 0.350 0.713 0.750 0.833 0.837 1.000

Appendix I

Similarity matrix based on presence or absence of each species.

SIMQUAL

```
========================= SIMQUAL ===== 6/24/91 13:49 ======================
Input matrix:a:nano.doc
"Input matrix nannoplankton"
type=1, size=80 by 13
1 1.000
2 0.838 1.000
3 0.575 0.613 1.000
4 0.713 0.750 0.787 1.000
5 0.613 0.750 0.688 0.825 1.000
6 0.875 0.887 0.575 0.738 0.713 1.000
7 0.850 0.887 0.575 0.713 0.637 0.875 1.000
8 0.713 0.725 0.487 0.625 0.525 0.713 0.787 1.000
9 0.800 0.838 0.550 0.688 0.662 0.875 0.825 0.738 1.000
10 0.662 0.700 0.412 0.575 0.525 0.738 0.713 0.700 0.738 1.000
11 0.675 0.637 0.500 0.613 0.537 0.700 0.700 0.637 0.650 0.713 1.000
12 0.762 0.750 0.538 0.700 0.625 0.787 0.838 0.750 0.762 0.650 0.762 1.000
13 0.900 0.863 0.600 0.787 0.688 0.800 0.900 0.762 0.850 0.713 0.750 0.8[illegible]
0

Press any key to continue
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Appendix II

Monthly Meterological Summary from Victoria International Airport for April 1990-April 1991. Values in brackets are monthy averages for the past 30 years.

Month	Precipitation (mm)	Temperature (°C)
April	64.2 (39.9)	9.8 (8.4)
May	45.0 (28.5)	11.4 (11.6)
June	44.9 (29.0)	14.3 (14.3)
July	4.4 (18.1)	17.8 (16.3)
August	40.8 (26.7)	17,2 (16.1)
September	15.4 (39.6)	14.4 (13.9)
October	97.0 (78.4)	8.8 (9.9)
November	270.6 (130.8	6.6 (6.0)
December	177.2 (157.3)	1.8 (4.2)
January	113.5 (154.3)	2.5 (3.1)
February	128.2 (99.2)	7.3 (4.8)
March	66.5 (71.7)	5.5 (5.7)
April	95.7 (39.3)	8.4 (8.4)

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PATRICIA SMITH

October 23, 1991
(Date)