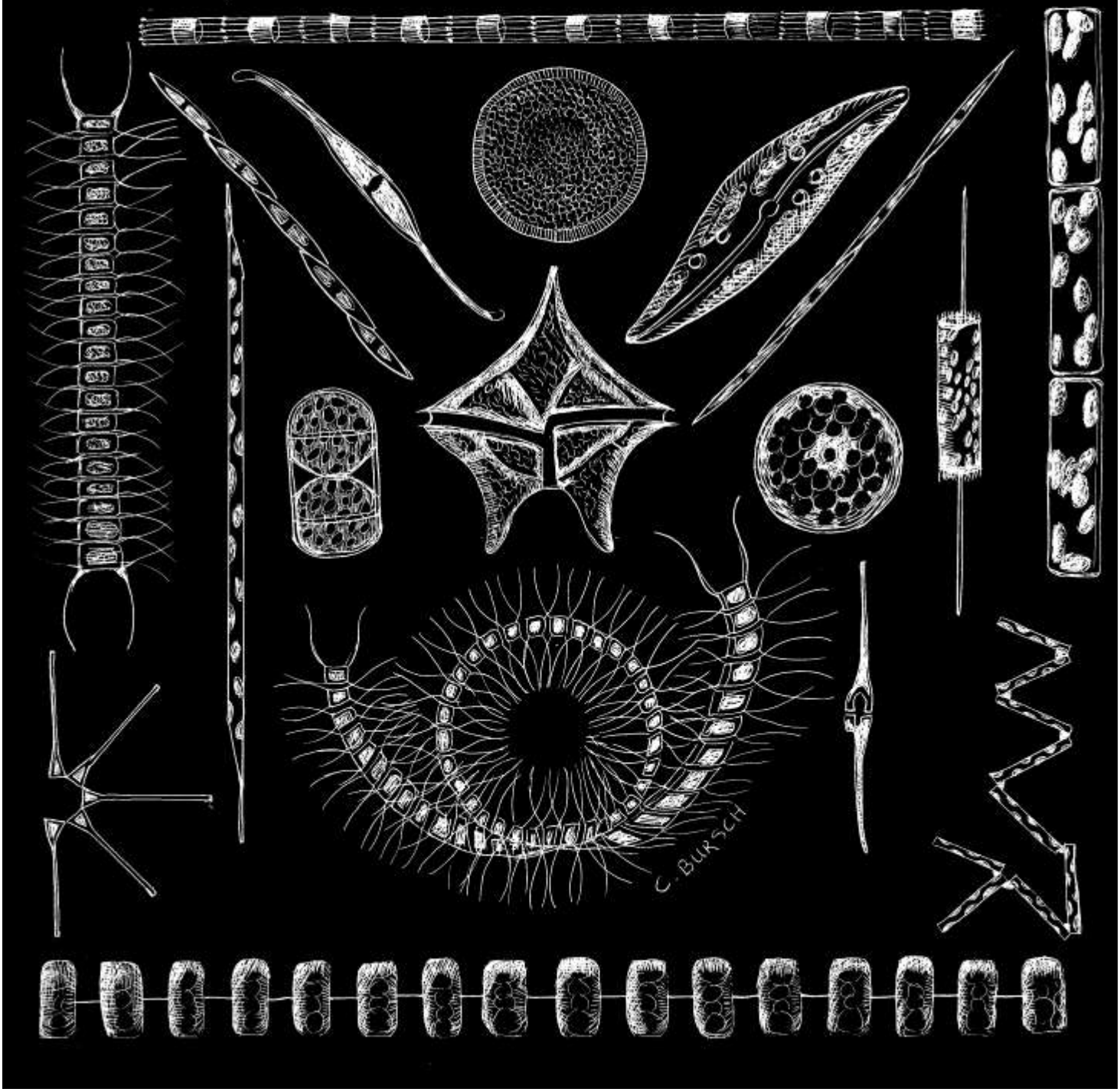
Marine Phytoplankton of Kachemak Bay

By Jane Middleton and Catie Bursch

Kachemak Bay Research Reserve—2015



PHYTOPLANKTON of KACHEMAK BAY, ALASKA

A GUIDE TO IDENTIFICATION

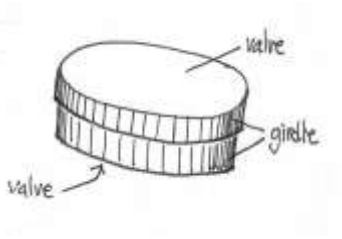
INTRODUCTION

Phytoplankton are one-celled organisms that float in sunlit surface water where they convert solar energy into the food energy that sustains almost all life in marine and estuarine ecosystems. They are normally microscopic (less than 100 microns in diameter. A micron is a millionth of a meter; 1000 microns is a millimeter.) The two most significant groups of phytoplankton that are visible with a microscope in the estuarine waters of Kachemak Bay and adjacent coves are **DIATOMS** and **DINOFLAGELLATES.**

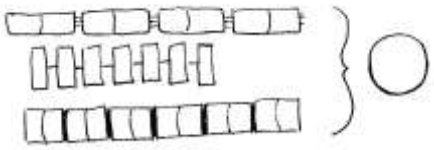
DIATOMS

Diatoms are comprised of a live cell surrounded by a glass cage made of silica that resembles a miniscule box—the bottom (hypotheca) fits snugly into a tight-fitting lid (epitheca)—much like a hatbox or tube of lipstick. The flat surfaces of the top of the epitheca and the bottom of the hypotheca are called "valves." Based on valve shape diatoms are loosely divided into two groups—centric and pennate.

Centric diatom valves have radial symmetry. Each valve is a circle that radiates outward from its midpoint like a snowflake or dinner plate. Hence diatoms with this shape are called "centric diatoms." The sides of the lid and the box are called the "girdle." The rectangular side view of a centric diatom (A) is called the edge lipstick the "girdle view." The rectangular girdle view may resemble of a thin coin, or be thicker like a hatbox or tall and thin like a tube.



A. Valve and girdle views of a single centric diatom.



B. Girdle views of 3 centric diatom chains

Typically, centric diatoms are not motile—meaning they cannot propel themselves through the water. Hence they flourish in the active surface waters where waves and currents move them about, continually exposing them to new concentrations of vital nutrients. Some centric diatoms form chains (B) by joining their valves with valves of adjacent centric diatoms of the same species. Chain formations, as well as spines, are adaptations that increase flotation of diatoms in the surface water.

Pennate valves have bilateral symmetry. The valves are usually wider in the middle and taper at both ends, but may be nearly rectangular. Most pennate diatoms are benthic—dwelling near or on the ocean

water of the slit at one end, creating an osmotic gradient along the raphe that pulls water into the raphe and moves it along to exit at the opposite end. This water action results in rather rapid motility of the diatom by jet propulsion, an important adaptation for obtaining nutrients in the benthic environment where there is little wave action to move them around.

A. Pennate: Girdle view

B. Pennate: Valve view

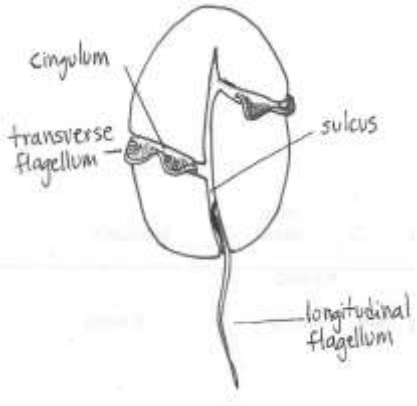
DINOFLAGELLATES

Dinoflagellates are another form of phytoplankton that we see under a microscope —zipping and twirling among the unmoving diatoms and in and out of the field of view of the microscope. A single dinoflagellate is basically a round cell confined in a capsule of close-fitting cellulose plates that may squeeze the cell into a different shape, like the one in Fig. C.

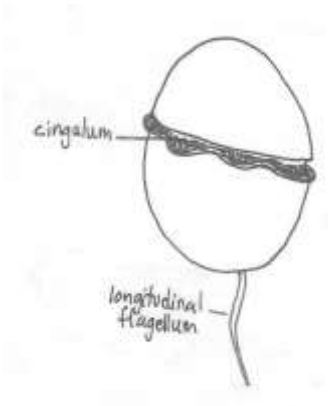
C. Dinoflagellate

A horizontal groove (cingulum) circles the cell and a second groove (sulcus) extends downward from the cingulum to the lower end of the cell. One flagellum lies in the cingulum and a second flagellum extends into the water from the sulcus.

The sulcus and ends of the cingulum can only be seen on the ventral (front) side of the dinoflagellate, as in Fig. D. Details of the positions of the cingulum ends relative to each other and to the sulcus vary greatly from one species to another, but are often helpful when identifying a given dinoflagellate. Wavy contractions of the transverse flagellum in the cingulum cause the dinoflagellate to spin, while the longitudinal flagellum in the sulcus propels the dinoflagellate forward.



D. Ventral side of dinoflagellate



E. Dorsal side of dinoflagellate

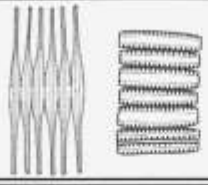
Phytoplankton Monitoring Network

Asterionellopsis morphotype

Cylindrotheca closterium

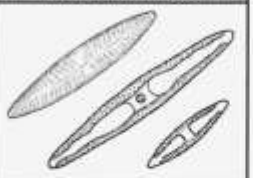
Entomoneis spp.

Fragilariopsis spp.



Licmophora spp.

Nawicula morphotype



Nitzschia morphotype

Pleurosigma morphotype

Pseudo-nitzschia spp.

Thalassionema spp.

PENNATE DIATOMS

Illustrations NOT to Scale:

Cupp, E.E., 1943. Marine Plankton Diatoms of the West Coast of North America, University of California Berkeley.

Tomas, C. (Ed.), 1997. Identifying Marine Phytoplankton. San Diego, CA.

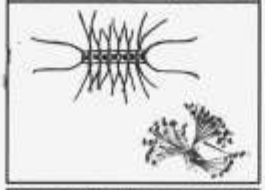
CENTRIC DIATOMS

Illustrations NOT to Scale:

Cupp, E.E., 1943. Marine Plankton Diatoms of the West Coast of North America, University of California Berkeley.

Tomas, C. (Ed.), 1997. Identifying Marine Phytoplankton. San Diego, CA

Chaetoceros spp.

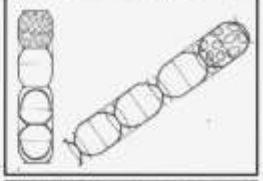


Coscinodiscus morphotype

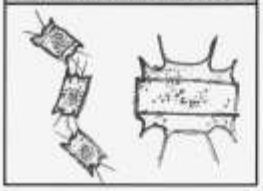
Ditylum spp.

Leptocylindrus spp.

Melosira sp.

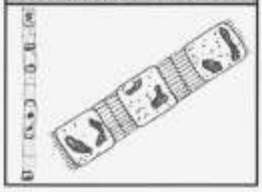


Odontella spp.

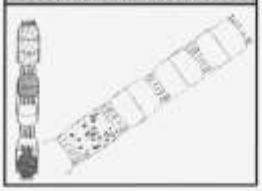


Rhizosolenia morphotype

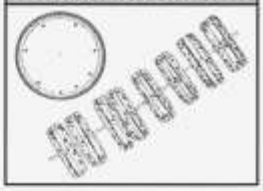
Skeletonema spp.



Stephanopyxis spp.



Thalassiosira spp.



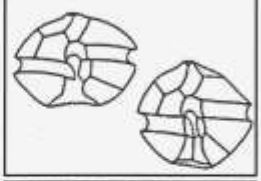
DINOFLAGELLATES

Illustrations NOT to Scale:

Tomas, C. (Ed.), 1997. Identifying Marine Phytoplankton. San Diego, CA.

Catie Bursch, Kachemak Bay Research Reserve

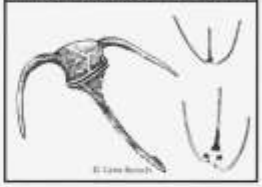
Alexandrium spp.



Ceratium furca morphotype

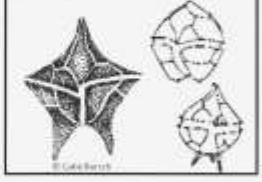
Ceratium fusus morphotype

Ceratium longipes morphotype



Dinophysis spp.

Protoperidinium spp.



Noctiluca spp.

Prorocentrum spp.

Karenia mikimotoi

ZOOPLANKTON

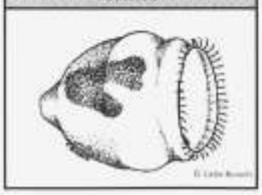
Illustrations NOT to Scale:

Catie Bursch, Kachemak Bay Research Reserve

Johnson, W.S., Allen, D.M., 2005. Zooplankton of the Atlantic and Gulf Coasts A Guide to Their Identification and Ecology. Baltimore, Maryland.

Barnacle nauplius

Ciliates

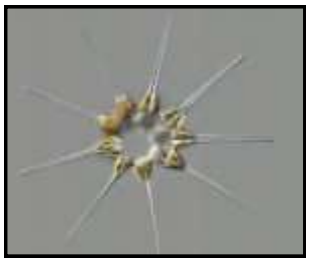


Copepod nauplius

PHYTOPLANKTON OF KACHEMAK BAY, ALASKA

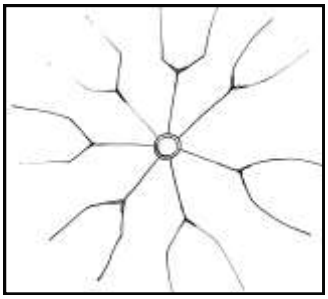
DIATOMS

***Asterionellopsis* sp.** (pennate diatom)



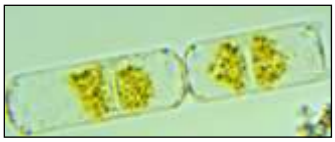
- Basal end is triangular and thicker than the other end, like a plunger.
- Cells are held together in a radial chain by the basal ends.
- Two chloroplasts are located in the basal ends but rarely seen.

***Bacteriastrum* sp** (centric diatom)



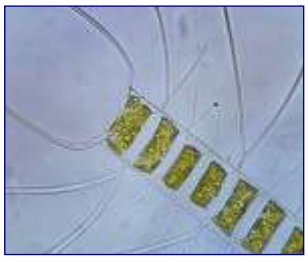
- Valves of cells are round and cells may be linked in chains.
- 10-20 hollow setae arise from rim of valves and fuse with setae on the valve rim of adjoining cells.
- Fused setae extend perpendicular to chain, then separate, producing a bifurcate end to the setae.
- Found with *Chaetoceros* but rarely dominate a sample.

Cerataulina sp. 30-60µm (centric diatom)



- Cylindrical cells with scattered large, often clumped, chloroplasts**.**
- Two small projections, opposite on the rim of each valve.
- Projections on one valve are not necessarily in line with those on opposite valve of the same cell.
- Chains form when projections on valve of one cell fit into depressions on valve of adjoining cell.

***Chaetoceros* spp.** 10-50µm (centric diatom)



- *Chaetoceros* spp. are dominant in Kachemak Bay in June-July.
- Every cell has 2 spines on each valve. (upper photo at right)
- Chains form when spines of adjoining cells fuse together at their
- bases.(lower photo)
- Valves of adjoining cells in the chain don't touch—there is a space between them called the "aperture."
- Cells in a chain appear rectangular because we are seeing them in girdle view. Valve view of cells is round.
- *Chaetoceros* is important in the marine food web—it does no apparent harm to animals that eat it. It is even cultured as food for the bi-valve industry.
- However, *Chaetoceros* does great harm to salmon smolt held in pens in the Nick Dudiak Fishing Lagoon on the Homer Spit.

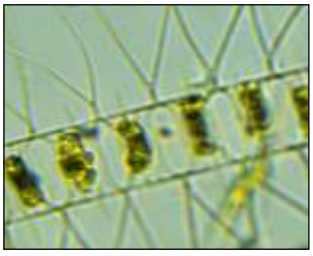
Chaetoceros spp. (continued)

- During a *Chaetoceros* spp. bloom, chains of cells clog the gills of salmon smolt and damage the tiny fish in three ways:
  - Spines lacerate the delicate gills.
  - Spines introduce bacteria to the bloodstream through the lacerations.
  - Irritation of the gill surface by spines stimulates mucus production that cuts off O_2 passage through the gills.
- There are more than 400 species of this genus world-wide. We have observed several different ones in our local tows. Ten are shown below with common English descriptions. We have yet to determine individual species names.

a. Curly-cue chain. "Eyelash" spines point outward.

b. Spiral. Large cells are wider than long.

c. Rectangular cells are wider than long. Oval holes.



d. Rectangular are longer than wide.

e. "Jigsaw puzzle valves."

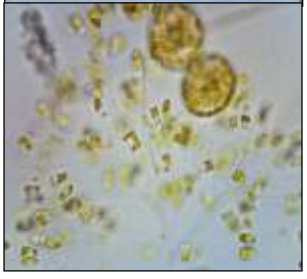
f. Giant spines

g. Criss-cross

h. Messy spines — Deteriorating (?)

i. Cells with rounded corners

j. *C. socialis* Scattered very small cells are attached by faintly visible tendrils to



DIATOMS

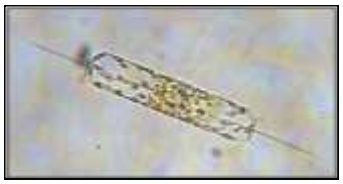
Corethron criophilum 20-200µm (centric diatom)

- Single, tubular cells with domed valves.
- Both valves bear marginal spines, pointing backward.
- Valve of epitheca bears a second set of shorter spines that end in twisted knobs and point forward like a crown.
- Chloroplasts numerous, small.

Coscinodiscus morphotype 50-170 µm (centric diatom)

- Valve is large and round, often confused with valves of *Thalassiosira* sp. but much larger.
- Girdle view, not often seen, resembles a hockey puck.
- *Coscinodiscus* sp. controls its buoyancy by releasing oil droplets through a large central pore and many smaller pores aligned radially and around the circumference.
- View of radial pores is often blocked by chloroplasts.

Ditylum brightwellii 100-320µm (centric diatom)



- Girdle view is long and rectangular.
- A single stiff spine on each end.
- Valve view is triangular, but not often visible.

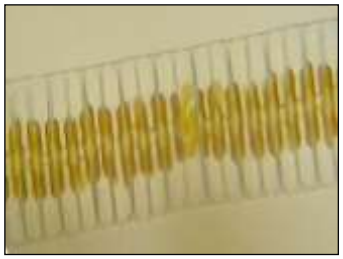
Entomoneis sp. 40-140µm (pennate diatom)

- Large rectangular cell, large chloroplast, visible raphe.
- Usually benthic but may get swirled into the surface water.
- = ***Amphiprora*** sp in older references.

Eucampia sp. 20µm (centric diatom)

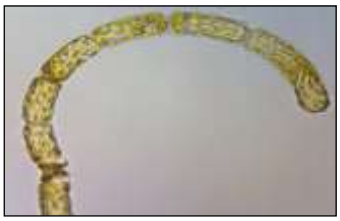
- Cells in curved chains.
- Cells connected by two blunt projections on both valves.
- Apertures large and circular.

Fragilariopsis **sp.** 30µm (pennate diatom)



- Cells flattened, either single or pressed together in belt-like chains.
- Valves rod-shaped or elliptical.
- Large, central chloroplasts.
- Mostly benthic.

DIATOMS

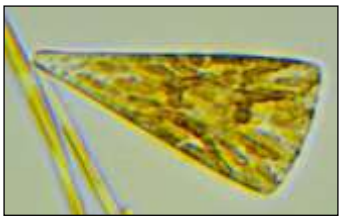


Guinardia sp. (centric diatom)

- Long cylindrical cells form straight or slightly curved chains.
- Valves somewhat convex.
- Chloroplasts many, small, round and often clumped.

***Leptocylindrus* sp.** 30-60µm (centric diatom)

- Long, slender cells form straight chains.
- In chains, cells are joined by the full surface of their flat valves.
- Cells have no spines nor horns.
- Important oyster food.

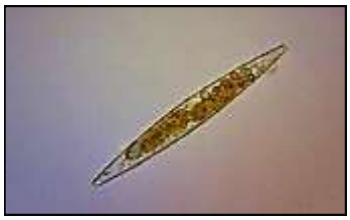


***Licmophora* sp.** 70µm (pennate diatom)

- Wedge shaped cells.
- Normally attached to seaweed or zooplankton but sometimes breaks loose and floats freely in the water.
- Chloroplasts tend to be olive-green.

***Melosira* sp.** 40µm (centric diatom)

- Pairs and triplets of cells are united in chains by mucilage pads at their valve centers.
- Cells drum-shaped.



Navicula morphotype 50-110µm (pennate diatom)

- Over 1000 pennate species have this morphotype (shape).
- Size ranges from mostly very small to a few quite large.
- Solitary, kayak shaped with somewhat rounded ends.
- Very active. A raphe is usually visible.

Nitzschia morphotype 60µm (pennate diatom)

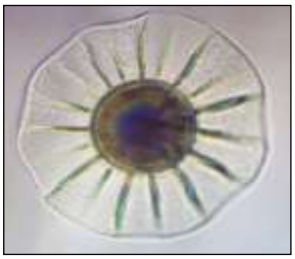
- Elongated cell with pointed, slightly curved ends.
- Two large chloroplasts centrally located.
- Cytoplasm extends into points of the cell.
- End curvature may not be apparent from a side view.
- *Cylindrotheca sp.* is a morphotype difficult to distinguish from *Nitzschia* sp.

DIATOMS

***Odontella* sp.** (centric diatom)

- Valves have prominent bumps.
- Cells occur singly or in straight or zigzag chains.
- Numerous chloroplasts lie against the girdle walls.

Planktoniella sol (centric diatom)



- Disc-shaped cell.
- A gel-like membrane circles the cell like a skirt.
- Rare in arctic, more common in Antarctic.

Pleurosigma morphotype 60-200µm (pennate diatom)

- Very large pennate diatom.
- Name from Gr. *Pleura*=rib and *sigma*=S-shaped.
- Ends always blunt—never pointed—and usually flex in opposite directions. Bending may not be apparent in side view.
- Raphe usually visible.

***Pseudo-nitzschia* sp.** Lg 130-250µm. Sm 50-100µm (pennate diatom)

- Elongated cells with two large chloroplasts in the center. Usually joined in chains by overlapping ends, but overlap is not obvious if specimen is oriented sideways. Single cells also occur.
- There are four cells in the chain in upper photo at right.
- Produces domoic acid (DA) which is toxic to humans. Humans may develop Amnesic Shellfish Poisoning (ASP) after eating shellfish (crabs, clams, mussels) contaminated by DA.
- All species of ***Pseudo-nitzschia*** produce DA, but at different levels and times.
- Photo (below) is a close-up that shows the distinctive chain formation by overlapping pointed ends of cells.

***Rhizosolenia* sp.** 200-400µm (centric diatom)

- Cylindrical with yellow-green chloroplasts.
- Most species are very long and large, but some are very short.
- Sharp, pointed spines on each end are straight on the outer edge, curved concavely on the inner edge.

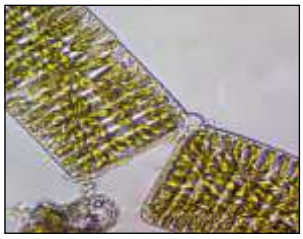
DIATOMS

***Skeletonema* sp.** 10-30um (centric diatom)

- Each valve bears a single ring of threads with a knuckle-like expansion at their ends. "Knuckles" of one cell attach to knuckles on threads of adjoining cells. The dark line of joined knuckles is visible between adjacent valves.

***Stephanopyxis* sp.** 20-30µm (centric diatom)

- Valves are circled by a single ring of threads just inside the valve margins and nearly parallel with the central axis.
- Adjacent valves do not touch.

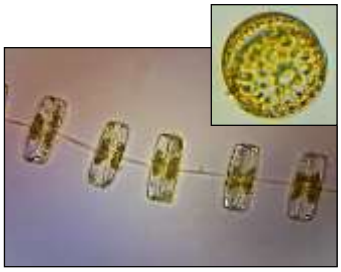


***Striatella* sp.** (pennate diatom)

- Rectangular in girdle view (at left).
- Valve view is kayak shaped.
- Many prominent horizontal bands.
- Adjoining cells attach at corners, forming zig-zag chains.

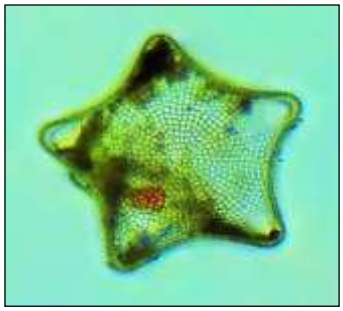
***Thalassionema* sp.** 30-100µm (pennate diatom)

- Long rectangular cells are joined randomly in zigzag chains by a gelatinous cushion at valve corners.
- Chloroplasts scattered throughout.



***Thalassiosira* spp.** 40-50µm (centric diatom)

- Cells are united in flexible chains by a single gelatinous thread connecting the centers of adjacent cells.
- Single cells resemble *Coscinodiscus* in valve view, but chloroplasts appear larger, compared to cell size, than those of *Coscinodiscus* sp.



***Triceratium* sp.** (centric diatom)

- Unique shape—a five-pointed star, in spite of the Genus name.
- We need to do more research on this one. It turned up in a tow in late November 2014.

DINOFLAGELLATES

***Alexandrium* sp.** 30-40µm

- Very small dinoflagellate.
- Waistline groove (cingulum) is deep.
- Densely pigmented reddish-brown.
- May occur singly or in chains and, like other dinoflagellates, may be bioluminescent. (glow in the water when disturbed)
- Several species produce saxitoxin, a powerful poison that causes potentially fatal Paralytic Shellfish Poisoning (PSP) in humans who have eaten shellfish infected by saxitoxin.

Ceratium furca morphotype 130-200µm

- *Ceratium* is a genus of dinoflagellates with three horns—one on the epitheca and two on the hypotheca.
- The two horns on the hypotheca are relatively straight and usually appear parallel to one another, but may be flexed outward somewhat.
- Horns on hypotheca are usually unequal in length.

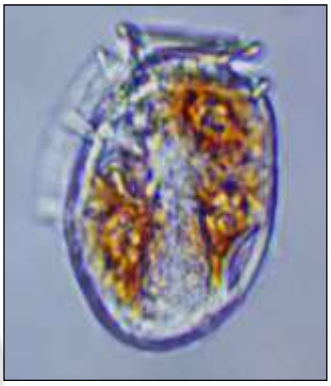
Ceratium fusus morphotype 100-300µm

- *C. fusus* has only two prominent horns, one on the epitheca and only one on the hypotheca.
- The second hypothecal horn is a rudimentary stub.

Ceratium longipes morphotype 200-300µm

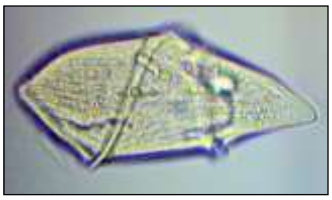
- The hypothecal horns on *C. longipes* are long and severely flexed forward.
- Horns of other species with this morphotype may be very long and have bizarre kinks and twists.

***Dinophysis* sp.**



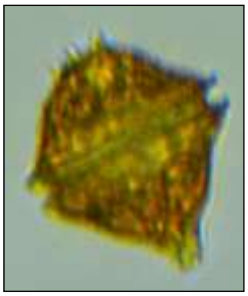
- Has unique collar above the cingulum near the top and a wing-like structure along the side.
- Common in Kachemak Bay and very active.
- Multiple species of ***Dinophysis*** produce a toxin, okadoic acid, which causes Diarrhetic Shellfish Poisoning (DSP).
- DSP is not fatal but causes intestinal discomfort in humans who eat shellfish that have eaten toxic ***Dinophysis*** sp.
- There are two similar species locally: *D. norvegica* (photo right) and one we call *D. rotunda*. Some authorities place the latter in a separate genus as *Phalacroma rotunda.*

DINOFLAGELLATES



Gyrodinium spiralis 800 µm x 230 µm

- Members of this genus are very active
- Some species quite small, some large.
- Tends to disintegrate in dilute formaldehyde solution.
- Cingulum descends sharply as it spirals around the cell so the ends are widely displaced in front. (Photo is a side view.)



Heterocapsa sp < 20µm

- A very small dinoflagellate often confused with *Alexandriium.*
- View at left is the dorsal view.
- Cingulum is deep, nearly circular.
- Epitheca nearly same size as hypotheca, which is slightly more pointed.

Karenia mikimotoi 40µm

- Small, slightly oval cell.
- One end cingulum is higher than the other on ventral side.
- Apical groove is offset from sulcus by a protruding flap.
- Dorsoventral compression becomes evident when cell spins.
- A major brownish bloom of *K. mikimotoi* occurred in Kachemak Bay and caused public alarm in Sept.-Oct. 2013.

Noctiluca scintillans 400 µm

- This very large cell has atypical structure for a dinoflagellate.
- Noctiluca is a heterotroph with two sticky food-gathering flagella extending from a slit along one side. Feeds mostly on diatoms.
- Often bioluminescent, greenish or blue, at night when water is disturbed. Most common near shore in marine water.
- Does not produce a toxin, but following a large bloom the dying cells release large amounts of ammonia that may kill fish.
- Large vacuole increases buoyancy.

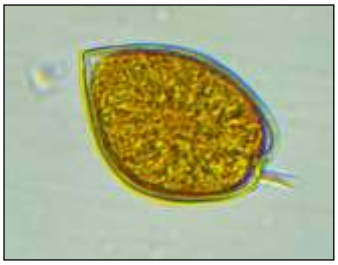
Polykrikos kofodii 130µm x 70 µm

- A pile of 4 to16 single dinoflagellate cells form a pseudocolony.
- Each cell has a cingulum, slightly descending in ventral view.
- All cells in the stack share a single sulcus down the middle.
- This is a phagocytrophic dinoflagellate that captures other cells including *Alexandrium tamarense.*

DINOFLAGELLATES

Prorocentrum sp.

- Many species worldwide, several locally.
- Spheroid to ovoid in shape with 1 or 2 flagella at apical end. One flagellum in line with the cell axis. The second flagellum encircles the first at its base.
- Active swimmers.



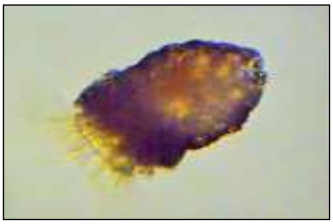
Protoperidinium **morphotype** 20-90µm

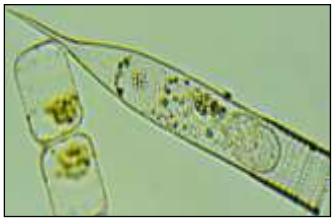
- Small, plump cell with two small horns on the hypotheca and one on the epitheca.
- Cingulum is prominent.
- Common in local tows—several species in Kachemak Bay.
- *Protoperidinium* sp. is a heterotroph. The "polka dots" in the cytoplasm are undigested pigments of the diatoms it eats.
- Several different species occur in our tows.

Scrippsiella **sp.** 30-50µm

- Small cell with conical epitheca and rounded hypotheca.
- Chloroplasts present.
- The pointed epitheca distinguishes it from *Alexandrium* sp.

OTHER MARINE MICROPLANKTON

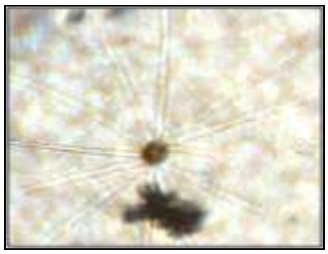




CILIOPHORA

Tintinnids.

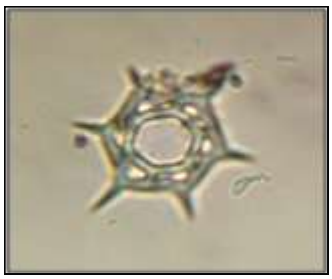
- These zooplankton occur often in our samples.
- They are ciliates enclosed in an external case, called a lorica.
- A collar of cilia (small motile hairs) around the opening creates currents that stir up the water, propelling the animal forward and drawing food particles in.
- Two kinds of tintinnids are pictured at left. The top photo shows *Tintinniopsis* sp. whose lorica is made of small bits of shell or other foreign material. The photo below is a tintinnid with a clear, transparent lorica.



SARCOMASTIGOPHORA 620µm, including spines

Actinopods

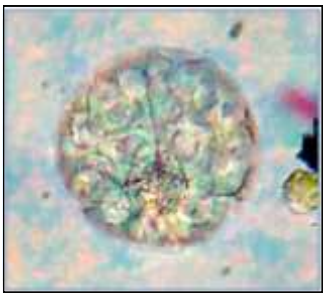
- This tiny zooplankton is related to amoebas.
- The cell is encased in a sphere usually made of silica with holes through which thin transparent feet of the amoeba extrude to capture food.



CHRYSOPHYTA, 19µm - 34µm + spines

***Dictyocha* sp.**

- Related to diatoms, this tiny hexagonal phytoplankton is encased in a silica wreath with 6 holes and 6 spines.
- Appears to be spherical in top view, but is actually fairly flat.
- Not common, but very distinctive.



PRYMNESIOPHYTA <30µm, may be <10µm

Coccolithophore

- These are tiny photosynthetic organisms formerly classed with diatoms in Phylum Chrysophyta.
- Very tiny and nearly colorless, the circular calcareous plates are characteristic of this species.
- There are many other bizarre forms of coccolithophores but this one is used most often to represent the group.
- Coccolithophores are rarely visible because the smaller species slip out through the 20µm mesh of our tows.
- Coccolithophores are very numerous and important food producers in the marine ecosystem.

GLOSSARY

Autotroph Organism capable of producing its own food by photosynthesis.

Basal The bottom or attached end of a spine or other structure.

Benthic Sea bottom or organism that lives at the bottom of the water column.

Bifurcate When a branch or spine divides into two.

Bilateral symmetry A body form that can be divided into two equal halves.

Cilia Microscopic hairs capable of moving in unison to capture food or move an organism.

Cingulum Groove around a dinoflagellate—contains the transverse flagellum.

Dorsal The back or upper side of an organism—back side of a dinoflagellate.

Epitheca Upper (and older) half of a diatom; part of dinoflagellate above the cingulum.

Estuary A partially enclosed bay or cove where fresh and sea water meet and mix.

Heterotroph Organism that cannot make its own food, must consume external food.

Horn On a diatom or dinoflagellate, any stout process that is not tapered or sharp.

Hypotheca The lower (and younger) half of a diatom; part of dinoflagellate below the cingulum.

Marginal Pertains to structures on the outer rim of a diatom valve.

Morphotype Having the same or similar shape.

Motile Having the ability to move under one's own power.

Osmotic gradient Movement of water across a membrane from area of higher concentration to area of lower concentration—creates current in raphe of pennate diatoms.

Phagocytropic An organism that gets its nutrition by consuming food made by other organisms.

Photosynthesis The chemical process that converts solar energy into food.

Phyto- A prefix that means "plants."

Plankton All the organisms that float in the sea and move with the waves and currents.

Process Any structure that juts out from a cell, such as spine, seta or horn.

Radial symmetry When a structure can be divided into two or more equal parts radiating from a central point.

Raphe A microscopic tube or fissure along the axis of a pennate diatom, makes movement possible.

Seta A thin, stiff hair or bristle, somewhat flexible.

Spine An elongated, thin, stiff process tapering to a blunt or sharp tip.

Sulcus On a dinoflagellate**,** a groove on the front side running from the cingulum to the posterior end.

Synonym When a scientific name of an organism is changed, the old name is listed as a synonym.

Valve On a diatom, the flat top or bottom: a circle in centric diatoms— kayak-shaped or rectangular on pennate diatoms.

REFERENCES

Bold, Harold C. & Michael J Wynne. 1978. Introduction to the Algae. 706 pp. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Cupp, Easter E. 1943. Marine Plankton Diatoms of the West Coast of North America. 237 pp. University of California Press. Berkeley and Los Angeles.

Round, F.E., Crawford, R.M., & Mann, D.G. 1990, The Diatoms, Biology and Morphology of the Genera. 747 pp. Cambridge University Press. Cambridge.

Tomas, Carmelo R. 1997. Identifying Marine Phytoplankton. 858 pp. Academic Press. San Diego.

Vinyard, William C. 1979. Diatoms of North America. 119 pp. Mad River Press, Inc. Eureka, California.

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2015

The production of this guide was a cooperative effort by KBRR volunteer Jane Middleton, KBRR staff Catie Bursch and Jeff Paternoster with NOAA Phytoplankton Monitoring Network.

Photographs by Jane Middleton, Catie Bursch and Ryan Ward (all photos from Kachemak Bay plankton except *Alexandrium* photo from NOAA, PMN).

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