Appendix 1

ALGAL SPECIES POTENTIALLY HARMFUL TO DESALINATION OPERATIONS

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1 INTRODUCTION

It is now well established that harmful algal blooms (HABs) represent a serious and growing threat to seawater reverse osmosis (SWRO) desalination plants worldwide. In many plants, these threats are indirectly monitored using parameters such as the Silt Density Index (SDI) or chlorophyll-*a* (see Chapter 5), but these only provide a general indication of the particulate fouling propensity of the water or the abundance of phytoplankton, respectively. Although it is often a challenge to obtain data on the phytoplankton species composition and abundance in the raw seawater, such information can be of great value in the long-term operation of desalination plants. Individual algal species vary dramatically in their properties and therefore in the extent to which they can disrupt plant operations (e. g., through the production of toxins that represent a potential threat to the safety of the drinking water produced, or organic matter that can clog filters and foul membranes). As a result, it is important for a desalination plant to make (and record) species identifications, and the concentrations of those species that are in the source seawater, particularly those that have disrupted normal plant operations. As described in Chapter 3, monitoring programs for seawater outside a plant and process monitoring at the plant can provide this type of information.

Identification of the algal species in seawater samples can be a challenge however. In Chapter 3, methods for sample collection, fixation, and identification are presented. Section 3.6.1.1 lists books that provide useful taxonomic information on marine HAB species, while section 3.6.1.2 lists websites where taxonomic information on algal species can be found. To augment this information and to provide a quick resource for operators or managers who need identification assistance, this appendix presents brief descriptions and a photograph of some algal species that either have caused problems at desalination plants, that produce potent toxins, or that are known to produce sufficient organic matter or biomass to be problematic. The list of species covered here is not comprehensive, as this is not intended to be an operator's sole source of taxonomic information. Instead, it is offered as a quick reference guide. For example, there are more than 30 species in the *Alexandrium* genus, and about half of those are toxic, but only three are described here. Readers are urged to refer to the many other resources that provide more detailed descriptions and photographs.

In this manual, we define toxic algae as those that produce potent toxins (i.e., poisonous substances produced within living cells or organisms), e.g., saxitoxin. These can cause illness or mortality in humans as well as marine life through either direct exposure to the toxin or ingestion of bioaccumulated toxin in higher trophic levels e.g. shellfish. Confusion arises, however, because non-toxic HABs can also result in mass mortalities of fish and other marine life. In this instance, the mortality results from the indirect effect of compounds produced by the algae - compounds that do not have specific targets or receptors, but instead are more general in their mechanism of damage, sometimes requiring chemical modifications by other compounds to become lethal. Examples of "harmful" but not "toxic" substances are reactive oxygen species that, when combined with polyunsaturated fatty acids, can rapidly

kill fish and other animals. Another example is a proteinaceous compound produced by *Akashiwo sanguinea* that accumulates on bird feathers, causing a loss in natural water repellency and widespread mortality of affected animals.

In this appendix, species that do not produce toxins but that do cause marine mortalities are termed "harmful".

The following glossary defines some of the taxonomic terminology used here.

Antapex – posterior-most (bottom) part of the cell body, excluding spines, lists and similar structures

Apex – anterior-most (top) part of the cell body

Areolate – ornamentation of the thecal plates that consists of depressions of variable depth and form

Cingulum – a furrow encircling the cell that contains the rotary flagellum

Cyst – the diploid zygotic dormant state in the sexual life cycle; usually morphologically dissimilar from the haploid motile stage; also called the 'dinocyst' or 'hypnozygote'

Dorsal Side – back side of the cell, opposite of the front or ventral side where the sulcus is located

Epicone – the part of a dinoflagellate cell above the cingulum; usually refers to an 'unarmored' (lacking cellulose plates) cell; may also be known as the epitheca or episome

Epitheca – the part of a dinoflagellate cell above the cingulum; usually refers to a thecate (with cellulose plates) cell; may also be known as the epicone or episome

Flagellar Area – the vicinity of the origin of the two flagella

Hypocone – the part of a dinoflagellate cell below the cingulum; usually refers to an 'unarmored' (lacking cellulose plates) cell; may also be referred to as the hypotheca or hyposome

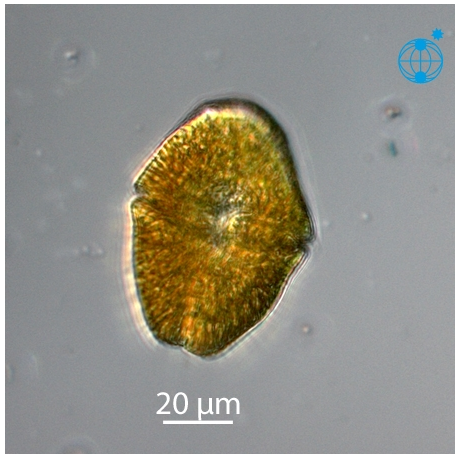
Hypotheca – the part of a dinoflagellate cell below the cingulum; usually refers to a thecate (with cellulose plates) cell; may also be referred to as the hypocone or hyposome

Lists – membranous extensions of the cingulum and/or sulcus that extend beyond the cell wall boundary

Pores – openings in the theca that can be involved in the extrusion of certain structures from the cell

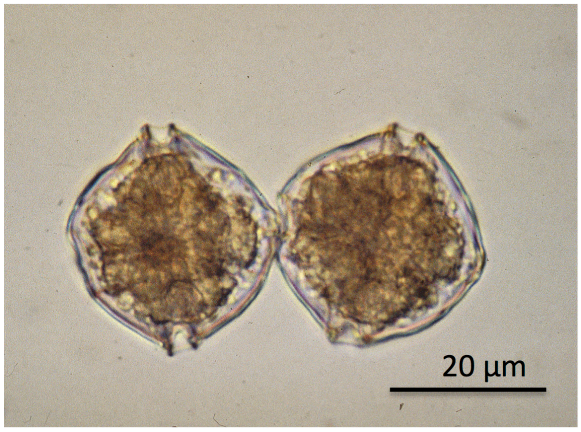
Sulcus – a longitudinal furrow, often partially enclosing the propulsive flagellum

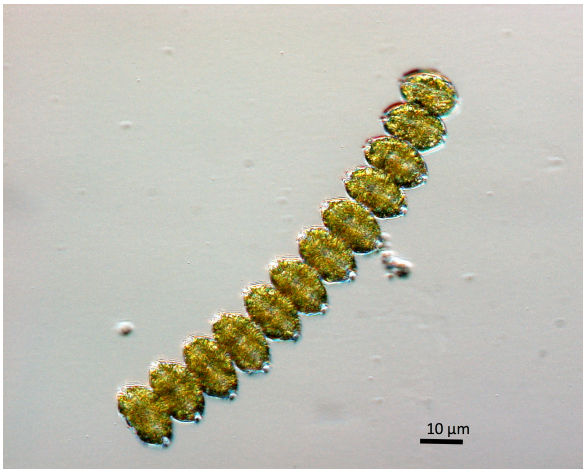
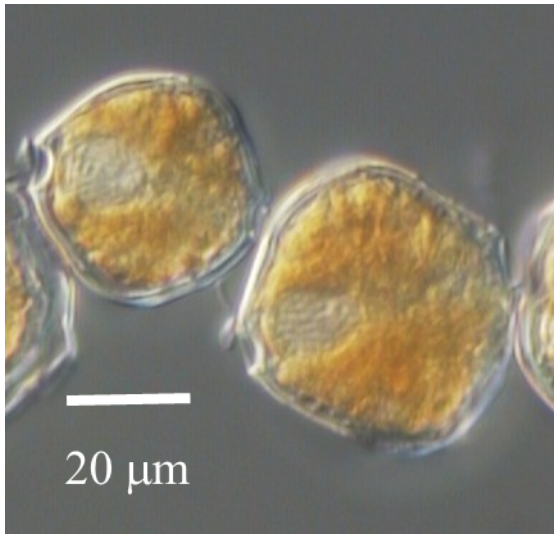
Thecate – having a cell wall of cellulose plates which have special designations and symbols according to their location on the cell

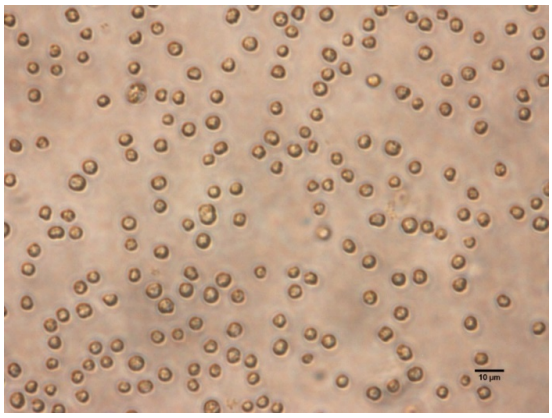
Akashiwo sanguinea Dinoflagellate A medium- to large-sized dinoflagellate with cell divided into approximately equal-sized conical epitheca and bilobed hypotheca, strongly cleaved by the sulcus. Cells are 40-80 µm long and 40-60 µm wide. Chloroplasts are numerous and golden; nucleus is large and centrally located. Harmful. Produces surfactants that can be associated with bird and fish kills.	 Photo: http://planktonnet.awi.de/repository/rawdata-PlanktonNet2/viewable/alexandra_akashiwo_080115_1_20150110174310_small.jpg

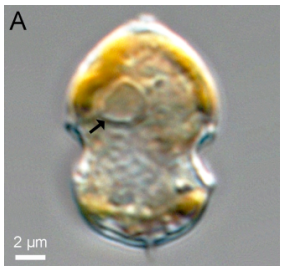
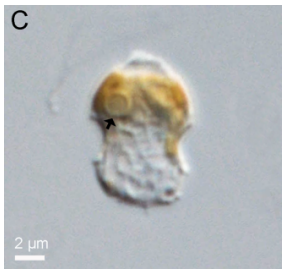
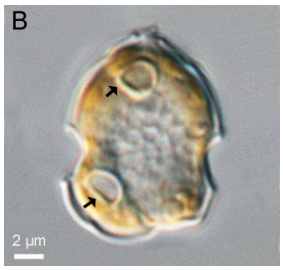
***Alexandrium* (genus description)**

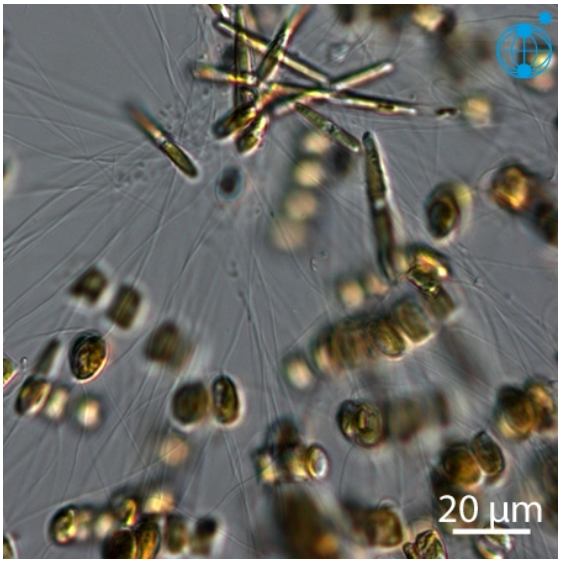
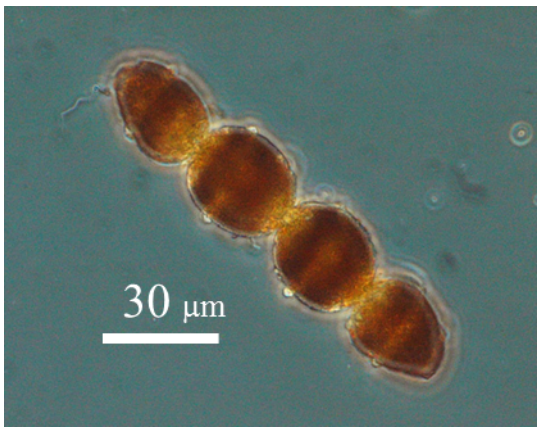
Alexandrium is a genus of planktonic, thecate (i.e., with rigid, cellulose cell walls) dinoflagellates. Many *Alexandrium* spp. are toxic and are the causative organisms for paralytic shellfish poisoning (PSP) outbreaks. All *Alexandrium* spp. in the descriptions that follow share these features: spherical to sub-spherical shape, a descending cingulum (with the right end of the cingulum displaced approximately one cingulum width), numerous golden-brown chloroplasts, and the presence of a comma-shaped aperture in the apical pore plate (Po plate). Species identification is based on thecal plate tabulation that requires specialized staining and microscopy. The descriptions below will aid in identification of *Alexandrium* spp. based on general morphology that is visible using light microscopy. Several common *Alexandrium* species are described below.

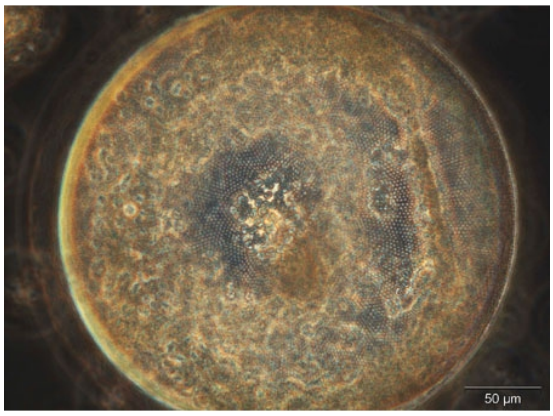
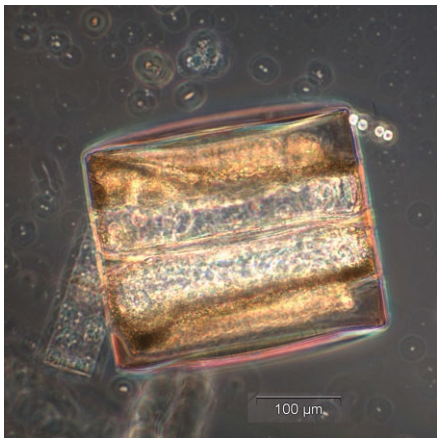
Alexandrium catenella Dinoflagellate Cells spherical to sub-spherical in shape and approximately 28-50 µm long by 25-45 µm wide; typically slightly longer than wide. Can be solitary, or in chains with 2, 4, and 8 cells. Note that there are five species recognized in what was once considered the *A. tamarense* complex that includes *A. catenella* (see John et al., 2014). Toxic. Produces multiple toxins within the saxitoxin family, causes paralytic shellfish poisoning (PSP).	 Photo: D.M. Anderson, Woods Hole Oceanographic Institution

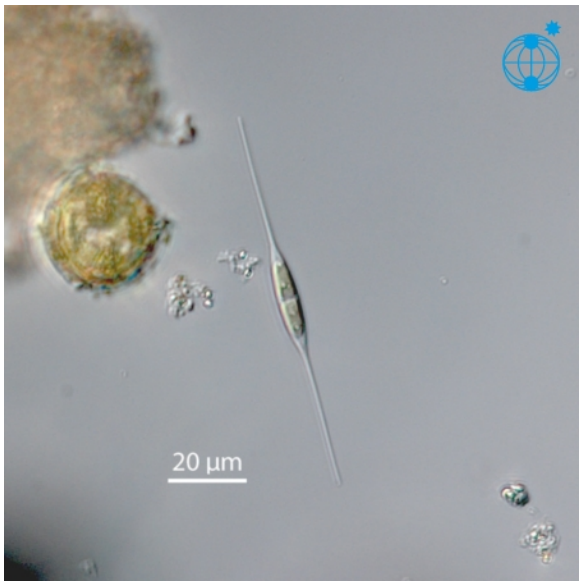
Alexandrium monilatum Dinoflagellate Cells flattened anteriorly-posteriorly and are 20-30 µm long by 30-45 µm wide; often forms chains of cells up to 32 cells or longer. The cingulum (e.g., groove halfway between the top and bottom of the cell) is deep, relatively wide and easily seen in light microscopy. The nucleus is located in the center of the cell, and the many chloroplasts radiate outward from the nucleus Toxic. Produces goniodomin, linked to fish and shellfish kills. Has not been associated with human toxicity although shellfish can be impaired by reduced filtration.	 Photo: W.M. Jones, III, Virginia Institute of Marine Science.
Alexandrium ostenfeldii Dinoflagellate Cells are relatively large (40-60 µm long by 40-50 µm wide) and have a nearly spherical shape. The epitheca has a slightly more pointed or conical shape than the hypotheca. The hypotheca often has a central flattened area. The cingulum is relatively shallow and has no lists along it and the sulcus is very shallow and difficult to see in light microscopy. This species has a characteristic large ventral pore on the first apical plate. Toxic. Produces saxitoxins and spirolides, has been associated with paralytic shellfish poisoning (PSP).	 Photo: Canadian Register of Marine Species (CARMS) http://images.vliz.be/resized/40248_alexandrium-ostenfeldii.jpg

Aureococcus anophagefferens Pelagophyte Small (2 µm diameter) solitary spherical cells with dark brown color. Due to the extremely small cell size and non-descript features, electron microscopy or immunofluorescent (antibody-based) methods are needed for positive identification. Harmful. Not known to produce toxins, but can form "brown tides" or dense blooms (10^9 cells L^{-1}) that cause water discoloration. Associated effects include shellfish mortality (shellfish may not consume *Aureococcus* cells and can thus lose viability) and seagrass mortality due to light attenuation during brown tide blooms.	 Photo: Koonja Yang, State University of New York at Stony Brook.

Azadinium/Amphidoma species Dinoflagellate Some species of Amphidomataceae are producers of azaspiracids, a group of lipophilic toxins responsible for azaspiracid shellfish toxicity. Up to now four of the ~20 species of the family have been found to produce toxins, *Azadinium spinosum* (A), *Az. poporum* (B), *Az. dexteroporum* (C), and *Amphidoma languida* (D). All are small, solitary thecate dinoflagellates; photosynthetic, with single chloroplast that is branched into both episome and hyposome; one or more pyrenoids (arrows) present, large nucleus usually visible in the hyposome. Note that there are other non-toxic species that are very similar at the light microscopy level, e.g., *Heterocapsa*. **Cells:** Depending upon the species, approximately 7-15 mm long and 5-12 mm wide. Toxic. Some species produce azaspiracid toxins, responsible for azaspiracid shellfish toxicity.	 	 
	Photos: U. Tillmann, Alfred Wegener Institute.	

Chaetoceros socialis Centric diatom A colonial *Chaetoceros* that forms spherical, mucous–bound colonies comprised of thousands of cells; colonies may reach millimeter-scale diameter. *C. socialis* is in the subgenus *Hyalochaete*, so its setae (spines) are thin and do not contain chloroplasts. Individual cells are 3 – 15 µm in diameter and contain a single chloroplast. A distinctive feature is that one setae is much longer than the others, and this fourth, elongate setae extends towards the center of the spherical colony. Cells: 3 – 15 µm diameter Colonies up to several mm in diameter Harmful. Non-toxic, but heavy mucilage producer.	 Photo: http://planktonnet.awi.de/
Cochlodinium polykrikoides Dinoflagellate An athecate (fragile cell walled) dinoflagellate that may occur as single cells or as long chains of cells. Cells are variable in shape, ranging from elongate to sub-spherical; brown rod-shaped chloroplasts present. Epitheca is slightly conical while hypotheca is bi-lobate. The key feature is a transverse cingulum that wraps approximately two times around the cell and the placement of the sulcus. 35-50 µm in length, 35-50 µm in width. Note, *Cochlodinium fluvescens* is toxic, and morphologically similar. Harmful. Non-toxic, but is associated with fish kills, larval mortality; also produces large amounts of mucilage.	 Photo: http://www.serc.si.edu/labs/phytoplankton/guide/addtl_collections/Cape%20Cod/Cochlopoly.aspx

Coscinodiscus wailesii Centric diatom A large (to 500 µm diameter), usually solitary centric diatom with numerous, irregular-shaped chloroplasts. In girdle view the mantle is tall and meets the valve at a right angle. The valve face has a clear central hyaline area and has rows of striae radiating from the central area to the valve edge. Two rings of marginal processes may be seen with light microscopy in some preparations. 300-500 µm in diameter 200-400 µm in height Harmful. Not toxic, but considered a nuisance taxon due to formation of dense mucilage-producing blooms.	Girdle view  Valve view  Photo: http://planktonnet.awi.de/

Cylindrotheca closterium Pennate diatom A slender, spindle-shaped pennate diatom approximately 50 to 400 µm long and <10 µm in width at the widest central region. Spindle-shaped central region with two thin, tapering extensions of the valve. Wide, central region of the cell has two chloroplasts. *Nitzschia longissima* is similar in size and shape, but is more heavily silicified. 50 - 400 µm in length 3 – 10 µm in width Harmful. Not toxic, but considered a nuisance taxa due to release of mucilage and alleopathic chemicals when present in dense blooms.	 Photo: http://planktonnet.awi.de/

Dinophysis spp**.**
Dinoflagellate

Dinophysis spp. are thecate dinoflagellates characterized by a distinctive dinophysoid body shape. This form features a small epitheca with a cingular list developed into a "collar" and a much larger hypotheca with a large left sulcal list. *Dinophysis* spp. cells range from small (20 µm long) to large (100 µm long). Species are distinguished by size, shape in lateral view, and presence of distinctive hypothecal horns in some species.

Most *Dinophysis* spp. are toxic, producing okadaic acid and other toxins responsible for diarrhetic shellfish poisoning (DSP); these other toxins include dinophysistoxins (DTXs). Several common *Dinophysis* species are described below.

Dinophysis acuminata
Dinoflagellate

Medium sized, thecate cells with a small collar-like epitheca (~1/5 of cell) and much larger (~4/5 of cell) hypotheca. Compressed laterally and usually viewed on microscope slide in lateral view. Cells ovoid to round in overall profile, with left sulcal list that extends from epitheca past the midline of the cell. Cell surface has visible pores and sometimes at the antapex (bottom of the hypotheca), a series of bumps or protrusions. Key features distinguishing *D. acuminata* from other *Dinophysis* spp. are smaller size, ovoid shape, and protrusions on the antapical end of the cell

Size: 40 – 60 µm long by 30 – 40 µm wide.

Toxic. Produces okadaic acid and other toxins causing diarrhetic shellfish poisoning (DSP).

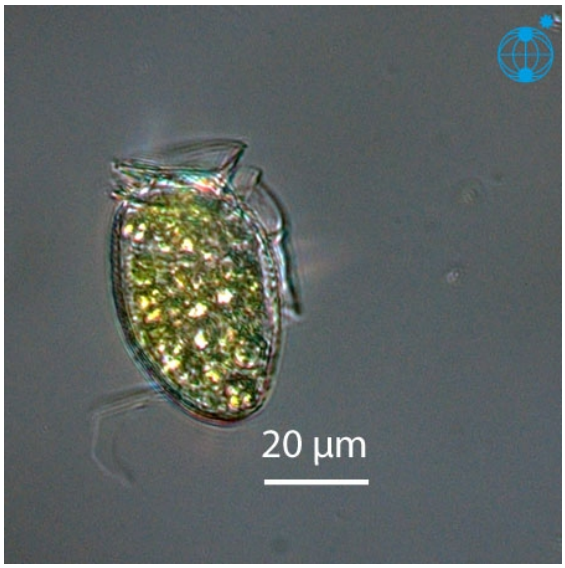
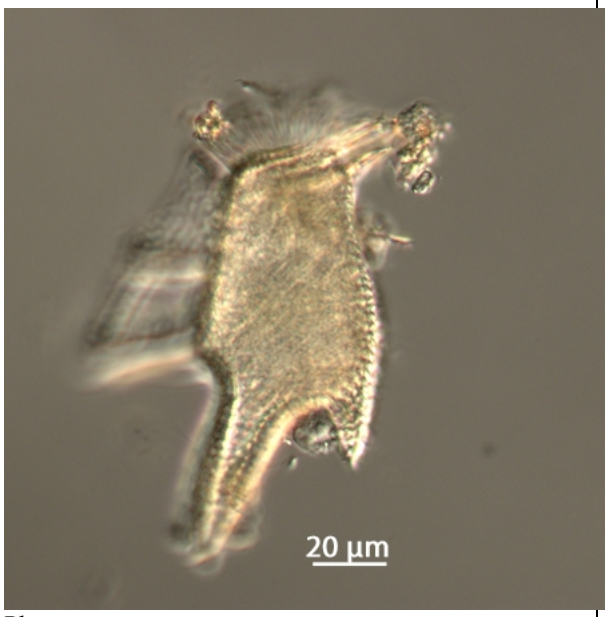
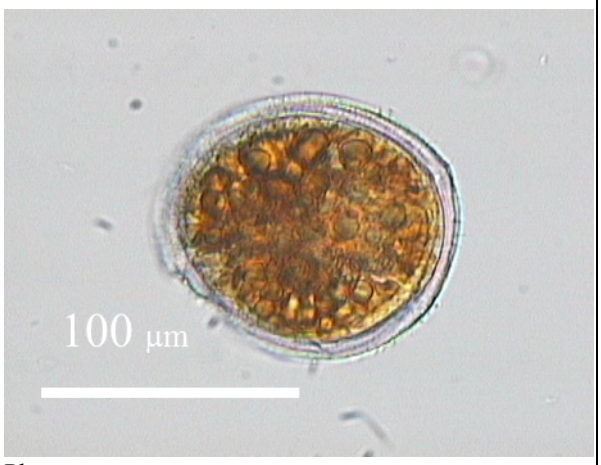
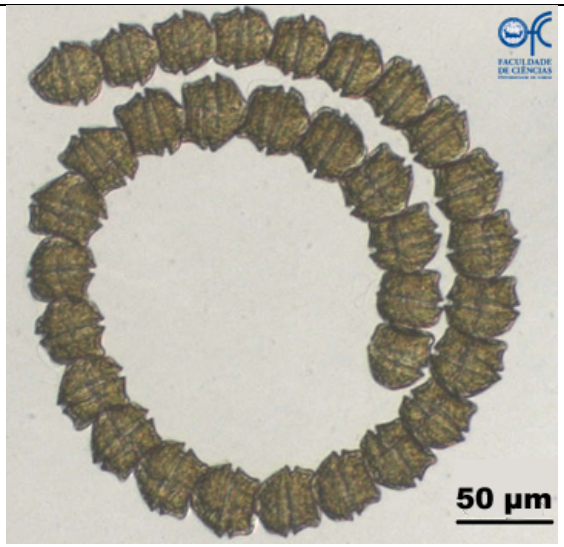


Photo:
http://planktonnet.awi.de/index.php?contenttype=image details&itemid=60229#content

Dinophysis fortii Dinoflagellate Large (60 – 80 µm long by 40 – 60 µm wide) thecate dinoflagellate with dinophysoid body shape: small epitheca with collar and much larger hypotheca and large left sulcal list. Distinguished in lateral view by the large, rounded hypotheca, with widest point of cell near the bottom of the cell. Cell surface covered with depressions and pores that are visible with a light microscope. Size: 60 - 80 µm long by 40 – 60 µm wide. Toxic. Produces okadaic acid and dinophysistoxins (DTXs) that are responsible for diarrhetic shellfish poisoning (DSP).	 Photo: http://planktonnet.awi.de/repository/rawdata-PlanktonNet2/viewable/vera_veloso_dinophysis_fortii_c01_xxw_20070621124535_small.jpg
Dinophysis tripos Dinoflagellate Large cells (90-120 µm long by 50-60 µm wide) with dinophysoid body shape, with the hypotheca formed into two posterior projections or horns. Non-toxic.	 Photo: http://planktonnet.awi.de/repository/rawdataPlanktonNet2/viewable/alexandra_dino_tripos_a1_ps95_stn2_20m_20160224104606_small.jpg

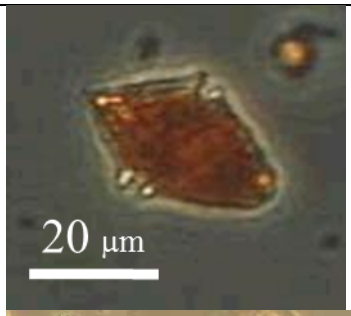
***Gambierdiscus* spp.** Dinoflagellate Multiple toxic species in this genus. As an example, *Gambierdiscus toxicus* is a solitary, benthic thecate dinoflagellate. Relatively large (40-150 µm in diameter, 50-150 µm in dorso-ventral length), sub-spherical shaped (slightly flattened anterio-posteriorly) so that the cells appear in apical or antapical views (i.e., from the top or bottom) in the counting slide. The epitheca and hypotheca are approximately the same size. Numerous chloroplasts visible. Cell surface with visible pores. This is an epiphytic species, meaning that it lives on surfaces like dead coral, seaweeds, sand, etc. Toxic. *Gambierdiscus* species can produce ciguatoxins, gambiertoxins and maitotoxin	 Photo: https://www.whoi.edu/redtide/photos/cfp?tid=542&cid=83388&c=3&idx=2&slideshow=30812
Gonyaulax fragilis, Gonyaulax hyalina Dinoflagellates Small thecate dinoflagellates with a shallow sulcus and thin thecal plates. Numerous chloroplasts present. Epitheca is slightly pointed and an elongate apical pore complex is moderately visible in light microscopy at the apex. Hypotheca is more broad and rounded than the epitheca. *Gonyaulax fragilis* and *G. hyalina* are similar in size and shape and can be differentiated by displacement of the cingulum. The cingulum of *G. hyalina* is displaced by one cingular width while that of *G. fragilis* is displaced (offset longitudinally) by greater than one width. 30 - 45 µm in length; 20 – 30 µm in width. Harmful. Not toxic, but considered a harmful taxa because blooms can release large amounts of mucilage.	 *Gonyaulax fragilis*. Photo: F. Guerrini, University of Bologna.

Gymnodinium catenatum Dinoflagellate An athecate marine dinoflagellate that often forms multi-cell chains. Individual cells are 30-45 µm in diameter by 35-65 µm in height. Cells have a distinct cingulum separating a slightly smaller, conical epitheca from the slightly larger and squared-off hypotheca. The cingulum is displaced 1.5 to 2-times it width. The sulcus divides the hypotheca into two lobes. Numerous chloroplasts are visible. Toxic. Produces PSP toxins (saxitoxins).	 Photo: http://planktonnet.awi.de/ - content
Heterocapsa circularisquama Dinoflagellate Small photosynthetic dinoflagellate approximately 15-20 µm wide by 20-30 µm in length. Cells have a conical epitheca that is more pointed than the round, hemispherical hypotheca. *H. circularisquama* is differentiated from other species by the presence of circular organic scales with radial ridges, general body shape, shape and position of the nucleus. Study of scales requires advanced microscopy. Toxic. Blooms have been associated with shellfish mortalities.	 Photo: http://feis.fra.affrc.go.jp/hcaphp/biology_e.htm

Heterocapsa triquetra
Dinoflagellate

Small (20 - 30 µm long by 15-20 µm wide at sulcus) thecate dinoflagellate with bi-conical shape. Has distinct transverse cingulum that divides cell into two approximately equal halves. The hypotheca is conical and formed into a point; the epitheca is also conical, but more rounded than the hypotheca. Chloroplasts are brown.

Harmful. Not toxic, but a bloom former that can cause high-biomass, water-discoloring blooms.



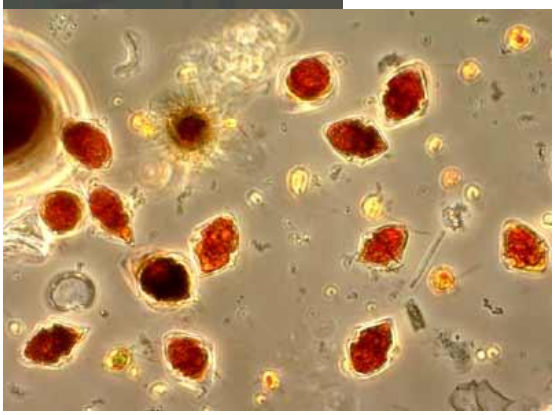


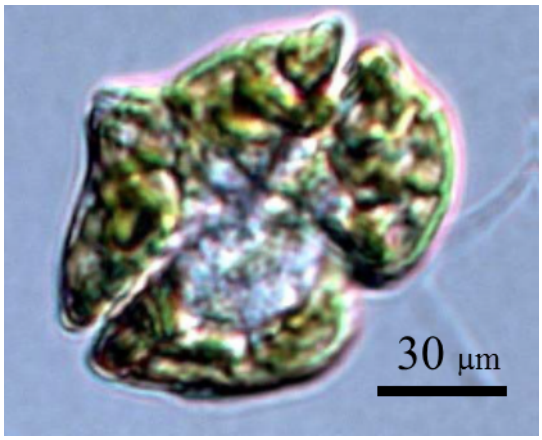
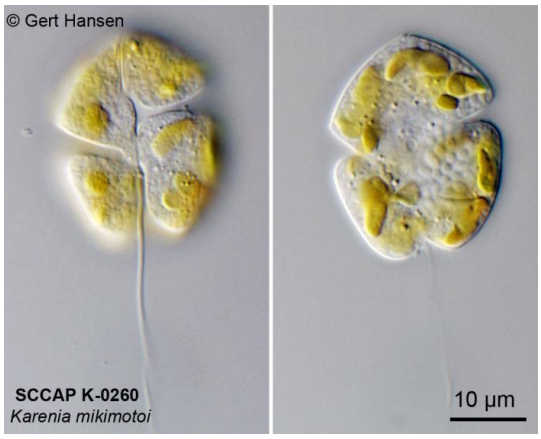
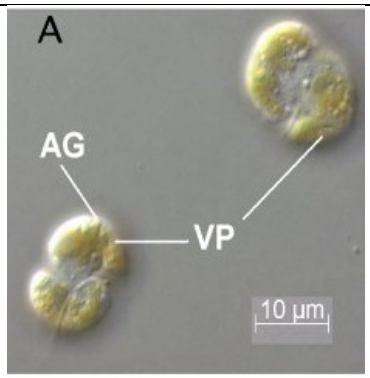
Photo: http://nordicmicroalgae.org/taxon/Heterocapsa%20triquetra?media_id=Heterocapsa%20triquetra_4.jpg

Heterosigma akashiwo
Raphidiophyte

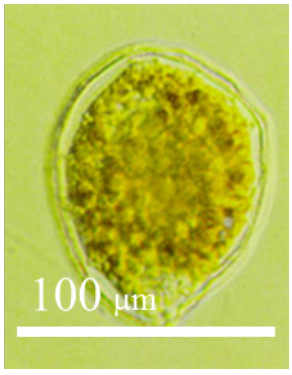
Small (15-20 µm diameter) spherical to ovoid shaped cells with yellow-green to brown colored chloroplasts that give the cell a 'lumpy' appearance. Two flagella visible in live material.

Harmful. Associated with fish kills, but mode of toxicity and fish mortality not well understood. Mortality appears to be caused by the production and release of free fatty acids that are chemically altered and made toxic by reactive oxygen species.

Photo: http://www.marinespecies.org/hab/

Karenia brevis Dinoflagellate Cells are flattened dorso-ventrally resulting in an oblong or square shape of 20 – 45 µm wide (along cingulum) and 15 – 40 µm long. An apical bump is usually visible on the epicone and the cingulum and sulcus are deep and prominent, with the sulcus extending well into the epitheca. Nucleus is located on the left side of the hypocone; numerous yellowish green chloroplasts are visible as is a long trailing flagellum. Toxic. Produces brevetoxins responsible for neurotoxic shellfish poisoning (NSP), marine vertebrate deaths; aerosolized toxin causes respiratory irritation in humans.	 Photo: www.nmfs.noaa.gov/pr/pdfs/health/brevetoxin.pdf
Karenia mikimotoi Dinoflagellate Cells are approximately ovoid and are 20-30 µm wide by 15-30 µm long with numerous yellow-brown chloroplasts. The relatively deep cingulum and sulcus appear to divide the cell into four lobes The cingulum is descending, displaced approximately twice the cingulum width. The sulcus extends into the epitheca. The nucleus is often at the periphery of the cell on the left side. Toxic. Produces gymnocins. Blooms have been associated with marine invertebrate mortalities and fish kills.	 Photo: http://nordicmicroalgae.org/taxon/Karenia%20mikimotoi
Karlodinium veneficum Dinoflagellate Small ovoid dinoflagellate with single, wide, distinct cingulum that is displaced 2+ cingular widths along the cell length. Cells are 15-20 µm long by 10-15 µm wide, have a centrally located nucleus and several chloroplasts. Difficult to distinguish from other small gymnodinoid species. Toxic. Produces karlotoxins and is associated with fish kills.	 Photo: https://microbewiki.kenyon.edu/index.php/Karlodinium_veneficum

Noctiluca scintillans Dinoflagellate A distinctive, large dinoflagellate with a sub-spherical shape, a single flagellum and a large, curving tentacle with visible transverse striations. Cells pinched slightly at the area of tentacle emergence giving a sub-spherical shape. This species is heterotrophic and uses the tentacle in feeding. Although it lacks its own chloroplasts, photosynthetic symbionts or oil and pigment accumulations typically give the cytoplasm (and blooms) a green or pink color. Bioluminescent. 300 µm to 2 mm in diameter Harmful. Non- toxic, but forms dense, water-discoloring blooms. Ammonia present in the cytoplasm may accumulate to toxic levels and has been linked to fish and invertebrate kills. Very common bloom former in the Arabian Sea and Gulf region.	 Photo: http://planktonnet.awi.de/

Ostreopsis siamensis Dinoflagellate A benthic, thecate dinoflagellate that is anterio-posteriorly flattened and typically is presented on microscope slides in apical or antapical view. Cells are oval to tear-drop shaped and are large (100-135 µm long by 75-95 µm wide) in apical/antapical view. Cell surface covered with visible pores. Identification to species based on measurement ratios, pores, and cingulum orientation. Toxic. Produces palytoxins.	 Photo: http://www.whoi.edu/science/B/redtide/species/cfp_images.html

Phaeocystis spp.

Phaeocystis spp. have a complex life cycle that alternates between a small (<10 µm diameter), motile, bi-flagellate single cell form and a large (cm-scale) colonial form comprised of up to thousands of cells. Single cells require specialized microscopy to identify, but colonial forms can be identified based on colony morphology. Some bloom-forming species are described below.

Phaeocystis antarctica
Colony forming Prymnesiophyte

Phaeocystis antarctica forms spherical colonies of up to 2 mm in diameter. Cells are distributed evenly throughout the periphery of the colony. Found in Southern Hemisphere in the Southern Ocean.

Colonies 20 µm to 2 mm in diameter
Cells 2-6 µm in diameter

Harmful. A nuisance alga if dense blooms are agitated by wave action to create beach foaming. Abundant mucilage also a potential problem with desalination plants.

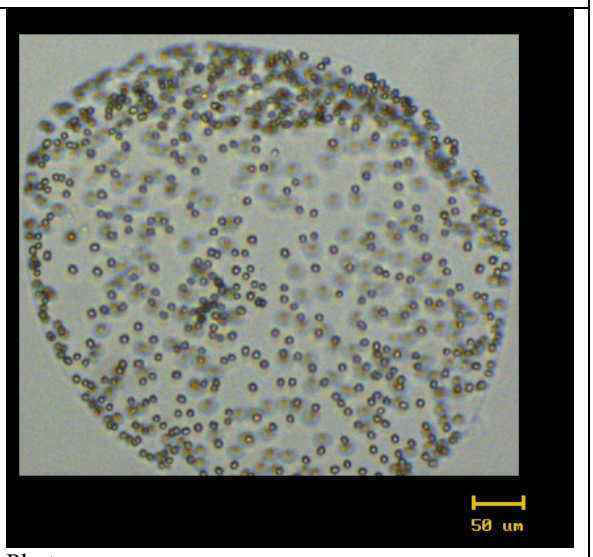


Photo:
http://www.bco-dmo.org/project/546758

Phaeocystis globosa
Colony forming Prymnesiophyte

Phaeocystis globosa forms spherical colonies that are much larger (up to 3 cm in diameter) than those of *P. antarctica* or *P. pouchetii*. Cells are distributed evenly throughout the periphery of the spherical colonies. Found in the North Atlantic and Indian Oceans.

Colonies 25 µm to 3 cm in diameter
Cells 4-7 µm in diameter

Harmful. A nuisance alga if dense blooms are agitated by wave action to create beach foaming. Abundant mucilage also a potential problem with desalination plants.

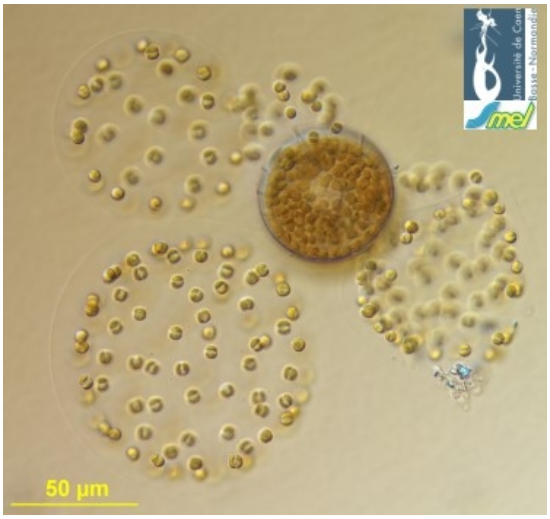


Photo:
http://planktonnet.awi.de/

Phaeocystis pouchetii
Colony forming Prymnesiophyte

Phaeocystis pouchetii is the only *Phaeocystis* spp. to form lobed colonies. The colonies are generally smaller (up to 2 mm in diameter) than those of *P. antarctica* or *P. globosa*. Unlike *P. globosa* and *P. antarctica*, cells within a colony have a clumped distribution with more cells in the edges of lobes, and often cells are in groups of four. Found in the Northern Hemisphere in polar to boreal waters of the Atlantic and Pacific Oceans.

Colonies 25 µm to 2 mm in diameter
Cells 2-6 µm in diameter
Harmful. A nuisance alga if dense blooms are agitated by wave action to create beach foaming. Abundant mucilage also a potential problem with desalination plants.

Photo:
http://planktonnet.awi.de/

***Prorocentrum* spp.**

Prorocentrum spp. are laterally flattened thecate dinoflagellates that are generally ovoid to almond-shaped and range from small (10-15 µm wide *P. minimum*) to large in size. Have two anterior flagella and are photosynthetic; cell surface often covered with visible pores. Species preliminarily distinguished by size, shape, pore and poroid patterns, and presence or absence of apical processes. Some bloom forming species are described below.

Prorocentrum lima
Dinoflagellate

Medium-sized cells approximately 35-40 µm long by 25-30 µm wide with ovate to ellipsoid shape being, typically, widest at posterior of cell. The anterior end of the left valve is straight while the anterior end of the right valve has a triangular concavity. Surface of cell covered with pores except for flattened central area.

Toxic. Produces okadaic acid, implicated in DSP and ciguatera poisoning.

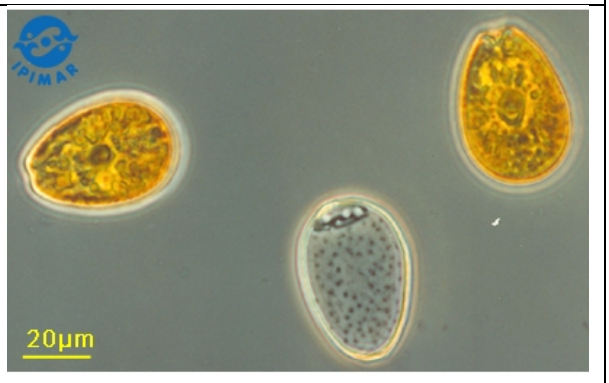
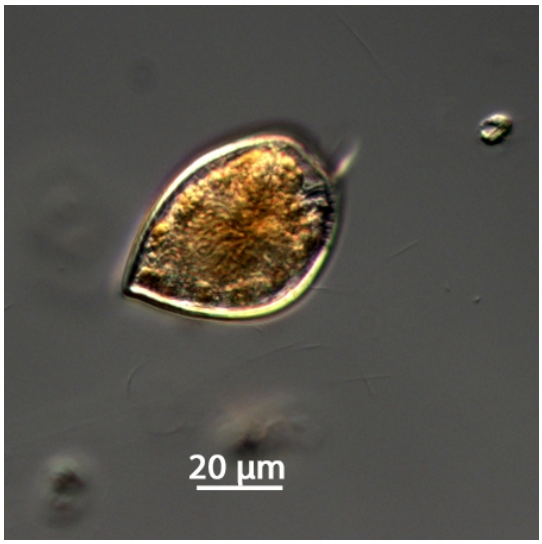
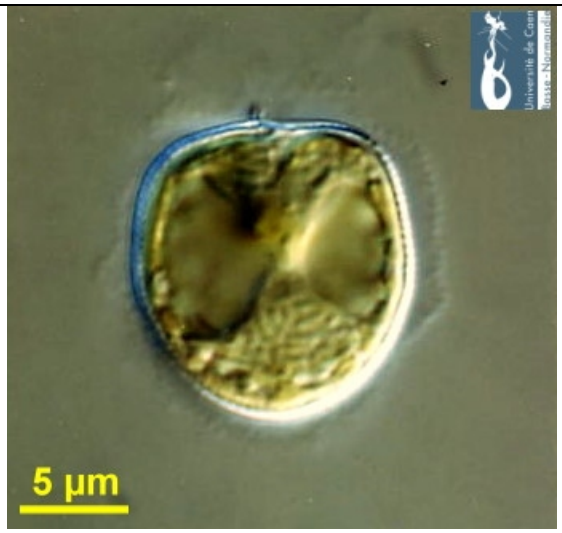
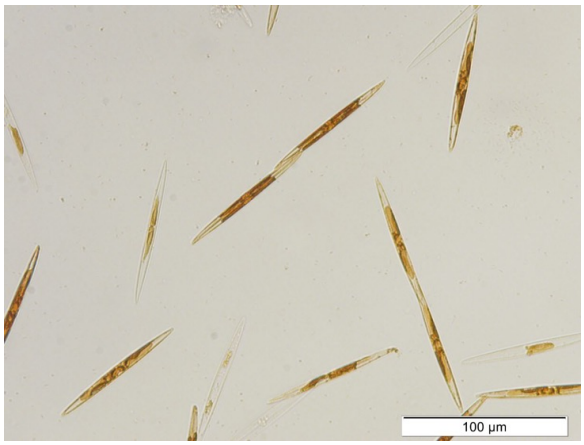
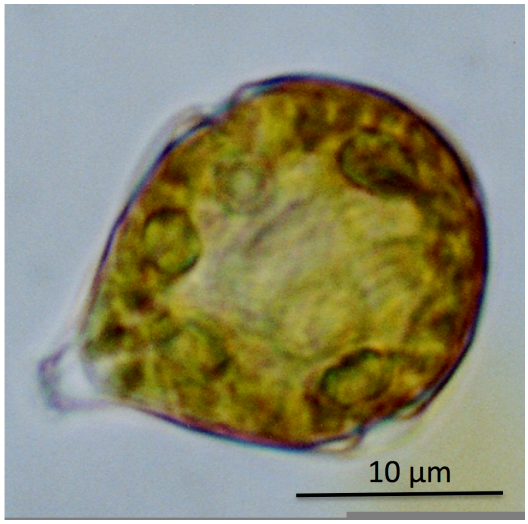
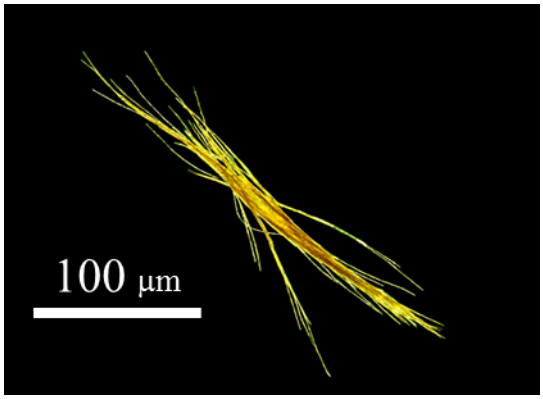
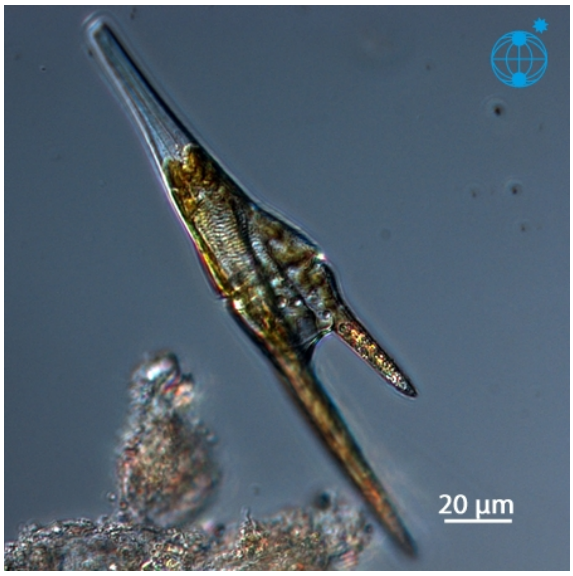
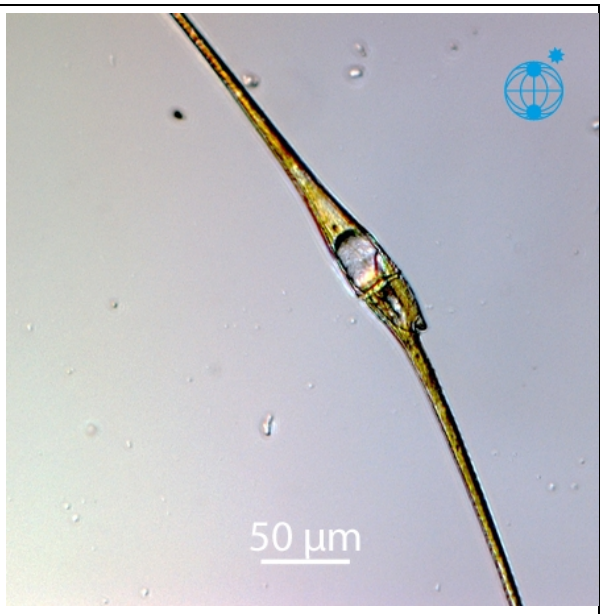


Photo:
http://planktonnet.awi.de/repository/rawdataPlanktonNet2/viewable/maria_antnia_sampayo_prorocentrum_lima_culture_2cells1theca_

Prorocentrum micans Dinoflagellate *Prorocentrum micans* is a medium to large size (30 – 70 µm long by 25 – 50 µm wide) thecate dinoflagellate that generally has a teardrop shape. Cells are flattened and are pointed at the posterior end, more rounded at the anterior end and are widest across the middle of the cell. Cells have variable lengths and widths, but usually have a length-to-width ratio of 2:1. A distinctive anterior spine (~ 10 µm long) is generally visible in light microscopy. Harmful. Toxicity is not confirmed for this species, but it can form dense, water-discoloring blooms that have been linked to shellfish mortality and reduced water column oxygen.	 Photo: http://planktonnet.awi.de/repository/rawdataPlanktonNet2/viewable/alexandra_pro_michе461_e1_180416_20160509114831_small.jpg
Prorocentrum minimum Dinoflagellate Small cells (15-20 µm long by 10-15 µm wide) with oval to triangular shape. Flattened on one side, often giving a "D" shape. A single apical spine often visible. Species also known as *P. cordatum*, a synonym. Toxic. Some strains may produce toxins; some blooms associated with shellfish poisoning and fish kills.	 Photo: http://planktonnet.awi.de/repository/rawdataPlanktonNet2/viewable/fjouenne_sbrbill0165w_20080304121251_small.jpg

Pseudo-nitzschia spp. Pennate diatom There are multiple toxic *Pseudo-nitzschia* species in this large genus. The example shown here, *P australis*, is a toxic form. It is very difficult to distinguish between *Pseudo-nitzschia* species using conventional light microscopy. When that level of identification is required, scanning electron microscopy or molecular approaches are typically used. Toxic. Some *Pseudo-nitzschia* species produce domoic acid.	 Photo: K. Hubbard, Florida Fish and Wildlife Conservation Commission
Scrippsiella trochoidea Dinoflagellate Relatively small (15 – 35 µm long by 20 – 25 µm wide) thecate dinoflagellate having a pointed or conical epitheca and a rounded hypotheca. The epitheca has a short, blunt apical process while the hypotheca is smooth and lacks any spines or processes. Photosynthetic, with numerous gold-brown chloroplasts visible. Harmful. Not toxic, but can cause high-biomass, water-discoloring blooms.	 Photo: J. Lewis, University of Westminster

Trichodesmium erythraeum Colonial cyanobacterium Planktonic colonial cyanobacteria forming bundles or fascicles of cells that are visible with the naked eye. Cells are 7-15 µm wide and are joined into chains (trichomes) that may be 50 to 800 µm long. Numerous trichomes are joined by mucilage to form bundles or tufts that can form water-discoloring blooms. Cells: 7 -15 µm in diameter Trichomes: 30 - 800 µm in length and 7 – 15 µm in width Toxic. Bundles form dense, water-discoloring blooms and are reported to contain toxins including microcystins and palytoxins.	 Photo: http://www.whoi.edu/oceanus/v2/article/images.do?id=62206
Tripos furca (=Ceratium furca) Dinoflagellate Occurs as solitary cells with 2 flagella; often forms large mono-specific blooms. Cells contain numerous yellow-brown chloroplasts. The cells are straight, slightly dorso-ventrally flattened and widest at the cingulum area. The epitheca tapers gradually into the anterior horn. Hypotheca is subtrapezoid, extending into a long left and a short right antapical horn, which are usually straight in line with the cell and may be slightly toothed along the sides. The left horn is twice as long as the right. Thecal plates are ornamented with a reticulum of ridges and pores. The nucleus is situated in the epitheca. 150-230 µm in length, 30-35 µm in width. Note: All marine *Ceratium* species were reassigned to the genus *Tripos* by Gómez et al. (2013). (CICIMAR Oceanides 28:1-22). Harmful. Non toxic, but can cause dense blooms with ecosystem impacts, often due to oxygen depletion.	 Photo: http://planktonnet.awi.de/

Tripos fusus Dinoflagellate Occurs as solitary cells with 2 flagella; contain numerous yellow-brown chloroplasts. The cells are elongate, straight to slightly curved and spindle-shaped in overall appearance. Only one long antapical, left horn. Right horn rudimentary or only slightly developed. Cell is 15-35 µm wide at center (near transverse cingulum) tapering to several um wide at tips. Length 125 to 300 µm, 15-35 µm in width. Harmful. Non toxic, but can cause dense blooms with ecosystem impacts, often due to oxygen depletion.	 Photo: http://planktonnet.awi.de/