An Investigation of Diatom Communities in Choctawhatchee Bay in Response to the BP Oil Spill

A Thesis Submitted
to the Graduate School
Valdosta State University

in partial fulfillment of requirements
for the degree of

MASTERS OF SCIENCE

in Biology

in the Department of Biology
of the College of the Arts & Sciences

July 2012

Heera Ilahi Malik

B.F.Sc, Govind Ballabh Pant University of Agriculture & Technology, 2009

This thesis, "An Investigation of Community Structure of Diatoms at Choctawhatchee Bay in Response to the BP Oil Spill," by Heera Malik, is approved by:

Thesis Chair

James A. Nienow, Ph.D.
Professor of Biology

Committee Member

David L. Bechler, Ph.D.
Professor of Biology

Thomas J. Manning, Ph.D.
Professor of Chemistry

Dean of the Graduate School

Alfred F. Fuciarelli, Ph.D.
Professor of Chemistry

FAIR USE

DUPLICATION

I authorize the Head of Interlibrary Loan or `the Head of Archives at the Odum Library at Valdosta State University to arrange for duplication of this thesis for educational or scholarly purposes when so requested by the library user. The duplication shall be at the user's expense.

Signature Heeie Malik

I refuse permission for this thesis to be duplicated in whole or in part.

Signature _____

ABSTRACT

The primary objective of this research was to characterize the structure of the diatom community in Choctawhatchee Bay in response to the BP oil spill. Three types of samples, net plankton, sediment, and whole water, were collected on a bimonthly basis for six months. Diatoms in the samples were identified at the species level whenever possible by both light microscopy (LM) and scanning electron microscopy (SEM). A total of 87 genera and 437 species were recorded; this represents approximately 40% of species previously recorded in the Gulf of Mexico. Net plankton samples were compared with historical data to determine if a significant shift in the community structure had occurred; the absence of similar data did not permit a comparison of sediment communities. Current and historical plankton associations showed only a 28% similarity. This low similarity could be result of natural variation in the composition of the phytoplankton, differences in sampling techniques used, differences in the application of taxonomic principles, or changes brought about by the BP oil spill. At this point we cannot distinguish which of these is the most important factor. Moreover, the number of abnormal valves observed, much less than 0.1% of the total number of valves, argues against a major impact of the BP oil spill on the diatom community.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Found in Appendix A

ACKNOWLEDGEMENT

I would like to acknowledge Dr. J.A. Nienow my thesis advisor for his guidance and advice that helped me obtain a better understanding of the subject as well as for his invaluable support and encouragement throughout the program. I would also like to show my gratitude to my committee members Dr. D. L. Becher and Dr. T. J. Manning for their support and suggestions. I am thankful to Valdosta State University and Florida State University for the financial support.

I am most grateful to my beloved parents, sister, and brother for their constant love, support, and encouragement that helped me in pursuing this degree.

Last but not least I would like to express my sincere gratitude to Almighty GOD, for His blessings, strength, and for providing me this wonderful opportunity, without whom this would have never been possible.

Chapter I

THE DEEP WATER HORIZON OIL SPILL AND EFFECTS OF AN OIL SPILL

Recently there have been many incidents of oil spills in marine systems, discharging millions of gallons of oil through inappropriate handling, offshore drilling, and natural calamities such as hurricanes and earthquakes (Gilbert, 1990). The recent Deepwater Horizon oil spill (commonly known as the BP oil spill), which occurred on April 20, 2010, is considered to be one of the largest oil spills on record. It released about 4.9 million barrels of oil and covered somewhere between 2,500 to 68,000 square miles. An investigation of the effects of an oil spill can, of necessity, only be carried out after the damage has occurred (Gilbert, 2000). Therefore, extensive baseline data is required to assess the actual damage. In most cases, this baseline ecological data is lacking. Oil spills can create environmental catastrophes either by coating organisms and surfaces with inert materials or by releasing toxic substances into the environment. An oil spill can affect algae, fishes, invertebrates, mammals, aquatic plants, and even sea birds. Of these, large animals, because they are mobile, may have a better chance to survive than plants, since they are be able to move away from the spill. But mobility can also cause them to become contaminated if they inadvertently enter the spill area. Animals can suffer from hypothermia, or oil can enter their respiratory system or liver causing death. In the case of fishes, oil may not stick directly to them because of their surface coating of mucous, but this protective covering can be destroyed by the use of dispersants. Fishes are most often affected by oil either by clogging their gills or by ingesting contaminated items,

including prey species. Coral reefs, sea grass beds, and mangroves can also be severely damaged, by both coating and by toxicity; this was demonstrated directly by an oil spill in the Caribbean Sea in 1986 that caused severe mortality in the sub tidal coral reefs, mangrove communities, and sea grass beds (Jackson et al., 1989). Since oil has density lower than water, it floats on the water and undergoes weathering when exposed to surface conditions. Oil can be divided into different categories based on its density. The oil released during the Deepwater Horizon oil spill was categorized as light crude (moderately volatile). This type of oil has the potential to develop into a contamination problem (United States Fish and Wildlife Services, 2010).

The effects of an oil spill depend upon many factors, including the original composition of the crude oil, the volume of oil released, the products resulting from degradation which can be more toxic than the original fuel, the use dispersants like Corexit, natural environmental processes, season, temperature, weather, tides, location of spill, and human intervention (Ramseur, 2010). The long-term harmful effects of oil spill can last for several years after the spill has occurred. Oil spilled during the Exxon Valdez oil spill in 1989 was still present in the sediment 30 years after the initial spill (Volkmann & Revill, 2002).

Diatoms, which are the base of the food chain in marine ecosystems, can also be affected by an oil spill. Several studies have been conducted previously to investigate the effect of oil on diatoms. For example, Karydis and Fogg (1980) studied the effect of hydrocarbons on marine diatom *Cyclotella cryptica*. They found that low concentrations of hydrocarbons (100 µg/L) had no effect on the growth rate; high concentrations (1mg/L) in contrast, inhibited growth. They also observed differences between types of

hydrocarbons. They found that both paraffins and aromatics affect the chlorophyll a, sugar, and protein content of a cell, but aromatics were more toxic than paraffins; paraffins were also observed to affect the cell wall. Van Baalen and O'Donnell (1984) found that pure cultures of *Nitzschia* sp. and *Chaetoceros* sp. were sensitive to the presence of two crude oil and two fuel oils at low temperatures. It was suggested that algae living at lower temperatures could be more sensitive to oil spills than algae growing at moderate temperatures. Guven et al. (2005) found a severe decrease in the phytoplankton community after an oil spill in Kucukcekmece Bay, Turkey. This spill also caused changes in community structure, species composition, abundance, and other aspects of the community dynamics of diatoms. A study conducted by Gonzalez et al. (2009) found that the effect of oil on diatoms may depend upon their size. They found that relatively large diatoms responded positively to high oil concentrations, while smaller diatoms, 20 µm in diameter, were negatively affected.

Overall, these studies suggest that an oil spill can have a significant impact on the diatom community, greater than might be expected from their small size. Furthermore, since they are at the base of the marine food chain, any effect on them has great potential to affect the structure and functioning of the entire ecosystem.

Chapter II

RATIONALE, OBJECTIVES, AND HYPOTHESES

Since an oil spill has the potential to affect diatom communities, we decided to study the effect of the Deepwater Horizon (BP) oil spill on the diatom community at Choctawhatchee Bay. This study would provide a better idea of understanding the whole community structure of diatoms at Choctawhatchee Bay in response to the BP oil spill. It can also provide information regarding the susceptibility of diatom communities to oil spills allowing us to assess the long-term hazards of oil spills on diatoms. Ultimately, this would contribute to our understanding of the ecological risk associated with food chain contamination and biomagnifications at each trophic level. It should be noted that this is not the first study to attempt to quantify the effects of an oil spill on the phytoplankton community. Previous studies include those of Linden et al. (1979), Johansson et al., 1980), and Guven et al. (2005). These were all hampered to some degree by the lack of historical data for comparison. In the case of Choctawhatchee Bay, there is a multi-year record of the phytoplankton (Livingston, 2001) to potentially help us with our assessment of the impacts of the Deepwater Horizon oil spill.

The objectives of the study were:

1. To characterize the structure of the current diatom community in Choctawhatchee Bay;
2. To investigate possible changes in the dominant taxonomic groups of the diatom community in response to the oil spill;
3. To investigate the effects of oil on frustule morphology;
4. To establish and extend baseline studies for future environmental work in the study area.

If the oil spill had a significant long-lasting impact on the diatom community we would expect to see:

- a possible decrease in species richness and diversity;
- a shift in the main dominant groups of diatom communities and a decrease in the richness and diversity of species due to the oil spill;
- an increase in the number of abnormal valves in our samples.

Chapter III

INTRODUCTION TO DIATOMS

Diatoms are one the most amazing groups of organisms to look at under the microscope. They are also extremely important as major components of the phytoplankton at the base of aquatic food chains. The word *diatom* is derived from the Greek word *diatomos*, meaning cut in half, because of the presence of two siliceous valves (Armbrust, 2009). They are currently classified as unicellular eukaryotes in the super group Chromalveolata, kingdom Heterokontae (Adl et al., 2005). Diatoms are probably the most diverse group of unicellular eukaryotes, with over 250 genera and an estimated 100,000 species (Scala & Bowler, 2001). Diatoms are photosynthetic, with plastids containing chlorophylls a and c and the carotenoid fucoxanthin; this combination gives them their characteristic yellowish brown color. They are found in abundance in almost every habitat including oceans, lakes, streams, and soil (Bold, 1978). Diatoms contribute about 45% of the primary marine production, and one thus responsible for about 20-25% of global net primary production (Nelson et al., 1995; Werner, 1977).

Diatom Classification

Diatoms can be normally view in two aspects: valve view, when cells are seen from one end; and girdle view, when cells are viewed from the side through their girdle bands. Usually valve view provides the most information for the purposes of identification.

Traditionally, diatoms have been divided into two groups, centric diatoms and pennate diatoms. Centric diatoms are generally circular in valve view, as in the genus *Cyclotella*, but there are numerous exceptions to this rule, such as the semicircular genus *Hemidiscus* or the triangular genus *Triceratium*. Pennate diatoms are almost exclusively bilaterally symmetric (Round et al., 1990). Further identification of diatom genera and species is based upon the structure and shape of the cell as well as on morphological/ morphometric features of the cell wall (Barber & Haworth, 1981). In the early days of diatom systematics, the classification of different species was based exclusively on features visible using light microscopy (LM). The advent of scanning electron microscopy (SEM) in the 1960s and1970s revolutionized diatom systematics, revealing taxonomically important ultra-structural features not visible with the light microscope. For example, in many species it is extremely difficult to observe the structure of areolae and striae with light microscopy; striae number and areolar structure play an important role in the identification of pennate species. In addition, it is impossible in many instances to resolve processes such as rimoportulae and fultoportulae, which play a vital role in the identification of centric diatoms. The use of SEM has become extremely important, if not essential, for the identification of species of diatoms.

More recently, molecular information has increased in importance in diatom systematics, a process begun by Medlin et al. (1986). Molecular studies conducted by Medlin et al. (1993) confirmed the earlier suggestion by Simonsen (1979), based on LM and SEM observation of fossil and extant genera that pennate diatoms evolved from centric forms. They also confirmed that the araphid pennate diatoms are paraphyletic and centric diatoms are more closely related to araphid, rather than raphid, pennates (Medlin

et al., 1993). More recently, Medlin and Kaczmarska (2004) proposed a new classification system based on their molecular data. In their system, diatoms can be divided into two subdivisions, *Coscinodiscophytina* and *Bacillariophytina.* The *Coscinodiscophytina* includes one class, the *Coscinodiscophyceae,* composed of radially symmetric centric diatoms. The *Bacillariophytina* includes two classes, the *Mediophyceae* and the *Bacillariophyceae*. *Mediophyceae* include radially symmetric diatoms with fultoportulae and many bi- to multipolar diatoms previously included among the centric diatoms. *Bacillariophyceae* includes both araphid and raphid pennate diatoms.

While they were initially distinguished on the basis of molecular data, the three classes were also found to differ in a number of basic biological features. Members of the class *Cocinodiscophyceae* have one pyrenoid per plastid. In addition, sexual reproduction is by oogamy, with flagellated sperm. The sperm formation in this group is of the merogenous type, in which spermatocytes are formed after two meiotic divisions. The resultant sperm have an elongated nucleus, mitochondria, and a residual body. The zygote forms an isometric enlarged auxospore. Rimoporulae are typically arranged in a peripheral position (Medlin & Kaczmarska, 2004). In contrast, in the *Mediophyceae,* fultoportulate diatoms of the order *Thalassiosirales* have one pyrenoid per plastid, while bi- and multi-polar forms may have multiple pyrenoids per plastid. Sexual reproduction is oogamous, but the resulting zygote forms a non-isometric properizonial auxospore. Sperm formation in this group is of the hologenous type, in which the spermatocyte is formed after two meiotic divisions. The resultant sperm have round nuclei, mitochondria, and no residual body. Rimoportulae are generally central, but may also be

marginal (Medlin & Kaczmarska, 2004). The class *Bacillariophyceae* uses the anisogamous or isogamous sexual reproduction. The zygote forms a non-isometric perizonial auxospore, which expands only in the polar region. Rimoportulae, when present, are generally located near the ends of the cell (Medlin & Kaczmarska, 2004).

Cell Size and Shape

Diatoms are microscopic, with cell sizes commonly ranging between 20 and 200 µm in diameter or length. Diatoms can be viewed with the help of either LM or SEM. The frustule, or wall, appears clear under LM and opaque under SEM, with a variety of pores and other ornamentation visible with either technique.

Diatoms, although unicellular, can be found in a variety of colonial forms, including filaments, fans, zigzag, or ribbon-shaped chains, or aggregates of individual cells sharing common mucilage. Cells can be attached to each other by siliceous spines, mucilage pads or stalks, or polysaccharide threads. Diatoms attached by siliceous spines, could have either solid, interlocking spines as in *Fragilaria* and *Aulacoseira*, or they could be hollow extensions of rimoportulae (labiate processes) as in *Stephanopyxis*, or fultoportulae (strutted processes) as in *Skeletonema* (Round et al., 1990).

Some groups of diatoms form colonies with the help of mucilage pads or stalks. These are typically formed at specialized pore fields at the poles of the cell. Depending upon the form and orientation of their attachment pads, the cells form either star-like colonies as in *Asterionella* and *Synedra*, or zigzag colonies as in *Biddulphia*, *Grammatophora*, and *Tabellaria*. There are also a few groups of centric diatoms that form colonies by means of threads of polysaccharides as in *Thalassiosira*.

Life Cycle

The diatom life cycle includes vegetative, sexual and resting stages. In general, diatoms reproduce by vegetative division, in which a single cell divides into two cells, each receiving one of the parental valves as its epitheca and developing a new hypotheca. Because one of the valves is smaller than the other, the daughter cell receiving that valve will be smaller in size. This cell remains smaller in size compared to both the parental cell and its sibling because the inorganic silica matrix of the valve cannot expand. Therefore the average cell size of a diatom population decreases, until some of the cells are about one-third of their maximum size.

In order to regain normal size, the diatoms need to undergo sexual reproduction and auxospore formation. The restoration of cell size by sexual reproduction is a unique feature of diatoms (Drebes, 1977). The members of class *Cocinodiscophyceae* undergo oogamous sexual reproduction and *Bacillariophyceae* undergo either anisogamous or isogamous sexual reproduction. But in both groups, zygote formation is followed by the formation of an enlarged cell called an auxospore. Auxospores are special types of cells that possess silica bands (perizonia), a different wall structure replacing the siliceous frustule. This allows the cell to swell to the maximum frustule size resulting, after additional mitotic divisions, in the production of frustules of normal size and morphology. Hence a new diatom, which is of normal size, is formed within the auxospore. During the unfavorable environmental conditions resting spores may be formed, which germinate on the return of favorable conditions.

Diatom Morphology

Each diatom cell is surrounded by a cell wall known as a frustule**.** The frustule is made up of silicon dioxide (silica), the primary constituent of glass. The frustule is made up of two valves fitted together by a connective zone called the girdle. Since one of the valves, the hypotheca is slightly smaller than the other valve, the epitheca, the two parts fit together like a Petri dish, encasing the protoplasm inside (Alexopoulos, 1967).

The presence of a siliceous frustule in diatoms provides numerous advantages. Silica is one of the most abundant minerals in the environment, primarily in the form of orthosilicic acid ($Si\ [OH]_4$) (Reynolds, 1984). Because the conversion of dissolved silicic acid to solid silica is primarily a precipitation reaction, building a silica-based cell wall requires less metabolic energy than forming an organic-based wall (Raven, 1983). The silica also provides strength and a strong protective covering to the diatoms, providing a degree of protection from predation and enzymatic activity (Beakes et al., 1992).

Both the valve and the girdle bands are marked by a variety of structures, including pores (areolae), pore fields, processes (tubes), spines, and hyaline areas that are important for the identification of species. Some of the general characteristics, which are always taken into account when classifying diatoms, are valve length, and width; frustule length, and width; type and arrangement of pores; length and width of spines; presence or absence of a raphe system; presence, position, and number of rimoportulae (labiate processes); and fultoportulae (strutted processes).

Rimoportulae

Rimoportulae, also known as labiate processes, are generally recognized as slits through the wall of the valve surrounded by two lips (labia) on the internal surface

(Round et al., 1990). It is present in most centric diatoms and in some araphid pennate forms, and seems to be involved in mucilage secretion. While centric diatoms are considered to be immobile, it has been suggested that the secretion of mucilage through rimoportulae is responsible for weak movement in a few centric species (Medlin et al., 1986). There is some variation in the structure of rimoportulae. Internally the opening could be more tubular than slit-like as is the case in *Coscinodiscus* and *Palmeria.* The opening could be attached directly to the valve surface or it could be raised above it on a short stalk as in the case of *Coscinodiscus*, *Roperia,* and *Actinocyclus* (Round et al., 1990). Externally, they open through simple pores, often associated with a tubular structure. The form of the rimportulae, both internally and externally, is considered to be a highly conservative characteristic for species. Sometimes the rimoportulae of a single valve are of different sizes or shapes. Individual processes significantly larger than the others on a valve are referred to as macrorimoportulae, and the small processes are referred to as microrimoportulae. The arrangement of rimoportulae varies from species to species. They could form a ring on the valve margin/valve mantle or clusters on the valve face either at the center as in the case of *Stictocyclus* or off-center as in the case of *Pleurosira* (Round, 1978). In pennate forms, rimoportulae are frequently found near the poles of the valve.

Fultoportulae

Fultoportulae, also known as strutted processes, are tubular structures present in some members of the *Mediophyceae.* The basic form is a narrow tube surrounded by two to five, sometimes more, struts and satellite pores. The basic function of fultoportulae is the secretion of chitin, crystalline fibrils of *N*-acetylglucosamine (Herth & Barthlott,

1979). Fultoportulae can be present either at the valve margin, or on the valve face away from the margin, or both. Valve face fultoportulae can occur as a single process at or near the center, as clusters of processes, or scattered over the entire surface (Round et al., 1990). The arrangement of processes is used to determine species and species clusters (Hasle & Syvertsen, 1996).

Carinoportulae and Endochiastic Areolae

There are two additional types of processes present in a small number of diatom species, endochiastic areolae and carinoportula. Endochiastic areolae are found in the species *Coscinodiscus alboranii* (Von Stosch, 1980). This species is also distinguished by by the presence of two types of vela covering valve-face areolae. The endochiastic areola is a complex of siliceous structure, with a slightly sunken outer layer and a bulbous inner structure perforated by a large opening. The outer layer is divided into four spokes each carrying a flap (Von Stosch, 1980).

Carinoportulae are a type of process present only in the genus *Orthoseira*. They open internally by a simple pore, externally by a pore with a well-defined rim or collar (Crawford, 1981).

Areolae

Areolae are perforations in the valve often covered on one side by a thin layer of silica called the velum (Ross et al., 1979; Anonymous, 1975). Three basic types of areolae have been recognized: poroid, locular, and pseudolocular. Poroid areolae are simple perforations in the wall of the valve whose openings are neither constricted nor covered by a velum. Locular areolae, in contrast, are constricted at one surface of valve and covered by a thin siliceous velum at the other surface. This gives them the

appearance of a small chamber within the structure of the valve. Pseudolocular areolae are similar in structure to locular areolae except that there is no constriction of the opening on one of the surfaces. They form when the distal parts of reticulate costae expand and form a chamber adjacent to the basal siliceous layer.

When these areolae are arranged into rows, the rows are called striae. Striae can be uniseriate (when present in single row), biseriate (when present in two rows), or multi-seriate (when present in multiple rows).

In centric diatoms, striae can be radial (going from centre of valve to its margin), fasciculate (forming bundles parallel to particular radial striae), or tangential (forming straight or curved non-radial rows). In pennate diatoms striae can be parallel (perpendicular to the central axis), convergent (angled toward the poles of the valve), or radiate (angled toward the valve center) (Hasle & Syvertsen, 1996).

Porefields

Porefields are another important taxonomic valve feature present in some bi- or multi-polar centric diatoms and in most araphid pennate diatoms. They are composed of numerous smaller perforations that can be either occluded or unoccluded. Major types of porefields include pseudocelli, ocelli, ocelluli, and ocellulimbi. Pseudocelli (singular = pseudocellus) are relatively well-defined regions of the valve surface where areolae gradually decrease in size without changing their basic structure examples can be found in the genera *Trigonium* and *Biddulphia* (Anonymous, 1975; Ross et al., 1979; Round et al., 1990). Ocelli (singular = ocellus) are special siliceous plates perforated by closely packed fine pores (porelli), surrounded by a rim of hyaline silica examples are found in the genera *Auliscus*, *Mastodiscus*, and *Triceratium* (Anonymous, 1975; Ross et al., 1979;

Round et al., 1990). Ocelluli (singular = ocellulus) are similar in structure to ocelli. However, the number of pores is smaller and the rim is elevated giving the entire structure funnel-like appearance examples are found in the genera *Cymatosira* and *Plagiogrammopsis* (Hasle et al., 1983). Ocellulimbi (singular = ocellulimbus) are also siliceous plates perforated by numerous porelli. However, in this case, the plate is located on the valve mantle, somewhat sunken below the valve surface examples are found in the genus *Synedra* (Williams, 1986).

In centric diatoms, porefields are typically located on the valve face, near the margin, or raised above the valve face on a type of process. A notable exception is the genus *Neohuttonia*, where the porefield is on the valve mantle. In pennate diatoms, the porefields are located at the apical poles, either on the valve face as in *Diatoma*, or one the valve mantle as in *Reimeria* (Round et al., 1990; Potapova, 2009). In each diatom the porefield is associated with mucus secretion for attachment and/or colony formation.

Raphe

The raphe is a longitudinal slit on the valve face, with a central nodule that divides the raphe in two parts (Anonymous, 1975; Ross et al., 1979). In biraphid diatoms a raphe is present on both valves, while in monoraphid diatoms a raphe is present on only one of the two valves. At the distal ends of the raphe, near the poles of the valve, the raphe terminates internally in a special structure called a helictoglossa (Mann, 1977). Externally, the raphe may continue in a blind groove that does not penetrate to the interior of valve beyond helictoglossa. This part of raphe is called the terminal fissure (Round et al., 1990). The terminal fissure can be T- or Y-shaped as in the genera *Frustulia* and *Neidium*, or it could be absent as in the genera *Cocconeis* and *Anorthoneis*.

The distal raphe ends near the center of the valve, can be curved or hooked-shaped, as in the genera *Gomphonema* and *Neidium*, T-shaped as in the genus *Scolioneis*, or simple as in the genus *Brachysira* (Round et al., 1990). In nitzschioid diatoms a series of siliceous struts, called fibulae, join the two sides of the valve across the raphe. These provide a measure of structural support, reducing the risk of the valve the splitting along the raphe as a result of elevated turgor pressure or other environmental stress (Pickett et al., 1979). Typically, the raphe is found in the center of the valve face. In some cases, for example, the genera *Amphora*, *Epithemia*, *Nitzschia*, and *Rhopalodia*, the raphe is displaced toward one of the margins. In the genera *Surrirella*, *Campylodiscus*, and *Cymatopleura*, the raphe is present at the margin along the entire circumference of valve.

The basic function of the raphe is for gliding motility. Gliding is associated with the secretion of a form of proteoglycan through the raphe (Lind et al., 1997), although the exact mechanism is not clear. In some genera, for example *Cocconeis*, motility has been superseded by attachment.

Cell Contents

Nucleus

The protoplasm of diatoms contains a spherical or lenticular nucleus with nucleoli embedded in a colorless cytoplasm. The size of the nuclear area varies from species to species. For example, in *Navicula pelliculosa* the area occupied by the nucleus is large (Reimann et al., 1966), while the nucleus in *Melosira varians* occupies a relatively small area (Crawford, 1973). There is also some variation in the shape of the nuclear area being spherical in *Cylindrotheca fusiformis* (Reimann et al., 1965), lenticular in *Melosira varians* (Crawford, 1973), and H-shaped in *Surirella ovalis* (Drum & Pankratz, 1964).

There is also some variation in the shape of the nucleoli. Most species have coarse and granular nucleoli, while in *Melosira varians* nucleoli are relatively large (Crawford, 1973).

Membrane System

The membranous system of diatoms consists of a nuclear envelope which encompasses the plastids, a tonoplast, a plasmalemma, the endoplasmic reticulum, the Golgi apparatus, the silicalemma, and other related structures. The nuclear envelope is a double layered membrane, consisting of an inner smooth-surfaced membrane called the perinuclear membrane, and an outer pericytoplasmic membrane similar in appearance to the rough endoplasmic reticulum. The two membranes are interrupted by many nuclear pores (Drum & Pankratz, 1964).

The plasmalemma and tonoplast take the form of large sheets. The shape of the plasmalemma is dependent upon siliceous frustule, since the plasmalemma is adjacent to the inner portion of the frustule. It could form smooth lines as in *Melosira varians* (Crawford, 1973), or it could develop projections and indentations to follow the boundaries of septa, pseudosepta, and partecta as in *Mastogloia grevillei* (Stoermer et al., 1964). The cytoplasm in many genera like *Nitzschia* and *Surirella* is extended into the cell wall through channels or chambers (Edgar, 1980). One of the important points still under discussion is whether the plasmalemma plays an important role in movement. Gordon and Drum (1970) suggested that gliding motility results from the dual action of the capillarity of raphe fissure and the fluid which is excreted into the raphe through plasmalemma; however, evidence in support of this mechanism is still equivocal.

Dictyosomes

Dictyosomes were first observed over a hundred years ago (Pfitzer, 1871), but their nature was not established until much later. It was Drum (1966) who, in his studies of *Pinnularia nobilis*, finally confirmed the connection between dictyosomes and the Golgi apparatus, an important part of the endomembrane system of all eukaryotes. The Golgi apparatus consists of stacks of membrane-bound structures called cisternae; each individual stack of cisternae corresponds to a dictyosome. No relationship has been found between cell size and the number of dictyosomes. In *Achnanthes longiceps*, up to 20 dictyosomes per cell have been found (Drum & Hopkins, 1966), while in *Pinnularia nobilis* 12 dictysomes per cell have been observed (Drum & Hopkins, 1966), and in *Phaeodactylum tricornutum* only four Dictyosomes per cell have been observed (Reimann & Volcani, 1968).

The role of dictyosomes in frustule formation is still unclear. In the *Chryosphyceae*, close relatives of the diatoms, silica deposition occurs in vesicles derived directly from dictyosomes. Reimann (1964) described a similar type of vesicle in the diatom *Cylindrotheca fusiformis. Cylindrotheca fusiformis* also possess dictyosomes, which are in close proximity to the silica deposition vesicles. Since the dictyosomes are usually present in the perinuclear space, the proximity of the dictyosomes to the silica deposition vesicle could be considered a secondary feature.

The Silicalemma and Silica Deposition Vesicles

The formation of the siliceous frustule in diatoms is one of their unique features. It occurs through the action of the silicalemma, a membrane encompassing the silica deposition vesicle (Reimann, 1964; Stoermer et al., 1964). Upon its first appearance, the

silica deposition vesicle already possesses the shape of the as yet unformed valve or girdle element. This can be seen as the deposition of polycondensed silicic acid, which makes the membrane visible. One of the important features of the silicalemma is that it contains two types of sites, spots where no silica deposition occurs and spots where silica deposition takes place. In *Navicula pelliculosa* the silica deposition takes place in areas adjacent to the raphe fissure (Reimann et al., 1966). The silicalemma has also been observed to surround forming siliceous structures, such as the two silica bands forming the raphe between them in *Cylindrotheca fusiformis* (Reimann et al., 1966).

It has been suggested that the silicalemma plays an active role in process of silicification either directly through membrane associated components or indirectly by providing a special micro-environment for the process of polymerization (Martin Jezequel et al., 2001). Intracellular transport of silicon to the silicalemma is not clearly understood although several possible mechanisms have been suggested (Hidlebrand, 2000). Since silica has been found in all major organelles (Mehard et al., 1974), one possible mechanism is though ionophore mediated diffusion. Another possible mechanism is the transportation of silica through specialized vesicles (Lee & Li, 1992).

In either case amorphous silica particles of relatively low molecular weight and ~1–10 nm in diameter are transported into the silica deposition vesicle (SDV), (Drum & Pankratz, 1964). The low pH within the SDV causes the particles to gel, forming the structure of the valve (Vrieling et al., 1999). Recently, a number of proteins have been identified that may also play a role in valve formation. Frustulins are a class of calcium-binding glycoproteins that have been localized in the cell wall of diatoms, suggesting that they may be important in wall formation (Kroger et al., 1994, 1996). However, they were

later found not to be associated with cell wall silica, indicating they may not be directly responsible for the process of silicification (Kroger et al., 1997). More recently a new class of polycationic peptides called silaffins has been discovered. Silaffins, in the presence of silica and low pH, catalyze the formation of siliceous nanospheres (Kroger et al., 1999). These results confirmed previous findings that silaffins are most active under acidic conditions (Vrieling et al., 1999) and that formation of spheres of silica also occurs during polymerization (Chiappino & Volcanii, 1977).

As polymerization takes place, silica first appears in very small amounts in the silica deposition vesicle beneath the cleavage furrow. As the process of polymerization continues more silica is deposited and SDV grows. The first structures to form in the SDV are radial or transapical ribs in form of fingers. As the SDV grows or expands these transapical ribs develop a series of interconnections (Li & Volcani, 1985)

In centric diatoms, the SDV first appears in the form of a small pancake. A ring of silica forms within the SDV is referred to as the central annulus (Von Stosch, 1977). As the valve develops, ribs begin to radiate out from the central annulus. In pennate diatoms, the SDV first appears in the form of a long and thin tube. As it develops it takes on a pinnate shape. Silica deposition begins in the form of an elongated strip of silica, called the sternum. In araphid diatoms, the formation of transapical ribs occurs symmetrically and synchronously on either side of sternum (Mann, 1984). The formation of connecting bridges between the ribs results in the delimitation of areolae or pores in the diatom valve (Schmid, 1976). In raphid diatoms, the formation of transapical ribs on the secondary side of the sternum cannot begin until the sternum has been extended around the raphe slit. However, it is still not clear what is blocking rib formation. It is

known that the delimitation of theraphe slits is due to presence of special raphe fibres (Pickett-Heaps et al., 1979).

Mitochondria

The shape of mitochondria ranges from spherical to oval to bacillary or tubular. The number of mitochondria can vary from species to species (Round et al., 1990). The membrane of mitochondria also shows variation in thickness from other membranes. For example, the average thickness of mitochondria membrane in *Cylindrotheca fusiformis* and *Navicula pelliculosa* is 5 nm as compared to other membranes, which have an average thickness of 7.5 nm (Reimann et al., 1966). In diatoms, the cristae are tubular projections extending into stroma which helps the cytoplasm extend into the chambers of the cell wall.

Plastids

Plastids in eukaryotes are believed to have arisen through a primary endosymbiotic event in which a unicellular eukaryotic heterotroph engulfed a photosynthetic cyanobacterium (Archibald & Keeling, 2002). The plastids in diatoms and other members of the *Chromalveolates*, are thought to have arisen through a secondary endosymbiotic event in which a second heterotrophic eukaryote engulfed a eukaryotic alga with primary plastid (McFadden, 2001). Each plastid has four membranes, two layers of endoplasmic reticulum, the outer of which is continuous with the nuclear envelope, and membranes directly associated with the organelle itself (Whatley & Whatley, 1981).

The shape and number of plastids varies between centric to pennate diatoms. Centric diatoms tend to have numerous disc-shaped plastids either at the periphery

surrounding a large central vacuole or scattered throughout the cell, while raphid diatoms generally have two to four large plastids associated along the girdle (Mann, 1996).
In addition, two types of chloroplast reproduction have been found in diatoms (Mann, 1996). In the autonomous type, common in centric diatoms, the plastid constricts to form two plastids without the help of any cytoplasmic agents. In the imposed type, common in pennate diatoms, division occurs under the influence of cytoplasmic activity, as for example, in the formation of cleavage furrows (Mann, 1996).

All plastids contain at least one pyrenoid, although the number of pyrenoids per plastid can vary from one or two to many. The shape of the pyrenoids can also vary, from lenticular or fusifrom to almost any other shape. For example, in *Amphipleura pellucida* pyrenoids are spherical, while those of *Mastogloia grevillei* are rectangular (Stoermer et al., 1965). Pyrenoids can be sometimes being embedded deeply in the plastid as is the case in *Melosira* (Crawford, 1973).

Storage Products

Diatoms store their carbohydrate reserves in the form of chrysolaminarin, a β 1-3 linked glucan, and oil (Anderson & Cummins 1979; Muller-Navarra et al., 2000). Accumulations of lipid droplets have been observed in many diatom species. These lipid or oil droplets are covered by membrane and appear as electron opaque or hyaline planes when viewed with Transsmission Electron Microscopy (TEM) in ultrathin sections. In *Amphipleura pellucida* large oil droplets have been found which cover the entire vacuole (Stoermer & Pankratz, 1964), while in *Pleurosira laevis,* they take the form of small dense bodies within the vacuole (Heath & Darley, 1972). The presence of polyphosphate granules has also been observed in diatoms with the help of toluidine blue staining

(Crawford, 1973). They are highly electron opaque when viewed in TEM in ultrathin sections as in *Amphipleura pellucida* (Stoermer & Pankratz, 1964) and *Melosira varians* (Crawford, 1973). According to Dawson (1973), lipid sections appear flat while phosphate sections have indentations. Several studies have been conducted to compare the lipids stored in marine and fresh water diatoms, but no significant differences have been observed in the fatty acid composition of marine and fresh water species (Darley, 1977).

Chapter IV

TAXONOMIC CHARACTERISTICS USED FOR SPECIES IDENTIFICATION

Diatom valves are ornamented by a variety of siliceous structures: porefields, areolae, striae, spines, labiate processes, and strutted processes. These structures are at the base of all current taxonomic systems for diatoms. Families and orders are defined by the presence or absence of particular structures. Within a family, particular suites of characteristics are used to distinguish different genera and species. Some of the more important characteristics used for identification in common groups of diatoms are discussed below.

Features of Centric Diatoms

This group of diatoms has valves with radial symmetry, a central annulus, and no raphe. This group includes a large number of genera and each genus has a number of distinctive features. The taxonomic characteristics used for identification of two members of this group common in the Gulf of Mexico (*Actinocyclus* and *Thalassiosira*) illustrate the types of features used.

Actinocyclus is distinguished by the presence of a pseudonodulus (Figure 4.1). Features used for the identification of species in the genus include the size and shape; the number of striae in 10 µm, the position of the pseudonodolus, and the number of rimoportulae present at the valve margin (Hasle, 1977).

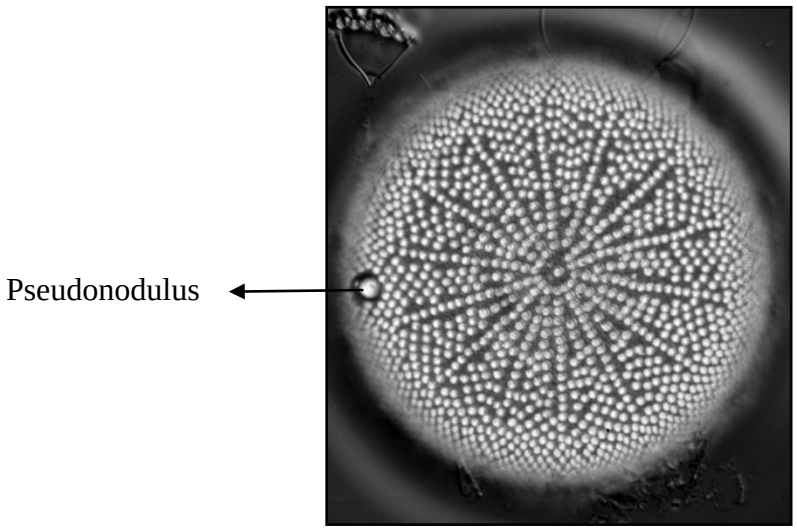


Figure 4.1. Presence of pseudonodulus in *Actinocyclus*

Thalassiosira are identified by the presence of a marginal ring of fultoportulae, frequently with spine-like external development (Figure 4.2). The identification of species depends upon the shape and size of the valve, type and number of areolae in 10 µm, the number and arrangement of strutted processes, and the number and position of rimoportulae.

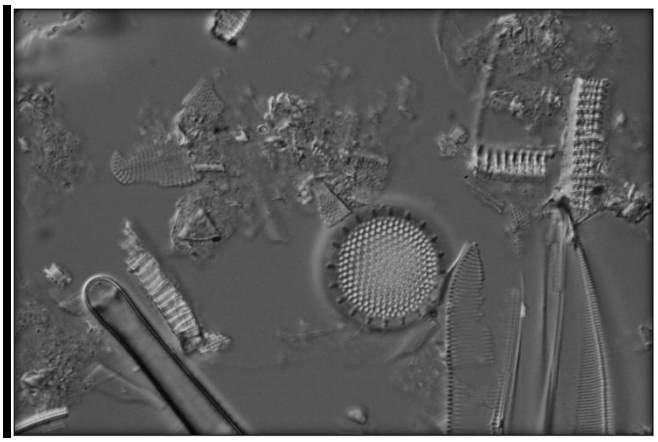


Figure 4.2. Presence of marginal spines in *Thalassiosira*

Features of Araphid Diatoms

This group of diatoms includes valves with bilateral symmetry and without raphes. The features used for identification of some of common genera in the Gulf of Mexico are outlined below.

Fragilaria is distinguished by elongate valves with apical pore fields and by a single rimoportula located at one end; cells are joined into ribbon-like colonies by marginal spines. Species are identified by the shape of the valve and valve apices, the size of the valve, type (coarse or fine) number of striae in 10 µm, and of the placement of the rimoportula.

Staurosira is distinguished by elliptical or cruciform valves and marginal spines. Areoale are circular or elliptical, the sternum very narrow, apical pore fields are present on both poles, and rimoportulae are absent. Species are identified by the shape of the valve, the size of the valve; the type and number of striae in 10 µm, the position of spines, and the variation in porefields.

Tabularia is distinguished by elongate, linear, or lanceolate valves. Striae are biseriate with one or two large areolae, areolae are round or elongate, porefields at both ends, single rimoportulae at one end and wide sternum. Species are identified by the shape of the valve and valve apices, the size of the valve, the type and number of striae in 10 µm, and the number of areolae.

Features of Monoraphid Diatoms

This group of diatoms has valves with bilateral symmetry and a raphe is present on only one valve. The features used for identification of some of the common genera in the Gulf of Mexico are given below.

Achnanthes is distinguished by heterovalvar frustules, i.e. frustules in which one valve posseses a raphe while the other does not, presence of fascia on the raphid valve only, and a distinct bend in the valve when seen in girdle view. Species identified by the shape of valve and valve apices, the size of valve (length & width), the type and number of striae in 10 µm, the type and number of areolae, and the shape of raphe.

Cocconeis is distinguished by heterovalvar frustules, valves with a very narrow valve mantle, and ring near the edge of the raphid valve (Figure 4.3). Species are identified by the the shape of valve and valve apices; the size of valve (length & width), the type and number of striae in 10 µm, the type and number of areolae in 10 µm, and the shape of raphe.

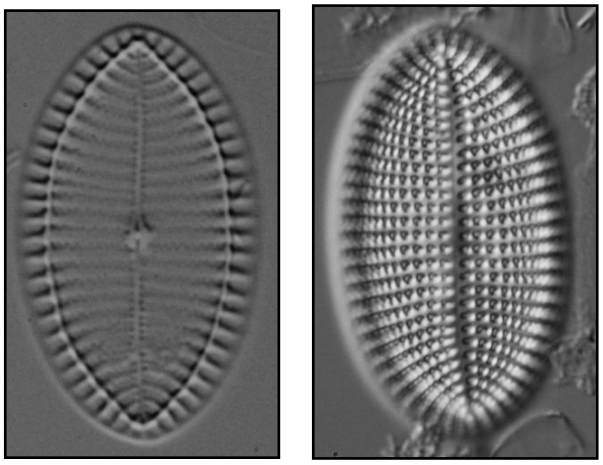


Figure 4.3. *Cocconeis* having heterovalvar frustule; the valve to the right with a raphe and the valve to the left without raphe.

Features of Symmetric Biraphid Diatoms

This group of diatoms has valves that are symmetric across both the apical axis and the transapical axis. They possess a raphe on both valves. The features used for identification of some of common genera in this group are described below.

Diploneis is defined by the presences of a longitudinal canal bounded by a thickened rib on either side of the raphe (Figure 4.4). Species of *Diploneis* are distinguished by the shape of valve and valve apices, the size of valve, the type and number of striae in 10 µm, the type and number of areolae in 10 µm, and the shape of raphe.

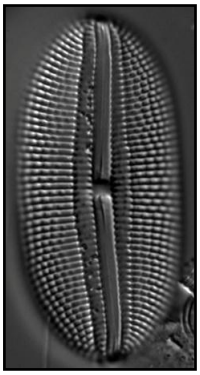


Figure 4.4. Presence of longitudinal ribs in *Diploneis*

Mastogloia is distinguished by the presence of complex silica chambers called partecta (Figure 4.5). Species are defined by the size and shape of the partecta, number of partecta in 10 µm, shape of the valve and valve apices, size of valve, type and number of striae in 10 µm, type and number of areolae in 10 µm, and shape of raphe.

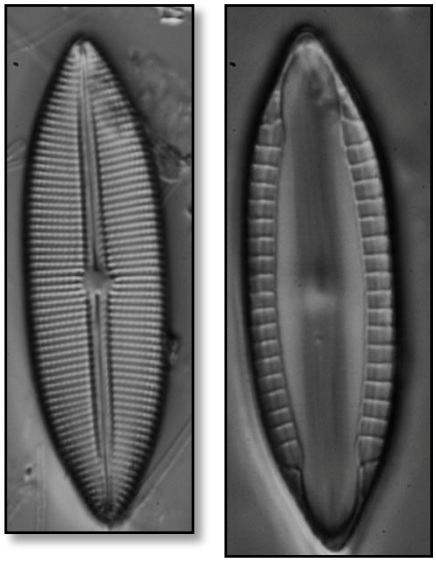


Figure 4.5. Presence of partecta in *Mastogloia*

Fallacia is marked by the presence of a lyre-shaped hyaline area on face of valve (Figure 4.6). Species are distinguished by the shape of valve and valve apices; the shape of the hyaline area, the size of valve, type and number of striae in 10 µm, type and number of areolae in 10 µm, and shape of raphe.

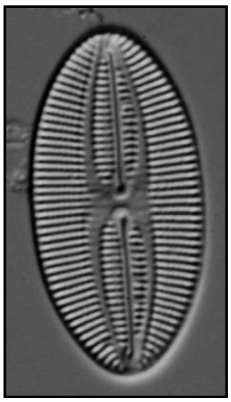


Figure 4.6. Presence of a lyre-shaped hyaline area in *Fallacia*

Features of Asymmetric Biraphid Diatoms

Diatoms in this group also have a raphe on both valves. However, unlike the members of the previous group, valves are asymmetric with respect to either the apical or the transapical axis. Some genera in this group possess apical pore fields. The features used for identification of some of common genera in the Gulf of Mexico are outlined below.

Amphora is distinguished by presence of an eccentric raphe, near the ventral side of the valve face, a dorsal side much deeper in comparison with the ventral side, the presence of a dorsal fascia in some species, and dorsal striae interrupted by intercostals ribs (Figure 4.7). Species are identified by the shape of valve and valve apices, the size of valve, the type and number of striae in 10 µm, type and number of areolae in 10 µm, and shape of raphe.

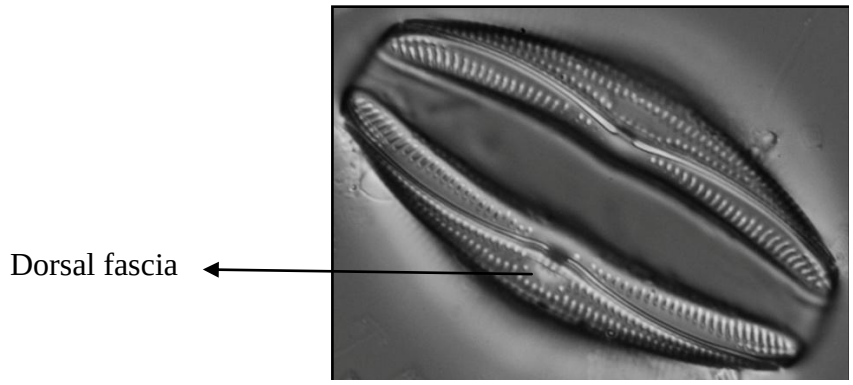


Figure 4.7. *Amphora* illustrating the eccentric raphe & dorsal fascia.

Entomoneis is distinguished by the presence of highly arched bilobate wings and some degree of torsion along the apical axis (Figure 4.8), note that *Entomoneis* also has a keeled raphe. Species are identified by the shape of valve and valve apices, size of valve, the type and number of striae in 10 µm, type and number of areolae in 10 µm.

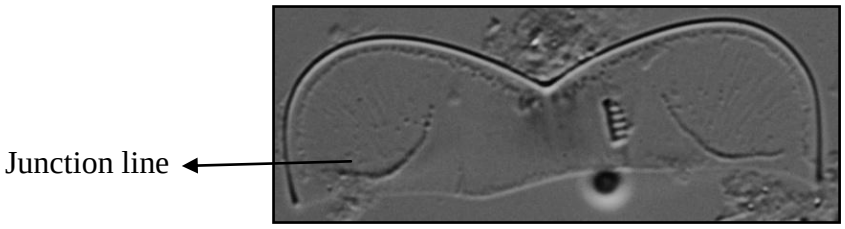


Figure 4.8. *Entomoneis* having short and curved junction lines.

Features of Nitzschioid Diatoms

This group of diatoms has a keeled raphe, i.e., the valve is reinforced by the presence of fibulae across the valve. The raphe is present on both valves, usually at the margin of the valve. The features used for identification of some of the common genera in the Gulf of Mexico are given below.

Nitzschia is distinguished by the presence of an eccentric keeled raphe, with the raphes of the two valves on the opposite sides (Figure 4.9). Species are identified by the

shape of valve and valve apices, the size of valve, the type and number of striae in 10 µm, and the number of fibulae in 10 µm.

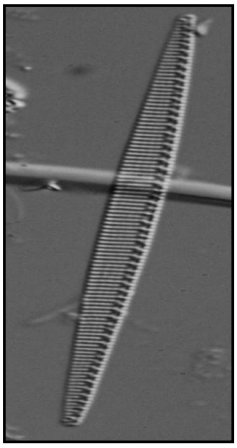


Figure 4.9. *Nitzschia* having eccentric raphe and fibulae.

Bacillaria is distinguished by the presence of a keeled raphe located in the center of the valve (Figure 4.10). Species are identified by the shape of valve and valve apices, the size of valve, the type and number of striae in 10 µm, and the number of fibulae in 10 µm.

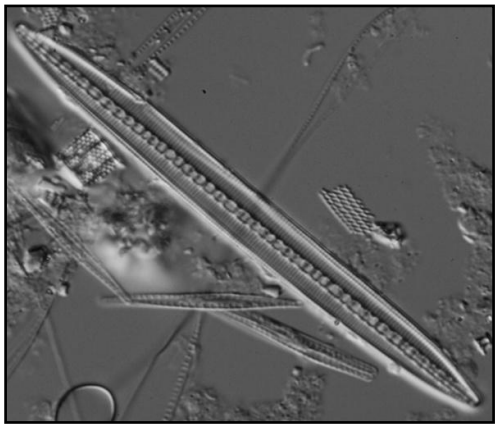


Figure 4.10. *Bacillaria* having centrally placed raphe in apical axis.

Chapter V

ECOLOGY OF DIATOMS

Habitat

Pennate diatoms are the major group of diatoms in freshwater habitats. They are also common in marine habitats. Centric diatoms reach their greatest diversity in marine environments, especially in the plankton. However, both centric and pennate diatoms have benthic and planktonic forms.

Diatoms are commonly thought of as major components of the phytoplankton, but can also be found in association with various substrates as either free living or attached forms. The attached communities can be further classified depending upon the type of substrate: epipelic diatoms growing on mud; epipsammic growing on sand grains; epilithic growing on rocks; epiphytic growing on plants; and epizoic growing on animals.

There are two different modes of attachment to the substrate: adnate and pedunculate. In the adnate mode the cells are directly attached to substrate while pedunculate cells are attached to the substrate by a stalk. Diatoms using the adnate mode rarely form colonies; examples include *Amphora*, *Cocconeis*, and *Epithemia*. Diatoms using the pedunculate mode, in contrast, are often colonial; examples include *Achnanthes*, *Gomphonema*, *Grammatophora*, *Licmophora*, and *Achnanthes* (Round etal, 1990).

Factors Affecting Primary Production and Diatom Community Composition

The variability in environment conditions plays an important role in structuring the phytoplankton communities (Chesson, 1994). Any changes in the physical factors have strong effect on aquatic communities (Steele, 1985). The structure and functioning of an aquatic ecosystem depends upon the phytoplankton composition. Since, they are the major source of primary production in aquatic ecosystem; the rate of primary production can be affected by different environmental factors that control the process of photosynthesis. The major three variables that control the process of photosynthesis are light, temperature and nutrients.

Photosynthesis and Light

The process of photosynthesis in diatoms is similar to that found in other phototrophic eukaryotes. The major exception lies in the genetics of ribulose 1,5-bisphosphate carboxylase/oxygenase (RUBISCO), the enzyme responsible for the carbon-fixation step. In most eukaryotes, both the small and large subunits of RUBISCO are encoded in the nucleus; in diatoms they are encoded in the plastid (Scala & Bowler, 2001). Recent studies have also shown that diatoms have the ability to undergo C4 metabolism, where the first compound formed during photosynthesis is a four-carbon compound. C4 metabolism is also found in a number of higher plants, including maize, sugar cane, and sorghum. It is considered to be more efficient than C3 metabolism, especially under conditions of high temperature and high light conditions. The ability of diatoms to use this type of photosynthesis could explain the high primary production of diatoms in oceans and their ecological success (Scala & Bowler, 2001).

Both the duration and the intensity of light are important for the optimum growth of species. The different species of diatoms require different intensities of light. For example, *Cyclotella meneghiniana* and *Fragilaria capucina* (Rice, 1938) require more light, therefore are found in shallow littoral zones, wheras diatoms such as *Melosira roeseana* require less light and therefore, are found in caves. The amount of light required for growth varies from species to species. There are some species which require less light intensity like *Melosira italica*, whereas other species require more light intensity like *Asterionella formosa* (Lund, 1954).

Many mathematical equations have been suggested for light as one of the major controlling factors in the process of photosynthesis (Frenette et al., 1993). A number of models have also been proposed to study the effect of light on photosynthesis in marine phytoplankton (Platt et al., 1980). One of the most common models is P^B – I curve (Platt & Jassby, 1976).

$$P^B = P_S^B [1-e^{(-\alpha I/ PSB)}] e^{-\beta/ PSB}$$

where, α = intial slope of P vs. I curve

β = photoinhibition parameter

$-\beta$ = negative slope at high light intensity

P_S^B = maximum photosynthetic rate without photoinhibition

Temperature

The range of temperature preferences varies from species to species. Some species like to grow in warm condition whereas other species prefer cool conditions. It has been found that some species have a narrow range whereas some species have a broader range of tolerance (Stockner, 1967). For example, *Nitzschia palea* achieves its

maximum photosynthetic rate at 33^{o}C; at 40^{o}C this rate is irreversibly reduced (Baker, 1935). Temperature may also have an indirect effect on species composition. An increase in temperature may affect the diffusion rate of chemicals changing the efficiency of uptake. It can lower the viscosity of the medium which can increase the sinking rate of planktonic diatoms.

Nitrogen and Phosphorus

In general, nitrogen and phosphorous are considered to be the major limiting nutrients for algae. However, in case of diatoms, dissolved silica must also be taken into account (Tilman et al., 1982). Diatoms are usually present under optimal conditions with high nutrients. Some diatoms, such as *Rhizosolenia*, can form large mats and survive even in nutrient-depleted conditions (Scala & Bowler, 2001). The main nutrient affecting the diatom composition is phosphorous, available in form of orthophosphate. Any change in phosphorous composition can affect the phytoplankton community and may also affect the benthic community (Whitmore, 1989). Nitrogen is usually available as ammonia and nitrate. Some species can take nitrogen in the form of ammonia whereas others prefer nitrogen in the form of nitrate. It has been found that in the eastern parts of the United States *Melosira varians, Synedra ulna,* and *Luticola mutica* grow in the presence of nitrates, while *Navicula minima* and *Nitzschia epiphytica* require ammonia (Bahls, 1973).

Usually the diatoms present in oligotrophic water bodies require lower concentrations of nutrients than diatoms in eutrophic water bodies (Patrick, 1967). The formation of seasonal blooms is related to the concentration of these nutrients.

Silica

Silica is taken up in the form of silicic acid or silicates. It also plays an important role in cell division. In *Cylindrotheca fusiformis* DNA replication is dependent on the concentration of silica (Darley & Volcani, 1969). The amount of silicate required for growth varies from species to species. The succession of diatoms occurs whenever there is any change in the concentration of silicate. For example when the concentration of silicate decreases from 6.5 – 5 mg/L, the population of *Asterionella formosa* tends to decrease (Lund, 1950) while the population of *Stephanodiscus astrea* increases when the concentration of silicate reaches 0.7 mg/L (Hutchinson, 1967). Whenever there is a decrease in silicate and an increase in phosphorous, there is a shift in the phytoplankton community to blue green algae (Schelske & Stoermer, 1972).

pH

pH is perhaps the most important factor affecting the species composition in freshwater. pH controls a number of physical and biological processes, including nutrient uptake, metal solubility, and enzyme activity (phosphatases). There are some genera which are typically found at low pH such as *Eunotia, Actinella, Frustulia,* and *Pinnularia* (Patrick, 1945), while the genera *Denticula* and *Epithemia* are found at high pH.

The use of diatoms as an indicator of water pH has been studied for many years. Hustedt (1937) first described the relationship between the diatoms and the pH of water and classified them into following groups:

1. Alkalibiontic: group of diatoms that occurs at pH > 7
2. Alkaliphilous: group of diatoms that occur at ~ pH 7 but has the widest distribution at pH > 7

3. Indifferent: group of diatoms that occurs equally on both sides of pH 7
4. Acidophilous: group of diatoms that occur at ~ pH 7 but has the widest distribution at pH < 7
5. Acidobiontic: group of diatoms that occurs at pH < 7 but has a maximum distribution at pH 5.5 or below.

Nyggard (1956) expanded on Hustedt's work by developing the alpha index which is a measure of the relationship between pH and diatoms

$$\text{Index } \acute{\alpha} = \frac{\%\ \text{acidophilous} + 5 \times \%\ \text{acidobiontic taxa}}{\%\ \text{alkaliphilous} + 5 \times \%\ \text{alaklibiontic taxa}}$$

This classification system developed by Hustedt became the basis for the paleo-limnological reconstruction of the pH of several lakes. This index has been further developed by using a variety of statistic methods by Davis and Anderson (1985) and Whiting et al. (1989).

Oxygen

Oxygen is an important parameter affecting the growth of diatoms. It is produced by the process of photosynthesis. The rate of process of photosynthesis depends upon a variety of factors, such as light, temperature, and nutrients, which ultimately determine the production of oxygen. The concentration of oxygen required varies from species to species. For example *Achnanthes minutissima* requires high concentrations of oxygen (Cholnoky, 1968) whereas *Navicula seminulum* requires low concentartions of oxygen for growth. Some species, for example, *Navicula formalis* can even grow in oxygen-deficient conditions (Schoemann, 1973).

Turbidity

Turbidity can decrease the penetration of light, thereby affecting the species composition. For example, Chandler (1942) found that turbidity was one of the important factors affecting the growth of diatoms in Lake Erie. The type of suspended solids, i.e. large particulate versus colloidal, can also influence diatom growth. Larger particles absorb light, while colloidal matter tends to scatter light, allowing some to pass thereby supporting diatom growth.

Turbulence/Current

Turbulence can also cause changes in the composition of the diatom community. It can remove benthic taxa from their point of attachment and suspend them in a water column, where they can be removed from the system. The same process benefits planktonic diatoms because all planktonic forms are non-motile and have a specific gravity greater than that of water and are subject to loss by sinking (Reynolds, 1984). Similarly, currents can affect species composition, especially of benthic populations, by bringing in fresh nutrients and carrying away waste products (Ruttner 1940). If the current is strong enough it can also be responsible for the removal of attached and motile forms.

Diatoms as Indicators of Water Quality

Diatoms have a long history of use as indicators of water quality. They are major components of most aquatic systems and play an important role at the base of the aquatic food chain. It has been observed that sometimes minor changes in physical and chemical parameters can cause some species of diatoms to reproduce at faster rate than other species, thereby changing the community composition. In some instances, the conditions

for growth and responses to environmental conditions are precisely known. This means that diatom community structure can be used as a biological indicator of environmental conditions (Cronk & Fennessy, 2001; Stevenson, 2001). Moreover, since diatoms are well preserved in sediments, they can also serve as useful proxies in the assessment of past climatic conditions (Fritz et al., 1991). Diatom-environment data sets are now widely available allowing diatom assemblages to be used to predict nutrients, pH, and salinity in freshwater systems (Stoermer & Smol, 1999; Battarbee et al., 2001).

Diatoms as Water Quality Indictor in Streams and Rivers

Diatoms are used extensively as ecological indicators to assess water quality in rivers and streams (Lowe & Pan, 1996). They form a diverse, species-rich community comprising a major part of biodiversity of streams and rivers (Patrick, 1961). They are ecologically important since they play a fundamental role in food webs (Lamberti, 1996) and they link biogeochemical cycles (Mulholland, 1996). Diatoms are also one of the more sensitive groups and have one of the shortest generation times among indicator species (Rott, 1991). Therefore, their populations respond quickly to any physical, chemical, and biological changes including temperature changes (Descy & Mouvet, 1984) and changes in nutrient concentrations (Pan et al., 1996), but not so quickly that meaningful trends in environmental parameters are hidden by short-term fluctuations.

As a result, diatoms are widely used through a variety of ecological indices (using species relative abundance) as indicators of organic water pollution (Coste et al., 1991), eutrophication, heavy metals, pH, and salinity (Stevenson, 1996). Indices have been developed at both the species level (Prygiel, 1991) and the generic level (Round, 1991). For example, the high relative abundance of the genera *Epithemia* and *Rhopalodia* is an

indicator of low nitrogen concentrations in streams or rivers (DeYoe et al., 1992). The percentage of mobile diatoms, such as *Cylindrotheca*, *Gyrosigma*, *Navicula*, and *Nitzschia*, can provide an index for siltation (Bahls, 1993). Since diatoms are the major primary producers, the rate of their different activities like photosynthesis, respiration, and phosphatase activity can be used to measure community production and phosphate limitation, respectively (Mulholland & Rosemond, 1992). Recently, growth rates have also been used as indicator of nutrient limitation in streams (Biggs, 1990).

Diatoms as Hydrological Indicator in Lakes

Diatoms have also been used as indicators of climatic and hydrological changes in lake systems. Based upon their preference and distribution environmental conditions can be estimated by using the surface sediment calibration set (Birks, 1995). The fossils of diatom assemblage can also be used to estimate past environmental conditions (Birks et al., 1990). The shift in the species composition can be used as indicator of changes in hydrological conditions. For example, in the case of the northern Great Plains, the earlier Holocene period tended to have cool moist conditions as indicated by the presence of the freshwater species *Cyclotella bodanica, Cyclotella michiganiana, Aulacoseira granulata*, *Stephanodiscus spp* (Birks et al., 1990). But a recent shift in species composition from freshwater to the saline species *Cyclotella choctawhatcheeana* and *Chaetoceros elmorei* shows the hydrological change in the lake in response to climatic warming.

Diatom as Eutrophication Indicators in Lakes

Many species of diatoms show specific sensitivity and tolerance to different nutrient conditions (Bennion et al., 1996). This range of sensitivity and tolerance can be used to determine the changes responsible for eutrophication in lakes. As discussed

previously, diatoms respond quickly to any physical or chemical changes and as primary producers are directly affected by changes in nutrient conditions or light intensity (Tilman et al., 1982), including changes related to eutrophication (Zeeb et al., 1994). At the same time, diatom valves are well preserved in lake sediments. Hence it is possible to sample sediment cores and analyze those samples to determine past environmental conditions. Nygaard (1949) was the first to develop a diatom index for lake eutrophication. He proposed that lake productivity can be estimated by the ratio of centric to pennate (C/P) diatoms. This was later changed by Stockner (1971) who proposed an index for lake productivity based upon ratio of araphid to centric (A/C) diatoms. These have since been superseded by a multiplicity of new indices for freshwater systems (Charles & Smol, 1994), few of which are applicable to marine systems.

Chapter VI

MATERIALS AND METHODS

Study Sites

This study was conducted at Choctawhatchee Bay, Gulf of Mexico. The Choctawhatchee Bay watershed encompasses nearly 13,856 km^2 (5,350 mi^2) and spans portions of northwest Florida and southern Alabama. Four stations were established (Figure 6.1).

- Choctawhatchee 01 (N 30°23 .860; W 86° 34. 973): Sandy bottom bay site with beds and clear water. The temperature ranged from 14 to 26°C, salinity from 26 to 30 ppt, and conductivity from 35 to 41.33 mS, while oxygen was a relatively constant 8.7 mg/L.
- Choctawhatchee 02 (N 30°23.472 ; W 86° 31.341): Sandy bottom bay site with seagrass beds and clear water, near the channel connecting Choctawhatchee Bay with the Gulf of Mexico. The temperature ranged from 12 to 24.5°C, oxygen from 8.2 to 11.2 mg/L, salinity from 32 to 33.7 ppt, and conductivity from 20.6 to 51.2 mS.
- Choctawhatchee 03 (N 30° 22. 982; W 86° 25 .253): Sandy beach on the Gulf of Mexico with clear water. The temperature ranged from 11 to 26°C, oxygen from 8.13 to 10.1mg/L, salinity from 32 to 35 ppt, and conductivity from 15 to 53.8 mS.

- Choctawhatchee 04 (N 30^{o} 23. 435; W 86^{o} 10. 380): Backbay site, with brackish water, muddy bottom, and visible turbidity. The temperature ranged from 12 to 28^{0}C, oxygen from 9.0 to 10.43 mg/L, salinity from 17.9 to 25.3 ppt, and conductivity from 28.91 to 39.73 mS.

Figure 6.1. Sample sites in Choctawhatchee Bay.

Samples were collected at bimonthly intervals for a period of six months starting in November, 2010. Sites 01 and 02 were also sampled during a preliminary visit in September 2010. For each collection and each station, three diatom samples were taken: a net-plankton sample collected with a 25-µm mesh, a 3-L whole water sample, and a 50-mL sediment sample. Liquid samples were split in the field, with a portion of each sample returned to the lab for culturing and the remainder preserved with Lugol's iodine. Sediment samples were returned as collected. Measurements of water temperatures, salinity, and oxygen concentration were recorded at the time of collection of January,

March, and May samples using a Pro2030 meter (YSI, Incorporated, Yellow Springs, Ohio).

Sample Preparation

Aliquots were cleaned and mounted for LM and SEM using standard techniques (Prasad et al. 1990; Prasad & Fryxell, 1991). The basic procedures are outlined below.

Preserved samples were transferred to large beakers and allowed to settle for at least one week. Then the surface water was carefully removed, leaving ~ 200 mL of sample in the beaker. The residue was allowed to settle for few more days, after which another 100 mL of water was carefully removed from the surface. The remaining sample ~ 100 mL, was mixed well and divided into two parts. One part (50 mL) was transferred to a centrifuge tube for further processing and the remainder (~50 mL) was archived.

The aliquot for further pocessing was centrifuged at ~1000 rpm for 10 min to form a pellet. The pellet was rinsed with de-ionized water and re-centrifuged. The resulting pellet was transferred to a small beaker, mixed with 2-5mL of 30% hydrogen peroxide, then incubated at room temperature for at least 30 min. At the end of the incubation period, the same amount of concentrated sulfuric acid was added directly to the samples. Then the tubes were boiled in water bath for at least 30 min. The mixture was then transferred back to the 50-mL centrifuge tubes and centrifuged at ~1000 rpm for 20 min. The supernatant was removed using a pipette. The tubes were filled with de-ionized water, mixed well, and re-centrifuged. This process was repeated at least 10 times to remove all acid and digested organic material.

Once the diatoms were cleaned and thoroughly rinsed, five slides of each sample were prepared. About 100 µL of sample was spread on a clean coverslip using a pipette.

The coverslips were then allowed to dry overnight in an incubator. When dry, a drop of Naphrax was added to the center of a clean and labeled slide; the high refractive index of Naphrax increases the contrast and makes the ornamentation more visible under the light microscope (Hasle & Syvertsen, 1996). The coverslip containing the diatom sample was placed on the drop of Naphrax sample-side down and the slides were placed on a hot plate set at ~ 200^{o}C until the most of toluene in the Naphrax evaporated. The finished slides were allowed to sit undisturbed until the resin was completely hardened.

For SEM, 50 µL of the cleaned material was applied to a clean glass coverslip previously mounted on an SEM stub with conductive tape. After drying, the mounted sample was sputter-coated with gold-palladium.

Analysis

Microscopy

Each cleaned sample was analyzed to determine species composition and species-specific relative abundances. Relative abundances were based on counts of a minimum of 500 valves per sample using the 100X objective and differential interference contrast (DIC) microscopy. Representatives of each species were photographed in DIC using an Olympus BX60 microscope (Olympus Corporation, Tokyo, Japan) equipped with a Canon EOS Rebel digital camera (Canon, Inc, Tokyo, Japan). Additional SEM images were taken whenever possible using a JEOL JSM 6480LV scanning electron microscope (JEOL Ltd., Tokyo, Japan) to confirm species identifications. The species identification were done using Witkowski et al. (2000), Hustedt (1985), Round et al. (1990), Peragallo (1888), Schmidt (1874-1959), and also using references from California Academy of

Sciences (http://researcharchive.calacademy.org/research/diatoms) and Algaebase (http://www.algaebase.org).

Calculation of Diversity Indices and Similarity Indices

The comparison of the species diversity at all sites for net plankton and sediment sample was calculated using the Shannon diversity index (Shannon & Weaver, 1949).

$$H = \sum_{i=1}^{S} - (P_i * \ln P_i)$$

Where; H = the Shannon diversity index

P_i = fraction of the entire population made up of species i

S = numbers of species encountered

$\sum$ = sum from species 1 to species S

Bray-Curtis similarity trees and multidimensional scaling analyses were computed separately for net plankton and sediment samples of all sites and months using Primer-E (version 5.0) (Clarke, 1993). The principal component analysis was conducted using Primer-E (version 5.0) (Clarke, 1993) to assess the important species contributing to the community structure. Net plankton samples were compared with historical data using Sørenson's index (Dombois & Ellenberg, 1974).

$$IS = \{(2 * C) / (A + B)\} * 100$$

Where, IS denotes Sørenson's Index, C represents the number of shared species, A represents the total number of species in sample A, and B represents the total number of species in sample B.

Chapter VII

RESULTS

Characterization of Community Structure of Choctawhatchee Bay

A total of 87 genera and 437 taxa were observed during the course of the study.A complete taxonomic list arranged according to the classification system of Round et al. (1990) can be found in Appendix A. The genera with the largest number of taxa were *Amphora* (73 taxa), *Navicula* (52 taxa), *Mastogloia* (40 taxa), and *Achnanthes* (30 taxa). The genera with a moderate number of species were *Diploneis* (19 taxa), *Cocconeis* (12 taxa), *Chaetoceros* (10 taxa), *Fallacia* (9 taxa), *Lyrella* (8 taxa), *Gyrosigma* (7 taxa), and *Pleurosigma* (7 taxa). The genera with the least number of species were *Entomoneis* (4 taxa), *Bacteriastrum* (3 taxa), *Biddulphia* (3 taxa), *Dimeregramm*a (3 taxa), *Grammatophora* (2 taxa), *Cymatosira* (2 taxa), *Campylosira* (1 taxon), *Ceratulina* (1 taxon), *Auliscus* (1 taxa), *Asteromplalu*s (1 taxon), and *Oestrupia* (1 taxon). All together this represents only ~40% of taxa present in the Gulf of Mexico (AKSK Prasad, Florida State University, personal communication). While in keeping with what might be expected in the aftermath of the oil spill, the observed reduced diversity of species is more likely to be the result of the restricted area of study.

Relative Abundance

The 10 most abundant species in each sample are given in the form of pie charts.

Relative Abundance of Species at Choctawhatchee 01 in September

The September net plankton samples from Choctawhatchee 01 were dominated by the genus *Mastogloia*; three species of *Mastogloia*, *M. elliptica, M. gracilis*, and *M. lanceolata* accounted for 25% of the community. Also present in large numbers were were *Diploneis smithi* and *Cyclotella* spp. 1. Of these five species, only *Cyclotella* is considered to be a planktonic form. The ten most abundant species are given in Figure 7.1.

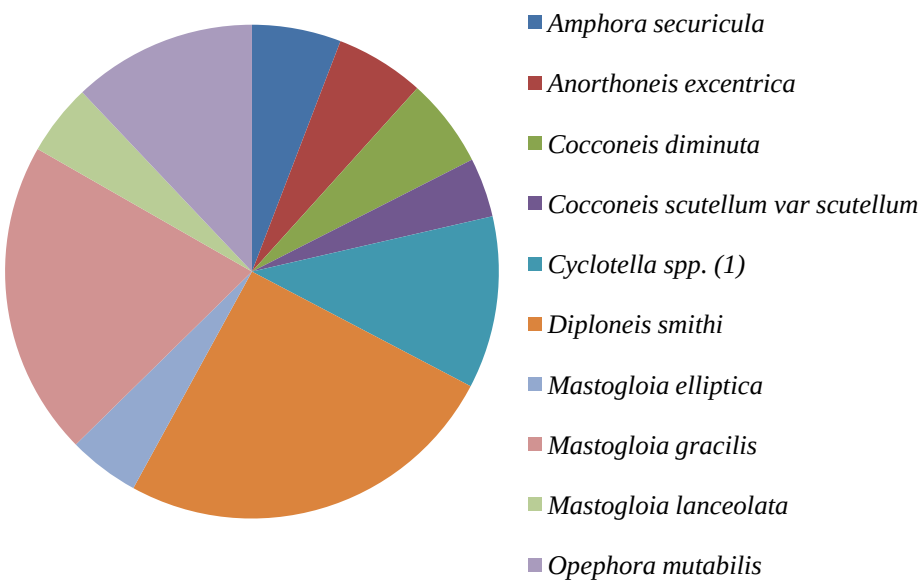


Figure 7.1. Ten most abundant species present in net plankton samples from Choctawhatchee 01 in September.

The sediment sample for September was also dominated by genus *Mastogloia*, with five species accounting for almost 75% of the valves counted. The species present with high relative abundance were *M. pumila* type 3, *M. exilis*, *M. pusilla* type 1 and *M.vasta*. The ten most abundant species are given in Figure 7.2.

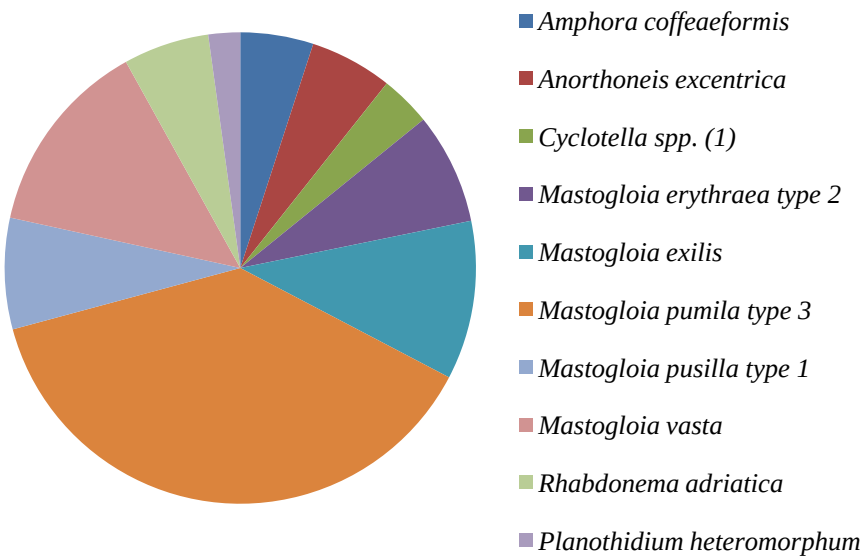


Figure 7.2. Ten most abundant species in sediment samples from Choctawhatchee 01 in September.

Relative Abundance of Species at Choctawhatchee 02 in September

The September net plankton samples from Choctawhatchee 02 were dominated by *Rhabdonema adriatica*, followed by *Planothidium lanceolata var rostrata* and *Cocconeis scutellum var scutellum.* The remaining dominant species are given in Figure 7.3.

The sediment sample was dominated by members of the genus *Fallacia*, F. *margin-punctata* and *F. cf. clypeiformis* in particular. The other two species present in

high numbers were *Cocconeis diminuta* and *Cocconeis scutellum var scutellum*. The ten most abundant species are given in Figure 7.4.

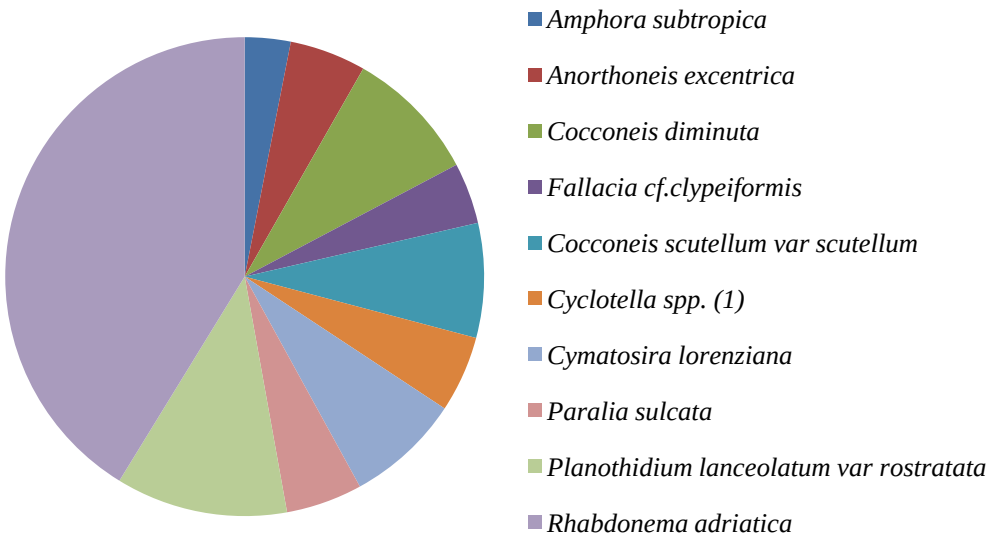


Figure 7.3. Ten most abundant species present in net plankton samples from Choctawhatchee 02 in September.

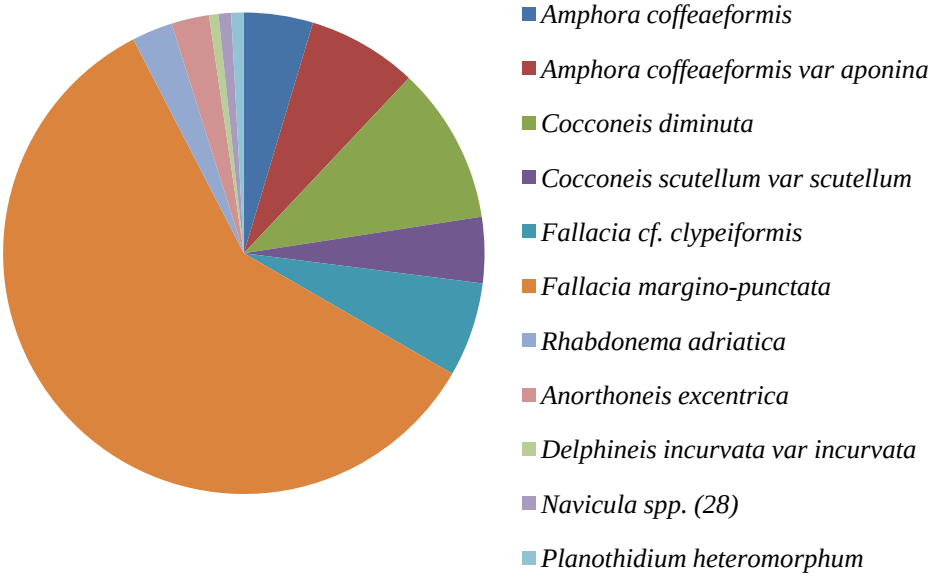


Figure 7.4. Ten most abundant species present in sediment samples from Choctawhatchee 02 in September.

Relative Abundance of Species at Choctawhatchee 01 in November

The November net plankton samples from Choctawhatchee 01 were dominated by the genera *Chaetoceros, Cocconeis*, and *Cyclotella*. The species belonging to these respective groups that were present in high relative abundance were the plankton species *Chaetoceros radicans*, *Chaetoceros affinis*, and *Cyclotella spp*. (1), and the benthic species *Cocconeis scutellum var* scutellum, and *Cocconeis diminuta*. The ten most abundant species are given in Figure 7.5.

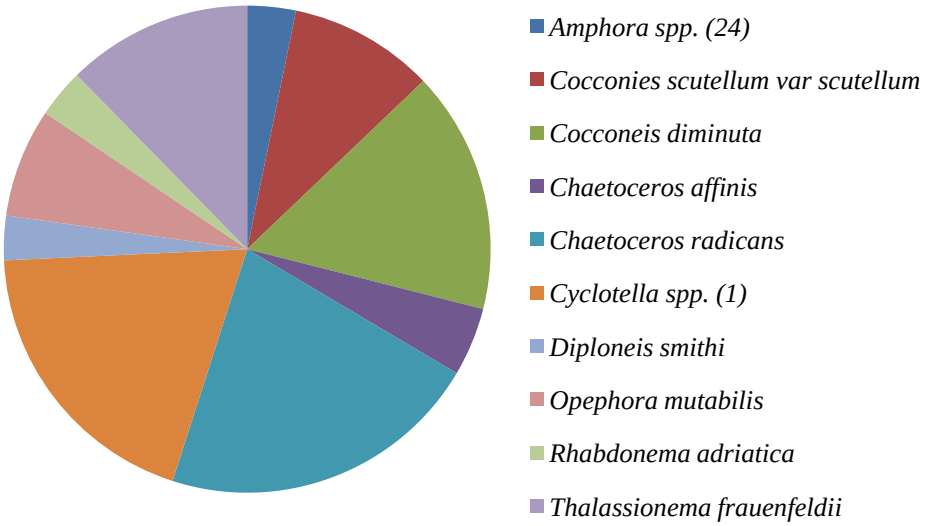


Figure 7.5. Ten most abundant species present in net plankton samples from Choctawhatchee 01 in November.

The sediment samples were dominated by the genera *Amphora, Cyclotella*, and *Cocconeis*. The species belonging to these genera in high relative abundance were *Amphora albudens, Amphora coffaeformis, Cyclotella spp*. (3), *Cocconeis scutellum* var. *scutellum*, and *Cocconeis diminuta*. The ten most abundant species are given in Figure 7.6.

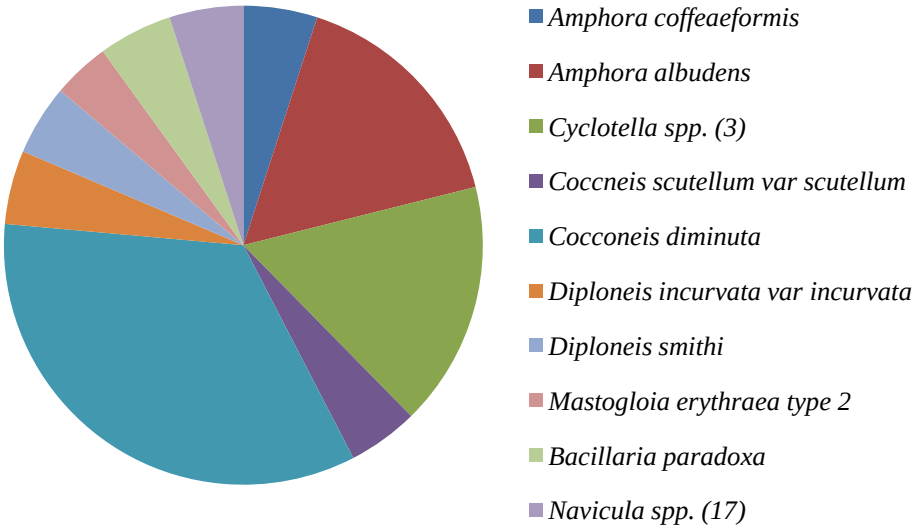


Figure 7.6. Ten most abundant species present in sediment samples from Choctawhatchee 01 in November.

Relative Abundance of Species in Choctawhatchee 02 in November

The November net plankton samples from Choctawhatchee 02 were dominated by the genera *Chaetoceros, Cocconeis*, and *Cyclotella*. The species belonging to these respective groups that were present in high numbers were *Chaetoceros radicans, Chaetoceros affinis, Cocconeis scutellum var scutellum, Cocconeis diminuta*, and *Cyclotella spp*. (3). The ten most abundant species are given in Figure 7.7. The suite of species is similar to that observed at Choctawhatchee 01.

The sediment sample was completely dominated by *Fallacia margin-punctata*, with this species accounting for almost 75% of the valves counted. It was followed in importance by *Cocconeis diminuta*. The ten most abundant species are given in Figure 7.8.

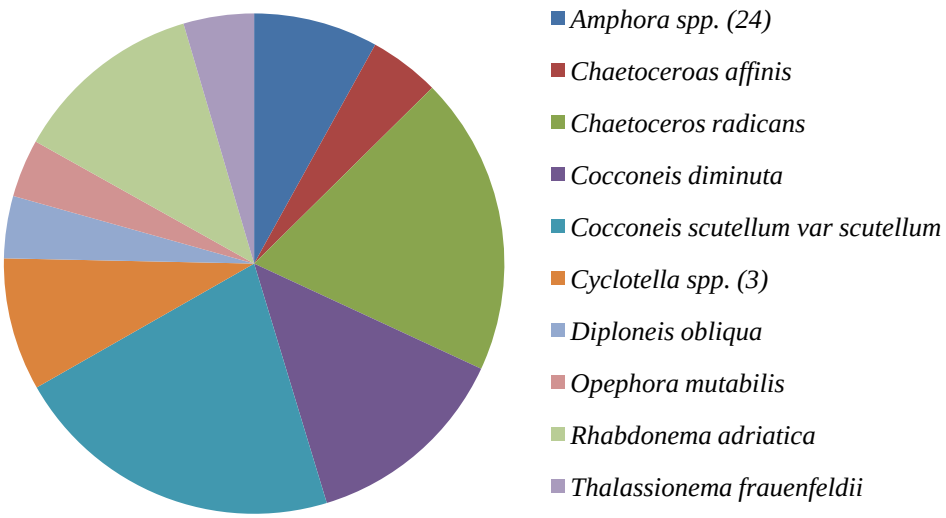


Figure 7.7. Ten most abundant species in net plankton samples from Choctawhatchee 02 in November.

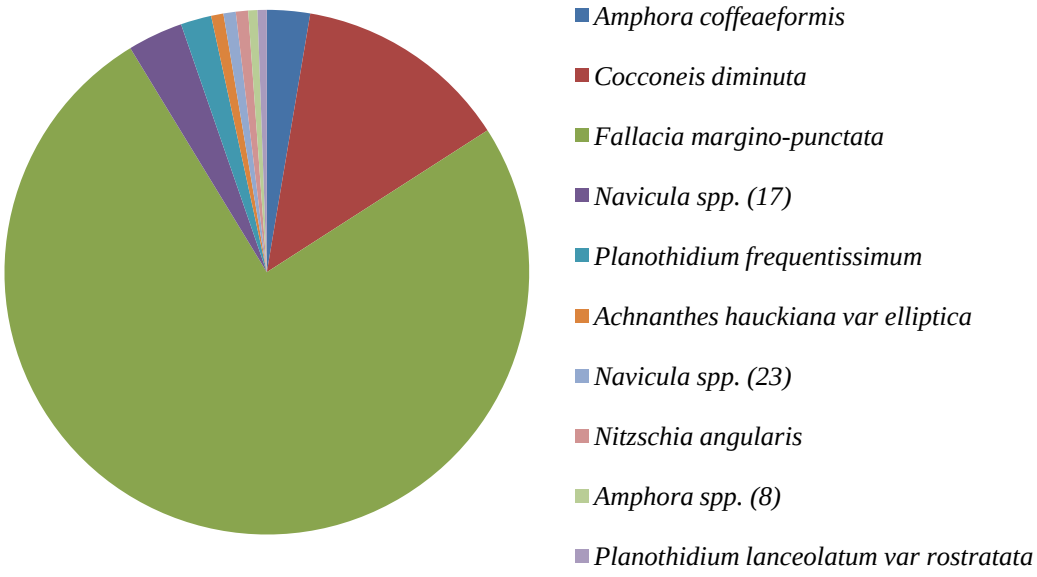


Figure 7.8. Ten most abundant species in sediment samples from Choctawhatchee 02 in November.

Relative Abundance of Species at Choctawhatchee 03 in November

The net plankton samples from Choctawhatchee 03 in November were dominated by the benthc species *Cocconeis diminuta*, *Cocconeis scutellum var scutellum*, *Delphineis surirelloides*, and *Paralia sulcata;* the planktonic species *Cyclotella spp.* 1 was also abundant. The ten most abundant species are given in Figure 7.9.

Sediment samples were dominated by *Cocconeis diminuta*, followed by *Cyclotella spp.* 3, *Delphineis surirelloides*, and *Amphora subtropica*. The ten most abundant species are given in Figure 7.10.

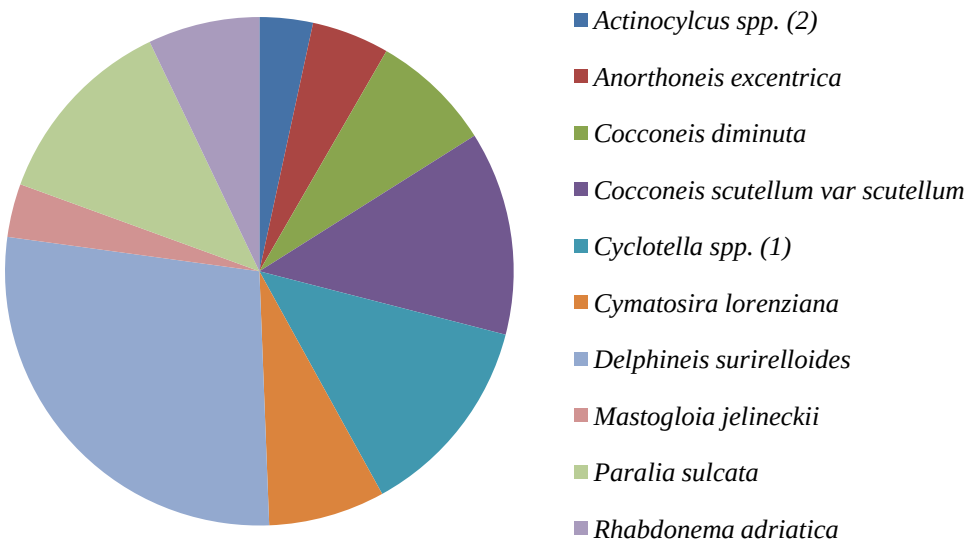


Figure 7.9. Ten most abundant species in net plankton samples from Choctawhatchee 03 in November.

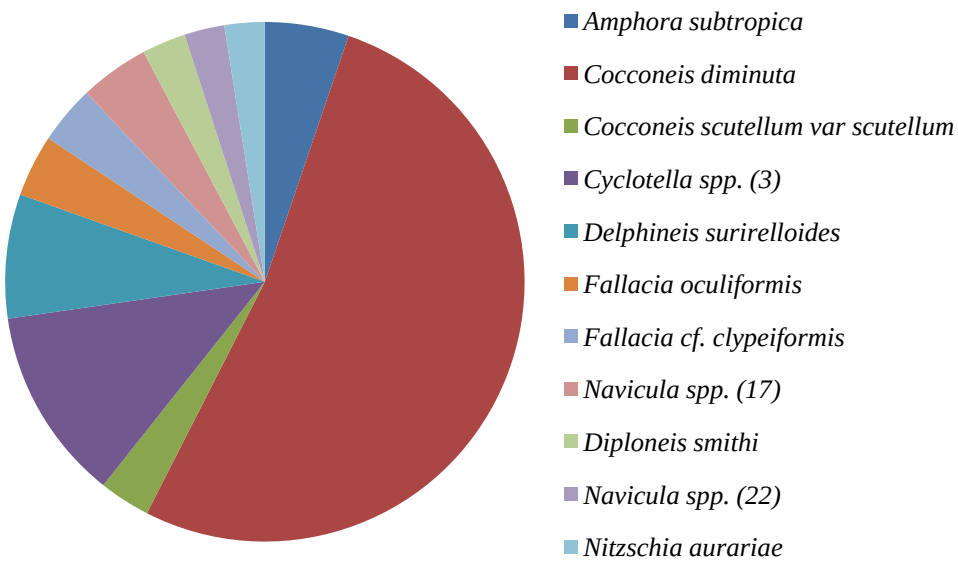


Figure 7.10. Ten most abundant species in sediment samples from Choctawhatchee 03 in November.

Relative Abundance of Species at Choctawhatchee 04 in November

The November net plankton samples from Choctawhatchee 04 were dominated by the planktonic species *Cylindrotheca spp,* and the benthic species *Navicula cf. caterva, Nitzschia angularis* and *Amphora coffaeformis.* The ten most abundant species are given in Figure 7.11.

The sediment sample was dominated by the benthic genera *Amphora*, *Navicula*, and *Nitzschia*. The species belonging to these groups that were present in high numbers were *Amphora albudens*, *Amphora coffeaeformis*, and *Nitzschia angularis.* The ten most abundant species are given in Figure 7.12.

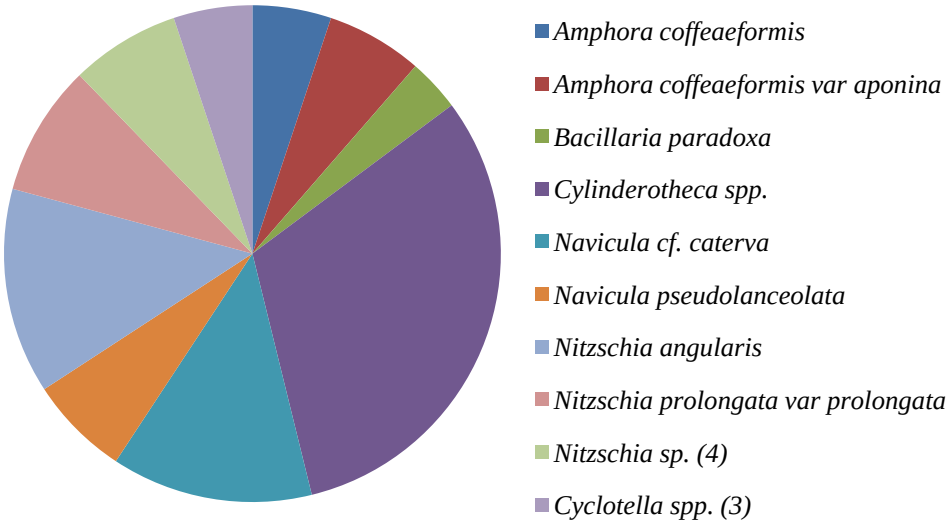


Figure 7.11. Ten most abundant species in net plankton samples from Choctawhatchee 04 in November.

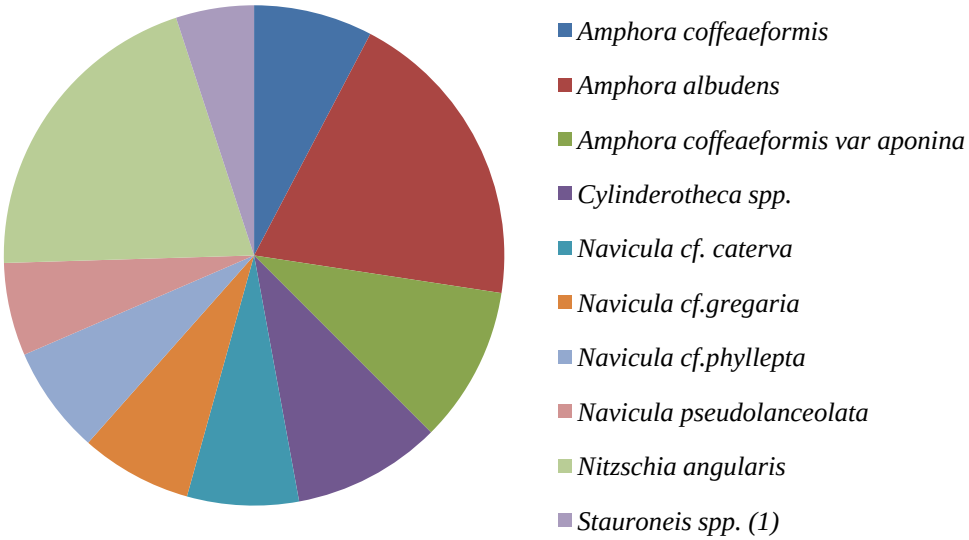


Figure 7.12. Ten most abundant species in sediment samples from Choctawhatchee 04 in November.

Relative Abundance of Species at Choctawhatchee 01 in January

The January net plankton samples from Choctawhatchee 01 were dominated by the planktonic species *Chaetoceros gracilis* which accounted for over 45% of the total population. The ten most abundant species are given in Figure 7.13.

Sediment samples were dominated by the benthic species *Cocconeis diminuta* and *Planothidium frequentissimum*. The ten most abundant species are given in Figure 7.14.

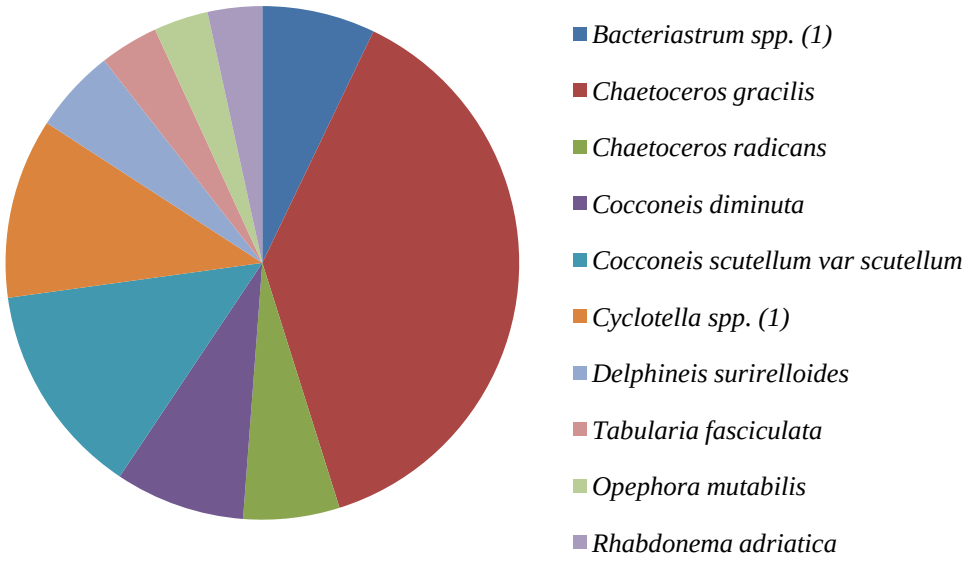


Figure 7.13. Ten most abundant species in net plankton samples from Choctawhatchee 01 in January.

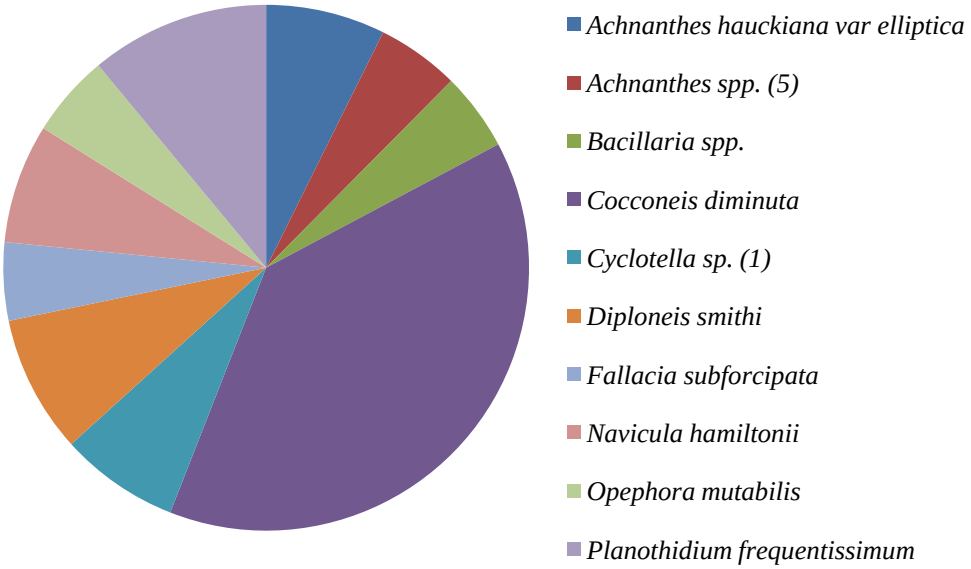


Figure 7.14. Ten most abundant species in sediment samples from Choctawhatchee 01 in January.

Relative Abundance of Species at Choctawhatchee 02 in January

In January net plankton samples from Choctawhatchee 02 were dominated by the planktonic species *Chateceros gracilis*, just as was the case at Choctawhatchee 01. Also present in large numbers were the benthic species *Cocconeis diminuta* and *Cocconeis scutellum* var *scutellum.* The ten most abundant species are given in Figure 7.15.

The sediment sample was dominated by *Fallacia cf. clypeiformis, Delphineis surirelloides, and Cocconeis scutellum var scutellum*. The ten most abundant species are given in Figure 7.16.

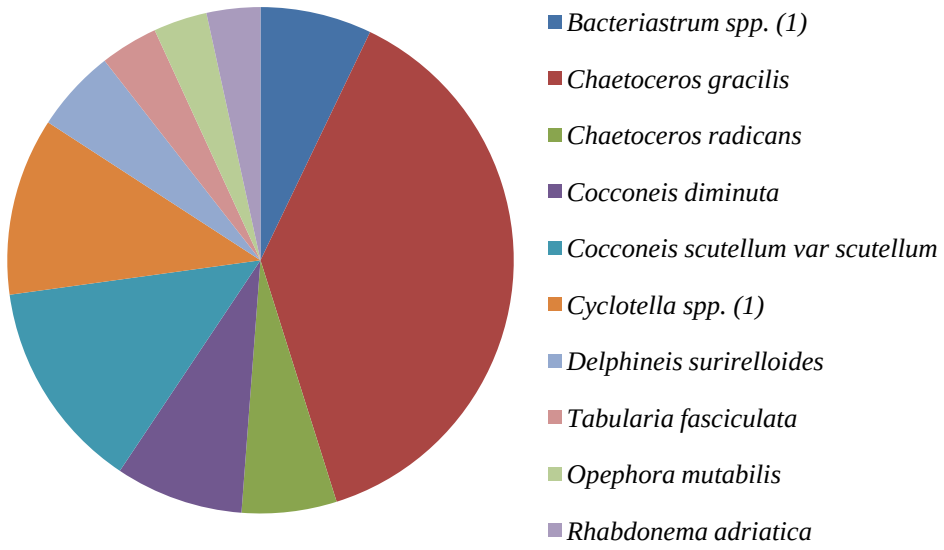


Figure 7.15. Ten most abundant species in net plankton samples from Choctawhatchee 02 in January.

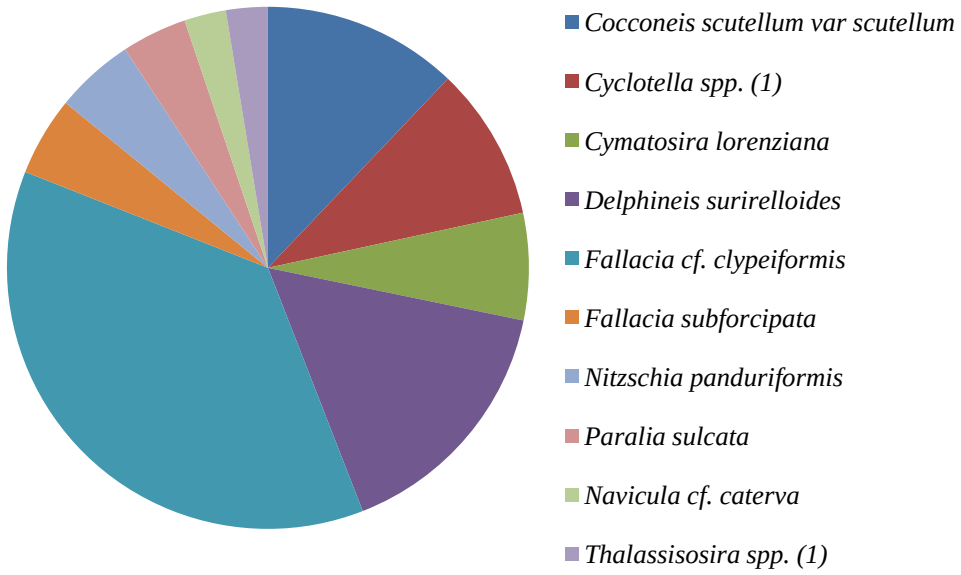


Figure 7.16. Ten most abundant species in sediment samples from Choctawhatchee site 02 in January.

Relative Abundance of Species at Choctawhatchee 03 in January

The January net plankton samples from Choctawhatchee 03 were dominated by the planktonic species *Chaetoceros radican* and *Chaetoceros radicans,* and the benthic species *Cymatosira lorenziana* and *Delphineis surirelloides.* The ten most abundant species are given in Figure 7.17.

No species were recorded in January sediment sample. This site is a sandy shore exposed directly to the Gulf of Mexico.

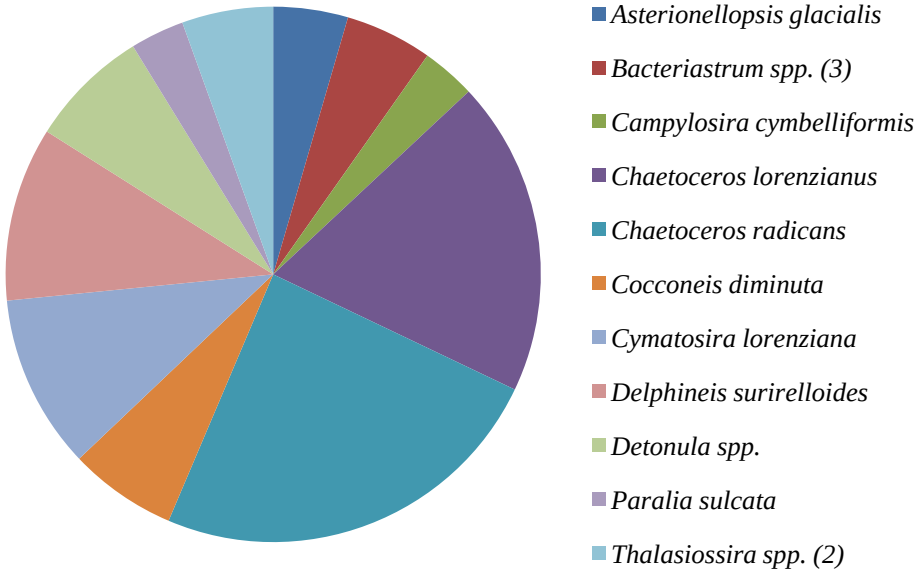


Figure 7.17. Ten most abundant species in net plankton samples from Choctawhatchee 03 in January.

Relative Abundance of Species at Choctawhatchee 04 in January

The January net plankton samples from Choctawhatchee 04 were dominated by the planktonic species *Chaetoceros gracilis*, *Chaetoceros radicans,* and *Chaetoceros compressus*, and the benthic species *Tabularia spp.* (2). *Chaetoceros* species thus

dominated the plankton samples for all station this month. The ten most abundant species are given Figure 7.18.

The sediment samples were mostly dominated by the benthic species *Amphora albudens, Tabularia spp.* (2), *Navicula cf. gregaria*, and *Stauroneis spp.* (1). The ten most abundant species are given in Figure 7.19.

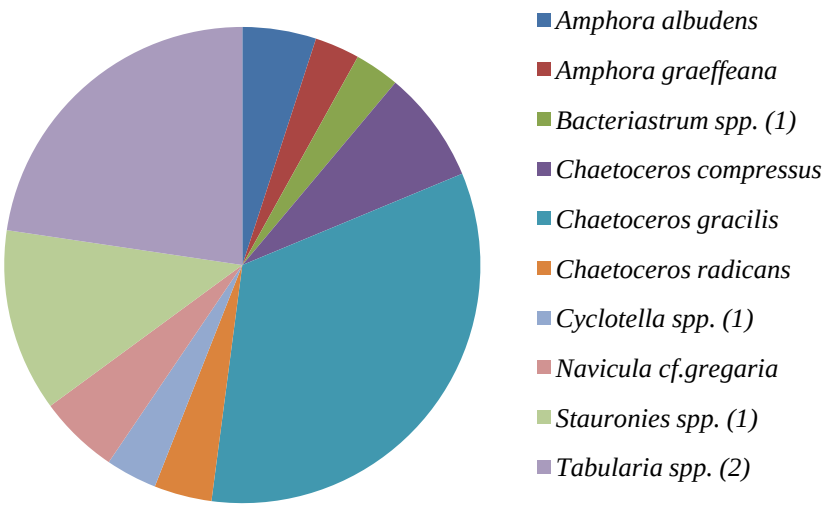
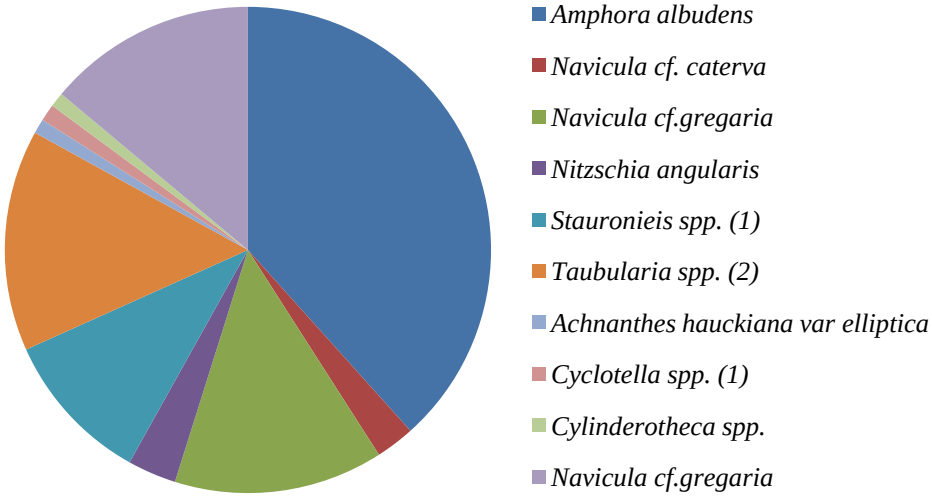


Figure 7.18. Ten most abundant species in net plankton samples from Choctawhatchee site 04 in January.



. Figure 7.19. Ten most abundant species in sediment samples from Choctawhatchee 04 in January.

Relative Abundance of Species at Choctawhatchee 01 in March

The March net plankton samples from Choctawhatchee 01 were completely dominated by the genus *Chaetoceros*. The species present in relative highest abundance were *Chaetoceros gracilis*, *Chaetoceros affinis*, and *Chaetoceros teres.* The ten most abundant species are given in Figure 7.20.

Sediment samples were dominated by the benthic species *Cocconeis diminuta, Anorthoneis excentrica*, *Planothidium frequentissimum*, and *Achnanthes hauckiana var elliptica*. The ten most abundant species are given in Figure 7.21.

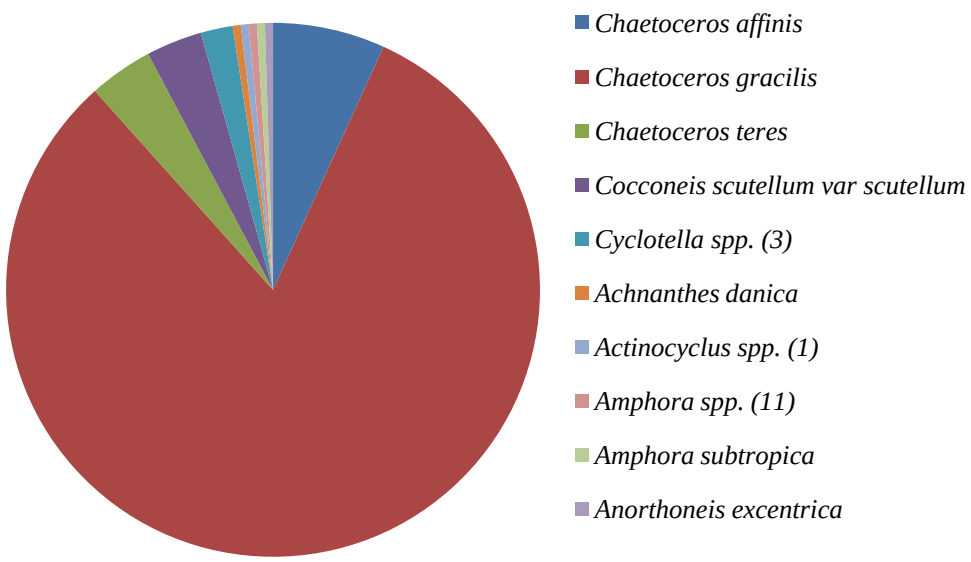


Figure 7.20. Ten most abundant species in net plankton samples from Choctawhatchee 01 in March.

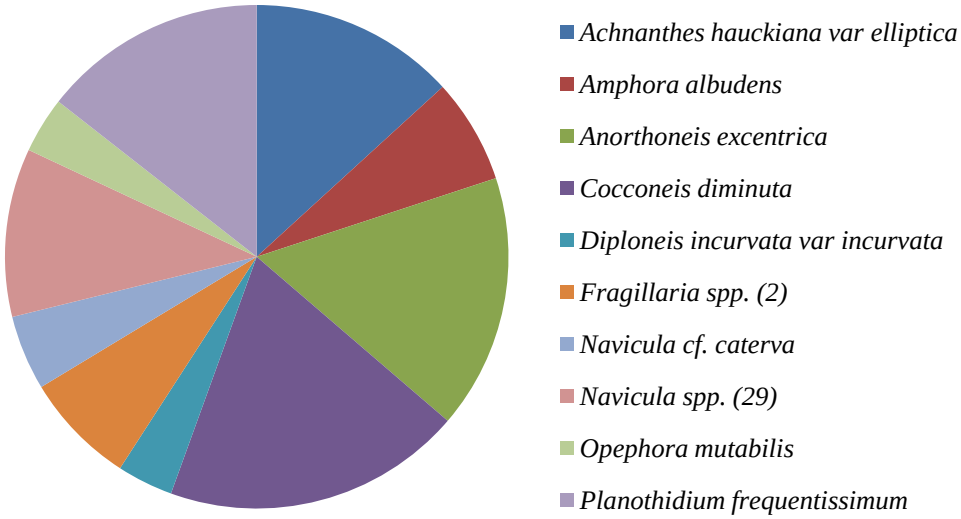


Figure 7.21. Ten most abundant species in sediment samples from Choctawhatchee 01 in March

Relative Abundance of Species at Choctawhatchee 02 in March

The March net plankton samples from Choctawhatchee site 02 were dominated by the planktonic species *Chaetoceros gracilis* and *Chaetoceros affinis*, and the benthic species *Cocconeis diminuta* and *Delphineis surirelloides*.. The ten most abundant species are given in Figure 7.22.

Sediment samples were dominated by *Fallacia margino-punctata*, followed by *Navicula cf. caterva* and *Achnanthes hauckiana var elliptica*. The ten most abundant species are given in Figure 7.23.

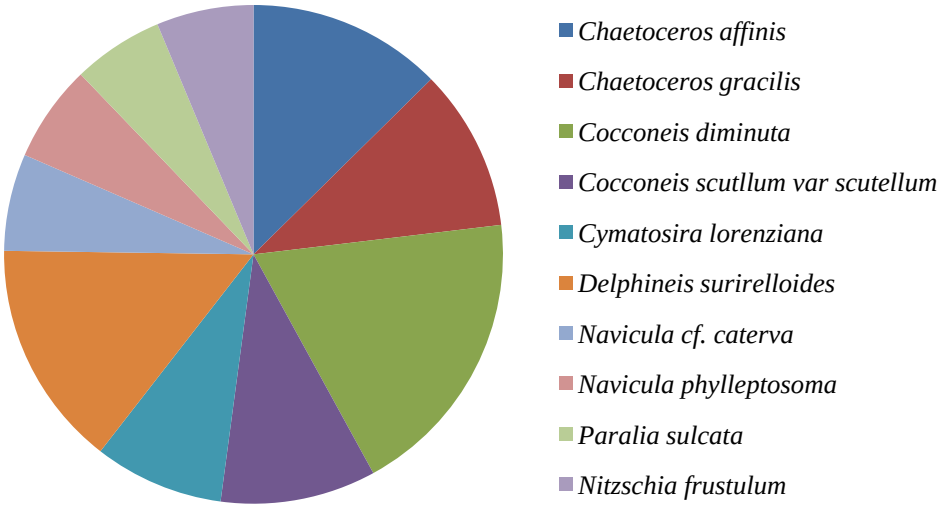


Figure 7.22. Ten most abundant species in net plankton samples from Choctawhatchee site 02 in March.

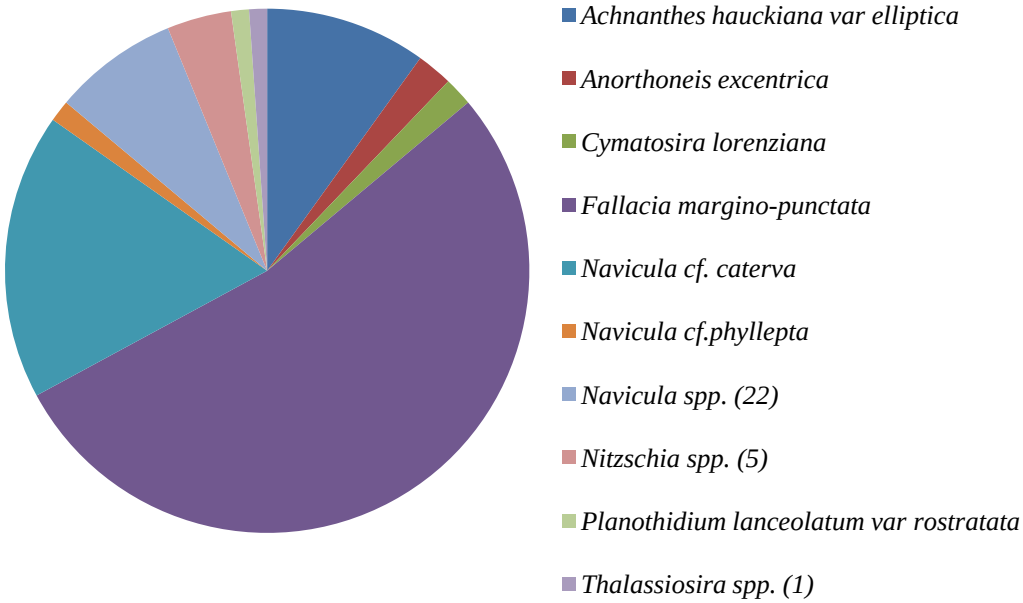


Figure 7.23. Ten most abundant species in sediment samples from Choctawhatchee 02 in March.

Relative Abundance of Species at Choctawhatchee 03 in March

In March no species truly dominated the net plankton samples from Choctawhatchee 03. Species present in the largest numbers were the benthic forms *Cocconeis scutellum* var *scutellum, Cocconeis diminuta* and *Delphineis surirelloides.* The ten most abundant species are given in Figure 7.24.

As was the case in January, no species were encountered in the March sediment sample.

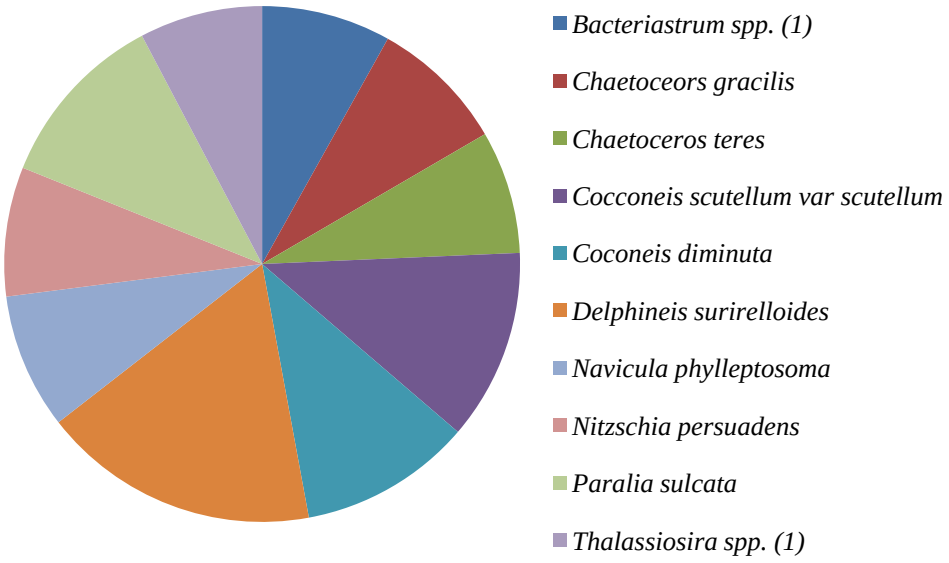


Figure 7.24. Ten most abundant species in net plankton samples from Choctawhatchee 03 in March.

Relative Abundance of Species at Choctawhatchee 04 in March

In March net plankton samples from Choctawhatchee 04 were dominated by *Chaetoceros gracilis* and *Chaetoceros affinis,* and the benthic species *Tabularia spp.* (2) and *Entomoneis punctata.* The ten most abundant species are given in Figure 7.25.

The species present in high relative numbers in sediment sample were the benthic forms *Tabularia* spp. (2), *Navicula* cf. *gregaria*, and *Amphora albudens*. The ten most abundant species are given in Figure 7.26.

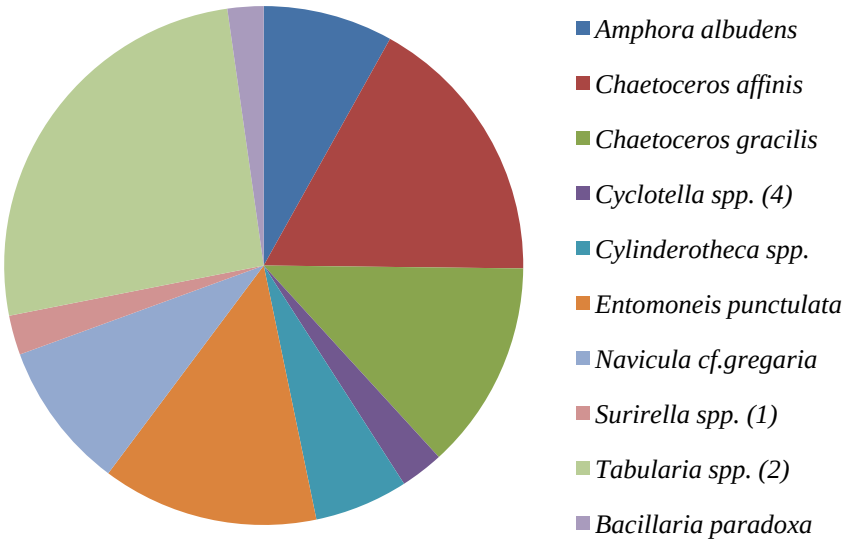


Figure 7.25. Ten most abundant species in net plankton samples from Choctawhatchee 04 in March.

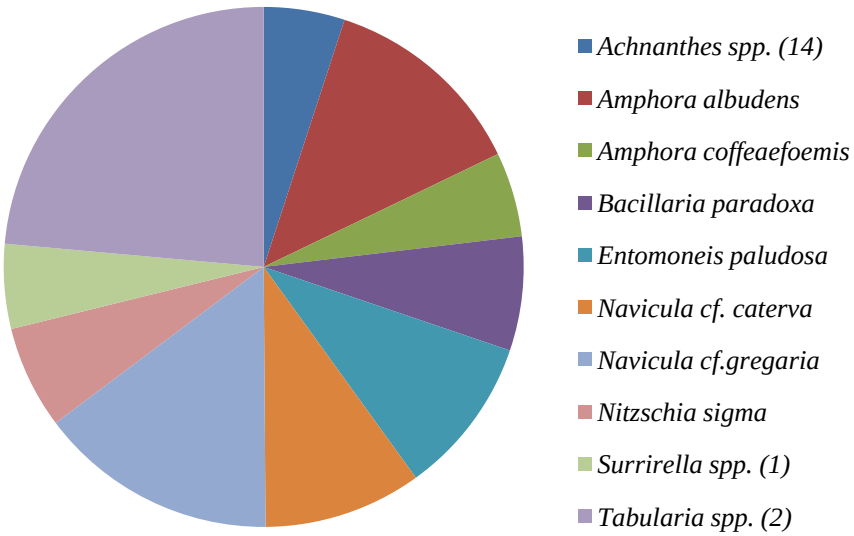


Figure 7.26. Ten most abundant speciecs in sediment samples from Choctawhatchee 04 in March.

Relative Abundance of Species at Choctawhatchee 01 in May

The May net plankton samples from Choctawhatchee 01 were dominated by the genus *Chaetoceros*. The species present in particularly high relative abundance were *Chaetoceros gracilis, Chaetoceros lorenziana, Chaetoceros affinis*, and *Chaetoceros radicans*. Together they account for over 75% of the population. The ten most abundant species are given in Figure 7.27.

The species present in high relative abundance in sediment samples were *Amphora lavaeissima, Amphora graeffeana, Amphora albudens*, and *Navicula cf.gregaria*. The ten most abundant species are given in Figure 7.28.

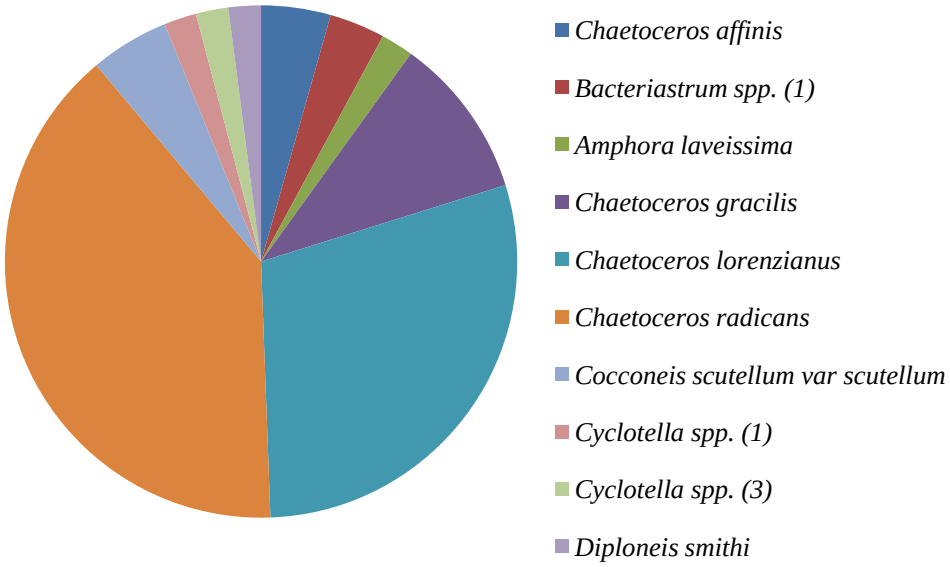


Figure 7.27. Ten most abundant species in net plankton samples from Choctawhatchee 01 in May.

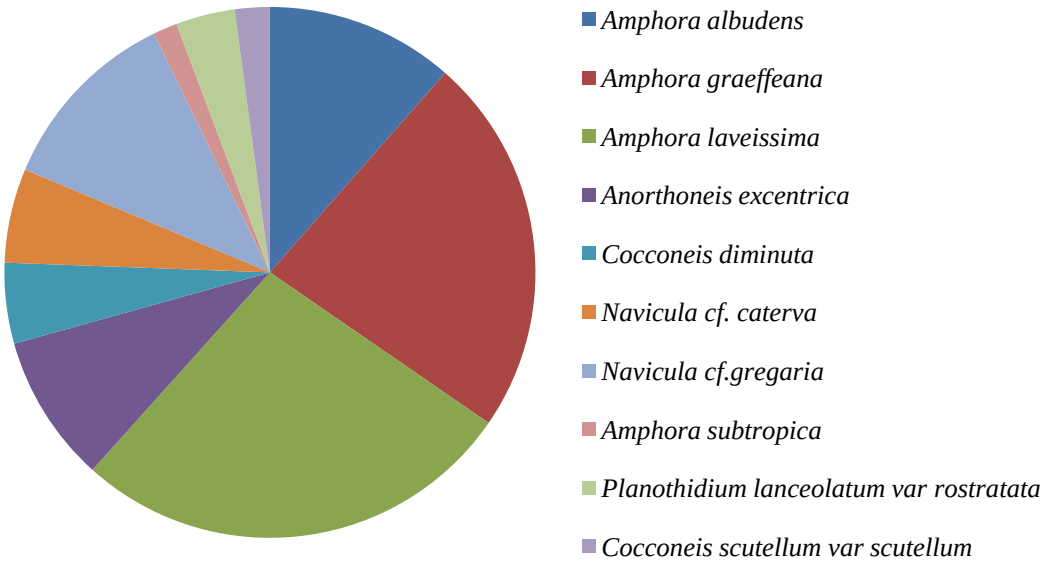


Figure 7.28. Ten most abundant species in sediment samples from Choctawhatchee 01 in May.

Relative Abundance of Species at Choctawhatchee 02 in May

The species present in high relative abundance in net plankton samples in May at Choctawhatchee 02 were the benthic species *Cocconeis scutellum var scutellum*, and *Cocconeis diminuta*, and the planktonic species *Cyclotella spp.* (4). The ten most abundant species are given in Figure 7.29.

The sediment sample was completely dominated by *Fallacia matgino-punctata.* The ten most abundant species are given in Figure 7.30.

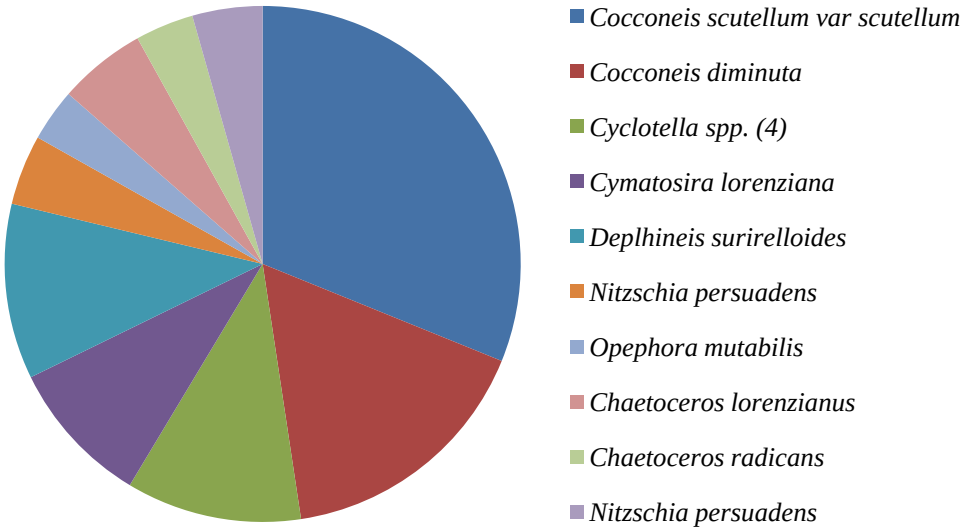


Figure 7.29. Ten most abundant species in net plankton samples from Choctawhatchee 02 in of May.

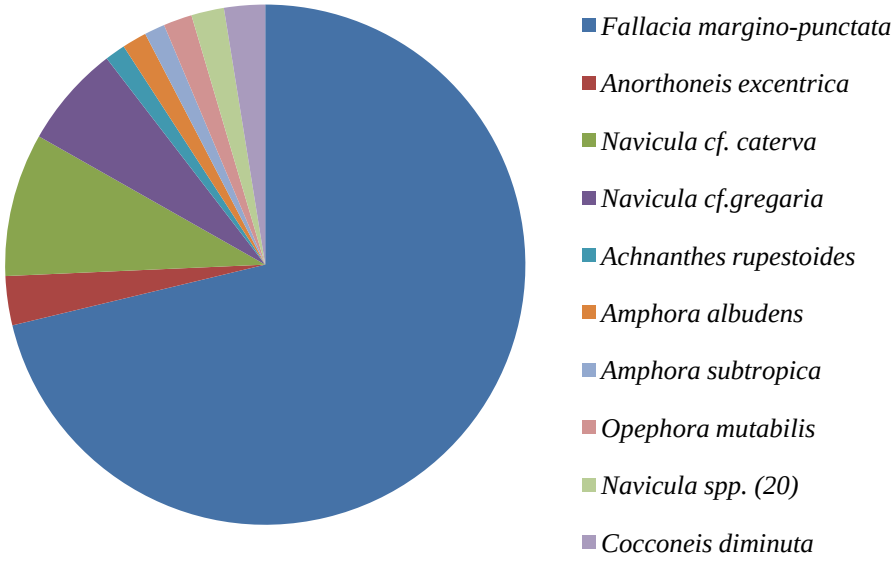


Figure 7.30. Ten most abundant species in sediment samples from Choctawhatchee 02 in May.

Relative abundance of species at Choctawhatchee 03 in May

The species present in high relative abundances in net plankton samples from Choctawhatchee 03 in May were the benthic species *Cocconeis scutellum var scutellum, Cocconeis diminuta, Delphineis surirelloides, and* the planktonic species *Chaetoceros gracilis* and *Chaetoceros radicans*. The ten most abundant species are given in Figure 7.31.

Again, no species were recorded in the May sediment sample.

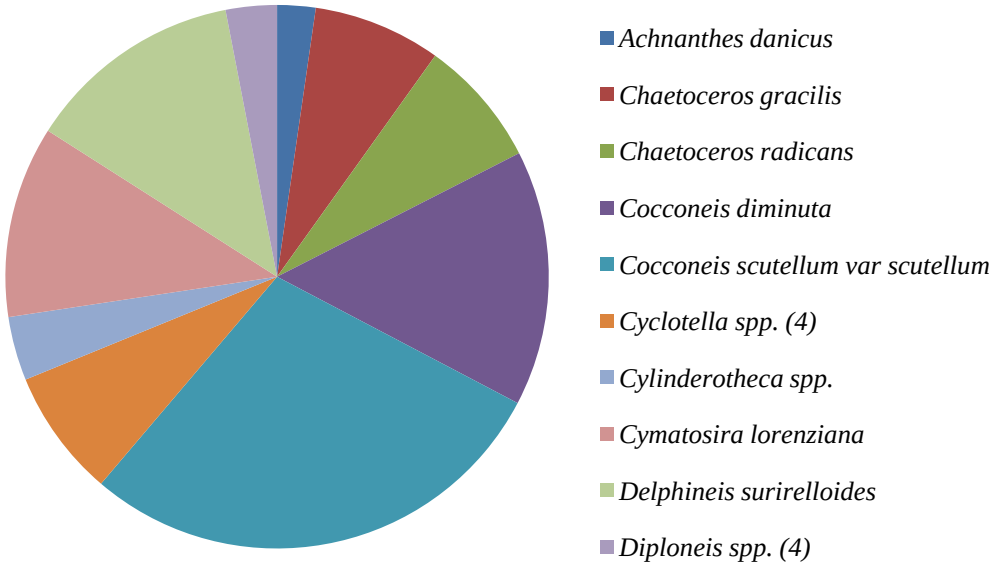


Figure 7.31. Ten most abundant species in net samples from Choctawhatchee 03 in May.

Relative Abundance of Species at Choctawhatchee 04 in May

The species present in high relative abundances in May net plankton samples from Choctawhatchee 04 were the benthic species *Navicula cf. caterva, Nitzschia frustulum,* and *Bacillaria paradoxa.* The ten most abundant species are given in Figure 7.32.

The species present in high relative abundance in sediment sample were the benthic forms *Navicula cf. caterva*, *Navicula cf. gregaria*, *Nitzschia frustulum*, and *Amphora albudens.* All of these were either common or abundant in the net plankton samples. The ten most abundant species are given in Figure 7.33.

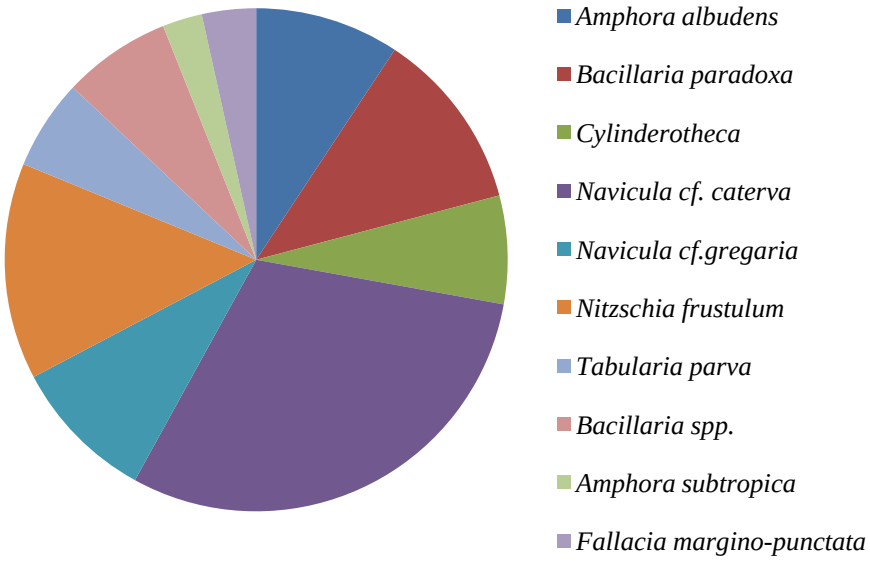
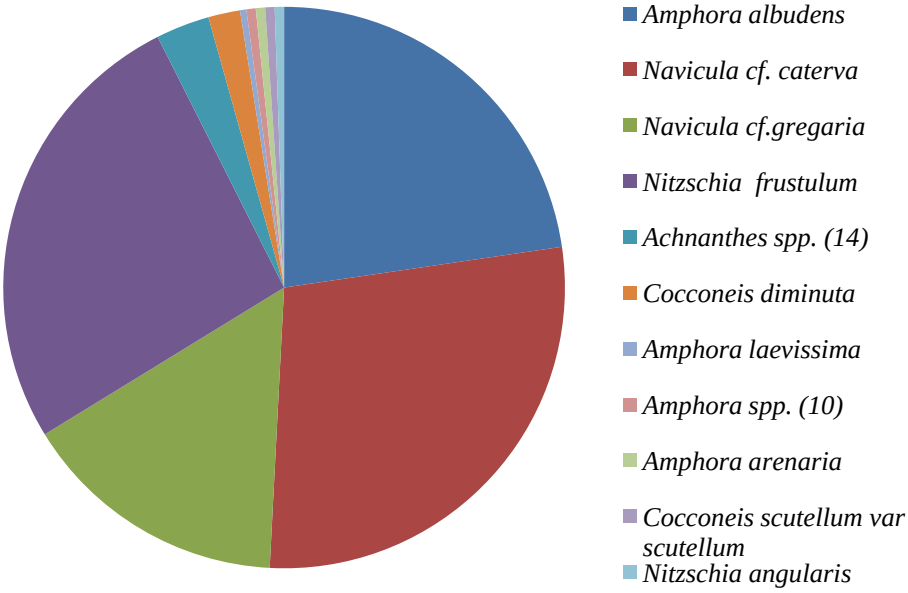


Figure 7.32. Ten most abundant species in net plankton samples from Choctawhatchee site 04 in May.



.

Figure 7.33. Ten most abundant species in sediment samples from Choctawhatchee 04 in May.

Shannon Diversity Indices

The Shannon diversity index was calculated for all net plankton and sediment samples. The results are given in Figure 7.34 for net plankton and Figure 7.35 for sediment samples. No specific trends were observed, although sediment samples for sites 01, 02, and 04 did increase during January. The absence of a trend consistent with the degree of change in the ten most abundance species observed at each site. It is not consistent with the expectation of a gradual rise in species diversity after an environmental disaster such as an oil spill.

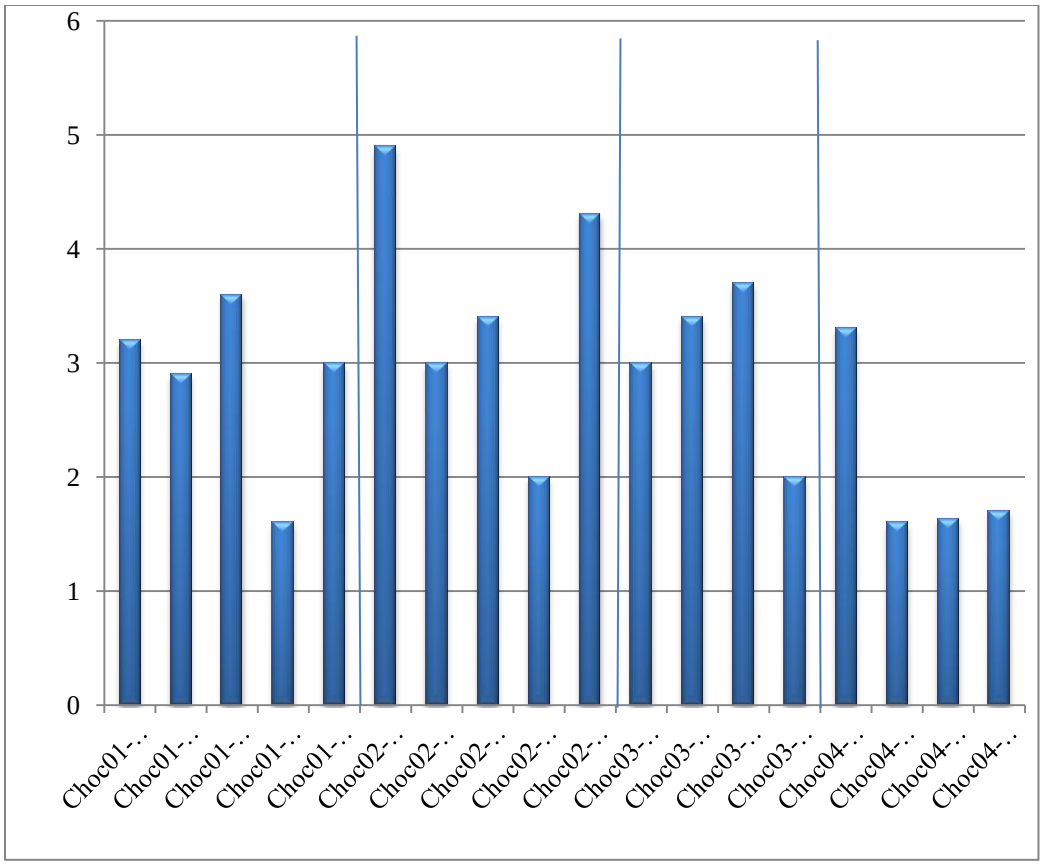


Figure 7.34. Shannon diversity index for all net planktonic samples for all sites. X axis: Choc01 represents Choctawhatchee 01, Choc02 represents Choctawhatchee 02, Choc03 represents Choctawhatchee 03, and Choc04 represents Choctawhatchee 04. N represents net plankton followed by the month sample collection; Y axis: Shannon diversity index.

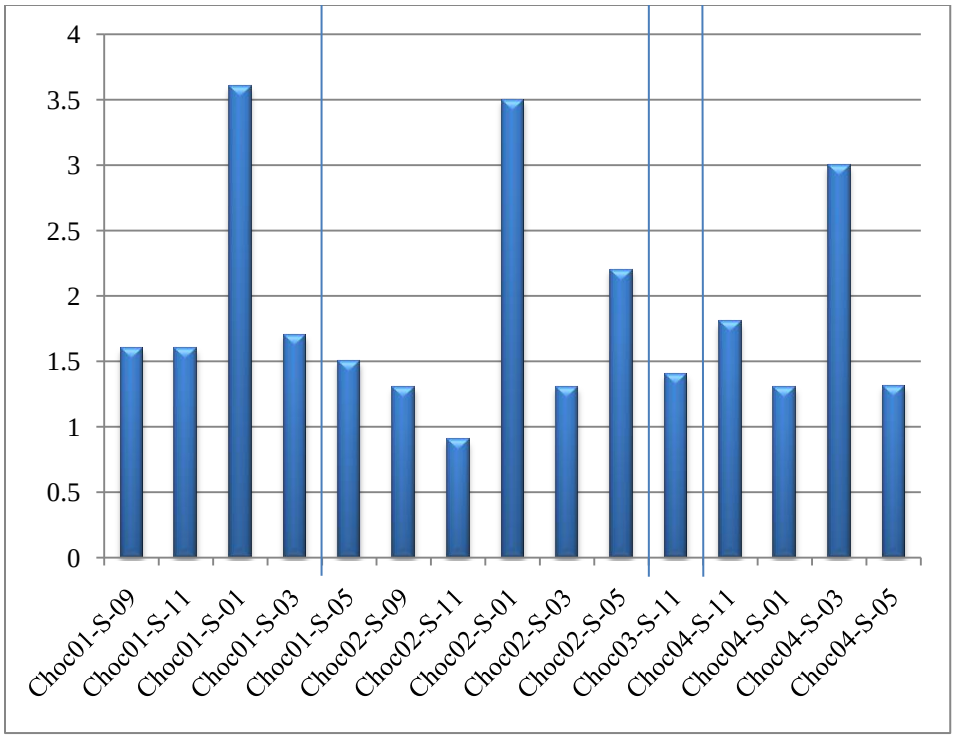


Figure 7.35. Shannon diversity index for all sediment samples for all sites. X axis: Choc01 represents Choctawhatchee 01, Choc02 represents Choctawhatchee 02, Choc03 represents Choctawhatchee 03, and Choc04 represents Choctawhatchee 04. S represents sediment followed by the month sample collection. Y axis: Shannon diversity index.

Bray Curtis Similarity

Bray Curtis Similarity trees were generated for net plankton and sediment samples separately. Overall, sediment samples showed a low degree of similarity (Figure 7.37), with only sediment samples for Choctawhatchee 04 for March and May and sediment samples for Choctawhatchee 01 and 03 for November, showing more than 60% similarity. No pairs of samples had a similarity greater than 80%. Among the net plankton samples, only Choctawhatchee 01 and Choctawhatchee 02 were similar at the 60% similarity level (Figure 7.36).

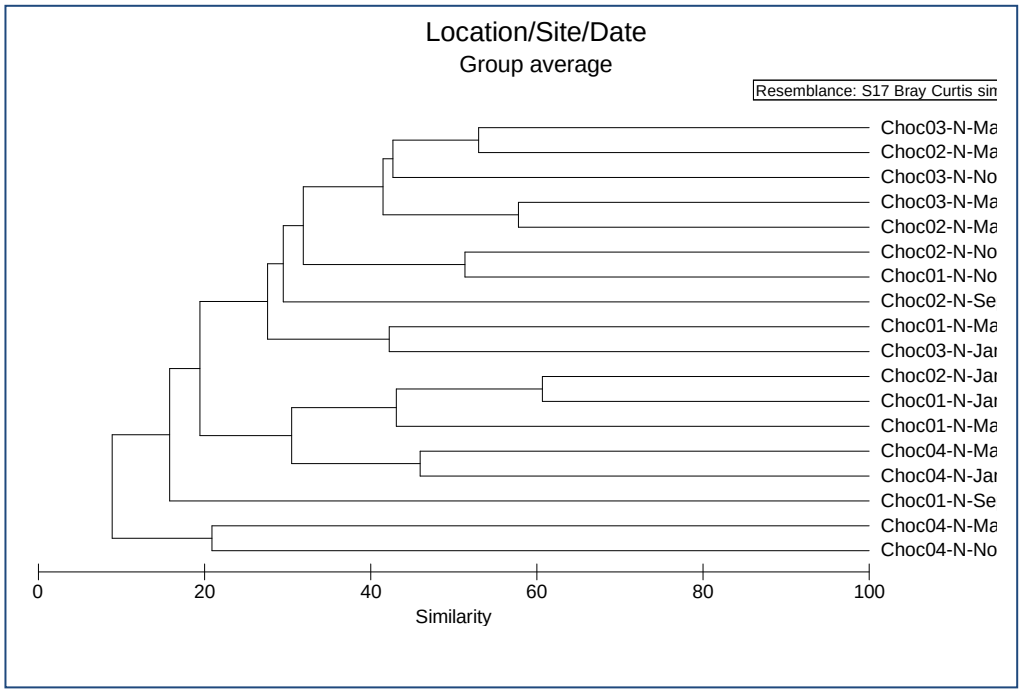


Figure 7.36. Bray Curtis Similarity Dendogram for net planktonic samples. The node represents sampling sites where Choc01 represents Choctawhatchee 01, Choc02 represents Choctawhatchee 02, Choc03 represents Choctawhatchee 03, and Choc04 represents Choctawhatchee 04. N represents Plankton followed by the month of sample collection.

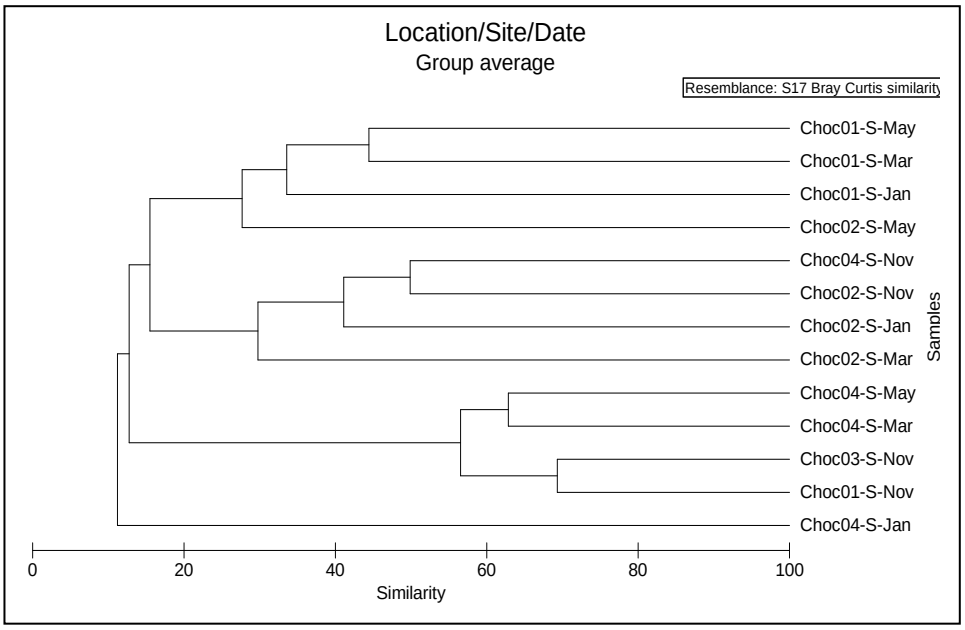


Figure 7.37. Bray Curtis Similarity Dendogram for sediment sample. The node represents sampling sites where Choc01 represents Choctawhatchee 01, Choc02 represents Choctawhatchee 02, Choc03 represents Choctawhatchee 03, and Choc04 represents Choctawhatchee 04. S represents sediment followed by the month of sample collection.

Multidimensional Scaling

The results from multidimensional scaling can be seen in Figures 7.38 (sediment samples) and 7.39 (net plankton samples). These figures are consistent with the results of the Bray-Curtis similarity analysis. Again, only limited similarity between any two pairs of samples is observed. Multidimensional scaling test was conducted based on Bray Curtis similarity. Likewise, Bray Curtis similarity dendogram only 60% overlapping was observed between sediment samples of Choctawhatchee 04 for March and May month and between the Choctawhatchee 01 and 03 for November month (Figure 60). No overlapping was observed in net plankton samples (Figure 61).

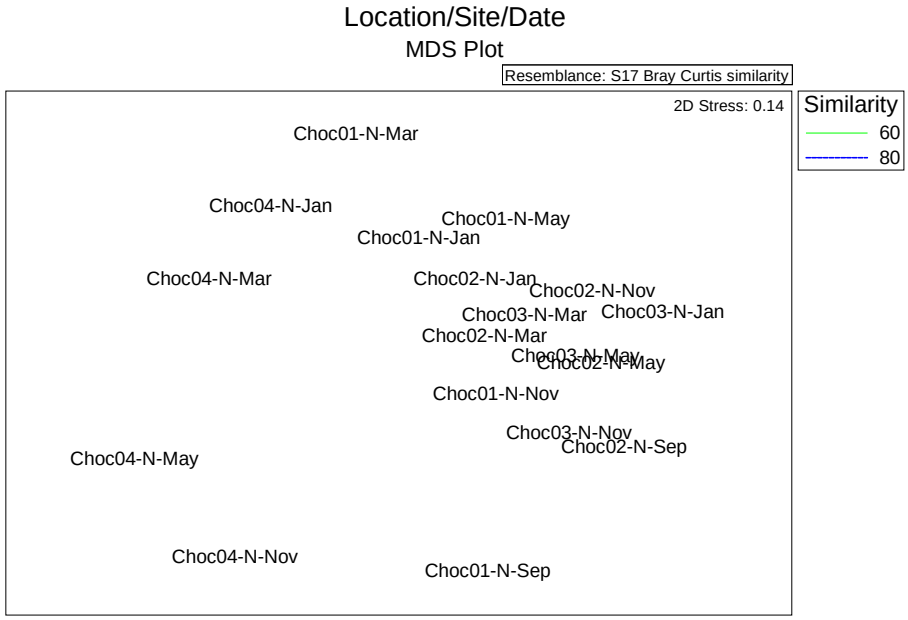


Figure 7.38: Multidimensional Scaling Plot based on Bray Curtis Similarity for net plankton samples. Choc01 represents Choctawhatchee 01, Choc02 represents Choctawhatchee 02, Choc03 represents Choctawhatchee 03, and Choc04 represents Choctawhatchee 04. N represents net plankton followed by the month of sample collection. Note that no two samples show greater that 60% similarity.

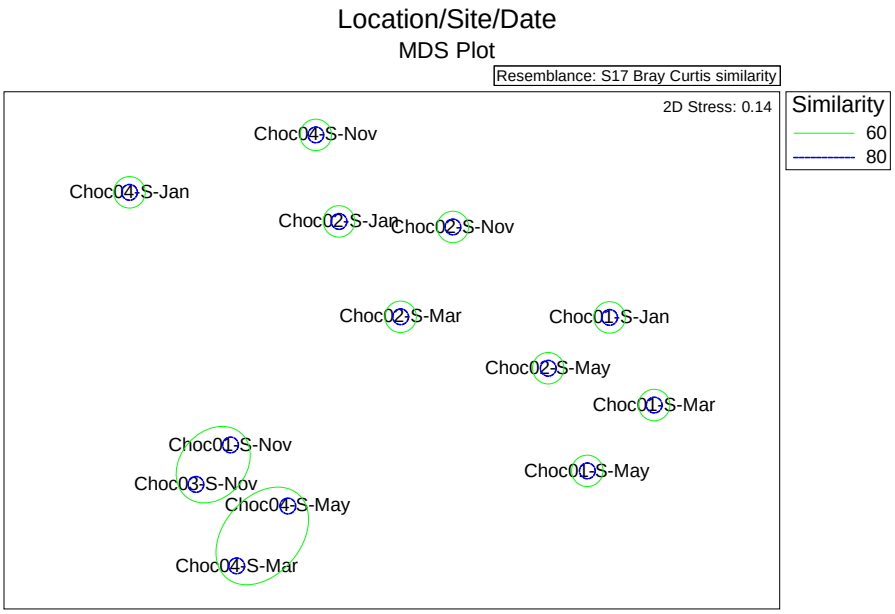


Figure 7.39: Multidimensional Scaling Plot based on Bray Curtis Similarity for sediment sample. Choc01 represents Choctawhatchee 01, Choc02 represents Choctawhatchee 02, Choc03 represents Choctawhatchee 03, and Choc04 represents Choctawhatchee 04. N represents net plankton followed by the month of sample collection.

Principal Component Analysis

The objective of conducting principal component analysis was to identify the important taxa involved in defining diatom assemblages in Choctawhatchee Bay. For net plankton samples, *Chaetoceros gracilis*, *Chaetoceros radicans*, *Chaetoceros lorenzianus*, *Cocconeis scutellum var scutellum. Navicula cf. caterva*, *Tabularia* sp 2, and *Amphora albudens* were the important species in defining the diatom assemblages (see Appendix B). For sediment samples, *Fallacia margin-punctata*, *Amphora albudens*, *Cocconeis diminuta. Tabularia* sp 2, *Amphora coffeaeformis var aponina*, and *Cyclotella* sp 3 were the important species in defining the diatom assemblages (see Appendix B).

Comparison of Present and Historical Data

We compared our net plankton data with the species lists provided by Livingston (2001) for net plankton in Choctawhatchee Bay collected during the mid-1980s. Livingston (2001) reported a total of 84 diatoms present at an abundance of at least 0.1%. We observed 74 net plankton species at the same abundance level. The decrease in 10 species would be consistent with damage caused by the oil spill. However, only 14 species were common to the two data sets. Furthermore, the similarity between the two communities as measured by Sørenson's index was only 28.57%. These values suggest either that the system was completely disrupted or that we are looking at two completely different systems.

Observation of Deformed Valves

Throughout the study were few abnormal valves were observed (see Figure 7.40 for examples). These valves represented a very small fraction, much less than 0.1%, of the more 15,000 valves counted during the course of the study. Therefore, no significant numbers of abnormal valves were observed.

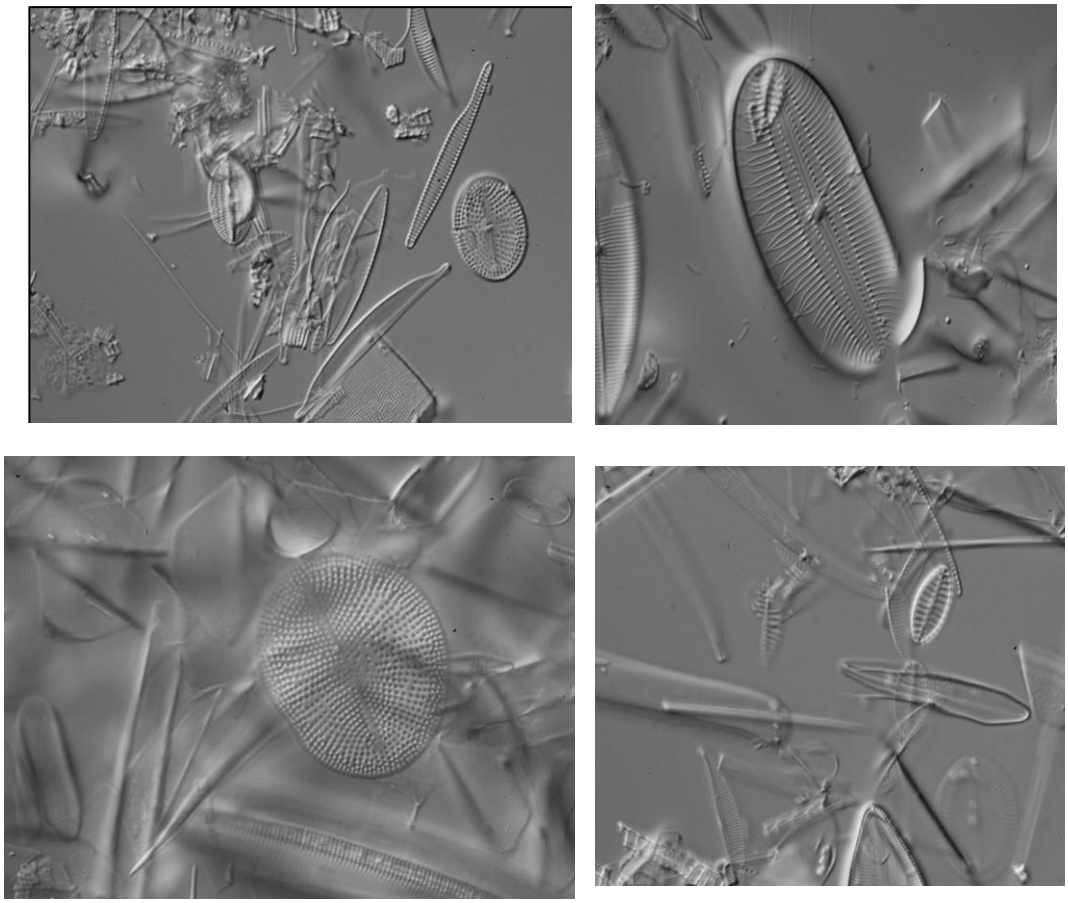


Figure 7.40. Deformed valves. *Tabularia* (on left top); *Diploneis* (right top); *Anorthoneis* (on left bottom); *Licmorphora* (on right bottom).

Chapter VI

DISCUSSION

Our species counts and diversity indices all indicate the present of healthy diatom associations at all sites. All of our samples included a large number of benthic species. This may be due to the shallow nature of our sample sites which allowed for some degree of mixing between the sediments and the water column. However, it should be noted that the mixing was not complete—the sediment and net plankton communities at any one site contain different sets of dominant forms. The net plankton samples of Choctawhatchee 01, 02, and 03 were dominated primarily by species of the planktonic genera *Chaetoceros* and *Cyclotella*, as well as by the benthic genus *Diploneis*. Sediment samples were dominated primarily by members of the benthic genera *Cocconeis, Fallacia, Navicula,* and *Nitzschia*. At Choctawhatchee 04, the shallowest of the sites, both net and plankton samples were dominated by the benthic genera *Amphora, Cocconeis, Navicula,* and *Nitzschia.*

We were only able to compare our net plankton samples with historical data because information concerning the benthic communities was not available. The fact that the current and previous communities have very few species in common, and that the Sørenson's index comparing the two data sets was only 28.57%, suggests that a shift in the community structure has occurred. However, it is not clear that the shift is the result of the oil spill. The low similarity between the two data sets may be due in part to differences in the application of taxonomic principles. For example, we followed

Witkowski et al. (2000) and subdivided some species of *Mastogloia* into varieties and types. We were unable to confirm the identity of other species using LM. These could lead to minor differences in the species lists. A second factor to consider is differences in sampling techniques and sample sites. Our sites were shallow, resulting in a larger proportion of benthic species in our plankton samples than were observed in the historical data set. Therefore, we are not certain that there was a significant shift in the dominance of the main groups of diatoms.

However, it could be possible that even if was been a shift that it may not have been caused by the oil spill. Previous investigations of the impact of oil on phytoplankton communities after specific oil spills have found that changes in the structure of the community and in species composition were either minor or within the natural variability of ecosystem. For example, in the case of Empress Oil spill a minor shift in species composition was observed, but is was within the range of the natural variability of the ecosystem (Batten et al., 1998). The observed shifts in dominant species and the results of the Bray-Curtiss analysis and multidimensional scaling all indicate the possibility of the existence of a high degree of natural variability in the phytoplankton community in Choctawhatchee Bay. The shifts that we observed could simply be a manifestation of this variability. The lack of a specific trend toward increasing diversity and the absence of significant numbers of abnormal valves are consistent with this interpretation of the data.

The question then arises concerning why there were no long-lasting effects in the bay. Several possibilities can be suggested, including the solubility of the fuel, active degradation of the crude oil by bacteria (Gutnick & Rosenberg, 1977), the dynamics of

the water body, and the metabolic capability of the phytoplankton and zooplankton (Walters, 1982). It has been reported that the phytoplankton recovers quickly even after a high concentration oil spill (Thomas et al., 1981). The reduced effects of the BP oil spill on diatom community might be due to the moderate density of the fuel fractions of which have the tendency to sink while other fractions evaporated quickly. It could be possible that significant amounts of the surface hydrocarbons were removed in zooplankton fecal pellets (Sleeter & Butler, 1982). Zooplankton has ability to feed on oil particles (Johansson et al., 1980; Sleeter & Butler, 1982) and convert them to fecal pellets (Honjo & Roman, 1978). Preliminary results from Mitra et al. (2012) suggest that the zooplankton have indeed been impacted by the Deepwater Horizon oil spill. They have observed certain chemicals in the zooplankton that could be linked to the oil from the spill.

In order to assess the impact of BP oil spill, we still need to have more information about the natural variability in the ecosystem. Due to the lack of complete historical data we cannot sure whether there has been any shift, or if there is any shift whether it is because of the oil spill, is within the natural variability of the ecosystem, or is the result of other environmental changes. We still need to have more information in order to assess the overall impact of BP oil spill on diatom community structure and species composition

REFERENCES

Adl, S. M., Simpson, A. G .B., Farmer, M. A., Andersen, R. A., Anderson, O. R., Barta, J. R., Bowser, S. S., Brugerolle, G., Fensome, R. A., Fredericq, S., James, T. Y., Karpov, S., Kugrens, P., Krug, J., Lane, C. E., Lewis, L. A., Lodge, J., Lynn, D. H., Mann, D. G., McCourt, R. M., Mendoza, L., Moestrup, Ø., Mozley-Standridge, S. E., Nerad, T. A., Shearer, C. A., Smirnov, A. V., Spiegel, F. W., Taylor, M. F. J. R., (2005). The new higher level classification of eukaryotes with emphasis on the taxonomy of protists. *Journal of Eukaryotic Microbiology*, 52: pp. 399.

Alexopoulos, C. J., & Bold, H. C. (1967). *Algae and Fungi*. The Macmillan Company. New York.

Anderson, N. H., & Cummins, K. W. (1979). Influences of diet on the life histories of aquatic insects. *Journal of the Fisheries Research Board of Canada,* 36: pp. 335−342.

Anonymous. (1975). Proposals for the standardization of diatom morphology and diagnoses. *Nova Hedwigia*, 53: pp. 323−354.

Archibald, J. M., & Keeling, P. J. (2002). Recycled plastids: a green movement in eukaryotic evolution. *Trends in Genetics,* 18: pp. 577−*584*.

Armbrust, V. (2009). The life of diatoms in the world's oceans. *Nature*, 459: pp. 185–192.

Bahls, L. L. (1973). Diatom community response to primary waste water effluent. *Journal of the Water Pollution Control Federation,* 45 (1): pp. 134−44.

Bahls, L. L. (1993). *Periphyton Bioassessment Methods for Montana Streams*. Department of Health and Environmental Science, Helena, MT: Water Quality Bureau.

Barber, H. G. & Haworth, E. Y. (1981). *A Guide to the Morphology of Diatom Frustules*. Freshwater Biological Association, Scientific Publication 42: 112 pp.

Barker, H. A. (1935). Photosynthesis in Diatoms. *Archives of Microbiology*, 6: pp. 141−56.

Battarbee, R.W., Juggins, S., Gasse, F., Anderson, N. J., Bennion, H., Cameron, N. G., Ryves, D. B., Pailles, C., Chalie, F., &Telford, N. (2001) European diatom database (EDDI). An information system for palaeoenvironmental reconstruction. *ECRC Research Report Number 81*. University College London. p. 210.

Batten, S. D., Allen, R. J. S., & Wotton, C.O. M. (1998). The effects of the Sea Empress Oil Spill on the phytoplankton of the southern Irish Sea. *Marine Pollution Bulletin* 36 (10): pp. 764−774.

Beakes, G. W., Canter, H. M., & Jaworski, G. H. M. (1992). Comparative ultrastructural ontogeny of zoosporangia of *Zygorhizidium affuens* and *Z. planktonicum*, chytrid parasites of the diatom *Asterionella formosa*. *Mycological Research*, 96: pp. 1047−1059.

Bennion, H., Juggins, S., & Anderson, N. J. (1996). Predicting epilimnetic phosphorus concentrations using an improved diatom based transfer function and its application to lake management. *Environmental Science and Technology*, 30: 2004-2007.

Biggs, B. F. (1990). Use of relative specific growth of periphtyon diatoms to assess enrichment of a stream. *New Zealand Journal of Marine and Fresh Water Research.* 24: pp. 9−19.

Birks, H. J .B. (1995). Quantitative paleoenvironmental reconstruction. In *Statistical Modelling of Quaternary Science Data*, ed. D. Maddy & J. S. Brew, pp. 161−254.

Birks, H. J. B., Line, J. M., Juggins, S., Stevenson, A. C., & ter Braak, C. J .F. (1990). Diatoms and pH reconstruction. *Philosphical Transcations Royal Society of London, Series B*, 327: pp. 263−78.

Bold, H. C., & Wynne, M. J. (1978). *Introduction to the Algae: Structure and Reproduction.* Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Charles, D. F., & Smol, J. P. (1994). Long term technical changes in lakes: Quantitative inferences using biotic remains in the sediment record. Environmental Chemistry of Lakes and Reservoirs: *Advances in Chemistry Series* 237, ed. L. Baker, pp. 3−31.

Chandler, D. C. (1942). Limnological studies of western Lake Erie. I. Plankton and certain physical chemical data of the Bass Islands region, from September, 1939, to November, 1939. *Ohio Journal of Science*, 40: pp. 291−336.

Chesson, P. (1994). Multispecies competition in variable environments. *Theoretical Population Biology*, 45: pp. 227−276.

Chiappino, M. L. & Volcanii, B. E. (1977). Studies on the biochemistry and fine structure of silica shell formation in diatoms. VIII. Sequential cell wall development in pennate *Navicula pelliculosa*. *Protoplasma* 93: pp. 205−21.

Cholonky, B. J. (1968). *Die Okologie der Diatomeen in Binnengewassern* (The ecology of diatoms in inland waters). J. Cramer, Lehre, 699 pp.

Clarke, K. R. (1993). Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology.* 18: pp. 117−143.

Coste, M., Bosca, V., & Dautta, A. (1991). Use of algae for monitoring rivers in France. In B.A. Whitton, E. Rott & G. Triedrichm (Eds.), *Use of Algae Monitoring Rivers* (pp. 75−88). Universitat Innsbruck, Innsbruck, Austria: E. Rott, Publisher, Institut fur Botanik.

Crawford, R. M. (1973). The protoplasmic ultrastructure of the vegetative cell of *Melosira varians* C. A. Agardh. *Journal of Phycology*, 9: pp. 50−61.

Crawford, R.M. (1981). The diatom genus Aulacoseira Thwaites: its structure and taxonomy. *Phycologia*, 20: pp. 174−92.

Cronk, J. K. & M. S. Fennessy. (2001). *Wetland plants: biology and ecology.* Lewis Publishers. Boca Raton, Florida, USA. P. 440.

Darley, W. M. & Volcani, B. E. (1969). A silicon requirement for deoxyribonucleic acid synthesis in the diatom *Cylinderotheca fusiformis* Reimann & Lewin. *Experimental Cell Research,* 58: pp. 334 – 42.

Darley, W. M. (1977). Biochemical Composition. In D. Werner (Ed.), *The Biology of Diatoms* (pp. 198 – 223). Oxford: Blackwells.

Davis, R. B., & Anderson, D. S. (1985). Methods of pH calibration of sedimentary diatom remains for reconstructing history of pH in lakes. *Hydrobiologia,* 120: pp. 69 – 87.

Dawson, P. A. (1973). Observation on the some of forms of *Gomphonema parvulum* Kutz. II. The internal organization. *Journal of Phycology,* 9: pp. 165 – 75.

Descy, J. P. & Mouvet, C. (1984). Impact of the Tihange nuclear power plant on periphyton and phytoplankton of the Muese River (Belgium). *Hydrobiologia,* 119: pp. 119 – 28.

Drebes, G. (1977). Sexuality. In D. Werner (Ed.), *The Biology of Diatoms* (pp. 250 – 283). Berkeley, CA: University of California Press.

Drum, R. (1966). Electron microscopy of Paired Golgi Structure in the Diatom *Pinnularia nobilis*. *Journal of Ultrastructure Research*, 15, pp. 100 – 107.

Drum, R. & Hopkins, J. T. (1966). Diatom locomotion an explanation. *Protoplasma*, 62: pp. 1 – 33.

Drum, R. W., & Pankratz, H. S. (1964). Pyrenoids, raphe and other fine structure in diatoms. *The American Journal of Botany*, 51 (4): pp. 405 – 18.

Edgar, L. A. (1980). Fine structure of *Caloneis amphisbaena*. (Bacillariophyceae). *Journal of Phycology,* 16: pp. 621 – 72.

Frenette, J.-J., Demers, S., Legendre, L., & Dodson, J. (1993). Lack of agreement among models for estimating the photosynthetic parameters. *Journal of Limnology and Oceanography,* 38: pp. 679−687.

Fritz, S. C., Juggins, S., Battarbee, R. W., & Engstrom, D. R. (1991). Reconstruction of past changes in salinity and climate using a diatom-based transfer function. *Nature*, 352: pp. 706 – 708.

Gilbert, T. D. (1990). Oil spills in the Australian marine environment: environmental consequences and response technologies. *Proceedings of the Australian Oil and Gas Conference* 22-23 April 1999. Perth, Western Australia.

Gilbert, T. D. (2000). Oil spills in the Australian marine environment: environmental consequences and response technologies. *Journal* of the *Alabama-Mississippi Sociological Association*, pp. 1–12.

Gonzalez, J., Figueiras, F. G., Aranguren-Gassis, M., Crespo, B. G., Fernandez, E., Moran, X. A. G., & Nieto-Cid, M. (2009). Effect of a simulated oil spill on natural assemblages of marine phytoplankton enclosed in microcosms. *Estuarine Coastal and Shelf Science*, 83: pp. 265–76.

Gordan, R., Drum, R. W. (1970). A capillarity mechanism for diatom gliding locomotion. *Proceedings of National Acadamey of Sciences*, 67: pp. 338–44.

Gutnick, D., & Rosenberg, E., (1977). Oil tankers and pollution: a microbiological approach. *Annual Review Microbiology*, 31: pp. 379–396.

Guven K.C., Sur H. I., Okus E., Yuksek A., Unlu, S., Altiok H., Tas S.,Muftuoglu A. E., Yilmaz N., Aslan-Yilmaz A. & Karhan, U. (2005). *Oil pollution of Volgoneft* 248 *accident*. Final Report. Istanbul.

Hasle, G. (1977). Morphology and taxonomy *of Actinocyclus normanii f. subsalsa* (Bacillariophyceae). *Phycologia*, 16: pp. 321–328.

Hasle, G. R, von Stosch HA, & Syvertsen, E. E. (1983). Cymatosiraceae, a new diatom family. *Bacillaria*, 6: pp. 9–156.

Hasle, G. R., & Syvertsen E. E (1996). Marine Diatoms. In: C. R. Tomas (Ed.). *Identifying Marine Diatoms and Dinoflagellates.* Academic Press, San Diego. pp. 1–386.

Heath, I. B. & Darley, W. M. (1972). Observation on the ultrastructure on the male gametes of *Biddulphia levis* Her. *Journal of Phycology*, 8: pp. 51–9.

Herth, W. & Barthlott, W. (1979). The site of *beta*-chitin formation in centric diatoms. I. Pores and fibril formation. *Journal of Ultrastructural Research*, 68: pp. 6–15.

Hidlebrand, M. (2000). Silicic acid transportation and its control during cell wall silicification in diatoms. In E. Baeuerlein (Ed.), *Biomineralization of Nano and Micro structures.* San Diego, CA:Wiley-VCH.

Hustedt, F. (1939). Systematische und okologische Untersuchungen uber die Diatomeenflora von Java, Bali und Sumatra (Systematic and ecological investigations of the diatom flora of Java, Bali, and Sumatra). *Arch. Hydrobiol., Suppl*, 15: 131–77; 16: 1–155; 16: 187–295.

Hustedt, F. (1955). Marine littoral diatoms of Beaufort, North Carolina. Duke University Press, North Carolina, 67 pp.

Hustedt, F. (1985). The Pennate Diatoms (Translation. Originally published as vol. VII of Dr. Rabenhorst's Kryptogamen- Flora von Deutschland, Osterreich und der Schweiz. Lepzig 1959) Koeltz Scientific Books. p. 918 .

Hutchinson, G. E. (1967). *A Treatise on Limnology, Vol. II. Introduction to Lake Biology and the Limnoplankton*. New York, NY: John Wiley & Sons, 1115 pp..

Jackson, J. B. C., Cubit, J. D., Keller, B. D., Batista, V., Burns, K., Caffey, H. M., Cladwell, R. L., Garrity, S. D., Getter, C. D., Gonzalez, C., Guzman, H. M.,

Kaufmann, K. W., Knap, A. H., Levings, S. C., Marshall, M. J., Steger, Thompson, R. C., & Weil, E. (1989). Ecological effects of a major oil spill on Panamanian coastal marine communities. *Science*, 243(4887): pp. 37–44.

Johansson, S., Larsson, U., Boehm, P. (1980). The Tsesis oil spill. Impact on the pelagic ecosystem. *Marine Pollution Bulletin*, 11 (10): pp. 284–293.

Karydis, M. & Fogg, G. E., (1980). Physiological effects of hydrocarbon on marine diatom *Cyclotella cryptic. Journal of Microbiology Ecology*, 6: 281–90.

Kreis, R. G, Jr., Stoermer, E. E, &Ladewski, T. B. (1985). Phytoplankton species composition, abundance, and distribution in Southern Lake Huron, 1980, including a comparativeanalysis with conditions in 1974 prior to nutrient loading reductions. Great lakes Research Division Special Report no. 107. Ann Arbor, MI: The University of Michigan.

Kroger, N., Bergsdorf, C., & Sumper, M. (1994). A new calcium binding glycoprotein family constitutes a major diatom cell wall component. *Journal of European Molecular Biology Organization*, 13: pp. 4676–83

Kroger, N., Bergsdorf, C., & Sumper, M. (1996). Frustulins: domain conservation in a protein family associated with diatom cell walls. *European Journal of Biochemistry*, 239: pp. 259–64.

Kroger, N., Bergsdorf, C., & Sumper, M. (1997). Characterization of a 200-KDa diatom protein that is specifically associated with silica based substructure of cell wall. *European Journal of Biochemistry*, 250: pp. 99–105.

Kroger, N., Bergsdorf, C., & Sumper, M. (1999). Polycationic peptides from diatom biosilica that direct silica nanosphere formation. *Science*. 286: pp. 1129–32.

Lamberti, G. A. (1996). The role of periphyton in benthic food webs. In R. J. Stevenson, M. L. Bothwell, & R. L. Lowe (Eds.), *Algal Ecology: Fresh Water Benthic Ecosystem* (pp. 533– 572). San Diego, CA: Academic Press.

Lee, M., & Li, C. W. (1992). The origin of silica deposition vesicle of diatoms. *Botanical Bulletin of the Academy Sinica* 33: pp. 317– 25.

Lewin, J. C. (1955). Silicon metabolism in diatoms. III. Respiration and silicon uptake in *Navicula pelliculosa. The Journal of General Physiology*, 39: pp. 1– 10.

Li, C. W. & Volcani, B. E. (1985). Aspects of Silicification in Wall Morphogenesis of Diatoms. *Philosophical Transactions of the Royal Society London*, Series B, 304: pp. 519– 28.

Linden, O., Elmgren, R., Boehm, P., 1979. The Tsesis oil spill: its impact on the coastal ecosystem of the Baltic Sea. *Journal of the Human Environment*, 8 (6): pp. 244–253.

Livingston, R. J. (2001) *Eutrophication Processes in Coastal Systems*. Boca Raton, FL: CRC Press.

Lowe, R. L., & Pan, Y. (1996). Benthic algal communities as biological monitors. In R. J. Stevenson, M. L Bothwell, & R. Lowe (Eds.), *Algal Ecology* (pp. 705-39). San Diego, CA: Academic Press.

Lund, J. W. G. (1950). Studies on *Asterionella formosa* hass. II. Nutrient depletion and the spring maximum. Parts I-II. *Journal of Ecology*, 38: pp. 1– 35.

Lund, J. W. G. (1954). The seasonal cycle of the plankton diatom *Melosira* (Ehr.) Kutz. subsp. *subartica* O. Mull. *Journal of Ecology*, 38: pp. 1-35.

Mann, D. G. (1977). The diatom genus *Hantzschia* Grunow an appraisal. *Nova Hedwigia Beihefte*, 54: pp. 323-54.

Mann, D. G**.** (1996). Chloroplast morphology, movements and inheritance in diatoms. In B. R. Chaudhary, S. B. Agrawal (Eds.), *Cytology, Genetics and Molecular Biology of Algae* (pp. 249–274). Amsterdam:SPB Academic Publishing.

Mann, D. G. (1984). An ontogenetic approach to diatom systematics. In D. G.Mann (Ed.), *Proceedings of the 7th International Diatom Symposium* (pp. 113–41). Koenigstein: O. Koeltz.

Martin-Jezequel, V., Hildebrand, M. & Brezinski, M. A. (2000). Silicon metabolism in diatoms: implications for growth. *Journal of Phycology*, 36: pp. 821–840.

McFadden, G. I. (2001). Primary and secondary endosymbiosis and the origin of plastids. *Journal of Phycology*, 37: pp. 1–9

Medlin, L. K., Crawford, R. M., & Andersen, R. A. (1986). Histochemical and ultrastructural evidence for the function of the labiate process in the movement of centric diatoms. *British phycological Journal*, 21: pp. 297–301.

Medlin, L. K., Williams, D. M., & Sims, P. A. (1993). The evolution of the diatoms (Bacillariophyta) I. Origin of the group and assessment of the monophyly of its major divisions. *European Journal of Phycology*, 28: pp. 261– 275.

Medlin, L. K. & Kaczmarska, I. (2004). Evolution of the diatoms: V. Morphological and cytological support for the major clades and a taxonomic revision. *Phycologia*, 43: pp. 245–270.

Mehard, C. W., Sullivan, C. W., Azam. F., & Volcani, B. E. (1974). Role of silicon in diatom metabolism. IV. Subcellular localization of silicon and germanium in

Nitzschia alba and *cylinderotheca fusiformis. Plant and Cell Physiology*, 30: pp. 265–72.

Mitra, S., Kimmel, D. G., Snyder, J., Scalise, K., McGlaughon, B. D., Roman, M. R., Jahn, G. L., Pierson, J. J., Brandt, S. B., Montoya, J. P., Rosenbauer, R. J., Lorenson, T. D., Wong, F. L., & Pamela L. Campbell, P. L. (2012). *Geophysical Research Letters*, 39, L01605, 7 pp., doi:10.1029/2011GL049505

Morales, E. (2010). *Staurosira construens*. In *Diatoms of the United States*. Retrieved July 12, 2012, from http://westerndiatoms.colorado.edu/taxa/species/staurosira_construens

Mulholland, P. J. & Rosemond, A. D. (1992). Periphyton response to longitudinal nutrient depletion in a woodland stream. Evidence of upstream-downstream linkage. *Journal of North American Benthological Society*,11: pp. 405–19.

Mulholland, P. J. (1996). Role in nutrient cycling in streams. In R. J. Stevenson, M. L Bothwell, & R. Lowe (Eds.), *Algal Ecology* (pp. 705-39). San Diego, CA: Academic Press.

Mueller-Dombois, D & Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology. New York, NY: John Wiley and Sons. p. 313.

Muller-Navarra, D. C., Brett, M. T., Liston, A. M., & Goldman, C. R.. (2000). A highly unsaturated fatty acid predicts carbon transfer between primary producers and consumers. *Nature*, 403: pp. 74–77.

Nelson, D. M., Treguer, P., Brzezinski, M. A., Leynaert, A., & Queguiner, B. (1995). Production and Dissolution of Biogenic Silica in the Ocean - Revised Global

Estimates, Comparison with Regional Data and Relationship to Biogenic Sedimentation. *Global Biogeochemical Cycles*, 9: pp. 359–372.

Nygaard, G. (1949). Hydrobiological studies on some Danish ponds and lakes II. The quotient hypothesis and some new or little known phytoplankton organisms. *Det Kongelinge Dansk Viden skabernes Selskab Biologiske Skrifter*, 7: pp. 1–193

Pan, Y., Stevenson, R. J., Hill, B. H., Herlihy, A. T. & Collins, G. B. (1996). Using diatoms as indictaor of ecological conditions in lotic systems: A regional assessment. *Journal of the North American Benthological Society*, 15: pp. 481–95.

Patrick, R. (1945). A taxonomic and ecologic study of some diatoms from the Pocono Plateau and adjacent regions. *Farlowia*, 2 (2): pp. 143–221.

Patrick R. (1967). The effect of varying amounts and ratios of nitrogen and phosphate on algae blooms. *Proceedings of the 21st Annual Industrial Waste Conference, Purdue U., Purdue, Indiana*, pp. 41-51.

Peragallo, H. (1888). Diatomées de la Baie de Villefranche. *Bulletin de la Société Histoire Naturelle de Toulouse* 22: pp. 1–100.

Pfitzer, E. (1871). Untersuchungen uber Bau und Entwicklung der Bacillariaceen. In *Botanische Abhandlungen aus dem Gebiet der Morphologie und Physiologie*, Volume 2. Bonn: Herausg. von J. Hanstein. 189 pp.

Pickett-Heaps, J. D., Tippit, D. H. & Andreozzi, J. A. (1979). Cell division in the pennate diatom *Pinnularia*. IV. Valve morphogenesis. *Journal of Molecular Cell Biology*. 35: pp. 199–203.

Platt, T. & Jassby, A. D. (1976). The relationship between photosynthesis and light for natural assemblages of coastal marine phytoplankton. *Journal of Phycology*, 12: pp. 421–430.

Platt, T., Gallegos, C. L., & Harrison, W. G. (1980), Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. *Journal of Marine Research*, 38: pp. 687–701.

Potapova, M. (2009). *Reimeria sinuata*. In Diatoms of the United States. Retrieved July 12, 2012, from http://westerndiatoms.colorado.edu/taxa/species/reimeria_sinuata

Prygiel, J. (1991). Use of benthic diatoms in surveillance of the Artois-Picardie basin hydro biological survey. In B.A. Whitton, E. Rott & G. Triedrich (Eds.), *Use of Algae Monitoring Rivers* (pp. 75–88). Universitat Innsbruck, Innsbruck, Austria: E. Rott, Publisher.

Ramseur, J. L. (2010). Deepwater Horizon Oil Spill: The Fate of the Oil. *Congressional Research Service*, pp. 75–700.

Raven, J. A. (1983). The transport and function of silicon in plants. *Biological Reviews* 58: pp. 179–207.

Reynolds, C. S. (1984). *The Ecology of Freshwater Phytoplankton*. Cambridge, United Kingdom: Cambridge University Press.

Reimann, B. E. F., & Lewin, J. C. (1964). The diatom genus *Cylinderotheca* Rabenhorst. *Journal of the Royal Microscopical Society*, 83(3): pp. 283–96.

Reimann, B. E. F., Lewin, J. C., & Volcani, B. E. (1965). Studies on biochemistry and fine structure of silica shell formation in diatoms. I. The structure of cell wall of

Cylinderotheca fusiformis Reimann & Lewin. *Journal of Cell Biology*, 24 (1): pp. 39–55.

Reimann, B. E. F., Lewin, J. C., & Volcani, B. E. (1966). Studies on biochemistry and fine structure of silica shell formation in diatoms. II. The structure of cell wall of *Navicula pelliculosa* (Breb) Hilse. *Journal of Phycology*, 2(2): pp. 74–84.

Rice, C. H. (1938). Studies in the phytoplankton of river Thames (1928-1932). I and II. *Annals of Botany*, New Series 2 (7): pp. 539–57.

Ross, R. & Sims, P. (1972). The fine structure of the frustule in centric diatoms: a suggested terminology. *British Phycological Journal* 7: pp. 139–163.

Rott, E. 1991. Methodological Aspects and Perspectives in the Use of Periphyton for Monitoring And Protecting Rivers. In B.A. Whitton, E. Rott & G. Friedrich (Eds.), *Use of Algae for Monitoring Rivers* (pp. 9–16). Institut Fur Botanik, Universitat Innsbruck, Innsbruck, Austria: E. Rott, Publisher.

Round, F. E. 1978. *Stictocyclus strictodiscus* (Bacillariophyta): comments on its ecology, structure and classification. *Journal of Phycology*, 14: pp. 150–56.

Round, F. E. (1991). Diatoms in rivers and water monitoring studies, *Journal of Applied Phycology*, 3: pp. 129–45.

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

Ruttner, F. (1940). *Grundriss der Limnologie.* Berlin:W. de Gruyter. 167 pp.

Scala, S and Bowler, C. (2001). Molecular insights into the novel aspects of diatom biology. *Cellular and Molecular Life Sciences* 58, pp. 1666–1673Schleiske, C. L

& Stoermer, E. F. (1972). Phosphorous, silica and eutrophication of Lake Michigan. *Limnology and Oceanography,* 1: pp. 157–71.

Schmid, A. M. M. (1977). Morphologische und physiologische Untersuchungen an Diatomeen des Neusiedler Sees. iI. licht und rasterelektronenmikroskopische Schalenanalyse der umweltabhangigen Zyklomorphose vn Anomoeoneis sphaerophora (KG.) Pfitzer. *Nova Hedwigia* 28: pp. 309-353.

Schmidt, A. (1874-1959). *Atlas der Diatomeenkunde.* Continued by M. Schmidt, F. Fricke O. Muller, H. Heiden and F. Hustedt. Aschersleben, Leipzig, Berlin.

Shannon, C. E. and W. Weaver. (1949). The Mathematical Theory of Communication. University of Illinois Press. Urbana, IL., USA

Shoemann, F. R. (1973). A systematical and ecological study of the diatom flora of Lesotho with special reference to water quality. National Institute for Water Research. Pretoria, South Africa. p. 355.

Simonsen, R. (1979). The diatom system: ideas on phylogeny. *Bacillaria* 2: pp. 9 – 71.

Smetacek, V. (1999). Diatoms and the ocean carbon cycle: *Protist*, 150: pp. 25-32.

Stee, J. H. (1985). A comparison of terrestrial and marine ecological systems. *Nature,* 313: pp. 355–358.

Stevenson, R. J. (1996). An introduction to the algal ecology in fresh water benthic habitats . In R. J. Stevenson, M. L. Bothwell, & R. Lowe (Eds.), *Algal Ecology* (pp. 3-30). San Diego, CA: Academic Press.

Stevenson, R. J. (2001). Using algae to assess wetlands with multivariate statistics, multimetric indices, and an ecological risk assessment framework. In D. P. Batzer, R. B. Rader, & S. A. Wissinger (Eds.), *Bioassessment and Management of*

North American Freshwater Wetlands (pp. 113-140). New York, NY: John Wiley and Sons.

Stockner, J. G. (1971). Preliminary characterization of lakes in the Experimental Lakes Area, northwestern Ontario, using diatom occurrence in sediments. *Journal of the Fisheries Research Board of Canada*, 28: pp. 265–275.

Stockner, J. G. 1972. Paleolimnology as a means of assessing eutrophication. *Verhandlungen Internationale Vereinigung für theoretische und angewandte Limnologie*), 18: pp. 1018–1030.

Stockner, J. G. & Benson, W. W. (1967). The succession of diatoms assemblages in the recent sediment of Lake Washington. *Limnology & Oceanography*, 12, pp. 513–32.

Stoermer, E. F, & Pankratz, H. S. (1964). Fine structure of diatom *Amphipleura pellicid*a. I. Wall structure. *American Journal of Botany*, 51(9): 986-90.

Stoermer, E. F., Pankratz, H. S., & Drum, R. W. (1964). The fine structure of the diatom *Mastogloia grevillei* Wm. Smith. *Protoplasma*, 59(1), 1–13.

Stoermer, E. F, and Smol, J. P. (1999). *The Diatoms: Applications for the Environmental and Earth Sciences*. Cambridge, UK: Cambridge University Press. 469 pp.

Stosch, H. A. Von. (1977). Observations on *Bellerochea* and *Streptotheca*, including descriptions of three new planktonic diatom species. *Nova Hedwigia, Beihefte*, 54: pp. 113–66.

Stosch, H. A. von. (1980). The endochiastic areola, a complex new type of siliceous structure in a diatom. *Bacillaria* 3: pp. 21–40.

Thomas, W. H., Rossi, S. S., & Seibert, D. L. R. (1981). Effects of some representative petroleum refinery effluent compounds of photosynthesis and growth of natural marine phytoplankton assemblages. *Journal of Marine Environmental Research*, 4 (3): pp. 203–215.

Tilman, D, Kilham S. S, & Kilham, P. (1982). Phytoplankton community ecology: the role of limiting nutrients. *Annual Review of Ecology and Systematics*, 13: pp. 349-72.

Talling, J. E. (1957). The phytoplankton population as a compound photosynthetic system. *New Phylologist*, 56: pp. 133–49.

U.S. Fish & Wildlife Service (2010). Effects of Oil on Wildlife and Habitat. http://www.fws.gov/home/dhoilspill/pdfs/DHJICFWSOilImpactsWildlifeFactSheet.pdf. (Downloaded July 12, 2012)

van Baalen, C., & O'Donnell, R. (2003). Sensitivity of two psychrophilic diatoms to crude oil and fuel oil. *Marine Environmental Research*, 12: pp. 63−68.

Volcani, B. E. (1981). Cell wall formation in diatoms: morphogenesis and biochemistry. In T. L. Simpson & B.E. Volcani (Eds.), *Silicon and Siliceous structures in Biological Systems* (pp. 157-200). New York, NT: Springer-Verlag.

Volkman, J. K. & Revill, A. T. (2002). Oil pollution and microbial regulation. In A. Sabljic (Ed,), *Environmental and Ecological Chemistry*.Vol II. In Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK, [http://www.eolss.net]

Vrieling, E. G., Gieskes, W. W. C. & Beelen, T. P. M. (1999). Silicon deposition in diatoms: control by the pH inside the silicon deposition vesicle. *Journal of Phycology*, 35: pp. 548-59.

Walters, J. M., (1982). *Fate of petroleum hydrocarbons in marine zooplankton.* Canterbury : University of Kent, 189 pp.

Werner, D. (1977). Introduction with a note on taxonomy. pp. 1-17 In D. Werner (Ed.), *The Biology of Diatoms* (pp. 1-17). Berkeley, CA: University of California Press.

Whatley, J. M & Whatley, F. R. (1981). Chloroplast evolution. *New Phycologist*, 87: pp. 233–47.

Whiting, M. C., Whitehead, D. R., Holmes, R. W., & Norton, S. A. (1989). Paleolimnological Reconstruction of Recent Acidity Changes in Four Sierra Nevada Lakes. *Journal of Paleolimnology*, 2: pp. 285–305.

Whitmore, T. J. (1989). Florida diatom assemblages as indicatord of trophic state and pH. *Limnology and Oceanography*, 34: pp. 882–95.

Williams, D. M. (1986). Comparative morphology of some species of *Synedra* Ehrenb. with a new definition of the genus. *Diatom Research*, 1: pp. 131–152.

Witkowski, A., Lange-Bertalot, H., Metzeltin, D. (2000). *Diatom Flora of Marine Coasts. I. Iconographia Diatomologica* 7: pp. 1–925.

Zeeb, B. A., Christie, C. E., Smol, J. P., Findlay, D. L., Kling, H. J., & Birks, H. J. B. (1994). Responses of diatom and chrysophyte assemblages in Lake 227 sediments to experimental eutrophication. *Canadian Journal of Fisheries and Aquatic Sciences*, 51: pp. 2300–11.

Appendix A

Monthly Species List

Monthly water quality parameters of each site

Table 1: Water quality parameters for January

Parameters / Sites	Temperature (^{o}C)	Dissolved oxygen (mg/L)	Salinity (ppt)	Conductivity (mS)
Choctawhatchee site 1	14.1	8.61	30	35
Choctawhatchee site 2	12.6	11.28	12.5	20.67
Choctawhatchee site 3	11.2	10.1	9.1	15.7
Choctawhatchee site 4	12.0	9.07	25.3	39.73

Table 2: Water quality parameters for March

Parameters / Sites	Temperature (^{o}C)	Dissolved oxygen (mg/L)	Salinity (ppt)	Conductivity (mS)
Choctawhatchee site 1	19.7	8.73	24.4	38.35
Choctawhatchee site 2	18.8	8.26	32.6	49.7
Choctawhatchee site 3	20.0	8.13	32.1	50.6
Choctawhatchee site 4	21.4	10.43	21.2	33.74

Table 3: Water quality parameters for May

Parameters / Sites	Temperature (^{o}C)	Salinity (ppt)	Conductivity (mS)
Choctawhatchee site 1	26	26	41.33
Choctawhatchee site 2	24.5	33.7	51.2
Choctawhatchee site 3	26	35.6	53.8
Choctawhatchee site 4	28.5	17.9	28.91

Table 4: Species list for Choctawhatchee Bay in September. C: represents Choctawhatchee Bay; 1, 2: represents site 1 and site 2; N, S, W: represents net plankton, sediment and whole water samples.

	C1N	C1S	C1W	C2N	C2S	C2W
Class Coscinodiscophyceae						
Order Thallasiosirales						
Cyclotella sp 1	+	+			+	
Cyclotella sp 2	+					+
Cyclotella sp 3	+	+	+	+	+	+
Cyclotella sp 4						
Cyclotella sp.5						+
Detonula sp	+	+		+	+	
Porosira sp 1						
Skeletonema sp	+	+		+	+	
Thalassiosira sp 1						+
Thalassiosira sp 2				+		+
Thalassiosira sp 3					+	
Thalassiosira sp 4		+				+
Thalassiosira sp 5						
Order Coscinodiscales						
Actinocyclus sp 1		+		+		
Actinocyclus sp 2						+
Actinocyclus sp 3						
Actinocyclus sp 4		+			+	
Actinoptychus senarius						
Coscinodiscus sp 1						
Coscinodiscus sp 3		+			+	+
Coscinodiscus sp 4						
Order Melosirales						
Melosira sp						
Order Paraliales						
Paralia sulcata	+			+	+	+
Order Asteriolamprales						
Asteromphalus flabellatus						
Order Triceratiales						
Auliscus sculptus						
Dimeregramma cf. marinum					+	
Dimeregramma minor var minor						
Dimeregramma minor var	+					

nana						
	C1N	C1S	C1W	C2N	C2S	C2W
Euphodiscus sp					+	
Neohuttonia sp				+		
Odentella sp 1						
Odentella sp 2	+	+	+	+	+	
Plagiogramma cf. antillarum	+	+	+	+	+	+
Plagiogramma cf. rhombicum	+	+	+	+	+	
Plagiogramma pygmaeum						+
Order Biddulphiales						
Biddulphia sp 1				+		+
Biddulphia sp 2				+		+
Order Hemiaulales						
Cerataulina sp				+		+
Eucampia sp						
Hemiaulus sp						
Order Anaulales					+	
Anaulus sp 1						
Anaulus sp 2						
Eunotogramma. sp 1						
Eunotogramma. sp 2						+
Eunnotogramma sp 3				+		+
Order Lithmodesmiales						
Lithodesmium undulatum						
Order Corethrales						
Corethron sp				+	+	
Order Cymatosirales					+	
Campylosira cymbelliformis				+	+	+
Cymatosira belgica						+
Cymatosira lorenziana				+		+
Order Rhizosolenales						
Rhizosolenia sp				+		+
Order Chaetocerotales						
Bacteriastrum sp 1						
Bacteriastrum sp 2						
Bacteriastrum sp 3						
Chaetoceros compressus				+		
Chaetoceros dichaeta	+					
Chaetoceros didymus						

	C1N	C1S	C1W	C2N	C2S	C2W
Chaetoceros eibonii				+		
Chaetoceros gracilis				+		
Chaetoceros lorenzianus				+		
Chaetoceros peruvianus						
Chaetoceros radicans						
Chaetoceros teres				+		
Class Fragilariophyceae						
Order Fragilariales						
Asterionellopsis glacialis	+	+	+	+		
Fragilaria magocsyi		+		+		
Fragillaria sp 1						+
Fragillaria sp 2	+	+				
Fragillaria sp 3				+		+
Fragillaria sp 4	+			+		
Oepehora mutabilis				+		+
Opephora marina						
Ardissonia crystallina			+			
Tabellaria sp.	+	+				
Tabularia fasciculata						
Tabularia parva						
Tabularia sp 1						
Tabularia sp 2	+	+				
Taloroneis fulgicerum		+				
Order Licmophorales						
Licmorphora abbreviata				+		
Licmorphora oedipus		+		+		
Licmorphora cf. paradoxa						+
Licmorphora paradoxa						
Licmorphora remulus					+	
Order Rhaphoneidales					+	
Delphineis surirella				+		+
Delphineis surirelloides				+	+	+
Delphineis minutissima					+	
Psammodiscus nitidus						
Rhaponeis amphiceros		+				
Order Toxariales						
Toxiarum sp					+	
Order Thalassionematales	+	+				

	C1N	C1S	C1W	C2N	C2S	C2W
Thalasionema frauenfeldii				+	+	
Thalasionema nitzschioides						
Order Rhabdonematales	+	+				
Rhabdonema adriaticum				+	+	+
Order Striatellales						
Grammatophora angulosa						+
Grammatophora oceanica var macilenta						+
Striatella unipunctata						
Class Bacillariophyceae					+	
Order Eunotiales				+		
Eunotia sp 1						
Eunotia sp 2		+				
Eunotia sp 3				+		
Eunotia sp 4	+	+		+	+	
Order Lyrellales						
Lyrella clavata				+		
Lyrella clavata var. caribbaea	+					
Lyrella diffluens				+		+
Lyrella hennedyi form 1						
Lyrella hennedyi form granulata						
Lyrella lyra						
Lyrella lyra var.1						
Lyrella sulcifera						
Petroneis humerosa		+				
Petroneis maculata						
Petroneis marina	+					+
Order Mastogloiales						
Mastogloia adriatica	+	+				
Mastogloia angusta		+		+		
Mastogloia angulata	+				+	
Mastogloia baldjikiana	+			+		
Mastogloia bionata	+				+	+
Mastogloia braunii		+				
Mastogloia cf.acutiuscula						
Mastogloia cf. aquilegiae	+	+				
Mastogloia cf. corsciana		+				
Mastogloia cf. lineata	+	+				

	C1N	C1S	C1W	C2N	C2S	C2W
Mastogloia cf. pisciculus		+			+	
Mastogloia elliptica	+		+			
Mastogloia elliptica var dansei		+				
Mastogloia erythraea type 1	+	+				
Mastogloia erythraea type 2					+	
Mastogloia erythraea type 3	+					
Mastogloia erythraea type 4		+				
Mastogloia exigua				+		
Mastogloia exilis						
Mastogloia foliolum	+	+		+	+	
Mastogloia gibbosa	+	+				
Mastogloia gracilis	+					
Mastogloia horvathiana	+	+				
Mastogloia jelineckii		+			+	
Mastogloia labuensis	+	+				+
Mastogloia lanceolata	+	+				
Mastogloia ovata		+			+	
Mastogloia pumila type 1		+				
Mastogloia pumila type 2		+				
Mastogloia pumila type 3		+				+
Mastogloia pusilla type 1						+
Mastogloia pusilla type 2		+				
Mastogloia pusilla var. linearalis						
Mastogloia sp 1						
Mastogloia sp 2						
Mastogloia sp 3						
Mastogloia sp 4					+	
Mastogloia sp 5						
Mastogloia sp 6						
Mastogloia sp 7						+
Mastogloia sp 8	+	+				
Mastogloia sp 9						
Mastogloia sp 10						
Mastogloia sp 11						
Mastogloia tenussiama						+
Mastogloia vasta						
Order Cymbellales						
Cymbella sp 1		+				

	C1N	C1S	C1W	C2N	C2S	C2W
Cymbella sp 2	+		+			
Order Achnanthales						
Achnanthes brevipes	+	+	+	+		
Achnanthes clevei				+		
Achnanthes curvirostrum		+	+			
Achnanthes cf. submarina					+	
Achnanthes brockmannii						
Achnanthes danica					+	+
Achnanthes hauckiana				+		
Achnanthes hauckiana var elliptica						
Achnanthes ingratiformis					+	
Achnanthes parvula						
Achnanthes rupestoides						+
Achnanthes sp 1		+				
Achnanthes sp 2						
Achnanthes sp 3						
Achnanthes sp 4						
Achnanthes sp 5						+
Achnanthes sp 6						
Achnanthes sp 7				+		
Achnanthes sp 8						
Achnanthes sp 9					+	
Achnanthes sp 10						
Achnanthes sp 11						+
Achnanthes sp 12						
Achnanthes sp 13						
Achnanthes sp 14						
Achnanthes sp 15				+		
Achnanthes sp 16				+		
Achnanthes sp 17	+		+		+	
Achnanthes sp 18	+				+	
Achnanthes sp 19				+		
Anorthoneis excentrica				+	+	+
cocconeiopsis cf. fraudulenta					+	
Cocconeis diminuta						+
Cocconeis disculus						+
Cocconeis hetroidea						
Cocconeis latecostata	+		+		+	

	C1N	C1S	C1W	C2N	C2S	C2W
Cocconeis pediculus				+	+	
Cocconeis pelta	+					+
Cocconeis peltoides	+			+		+
Cocconeis pinnata		+	+	+	+	
Cocconeis placentula				+		+
Cocconeis placentula var lineata						
Cocconeis scutellum var parva					+	+
Cocconeis scutellum var scutellum						+
Cocconeis sp	+				+	+
Planothidium frequentissimum						+
Planothidium heteromorphum						+
Planothidium lanceolatum var australis						
Planothidium lanceolatum var rostratata	+	+			+	
Order Naviculales						
Caloneis amphisbaena	+		+			
Caloneis liber		+		+		
Diploneis aestuari		+				
Diploneis caffra		+		+	+	
Diploneis didyma	+	+				
Diploneis incurvata var dubia				+		+
Diploneis incurvata var incurvata	+					
Diploneis notabilis	+	+			+	
Diploneis obliqua	+					
Diploneis parca						
Diploneis smithi	+	+			+	
Diploneis smithi var pumila					+	+
Diploneis smithi var. recta		+				
Diploneis sp 1				+		
Diploneis sp 2					+	
Diploneis sp 3						
Diploneis sp 4						
Diploneis sp 5				+	+	+
Diploneis subocularis	+					
Diploneis vacillana var. renitens					+	
Diploneis weissflogii						
Donikia sp	+	+			+	

	C1N	C1S	C1W	C2N	C2S	C2W
Fallacia cf. clypeiformis			+	+		+
Fallacia inscriptura		+		+		
Fallacia littoricola	+				+	+
Fallacia margino-punctata					+	
Fallacia ny.					+	
Fallacia oculiformis	+				+	+
Fallacia pygmaea	+					+
Fallacia shoemaniana						+
Fallacia subforcipata						
Fallacia vittata				+	+	
Gyrosigma balticum						
Gyrosigma distortum						
Gyrosigma exoticum	+					+
Gyrosigma fasciola		+				
Gyrosigma hummii	+	+				
Gyrosigma obtusatum	+			+		
Gyrosigma sp 1						
Haslea sp		+			+	
Navicula angusta	+	+			+	
Navicula bipustulata		+				
Navicula cf. capitatoradiata	+				+	
Navicula cf. caterva		+				+
Navicula cf. cryptonella			+	+		+
Navicula cf. digitoradiata				+		
Navicula cf.gregaria				+		
Navicula cf.phyllepta	+				+	
Navicula cryptocephala				+		
Navicula erifuga	+		+			
Navicula hamiltonii	+	+				+
Navicula jentzschii						
Navicula oblonga						+
Navicula peregrina			+			
Navicula phylleptosoma						
Navicula pseudolanceolata						+
Navicula recens						+
Navicula salinarum var. salinarum						
Navicula sp 1						
Navicula sp 2	+					

	C1N	C1S	C1W	C2N	C2S	C2W
Navicula sp 3				+		
Navicula sp 4						
Navicula sp 5					+	
Navicula sp 6						
Navicula sp 7						+
Navicula sp 8						+
Navicula sp 9						
Navicula sp 10						
Navicula sp 11						
Navicula sp 12						
Navicula sp 13				+		
Navicula sp 14						
Navicula sp 15				+		
Navicula sp 16		+				
Navicula sp 17				+		
Navicula sp 18					+	
Navicula sp 19						
Navicula sp 20						+
Navicula sp 21						
Navicula sp 22						+
Navicula sp 23						
Navicula sp 24						
Navicula sp 25						+
Navicula sp 26					+	
Navicula sp 27		+				
Navicula sp 28				+		
Navicula sp 29					+	
Navicula sp 30					+	
Navicula sp 31						
Navicula sp 32						
Navicula sp 33						
Navicula sp 34						
Navicula sp 35	+	+				
Navicula sp 36						
Neidium sp 1	+	+	+		+	
Neidium sp 2	+	+	+	+		
Neidium sp 3	+	+	+	+	+	
Neidium sp 4	+			+	+	

	C1N	C1S	C1W	C2N	C2S	C2W
Oestrupia powelii				+	+	
Pinnularia sp 1					+	
Plagiogramma cf. antillarum	+				+	+
Plagiogramma cf. rhombicum					+	+
Plagiogramma pygmaeum	+			+		+
Plagiotropis sp 1			+	+		+
Plagiotropis sp 2						
Plagiotropis sp 3					+	
Plagiotropis sp. 4					+	
Pleurosigma angulatum var. aestuarii						
Pleurosigma australe						
Pleurosigma cf. elongatum						
Pleurosigma delicatum						
Pleurosigma formosum						
Pleurosigma speciosum var javanica						
Pleurosigma sp 2		+				
Pleurosigma sp 3						
Pleurosigma sp 4	+	+	+			
Pleurosigma williamsii						
Pleurosigma. sp 1				+	+	
Sellaphora sp 1					+	
Seminavis robusta						
Trachyneis aspera						
Order Thalassiophysales		+				
Amphora albudens		+	+		+	
Amphora arcus						
Amphora arenaria	+	+				
Amphora arenicola						
Amphora bigibba var capitata	+	+			+	
Amphora bigibba var interrupta	+	+		+		
Amphora coffeaeformis				+		
Amphora coffeaeformis var aponina	+					+
Amphora cuneata					+	
Amphora cymbifera						
Amphora delphinea var. minor						
Amphora gigantea var fusca						
Amphora graeffeana	+	+				+

	C1N	C1S	C1W	C2N	C2S	C2W
Amphora gruendleri	+					
Amphora hinzae		+				
Amphora laevissima	+	+				
Amphora obtusa		+		+	+	
Amphora obtusa var oceanica				+		
Amphora obtusa var radula						
Amphora ocellata		+				
Amphora ostrearia						
Amphora Ostrearia var vitrea						
Amphora ovalis var ovalis						+
Amphora ovalis var tenuis						
Amphora securicula						
Amphora sp 1						
Amphora sp 2						
Amphora sp 3						
Amphora sp 4	+					
Amphora sp 5						
Amphora sp 6						
Amphora sp 7	+					
Amphora sp 8	+	+				
Amphora sp 9						
Amphora sp 10						
Amphora sp 11						
Amphora sp 12						
Amphora sp 13						
Amphora sp 14						
Amphora sp 15						
Amphora sp 16				+		
Amphora sp 17	+					
Amphora sp 18		+	+	+		
Amphora sp 19		+			+	
Amphora sp 20		+				
Amphora sp 21						
Amphora sp 22						
Amphora sp 23						
Amphora sp 24						+
Amphora sp 25						+
Amphora sp 26						

	C1N	C1S	C1W	C2N	C2S	C2W
Amphora sp 27						
Amphora sp 28						
Amphora sp 29						
Amphora sp 30						
Amphora sp 31						
Amphora sp 32						
Amphora sp 33	+				+	
Amphora sp 34	+					
Amphora sp 35						
Amphora sp 36						
Amphora sp 37						
Amphora sp 38						
Amphora sp 39						
Amphora sp 40						
Amphora sp 41						
Amphora sp 42		+	+			
Amphora sp 43				+		
Amphora sp 44						
Amphora sp 45		+				
Amphora sp 46	+	+	+		+	
Amphora sp 47				+		
Amphora sp 48						
Amphora subtropica	+			+		+
Halamphora pseudospectabilis					+	
Halamphora subcuneata	+	+	+			+
Halamphora subholstatica				+		
Hantzschia pseudomarina	+	+	+		+	+
Order Bacillariales						
Bacillaria paradoxa					+	+
Bacillaria sp						
Cylinderotheca v	+					
Hantzschia pseudomarina						
Hantzschia virgata						
Nitzschia angularis	+					
Nitzschia aurariae						+
Nitzschia constructa		+				
Nitzschia distans var tumescens						
Nitzschia flumenensis		+				

	C1N	C1S	C1W	C2N	C2S	C2W
Nitzschia fossilis				+		
Nitzschia frequens						
Nitzschia frustulum						+
Nitzschia hadratica						
Nitzschia improvisa					+	
Nitzschia laevis				+		
Nitzschia liebetruthii					+	
Nitzschia littorea				+		
Nitzschia microcephla						
Nitzschia miserabilis				+		
Nitzschia nana						
Nitzschia palea						
Nitzschia persuadens						+
Nitzschia prolongata var prologata						
Nitzschia sigma						
Nitzschia sp 1				+		
Nitzschia sp 10		+				
Nitzschia sp 2						
Nitzschia sp 3						
Nitzschia sp 4						
Nitzschia sp 5	+	+				
Nitzschia sp 6						
Nitzschia sp 7				+		
Nitzschia sp 8						
Nitzschia sp 9						+
Nitzschia thermaloides	+					
Nitzschia virgata var virgata					+	
Pseudonitzschia pseudodelicatissima						
Order Rophalodiales						
Rhopalodia acuminata					+	
Rhopalodia brebissonii						
Rhopalodia constricta						
Rhopalodia musculus						+
Order Surirrellales						
Entomoneis alata	+					
Entomoneis paludosa						
Entomoneis punctulata						

	C1N	C1S	C1W	C2N	C2S	C2W
Entomoneis sp 1						
Surirella sp 2						
Surirella sp 1						

Table 5: Species list for Choctawhatchee Bay in November. C: represents Choctawhatchee Bay; 1, 2, 3, 4: represents site 1, 2, 3 and 4; N, S, W: represents net plankton, sediment and whole water samples.

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Class Coscinodiscophyceae												
Order Thallasiosirales												
Cyclotella sp 1	+	+	+	+	+	+	+	+	+			
Cyclotella sp 2												
Cyclotella sp 3	+	+		+	+	+		+	+	+		+
Cyclotella sp 4							+			+	+	+
Cyclotella sp 5												
Cyclotella sp 6						+						
Detonula sp							+		+			
Porosira sp 1					+	+				+		+
Skeletonema sp												
Thalassiosira sp 1	+	+			+	+	+	+	+			
Thalassiosira sp 2					+	+	+		+			
Thalassiosira sp 3		+										
Thalassiosira sp 4							+					
Thalassiosira sp 5							+					
Order Coscinodiscales												
Actinocyclus sp 1		+			+	+	+		+			
Actinocyclus sp 2							+					
Actinocyclus sp 3				+		+	+		+			
Actinocyclus sp 4		+			+		+					
Actinoptychus senarius	+	+		+		+	+					
Coscinodiscus sp 1				+	+							
Coscinodiscus sp 2									+			
Coscinodiscus sp 3						+						
Coscinodiscus sp 4	+				+		+		+	+		
Coscinodiscus sp 5		+					+					
Order Melosirales												
Melosira sp							+					
Order Paraliales												
Paralia sulcata					+		+		+	+		
Order Asteriolamprales												
Asteromphalus flabellatus						+	+					

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Order Triceratiales				+								
Auliscus sculptus							+					
Dimeregramma cf. marinum	+	+										
Dimeregramma minor var minor			+		+	+	+					
Dimeregramma minor var nana						+						
Euphodiscus sp.												
Neohuttonia sp												
Odentella sp 1												
Odentella sp 2	+											
Plagiogramma cf. antillarum				+			+					
Plagiogramma cf. rhombicum												
Plagiogramma pygmaeum							+	+				
Order Biddulphiales												
Biddulphia sp 1				+		+	+		+	+		
Biddulphia sp 2					+		+					
Triceratium sp.					+							
Order Hemiaulales												
Cerataulina sp							+	+	+			+
Eucampia sp												
Hemiaulus sp						+						
Order Anaulales												
Anaulus sp 1												
Anaulus sp 2												
Eunotogramma. sp 1							+	+				
Eunotogramma. sp 2												
Eunnotogramma sp 3												
Order Lithmodesmiales												
Lithodesmium undulatum												
Order Corethrales												
Corethron sp												
Order Cymatosirales												
Campylosira cymbelliformis					+	+	+	+	+			
Cymatosira belgica						+		+	+			

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Cymatosira lorenziana				+	+	+	+	+	+	+		
Order Rhizosolenales												
Rhizosolenia sp							+			+		
Order Chaetocerotales	+											
Bacteriastrum sp 1				+		+	+		+			
Bacteriastrum sp 3				+					+			
Bacteriastrum sp 2	+											
Chaetoceros affinis				+		+						
Chaetoceros compressus												
Chaetoceros dichaeta												
Chaetoceros didymus						+						
Chaetoceros eibonii				+		+						
Chaetoceros gracilis	+			+		+						
Chaetoceros lorenzianus						+						
Chaetoceros peruvianus	+					+						
Chaetoceros radicans						+						
Chaetoceros sp.1						+						
Chaetoceros teres				+		+						
Class Fragilariophyceae												
Order Fragilariales												
Asterionellopsis glacialis									+			
Fragilaria magocsyi												
Fragillaria sp 1										+		
Fragillaria sp 2												
Fragillaria sp 3						+			+			
Fragillaria sp 4	+											
Opephora mutabilis	+	+		+		+	+		+	+	+	
Opephora marina						+						
Ardissonia crystallina				+	+	+	+					
Tabellaria sp												
Tabularia fasciculata									+	+		
Tabularia parva				+	+	+	+			+	+	

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Tabularia sp 1						+						
Tabularia sp 2												
Taloroneis fulgicerum												
Order Licmophorales												
Licmorphora abbreviata												+
Licmorphora oedipus												
Licmorphora cf. paradoxa												
Licmorphora paradoxa				+			+					
Licmorphora remulus												
Order Rhaphoneidales												
Delphineis surirella				+	+		+	+	+			
Delphineis surirelloides					+	+	+	+	+			
Delphineis minutissima				+	+	+	+	+	+			
Psammodiscus nitidus				+	+		+	+	+	+		
Rhaponeis amphiceros				+	+	+	+	+	+			
Order Toxariales												
Toxiarum undulatum		+										
Order Thalassionematales												
Thalasionema frauenfeldii	+	+		+		+	+	+	+			
Thalasionema nitzschioides				+			+			+		
Order Rhabdonematales												
Rhabdonema adriaticum	+	+		+	+	+	+	+	+		+	
Order Striatellales												
Grammatophora angulosa					+							
Grammatophora oceanica var macilenta	+	+	+	+	+	+	+		+			
Striatella unipunctata						+	+		+			
Class Bacillariophyceae												
Order Eunotiales												

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Eunotia sp 1												
Eunotia sp 2												
Eunotia sp 3												
Eunotia sp 4												
Order Lyrellales												
Lyrella clavata	+	+		+		+	+	+	+			
Lyrella clavata var. caribbaea												
Lyrella diffluens		+			+	+	+	+				
Lyrella hennedyi form 1							+					
Lyrella hennedyi form granulata	+						+					
Lyrella lyra				+	+		+					
*Lyrella lyra var.*1												
Lyrella sulcifera												
Petroneis humerosa	+											
Petroneis maculata										+	+	
Petroneis marina		+								+		+
Order Mastogloiales												
Mastogloia adriatica		+		+								
Mastogloia angusta												
Mastogloia angulata	+			+	+	+	+					
Mastogloia baldjikiana		+		+	+	+						
Mastogloia bionata				+	+	+						
Mastogloia braunii		+			+							
Mastogloia cf.acutiuscula												
Mastogloia cf. aquilegiae							+					
Mastogloia cf. corsciana												
Mastogloia cf. lineata	+											
Mastogloia cf. pisciculus			+		+	+						
Mastogloia elliptica	+											
Mastogloia elliptica var dansei		+			+	+	+					
Mastogloia erythraea type 1	+						+					
Mastogloia		+				+						

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
erythraea type 2												
Mastogloia erythraea type 3												
Mastogloia erythraea type 4		+		+	+	+			+			
Mastogloia exigua	+	+										
Mastogloia exilis	+											
Mastogloia foliolum		+		+		+	+					
Mastogloia gibbosa		+										
Mastogloia gracilis		+	+	+	+	+	+					
Mastogloia horvathiana	+					+						
Mastogloia jelinickii	+						+	+	+			
Mastogloia labuensis	+	+	+		+	+	+					
Mastogloia lanceolata		+			+	+						
Mastogloia ovata												
Mastogloia pumila type 1												
Mastogloia pumila type 2												
Mastogloia pumila type 3												
Mastogloia pusilla type 1	+					+				+		
Mastogloia pusilla type 2												
Mastogloia pusilla var. linearalis												
Mastogloia sp 1		+				+	+					
Mastogloia sp 2												
Mastogloia sp 3												
Mastogloia sp 4												
Mastogloia sp 5												
Mastogloia sp 6												
Mastogloia sp 7												
Mastogloia sp 8												
Mastogloia sp 9												
Mastogloia sp 10												
Mastogloia sp 11												
Mastogloia tenuissiama						+		+				
Mastogloia vasta												

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Order Cymbellales												
Cymbella sp 1												
Cymbella sp 2												
Order Achnanthales												
Achnanthes brevipes												
Achnanthes clevei	+								+	+		
Achnanthes curvirostrum							+			+		+
Achnanthes cf. submarina												
Achnanthes brockmannii								+				
Achnanthes danica		+		+	+	+	+	+	+	+		
Achnanthes hauckiana			+									
Achnanthes hauckiana var elliptica				+	+	+	+			+	+	+
Achnanthes ingratiformis										+		
Achnanthes parvula												
Achnanthes rupestoides								+	+			
Achnanthes sp 1												
Achnanthes sp 2												
Achnanthes sp 3												
Achnanthes sp 4				+								
Achnanthes sp 5												
Achnanthes sp 6												
Achnanthes sp 7		+								+	+	+
Achnanthes sp 8												
Achnanthes sp 9												
Achnanthes sp 10												
Achnanthes sp 11						+	+			+	+	+
Achnanthes sp 12												
Achnanthes sp 13									+	+	+	+
Achnanthes sp 14						+		+			+	
Achnanthes sp 15										+	+	+
Achnanthes sp 16												
Achnanthes sp 17												
Achnanthes sp 18								+	+			
Achnanthes sp 19												

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Anorthoneis excentrica	+	+	+		+	+	+	+	+			+
cocconeiopsis cf. fraudulenta	+							+	+			
Cocconeis diminuta		+		+	+	+	+	+	+	+	+	+
Cocconeis disculus					+	+	+		+			
Cocconeis heteroidea						+						
Cocconeis latecostata							+	+	+			
Cocconeis pediculus											+	+
Cocconeis pellucida						+						
Cocconeis pelta						+	+	+				
Cocconeis peltoides								+	+	+		
Cocconeis pinnata												
Cocconeis placentula			+	+	+	+		+				
Cocconeis placentula var lineata												
Cocconeis scutellum var parva						+		+	+	+		
Cocconeis scutellum var scutellum	+	+	+	+	+	+	+		+			
Cocconeis sp						+		+	+			
Planothidium frequentissimum				+		+			+	+	+	+
Planothidium heteromorphum		+							+			+
Planothidium lanceolatum var australis								+				+
Planothidium lanceolatum var rostratata						+						
Order Naviculales												
Caloneis amphisbaena												
Caloneis liber	+			+		+	+	+				
Diploneis aestuari												
Diploneis caffra												
Diploneis didyma		+		+			+					
Diploneis incurvata var dubia			+				+	+	+			
Diploneis incurvata var incurvata	+	+		+	+	+	+	+	+			

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Diploneis notabilis							+					
Diploneis obliqua	+		+	+	+	+			+			
Diploneis parca						+		+				
Diploneis smithi	+		+		+	+	+	+	+			
Diploneis smithi var pumila				+								
Diploneis smithi var. recta												
Diploneis sp 1		+										
Diploneis sp 2					+			+				
Diploneis sp 3						+		+				
Diploneis sp 4				+								
Diploneis sp 5			+						+			
Diploneis subocularis						+						
Diploneis vacillans var. renitens				+		+		+				
Diploneis weissflogii						+						
Donikia sp		+		+	+		+					
Fallacia cf. clypeiformis	+			+	+	+		+				
Fallacia inscriptura												
Fallacia littoricola					+	+	+					
Fallacia margino-punctata						+						
Fallacia ny.												
Fallacia oculiformis							+	+				
Fallacia pygmaea		+	+	+	+				+			
Fallacia shoemaniana						+						
Fallacia subforcipata	+				+	+						
Fallacia vittata						+						
Gyrosigma balticum										+	+	+
Gyrosigma distortum												
Gyrosigma exoticum						+						
Gyrosigma fasciola										+		+
Gyrosigma hummii						+						
Gyrosigma obtusatum												
Gyrosigma sp 1												

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Luticola sp								+	+			
Haslea sp									+			
Navicula angusta												
Navicula bipustulata												
Navicula cf. capitatoradiata			+		+				+			+
Navicula cf. caterva				+		+	+	+	+	+	+	+
Navicula cf. cryptonella	+	+		+	+	+	+					
Navicula cf. digitoradiata												
Navicula cf.gregaria					+		+			+	+	+
Navicula cf.phyllepta		+								+		+
Navicula cryptocephala				+						+		
Navicula erifuga												
Navicula hamiltonii												
Navicula jentzschii								+	+			
Navicula oblonga												
Navicula peregrina	+	+		+		+	+			+		+
Navicula phylleptosoma												
Navicula pseudolanceolata			+	+		+			+		+	
Navicula recens		+	+		+			+		+	+	
Navicula salinarum var. salinarum												
Navicula sp 1			+			+			+	+		
Navicula sp 2											+	
Navicula sp 3											+	+
Navicula sp 4												
Navicula sp 5		+					+			+	+	
Navicula sp 6										+		
Navicula sp 7					+		+	+	+			+
Navicula sp 8						+	+		+			+
Navicula sp 9											+	
Navicula sp 10												
Navicula sp 11							+	+	+			
Navicula sp 12									+			
Navicula sp 13												

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Navicula sp 14						+						
Navicula sp 15												
Navicula sp 16												
Navicula sp 17												
Navicula sp 18					+					+	+	
Navicula sp 19												
Navicula sp 20									+	+		
Navicula sp 21								+				
Navicula sp 22							+	+	+	+	+	+
Navicula sp 23												+
Navicula sp 24												
Navicula sp 25						+						
Navicula sp 26				+	+		+		+			
Navicula sp 27								+				
Navicula sp 28												
Navicula sp 29												
Navicula sp 30												
Navicula sp 31												
Navicula sp 32												
Navicula sp 33						+	+	+	+			
Navicula sp 34												
Navicula sp 35												
Navicula sp 36												
Neidium sp 1		+				+		+		+	+	
Neidium sp 2												
Neidium sp 3												
Neidium sp 4						+			+			
Oestrupia powelii	+	+										
Pinnularia sp 1					+	+	+					
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma pygmaeum	+	+	+		+	+	+	+	+	+	+	+
Plagiotropis sp 1					+	+	+	+	+			
Plagiotropis sp 2												
Plagiotropis sp 3							+			+		
Plagiotropis sp 4												
Pleurosigma				+	+	+	+		+	+		

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
angulatum var. aestuarii												
Pleurosigma australe		+				+					+	
Pleurosigma cf. elongatum									+			
Pleurosigma delicatum												
Pleurosigma formosum												
Pleurosigma speciosum var javanica					+	+						
Pleurosigma sp 2												
Pleurosigma sp 3												
Pleurosigma sp 4												
Pleurosigma williamsii	+			+		+	+					
Pleurosigma sp 1							+		+			
Sellaphora sp												+
Seminavis robusta			+			+						
Stauroneis sp 1												+
Stauroneis sp 2										+		+
Trachyneis aspera							+					
Order Thalassiophysales												
Amphora albudens		+		+	+	+		+		+	+	+
Amphora arcus	+	+				+	+		+			
Amphora arenaria			+		+		+	+		+	+	+
Amphora arenicola												+
Amphora bigibba var capitata					+							
Amphora bigibba var interrupta	+	+				+			+			
Amphora coffeaeformis			+		+	+	+	+	+	+	+	+
Amphora coffeaeformis var aponina				+		+	+			+	+	+
Amphora cuneata												
Amphora cymbifera	+			+							+	
Amphora delphinea var. minor									+			
Amphora gigantea var fusca	+	+		+	+	+	+			+	+	
Amphora graeffeana			+	+	+	+	+		+			

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Amphora gruendleri							+		+			
Amphora hinzae												
Amphora laevissima						+	+	+	+		+	+
Amphora obtusa						+						
Amphora obtusa var oceanica					+							
Amphora obtusa var radula					+		+					
Amphora ocellata							+					+
Amphora ostrearia		+					+	+	+			
Amphora Ostrearia var vitrea						+						
Amphora ovalis var ovalis		+			+	+	+			+		
Amphora ovalis var tenuis				+		+	+					+
Amphora securicula	+									+	+	+
Amphora sp 1												
Amphora sp 2												+
Amphora sp 3												
Amphora sp 4										+		
Amphora sp 5												
Amphora sp 6												
Amphora sp 7						+						
Amphora sp 8	+			+	+		+			+	+	+
Amphora sp 9									+		+	
Amphora sp 10												
Amphora sp 11												
Amphora sp 12												
Amphora sp 13						+	+					
Amphora sp 14		+								+		
Amphora sp 15												
Amphora sp 16										+		
Amphora sp 17											+	+
Amphora sp 18												
Amphora sp 19												
Amphora sp 20												
Amphora sp 21												
Amphora sp 22				+								
Amphora sp 23										+		

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Amphora sp 24				+		+						
Amphora sp 25			+		+	+			+			
Amphora sp 26												
Amphora sp 27			+									+
Amphora sp 28						+						
Amphora sp 29										+		
Amphora sp 30												
Amphora sp 31												
Amphora sp 32												
Amphora sp 33												
Amphora sp 34												
Amphora sp 35										+		
Amphora sp 36												
Amphora sp 37												
Amphora sp 38												
Amphora sp 39	+								+			
Amphora sp 40						+						
Amphora sp 41												
Amphora sp 42												
Amphora sp 43												
Amphora sp 44							+					
Amphora sp 45												
Amphora sp 46												
Amphora sp 47												
Amphora sp 48												
Amphora sp 49						+	+			+		+
Amphora subtropica	+		+	+		+		+	+			+
Amphora pseudospectabilis							+				+	
Halamphora subcuneata	+	+		+		+		+				
Halamphora subholstatica	+	+								+	+	+
Hantzschia pseudomarina	+	+	+	+	+	+	+	+	+	+	+	+
Order Bacillariales												
Bacillaria paradoxa	+						+			+	+	+
Bacillaria sp	+	+		+		+		+				
Cylinderotheca sp				+						+		+
Hantzschia	+	+	+	+	+	+	+	+	+	+	+	+

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
pseudomarina												
Hantzschia virgata						+			+			
Hyalosira interrupta					+							
Nitzschia angularis	+	+			+	+	+		+	+	+	+
Nitzschia aurariae								+				
Nitzschia carcinobarica		+		+	+	+			+	+	+	
Nitzschia constricta					+					+		
Nitzschia diversa	+											
Nitzschia distans var tumescens												
Nitzschia flumenensis		+				+	+	+	+			
Nitzschia fossilis												+
Nitzschia frequens									+			
Nitzschia frustulum				+		+				+	+	+
Nitzschia fusiformis											+	
Nitzschia hadratica												
Nitzschia improvisa												
Nitzschia laevis												
Nitzschia liebetruthii		+				+				+	+	+
Nitzschia littorea												
Nitzschia microcephla									+			
Nitzschia miserabilis												+
Nitzschia nana												
Nitzschia palea	+		+	+						+		
Nitzschia panduriformis							+		+			+
Nitzschia persuadens				+		+		+	+			
Nitzschia prolongata var prologata						+	+		+			
Nitzschia sigma										+		
Nitzschia sp 1						+		+				
Nitzschia sp 10												
Nitzschia sp 2							+					
Nitzschia sp 3				+								
Nitzschia sp 4												
Nitzschia sp 5												

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 S	C3 W	C4 N	C4 S	C4 W
Nitzschia sp 6												
Nitzschia sp 7									+			
Nitzschia sp 8												
Nitzschia sp 9						+						+
Nitzschia thermaloides												
Nitzschia virgata var virgata												
Pseudonitzschia pseudodelicatissima						+						
Order Rophalodiales												
Rhopalodia acuminata	+	+		+	+	+	+					
Rhopalodia brebissonii												
Rhopalodia constricta												
Rhopalodia musculus						+	+					
Order Surirellales												
Entomoneis alata	+	+			+	+				+		+
Entomoneis paludosa				+			+					
Entomoneis punctulata												
Entomoneis sp 1						+						
Entomoneis sp 2						+						
Surirella sp 2											+	
Surirella sp 1											+	

Table 6: Species list for Choctawhatchee Bay in January. C: represents Choctawhatchee Bay; 1, 2, 3, 4: represents site 1, 2, 3 and 4; N, S, W: represents net plankton, sediment and whole water samples.

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Class Coscinodiscophyceae											
Order Thallasiosirales											
Cyclotella sp. 1	+	+	+		+	+	+		+	+	
Cyclotella sp. 2											
Cyclotella sp. 3	+	+	+		+	+					+
Cyclotella sp. 4	+		+			+				+	+
Cyclotella sp. 5											
Cyclotella sp. 6											
Detonula sp.							+				
Porosira sp. 1			+		+						
Skeletonema sp.									+		
Thalassiosira sp. 1	+	+	+	+	+		+	+	+	+	+
Thalassiosira sp. 2	+		+					+			+
Thalassiosira sp. 3											
Thalassiosira sp. 4				+							+
Thalassiosira sp. 5					+				+		
Order Coscinodiscales											
*Actinocyclu*s sp. 1	+		+			+		+			
Actinocyclus sp. 2	+				+		+				
Actinocyclus sp. 3							+				
Actinocyclus sp. 4							+				
Actinoptychus senarius	+	+	+		+	+	+	+			
Coscinodiscus sp. 1				+							
*Coscinodiscu*s sp. 3	+					+					
Coscinodiscus sp. 4	+		+			+		+		+	
Coscinodiscus sp. 5				+	+				+		
*Coscinodiscu*s sp. 6									+		
Order Melosirales											
*Melosir*a sp.											
Order Paraliales											
Paralia sulcata				+	+		+	+	+		
Asteriolamprales											
Asteromphalus flabellatus				+							
Order Triceratiales											
Amphitetras sp.							+				

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Auliscus sculptus							+	+			
Dimeregramma cf. marina		+				+					
Dimeregramma minor var minor	+	+	+	+		+	+	+			
Dimeregramma minor var nana	+		+		+	+		+			
Euphodiscus sp.											
Neohuttonia sp.											
Odentella sp. (1)					+		+				
Odentella sp. (2)					+		+				
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma pygmaeum	+	+	+	+	+	+	+	+	+	+	+
Order Biddulphiales											
Biddulphia sp. (1)	+		+	+	+		+	+			
Biddulphia sp. (2)				+			+				
*Biddulphi*a sp. 3										+	
*Triceratiu*m sp.											
Order Hemiaulales											
Cerataulina sp.				+	+		+	+			
Eucampia sp.			+				+	+			
Hemiaulus sp.									+		
Order Anaulales											
Anaulus sp. (1)											
Anaulus sp. (2)						+		+			+
Eunotogramma. sp. (1)			+			+		+	+		
*Eunotogramm*a. sp. (2)					+			+			
Eunnotogramma sp. 3											
Order Lithmodesmiales											
Lithodesmium undulatum							+				
Order Corethrales											
Corethron sp.					+						
Order Cymatosirales											
Campylosira cymbelliformis				+			+	+	+		
Cymatosira belgica			+			+		+			+
Cymatosira lorenziana	+		+	+	+	+	+	+	+		
Order Rhizosolenales											

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Rhizosolenia sp							+				
Order Chaetocerotales											
Bacteriastrum sp. (1)	+	+			+		+	+	+		+
Bacteriastrum sp. 3							+				
Bacteriastrum sp. (2)	+						+		+		
Chaetoceros affinis	+			+					+	+	
Chaetoceros compressus	+			+			+		+		
Chaetoceros dichaeta							+				
Chaetoceros didymus				+			+		+		
Chaetoceros eibonii	+			+					+	+	
Chaetoceros gracilis	+		+	+					+		+
Chaetoceros lorenzianus			+				+				+
Chaetoceros peruvianus											
Chaetoceros radicans	+			+			+		+		+
Chaetoceros sp.1											
Chaetoceros sp.2											
Chaetoceros sp.3	+			+			+				
Chaetoceros teres	+			+							
Class Fragilariophyceae											
Fragilariales											
Asterionellopsis glacialis	+										
Diatoma sp. 1								+			
Diatoma sp. 2								+			
Fragilaria magocsyi									+	+	
Fragillaria sp. 1			+								
Fragillaria sp. 2			+			+					+
Fragillaria sp. 3	+		+								
Fragillaria sp. 4			+								
Opephora mutabilis	+	+	+			+			+	+	+
Opephora marina	+										
Ardissonia crystallina	+			+							
Tabellaria sp.				+							
Tabularia fasciculata				+	+			+			
Tabularia parva	+		+		+	+			+	+	+
Tabularia sp. (1)	+		+		+			+	+		+
Tabularia sp. (2)	+										
Taloroneis fulgicerum					+		+				

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Order Licmophorales											
Licmorphora abbreviata	+	+				+			+		
Licmorphora oedipus											
Licmorphora cf. paradoxa	+					+					
Licmorphora paradoxa											
Licmorphora remulus											
Nov.spec	+					+					
Order Rhaphoneidales											
Delphineis surirella	+		+	+	+	+	+	+	+		
Delphineis surirelloides	+		+	+	+	+	+	+	+		
Delphineis minutissima			+		+			+			
Psammodiscus nitidus				+	+		+	+	+		
Rhaponeis amphiceros					+		+	+	+		
Order Toxariales											
Toxiarum undulatum	+	+			+						
Order Thalassionematales											
Thalasionema frauenfeldii	+	+	+	+		+		+	+		+
Thalasionema nitzschioides			+			+					
Order Rhabdonematales								+			
Rhabdonema adriaticum	+	+	+	+	+	+	+				
Order Striatellales											
Grammatophora angulosa				+	+	+					
Grammatophora oceanica var macilenta	+	+	+	+	+	+		+			
Striatella unipunctata	+	+		+		+		+			
Class Bacillariophyceae											
Order Eunotiales											
Eunotia sp. (1)						+					
Eunotia sp. (2)			+			+					
Eunotia sp. 3								+			+
Eunotia sp. 4						+					
Order Lyrellales											
Lyrella clavata	+			+	+		+	+			
Lyrella clavata var. caribbaea					+						

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Lyrella diffluens	+	+									
Lyrella hennedyi form 1					+	+		+			
Lyrella hennedyi form granulata					+		+	+			
Lyrella lyra	+	+		+	+		+			+	
Lyrella lyra var.1		+									
Lyrella sulcifera									+	+	
Petroneis humerosa											
Petroneis maculata				+	+					+	+
Petroneis marina				+	+				+	+	
Order Mastogloiales											
Mastogloia adriatica	+		+								
Mastogloia angusta						+					
Mastogloia angulata				+							
Mastogloia baldjikiana	+		+								
Mastogloia bionata	+		+		+						
Mastogloia braunii											
Mastogloia cf.acutiuscula											
Mastogloia cf. aquilegiae											
Mastogloia cf. corsciana											
Mastogloia cf. lineata											
Mastogloia cf. pisciculus	+	+	+								
Mastogloia elliptica			+								
Mastogloia elliptica var dansei	+	+	+		+	+					
Mastogloia erythraea type 1						+					
Mastogloia erythraea type 2											
Mastogloia erythraea type 3			+	+							
Mastogloia erythraea type 4	+	+	+	+		+					
Mastogloia erythraea type 5			+								
Mastogloia exigua											
Mastogloia exilis											
Mastogloia foliolum	+		+			+					
Mastogloia gibbosa	+		+		+	+					
Mastogloia gracilis	+		+	+				+			

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Mastogloia horvathiana											
Mastogloia jelinickii	+						+	+			
Mastogloia labuensis	+		+								
Mastogloia lanceolata	+	+	+	+		+					
Mastogloia ovata			+								
Mastogloia pumila type 1			+		+						
Mastogloia pumila type 2			+								
Mastogloia pumila type 3											
Mastogloia pusilla type 1	+										
Mastogloia pusilla type 2					+						
Mastogloia pusilla var. linearalis	+										
Mastogloia sp. (1)			+			+					
Mastogloia sp. (2)	+		+	+							
Mastogloia sp. 3	+		+								
Mastogloia sp. 4											
Mastogloia sp. 5			+								
Mastogloia sp. 6											
Mastogloia sp. 7											
Mastogloia sp. 8			+								
Mastogloia sp. 9											
Mastogloia sp. 10											
Mastogloia sp. 11											
Mastogloia tenuissiama								+			
Mastogloia vasta											
Order Cymbellales											
Cymbella sp. (1)		+									
Cymbella sp. (2)					+						
Order Achnanthales											
Achnanthes brevipes	+		+								
Achnanthes clevei	+					+					
Achnanthes curvirostrum			+			+	+		+	+	+
Achnanthes cf. submarina									+		
Achnanthes brockmannii						+	+				

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Achnanthes danica	+	+	+	+	+	+	+	+			
Achnanthes hauckiana									+		
Achnanthes hauckiana var elliptica		+	+			+					+
Achnanthes ingratiformis											
Achnanthes parvula											
Achnanthes rupestoides			+					+			+
Achnanthes sp. 1					+			+			
Achnanthes sp. 2										+	
Achnanthes sp. 3											+
Achnanthes sp. 4											
Achnanthes sp. 5											
Achnanthes sp. 6											+
Achnanthes sp. 7		+							+	+	+
Achnanthes sp. 8											
Achnanthes sp. 9										+	
Achnanthes sp. 10			+						+	+	
Achnanthes sp. 11	+		+						+	+	+
Achnanthes sp. 12											
Achnanthes sp. 13						+					+
Achnanthes sp. 14								+	+		+
Achnanthes sp. 15											
Achnanthes sp. 16											
Achnanthes sp. 17											
Achnanthes sp. (18)											
Achnanthes sp. (19)			+								
Anorthoneis excentrica	+	+	+	+	+	+	+	+			
cocconeiopsis cf. fraudulenta	+	+	+			+		+			
Cocconeis diminuta	+	+						+			
Cocconeis disculus	+			+	+	+		+			+
Cocconeis heteroidea				+							
Cocconeis latecostata						+		+			
Cocconeis pediculus											
Cocconeis pellucida											
Cocconeis pelta						+		+			
Cocconeis peltoides	+					+		+			
Cocconeis pinnata											
Cocconeis placentula			+	+		+		+		+	

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Cocconeis placentula var lineata			+								
Cocconeis scutellum var parva	+			+				+			
Cocconeis scutellum var scutellum	+	+	+	+	+	+	+	+	+		
Cocconeis sp.			+		+			+			
Planothidium frequentissimum	+	+	+					+		+	+
Planothidium heteromorphum	+		+				+	+			
Planothidium lanceolatum var australis				+							
Planothidium lanceolatum var rostratata											
Order Naviculales											
Caloneis amphisbaena											
Caloneis liber		+			+						
Diploneis aestuari			+				+				
Diploneis caffra											
Diploneis didyma	+									+	+
Diploneis incurvata var dubia					+	+	+	+			
Diploneis incurvata var incurvata	+	+	+	+				+			
Diploneis notabilis											
Diploneis obliqua	+	+	+	+	+	+	+				
Diploneis parca					+		+	+			
Diploneis smithi	+		+		+	+	+	+			
Diploneis smithi var pumila	+	+	+			+					
Diploneis smithi var. recta	+			+							
Diploneis smithi var rhombica					+						
Diploneis sp. 1											
Diploneis sp. 2								+			
Diploneis sp. 3								+			
Diploneis sp. 4			+								
Diploneis sp. 5	+					+		+			
Diploneis subocularis	+			+			+	+			
Diploneis vacillans var. renitens		+	+		+			+		+	
Diploneis weissflogii					+		+				

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Donikia sp.	+			+	+	+		+	+		
Fallacia cf. clypeiformis					+						
Fallacia inscriptura			+								
Fallacia littoricola			+	+	+			+		+	
Fallacia margino-punctata											
Fallacia ny.	+		+								
Fallacia oculiformis		+	+		+			+			
Fallacia pygmaea											
Fallacia shoemaniana	+		+								
Fallacia subforcipata	+	+	+		+			+			
Fallacia vittata								+			
Frustulia rhomboids						+					
Gyrosigma balticum	+								+		
Gyrosigma distortum											
Gyrosigma exoticum										+	
Gyrosigma fasciola	+								+		+
Gyrosigma hummii							+				
Gyrosigma obtusatum									+		
Gyrosigma sp. 1				+							
Luticola sp.								+			
Haslea sp.											
Navicula angusta											
Navicula bipustulata											
Navicula cf. capitatoradiata	+								+	+	+
Navicula cf. caterva	+		+		+			+	+	+	+
Navicula cf. cryptonella		+					+	+			
Navicula cf. digitoradiata											
Navicula cf.gregaria	+	+							+	+	+
Navicula cf.phyllepta	+		+		+				+	+	+
Navicula crucifera							+				
Navicula cryptocephala			+					+			
Navicula erifuga	+		+						+		
Navicula hamiltonii						+		+			
Navicula jentzschii			+					+			
Navicula oblonga											

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Navicula peregrina	+		+			+	+	+		+	
Navicula phylleptosoma											
Navicula pseudolanceolata		+	+			+	+			+	+
Navicula recens	+		+						+		+
Navicula salinarum var. salinarum	+					+			+	+	
Navicula sp. 1			+		+			+			+
Navicula sp. 2											
Navicula sp. 3											
Navicula sp. 4											
Navicula sp. 5											
Navicula sp. 6									+		
Navicula sp. 7	+		+			+		+		+	
Navicula sp. 8			+								
Navicula sp. 9			+								
Navicula sp. 10	+		+						+		+
Navicula sp. 11			+			+		+	+		
Navicula sp. 12	+		+						+		
Navicula sp. 13									+	+	
Navicula sp. 14							+				+
Navicula sp. 15											
Navicula sp. 16			+			+			+		
Navicula sp. 17							+			+	+
Navicula sp. (18)	+									+	
Navicula sp. (19)											
Navicula sp. (20)						+					
Navicula sp. (21)										+	
Navicula sp. (22)	+	+	+			+		+		+	+
Navicula sp. (23)											
Navicula sp. (24)		+									+
Navicula sp. (25)	+										
Navicula sp. (26)		+	+								
Navicula sp. (27)											
Navicula sp. (28)											
Navicula sp. (29)											+
Navicula sp. (30)	+									+	
Navicula sp. 31		+	+								
Navicula sp. 32			+								

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Navicula sp.33				+		+	+				
Navicula sp. 34								+			
Navicula sp. 35							+				
Navicula sp. 36	+		+								
Neidium sp. 1	+		+			+		+			+
Neidium sp. 2	+										
Neidium sp. 3	+		+								
Neidium sp. 4											
Oestrupia powelii		+	+			+					
Pinnularia sp. (1)	+					+					
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma pygmaeum	+	+	+	+	+	+	+	+	+	+	+
Plagiotropis sp. 1	+		+			+	+	+			
Plagiotropis sp. 2			+						+		
Plagiotropis sp. 3	+							+			+
Plagiotropis sp. 4			+								
Pleurosigma angulatum var. aestuarii					+		+	+			
Pleurosigma australe	+							+		+	
Pleurosigma cf. elongatum											
Pleurosigma exoticum	+										
Pleurosigma delicatum											
Pleurosigma formosum		+									
Pleurosigma speciosum	+										
Pleurosigma speciosum var javanica	+					+					
Pleurosigma sp. 2										+	
Pleurosigma sp. 3											
Pleurosigma sp. 4											
Pleurosigma williamsii							+	+			
Pleurosigma sp. (1)					+			+			
Sellaphora sp.			+								
Seminavis robusta											
Stauroneis sp. 1									+	+	+
Stauroneis sp. 2									+	+	+

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Trachyneis aspera											
Order Thalassiophysales											
Amphora albudens	+	+	+		+				+	+	+
Amphora arcus	+										
Amphora arenaria	+		+	+				+	+	+	
Amphora arenicola			+								+
Amphora bigibba var capitata	+							+			
Amphora bigibba var interrupta		+	+	+	+	+		+			
Amphora coffeaeformis	+	+	+			+	+	+		+	+
Amphora coffeaeformis var aponina	+		+			+		+		+	+
Amphora cuneata											
Amphora cymbifera		+			+		+	+		+	
Amphora delphinea var. minor							+				
Amphora eunotia								+			
Amphora gibberula					+						
Amphora gigantea var fusca	+	+			+		+	+	+		
Amphora graeffeana		+	+	+	+	+	+	+	+		
Amphora gruendleri								+			
Amphora hinzae											
Amphora laevissima	+	+	+	+		+		+	+	+	
Amphora obtusa											
Amphora obtusa var oceanica											
Amphora obtusa var radula		+	+					+			
Amphora ocellata	+					+	+	+			
Amphora ostrearia		+					+	+			
Amphora Ostrearia var vitrea			+								
Amphora ovalis var ovalis	+		+	+		+	+		+		+
Amphora ovalis var tenuis	+		+	+	+	+	+		+		+
Amphora securicula			+	+						+	+
Amphora sp. 1	+		+					+			
Amphora sp. 2											
Amphora sp. 3					+				+		+
Amphora sp. 4											

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Amphora sp. 5								+			
Amphora sp. 6											
Amphora sp. 7					+		+		+		
Amphora sp. 8	+	+		+	+				+	+	+
Amphora sp. 9	+		+							+	
Amphora sp. 10			+				+			+	
Amphora sp. 11	+									+	
Amphora sp. 12											
Amphora sp. 13			+		+						
Amphora sp. 14										+	
Amphora sp. 15			+								
Amphora sp. 16										+	
Amphora sp. 17								+			
Amphora sp. 18											
Amphora sp. 19											
Amphora sp. 20											
Amphora sp. 21											+
Amphora sp. 22							+				
Amphora sp. 23											+
Amphora sp. 24	+					+					
Amphora sp. 25											
Amphora sp. 26											
Amphora sp. 27											
Amphora sp. 28			+								
Amphora sp. 29			+					+			
Amphora sp. 30											
Amphora sp. 31						+					
Amphora sp. 32											
Amphora sp. 33											
Amphora sp. 34											
Amphora sp. 35	+										
Amphora sp. 36											
Amphora sp. 37		+	+	+		+				+	
Amphora sp. 38											
Amphora sp. 39		+									
Amphora sp. 40	+		+					+			+
Amphora sp. 41											
Amphora sp. 42											

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
A*mphora* sp. 43					+						
Amphora sp. 44											
Amphora sp. 45			+								
Amphora sp. 46											
Amphora sp. 47											
Amphora sp. 48											
Amphora sp. 49											+
Amphora subtropica		+		+		+		+			+
Amphora pseudospectabilis					+						
Halamphora subcuneata			+	+		+					
Halamphora subholstatica			+		+			+			+
Hantzschia pseudomarina	+	+	+	+	+	+	+	+	+	+	+
Bacillariales											
Bacillaria paradoxa	+		+	+	+			+	+	+	+
Bacillaria sp.	+	+	+			+					
Cylinderotheca sp.	+		+		+				+	+	
Hantzschia pseudomarina	+	+	+	+	+	+	+	+	+	+	+
Hantzschia virgata											
Hyalosira interrupta	+	+									
Nitzschia angularis				+		+	+	+		+	+
Nitzschia aurariae	+										
Nitzschia carcinobarica	+		+					+			
Nitzschia constricta	+		+								
Nitzschia diversa											
Nitzschia distans var tumescens											
Nitzschia flumenensis	+	+	+								
Nitzschia fossilis											
Nitzschia frequens								+			
Nitzschia frustulum			+							+	+
Nitzschia fusiformis											
Nitzschia hadratica	+						+				
Nitzschia improvisa											
Nitzschia laevis											
Nitzschia liebetruthii			+			+				+	+
Nitzschia littorea					+						

	C1 N	C1S	C1 W	C2 N	C2S	C2 W	C3 N	C3 W	C4 N	C4S	C4W
Nitzschia marginulata			+								
Nitzschia microcephla											
Nitzschia miserabilis								+			
Nitzschia nana		+									
Nitzschia palea	+		+								
Nitzschia panduriformis	+				+			+	+		
Nitzschia persuadens			+					+			
Nitzschia prolongata var prologata	+	+			+					+	
Nitzschia sigma	+								+		
Nitzschia sp. 1	+										
Nitzschia sp. 10		+									
Nitzschia sp. 2								+			
Nitzschia sp. 3							+		+		
Nitzschia sp. 4										+	
Nitzschia sp. 5											
Nitzschia sp. 6		+								+	
Nitzschia sp. 7											
Nitzschia sp. 8											
Nitzschia sp. 9											
Nitzschia thermaloides											
Nitzschia virgata var virgata			+	+			+				
Pseudonitzschia pseudodelicatissima							+				
Order Rophalodiales											
Rhopalodia acuminata	+	+	+	+	+	+					
Rhopalodia brebissonii											
Rhopalodia constricta											
Rhopalodia musculus				+	+					+	
Order Surirellales											
Entomoneis alata		+	+				+		+		
Entomoneis paludosa	+										+
Entomoneis punctulata		+							+	+	
Entomoneis sp. (1)											
Entomoneis sp. (2)											
Surirella sp. (1)									+		
Surirella sp. (2)									+	+	
Surirella sp. 3									+		

Table 7: Species list for Choctawhatchee Bay in March. C: represents Choctawhatchee Bay; 1, 2, 3, 4: represents site 1, 2, 3 and 4; N, S, W: represents net plankton, sediment and whole water samples.

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Class Coscinodiscophyceae											
Thallasiosirales											
Cyclotella sp 1			+	+				+			
Cyclotella sp 2				+							
Cyclotella sp 3	+	+	+		+	+	+				
Cyclotella sp 4	+	+	+	+		+	+	+			
Cyclotella sp 5											
Cyclotella sp 6											
Detonula sp											
Porosira sp 1				+		+		+			
Skeletonema sp				+							
Thalassiosira sp 1	+		+	+		+	+	+			
Thalassiosira sp 2						+	+				
Thalassiosira sp 3											
Thalassiosira sp 4											
Thalassiosira sp 5							+				
Coscinodiscales											
Actinocyclus sp 1	+			+		+					
Actinocyclus sp 2	+			+		+	+				
Actinocyclus sp 3							+				
Actinocyclus sp 4											
Actinoptychus senarius	+			+		+	+	+			
Coscinodiscus sp 1			+	+							
Coscinodiscus sp 3	+	+				+		+			
Coscinodiscus sp 4	+										
Coscinodiscus sp 5											
Coscinodiscus sp 6											
Order Melosirales											
Melosira sp				+		+		+			
Order Paraliales											
Paralia sulcata				+			+	+			
Order Asteriolamprales											
Asteromphalus flabellatus											
Triceratiales											
Amphitetras sp.											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Auliscus sculptus											
Dimeregramma cf. marina											
Dimeregramma minor var minor	+	+		+		+		+			
Dimeregramma minor var nana	+	+	+	+				+			
Euphodiscus sp.											
Neohuttonia sp											
Odentella sp 1							+				
Odentella sp 2						+	+				
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+			
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+			
Plagiogramma pygmaeum	+	+	+	+	+	+	+	+			
Order Biddulphiales											
Biddulphia sp 1				+		+	+	+			
Biddulphia sp 2											
Biddulphia sp 3											
Triceratium sp.											
Order Hemiaulales											
Cerataulina sp				+	+	+	+	+			
Eucampia sp											
Hemiaulus sp											
Order Anaulales											
Anaulus sp. 1											
Anaulus sp. 2				+		+	+	+			
Eunotogramma. sp 1				+		+		+			
Eunotogramma. sp 2											
Eunnotogramma sp 3											
Order Lithmodesmiales											
Lithodesmium undulatum											
Corethrales											
Corethron sp											
Cymatosirales											
Campylosira cymbelliformis					+	+		+			
Cymatosira belgica				+		+		+			
Cymatosira lorenziana	+		+	+	+	+	+	+			

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Order Rhizosolenales											
Rhizosolenia sp				+							
Chaetocerotales											
Bacteriastrum sp 1	+	+	+		+	+		+			
Bacteriastrum sp 3											
Bacteriastrum sp 2							+				
Chaetoceros affinis	+			+			+				
Chaetoceros compressus											
Chaetoceros dichaeta											
Chaetoceros didymus											
Chaetoceros eibonii	+										
Chaetoceros gracilis	+	+	+	+			+				
Chaetoceros lorenzianus		+									
Chaetoceros peruvianus											
Chaetoceros radicans											
Chaetoceros sp.1				+							
Chaetoceros sp.2											
Chaetoceros sp.3											
Chaetoceros teres	+			+		+	+				
Class Fragilariophyceae											
Order Fragilariales											
Asterionellopsis glacialis											
Diatoma sp 1											
Diatoma sp 2								+			
Fragilaria magocsyi											
Fragillaria sp 1		+	+								
Fragillaria sp 2				+							
Fragillaria sp 3		+	+	+		+					
Fragillaria sp 4											
Opephora mutabilis	+	+	+	+	+	+	+	+			
Opephora marina	+			+							
Ardissonia crystallina	+					+					
Tabellaria sp											
Tabularia fasciculata				+							
Tabularia parva	+	+	+	+		+					
Tabularia sp 1	+			+							
Tabularia sp 2	+	+									
Taloroneis fulgicerum							+				

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Licmophorales											
Licmorphora abbreviata	+										
Licmorphora oedipus											
Licmorphora cf. paradoxa	+	+		+							
Licmorphora paradoxa											
Licmorphora remulus			+								
Nov.spec	+										
Rhaphoneidales											
Delphineis surirella				+	+	+	+	+			
Delphineis surirelloides	+		+	+	+	+	+	+			
Delphineis minutissima				+		+	+	+			
Psammodiscus nitidus							+				
Rhaponeis amphiceros						+	+	+			
Order Toxariales											
Toxiarum undulatum											
Thalassionematales											
Thalasionema frauenfeldii	+	+	+	+	+	+	+	+			
Thalasionema nitzschioides				+							
Rhabdonematales											
Rhabdonema adriaticum	+	+	+	+	+	+					
Striatellales											
Grammatophora angulosa			+	+		+					
Grammatophora oceanica var macilenta	+	+		+		+					
Striatella unipunctata				+							
Class Bacillariophyceae											
Dictyoneidales											
Dictyoneis marginata				+		+					
Order Eunotiales											
Eunotia sp 1											
Eunotia sp 2											
Eunotia sp 3											
Eunotia sp 4											
Lyrellales											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Lyrella clavata	+	+	+			+	+				
Lyrella clavata var. caribbaea											
Lyrella diffluens	+										
Lyrella hennedyi form 1					+	+	+				
Lyrella hennedyi form granulata						+	+	+			
Lyrella lyra	+						+				
*Lyrella lyra var.*1											
Lyrella sulcifera											
Petroneis humerosa											
Petroneis maculata											
Petroneis marina				+			+				
Order Mastogloiales											
Mastogloia adriatica	+										
Mastogloia angusta											
Mastogloia angulata											
Mastogloia baldjikiana		+	+	+		+					
Mastogloia bionata				+							
Mastogloia braunii											
Mastogloia cf.acutiuscula											
Mastogloia cf. aquilegiae											
Mastogloia cf. corsciana											
Mastogloia cf. lineata											
Mastogloia cf. pisciculus	+										
Mastogloia elliptica			+	+							
Mastogloia elliptica var dansei											
Mastogloia erythraea type 1		+									
Mastogloia erythraea type 2											
Mastogloia erythraea type 3	+		+								
Mastogloia erythraea type 4	+		+			+					
Mastogloia erythraea type 5											
Mastogloia exigua											
Mastogloia exilis											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Mastogloia foliolum	+										
Mastogloia gibbosa	+		+								
Mastogloia gracilis	+	+	+								
Mastogloia horvathiana											
Mastogloia jelinickii				+							
Mastogloia labuensis	+		+								
Mastogloia lanceolata	+	+	+								
Mastogloia ovata											
Mastogloia pumila type 1	+			+							
Mastogloia pumila type 2											
Mastogloia pumila type 3											
Mastogloia pusilla type 1				+			+				
Mastogloia pusilla type 2											
Mastogloia pusilla var. linearalis											
Mastogloia sp 1											
Mastogloia sp 2											
Mastogloia sp 3											
Mastogloia sp 4											
Mastogloia sp 5											
Mastogloia sp 6											
Mastogloia sp 7											
Mastogloia sp 8											
Mastogloia sp 9		+									
Mastogloia sp 10											
Mastogloia sp 11											
Mastogloia tenuissiama				+		+	+	+			
Mastogloia vasta											
Order Cymbellales											
Cymbella sp 1											
Cymbella sp 2											
Order Achnanthales											
Achnanthes brevipes	+	+	+								
Achnanthes clevei	+	+									
Achnanthes curvirostrum		+	+								

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Achnanthes cf. submarina											
Achnanthes brockmannii	+			+		+		+			
Achnanthes danica	+	+	+	+	+	+	+	+			
Achnanthes hauckiana		+		+							
Achnanthes hauckiana var elliptica	+	+		+		+					
Achnanthes ingratiformis		+									
Achnanthes parvula						+					
Achnanthes rupestoides						+	+	+			
Achnanthes sp 1						+					
Achnanthes sp 2											
Achnanthes sp 3											
Achnanthes sp 4											
Achnanthes sp 5				+							
Achnanthes sp 6											
Achnanthes sp 7				+							
Achnanthes sp 8				+							
Achnanthes sp 9											
Achnanthes sp 10											
Achnanthes sp 11			+								
Achnanthes sp 12											
Achnanthes sp 13				+				+			
Achnanthes sp 14							+				
Achnanthes sp 15		+	+				+				
Achnanthes sp 16						+					
Achnanthes sp 17											
Achnanthes sp 18											
Achnanthes sp 19											
Achnanthes sp 20		+									
Anorthoneis excentrica	+	+	+	+	+	+	+	+			
cocconeiopsis cf. fraudulenta		+	+	+		+	+	+			
Cocconeis diminuta	+	+	+	+			+	+			
Cocconeis disculus	+	+	+	+		+	+	+			
Cocconeis heteroidea											
Cocconeis latecostata				+		+	+	+			

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Cocconeis pediculus				+			+	+			
Cocconeis pellucida											
Cocconeis pelta						+		+			
Cocconeis peltoides	+	+	+		+	+	+	+			
Cocconeis pinnata				+		+					
Cocconeis placentula			+	+		+	+				
Cocconeis placentula var lineata											
Cocconeis scutellum var parva	+	+	+	+		+	+				
Cocconeis scutellum var scutellum	+	+	+	+	+	+					
Cocconeis sp				+				+			
Planothidium frequentissimum		+	+	+		+	+	+			
Planothidium heteromorphum	+		+	+		+	+				
Planothidium lanceolatum var australis				+			+				
Planothidium lanceolatum var rostratata				+							
Naviculales											
Caloneis amphisbaena											
Caloneis liber	+	+				+					
Diploneis aestuari				+		+	+	+			
Diploneis caffra											
Diploneis didyma	+		+	+							
Diploneis incurvata var dubia				+				+			
Diploneis incurvata var incurvata	+	+	+					+			
Diploneis notabilis				+							
Diploneis obliqua	+	+	+	+	+	+					
Diploneis parca						+		+			
Diploneis smithi	+	+	+	+	+	+	+	+			
Diploneis smithi var pumila	+					+	+				
Diploneis smithi var. recta											
Diploneis smithi var rhombica											
Diploneis sp 1											
Diploneis sp 2					+	+		+			
Diploneis sp 3				+		+	+	+			

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Diploneis sp 4			+								
Diploneis sp 5	+							+			
Diploneis subocularis		+	+			+	+				
Diploneis vacillans var. renitens		+						+			
Diploneis weissflogii				+		+	+				
Donikia sp	+										
Fallacia cf. clypeiformis						+	+				
Fallacia inscriptura							+	+			
Fallacia littoricola		+	+	+		+	+				
Fallacia margino-punctata											
Fallacia nummularia						+					
Fallacia ny.											
Fallacia oculiformis		+	+	+		+	+	+			
Fallacia pygmaea		+	+	+	+	+					
Fallacia shoemaniana		+		+		+	+	+			
Fallacia subforcipata				+	+			+			
Fallacia vittata											
Frustulia rhomboids											
Frustulia sp				+							
Gyrosigma balticum	+										
Gyrosigma distortum				+			+				
Gyrosigma exoticum											
Gyrosigma fasciola											
Gyrosigma hummii				+							
Gyrosigma obtusatum											
Gyrosigma sp 1	+			+			+				
Luticola sp											
Haslea sp				+							
Navicula angusta											
Navicula bipustulata											
Navicula cf. capitatoradiata											
Navicula cf. caterva		+	+	+	+		+	+			
Navicula cf. cryptonella	+			+		+					
Navicula cf. digitoradiata											
Navicula cf.gregaria	+	+		+	+		+				
Navicula cf.phyllepta	+	+	+		+	+		+			

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Navicula crucifera											
Navicula cryptocephala	+		+	+							
Navicula erifuga				+							
Navicula hamiltonii											
Navicula jentzschii				+		+	+	+			
Navicula oblonga						+					
Navicula peregrina	+			+		+	+	+			
Navicula phylleptosoma				+							
Navicula pseudolanceolata				+		+					
Navicula recens						+					
Navicula salinarum var. salinarum											
Navicula sp 1						+	+	+			
Navicula sp 2				+							
Navicula sp 3											
Navicula sp 4											
Navicula sp 5											
Navicula sp 6											
Navicula sp 7	+		+				+	+			
Navicula sp 8			+								
Navicula sp 9											
Navicula sp 10	+		+	+							
Navicula sp 11	+										
Navicula sp 12											
Navicula sp 13											
Navicula sp 14							+				
Navicula sp 15											
Navicula sp 16											
Navicula sp 17	+			+	+		+				
Navicula sp 18	+	+									
Navicula sp 19											
Navicula sp 20											
Navicula sp 21											
Navicula sp 22		+	+	+		+	+	+			
Navicula sp 23				+							
Navicula sp 24							+				
Navicula sp 25				+							
Navicula sp 26				+	+						

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Navicula sp 27				+							
Navicula sp 28				+							
Navicula sp 29											
Navicula sp 30	+										
Navicula sp 31											
Navicula sp 32											
Navicula sp 33								+			
Navicula sp 34											
Navicula sp 35											
Navicula sp 36				+							
Neidium sp 1	+	+	+	+		+					
Neidium sp 2	+										
Neidium sp 3	+										
Neidium sp 4								+			
Oestrupia powelii			+								
Pinnularia sp 1	+	+	+		+	+	+				
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+			
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+			
Plagiogramma pygmaeum	+	+	+	+	+	+	+	+			
Plagiotropis sp 1	+	+		+	+	+	+	+			
Plagiotropis sp 2											
Plagiotropis sp 3											
Plagiotropis sp 4											
Pleurosigma angulatum var. aestuarii				+	+		+				
Pleurosigma australe	+			+		+		+			
Pleurosigma cf. elongatum											
Pleurosigma exoticum											
Pleurosigma delicatum											
Pleurosigma formosum											
Pleurosigma speciosum											
Pleurosigma speciosum var javanica											
Pleurosigma sp 2											
Pleurosigma sp 3											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Pleurosigma sp 4											
Pleurosigma williamsii	+			+		+	+	+			
Pleurosigma sp 1				+							
Sellaphora sp											
Seminavis robusta				+							
Stauroneis sp 1											
Stauroneis sp 2											
Trachyneis aspera						+					
Thalassiophysales											
Amphora albudens		+		+							
Amphora arcus	+										
Amphora arenaria	+	+					+				
Amphora arenicola								+			
Amphora bigibba var capitata						+					
Amphora bigibba var interrupta				+		+	+	+			
Amphora coffeaeformis	+	+		+	+	+	+	+			
Amphora coffeaeformis var aponina	+	+	+	+	+	+	+	+			
Amphora cuneata											
Amphora cymbifera											
Amphora delphinea var. minor											
Amphora eunotia				+							
Amphora gibberula											
Amphora gigantea var fusca	+	+		+		+		+			
Amphora graeffeana	+	+	+	+				+			
Amphora gruendleri											
Amphora hamtata	+			+			+				
Amphora hinzae											
Amphora laevissima	+	+	+	+							
Amphora obtusa							+				
Amphora obtusa var oceanica											
Amphora obtusa var radula			+								
Amphora ocellata	+		+					+			
Amphora ostrearia		+									
Amphora Ostrearia											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
var vitrea											
Amphora ovalis var ovalis	+			+		+					
Amphora ovalis var tenuis	+										
Amphora securicula	+			+			+				
Amphora sp 1	+										
Amphora sp 2				+							
Amphora sp 3											
Amphora sp 4											
Amphora sp 5											
Amphora sp 6											
Amphora sp 7											
Amphora sp 8	+										
Amphora sp 9	+	+	+	+			+	+			
Amphora sp 10	+						+				
Amphora sp 11											
Amphora sp 12											
Amphora sp 13				+							
Amphora sp 14											
Amphora sp 15											
Amphora sp 16											
Amphora sp 17	+	+	+								
Amphora sp 18			+			+					
Amphora sp 19						+					
Amphora sp 20											
Amphora sp 21											
Amphora sp 22											
Amphora sp 23											
Amphora sp 24		+	+	+		+	+	+			
Amphora sp 25											
Amphora sp 26											
Amphora sp 27			+								
Amphora sp 28				+							
Amphora sp 29		+						+			
Amphora sp 30											
Amphora sp 31											
Amphora sp 32											
Amphora sp 33											
Amphora sp 34											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Amphora sp 35											
Amphora sp 36				+							
Amphora sp 37											
Amphora sp 38											
Amphora sp 39					+						
Amphora sp 40	+	+		+			+	+			
Amphora sp 41											
Amphora sp 42											
Amphora sp 43								+			
Amphora sp 44											
Amphora sp 45						+					
Amphora sp 46			+								
Amphora sp 47			+								
Amphora sp 48				+							
Amphora sp 49											
Amphora subtropica	+	+		+	+	+	+	+			
Amphora pseudospectabilis											
Amphora weissflogii							+	+			
Halamphora subcuneata			+	+		+					
Halamphora subholstatica			+			+	+	+			
Hantzschia pseudomarina	+	+	+	+	+	+	+	+			
Bacillariales											
Bacillaria paradoxa	+			+		+	+	+			
Bacillaria sp	+		+	+							
Cylinderotheca sp	+			+			+				
Hantzschia pseudomarina	+	+	+	+	+	+	+	+			
Hantzschia virgata						+					
Hyalosira interrupta							+				
Nitzschia angularis		+	+	+		+	+	+			
Nitzschia aurariae	+					+					
Nitzschia carcinobarica	+			+		+	+				
Nitzschia constricta	+										
Nitzschia diversa											
Nitzschia distans var tumescens											
Nitzschia flumenensis											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Nitzschia fossilis											
Nitzschia frequens											
Nitzschia frustulum			+	+	+		+				
Nitzschia fusiformis											
Nitzschia hadratica											
Nitzschia improvisa						+					
Nitzschia laevis											
Nitzschia liebetruthii			+			+	+	+			
Nitzschia littorea											
Nitzschia marginulata											
Nitzschia microcephla											
Nitzschia miserabilis								+			
Nitzschia nana	+			+							
Nitzschia palea	+	+	+	+			+				
Nitzschia panduriformis	+	+		+			+				
Nitzschia persuadens			+	+		+	+	+			
Nitzschia prolongata var prologata				+	+	+	+	+			
Nitzschia sigma	+			+			+				
Nitzschia sp 1	+			+							
Nitzschia sp 10		+		+							
Nitzschia sp 2		+			+						
Nitzschia sp 3											
Nitzschia sp 4											
Nitzschia sp 5			+		+						
Nitzschia sp 6							+				
Nitzschia sp 7											
Nitzschia *sp 8*		+	+								
Nitzschia *sp 9*											
Nitzschia thermaloides											
Nitzschia virgata var virgata											
Pseudonitzschia pseudodelicatissima			+								
Order Rophalodiales											
Rhopalodia acuminata	+		+	+		+					
Rhopalodia brebissonii											
Rhopalodia constricta											

	C1N	C1S	C1W	C2N	C2S	C2W	C3N	C3W	C4N	C4S	C4W
Rhopalodia musculus	+			+							
Order Surirrellales											
Entomoneis alata	+	+		+							
Entomoneis paludosa				+							
Entomoneis punctulata											
Entomoneis sp 1											
Entomoneis sp 2											
Surirella sp 1											
Surirella sp 2											
Surirella sp 3											

Table 8: Species list for Choctawhatchee Bay in May. C: represents Choctawhatchee Bay; 1, 2, 3, 4: represents site 1, 2, 3 and 4; N, S, W: represents net plankton, sediment and whole water samples.

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Class Coscinodiscophyceae											
Order Thallasiosirales											
Cyclotella sp 1					+	+				+	+
Cyclotella sp 2							+				
Cyclotella sp 3	+	+	+	+			+		+		
Cyclotella sp 4		+		+	+	+		+	+	+	+
Detonula sp											
Porosira sp 1	+		+	+		+			+		+
Skeletonema sp	+						+				
Thalassiosira sp 1	+				+	+				+	+
Thalassiosira sp 2					+					+	
Thalassiosira sp 3											
Thalassiosira sp 4						+					+
Thalassiosira sp 5											
Order Coscinodiscales											
Actinocyclus sp 1			+								
Actinocyclus sp 2	+			+		+	+	+	+		+
Actinocyclus sp 3				+				+	+		
Actinocyclus sp 4											
Actinoptychus senarius	+		+	+				+	+		
Coscinodiscus sp 1							+	+			
Coscinodiscus sp 3				+					+		
Coscinodiscus sp 4	+										
Coscinodiscus sp 5				+		+	+		+		+
Order Melosirales											
Melosira sp											
Order Paraliales											
Paralia sulcata				+	+	+	+	+	+	+	+
Asteriolamprales											
Asteromphalus flabellatus											
Triceratiales											
Auliscus sculptus											

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Dimeregramma cf. marinum											
Dimeregramma minor var minor	+		+	+		+			+		+
Dimeregramma minor var nana			+			+					+
Euphodiscus sp.											
Neohuttonia sp											
Odentella sp 1											
Odentella sp 2											
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma pygmaeum	+	+	+	+	+	+	+	+	+	+	+
Biddulphiales											
Biddulphia sp 1							+				
Biddulphia sp 2											
Order Hemiaulales											
Cerataulina sp				+			+		+		
Eucampia sp											
Hemiaulus sp	+		+	+					+		
Order Anaulales											
Anaulus sp. 1							+				
Anaulus sp. 2						+	+	+			+
Eunotogramma. sp 1				+			+		+		
Eunotogramma. sp 2											
Order Lithmodesmiales											
Lithodesmium undulatum											
Order Corethrales											
Corethron sp											
Order Cymatosirales											
Campylosira cymbelliformis					+	+		+		+	+
Cymatosira belgica			+	+	+	+	+	+	+	+	+
Cymatosira lorenziana	+		+	+	+	+	+		+	+	+
Rhizosolenales											
Rhizosolenia sp			+	+		+	+	+	+		+
Chaetocerotales											
Bacteriastrum sp 1	+		+	+		+			+		+

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Bacteriastrum sp 3				+		+	+	+	+		+
Bacteriastrum sp 2	+										
Chaetoceros affinis	+										
Chaetoceros compressus											
Chaetoceros dichaeta											
Chaetoceros didymus	+										
Chaetoceros eibonii	+			+					+		
Chaetoceros gracilis	+			+	+		+		+	+	
Chaetoceros lorenzianus				+					+		
Chaetoceros peruvianus											
Chaetoceros radicans	+			+			+		+		
Chaetoceros sp 1	+										
Chaetoceros sp 2	+										
Chaetoceros teres	+			+					+		
Class Fragilariophyceae											
Order Fragilariales											
Asterionellopsis glacialis							+				
Fragilaria magocsyi											
Fragillaria sp 1		+	+				+	+			
Fragillaria sp 2						+					+
Fragillaria sp 3						+		+			+
Fragillaria sp 4											
Oepehora mutabilis		+	+		+	+	+	+		+	+
Opephora marina			+			+					+
Ardissonia crystallina	+		+	+					+		
Tabellaria sp											
Tabularia fasciculata			+	+					+		
Tabularia parva	+	+	+								
Tabularia sp			+								
Tabularia sp 1											
Tabularia sp 2											
Taloroneis fulgicerum						+					+
Order Licmophorales											
Licmorphora abbreviata											
Licmorphora oedipus											

Licmorphora cf. paradoxa											
	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Licmorphora paradoxa											
Licmorphora remulus	+										
Order Rhaphoneidales											
Delphineis surirella											
Delphineis surirelloides					+					+	
Delphineis minutissima											
Psammodiscus nitidus							+	+			
Rhaponeis amphiceros	+				+			+		+	
Order Toxariales											
Toxiarum sp											
Thalassionematales											
Thalasionema frauenfeldii	+		+			+	+	+			+
Thalasionema nitzschioides						+					+
Order Rhabdonematales											
Rhabdonema adriaticum	+	+	+	+	+	+	+		+	+	+
Order Striatellales											
Grammatophora angulosa			+	+			+	+	+		
Grammatophora oceanica var macilenta	+	+	+	+	+				+	+	
Striatella unipunctata				+	+				+	+	
Class Bacillariophyceae											
Order Eunotiales											
Eunotia sp 1											
Eunotia sp 2											
Eunotia sp 3											
Eunotia sp 4											
Order Lyrellales											
Lyrella clavata											
Lyrella clavata var. caribbaea											
Lyrella diffluens											
Lyrella hennedyi form 1											
Lyrella hennedyi form granulata											
Lyrella lyra											
*Lyrella lyra var.*1											

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Lyrella sulcifera											
Petroneis humerosa			+								
Petroneis maculata			+								
Petroneis marina	+				+					+	
Mastogloiales											
Mastogloia adriatica											
Mastogloia angusta											
Mastogloia angulata					+					+	
Mastogloia baldjikiana											
Mastogloia bionata				+				+	+		
Mastogloia braunii	+		+								
Mastogloia cf.acutiuscula											
Mastogloia cf. aquilegiae				+					+		
Mastogloia cf. corsciana											
Mastogloia cf. exigua							+				
Mastogloia cf. lineata											
Mastogloia cf. pisciculus	+		+	+					+		
Mastogloia elliptica											
Mastogloia elliptica var dansei	+				+					+	
Mastogloia erythraea type 1											
Mastogloia erythraea type 2			+	+					+		
Mastogloia erythraea type 3											
Mastogloia erythraea type 4	+					+					+
Mastogloia erythraea type 5	+							+			
Mastogloia exigua											
Mastogloia exilis	+										
Mastogloia foliolum			+								
Mastogloia gibbosa											
Mastogloia gracilis	+		+		+	+				+	+
Mastogloia horvathiana											
Mastogloia jelineckii	+		+	+					+		
Mastogloia labuensis			+								
Mastogloia lanceolata	+		+	+					+		

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Mastogloia ovata				+		+			+		+
Mastogloia pumila type 1			+	+		+			+		+
Mastogloia pumila type 2	+		+	+		+			+		+
Mastogloia pumila type 3			+								
Mastogloia pusilla type 1	+		+	+		+			+		+
Mastogloia pusilla type 2											
Mastogloia pusilla var. linearalis											
Mastogloia sp 1											
Mastogloia sp 2						+					+
Mastogloia sp 3											
Mastogloia sp 4											
Mastogloia sp 5											
Mastogloia sp 6											
Mastogloia sp 7				+					+		
Mastogloia sp 8											
Mastogloia sp 9											
Mastogloia sp 10				+		+			+		+
Mastogloia sp 11						+					+
Mastogloia tenussiama							+	+			
Mastogloia vasta											
Order Cymbellales											
Cymbella sp 1											
Cymbella sp 2											
Order Achnanthales											
Achnanthes brevipes											
Achnanthes clevei											
Achnanthes curvirostrum	+		+								
Achnanthes cf. submarina											
Achnanthes brockmannii											
Achnanthes danica	+		+	+		+	+	+	+		+
Achnanthes hauckiana	+	+		+					+		
Achnanthes hauckiana var elliptica				+				+	+		
Achnanthes ingratiformis											

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Achnanthes parvula											
Achnanthes rupestoides		+			+	+	+	+		+	+
Achnanthes sp 1			+	+		+			+		+
Achnanthes sp 2											
Achnanthes sp 3											
Achnanthes sp 4			+								
Achnanthes sp 5											
Achnanthes sp 6											
Achnanthes sp 7		+		+		+			+		+
Achnanthes sp 8											
Achnanthes sp 9											
Achnanthes sp 10											
Achnanthes sp 11				+					+		
Achnanthes sp 12											
Achnanthes sp 13								+			
Achnanthes sp 14	+							+			
Achnanthes sp 15	+										
Achnanthes sp 16						+					+
Achnanthes sp 17	+										
Achnanthes sp 18											
Achnanthes sp 19											
Anorthoneis excentrica	+	+	+	+	+	+	+	+	+	+	+
cocconeiopsis cf. fraudulenta			+	+		+		+	+		+
Cocconeiopsis sp						+		+			+
Cocconeis diminuta	+	+	+	+	+	+	+	+	+	+	+
Cocconeis disculus	+	+	+	+		+			+		+
Cocconeis hetroidea											
Cocconeis latecostata				+				+	+		
Cocconeis pediculus				+					+		
Cocconeis pelta				+				+	+		
Cocconeis peltoides		+	+	+		+	+	+	+		+
Cocconeis pinnata											
Cocconeis placentula	+			+	+		+		+	+	
Cocconeis placentula var lineata											
Cocconeis scutellum var parva	+			+			+	+	+		
Cocconeis scutellum var scutellum	+		+	+	+	+			+	+	+

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Cocconeis schmidtii					+					+	
Cocconeis sp				+				+	+		
Planothidium frequentissimum	+	+		+	+	+	+	+	+	+	+
Planothidium heteromorphum	+		+			+		+			+
Planothidium lanceolatum var australis											
Planothidium lanceolatum var rostratata											
Order Naviculales											
Caloneis amphisbaena											
Caloneis liber	+		+	+					+		
Diploneis aestuari											
Diploneis caffra											
Diploneis didyma											
Diploneis incurvata var dubia											
Diploneis incurvata var incurvata					+					+	
Diploneis notabilis											
Diploneis obliqua										+	
Diploneis parca											
Diploneis smithi											
Diploneis smithi var pumila											
Diploneis smithi var. recta											
Diploneis sp 1											
Diploneis sp 2											
Diploneis sp 3											
Diploneis sp 4											
Diploneis sp 5											
Diploneis subocularis					+					+	
Diploneis vacillana var. renitens											
Diploneis weissflogii											
Donikia sp		+	+	+		+			+		+
Fallacia cf. clypeiformis								+			
Fallacia inscriptura											
Fallacia littoricola											

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Fallacia margino-punctata					+					+	
Fallacia ny.											
Fallacia oculiformis										+	
Fallacia pygmaea					+						
Fallacia shoemaniana											
Fallacia subforcipata					+					+	
Fallacia vittata											
Gyrosigma balticum	+				+					+	
Gyrosigma distortum	+										
Gyrosigma exoticum											
Gyrosigma fasciola			+	+					+		
Gyrosigma hummii											
Gyrosigma obtusatum											
Gyrosigma sp 1											
Haslea sp						+					+
Navicula angusta											
Navicula bipustulata											
Navicula cf. capitatoradiata											
Navicula cf. caterva	+	+		+	+	+	+	+	+	+	+
Navicula cf. cryptonella				+	+	+			+	+	+
Navicula cf. digitoradiata			+								
Navicula cf.gregaria	+	+	+	+	+				+	+	
Navicula cf.phyllepta	+				+	+				+	+
Navicula cryptocephala	+	+						+			
Navicula erifuga		+	+								
Navicula hamiltonii											
Navicula jentzschii				+		+		+	+		+
Navicula oblonga			+								
Navicula peregrina	+		+								
Navicula phylleptosoma											
Navicula pseudolanceolata		+	+	+					+		
Navicula recens			+	+		+		+	+		+
Navicula salinarum var. salinarum											
Navicula sp 1			+					+			
Navicula sp 2											
Navicula sp 3				+		+			+		+

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Navicula sp 4						+	+	+			+
Navicula sp 5											
Navicula sp 6											
Navicula sp 7	+						+				
Navicula sp 8	+		+	+		+			+		+
Navicula sp 9											
Navicula sp 10											
Navicula sp 11								+			
Navicula sp 12				+	+				+	+	
Navicula sp 13							+				
Navicula sp 14											
Navicula sp 15											
Navicula sp 16											
Navicula sp 17							+				
Navicula sp 18											
Navicula sp 19				+					+		
Navicula sp 20		+			+					+	
Navicula sp 21											
Navicula sp 22		+	+		+	+		+		+	+
Navicula sp 23							+	+			
Navicula sp 24											
Navicula sp 25											
Navicula sp 26											
Navicula sp 27			+								
Navicula sp 28								+			
Navicula sp 29											
Navicula sp 30				+					+		
Navicula sp 31											
Navicula sp 32											
Navicula sp 33						+					+
Navicula sp 34						+					+
Navicula sp 35											
Navicula sp 36	+										
Neidium sp 1		+	+	+	+				+	+	
Neidium sp 2								+			
Neidium sp 3			+								
Neidium sp 4	+										
Oestrupia powelii			+								

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Pinnularia sp 1			+			+					+
Plagiogramma cf. antillarum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma cf. rhombicum	+	+	+	+	+	+	+	+	+	+	+
Plagiogramma pygmaeum	+	+	+	+	+	+	+	+	+	+	+
Plagiotropis sp 1	+	+	+	+		+		+	+		+
Plagiotropis sp 2											
Plagiotropis sp 3											
Plagiotropis sp 4		+									
Pleurosigma angulatum var. aestuarii											
Pleurosigma australe		+	+	+					+		
Pleurosigma cf. elongatum											
Pleurosigma delicatum											
Pleurosigma formosum	+										
Pleurosigma speciosum var javanica											
Pleurosigma sp 2											
Pleurosigma sp 3	+										
Pleurosigma sp 4				+			+		+		
Pleurosigma williamsii						+					+
*Pleurosigma.*sp 1											
Sellaphora sp 01											
Seminavis robusta			+								
Trachyneis aspera											
Thalassiophysales											
Amphora albudens	+	+		+	+		+		+	+	
Amphora arcus	+	+	+								
Amphora arenaria			+		+			+		+	
Amphora arenicola			+								
Amphora bigibba				+					+		
Amphora bigibba var capitata											
Amphora bigibba var interrupta											
Amphora coffeaeformis		+	+	+	+	+			+	+	+
Amphora coffeaeformis var aponina			+	+		+	+		+		+
Amphora cuneata											
Amphora cymbifera											

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Amphora delphinea var. minor											
Amphora gigantea var fusca	+		+		+					+	
Amphora graeffeana	+	+	+	+	+	+			+	+	+
Amphora gruendleri											
Amphora hamata							+				
Amphora hinzae											
Amphora laevissima	+	+	+	+	+	+		+	+	+	+
Amphora obtusa	+		+								
Amphora obtusa var oceanica											
Amphora obtusa var radula	+		+								
Amphora ocellata	+		+			+					+
Amphora ostrearia			+								
Amphora Ostrearia var vitrea			+			+					+
Amphora ovalis var ovalis	+		+					+			
Amphora ovalis var tenuis	+		+	+			+		+		
Amphora pseudospecatbilis		+						+			
Amphora securicula				+			+	+	+		
Amphora sp 1											
Amphora sp 2			+								
Amphora sp 3											
Amphora sp 4			+								
Amphora sp 5											
Amphora sp 6			+								
Amphora sp 7											
Amphora sp 8			+								
Amphora sp 9	+					+		+			+
Amphora sp 10	+										
Amphora sp 11			+								
Amphora sp 12	+										
Amphora sp 13											
Amphora sp 14	+										
Amphora sp 15	+		+								
Amphora sp 16											
Amphora sp 17	+			+				+	+		

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Amphora sp 18											
Amphora sp 19				+				+	+		
Amphora sp 20			+								
Amphora sp 21											
Amphora sp 22											
Amphora sp 23											
Amphora sp 24				+				+	+		
Amphora sp 25											
Amphora sp 26											
Amphora sp 27											
Amphora sp 28						+		+			+
Amphora sp 29	+		+			+	+				+
Amphora sp 30											
Amphora sp 31											
Amphora sp 32											
Amphora sp 33	+										
Amphora sp 34	+										
Amphora sp 35											
Amphora sp 36		+									
Amphora sp 37											
Amphora sp 38								+			
Amphora sp 39											
Amphora sp 40	+			+				+	+		
Amphora sp 41											
Amphora sp 42											
Amphora sp 43											
Amphora sp 44											
Amphora sp 45											
Amphora sp 46											
Amphora sp 47											
Amphora sp 48											
Amphora subtropica	+	+	+	+	+	+	+	+	+	+	+
Amphora tegetum						+					+
Amphora weissflogii						+	+	+			+
Halamphora pseudospectabilis											
Halamphora subcuneata			+				+				
Halamphora subholstatica				+					+		

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Hantzschia pseudomarina	+	+	+	+	+	+	+	+	+	+	+
Bacillariales											
Bacillaria paradoxa	+			+					+		
Bacillaria sp											
Cylinderotheca sp						+	+				+
Hantzschia pseudomarina	+	+		+	+	+	+	+	+	+	+
Hantzschia virgata											
Nitzschia angularis	+	+	+	+		+	+	+	+		+
Nitzschia aurariae							+				
Nitzschia capitella	+										
Nitzschia carcinobarica	+		+				+				
Nitzschia constructa											
Nitzschia distans var tumescens											
Nitzschia flumenensis											
Nitzschia fossilis											
Nitzschia frequens											
Nitzschia frustulum					+	+	+			+	+
Nitzschia hadratica											
Nitzschia improvisa											
Nitzschia laevis											
Nitzschia liebetruthii			+								
Nitzschia littorea											
Nitzschia microcephla											
Nitzschia miserabilis											
Nitzschia nana											
Nitzschia palea	+			+					+		
Nitzschia panduriformis			+		+					+	
Nitzschia persuadens			+	+		+	+	+	+		+
Nitzschia prolongata var prologata	+		+	+					+		
Nitzschia sigma	+			+					+		
Nitzschia sp 1											
Nitzschia sp 10			+								
Nitzschia sp 2											
Nitzschia sp 3											
Nitzschia sp 4											
Nitzschia sp 5	+										

	C1 N	C1 S	C1 W	C2 N	C2 S	C2 W	C3 N	C3 W	C4 N	C4 S	C4 W
Nitzschia sp 6	+										
Nitzschia sp 7											
Nitzschia sp 8											
Nitzschia sp 9											
Nitzschia thermaloides											
Nitzschia virgata var virgata											
Pseudonitzschia pseudodelicatissima											
Order Rophalodiales											
Rhopalodia acuminata	+		+	+					+		
Rhopalodia brebissonii			+								
Rhopalodia constricta				+					+		
Rhopalodia musculus											
Order Surirrellales											
Entomoneis alata		+			+					+	
Entomoneis paludosa				+					+		
Entomoneis punctulata											
Entomoneis sp 1											
Surirella sp. 2											
Surirella sp 1											

Appendix B

Statistical Analysis

Friedman test Sediment Collections

Variables: Choc02-S-Sep, Choc01-S-Nov, Choc02-S-Nov, Choc03-S-Nov, Choc04-S-Nov, Choc01-S-Jan, Choc02-S-Jan, Choc04-S-Jan, Choc01-S-Mar, Choc02-S-Mar, Choc04-S-Mar, Choc01-S-May, Choc02-S-May, Choc04-S-May

Mean rank: 7.27, 7.06, 7.54, 6.89, 7.45, 7.52, 8.16, 8.56, 7.16, 7.51, 7.08, 7.92, 6.97, 7.89

Treatment average sum of squares of ranks = 171462.5

Number of blocks = 194

T_1 (chi-square) = 80.821913

df = 13

After Iman & Davenport (1980):

T_2 (F) = 6.389796

$P < 0.0001$

At least one of your sample populations tends to yield larger observations than at least one other sample population.

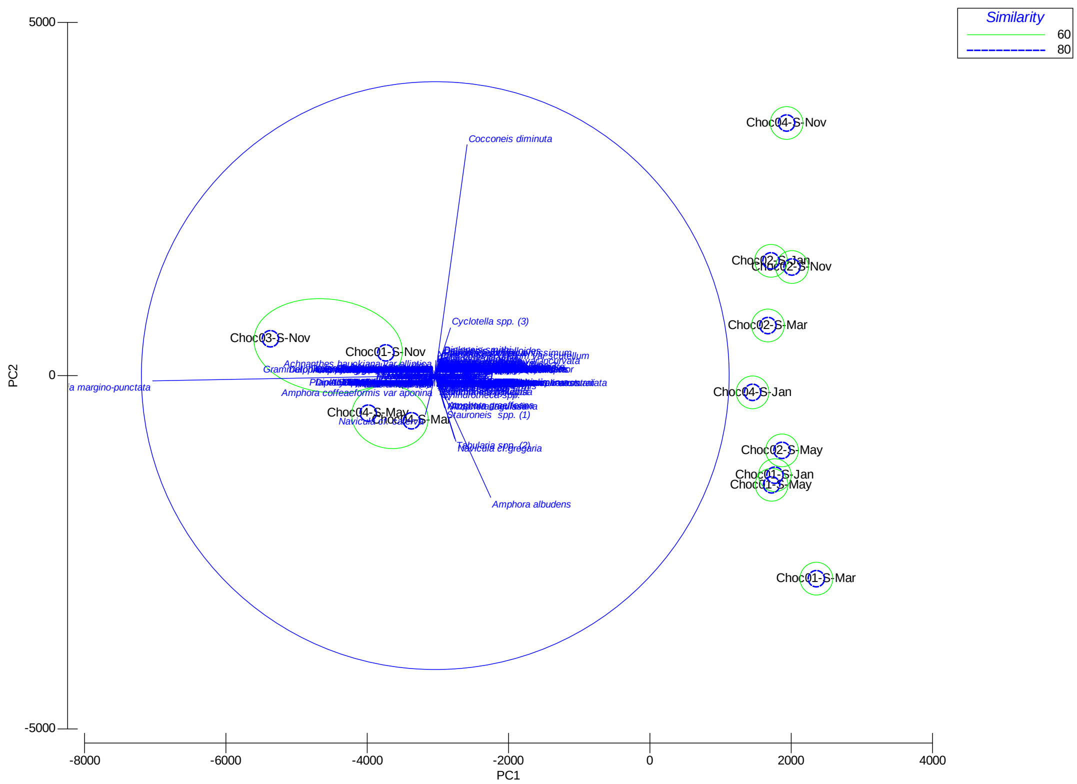
Friedman: all pairwise comparisons (Conover)

Critical t (2509 df) = 1.96091

Choc02-S-Sep vs. Choc02-S-Jan	P = 0.0011
Choc02-S-Sep vs. Choc04-S-Jan	P < 0.0001
Choc02-S-Sep vs. Choc01-S-May	P = 0.0173
Choc01-S-Nov vs. Choc02-S-Jan	P < 0.0001
Choc01-S-Nov vs. Choc04-S-Jan	P < 0.0001
Choc01-S-Nov vs. Choc01-S-May	P = 0.0016
Choc01-S-Nov vs. Choc04-S-May	P = 0.0022
Choc02-S-Nov vs. Choc03-S-Nov	P = 0.0173
Choc02-S-Nov vs. Choc02-S-Jan	P = 0.0228
Choc02-S-Nov vs. Choc04-S-Jan	P = 0.0002
Choc02-S-Nov vs. Choc02-S-May	P = 0.0359
Choc03-S-Nov vs. Choc04-S-Nov	P = 0.0413
Choc03-S-Nov vs. Choc01-S-Jan	P = 0.0212
Choc03-S-Nov vs. Choc02-S-Jan	P < 0.0001
Choc03-S-Nov vs. Choc04-S-Jan	P < 0.0001
Choc03-S-Nov vs. Choc02-S-Mar	P = 0.0234
Choc03-S-Nov vs. Choc01-S-May	P = 0.0002
Choc03-S-Nov vs. Choc04-S-May	P = 0.0003
Choc04-S-Nov vs. Choc02-S-Jan	P = 0.0089
Choc04-S-Nov vs. Choc04-S-Jan	P < 0.0001
Choc01-S-Jan vs. Choc02-S-Jan	P = 0.0187
Choc01-S-Jan vs. Choc04-S-Jan	P = 0.0001
Choc01-S-Jan vs. Choc02-S-May	P = 0.0432
Choc02-S-Jan vs. Choc01-S-Mar	P = 0.0002
Choc02-S-Jan vs. Choc02-S-Mar	P = 0.0168
Choc02-S-Jan vs. Choc04-S-Mar	P < 0.0001
Choc02-S-Jan vs. Choc02-S-May	P < 0.0001
Choc04-S-Jan vs. Choc01-S-Mar	P < 0.0001
Choc04-S-Jan vs. Choc02-S-Mar	P = 0.0001
Choc04-S-Jan vs. Choc04-S-Mar	P < 0.0001
Choc04-S-Jan vs. Choc01-S-May	P = 0.0191
Choc04-S-Jan vs. Choc02-S-May	P < 0.0001
Choc04-S-Jan vs. Choc04-S-May	P = 0.0144
Choc01-S-Mar vs. Choc01-S-May	P = 0.0055
Choc01-S-Mar vs. Choc04-S-May	P = 0.0075
Choc02-S-Mar vs. Choc02-S-May	P = 0.0472
Choc04-S-Mar vs. Choc01-S-May	P = 0.002
Choc04-S-Mar vs. Choc04-S-May	P = 0.0028
Choc01-S-May vs. Choc02-S-May	P = 0.0005
Choc02-S-May vs. Choc04-S-May	P = 0.0007

PCA

Principal Component Analysis



Data worksheet

Name: Data1

Data type: Other

Sample selection: All

Variable selection: All

Eigenvalues			
PC	Eigenvalues	%Variation	Cum.%Variation
1	8.41E+06	55.5	55.5
2	2.76E+06	18.3	73.8
3	1.21E+06	8	81.7
4	8.95E+05	5.9	87.7
5	5.84E+05	3.9	91.5
6	4.05E+05	2.7	94.2
7	3.43E+05	2.3	96.5
8	2.23E+05	1.5	97.9
9	1.36E+05	0.9	98.8
10	1.02E+05	0.7	99.5

Eigenvectors

(Coefficients in the linear combinations of variables making up PC's)

Variable	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**	**PC8**	**PC9**	**PC10**
Achnanthes clevei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes curvirostrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes danica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes hauckiana var elliptica	0.0	0.0	0.0	0.0	0.4	-0.1	0.2	-0.2	0.0	0.0
Achnanthes rupestoides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes sp.(13)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
(11)										
Achnanthes spp. (14)	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1	0.0
Achnanthes spp. (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.2	-0.1
Achnanthes spp. (7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2
Actinoptychus senarius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora albudens	0.2	-0.4	0.6	0.0	-0.2	0.1	0.4	-0.2	0.1	-0.1
Amphora arenaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora bigibba var interrupta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora coeffaeformis	0.0	0.0	0.0	0.0	0.0	0.2	-0.1	0.2	0.1	-0.1
Amphora coffeaeformis var aponina	0.0	0.0	0.0	0.1	0.1	0.2	-0.1	0.3	0.2	0.2
Amphora cymbifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora gigantea var fusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora graeffeana	0.0	-0.1	-0.1	-0.5	-0.2	0.0	0.0	0.0	0.0	0.0
Amphora laevissima	0.0	-0.1	-0.2	-0.6	-0.3	0.0	0.0	0.0	0.0	0.1
Amphora ocellata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora ostrearia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora ovalis var tenuis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora pseudospectabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora securicula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (13)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (24)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Amphora spp. (35)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (37)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Amphora spp. (8)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora subtropica	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.2
Anorthoneis excentrica	0.0	0.0	-0.1	-0.2	0.2	0.0	0.3	0.1	0.3	0.1
Asterionellaopsis glacialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bacillaria paradoxa	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	0.0	0.2	-0.2
Bacillaria spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1
Bacteriastrum spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biddulphia spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Campylosira cymbelliformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cerataulina spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros affinis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros gracilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros radicans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeiopsis cf. *fraudulenta*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0
Cocconeis diminuta	0.1	0.8	0.4	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.2
Cocconeis placentula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis scutellum var *parva*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis scutellum var scutellum	0.0	0.0	-0.1	0.1	-0.2	0.0	0.1	0.0	0.1	-0.2
Cocconeis spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella sp. (1)	0.0	0.0	-0.1	0.1	0.0	0.0	0.1	0.0	-0.3	-0.1
Cyclotella spp. (3)	0.1	0.2	0.1	0.0	-0.2	0.1	-0.2	-0.3	0.4	-0.3
Cyclotella spp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cylindrotheca spp.	0.0	0.0	0.0	0.0	0.0	0.2	-0.1	0.1	0.0	0.2
Cymatosira belgica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatosira lorenziana	0.0	0.0	-0.1	0.1	0.0	0.0	0.0	-0.2	0.0	0.0
Delphineis incurvata var	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
incurvata										
Delphineis surirella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delphineis surirelloides	0.0	0.1	-0.2	0.2	-0.2	-0.1	0.1	-0.1	0.0	0.3
Dimeregramma minor var *minor*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis didyma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis incurvata var *dubia*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis incurvata var *incurvata*	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	-0.3
Diploneis notabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis obliqua	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis smithi	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2
Diploneis smithi var pumilla	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis spp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis spp. (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis subocularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis vacillans var *renitens*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Donkinia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entomoneis alata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Entomoneis paludosa	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2	0.1	0.1	0.0
Entomoneis punctulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunotogramma spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallacia cf. *clypeiformis*	0.0	0.0	-0.4	0.4	-0.4	0.0	0.3	0.0	0.2	0.1
Fallacia littoricola	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1	0.0
Fallacia margino-punctata	-1.0	0.0	0.2	0.0	-0.1	0.0	0.1	0.0	0.0	0.0
Fallacia oculiformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Fallacia pygmaea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Fallacia shoemaniana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Fallacia subforcipata	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1
Fragilaria sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Fragilaria sp. (2)	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.1
Fragilaria sp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grammatophora angulosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grammatophora oceanica var *macilenta*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma balticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma distortum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma fasciola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hantzschia pseudomarina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyalosira interrupta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Licmophora abbreviata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Licmorphora oedipus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Licmorphora remulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella clavata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella henndeyi form 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella sulcifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastoglia erythraea type 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia angulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia elliptica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia elliptica var *dansei*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia erythraea type 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia erythraea type 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.2
Mastogloia exilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia gracilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia jelineckii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Mastogloia labuensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia lanceolata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pumila type 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pumila type 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pusilla type 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pusilla type 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia vasta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Melosira spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cf. *capitatoradiata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cf. caterva	0.0	-0.1	-0.1	-0.1	0.3	0.0	-0.3	-0.6	0.0	0.1
Navicula cf.cryptonella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Navicula cf.gregaria	0.1	-0.2	0.1	-0.1	-0.1	-0.2	-0.1	0.1	-0.1	0.2
Navicula cf.phyllepta	0.0	0.0	0.0	0.0	0.0	0.2	-0.1	0.0	0.0	0.1
Navicula hamiltonii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.3	-0.1
Navicula jentzschii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula phylleptosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula pseudolanceolata	0.0	0.0	0.0	0.0	0.0	0.2	-0.1	0.0	-0.1	0.0
Navicula salinarum var. *salinarum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (22)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (23)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (27)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (36)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (8)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (12)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (13)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Navicula spp. (17)	0.0	0.1	0.1	0.0	-0.1	0.1	-0.1	0.0	0.1	0.0
Navicula spp. (20)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (22)	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	-0.3	-0.1	0.1
Navicula spp. (23)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (28)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (29)	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.1	0.3	0.1
Navicula spp. (30)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neidium sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia angularia	0.0	-0.1	0.1	0.1	0.0	0.6	-0.1	0.1	-0.1	0.2
Nitzschia aurariae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Nitzschia carcinobarica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia fluminensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Nitzschia fossilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia frustulum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Nitzschia leibetruthii	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
Nitzschia littorea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia palea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia panduriformis	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia persuadens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia rorida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia sigma	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1	0.0
Nitzschia spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Nitzschia spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia spp. (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0
Odontella spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opephora mutabilis	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	-0.1	-0.2
Paralia sulcata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroneis marina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagiotropis spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagiotropis spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Planothidium frequentissimum	0.0	0.1	-0.1	0.0	0.3	-0.1	0.3	0.2	-0.1	0.0
Planothidium heteromorphum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planothidium lanceolatum var *rostratata*	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.0
Pleurosigma angulatum var *aestuarii*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma australe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma formosum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porosira spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhabdonema adriatica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Rhaponeis amphiceros	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhopalodia acuminata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhopalodia musculus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sellaphora spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skeletonema spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stauroneis spp. (1)	0.0	-0.1	0.2	0.1	-0.1	0.0	0.2	-0.1	-0.1	0.2
Stauroneis spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Striatella unipunctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Surirella spp. (1)	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1	0.0
Tabularia fasciculata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tabularia parva	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tabularia spp. (2)	0.1	-0.2	0.2	0.2	0.0	-0.5	-0.2	0.2	0.1	0.2
Thalassionema frauenfeldii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Thalassiosira sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Thalassiosira spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toxarium undulatum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.2	-0.1

Principal Component Scores										
Sample	Score1	Score2	Score3	Score4	Score5	Score6	Score7	Score8	Score9	Score10
Choc01-S-Nov	-3740.0	322.0	-30.5	231.0	-411.0	172.0	115.0	606.0	291.0	18.7
Choc02-S-Nov	2010.0	1540.0	1090.0	72.1	-378.0	364.0	-108.0	-234.0	396.0	-823.0
Choc03-S-Nov	-5370.0	522.0	700.0	-98.9	-320.0	-18.4	197.0	419.0	-10.3	70.9
Choc04-S-Nov	1930.0	3580.0	693.0	84.2	-618.0	-219.0	-341.0	-404.0	62.5	608.0
Choc01-S-Jan	1770.0	-1410.0	146.0	375.0	328.0	1790.0	-547.0	155.0	-69.9	246.0
Choc02-S-Jan	1710.0	1630.0	-105.0	11.3	628.0	-175.0	84.9	432.0	-999.0	-239.0
Choc04-S-Jan	1450.0	-236.0	-2650.0	1500.0	-955.0	-81.1	427.0	-109.0	25.5	-53.6
Choc01-S-Mar	2350.0	-2870.0	2000.0	568.0	-516.0	-424.0	859.0	-218.0	-164.0	136.0
Choc02-S-Mar	1670.0	709.0	-434.0	-297.0	1750.0	-110.0	958.0	181.0	504.0	141.0
Choc04-S-Mar	-3380.0	-639.0	-447.0	-70.9	831.0	-60.5	-288.0	-1190.0	-125.0	-61.4
Choc01-S-May	1720.0	-1550.0	-6.2	481.0	460.0	-1090.0	-1310.0	424.0	244.0	-6.8
Choc02-S-May	1870.0	-1060.0	-931.0	-2760.0	-759.0	-44.0	3.2	23.7	0.8	14.4
Choc04-S-May	-3990.0	-531.0	-33.2	-101.0	-39.7	-106.0	-53.8	-82.0	-154.0	-51.1

MDS on Sediments

Data worksheet

Name: Data1

Data type: Other

Sample selection: All

Variable selection: All

Parameters

Analyse between: Samples

Resemblance measure: S17 Bray Curtis similarity

	Choc 01-S-Nov	Choc 02-S-Nov	Choc 03-S-Nov	Choc 04-S-Nov	Choc 01-S-Jan	Choc 02-S-Jan	Choc 04-S-Jan	Choc 01-S-Mar	Choc 02-S-Mar	Choc 04-S-Mar	Choc 01-S-May	Choc 02-S-May
Choc02-S-Nov	20.69											
Choc03-S-Nov	69.31	21.21										
Choc04-S-Nov	19.33	49.86	17.46									
Choc01-S-Jan	13.29	30.62	7.37	8.45								
Choc02-S-Jan	17.74	47.36	19.95	34.81	12.43							
Choc04-S-Jan	14.99	8.68	5.25	20.94	6.19	19.21						
Choc01-S-Mar	2.70	18.23	4.39	2.43	35.01	9.73	7.45					
Choc02-S-Mar	19.31	30.52	19.64	18.77	16.11	39.96	9.12	12.82				
Choc04-S-Mar	52.33	2.51	51.68	7.05	8.15	9.38	10.00	5.56	18.78			
Choc01-S-May	9.41	20.88	6.66	2.68	32.10	10.03	7.25	44.42	18.04	11.82		
Choc02-S-	11.53	25.12	6.97	12.06	28.02	18.38	8.36	26.15	29.57	10.52	28.81	

May												
Choc04-S-May	61.13	9.09	60.97	10.40	14.70	16.68	16.76	11.44	15.54	62.84	16.47	21.56

CLUSTER

Hierarchical Cluster analysis

Resemblance worksheet

Name: Resem1

Data type: Similarity

Selection: All

Samples

1 Choc01-S-Nov

2 Choc02-S-Nov

3 Choc03-S-Nov

4 Choc04-S-Nov

5 Choc01-S-Jan

6 Choc02-S-Jan

7 Choc04-S-Jan

8 Choc01-S-Mar

9 Choc02-S-Mar

10 Choc04-S-Mar

11 Choc01-S-May

12 Choc02-S-May

13 Choc04-S-May

Parameters

Cluster mode: Group average

Combining

1+3 -> 14 at 69.31

10+13 -> 15 at 62.84

14+15 -> 16 at 56.53

2+4 -> 17 at 49.86

8+11 -> 18 at 44.42

6+17 -> 19 at 41.09

5+18 -> 20 at 33.56

9+19 -> 21 at 29.75

12+20 -> 22 at 27.66

21+22 -> 23 at 15.47

16+23 -> 24 at 12.73

7+24 -> 25 at 11.18

MDS

Non-metric Multi-Dimensional Scaling

Resemblance worksheet

Name: Resem1

Data type: Similarity

Selection: All

Parameters

Kruskal stress formula: 1

Minimum stress: 0.01

Best 3-d configuration (Stress: 0.07)

Sample	1	2	3	%
Choc01-S-Nov	-0.85	0.25	0.02	3.8
Choc02-S-Nov	0.37	-0.7	-0.09	13.2
Choc03-S-Nov	-0.95	0.24	-0.25	9
Choc04-S-Nov	-0.25	-1.06	0.21	8
Choc01-S-Jan	0.96	0.11	0.16	10.9
Choc02-S-Jan	-0.14	-0.85	-0.25	8.3
Choc04-S-Jan	-0.33	-0.25	1.22	17.2
Choc01-S-Mar	0.98	0.52	0.41	4.7
Choc02-S-Mar	0.1	-0.37	-0.74	11.1
Choc04-S-Mar	-0.79	0.73	-0.18	2.3
Choc01-S-May	0.82	0.65	-0.01	2.3
Choc02-S-May	0.72	0.13	-0.51	7
Choc04-S-May	-0.64	0.59	0.01	2.1

Best 2-d configuration (Stress: 0.14)

Sample	1	2	%
Choc01-S-Nov	-0.73	-0.41	4.8
Choc02-S-Nov	0.33	0.62	7.1
Choc03-S-Nov	-0.89	-0.6	15.5
Choc04-S-Nov	-0.32	1.06	7.9
Choc01-S-Jan	1.07	0.19	8.1
Choc02-S-Jan	-0.21	0.65	2.5
Choc04-S-Jan	-1.2	0.79	22.4
Choc01-S-Mar	1.28	-0.22	7.6
Choc02-S-Mar	0.08	0.2	9.5
Choc04-S-Mar	-0.7	-0.98	1.7
Choc01-S-May	0.97	-0.53	4.9
Choc02-S-May	0.78	-0.05	3.5
Choc04-S-May	-0.45	-0.7	4.5

STRESS VALUES		
Repeat	3D	2D
1	0.07	0.17
2	0.07	0.17
3	0.07	0.2
4	0.11	0.2
5	0.07	0.17
6	0.07	0.14
7	0.07	0.15
8	0.19	0.17
9	0.08	0.14
10	0.08	0.2
11	0.09	0.17
12	0.07	0.14
13	0.07	0.14
14	0.08	0.14
15	0.16	0.15
16	0.07	0.2
17	0.07	0.14
18	0.07	0.14
19	0.07	0.17
20	0.07	0.14
21	0.08	0.15
22	0.07	0.17
23	0.07	0.14
24	0.08	0.18
25	0.08	0.14

** = Maximum number of iterations used

3-d : Minimum stress: 0.07 occurred 15 times

2-d : Minimum stress: 0.14 occurred 10 times

Plankton Net Samples

Friedman test

Variables: Choc01-N-Sep, Choc02-N-Sep, Choc01-N-Nov, Choc02-N-Nov, Choc03-N-Nov, Choc04-N-Nov, Choc01-N-Jan, Choc02-N-Jan, Choc03-N-Jan, Choc04-N-Jan, Choc01-N-Mar, Choc02-N-Mar, Choc03-N-Mar, Choc04-N-Mar, Choc01-N-May, Choc02-N-May, Choc03-N-May, Choc04-N-May

Mean rank: 9.48, 9.67, 9.47, 9.29, 9.84, 9.65, 9.81, 9.6, 9.63, 9.05, 9.11, 9.45, 9.71, 8.84, 9.62, 10.24, 9.42, 9.12

Treatment average sum of squares of ranks = 485532.5

Number of blocks = 266

T_1 (chi-square) = 42.647752

df = 17

After Iman & Davenport (1980):

T_2 (F) = 2.523055

P = 0.0005

At least one of your sample populations tends to yield larger observations than at least one other sample population.

Friedman: all pairwise comparisons (Conover)

Critical t (4505 df) = 1.960491

Choc01-N-Sep vs. Choc04-N-Mar	P = 0.0321
Choc01-N-Sep vs. Choc02-N-May	P = 0.0106
Choc02-N-Sep vs. Choc04-N-Jan	P = 0.0369
Choc02-N-Sep vs. Choc04-N-Mar	P = 0.0056
Choc01-N-Nov vs. Choc04-N-Mar	P = 0.0347
Choc01-N-Nov vs. Choc02-N-May	P = 0.0097
Choc02-N-Nov vs. Choc02-N-May	P = 0.0013
Choc03-N-Nov vs. Choc04-N-Jan	P = 0.0076
Choc03-N-Nov vs. Choc01-N-Mar	P = 0.0134
Choc03-N-Nov vs. Choc04-N-Mar	P = 0.0008
Choc03-N-Nov vs. Choc04-N-May	P = 0.0152
Choc04-N-Nov vs. Choc04-N-Jan	P = 0.0424
Choc04-N-Nov vs. Choc04-N-Mar	P = 0.0067
Choc04-N-Nov vs. Choc02-N-May	P = 0.0471
Choc01-N-Jan vs. Choc04-N-Jan	P = 0.0099
Choc01-N-Jan vs. Choc01-N-Mar	P = 0.0171
Choc01-N-Jan vs. Choc04-N-Mar	P = 0.0011
Choc01-N-Jan vs. Choc04-N-May	P = 0.0193
Choc02-N-Jan vs. Choc04-N-Mar	P = 0.0108
Choc02-N-Jan vs. Choc02-N-May	P = 0.0316
Choc03-N-Jan vs. Choc04-N-Jan	P = 0.0492
Choc03-N-Jan vs. Choc04-N-Mar	P = 0.0081
Choc03-N-Jan vs. Choc02-N-May	P = 0.0405
Choc04-N-Jan vs. Choc03-N-Mar	P = 0.0252
Choc04-N-Jan vs. Choc02-N-May	P < 0.0001
Choc01-N-Mar vs. Choc03-N-Mar	P = 0.0411
Choc01-N-Mar vs. Choc02-N-May	P = 0.0001
Choc02-N-Mar vs. Choc04-N-Mar	P = 0.0411
Choc02-N-Mar vs. Choc02-N-May	P = 0.0079
Choc03-N-Mar vs. Choc04-N-Mar	P = 0.0035
Choc03-N-Mar vs. Choc04-N-May	P = 0.0457
Choc04-N-Mar vs. Choc01-N-May	P = 0.009
Choc04-N-Mar vs. Choc02-N-May	P < 0.0001
Choc01-N-May vs. Choc02-N-May	P = 0.0369
Choc02-N-May vs. Choc03-N-May	P = 0.0056
Choc02-N-May vs. Choc04-N-May	P = 0.0002

Data worksheet

Name: Data2

Data type: Other

Sample selection: All

Variable selection: All

Parameters

Analyse between: Samples

Resemblance measure: S17 Bray Curtis similarity

	Choc01-N-Sep	Choc02-N-Sep	Choc01-N-Nov	Choc02-N-Nov	Choc03-N-Nov	Choc04-N-Nov	Choc01-N-Jan	Choc02-N-Jan	Choc03-N-Jan	Choc04-N-Jan	Choc01-N-Mar	Choc02-N-Mar	Choc03-N-Mar	Choc04-N-Mar	Choc01-N-May	Choc02-N-May	Choc03-N-May
Choc02-N-Sep	19.72																
Choc01-N-Nov	27.91	22.95															
Choc02-N-Nov	13.15	28.97	51.33														
Choc03-N-Nov	29.80	36.65	36.23	28.82													
Choc04-N-Nov	12.51	6.27	12.69	10.42	8.98												

Choc04-N-May	Choc03-N-May	Choc02-N-May	Choc01-N-May	Choc04-N-Mar	Choc03-N-Mar	Choc02-N-Mar	Choc01-N-Mar	Choc04-N-Jan	Choc03-N-Jan	Choc02-N-Jan	Choc01-N-Jan
6.78	13.26	18.16	15.45	6.35	13.88	14.61	7.81	8.69	10.51	20.08	17.30
6.63	31.05	28.90	14.03	2.71	24.29	33.38	7.69	7.39	22.02	25.56	17.13
5.36	25.42	30.15	40.15	11.94	28.46	32.66	15.29	15.80	28.40	43.39	35.07
4.45	39.02	41.65	32.08	7.45	25.80	30.43	13.65	8.55	25.42	38.64	28.24
3.49	38.27	40.08	20.32	6.09	43.78	41.54	8.29	8.28	32.09	39.79	22.26
20.87	9.79	10.21	10.33	19.25	8.25	11.89	7.96	11.34	7.70	7.59	10.08
6.38	22.08	19.52	27.47	19.65	23.09	26.83	44.58	43.48	11.31	60.65	
3.43	39.04	37.49	32.98	19.66	40.91	44.87	41.55	41.05	28.32		
2.23	35.87	29.40	42.22	4.35	27.62	33.36	5.46	8.99			
12.72	11.00	9.43	22.45	45.94	14.31	16.00	36.31				
3.53	11.51	12.41	24.30	22.66	18.97	22.73					
15.12	47.46	41.89	27.75	19.98	52.98						
6.06	42.54	38.58	25.32	14.31							
20.30	11.87	9.45	16.42								
6.88	20.12	27.17									
6.45	57.77										
8.34											

MDS

Non-metric Multi-Dimensional Scaling

Resemblance worksheet

Name: Resem2

Data type: Similarity

Selection: All

Parameters

Kruskal stress formula: 1

Minimum stress: 0.01

Best 3-d configuration (Stress: 0.1)

Sample	1	2	3	%
Choc01-N-Sep	-0.24	-0.63	-1.02	4.6
Choc02-N-Sep	-0.7	-0.74	0.12	6.6
Choc01-N-Nov	-0.41	0.07	-0.41	2.8
Choc02-N-Nov	-0.73	0.15	-0.18	6.6
Choc03-N-Nov	-0.65	-0.38	-0.26	6.8
Choc04-N-Nov	1.14	-0.97	-0.4	9.7
Choc01-N-Jan	0.18	0.53	-0.43	3.3
Choc02-N-Jan	-0.09	0.34	-0.11	11
Choc03-N-Jan	-0.95	0.18	0.49	11.1
Choc04-N-Jan	0.96	0.68	-0.19	4.2
Choc01-N-Mar	0.51	1.1	-0.12	3.9
Choc02-N-Mar	-0.1	-0.09	0.3	3.3
Choc03-N-Mar	-0.22	0.13	0.52	6.3
Choc04-N-Mar	1.27	0.28	0.23	0.7
Choc01-N-May	-0.29	0.7	0.1	7.4
Choc02-N-May	-0.65	-0.21	0.3	4
Choc03-N-May	-0.41	-0.3	0.43	2.8
Choc04-N-May	1.37	-0.85	0.63	5

Best 2-d configuration (Stress: 0.14)

Sample	1	2	%
Choc01-N-Sep	0.16	-1.2	6.3
Choc02-N-Sep	0.89	-0.55	6.9
Choc01-N-Nov	0.21	-0.27	5.2
Choc02-N-Nov	0.72	0.28	6.4
Choc03-N-Nov	0.59	-0.47	4.7
Choc04-N-Nov	-1.17	-1.13	4.8
Choc01-N-Jan	-0.2	0.56	5.3
Choc02-N-Jan	0.1	0.35	9.8
Choc03-N-Jan	1.09	0.17	8.4
Choc04-N-Jan	-0.99	0.73	4.6
Choc01-N-Mar	-0.54	1.11	3.4
Choc02-N-Mar	0.15	0.04	5.9
Choc03-N-Mar	0.36	0.15	3.7
Choc04-N-Mar	-1.31	0.35	2
Choc01-N-May	0.26	0.66	6
Choc02-N-May	0.76	-0.1	3.7
Choc03-N-May	0.63	-0.06	4.8
Choc04-N-May	-1.71	-0.61	8.1

STRESS VALUES		
Repeat	3D	2D
1	0.1	0.14
2	0.1 **	0.16
3	0.1	0.15
4	0.1	0.19
5	0.1	0.16
6	0.1	0.14
7	0.1	0.16
8	0.1	0.15
9	0.1	0.14
10	0.12	0.16
11	0.1	0.16
12	0.11	0.14
13	0.1	0.15
14	0.11	0.15
15	0.1	0.16
16	0.1	0.14
17	0.11	0.15

18	0.1	0.16
19	0.1	0.15
20	0.1	0.19
21	0.1	0.15
22	0.12	0.14
23	0.1	0.15
24	0.1	0.15
25	0.11	0.14

** = Maximum number of iterations used

3-d : Minimum stress: 0.1 occurred 19 times

2-d : Minimum stress: 0.14 occurred 7 times

CLUSTER

Hierarchical Cluster analysis

Resemblance worksheet

Name: Resem2

Data type: Similarity

Selection: All

Samples

1 Choc01-N-Sep

2 Choc02-N-Sep

3 Choc01-N-Nov

4 Choc02-N-Nov

5 Choc03-N-Nov

6 Choc04-N-Nov

7 Choc01-N-Jan

8 Choc02-N-Jan

9 Choc03-N-Jan

10 Choc04-N-Jan

11 Choc01-N-Mar

12 Choc02-N-Mar

13 Choc03-N-Mar

14 Choc04-N-Mar

15 Choc01-N-May

16 Choc02-N-May

17 Choc03-N-May

18 Choc04-N-May

Parameters

Cluster mode: Group average

Combining

7+8 -> 19 at 60.65

16+17 -> 20 at 57.77

12+13 -> 21 at 52.98

3+4 -> 22 at 51.33

10+14 -> 23 at 45.94

11+19 -> 24 at 43.07

5+21 -> 25 at 42.66

9+15 -> 26 at 42.22

20+25 -> 27 at 41.47

22+27 -> 28 at 31.87

23+24 -> 29 at 30.47

2+28 -> 30 at 29.46

26+30 -> 31 at 27.57

6+18 -> 32 at 20.87

29+31 -> 33 at 19.42

1+33 -> 34 at 15.78

32+34 -> 35 at 8.86

PCA

Principal Component Analysis

Data worksheet

Name: Data2

Data type: Other

Sample selection: All

Variable selection: All

Eigenvalues			
PC	Eigenvalues	%Variation	Cum.%Variation
1	3.16E+06	39.4	39.4
2	1.04E+06	13	52.4
3	8.79E+05	11	63.4
4	5.96E+05	7.4	70.8
5	5.33E+05	6.6	77.4
6	4.46E+05	5.6	83
7	3.70E+05	4.6	87.6
8	3.06E+05	3.8	91.4
9	1.96E+05	2.4	93.9
10	1.53E+05	1.9	95.8

Eigenvectors

(Coefficients in the linear combinations of variables making up PC's)

Variable	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**	**PC8**	**PC9**	**PC10**
Achnanthes cf. *submarina*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes clevei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes curvirostrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes cymbifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes danica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes hauckiana var *elliptica*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Achnanthes sp.(13)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes spp. (11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes spp. (14)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes spp. (6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes spp. (7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actinocyclus spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actinocyclus spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actinocyclus spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actinoptychus senarius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphitetras spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora albudens	0.0	-0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora arcus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora arenaria	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Amphora bigibba var *interrupta*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora coeffaeformis	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Amphora coffeaeformis var *aponina*	0.0	-0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.0
Amphora cymbifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora gigantea var fusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora graeffeana	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	0.1	0.1
Amphora laevissima	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Amphora ocellata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora ostrearia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora ovalis var *ovalis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora ovalis var *tenuis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora pseudospectabilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora securicula	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Amphora spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (12)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (16)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (24)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Amphora spp. (32)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (33)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (37)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (38)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (39)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (40)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (49)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (7)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Amphora spp. (8)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora spp. (9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphora subtropica	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Anaulus spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anorthoneis excentrica	0.0	0.0	-0.1	0.0	0.0	0.1	0.0	-0.1	0.0	0.0
Asterionellaopsis glacialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Asteromphalus spp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bacillaria paradoxa	0.0	-0.1	0.1	0.1	0.1	0.0	-0.2	0.1	-0.1	0.0
Bacillaria spp.	0.0	-0.1	0.0	0.1	0.1	0.0	-0.1	0.0	0.0	0.0
Bacteriastrum spp. (1)	0.0	0.1	0.0	0.0	-0.1	0.0	0.0	0.1	-0.1	0.0
Bacteriastrum spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bacteriastrum spp. (3)	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.1	0.1
Biddulphia spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biddulphia spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Caloneis liber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Campylosira cymbelliformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Cerataulina spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceroas affinis	0.1	-0.1	0.1	-0.2	-0.1	-0.1	0.0	0.2	0.0	-0.6
Chaetoceros compressus	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.3
Chaetoceros didyma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros ebenii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros eibonii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros gracilis	1.0	0.2	-0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Chaetoceros lorenzianus	-0.1	0.3	0.4	0.0	0.1	-0.1	0.0	-0.3	0.2	-0.1
Chaetoceros radicans	-0.1	0.5	0.5	0.0	0.2	0.0	0.0	0.2	-0.1	0.1
Chaetoceros spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros teres	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis diminuta	-0.1	0.2	-0.2	0.0	-0.1	-0.1	-0.1	0.2	-0.1	-0.1
Cocconeis disculus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis pelta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis pinnata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis placentula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis schmidtii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis scutellum var *scutellum*	-0.1	0.2	-0.3	0.0	-0.2	-0.2	0.0	0.5	0.4	0.2
Coscinodiscus spp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coscinodiscus spp. (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coscinodiscus spp. (6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella sp. (1)	0.0	0.1	-0.1	-0.1	-0.1	0.3	-0.2	0.1	-0.6	0.1
Cyclotella spp. (3)	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0
Cyclotella spp. (4)	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.1	0.2	0.0
Cylindrotheca	0.0	-0.1	0.0	0.1	0.1	0.0	-0.1	0.0	0.0	0.0
Cylindrotheca spp.	0.0	-0.3	0.1	0.1	0.1	0.1	0.7	0.1	-0.1	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Cymatosira belgica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymatosira lorenziana	-0.1	0.1	-0.1	0.0	0.0	-0.2	0.0	-0.2	0.0	0.0
Delphineis minutissima	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delphineis surirella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delphineis surirelloides	-0.1	0.1	-0.2	0.1	-0.4	-0.3	0.0	-0.3	-0.3	0.0
Detonula spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Dimeregramma minor var *minor*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis caffra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis didyma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis incurvata var *dubia*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis incurvata var *incurvata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis obliqua	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Diploneis smithi	0.0	0.0	0.0	0.0	-0.2	0.5	-0.1	-0.2	0.2	-0.1
Diploneis spp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Diploneis spp. (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis subocularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diploneis weissflogii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Donkinia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entomoneis alata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entomoneis paludosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entomoneis punctulata	0.0	-0.1	0.1	-0.2	-0.1	0.0	0.0	0.0	0.0	-0.3
Eucampia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eunotogramma spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallacia cf. *clypeiformis*	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Fallacia clypeiformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallacia littoricola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallacia margino-punctata	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	0.0	0.0	0.0
Fallacia oculiformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Fallacia shoemaniana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fallacia subforcipata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria sp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Frustulia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grammatophora angulosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Grammatophora oceanica var macilenta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma balticum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma distortum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma fasciola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma hummii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma macrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Halamphora subcuneata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haslea spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hemialus spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyalosira interrupta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Licmophora abbreviata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Licmorphora oedipus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Licmorphora paradoxa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella clavata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella clavata var *carribea*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella diffluens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella henndeyi form 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella hennedyi form *granulata*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella lyra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lyrella sulcifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia angulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia baldjikiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia baldjikiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Mastogloia bionata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia braunii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia cf. *aquilegiae*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia elliptica	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Mastogloia elliptica var *dansei*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia erythraea type 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia erythraea type 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia erythraea type 4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Mastogloia exilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia foliolum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia gibbosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia gracilis	0.0	0.0	0.0	0.0	-0.1	0.4	-0.1	-0.1	0.2	0.0
Mastogloia horvathiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia jelineckii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia labuensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia lanceolata	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Mastogloia ovata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pumila type 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pusilla type 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pusilla type 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia pusilla var *linearalis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastogloia tenuissiama	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Melosira spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cf. capitatoradiata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cf. *caterva*	-0.1	-0.4	0.1	0.4	0.3	-0.1	-0.2	0.1	0.0	0.0

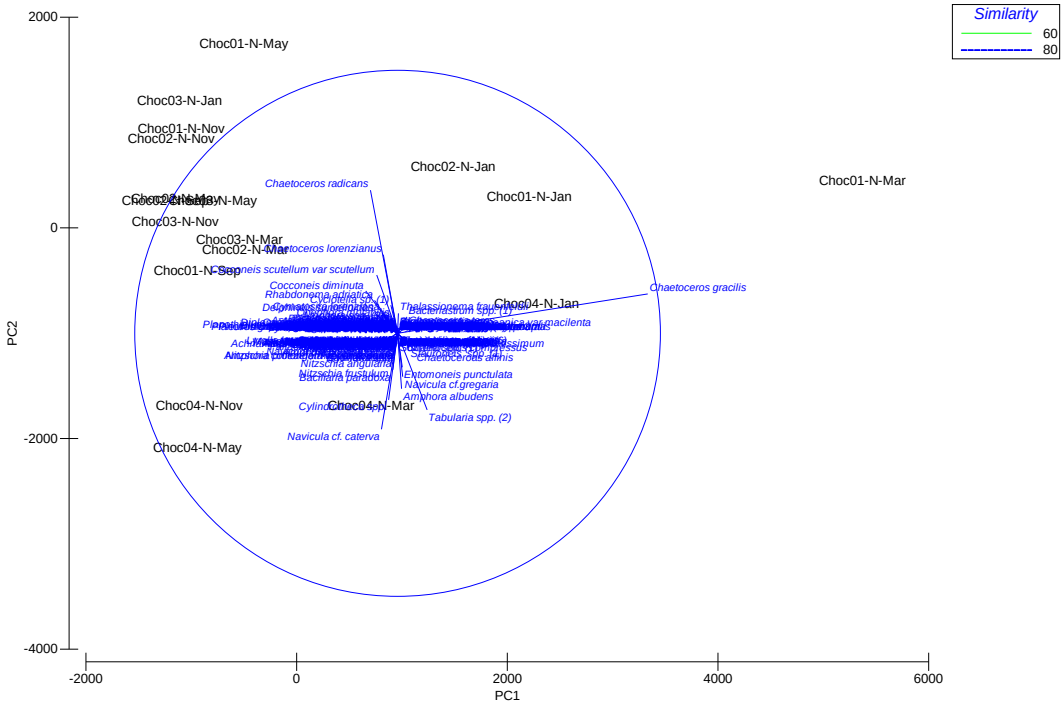
Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Navicula cf. *cryptonella*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cf. *gregaria*	0.0	-0.2	0.1	-0.1	0.0	-0.1	-0.2	0.0	0.0	0.0
Navicula cf. *phyllepta*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cryptocephala	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula hamiltonii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula jentzschii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula peregrina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula phylleptosoma	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	-0.1	-0.1	-0.1
Navicula pseudolanceolata	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Navicula sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (14)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (18)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (23)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (29)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (33)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (35)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (36)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula sp. (8)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (11)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (12)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (17)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Navicula spp. (22)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (25)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (26)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (28)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula spp. (7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neidium sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neidium spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neidium spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia	0.0	-0.1	0.0	0.1	0.0	0.1	0.3	0.0	-0.1	0.1

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
angularia										
Nitzschia aurariae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia carcinobarica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia diversa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia fluminensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia frustulum	0.0	-0.1	0.0	0.2	0.1	-0.1	-0.2	0.0	0.1	0.0
Nitzschia hadriatica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia leibetruthii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia palea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia panduriformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia persuadens	0.0	0.0	-0.1	0.0	-0.1	-0.1	0.0	0.0	0.1	0.0
Nitzschia prolongata var prolongata	0.0	-0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Nitzschia sigma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia socialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia sp. (10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia sp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Nitzschia spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Odontella spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Odontella spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oestrupia powelii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opephora marina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opephora mutabilis	0.0	0.1	0.0	0.0	-0.1	0.3	-0.1	0.1	0.0	0.0
Paralia sulcata	0.0	0.0	-0.1	0.0	-0.1	-0.1	0.0	-0.2	-0.2	0.0
Petroneis maculata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroneis marina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinnularia sp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagiogramma pygmaeum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagiotropis spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagiotropis spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagiotropis spp. (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planothidium frequentissimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Planothidium heteromorphum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planothidium lanceolatum var *australis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planothidium lanceolatum var *rostratata*	0.0	0.0	-0.1	-0.1	0.2	0.0	0.0	-0.1	0.0	0.0
Pleurosigma angulatum var *aestuarii*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma australe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma formosum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma spp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma williamsii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porosira spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porosira spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Psammodiscus nitidus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhabdonema adriatica	-0.1	0.1	-0.4	-0.4	0.7	0.0	0.0	-0.1	0.0	0.0
Rhaponeis amphiceros	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhizosolenia spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Rhopalodia acuminata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhopalodia musculus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skeletonema spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Stauroneis spp. (1)	0.0	-0.1	0.1	-0.1	0.0	0.0	0.0	0.0	-0.1	0.5
Stauroneis spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Striatella unipunctata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Surirella spp. (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Synedra crystalina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tabularia fasciculata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tabularia parva	0.0	-0.1	0.0	0.1	0.0	0.0	-0.1	0.0	0.0	0.0
Tabularia spp. (2)	0.1	-0.3	0.2	-0.6	-0.2	-0.1	-0.1	0.0	0.0	0.2
Thalasiossira spp. (4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Variable	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**	**PC8**	**PC9**	**PC10**
Thalassionema frauenfeldii	0.0	0.1	0.0	0.0	0.0	0.1	-0.1	0.3	-0.3	0.0
Thalassiosira sp. (1)	0.0	0.0	-0.1	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0
Thalassiosira spp. (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Toxarium undulatum	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-0.1	0.0
Trachyneis aspera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Principal Component Scores										
Sample	Score1	Score2	Score3	Score4	Score5	Score6	Score7	Score8	Score9	Score10
Choc01-N-Sep	-945.0	-408.0	-205.0	120.0	-693.0	2220.0	-420.0	-583.0	587.0	-48.7
Choc02-N-Sep	-1240.0	255.0	-1730.0	-1180.0	2100.0	80.6	-3.3	-523.0	40.9	-48.1
Choc01-N-Nov	-1100.0	938.0	360.0	-190.0	-103.0	787.0	-393.0	1110.0	-967.0	-44.0
Choc02-N-Nov	-1190.0	843.0	-169.0	-320.0	316.0	-95.1	76.9	1060.0	388.0	39.6
Choc03-N-Nov	-1150.0	57.4	-959.0	42.1	-743.0	-311.0	-9.0	-707.0	-731.0	140.0
Choc04-N-Nov	-923.0	-1690.0	588.0	667.0	468.0	407.0	1970.0	156.0	-235.0	148.0
Choc01-N-Jan	2210.0	299.0	-334.0	309.0	162.0	327.0	-6.9	257.0	-99.4	31.8
Choc02-N-Jan	1490.0	576.0	-482.0	249.0	-173.0	56.1	-28.1	309.0	-325.0	-49.2
Choc03-N-Jan	-1110.0	1210.0	1320.0	166.0	-53.2	-463.0	154.0	-984.0	-156.0	17.1
Choc04-N-Jan	2280.0	-715.0	713.0	-1140.0	-160.0	-86.6	-380.0	-205.0	-161.0	1160.0
Choc01-N-Mar	5380.0	445.0	-417.0	725.0	321.0	11.8	210.0	-144.0	196.0	-328.0
Choc02-N-Mar	-486.0	-206.0	-600.0	217.0	-408.0	-475.0	-194.0	-146.0	-202.0	-514.0
Choc03-N-Mar	-539.0	-115.0	-597.0	287.0	-825.0	-432.0	21.4	-372.0	-174.0	-219.0
Choc04-N-Mar	708.0	-1690.0	951.0	-1930.0	-534.0	-356.0	-4.7	209.0	166.0	-746.0
Choc01-N-May	-497.0	1750.0	2200.0	83.7	555.0	-45.5	17.6	-261.0	324.0	-167.0
Choc02-N-May	-1150.0	275.0	-628.0	174.0	-676.0	-528.0	89.3	404.0	777.0	234.0
Choc03-N-May	-798.0	260.0	-672.0	241.0	-522.0	-644.0	231.0	270.0	547.0	374.0
Choc04-N-May	-937.0	-2090.0	668.0	1480.0	973.0	-449.0	-1330.0	156.0	24.1	21.2


Similarity
60
80
2000
0
-2000
-4000
PC2
-2000
0
2000
4000
6000
PC1
Choc01-N-May
Choc03-N-Jan
Choc01-N-Nov
Choc02-N-Nov
Choc02-N-Jan
Choc01-N-Mar
Choc01-N-Jan
Choc03-N-May
Choc03-N-Nov
Choc03-N-Mar
Choc02-N-Mar
Choc01-N-Sep
Choc04-N-Jan
Choc04-N-Nov
Choc04-N-Mar
Choc04-N-May
Chaetoceros radicans
Chaetoceros gracilis
Cocconeis diminuta
Navicula cf.gregaria
Amphora albudens
Tabularia spp. (2)
Navicula cf. caterva

APPENDIX C

Images of Selected Taxa

Plate 1. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Cyclotella* sp 1 (scale – 10 microns)

B. *Cyclotella* sp 2 (scale – 5 microns)

C. *Cyclotella* sp 3 (scale – 10 microns)

D. *Cyclotella* sp 4 (scale – 5 microns)

E. *Detonula* sp (scale – 10 microns)

F. *Porosira* sp (scale – 10 microns)

G. *Porosira* sp (scale – 10 microns)

H. *Skeletonema* sp (scale – 10 microns)

I. *Thalassiosira* sp 1 (scale – 10 microns)

J. *Thalassiosira* sp 2 (scale – 5 microns)

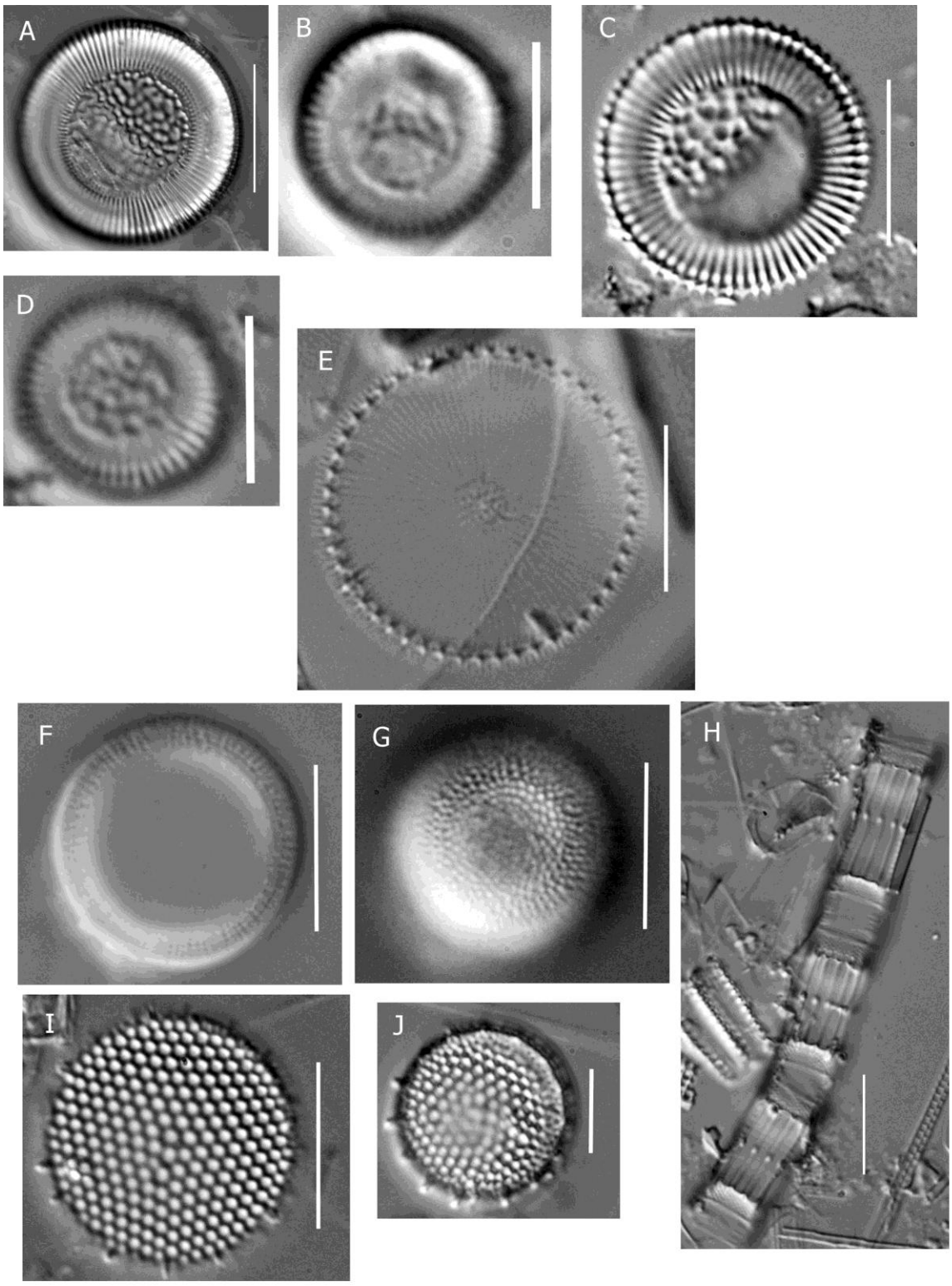

A
B
C
D
E
F
G
H
I
J

Plate 2. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Thalassiosira* sp 3 (scale – 10 microns)

B. *Thalassiosira* sp 4 (scale – 10 microns)

C. *Actinocyclus* sp 1 (scale – 10 microns)

D. *Actinocyclus* sp 2 (scale – 10 microns)

E. *Actibocyclus* sp (scale – 10 microns)

F. *Actinoptychus senarius* (scale – 10 microns)

G. *Coscinodiscus* sp 1 (1 scale – 10 microns)

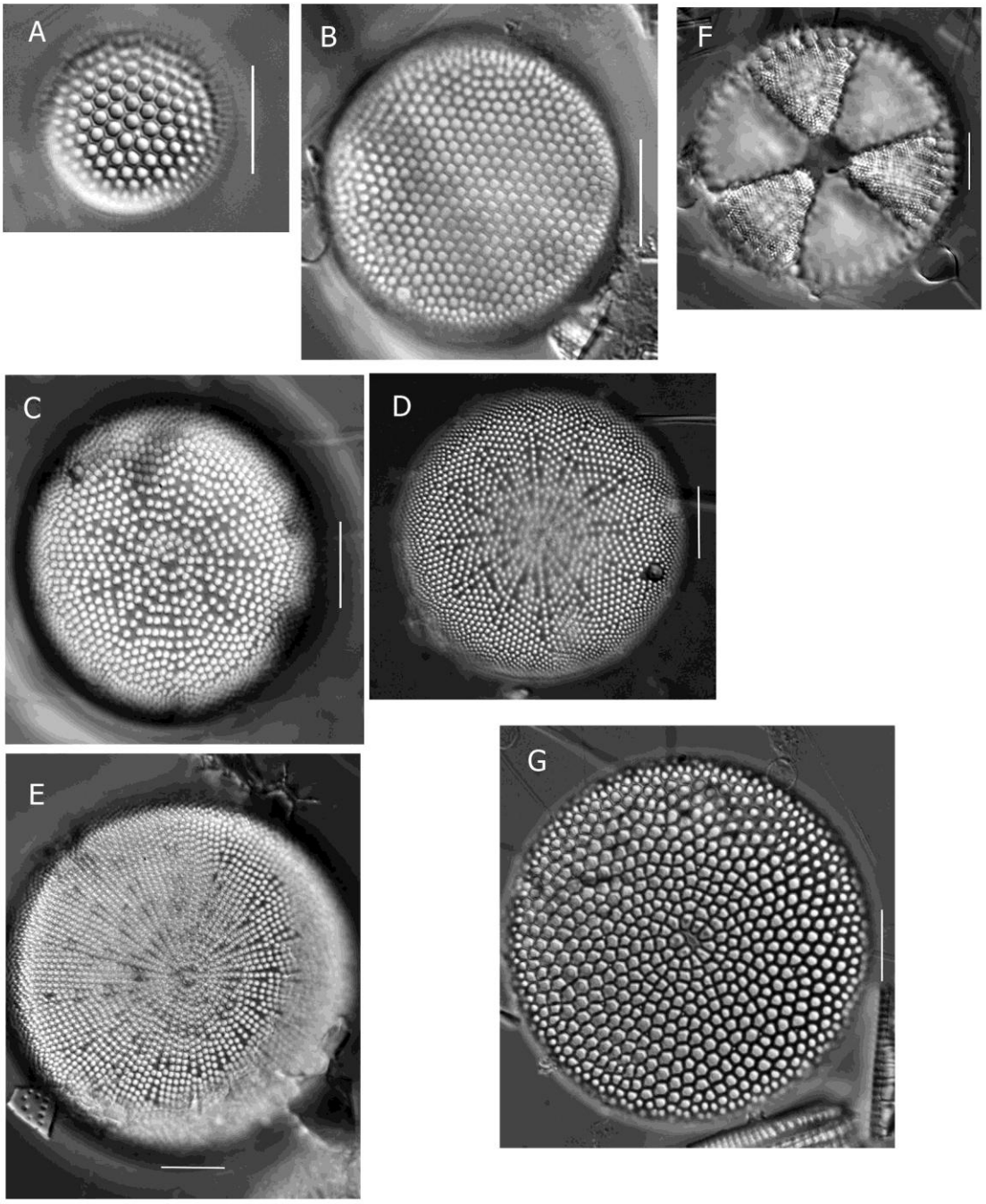

A
B
F
C
D
E
G

Plate 3. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Coscinodiscus* sp 3 (scale – 10 microns)

B. *Coscinodiscus* sp 4 (scale – 10 microns)

C. *Coscinodiscus s*p 4 (scale – 10 microns)

D. *Coscinodiscus* sp 5 (scale – 10 microns)

E. *Melosira* sp (scale – 10 microns)

F. *Melosira* sp (scale – 10 microns)

G. *Paralia sulcata* (scale – 10 microns)

H. *Asteromphalus flabellatus (*scale – 10 microns)

I. *Amphitetras* sp (scale – 10 microns)

J. *Mastodiscus radiatus* (scale – 10 microns)

K. *Dimeregramma* cf *marinum* (scale – 10 microns)

L. *Dimeregramma minor* var *minor* (scale – 10 microns)

M. *Dimeregramma minor* var *nana* (scale – 10 microns)

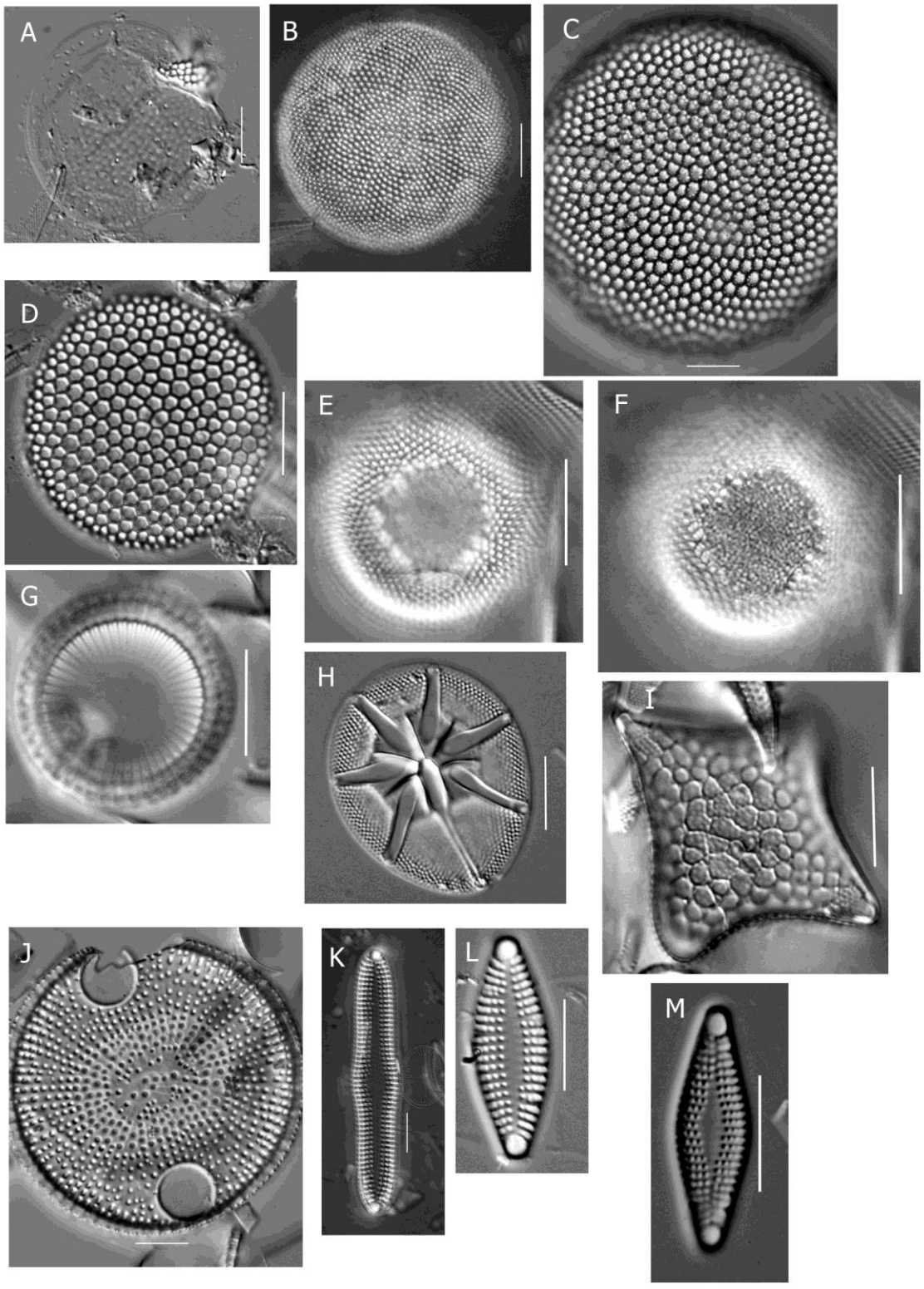

A
B
C
D
E
F
G
H
I
J
K
L
M

Plate 4. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Eupodiscus* sp (scale – 10 microns)

B. *Neohuttonia reichardtii* (scale – 10 microns)

C. *Odontella* sp 1 (scale – 10 microns)

D. *Odontella* sp 1 (scale – 10 microns)

E. *Odontella* sp 2 (scale – 10 microns)

F. *Plagiogramma* cf *antillarum* (scale – 10 microns)

G. *Plagiogramma pygmaeum* (scale – 10 microns)

H. *Plagiogramma* cf *rhombicum* (scale – 10 microns)

I. *Biddulphia* sp 1 (scale – 10 microns)

J. *Biddulphia* sp 2 (scale – 10 microns)

K. *Triceratium* sp (scale – 10 microns)

L. *Triceratium* sp (scale – 10 microns)

M. *Hemiaulus* sp (scale – 10 microns)

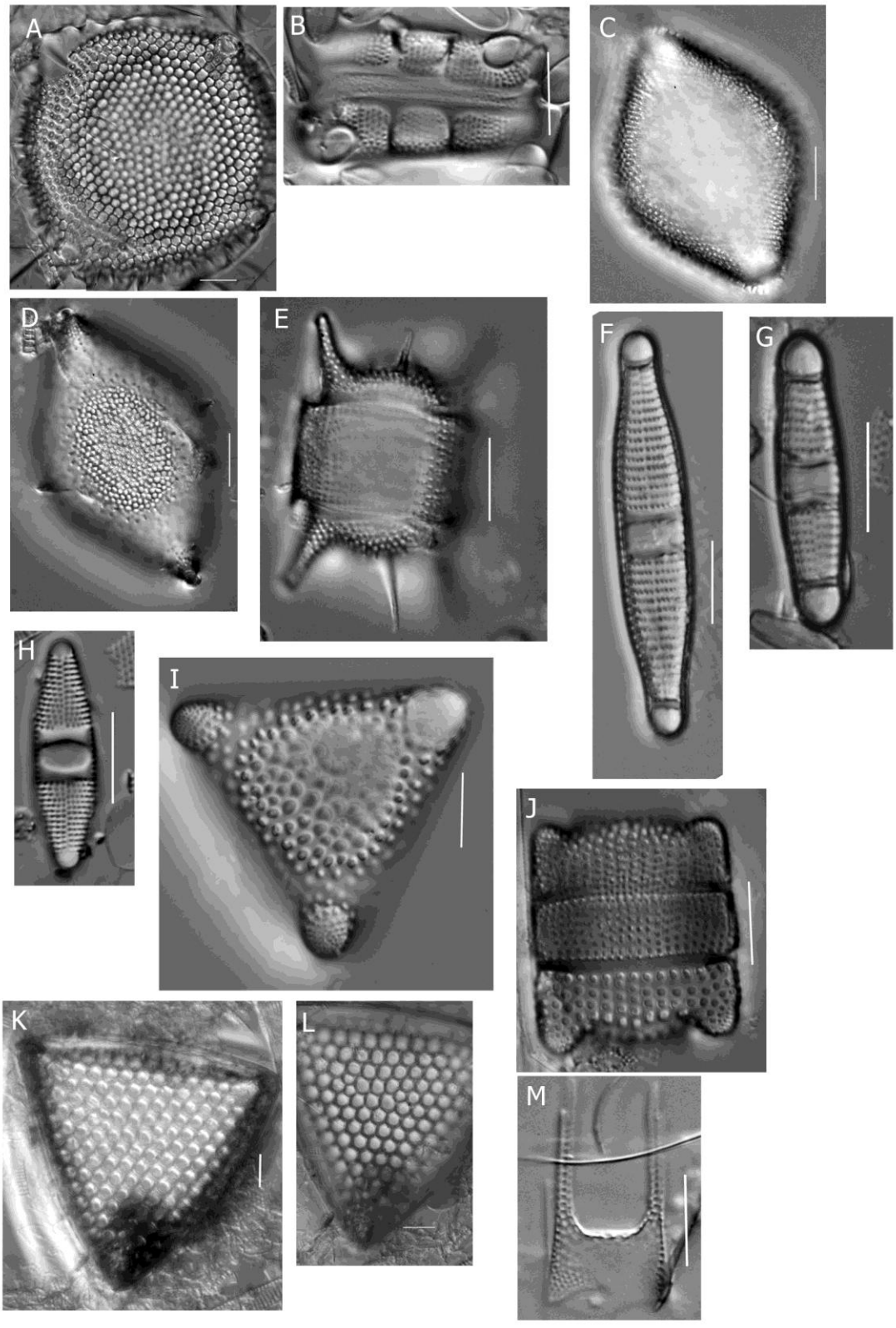

A
B
C
D
E
F
G
H
I
J
K
L
M

Plate 5. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Ceratulina* sp (scale – 10 microns)

B. *Ceratulina* sp (scale – 10 microns)

C. *Eucampia* sp (scale – 10 microns)

D. *Anaulus* sp 1 (scale – 10 microns)

E. *Anaulus s*p 2 (scale – 5 microns)

F. *Eunotogramma* sp 1 (scale – 10 microns)

G. *Eunotogramma* sp 1 (scale – 10 microns)

H. *Lithodesmium undulatum* (scale – 10 microns)

I. *Campylosira cymbelliformis* (scale – 10 microns)

J. *Cymatosira lorenziana* (scale – 10 microns)

K. *Cymatosira belgica* (scale – 10 microns)

L. *Rhizosolenia* sp (scale – 20 microns)

M. *Bacteriastrum* sp 1 (scale – 20 microns)

N. *Bacteriastrum* sp (scale – 20 microns)

O. *Bacteriastrum* sp 3 (scale – 20 microns)

P. *Chaetoceros affinis* (scale – 10 microns)

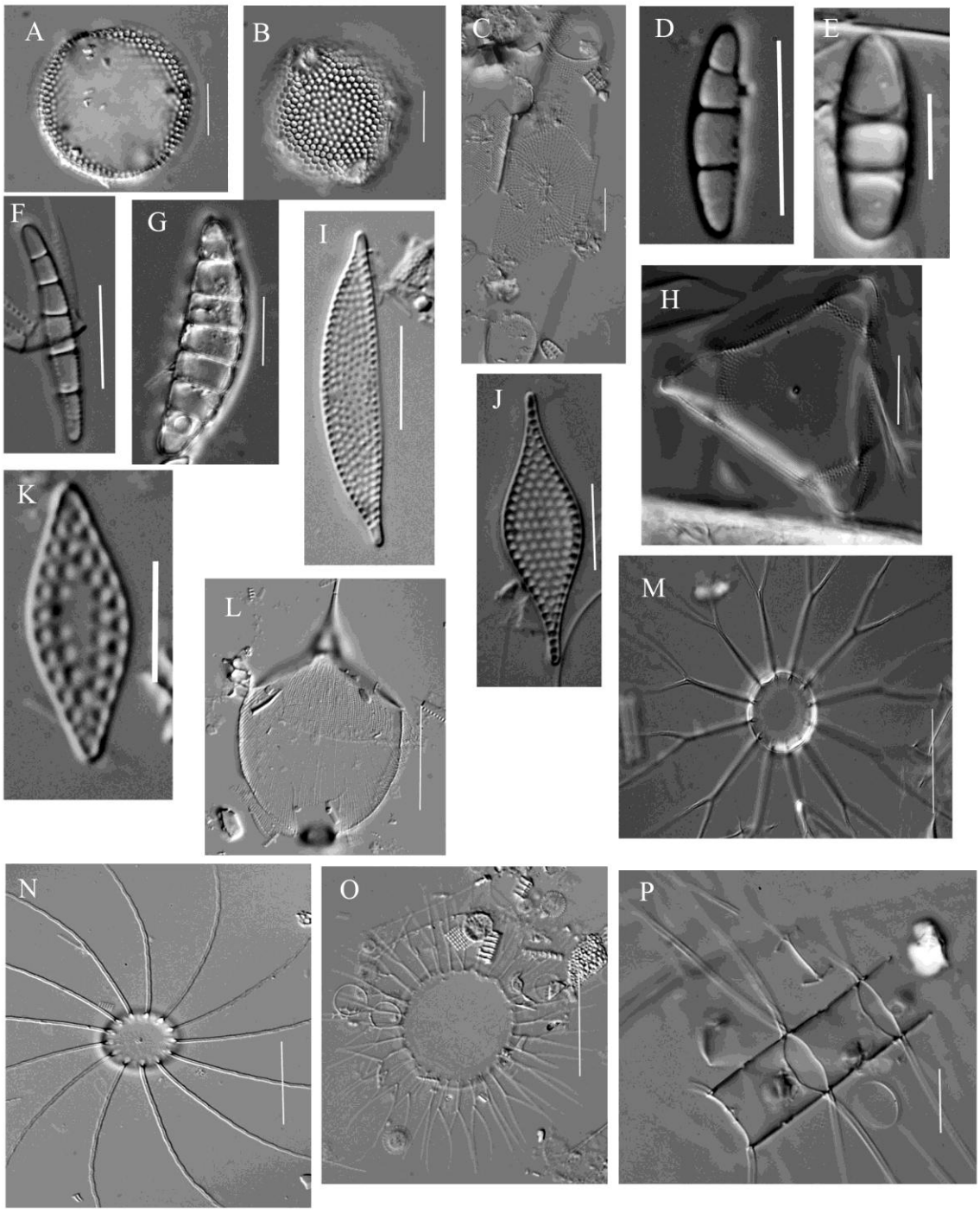

A
B
C
D
E
F
G
I
H
J
K
L
M
N
O
P

Plate 6. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Chaetoceros compressus* (scale – 10 microns)

B. *Chaetoceros dichaeta* (scale – 10 microns)

C. *Chaetoceros didymus* (scale – 10 microns)

D. *Chaetoceros eibonii* (scale – 10 microns)

E. *Chaetoceros gracilis* (scale – 10 microns)

F. *Chaetoceros lorenzianus* (scale – 10 microns)

G. *Chaetoceros radicans* (scale – 10 microns)

H. *Chaetoceros teres* (scale – 10 microns)

I. *Chaetoceros* sp 1 (scale – 5 microns)

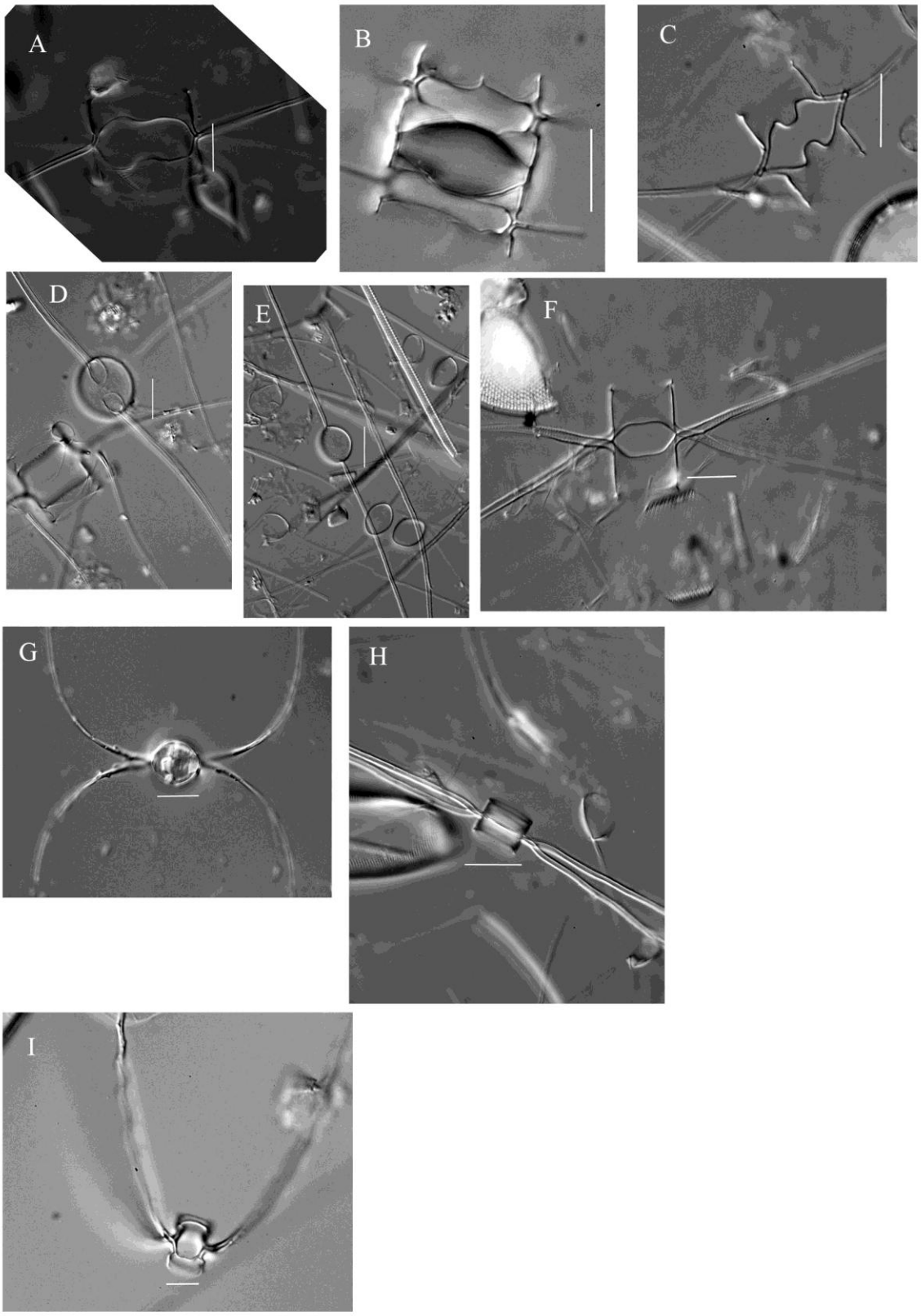

A
B
C
D
E
F
G
H
I

Plate 7. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Asterionellopsis glacialis* (scale – 10 microns)

B. *Fragilaria magocsyi* (scale – 10 microns)

C. *Fragilaria* sp 1 (scale – 10 microns)

D. *Fragilaria* sp 2 (scale – 10 microns)

E. *Fragilaria* sp 3 (scale – 10 microns)

F. *Opephora marina* (scale – 10 microns)

G. *Opephora mutabilis* (scale – 10 microns)

H. *Ardissonia crystallina* (scale – 10 microns)

I. *Tabellaria* sp (scale – 10 microns)

J. *Tabularia fasciculata* (scale – 10 microns)

K. *Tabularia parva* (scale – 10 microns)

L. *Tabularia* sp 1 (scale – 20 microns)

M. *Tabularia* sp 2 (scale – 5 microns)

N. *Talaroneis fulgicerum* (scale – 10 microns)

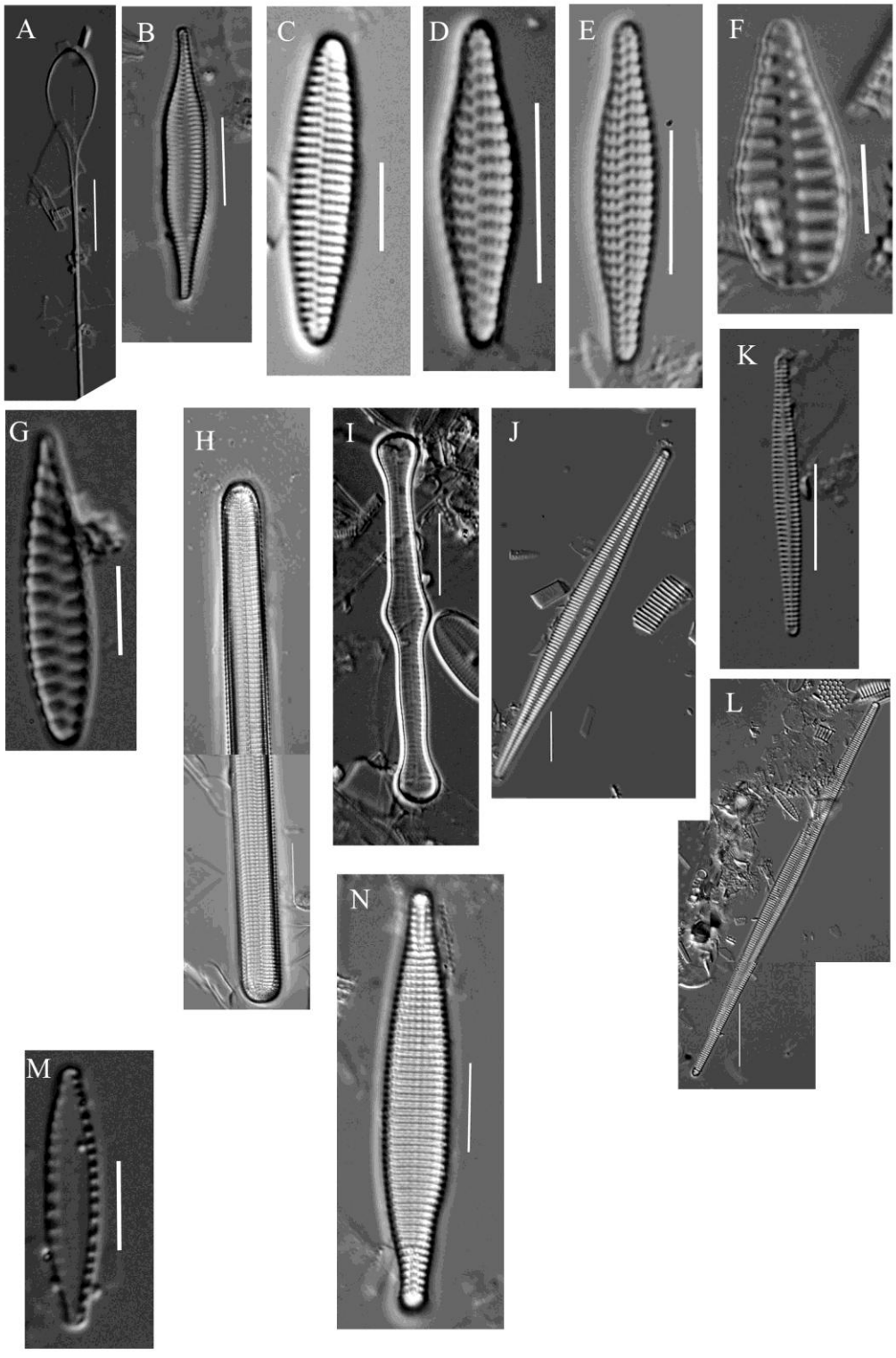

A
B
C
D
E
F
G
H
I
J
K
L
M
N

Plate 8. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Licmophora* cf *paradoxa* (scale – 10 microns)

B. *Licmophora abbreviata* (scale – 10 microns)

C. *Licmophora* sp. (scale – 20 microns)

D. *Licmophora abbreviata* (scale – 10 microns)

E. *Licmophora remulus* (scale – 10 microns)

F. *Licmophora Oedipus* (scale – 10 microns)

G. *Delphineis surirella* (scale – 10 microns)

H. *Delphineis surirelloides* (scale – 10 microns)

I. *Delphineis minutissima* (scale – 5 microns)

J. *Psammodiscus nitidus* (scale – 10 microns)

K. *Rhaphoneis amphiceros* (scale – 10 microns)

L. *Toxarium undulatum* (scale – 10 microns)

M. *Rhabdonema ariatica* (scale – 10 microns)

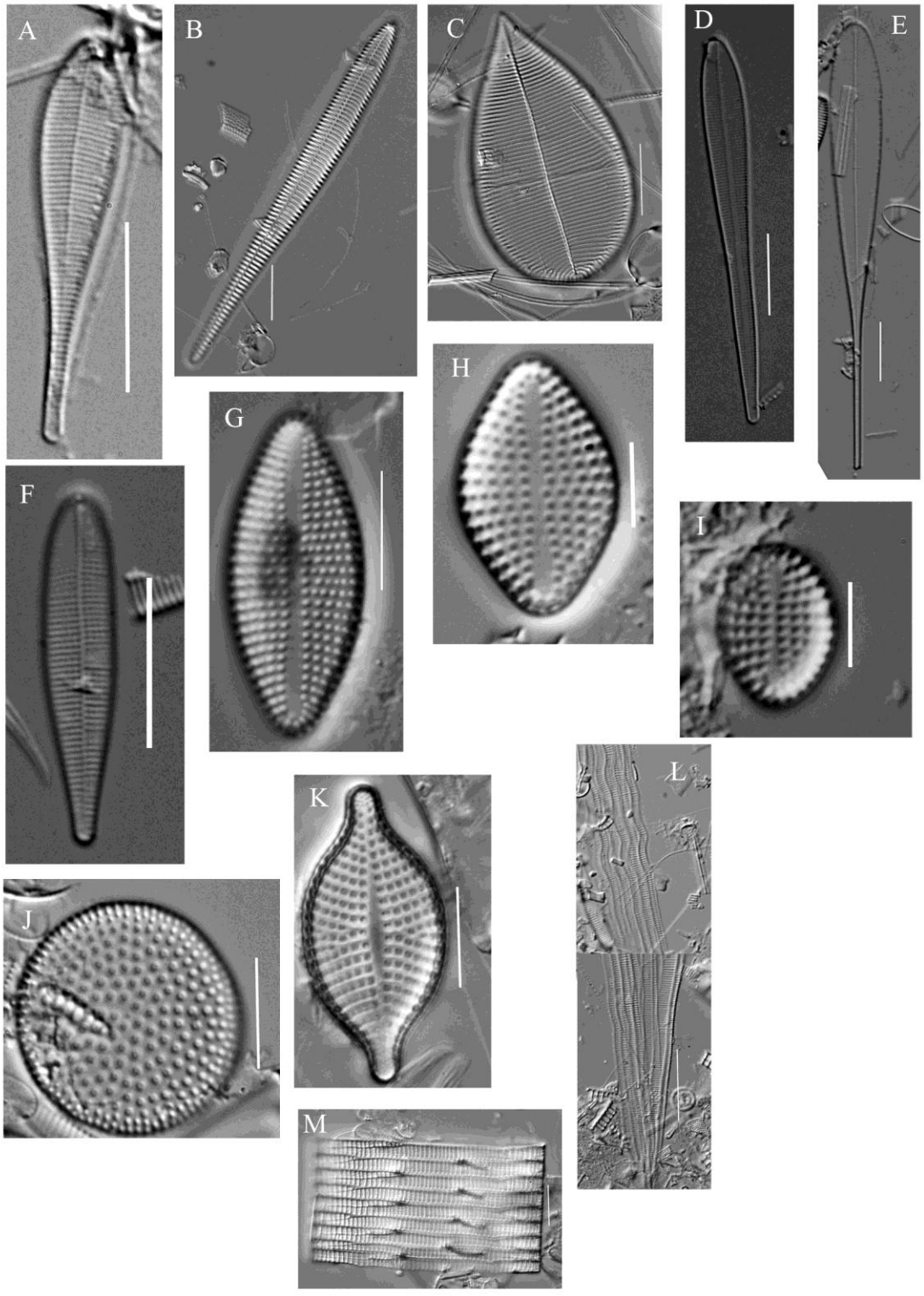

A
B
C
D
E
F
G
H
I
J
K
Ł
M

Plate 9. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Thalassionema frauenfeldii* (scale – 10 microns)

B. *Thalassionema nitzschioides* (scale – 10 microns)

C. *Grammatophora angulosa* (scale – 10 microns)

D. *Grammatophora oceanic* var *macilenta* (scale – 10 microns)

E. *Striatella unipunctata* (scale – 20 microns)

F. *Eunotia* sp 1 (scale – 10 microns)

G. *Eunotia* sp 2 (scale – 10 microns)

H. *Eunotia* sp 3 (scale – 10 microns)

I. *Eunotia* sp 4 (scale – 5 microns)

J. *Petroneis marina* (scale – 10 microns)

K. *Petroneis maculata* (scale – 10 microns)

L. *Lyrella clavata* (scale – 10 microns)

M. *Lyrella diffluens* (scale – 10 microns)

N. *Lyrella* var *lyra* form 1 (scale – 10 microns)

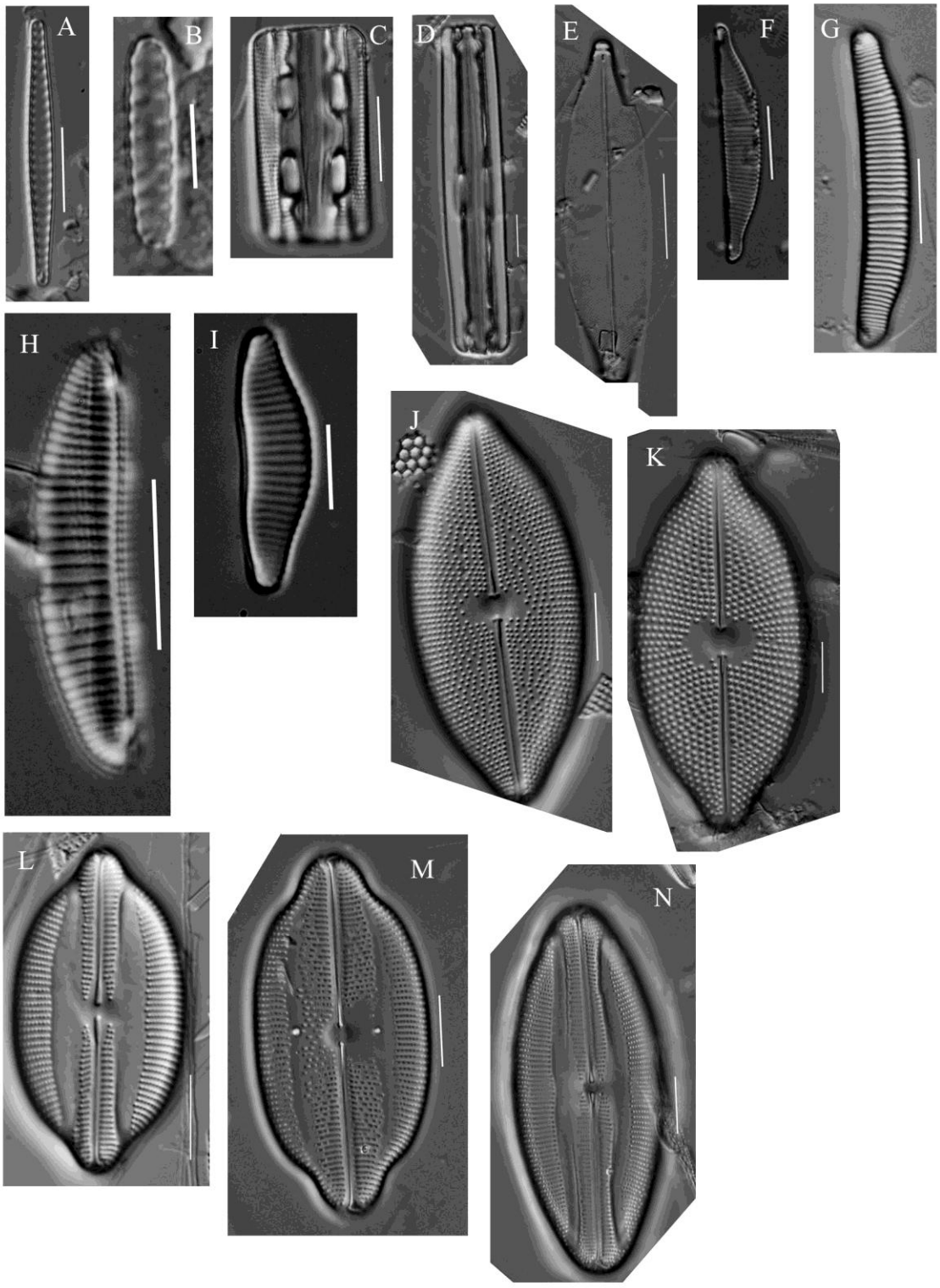

A
B
C
D
E
F
G
H
I
J
K
L
M
N

Plate 10. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Lyrella clavata* var *carribea* (scale – 10 microns)

B. *Lyrella hennedyi* form *granulata* (scale – 10 microns)

C. *Lyrella hennedyi* form 1 (scale – 10 microns)

D. *Lyra* var *lyra* (scale – 10 microns)

E. *Lyrella sulcifera* (scale – 10 microns)

F. *Cocconeiopsis* cf. *fraudulenta* (scale – 10 microns)

G. *Cocconeis pelta* (scale – 10 microns)

H. *Cocconeis latecostata* (scale – 10 microns)

I. *Cocconeis peltoides* (scale – 10 microns)

J. *Cocconeiopsis* sp. (scale – 5 microns)

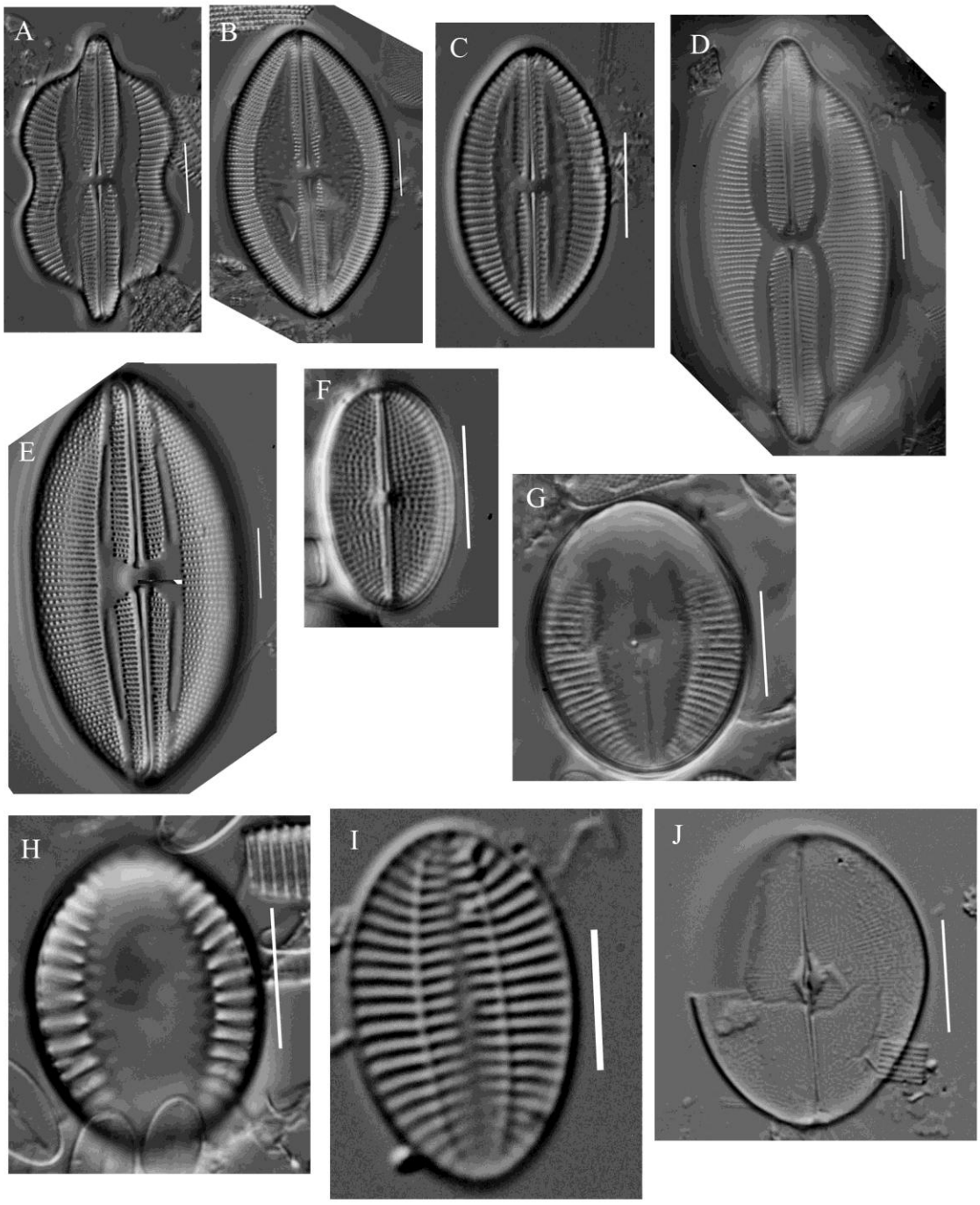

A
B
C
D
E
F
G
H
I
J

Plate 11. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Cocconeis disculus* (scale – 10 microns)

B. *Cocconeis placentula* (scale – 5 microns)

C. *Anorthoneis excentrica* (10)

D. *Cocconeis scutellum var scutellum* (scale – 10 microns)

E. *Cocconeis heteroidea* (scale – 10 microns)

F. *Cocconeis scutellum var parva* (scale – 10 microns)

G. *Cocconeis diminuta* (scale – 5 microns)

H. *Cocconeis pediculus* (scale – 10 microns)

I. *Cocconeis pinnata* (scale – 10 microns)

J. *Diploneis weissflogii (*scale – 10 microns)

K. *Diploneis parca* (scale – 10 microns)

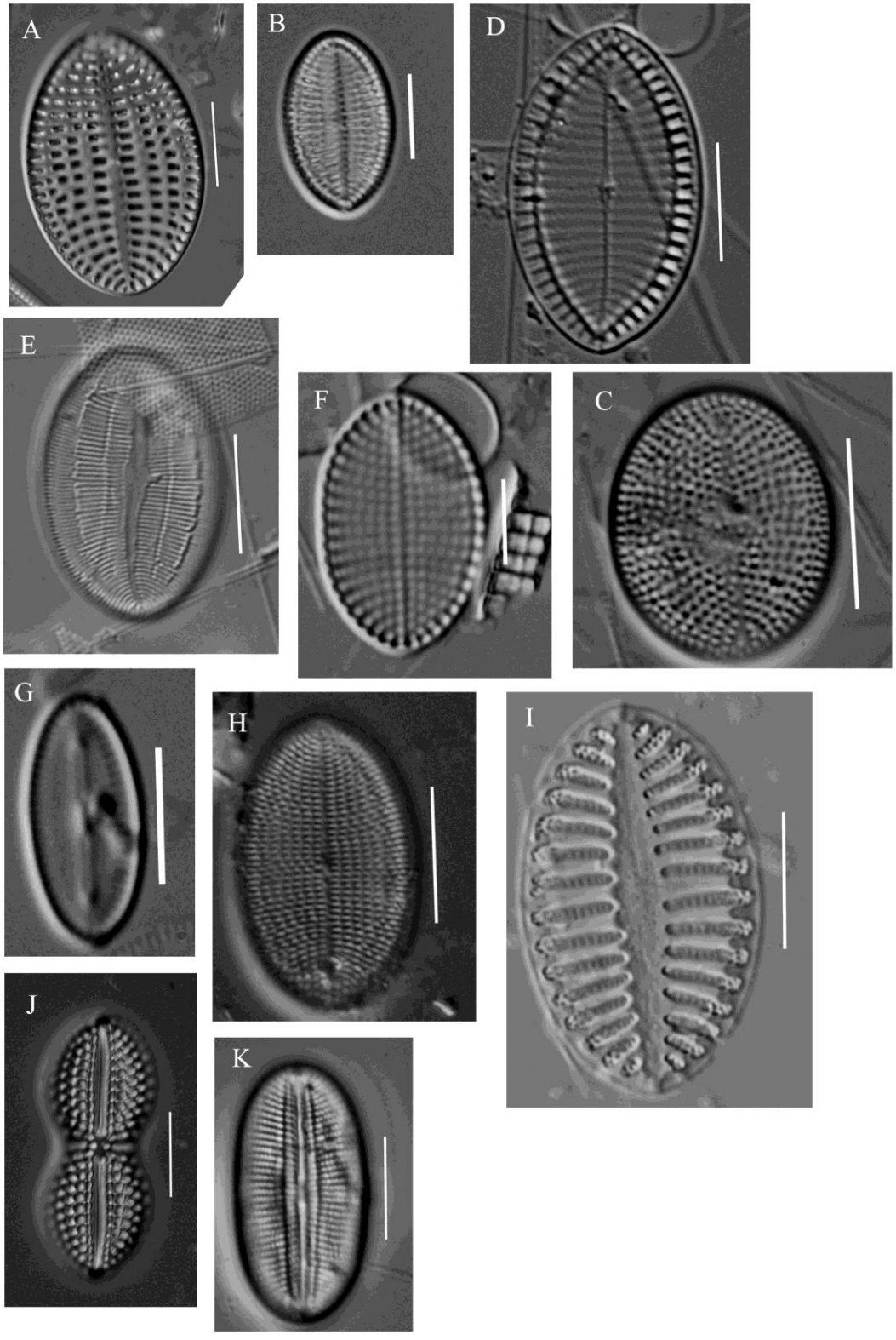

A
B
D
E
F
C
G
H
I
J
K

Plate 12. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Diploneis smithi var rhombica* (scale – 10 microns)

B. *Diploneis caffra* (scale – 10 microns)

C. *Fallacia vittata* (scale – 5 microns)

D. *Fallacia marginopunctata* (scale – 5 microns)

E. *Fallacia suboculiformis* (scale – 5 microns)

F. *Fallacia shoemaniana* (scale – 5 microns)

G. *Fallacia pygmaea* (scale – 5 microns)

H. *Fallacia littoricola* (scale – 10 microns)

I. *Fallacia subforcipata* (scale – 10 microns)

J. *Fallacia ny* (scale – 10 microns)

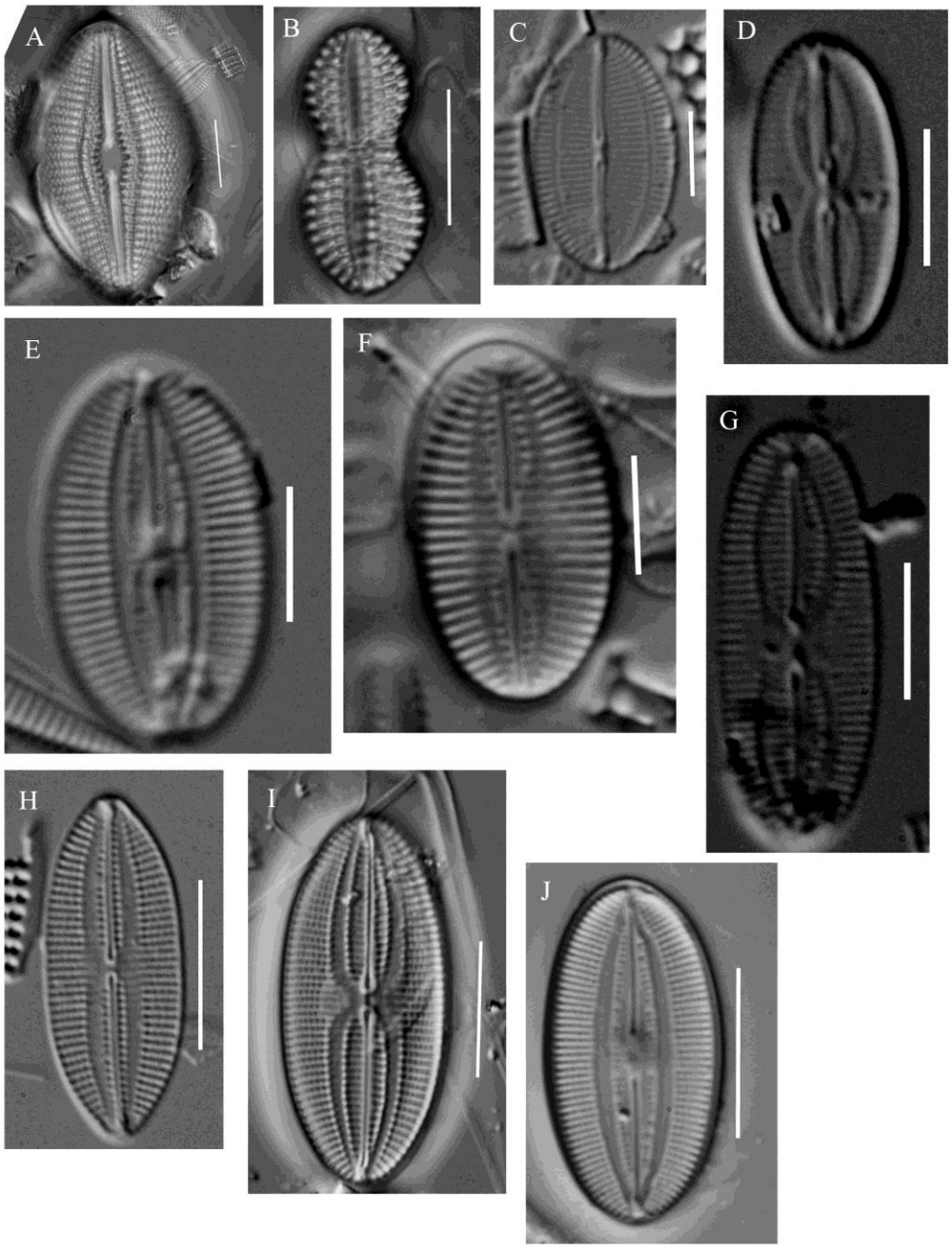

A
B
C
D
E
F
G
H
I
J

Plate 13. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Fallacia inscriptura* (scale – 5 microns)

B. *Donkinia* sp. (scale – 10 microns)

C. *Navicula angusta* (scale – 10 microns)

D. *Navicula* cf *capitoradiata* (scale – 10 microns)

E. *Navicula* cf *caterva* (scale – 10 microns)

F. *Navicula* cf *digitoradiata* (scale – 10 microns)

G. *Navicula* cf *cryptonella* (scale – 10 microns)

H. *Navicula* cf *gregaria* (scale – 10 microns)

I. *Navicula* cf *phyllepta* (scale – 10 microns)

J. *Navicula cryptocephala* (scale – 10 microns)

K. *Navicula erifuga* (scale – 10 microns)

L. *Navicula hamiltonii* (scale – 10 microns)

M. *Navicula jentzschii* (scale – 10 microns)

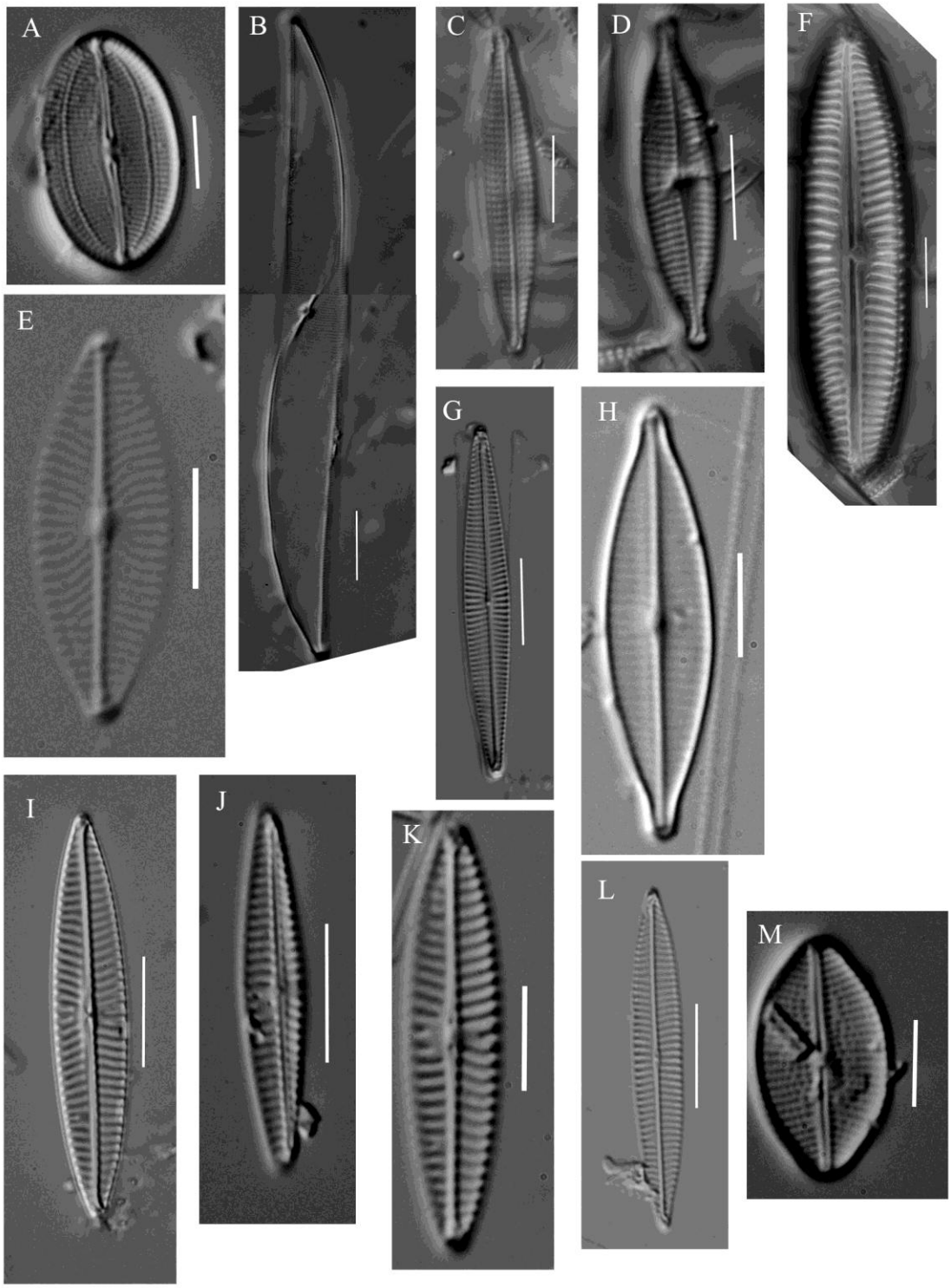

A
B
C
D
F
E
G
H
I
J
K
L
M

Plate 14. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Navicula oblonga* (scale – 10 microns)

B. *Navicula peregrina* (scale – 10 microns)

C. *Navicula pseudolanceolata* (scale – 10 microns)

D. *Navicula recens* (scale – 10 microns)

E. *Navicula salinarum var salinarum* (scale – 10 microns)

F. *Neidium* sp 1 (scale – 10 microns)

G. *Neidium* sp 2 (scale – 10 microns)

H. *Neidium s*p 3 (scale – 10 microns)

I. *Amphora arenicola* (scale – 10 microns)

J. *Amphora coffeaeformis var aponina* (scale – 10 microns)

K. .*Amphora cuneata* (scale – 10 microns)

L. *Amphora cymbifera* (scale – 10 microns)

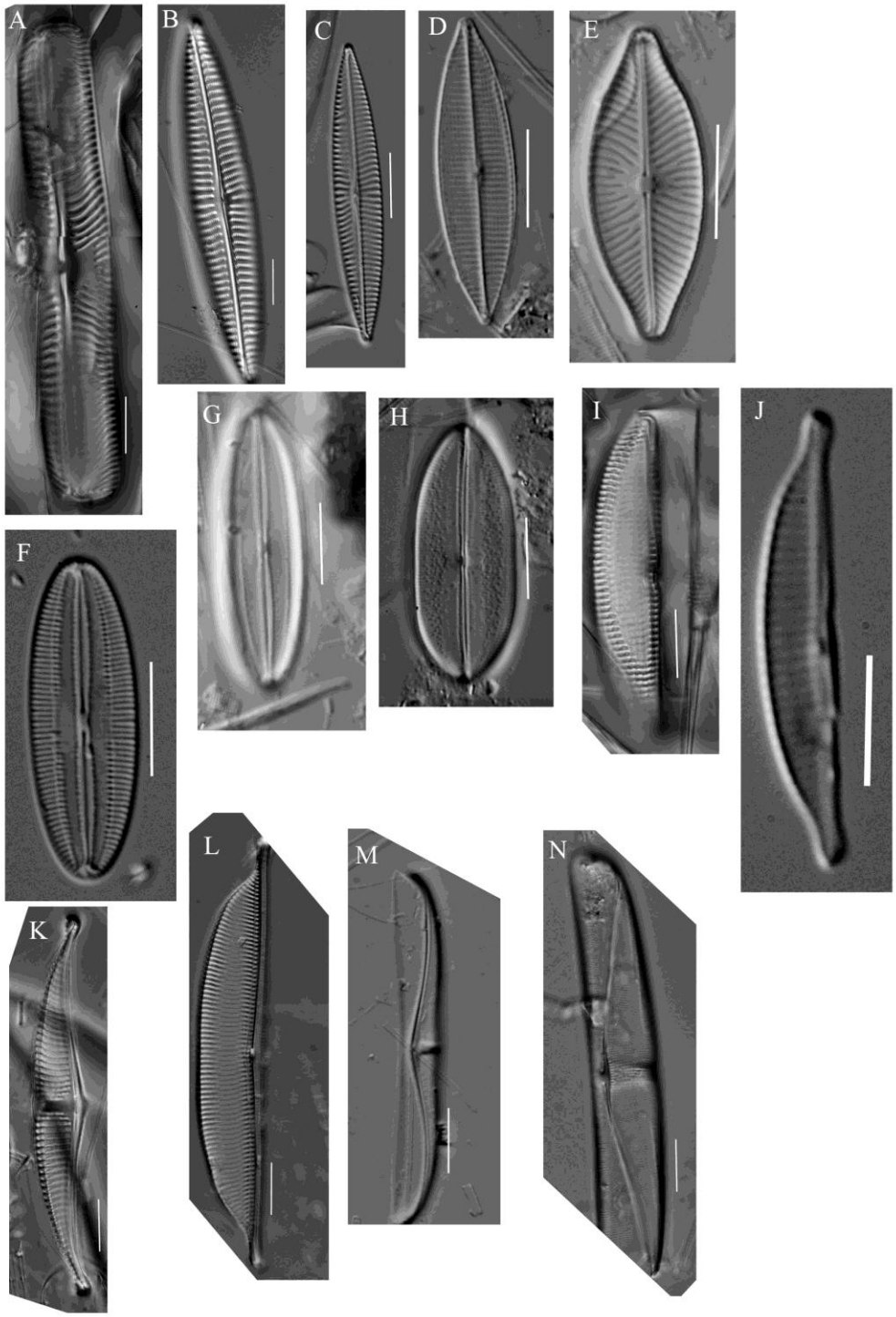

A
B
C
D
E
F
G
H
I
J
K
L
M
N

Plate 15. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Amphora albudens* (scale – 10 microns)

B. *Amphora arenaria* (scale – 10 microns)

C. *Amphora bigibba* var *interrupta* (scale – 10 microns)

D. *Amphora gigantean* var *fusca* (scale – 10 microns)

E. *Amphora graeffeana* (scale – 10 microns)

F. *Amphora obtusa* (scale – 10 microns)

G. *Amphora ostrearia* (scale – 10 microns)

H. *Amphora securicula* (scale – 10 microns)

I. *Amphora ocellata* (scale – 10 microns)

J. *Amphora coffeaeformis* (scale – 10 microns)

K. *Amphora delphineia* var *minor* (scale – 10 microns)

L. *Amphora arcus* (scale – 10 microns)

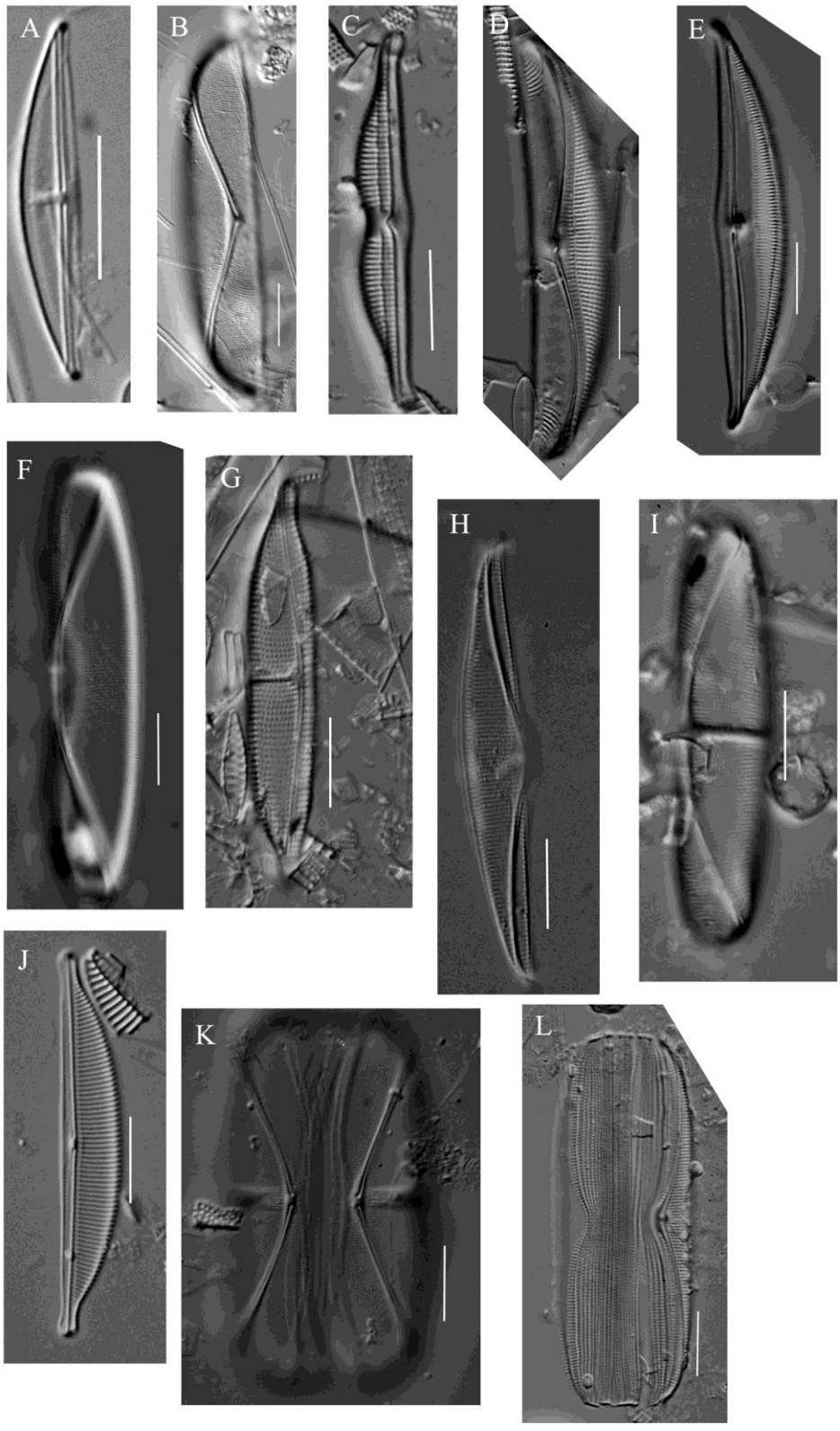

A
B
C
D
E
F
G
H
I
J
K
L

Plate 16. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Rophalodia acuminata* (scale – 10 microns)

B. *Rophalodia musculus* (scale – 10 microns)

C. *Entomoneis alata* (scale – 10 microns)

D. *Entomoneis paludosa* (scale – 10 microns)

E. *Entomoneis punctulata* (scale – 10 microns)

F. *Surirella* sp 1 (scale – 10 microns)

G. *Surirella* sp 2 (scale – 10 microns)

H. *Stauroneis* sp 1 (scale – 10 microns)

I. *Stauroneis* sp 2 (scale – 10 microns)

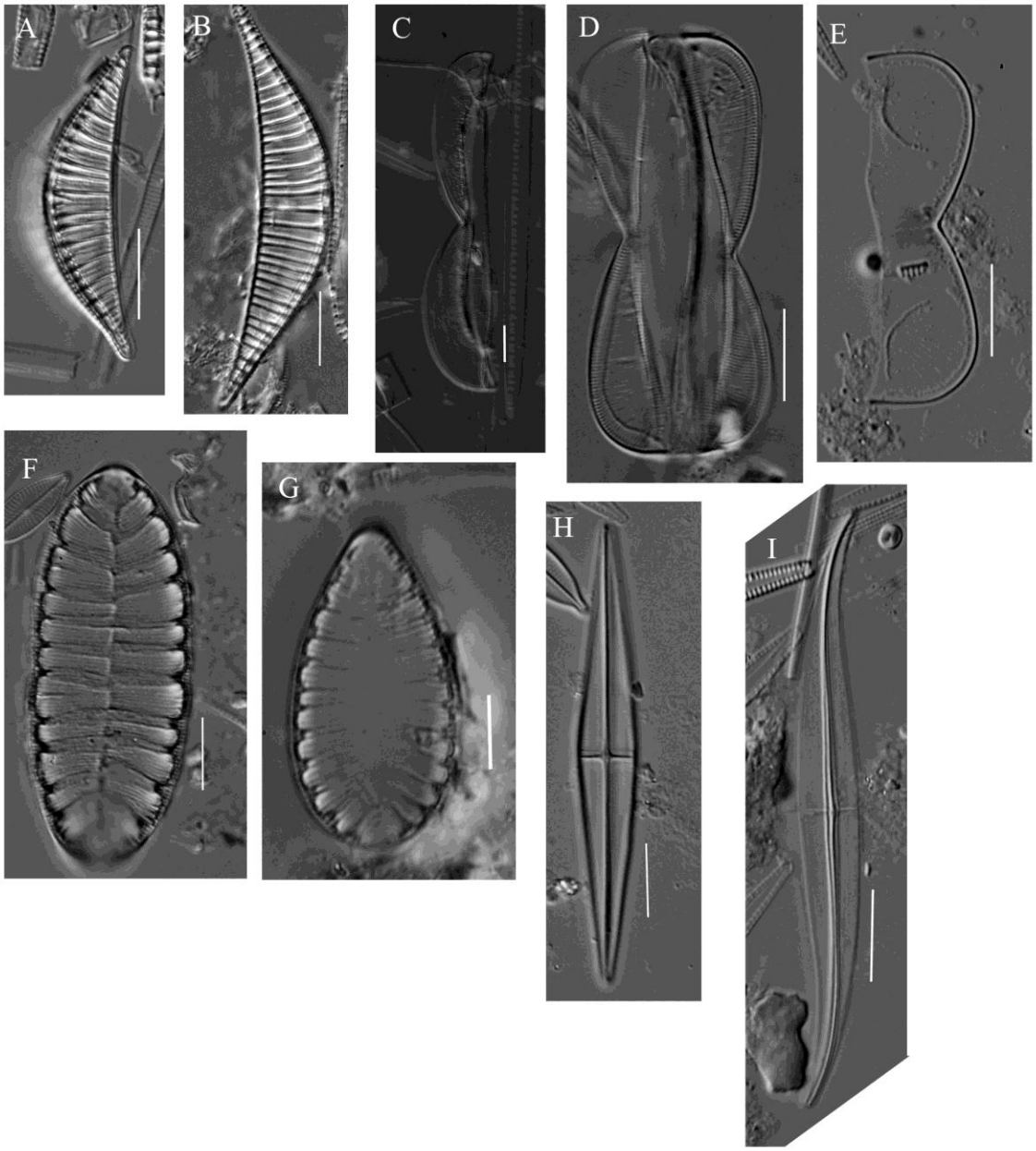

A
B
C
D
E
F
G
H
I

Plate 17. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Diploneis aestuari* (scale – 10 microns)

B. *Diploneis didyma* (scale – 10 microns)

C. *Diploneis incurvata var dubia* (scale – 10 microns)

D. *Diploneis incurvata var incurvata* (scale – 10 microns)

E. *Diploneis notabilis* (scale – 10 microns)

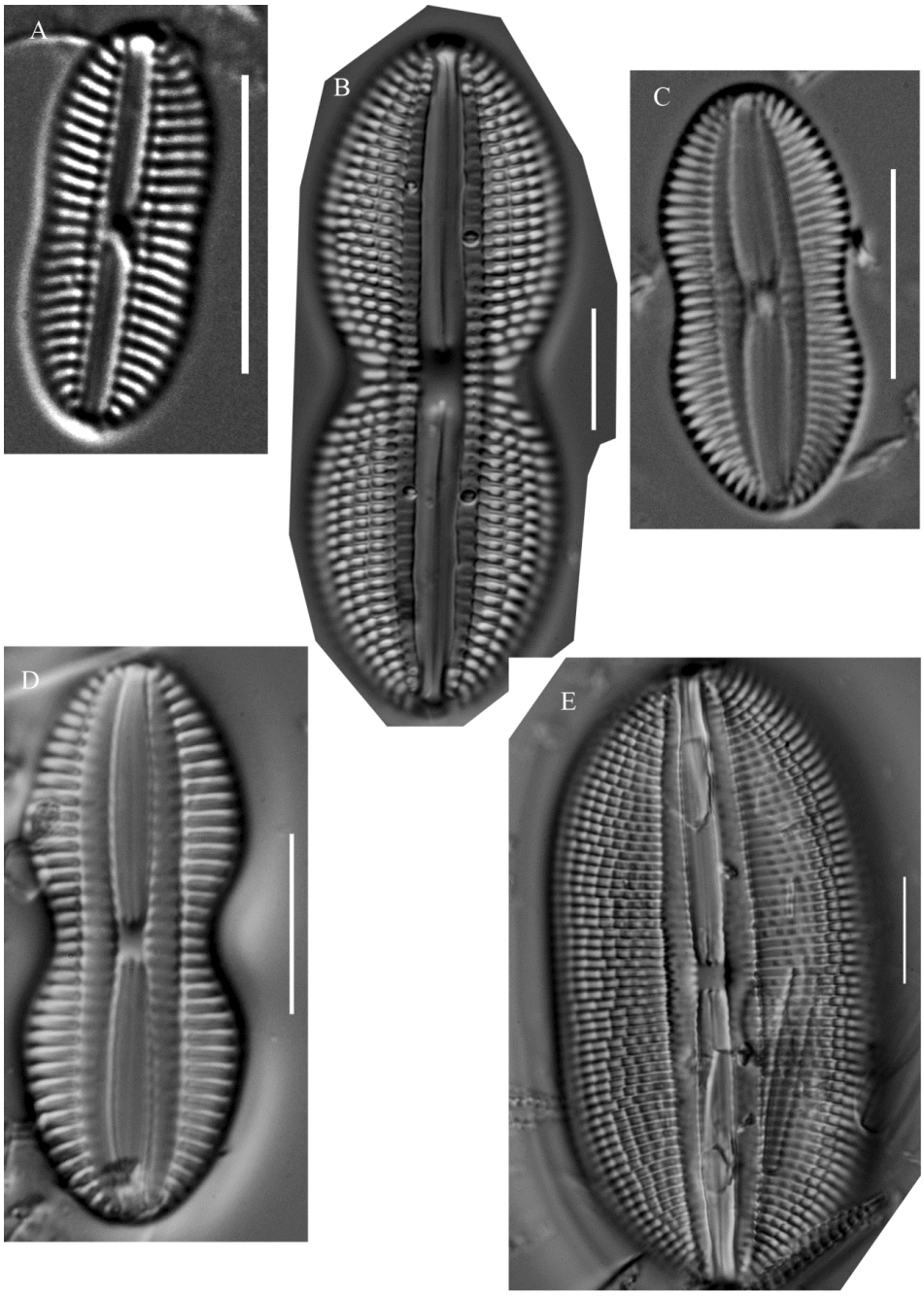

A
B
C
D
E

Plate 18. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Diploneis obliqua* (scale – 10 microns)

B. *Diploneis smithii* var *recta* (scale – 10 microns)

C. *Diploneis smithii* var *smithii* (scale – 10 microns)

D. *Diploneis smithii* var *pumila* (scale – 10 microns)

E. *Diploneis suborbicularis* (scale – 10 microns)

F. *Diploneis vacillans* var *renitens* (scale – 10 microns)

G. *Diploneis vacillans* var *vacillans* (scale – 10 microns)

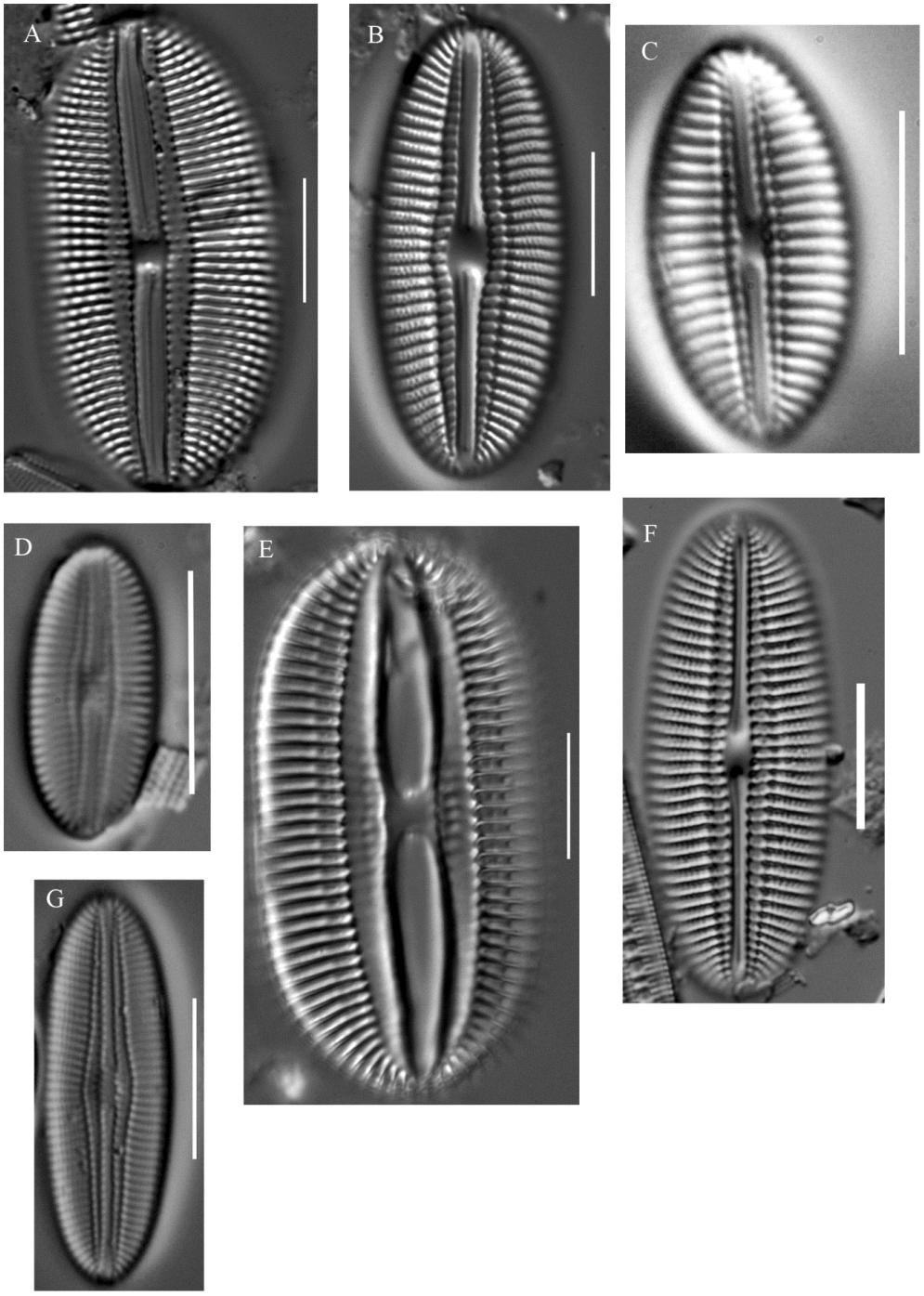

A
B
C
D
E
F
G

Plate 19. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Mastogloia elliptica* var *dansei* (scale – 10 microns)

B. *Mastogloia* sp *5* (scale – 10 microns)

C. *Mastogloia angulata* (scale – 10 microns)

D. *Mastogloia cf. exigua* (scale – 10 microns)

E. *Mastogloia acutiuscula* (scale – 10 microns)

F. *Mastogloia labuensis* (scale – 10 microns)

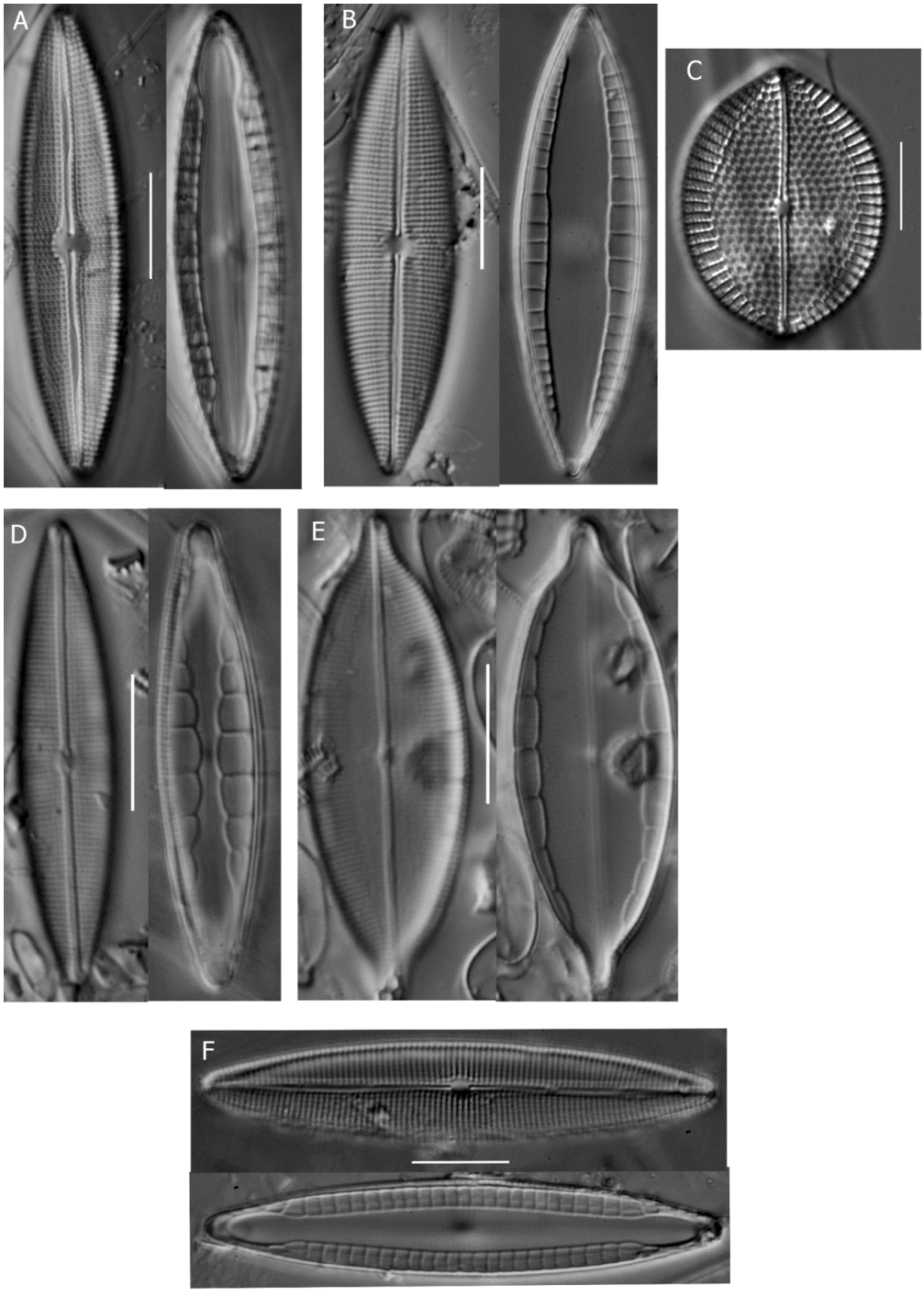

A
B
C
D
E
F

Plate 20. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Mastogloia adriatica* (scale – 10 microns)

B. *Mastogloia angulata* (scale – 10 microns)

C. *Mastogloia angusta* (scale – 10 microns)

D. *Mastogloia bonata* (scale – 10 microns)

E. *Mastogloia* sp 5 (scale – 10 microns)

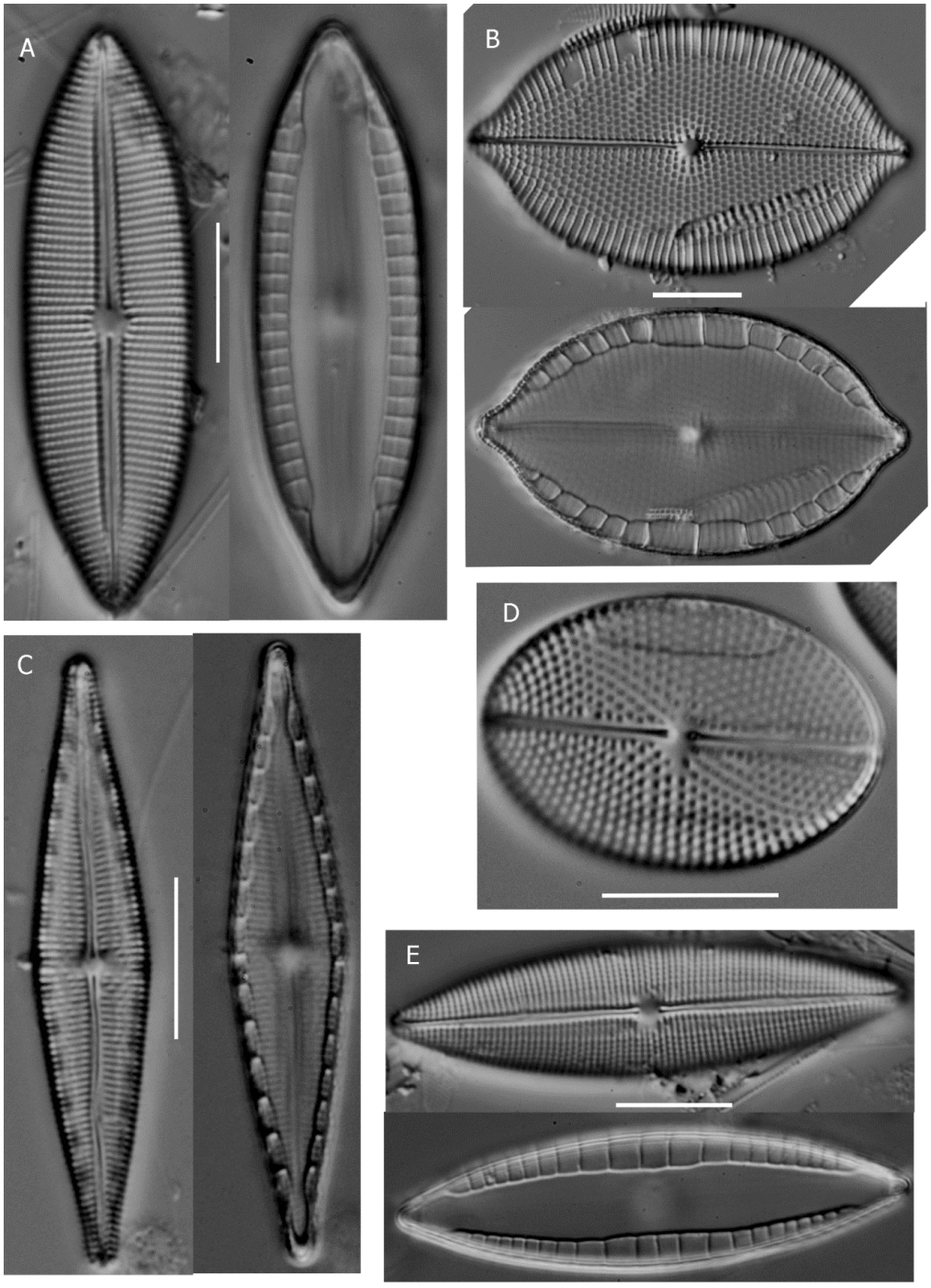

A
B
C
D
E

Plate 21. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Mastogloia elliptica* var *dansei* (scale – 10 microns)

B. *Mastogloia erythraea* type 4 (scale – 10 microns)

C. *Mastogloia erythraea* type 1 (scale – 10 microns)

D. *Mastogloia foliolum* (scale – 10 microns)

E. *Mastogloia baldijikiana* (scale – 10 microns)

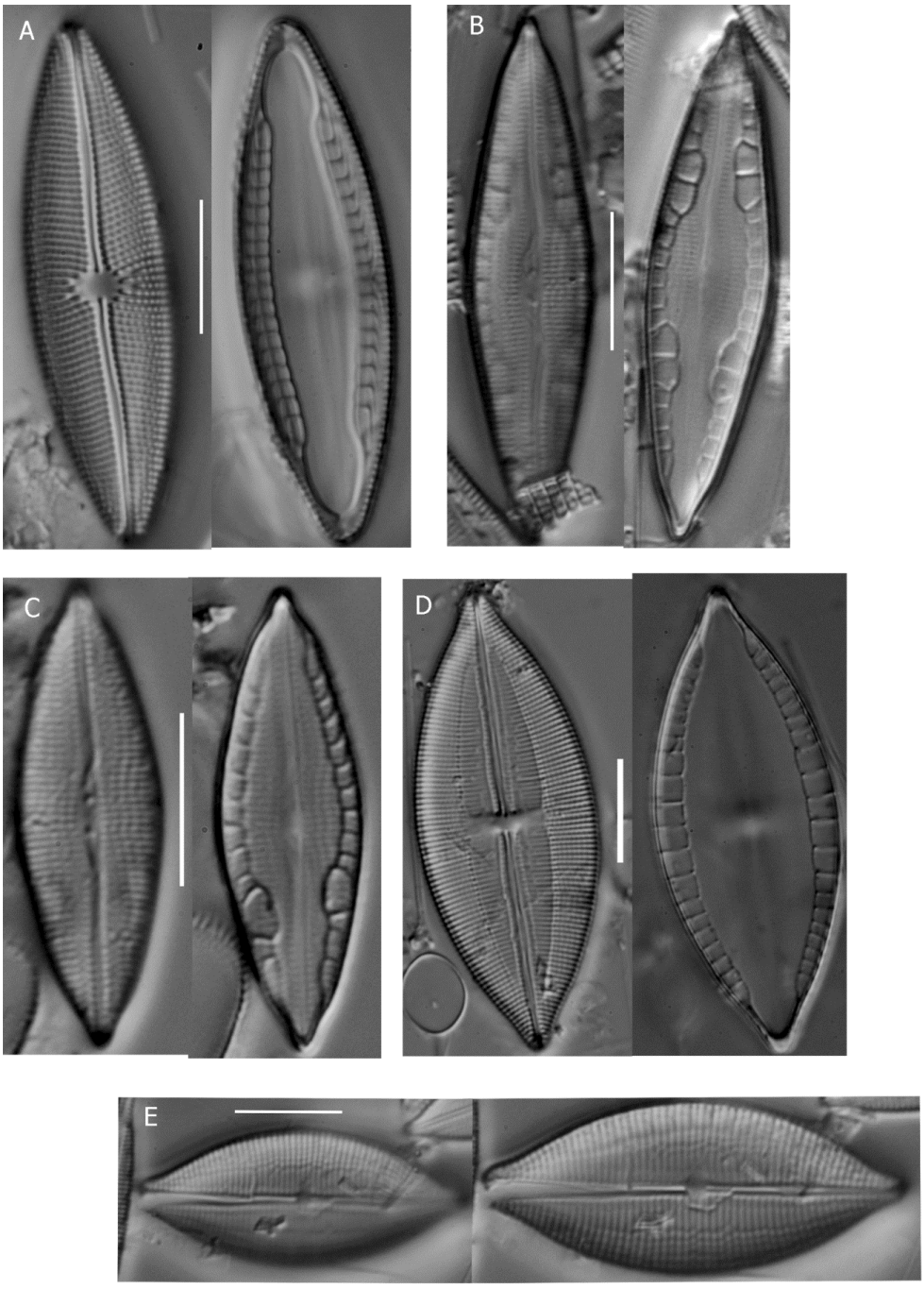

A
B
C
D
E

Plate 22. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Mastogloia lanceolata* (scale – 10 microns)

B. *Mastogloia lanceolata* (scale – 10 microns)

C. *Mastogloia baldjikiana* (scale – 10 microns)

D. *Mastogloia* cf *pisciculus* (scale – 10 microns)

E. *Mastogloia baldijikiana* (scale – 10 microns)

F. *Mastogloia pusila* type 2 (scale – 10 microns)

G. *Mastogloia vasta* (scale – 10 microns)

H. *Mastogloia pusila* type 1 (scale – 10 microns)

I. *Mastogloia tenuissiama* (scale – 10 microns)

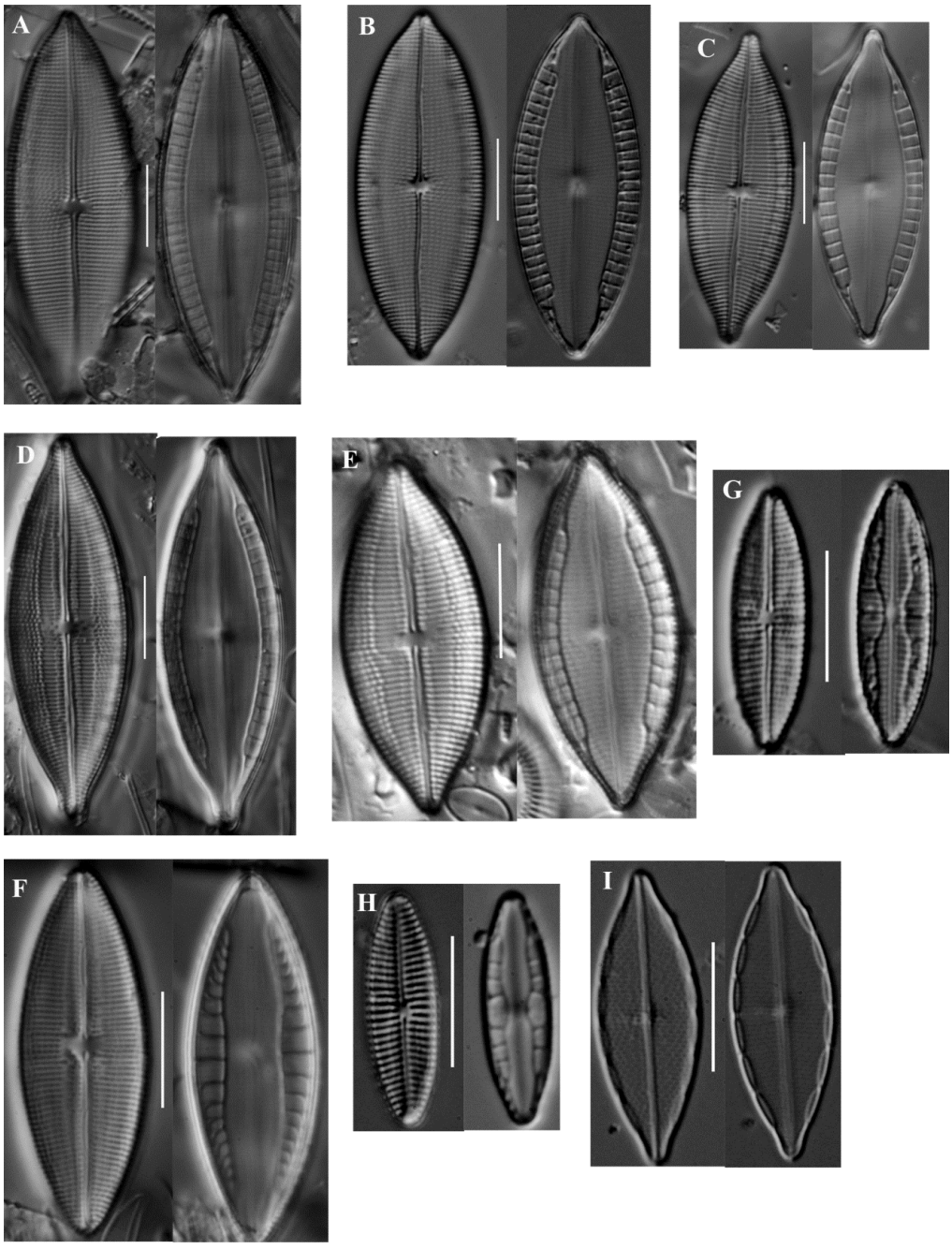

A
B
C
D
E
G
F
H
I

Plate 23. Choctawhatchee Bay-Acid Cleaned-DIC

A. *Mastogloia adriatica* (scale – 10 microns)

B. *Mastogloia elliptica* var *dansei* (scale – 10 microns)

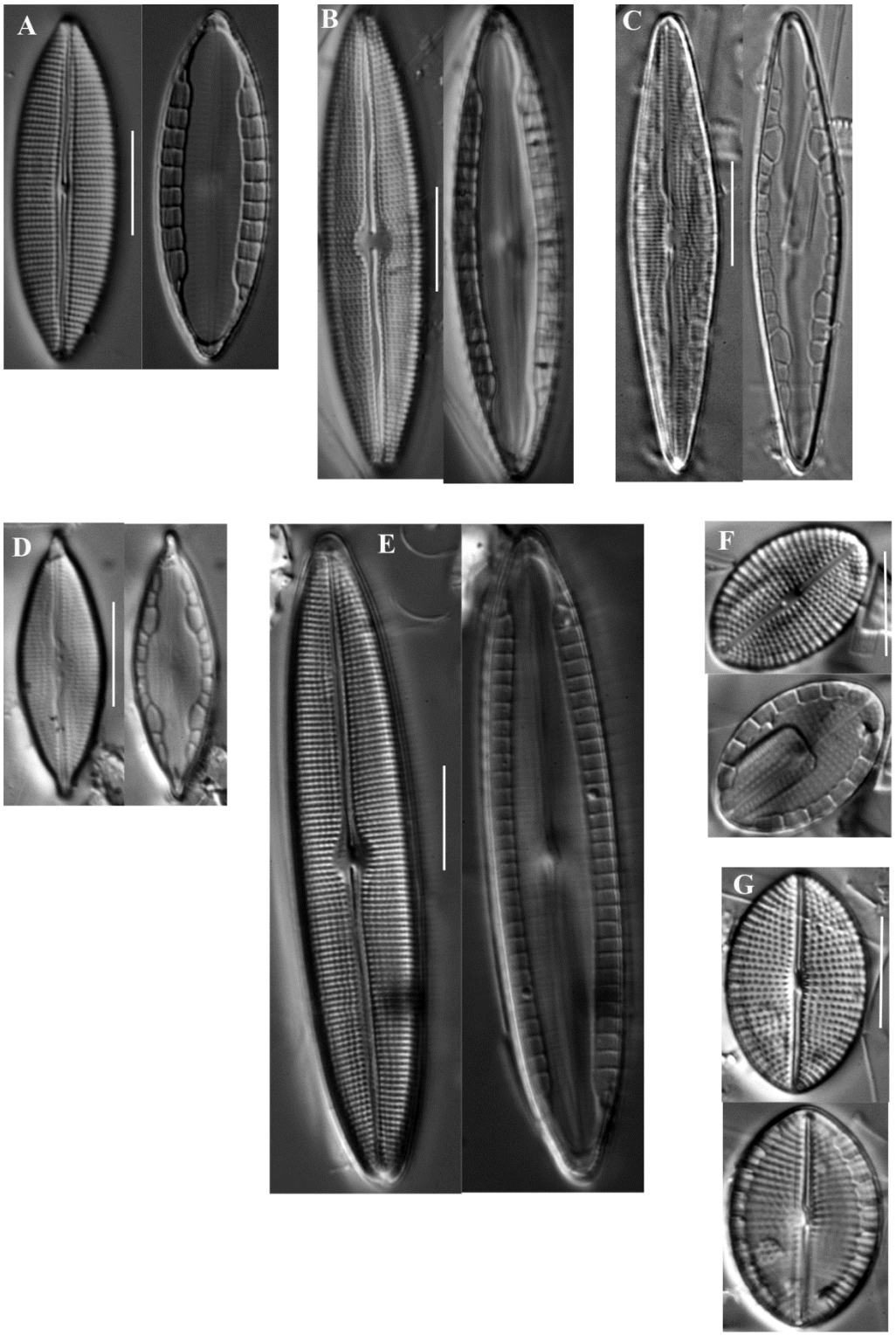
C. *Mastogloia erythraea* type 2 (scale – 10 microns)

D. *Mastogloia erythraea* type 4 (scale – 10 microns)

E. *Mastogloia labuensis* (scale – 10 microns)

F. *Mastogloia ovata* (scale – 10 microns)

G. *Mastogloia ovata* (scale – 10 microns)


A
B
C
D
E
F
G