DYNAMIC SYSTEMS ANALYSIS OF FOSSIL DINOFLAGELLATES FROM THE ATLANTIC COASTAL PLAIN, USA.

by

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ABSTRACT

Dynamic Systems modeling suggests that complex coastal dinoflagellate biosystems can be modeled using environmental parameters such as temperature, salinity, and bulk nutrient levels. The former Salisbury Embayment of northern Virginia and Maryland is modeled here, using STELLA II and FORTRAN models based on physical oceanography and temperature, salinity, and nutrient conditions of the modern Yellow Sea. In these models, dinoflagellate assemblages are predicted based on environmental conditions associated with depth.

Cluster analyses of fossil dinoflagellate frequency data from Tertiary Pamunky Group (Aquia and Nanjemoy Formations) of the Salisbury Embayment produce 17 discrete groupings. Samples within the Salisbury fossil cluster groups are statistically similar (via ANOVA analysis), but not the same. Therefore they represent paleocommunity types rather than paleocommunities. Although individual sinoflagellate species reccur in similar environmental settings, the paleocommunity types do not appear to repeat.

In the past, such associations have been used as depth indicators. It is suggested here that they relate to estuarine, nearshore, and offshore coastal regions because of the temperature, salinity, and nutrient conditions of each.

In the modern Yellow Sea, nearshore and offshore regions are separated by discrete lateral fronts in some areas, and by gradational regions of mixing in others. Both types of watermass boundaries are modeled in this study. Results suggest that evidences that discrete watermass boundaries might have occurred between some fossil dinoflagellate associations. Circulation patterns of the Salisbury Embayment may have been roughly similar to those of the modern Yellow Sea.

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INTRODUCTION

General Comments

Fossil marine dinoflagellates (microscopic phytoplankton belonging to the Division Pyrrhophyta) are used extensively for age dating, correlation, and paleoenvironmental analysis. However, they have never been studied via system dynamics analyses of their community structure. System dynamics are used routinely in many fields of science to study complex multivariate systems (Roberts, 1983: Rose, 1987). Analyses of living systems and their environment involve complex interactions (May, 1981; May, 1993). This study is the first to use system dynamics to study fossil marine dinoflagellate assemblages.

The Virginia Tech Palynology Program produced numerous dissertations and theses on the taxonomy, morphology, and biostratigraphy of Cretaceous and Tertiary dinoflagellates from the Atlantic Coastal Plain. This current study uses data from previous studies of the Aquia (Paleocene) and Nanjemoy (Eocene) Formations of the Virginia Coastal Plain (McLean, 1969; McLean, 1972; Witmer, 1975; Goodman, 1975; and Witmer, 1987). The Aquia and Nanjemoy Formations were deposited in an ancient embayment known as the Salisbury Embayment located geographically in the region of the present Chesapeake Bay and Atlantic Coastal Plain in the states of Virginia, Maryland, and Delaware (Figure 1). The localities studied herein are from Virginia, in the central and southern parts of the Salisbury Embayment.

Objectives of this Study

The primary objective of this study is to examine fossil dinoflagellate frequency data from the Salisbury Embayment for paleocommunity structure and environmental association using system dynamics and paleocommunity analysis. A second objective of this study is to test the potential of using system dynamics FORTRAN modeling in describing coastal plankton systems.

Methodology

Data from the Tertiary Pamunky group was used in this project for three main reasons. This stratigraphic interval provides a relatively continuous record of changing local environmental conditions (a regression followed by a transgression). The depositional record for this interval is assumed to be relatively constant (as opposed to K/T boundary sediment below, or upper Eocene possibly meteor impact-disturbed sediment above (Ward, 1993)). In addition, significant fossil dinoflagellate frequency data exist for this interval.

The frequency data used are derived from previous taxonomic studies of this interval.2

Environmental association is explored by modeling paleoenvironmental conditions of the Salisbury Embayment during the Tertiary based on modern analogs of the Yellow Sea and the Gulf and Atlantic Seaboard. The Yellow Sea was chosen as the primary physical analog because of its similarity in size, extent, geographical orientation, and possibly similar circulation patterns to the Salisbury Embayment. The modern analogs are used to construct both dynamic systems STELLA II and FORTRAN computer models, based on biological and environmental information, by which possible dinoflagellate environments and interactions may be modeled. STELLA II is a model construction program which uses an iterative approach to exploring dynamic processes. STELLA II is used to design and test structural diagrams (see Richmond, et al., 1987). FORTRAN modelling, however is more mathematicallly rigorous. Data sets for both modeling approaches were manipulated using EXEL spreadsheets (See Cobb, 1985).

Potential paleocommunity structure is tested for using Q-mode cluster analysis and analysis of varience techniques. Cluster analysis and comparative sorting and graphing techniques are used to delineate separate species groups based on similarity coefficients.

Groups produced by cluster analysis appear preferentially associated with particular coastal regions and their physical conditions.

I. GEOGRAPHICAL AND GEOLOGICAL SETTING

The Salisbury Embayment

The Atlantic Coastal Plain is made up of several ancient embayments separated from one another by tectonic arches (Figure 1). The Salisbury Embayment (Figure 2) was one of these ancient embayments. It existed mostly during Tertiary time, covering areas of what are now Virginia, Maryland, and Delaware (Glaser, 1968; Gallagher, 1984; Gibson, 1989). The modern Chesapeake Bay, centered over the old Salisbury Embayment is several times smaller than its ancient counterpart.

The Salisbury Embayment was continuously connected to the open Atlantic Ocean. Water level in the Salisbury was a function of tectonic and eustatic sea level changes. At its maximum, it covered up to 20 thousand km2 at depths up to 150 meters in its eastern deepest part. Sediments deposited in the Salisbury Embayment indicate sediment-starved (glauconite-rich) nearshore marine to brackish-water conditions (Ward and Krafft, 1985).

The Norfolk Arch provided a primary structural control for the Salisbury Embayment during this time by affecting the shape and orientation of the embayment (Figure 2). Aquia and Nanjemoy sediments contain mica flakes in sands and coarse material which match with Roanoake River group sediments, derived primarily from the Virginia Piedmont (Ward and Krafft, 1985). The Piedmont region lies immediately southwest of the embayment. The Norfolk Arch structure to the south diverted freshwater Piedmont drainage northward and into the embayment. Also Norfolk Arch controlled both access from the open sea and circulation within the embayment. Throughout the Paleocene and early Eocene, normal marine flow entered the embayment primarily as bottom waters but was controlled by arch and bottom topography. The wide mouth of the embayment may have been protected to varying degree by banks or bars, and/or the topographically high remains of a Jurassic aged reef complex just to the northeast of the embayment mouth (Poag, 1993). Topographic submarine highs may have acted as partial sediment dams, keeping sand and fine clay within the embayment.

The presence of glauconite in the sediments and marine macro-fossils, particularly bivalves (Ward and Krafft, 1985; Edwards, 1989) indicate marine conditions. Glauconite, along with phosphate pellets and local carbonate, may reflect sediment starvation, and the

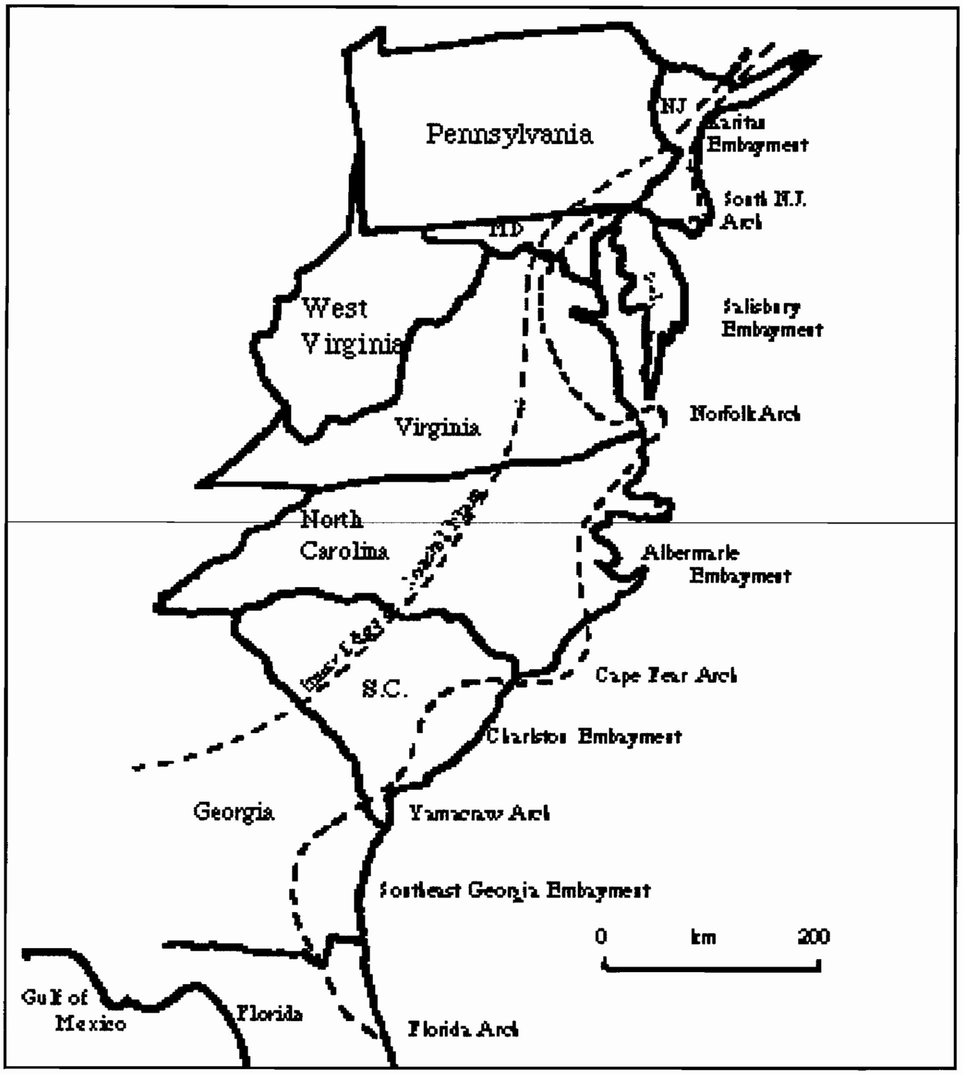


Figure 1. East Coast of US. showing Arches and Embayments.

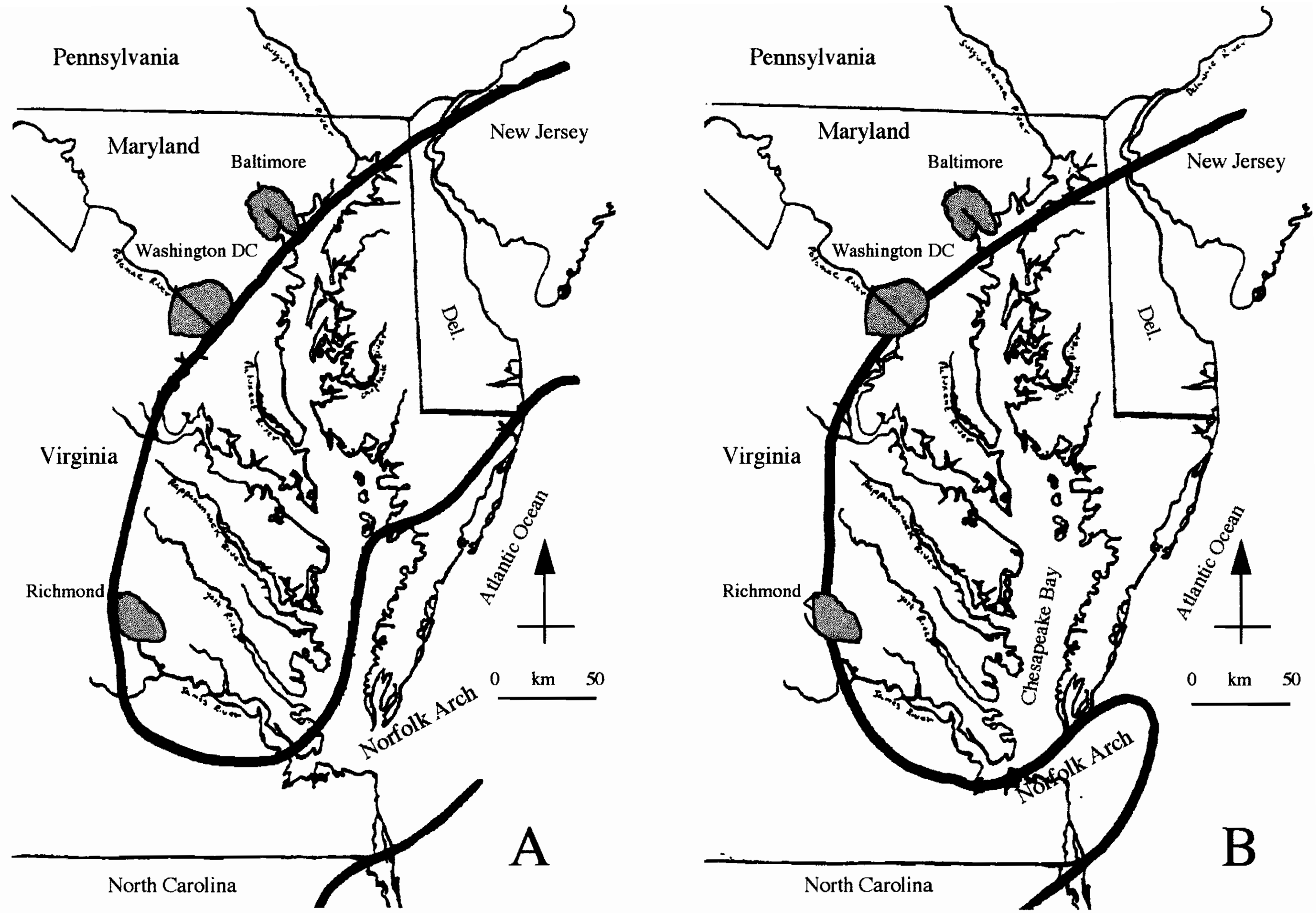


Figure 2. Approximate areal extent of the Salisbury Embayment during A) Aquia Deposition, B) Nanjemoy Deposition (after Ward and Krafft, 1985.)

presence of fine terrestrial clays in contact with warm marine water (Mallinson and Lee,1986). Glauconite has been associated with local marine flooding events (Tenison, 1989). Percentages of glauconite have been used to estimate depth and/or amount of marine influence within the Salisbury Embayment (Porrenga, 1967).

Salisbury Embayment sediments represent a series of unconformity bounded cyclic pulses of sediment during the times of transgression (Baum, 1986; Harris, 1993). Ward and Krafft (1985) note that, "the Atlantic basins...were characterized by relatively thin deposits, principally marine, with only remnants of nearshore facies. It is clear that large volumes of sediment were not being transported to the Atlantic Coastal Plain during the Tertiary."

Samples for this study are from the marine Pamunkey Group (Paleocene and Eocene) from the central and southwestern portions of the Salisbury Embayment.

The Pamunkey Group

The Pamunkey Group (Figure 3) is the basal Tertiary unit of the Virginia-Maryland Coastal Plain. It is subdivided into the Aquia (Paleocene) and Nanjemoy (Eocene) Formations (Figure 3).

The Pamunky Group was described and named as a formation by Darton (1891). Clark (1895) subdivided the Pamunky Group into Aquia Creek and Woodstock "Stages." Clark and Martin (1901) divided the group into the Aquia and Nanjemoy Formations which were each subdivided into two members (Figure 3), and into several finer scale "zones" which were based on lithology and fossils.

The "zones" of Clark and Martin do not correspond with the modern definition of a "zone" as set by the Code of Stratigraphic Nomenclature (1970). The term "unit" will be used in this work (after McLean, 1969).

The Marlboro clay, a meter thick clay unit elevated to formational status by Glaser (1971), separates the Aquia and Nanjemoy Formations.

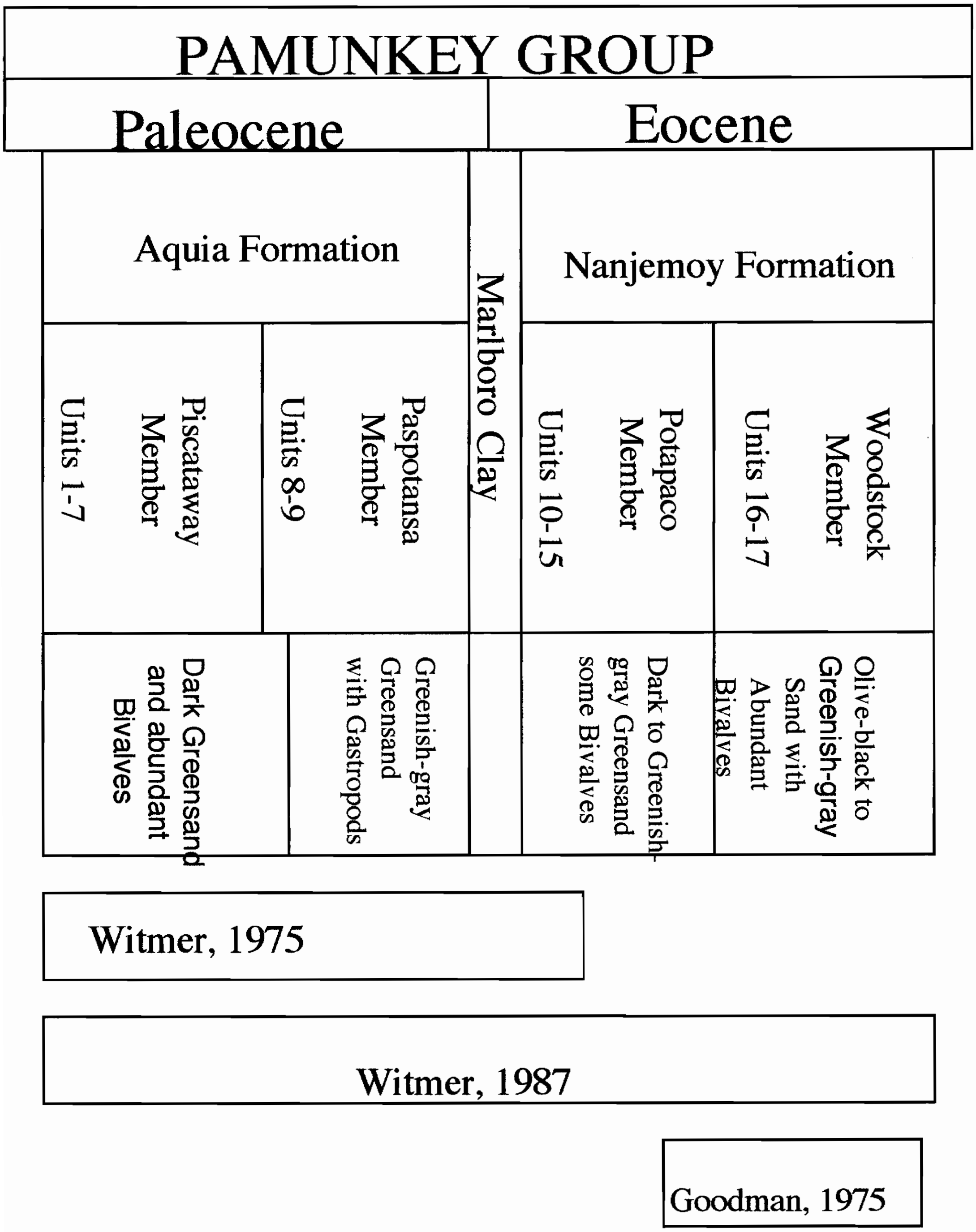


Figure 3. Pamunkey Group geologic column. (After Witmer, 1987)

The Aquia Formation

The Aquia Formation is the basal unit of the Pamunkey Group. It rests unconformably upon Late Cretaceous marine sediments over most of its geographical extent.

The type locality of the Aquia Formation is at the mouth of the Aquia Creek in Stafford County, Virginia. Its thickness ranges from about 30 meters at its type locality to a maximum of 76 meters at its eastern-most extent in Delaware and New Jersey. It consists primarily of glauconitic quartz sands. The Aquia contains fossil remains of tropical reptiles, mammals, and birds including pelican and albatross (Olsen, 1985; Weems, 1985). It is subdivided into the Piscataway (basal) and Paspotansa (overlying) members (Figure 3).

The Piscataway Member is a glauconitic (20 to 70 percent) clay rich and silty quartz sand trangressive marine unit (Ward and Krafft, 1985) deposited at a water depth of about 100 meters (Nogan, 1964). Common macrofossils include large bivalves and occasional *Turritella* gastropods (see Ward and Krafft, 1985, for details). The Piscataway Member contains units 1-7 of Clark and Martin.

The Paspotansa Member consists of glauconitic micaceous silty quartz sands somewhat better sorted than those of the Piscataway Member, and may represent a higher energy depositional environment (Ward and Krafft, 1985). A few beds contain bivalve macrofossils (see Ward and Krafft, 1985, for details).

The Paspotansa also is a transgressive unit deposited under progressively shoaling conditions. It includes units 8 and 9 of Clark and Martin.

The Marlboro Formation

The Marlboro Formation is a roughly meter-thick silty clay unit that separates the Aquia and Nanjemoy Formations. It varies in thickness, and is missing at some localities. It rests unconformably upon the Aquia Formation and is in turn overlain unconformably by the Nanjemoy Formation.

Interpretation of the depositional environment has been controversial. Ward and Krafft interpret the Marlboro as tidal flat deposition (Ward and Krafft, 1985), based partially on ripple marks within siltier portions of the unit. Others have evoked deposition in quiet waters of a protected embayment (Roger Cuffey, personal communication, 1996.)

The Marlboro is not included in the present study because of poor preservation, paucity of dinoflagellates, and reworking (Dewey McLean, personal communication, 1996).

The Nanjemoy Formation

The Nanjemoy sediment is composed of fine glauconitic quartz sands which are often argillaceous and sometimes calcareous with some beds containing abundant gypsum crystals. At the type locality along Nanjemoy Creek, Charles County, Maryland it is about 38 meters thick. The beds thicken to the east and northeast. The Nanjemoy Formation is divided into the Potapaco and overlying Woodstock members.

The Potapaco Member includes units 10-15 of Clark and Martin. Lower portions of the Potapaco consist of black to pink clay-rich sands containing (often detrital) glauconite. Some layers contain gypsum crystals and concretions. Worn and broken small bivalve fossils, scaphopods, *Calianassa* burrows and other bioturbation indicate more energetic conditions, possibly because of shoaling. Upper portions of the member contain higher amounts of glauconite, along with phosphate pebbles and wood fragments. This suggests a transgressive pulse during which sedimentation rates were low (Ward and Krafft, 1985).

The Woodstock Member lies unconformably upon the Potapaco Member. It includes units 16 and 17 of Clark and Martin. The basal Woodstock is marked by a pebble concentration, burrows and wood fragments. The Woodstock consists of very fine, well-sorted, silty glauconitic sands. Glauconite increases upward through the member whereas wood fragments decrease. The Woodstock contains diverse molluscan fossils (Ward and Krafft, 1985). It was deposited during transgression which returned the embayment from relatively nearshore to offshore marine shelf conditions. Woodstock sediments at Popes Creek, Maryland contain fossil fruits of *Wetherellia marylandica*. (Tiffney, 1985). These, and similar tropical mangrove-like fossil fruits from time-equivalent beds in Mississippi (Call, 1993), suggest that tropical climate existed throughout the region of the Salisbury Embayment.

II. THE DINOFLAGELLATES

R. H. Whittaker divided life into 5 kingdoms: Animalia, Plantae, Monera, Fungi, and Protoctista. The dinoflagellates belong to the latter, and more specifically, to the Division Pyrrhophyta (Pascher, 1913) and the Class Dinophyceae (Fritch, 1935). Lee (1992) recognizes six orders of modern Dinophyceae: Prorocentrales, Dinophysiales, Peridiniales, Dinocapsales, Dinococcales, and Dinotrichales. Of these, only the Peridiniales (Heackel, 1894) are important to this study.

Dinoflagellates are eukaryotes, but because of their nuclear organization, they are best described as mesokaryotic (between prokaryotic and eukaryotic). Most are single celled, but some form colonies. Thousands of species, both marine and freshwater, exist. Most are marine and are most abundant in warm waters. Most are heterotrophic, but some are phagotropic and predatory (Burkholder, 1992; 1995; Steidinger, 1996). This study deals with single celled marine dinoflagellates.

Dinoflagellate Life Cycles: Theca Versus Cyst Forms

Dinoflagellates are microscopic single celled organisms with complex life cycles many of which include both asexual and sexual reproduction, and both motile and resting stages (see figure 4 for generalized life cycle and description). What is known of fossil dinoflagellate life cycles is based on studies of modern dinoflagellates. It is assumed that many fossil forms utilized similar strategies.

Living motile dinoflagellates range in size from 20 to over 200 micrometers. Many species encase the protoplasm within a cellulosic shell or theca. Unfortunately, since cellulose is not well-preserved in the fossil record, our knowlege of fossil dinoflagellates is based on the study of resting cysts.

Cysts are composed of a complex chemically resistant carotenoid-like organic polymer known as sporopollenin, which is preserved in the fossil record. Dinoflagellate cysts often exist in sediments in which calcareous and silicious microfossils have been destroyed. Many cyst forms reflect faithfully the tabulation pattern of its corresponding thecate form. Dinoflagellate thecae are made up of numerous tiny plates, each of which has a unique shape and position in the theca (figure 5). These plates are arranged into series (See figure 5). The overall arrangement of plates is referred to as tabulation. Tabulation is an important criterion in dinoflagellate classification. The resulting pattern provides diagnostic cyst morphotypes by which we can identify modern or fossil cysts. In

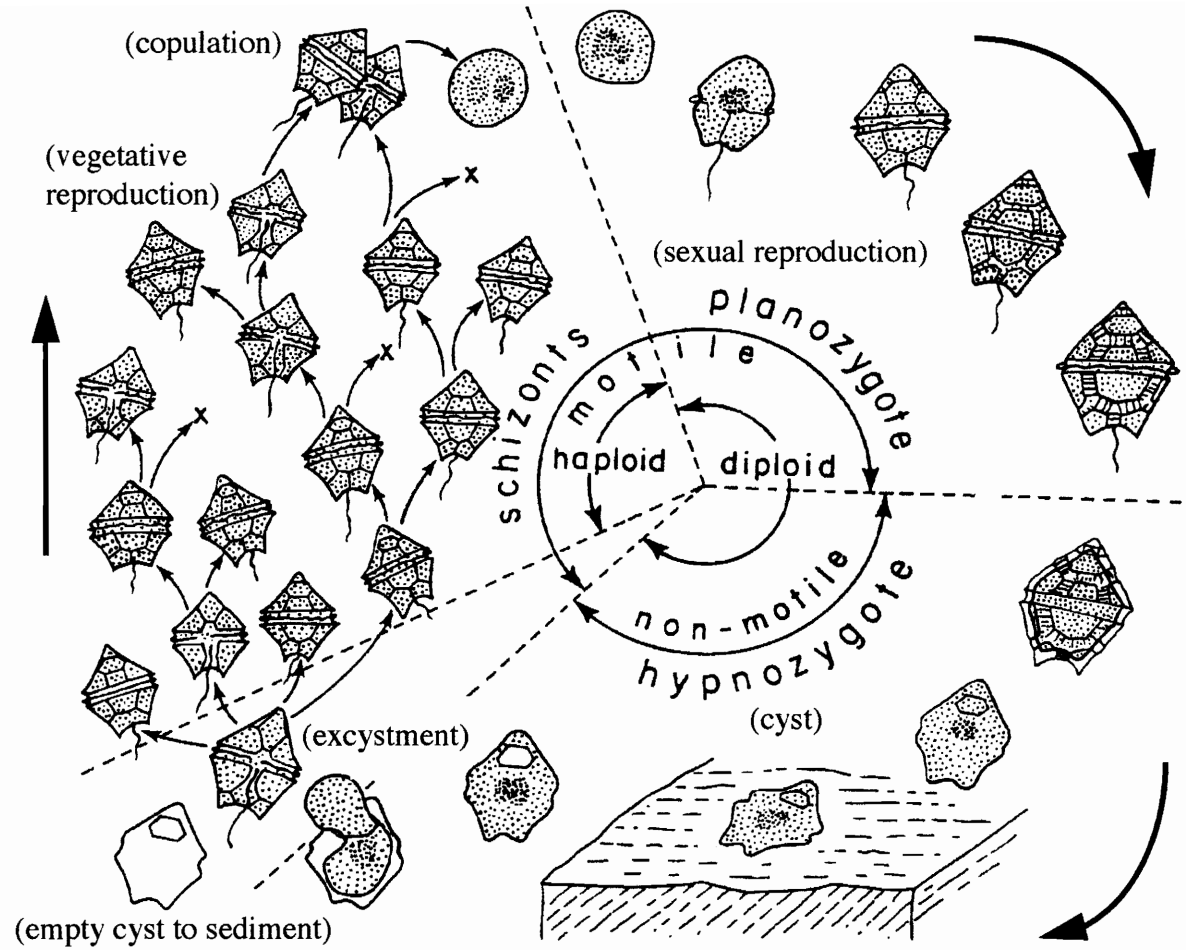


Figure 4. Dinoflagellate Lifecycle. After Evitt, 1985.

accordance with Evitt (1976; 1985), such cyst features are referred to with the prefix para- attached. Thus, cyst features become paraplates, paratabulation, parasulcus, and paracingulum (See figure 4).

There are two primary architectural styles of tabulation/ paratabulation in the peridinialean dinoflagellates. Those whose thecal plate arrangement resembles that of living *Gonyaula*x are placed in the "group" Gonyaulacaceae. Those whose plate pattern approximates that of modern *Peridiniu*m are referred to "group" Peridiniaceae.

In some cysts the cyst wall is deposited within, and next to the thecal wall. These are known as proximate cysts. Chorate cysts are similar, but have well-developed ornamentation or processes caused by shrinkage of the inner cyst from the inside of the thecal wall. Gonyaulacoid cysts tend to be chorate. In cavate cysts, space exists between layers of the cyst wall, and layers are separated by often intricate perpendicular walls or columns. Peridinioid cysts are often cavate.

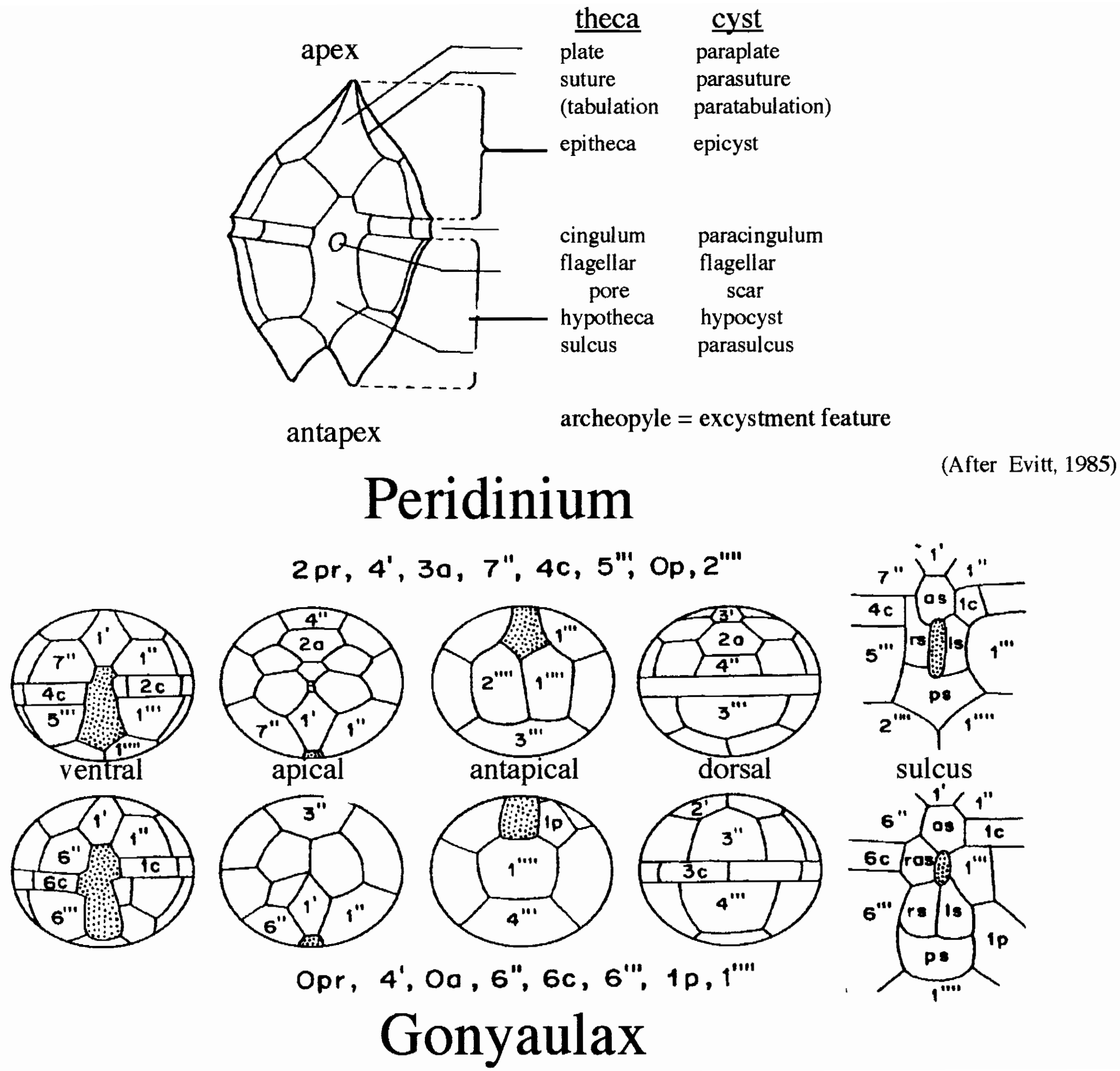
Other criteria used for cyst classification include shape, ornamentation such as processes or spines, etc., cyst wall structure, and archeopyle type (opening in the cyst wall(s) through which the protoplasm escapes the cyst). See figure 5.

FIGURE 5. Dinoflagellate Morphology

The sulcus is a longitudinal furrow located on the ventral portion of the theca. A smooth (acronematic) longitudinal flagellum is attached to the sulcus. It is responsible for both steering and forward movement of the dinoflagellate. The cingulum (or girdle) is an equatorial furrow which divides the theca into upper and lower hemispheres. The ends of the cingulum meet the sulcus, and may vertically offset one another. A transverse flagellum lies coiled helically within the cingulum. This transverse flagellum is usually covered with mastigonemes (small fibrillar hairs). A rhythmic beating of this flagellum causes both forward movement of the dinoflagellate and also a rotational movement of the cell through the water (Thomas, 1995).

The archeopyle is the aperture formed by the loss of either a single paraplate or group of paraplates (plate field) which allows the protoplasm to escape from the cyst during excystment (Evitt, 1976). The archeopyle of a given species is uniform in shape, precisely located and oriented, and can be used in determinations of cyst morphospecies. The paraplate or paraplate field which is opened or detached in the formation of an archeopyle is called the operculum.

Thecate dinoflagellates reproduce both sexually and asexually, depending on season or as environmental conditions begin to change (Lee, 1992). When sexual reproduction occurs, a planozygote or zygospore is formed. This is usually (though not always) in the form of an organic walled (sporopollenin) resting cyst. The tabulation pattern of the cyst is directly related to the thecal tabulation pattern, although the cyst may or may not reflect the original theca. After an inert period, spent either within the water column or within bottom sediments, the zygocyst germinates and reestablishes a motile phase. Some dinoflagellate cyst morphologies, such as spines and appendages, retard sinking (Parsons 1977). Because excystment is controlled by both water temperature and cyst age, cysts falling below about 200 meters rarely germinate (Lentin 1980).


apex
antapex
theca
plate
suture
(tabulation
epitheca
cingulum
flagellar
pore
hypotheca
sulcus
cyst
paraplate
parasuture
paratabulation)
epicyst
paracingulum
flagellar
scar
hypocyst
parasulcus
archeopyle = excystment feature
(After Evitt, 1985)
Peridinium
2pr, 4', 3a, 7", 4c, 5''', Op, 2''''
ventral
apical
antapical
dorsal
sulcus
Opr, 4', Oa, 6", 6c, 6''', 1p, 1''''
Gonyaulax

DINOFLAGELLATES: FACTORS CONTROLLING ABUNDANCE, DIVERSITY AND PRESERVATION

General Statement

Many factors control dinoflagellate abundance in living populations and in the fossil record. As microscopic phytoplankton, living dinoflagellates respond to environmental conditions of the photic zone. Some modern species encyst during unfavorable conditions. Others encyst as part of a seasonal life cycle, while others, especially open marine forms, do not produce cysts (Dodge, 1995). When produced, cysts must often sink through great water depths to become preserved in the fossil record. Many factors, such as feeding, breakage or chemical dissolution may destroy dinoflagellate cysts before they reach the sea floor.

Even after cysts reach the sea bottom, other factors such as bioturbation or diagenesis can still selectively destroy them. Because of both encystment patterns and taphonomic factors, fossil cyst assemblages may not reflect the composition of living assemblages.

Physical Factors Controlling Abundance and Diversity

Temperature

Ambient temperatures and temperature fluctuation influence dinoflagellate abundance via affects on metabolism and photosynthesis (Loeblich, 1967; Parsons, 1977). In addition, temperature difference is often a cause of water column stratification which may encourage dinoflagellates. Dinoflagellates exist at wide ranges of temperatures, but generally prefer warm waters. Maximum reproduction rates often occur near upper temperature tolerance levels (Taylor, 1987). Reproductive optimum temperatures for nearshore species are from 15° to 25° C., and for oceanic species occur at 20° C. (Loeblich, 1967).

Dinoflagellate populations are sparse in cold seasons or colder waters. Diatoms tend to replace dinoflagellates in cooler conditions (Guillard and Kilham, 1977).

Salinity

Marine surficial salinities vary with mixing, upwelling, and evaporation. In nearshore environments, freshwater flows out over more saline estuarine and coastal waters, maintaining a less saline surficial layer in which phytoplankton congregate (Thurman, 1994).

Nearshore and estuarine dinoflagellates range from obligate freshwater forms (such as *Peridinium limbatum*) to cosmopolitan euryhaline species. Terrestrial nutrients in estuarine environments correlate inversely with salinity (Mallin et al., 1991). Thompson (1987) notes many "stenohaline" associations may be dependent on, or intolerant of, run-off related constituents other than salt. Generally, peridiniacean dinoflagellates prefer near-shore environments. The presence of proximate and peridinioid cysts suggests marginal marine or reduced salinity conditions (Harker et al., 1990).

Offshore waters are relatively stable salinity-wise, and contain mixed cosmopolitan and stenohaline (or runoff-intolerant) dinoflagellate species, including many gonyaulacoid types. In the fossil record, the presence of mainly spiny chorate and gonyaulacoid or gymnodinioid cysts reflects normal marine salinity (Harker et al., 1990).

Eddies, Fronts and Upwelling

Flow of deep marine water into shallow coastal areas promotes mixing or upwelling. Fronts, however, occur at the contact between two water masses having different densities, due to temperature, salinity, or other factors. In these situations, a relatively sharp boundary occurs between the two water masses instead of a well-mixed zone. Fronts are often zones of convergence, capturing foam, floating wood and detritus, and near-surface phytoplankton (Bowden, 1983). Eddies occur when a portion of an intruding watermass is "spun off" into dissimilar coastal waters.

Eddies, fronts and upwelling are often associated with high nutrient conditions, and are often sites of highly productive, though sometimes patchy, phytoplankton growth (Tappan, 1985). Phytoplankton productivity in response to front-induced conditions may continue at times when frontal conditions are no longer present (Barry and Dayton, 1991). Where stratification or convergence occurs, dinoflagellates may have functional advantage over other phytoplankton, and occur in high numbers and/or diversity. Boundary regions too cold for dinoflagellates are occupied primarily by diatoms (Smayda, 1967; Guillard and Kilham, 1977).

Fronts often separate different floras, associated with the different water masses. Phytoplankton populations along fronts and upwelling zones often contain higher diversity, and/or different species associations than do waters on either side of the boundary (Gray, 1981). Bottom sediments beneath the boundary may preserve records of phytoplankton from one or all flora, depending on sedimentation patterns, sediment mixing, and locational stability (or seasonal repeatability) of the boundary. Long-standing boundary conditions may locally affect the gradient of change of fossil phytoplankton. Even sharp boundaries, however, will produce a "blurred" record due to mixing.

Nutrients

Dinoflagellates utilize nearshore (terrestrially-derived) nutrient sources moreso than upwelled oceanic nutrients (Thompson, 1987). Nitrogen and phosphorus availability are primary limiting factors in near-shore conditions. Iron, organic nutrients, and vitamins (such as B12) are important limiting factors, particularly in open oceanic conditions (Parsons, 1977; Bonin and Maestrini, 1981; Thompson, 1987).

Nitrogen and phosphorus (usually at a ratio of 15N to 1P) tie linearly to productivity (Parsons, 1983). In summer, stratified near surface waters are often deficient in nitrogen and phosphorus, reducing dinoflagellate productivity (Lieberman, 1994). During dinoflagellate blooms, sexual reproduction (and encystment) occurs when nitrogen levels eventually drop, suggesting that it is nitrogen which becomes a limiting factor (Weeks, et al., 1993). Decrease in nitrogen available might instead trigger sexual reproduction by changing the local carbon/nitrogen ratio (Bruce Parker 1994, personal communication). In this case, algal productivity may become self-terminating before nitrogen becomes a true limiting nutritive factor.

Phytoplankton require iron for their respiration and photosynthesis reactions (Glover et al., 1978). In near-shore areas, iron is available from terrestrial runoff, though only some forms are chemically useful to algae (Parsons, 1977). Open ocean waters are generally iron deficient (Menzel, 1961; Tranter, 1963). Studies by Ryther and Kramer (1961) found that oceanic dinoflagellates (especially Gonyaulicoids) have lower iron requirements than do near-shore types (including the Peridineaceans).

Organic nutrients and vitamins are often derived from terrestrial runoff, and are more available in nearshore, less saline waters (Gallegos, 1992; Carlsson and Graneli, 1993; Lopez, 1993).

Light

Light levels vary with turbidity and season. Seasonal light variation operates in conjunction with temperature to trigger encystment and productivity changes (Lee, 1992). In turbid or eutrophic environments, some dinoflagellates ingest other plankton, including diatoms (Marshall and Alden, 1993; Mullin, 1995). Dinoflagellates are often replaced by diatoms in times or areas of high turbidity (Marshall and Alden, 1993).

Biological Responses to Physical Factors

Succession

Succession is an ongoing shift in community structure or makeup as it continuously readjusts to changing environmental conditions (Margalef, 1968; Drury, 1973). Phytoplankton often progresses through a seasonal succession beginning with early season pioneer species and progressing to later, stability-associated species such as dinoflagellates. Within each successional range, incumbency plays a significant role. Once a species group is established, it dominates resources until conditions change, and it is displaced by a different group (Rosenzweig, 1991).

Study of seasonal succession suggests that dinoflagellate species occurring together in a fossil assemblage may not have existed together or interacted significantly with each other while alive. For example, a dinoflagellate species dominant when the water is first warmed in the summer may not interact with one dominant only in the fall. The length of dominant periods also changes with conditions: a dinoflagellate may flourish in tropical environments over 8 months of the year, while the same species will be active only through July and August in colder waters.

The fossil record indicates that dinoflagellate species groups or associations also change with environmental conditions over longer periods of time Offshore sediments have different associations or assemblages of dinoflagellate cysts than do sediments deposited in shallow estuarine or shallow coastal settings. Fossil dinoflagellate cysts change stratigraphically in sedimentary layers in a way which correlates with transgression/regression patterns of the paleocoastline (Habib, 1989). The fossil record may suggest persistence of general estuarine dinoflagellate “gene pools,” sensu Buzas and Culver (1994) through time.

A species (or species association) may become dominant when environmental conditions become optimal to its particular needs (Harrison and Quinn, 1989). During other times, it may remain present in the local environment, but remain encysted, suppressed, or as a minor fraction of the community. Oliver (1990) refers to continuous presence of many species, even when not dominant (in regard to forest stand dynamics) as an "initial floristics model."

Inoculation

Survival of a dinoflagellate species in a region depends on at least some cysts remaining in or returning to the local environment (Keafer et al., 1992). When cysts hatch under optimal conditions, they may remain rare, or they may reproduce asexually in great numbers, potentially allowing even a single cyst to produce a large population.

Cyst abundances less than 1% ("rare") in rock samples are usually not considered to be statistically significant (Ludwig and Reynolds, 1988). Even rare cysts, however, are present in local sediments in large numbers, and represent potentially viable stock during that time. Even cyst types not encountered within sample counts may be present, although below a threshold where they are found in most individual samples. Cairns (1969) discusses the threshold density of finding a single specimen of a rare species within modern ecosystems, concluding that one almost never finds "rare" living species in samples, although their overall population density must be adequate to sustain them.

Dinoflagellate Blooms

Optimal environmental conditions may give rise to large populations of dinoflagellates. These dinoflagellate blooms, or "red tides" can occur periodically due to seasonal or localized environmental conditions. Environmental factors conducive to dinoflagellate blooms include warm stratified surface water, gentle onshore winds, intense sunlight, and high nutrient levels (Lee, 1992). Nearshore environments and upwelling regions are often nutrient-rich, and often become sites of abundant dinoflagellate growth (Harris, 1986, Xiaohong et al., 1991). Dinoflagellate blooms often occur after cessation of upwelling, and/or directly diatom blooms. Diatoms "set up" specific nutrient and pH conditions amenable to dinoflagellate blooms (Smayda, 1967; Hinga, 1993) Dinoflagellate blooms are often toxic, producing extensive fish kills, poisoning shellfish, and destroying much of the local non-dinoflagellate phytoplankton (Prakash, 1967; Mullin, 1995).

During late stages of a bloom, mass encystment of dinoflagellates takes place (Heiskanen, 1993). Cysts remain inert within the water column or sediment, sometimes for several years until bloom conditions return (Keafer, 1992). Those buried deeply may never hatch.

Dinoflagellate biomass is greatest in near-shore and/or estuarine environments. Dinoflagellate species diversity drops off from open shelf environments toward shore, roughly correlative with decreasing water depth (Hulbert, 1963; Wall, 1977). In estuarine environments the reduction may be so drastic that the dinoflagellate community is represented by only a few tolerant species.

Many living dinoflagellate species cannot cope effectively with rapid salinity changes, or with temperature changes greater than about 5° C at a time (Parsons, 1977). Nearshore dinoflagellates often migrate geographically within estuaries in response to drastically changing environmental conditions (Habib, 1989; Firth, 1993; Burkholder, 1995). Vertical diurnal migration strategies allow modern nearshore and estuarine dinoflagellates to exist in variable, or eutrophic settings (Santos and Carreto, 1992; Salonen, 1994). Some nearshore and estuary dinoflagellate species can encyst within minutes when exposed to unfavorable conditions. Such production of resting cysts seems a specific adaptation to unstable environments within estuaries (Burkholder, 1995).

Large numbers of fossil specimens representing a single species may indicate environments where blooms occurred repeatedly. Whereas diverse dinoflagellate fossil assemblages may reflect seaward paleoenvironments low diversity may indicate nearshore or estuarine conditions.

Factors Controlling Preservation

Copepods and other zooplankton eat encysted dinoflagellates, breaking, and often destroying, the cysts. However, some cysts preferentially pass through the zooplankter gut intact and become incorporated into fecal pellets. The relatively large fecal pellets settle rapidly to the sea floor. Buck and Newton (1995) note that most dinoflagellate cysts become incorporated into the fossil record in this manner. Additionally, zooplankters prefer some prey species over others, introducing feeding bias into the record.

Within bottom sediment, changes in sedimentation rate can concentrate or dilute the relative numbers of cysts present (Rutherford, 1994).

Bioturbation and other time averaging obscures details and decrease resolution of the dinoflagellate record (Walker and Bambach, 1971). Time averaging may limit dinoflagellate data resolution to thousands or tens of thousands of years (Flessa, 1993).

Diagenesis also influences dinoflagellate preservation. Cysts are damaged or destroyed by local pore fluid and sediment chemistry, especially where hot or basic. Most dinoflagellate cysts contain sporopollenin which is resistant to chemical breakdown (Evitt, 1985; Traverse, 1988) except to oxidation, such as in high pH conditions. In calcareous samples, for example, dinoflagellate recovery is often poor. In ferric sandstones and siltstones, as well as in close proximity to Jurassic and Cretaceous dinosaur bones in lakes and brackish seaways, general palinomorph recovery is often poor (Alfred Traverse, personal communication, 1995). Recovery in organic rich sediments, and in relatively acidic or reducing conditions is often high.

IV. THE YELLOW SEA AS A MODERN PHYSICAL ANALOG FOR THE SALISBURY EMBAYMENT

In developing a model of the Salisbury Embayment, The Yellow Sea is an appropriate modern analog. It (along with inner portions of the East China Sea) is similar in extent, depth and physical structure, latitude, and eastern contenental location to the Salisbury Embayment (figure 6). It might share similar circulation and current structures with the former Salisbury Embayment.

The Yellow Sea is a shallow embayment bordered by China to the West and North, and by Korea to the East. It opens to the East China Sea to the south. TheYellow Sea bottom structure includes a north-south oriented deep trough (located somewhat nearer to Korea than to China) that provides the Yellow Sea with a core of warm, saline marine water derived from the Kuroshio, or regional boundary current.

Zhou (1989) has described the dynamic deposition systems of the Yellow (and East China) Sea. Even though influenced by human activities (Milliman et al., 1987), the depositional patterns and structures (Wang and Zhu, 1990; Park et al. 1992) may be analogous to those of the Aquia, Marlboro and Nanjemoy Formations of the Salisbury Embayment (See also Je et al. 1988). Glauconite is produced in deeper, offshore waters of the Yellow Sea Embayment and East China Sea (Lu-Xiaozhen, 1989).

Circulation within the Yellow Sea appears driven by wind-induced (i.e., Ekman upwelling) and tidal currents (figure 6). These currents wax and wane with seasonal monsoon winds and freshwater input (Park, 1986). Warm Kuroshio water enters the deepest portions of the embayment via the Yellow Sea Warm Current (Hwang and Choi, 1993).

In the northern half of the Yellow Sea Embayment, seasonal winds create an extensive surface zone of upwelling and mixing, forcing warm marine water to migrate northward as far as the Bohai Gulf (Tomczak and Godfrey, 1994) The marine influence varies seasonally as a function of wind strength and direction.

The China Coastal Current transports cool, low salinity water southward from northern portions of the Yellow Sea. A similar coastal current flows southward along the western coastline of Korea. These currents are strengthened seasonally by monsoonal freshwater influx into the margins of the Yellow Sea Embayment.

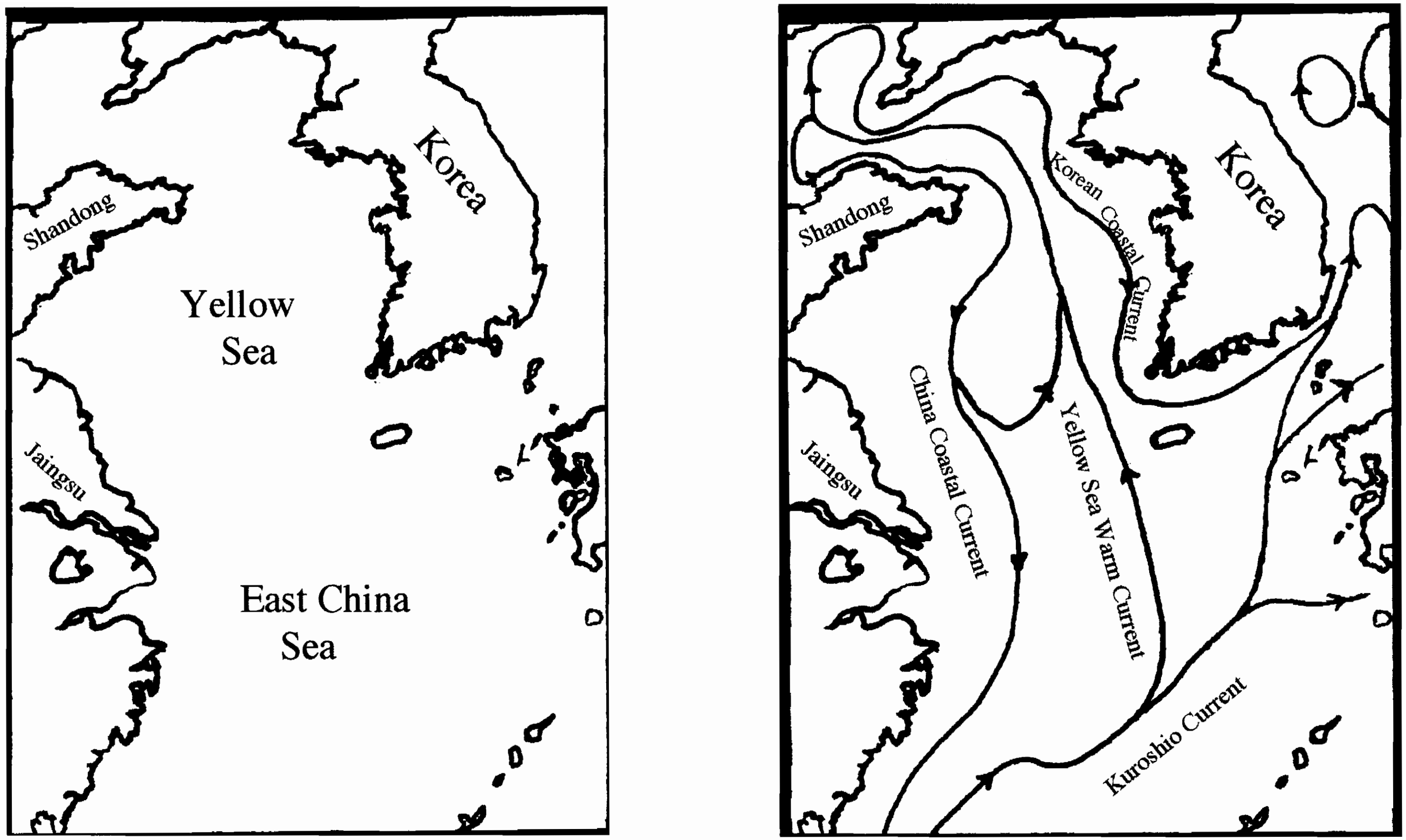


Figure 6. The Yellow Sea, showing coastline features and major currents.

The northward and southward flows are separated by lateral oceanic fronts (see figure 6). Here, the warm marine Kuroshio-influenced water mass meets with cooler less saline coastal water. Due to density differences, the two masses slide past each other without mixing significantly.

Freshwater drainage into the Yellow Sea Embayment creates local estuarine conditions, bounded by salinity and turbidity fronts, which separate them to varying degrees from nearshore coastal waters. These regions include portions of the Bohai (Yellow River) Gulf (Deng, 1988), the Yangtze River (Tomczak and Godfrey, 1994), the Kyongg Bay, the Kum River Estuary, and other areas (Yoo, 1986).

This physical circulation pattern produces a system of three relatively distinct water masses. They are: offshore, onshore, and estuarine. Offshore (warm, more marine) conditions are separated by an oceanic front from nearshore (cool, less marine) conditions. Salinity and/or turbidity fronts in turn separate nearshore conditions from more extreme and brackish conditions within estuaries (Seung et al. 1990: Shim et al., 1991)

In general, temperature and salinity in nearshore waters increase seaward. Offshore waters continue to show seaward temperature increases, although salinity there remains at about 34.4 o/oo (Kim et al. 1991; Cheong et al. 1992). Yellow Sea temperatures range from less than 2° C in nearshore winter waters, to about 27 °C in offshore summer waters (Kim et al. 1991;Tomczak and Godfrey, 1994). Temperatures of the warm Kuroshio Current range from 16 °C in winter to 29°C in summer. Its salinity ranges from 33.7 to 34.9 o/oo (Kim et al. 1991, Schweitzer, 1993).

During the summer season, thermoclines and stratification become well-developed in the Yellow Sea, especially in conjunction with front regions (Matsuda et al., 1989; Seung et al., 1990). Deep waters are characterized by high salinity. Surface waters are often nutrient poor (Chang et al., 1990; Yang and Kim, 1991). Primary productivity along the regional fronts is higher than that of either the outer stratified waters or the inner mixed coastal waters. This productivity is associated with increased light (decreased turbidity) and high nutrient levels along the fronts (Choi, 1991)

Because of the relatively cool temperatures and turbid conditions in shallow nearshore portions of the Yellow Sea, diatoms dominate the phytoplankton (Chang, 1986, Choi and Shim, 1986, Lee et al., 1989). Dinoflagellate populations are sparse, making up portions of the phytoplankton primarily in late summer. The dinoflagellates occur primarily in warmer, more stratified waters, and in association with the regional fronts. Within the estuaries, phytoplankton is reduced by levels of turbidity. Dinoflagellates and other phytoplankton are sparse in highly turbid environments (Shim et al., 1991), with diatoms predominant.

V. METHODS

Sources of Data Sets

Samples for most data sets were collected by former graduate students in the Virginia Tech palynology program from surface outcrop localities within the former Salisbury Embayment (figure 7). Witmer collected samples from the Oak Grove core (Witmer, 1987). Samples were numbered stratigraphically upwards at each collecting site. Samples were prepared via standard palynological maceration techniques to recover the organic-walled dinoflagellates. The technique destroys calcareous and siliceous microfossils such as diatoms and formaninfera.

Taxonomic identification and speciman counts were made by the original workers. In this study, original data sets were transformed to percentage equivalent values to allow comparison between data sets. Transformed percentage data sets are presented in Appendix A.

The species names used in this study are those of the original workers. This is not a taxonomic project. The reader is referred to the original thesis sources for species descriptions (See also Barss and Williams, 1983).

Correlation of Samples (Cluster analysis)

Cluster analysis is a straightforward form of multivariate analysis, whereby data are grouped into a hierarchical classification based on quantitative measure of their individual similarity of occurrence to one another. The output for a cluster analysis is a dendrogram, which groups and ranks the samples by similarity coefficient. Samples whose components are similar group together with high similarity coefficients, producing short dendrogram branches. In this study, cluster analysis is used to divide the combined Aquia-Nanjemoy dinoflagellate data set into dinoflagellate similarity clusters.

Cluster analysis begins with a comparison of (occurrence) similarity of all samples being tested. This produces a data matrix of similarity coefficients. From this matrix, the two samples which are most similar cluster first. The average value of this first cluster element is then compared with all other remaining values, and the next most similar sample is added to the next cluster level. This comparison and clustering continues until all samples are integrated (or forced) into the hierarchical dendrogram. After a sample is clustered, its coefficient value is averaged into the group value, and the sample is no longer

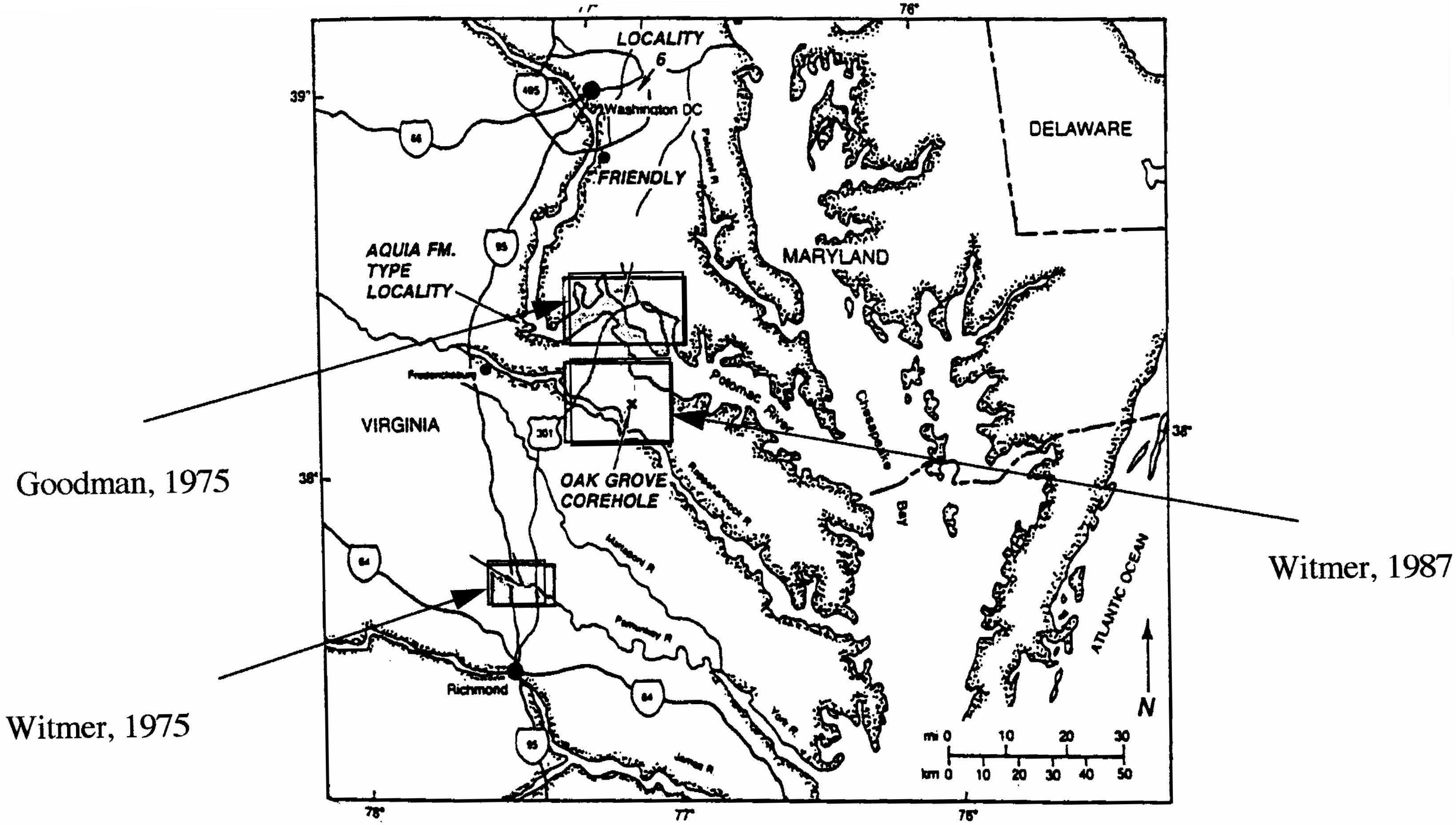


Figure 7. Site Locations

compared individually with any other sample in the data set. As new samples are clustered, their individual relationships become less distinct. Several results are possible. For one, the precise relationships of samples within cluster groups may not be accurate, although the cluster grouping is accurate. Clustering which occurs at low coefficients of similarity may not be as reliable as those grouping at higher similarities. Clusters at low similarities may be artifacts, associated only because the calculating engine joins together all loose dendrogram branches before terminating the analysis. Cluster analysis, however, is sufficient to quantitatively sort groups with similar characteristics, even though any suggested relationships between such clustered groups may be suspect (Size, 1987).

Q-mode Cluster Analysis

Q-mode cluster analysis forms hierarchical clusters of samples by comparing the similarities of occurrence of the species in each. Thus, Q-mode clusters represent physical or geographical units of similarity. They serve to determine potential boundaries of environmental settings among samples. Misunderstanding exists on how Q-mode analysis produces similarity clusters, particularly in gradient situations. Given a constant environmental gradient, Q-mode analysis forces the data into arbitrary subdivisions across the gradient, generating boundary conditions where none exist. However, Q-mode analysis will place group boundaries along non-constant gradients preferentially at points where boundaries do exist, or where the slope of the gradient changes most significantly over a short distance. Because the effects of even relatively sharp environmental boundaries grade into "transition zones" (expressed as a change in gradient slope.), Q-mode analysis is an appropriate tool.

Clustering for this project was done via a FORTRAN program written by Robert Plants (1977) for the IBM370 mainframe, and modified by Tom Rounds and Arnie Miller (1981; see appendix C). This program provided consistency with earlier cluster analysis by Virginia Tech palynology students(See Welch, 1986). The Virginia Tech IBM 3090-300 E mainframe computer was used for this analysis. In this project, the Czekanowski (or "dice") coefficient was used with UPGWA for comparing and choosing similar sample values within the clustering program. See the Results section for the output dendrograms of these analyses.

Q-mode dendrograms were also produced from data subsets containing only Very Common (greater than 25% of the sample makeup), common (greater than 10% of the sample makeup), intermediate (between 10% and 1% of sample makeup) and rare (less than 1% of the sample makeup) species. These dendrograms provide comparison of species within these general frequency groups in the "paleocommunity." See the Results section for discussion of these separate dendrograms.

Fossil Community Definitions

Coastal dinoflagellate associations change geographically according to environmental conditions from offshore to nearshore to estuarine regions (Steele, 1978). These regions may be gradational, or they may be separated by physical environmental boundaries, such as fronts (Springer and Bambach, 1985).

A sample of plankton consists of phytoplankton (including dinoflagellates, diatoms, etc.) and zooplankton (including copepods, etc.). In the living sample, the species and (potential) interactions between them form a local community. Often, only a subset of the overall local community is studied (Bennington, 1995); such as in this study the "dinoflagellate" local community is the unit of interest. An aggregate of statistically significantly similar living local communities in a region constitutes a community. The community boundaries can be defined by the degree of statistical similarity or difference between recurring local communities. In the case where local communities resemble one another, but are not statistically the "same," then the term community type is used (Bennington and Bambach, 1996).

Fossil assemblages may not closely resemble the original living community. Bennington and Bambach (1996) suggested using fossil record definitions comparable to modern community definitions. An assemblage present in a fossil sample is thus termed a local paleocommunity. An aggregate of statistically identical local paleocommunities is a paleocommunity. Related sets of local paleocommunities that are similar, but not statistically the same, are designated as paleocommunity types. Paleocommunity types group together in statistical cluster analysis of fossil data sets (Bennington and Bambach, 1996). Generally, temporally or geographically similar samples should be similar (particularly when the environment appears similar), whereas samples separated by time, geography, or environmental conditions, are often more dissimilar.

Bennington (Bennington, 1995; Bennington and Bambach, 1996) used ANOVA (analysis of variance of means, as described below) for determining "sameness" between local paleocommunities in benthic marine assemblages (See also Zenetos, 1991). ANOVA analysis is used in this study to compare member samples of cluster groups.

ANOVA Analysis

Analysis of Variance compares the means of individual sample groups. ANOVA calculates two components of variance (within-group variation, and between group variation) and then compares the ratio of the two components. The resulting number (or F-value) suggests the sameness or difference between members of the group. A probability (or P-value) is then calculated for the liklihood that the F-value will be more extreme than the one reported. Generally, a P-value of less than 0.05 indicates that one or more samples within the group are statistically dissimilar. See Sokal and Rohlf (1969; also Young, 1962; Fredericksen, 1974) for a description of ANOVA procedures.

All ANOVA statistics for this project were run using the Macintosh program STATVIEW, on a Macintosh IIsi computer. See Appendix A for ANOVA results of individual cluster groups.

Dynamic Systems Modeling

A major project goal was to construct a dynamic systems model of dinoflagellate species behavior using oceanographic and biologic data. Initial stages of this modeling used the dynamic systems modeling program STELLA II for the Macintosh computer. For a discussion of STELLA modeling, see Richmond (1987).

STELLA II modeling explored the correlation between dinoflagellate cyst distribution and paleobathymetry, as developed by others. In this model, six dinoflagellate species were created whose populations operated independently of each other and dependent only on depth. Two were "shallow water" species, two were "deep water" species, and two were "intermediate" depth species. Population growth rates differed between the species. No differentiation was made between living thecal populations and fossil cyst populations. Cyst counts for possibly analogous species from a portion of the Oak Grove core data set (Witmer, 1987) were entered into STELLA II format for direct comparison with the model species. Similar estimated depth ("shallow up") curves were plotted for the data and run for the STELLA II model.

More complex modeling required use of FORTRAN programming. Code structures for the FORTRAN model could be specifically designed for the modern analog of the Yellow Sea. FORTRAN models for this project were designed and run on an IBM 486 personal computer, using KEDIT and a WATFOR87 compiler.

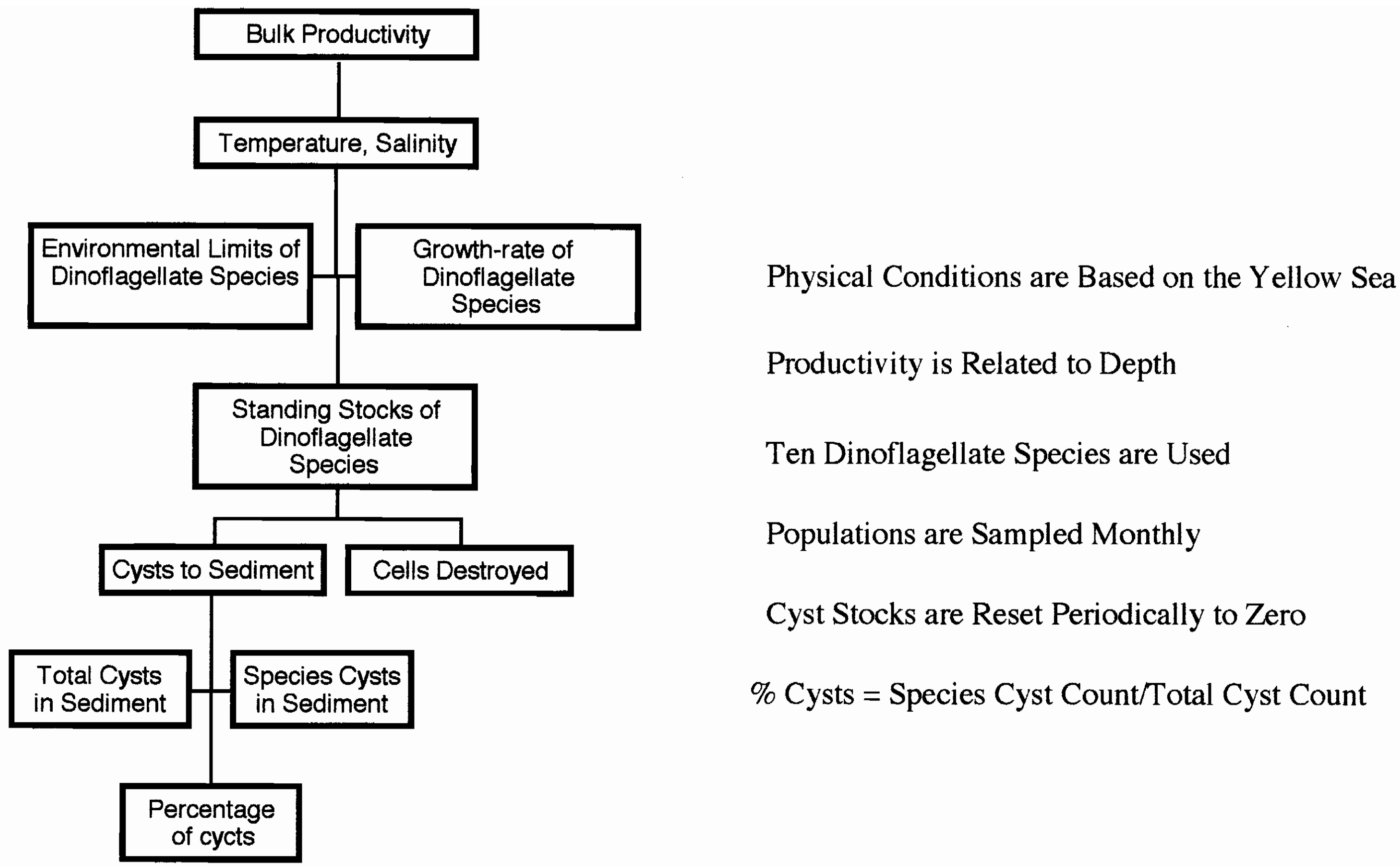


Figure 8. FORTRAN Model Flowchart

FORTRAN modeling for this project began with the construction of a simple linear-donor-controlled model, in which the results of each model step are controlled only by the previous step. The flow chart diagram of this structure is shown in figure 8. By successively adding complex relationships to the model code, three time varying non-linear

Figure 8

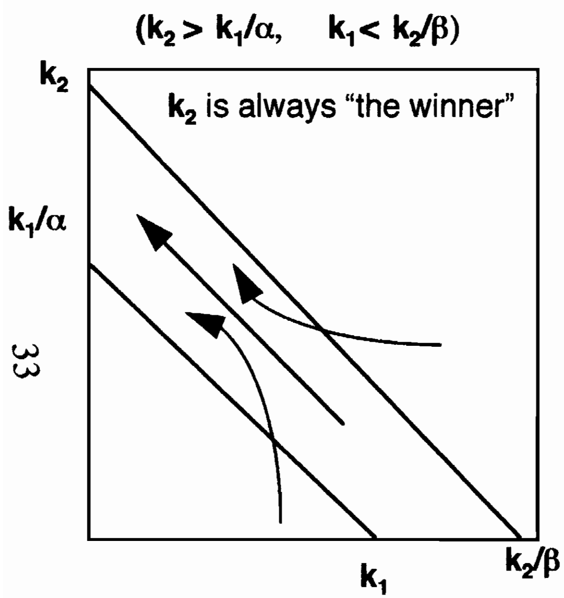
models were created. The final FORTRAN model code is shown in Appendix B. Data for the final models were drawn from information discussed in the background sections of this report (Also including Balech, 1967; Atkinson et al., 1985; Begon et al., 1986; Brock and Madigan, 1991). The FORTRAN model is broken down into three separate portions. The first is a module describing environmental parameters and relationships. The second presents hypothetical dinoflagellate species and their environmental requirements, growth parameters, encystment parameters, and environmental limitations. The third contains the assumptions and procedures associated with dinoflagellate cysts added to the sediment, and with time averaging. Results of these FORTRAN models are given in the Results section.

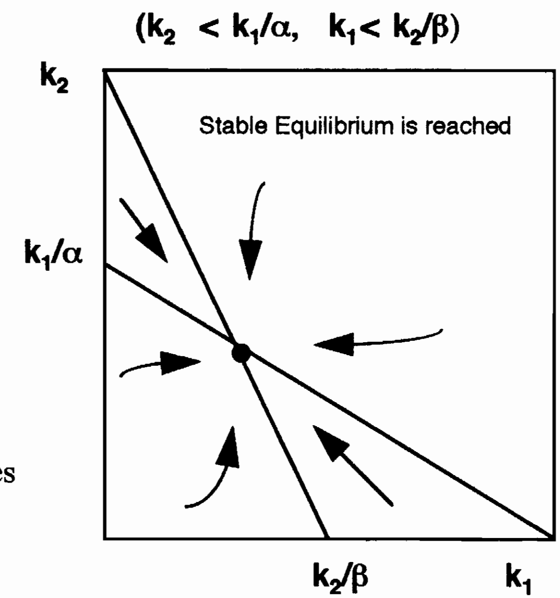
Phase Plane Interactions

Phase planes are a method for graphically testing possible species interactions. In this graphical technique, two species' population values are compared relative to each other, rather than as a time series. If one species is systematically affecting the other (Davidson, 1995), then the population values of both species may show the interaction geometrically when plotted in x-y phase plane space. When oscillations in population numbers of interacting species are stable with respect to each other through time (such as in a traditional Lynx versus Hares predation model), the phase diagram "stability field" produces a circular equilibrium figure, which repeats through time.

When the parameters of the system interact convergently toward an equilibrium condition, the stability field is expressed as an inward spiral, toward a circular equilibrium figure. When the parameters diverge from equilibrium, the spiral is outwards.

There are specific patterns which are stable and others which are not (figure 9). Interaction figures in real data may be overprinted by strong environmental signals, or interactions with more than one species at once. Two species reacting similarly to each other may both be reacting to a third over-riding factor. In such cases, the phase plane figures are erratic, and produce figures unlike those of the accepted archtypes. Interaction, where it exists, may be most apparent during times of overlap and replacement between populations, or may all be below the level of resolution of the data set.





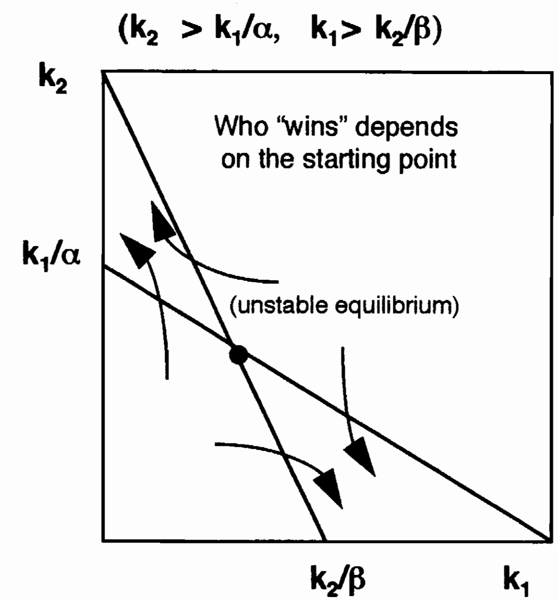


Figure 9. Phase Plane Archtypes

VI. RESULTS AND DISCUSSION

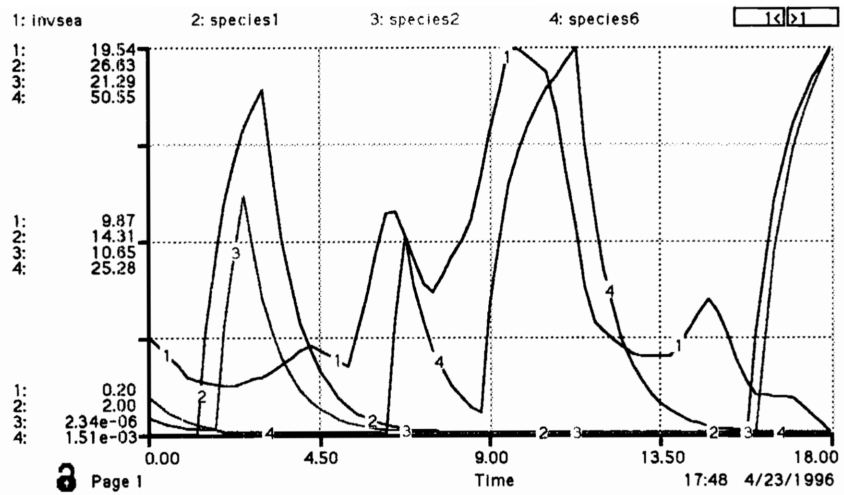
Stella Dynamic Systems Model

The STELLA II model assumes that instability and variability increases with sea level shallowing. It plots species frequencies dependent on the sea level and according to simple growth rate equations in the model code. The resulting time series (figure 10a) is graphed against a "shallow-up" relative sea level curve from a portion of the Oak Grove Core (Witmer, 1987).

The model output can be compared with equivalent data plots *of Areoligera*, *Deflandr*ia, *and Wetzelie*lla from the Oak Grove core (figure 10b). Line 1 (inversea) in both models represents the inverted sea level curve.

In both the model (top), and in the graphed data set (bottom), "deep" versus "shallow" species are present. The most noticeable contrast between the model and the plotted data is the finer scale shape and position of the frequency curves from the real data. In the model, there is a slow (mathematical) response time between sea level change and calculated dinoflagellate response. This is primarily due to the iteration period used within the model. Shapes of the modeled curves are simpler than those from data because they are defined by relatively simple mathematical modeling equations.

In general, the STELLA II model suggests that depth corellations might be quantifiable for some species, if precise dinoflagellate counts and detailed sea level information were available. Still, associations with bathymmetry do not directly suggest causation.



- STELLA II model output of three dinoflagellate species and (inverse) water depth, plotted against time.

- STELLA II plot of actual dinoflagellate data from a portion of the Oak Grove core. (data from Witmer, 1987)

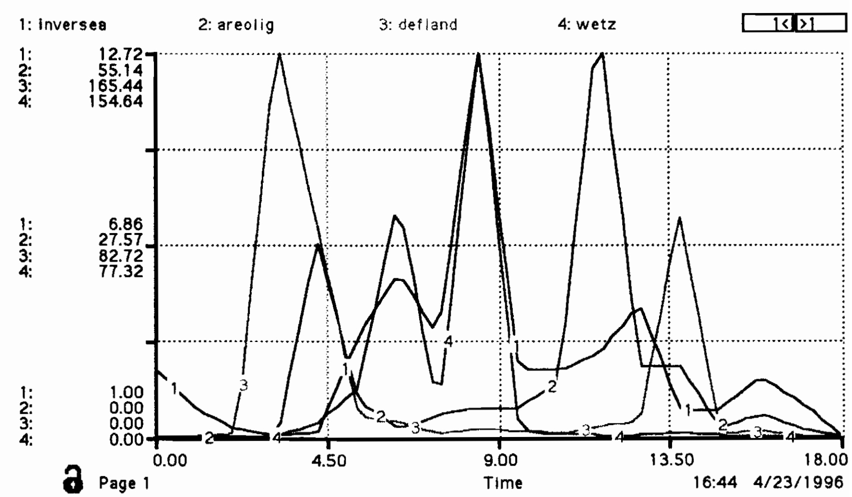


Figure 10. . STELLA II Model Time Series

Results of the FORTRAN Dynamic Systems Models

The FORTRAN models X, Y, and Z predict dinoflagellate populations according to depth related changes in temperature, salinity, and nutrient based on conditions of the Yellow Sea. Preliminary runs of the FORTRAN models using (cool) Yellow Sea temperatures produced small dinoflagellate populations. Increasing the average model temperatures by 5° C produced more extensive dinoflagellate populations. The warmer model variations are presented here. Results of the modeling suggest that the Salisbury Embayment may have been somewhat warmer than the modern Yellow Sea.

Dinoflagellate Model X reflects mixed conditions between nearshore and offshore waters, such as occur in the northern region of the Yellow Sea. Table B-1 (Appendix B) contains output from this model. For regions of mixing, Model X suggests gradational change in dinoflagellate associations from nearshore to offshore. Individual dinoflagellate species fluctuate seasonally as temperature and salinity conditions change.

Dinoflagellate Model Y describes the effects of a front boundary separating nearshore from offshore waters, such is found in lateral regions of the Yellow Sea. Table B-2 contains output from the second model.

For front-bounded conditions, Model Y suggests disparity between the two watermasses, their environmental conditions and the dinoflagellates present. Nearshore forms remain more separate from offshore forms. The physical and geographical change between the two groups remains sharper even with seasonal changes. Both mixed and front conditions may be found within the modern Yellow Sea. Lateral fronts remain at relatively constant locations, while the large mixed zone migrates seasonally, and has no sharply definable boundaries. Similar conditions may have existed within the Salisbury Embayment.

Table B-3 contains output from the third dynamic system model version, Dinoflagellate Model Z. This version produces model cyst data based on the dinoflagellate populations described above. Model depth increases by 5 meters at each sampling event. After each sampling period, all cyst values (including total cysts present) are reset to zero. The model reports cyst data for each species as a percentage of the total number of cysts present. Cyst species 11 and 12 represent secondary morphotypes of species 3 and 4.

Cyst information produced by the model suggests that dinoflagellate changes across

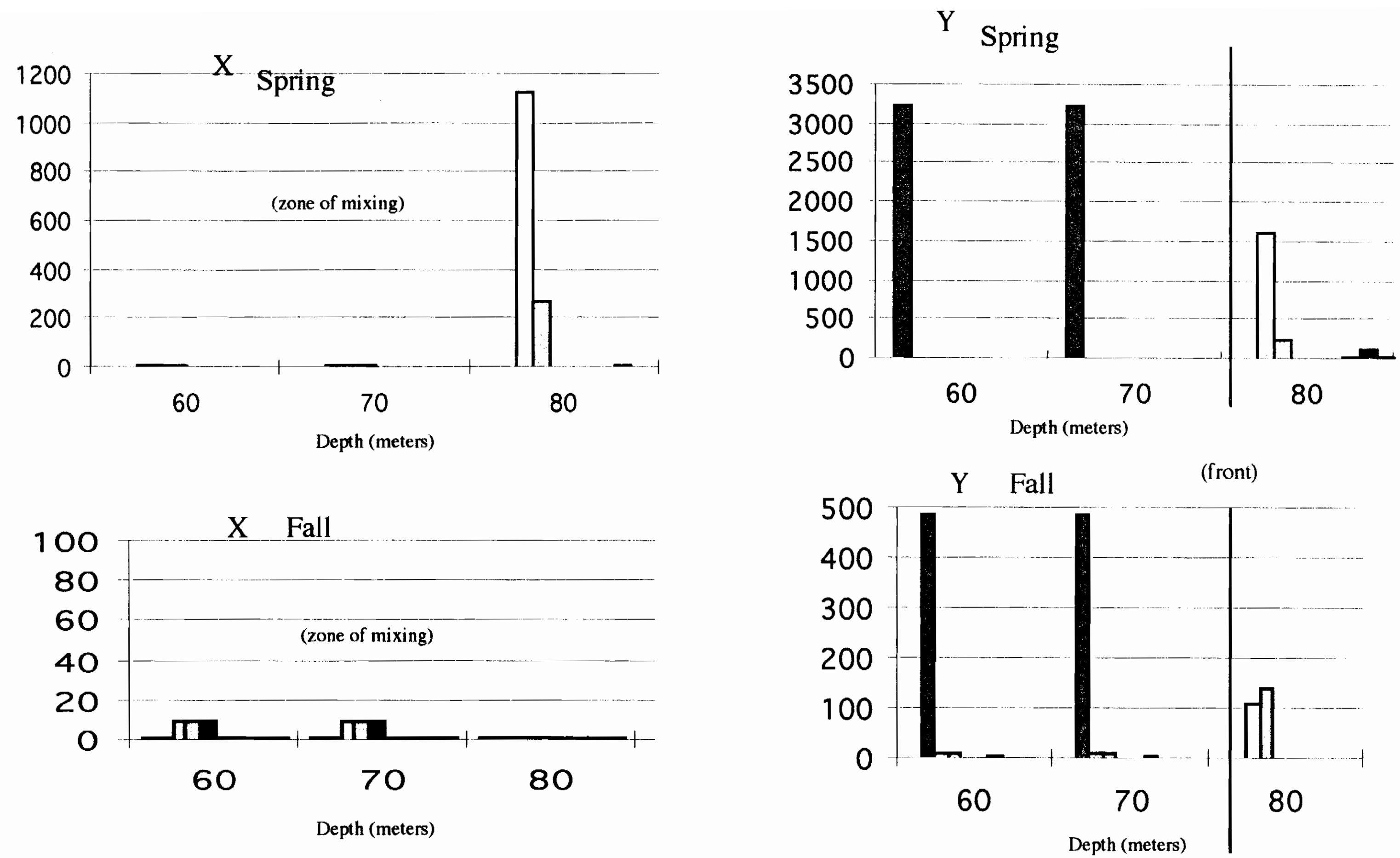


Figure 11. Representitive model output for model X, showing effect of mixed conditions in Spring and Fall, and for Model Y, showing separation of nearshore and offshore conditions associated with a coastal front. (Bars represent species counts of model species 1 to 10.)

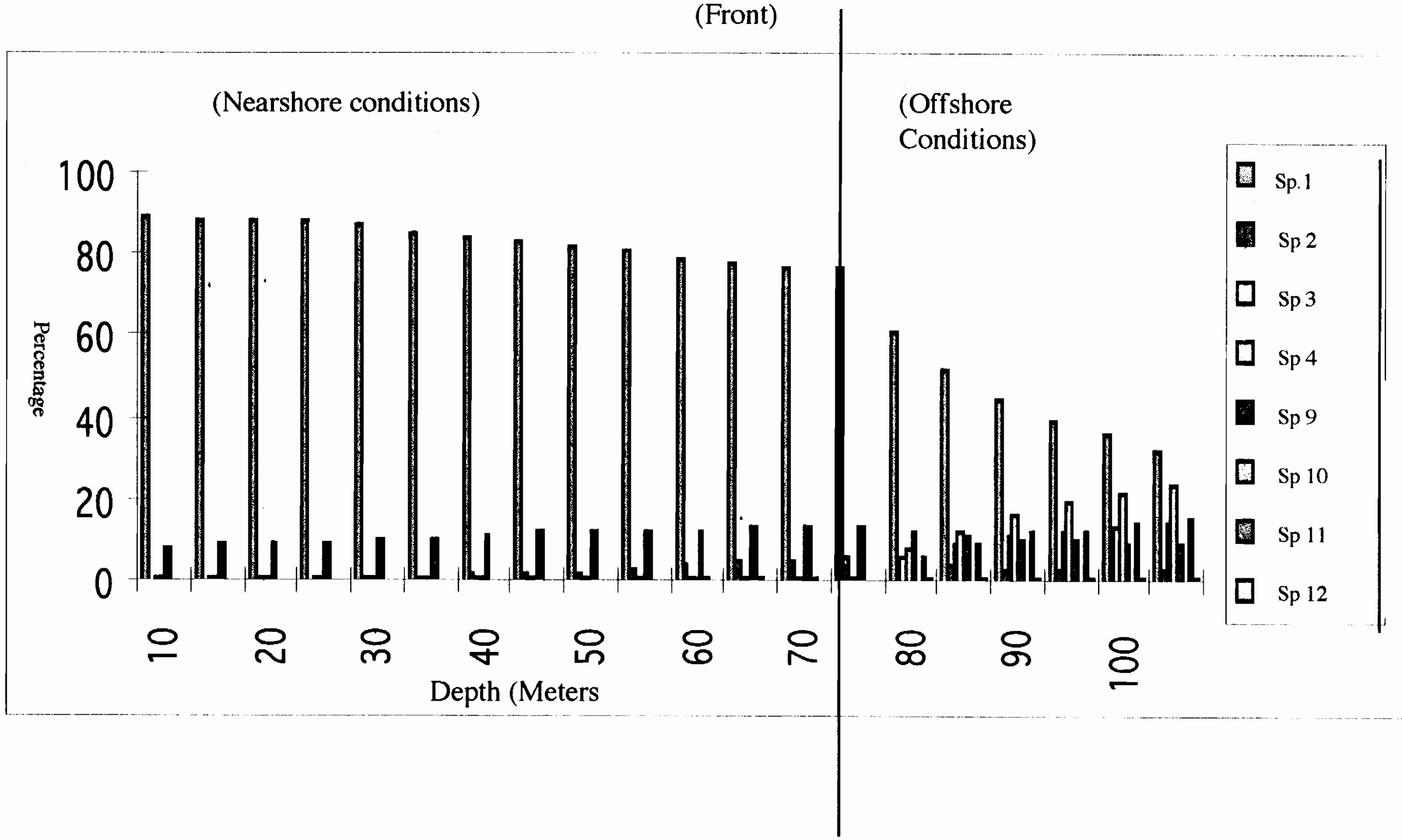


Figure 12. Model Z output, percentages of cyst types in sediment with depth. Modeled front is at 75 meters.

a front or boundary between coastal regions might be discernible in fossil assemblages (figure 11). This is also suggested by community analysis of the fossil dinoflagellate sets in this study. This assumes that effects of real front or boundary conditions would be significant enough to be recognized above background gradient effects (see figure 12).

The models, although preliminary, suggest that coastal dinoflagellate systems can effectively be described. Sets of potential conditions can be tested in a dynamic manner, provided that background modeling information is of good resolution, and modern analogs are carefully chosen.

Discussion of the FORTRAN Models

Models simulate and simplify reality (See Caswell, 1972; Drew, 1985; Goodman, 1988). The modeler tries to reproduce dynamic patterns using the fewest parameters possible. He then considers additional factors individually, to add refinement and complexity to his model. The modeling is a method for discovering the relative importance of different processes in the dynamic system.

In this modeling, I began by addressing dinoflagellate species temperature thresholds. Modern dinoflagellates survive well across wide temperature ranges. Temperature affects dinoflagellate growth most acutely on the seasonal scale. Temperature fluctuation is a strong limiting factor in shallow water, particularly where low temperatures occur. Temperature alone, however, proved unsatisfactory as a limiting boundary condition in the models.

Salinity seems a more powerful control in coastal and near-shore environments. Low and variable near-shore salinity limits dinoflagellates. In other coastal environments dinoflagellates exist in conditions near their upper salinity limit. These upper (seaward) limits model well as range limits. It is difficult, though, to determine dinoflagellate responses to salinity from responses to terrestrially-derived nutrients and compounds.

Nutrient or potential productivity in the model was problematic. Dinoflagellate auxotrophy is complex, and all simplifications quickly became unsatisfactory. Gross potential productivity calculations for phytoplankton are not specific to dinoflagellates (Richards and McGavan, 1989; Kang, 1992). Photosynthetic rates are affected by temperature, turbidity, and diurnal migration patterns. Light plays significant (but not well explained) roles in cueing dinoflagellate activities and life cycle stages. These effects are difficult to model in a meaningful way.

It became obvious during model construction that near-shore dinoflagellates are tied closely to terrestrial nutrient input and terrestrial drainage patterns. Possibly, these terrestrial factors, along with salinity, largely control coastal dinoflagellates. Terrestrial nutrient input is difficult to quantify.

Nutrient control entered the models as a growth-limiting factor, as nitrogen or phosphorus depletion limits bloom conditions. While this does provide limitations on logistic growth in the models, it does not reflect the broader role of nutrients on real dinoflagellates.

When these parameters are integrated, a plausible preliminary model is produced. The models do appear to resemble their natural analog. Still, they lack refinement. Use and adjustment of the models is necessary. Additional parameters should be explored.

Results of Q-mode Cluster analysis

Total Data set

Cluster analysis of the combined fossil data set results in 17 clusters at a coefficient of similarity of 0.4 (figure 13). These groups reflect changes in dinoflagellate associations, controlled largely by environmental conditions. Clustering follows the biostratigraphic order of the samples, representing a shallowing trend from the lower to upper Aquia (from sample 174 to 197), through a shallow and variable period of the uppermost Aquia and lowermost Nanjemoy (samples 303 to 318), and then a deepening trend into the Woodstock Member of the Nanjemoy (samples from 324 to 339 and 239 to 271).

Low association between geographically different data sets occurs between samples 317 and 324, and between 201 and 303.

An Areoligera-dominated association occurs during two separate time intervals. Samples 247 to 249 of the Nanjemoy cluster with 174 through 178 of the lower Aquia. Although the two assemblages are similar, they are not statistically the same.

Clusters representing (regressive) Aquia samples are more similar to each other than are clusters of the (transgressive) Nanjemoy samples. This suggests a more set pattern of incumbent species in the regressive samples.

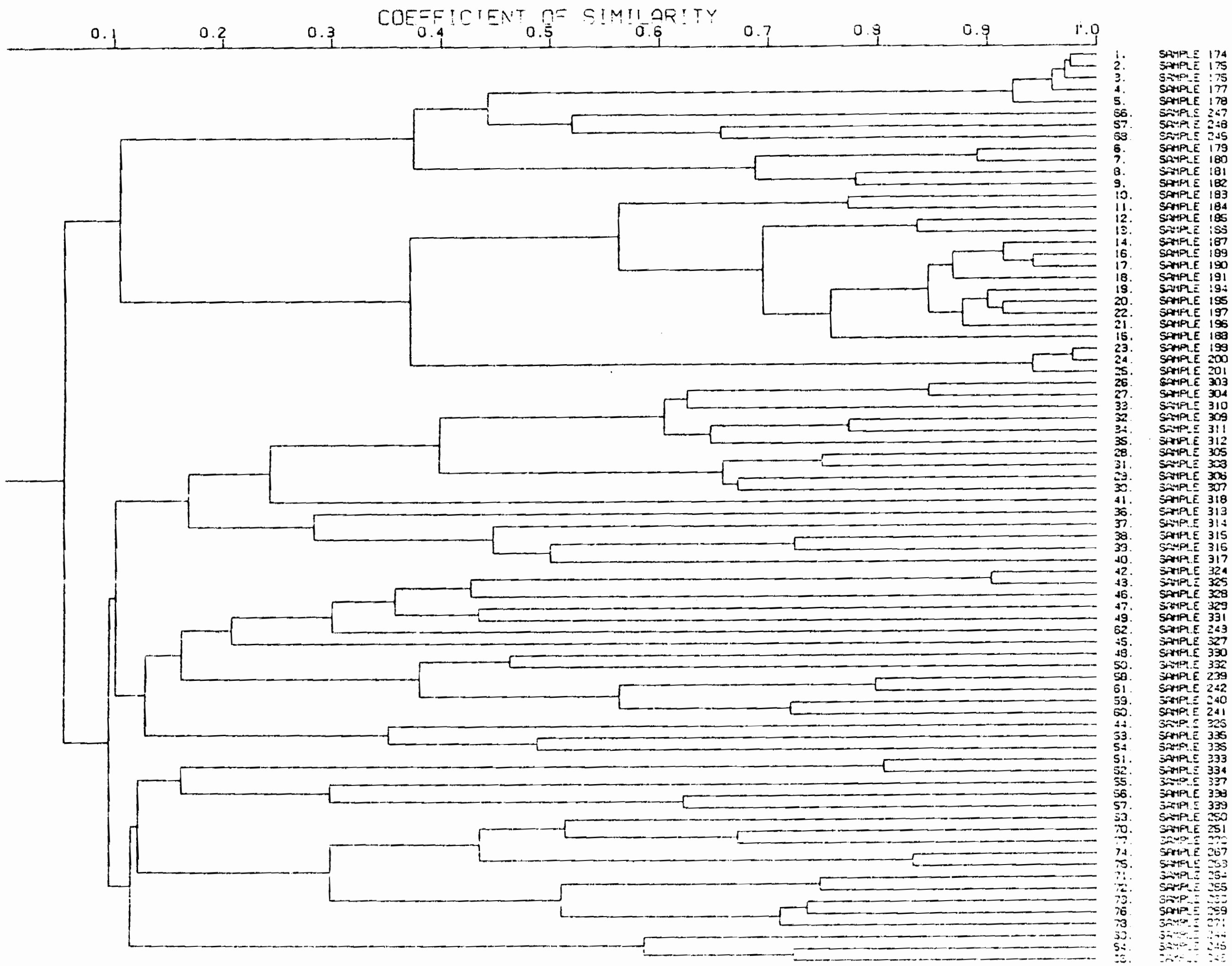


Figure 13. Total Data Set Q-mode Cluster Dendrogram.
Cluster groups were chosen at the 0.4 similarity coefficient level.

Common Species Cluster Associations (>10%)

The common species subset includes dinoflagellates composing more than 10% of any sample. These represent the largest species biomass, and largely determinethe "structure" of the groups.

The Q-mode dendrogram for the common portion of the data set is similar to the pattern of the total data set dendrogram. Again, 17 groupings occur at or above the 0.4 similarity coefficient. Group makeup is similar, though not identical to that of the total data set. (See table 1)

Here, single,dissimilar samples become more apparent (i.e., samples 327, 313) These may represent transition or boundary conditions between larger, unlike groups. *Areoliger*a-dominated samples within the Aquia) cluster at high levels of similarity, highlighting the role of the most common species in forming the statistical basis of the cluster. Nanjemoy samples appear more evenly clustered between sample sets.

Intermediate Species Cluster Associations (1-10%)

The second subset dendrogram includes intermediate species, defined as representing between 1% and 10% of any sample. Intermediate species occur an order of magnitude less than the common species.

The intermediate dendrogram does not correspond well structurally to either the total or the common data. Individual species within the intermediate subset do not necessarily follow the boundaries defined by the ranges of more common species.. When only clusters at or above the 0.4 similarity coefficient are considered, however, the result is more recognizable. Intermediate frequency species do respond in the same general pattern as the complete system.

Rare Species Cluster Associations (<1%)

Rare species (less than 1% of any given sample) individually have very little statistical impact on the structure or grouping of the samples. The dendrogram for rare species follows environmental or stratigraphic order of the samples . The species within this subset occur in low numbers (by definition) and have low impact. In this dendrogram, the geographical boundaries between sample sets (between samples 201 and 303, and between 339 and 239) are evident. This dendrogram also produces 17 groupings at 0.4 similarity or above. When rare groupings are tabulated against those of common or intermediate sets (table 1), the similarity is apparent.

Table 1 numerical comparison of dendrogram groups

Q-mode Groupings
(Paleocommunity types)

	All	common	Intermediate	Rare
	174	174	174	174
	175	175	175	175
	176	176	176	176
PT 1	177	177	177	177
	178	178	312	178
	247	249	314	
	248	179		
	249	180	178	
		247		
		248	181	
		181		179
	179	182	179	180
PT 2	180		180	182
	182		181	183
			182	181
			183	
			184	
	183	183	316	184
	184	184		185
	185	185	185	
	186	186	186	186
	187	188		187
PT 3	189	187	187	188
	190	195	189	189
	191	189	190	190
	194	197	188	191
	195	190	196	194
	197	194	197	196
	196	196	194	197
	188	191	195	195
			191	
			328	
			251	
			199	
	199	199		199
PT 4	200	200	200	200
	201	201		201
			201	
				311
	303	303	303	314
	304	311	304	312
PT 5	310	304	309	
	309	309	310	303
	311	310	311	304
	312	312		309
				306
				307
	305	305	305	308
PT 6	308	308	308	
	306	306	306	305
	307	307	307	
	314	314		315
PT 7	315	315	315	316

Q-mode Groupings
(Paleocommunity types)

	316	316		
	317	317	317	317
				318
				310
(sample 313)	313	313	313	313
(sample 318)	318	318	318	318
	324	324	324	324
PT 8	325	325	325	325
	328	328		
				326
				327
	329	329	329	328
PT 9	331			329
		331	331	331
	330	330	330	330
PT 10	332			332
			332	
PT 11	333	333		333
	334	334		334
PT 12	335	335	335	335
	336	336		
				336
(sample 337)	337	337	337	337
	338	338	338	338
PT 13	339	339		
				339
		332		
	239	240	239	242
PT 14	242	241	242	240
	240	239	241	241
	241	242	240	243
				246
(sample 243)	243	243	243	245
(sample 247)	247		247	247
			244	
	244	244		
PT 15	245	245	245	
	246	246		
			246	
				248
			249	249
				250

Figure 22
Q-mode Groupings
(Paleocommunity types)

			250	
	250	250	334	
	251	251	256	251
PT 16	270	267	271	
	267	268	336	
	268	266	270	
		270	267	
		269	268	
		271		
	264	264	264	264
PT 17	265	265	265	265
	266			
	269		269	266
	271			267
				268
				269
				270
				271

Discussion of Paleocommunity Makeup

Q-mode clustering of the data sets all show approximately 17 coherent subgroupings, or paleocommunity types, in addition to individual samples which are consistently dissimilar to other samples. Both of these observations suggest real rather than arbitrary cluster boundaries. These boundaries likely represent changes in the physical environment through time. ANOVA analysis shows that, at the 0.4 similarity level, all grouped samples are statistically similar, but are not the same. Therefore, the cluster groups in this study are paleocommunity types. Only in *Areoligera*-dominated samples of the Aquia, where similarity is much higher between some samples might a paleocommunity occur.

There are 255 dinoflagellate species represented in this study. These species, and their general relative frequencies are shown in table 2. The first column contains a species identification number. The first 176 numbers correspond to species identification numbers assigned by Witmer (1987) to species of the Oak Grove core; succeeding numbers are additional species reported in other data sets.

Table 5 shows that a large number of species only ever occur as rare (R%=100). Such species represent no appreciable impact on community structure at any time. Where only a single cyst is reported across the entire data set, the percentage value does not record its presence (R%=0, S%=0, C%=0).

There are several species which are nearly always common. The most extreme case of this is *Spinidinium macmurdoensis*, which is present as a common and dominant species, or is not present at all. Within this extreme presence-absence pattern, a'preferential prey' or preservation effect may be in operation. There is a trend of common species as preferentially "near-shore" types (although the case of *Areoligera* appears different), which might reflect bloom behavior.

Other species alternate between rare to intermediate, or from rare to common, in varying proportions.

Table 2. Dinoflagellate Master List and Count Tabulation.

	ttl#	Count values			Percentage values			>25% values	
		R#	S#	C#	R%	S%	C%	VC#	VC%
1 Achiella biformoides	25.1	7.2	18.9	0	27.6	72.4	0	0	0
2 Adnatosphaeridium multispinosum	195	3.47	42.3	150	1.77	21.6	76.6	114	58.2
3 Adnatosphaeridium robustum	73.3	1.33	38.6	33.9	1.81	52.3	45.9	0	0
4 Alisocysta cf. A. margarita	2.67	1	1.67	0	37.5	62.5	0	0	0
5 Andalusiella rhomboedra	4.33	1.67	2.67	0	38.5	61.5	0	0	0
6 Apectodinium homomorphum complex	81.7	2.33	2	77.3	2.86	2.45	94.7	31	38
7 Apectodinium sp. a	0	0	0	0	0	0	0	0	0
8 Apectodinium australiense	5.33	0	5.33	0	0	100	0	0	0
9 Apteodinium cribosum	8.73	1.87	6.87	0	21.4	78.6	0	0	0
10 Apteodinium labyrinthum	0.33	0.33	0	0	100	0	0	0	0
11 Apteodinium reticulum	1.67	1.67	0	0	100	0	0	0	0
12 Areoligera sp.	874	3.07	113	758	0.35	12.9	86.8	701	80.2
13 Ascotomocystus hydria	8.33	2.33	6	0	28	72	0	0	0
14 Batiacasphaera microreticulata	0	0	0	0	0	0	0	0	0
15 Batiacasphaera sp.	4	3	1	0	75	25	0	0	0
16 Biconidinium longissimum	0	0	0	0	0	0	0	0	0
17 Caligodinium amiculum	21.7	3	18.7	0	13.8	86.2	0	0	0
18 Cassidium paleocenicum	21.7	2.67	2.33	16.7	12.3	10.8	76.9	0	0
19 Chiropteridium partispinatum	0	0	0	0	0	0	0	0	0
20 Chlamydophorella cf. C. urna	157	8.23	20.8	128	5.23	13.2	81.5	0	0
21 Cladopyxidium saeptum	4	4	0	0	100	0	0	0	0
22 Cleistosphaeridium diversispinosum	107	4.73	27.4	74.6	4.44	25.7	69.9	0	0
23 Conniximura fimbriata	3	3	0	0	100	0	0	0	0
24 Cordosphaeridium biarmatum	2.67	1.67	1	0	62.5	37.5	0	0	0
25 Cordosphaeridium fibrospinosum	12.7	12.7	0	0	100	0	0	0	0
26 Cordosphaeridium giganteum	73.7	1	14	58.7	1.36	19	79.6	0	0
27 Cordosphaeridium gracilis	50.1	9.13	40.9	0	18.2	81.8	0	0	0
28 Cordosphaeridium inodes	81.6	17.7	63.8	0	21.7	78.3	0	0	0
29 Cordosphaeridium inodes robustum	1	1	0	0	100	0	0	0	0
30 Cordosphaeridium multispinosum	2.73	2.73	0	0	100	0	0	0	0
31 Cordosphaeridium solaster	0.33	0.33	0	0	100	0	0	0	0
32 Cordosphaeridium amputatospinosum	0	0	0	0	0	0	0	0	0
33 ?Cordosphaeridium callosum	10.8	9.47	1.33	0	87.7	12.3	0	0	0
34 Danea sp.	14.3	1.33	13	0	9.3	90.7	0	0	0
35 Dapsilidinium pseudocolligerum	0	0	0	0	0	0	0	0	0
36 Deflandrea dartmoria	54.6	0.67	53.9	0	1.22	98.8	0	0	0
37 Deflandrea phosphoritica	208	6.27	41.8	160	3.02	20.1	76.9	160	76.9
38 Deflandrea wardenensis	8.8	8.8	0	0	100	0	0	0	0
39 Dinopterygium cladoides	7.33	3.33	4	0	45.5	54.5	0	0	0
40 Dinopterygium fehmarnense	9	1	8	0	11.1	88.9	0	0	0
41 Diphyes colligerum	26.5	10.7	15.8	0	40.5	59.5	0	0	0
42 Diphyes colligerum	6	4.67	1.33	0	77.8	22.2	0	0	0
43 Diphyes colligerum (sensu cookson 1985)	5	5	0	0	100	0	0	0	0
44 Distatodinium paradoxum	0	0	0	0	0	0	0	0	0
45 Electrocysta densobaculata	43	7	20.3	15.7	16.3	47.3	36.4	0	0
46 Electrocysta obscurotabulata	137	3	46	88	2.19	33.6	64.2	29	21.2
47 Eocladopyxis peniculatum	242	9.03	20.7	212	3.74	8.56	87.7	60.8	25.2
48 Exochosphaeridium bifidum	4.33	4.33	0	0	100	0	0	0	0
49 Fibradinium annetorpense	181	1.83	10.7	168	1.01	5.9	93.1	64.3	35.6
50 Fibrocysta bipolare	5	3	2	0	60	40	0	0	0
51 Fibrocysta lappacea	1.33	1.33	0	0	100	0	0	0	0
52 Fibrocysta ovalitospinosa	2.67	1.67	1	0	62.5	37.5	0	0	0
53 Fibrocysta radiata	4	4	0	0	100	0	0	0	0
54 Fibrocysta sp.	1	1	0	0	100	0	0	0	0
55 Florentinia ferox	11.7	1.67	10	0	14.3	85.7	0	0	0
56 Forma A	4.33	3	1.33	0	69.2	30.8	0	0	0
57 Forma B	25.3	0.33	8.33	16.7	1.32	32.9	65.8	0	0
58 Forma C	61	1	6.67	53.3	1.64	10.9	87.4	0	0
59 Forma D	2	2	0	0	100	0	0	0	0

60 Forma E	0	0	0	0	0	0	0	0	0
61 Fromea fragilis	11	5	6	0	45.5	54.5	0	0	0
62 Fromea? laevigata	0.67	0.67	0	0	100	0	0	0	0
63 Glaphyrocysta exuberans cplx	322	2	17.7	302	0.62	5.49	93.9	248	77
64 Glaphyrocysta ordinata	55.3	0.33	3.67	51.3	0.6	6.63	92.8	31.7	57.2
65 Glaphyrocysta sp. A	169	1.67	27.3	140	0.99	16.2	82.8	140	82.8
66 Glaphyrocysta sp. B	6	0.67	5.33	0	11.1	88.9	0	0	0
67 Hafniasphaera cf. h. septata	0.67	0.67	0	0	100	0	0	0	0
68 Hafniasphaera septata	18	6	12	0	33.3	66.7	0	0	0
69 Heteraulacacysta campanula	7.6	5.4	2.2	0	71.1	28.9	0	0	0
70 Homotriblium caliculum	1.33	1.33	0	0	100	0	0	0	0
71 Homotryblium tasmaniense	27.9	2.87	25.1	0	10.3	89.7	0	0	0
72 Homotryblium pallidum	57.3	2.33	6.67	48.3	4.07	11.6	84.3	27.3	47.7
73 Hourologinella apiculata	1.67	1.67	0	0	100	0	0	0	0
74 Hystrichokolpoma eisenackii	2	2	0	0	100	0	0	0	0
75 Hystrichokolpoma mentitum	0.33	0.33	0	0	100	0	0	0	0
76 Hystrichokolpoma rigaudae	18.2	8.2	10	0	45.1	54.9	0	0	0
77 Hystrichokolpoma tumescens	6.73	4.43	2.3	0	65.8	34.2	0	0	0
78 Hystrichokolpoma unispinum	2.1	2.1	0	0	100	0	0	0	0
79 Hystrichosphaeridium cf. h. tubiferum	0.8	0.8	0	0	100	0	0	0	0
80 Hystrichosphaeridium spp.	6.33	6.33	0	0	100	0	0	0	0
81 Hystrichosphaeridium tubiferum	40.8	13.1	27.7	0	32	68	0	0	0
82 Hystrichosphaeridium tubiferum brevispin	1.33	1.33	0	0	100	0	0	0	0
83 ?Hystrichosphaeropsis ovum	1.2	1.2	0	0	100	0	0	0	0
84 Impagidinium cf. i. speciosum	10.7	0.67	10	0	6.25	93.8	0	0	0
85 Impagidinium sp. A	0.67	0.67	0	0	100	0	0	0	0
86 Impagidinium sp. B	0	0	0	0	0	0	0	0	0
87 Impagidinium speciosum	8.67	0	8.67	0	0	100	0	0	0
88 Impletosphaeridium kroemmelbeinii	0.67	0.67	0	0	100	0	0	0	0
89 Impletosphaeridium rugosum	17.7	15.4	2.33	0	86.8	13.2	0	0	0
90 Impletosphaeridium? sp. A	0	0	0	0	0	0	0	0	0
91 Inversidinium exilimuram	6.2	3.87	2.33	0	62.4	37.6	0	0	0
92 Isabelidinium cooksoniae	0.33	0.33	0	0	100	0	0	0	0
93 Kallosphaeridium brevibarbatum	37.9	12.3	25.6	0	32.4	67.6	0	0	0
94 Kisselovia coleothrypta	2.67	1.67	1	0	62.5	37.5	0	0	0
95 Lejeunecysta? sp. A	0	0	0	0	0	0	0	0	0
96 Lentinia ruginosa	10.3	3.33	7	0	32.3	67.7	0	0	0
97 Lentinia spinigera	14.3	4.67	9.67	0	32.6	67.4	0	0	0
98 Lingulodinium machaerophorum	70.4	12	41.5	16.8	17.1	59	23.9	0	0
99 Melitasphaeridium pseudocurvatum	1.67	1.67	0	0	100	0	0	0	0
100 Membranilarnacia leptoderma	12.1	5.6	6.53	0	46.2	53.8	0	0	0
101 Microdinium ornatum	89.9	10.5	11.6	67.8	11.6	12.9	75.4	55.8	62.1
102 Millioudodinium guiseppi major	10	4	6	0	40	60	0	0	0
103 Muratodinium fimbriatum	115	4.33	30.5	80.5	3.75	26.5	69.7	30.5	69.7
104 Nematosphaeropsis cf. n. pertusa	0.73	0.73	0	0	100	0	0	0	0
105 Nematosphaeropsis pertusa	6.33	4.67	1.67	0	73.7	26.3	0	0	0
106 Nematosphaeropsis pulsulosa	1.33	0.33	1	0	25	75	0	0	0
107 Nematosphaeropsis trabeculata	16.3	8	8.33	0	49	51	0	0	0
108 Oligosphaeridium complex	3.33	1.33	2	0	40	60	0	0	0
109 Operculodinium brevispinosum	2.67	1.67	1	0	62.5	37.5	0	0	0
110 Operculodinium centrocarpum	26.6	17	9.6	0	63.9	36.1	0	0	0
111 Operculodinium cf. o. brevispinosum	0.33	0.33	0	0	100	0	0	0	0
112 Operculodinium israelianum	10.4	2.4	8	0	23.1	76.9	0	0	0
113 Operculodinium multispinosum	5.33	1.67	3.67	0	31.3	68.8	0	0	0
114 Operculodinium vanespinosum	0	0	0	0	0	0	0	0	0
115 Palaeocystodinium golzowense	28.8	14.2	14.6	0	49.4	50.6	0	0	0
116 Palaeoperidinium pyrophorum	19	0.67	18.3	0	3.51	96.5	0	0	0
117 Paralecaniella indentata	68.2	4.63	48.6	15	6.79	71.2	22	0	0
118 Paucisphaeridium inversibuccinum	1	1	0	0	100	0	0	0	0
119 Pentadinium laticinctum granulatum	0	0	0	0	0	0	0	0	0
120 Phelodinium magnificum	5	3.67	1.33	0	73.3	26.7	0	0	0

121	Phthanoperidinium cf. p. tritonium	0.33	0.33	0	0	100	0	0	0	0
122	Phthanoperidinium echinatum	9	3	6	0	33.3	66.7	0	0	0
123	Polysphaeridium cf. p. zonaryi	1.67	1.67	0	0	100	0	0	0	0
124	Polysphaeridium zonaryi	4	2.33	1.67	0	58.3	41.7	0	0	0
125	Renidinium membraniferum	6.33	5.33	1	0	84.2	15.8	0	0	0
126	Renidinium sp. A	1	1	0	0	100	0	0	0	0
127	Rottnestia borussica	5.33	4.33	1	0	81.3	18.8	0	0	0
128	Samlandia chlamydophora	2.2	2.2	0	0	100	0	0	0	0
129	Samlandia reticulifera	6.33	1.33	5	0	21.1	78.9	0	0	0
130	Senegalinium? obscuram	10.3	3	7.33	0	29	71	0	0	0
131	Senegalinium? asymmetricum	1.33	1.33	0	0	100	0	0	0	0
132	Senegalinium? dilwynense	49.7	5.67	12.3	31.7	11.4	24.8	63.8	0	0
133	Spinidinium essoi	1.53	1.53	0	0	100	0	0	0	0
134	Spinidinium macmurdoense	72.7	0	0	72.7	0	0	100	72.7	100
135	Spinidinium paratabulatum	13.3	0.67	12.7	0	5	95	0	0	0
136	Spiniferites crassipellis A	11.6	9.3	2.33	0	79.9	20.1	0	0	0
137	Spiniferites crassipellis B	2	0.67	1.33	0	33.3	66.7	0	0	0
138	Spiniferites crassipellis C	4.47	3.27	1.2	0	73.1	26.9	0	0	0
139	Spiniferites cf. s. pterotus	0.33	0.33	0	0	100	0	0	0	0
140	Spiniferites cingulatus	0.67	0.67	0	0	100	0	0	0	0
141	Spiniferites cornutus A	1.33	1.33	0	0	100	0	0	0	0
142	Spiniferites cornutus B	0	0	0	0	0	0	0	0	0
143	Spiniferites cornutus C	1	1	0	0	100	0	0	0	0
144	Spiniferites mirabilis	0	0	0	0	0	0	0	0	0
145	Spiniferites monilis	2.8	2.8	0	0	100	0	0	0	0
146	Spiniferites pseudofurcatus	11.3	11.3	0	0	100	0	0	0	0
147	Spiniferites ramosus subsp. granomembrana	4.93	4.93	0	0	100	0	0	0	0
148	Spiniferites ramosus subsp. granosus	9.97	9.97	0	0	100	0	0	0	0
149	Spiniferites ramosus subsp. membranaceous	6.67	6.67	0	0	100	0	0	0	0
150	Spiniferites ramosus subsp. multibrevis	6.47	5.47	1	0	84.5	15.5	0	0	0
151	Spiniferites ramosus subsp. ramosus	72.4	15.6	43.8	13	21.5	60.5	18	0	0
152	Spiniferites ramuliferus	0.67	0.67	0	0	100	0	0	0	0
153	Spiniferites A	1	1	0	0	100	0	0	0	0
154	Spiniferites B	0	0	0	0	0	0	0	0	0
155	Spiniferites C	0	0	0	0	0	0	0	0	0
156	Systematophora placacantha	51.7	1.67	2.33	47.7	3.23	4.52	92.3	47.7	92.3
157	Tanyosphaeridium variecalamum	2	1	1	0	50	50	0	0	0
158	Tectatodinium pellitum	12.4	5.67	6.73	0	45.7	54.3	0	0	0
159	Thalassiphora delicata	39.6	5	8.3	26.3	12.6	20.9	66.4	26.3	66.4
160	Thalassiphora pelagica	205	4.33	50	151	2.11	24.4	73.5	106	51.6
161	Trichodinium hirsutum	1.33	1.33	0	0	100	0	0	0	0
162	Trigonopyxidia ginella	3	3	0	0	100	0	0	0	0
163	Tuberculodinium vancampoae	0	0	0	0	0	0	0	0	0
164	Tuberculodinium sp.	0	0	0	0	0	0	0	0	0
165	Tubidermodinium sulcatum	7.13	7.13	0	0	100	0	0	0	0
166	Turbiosphaera filosa	61.6	0.67	21.6	39.3	1.08	35	63.9	39.3	63.9
167	Turbiosphaera paratabulata	8.33	0.67	7.67	0	8	92	0	0	0
168	Turbiosphaera rotunda	3.33	0.33	3	0	10	90	0	0	0
169	Wetzeliella cf. w. irtyschensis	1.97	1.97	0	0	100	0	0	0	0
170	Wetzeliella hampdenensis	131	3.73	54.8	72.2	2.86	41.9	55.2	38	29.1
171	Wetzeliella lunaris	466	3.33	33.5	429	0.72	7.18	92.1	406	87.1
172	Wetzeliella samlandica	296	1.93	16.3	277	0.65	5.5	93.8	277	93.8
173	Wetzeliella sp. A	2.33	0	2.33	0	0	100	0	0	0
174	Wetzeliella varielongituda	12	0	1.67	10.3	0	13.9	86.1	0	0
175	Wilsonidium tabulatum	46.3	2	0	44.3	4.32	0	95.7	44.3	95.7
176	Xenikoon australis	74.6	2.13	38.1	34.3	2.86	51.1	46	0	0
177	Cyclopsiella elliptica	0	0	0	0	0	0	0	0	0
178	Cyclopsiella vieta	17.9	6.93	11	0	38.7	61.3	0	0	0
179	Micrhystridium cf. m. fragile	4	4	0	0	100	0	0	0	0
180	Micrhystridium cf. m. variabile	27	3.67	23.3	0	13.6	86.4	0	0	0
181	Micrhystridium spp.	22.2	17.2	5	0	77.4	22.6	0	0	0

182	Cymatiosphaera spp.	6.5	6.5	0	0	100	0	0	0	0
183	Palambages sp. A	2.67	1.33	1.33	0	50	50	0	0	0
184	Palambages sp. B	4.33	3.33	1	0	76.9	23.1	0	0	0
185	Palambages sp. C	21.3	2.33	9	10	10.9	42.2	46.9	0	0
186	Pterospermopsis spp.	15.2	14.2	1	0	93.4	6.58	0	0	0
187	Apteodinium incompositum	1	1	0	0	100	0	0	0	0
188	Autria erinacea	1.6	1.6	0	0	100	0	0	0	0
189	Dionysopsis buccinata	4.8	3.6	1.2	0	75	25	0	0	0
190	Dionysopsis capitata	9.8	9.8	0	0	100	0	0	0	0
191	Gonyaulacysta giuseppei subsp. major	13	2.6	10.4	0	20	80	0	0	0
192	Hyoridasphaera marylandense	1	1	0	0	100	0	0	0	0
193	Hystrichokolpoma bulbosa	1	1	0	0	100	0	0	0	0
194	Hystrichosphaeropsis borussica	2.2	2.2	0	0	100	0	0	0	0
195	Lanternosphaeridium bipolare	5.2	5.2	0	0	100	0	0	0	0
196	Lanternosphaeridium lanosum	101	0.2	58	43.1	0.2	57.3	42.5	0	0
197	Lanternosphaeridium lappaceum	1.2	1.2	0	0	100	0	0	0	0
198	Lanternosphaeridium pilatum	0.4	0.4	0	0	100	0	0	0	0
199	Lanternosphaeridium radiatum	1	1	0	0	100	0	0	0	0
200	Operculodinium amiculum	5.8	3.6	2.2	0	62.1	37.9	0	0	0
201	Operculodinium potomacense	11.4	1.8	9.6	0	15.8	84.2	0	0	0
202	Schnodinium (S.) australiense	24.2	1.2	23	0	4.96	95	0	0	0
203	Spiniferites bulloideus	0.2	0.2	0	0	100	0	0	0	0
204	Spiniferites cf. S. crassipellis	1.8	1.8	0	0	100	0	0	0	0
205	Spiniferites hypercanthus	1.6	1.6	0	0	100	0	0	0	0
206	Spiniferites membranaceous	1.6	1.6	0	0	100	0	0	0	0
207	Spiniferites cf. S. ramosus subsp. ramosus	1.8	1.8	0	0	100	0	0	0	0
208	Spiniferites scabratus	0.4	0.4	0	0	100	0	0	0	0
209	Spiniferites supparus	41	1	40	0	2.44	97.6	0	0	0
210	Tectatodinium pellitum	4.2	1.2	3	0	28.6	71.4	0	0	0
211	Tubulosphaeridium pseudocurvatum	1.4	1.4	0	0	100	0	0	0	0
212	Deflandrea asymmetrica	9.2	2.8	6.4	0	30.4	69.6	0	0	0
213	Deflandrea dilwynensis	98.7	3.4	1.6	93.7	3.44	1.62	94.9	93.7	94.9
214	Deflandrea macmurdoensis	121	1	6.2	114	0.83	5.12	94	91	75.2
215	Phthanoperidinium resistente	25.6	3.4	10.6	11.6	13.3	41.4	45.3	0	0
216	Spinidinium bilineatum	239	1.2	0	237	0.5	0	99.5	217	91.1
217	Spinidinium rotundum	0.4	0.4	0	0	100	0	0	0	0
218	Wetzeliella (Rhombodinium) glabra	0.2	0.2	0	0	100	0	0	0	0
219	Wetzeliella (W.) articulata	1.4	1.4	0	0	100	0	0	0	0
220	Wetzeliella (W.) coalita	7.2	0.6	6.6	0	8.33	91.7	0	0	0
221	Wetzeliella (W.) coleothrypta	35.2	0.8	12.8	21.6	2.27	36.4	61.4	0	0
222	Adnatosphaeridium vittatum	4.6	3.6	1	0	78.3	21.7	0	0	0
223	Canningia minor	0.2	0.2	0	0	100	0	0	0	0
224	Cannosphaeropsis pustulosa	1.4	1.4	0	0	100	0	0	0	0
225	Chlamydophorella rauca	0.2	0.2	0	0	100	0	0	0	0
226	Cyclonephelium incultum	1	1	0	0	100	0	0	0	0
227	Cyclonephelium lemniscatum	2.6	1.2	1.4	0	46.2	53.8	0	0	0
228	Dinopterygium cladoides	4	4	0	0	100	0	0	0	0
229	?Eisenackia scrobiculata	0.8	0.8	0	0	100	0	0	0	0
230	Fusidinium tabulatum	117	1.2	5.2	110	1.03	4.45	94.6	92.6	79.3
231	Hemicystodinium aculeatum	4.6	1	3.6	0	21.7	78.3	0	0	0
232	Hemicystodinium zonaryi	3.6	3.6	0	0	100	0	0	0	0
233	Heteraulacacysta fenmamensis	6.6	5.4	1.2	0	81.8	18.2	0	0	0
234	Homotryblium alisum	1.2	1.2	0	0	100	0	0	0	0
235	Impletosphaeridium transfodum	5	5	0	0	100	0	0	0	0
236	?Litosphaeridium inversibuccinum	1.6	1.6	0	0	100	0	0	0	0
237	Systematophora ancyrea	5.6	1.4	4.2	0	25	75	0	0	0
238	Apteodinium baculatum	1.1	1.1	0	0	100	0	0	0	0
239	Aquiasphaeridium	2	0	2	0	0	100	0	0	0
240	Cordosphaeridium marylandense	4	4	0	0	100	0	0	0	0
241	Cordosphaeridium species A	1.6	1.6	0	0	100	0	0	0	0
242	Deflandrea cf. D. magnifica	3.6	2.5	1.1	0	69.4	30.6	0	0	0

243	Deflandria obscura	3	5.7	2.3	0	71.3	29.3	0	0	0
244	Deflandria rhombohedra	0.6	0.6	0	0	100	0	0	0	0
245	Deflandria rugınosa	0	0	0	0	100	0	0	0	0
246	Deflandria spinicera	20.4	2.3	17.6	0	13.7	86.3	0	0	0
247	Leptodinium virginianum	63.3	3.1	20.4	39.8	4.9	32.2	62.9	0	0
248	Membranosphaera tabulata	251	4.1	11.3	236	1.63	4.5	93.9	203	80.6
249	Nematosphaeropsis trabeculata	10.8	6.4	4.4	0	59.3	40.7	0	0	0
250	Palaeostomacystus- fragilis	14	2	12	0	14.3	85.7	0	0	0
251	Spiniferites cingulatus subsp.reticulatus	1.5	1.5	0	0	100	0	0	0	0
252	Spiniferites septatus	10.9	9.3	1.6	0	85.3	14.7	0	0	0
253	Spiniferites cf. S. septatus	10.9	9.3	1.6	0	85.3	14.7	0	0	0
254	Vervhachium spp.	0.6	0.6	0	0	100	0	0	0	0
255	Wetzeliella (W.) homomorpha subsp. quinqu	649	0	4.1	645	0	0.63	99.4	645	99.4
		total								
		3125	779	1802	5544					

Results of Chosen Phase Plane Plots

Phase plane plots were produced for a number of species pairs from the data. Four phase plane plots, of common species, have been selected as representitive (figure 14). Results of the phase plane plots are difficult to interpret. Although loops about a possible equilibrium occur, it is usually when one species is replacing another. The periods of overlap, on this scale, are short, and seldom repeat.

When replacement occurs more than once in the data set, similar loop figures occur, but are not centered around the same equilibrium point. A feature of these phase plane diagrams is a strong trend roughly perpendicular to the equilibrium axis, rather than parallel to it. This trend is expected when both species are affected by some outside factor more than by interaction with each other. On the scale of this data, the outside influence appears to parallel local environmental shifts. Although phase plane analysis does show potential for finding interaction patterns in fossil data, both environmental overprint, and data resolution on this scale limit its effectiveness.

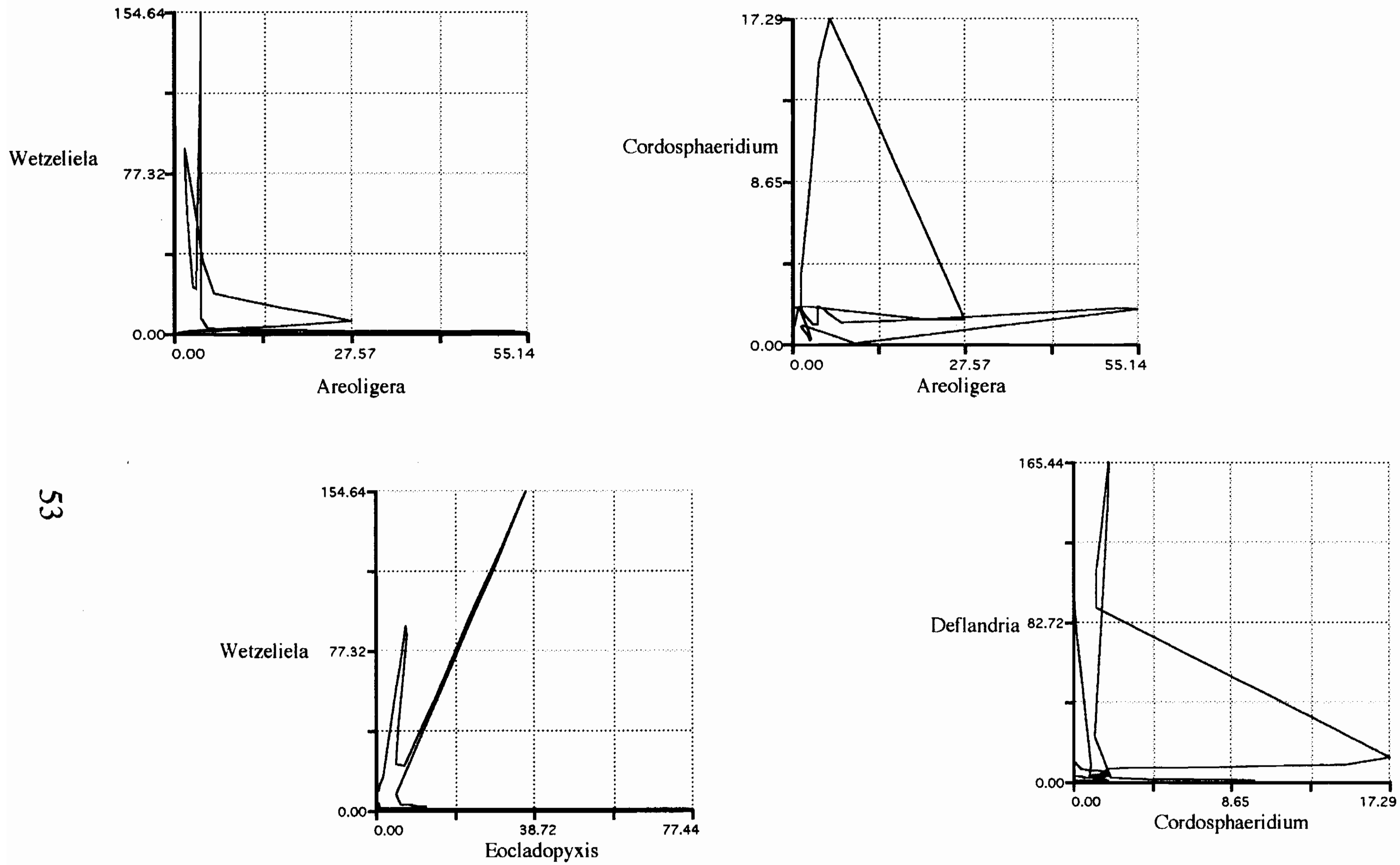


Figure 14.. Phase Plane Examples

VII. CONCLUSION S

The following conclusions are based on the dynamic systems modeling, and statistical analysis of fossil dinoflagellates studied during this project.

1. Dynamic systems modeling is directly applicable to both modern and fossil coastal dinoflagellate analysis. Success of modeling however depends on refinement, and on resolution of the input data. The models used in this study are preliminary.

2. Coastal dinoflagellate dynamics can be approximated using parameters of temperature, salinity, and limiting nutrient. Other parameters are necessary for model refinement.

3. The models suggest that differences in boundaries between watermasses might be discernible in dinoflagellate associations in rock or sediment. The fossil data appear consistent with this, at least within the resolution of the samples.

4. Cluster analysis of the Salisbury fossil data indicates that cluster boundaries produced are not gradient artifacts, but represent real changes in dinoflagellate associations. These parallel changes in sediment (watermass) characteristics.

5. Cluster analysis indicates 17 separate dinoflagellate associations which can be interpreted individually as occurring in estuarine, nearshore, or offshore conditions. Individual dissimilar samples between groups may represent boundary or transitional environments.

6. Samples in cluster groups are statistically similar, but not the same, and represent paleocommunity types rather than paleocommunities. Individual species reccur in similar environmental settings through time, but paleocommunity types do not repeat within the Pamunky Group data.

7. Circulation patterns of the Salisbury Embayment during the Tertiary may have resembled those of the modern Yellow Sea, with both lateral fronts, and regions of mixing. Fossil dinoflagellate data and modeling suggest that water conditions of the Salisbury Embayment may have been warmer than the modern Yellow Sea.

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APPENDIX A:

TRANSFORMED DINOFLAGELLATE DATA SETS

ANOVA ANALYSIS OF DINOFLAGELLATE DATA SETS

174		174 witmer aquia m1	175		175 witmer aquia m1	176		176 witmer aquia m1
39.50	12	Areoligera sp.	37.00	12	Areoligera sp.	39.00	12	Areoligera sp.
2.10	166	Turbiosphaera filosa	1.30	166	Turbiosphaera filosa	1.40	166	Turbiosphaera filosa
1.20	117	Paralecaniella indentata	1.20	117	Paralecaniella indentata	1.30	176	Xenikoon australis
1.10	176	Xenikoon australis	1.20	176	Xenikoon australis	1.20	159	Thalassiphora delicata
0.60	49	Fibradinium annetorpense	0.90	49	Fibradinium annetorpense	1.00	117	Paralecaniella indentata
0.50	248	Membranosphaera tabulata	0.70	248	Membranosphaera tabulata	0.60	248	Membranosphaera tabulata
0.50	181	Micrhystridium spp.	0.70	181	Micrhystridium spp.	0.40	181	Micrhystridium spp.
0.40	101	Microdinium ornatum	0.60	159	Thalassiphora delicata	0.40	186	Pterospermopsis spp.
0.40	159	Thalassiphora delicata	0.40	39	Impletosphaeridium rugosum	0.40	151	Spiniferites ramosus subsp. ramosus
0.30	39	Impletosphaeridium rugosum	0.40	247	Leptodinium virginianum	0.30	20	Chlamydophorella cf. C. urna
0.20	20	Chlamydophorella cf. C. urna	0.30	182	Cymatiosphaera spp.	0.30	247	Leptodinium virginianum
0.20	182	Cymatiosphaera spp.	0.30	246	Deflandrea spinigera	0.30	101	Microdinium ornatum
0.20	246	Deflandrea spinigera	0.30	101	Microdinium ornatum	0.20	178	Cyclopsiella vieta
0.20	189	Dionyesopsis buccinata	0.30	186	Pterospermopsis spp.	0.20	242	Deflandrea cf. D. magnifica
0.20	110	Operculodinium centrocarpum	0.20	20	Chlamydophorella cf. C. urna	0.20	246	Deflandrea spinigera
0.20	151	Spiniferites ramosus subsp. ramosus	0.20	242	Deflandrea cf. D. magnifica	0.20	189	Dionyesopsis buccinata
0.10	242	Deflandrea cf. D. magnifica	0.20	243	Deflandrea obscura	0.20	190	Dionyesopsis capitata
0.10	243	Deflandrea obscura	0.20	190	Dionyesopsis capitata	0.20	39	Impletosphaeridium rugosum
0.10	190	Dionyesopsis capitata	0.20	110	Operculodinium centrocarpum	0.20	115	Palaeocystodinium golzowense
0.10	31	Hystrichosphaeridium tubiferum	0.20	115	Palaeocystodinium golzowense	0.20	146	Spiniferites pseudofurcatus
0.10	249	Nematosphaeropsis trabeculata	0.20	151	Spiniferites ramosus subsp. ramosus	0.20	254	Veryhachium spp.
0.10	115	Palaeocystodinium golzowense	0.10	189	Dionyesopsis buccinata	0.10	243	Deflandrea obscura
			0.10	31	Hystrichosphaeridium tubiferum	0.10	31	Hystrichosphaeridium tubiferum
			0.10	249	Nematosphaeropsis trabeculata	0.10	249	Nematosphaeropsis trabeculata
						0.10	110	Operculodinium centrocarpum

177	177 witmer aquia mt	178	178 witmer aquia mt
36.50	12 Areoligera sp.	32.10	12 Areoligera sp.
1.70	166 Turbiosphaera filosa	2.00	239 Aquiasphaendium
1.50	159 Thalassiphora delicata	1.80	166 Turbiosphaera filosa
1.30	117 Paralecaniella indentata	1.60	159 Thalassiphora delicata
1.20	248 Membranosphaera tabulata	1.30	246 Deflandrea spinigera
1.20	175 Xenikoon australis	1.20	117 Paralecaniella indentata
0.30	181 Micrhystridium spp.	1.10	242 Deflandrea cf. D. magnifica
0.60	186 Pterospermopsis spp.	0.30	181 Micrhystridium spp.
0.50	101 Microdinium ornatum	0.80	176 Xenikoon australis
0.40	20 Chlamydophorella cf. C. urna	0.50	186 Pterospermopsis spp.
0.40	242 Deflandrea cf. D. magnifica	0.50	151 Spiniferites ramosus subsp. ramosus
0.40	246 Deflandrea spinigera	0.40	190 Dionyesopsis capitata
0.30	190 Dionyesopsis capitata	0.40	99 Impletosphaeridium rugosum
0.30	31 Hystrichosphaeridium tubiferum	0.40	33 Kallosphaeridium brevibarbatum
0.30	99 Impletosphaeridium rugosum	0.40	248 Membranosphaera tabulata
0.30	33 Kallosphaeridium brevibarbatum	0.40	101 Microdinium ornatum
0.30	151 Spiniferites ramosus subsp. ramosus	0.40	115 Palaeocystodinium golzowense
0.20	243 Deflandrea obscura	0.30	20 Chlamydophorella cf. C. urna
0.20	249 Nematosphaeropsis trabeculata	0.30	178 Cyclopsiella vieta
0.20	110 Operculodinium centrocarpum	0.30	243 Deflandrea obscura
0.20	115 Palaeocystodinium golzowense	0.30	249 Nematosphaeropsis trabeculata
0.10	189 Dionyesopsis buccinata	0.30	250 Palaeostomacystus fragilis
0.10	146 Spiniferites pseudofurcatus	0.20	189 Dionyesopsis buccinata
		0.20	31 Hystrichosphaeridium tubiferum
		0.20	110 Operculodinium centrocarpum
		0.10	146 Spiniferites pseudofurcatus

248	248 goodman, Nani woodstock zone 16	249	249 goodman, Nani woodstock zone 16
44.50	12 Areoligera sp.	58.90	12 Areoligera sp.
34.60	160 Thalassiphora pelagica	23.40	171 Wetzeliella (W.) lunaris
9.40	171 Wetzeliella (W.) lunaris	9.20	160 Thalassiphora pelagica
5.40	76 Hystrichokolpoma rigaudae	5.20	37 Deflandrea phosphoritica
1.20	37 Deflandrea phosphoritica	1.30	76 Hystrichokolpoma rigaudae
1.00	237 Systematophora ancyrea	1.00	72 Homotryblium pallidum
0.30	103 Muratodinium fimbriatum	0.80	212 Deflandrea asymmetrica
0.30	228 Dinopterygium cladoides	0.60	213 Deflandrea dilwynensis
0.60	28 Cordosphaeridium inodes	0.40	28 Cordosphaeridium inodes
0.60	214 Deflandrea macmurdoensis	0.40	170 Wetzeliella (W.) hampdenensis
0.60	221 Wetzeliella (W.) coleothrypta	0.40	22 Cleistosphaeridium diversispinosum
0.60	232 Hemicystodinium zoharyi	0.40	19 Heteraulacacysta campanula
0.40	1 Achiella biformoides n. gen., n. comb.	0.40	233 Heteraulacacysta lenmamensis
0.20	188 Autna erinacea n. gen., n. comb.	0.20	1 Achiella biformoides n. gen., n. comb.
0.20	27 Cordosphaeridium gracilis	0.20	41 Diphyes colligerum
0.20	41 Diphyes colligerum	0.20	93 Kallosphaeridium brevibarbatum
0.20	79 Hystrichosphaeridium tubiferum	0.20	195 Lanternosphaeridium bicolare
0.20	98 Lingulodinium machaerophorum	0.20	138 Spiniferites crassipellis
0.20	200 Operculodinium amiculum n. sp.	0.20	146 Spiniferites pseudofurcatus
0.20	202 Scnnodinium (S.) australiense	0.20	150 Spiniferites ramosus subsp. multibrevis
0.20	212 Deflandrea asymmetrica	0.20	210 Tectatodinium psilatum
0.20	213 Deflandrea dilwynensis	0.20	38 Deflandrea wardenensis
0.20	38 Deflandrea wardenensis	0.20	215 Phthanoperidinium resistente
0.20	115 Palaeocystodinium golzowense	0.20	219 Wetzeliella (W.) articulata
0.20	219 Wetzeliella (W.) articulata	0.20	237 Systematophora ancyrea
0.20	170 Wetzeliella (W.) hampdenensis		
0.20	172 Wetzeliella (W.) samlandica		
0.20	2 Adnatosphaeridium multispinosum		
0.20	22 Cleistosphaeridium diversispinosum		
0.20	47 Eocladopyxis peniculatum		
0.20	233 Heteraulacacysta lenmamensis		
0.20	39 Impletosphaeridium rugosum		

iceous

, n. comb.

Corellation matrix for PT1

Correlation Matrix for Variables: $X_1 \ldots X_5$

	174	175	176	177	178
174	1				
175	.99996	1			
176	.99987	.99987	1		
177	.99979	.99983	.99991	1	
178	.99932	.99936	.99943	.99952	1

Anova table for PT1

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_5$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	37545.0858	147.8153	3494.61349	.0001
Within subjects	1020	43.144	.0423		
treatments	4	.00282	.00071	.01662	.9995
residual	1016	43.14118	.04246		
Total	1274	37588.2298			

Reliability Estimates for- All treatments: .99971 Single Treatment: .99857

PT2 "*Areoligera/Eocladopyxis peniculatum* " Association

79			180			181		
49.50	12	Areoligera sp.	47.50	12	Areoligera sp.	31.00	12	Areoligera sp.
20.50	47	Eocladopyxis peniculatum	21.50	47	Eocladopyxis peniculatum	24.00	47	Eocladopyxis peniculatum
5.60	36	Deflandrea dartmona	7.50	196	Lanternosphaeridium lanosum	15.50	196	Lanternosphaeridium lanosum
4.80	3	Adnatosphaeridium robustum	7.30	3	Adnatosphaeridium robustum	15.20	3	Adnatosphaeridium robustum
4.50	29	Cordosphaeridium inodes	4.10	29	Cordosphaeridium inodes	5.60	29	Cordosphaeridium inodes
4.40	196	Lanternosphaeridium lanosum	2.50	247	Leptodinium virginianum	2.90	93	Kallosphaeridium brevibarbatum
0.70	37	Deflandrea phosphoritica	1.30	36	Deflandrea dartmona	2.70	247	Leptodinium virginianum
0.90	93	Kallosphaeridium brevibarbatum	1.30	93	Kallosphaeridium brevibarbatum	2.00	37	Deflandrea phosphoritica
0.90	247	Leptodinium virginianum	1.70	37	Deflandrea phosphoritica	1.00	36	Deflandrea dartmona
0.50	248	Membranosphaera tabulata	0.90	253	Spiniferites cf. S. septatus	0.50	186	Pterospermopsis spp.
0.40	181	Micrhystridium spp.	0.90	252	Spiniferites septatus	0.40	243	Deflandrea obscura
0.30	243	Deflandrea obscura	0.30	248	Membranosphaera tabulata	0.40	249	Nematosphaeropsis trabeculata
0.30	190	Dionyesopsis capitata	0.30	181	Micrhystridium spp.	0.40	253	Spiniferites cf. S. septatus
0.30	250	Palaeostomacystus fragilis	0.30	249	Nematosphaeropsis trabeculata	0.40	252	Spiniferites septatus
0.30	117	Paralecaniella indentata	0.20	20	Chlamydophorella cf. C. urna	0.30	241	Cordosphaeridium species A
0.20	238	Apteodinium baculatum	0.20	241	Cordosphaeridium species A	0.20	240	Cordosphaeridium marylandense
0.20	39	Impletosphaeridium rugosum	0.20	242	Deflandrea cf. D. magnifica	0.20	190	Dionyesopsis capitata
0.20	115	Palaeocystodinium golzowense	0.20	243	Deflandrea obscura	0.20	98	Linguiodinium machaerophorum
0.20	253	Spiniferites cf. S. septatus	0.20	190	Dionyesopsis capitata	0.20	248	Membranosphaera tabulata
0.20	141	Spiniferites cornutus A	0.20	250	Palaeostomacystus fragilis	0.20	115	Palaeocystodinium golzowense
0.20	136	Spiniferites crassipellis A	0.20	251	Spiniferites cingulatus subsp. reticulatus	0.20	141	Spiniferites cornutus A
0.20	252	Spiniferites septatus	0.10	238	Apteodinium baculatum	0.10	20	Chlamydophorella cf. C. urna
0.10	20	Chlamydophorella cf. C. urna	0.10	178	Cyclopsiella vieta	0.10	242	Deflandrea cf. D. magnifica
0.10	241	Cordosphaeridium species A	0.10	39	Impletosphaeridium rugosum	0.10	39	Impletosphaeridium rugosum
0.10	178	Cyclopsiella vieta	0.10	98	Linguiodinium machaerophorum	0.10	110	Operculodinium centrocarpum
0.10	242	Deflandrea cf. D. magnifica	0.10	110	Operculodinium centrocarpum	0.10	251	Spiniferites cingulatus subsp. reticulatus
0.10	98	Linguiodinium machaerophorum	0.10	115	Palaeocystodinium golzowense	0.10	136	Spiniferites crassipellis A
0.10	249	Nematosphaeropsis trabeculata	0.10	141	Spiniferites cornutus A			
0.10	110	Operculodinium centrocarpum	0.10	136	Spiniferites crassipellis A			
0.10	254	Vervhachium spp.	0.10	254	Vervhachium spp.			

182		
32.50	47	Eocladopyxis peniculatum
17.20	196	Lanternosphaeridium lanosum
16.30	12	Areoligera sp.
8.10	3	Adnatosphaeridium robustum
6.30	28	Cordosphaeridium inodes
5.10	247	Leptodinium virginianum
4.10	255	Wetzeliella (W.) homomorpha subsp. quinq
1.80	93	Kallosphaeridium brevibarbatum
1.70	37	Deflandrea phosphoritica
1.10	36	Deflandrea dartmoria
0.80	253	Spiniferites cf. S. septatus
0.80	252	Spiniferites septatus
0.50	249	Nematosphaeropsis trabeculata
0.40	186	Pterospermopsis spp.
0.30	20	Chlamydophorella cf. C. urna
0.30	243	Deflandrea obscura
0.30	151	Spiniferites ramosus subsp. ramosus
0.20	182	Cymatiosphaera spp.
0.20	242	Deflandrea cf. D. magnifica
0.20	190	Dionvesopsis capitata
0.20	81	Hystrichosphaeridium tubiferum
0.20	89	Impletosphaeridium rugosum
0.20	98	Lingulodinium machaerophorum
0.20	248	Membranosphaera tabulata
0.20	181	Micrhystridium spp.
0.20	110	Operculodinium centrocarpum
0.20	136	Spiniferites crassipellis A
0.10	241	Cordosphaeridium species A
0.10	178	Cyclopsiella vieta
0.10	245	Deflandrea ruginosa
0.10	246	Deflandrea spinigera
0.10	115	Palaeocystodinium golzowense
0.10	251	Spiniferites cingulatus subsp. reticulatus
0.10	141	Spiniferites cornutus A
0.10	169	Wetzeliella cf. w. artyschensis

Corellation Matrix for PT2

Correlation Matrix for Variables: $X_1 \ldots X_4$

	179	180	181	182
179	1			
180	.99113	1		
181	.88925	.92817	1	
182	.70533	.75445	.90491	1

ANOVA Table for PT2

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_4$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	8488.78035	33.4204	24.50405	.0001
Within subjects	765	1043.3625	1.36387		
treatments	3	.04097	.01366	.00997	.9986
residual	762	1043.32153	1.36919		
Total	1019	9532.14285			

Reliability Estimates for- All treatments: .95919 Single Treatment: .85457

PT3 "Wetzeliella (W.) homomorpha/ Membranosphaera tabulata/ Eocladopyxis peniculatum" Association

183			184		
31.30	255	Wetzeliella (W.) homomorpha subsp. quinq	49.80	255	Wetzeliella (W.) homomorpha subsp. quinq
22.40	47	Eocladopyxis peniculatum	14.60	47	Eocladopyxis peniculatum
17.30	247	Leptodinium virginianum	10.50	247	Leptodinium virginianum
10.50	12	Areoligera sp.	10.30	12	Areoligera sp.
5.10	196	Lanternosphaeridium lanosum	2.50	196	Lanternosphaeridium lanosum
3.70	28	Cordosphaeridium inodes	1.70	93	Kallosphaeridium brevibarbatum
2.30	93	Kallosphaeridium brevibarbatum	1.50	28	Cordosphaeridium inodes
1.50	3	Adnatosphaeridium robustum	1.20	3	Adnatosphaeridium robustum
0.80	37	Deflandrea phosphoritica	1.10	249	Nematosphaeropsis trabeculata
0.70	253	Spiniferites cf. S. septatus	0.90	190	Dionyesopsis capitata
0.70	252	Spiniferites septatus	0.70	91	Hystrichosphaeridium tubiferum
0.50	249	Nematosphaeropsis trabeculata	0.50	181	Micrhystridium spp.
0.40	190	Dionyesopsis capitata	0.40	37	Deflandrea phosphoritica
0.30	241	Cordosphaeridium species A	0.40	101	Microdinium ornatum
0.30	91	Hystrichosphaeridium tubiferum	0.40	115	Palaeocystodinium golzowense
0.30	151	Spiniferites ramosus subsp. ramosus	0.30	242	Deflandrea cf. D. magnifica
0.20	20	Chlamydophorella cf. C. urna	0.30	243	Deflandrea obscura
0.20	243	Deflandrea obscura	0.30	246	Deflandrea spinigera
0.20	246	Deflandrea spinigera	0.30	248	Membranosphaera tabulata
0.20	248	Membranosphaera tabulata	0.30	151	Spiniferites ramosus subsp. ramosus
0.20	110	Operculodinium centrocarpum	0.20	99	Impletosphaeridium rugosum
0.20	250	Palaeostomocystis fragilis	0.20	98	Linguodinium machaerophorum
0.20	141	Spiniferites cornutus A	0.20	253	Spiniferites cf. S. septatus
0.10	178	Cyclopsiella vieta	0.20	251	Spiniferites cingulatus subsp. reticulatus
0.10	242	Deflandrea cf. D. magnifica	0.20	252	Spiniferites septatus
0.10	245	Deflandrea ruginosa	0.10	20	Chlamydophorella cf. C. urna
0.10	194	Hystrichosphaeropsis borussica	0.10	240	Cordosphaeridium marylandense
0.10	39	Impletosphaeridium rugosum	0.10	241	Cordosphaeridium species A
0.10	38	Linguodinium machaerophorum	0.10	173	Cyclopsiella vieta
0.10	115	Palaeocystodinium golzowense	0.10	245	Deflandrea ruginosa
0.10	186	Pterospermopsis spp.	0.10	194	Hystrichosphaeropsis borussica
0.10	251	Spiniferites cingulatus subsp. reticulatus	0.10	110	Operculodinium centrocarpum
0.10	136	Spiniferites crassipellis A	0.10	136	Spiniferites crassipellis A
0.10	254	Verynachium spp.	0.10	148	Spiniferites ramosus subsp. granosus
0.10	169	Wetzeliella cf. W. ovalis/lunaris			

1985	No.	Taxon	1986	No.	Taxon	1987	No.	Taxon
54.30	255	Wetzeliella (W.) homomorpha subsp. quinq	58.00	255	Wetzeliella (W.) homomorpha subsp. quinq	35.40	255	Wetzeliella (W.) homomorpha subsp. quinq
12.00	247	Leptodinium virginianum	8.70	248	Membranosphaera tabulata	25.80	248	Membranosphaera tabulata
8.10	12	Areoligera sp.	7.30	247	Leptodinium virginianum	16.10	20	Chlamydophorella cf. C. urna
5.90	31	Hystrichosphaeridium tubiferum	6.80	12	Areoligera sp.	5.80	12	Areoligera sp.
2.30	196	Lanternosphaeridium lanosum	5.20	20	Chlamydophorella cf. C. urna	2.40	196	Lanternosphaeridium lanosum
1.60	253	Spiniferites cf. S. septatus	2.00	196	Lanternosphaeridium lanosum	2.20	246	Deflandrea spinigera
1.60	252	Spiniferites septatus	1.70	246	Deflandrea spinigera	1.70	247	Leptodinium virginianum
1.50	93	Kallosphaeridium brevibarbatum	1.20	115	Palaeocystodinium golzowense	1.40	115	Palaeocystodinium golzowense
1.40	248	Membranosphaera tabulata	1.20	250	Palaeostomacystus fragilis	1.40	250	Palaeostomacystus fragilis
1.20	20	Chlamydophorella cf. C. urna	1.10	249	Nematosphaeropsis trabeculata	1.00	93	Kallosphaeridium brevibarbatum
1.20	246	Deflandrea spinigera	1.00	93	Kallosphaeridium brevibarbatum	0.80	31	Hystrichosphaeridium tubiferum
1.20	249	Nematosphaeropsis trabeculata	0.90	31	Hystrichosphaeridium tubiferum	0.80	253	Spiniferites cf. S. septatus
1.10	250	Palaeostomacystus fragilis	0.90	253	Spiniferites cf. S. septatus	0.80	252	Spiniferites septatus
0.90	190	Dionyesopsis capitata	0.90	252	Spiniferites septatus	0.50	249	Nematosphaeropsis trabeculata
0.90	115	Palaeocystodinium golzowense	0.40	110	Operculodinium centrocarpum	0.40	25	Cordosphaeridium fibrospinosum
0.80	47	Eocladopyxis peniculatum	0.40	151	Spiniferites ramosus subsp. ramosus	0.40	190	Dionyesopsis capitata
0.70	28	Cordosphaeridium inodes	0.30	28	Cordosphaeridium inodes	0.30	47	Eocladopyxis peniculatum
0.60	98	Lingulodinium machaerophorum	0.20	241	Cordosphaeridium species A	0.30	181	Micrhystridium spp.
0.40	243	Deflandrea obscura	0.20	243	Deflandrea obscura	0.30	101	Microdinium ornatum
0.40	245	Deflandrea ruginosa	0.20	190	Dionyesopsis capitata	0.20	28	Cordosphaeridium inodes
0.40	110	Operculodinium centrocarpum	0.20	47	Eocladopyxis peniculatum	0.20	192	Cymatiosphaera spp.
0.30	181	Micrhystridium spp.	0.20	98	Lingulodinium machaerophorum	0.20	242	Deflandrea cf. D. magnifica
0.20	242	Deflandrea cf. D. magnifica	0.20	101	Microdinium ornatum	0.20	245	Deflandrea ruginosa
0.20	194	Hystrichosphaeropsis borussica	0.20	186	Pterospermopsis spp.	0.20	39	Impletosphaeridium rugosum
0.20	186	Pterospermopsis spp.	0.10	240	Cordosphaeridium marylandense	0.20	110	Operculodinium centrocarpum
0.20	136	Spiniferites crassipellis A	0.10	242	Deflandrea cf. D. magnifica	0.20	186	Pterospermopsis spp.
0.20	151	Spiniferites ramosus subsp. ramosus	0.10	37	Deflandrea phosphoritica	0.20	169	Wetzeliella cf. W. irtyschensis
0.10	240	Cordosphaeridium marylandense	0.10	245	Deflandrea ruginosa	0.10	240	Cordosphaeridium marylandense
0.10	37	Deflandrea phosphoritica	0.10	39	Impletosphaeridium rugosum	0.10	178	Cyclopsiella vieta
0.10	244	Deflandrea rhombohedra	0.10	181	Micrhystridium spp.	0.10	243	Deflandrea obscura
0.10	78	Hystrichokolpoma unispinum	0.10	251	Spiniferites cingulatus subsp. reticulatus	0.10	37	Deflandrea phosphoritica
0.10	39	Impletosphaeridium rugosum	0.10	136	Spiniferites crassipellis A	0.10	76	Hystrichokolpoma rigaudae
0.10	101	Microdinium ornatum	0.10	148	Spiniferites ramosus subsp. granosus	0.10	98	Lingulodinium machaerophorum
0.10	251	Spiniferites cingulatus subsp. reticulatus	0.10	169	Wetzeliella cf. W. irtyschensis	0.10	251	Spiniferites cingulatus subsp. reticulatus
0.10	148	Spiniferites ramosus subsp. granosus				0.10	136	Spiniferites crassipellis A
						0.10	148	Spiniferites ramosus subsp. granosus
						0.10	151	Spiniferites ramosus subsp. ramosus

188			189			190		
48.20	255	Wetzeliella (W.) homomorpha subsp. quinq	33.40	255	Wetzeliella (W.) homomorpha subsp. quinq	30.80	255	Wetzeliella (W.) homomorpha subsp. quinq
12.50	248	Membranosphaera tabulata	26.00	248	Membranosphaera tabulata	27.50	248	Membranosphaera tabulata
9.60	196	Lanternosphaeridium lanosum	17.00	20	Chlamydophorella cf. C. urna	16.70	20	Chlamydophorella cf. C. urna
7.40	20	Chlamydophorella cf. C. urna	6.10	12	Areoligera sp.	5.90	12	Areoligera sp.
5.20	12	Areoligera sp.	3.40	196	Lanternosphaeridium lanosum	5.60	196	Lanternosphaeridium lanosum
2.40	246	Deflandrea spinigera	1.50	246	Deflandrea spinigera	1.80	246	Deflandrea spinigera
1.10	247	Leptodinium virginianum	1.20	115	Palaeocystodinium golzowense	1.50	81	Hystrichosphaeridium tubiferum
1.10	115	Palaeocystodinium golzowense	1.20	250	Palaeostomacystus fragilis	1.20	77	Hystrichokolpoma tumescens
1.10	250	Palaeostomacystus fragilis	1.10	77	Hystrichokolpoma tumescens	1.10	115	Palaeocystodinium golzowense
1.00	249	Nematosphaeropsis trabeculata	0.90	28	Cordosphaeridium inodes	1.10	250	Palaeostomacystus fragilis
0.90	25	Cordosphaeridium fibrospinosum	0.90	81	Hystrichosphaeridium tubiferum	0.80	28	Cordosphaeridium inodes
0.90	253	Spiniferites cf. S. septatus	0.90	253	Spiniferites cf. S. septatus	0.80	249	Nematosphaeropsis trabeculata
0.90	252	Spiniferites septatus	0.90	252	Spiniferites septatus	0.70	253	Spiniferites cf. S. septatus
0.80	81	Hystrichosphaeridium tubiferum	0.80	25	Cordosphaeridium fibrospinosum	0.70	252	Spiniferites septatus
0.70	240	Cordosphaeridium marylandense	0.80	190	Dionyesopsis capitata	0.60	25	Cordosphaeridium fibrospinosum
0.70	190	Dionyesopsis capitata	0.40	240	Cordosphaeridium marylandense	0.40	240	Cordosphaeridium marylandense
0.60	28	Cordosphaeridium inodes	0.40	93	Kallosphaeridium brevibarbatum	0.30	243	Deflandrea obscura
0.60	93	Kallosphaeridium brevibarbatum	0.30	195	Lanternosphaeridium bipolare	0.30	245	Deflandrea ruginosa
0.60	110	Operculodinium centrocarpum	0.30	247	Leptodinium virginianum	0.30	93	Kallosphaeridium brevibarbatum
0.40	136	Spiniferites crassipellis A	0.30	249	Nematosphaeropsis trabeculata	0.30	110	Operculodinium centrocarpum
0.30	243	Deflandrea obscura	0.30	148	Spiniferites ramosus subsp. granosus	0.20	178	Cyclopsiella vieta
0.30	77	Hystrichokolpoma tumescens	0.20	243	Deflandrea obscura	0.20	195	Lanternosphaeridium bipolare
0.30	146	Spiniferites pseudofurcatus	0.20	78	Hystrichokolpoma unispinum	0.20	98	Lingulodinium machaerophorum
0.20	241	Cordosphaeridium species A	0.20	98	Lingulodinium machaerophorum	0.20	186	Pterospermopsis spp.
0.20	244	Deflandrea rhombonedra	0.20	181	Micrhystridium spp.	0.20	136	Spiniferites crassipellis A
0.20	47	Eocladopyxis peniculatum	0.20	101	Microdinium ornatum	0.20	146	Spiniferites pseudofurcatus
0.20	194	Hystrichosphaeropsis borussica	0.20	110	Operculodinium centrocarpum	0.20	148	Spiniferites ramosus subsp. granosus
0.20	195	Lanternosphaeridium bipolare	0.20	136	Spiniferites crassipellis A	0.10	244	Deflandrea rhombonedra
0.20	251	Spiniferites cingulatus subsp. reticulatus	0.20	146	Spiniferites pseudofurcatus	0.10	190	Dionyesopsis capitata
0.20	169	Wetzeliella cf. W. rtyschensis	0.20	151	Spiniferites ramosus subsp. ramosus	0.10	78	Hystrichokolpoma unispinum
0.10	242	Deflandrea cf. D. magnifica	0.10	241	Cordosphaeridium species A	0.10	194	Hystrichosphaeropsis borussica
0.10	245	Deflandrea ruginosa	0.10	179	Cyclopsiella vieta	0.10	89	Impletosphaeridium rugosum
0.10	78	Hystrichokolpoma unispinum	0.10	245	Deflandrea ruginosa	0.10	247	Leptodinium virginianum
0.10	89	Impletosphaeridium rugosum	0.10	76	Hystrichokolpoma rigaudiae	0.10	181	Micrhystridium spp.
0.10	98	Lingulodinium machaerophorum	0.10	194	Hystrichosphaeropsis borussica	0.10	151	Spiniferites ramosus subsp. ramosus
0.10	148	Spiniferites ramosus subsp. granosus	0.10	89	Impletosphaeridium rugosum			
0.10	151	Spiniferites ramosus subsp. ramosus	0.10	186	Pterospermopsis spp.			

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38.00	255	Wetzeliella (W.) homomorpha subsp. quinq
19.70	248	Membranosphaera tabulata
15.90	20	Chlamydophorella cf. C. urna
10.40	196	Lanternosphaeridium lanosum
5.30	12	Areoligera sp.
1.30	115	Palaeocystodinium golzowense
1.30	250	Palaeostomacystis fragilis
0.90	253	Spiniferites cf. S. septatus
0.90	252	Spiniferites septatus
0.80	31	Hystrichosphaeridium tubiferum
0.70	28	Cordosphaeridium inodes
0.70	93	Kallosphaeridium brevibarbatum
0.60	246	Deflandrea spinigera
0.40	25	Cordosphaeridium fibrospinosum
0.40	195	Lanternosphaeridium bipolare
0.40	98	Lingulodinium machaerophorum
0.30	77	Hystrichokolpoma tumescens
0.20	240	Cordosphaeridium marylandense
0.20	243	Deflandrea obscura
0.20	245	Deflandrea ruginosa
0.20	39	Impletosphaeridium rugosum
0.20	181	Micrhystridium spp.
0.20	249	Nematosphaeropsis trabeculata
0.20	186	Pterospermopsis spp.
0.20	146	Spiniferites pseudofurcatus
0.10	238	Apteodinium baculatum
0.10	182	Cymatiosphaera spp.
0.10	190	Dionyesopsis capitata
0.10	176	Hystrichokolpoma rigaudiae
0.10	194	Hystrichosphaeropsis borussica
0.10	247	Leptodinium virginianum
0.10	110	Operculodinium centrocarpum
0.10	251	Spiniferites cingulatus subsp. reticulatus
0.10	136	Spiniferites crassipellis A
0.10	148	Spiniferites ramosus subsp. granosus
0.10	151	Spiniferites ramosus subsp. ramosus
0.10	254	Veryhachium spp.

194			195			196		
34.30	255	Wetzeliella (W.) homomorpha subsp. quinq	40.10	255	Wetzeliella (W.) homomorpha subsp. quinq	30.40	255	Wetzeliella (W.) homomorpha subsp. quinq
32.50	248	Membranosphaera tabulata	29.20	248	Membranosphaera tabulata	30.00	248	Membranosphaera tabulata
16.30	20	Chlamydophorella cf. C. urna	18.00	20	Chlamydophorella cf. C. urna	15.50	20	Chlamydophorella cf. C. urna
2.00	246	Deflandrea spinigera	2.20	246	Deflandrea spinigera	7.00	196	Lanternosphaeridium lanosum
2.00	196	Lanternosphaeridium lanosum	2.10	115	Palaeocystodinium golzowense	2.00	93	Kallosphaeridium brevibarbatum
1.40	28	Cordosphaeridium inodes	2.10	250	Palaeostomacystis fragilis	1.50	115	Palaeocystodinium golzowense
1.30	93	Kallosphaeridium brevibarbatum	1.80	196	Lanternosphaeridium lanosum	1.50	250	Palaeostomacystis fragilis
1.20	12	Areoligera sp.	1.20	243	Deflandrea obscura	1.30	12	Areoligera sp.
1.10	243	Deflandrea obscura	1.10	12	Areoligera sp.	1.20	246	Deflandrea spinigera
0.60	25	Cordosphaeridium fibrospinosum	0.60	101	Microdinium ornatum	0.70	240	Cordosphaeridium marylandense
0.60	77	Hystrichokolpoma tumescens	0.40	181	Micrhystridium spp.	0.70	31	Hystrichosphaeridium tubiferum
0.60	250	Palaeostomacystis fragilis	0.30	186	Pterospermopsis spp.	0.60	25	Cordosphaeridium fibrospinosum
0.50	181	Micrhystridium spp.	0.20	238	Apteodinium baculatum	0.50	243	Deflandrea obscura
0.50	115	Palaeocystodinium golzowense	0.20	25	Cordosphaeridium fibrospinosum	0.50	77	Hystrichokolpoma tumescens
0.40	240	Cordosphaeridium marylandense	0.20	28	Cordosphaeridium inodes	0.50	38	Lingulodinium machaerophorum
0.40	249	Nematosphaeropsis trabeculata	0.20	244	Deflandrea momoonedra	0.50	249	Nematosphaeropsis trabeculata
0.40	253	Spiniferites cf. S. septatus	0.20	245	Deflandrea ruginosa	0.50	136	Spiniferites crassipellis A
0.40	252	Spiniferites septatus	0.20	39	Impletosphaeridium rugosum	0.50	151	Spiniferites ramosus subsp. ramosus
0.30	37	Deflandrea phosphoritica	0.20	93	Kallosphaeridium brevibarbatum	0.40	28	Cordosphaeridium inodes
0.30	245	Deflandrea ruginosa	0.20	247	Leptodinium virginianum	0.40	195	Lanternosphaeridium bipolare
0.30	39	Impletosphaeridium rugosum	0.20	249	Nematosphaeropsis trabeculata	0.30	245	Deflandrea ruginosa
0.30	195	Lanternosphaeridium bipolare	0.20	136	Spiniferites crassipellis A	0.30	190	Dionyesopsis capitata
0.30	247	Leptodinium virginianum	0.20	151	Spiniferites ramosus subsp. ramosus	0.30	39	Impletosphaeridium rugosum
0.30	136	Spiniferites crassipellis A	0.20	169	Wetzeliella cf. w. ryschensis	0.30	247	Leptodinium virginianum
0.20	190	Dionyesopsis capitata	0.10	240	Cordosphaeridium marylandense	0.30	101	Microdinium ornatum
0.20	31	Hystrichosphaeridium tubiferum	0.10	190	Dionyesopsis capitata	0.30	253	Spiniferites cf. S. septatus
0.20	38	Lingulodinium machaerophorum	0.10	77	Hystrichokolpoma tumescens	0.30	148	Spiniferites ramosus subsp. granosus
0.20	101	Microdinium ornatum	0.10	78	Hystrichokolpoma unispinum	0.30	252	Spiniferites septatus
0.20	110	Operculodinium centrocarpum	0.10	31	Hystrichosphaeridium tubiferum	0.20	238	Apteodinium baculatum
0.20	186	Pterospermopsis spp.	0.10	195	Lanternosphaeridium bipolare	0.20	182	Cymatiosphaera spp.
0.20	151	Spiniferites ramosus subsp. ramosus	0.10	38	Lingulodinium machaerophorum	0.20	78	Hystrichokolpoma unispinum
0.10	238	Apteodinium baculatum	0.10	110	Operculodinium centrocarpum	0.20	194	Hystrichosphaeropsis borussica
0.10	75	Hystrichokolpoma rigaudae	0.10	253	Spiniferites cf. S. septatus	0.20	110	Operculodinium centrocarpum
0.10	78	Hystrichokolpoma unispinum	0.10	146	Spiniferites pseudofurcatus	0.20	146	Spiniferites pseudofurcatus
0.10	146	Spiniferites pseudofurcatus	0.10	148	Spiniferites ramosus subsp. granosus	0.10	178	Cyclopsiella vieta
0.10	148	Spiniferites ramosus subsp. granosus	0.10	252	Spiniferites septatus	0.10	186	Pterospermopsis spp.
0.10	169	Wetzeliella cf. w. ryschensis				0.10	169	Wetzeliella cf. w. ryschensis

197		
4? 40	255	Wetzeliella (W.) homomorpha subsp. quinq
31.50	248	Membranosphaera tabulata
14.20	20	Chlamydophorella cf. C. urna
2.40	196	Lanternosphaeridium lanosum
1.40	12	Areoligera sp.
0.80	93	Kallosphaeridium brevibarbatum
0.50	25	Cordosphaeridium fibrospinosum
0.50	240	Cordosphaeridium marylandense
0.50	245	Deflandrea ruginosa
0.40	243	Deflandrea obscura
0.40	246	Deflandrea spinigera
0.40	98	Lingulodinium machaerophorum
0.40	181	Micrhystridium spp.
0.40	250	Palaeostomacystus fragilis
0.40	151	Spiniferites ramosus subsp. ramosus
0.30	28	Cordosphaeridium inodes
0.30	77	Hystrichokolpoma tumescens
0.30	89	Impletosphaeridium rugosum
0.20	238	Apteodinium baculatum
0.20	190	Dionvesopsis capitata
0.20	78	Hystrichokolpoma unispinum
0.20	81	Hystrichosphaeridium tubiferum
0.20	195	Lanternosphaeridium bipolare
0.20	247	Leptodinium virginianum
0.20	101	Microdinium ornatum
0.20	249	Nematosphaeropsis trabeculata
0.20	110	Operculodinium centrocarpum
0.20	115	Palaeocystodinium golzowense
0.20	186	Pterospermopsis spp.
0.20	253	Spiniferites cf. S. septatus
0.20	251	Spiniferites cingulatus subsp. reticulatus
0.20	136	Spiniferites crassipellis A
0.20	252	Spiniferites septatus
0.20	169	Wetzeliella cf. W. irtyschensis
0.10	178	Cyclopsiella vieta
0.10	194	Hystrichosphaeropsis borussica
0.10	146	Spiniferites pseudofurcatus
0.10	148	Spiniferites ramosus subsp. granosus

Correlation Matrix for PT3

Correlation Matrix for Variables: $X_1 \ldots X_{13}$

	183	184	185	186	187	188	189	190
183	1							
184	.92104	1						
185	.80824	.95885	1					
186	.76673	.94216	.98162	1				
187	.58132	.72576	.76791	.85738	1			
188	.71181	.88932	.92917	.9734	.91282	1		
189	.55201	.69553	.73805	.8328	.99757	.89957	1	
190	.52405	.65604	.69874	.79761	.99103	.87937	.99642	1
191	.62173	.77427	.81607	.89201	.97384	.95895	.97351	.96739
194	.49197	.6332	.67804	.78548	.98541	.8586	.98724	.98814
195	.54982	.71283	.75957	.85607	.99233	.91239	.98856	.98128
196	.49126	.62143	.66643	.77213	.97907	.86298	.98365	.9911
197	.55276	.71423	.759	.8546	.98904	.91245	.9856	.97982

Correlation Matrix for Variables: $X_1 \ldots X_{13}$

	191	194	195	196	197
191	1				
194	.94293	1			
195	.96549	.98977	1		
196	.95451	.99224	.98083	1	
197	.96219	.99004	.99654	.98187	1

ANOVA Table for PT3

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_{13}$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	27994.76687	110.21562	69.39686	.0001
Within subjects	3060	4859.87077	1.58819		
treatments	12	.00524	.00044	.00027	1
residual	3048	4859.86553	1.59444		
Total	3314	32854.63763			

Reliability Estimates for- All treatments: .98559 Single Treatment: .34029

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_{13}$

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
183	255	.39412	2.72401	.17058
184	255	.39176	3.3715	.21113
185	255	.39647	3.56685	.22336
186	255	.39373	3.73425	.23385
187	255	.39373	2.93882	.18404

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_{13}$

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
188	255	.39529	3.23527	.2026
189	255	.3949	2.87663	.18014
190	255	.39451	2.82223	.17674
191	255	.39529	2.93586	.18385
194	255	.39451	3.12191	.1955

PT4 *"Wetzeliella (W.) homomorpha/Deflandria dilwynensis/Muratodinium fimbriatum"* Association

199			200			201		
42.10	255	Wetzeliella (W.) homomorpha subsp. quinq	40.70	255	Wetzeliella (W.) homomorpha subsp. quinq	36.50	255	Wetzeliella (W.) homomorpha subsp. quinq
30.00	213	Deflandria dilwynensis	31.20	213	Deflandria dilwynensis	32.50	213	Deflandria dilwynensis
25.20	103	Muratodinium fimbriatum	25.30	103	Muratodinium fimbriatum	29.50	103	Muratodinium fimbriatum
1.00	186	Pterospermopsis spp.	0.30	186	Pterospermopsis spp.	0.50	186	Pterospermopsis spp.
0.50	181	Micrhystridium spp.	0.40	181	Micrhystridium spp.	0.40	181	Micrhystridium spp.
0.30	120	Chlamydophorella cf. C. urna	0.40	151	Spiniferites ramosus subsp. ramosus	0.20	243	Deflandria obscura
0.20	248	Membranosphaera tabulata	0.30	249	Nematosphaeropsis trabeculata	0.20	249	Nematosphaeropsis trabeculata
0.20	249	Nematosphaeropsis trabeculata	0.20	243	Deflandria obscura	0.10	182	Cymatiosphaera spp.
0.10	182	Cymatiosphaera spp.	0.10	182	Cymatiosphaera spp.	0.10	151	Spiniferites ramosus subsp. ramosus
0.10	243	Deflandria obscura						
0.10	246	Deflandria spinigera						
0.10	195	Lanternosphaeridium bipolare						
0.10	151	Spiniferites ramosus subsp. ramosus						

Correlation Matrix for Variables: $X_1 \ldots X_3$

	199	200	201
199	1		
200	.99938	1	
201	.99133	.99489	1

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_3$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	9716.17783	38.25267	624.75003	.0001
Within subjects	510	31.22667	.06123		
treatments	2	.00003	.00001	.00021	.9998
residual	508	31.22664	.06147		
Total	764	9747.4045			

Reliability Estimates for- All treatments: .9984 Single Treatment: .99521

PT5 "Glaphyrocysta exuberans complex/Fibradinium annetorpense" Association

303	witmer aqua percentages	304	witmer aqua percentages
28.67	53 Glaphyrocysta exuberans cpix	26.00	53 Glaphyrocysta exuberans cpix
14.00	49 Fibradinium annetorpense	20.00	49 Fibradinium annetorpense
7.33	46 Electrocysta obscurotabulata	8.00	175 Xenikoon australis
6.33	175 Xenikoon australis	7.00	46 Electrocysta obscurotabulata
6.00	26 Cordosphaeridium giganteum	6.33	116 Palaeoperidinium pyrophorum
5.67	116 Palaeoperidinium pyrophorum	4.67	36 Deflandrea dartmoria
3.33	31 Hystrichosphaeridium tubiferum	3.33	180 Micrhystridium cf. m. variabile
3.00	180 Micrhystridium cf. m. variabile	3.00	28 Cordosphaeridium inodes
2.67	28 Cordosphaeridium inodes	2.33	26 Cordosphaeridium giganteum
2.67	35 Deflandrea dartmoria	2.33	55 Florentinia ferox
2.33	27 Cordosphaeridium gracilis	2.33	31 Hystrichosphaeridium tubiferum
1.67	34 Danea sp.	2.00	117 Paralecaniella indentata
1.33	17 Calligodinium amiculum	1.67	17 Calligodinium amiculum
1.33	183 Palambages sp. A	1.33	27 Cordosphaeridium gracilis
1.00	20 Chlamydophorella cf. C. urna	0.67	34 Danea sp.
1.00	110 Coerculodinium centrocarpum	0.67	45 Electrocysta densobaculata
1.00	151 Spiniferites ramosus subsp. ramosus	0.67	110 Coerculodinium centrocarpum
1.00	134 Palambages sp. B	0.67	151 Spiniferites ramosus subsp. ramosus
0.67	21 Cladopyxidium saeptum	0.67	159 Thalassiphora delicata
0.67	23 Conneximura fimbriata	0.67	183 Palambages sp. A
0.67	45 Electrocysta densobaculata	0.33	5 Andalusiella mombonecra
0.67	54 Fibrocysta sp.	0.33	20 Chlamydophorella cf. C. urna
0.67	55 Florentinia ferox	0.33	21 Cladopyxidium saeptum
0.67	58 Hafniasphaera septata	0.33	23 Conneximura fimbriata
0.67	115 Palaeocystodinium golzowense	0.33	25 Cordosphaeridium fibrospinosum
0.67	117 Paralecaniella indentata	0.33	33 ?Cordosphaeridium callosum
0.67	159 Thalassiphora delicata	0.33	41 Diphyes colligerum
0.33	25 Cordosphaeridium fibrospinosum	0.33	43 Diphyes colligerum (sensu Cookson 1985)
0.33	33 ?Cordosphaeridium callosum	0.33	48 Exochosphaeridium bifidum
0.33	41 Diphyes colligerum	0.33	54 Fibrocysta sp.
0.33	43 Diphyes colligerum (sensu Cookson 1985)	0.33	56 Forma A
0.33	48 Exochosphaeridium bifidum	0.33	61 Fromea fragilis
0.33	56 Forma A	0.33	68 Hafniasphaera septata
0.33	61 Fromea fragilis	0.33	73 Horologinella apiculata
0.33	78 Hystrichokolpoma unispinum	0.33	39 Impletosphaeridium rugosum
0.33	32 Hystrichosphaeridium tubiferum brevispin	0.33	101 Microdinium ornatum
0.33	39 Impletosphaeridium rugosum	0.33	105 Nematosphaeropsis pertusa
0.33	91 Inversidinium exilimuram	0.33	108 Oligosphaeridium complex
0.33	101 Microdinium ornatum	0.33	115 Palaeocystodinium golzowense
0.33	105 Nematosphaeropsis pertusa	0.33	120 Pheloodinium magnificum
0.33	108 Oligosphaeridium complex	0.33	132 Senegalinium? dilwynense
0.33	120 Pheloodinium magnificum	0.33	136 Spiniferites crassipellis A
0.33	125 Renidinium membraniferum	0.33	146 Spiniferites pseudofurcatus
0.33	132 Senegalinium? dilwynense	0.33	147 Spiniferites ramosus subsp. granomembran
0.33	136 Spiniferites crassipellis A	0.33	149 Spiniferites ramosus subsp. membranaceou
0.33	146 Spiniferites pseudofurcatus	0.33	150 Spiniferites ramosus subsp. multibrevis
0.33	147 Spiniferites ramosus subsp. granomembrana	0.33	157 Tanyosphaeridium variecalamum
0.33	148 Spiniferites ramosus subsp. granosus	0.33	179 Micrhystridium cf. m. fragile
0.33	150 Spiniferites ramosus subsp. multibrevis	0.33	181 Micrhystridium spp.
0.33	157 Tanyosphaeridium variecalamum	0.33	182 Cymatiosphaera spp.
0.33	160 Thalassiphora pelagica	0.33	186 Pterospermopsis spp.
0.33	162 Trigonopyxidia ginella		
0.33	179 Micrhystridium cf. m. fragile		
0.33	182 Cymatiosphaera spp.		
0.33	186 Pterospermopsis spp.		

309	witmer aqua percentages	310	witmer aqua percentages	311	witmer aqua percentages
54.33	63 Glaphyrocysta exuberans cplx	33.00	49 Fibradinium annetorpense	60.00	63 Glaphyrocysta exuberans cplx
31.33	49 Fibradinium annetorpense	21.33	63 Glaphyrocysta exuberans cplx	23.00	49 Fibradinium annetorpense
19.67	176 Xenikoon australis	14.67	176 Xenikoon australis	4.67	46 Electrocysta obscurotabulata
4.00	46 Electrocysta obscurotabulata	3.67	46 Electrocysta obscurotabulata	3.00	65 Glaphyrocysta sp A
3.33	65 Glaphyrocysta sp A	3.00	26 Cordosphaeridium giganteum	2.33	36 Deflandrea dartmoria
3.00	17 Cauigodinium amiculum	2.67	65 Glaphyrocysta sp A	1.33	27 Cordosphaeridium gracilis
2.67	26 Cordosphaeridium giganteum	2.33	178 Cyclopsiella vieta	1.00	181 Micrhystridium spp.
2.00	180 Micrhystridium cf m. variabile	2.00	27 Cordosphaeridium gracilis	0.67	28 Cordosphaeridium inodes
1.33	28 Cordosphaeridium inodes	2.00	166 Turbiosphaera filosa	0.67	45 Electrocysta densobaculata
1.33	116 Palaeoperidinium pyrophorum	1.67	36 Deflandrea dartmoria	0.67	97 Lentinia spinigera
0.67	15 Batiacasphaera sp.	1.67	117 Paralecaniella indentata	0.67	166 Turbiosphaera filosa
0.67	34 Danea sp.	1.33	180 Micrhystridium cf m. variabile	0.67	176 Xenikoon australis
0.67	36 Deflandrea dartmoria	1.00	97 Lentinia spinigera	0.33	13 Ascotomocystus hydna
0.67	45 Electrocysta densobaculata	1.00	115 Palaeocystodinium golzowense	0.33	15 Batiacasphaera sp.
0.67	61 Fromea fragilis	1.00	151 Spiniferites ramosus subsp. ramosus	0.33	17 Cauigodinium amiculum
0.67	68 Hafniasphaera septata	0.67	28 Cordosphaeridium inodes	0.33	20 Chlamydophorella cf. C. urna
0.67	117 Paralecaniella indentata	0.67	68 Hafniasphaera septata	0.33	25 Cordosphaeridium fibrospinosum
0.67	184 Palambages sp. B	0.67	105 Nematosphaeropsis pertusa	0.33	26 Cordosphaeridium giganteum
0.33	13 Ascotomocystus hydna	0.67	120 Pheiodinium magnificum	0.33	41 Diphyes colligerum
0.33	20 Chlamydophorella cf. C. urna	0.67	148 Spiniferites ramosus subsp. granosus	0.33	42 Diphyes colligerum
0.33	21 Cladopyxidium saeptum	0.33	17 Cauigodinium amiculum	0.33	56 Forma A
0.33	23 Connexumura fimbriata	0.33	20 Chlamydophorella cf. C. urna	0.33	61 Fromea fragilis
0.33	27 Cordosphaeridium gracilis	0.33	21 Cladopyxidium saeptum	0.33	68 Hafniasphaera septata
0.33	33 ?Cordosphaeridium callosum	0.33	33 ?Cordosphaeridium callosum	0.33	73 Horologinella apiculata
0.33	48 Exochosphaeridium bifidum	0.33	42 Diphyes colligerum	0.33	81 Hystrichosphaeridium tubiferum
0.33	55 Florentinia ferox	0.33	43 Diphyes colligerum (sensu cookson 1985)	0.33	89 Impletosphaeridium rugosum
0.33	73 Horologinella apiculata	0.33	45 Electrocysta densobaculata	0.33	91 Inversidinium exilimuram
0.33	81 Hystrichosphaeridium tubiferum	0.33	56 Forma A	0.33	101 Microdinium ornatum
0.33	101 Microdinium ornatum	0.33	61 Fromea fragilis	0.33	105 Nematosphaeropsis pertusa
0.33	105 Nematosphaeropsis pertusa	0.33	62 Fromea? laevigata	0.33	115 Palaeocystodinium golzowense
0.33	108 Oligosphaeridium complex	0.33	75 Hystrichokolpoma mentitum	0.33	117 Paralecaniella indentata
0.33	110 Operculodinium centrocarpum	0.33	80 Hystrichosphaeridium spp.	0.33	120 Pheiodinium magnificum
0.33	120 Pheiodinium magnificum	0.33	81 Hystrichosphaeridium tubiferum	0.33	125 Renidinium membraniferum
0.33	127 Rottnestia borussica	0.33	107 Nematosphaeropsis trabeculata	0.33	129 Samlandia reticulifera
0.33	129 Samlandia reticulifera	0.33	110 Operculodinium centrocarpum	0.33	133 Spinidinium essoi
0.33	132 Senegalinium? dilwynense	0.33	127 Rottnestia borussica	0.33	151 Spiniferites ramosus subsp. ramosus
0.33	133 Spinidinium essoi	0.33	129 Samlandia reticulifera	0.33	159 Thalassiphora delicata
0.33	139 Spiniferites cf. s. pterotus	0.33	130 Senegalinium? obscurum	0.33	162 Trigonopyxidia ginella
0.33	151 Spiniferites ramosus subsp. ramosus	0.33	136 Spiniferites crassipellis A	0.33	178 Cyclopsiella vieta
0.33	156 Systematophora placacantha	0.33	147 Spiniferites ramosus subsp. granomembran	0.33	179 Micrhystridium cf m. fragile
0.33	159 Thalassiphora delicata	0.33	149 Spiniferites ramosus subsp. membranaceou	0.33	184 Palambages sp. B
0.33	179 Micrhystridium cf m. fragile	0.33	152 Spiniferites ramuliferus	0.33	186 Pterospermopsis spp.
0.33	182 Cymatiosphaera spp.	0.33	159 Thalassiphora delicata		
0.33	186 Pterospermopsis spp.	0.33	162 Trigonopyxidia ginella		

J12		witmer aqua percentages
58.67	63	Glaphyrocysta exuberans cpix
7.33	166	Turbiosphaera filosa
4.67	36	Deflandrea dartmoria
3.33	176	Xenikoon australis
3.00	65	Glaphyrocysta sp. A
2.33	27	Cordosphaeridium gracilis
1.67	178	Cyclopsiella vieta
1.33	46	Electrocysta obscurotabulata
1.00	29	Cordosphaeridium inodes
0.67	17	Caligodinium amiculum
0.67	45	Electrocysta densobaculata
0.67	51	Fromea fragilis
0.67	97	Lentinia spinigera
0.67	146	Spiniferites pseudofurcatus
0.67	181	Micrhystridium spp.
0.67	184	Palambages sp. B
0.33	4	Alisocysta cf. a. margarita
0.33	13	Ascostomocystis hydria
0.33	15	Batiacasphaera sp.
0.33	20	Chlamydophorella cf. C. urna
0.33	26	Cordosphaeridium giganteum
0.33	37	Deflandrea phosphoritica
0.33	49	Fibradinium annetorpense
0.33	58	Hafniasphaera septata
0.33	80	Hystrichosphaeridium spp.
0.33	81	Hystrichosphaeridium tubiferum
0.33	104	Nematosphaeropsis cf. n. pertusa
0.33	105	Nematosphaeropsis pertusa
0.33	107	Nematosphaeropsis trabeculata
0.33	110	Operculodinium centrocarpum
0.33	115	Palaeocystodinium golzowense
0.33	117	Paralecaniella indentata
0.33	125	Renidinium memoraniferum
0.33	132	Senegalinium? dilwynense
0.33	151	Spiniferites ramosus subsp. ramosus
0.33	159	Thalassiphora delicata
0.33	180	Micrhystridium cf. m. variabile
0.33	182	Cymatiosphaera spp.

Correlation Matrix for PT 5

Correlation Matrix for Variables: $X_1 \ldots X_5$

	304	309	310	311	312
304	1				
309	.93835	1			
310	.90098	.85814	1		
311	.89215	.96045	.75493	1	
312	.74139	.87105	.52544	.92808	1

ANOVA Table for PT 5

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_5$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	14311.97736	56.34637	18.42889	.0001
Within subjects	1020	3118.65252	3.0575		
treatments	4	5.43712	1.35928	.4436	.7771
residual	1016	3113.2154	3.06419		
Total	1274	17430.62988			

Reliability Estimates for- All treatments: .94574 Single Treatment: .77707

PT6 "Glaphyrocysta exuberans complex/ Cordospharidium giganteum/ Fibradinium annetorpense" Association

305		wemer aqua percentages
22.67	49	Fibradinium annetorpense
16.33	26	Cordosphaeridium giganteum
9.33	46	Electrocysta obscurotabulata
5.67	36	Dellandrea dartmooria
4.67	53	Glaphyrocysta exuberans cplx
4.00	34	Danea sp.
3.33	180	Micrhystridium cf. m. variabile
2.67	101	Microdinium ornatum
2.00	27	Cordosphaeridium gracilis
2.00	45	Electrocysta densobaculata
1.67	20	Chlamydophorella cf. C. urna
1.67	28	Cordosphaeridium inodes
1.67	55	Florentinia ferox
1.67	105	Nematosphaeropsis pertusa
1.67	117	Paralecaniella indentata
1.67	129	Samlandia reticulifera
1.33	56	Forma A
1.33	81	Hystrichosphaeridium tubiferum
1.33	176	Xenikoon australis
1.00	15	Batiacasphaera sp.
1.00	151	Spiniferites ramosus subsp. ramosus
0.67	5	Andalusiella rhombohedra
0.67	17	Caligodinium amiculum
0.67	68	Hafniasphaera septata
0.67	110	Operculodinium centrocarpum
0.67	116	Palaeoperidinium pyrophorum
0.67	136	Spiniferites crassipellis A
0.67	162	Trigonopyxidia ginella
0.33	13	Ascotomocystus hydna
0.33	21	Cladopyxidium saeptum
0.33	23	Connaximura fimbriata
0.33	25	Cordosphaeridium fibrospinosum
0.33	42	Diphyes colligerum
0.33	48	Exochosphaeridium bifidum
0.33	61	Fromea fragilis
0.33	82	Hystrichosphaeridium tubiferum brevispin
0.33	85	Impagidinium sp. A
0.33	89	Impletosphaeridium rugosum
0.33	91	Inversidinium exilimurum
0.33	97	Lentinia spinigera
0.33	115	Palaeocystodinium golzowense
0.33	120	Phelodinium magnificum
0.33	125	Renidinium membraniferum
0.33	127	Rottnestia borussica
0.33	133	Spinidinium essoi
0.33	141	Spiniferites cornutus A
0.33	146	Spiniferites pseudofurcatus
0.33	147	Spiniferites ramosus subsp. granomembrana
0.33	148	Spiniferites ramosus subsp. granosus
0.33	149	Spiniferites ramosus subsp. membranaceou
0.33	179	Micrhystridium cf. m. fragile
0.33	182	Cymatiosphaera spp.
0.33	183	Palambages sp. A

306	witmer aquia percentages	307	witmer aquia percentages	308	witmer aquia percentages
22.00	63 Glaphyrocysta exuberans cpx	19.67	26 Cordosphaeridium giganteum	24.33	49 Fibradinium annetorpense
10.67	26 Cordosphaeridium giganteum	16.67	46 Electrocysta obscurotabulata	19.33	46 Electrocysta obscurotabulata
10.00	46 Electrocysta obscurotabulata	11.00	63 Glaphyrocysta exuberans cpx	12.00	26 Cordosphaeridium giganteum
6.33	117 Paralecaniella indentata	6.33	17 Caligodinium amiculum	6.33	63 Glaphyrocysta exuberans cpx
5.67	49 Fibradinium annetorpense	5.00	49 Fibradinium annetorpense	5.00	176 Xenikoon australis
5.33	81 Hystrichosphaeridium tubiferum	3.67	36 Deflandrea dartmoria	3.67	28 Cordosphaeridium inodes
3.67	180 Micrhystridium cf. m. variabile	3.67	180 Micrhystridium cf. m. variabile	3.00	34 Danea sp.
3.33	55 Florentinia ferox	3.33	28 Cordosphaeridium inodes	3.00	180 Micrhystridium cf. m. variabile
3.00	28 Cordosphaeridium inodes	3.00	27 Cordosphaeridium gracilis	2.67	17 Caligodinium amiculum
3.00	34 Danea sp.	3.00	65 Glaphyrocysta sp. A	2.00	101 Microdinium ornatum
2.00	58 Hafniasphaera septata	3.00	58 Hafniasphaera septata	1.67	20 Chlamydophorella cf. C. urna
1.67	17 Caligodinium amiculum	3.00	116 Palaeoperidinium pyrophorum	1.67	36 Deflandrea dartmoria
1.67	27 Cordosphaeridium gracilis	2.67	55 Florentinia ferox	1.67	81 Hystrichosphaeridium tubiferum
1.67	176 Xenikoon australis	2.33	81 Hystrichosphaeridium tubiferum	1.67	129 Samlandia reticulifera
1.33	36 Deflandrea dartmoria	2.00	117 Paralecaniella indentata	1.33	117 Paralecaniella indentata
1.33	45 Electrocysta densobaculata	1.67	101 Microdinium ornatum	1.00	45 Electrocysta densobaculata
1.33	151 Spiniferites ramosus subsp. ramosus	1.67	129 Samlandia reticulifera	1.00	91 Inversidinium exilimurum
1.00	61 Fromea fragilis	1.33	20 Chlamydophorella cf. C. urna	1.00	116 Palaeoperidinium pyrophorum
1.00	110 Operculodinium centrocarpum	1.33	34 Danea sp.	0.67	15 Batiacasphaera sp.
1.00	116 Palaeoperidinium pyrophorum	1.00	110 Operculodinium centrocarpum	0.67	27 Cordosphaeridium gracilis
1.00	157 Tanyosphaeridium variecalamum	1.00	151 Spiniferites ramosus subsp. ramosus	0.67	55 Florentinia ferox
0.67	15 Batiacasphaera sp.	1.00	176 Xenikoon australis	0.67	56 Forma A
0.67	20 Chlamydophorella cf. C. urna	0.67	23 Conniximura fimbriata	0.67	110 Operculodinium centrocarpum
0.67	21 Cladopyxidium saeptum	0.67	45 Electrocysta densobaculata	0.67	115 Palaeocystodinium golzowense
0.67	25 Cordosphaeridium fibrospinosum	0.67	48 Exochosphaeridium bifidum	0.67	150 Spiniferites ramosus subsp. multibrevis
0.67	65 Glaphyrocysta sp. A	0.67	56 Forma A	0.67	151 Spiniferites ramosus subsp. ramosus
0.67	101 Microdinium ornatum	0.67	105 Nematosphaeropsis pertusa	0.67	181 Micrhystridium spp.
0.67	105 Nematosphaeropsis pertusa	0.67	159 Thalassiphora delicata	0.33	23 Conniximura fimbriata
0.67	136 Spiniferites crassipellis A	0.67	181 Micrhystridium spp.	0.33	33 ?Cordosphaeridium callosum
0.33	5 Ancalusiella rhombohedra	0.33	13 Ascotomocystis hydria	0.33	48 Exochosphaeridium bifidum
0.33	13 Ascotomocystis hydria	0.33	15 Batiacasphaera sp.	0.33	61 Fromea fragilis
0.33	23 Conniximura fimbriata	0.33	30 Cordosphaeridium multispinosum	0.33	65 Glaphyrocysta sp. A
0.33	33 ?Cordosphaeridium callosum	0.33	33 ?Cordosphaeridium callosum	0.33	68 Hafniasphaera septata
0.33	41 Diphyes colligerum	0.33	41 Diphyes colligerum	0.33	80 Hystrichosphaeridium spp.
0.33	48 Exochosphaeridium bifidum	0.33	43 Diphyes colligerum (sensu cookson 1985)	0.33	85 Impagidinium sp. A
0.33	56 Forma A	0.33	80 Hystrichosphaeridium spp.	0.33	89 Impletosphaeridium rugosum
0.33	67 Hafniasphaera cf. h. septata	0.33	89 Impletosphaeridium rugosum	0.33	92 Isabelidinium cooksoniae
0.33	97 Lentinia spinigera	0.33	115 Palaeocystodinium golzowense	0.33	105 Nematosphaeropsis pertusa
0.33	108 Oligosphaeridium complex	0.33	127 Rottnestia borussica	0.33	148 Spiniferites ramosus subsp. granosus
0.33	115 Palaeocystodinium golzowense	0.33	132 Senegalinium? dilwynense	0.33	157 Tanyosphaeridium variecalamum
0.33	129 Samlandia reticulifera	0.33	136 Spiniferites crassipellis A	0.33	159 Thalassiphora delicata
0.33	132 Senegalinium? dilwynense	0.33	147 Spiniferites ramosus subsp. granomembrana	0.33	179 Micrhystridium cf. m. fragile
0.33	133 Spinidinium essoi	0.33	148 Spiniferites ramosus subsp. granosus	0.33	186 Pterospermopsis spp.
0.33	148 Spiniferites ramosus subsp. granosus	0.33	149 Spiniferites ramosus subsp. membranaceous		
0.33	149 Spiniferites ramosus subsp. membranaceou	0.33	150 Spiniferites ramosus subsp. multibrevis		
0.33	152 Spiniferites ramuliferus	0.33	156 Systematophora placacantha		
0.33	156 Systematophora placacantha	0.33	162 Trigonopyxidia ginella		
0.33	159 Thalassiphora delicata	0.33	179 Micrhystridium cf. m. fragile		
0.33	160 Thalassiphora pelagica	0.33	186 Pterospermopsis spp.		
0.33	161 Trichodinium hirsutum				
0.33	179 Micrhystridium cf. m. fragile				
0.33	183 Palambages sp. A				
0.33	186 Pterospermopsis spp.				

Correlation Matrix for PT6

Correlation Matrix for Variables: $X_1 \ldots X_4$

	305	306	307	308
305	1			
306	.59792	1		
307	.73364	.80327	1	
308	.92007	.62847	.75536	1

ANOVA Table for PT6

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_4$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	3160.85165	12.4443	12.36574	.0001
Within subjects	765	769.86015	1.00635		
treatments	3	.08939	.0298	.0295	.9932
residual	762	769.77076	1.0102		
Total	1019	3930.7118			

Reliability Estimates for- All treatments: .91913 Single Treatment: .73968

Sample 313

313		witmer aquia percentages
39.33	166	Turbiosphaera filosa
9.67	55	Glaphyrocysta sp A
9.00	36	Deflandrea dartmoria
6.67	176	Xenikoon australis
5.33	117	Paralecaniella indentata
4.67	63	Glaphyrocysta exuberans cplx
4.00	159	Thalassiphora delicata
3.33	61	Fromea fragilis
2.33	97	Lentinia spinigera
2.00	17	Caligodinium amiculum
1.67	4	Alisocysta cf. a. margarita
1.33	13	Ascotomocystus hydria
1.33	20	Chlamydophorella cf. C. urna
1.33	46	Electrocysta obscurotabulata
1.33	178	Cyclopsiella vieta
1.00	68	Hafniasphaera septata
1.00	151	Spiniferites ramosus subsp. ramosus
0.67	110	Operculodinium centrocarpum
0.67	120	Pheiodinium magnificum
0.67	148	Spiniferites ramosus subsp. granosus
0.67	180	Micrhystridium cf m. variabile
0.67	184	Palambages sp. B
0.33	21	Cladopyxidium saeptum
0.33	27	Cordosphaeridium gracilis
0.33	28	Cordosphaeridium inodes
0.33	37	Deflandrea phosphoritica
0.33	45	Electrocysta densobaculata
0.33	62	Fromea? laevigata
0.33	73	Horologinella apiculata
0.33	80	Hystrichosphaeridium spp
0.33	81	Hystrichosphaeridium tubiferum
0.33	89	Impletosphaeridium rugosum
0.33	101	Microdinium ornatum
0.33	105	Nematosphaeropsis pertusa
0.33	107	Nematosphaeropsis trabeculata
0.33	115	Palaeocystodinium golzowense
0.33	136	Spiniferites crassipellis A
0.33	146	Spiniferites pseudofurcatus
0.33	182	Cymatiosphaera spp.
0.33	186	Pterospermopsis spp

Statistical Information for Sample 313

X_1: 304					
Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.41008	2.22636	.13942	4.95669	542.91125	255
Minimum:	Maximum:	Range:	Sum:	Sum of Sqr.:	# Missing:
0	26	26	104.57	1301.8805	0

X_2: 313					
Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.41416	2.68898	.16839	7.2306	649.26547	255
Minimum:	Maximum:	Range:	Sum:	Sum of Sqr.:	# Missing:
0	39.33	39.33	105.61	1880.3115	0

PT7 "*Glaphytocysta* species A/ *Eocladopyxis peniculatum*" Association

314		witmer aquia percentages
35.00	55	Glaphyrocysta sp. A
26.33	159	Thalassiphora delicata
15.00	117	Paralecaniella indentata
3.33	166	Turbiosphaera filosa
2.33	36	Deflandrea dartmoria
1.33	88	Hafniasphaera septata
1.33	91	Inversidinium exilimurum
1.00	46	Electrocysta obscurotabulata
1.00	53	Glaphyrocysta exuberans cplx
1.00	151	Spiniferites ramosus subsp. ramosus
1.00	181	Micrhystridium spp.
0.67	4	Alisocysta cf. A. margarita
0.67	28	Cordosphaeridium inodes
0.67	41	Dionyes colligerum
0.67	89	Impletosphaeridium rugosum
0.67	101	Microdinium ornatum
0.67	107	Nematosphaeropsis trabeculata
0.67	110	Operculodinium centrocarpum
0.67	176	Xenikoon australis
0.67	180	Micrhystridium cf. m. variabile
0.33	3	Adnatosphaeridium robustum
0.33	17	Caligodinium amiculum
0.33	18	Cassidium paleocenicum
0.33	25	Cordosphaeridium fibrospinosum
0.33	26	Cordosphaeridium giganteum
0.33	27	Cordosphaeridium gracilis
0.33	33	?Cordosphaeridium callosum
0.33	43	Dionyes colligerum (sensu cookson 1985)
0.33	45	Electrocysta densobaculata
0.33	61	Fromea fragilis
0.33	80	Hystrichosphaeridium spp.
0.33	81	Hystrichosphaeridium tubiferum
0.33	97	Lentinia spinigera
0.33	120	Pheodinium magnificum
0.33	125	Renidinium membraniferum
0.33	127	Rottnestia borussica
0.33	146	Spiniferites pseudofurcatus
0.33	152	Trigonopyxidia ginella
0.33	179	Micrhystridium cf. m. fragile
0.33	184	Palambages sp. B
0.33	186	Pterospermopsis spp.

315		witmer aquia percentages
41.57	55	Glaphyrocysta sp. A
14.00	47	Eocladopyxis peniculatum
3.33	34	Impagidinium cf. I. speciosum
4.67	96	Lentinia ruginosa
2.67	36	Deflandrea dartmoria
2.33	132	Senegalinium? dilwynense
1.67	3	Adnatosphaeridium robustum
1.67	28	Cordosphaeridium inodes
1.33	115	Palaeocystodinium golzowense
1.33	120	Pheodinium magnificum
1.33	130	Senegalinium? obscuram
1.00	5	Andalusiella rhombohedra
1.00	13	Ascotomocystus hydria
1.00	46	Electrocysta obscurotabulata
1.00	37	Impagidinium speciosum
1.00	97	Lentinia spinigera
1.00	167	Turbiosphaera paratabulata
0.67	18	Cassidium paleocenicum
0.67	24	Cordosphaeridium biarmatum
0.67	25	Cordosphaeridium fibrospinosum
0.67	53	Glaphyrocysta exuberans cplx
0.67	68	Hafniasphaera septata
0.67	81	Hystrichosphaeridium tubiferum
0.67	98	Linguiodinium machaerophorum
0.67	110	Operculodinium centrocarpum
0.67	117	Paralecaniella indentata
0.67	125	Renidinium membraniferum
0.67	136	Spiniferites crassipellis A
0.67	146	Spiniferites pseudofurcatus
0.67	178	Cyclopsiella vieta
0.33	17	Caligodinium amiculum
0.33	20	Chlamydophorella cf. C. urna
0.33	21	Cladopyxidium saeptum
0.33	27	Cordosphaeridium gracilis
0.33	37	Deflandrea phosphoritica
0.33	41	Dionyes colligerum
0.33	45	Electrocysta densobaculata
0.33	61	Fromea fragilis
0.33	76	Hystrichokolpoma rigaude
0.33	77	Hystrichokolpoma tumescens
0.33	89	Impletosphaeridium rugosum
0.33	93	Kallosphaeridium brevibarbatum
0.33	101	Microdinium ornatum
0.33	105	Nematosphaeropsis pertusa
0.33	107	Nematosphaeropsis trabeculata
0.33	127	Rottnestia borussica
0.33	137	Spiniferites crassipellis B
0.33	148	Spiniferites ramosus subsp. granosus
0.33	149	Spiniferites ramosus subsp. memoranaceou
0.33	168	Turbiosphaera rotunda
0.33	179	Micrhystridium cf. m. fragile
0.33	180	Micrhystridium cf. m. variabile
0.33	181	Micrhystridium spp.

316		witmer aquia percentages
38.00	55	Glaphyrocysta sp. A
21.33	47	Eocladopyxis peniculatum
6.33	3	Adnatosphaeridium robustum
3.33	37	Deflandrea phosphoritica
2.00	28	Cordosphaeridium inodes
2.00	167	Turbiosphaera paratabulata
1.67	27	Cordosphaeridium gracilis
1.67	46	Electrocysta obscurotabulata
1.67	34	Impagidinium cf. I. speciosum
1.33	68	Hafniasphaera septata
1.00	24	Cordosphaeridium biarmatum
1.00	50	Fibrocysta bipolare
1.00	53	Glaphyrocysta exuberans cplx
1.00	37	Impagidinium speciosum
1.00	89	Impletosphaeridium rugosum
1.00	93	Kallosphaeridium brevibarbatum
1.00	96	Lentinia ruginosa
1.00	110	Operculodinium centrocarpum
1.00	136	Spiniferites crassipellis A
1.00	168	Turbiosphaera rotunda
0.67	18	Cassidium paleocenicum
0.67	25	Cordosphaeridium fibrospinosum
0.67	45	Electrocysta densobaculata
0.67	61	Fromea fragilis
0.67	81	Hystrichosphaeridium tubiferum
0.67	107	Nematosphaeropsis trabeculata
0.67	148	Spiniferites ramosus subsp. granosus
0.67	151	Spiniferites ramosus subsp. ramosus
0.67	180	Micrhystridium cf. m. variabile
0.33	5	Apectodinium Homomorphum complex
0.33	11	Areoligera retiolum
0.33	17	Caligodinium amiculum
0.33	21	Cladopyxidium saeptum
0.33	33	?Cordosphaeridium callosum
0.33	41	Dionyes colligerum
0.33	77	Hystrichokolpoma tumescens
0.33	80	Hystrichosphaeridium spp.
0.33	115	Palaeocystodinium golzowense
0.33	125	Renidinium membraniferum
0.33	127	Rottnestia borussica
0.33	132	Senegalinium? dilwynense
0.33	137	Spiniferites crassipellis B
0.33	149	Spiniferites ramosus subsp. memoranaceou
0.33	178	Cyclopsiella vieta
0.33	179	Micrhystridium cf. m. fragile
0.33	181	Micrhystridium spp.

017		werner aqua percentages
25.33	55	Glaphyrocysta sp A
18.67	3	Adnatosphaeridium robustum
13.00	46	Electrocysta obscurotabulata
5.67	37	Impagidinium speciosum
5.33	37	Deflandrea phosphoritica
4.00	47	Eocladopyxis peniculatum
3.67	45	Electrocysta densobaculata
2.67	132	Senegalinium? dilwynense
2.33	18	Cassidium paleocenicum
1.67	5	Andalusiella mombonedra
1.67	93	Kallosphaeridium brevibarbatum
1.67	101	Microdinium ornatum
1.67	130	Senegalinium? obscuram
1.00	8	Apectodinium Homomorphum complex
1.00	125	Renidinium membraniferum
1.00	168	Turbiosphaera rotunda
0.67	11	Apteodinium reticulum
0.67	20	Chlamydophorella cf. C. urna
0.67	24	Cordosphaeridium biarmatum
0.67	27	Cordosphaeridium gracilis
0.67	28	Cordosphaeridium inodes
0.67	34	Impagidinium cf i. speciosum
0.67	91	Inversidinium exilimuram
0.67	96	Lentinia ruginosa
0.67	115	Palaeocystodinium golzowense
0.67	143	Spiniferites cornutus C
0.67	167	Turbiosphaera paratabulata
0.67	181	Micrhystridium spp.
0.33	21	Cladopyxidium saeptum
0.33	43	Dioxyes colligerum (sensu cookson 1965)
0.33	51	Fromea fragilis
0.33	63	Glaphyrocysta exuberans cplx
0.33	73	Horologinella apiculata
0.33	77	Hystrichokolpoma tumescens
0.33	107	Nematosphaeropsis trabeculata
0.33	120	Pheliodinium magnificum
0.33	127	Rottnestia borussica
0.33	148	Spiniferites ramosus subsp. granosus
0.33	151	Spiniferites ramosus subsp. ramosus
0.33	162	Trigonopyxidia ginella
0.33	178	Cyclopsiella vieta
0.33	179	Micrhystridium cf m. fragile
0.33	180	Micrhystridium cf m. variabile
0.33	182	Cymatiosphaera spp.
0.33	186	Pterospermopsis spp.

Correlation Matrix for PT7

Correlation Matrix for Variables: $X_1 \ldots X_4$

	314	315	316	317
314	1			
315	.69485	1		
316	.64003	.95364	1	
317	.53587	.72663	.76434	1

ANOVA Table for PT7

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_4$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	5756.58743	22.66373	10.96607	.0001
Within subjects	765	1581.0357	2.06671		
treatments	3	.02361	.00787	.00379	.9997
residual	762	1581.01209	2.07482		
Total	1019	7337.62313			

Reliability Estimates for- All treatments: .90881 Single Treatment: .71359

Sample number 318

318		wilmer aqua percentages
31.00	6	Apectodinium homomorphum complex
29.00	46	Electrocysta obscurotabulata
4.67	167	Turbiosphaera paratabulata
4.00	45	Electrocysta densobaculata
2.67	12	Ascostomocystus hydria
2.00	93	Kallosphaeridium brevibarbatum
1.67	61	Fromea fragilis
1.33	96	Lentinia ruginosa
1.33	115	Palaeocystodinium golzowense
1.33	137	Spiniferites crassipellis B
1.00	28	Cordosphaeridium inodes
1.00	55	Glaphyrocysta sp A
1.00	87	Impagidinium speciosum
1.00	97	Lentinia spinigera
1.00	98	Linguiodinium machaerophorum
1.00	101	Microdinium ornatum
1.00	117	Paralecaniella indentata
1.00	168	Turbiosphaera rotunda
0.67	11	Apteodinium reticulum
0.67	20	Chlamydophorella cf. C. urna
0.67	47	Eocladopyxis peniculatum
0.67	53	Fibrocysta radiata
0.67	80	Hystrichosphaeridium spp.
0.67	81	Hystrichosphaeridium tubiferum
0.67	107	Nematosphaeropsis trabeculata
0.67	110	Coerculodinium centrocarpum
0.67	130	Senegalinium? obscuram
0.67	151	Spiniferites ramosus subsp. ramosus
0.67	169	Wetzeliella cf. w. myschensis
0.67	180	Micrhystridium cf m. variabile
0.67	181	Micrhystridium spp.
0.67	184	Palambages sp. B
0.33	3	Adnatosphaeridium robustum
0.33	5	Andalusiella rhomboedra
0.33	18	Cassidium paleocenicum
0.33	24	Cordosphaeridium biarmatum
0.33	25	Cordosphaeridium fibrospinosum
0.33	30	Cordosphaeridium multispinosum
0.33	33	?Cordosphaeridium callosum
0.33	37	Cerlandia phosphoritica
0.33	42	Dionyes colligerum
0.33	50	Fibrocysta bipolare
0.33	67	Hafniasphaera cf h septata
0.33	68	Hafniasphaera septata
0.33	76	Hystrichokolpoma rigaudiae
0.33	77	Hystrichokolpoma tumescens
0.33	78	Hystrichokolpoma unispinum
0.33	89	Impletosphaeridium rugosum
0.33	91	Inversidinium exilimuram
0.33	132	Senegalinium? dilwynense
0.33	136	Spiniferites crassipellis A
0.33	143	Spiniferites cornutus C
0.33	146	Spiniferites pseudofurcatus
0.33	178	Cyclopsiella vieta

PT8 "*Adnatosphaeridium multispinosum/ Apectodinium homomorphum*" Association

324		324 witmer, Nani, zone 6
29.00	2	Adnatosphaeridium multispinosum
23.33	6	Apectodinium homomorphum complex
16.33	132	Senegalinium? dilwynense
4.67	112	Operculodinium israelianum
3.33	103	Muratodinium fimbriatum
3.00	28	Cordosphaeridium inodes
2.67	39	Dinopterygium cladoides
2.33	107	Nematosphaeropsis trabeculata
2.33	151	Spiniferites ramosus subsp. ramosus
1.00	68	Hafniasphaera septata
1.00	102	Millioudodinium guiseppi major
1.00	181	Micrhystridium spp.
0.67	37	Deflandrea phosphoritica
0.67	130	Senegalinium? obscuram
0.67	160	Thalassiphora pelagica
0.33	27	Cordosphaeridium gracilis
0.33	29	Cordosphaeridium inodes robustum
0.33	30	Cordosphaeridium multispinosum
0.33	33	?Cordosphaeridium callosum
0.33	41	Dionyes colligerum
0.33	42	Dionyes colligerum
0.33	50	Fibrocysta bipolare
0.33	51	Fibrocysta lappacea
0.33	63	Glaphyrocysta exuberans cpix
0.33	80	Hystrichosphaeridium spp.
0.33	89	Impletosphaeridium rugosum
0.33	93	Kallosphaeridium brevibarbatum
0.33	97	Lentinia spinigera
0.33	98	Lingulodinium machaerophorum
0.33	110	Operculodinium centrocarpum
0.33	125	Renidinium membraniferum
0.33	146	Spiniferites pseudofurcatus
0.33	147	Spiniferites ramosus subsp. granomembranı
0.33	148	Spiniferites ramosus subsp. granosus
0.33	150	Spiniferites ramosus subsp. multibrevis
0.33	161	Trichodinium hirsutum
0.33	182	Cymatiosphaera spp.
0.33	186	Pterospermopsis spp.

325		325 witmer, Nani zone 5
28.33	2	Adnatosphaeridium multispinosum
23.00	6	Apectodinium homomorphum complex
15.33	132	Senegalinium? dilwynense
4.33	103	Muratodinium fimbriatum
4.00	151	Spiniferites ramosus subsp. ramosus
3.33	28	Cordosphaeridium inodes
3.33	112	Operculodinium israelianum
2.67	107	Nematosphaeropsis trabeculata
1.67	130	Senegalinium? obscuram
1.33	39	Dinopterygium cladoides
1.33	68	Hafniasphaera septata
1.33	89	Impletosphaeridium rugosum
1.00	27	Cordosphaeridium gracilis
1.00	150	Spiniferites ramosus subsp. multibrevis
0.67	33	?Cordosphaeridium callosum
0.67	51	Fibrocysta lappacea
0.67	110	Operculodinium centrocarpum
0.67	181	Micrhystridium spp.
0.33	30	Cordosphaeridium multispinosum
0.33	37	Deflandrea phosphoritica
0.33	42	Dionyes colligerum
0.33	47	Eocladopyxis peniculatum
0.33	50	Fibrocysta bipolare
0.33	65	Glaphyrocysta sp A
0.33	78	Hystrichokolpoma unispinum
0.33	80	Hystrichosphaeridium spp.
0.33	98	Lingulodinium machaerophorum
0.33	102	Millioudodinium guiseppi major
0.33	125	Renidinium membraniferum
0.33	127	Rottnestia borussica
0.33	136	Spiniferites crassipellis A
0.33	145	Spiniferites monilus
0.33	146	Spiniferites pseudofurcatus
0.33	147	Spiniferites ramosus subsp. granomembran:
0.33	148	Spiniferites ramosus subsp. granosus
0.33	160	Thalassiphora pelagica
0.33	161	Trichodinium hirsutum
0.33	182	Cymatiosphaera spp.
0.33	186	Pterospermopsis spp.

329		witmer nanlemoy percentages
30.00	2	Adnatosphaeridium multispinosum
9.33	12	Areoligera sp.
2.33	156	Systematophora placacantha
2.00	151	Spiniferites ramosus subsp. ramosus
1.67	172	Wetzeliella samlandica
1.33	37	Deflandrea phosphoritica
1.33	47	Eocladopyxis peniculatum
1.00	6	Apectodinium Homomorphum complex
1.00	103	Muratodinium fimbriatum
0.67	27	Cordosphaeridium gracilis
0.67	41	Dionyes colligerum
0.67	45	Electrocysta densobaculata
0.67	58	Forma C
0.67	66	Glaphyrocysta sp B
0.67	97	Lentinia spinigera
0.67	102	Millioudodinium guiseppi major
0.67	107	Nematosphaeropsis trabeculata
0.67	149	Spiniferites ramosus subsp. membranaceou
0.67	170	Wetzeliella hampdenensis
0.33	28	Cordosphaeridium inodes
0.33	30	Cordosphaeridium multispinosum
0.33	31	Cordosphaeridium solaster
0.33	39	Dinopterygium cladoides
0.33	43	Dionyes colligerum (sensu cookson 1985)
0.33	46	Electrocysta obscurotabulata
0.33	53	Fibrocysta radiata
0.33	57	Forma B
0.33	63	Glaphyrocysta exuberans cplx
0.33	65	Glaphyrocysta sp A
0.33	68	Hafniasphaera septata
0.33	76	Hystrichokolpoma rigaude
0.33	77	Hystrichokolpoma tumescens
0.33	81	Hystrichosphaeridium tubiferum
0.33	93	Kallosphaeridium brevibarbatum
0.33	96	Lentinia ruginosa
0.33	98	Lingulodinium machaerophorum
0.33	99	Melitasphaeridium pseudocurvatum
0.33	112	Operculodinium israelianum
0.33	115	Palaeocystodinium golzowense
0.33	117	Paralecaniella indentata
0.33	124	Polysphaeridium zoharyi
0.33	125	Renidinium membraniferum
0.33	127	Rottnestia borussica
0.33	136	Spiniferites crassipellis A
0.33	145	Spiniferites monilus
0.33	146	Spiniferites pseudofurcatus
0.33	158	Tectatodinium pellitum
0.33	160	Thalassiphora pelagica
0.33	175	Wilsonidium tabulatum
0.33	181	Micrhystridium spp.
0.33	186	Pterospermopsis spp.

326		326 witmer, Nanj. zone 7
44.33	175	Wilsonidium tabulatum
31.67	37	Deflandrea phosphoritica
3.33	102	Millioudodinium guiseppi major
2.67	103	Muratodinium fimbriatum
2.33	2	Adnatosphaeridium multispinosum
2.00	132	Senegalinium? dilwynense
1.67	93	Kallosphaeridium brevibarbatum
1.67	97	Lentinia spinigera
1.33	46	Electrocysta obscurotabulata
1.00	110	Operculodinium centrocarpum
1.00	151	Spiniferites ramosus subsp. ramosus
1.00	181	Micrhystridium spp.
0.67	50	Fibrocysta bipolare
0.67	107	Nematosphaeropsis trabeculata
0.67	156	Systematophora placacantha
0.67	186	Pterospermopsis spp.
0.33	20	Chlamydophorella cf. C. urna
0.33	25	Cordosphaeridium fibrospinosum
0.33	27	Cordosphaeridium gracilis
0.33	28	Cordosphaeridium inodes
0.33	39	Dinopterygium cladoides
0.33	41	Diphyes colligerum
0.33	42	Diphyes colligerum
0.33	43	Diphyes colligerum (sensu Cookson 1965)
0.33	63	Glaphyrocysta exuberans cpx
0.33	68	Hafniasphaera septata
0.33	76	Hystrichokolpoma rigaudae
0.33	81	Hystrichosphaeridium tubiferum
0.33	89	Impletosphaeridium rugosum
0.33	91	Inversidinium exilimurum
0.33	96	Lentinia ruginosa
0.33	98	Lingulodinium machaerophorum
0.33	99	Melitasphaeridium pseudocurvatum
0.33	101	Microdinium ornatum
0.33	117	Paralecaniella indentata
0.33	125	Renidinium membraniferum
0.33	130	Senegalinium? obscuram
0.33	160	Thalassiphora pelagica
0.33	182	Cymatiosphaera spp.

327		327 witmer, Nanj. zone 7
47.67	156	Systematophora placacantha
5.67	57	Forma B
4.67	151	Spiniferites ramosus subsp. ramosus
4.00	81	Hystrichosphaeridium tubiferum
3.33	117	Paralecaniella indentata
3.33	132	Senegalinium? dilwynense
2.67	2	Adnatosphaeridium multispinosum
2.33	41	Diphyes colligerum
2.33	107	Nematosphaeropsis trabeculata
2.00	37	Deflandrea phosphoritica
1.67	98	Lingulodinium machaerophorum
1.67	102	Millioudodinium guiseppi major
1.33	97	Lentinia spinigera
1.33	136	Spiniferites crassipellis A
1.00	45	Electrocysta densobaculata
1.00	50	Fibrocysta bipolare
1.00	110	Operculodinium centrocarpum
0.67	28	Cordosphaeridium inodes
0.67	42	Diphyes colligerum
0.67	46	Electrocysta obscurotabulata
0.67	47	Eocladopyxis peniculatum
0.67	103	Muratodinium fimbriatum
0.67	150	Spiniferites ramosus subsp. multibrevis
0.67	181	Micrhystridium spp.
0.33	6	Apectodinium Homomorphum complex
0.33	20	Chlamydophorella cf. C. urna
0.33	25	Cordosphaeridium fibrospinosum
0.33	27	Cordosphaeridium gracilis
0.33	33	?Cordosphaeridium callosum
0.33	76	Hystrichokolpoma rigaudae
0.33	93	Kallosphaeridium brevibarbatum
0.33	96	Lentinia ruginosa
0.33	99	Melitasphaeridium pseudocurvatum
0.33	112	Operculodinium israelianum
0.33	115	Palaeocystodinium golzowense
0.33	125	Renidinium membraniferum
0.33	146	Spiniferites pseudofurcatus
0.33	147	Spiniferites ramosus subsp. granomembran
0.33	148	Spiniferites ramosus subsp. granosus
0.33	149	Spiniferites ramosus subsp. membranaceou
0.33	158	Tectatodinium pellitum
0.33	175	Wilsonidium tabulatum
0.33	178	Cyclopsiella vieta
0.33	182	Cymatiosphaera spp.
0.33	186	Pterospermopsis spp.

Correlation Matrix for PT8

Correlation Matrix for Variables: $X_1 \ldots X_3$

	324	325	328
324	1		
325	.99585	1	
328	.68368	.68571	1

ANOVA Table for PT8

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_3$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	3683.1426	14.50056	12.34664	.0001
Within subjects	510	598.9718	1.17445		
treatments	2	2.91387	1.45694	1.2417	.2898
residual	508	596.05793	1.17334		
Total	764	4282.1144			

Reliability Estimates for- All treatments: .91901 Single Treatment: .79089

PT9 "Wetzeliella hampdenensis/ Adnatosphaeridium multispinosum/ Thalassiophora pelagica" Association

329		329 witmer, Nani. zone 7
38.00	170	Wetzeliella hampdenensis
17.00	2	Adnatosphaeridium multispinosum
6.67	160	Thalassiophora pelagica
6.00	28	Cordosphaeridium inodes
5.67	71	Homotryblium tasmaniense
5.33	66	Glaphyrocysta sp B
5.00	58	Forma C
4.33	45	Electrocysta densobaculata
4.33	47	Eocladopyxis peniculatum
4.33	172	Wetzeliella samlandica
2.67	151	Spiniferites ramosus subsp. ramosus
2.33	98	Lingulodinium machaerophorum
1.67	3	Adnatosphaeridium robustum
1.67	12	Areoligera sp.
1.67	27	Cordosphaeridium gracilis
1.67	41	Dionyes colligerum
1.67	57	Forma B
1.67	65	Glaphyrocysta sp A
1.33	42	Dionyes colligerum
1.33	97	Lentinia spinigera
1.00	68	Hafniasphaera septata
1.00	106	Nematosphaeropsis pulsulosa
1.00	107	Nematosphaeropsis trabeculata
1.00	110	Operculodinium centrocarpum
1.00	127	Rottnestia borussica
1.00	181	Micrhystridium spp.
0.67	25	Cordosphaeridium fibrospinosum
0.67	30	Cordosphaeridium multispinosum
0.67	39	Dinopterygium cladoides
0.67	46	Electrocysta obscurotabulata
0.67	81	Hystrichosphaeridium tubiferum
0.67	96	Lentinia ruginosa
0.67	99	Melitasphaeridium pseudocurvatum
0.67	102	Millioudodinium guiseppi major
0.67	126	Renidinium sp. A
0.67	145	Spiniferites monilius
0.67	146	Spiniferites pseudofurcatus
0.67	147	Spiniferites ramosus subsp. granomembrana
0.67	148	Spiniferites ramosus subsp. granosus
0.67	149	Spiniferites ramosus subsp. membranaceou
0.67	158	Tectatodinium pellitum
0.33	1	Achilleodinium biformoides n. gen., n. comb.
0.33	6	Apectodinium Homomorphum complex
0.33	29	Cordosphaeridium inodes robustum
0.33	33	?Cordosphaeridium callosum
0.33	43	Dionyes colligerum (sensu cookson 1985)
0.33	48	Exochosphaeridium bifidum
0.33	50	Fibrocysta bipolare
0.33	51	Fibrocysta lappacea
0.33	52	Fibrocysta coalitospinosa
0.33	53	Fibrocysta radiata
0.33	76	Hystrichokolpoma rigaudae
0.33	77	Hystrichokolpoma tumescens
0.33	80	Hystrichosphaeridium spp.
0.33	89	Impletosphaeridium rugosum
0.33	93	Kallosphaeridium brevibarbatum
0.33	103	Muratodinium fimbriatum
0.33	112	Operculodinium israelianum
0.33	115	Palaeocystodinium golzowense
0.33	117	Paralecaniella indentata
0.33	123	Polysphaeridium cf p. zonaryi
0.33	124	Polysphaeridium zonaryi
0.33	130	Senegalinium? obscuram
0.33	136	Spiniferites crassipellis A
0.33	150	Spiniferites ramosus subsp. multibrevis
0.33	153	Spiniferites A
0.33	161	Trichodinium hirsutum
0.33	165	Tubidermodinium sulcatum
0.33	175	Wilsonidium tabulatum

331		331 witmer, Nani. zone 8
19.00	2	Adnatosphaeridium multispinosum
12.67	47	Eocladopyxis peniculatum
12.67	58	Forma C
10.33	174	Wetzeliella varielongituda
5.00	3	Adnatosphaeridium robustum
4.67	117	Paralecaniella indentata
3.33	98	Lingulodinium machaerophorum
3.00	45	Electrocysta densobaculata
2.67	103	Muratodinium fimbriatum
2.67	172	Wetzeliella samlandica
2.00	170	Wetzeliella hampdenensis
1.67	124	Polysphaeridium zonaryi
1.67	160	Thalassiophora pelagica
1.00	12	Areoligera sp.
1.00	37	Deflandrea phosphoritica
1.00	46	Electrocysta obscurotabulata
0.67	18	Cassidium paleocenicum
0.67	53	Fibrocysta radiata
0.67	69	Heteraulacacysta campanula
0.67	76	Hystrichokolpoma rigaudae
0.67	80	Hystrichosphaeridium spp.
0.67	102	Millioudodinium guiseppi major
0.67	107	Nematosphaeropsis trabeculata
0.67	109	Operculodinium brevispinosum
0.67	110	Operculodinium centrocarpum
0.67	122	Phthanoperidinium echinatum
0.67	151	Spiniferites ramosus subsp. ramosus
0.67	158	Tectatodinium pellitum
0.67	179	Cyclopsiella vieta
0.33	20	Chlamydophorella cf. C. urna
0.33	27	Cordosphaeridium gracilis
0.33	28	Cordosphaeridium inodes
0.33	29	Cordosphaeridium inodes robustum
0.33	33	?Cordosphaeridium callosum
0.33	39	Dinopterygium cladoides
0.33	41	Dionyes colligerum
0.33	43	Dionyes colligerum (sensu cookson 1985)
0.33	48	Exochosphaeridium bifidum
0.33	68	Hafniasphaera septata
0.33	71	Homotryblium tasmaniense
0.33	77	Hystrichokolpoma tumescens
0.33	81	Hystrichosphaeridium tubiferum
0.33	93	Kallosphaeridium brevibarbatum
0.33	96	Lentinia ruginosa
0.33	100	Membranilarnacia leptoderma
0.33	111	Operculodinium cf. d. brevispinosum
0.33	112	Operculodinium israelianum
0.33	115	Palaeocystodinium golzowense
0.33	123	Polysphaeridium cf p. zonaryi
0.33	126	Renidinium sp. A
0.33	136	Spiniferites crassipellis A
0.33	145	Spiniferites monilius
0.33	146	Spiniferites pseudofurcatus
0.33	148	Spiniferites ramosus subsp. granosus
0.33	149	Spiniferites ramosus subsp. membranaceou
0.33	153	Spiniferites A
0.33	165	Tubidermodinium sulcatum
0.33	181	Micrhystridium spp.
0.33	185	Palambages sp. C

Correlation Matrix for PT9

Correlation Matrix for Variables: $X_1 \ldots X_2$

	329	331
329	1	
331	.4135	1

ANOVA Table for PT9

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_2$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	1926.28088	7.58378	2.23858	.0001
Within subjects	255	863.88175	3.38777		
treatments	1	2.4948	2.4948	.73565	.3919
residual	254	861.38695	3.39129		
Total	509	2790.16263			

Reliability Estimates for- All treatments: .55329 Single Treatment: .38244

330	330 witmer. Nanj. zone 8
32.30	172 Wetzeliella samlandica
16.67	57 Forma B
15.67	45 Electrocysta densobaculata
10.67	160 Thalassiphora pelagica
1.67	58 Forma C
1.67	170 Wetzeliella hamodenensis
1.67	174 Wetzeliella vanelongituda
1.33	46 Electrocysta obscurotabulata
1.33	47 Eocladopyxis peniculatum
1.00	2 Adnatosphaeridium multispinosum
1.00	151 Spiniferites ramosus subsp. ramosus
0.67	3 Adnatosphaeridium robustum
0.67	27 Cordosphaeridium gracilis
0.67	28 Cordosphaeridium inodes
0.67	37 Deflandrea phosphoritica
0.67	96 Lentinia ruginosa
0.67	97 Lentinia spinigera
0.67	98 Linguiodinium machaerophorum
0.67	101 Microdinium ornatum
0.67	107 Nematosphaeropsis trabeculata
0.67	115 Palaeocystodinium golzowense
0.67	122 Phthanoperidinium echinatum
0.67	165 Tubidermodinium sulcatum
0.67	181 Micrhystridium spp.
0.67	186 Pterospermopsis spp.
0.33	1 Achiella biformoides n. gen., n. comb.
0.33	5 Apectodinium Homomorphum complex
0.33	12 Areoligera sp.
0.33	25 Cordosphaeridium fibrospinosum
0.33	43 Diphyes colligerum (sensu cookson 1985)
0.33	52 Fibrocysta coaitospinosa
0.33	71 Homotryblium tasmaniense
0.33	76 Hystrichokolpoma rigaudae
0.33	80 Hystrichosphaeridium spp.
0.33	91 Inversidinium exilimuram
0.33	93 Kallosphaeridium brevibarbatum
0.33	100 Membranilarnacia leptoderma
0.33	102 Millioudodinium guiseppi major
0.33	103 Muratodinium fimbriatum
0.33	110 Operculodinium centrocarpum
0.33	112 Operculodinium israelianum
0.33	117 Paralecaniella indentata
0.33	124 Polysphaeridium zoharyi
0.33	125 Renidinium membraniferum
0.33	127 Rottnestia borussica
0.33	132 Senegalinium? dilwynense
0.33	146 Spiniferites pseudofurcatus
0.33	149 Spiniferites ramosus subsp. membranaceou
0.33	153 Spiniferites A
0.33	162 Trigonopyxidia ginella
0.33	175 Wilsonidium tabulatum
0.33	178 Cyclopsiella vieta
0.33	182 Cymatiosphaera spp.
0.33	185 Palambages sp. C

332	332 witmer, Nanj. zone 8
51.00	172 Wetzeliella samlandica
16.67	18 Cassidium paleocenicum
8.33	2 Adnatosphaeridium multispinosum
5.33	8 Apectodinium australiense
3.00	1 Achiella biformoides n. gen., n. comb.
1.33	12 Areoligera sp.
1.33	47 Eocladopyxis peniculatum
1.33	100 Membranilarnacia leptoderma
1.33	151 Spiniferites ramosus subsp. ramosus
1.33	170 Wetzeliella hamodenensis
1.00	40 Dinopterygium fehmarnense
1.00	76 Hystrichokolpoma rigaudae
1.00	103 Muratodinium fimbriatum
0.67	28 Cordosphaeridium inodes
0.67	53 Fibrocysta radiata
0.67	98 Linguiodinium machaerophorum
0.67	181 Micrhystridium spp.
0.67	186 Pterospermopsis spp.
0.33	5 Apectodinium Homomorphum complex
0.33	27 Cordosphaeridium gracilis
0.33	37 Deflandrea phosphoritica
0.33	43 Diphyes colligerum (sensu cookson 1985)
0.33	45 Electrocysta densobaculata
0.33	46 Electrocysta obscurotabulata
0.33	50 Fibrocysta bipolare
0.33	58 Forma C
0.33	71 Homotryblium tasmaniense
0.33	80 Hystrichosphaeridium spp.
0.33	89 Impletosphaeridium rugosum
0.33	91 Inversidinium exilimuram
0.33	93 Kallosphaeridium brevibarbatum
0.33	97 Lentinia spinigera
0.33	101 Microdinium ornatum
0.33	102 Millioudodinium guiseppi major
0.33	107 Nematosphaeropsis trabeculata
0.33	109 Operculodinium brevispinosum
0.33	110 Operculodinium centrocarpum
0.33	115 Palaeocystodinium golzowense
0.33	117 Paralecaniella indentata
0.33	122 Phthanoperidinium echinatum
0.33	123 Polysphaeridium cf. p. zoharyi
0.33	124 Polysphaeridium zoharyi
0.33	125 Renidinium membraniferum
0.33	132 Senegalinium? dilwynense
0.33	146 Spiniferites pseudofurcatus
0.33	150 Spiniferites ramosus subsp. multibrevis
0.33	160 Thalassiphora pelagica
0.33	165 Tubidermodinium sulcatum
0.33	182 Cymatiosphaera spp.
0.33	185 Palambages sp. C

Correlation Matrix for PT10

Correlation Matrix for Variables: $X_1 \ldots X_2$

	330	332
330	1	
332	.71924	1

ANOVA Table for PT10

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_2$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	3954.2721	15.568	5.5413	.0001
Within subjects	255	716.4093	2.80945		
treatments	1	.00311	.00311	.0011	.9735
residual	254	716.40619	2.8205		
Total	509	4670.6814			

Reliability Estimates for- All treatments: .81954 Single Treatment: .69425

PT11 "Spinidinium macmurdoense / Forma C" Association

333.		333 witmer, Nanj. zone 9	334:		334 witmer, Nanj. zone 9
40.67	134	Spinidinium macmurdoense	32.00	134	Spinidinium macmurdoense
19.33	58	Forma C	21.33	58	Forma C
7.67	185	Palambages sp. C	10.00	185	Palambages sp. C
2.67	47	Eocladopyxis peniculatum	3.00	160	Thalassiphora pelagica
2.00	37	Deflandrea phosphoritica	2.67	37	Deflandrea phosphoritica
1.67	130	Senegalinium? obscuram	2.33	170	Wetzeliella hampdenensis
1.33	12	Areoligera sp.	2.00	12	Areoligera sp.
1.00	2	Adnatosphaeridium multispinosum	1.67	158	Tectatodinium pellitum
1.00	94	Kisselovia coleothrypta	1.33	151	Spiniferites ramosus subsp. ramosus
1.00	98	Lingulodinium machaerophorum	1.00	72	Homotryblium pallidum
1.00	113	Operculodinium multispinosum	1.00	93	Kallosphaeridium brevibarbatum
1.00	117	Paralecaniella indentata	1.00	98	Lingulodinium machaerophorum
1.00	122	Phthanoperidinium echinatum	1.00	109	Operculodinium brevispinosum
1.00	160	Thalassiphora pelagica	1.00	117	Paralecaniella indentata
0.67	1	Achiella biformoides n. gen., n. comb.	1.00	130	Senegalinium? obscuram
0.67	38	Deflandrea wardenensis	1.00	132	Senegalinium? dilwynense
0.67	40	Dinopterygium fehmarnense	1.00	171	Wetzeliella lunaris
0.67	69	Heteraulacacysta campanula	0.67	1	Achiella biformoides n. gen., n. comb.
0.67	71	Homotryblium tasmaniense	0.67	22	Cleistosphaeridium diversispinosum
0.67	72	Homotryblium pallidum	0.67	28	Cordosphaeridium inodes
0.67	93	Kallosphaeridium brevibarbatum	0.67	38	Deflandrea wardenensis
0.67	109	Operculodinium brevispinosum	0.67	41	Diphyes colligerum
0.67	131	Senegalinium? asymmetricum	0.67	46	Electrocysta obscurotabulata
0.67	132	Senegalinium? dilwynense	0.67	47	Eocladopyxis peniculatum
0.67	151	Spiniferites ramosus subsp. ramosus	0.67	52	Fibrocysta coalitospinosa
0.67	170	Wetzeliella hampdenensis	0.67	59	Forma D
0.67	172	Wetzeliella samlandica	0.67	71	Homotryblium tasmaniense
0.67	178	Cyclopsiella vieta	0.67	74	Hystrichokolpoma eisenackii
0.33	10	Apteodinium labyrinthum	0.67	94	Kisselovia coleothrypta
0.33	20	Chlamydophorella cf. C. urna	0.67	113	Operculodinium multispinosum
0.33	22	Cleistosphaeridium diversispinosum	0.67	118	Paucisphaeridium inversibuccinum
0.33	25	Cordosphaeridium fibrospinosum	0.67	128	Samlandia chlamydophora
0.33	27	Cordosphaeridium gracilis	0.67	131	Senegalinium? asymmetricum
0.33	28	Cordosphaeridium inodes	0.67	165	Tubidermodinium sulcatum
0.33	33	?Cordosphaeridium callosum	0.33	9	Apteodinium cribosum
0.33	39	Dinopterygium cladoides	0.33	25	Cordosphaeridium fibrospinosum
0.33	41	Diphyes colligerum	0.33	27	Cordosphaeridium gracilis
0.33	42	Diphyes colligerum	0.33	39	Dinopterygium cladoides
0.33	43	Diphyes colligerum (sensu cookson 1985)	0.33	40	Dinopterygium fehmarnense
0.33	46	Electrocysta obscurotabulata	0.33	42	Diphyes colligerum
0.33	70	Homotryblium caliculum	0.33	53	Fibrocysta radiata
0.33	74	Hystrichokolpoma eisenackii	0.33	69	Heteraulacacysta campanula
0.33	91	Inversidinium exilimuram	0.33	76	Hystrichokolpoma rigaudae
0.33	100	Membranilarnacia leptoderma	0.33	80	Hystrichosphaeridium spp.
0.33	102	Millioudodinium guiseppi major	0.33	83	?Hystrichosphaeropsis ovum
0.33	110	Operculodinium centrocarpum	0.33	91	Inversidinium exilimuram
0.33	112	Operculodinium israelianum	0.33	97	Lentinia spinigera
0.33	115	Palaeocystodinium golzowense	0.33	110	Operculodinium centrocarpum
0.33	118	Paucisphaeridium inversibuccinum	0.33	122	Phthanoperidinium echinatum
0.33	123	Polysphaeridium cf p. zoharyi	0.33	123	Polysphaeridium cf p. zoharyi
0.33	128	Samlandia chlamydophora	0.33	124	Polysphaeridium zoharyi
0.33	136	Spiniferites crassipellis A	0.33	127	Rottnestia borussica
0.33	145	Spiniferites monilis	0.33	136	Spiniferites crassipellis A
0.33	146	Spiniferites pseudofurcatus	0.33	146	Spiniferites pseudofurcatus
0.33	148	Spiniferites ramosus subsp. granosus	0.33	149	Spiniferites ramosus subsp. membranaceou
0.33	149	Spiniferites ramosus subsp. membranaceou	0.33	172	Wetzeliella samlandica
0.33	150	Spiniferites ramosus subsp. multibrevis	0.33	175	Wilsonidium tabulatum
0.33	165	Tubidermodinium sulcatum	0.33	178	Cyclopsiella vieta
0.33	171	Wetzeliella lunaris			

Correlation Matrix for PT11

Correlation Matrix for Variables: $X_1 \dots X_2$

	333	334
333	1	
334	.97969	1

ANOVA Table for PT11

One Factor ANOVA-Repeated Measures for $X_1 \dots X_2$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	3609.80249	14.21182	67.7084	.0001
Within subjects	255	53.52385	.2099		
treatments	1	.0056	.0056	.02658	.8706
residual	254	53.51825	.2107		
Total	509	3663.32634			

Reliability Estimates for- All treatments: .98523 Single Treatment: .97089

PT12 "Deflandria phosphoritica/ Areoligera" Association

336		336 witmer, Nanj. zone 10
57.00	37	Deflandria phosphoritica
5.33	170	Wetzeliella hamodenensis
3.33	12	Areoligera sp.
2.33	160	Thalassiphora pelagica
2.00	135	Spinidinium paratabulatum
1.00	117	Paralecaniella indentata
1.00	132	Senegalinium? dilwynense
0.67	22	Cleistosphaeridium diversispinosum
0.67	59	Forma D
0.67	72	Homotryblium palladum
0.67	74	Hystrichokolpoma eisenackii
0.67	171	Wetzeliella lunaris
0.67	185	Palambages sp. C
0.33	1	Achiella biformoides n. gen., n. comb.
0.33	2	Adnatosphaeridium multispinosum
0.33	6	Apectodinium Homomorphum complex
0.33	47	Eocladopyxis peniculatum
0.33	50	Fibrocysta bipolare
0.33	52	Fibrocysta coalitospinosa
0.33	53	Fibrocysta radiata
0.33	64	Glaphyrocysta ordinata
0.33	76	Hystrichokolpoma rigaudae
0.33	93	Kallosphaeridium brevibarbatum
0.33	94	Kisselovia coleothrypta
0.33	98	Lingulodinium machaerophorum
0.33	100	Membranilarnacia leptoderma
0.33	102	Millioudodinium guiseppi major
0.33	107	Nematosphaeropsis trabeculata
0.33	113	Operculodinium multispinosum
0.33	115	Palaeocystodinium golzowense
0.33	128	Samlandia chlamydophora
0.33	130	Senegalinium? obscuram
0.33	146	Spiniferites pseudofurcatus
0.33	151	Spiniferites ramosus subsp. ramosus
0.33	158	Tectatodinium pellitum
0.33	172	Wetzeliella samlandica
0.33	178	Cyclopsiella vieta
0.33	182	Cymatiosphaera spp.

335		335 witmer, Nanj. zone 10
30.33	37	Deflandria phosphoritica
20.00	12	Areoligera sp.
19.00	22	Cleistosphaeridium diversispinosum
3.67	160	Thalassiphora pelagica
2.67	158	Tectatodinium pellitum
2.33	117	Paralecaniella indentata
2.33	173	Wetzeliella sp. A
2.00	72	Homotryblium palladum
1.67	113	Operculodinium multispinosum
1.67	170	Wetzeliella hamodenensis
1.67	178	Cyclopsiella vieta
1.33	64	Glaphyrocysta ordinata
1.33	185	Palambages sp. C
1.00	135	Spinidinium paratabulatum
0.67	2	Adnatosphaeridium multispinosum
0.67	93	Kallosphaeridium brevibarbatum
0.67	98	Lingulodinium machaerophorum
0.67	186	Pterospermopsis spp.
0.33	1	Achiella biformoides n. gen., n. comb.
0.33	38	Deflandria wardenensis
0.33	50	Fibrocysta bipolare
0.33	53	Fibrocysta radiata
0.33	59	Forma D
0.33	69	Heteraulacacysta campanula
0.33	70	Homotryblium caliculum
0.33	71	Homotryblium tasmaniense
0.33	82	Hystrichosphaeridium tubiferum brevispin
0.33	94	Kisselovia coleothrypta
0.33	122	Phthanoperidinium echinatum
0.33	124	Polysphaeridium zoharyi
0.33	128	Samlandia chlamydophora
0.33	130	Senegalinium? obscuram
0.33	132	Senegalinium? dilwynense
0.33	151	Spiniferites ramosus subsp. ramosus
0.33	165	Tubidermodinium sulcatum
0.33	171	Wetzeliella lunaris
0.33	175	Wilsonidium tabulatum
0.33	181	Micrhystridium spp.

Correlation Matrix for PT12

Correlation Matrix for Variables: $X_1 \ldots X_2$

	335	336
335	1	
336	.76476	1

ANOVA Table for PT12

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_2$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	4296.06572	16.91364	6.28092	.0001
Within subjects	255	686.6793	2.69286		
treatments	1	.44235	.44235	.16373	.6861
residual	254	686.23695	2.70172		
Total	509	4982.74502			

Reliability Estimates for- All treatments: .84079 Single Treatment: .72531

Sample 337

337		337 witmer, Nanj. zone 10
28.33	47	Eocladopyxis peniculatum
24.33	22	Cleistosphaeridium diversispinosum
24.00	170	Wetzeliella hamodenensis
3.67	135	Spinidinium paratabulatum
4.33	1	Achiella biformoides n. gen., n. comb.
4.00	71	Homotryblium tasmaniense
3.33	2	Adnatosphaeridium multispinosum
3.33	122	Phthanoperidinium echinatum
2.33	64	Glaphytocysta ordinata
2.00	98	Lingulodinium machaerophorum
1.67	9	Apteodinium cribosum
1.57	72	Homotryblium palladum
1.67	160	Thalassiphora pelagica
1.57	171	Wetzeliella lunaris
1.00	40	Dinopterygium fehmarnense
1.00	52	Fibrocysta coaitospinosa
1.00	93	Kallosphaeridium brevibarbatum
1.00	100	Membranilarnacia leptoderma
1.00	113	Operculodinium multispinosum
1.00	151	Spiniferites ramosus subsp. ramosus
0.67	38	Deflandrea wardenensis
0.67	39	Dinopterygium cladoides
0.67	42	Diphyes colligerum
0.67	158	Tectatodinium pellitum
0.67	178	Cyclopsiella vieta
0.33	6	Apectodinium Homomorphum complex
0.33	12	Areoligera sp.
0.33	28	Cordosphaeridium inodes
0.33	33	?Cordosphaeridium callosum
0.33	37	Deflandrea phosphoritica
0.33	41	Diphyes colligerum
0.33	43	Diphyes colligerum (sensu cookson 1985)
0.33	53	Fibrocysta radiata
0.33	80	Hystrichosphaeridium spp.
0.33	94	Kisselovia coleothrypta
0.33	102	Millioudodinium guiseppi major
0.33	115	Palaeocystodinium golzowense
0.33	121	Phthanoperidinium cf p. trilonum
0.33	125	Renidinium membraniferum
0.33	128	Samlandia chlamydophora
0.33	132	Senegalinium? dilwynense
0.33	146	Spiniferites pseudofurcatus
0.33	149	Spiniferites ramosus subsp. membranaceou
0.33	165	Tubidermodinium sulcatum
0.33	181	Micrhystridium spp.
0.33	185	Palambages sp. C
0.33	186	Pterospermopsis spp.

Statistical Information for Sample 337

X_1: 337

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.50173	2.85452	.17876	8.1483	568.94104	255
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
0	28.33	28.33	127.94	2133.8582	0

PT13 "Glaphyrocysta ordinata/ Homotriblium palladium" Association

339		339 witmer. Nani. zone 11
31.67	64	Glaphyrocysta ordinata
21.00	72	Homotryblium palladum
19.33	22	Cleistosphaeridium diversispinosum
6.33	171	Wetzeliella unans
5.67	98	Lingulodinium machaerophorum
2.33	178	Cyclopsiella vieta
1.67	122	Phthanoperidinium echinatum
1.33	33	?Cordosphaeridium callosum
1.33	151	Spiniferites ramosus subsp. ramosus
1.00	100	Membranilarnacia leptoderma
1.00	117	Paralecaniella indentata
0.67	28	Cordosphaeridium inodes
0.67	47	Eocladopyxis peniculatum
0.67	135	Spinidinium paratabulatum
0.67	140	Spiniferites cingulatus
0.67	149	Spiniferites ramosus subsp. membranaceou
0.33	1	Achnella biformoides n. gen., n. comb.
0.33	13	Ascotomocystus hydria
0.33	39	Dinopterygium cladoides
0.33	41	Diphyes colligerum
0.33	43	Diphyes colligerum (sensu cookson 1985)
0.33	70	Homotriblium caliculum
0.33	74	Hystrichokolpoma eisenackii
0.33	76	Hystrichokolpoma rigaudae
0.33	80	Hystrichosphaeridium spp.
0.33	83	?Hystrichosphaeropsis ovum
0.33	88	Impletosphaeridium kroemmelbeinii
0.33	99	Impletosphaeridium rugosum
0.33	93	Kallosphaeridium brevibarbatum
0.33	106	Nematosphaeropsis pusulosa
0.33	107	Nematosphaeropsis trabeculata
0.33	110	Operculodinium centrocarpum
0.33	113	Operculodinium multispinosum
0.33	132	Senegalinium? dilwynense
0.33	138	Spiniferites crassipellis C
0.33	158	Tectatodinium pellitum
0.33	181	Micrhystridium spp.
0.33	182	Cymatiosphaera spp.
0.33	185	Palambages sp. C
0.33	186	Pterospermopsis spp.

338		338 witmer. Nani. zone 11
27.33	72	Homotryblium palladum
19.67	64	Glaphyrocysta ordinata
8.33	1	Achnella biformoides n. gen., n. comb.
6.67	171	Wetzeliella unans
6.33	98	Lingulodinium machaerophorum
6.00	40	Dinopterygium tenmarnense
5.67	47	Eocladopyxis peniculatum
4.00	117	Paralecaniella indentata
2.67	170	Wetzeliella hampdenensis
1.67	178	Cyclopsiella vieta
1.00	13	Ascotomocystus hydria
1.00	135	Spinidinium paratabulatum
1.00	151	Spiniferites ramosus subsp. ramosus
0.67	2	Adnatosphaeridium multispinosum
0.67	22	Cleistosphaeridium diversispinosum
0.67	33	?Cordosphaeridium callosum
0.67	38	Deflandrea wardenensis
0.67	100	Membranilarnacia leptoderma
0.67	107	Nematosphaeropsis trabeculata
0.67	122	Phthanoperidinium echinatum
0.67	132	Senegalinium? dilwynense
0.67	160	Thalassiphora pelagica
0.33	9	Apteodinium cribosum
0.33	42	Diphyes colligerum
0.33	59	Forma D
0.33	70	Homotriblium caliculum
0.33	82	Hystrichosphaeridium tubiferum brevispin
0.33	83	?Hystrichosphaeropsis ovum
0.33	88	Impletosphaeridium kroemmelbeinii
0.33	89	Impletosphaeridium rugosum
0.33	113	Operculodinium multispinosum
0.33	124	Polysphaeridium zoharyi
0.33	127	Rottnestia borussica
0.33	138	Spiniferites crassipellis C
0.33	149	Spiniferites ramosus subsp. membranaceou
0.33	158	Tectatodinium pellitum

Correlation Matrix for PT13

Correlation Matrix for Variables: $X_1 \ldots X_2$

	338	339
338	1	
339	.79852	1

ANOVA Table for PT13

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_2$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	2875.11607	11.31935	8.47392	.0001
Within subjects	255	340.6259	1.33579		
treatments	1	.00738	.00738	.0055	.9409
residual	254	340.61852	1.34102		
Total	509	3215.74197			

Reliability Estimates for- All treatments: .88199 Single Treatment: .78889

PT14 "*Wetzeliella (W.) samlandica/ Fusidinium tabulatum*" Association

239	239 goodman, Nani woodstock zone 16	240	240 goodman, Nani woodstock zone 16	241	241 goodman, Nani woodstock zone 16
41.60	172 Wetzeliella (W.) samlandica	53.80	172 Wetzeliella (W.) samlandica	72.40	172 Wetzeliella (W.) samlandica
39.60	230 Fusidinium tabulatum n. gen., n. sp.	16.80	98 Lingulodinium machaerophorum	17.80	230 Fusidinium tabulatum n. gen., n. sp.
7.50	202 Scrinodinium (S.) australiense	5.00	209 Spiniferites supparus	5.80	209 Spiniferites supparus
4.20	209 Spiniferites supparus	4.80	2 Adnatosphaeridium multispinosum	2.60	98 Lingulodinium machaerophorum
1.60	98 Lingulodinium machaerophorum	4.20	202 Scrinodinium (S.) australiense	2.20	200 Operculodinium amiculum n. sp.
1.00	101 Microdinium ornatum	3.40	230 Fusidinium tabulatum n. gen., n. sp.	2.20	202 Scrinodinium (S.) australiense
0.60	103 Muratodinium fimbriatum	2.80	103 Muratodinium fimbriatum	2.20	12 Areoligera sp.
0.50	110 Operculodinium centrocarpum	1.40	227 Cyclonephelium lemniscatum	1.80	2 Adnatosphaeridium multispinosum
0.60	213 Deflandrea dilwynensis	1.00	100 Membranilarnacia leptoderma	0.60	100 Membranilarnacia leptoderma
0.60	12 Areoligera sp.	0.80	215 Phthanoperidinium resistente	0.60	222 Adnatosphaeridium vittatum
0.60	233 Heteraulacacysta fehmarnensis	0.80	222 Adnatosphaeridium vittatum	0.40	76 Hystrichokolpoma rigaudae
0.40	41 Diphyes colligerum	0.80	101 Microdinium ornatum	0.40	195 Lanternosphaeridium bipolare
0.40	76 Hystrichokolpoma rigaudae	0.60	200 Operculodinium amiculum n. sp.	0.40	103 Muratodinium fimbriatum
0.40	93 Kallosphaeridium brevibarbatum	0.40	1 Achilleodinium biformoides n. gen., n. comb.	0.40	215 Phthanoperidinium resistente
0.40	195 Lanternosphaeridium bipolare	0.40	148 Spiniferites ramosus subsp. granosus	0.40	228 Dinopterygium cladoides
0.40	100 Membranilarnacia leptoderma	0.40	47 Eocladopyxis peniculatum	0.40	89 Impletosphaeridium rugosum
0.40	200 Operculodinium amiculum n. sp.	0.40	233 Heteraulacacysta fehmarnensis	0.40	235 Impletosphaeridium transfodum
0.40	207 Spiniferites cf. S. ramosus subsp. ramosus	0.40	89 Impletosphaeridium rugosum	0.20	1 Achilleodinium biformoides n. gen., n. comb.
0.40	115 Palaeocystodinium golzowense	0.40	235 Impletosphaeridium transfodum	0.20	33 ?Cordosphaeridium callosum
0.40	2 Adnatosphaeridium multispinosum	0.20	33 ?Cordosphaeridium callosum	0.20	27 Cordosphaeridium gracilis
0.40	222 Adnatosphaeridium vittatum	0.20	27 Cordosphaeridium gracilis	0.20	28 Cordosphaeridium inodes
0.40	226 Cyclonephelium incultum	0.20	41 Diphyes colligerum	0.20	41 Diphyes colligerum
0.40	235 Impletosphaeridium transfodum	0.20	191 Gonyaulacysta giuseppei subsp. major	0.20	194 Hystrichosphaeropsis borussica
0.20	1 Achilleodinium biformoides n. gen., n. comb.	0.20	76 Hystrichokolpoma rigaudae	0.20	199 Lanternosphaeridium radiatum
0.20	33 ?Cordosphaeridium callosum	0.20	194 Hystrichosphaeropsis borussica	0.20	201 Operculodinium potomacense n. sp.
0.20	27 Cordosphaeridium gracilis	0.20	93 Kallosphaeridium brevibarbatum	0.20	146 Spiniferites pseudofurcatus
0.20	191 Gonyaulacysta giuseppei subsp. major	0.20	195 Lanternosphaeridium bipolare	0.20	150 Spiniferites ramosus subsp. multibrevis
0.20	194 Hystrichosphaeropsis borussica	0.20	199 Lanternosphaeridium radiatum	0.20	151 Spiniferites ramosus subsp. ramosus
0.20	147 Spiniferites ramosus subsp. granomembran	0.20	110 Operculodinium centrocarpum	0.20	208 Spiniferites scabratus
0.20	160 Thalassiphora pelagica	0.20	204 Spiniferites cf. S. crassipellis	0.20	213 Deflandrea dilwynensis
0.20	211 Tubulosphaeridium pseudocurvatum n. gen.	0.20	206 Spiniferites membranaceous	0.20	38 Deflandrea wardenensis
0.20	38 Deflandrea wardenensis	0.20	145 Spiniferites monilus	0.20	115 Palaeocystodinium golzowense
0.20	215 Phthanoperidinium resistente	0.20	150 Spiniferites ramosus subsp. multibrevis	0.20	219 Wetzeliella (W.) articulata
0.20	227 Cyclonephelium lemniscatum	0.20	151 Spiniferites ramosus subsp. ramosus	0.20	224 Cannosphaeropsis pusulosa
0.20	228 Dinopterygium cladoides	0.20	158 Tectatodinium pellitum	0.20	226 Cyclonephelium incultum
0.20	89 Impletosphaeridium rugosum	0.20	160 Thalassiphora pelagica	0.20	227 Cyclonephelium lemniscatum
0.20	165 Tubidermodinium sulcatum	0.20	211 Tubulosphaeridium pseudocurvatum n. gen.	0.20	69 Heteraulacacysta campanula
		0.20	213 Deflandrea dilwynensis	0.20	233 Heteraulacacysta fehmarnensis
		0.20	38 Deflandrea wardenensis	0.20	101 Microdinium ornatum
		0.20	219 Wetzeliella (W.) articulata	0.20	165 Tubidermodinium sulcatum
		0.20	12 Areoligera sp.		
		0.20	228 Dinopterygium cladoides		
		0.20	69 Heteraulacacysta campanula		
		0.20	236 ?Litosphaeridium inversibuccinum		
		0.20	165 Tubidermodinium sulcatum		

242		242 goodman, Nani woodstock zone 16
53.00	230	Fusidinium tabulatum n. gen., n. sp.
25.60	172	Wetzeliella (W.) samlandica
9.30	202	Schinodinium (S.) australiense
6.40	209	Spiniferites supparus
1.20	2	Adnatosphaeridium multispinosum
0.80	28	Cordosphaeridium inodes
0.60	100	Membranilarnacia leptoderma
0.50	103	Muratodinium fimbriatum
0.60	232	Hemicystodinium zonaryi
0.60	233	Heteraulacacysta leffmamensis
0.40	27	Cordosphaeridium gracilis
0.40	98	Lingulodinium machaerophorum
0.40	38	Deflandrea wardenensis
0.40	227	Cyclonephelium lemniscatum
0.20	1	Achiella biformoides n. gen., n. comb.
0.20	33	?Cordosphaeridium callosum
0.20	25	Cordosphaeridium fibrospinosum
0.20	41	Diphyes colligerum
0.20	190	Diphyesopsis capitata n. gen., n. sp.
0.20	48	Exochosphaeridium bifidum
0.20	191	Gonyaulacysta guiseppi subsp. major
0.20	76	Hystrichokolpoma rigaudae
0.20	93	Kallosphaeridium brevibarbatum
0.20	195	Lanternosphaeridium bipolare
0.20	200	Operculodinium amiculum n. sp.
0.20	110	Operculodinium centrocarpum
0.20	205	Spiniferites hypercanthus
0.20	206	Spiniferites membranaceous
0.20	145	Spiniferites monilus
0.20	147	Spiniferites ramosus subsp. granomembran
0.20	151	Spiniferites ramosus subsp. ramosus
0.20	207	Spiniferites cf. S. ramosus subsp. ramosus
0.20	211	Tubulosphaeridium pseudocurvatum n. gen.
0.20	213	Deflandrea dilwynensis
0.20	115	Palaeocystodinium golzowense
0.20	215	Phthanoperidinium resistente
0.20	219	Wetzeliella (W.) articulata
0.20	222	Adnatosphaeridium vittatum
0.20	12	Areoligera sp.
0.20	224	Cannosphaeropsis pusulosa
0.20	47	Eocladopyxis peniculatum
0.20	89	Impletosphaeridium rugosum
0.20	235	Impletosphaeridium transfodum
0.20	101	Microdinium ornatum
0.20	165	Tuberculodinium sulcatum

Correlation Matrix for PT14

Correlation Matrix for Variables: $X_1 \ldots X_3$

	240	241	242
240	1		
241	.94496	1	
242	.48557	.64424	1

ANOVA Table for PT14

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_3$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	9826.52528	38.68711	7.68774	.0001
Within subjects	510	2566.48	5.03231		
treatments	2	.28936	.14468	.02864	.9718
residual	508	2566.19064	5.05156		
Total	764	12393.00528			

Reliability Estimates for- All treatments: .86992 Single Treatment: .69033

Sample 243

243		243 goodman, Nanj woodstock zone 18
55.80	101	Microdinium ornatum
26.40	2	Adnatosphaeridium multispinosum
3.40	103	Muratodinium fimbriatum
3.00	172	Wetzeliella (W.) samlandica
2.20	98	Lingulodinium machaerophorum
1.20	209	Spiniferites supparus
1.00	215	Phthanoperidinium resistente
0.80	41	Diphyes colligerum
0.80	235	Impletosphaeridium transfodum
0.60	28	Cordosphaeridium inodes
0.60	100	Membranilarnacia leptoderma
0.60	110	Operculodinium centrocarpum
0.60	151	Spiniferites ramosus subsp. ramosus
0.60	222	Adnatosphaeridium vittatum
0.60	230	Fusidinium tabulatum n. gen., n. sp.
0.40	147	Spiniferites ramosus subsp. granomembran
0.40	38	Deflandrea wardenensis
0.40	89	Heteraulacacysta campanula
0.40	233	Heteraulacacysta lehmanensis
0.40	39	Impletosphaeridium rugosum
0.40	165	Tubidermodinium sulcatum
0.20	1	Achilleia biformoides n. gen., n. comb.
0.20	33	?Cordosphaeridium callosum
0.20	25	Cordosphaeridium fibrospinosum
0.20	27	Cordosphaeridium gracilis
0.20	189	Diphyesopsis buccinata n. gen., n. sp.
0.20	190	Diphyesopsis capsata n. gen., n. sp.
0.20	48	Exochosphaeridium bifidum
0.20	191	Gonyaulacysta giuseppei subsp. major
0.20	192	Hybridasphaera marylandense n. gen., n. sp
0.20	193	Hystrichokolpoma bulbosa
0.20	76	Hystrichokolpoma rigaude
0.20	79	Hystrichosphaeridium tubiferum
0.20	194	Hystrichosphaeropsis borussica
0.20	93	Kallosphaeridium brevibarbatum
0.20	195	Lanternosphaeridium bipolare
0.20	199	Lanternosphaeridium radiatum
0.20	200	Operculodinium amicuum n. sp.
0.20	202	Senoniasphaera (S.) australiense
0.20	203	Spiniferites bulloideus
0.20	138	Spiniferites crassipellis
0.20	204	Spiniferites cf. S. crassipellis
0.20	205	Spiniferites hypercanthus
0.20	206	Spiniferites membranaceous
0.20	146	Spiniferites pseudofurcatus
0.20	148	Spiniferites ramosus subsp. granosus
0.20	150	Spiniferites ramosus subsp. multibrevis
0.20	207	Spiniferites cf. S. ramosus subsp. ramosus
0.20	208	Spiniferites scabratus
0.20	158	Tectatodinium pellitum
0.20	211	Tubulosphaeridium pseudocurvatum n. gen.
0.20	37	Deflandrea phosphoritica
0.20	115	Palaeocystodinium golzowense
0.20	219	Wetzeliella (W.) articulata
0.20	12	Areoligera sp.
0.20	225	Chlamydophorella rauca n. sp.
0.20	22	Cleistosphaeridium diversispinosum
0.20	226	Cyclonephelium incultum
0.20	227	Cyclonephelium lemniscatum
0.20	228	Dinopterygium cladoides
0.20	231	Hemicystodinium aculeatum n. sp.

Statistical information for Sample 243

X_1: 243

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.42588	3.86698	.24216	14.9535	907.99152	255
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
0	55.8	55.8	108.6	3844.44	0

PT15 *"Deflandria macmurdoensis"* Association

244		244 goodman, Nanj woodstock zone 16
22.80	214	Deflandria macmurdoensis
12.00	101	Microdinium ornatum
10.60	221	Wetzeliella (W.) coleothrypta
3.40	12	Areoligera sp.
5.80	98	Lingulodinium machaerophorum
5.40	37	Deflandria phosphoritica
4.80	41	Dionyes colligerum
3.60	27	Cordosphaeridium gracilis
3.20	172	Wetzeliella (W.) samlandica
2.80	201	Operculodinium potomacense n. sp.
1.80	210	Tectatodinium psilatum
1.80	160	Thalassiphora pelagica
1.80	230	Fusidinium tabulatum n. gen., n. sp.
1.40	103	Muratodinium fimbriatum
1.00	151	Spiniferites ramosus subsp. ramosus
1.00	209	Spiniferites supparus
1.00	222	Adnatosphaeridium vittatum
1.00	22	Cleistosphaeridium diversispinosum
0.80	215	Phthanoperidinium resistente
0.80	2	Adnatosphaeridium multispinosum
0.80	232	Hemicystodinium zonaryi
0.80	89	Impletosphaeridium rugosum
0.60	200	Operculodinium amiculum n. sp.
0.60	138	Spiniferites crassipellis
0.60	38	Deflandria wardenensis
0.40	25	Cordosphaeridium fibrospinosum
0.40	76	Hystrichokolpoma riguade
0.40	93	Kallosphaeridium brevibarbatum
0.40	110	Operculodinium centrocarpum
0.40	112	Operculodinium israelianum
0.40	212	Deflandria asymmetrica
0.40	47	Eocladopyxis peniculatum
0.40	231	Hemicystodinium aculeatum n. sp.
0.40	235	Impletosphaeridium transfodum
0.20	1	Achiella biformoides n. gen., n. comb.
0.20	188	Autria ennacea n. gen., n. comb.
0.20	33	?Cordosphaeridium callosum
0.20	28	Cordosphaeridium inodes
0.20	189	Diphyesopsis buccinata n. gen., n. sp.
0.20	190	Diphyesopsis capitata n. gen., n. sp.
0.20	48	Exochosphaeridium bifidum
0.20	192	Hyondasphaera marylandense n. gen., n. sp
0.20	193	Hystrichokolpoma bulbosa
0.20	194	Hystrichosphaeropsis borussica
0.20	195	Lanternosphaeridium bipolare
0.20	199	Lanternosphaeridium radiatum
0.20	100	Membranilarnacia leptoderma
0.20	202	Scrinodinium (S.) australiense
0.20	204	Spiniferites cf. S. crassipellis
0.20	205	Spiniferites hypercanthus
0.20	206	Spiniferites membranaceous
0.20	146	Spiniferites pseudofurcatus
0.20	147	Spiniferites ramosus subsp. granomembran
0.20	148	Spiniferites ramosus subsp. granosus
0.20	207	Spiniferites cf. S. ramosus subsp. ramosus
0.20	158	Tectatodinium pellitum
0.20	213	Deflandria dilwynensis
0.20	115	Palaeocystodinium golzowense
0.20	218	Wetzeliella (Rhombodinium) glabra
0.20	219	Wetzeliella (W.) articulata
0.20	228	Dinopterygium cladoides
0.20	69	Heteraulacacysta campanula
0.20	233	Heteraulacacysta lehmamensis
0.20	236	?Litosphaeridium inversibuccinum
0.20	237	Systematophora ancyrea
0.20	165	Tubidermodinium sulcatum

245		245 goodman, Nanj woodstock zone 16
39.20	214	Deflandria macmurdoensis
9.80	221	Wetzeliella (W.) coleothrypta
7.20	27	Cordosphaeridium gracilis
7.00	22	Cleistosphaeridium diversispinosum
6.20	12	Areoligera sp.
3.20	237	Systematophora ancyrea
2.60	98	Lingulodinium machaerophorum
2.60	110	Operculodinium centrocarpum
2.00	201	Operculodinium potomacense n. sp.
2.00	215	Phthanoperidinium resistente
1.80	41	Dionyes colligerum
1.80	37	Deflandria phosphoritica
1.60	213	Deflandria dilwynensis
1.40	172	Wetzeliella (W.) samlandica
1.20	100	Membranilarnacia leptoderma
1.00	151	Spiniferites ramosus subsp. ramosus
0.80	93	Kallosphaeridium brevibarbatum
0.80	158	Tectatodinium pellitum
0.80	212	Deflandria asymmetrica
0.80	171	Wetzeliella (W.) lunaris
0.80	232	Hemicystodinium zonaryi
0.60	188	Autria ennacea n. gen., n. comb.
0.60	76	Hystrichokolpoma riguade
0.60	195	Lanternosphaeridium bipolare
0.60	210	Tectatodinium psilatum
0.60	228	Dinopterygium cladoides
0.60	69	Heteraulacacysta campanula
0.60	235	Impletosphaeridium transfodum
0.40	30	Cordosphaeridium multispinosum
0.40	190	Diphyesopsis capitata n. gen., n. sp.
0.40	138	Spiniferites crassipellis
0.40	205	Spiniferites hypercanthus
0.40	170	Wetzeliella (W.) hamodenensis
0.40	89	Impletosphaeridium rugosum
0.20	1	Achiella biformoides n. gen., n. comb.
0.20	33	?Cordosphaeridium callosum
0.20	25	Cordosphaeridium fibrospinosum
0.20	28	Cordosphaeridium inodes
0.20	48	Exochosphaeridium bifidum
0.20	192	Hyondasphaera marylandense n. gen., n. sp
0.20	193	Hystrichokolpoma bulbosa
0.20	79	Hystrichosphaeridium tubiferum
0.20	197	Lanternosphaeridium lappaceum
0.20	103	Muratodinium fimbriatum
0.20	104	Nematosphaeropsis balcombiana
0.20	200	Operculodinium amiculum n. sp.
0.20	141	Spiniferites cornutus
0.20	204	Spiniferites cf. S. crassipellis
0.20	206	Spiniferites membranaceous
0.20	145	Spiniferites monilus
0.20	146	Spiniferites pseudofurcatus
0.20	147	Spiniferites ramosus subsp. granomembran
0.20	148	Spiniferites ramosus subsp. granosus
0.20	150	Spiniferites ramosus subsp. multibrevis
0.20	209	Spiniferites supparus
0.20	160	Thalassiphora pelagica
0.20	211	Tubulosphaeridium pseudocurvatum n. gen
0.20	38	Deflandria wardenensis
0.20	2	Adnatosphaeridium multispinosum
0.20	222	Adnatosphaeridium vittatum
0.20	224	Cannosphaeropsis pusulosa
0.20	226	Cyclonephelium incultum
0.20	227	Cyclonephelium lemniscatum
0.20	47	Eocladopyxis peniculatum
0.20	230	Fusidinium tabulatum n. gen., n. sp.
0.20	231	Hemicystodinium aculeatum n. sp.
0.20	233	Heteraulacacysta lehmamensis
0.20	101	Microdinium ornatum
0.20	165	Tubidermodinium sulcatum

246		246 goodman, Nanj woodstock zone 16
51.80	214	Deflandria macmurdoensis
11.00	221	Wetzeliella (W.) coleothrypta
9.20	22	Cleistosphaeridium diversispinosum
6.20	215	Phthanoperidinium resistente
2.60	231	Hemicystodinium aculeatum n. sp.
3.00	212	Deflandria asymmetrica
2.90	41	Dionyes colligerum
2.60	201	Operculodinium potomacense n. sp.
2.20	69	Heteraulacacysta campanula
1.60	27	Cordosphaeridium gracilis
1.60	170	Wetzeliella (W.) hamodenensis
1.60	101	Microdinium ornatum
1.40	98	Lingulodinium machaerophorum
1.20	151	Spiniferites ramosus subsp. ramosus
1.20	233	Heteraulacacysta lehmamensis
0.80	12	Areoligera sp.
0.60	190	Diphyesopsis capitata n. gen., n. sp.
0.60	146	Spiniferites pseudofurcatus
0.60	207	Spiniferites cf. S. ramosus subsp. ramosus
0.60	209	Spiniferites supparus
0.60	38	Deflandria wardenensis
0.60	47	Eocladopyxis peniculatum
0.60	232	Hemicystodinium zonaryi
0.60	89	Impletosphaeridium rugosum
0.40	188	Autria ennacea n. gen., n. comb.
0.40	100	Membranilarnacia leptoderma
0.40	110	Operculodinium centrocarpum
0.40	213	Deflandria dilwynensis
0.40	37	Deflandria phosphoritica
0.40	171	Wetzeliella (W.) lunaris
0.40	228	Dinopterygium cladoides
0.20	1	Achiella biformoides n. gen., n. comb.
0.20	33	?Cordosphaeridium callosum
0.20	25	Cordosphaeridium fibrospinosum
0.20	189	Diphyesopsis buccinata n. gen., n. sp.
0.20	192	Hyondasphaera marylandense n. gen., n. sp
0.20	193	Hystrichokolpoma bulbosa
0.20	76	Hystrichokolpoma riguade
0.20	93	Kallosphaeridium brevibarbatum
0.20	195	Lanternosphaeridium bipolare
0.20	199	Lanternosphaeridium radiatum
0.20	104	Nematosphaeropsis balcombiana
0.20	200	Operculodinium amiculum n. sp.
0.20	202	Scrinodinium (S.) australiense
0.20	138	Spiniferites crassipellis
0.20	205	Spiniferites hypercanthus
0.20	206	Spiniferites membranaceous
0.20	145	Spiniferites monilus
0.20	147	Spiniferites ramosus subsp. granomembran
0.20	148	Spiniferites ramosus subsp. granosus
0.20	150	Spiniferites ramosus subsp. multibrevis
0.20	158	Tectatodinium pellitum
0.20	160	Thalassiphora pelagica
0.20	211	Tubulosphaeridium pseudocurvatum n. gen
0.20	217	Spinidinium rotundum
0.20	172	Wetzeliella (W.) samlandica
0.20	2	Adnatosphaeridium multispinosum
0.20	222	Adnatosphaeridium vittatum
0.20	224	Cannosphaeropsis pusulosa
0.20	230	Fusidinium tabulatum n. gen., n. sp.
0.20	235	Impletosphaeridium transfodum
0.20	236	?Litosphaeridium inversibuccinum
0.20	237	Systematophora ancyrea

Correlation Matrix for PT15

Correlation Matrix for Variables: $X_1 \ldots X_3$

	244	245	246
244	1		
245	.84606	1	
246	.80409	.96751	1

ANOVA Table for PT15

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_3$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	4981.02975	19.61035	14.80823	.0001
Within subjects	510	675.38667	1.32429		
treatments	2	.23414	.11707	.08809	.9157
residual	508	675.15252	1.32904		
Total	764	5656.41642			

Reliability Estimates for- All treatments: .93247 Single Treatment: .82152

Sample 247

247		247 goodman, Nan woodstock zone 6
35.60	12	Areoligera sp.
17.00	160	Thalassiphora pelagica
11.60	215	Phthanoperidinium resistente
9.00	103	Muratodinium fimbriatum
6.20	214	Deflandrea macmurdoensis
3.40	212	Deflandrea asymmetrica
2.00	108	Oligosphaeridium ?coelenteratum
1.80	76	Hystrichokolpoma rigaude
1.80	221	Wetzeliella (W.) coleothrypta
1.40	158	Tectatodinium pellitum
1.20	210	Tectatodinium psilatum
1.20	2	Adnatosphaeridium multispinosum
1.00	27	Cordosphaeridium gracilis
1.00	41	Diphyes colligerum
1.00	100	Membranilarnacia leptoderma
0.80	98	Lingulodinium machaerophorum
0.80	201	Operculodinium potomacense n. sp.
0.80	151	Spiniferites ramosus subsp. ramosus
0.80	170	Wetzeliella (W.) hampdenensis
0.90	171	Wetzeliella (W.) lunaris
0.80	228	Dinopterygium cladoides
0.80	233	Heteraulacacysta leonmarnensis
0.80	165	Tubidermodinium sulcatum
0.60	150	Spiniferites ramosus subsp. multibrevis
0.60	22	Cleistosphaeridium diversispinosum
0.60	234	Homotryblium alisum n. sp.
0.40	208	Spiniferites membranaceous
0.40	38	Deflandrea wardenensis
0.20	1	Achiella biformoides n. gen., n. comb.
0.20	188	Aurna ennacea n. gen., n. comb.
0.20	28	Cordosphaeridium inodes
0.20	189	Diphyesopsis buccinata n. gen., n. sp.
0.20	190	Diphyesopsis capitata n. gen., n. sp.
0.20	193	Hystrichokolpoma bulbosa
0.20	83	?Hystrichosphaeropsis ovum
0.20	93	Kallosphaeridium brevibarbatum
0.20	196	Lanternosphaeridium lanosum
0.20	200	Operculodinium amiculum n. sp.
0.20	110	Operculodinium centrocarpum
0.20	128	Samlandia reticulifera
0.20	202	Senegalinium (S.) australiense
0.20	205	Spiniferites hypercanthus
0.20	147	Spiniferites ramosus subsp. granomembran
0.20	148	Spiniferites ramosus subsp. granosus
0.20	209	Spiniferites supparus
0.20	211	Tubulosphaeridium pseudocurvatum n. gen
0.20	213	Deflandrea dilwynensis
0.20	37	Deflandrea phosphoritica
0.20	217	Spinidinium rotundum
0.20	172	Wetzeliella (W.) samlandica
0.20	222	Adnatosphaeridium vittatum
0.20	223	Canningia minor
0.20	224	Cannosphaeropsis pusulosa
0.20	20	Chlamydophorella cf. C. urna
0.20	230	Fusidinium tabulatum n. gen., n. sp.
0.20	231	Hemicystodinium aculeatum n. sp.
0.20	232	Hemicystodinium zoharyi
0.20	69	Heteraulacacysta campanula
0.20	89	Impletosphaeridium rugosum
0.20	235	Impletosphaeridium transfodum
0.20	91	Inversidinium exilimuram
0.20	236	?Litosphaeridium inversibuccinum
0.20	237	Systematophora ancyrea

Statistical information for Sample 247

X_1: 247

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.43216	2.64987	.16594	7.0218	613.17255	255

Minimum:	Maximum:	Range:	Sum:	Sum of Sqr.:	# Missing:
0	35.6	35.6	110.2	1831.16	0

PT16 "Wetzeliella (W.) lunaris/ Deflandria phosphortica/ Thalassiophora pelagica" Association

251		251 goodman. Nani woodstock zone 16
36.20	171	Wetzeliella (W.) lunaris
1.60	12	Areoligera sp.
1.40	37	Deflandria phosphoritica
0.40	237	Systematophora ancyrea
0.20	214	Deflandria macmurdoensis
0.20	69	Heteraulacacysta campanula

250		250 goodman. Nani woodstock zone 16
51.40	171	Wetzeliella (W.) lunaris
40.80	37	Deflandria phosphoritica
7.20	27	Cordosphaeridium gracilis
0.80	212	Deflandria asymmetrica
0.60	170	Wetzeliella (W.) hampdenensis
0.20	160	Thalassiphora pelagica
0.20	213	Deflandria dilwynensis
0.20	214	Deflandria macmurdoensis
0.20	12	Areoligera sp.
0.20	22	Cleistosphaeridium diversispinosum
0.20	69	Heteraulacacysta campanula
0.20	237	Systematophora ancyrea

267		SPECIES	268		SPECIES	270		SPECIES
47.50	171	Wetzeliella (W.) lunans	38.00	160	Thalassiphora pelagica	71.50	171	Wetzeliella (W.) lunans
33.20	160	Thalassiphora pelagica	37.60	171	Wetzeliella (W.) lunans	20.00	216	Spinidinium bilineatum n. sp.
7.20	170	Wetzeliella (W.) hampdenensis	8.40	12	Areoligera sp.	3.40	170	Wetzeliella (W.) hampdenensis
5.60	12	Areoligera sp.	7.40	2	Adnatosphaeridium multispinosum	5.20	160	Thalassiphora pelagica
2.60	2	Adnatosphaeridium multispinosum	5.60	170	Wetzeliella (W.) hampdenensis	0.40	151	Spiniferites ramosus subsp. ramosus
2.40	71	Homotryblium tasmaniense	2.80	22	Cleistosphaeridium diversispinosum	0.40	38	Deflandrea wardenensis
1.20	189	Diphyesopsis buccinata n. gen., n. sp.	0.80	151	Spiniferites ramosus subsp. ramosus	0.20	138	Spiniferites crassipellis
1.20	151	Spiniferites ramosus subsp. ramosus	0.80	216	Spinidinium bilineatum n. sp.	0.20	72	Homotryblium pallidum
1.20	209	Spiniferites supparus	0.60	1	Achiella biformoides n. gen., n. comb.			
1.20	22	Cleistosphaeridium diversispinosum	0.60	187	Apteodinium incompositum n. sp.			
0.60	41	Diphyes colligerum	0.60	233	Heteraulacacysta fehmarnensis			
0.60	38	Deflandrea wardenensis	0.40	189	Diphyesopsis buccinata n. gen., n. sp.			
0.40	1	Achiella biformoides n. gen., n. comb.	0.40	98	Lingulodinium machaerophorum			
0.40	191	Gonyaulacysta guiseppi subsp. major	0.20	9	Apteodinium cribosum			
0.40	201	Operculodinium potomacense n. sp.	0.20	27	Cordosphaeridium gracilis			
0.40	138	Spiniferites crassipellis	0.20	41	Diphyes colligerum			
0.40	216	Spinidinium bilineatum n. sp.	0.20	190	Diphyesopsis capitata n. gen., n. sp.			
0.20	27	Cordosphaeridium gracilis	0.20	191	Gonyaulacysta guiseppi subsp. major			
0.20	197	Lanternosphaeridium lappaceum	0.20	76	Hystrichokolpoma rigaudae			
0.20	98	Lingulodinium machaerophorum	0.20	197	Lanternosphaeridium lappaceum			
0.20	200	Operculodinium amiculum n. sp.	0.20	110	Operculodinium centrocarpum			
0.20	222	Adnatosphaeridium vittatum	0.20	201	Operculodinium potomacense n. sp.			
0.20	47	Eocladopyxis peniculatum	0.20	146	Spiniferites pseudofurcatus			
0.20	69	Heteraulacacysta campanula	0.20	38	Deflandrea wardenensis			
0.20	234	Homotryblium alisum n. sp.	0.20	115	Palaeocystodinium golzowense			
0.20	89	Impletosphaeridium rugosum	0.20	222	Adnatosphaeridium vittatum			
0.20	235	Impletosphaeridium transfodum	0.20	71	Homotryblium tasmaniense			

Correlation Matrix for PT16

Correlation Matrix for Variables: $X_1 \ldots X_5$

	250	251	267	268	270
250	1				
251	.7864	1			
267	.62844	.80887	1		
268	.53083	.68455	.97611	1	
270	.74225	.95447	.82454	.71318	1

ANOVA Table for PT16

One Factor ANOVA-Repeated Measures for $X_1 \ldots X_5$

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	20121.07464	79.21683	14.9525	.0001
Within subjects	1020	5403.856	5.2979		
treatments	4	.20342	.05085	.00956	.9998
residual	1016	5403.65258	5.31856		
Total	1274	25524.93064			

Reliability Estimates for- All treatments: .93312 Single Treatment: .73618

PT17 *"Spinidinium bilineatum" Association*

264	SPECIES	265	SPECIES	266	SPECIES
51.40	216 Spinidinium bilineatum n. sp.	71.20	216 Spinidinium bilineatum n. sp.	35.20	171 Wetzeliella (W.) lunaris
11.30	22 Cleistosphaeridium diversispinosum	7.30	191 Gonyaulacysta giuseppei subsp. major	25.30	216 Spinidinium bilineatum n. sp.
6.60	220 Wetzeliella (W.) coalita n. sp.	5.00	171 Wetzeliella (W.) lunaris	5.20	170 Wetzeliella (W.) hampdenensis
4.80	209 Spiniferites supparus	4.20	209 Spiniferites supparus	5.40	12 Areoligera sp.
3.40	171 Wetzeliella (W.) lunaris	2.00	22 Cleistosphaeridium diversispinosum	5.20	3 Apteodinium cribosum
3.40	71 Homotryblium tasmaniense	2.00	71 Homotryblium tasmaniense	5.20	160 Thalassiphora pelagica
2.60	191 Gonyaulacysta giuseppei subsp. major	1.80	170 Wetzeliella (W.) hampdenensis	4.20	22 Cleistosphaeridium diversispinosum
2.20	170 Wetzeliella (W.) hampdenensis	1.40	41 Diphyes colligerum	3.40	71 Homotryblium tasmaniense
1.80	160 Thalassiphora pelagica	1.20	1 Achiella biformoides n. gen., n. comb.	2.60	209 Spiniferites supparus
1.80	12 Areoligera sp.	1.20	160 Thalassiphora pelagica	2.00	151 Spiniferites ramosus subsp. ramosus
1.20	201 Operculodinium potomacense n. sp.	1.00	98 Lingulodinium machaerophorum	1.40	215 Phthanoperidinium resistente
1.00	1 Achiella biformoides n. gen., n. comb.	1.00	201 Operculodinium potomacense n. sp.	1.40	2 Adnatosphaeridium multispinosum
0.80	47 Eocladopyxis peniculatum	0.80	9 Apteodinium cribosum	1.20	221 Wetzeliella (W.) coleothrypta
0.60	33 ?Cordosphaeridium callosum	0.80	235 Impletosphaeridium transfodum	1.00	1 Achiella biformoides n. gen., n. comb.
0.60	41 Diphyes colligerum	0.60	33 ?Cordosphaeridium callosum	1.00	158 Tectatodinium pellitum
0.60	204 Spiniferites cf. S. crassipellis	0.60	28 Cordosphaeridium inodes	1.00	72 Homotryblium palladum
0.60	215 Phthanoperidinium resistente	0.60	151 Spiniferites ramosus subsp. ramosus	0.60	41 Diphyes colligerum
0.60	89 Impletosphaeridium rugosum	0.60	220 Wetzeliella (W.) coalita n. sp.	0.60	191 Gonyaulacysta giuseppei subsp. major
0.60	165 Tubidermodinium sulcatum	0.60	47 Eocladopyxis peniculatum	0.60	98 Lingulodinium machaerophorum
0.40	28 Cordosphaeridium inodes	0.40	189 Diphyesopsis buccinata n. gen., n. sp.	0.60	47 Eocladopyxis peniculatum
0.40	98 Lingulodinium machaerophorum	0.40	204 Spiniferites cf. S. crassipellis	0.60	165 Tubidermodinium sulcatum
0.40	100 Membranilarnacia leptoderma	0.40	69 Heteraulacacysta campanula	0.40	115 Palaeocystodinium golzowense
0.40	224 Cannosphaeropsis pusulosa	0.40	72 Homotryblium palladum	0.40	89 Impletosphaeridium rugosum
0.40	229 ?Eisenackia scrobiculata	0.20	27 Cordosphaeridium gracilis	0.40	236 ?Litosphaeridium inversibuccinum
0.40	233 Heteraulacacysta lenmarnensis	0.20	190 Diphyesopsis capitata n. gen., n. sp.	0.20	27 Cordosphaeridium gracilis
0.40	72 Homotryblium palladum	0.20	76 Hystrichokolpoma rigaudae	0.20	28 Cordosphaeridium inodes
0.20	9 Apteodinium cribosum	0.20	79 Hystrichosphaeridium tubiferum	0.20	189 Diphyesopsis buccinata n. gen., n. sp.
0.20	25 Cordosphaeridium fibrospinosum	0.20	93 Kallosphaeridium brevibarbatum	0.20	195 Lanternosphaeridium bipolare
0.20	27 Cordosphaeridium gracilis	0.20	197 Lanternosphaeridium lappaceum	0.20	197 Lanternosphaeridium lappaceum
0.20	189 Diphyesopsis buccinata n. gen., n. sp.	0.20	100 Membranilarnacia leptoderma	0.20	198 Lanternosphaeridium pilatum n. sp.
0.20	190 Diphyesopsis capitata n. gen., n. sp.	0.20	103 Muratodinium fimbriatum	0.20	100 Membranilarnacia leptoderma
0.20	48 Exochosphaeridium bifidum	0.20	200 Operculodinium amiculum n. sp.	0.20	103 Muratodinium fimbriatum
0.20	192 Hyondasphaera marylandense n. gen., n. sp.	0.20	110 Operculodinium centrocarpum	0.20	200 Operculodinium amiculum n. sp.
0.20	76 Hystrichokolpoma rigaudae	0.20	158 Tectatodinium pellitum	0.20	110 Operculodinium centrocarpum
0.20	195 Lanternosphaeridium bipolare	0.20	210 Tectatodinium psilatum	0.20	201 Operculodinium potomacense n. sp.
0.20	197 Lanternosphaeridium lappaceum	0.20	38 Dellandria wardenensis	0.20	138 Spiniferites crassipellis
0.20	198 Lanternosphaeridium pilatum n. sp.	0.20	115 Palaeocystodinium golzowense	0.20	213 Dellandria dilwynensis
0.20	200 Operculodinium amiculum n. sp.	0.20	215 Phthanoperidinium resistente	0.20	38 Dellandria wardenensis
0.20	110 Operculodinium centrocarpum	0.20	221 Wetzeliella (W.) coleothrypta	0.20	228 Dinopterygium cladoides
0.20	202 Schinodinium (S.) australiense	0.20	12 Areoligera sp.	0.20	229 ?Eisenackia scrobiculata
0.20	205 Spiniferites hypercanthus	0.20	229 ?Eisenackia scrobiculata	0.20	233 Heteraulacacysta lenmarnensis
0.20	151 Spiniferites ramosus subsp. ramosus	0.20	233 Heteraulacacysta lenmarnensis	0.20	234 Homotryblium alisum n. sp.
0.20	207 Spiniferites cf. S. ramosus subsp. ramosus	0.20	89 Impletosphaeridium rugosum	0.20	235 Impletosphaeridium transfodum
0.20	158 Tectatodinium pellitum	0.20	236 ?Litosphaeridium inversibuccinum		
0.20	210 Tectatodinium psilatum	0.20	165 Tubidermodinium sulcatum		
0.20	213 Dellandria dilwynensis				
0.20	38 Dellandria wardenensis				
0.20	115 Palaeocystodinium golzowense				
0.20	69 Heteraulacacysta campanula				
0.20	234 Homotryblium alisum n. sp.				
0.20	235 Impletosphaeridium transfodum				
0.20	236 ?Litosphaeridium inversibuccinum				

269		SPECIES
40.00	171	Wetzeliella (W.) lunaris
28.80	216	Spinidinium bilineatum n. sp.
14.20	160	Thalassiphora pelagica
10.20	170	Wetzeliella (W.) hamodenensis
6.40	151	Spiniferites ramosus subsp. ramosus
2.40	12	Areoligera sp.
2.00	2	Adnatosphaeridium multispinosum
1.00	71	Homotryblium tasmaniense
0.40	1	Achiella biformoides n. gen., n. comb.
0.40	187	Apteodinium incompositum n. sp.
0.40	27	Cordosphaeridium gracilis
0.40	191	Gonyaulacysta guiseppi subsp. major
0.40	22	Cleistosphaeridium diversispinosum
0.20	76	Hystrichokolpoma rigaude
0.20	138	Spiniferites crassipellis
0.20	148	Spiniferites ramosus subsp. granosus
0.20	38	Deflandria wardenensis
0.20	133	Spinidinium essoi

271		SPECIES
40.20	216	Spinidinium bilineatum n. sp.
26.20	171	Wetzeliella (W.) lunaris
13.00	151	Spiniferites ramosus subsp. ramosus
5.60	160	Thalassiphora pelagica
3.80	170	Wetzeliella (W.) hamodenensis
3.60	209	Spiniferites supparus
3.20	71	Homotryblium tasmaniense
2.40	12	Areoligera sp.
1.20	138	Spiniferites crassipellis
1.20	2	Adnatosphaeridium multispinosum
0.80	189	Diphyesopsis buccinata n. gen., n. sp.
0.80	98	Lingulodinium machaerophorum
0.40	76	Hystrichokolpoma rigaude
0.40	22	Cleistosphaeridium diversispinosum
0.20	1	Achiella biformoides n. gen., n. comb.
0.20	29	Cordosphaeridium inodes
0.20	41	Diphyes colligerum
0.20	191	Gonyaulacysta guiseppi subsp. major
0.20	38	Deflandria wardenensis

Correlation Matrix for PT17

Correlation Matrix for Variables: $X_1 \ldots X_5$

	264	265	266	269	271
264	1				
265	.97045	1			
266	.62956	.6265	1		
269	.58464	.59889	.96461	1	
271	.81201	.83367	.90005	.90565	1

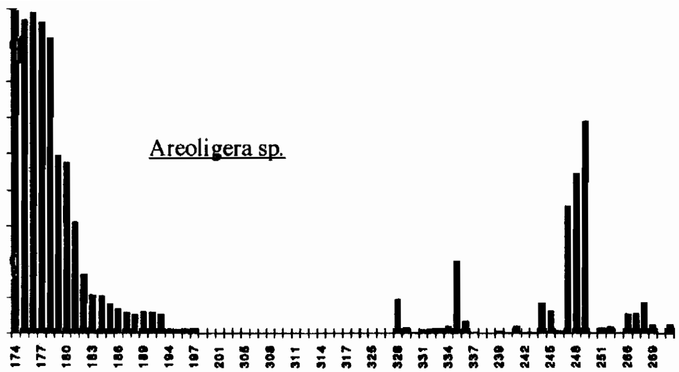
ANOVA Table for PT17

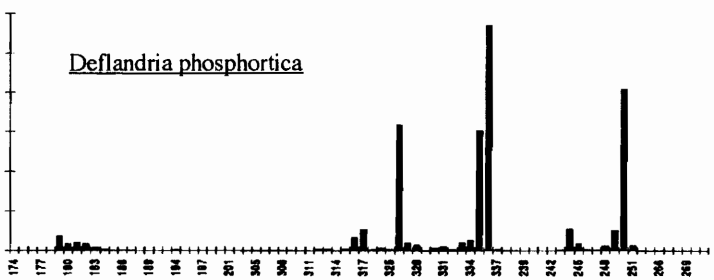
One Factor ANOVA-Repeated Measures for $X_1 \ldots X_5$

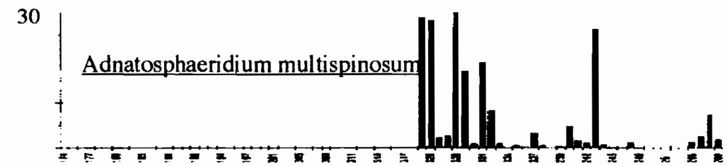
Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	254	12255.06867	48.2483	16.25591	.0001
Within subjects	1020	3027.408	2.96805		
treatments	4	.15354	.03838	.01288	.9997
residual	1016	3027.25446	2.97958		
Total	1274	15282.47667			

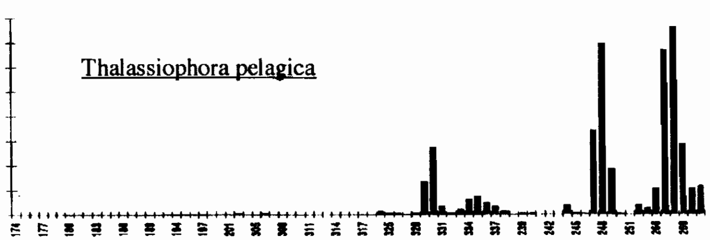
Reliability Estimates for- All treatments: .93848 Single Treatment: .75316

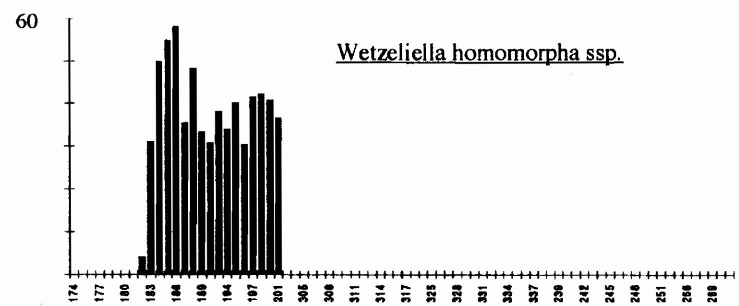
. Graphical representation of very common (> 25%) dinoflagellate species.



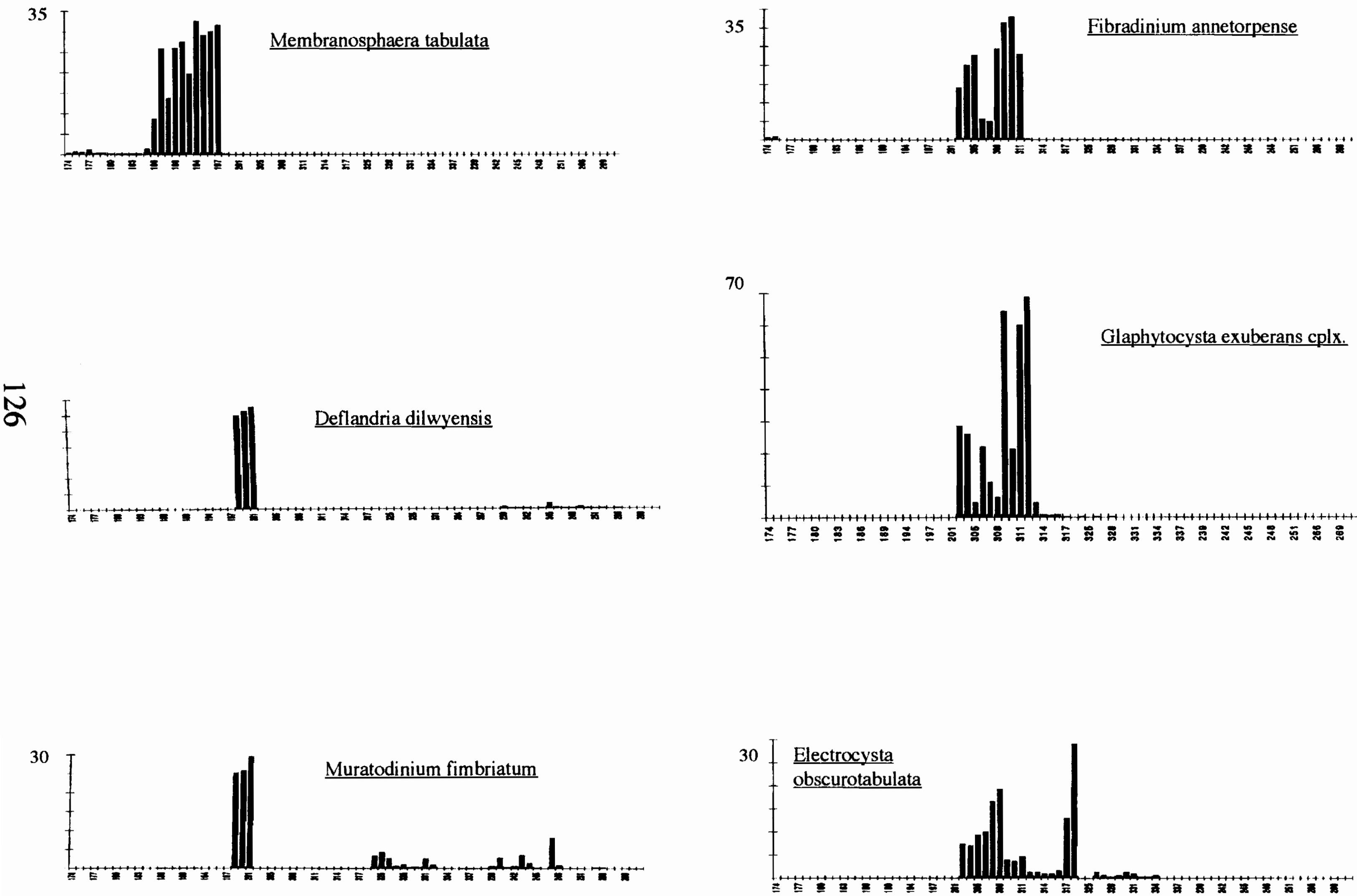






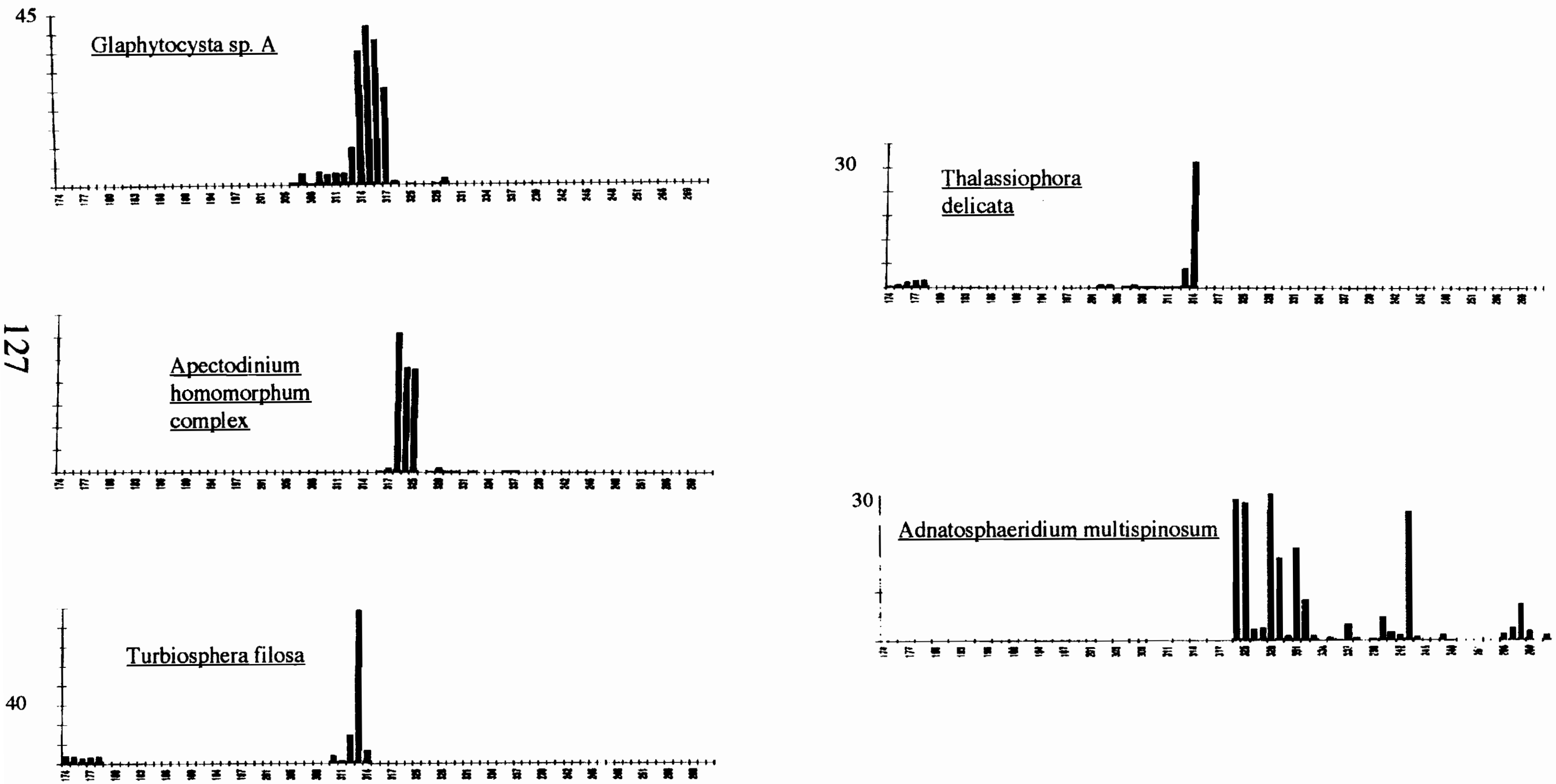


1

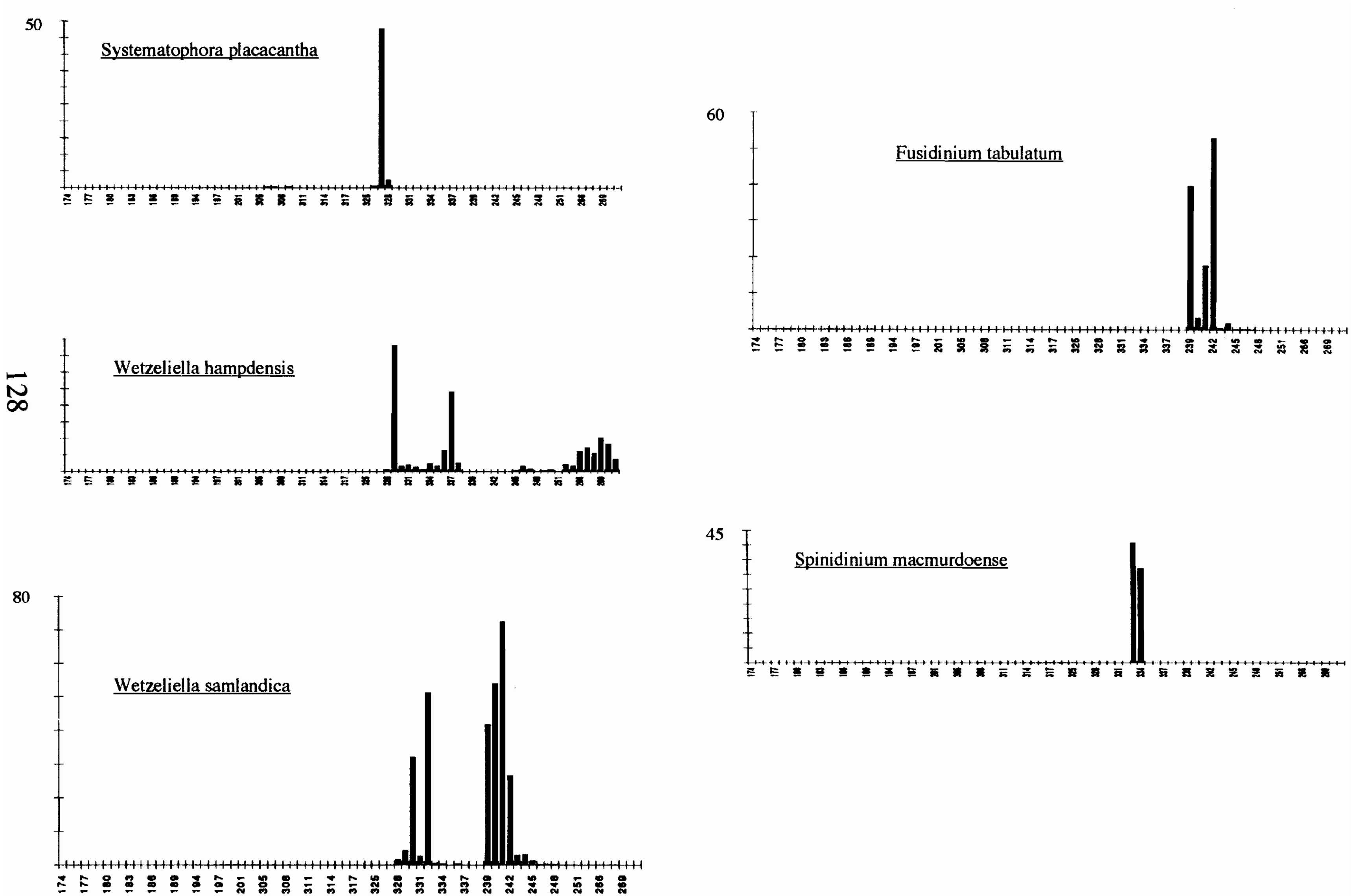


35
Membranosphaera tabulata
35
Fibradinium annetorpense
70
Glaphytocysta exuberans cplx.
Deflandria dilwyensis
30
Muratodinium fimbriatum
30
Electrocysta obscurotabulata

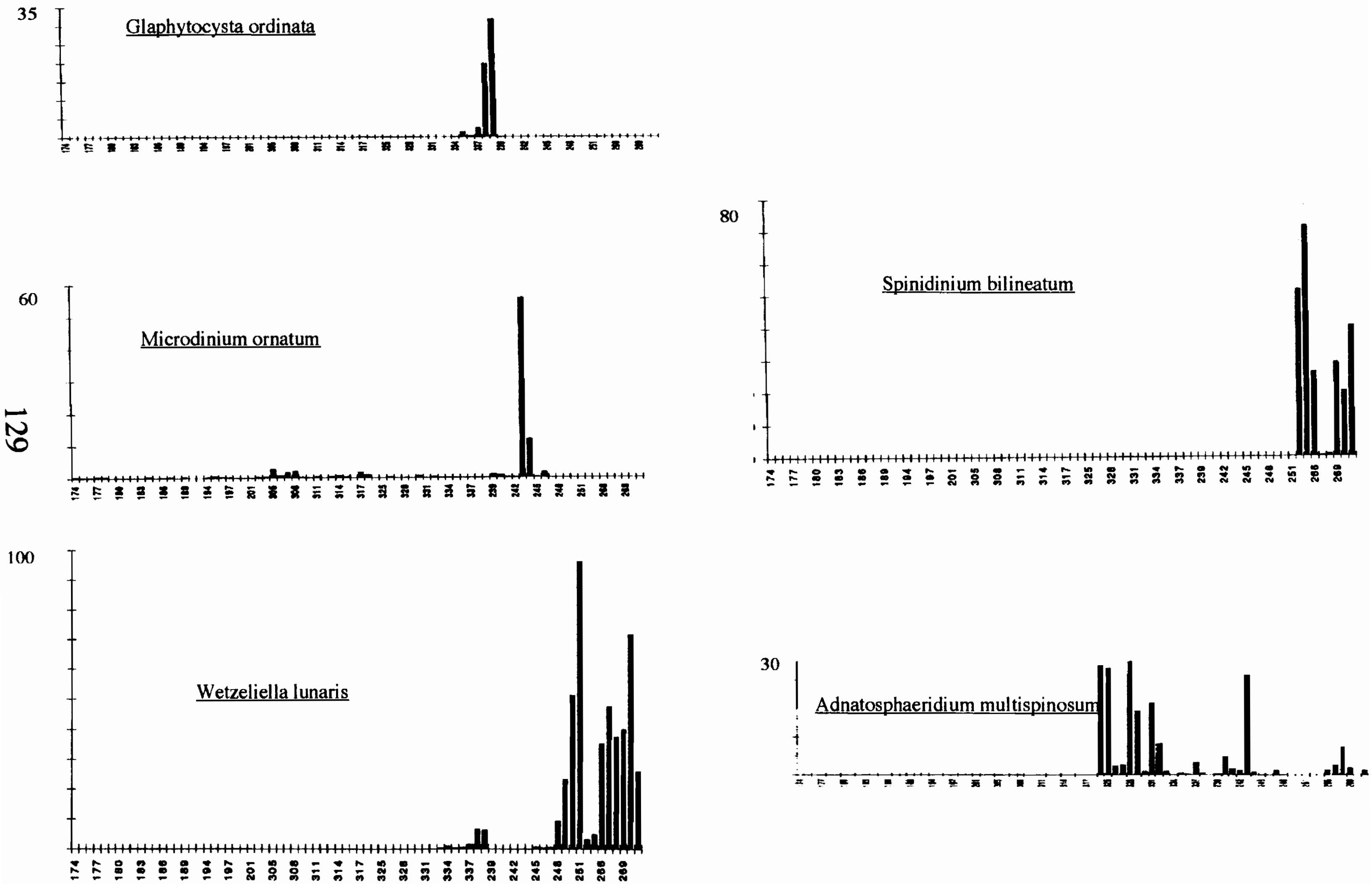
2


45
Glaphytocysta sp. A
Apectodinium homomorphum complex
Turbiosphera filosa
40
30
Thalassiophora delicata
30
Adnatosphaeridium multispinosum

3


50
Systematophora placacantha
Wetzeliella hampdensis
80
Wetzeliella samlandica
60
Fusidinium tabulatum
45
Spinidinium macmurdoense
174
177
180
183
186
189
194
197
201
305
308
311
314
317
325
328
331
334
337
239
242
245
248
251
266
269

4


35
Glaphytocysta ordinata
60
Microdinium ornatum
100
Wetzeliella lunaris
80
Spinidinium bilineatum
30
Adnatosphaeridium multispinosum

5

APPENDIX B:

MODERN ANALOG FORTRAN MODEL X, Z

MODEL OUTPUT DATA

```
C     DINOFLAGELLATE MODEL X
C     A DINOFLAGELLATE ECOSYSTEM DYNAMICS MODEL
C     5 DEGREES WARMER THAN BASIC YELLOW SEA MODEL
C     BY J. C. CAWLEY, 1996
C     X23   PHYTOPLANKTON POTENTIAL (NUTRIENT)
C     X1-X10   SPECIES 1-10
C     X11-22   CYSTS TO SEDIMENT
C
      IMPLICIT REAL (L,M)
      DIMENSION X(23),XD(23)
      DIMENSION AC(12)
      COMMON TDY
      REAL M41,M42,M43
      OPEN (6,FILE='CON')
      OPEN (7,FILE='C:OUT.DAT')
C SET INITIAL CONDITIONS
      DATA X /1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,
     +1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,500./
      DATA AC /1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1./
      D=05.
      TEMP=19.
      SAL=2.
C TA=TOTAL CYSTS IN SEDIMENT
      TA=1.
      N=4
      T=0.
      TMAX=1.0
C DT IS 0.001 YEAR
      DT=.001
C IOUTR IS THE NUMBER OF ITERATIONS PER OUTPUT
      IOUTR=83.33333333
C IOUT IS THE COUNTER FOR THE OUTPUT INTERVAL
      IOUT=IOUTR+1
C WRITE  COLUMN HEADINGS
      WRITE(6,1)D
      WRITE(7,1)D
1     FORMAT('(DEPTH=',F5.1,' METERS)')
C
      WRITE(6,2)
      WRITE(7,2)
2     FORMAT(' TIME,   SP1    SP2    SP3    SP4    SP5    SP6    SP7
     +SP8   SP9   SP10')
C
C BEGINNING OF CALCULATION LOOP
3     CONTINUE
      IF(IOUT.LT.IOUTR)GO TO 5
      WRITE(6,4)T,(X(I),I=1,10)
      WRITE(7,4)T,(X(I),I=1,10)
4     FORMAT('',F5.2,10F7.0)
      IOUT=0
5     IOUT=IOUT+1
C  CHECK FOR END OF SIMULATION
      IF(T.GE.TMAX)GO TO 99
      CALL RKS(X,XD,T,DT,N,D,TA,AC,TEMP,SAL)
      T=T+DT
      GO TO 3
99    STOP
      END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      SUBROUTINE DFQS(X,XD,T,N,D,TA,AC,TEMP,SAL)
```

```
      IMPLICIT REAL (L,M)
      DIMENSION XD(23),X(23)
      DIMENSION MONTH(14),S(14)
      DIMENSION AC(12)
C     COMMON TDY
C
C
C THIS SUBROUTINE CONTAINS THE DIFFERENTIAL EQUATIONS
C
C STATEMENTS BELOW ARE USED TO FLUCTUATE TIME FOR SEASONS
      TWY=T-AINT(T)
C  TDY IS TIME WITHIN YEAR IN DAYS
      TDY=TWY*365.
C  TR IS TWY IN RADIANS
        TR=(TWY)*6.28318
C  MONTH IS THE MIDDLE DAY OF EACH MONTH
      DATA MONTH/0.,15.,46.,74.,105.,136.,166.,196.,
     +227.,258.,288.,319.,349.,365./
C
C  STATEMENTS BELOW VARY TEMP AS A SEASONAL SINE FUNCTION
C    AMT IS THE ANNUAL MEAN WATER TEMPERATURE
      IF(D.LT.25.)AMT=15.
      IF((D.GE.25).AND.(D.LT.75))AMT=20
      IF(D.GE.75.)AMT=25.
C    TAMP IS THE AMPLITUDE OF THE TEMPERTATURE CURVE
      IF(D.LE.25.)TAMP=10.0
      IF((D.GT.25.).AND.(D.LE.50.))TAMP=5.0
      IF((D.GT.50.).AND.(D.LE.75.))TAMP=4.0
      IF(D.GT.75.)TAMP=4.0
C    TPS IS THE PHASE SHIFT OF TEMP CURVE IN RADIANS
      TPS=1.75585
      TEMP=AMT+SIN(TR-TPS)*TAMP
      FLAG=1
      IF (TEMP.LT.18.)FLAG=0.
C
C  STATEMENTS BELOW VARY SALINITY THROUGH TIME
        DATA S/1.2,1.1,1.1,0.8,0.6,0.8,0.8,1.1,
     +1.4,1.4,1.0,0.8,1.1,1.2/
        DO 101 I=1,14
101     IF(MONTH(I).GT.TDY)GOTO 102
102     HFA=(TDY-MONTH(I-1))/(MONTH(I)-MONTH(I-1))
        HMC=S(I)-S(I-1)
        SAL=(HFA*HMC)+S(I-1)
       IF(D.LT.15.)SAL=(SAL*1.4)
       IF((D.GE.15.).AND.(D.LE.25.))SAL=(SAL*2.0)
       IF((D.GT.25.).AND.(D.LE.50.))SAL=(SAL*2.5)
       IF((D.GT.50.).AND.(D.LE.75.))SAL=(SAL*3.0)
       IF(D.GT.75.)SAL=3.4
C    INPUTS, Z IS DEPENDANT ON DEPTH IN METERS
        Z1=150.
        IF(D.GT.100.)Z1=100.
        IF((D.LE.100.).AND.(D.GT.50.))Z1=150.
        IF((D.LE.50.).AND.(D.GT.25.))Z1=300.
        IF(D.LE.25.)Z1=750.
C
C THIS SECTION IS FOR SPECIES 1, A NEARSHORE 'BLOOMER'
C    THIS IS SPECIES 1 GROWTHRATE:
       V123=1.0*X(1)
       IF((TAMP.LT.4.).OR.(SAL.GE.2.5))X(1)=1.
       IF((TEMP.GE.20.).AND.(SAL.GT.1.))X(1)=(1.05*X(1))
```

```
      IF((TEMP.LT.15.).AND.(X(1).GE.10.)) X(1)=(0.95*X(1))
C    THESE ARE CONDITIONS OF SPECIES 1 ENCYSTMENT:
      IF(X(23).LT.50.)X(11)=((.1*X(1))+X(11))
      IF((TEMP.LT.23.02).AND.(TEMP.GT.23.))X(11)=((0.1*X(1))+X(11))
C    THIS IS WHAT HAPPENS IF SPECIES 1 RUNS OUT OF NUTRIENTS:
      IF(X(23).LT.50.)X(1)=1.
C
C THIS SECTION IS FOR SPECIES 10, AN OCEANIC FORM
C    THIS IS SPECIES 10 GROWTHRATE
      V1023=1.0*X(10)
      IF((TEMP.LT.18.).OR.(SAL.GT.2.0))X(10)=(1.02*X(10))
      IF((TEMP.LT.18.).OR.(SAL.LT.2.0))X(10)=1.
C    THESE ARE CONDITIONS OF SPECIES 10 ENCYSTMENT
      IF((TEMP.LT.18.02).AND.(FLAG.EQ.1.))X(20)=(0.50*X(10))+
     +X(20)
C    THIS IS WHAT HAPPENS IF SPECIES 10 RUNS OUT OF NUTRIENTS
      IF(X(23).LT.50.)X(10)=1.
C
C THIS SECTION IS FOR SPECIES 2, A COOLER NEARSHORE BLOOMER
C    THIS IS SPECIES 2 GROWTHRATE
       V223=1.0*X(2)
       IF(((TEMP.GT.15.).AND.(TEMP.LT.20.)).AND.(SAL.GT.1.))X(2)=
     +(1.05*X(2))
      IF((((TEMP.LT.15.).OR.(TEMP.GT.20.)).OR.(SAL.LE.1.)))
     +X(2)=1.
      IF(TAMP.LT.2.0)X(2)=1.
C    THESE ARE CONDITIONS OF SPECIES 2 ENCYSTMENT
      IF(X(23).LT.50)X(12)=(0.1*X(2))+X(12)
      IF((TEMP.LT.15.2).AND.(TEMP.GE.15.0))X(12)=(0.05*X(2))+X(12)
      IF((TEMP.GT.17.08).AND.(TEMP.LT.18.))X(12)=(0.05*X(2))+X(12)
C    THIS IS WHAT HAPPENS IF SPECIES 2 RUNS OUT OF NUTRIENTS
      IF (X(23).LT.50.)X(2)=1.
C
C THIS SECTION IS FOR SPECIES 9, AN OCEANIC FORM
C    THIS IS SPECIES 9 GROWTHRATE
      V923=1.0*X(9)
      IF((TEMP.GE.18.).AND.(SAL.GT.3.2))X(9)=1.03*X(9)
      IF((TEMP.LT.18.).OR.(SAL.LT.3.2))X(9)=1.
C    THESE ARE THE CONDITIONS OF SPECIES 9 ENCYSTMENT
      DO 111 I=1,14
111   IF(MONTH(I).GE.TDY)X(19)=(0.05*X(9))+X(19)
C    THIS IS WHAT HAPPENS IF SPECIES 9 RUNS OUT OF NUTRIENTS
      IF(X(23).LT.50.)X(9)=1.
C
C  THIS SECTION IS FOR SPECIES 3, AN OCEANIC FORM, ASSOC SP 4
C    THIS IS SPECIES 3 GROWTHRATE
      V323=1.0*X(3)
      IF((TEMP.GT.20.).AND.(SAL.GT.3.0))X(3)=(X(3)+20.)
      IF(X(4).LE.100.)X(3)=(1.01*X(4))
      IF(X(4).GT.100.)X(3)=(X(3)*0.99)
      IF((TEMP.LE.18.).OR.(SAL.LE.3.0))X(3)=10.
      IF(TAMP.LT.2.5)X(3)=(X(3)/100)
C    THESE ARE THE CONDITIONS OF SPECIES 3 ENCYSTMENT
      IF(X(23).LT.50.)X(13)=0.1*X(3)+X(13)
      IF(X(4).GE.100.)X(21)=(X(3)*0.1)+X(21)
C     THIS IS WHAT HAPPENS IF SPECIES 3 RUNS OUT OF NUTRIENTS
       IF (X(23).LT.50.)X(3)=1.
C
C  THIS SECTION IS FOR SPECIES 4, AN OCEANIC FORM
C     THIS IS SPECIES 4 GROWTHRATE
```

```
          IF((TEMP.GT.18.).AND.(SAL.GT.3.0))X(4)=(X(4)+30.)
          IF(X(3).LE.100.)X(4)=1.02*X(4)
          IF(X(3).GT.100.)X(4)=X(4)*0.90
          IF((TEMP.LE.18.).OR.(SAL.LE.3.0))X(4)=10.
          IF(TAMP.LT.2.5)X(4)=(X(4)/10)
C       THESE ARE THE CONDITIONS OF SPECIES 4 ENCYSTMENT
          IF(X(23).LT.50.)X(14)=(0.1*X(4))+X(14)
          IF(X(3).GE.100.)X(22)=(X(4)*0.1)+X(22)
C       THIS IS WHAT HAPPENS IF SPECIES 4 RUNS OUT OF NUTRIENTS
          IF (X(23).LT.50.)X(4)=1.
C
C   THIS SECTION IS FOR SPECIES 8, A MID-DEPTH COSMOPOLITAN FORM
C     THIS IS SPECIES 8 GROWTHRATE
        V823=1.0*X(8)
        IF((TEMP.GT.18.).AND.(SAL.GT.2.0))X(8)=1.02*X(8)
        IF((TEMP.GT.18.).AND.(TAMP.LT.2.))X(8)=1.005*X(8)
        IF((TEMP.LE.18.).OR.(SAL.LE.2.0))X(8)=1.
C     THESE ARE THE CONDITIONS OF SPECIES 8 ENCYSTMENT
        IF(X(23).LT.50.)X(18)=(0.1*X(8))+X(18)
        IF((TDY.GE.319.).AND.(TDY.LT.319.3))X(18)=(0.5*X(8))+X(18)
C     THIS IS WHAT HAPPENS IF SPECIES 8 RUNS OUT OF NUTRIENTS
        IF(X(23).LT.50.)X(8)=1.
C
C   THIS SECTION IS FOR SPECIES 7, A MIDDEPTH FORM
C      THIS IS SPECIES 7 GROWTHRATE
        V723=1.0*X(7)
        IF(((SAL.GT.1.5).AND.(TEMP.GT.17.)).AND.(X(8).LT.10.))
     +X(7)=1.01*X(7)
        IF(X(8).GE.500.)X(7)=5.
        IF((SAL.LE.1.5).OR.(TEMP.LE.17.))X(7)=1.
C     THESE ARE CONDITIONS OF SPECIES 7 ENCYSTMENT
        IF(X(23).LT.50.)X(17)=(0.1*X(7))+X(17)
        IF((TDY.GE.200.).AND.(TDY.LT.200.3))X(17)=(0.1*X(7))+X(17)
C     THIS IS WHAT HAPPENS IF SPECIES 7 RUNS OUT OF NUTRIENTS
        IF (X(23).LT.50.)X(7)=1.
C
C   THIS SECTION IS FOR SPECIES 6, A MIDDEPTH FORM
C     THIS IS SPECIES 6 GROWTHRATE
        V623=1.0*X(6)
        IF((SAL.LT.2.5).OR.(X(8).GT.100.))X(6)=(.75*X(8))
        IF((SAL.GT.2.5).AND.(X(8).LT.100.))X(6)=(1.008*X(6))
C     THESE ARE THE CONDITIONS OF SPECIES 6 ENCYSTMENT
        IF(X(23).LT.50.)X(16)=(0.1*X(6))+X(16)
        IF((TDY.GE.200.).AND.(TDY.LT.200.3))X(16)=(0.1*X(6))+X(16)
C     THIS IS WHAT HAPPENS IF SPECIES 6 RUNS OUT OF NUTRIENTS
        IF(X(23).LT.50.)X(6)=1
C
C   THIS SECTION IS FOR SPECIES 5, A MID DEPTH COOLER FORM
C     THIS IS SPECIES 5 GROWTHRATE
        V523=1.0*X(5)
        IF(((TEMP.GT.15.).AND.(TEMP.LT.18.)).AND.((SAL.GT.1.5).AND.
     +(SAL.LT.3.0)))X(5)=1.01*X(5)
        IF((TEMP.LE.15.).OR.(SAL.LE.1.5))X(5)=10.
        IF((TEMP.GE.18.).OR.(SAL.GE.3.0))X(5)=1.
C     THESE ARE THE CONDITIONS OF SPECIES 5 ENCYSTMENT
        IF(X(23).LT.50.)X(15)=(0.1*X(5))+X(15)
        IF((TDY.GE.300.).AND.(TDY.LT.300.3))X(15)=(0.1*X(5))+X(15)
C     THIS IS WHAT HAPPENS IF SPECIES 5 RUNS OUT OF NUTRIENTS
        IF(X(23).LT.50.)X(5)=1.
C
```

```
C     DIFFERENTIAL EQUATIONS
       XD(23)=Z1-V123-V223-V323-V423-V523-V623-V723-
      +V823-V923-V1023
       XD(1)=V123-(1.0*X(1))
       XD(2)=V223-(1.0*X(2))
       XD(3)=V323-(1.0*X(3))
       XD(4)=V423-(1.0*X(4))
       XD(5)=V523-(1.0*X(5))
       XD(6)=V623-(1.0*X(6))
       XD(7)=V723-(1.0*X(7))
       XD(8)=V823-(1.0*X(8))
       XD(9)=V923-(1.0*X(9))
       XD(10)=V1023-(1.0*X(10))
C
C THE FOLLOWING ARE THE BASELINE CHANGES FOR ENCYSTMENT
        XD(11)=0.
        XD(12)=0.
        XD(13)=0.
        XD(14)=0.
        XD(15)=0.
        XD(16)=0.
        XD(17)=0.
        XD(18)=0.
        XD(19)=0.
        XD(20)=0.
        XD(21)=0.
        XD(22)=0.
C
C TA EQUALS TOTAL CYSTS IN SEDIMENT
       TA=X(11)+X(12)+X(13)+X(14)+X(15)+X(16)+X(17)+
      +X(18)+X(19)+X(20)+X(21)+X(22)
C
C AC EQUALS THE PERCENT OF CYST TYPE IN TOTAL
       AC(1)=X(11)/TA
       AC(2)=X(12)/TA
       AC(3)=X(13)/TA
       AC(4)=X(14)/TA
       AC(5)=X(15)/TA
       AC(6)=X(16)/TA
       AC(7)=X(17)/TA
       AC(8)=X(18)/TA
       AC(9)=X(19)/TA
       AC(10)=X(20)/TA
       AC(11)=X(21)/TA
       AC(12)=X(22)/TA
       RETURN
       END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
       SUBROUTINE RKS(X,XD,T,DT,N,D,TA,AC,TEMP,SAL)
       DIMENSION X(23),XD(23)
       DIMENSION AC(12)
       DIMENSION XP(23),XQ(23),XR(23),XPD(23),XQD(23),XRD(23)
       DT2=DT/2
       T2=T+DT2
       TT=T+DT
       CALL DFQS(X,XD,T,N,D,TA,AC,TEMP,SAL)
       DO 1 I=1,23
1      XP(I)=X(I)+XD(I)*DT2
       CALL DFQS(XP,XPD,T2,N,D,TA,AC,TEMP,SAL)
       DO 2 I=1,23
```

```
2       XQ(I)=X(I)+XPD(I)*DT2
        CALL DFQS(XQ,XQD,T2,N,D,TA,AC,TEMP,SAL)
        DO 3 I=1,23
3       XR(I)=X(I)+XQD(I)*DT
        CALL DFQS(XR,XRD,TT,N,D,TA,AC,TEMP,SAL)
        DO 4 I=1,23
4       X(I)=X(I)+(XD(I)+2*XPD(I)+2*XQD(I)+XRD(I))*(DT/6.)
        RETURN
        END
```

(DEPTH= 60.0 METERS) MODEL X OUTPUT

TIME,	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
0.00	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.08	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.
0.17	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.
0.25	1.	13.	10.	10.	10.	1.	1.	1.	1.	1.
0.33	1.	720.	10.	10.	1.	1.	1.	1.	1.	1.
0.41	52.	1.	10.	10.	1.	1.	2.	1.	1.	1.
0.50	2961.	1.	10.	10.	1.	1.	4.	1.	1.	1.
0.58	1.	1.	10.	10.	1.	1.	1.	1.	1.	1.
0.66	1.	1.	10.	10.	1.	2.	3.	7.	1.	7.
0.75	1.	3.	10.	10.	1.	25.	3.	34.	1.	34.
0.83	1.	159.	10.	10.	2.	1.	1.	1.	1.	1.
0.91	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.
1.00	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.

(DEPTH= 70.0 METERS)

TIME,	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
0.00	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.08	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.
0.17	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.
0.25	1.	13.	10.	10.	10.	1.	1.	1.	1.	1.
0.33	1.	720.	10.	10.	1.	1.	1.	1.	1.	1.
0.41	52.	1.	10.	10.	1.	1.	2.	1.	1.	1.
0.50	2961.	1.	10.	10.	1.	1.	4.	1.	1.	1.
0.58	1.	1.	10.	10.	1.	1.	1.	1.	1.	1.
0.66	1.	1.	10.	10.	1.	2.	3.	7.	1.	7.
0.75	1.	3.	10.	10.	1.	25.	3.	34.	1.	34.
0.83	1.	159.	10.	10.	2.	1.	1.	1.	1.	1.
0.91	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.
1.00	1.	1.	10.	10.	10.	1.	1.	1.	1.	1.

(DEPTH= 80.0 METERS)

TIME,	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
0.00	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.08	1.	1.	1127.	270.	1.	2.	2.	5.	12.	5.
0.17	1.	1.	1609.	270.	1.	4.	3.	27.	135.	27.
0.25	1.	1.	1819.	270.	1.	103.	3.	138.	1560.	138.
0.33	1.	1.	96.	127.	1.	1.	1.	1.	1.	1.
0.41	1.	1.	188.	186.	1.	1.	1.	1.	1.	1.
0.50	1.	1.	276.	220.	1.	1.	1.	1.	2.	1.
0.58	1.	1.	63.	95.	1.	1.	1.	1.	1.	1.
0.66	1.	1.	223.	202.	1.	1.	1.	1.	1.	1.
0.75	1.	1.	63.	95.	1.	1.	1.	1.	1.	1.
0.83	1.	1.	170.	176.	1.	1.	1.	1.	1.	1.
0.91	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.00	1.	1.	63.	95.	1.	1.	1.	1.	1.	1.

(DEPTH= 60.0 METERS) MODEL Y OUTPUT

TIME,	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
0.00	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.08	1.	57.	10.	10.	1.	2.	1.	1.	1.	1.
0.17	1.	3265.	10.	10.	1.	4.	1.	1.	1.	1.
0.25	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.33	13.	1.	10.	10.	1.	1.	2.	1.	1.	1.
0.41	720.	1.	10.	10.	1.	5.	5.	7.	1.	7.
0.50	1.	1.	10.	10.	1.	2.	2.	4.	1.	4.
0.58	1.	1.	114.	141.	1.	1.	1.	1.	1.	1.
0.66	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.75	1.	1.	96.	127.	1.	1.	1.	1.	1.	1.
0.83	1.	9.	10.	10.	1.	1.	2.	2.	1.	2.
0.91	1.	488.	10.	10.	2.	1.	4.	1.	1.	1.
1.00	1.	29.	10.	10.	1.	2.	1.	1.	1.	1.

(DEPTH= 70.0 METERS)

TIME,	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
0.00	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.08	1.	57.	10.	10.	1.	2.	1.	1.	1.	1.
0.17	1.	3265.	10.	10.	1.	4.	1.	1.	1.	1.
0.25	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.33	13.	1.	10.	10.	1.	1.	2.	1.	1.	1.
0.41	720.	1.	10.	10.	1.	5.	5.	7.	1.	7.
0.50	1.	1.	10.	10.	1.	2.	2.	4.	1.	4.
0.58	1.	1.	114.	141.	1.	1.	1.	1.	1.	1.
0.66	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.75	1.	1.	96.	127.	1.	1.	1.	1.	1.	1.
0.83	1.	9.	10.	10.	1.	1.	2.	2.	1.	2.
0.91	1.	488.	10.	10.	2.	1.	4.	1.	1.	1.
1.00	1.	29.	10.	10.	1.	2.	1.	1.	1.	1.

(DEPTH= 80.0 METERS)

TIME,	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
0.00	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.08	1.	1.	1127.	270.	1.	2.	2.	5.	12.	5.
0.17	1.	1.	1609.	270.	1.	4.	3.	27.	135.	27.
0.25	1.	1.	1819.	270.	1.	103.	3.	138.	1560.	138.
0.33	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.41	1.	1.	133.	154.	1.	1.	1.	1.	1.	1.
0.50	1.	1.	1.	32.	1.	1.	1.	1.	1.	1.
0.58	1.	1.	114.	141.	1.	1.	1.	1.	1.	1.
0.66	1.	1.	1.	32.	1.	1.	1.	1.	1.	1.
0.75	1.	1.	96.	127.	1.	1.	1.	1.	1.	1.
0.83	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.91	1.	1.	114.	141.	1.	1.	1.	1.	1.	1.
1.00	1.	1.	1.	32.	1.	1.	1.	1.	1.	1.

```
C      DINOFLAGELLATE MODEL Z
C      A DINOFLAGELLATE ECOSYSTEM DYNAMICS MODEL
C      5 DEGREES WARMER  DEPTH CHANGE AND CYSTS (VERSION WITH FRONT)
C      BY J. C. CAWLEY, 1996
C      X23   PHYTOPLANKTON POTENTIAL (NUTRIENT)
C      X1-X10   SPECIES 1-10
C      X11-22   CYSTS TO SEDIMENT
C
       IMPLICIT REAL (L,M)
       DIMENSION X(23),XD(23)
       DIMENSION AC(12)
       COMMON TDY
       REAL M41,M42,M43
       OPEN (6,FILE='CON')
       OPEN (7,FILE='C:OUT.DAT')
C SET INITIAL CONDITIONS
       DATA X /1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,
      +1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,500./
       DATA AC /1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1./
       D=05.
       TEMP=19.
       SAL=2.
C TA=TOTAL CYSTS IN SEDIMENT
       TA=1.
       N=4
       T=0.
       TMAX=40.
C DT IS 0.001 YEAR
       DT=.001
C IOUTR IS THE NUMBER OF ITERATIONS PER OUTPUT
       IOUTR=2000
C IOUT IS THE COUNTER FOR THE OUTPUT INTERVAL
       IOUT=IOUTR+1
C WRITE  COLUMN HEADINGS
       WRITE(6,1)
       WRITE(7,1)
1      FORMAT(' TIME,  SP1 SP2 SP3 SP4 SP5 SP6 SP7 SP8 SP9 SP10 SP11
      +SP12')
C
C BEGINNING OF CALCULATION LOOP
3      CONTINUE
       IF(IOUT.LT.IOUTR)GO TO 2
       WRITE(6,5)D
       WRITE(7,5)D
5      FORMAT('TIME   (DEPTH=',F5.1,')')
       WRITE(6,4)T,(AC(I),I=1,12)
       WRITE(7,4)T,(AC(I),I=1,12)
4      FORMAT('',F5.2,12F5.2)
       D=(D+5.0)
       AC(1)=0.
       AC(2)=0.
       AC(3)=0.
       AC(4)=0.
       AC(5)=0.
       AC(6)=0.
       AC(7)=0.
       AC(8)=0.
       AC(9)=0.
       AC(10)=0.
       TA=0.
```

```
      IOUT=0
2     IOUT=IOUT+1
C  CHECK FOR END OF SIMULATION
      IF(T.GE.TMAX)GO TO 99
      CALL RKS(X,XD,T,DT,N,D,TA,AC,TEMP,SAL)
      T=T+DT
      GO TO 3
99    STOP
      END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      SUBROUTINE DFQS(X,XD,T,N,D,TA,AC,TEMP,SAL)
      IMPLICIT REAL (L,M)
      DIMENSION XD(23),X(23)
      DIMENSION MONTH(14),S(14)
      DIMENSION AC(12)
C     COMMON TDY
C
C
C THIS SUBROUTINE CONTAINS THE DIFFERENTIAL EQUATIONS
C
C STATEMENTS BELOW ARE USED TO FLUCTUATE TIME FOR SEASONS
      TWY=T-AINT(T)
C  TDY IS TIME WITHIN YEAR IN DAYS
      TDY=TWY*365.
C  TR IS TWY IN RADIANS
        TR=(TWY)*6.28318
C  MONTH IS THE MIDDLE DAY OF EACH MONTH
      DATA MONTH/0.,15.,46.,74.,105.,136.,166.,196.,
     +227.,258.,288.,319.,349.,365./
C
C  STATEMENTS BELOW VARY TEMP AS A SEASONAL SINE FUNCTION
C    AMT IS THE ANNUAL MEAN WATER TEMPERATURE
      IF(D.LT.25.)AMT=17.
      IF((D.GE.25).AND.(D.LT.75))AMT=18
      IF(D.GE.75.)AMT=25.
C    TAMP IS THE AMPLITUDE OF THE TEMPERTATURE CURVE
      IF(D.LE.25.)TAMP=10.0
      IF((D.GT.25.).AND.(D.LE.50.))TAMP=7.0
      IF((D.GT.50.).AND.(D.LE.75.))TAMP=6.0
      IF(D.GT.75.)TAMP=4.0
C    TPS IS THE PHASE SHIFT OF TEMP CURVE IN RADIANS
      TPS=1.75585
      TEMP=AMT+SIN(TR-TPS)*TAMP
      FLAG=1
      IF (TEMP.LT.18.)FLAG=0.
C
C  STATEMENTS BELOW VARY SALINITY THROUGH TIME
        DATA S/1.2,1.1,1.1,0.8,0.6,0.8,0.8,1.1,
     +1.4,1.4,1.0,0.8,1.1,1.2/
        DO 101 I=1,14
101     IF(MONTH(I).GT.TDY)GOTO 102
102     HFA=(TDY-MONTH(I-1))/(MONTH(I)-MONTH(I-1))
        HMC=S(I)-S(I-1)
        SAL=(HFA*HMC)+S(I-1)
       IF(D.LT.15.)SAL=(SAL*1.4)
       IF((D.GE.15.).AND.(D.LE.25.))SAL=(SAL*1.8)
       IF((D.GT.25.).AND.(D.LE.75.))SAL=(SAL*2.0)
       IF(D.GT.75.)SAL=3.4
C    INPUTS, Z IS DEPENDANT ON DEPTH IN METERS
        Z1=150.
```

```
        IF(D.GT.75.)Z1=100.
        IF((D.LE.75.).AND.(D.GT.25.))Z1=300.
        IF(D.LE.25.)Z1=750.
C
C THIS SECTION IS FOR SPECIES 1, A NEARSHORE 'BLOOMER'
C    THIS IS SPECIES 1 GROWTHRATE:
       V123=1.0*X(1)
       IF((TAMP.LT.4.).OR.(SAL.GE.2.5))X(1)=1.
       IF((TEMP.GE.20.).AND.(SAL.GT.1.))X(1)=(1.05*X(1))
       IF((TEMP.LT.15.).AND.(X(1).GE.10.)) X(1)=(0.95*X(1))
C    THESE ARE CONDITIONS OF SPECIES 1 ENCYSTMENT:
       IF(X(23).LT.50.)X(11)=((.1*X(1))+X(11))
       IF((TEMP.LT.23.02).AND.(TEMP.GT.23.))X(11)=((0.1*X(1))+X(11))
C    THIS IS WHAT HAPPENS IF SPECIES 1 RUNS OUT OF NUTRIENTS:
       IF(X(23).LT.50.)X(1)=1.
C
C THIS SECTION IS FOR SPECIES 10, AN OCEANIC FORM
C    THIS IS SPECIES 10 GROWTHRATE
       V1023=1.0*X(10)
       IF((TEMP.LT.18.).OR.(SAL.GT.2.0))X(10)=(1.02*X(10))
       IF((TEMP.LT.18.).OR.(SAL.LT.2.0))X(10)=1.
C    THESE ARE CONDITIONS OF SPECIES 10 ENCYSTMENT
       IF((TEMP.LT.18.02).AND.(FLAG.EQ.1.))X(20)=(0.50*X(10))+
     +X(20)
C    THIS IS WHAT HAPPENS IF SPECIES 10 RUNS OUT OF NUTRIENTS
       IF(X(23).LT.50.)X(10)=1.
C
C THIS SECTION IS FOR SPECIES 2, A COOLER NEARSHORE BLOOMER
C    THIS IS SPECIES 2 GROWTHRATE
        V223=1.0*X(2)
        IF(((TEMP.GT.15.).AND.(TEMP.LT.20.)).AND.(SAL.GT.1.))X(2)=
     +(1.05*X(2))
       IF(((TEMP.LT.15.).OR.(TEMP.GT.20.)).OR.(SAL.LE.1.)))
     +X(2)=1.
       IF(TAMP.LT.2.0)X(2)=1.
C    THESE ARE CONDITIONS OF SPECIES 2 ENCYSTMENT
       IF(X(23).LT.50)X(12)=(0.1*X(2))+X(12)
       IF((TEMP.LT.15.2).AND.(TEMP.GE.15.0))X(12)=(0.05*X(2))+X(12)
       IF((TEMP.GT.17.08).AND.(TEMP.LT.18.))X(12)=(0.05*X(2))+X(12)
C    THIS IS WHAT HAPPENS IF SPECIES 2 RUNS OUT OF NUTRIENTS
       IF (X(23).LT.50.)X(2)=1.
C
C THIS SECTION IS FOR SPECIES 9, AN OCEANIC FORM
C    THIS IS SPECIES 9 GROWTHRATE
       V923=1.0*X(9)
       IF((TEMP.GE.18.).AND.(SAL.GT.3.2))X(9)=1.03*X(9)
       IF((TEMP.LT.18.).OR.(SAL.LT.3.2))X(9)=1.
C    THESE ARE THE CONDITIONS OF SPECIES 9 ENCYSTMENT
       DO 111 I=1,14
111    IF(MONTH(I).GE.TDY)X(19)=(0.05*X(9))+X(19)
C    THIS IS WHAT HAPPENS IF SPECIES 9 RUNS OUT OF NUTRIENTS
       IF(X(23).LT.50.)X(9)=1.
C
C  THIS SECTION IS FOR SPECIES 3, AN OCEANIC FORM, ASSOC SP 4
C    THIS IS SPECIES 3 GROWTHRATE
       V323=1.0*X(3)
       IF((TEMP.GT.20.).AND.(SAL.GT.3.0))X(3)=(X(3)-20.)
       IF(X(4).LE.100.)X(3)=(1.01*X(4))
       IF(X(4).GT.100.)X(3)=(X(3)*0.99)
       IF((TEMP.LE.18.).OR.(SAL.LE.3.0))X(3)=10.
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      IF(TAMP.LT.2.5)X(3)=(X(3)/100)
C    THESE ARE THE CONDITIONS OF SPECIES 3 ENCYSTMENT
      IF(X(23).LT.50.)X(13)=0.1*X(3)+X(13)
      IF(X(4).GE.100.)X(21)=(X(3)*0.1)+X(21)
C     THIS IS WHAT HAPPENS IF SPECIES 3 RUNS OUT OF NUTRIENTS
       IF (X(23).LT.50.)X(3)=1.
C
C  THIS SECTION IS FOR SPECIES 4, AN OCEANIC FORM
C     THIS IS SPECIES 4 GROWTHRATE
        V423=1.0*X(4)
        IF((TEMP.GT.18.).AND.(SAL.GT.3.0))X(4)=(X(4)+30.)
        IF(X(3).LE.100.)X(4)=1.02*X(4)
        IF(X(3).GT.100.)X(4)=X(4)*0.90
        IF((TEMP.LE.18.).OR.(SAL.LE.3.0))X(4)=10.
        IF(TAMP.LT.2.5)X(4)=(X(4)/10)
C     THESE ARE THE CONDITIONS OF SPECIES 4 ENCYSTMENT
        IF(X(23).LT.50.)X(14)=(0.1*X(4))+X(14)
        IF(X(3).GE.100.)X(22)=(X(4)*0.1)+X(22)
C     THIS IS WHAT HAPPENS IF SPECIES 4 RUNS OUT OF NUTRIENTS
        IF (X(23).LT.50.)X(4)=1.
C
C  THIS SECTION IS FOR SPECIES 8, A MID-DEPTH COSMOPOLITAN FORM
C    THIS IS SPECIES 8 GROWTHRATE
      V823=1.0*X(8)
      IF((TEMP.GT.18.).AND.(SAL.GT.2.0))X(8)=1.02*X(8)
      IF((TEMP.GT.18.).AND.(TAMP.LT.2.))X(8)=1.005*X(8)
      IF((TEMP.LE.18.).OR.(SAL.LE.2.0))X(8)=1.
C    THESE ARE THE CONDITIONS OF SPECIES 8 ENCYSTMENT
      IF(X(23).LT.50.)X(18)=(0.1*X(8))+X(18)
      IF((TDY.GE.319.).AND.(TDY.LT.319.3))X(18)=(0.5*X(8))+X(18)
C    THIS IS WHAT HAPPENS IF SPECIES 8 RUNS OUT OF NUTRIENTS
      IF(X(23).LT.50.)X(8)=1.
C
C  THIS SECTION IS FOR SPECIES 7, A MIDDEPTH FORM
C     THIS IS SPECIES 7 GROWTHRATE
      V723=1.0*X(7)
      IF(((SAL.GT.1.5).AND.(TEMP.GT.17.)).AND.(X(8).LT.10.))
     +X(7)=1.01*X(7)
      IF(X(8).GE.500.)X(7)=5.
      IF((SAL.LE.1.5).OR.(TEMP.LE.17.))X(7)=1.
C    THESE ARE CONDITIONS OF SPECIES 7 ENCYSTMENT
      IF(X(23).LT.50.)X(17)=(0.1*X(7))+X(17)
      IF((TDY.GE.200.).AND.(TDY.LT.200.3))X(17)=(0.1*X(7))+X(17)
C    THIS IS WHAT HAPPENS IF SPECIES 7 RUNS OUT OF NUTRIENTS
      IF (X(23).LT.50.)X(7)=1.
C
C  THIS SECTION IS FOR SPECIES 6, A MIDDEPTH FORM
C    THIS IS SPECIES 6 GROWTHRATE
      V623=1.0*X(6)
      IF((SAL.LT.2.5).OR.(X(8).GT.100.))X(6)=(.75*X(8))
      IF((SAL.GT.2.5).AND.(X(8).LT.100.))X(6)=(1.008*X(6))
C    THESE ARE THE CONDITIONS OF SPECIES 6 ENCYSTMENT
      IF(X(23).LT.50.)X(16)=(0.1*X(6))+X(16)
      IF((TDY.GE.200.).AND.(TDY.LT.200.3))X(16)=(0.1*X(6))+X(16)
C    THIS IS WHAT HAPPENS IF SPECIES 6 RUNS OUT OF NUTRIENTS
      IF(X(23).LT.50.)X(6)=1
C
C  THIS SECTION IS FOR SPECIES 5, A MID DEPTH COOLER FORM
C    THIS IS SPECIES 5 GROWTHRATE
      V523=1.0*X(5)
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        IF(((TEMP.GT.15.).AND.(TEMP.LT.18.)).AND.((SAL.GT.1.5).AND.
     +(SAL.LT.3.0)))X(5)=1.01*X(5)
        IF((TEMP.LE.15.).OR.(SAL.LE.1.5))X(5)=10.
        IF((TEMP.GE.18.).OR.(SAL.GE.3.0))X(5)=1.
C     THESE ARE THE CONDITIONS OF SPECIES 5 ENCYSTMENT
        IF(X(23).LT.50.)X(15)=(0.1*X(5))+X(15)
        IF((TDY.GE.300.).AND.(TDY.LT.300.3))X(15)=(0.1*X(5))+X(15)
C     THIS IS WHAT HAPPENS IF SPECIES 5 RUNS OUT OF NUTRIENTS
        IF(X(23).LT.50.)X(5)=1.
C
C     DIFFERENTIAL EQUATIONS
       XD(23)=Z1-V123-V223-V323-V423-V523-V623-V723-
     +V823-V923-V1023
       XD(1)=V123-(1.0*X(1))
       XD(2)=V223-(1.0*X(2))
       XD(3)=V323-(1.0*X(3))
       XD(4)=V423-(1.0*X(4))
       XD(5)=V523-(1.0*X(5))
       XD(6)=V623-(1.0*X(6))
       XD(7)=V723-(1.0*X(7))
       XD(8)=V823-(1.0*X(8))
       XD(9)=V923-(1.0*X(9))
       XD(10)=V1023-(1.0*X(10))
C
C THE FOLLOWING ARE THE BASELINE CHANGES FOR ENCYSTMENT
        XD(11)=0.
        XD(12)=0.
        XD(13)=0.
        XD(14)=0.
        XD(15)=0.
        XD(16)=0.
        XD(17)=0.
        XD(18)=0.
        XD(19)=0.
        XD(20)=0.
        XD(21)=0.
        XD(22)=0.
C
C TA EQUALS TOTAL CYSTS IN SEDIMENT
       TA=X(11)+X(12)+X(13)+X(14)+X(15)+X(16)+X(17)+
     +X(18)+X(19)+X(20)+X(21)+X(22)
C
C AC EQUALS THE PERCENT OF CYST TYPE IN TOTAL
       AC(1)=X(11)/TA
       AC(2)=X(12)/TA
       AC(3)=X(13)/TA
       AC(4)=X(14)/TA
       AC(5)=X(15)/TA
       AC(6)=X(16)/TA
       AC(7)=X(17)/TA
       AC(8)=X(18)/TA
       AC(9)=X(19)/TA
       AC(10)=X(20)/TA
       AC(11)=X(21)/TA
       AC(12)=X(22)/TA
       RETURN
       END
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
       SUBROUTINE RKS(X,XD,T,DT,N,D,TA,AC,TEMP,SAL)
       DIMENSION X(23),XD(23)
```

```
      DIMENSION AC(12)
      DIMENSION XP(23),XQ(23),XR(23),XPD(23),XQD(23),XRD(23)
      DT2=DT/2
      T2=T+DT2
      TT=T+DT
      CALL DFQS(X,XD,T,N,D,TA,AC,TEMP,SAL)
      DO 1 I=1,23
1     XP(I)=X(I)+XD(I)*DT2
      CALL DFQS(XP,XPD,T2,N,D,TA,AC,TEMP,SAL)
      DO 2 I=1,23
2     XQ(I)=X(I)+XPD(I)*DT2
      CALL DFQS(XQ,XQD,T2,N,D,TA,AC,TEMP,SAL)
      DO 3 I=1,23
3     XR(I)=X(I)+XQD(I)*DT
      CALL DFQS(XR,XRD,TT,N,D,TA,AC,TEMP,SAL)
      DO 4 I=1,23
4     X(I)=X(I)+(XD(I)+2*XPD(I)+2*XQD(I)+XRD(I))*(DT/6.)
      RETURN
      END
```

MODEL 2 OUTPUT

```
 TIME,   SP1 SP2 SP3 SP4 SP5 SP6 SP7 SP8 SP9 SP10 SP11      SP12
TIME     (DEPTH=  5.0)
 0.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
TIME     (DEPTH= 10.0)
 2.00 0.90 0.00 0.01 0.01 0.00 0.00 0.00 0.00 0.08 0.00 0.00 0.00
TIME     (DEPTH= 15.0)
 4.00 0.89 0.00 0.01 0.01 0.00 0.00 0.00 0.00 0.09 0.00 0.00 0.00
TIME     (DEPTH= 20.0)
 6.00 0.89 0.00 0.01 0.01 0.00 0.00 0.00 0.00 0.09 0.00 0.00 0.00
TIME     (DEPTH= 25.0)
 8.00 0.89 0.00 0.01 0.01 0.00 0.00 0.00 0.00 0.09 0.00 0.00 0.00
TIME     (DEPTH= 30.0)
10.00 0.87 0.01 0.01 0.01 0.00 0.00 0.00 0.00 0.10 0.00 0.00 0.00
TIME     (DEPTH= 35.0)
12.00 0.85 0.01 0.01 0.01 0.00 0.00 0.00 0.00 0.10 0.00 0.00 0.00
TIME     (DEPTH= 40.0)
14.00 0.84 0.02 0.01 0.01 0.00 0.00 0.00 0.00 0.11 0.00 0.00 0.00
TIME     (DEPTH= 45.0)
16.00 0.83 0.02 0.01 0.01 0.00 0.00 0.00 0.00 0.12 0.00 0.00 0.00
TIME     (DEPTH= 50.0)
18.00 0.82 0.02 0.01 0.01 0.00 0.00 0.00 0.00 0.12 0.00 0.00 0.00
TIME     (DEPTH= 55.0)
20.00 0.81 0.03 0.01 0.01 0.00 0.00 0.00 0.00 0.13 0.00 0.00 0.00
TIME     (DEPTH= 60.0)
22.00 0.79 0.04 0.01 0.01 0.00 0.00 0.00 0.00 0.13 0.01 0.00 0.00
TIME     (DEPTH= 65.0)
24.00 0.78 0.05 0.01 0.01 0.00 0.00 0.00 0.00 0.14 0.01 0.00 0.00
TIME     (DEPTH= 70.0)
26.00 0.77 0.05 0.01 0.01 0.00 0.00 0.00 0.00 0.14 0.01 0.00 0.00
TIME     (DEPTH= 75.0)
28.00 0.77 0.06 0.01 0.01 0.00 0.00 0.00 0.00 0.14 0.01 0.00 0.00
TIME     (DEPTH= 80.0)
30.00 0.61 0.04 0.06 0.08 0.00 0.00 0.00 0.00 0.12 0.00 0.06 0.01
TIME     (DEPTH= 85.0)
31.99 0.52 0.04 0.09 0.13 0.00 0.00 0.00 0.00 0.11 0.00 0.09 0.01
TIME     (DEPTH= 90.0)
33.99 0.45 0.03 0.11 0.17 0.00 0.00 0.00 0.00 0.10 0.00 0.12 0.01
TIME     (DEPTH= 95.0)
35.99 0.40 0.03 0.13 0.20 0.00 0.00 0.00 0.00 0.10 0.00 0.13 0.01
TIME     (DEPTH=100.0)
37.99 0.36 0.03 0.14 0.22 0.00 0.00 0.00 0.00 0.09 0.00 0.15 0.01
TIME     (DEPTH=105.0)
39.99 0.32 0.03 0.15 0.24 0.00 0.00 0.00 0.00 0.09 0.00 0.16 0.01
```

APPENDIX C:

PLANTS 77 FORTRAN CLUSTER ANALYSIS PROGRAM

```
   DEBUG SUBCHK
C   DEBUG TRACE
C   AT 4839
C   TRACE ON
C   AT 12345
C   TRACE OFF
   END DEBUG
C*******************************************************************
*
C   PROGRAM PLANTS2 : PERFORMS CLUSTER ANALYSIS OF INPUT DATA.
*
C   WRITTEN BY PLANTS, REVISED BY ARNIE MILLER & TOM ROUNDS        *
C   MODIFIED BY BRET BENNINGTON                          *
C                                          *
C   FILEDEFS : 04 = INPUT OF PLOTTING AND CONTROL PARAMETERS       *
C           05 = INPUT OF DATA SET                      *
C           06 = OUTPUT OF TEXT OF RESULTS                *
C           07 = OUTPUT OF DATA SET (+/- INVERS. OR TRANSF.)    *
C           10 = OUTPUT OF PLOTTING INSTRUCTIONS            *
C                                          *
C*******************************************************************
*
C THE INPUT DATA WILL USUALLY BE IN THE FOLLOWING FORM:            *
C                                          *
C           N ROWS    : FOR SAMPLES(I),I=1,N_SAMPLES          *
C       BY   M COLUMNS : FOR SPECIES(J),J=1,M_SPECIES          *
C                                          *
C*******************************************************************
*
C CONTROL CARD PARAMETER: ITEST (USED TO SPECIFY Q OR R MODE)
*
C  ITEST = +1 : NO INVERSION OF DATA MATRIX (Q-MODE)           *
C  ITEST = -1 : INVERSION OF DATA MATRIX (R-MODE)            *
C  ITEST = 00 : ENDS RUN OF PROGRAM (THIS MUST BE ON THE VERY LAST
*
C           CARD FOR THE PROGRAM TO END SUCESSFULLY)          *
C         ALSO MAY BE USED TO CONVERT/INVERT DATA W/O
CALCULATING*
C          SIMILARITY COEFFICIENTS & W/O PLOTTING IF USED WITH   *
C          NCOEFF -1                          *
C                                          *
C SIM. COEFF. CODE: MCOEFF                          *
C  MCOEFF = 01 : NO TRANS. + JACCARD COEFF. (P/A)            *
C  MCOEFF = 02 : NO TRANS. + CZEK. (DICE) COEFF.            *
C  MCOEFF = 03 : PERCENT TRANS. + CZEK. COEFF.             *
C  MCOEFF = 04 : PERCENT MAX. TRANS. + CZEK. COEFF.           *
C  MCOEFF = 05 : LOG10 TRANS. + CZEK. COEFF.  -            *
C  MCOEFF = 06 : NO TRANS. + HOMOGEN. FUNCTION              *
C  MCOEFF = 07 : PERCENT TRANS. + HOMOGEN. FUNCTION           *
C  MCOEFF = 08 : PERCENT MAX. TRANS. + HOMOGEN. FUNCTION         *
C  MCOEFF = 09 : LOG10 TRANS. + HOMOGEN. FUNCTION            *
C  MCOEFF = 10 : D'BLE TRANS. IF INVERSION ELSE PERCENT TRANS.. +
DICE *
C           D'BLE TRANS = PERCENT TRANS. FOLLOWED BY PERCENT    *
```

```
C                    TRANS. AFTER INVERSION.          *
C  MCOEFF = 11 : PERCENT TRANS + FREEMAN-TUKEY TRANS. + CZEK.
COEFF.  *
C  MCOEFF = 12 : PERCENT TRANS. + CHORD DISTANCE COEFF. (CRD)        *
C                                 *
C NEW SIM. COEFF CODE : NCOEFF                              *
C  NCOEFF = -1 :TERMINATES RUN AFTER DATA TRANSFORMATION AND/OR
*
C          INVERSION WITHOUT CALCULATING SIMILARITY COEFFICIENTS *
C          AND WITHOUT PRODUCING A DENDROGRAM IF USED WITH       *
C          ITEST 00                    *
C  NCOEFF = 01 TO 09 : SAME AS MCOEFF                    *
C*******************************************************************
*
    INTEGER TITLE(20),FORMT(20),CSIM(7),LABEL(12),BLANK
     INTEGER M,N,ITEST,MCOEFF,NCOEFF,VAL1,VAL2,D,I,J,K,MT,NX,

*NPASS,IM1,LVROW,LVCOL,NBROW,NBCOL,NXM1,JADJ,NROWS,NUM,KOLT
,KOLF.
     *NROWT,IX,IXM1,NUMX,IC,NM1,NP1,IBOOK,INDEX1,INDEX2,NP,IPASS
    REAL
PERC,PMAX,PQ,PNO,V,W,VALMIN,VALMAX,SMAX,COMBO,HEIGHT,LENGTH
,
    *X,Y,YSCALE,CHARHT,XNUM,XSYM,YPOS,CONST
    REAL MULTTOT,SQTOTI,SQTOTK,CCOS,CRD
    INTEGER ROWCD(200,12),TEMCD(200,12),NUMBR(200)
    INTEGER    COLCD(200,12)
     REAL DATA(200,200),OUT(200,3),SIMCO(200,200),BOOK(200,200),
    *SUM(200),T(200),PLOCX(200),PLOCY(200),TMP(200,200)
    EQUIVALENCE (SIMCO,BOOK)
    DATA BLANK,IPASS/0,0/
4839  CALL PLOTS(0.0,50)
C*******************************************************************
*
C READ IN TITLE HEADING (UP TO 80 CHARACTERS)
4840  READ (5,100) TITLE
    WRITE (6,100) TITLE
100  FORMAT(20A4)
C*******************************************************************
*
C READ IN EXECUTION-TIME FORMAT FOR INPUT DATA
4841  READ (5,100) FORMT
    WRITE (6,100) FORMT
C*******************************************************************
*
C READ IN N (#ROWS/SAMPLES) & M (#COLS/SPECIES) AND FIND MAX. OF N
OR M
4842  READ (5,101) N,M
    WRITE(6,101) N,M
101  FORMAT(I3,2X,I3)
    D=N
    IF(M.GT.N) D=M
C*******************************************************************
*
```

```
C DIMENSIONALIZE ARRAYS
C FIND OUT HOW TO DIMENSIONALIZE ARRAYS AT EXECUTION TIME IF
POSSIBLE.
C*********************************************************************
*
C INITIALIZE COLUMN AND ROW CODE ARRAYS
   DO 1234 J=1,M
   DO 5678 K=1,12
   COLCD(J,K)=BLANK
5678  CONTINUE
1234  CONTINUE
   DO 8765 I=1,N
   DO 4321 K=1,12
   ROWCD(I,K)=BLANK
4321  CONTINUE
8765  CONTINUE
C*********************************************************************
*
C READ IN COLUMN CODES (12-A4 FIELDS EACH) FOR SPECIES, 1 TO A CARD.
23   DO 3 J=1,M
24    READ (5,100) (COLCD(J,K),K=1,12)
3    CONTINUE
C*********************************************************************
*
C READ IN ROW CODES (TWO 4-CHAR. FIELDS EACH) (USUALLY SAMPLES)
C  AND THE DATA MATRIX (N-ROWS BY M-COLUMNS)
25   DO 4 I=1,N
26     READ (5,100) (ROWCD(I,K),K=1,12)
27     READ (5,FORMT) (DATA(I,J),J=1,M)
C      READ (5,FORMT) (ROWCD(I,K),K=1,2),(DATA(I,J),J=1,M)
4    CONTINUE
12345 CONTINUE
C*********************************************************************
*
C READ IN HEIGHT AND LENGTH OF DENDROGRAM PLOT IN INCHES, ALONG
WITH
C  THE VALUE OF "NEWPEN", THE PLOT LINE THICKNESS (1-NARROW TO 5-
WIDE).
C  THEN CHECK FOR ILLEGAL VALUES AND SET TO MAXIMUM IF FOUND.
    READ (4,104) HEIGHT,LENGTH,NP
104   FORMAT(F4.1,1X,F4.1,1X,I1)
     IF(HEIGHT.GT.34.0) HEIGHT=34.0
C*********************************************************************
*
C READ IN CONTROL CARD PARAMETER (ITEST), AND SIM. COEFF. CODE
(MCOEFF)
   READ (4,102) ITEST,MCOEFF,CONST
102   FORMAT(I2,1X,I2,1X,F7.3)
C*********************************************************************
*
C TEST FOR ILLEGAL MCOEFF VALUE
   IF(MCOEFF.GE.1.OR.MCOEFF.LE.12) GO TO 835
   WRITE(6,105) MCOEFF
105   FORMAT('SIM COEFF. VALUE OF ',I2,' IS ILLEGAL.')
```

```
      GO TO 999
C*********************************************************************
*
C TEST FOR TRANSFORMATION TYPE (IF ANY)
835   IF(MCOEFF.EQ.1.OR.MCOEFF.EQ.2.OR.MCOEFF.EQ.6) GO TO 825
      IF(MCOEFF.EQ.4.OR.MCOEFF.EQ.8) GO TO 1226
      IF(MCOEFF.EQ.5.OR.MCOEFF.EQ.9) GO TO 1227
      IF(MCOEFF.EQ.11) GO TO 1228
C*********************************************************************
*
C CONVERTS RAW DATA TO PERCENTAGES : (MCOEFF=03,07,10,12)
1225  PERC=0.
      DO 89 I=1,N
      DO 87 J=1,M
      PERC=PERC+DATA(I,J)
87    CONTINUE
      DO 88 K=1,M
      DATA(I,K)=(100*DATA(I,K)/PERC)
88    CONTINUE
      PERC=0.
89    CONTINUE
      GO TO 825
C*********************************************************************
*
C PERFORM ARCSIN FREEMAN TUKEY TRANSFORMATION (MCOEFF=11)
1228  DO 404 I=1,N
       MULTTOT=0.0
       DO 408 J=1,M
        MULTTOT=MULTTOT+DATA(I,J)
408    CONTINUE
      DO 414 J=1,M
       DATA(I,J)=.5*(ASIN(SQRT(DATA(I,J)/(MULTTOT+1)))+
     $           ASIN(SQRT((DATA(I,J)+1)/(MULTTOT+1))))
414   CONTINUE
404   CONTINUE
      IF (IPASS.GT.0) GO TO 830
420   GO TO 825
C*********************************************************************
*
C COMPUTES A PERCENT MAXIMUM DATA TRANSFORMATION :
(MCOEFF=04,08)
1226  PMAX=0.
      DO 96 J=1,M
      DO 97 I=1,N
      IF(DATA(I,J).GT.PMAX) PMAX=DATA(I,J)
97    CONTINUE
      DO 98 I1=1,N
      DATA(I1,J)=(DATA(I1,J)/PMAX)*100.
98    CONTINUE
      PMAX=0
96    CONTINUE
      GO TO 825
C*********************************************************************
*
```

```
C COMPUTES A LOG10 TRANSFORMATION (MCOEFF=05,09)
C IF NO CONSTANT IS SPECIFIED A VALUE OF 1.0 WILL BE USED.
C (NOTE : DECILES WILL BE COMPUTED BASED ON A COUNT SIZE OF 300)
1227  IF(CONST.LT.0.0001) CONST=1.0
    DO 111 I=1,N
    DO 112 J=1,M
    DATA(I,J)=ALOG10((DATA(I,J)/30)+CONST)
112  CONTINUE
111  CONTINUE
C*****************************************************************
*
C TEST FOR DATA INVERSION (ITEST NEGATIVE)
825  IF(ITEST.GT.0) GO TO 830
C*****************************************************************
*
C INVERT 'DATA' MATRIX FOR R-MODE CLUSTERING.
800  DO 801 I=1,N
    DO 802 J=1,M
    TMP(J,I)=DATA(I,J)
802  CONTINUE
801  CONTINUE
    DO 805 I=1,N
    DO 806 J=1,M
    DATA(J,I)=TMP(J,I)
806  CONTINUE
805  CONTINUE
    DO 810 I=1,N
    DO 811 K=1,12
    TEMCD(I,K)=ROWCD(I,K)
811  CONTINUE
810  CONTINUE
    DO 815 J=1,M
    DO 816 K=1,12
    ROWCD(J,K)=COLCD(J,K)
816  CONTINUE
815  CONTINUE
    DO 821 I=1,N
    DO 822 K=1,12
    COLCD(I,K)=TEMCD(I,K)
822  CONTINUE
821  CONTINUE
    MT=M
    M=N
    N=MT
    IPASS = IPASS + 1
    IF(MCOEFF.EQ.10) GO TO 1225
C******************************************************************
C WRITE OUT DATA MATRIX (TRANSFORMED IF REQUESTED) TO FILEDEF
UNIT 07
830  WRITE (7,100) TITLE
    IF(MCOEFF.EQ.1.OR.MCOEFF.EQ.2.OR.MCOEFF.EQ.6) WRITE(7,301)
    IF(MCOEFF.EQ.3.OR.MCOEFF.EQ.7.OR.MCOEFF.EQ.12) WRITE(7,302)
    IF(MCOEFF.EQ.4.OR.MCOEFF.EQ.8) WRITE(7,303)
    IF(MCOEFF.EQ.10.AND.ITEST.LT.0) WRITE(7,313)
```

```
    IF(MCOEFF.EQ.10.AND.ITEST.GT.0) WRITE(7,302)
    IF(MCOEFF.EQ.5.OR.MCOEFF.EQ.9) WRITE(7,310) CONST
    IF(MCOEFF.EQ.11) WRITE(7,315)
    IF(MCOEFF.EQ.13) WRITE(7,315)
301  FORMAT(' NO TRANSFORMATION')
302  FORMAT(' PERCENT TRANSFORMATION')
303  FORMAT(' PERCENT-MAXIMUM TRANSFORMATION')
313  FORMAT(' DOUBLE TRANSFORMED')
315  FORMAT(' PERCENT AND FREEMAN-TUKEY TRANSFORMED')
310  FORMAT(' LOG-10 TRANSFORMATION, CONSTANT = ',F7.3)
    WRITE(7,304)
304  FORMAT('DATA IS IN A (10(F7.3,1X)) FORMAT')
    WRITE (7,200)
200  FORMAT(' ')
    DO 5 J=1,M
     WRITE (7,100) (COLCD(J,K),K=1,12)
5    CONTINUE
    DO 6 I=1,N
     WRITE(7,100) (ROWCD(I,K),K=1,12)
     WRITE(7,201) (DATA(I,J),J=1,M)
201  FORMAT(10(F7.3,1X))
6    CONTINUE
    WRITE (7,200)
C*********************************************************************
*
C TEST FOR END OF PROGRAM (USE TO CONVERT/INVERT DATA W/O
PERFORMING
C  CLUSTER ANALYSIS)
    READ(4,102) ITEST,NCOEFF,CONST
    IF(ITEST.EQ.0.AND.NCOEFF.LT.0) GO TO 9999
     IF(CONST.LT.0.0001) CONST=1.0
C*********************************************************************
*
C INITIALIZE MATRICES.
    DO 8 I=1,N
     SUM(I)=0.
     T(I)=1.
     NUMBR(I)=1
    DO 9 J=1,M
     SIMCO(I,J)=0.
9    CONTINUE
8    CONTINUE
C*********************************************************************
*
C TEST FOR SIM. COEFF. TYPE (JACCARD, CZEKANOWSKI, HQM, OR CRD)
    IF(MCOEFF.EQ.1) GO TO 125
     IF(MCOEFF.GE.6.AND.MCOEFF.LT.10) GO TO 126
    IF(MCOEFF.GE.12) GO TO 450
C*********************************************************************
*
C COMPUTE 'CZEKANOWSKI' COEFFICIENTS AND STORE IN LOWER
TRIANGULAR
C  (LESS DIAGONAL) PART OF MATRIX 'SIMCO'. (MCOEFF=02,03,04,05,10,11)
    DO 10 I=1,N
```

```
      DO 20 J=1,M
20    SUM(I)=SUM(I)+DATA(I,J)
      DO 30 K=1,I
      IF (I.EQ.K)GOTO 30
      W=0.
      DO 40 J=1,M
      VALMIN=AMIN1(DATA(I,J),DATA(K,J))
40    W=W+VALMIN
      SIMCO(I,K)=(2.*W)/(SUM(I)+SUM(K))
30    CONTINUE
10    CONTINUE
      GO TO 15
C*********************************************************************
*
C COMPUTE CHORD DISTANCE COEFFICIENTS AND STORE IN LOWER
TRIANGULAR
C  (LESS DIAGONAL) PART OF MATRIX 'SIMCO'. (MCOEFF=12)
450   DO 455 I=1,N
      DO 460 K=1,I
      IF (I.EQ.K)GOTO 460
      MULTTOT=0.
      SQTOTI=0.
      SQTOTK=0.
      DO 465 J=1,M
      MULTTOT=MULTTOT+(DATA(I,J)*DATA(K,J))
      SQTOTI=SQTOTI+DATA(I,J)**2
      SQTOTK=SQTOTK+DATA(K,J)**2
465   CONTINUE
      CCOS=MULTTOT/SQRT(SQTOTI*SQTOTK)
      CRD=SQRT(2.*(1-CCOS))
C-- ADJUST CRD TO O TO 1 LOW TO HIGH SCALE
      SIMCO(I,K)=1-CRD/SQRT(2.0)
460   CONTINUE
455   CONTINUE
      GO TO 15
C*********************************************************************
*
C HQM : FREQUENCY MODULATED RELATIVE HOMOGENEITY FUNCTION
(HALL 1967A)
C (MCOEFF=06,07,08,09)
126   DO 11 I=1,N
      DO 21 J=1,M
      SUM(I)=SUM(I)+DATA(I,J)
21    CONTINUE
      DO 31 K=1,I
      IF (I.EQ.K) GO TO 31
      W=0.0
      DO 41 J=1,M
      VALMIN=AMIN1(DATA(I,J),DATA(K,J))
      VALMAX=AMAX1(DATA(I,J),DATA(K,J))
      W=W+VALMIN
      V=V+VALMAX
41    CONTINUE
      SIMCO(I,K)=(W+(W*W/V))/(SUM(I)+SUM(K))
```

```
31   CONTINUE
11   CONTINUE
   GO TO 15
C*********************************************************************
*
C COMPUTE JACCARD COEFF (MCOEFF=01)
125  DO 95 I=1,N
    DO 94 K=1,I
    IF(I.EQ.K)GO TO 94
    PQ=0.
    PNO=0.
    DO 93 J=1,M
     IF(DATA(K,J).GT.0..AND.DATA(I,J).GT.0.)PQ=PQ+1.
     IF(DATA(K,J).GT.0..AND.DATA(I,J).EQ.0.)PNO=PNO+1.
     IF(DATA(K,J).EQ.0..AND.DATA(I,J).GT.0.)PNO=PNO+1.
93   CONTINUE
    SIMCO(I,K)=PQ/(PNO+PQ)
94   CONTINUE
95   CONTINUE
C*********************************************************************
*
C ARRAY'BOOK', WHICH OCCUPIES SAME LOCATIONS IN MEMORY AS
ARRAY 'SIMCO'
C  IN ORDER TO CONSERVE SPACE, WILL BE USED FOR BOOKKEEPING
PURPOSES.
C  ONLY THE UPPER TRIANGULAR (INCLUDING DIAGONAL) PART OF 'BOOK'
WILL BE
C  USED, SO VALUES CONTAINED IN 'SIMCO' WILL BE UNDISTURBED. EACH
COLUMN
C  IN ARRAY 'BOOK' CONTAINS THE NUMBERS OF THE SAMPLES
CLUSTERED
C  TOGETHER IN THE OPPOSITE COLUMN IN 'SIMCO'.
15   DO 16 I=1,N
16   BOOK(1,I)=FLOAT(N-I)+1.
     NX=N
     NPASS=1
C*********************************************************************
*
C 'SMAX' WILL CONTAIN THE LARGEST CORRELATION COEFFICIENT IN THE
CURRENT
C  'SIMCO' MATRIX. THE ROW AND COLUMN NUMBER OF THAT VALUE ARE
RECORDED
C  IN 'LVROW' AND 'LVCOL', RESPECTIVELY.  'SMAX' IS INITIALIZED AT THE
C  BEGINNING OF THE SEARCH TO A VALUE LOWER THAN THE FIRST
CORRELATION
C  COEFFICIENT ENCOUNTERED.  THE SAMPLES OR CLUSTERS WITH THESE
HIGHEST
C  VALUES WILL THEN BE CLUSTERED.
45    SMAX=SIMCO(2,1)-1.
     DO 50 I=2,NX
     IM1=I-1
     DO 51 J=1,IM1
     IF(SMAX.GE.SIMCO(I,J)) GO TO 51
     SMAX=SIMCO(I,J)
```

```
      LVROW=I
      LVCOL=J
51    CONTINUE
50    CONTINUE
C***********************************************************************
*
C SAMPLE (OR CLUSTER) NUMBERS ARE CLUSTERED AND THEIR
SIMILARITY
C  COEFFICIENT IS RECORDED IN ARRAY 'OUT' FOR LATER PRINTOUT AND
PLOT.
      COMBO=T(LVROW)+T(LVCOL)
      NBCOL=N-LVCOL+1
      NBROW=N-LVROW+1
      OUT(NPASS,1)=BOOK(1,NBCOL)
      OUT(NPASS,2)=BOOK(1,NBROW)
      OUT(NPASS,3)=SMAX
C***********************************************************************
*
C SIMILARITY COEFFICIENTS ARE CALCULATED FOR THE NEW CLUSTER &
COMPUTED
C  AND STORED IN 'SIMCO'. 'SIMCO' IS THEN COMPACTED BY REMOVING
THE ROW
C  AND COLUMN OF THE SAMPLE WITH THE LARGER NUMBER WHICH WAS
CLUSTERED.
C  ARRAY 'BOOK' IS ALSO UPDATED TO REFLECT THE CHANGE DUE TO THE
NEW
C  CLUSTERING.
      DO 60 I=1,NX
      IF(I.EQ.LVCOL) GO TO 60
      IF(I.LT.LVCOL) SIMCO(LVCOL,I)=
     *(T(LVCOL)*SIMCO(LVCOL,I)+T(LVROW)*SIMCO(LVROW,I))/COMBO
      IF(I.GT.LVCOL.AND.I.LT.LVROW) SIMCO(I,LVCOL)=
     *(T(LVCOL)*SIMCO(I,LVCOL)+T(LVROW)*SIMCO(LVROW,I))/COMBO
      IF(I.GT.LVROW) SIMCO(I,LVCOL)=
     *(T(LVCOL)*SIMCO(I,LVCOL)+T(LVROW)*SIMCO(I,LVROW))/COMBO
60    CONTINUE
      T(LVCOL)=COMBO
      NXM1=NX-1
      DO 70 I=LVROW,NXM1
      JADJ=0
      DO 75 J=1,I
      IF (J.EQ.LVROW) JADJ=1
      SIMCO(I,J)=SIMCO(I+1,J+JADJ)
75    CONTINUE
70    CONTINUE
C***********************************************************************
*
C ARRAY 'NUMBR' CONTAINS THE NUMBER OF SAMPLES COMPRISING
EACH CLUSTER.
      NROWS=NUMBR(LVCOL)
      NUM=NUMBR(LVROW)
      KOLT=NBCOL
      KOLF=NBROW
      DO 501 I=1,NUM
```

```
    NROWT=NROWS+I
    BOOK(NROWT,KOLT)=BOOK(I,KOLF)
501  BOOK(I,KOLF)=0.
    IF(LVROW.EQ.NX)GO TO 535
    DO 505 I=LVROW,NXM1
    IX=N-I+1
    IXM1=IX-1
    NUMX=MAX0(NUMBR(I),NUMBR(I+1))
    DO 515 IC=1,NUMX
    BOOK(IC,IX)=BOOK(IC,IXM1)
515  CONTINUE
505  CONTINUE
535  NUMBR(LVCOL)=NUMBR(LVCOL)+NUMBR(LVROW)
    IF(LVROW.EQ.NX) GO TO 545
    DO 510 I=LVROW,NXM1
510  NUMBR(I)=NUMBR(I+1)
545  NUMBR(NX)=0
    DO 550 I=1,NX
550  SIMCO(NX,I)=0.
    NPASS=NPASS+1
    NX=NX-1
    IF (NX.EQ.1) GO TO 80
    GO TO 45
80  CONTINUE
    NM1=N-1
C***********************************************************************
*
C WRITE OUT RESULTS AS TEXT FILE TO FILEDEF UNIT 06
    WRITE(6,100) TITLE
    WRITE(12,100) TITLE
      WRITE(12,'(I4,2X,"SAMPLES")') N
    WRITE(14,100) TITLE
2001 FORMAT(I5)
    IF(ITEST.EQ.1) WRITE(6,305)
305  FORMAT(' Q-MODE')
    IF(ITEST.EQ.-1) WRITE(6,306)
306  FORMAT(' R-MODE')
    IF(MCOEFF.EQ.1) WRITE(6,307)
307  FORMAT(' JACCARD COEFFICIENT')
    IF(MCOEFF.GE.2.AND.MCOEFF.LE.5) WRITE(6,308)
308  FORMAT(' CZEKANOWSKI COEFFICIENT')
    IF(MCOEFF.GE.6.AND.MCOEFF.LE.9) WRITE(6,309)
309  FORMAT(' HOMOGENEITY FUNCTION')
    IF(MCOEFF.EQ.1.OR.MCOEFF.EQ.2.OR.MCOEFF.EQ.6) WRITE(6,301)
    IF(MCOEFF.EQ.3.OR.MCOEFF.EQ.7) WRITE(6,302)
    IF(MCOEFF.EQ.4.OR.MCOEFF.EQ.8) WRITE(6,303)
    IF(MCOEFF.EQ.5.OR.MCOEFF.EQ.9) WRITE(6,310) CONST
    WRITE(6,200)
    WRITE(6,202)
202  FORMAT('SIM. COEFF. VALUES FOR DENDRO. BRANCHES:')
    DO 90 I=1,NM1
    VAL1=IFIX(OUT(I,1))
    VAL2=IFIX(OUT(I,2))
    WRITE(6,203) OUT(I,1),(ROWCD(VAL1,K),K=1,12),OUT(I,2),
```

```
     *(ROWCD(VAL2,K),K=1,12),OUT(I,3)
203    FORMAT(F4.0,'=',12A4,5X,F4.0,'=',12A4,5X,F5.3)
90  CONTINUE
    WRITE(6,200)
    WRITE(6,204)
204  FORMAT('DENDRO. BRANCH CODES IN DENDROGRAM ORDER')
    DO 91 I=1,N
    IBOOK=IFIX(BOOK(I,N))
     WRITE(12,'(F4.0)') BOOK(I,N)
    WRITE(14,205) I,(ROWCD(IBOOK,K),K=1,12)
C    WRITE(6,205) BOOK(I,N),(ROWCD(IBOOK,K),K=1,12)
205  FORMAT(I4,' = ',12A4)
91  CONTINUE
    WRITE(6,200)
C*******************************************************************
C PLOT THE DENDROGRAM. (SENDS PLOTTING INSTRUCTIONS TO FILEDEF
UNIT 10)
C 34 INCHES IS THE MAXIMUM WORKING HEIGHT FOR THIS ROUTINE ON
THE
C VERSATEC PLOTTER, WHILE THE LENGTH MAY BE CHOSEN AS DESIRED.
C THE VALUE OF "NEWPEN" DETERMINES THE PLOT LINE THICKNESS.
    CALL NEWPEN(NP)
C-------------------------------------------------------------------
C THIS DRAWS THE AXIS.
    DATA CSIM /4HCOEF,4HFICI,4HENT ,4HOF S,4HIMIL,4HARIT,4HY  /
      CALL  SAXIS(0.0,(HEIGHT+0.1),CSIM,25,LENGTH,0.0,0.1,0.1,
    *(LENGTH/10),(LENGTH/10))
C-------------------------------------------------------------------
C THIS SCALES THE DENDROGRAM.
     NP1=N+1
    YSCALE=HEIGHT/FLOAT(N)
     XNUM=LENGTH+0.2
     XSYM=LENGTH+0.9
     CHARHT=0.2
     IF(YSCALE.LT.0.25) CHARHT=0.075
     IF(YSCALE.LT.0.25) XSYM=LENGTH+0.7
    DO 601 I=1,N
    IBOOK=IFIX(BOOK(I,N))
    Y=FLOAT(NP1-I)
    PLOCX(IBOOK)=LENGTH
    PLOCY(IBOOK)=Y*YSCALE
C    IF(YSCALE.LT.0.15) GO TO 601
C-------------------------------------------------------------------
C THIS NUMBERS AND LABELS THE BRANCHES OF THE DENDROGRAM.
    YPOS=PLOCY(IBOOK)-(CHARHT/2)
     CALL NUMBER(XNUM,YPOS,CHARHT,BOOK(I,N),0.0,0)
    DO 71 K=1,12
    LABEL(K)=ROWCD(IBOOK,K)
71  CONTINUE
    CALL SYMBOL(XSYM,YPOS,CHARHT,LABEL,0.0,48)
601  CONTINUE
C-------------------------------------------------------------------
C THIS DRAWS THE DENDROGRAM'S BRANCHES.
    NM1=N-1
```

```
      DO 610 I=1,NM1
      X=LENGTH*OUT(I,3)
      INDEX1=IFIX(OUT(I,1))
      INDEX2=IFIX(OUT(I,2))
      CALL PLOT(PLOCX(INDEX1),PLOCY(INDEX1),3)
      CALL PLOT(X,PLOCY(INDEX1),2)
      CALL PLOT(X,PLOCY(INDEX2),2)
      CALL PLOT(PLOCX(INDEX2),PLOCY(INDEX2),2)
      PLOCX(INDEX1)=X
      PLOCY(INDEX1)=(PLOCY(INDEX1)+PLOCY(INDEX2))/2.
610   CONTINUE
      CALL PLOT(PLOCX(INDEX1),PLOCY(INDEX1),3)
      CALL PLOT(0.0,PLOCY(INDEX1),2)
C*********************************************************************
C TEST CONTROL CARD VALUE FOR END OF PROGRAM OR FOR RE-
EXECUTION OF
C  PROGRAM (IF REQUESTED)
      IF(ITEST.EQ.0)GO TO 999
      CALL PLOT(LENGTH+3.,0.,-3)
      GO TO 825
C END PROGRAM
*********************************************************
999   CONTINUE
      CALL PLOT(LENGTH+3.,0.,999)
      RETURN
9999  END
```

VITA: Jon C. Cawley

EDUCATION:

1994-1996 — **Virginia Polytechnic Institute and State Univ.,** Blacksburg, VA
Masters of Science. Defended July 29, 1996.
*Major Advisors: R. K. Bambach / D.M. McLean / B. Parker
*Topic: Dynamic Systems Analysis of Fossil Dinoflagellates from the Atlantic Coastal Plain, USA.

Aug. 1993 — **SD School of Mines and Technology/NJ State Museum**
Summer Field Course: Field Paleontology and Biostratigraphy
Crow Creek (Lakota Sioux) Lands, South Dakota
*Collected and Documented Cretaceous Vertebrates (Mosasaurs, Plesiosaurs, Turtles).
*Conducted stratigraphic measurement and sampling of Cretaceous Pierre Shale sections.
*Graduate level project: Palynological lab processing and investigation of fossil spores and pollen from Pierre Shale members; paper submitted.

1981-1986 — **The Pennsylvania State University,** State College, PA
Bachelor of Science
*Major: Earth Science (Geology) Minor: Writing
*Earth and Mineral Sciences Interest House member
- Chairman of academic committee, 1 year
- Creator and Editor of bi-weekly house newsletter. 1983-1986
- Field trip Officer for PSU Geosciences Club.

*PSU Museum of Anthropology, Intern (worked with European Paleolithics)

1983-1985

Undergraduate Thesis:
The Bradford Oil Basin: A Regional History of Oil Technology, 1986.
(39 thousand words)

EXPERIENCE:

August, 1995 — **Pennsylvania Registered Professional Geologist** # PG-001529-G

Sept. 1993 — **NICET Certification in Engineering Technology, Level 1**
Certification number: 084120

1989-Present — **CQS Inc.,** Harrisburg, PA
Development and Technical Partner
Develop and implement laboratory testing procedures; perform aggregate tests to PA and AASHTO specifications; develop environmental consulting programs; oversee field projects. Studies in Geomorphology and land use. Project work in limestone for sorbent purposes, field and lab projects in Alkali Silica Reactivity and use of fly ash as pozzolon.
*Corporate Officer, November 1990; AASHTO lab accreditation, July 1991.
*Co-author of PACA Resolution on Alkali Silica Reactivity. 1992.
*Named in Whos Who Registry of Business Leaders, 1994/1995

1989-1994

Temple University Geology Department, Philadelphia, PA
Manager
Organization of teaching labs and field trips; substitute lab instructor; responsibility for department equipment and vehicles; maintenance and operation of thin section lab, photography lab and darkroom; maintenance and expansion of teaching collections; design of geologic displays; liaison between vendors and department for purchasing of equipment; general support to faculty, staff and students.
*Member of Dean's Committee on Hazardous Chemicals
- Author of CAS Guidelines on Lab Training and Practice.

*Member of Dean's Security Task Force Committee.

1986-1989

Tethys Consultants Inc./ Mid-Atlantic Testing, Harrisburg, PA
Staff Geologist
Performed field geology; data reduction;report preparation and editing; implemented water sampling programs;established SARA III chemical inventories for industry. Assisted and implemented drilling programs in coal waste and limestone for cogeneration and aggregate use. Co-developed and set up Mid-Atlantic aggregates testing lab; performed aggregates tests to PA and AASHTO standards. Performed carbonate measurements for limestone in cogeneration.
*AASHTO accreditation for laboratory, April 1988 (1st in the U.S.)

UNIVERSITY TEACHING AND AWARDS

May, 1996

Virginia Polytechnic Institute -
1996 Tillman Excellence-in- Teaching Award.

May, 1995

Virginia Polytechnic Institute -
1995 Tillman Excellence-in-Teaching Award.

Virginia Tech, Paleontology 4304 Spring Semesters 1994 and 1995.
Lab Instructor
(Upper-level class included invertebrate, vertebrate, and botanical Paleontology for majors.)

Virginia Tech, Physical Geology 1104 Fall Semester 1994, Summer 1995. *Lab Instructor*
(Chosen for pilot program of interactive teaching for Physical Geology to nonmajors, Fall 1994.)

Virginia Tech, Historical Geology 1114 Summer 94, Fall and Spring 95/96. *Lab Instructor*
(Topics included land processes, fossils, time relationships. For majors/nonmajors.)

ACTIVITIES:

1995-1996

Sigma Gamma Epsilon - Earth Sciences National Honor Society.
Virginia Tech (Alpha Mu) Chapter. Blacksburg, VA
(Advisor for undergraduate Earth Sciences Honor Society. Placed emphasis on interdisciplinary communication between the different Earth Science departmental majors on campus.)