

PHYTOPLANKTON VARIATION IN BEAR CUT
AS RELATED TO TIDAL MOVEMENT

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Introduction

Many studies of the diurnal vertical variation of phytoplankton populations have been made. However, due to a great degree of turbulence, such variation would not be of much importance in a relatively shallow tidal channel. This study was designed to investigate changes in the phytoplankton population in such a channel.

Bear Cut is located between Virginia Key and Key Biscayne, Florida (L 25°43.9' N, Lo 80°09.1' W) and has a maximum depth of about 7 meters. It is the major tidal inlet for the southern half of Biscayne Bay (Rickenbacker Causeway to Featherbed Bank), and tidal effects from the Cut are felt over most of this area. Morrill and Olson (1955) believe that the line of equal influence (where tidal influence from the northern inlets -- Bakers Haulover, Government Cut, and Norris Cut -- balances the influence from Bear Cut) is approximately at the middle and west bridges of Rickenbacker Causeway. Therefore, influences on the Bear Cut water circulation from the northern part of the bay would be negligible. The plankton populations in Bear Cut, would be those from southern Biscayne Bay and the coastal area off of Key Biscayne, possibly influenced by the Gulf Stream. The problem was to determine the relative importance of these two populations on the phytoplankton distribution in Bear Cut.

I am very grateful to Miss Teen Kline for her assistance in the collection and preparation of the samples.

Methods

Three series of hourly samples were taken, two covering a 24 hour period (2 tidal cycles) and one covering 13 hours (one tidal cycle). All samples were taken at the surface from the acoustics tower in the center of Bear Cut for Stations I and II, and from the end of the Institute of Marine Science dock for Station III, using a plastic bucket. Water temperature measurements were made using a standard -20° to 110°C . thermometer and salinity samples were taken and later determined on a salinity bridge (temperature was measured for Stations I and II, salinities for Station II). The plankton samples were taken in bottles of uniform volume, but different size samples were taken at different stations. Since quantitative counts were made only for Station III, however, the differences are not significant. A liter sample was taken in this case. The samples were centrifuged in a Kimball-Wood (1965) centrifuge, and fluorescence and acridine orange counts (Wood, 1955) were made for quantitative purposes. It was possible to make fluorescence counts at Station III only. The remaining material was used for qualitative determination of the populations.

The methods used for qualitative work were varied. The samples from Station I were digested in hot concentrated HCl and HNO_3 , and were then centrifuged, washed with distilled water, and were made into permanent slides. Samples from the second station were divided into two portions, one being preserved with Lugol's iodine, and the other being stored at 10°C . for later examination. The third set of samples was examined live, immediately after collection, and was then preserved with Lugol's iodine.

Qualitative examination of the concentrated samples was made by placing a few drops of the gravity precipitated material in a

well slide (as described by Wood, 1965). The only objects which could be identified in the acid-treated slides (Station I) were diatom frustules, for the treatment destroyed all organisms containing calcium carbonate (coccolithophores, foraminifera) and other delicate phytoplankton (naked flagellates and dinoflagellates). Preservation with Lugol's iodine (Station II) probably destroyed the flagellates and perhaps some other delicate organisms. Consequently, live examination (Station III) proved to be best for a complete picture of the population. Abundance was determined by examining the slides and estimating the relative proportions of the most common organisms. The following publications were used for identification of the organisms: Cupp(1943), Gemeinhardt (1930), Rabenhorst (1933), Schiller (1930), Schmidt (1875-19--), Van Heurck (1880-1881). Most identifications were made only to genus, due to the quantity of material to be examined.

Results

Temperature variations are seen from Fig. 4 to vary with incident radiation, the highest temperatures being reached at about 1300 to 1400 hours. Other variations are probably due to such factors as cloud cover, rain, etc. However, it does not seem that there is a noticeable difference between the offshore and bay waters.

Salinity changes, although they also vary seasonally, can be seen to vary with the incoming and outgoing water masses (Fig. 4). Here, the higher salinities are found at low tide, due to more evaporation in the bay than in the offshore waters. Thus, salinity might be used as an accurate indication of the true time of slack tides. As seen in Fig. 4, the high and low tides, indicated by the lowest and highest salinities, respectively, were between one and two hours later than those predicted in the U.S.C.&G.S. Tide Tables (1964), as corrected by Platt (1960, unpublished), who found

the tides in Bear Cut to be fifty minutes later than those of Government Cut.

The variations found in phytoplankton populations are given in Figs. 1, 2, & 3, and in Table 1.

At the first station, Chaetoceros sp. (possibly Ch. diversus) was dominant at low tide, and far outnumbered other organisms present. Navicula and Cocconeis dominated at high tide, but the total high tide population was significantly smaller than that of low tide. The paucity of organisms in the first six samples is very likely due to faulty treatment of the organisms when the slides were made. However, a regular cyclic pattern can be seen, and probably should be extrapolated to include the first six samples.

At Station II, five weeks later, Chaetoceros spp. were also dominant at low tide, but in this case, there were a great many different species present, all in good quantity. Here, Chaetoceros diversus (?), Ch. affinis, Ch. laciniosus, and Ch. didymus were all quite abundant. Nitzschia closterium and N. seriata were abundant with the Chaetoceros population. At high tide (0130) the Chaetoceros-Nitzschia population almost disappeared, being replaced by various species of Navicula, which could not be identified. The second high tide (1400 hours) did not follow the preceding pattern, although Chaetoceros was again depleted.

Fluorescence counts, made at Station III, showed a great abundance of chlorophyll-containing organisms at low tide, almost entirely due to chains of Skeletonema costatum, accompanied by Rhizosolenia fragillissima, another chain forming species. There was a great deal of morphological variation within Skeletonema, the cells varying from long and slender with very short connecting

setae, to short, broad cells connected by much longer setae. Dinoflagellates were very abundant here, especially at higher tides, a great variety of Peridinium spp. being observed. They could perhaps have been important at other stations, but were not preserved by the methods employed. On this date there was a very strong and constant east wind which tended to delay low tide and raise high tide, by pushing the water inland. This, accompanied by the discrepancy in tides noted in figure 1, would probably have delayed low tide by at least two hours, coinciding with the change in population at 1900 hours. It should also be noted that the predicted tidal range was considerably greater here, than at the other two stations, and this was undoubtedly augmented by the strong winds.

Discussion

It can be seen that there is great variation in the phytoplankton population in Bear Cut as the tides change, the bay population being present at low tide and the offshore one at high tide, with regular gradations during flooding and ebbing tides. Also, there was a considerable change in the dominant species as the season progressed. It is interesting to note that almost all of the abundant species in the bay population were chain-forming types (Chaetoceros and Skeletonema, as well as Rhizosolenia fragillissima, Nitzschia seriata, and Thalassionema nitzschiodes at various times), whereas the most characteristic offshore types were Navicula and Cocconeis (single, oval-shaped organisms). Also of interest is the fact that when one species was dominant, it was accompanied by other members of the same genus in large quantity (Chaetoceros, Nitzschia, Navicula).

Biscayne Bay is very shallow throughout most of its area

(usually between 1 and 4 m. deep), the only deep areas (10 m. or more) being in Government Cut and the Main Ship Channel in the northern half of the bay (Morrill and Olson, 1955). For this reason, the wind has a great effect on water circulation, which would thus vary consistently with the seasons, since prevailing winds vary with the seasons, as well as with daily fluctuations. Also, the overall shallowness would cause a great deal of turbulence, especially where depths change abruptly and a swift current exists (up to 3 knots in Bear Cut). Consequently, evaluation of this phytoplankton data as to origin of populations, etc. is extremely difficult, if not actually impossible. The organisms which are present in small quantity are probably of no use, except for the demonstration of turbidity (Pleurosigma sp. - benthic, Licmophora, Achnanthes - epiphytic). The normal pattern of tidal circulation through Bear Cut is given in Figure 5.

The species which are very abundant at low tide probably come from the ^{area} south of Rickenbacker Causeway to about Dinner Key Marina and the middle of Key Biscayne. The high tide species probably come from the offshore waters east of Key Biscayne. Since more water comes in through Bear Cut on the flooding tide, than leaves at ebb (Morrill and Olson, 1955), the dominance of Skeletonema in so many of the samples of Station III would indicate that the bay population probably extends at least to the end of Bear Cut, the offshore population entering the western end, where the samples were taken, only at the peak of high tide. The earlier predominance of Chaetoceros (Stations I & II), seems to be more limited to low tide, and probably was not as extensive, at least in the direction of the Cut.

Since the two populations were always quite different and relatively distinct, it would seem to be a relatively simple matter to follow the population changes of at least the northern half of southern Biscayne Bay by taking a sample at low tide from the dock. Centrifugation, fluorescence counts, and live examination would take no more than an hour and, if done every four to six days, would probably present quite a clear picture of seasonal changes within the bay. The offshore populations, generally were not as distinctive as the inshore ones, although occasionally at the peak of high tide (Station III, sample 5, being quite a bit higher than usual due to winds and spring tides) many new genera were found.

Conclusions

1. The protoplankton population in Bear Cut was found to vary with the tide, species from Biscayne Bay being present at low tide and those from offshore areas dominating at high tide.
2. Chain-forming species were found to be extremely abundant in the bay and relatively scarce in offshore waters, whereas Naviculoid types dominated in the latter area.
3. It is concluded that seasonal changes in the bay could be easily followed by sampling every four to six days, from the Marine Lab dock, at low tide. In further studies dealing with the tides it must be kept in mind that the tides are influenced by winds, etc., and may not correspond very closely to those predicted in the U.S.C. & G.S. Tide Tables. For this reason, salinities should be taken to determine the true time of the slack tides.

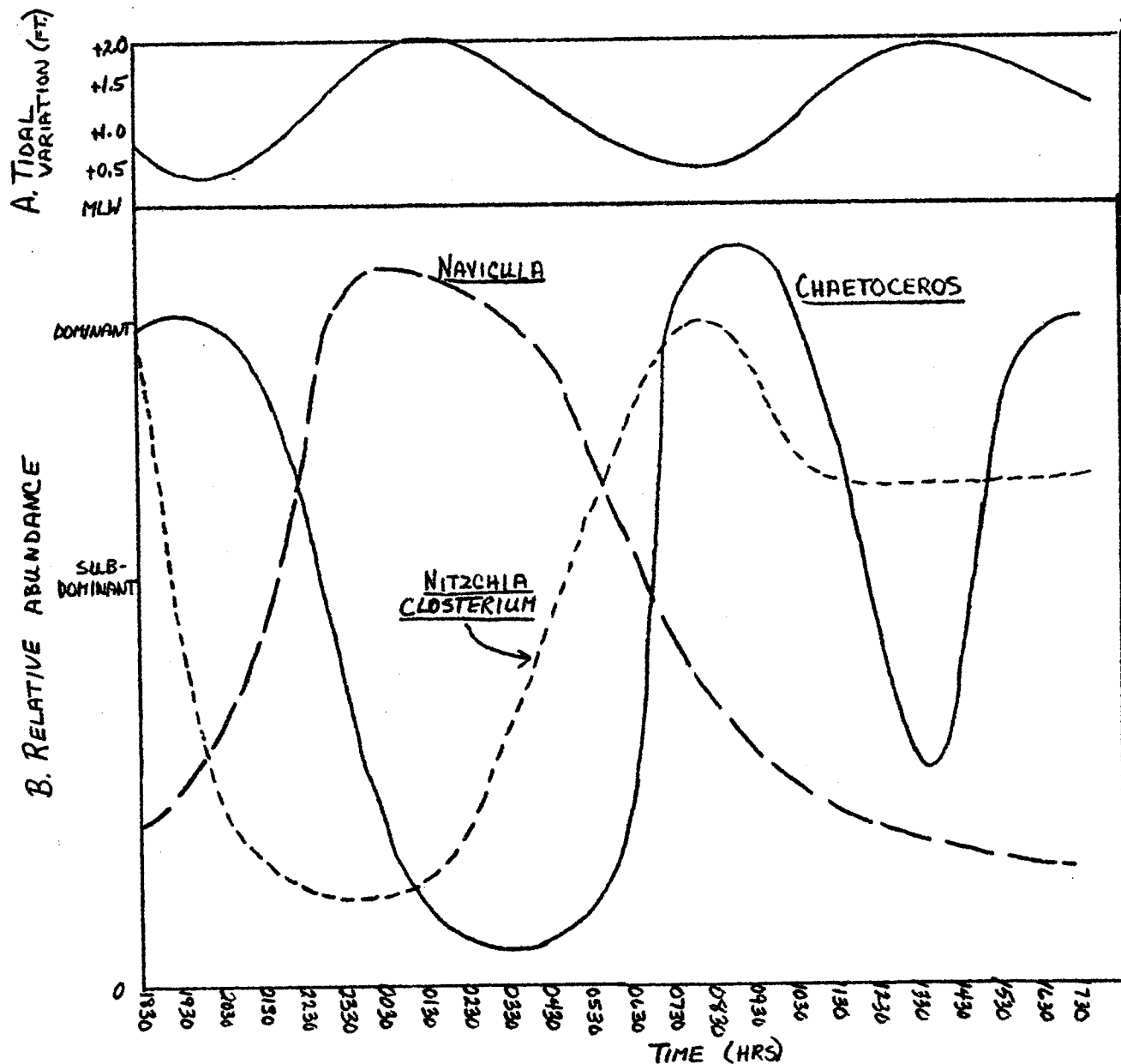


FIGURE 2 A. PREDICTED TIDAL VARIATION
 B. RELATIVE ABUNDANCE OF DOMINANT PHYTOPLANKTON TYPES
 (BEAR CUT. STATION II - 22,23 APRIL, 1965)

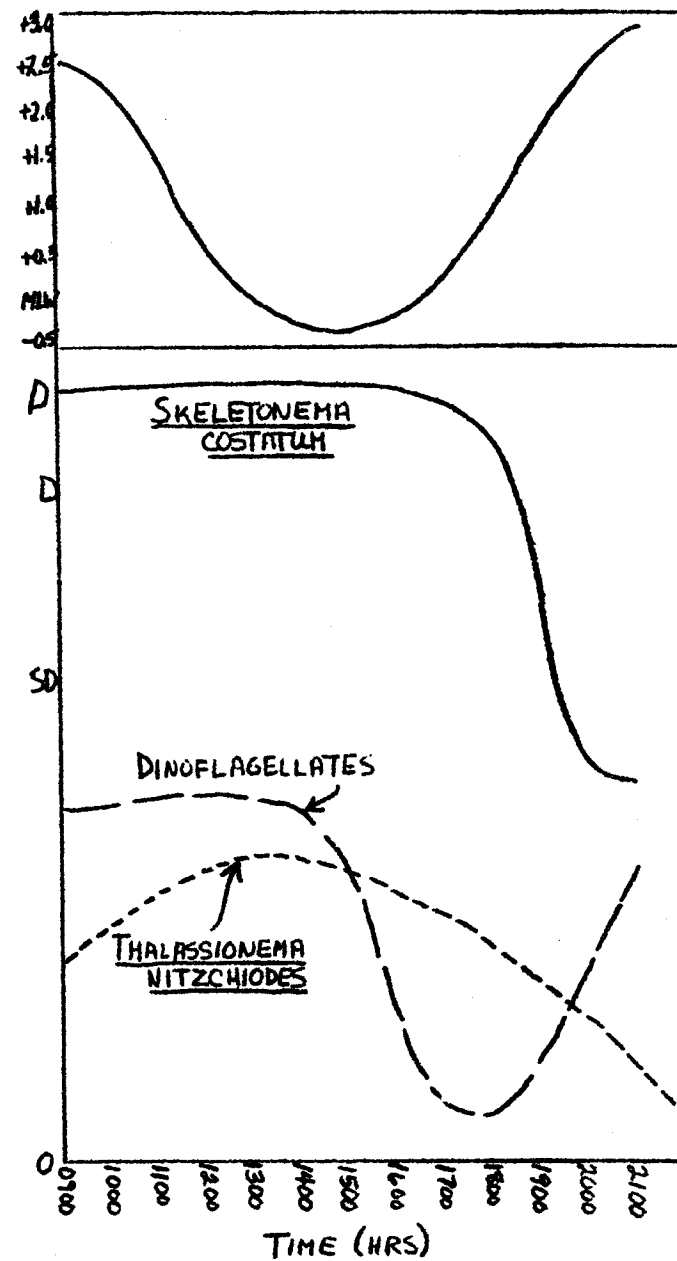


FIGURE 3. (BEAR CUT. STATION III
 15 MAY, 1965)

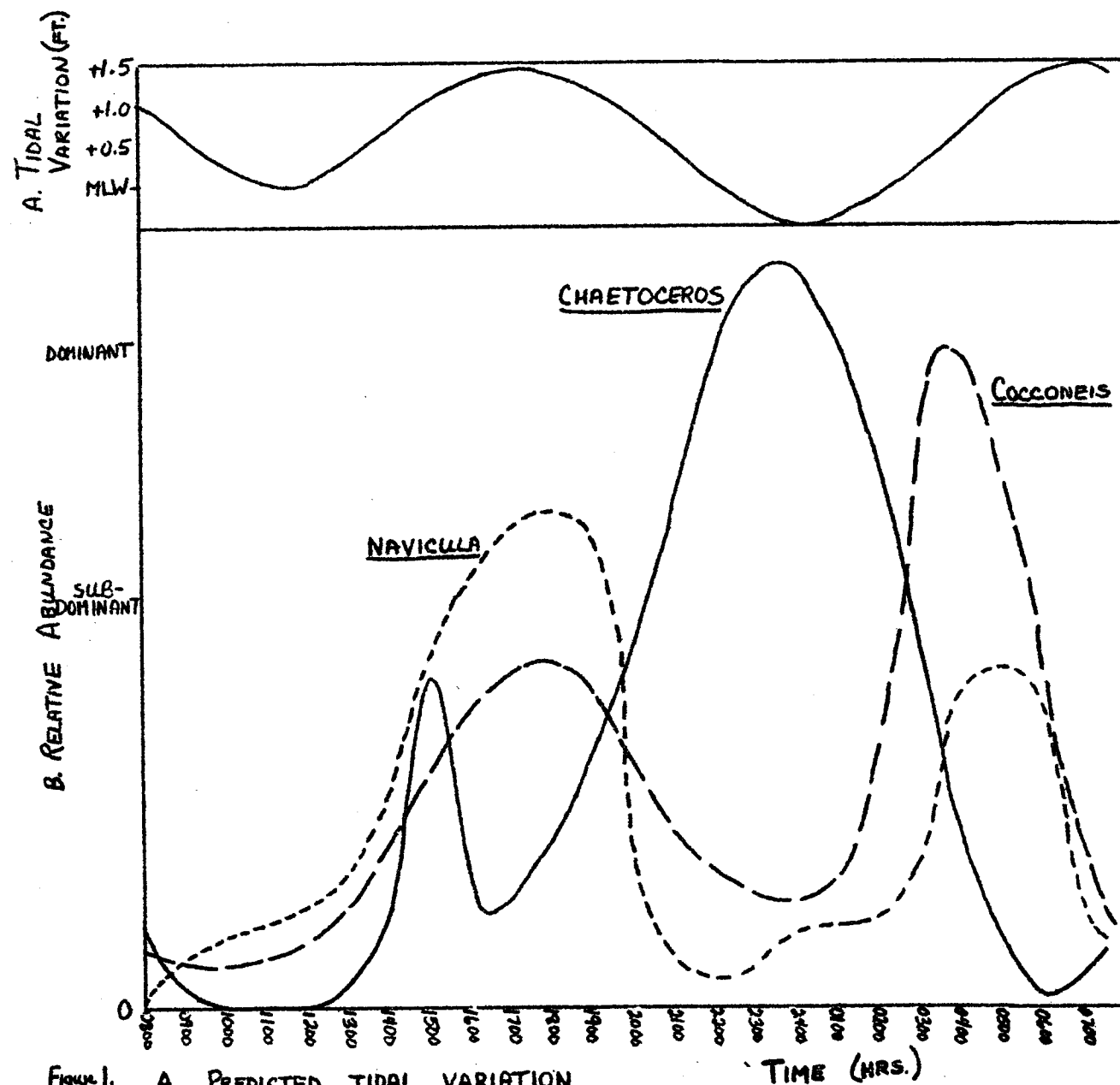


Figure 1. A. PREDICTED TIDAL VARIATION
 B. RELATIVE ABUNDANCE OF DOMINANT PHYTOPLANKTON TYPES
 (BEAR CULT. STATION I - 13/14 MARCH, 1965)

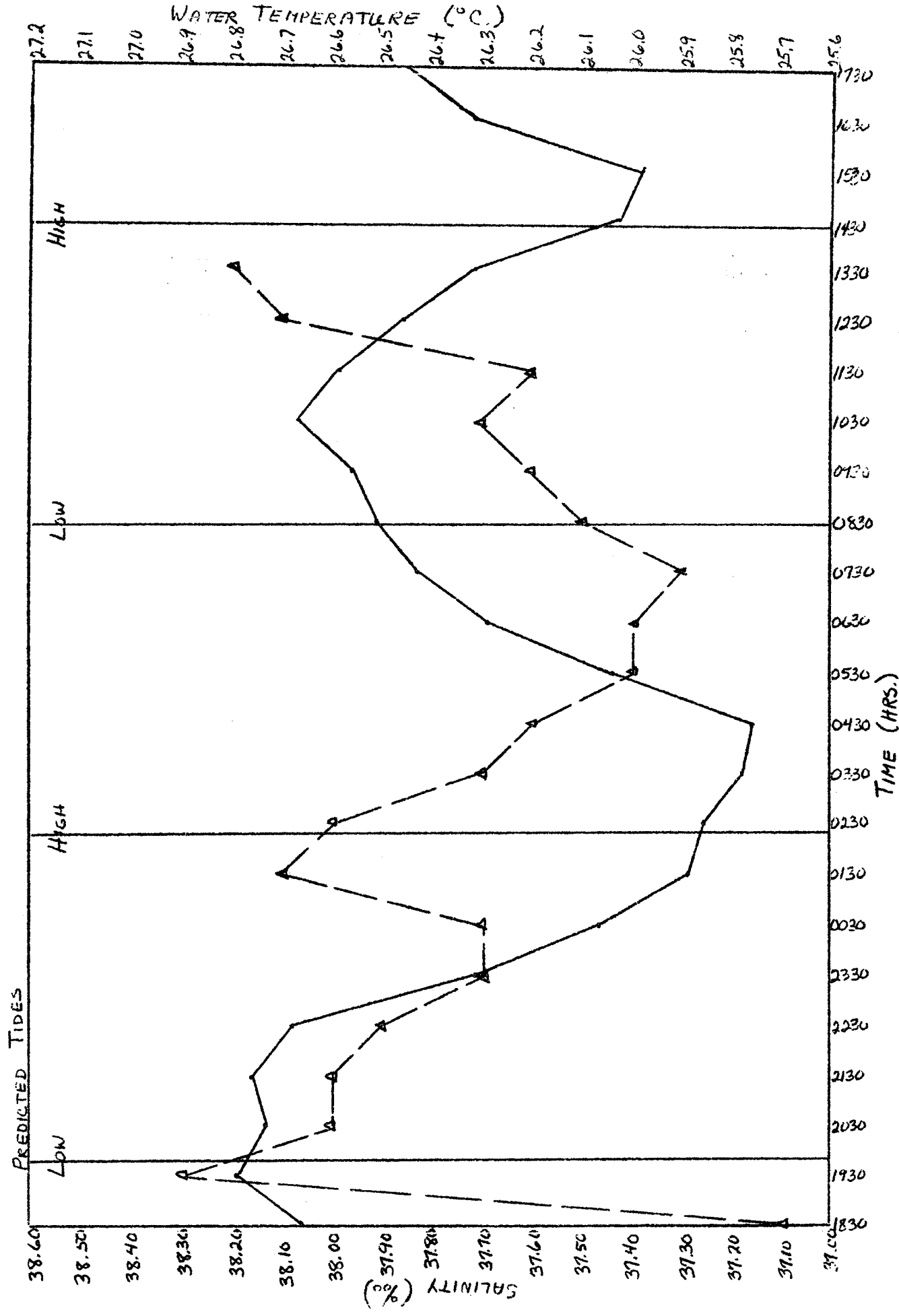


FIGURE 4. TEMPERATURE AND SALINITY VS. TIME (BEAR CUT. STATION II - 23, 24 APRIL, 1965)

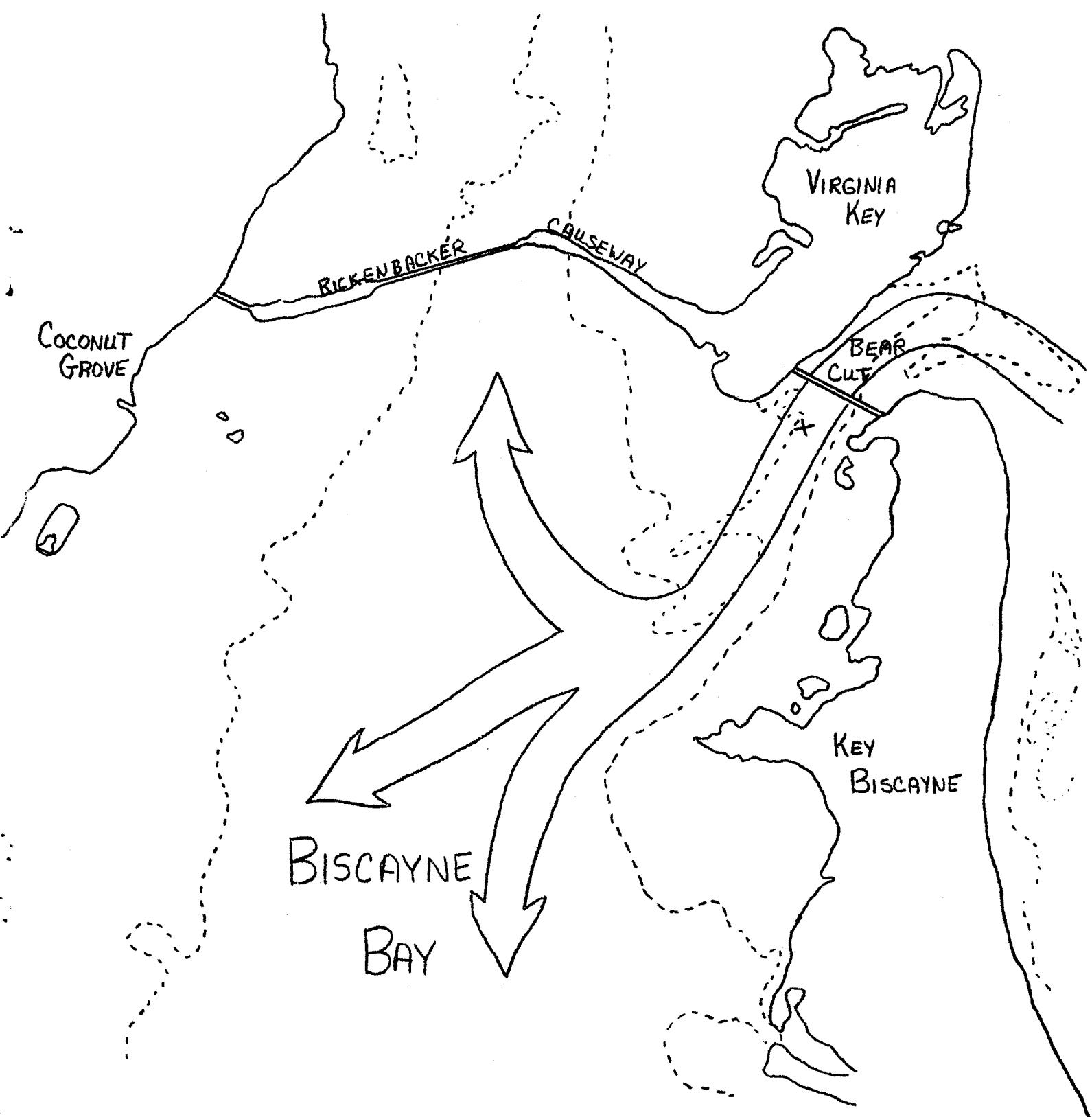


FIGURE 5. DIRECTION OF TIDAL FLOW

---- INDICATES SHALLOW-DEEP WATER BOUNDARY (2m.)

→ FLOODING TIDE; EBBING TIDE IS THE REVERSE

X ACOUSTICS TOWER IN BEAR CUT

Table 1

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PROTOPLANKTON SPECIES FOUND IN BEAR CUT (MARCH - MAY, 1965)

Dominant

(Very abundant in many samples)

Diatoms

Chaetoceros diversus (?) (low)
Cocconeis spp. (High)
Navicula spp. (high)
Nitzschia closterium (low)
Skeletonema costatum (low)

Sub-Dominant

(Abundant in a few samples)

Diatoms

Chaetoceros affinis
Ch. laciniosus
Ch. didymus
Nitzschia seriata
Rhizosolenia fragillissima (low)
Dinoflagellates
Gymnodinium lacustre, etc. (low)

Present throughout

(more than $\frac{1}{2}$ of samples, not abundant)

Diatoms

Amphora sp., including
A. bigibba
A. laevissima
A. pellucida
A. proteus
Coscinodiscus sp., including
C. asteromphalus
C. excentricus
Licmophora sp., including
L. dalmatica
L. grandis
Melosira sculpta, etc.
Nitzschia longissima
Pleurosigma angulatum, etc.
Synedra sp., including
S. crotonensis
S. fulgens, etc.
Thalassionema nitzchiodes

Dinoflagellates

Peridinium sp. including
P. aciculiferum
P. Brocki
P. claudicans
P. Granii
P. pellucidum
P. solidicorne

Flagellates

Common

(found in about $\frac{1}{2}$ to $\frac{1}{3}$ of samples, not abundant)

Diatoms

Achmanthes sp., including
A. coarctata
A. subsessilis
Asterionella formosa
Asterionella japonica
Chaetoceros sp., including
Ch. brevis
Ch. ingolfianus
Fragillaria oceanicus, etc.
Grammatophora angulifera
Grammatophora marina
Grammatophora undulata
Mastogloia rostrata, etc.
Plagiosgramma gregorianum
Rhaphoneis amphicerose etc.
Thalassiothrix frauenfeldi
Triceratium sp. including
T. bullosum
T. punctata
Coccolithophores
Calyptrosphaera, etc.
Foraminifera
Discorbis sp.
Tintinids

Rare

(found in less than $\frac{1}{4}$ of samples, very scarce)

Diatoms

Amphiprora
Aulacodiscus
Biddulphia aurita
B. laevis
B. tuomeyi
Campylodiscus
Cestodiscus obscurus
Cymatosira belgica
C. lorenziana
Cymbella spp.
Denticula indica
Diatoma tenue
Ditylum brightwellii
Encyonema
Eucampia
Gomphonema
Hantzschia spp.
Hemiaulus
Isthmia
Navicula schultzei, etc.

(Table 1 cont')

Rare (cont')

Diatoms

Nitzschia sp. including

N. acicularia

N. fasciculata

N. hantzschiana

N. lorenziana

N. navicularis

N. panduriformis

N. sigma

N. valida

Plagiogramma vanheurckii

Pleurodesmium Brebissoni

Pinnularia

Rhizosolenia setigera

Schizonema

Stephanopyxis palmeriana

Striatella interrupta

S. unipunctata

Surirella fastuosa

Thalassiothrix longissima

Tripodoneis

Dinoflagellates

Amphidinium

Ceratium fusus

C. hircus

Exuviella

Prorocentrum

Silicoflagellates

Note: (high) and (low) refer to the part of the tidal cycle at which these species were most dominant.

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