THE EFFECTS OF POWER PLANT EFFLUENTS ON THE GROWTH OF PHYTOPLANKTON IN ADJACENT AREAS OF TRINITY BAY

A Thesis

by

HENRY LLOYD MULLINS

Submitted to the Graduate College of
Texas A&M University
in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE

August 1979

Major Subject: Wildlife and Fisheries Sciences

THE EFFECTS OF POWER PLANT EFFLUENTS ON

THE GROWTH OF PHYTOPLANKTON IN ADJACENT AREAS

OF TRINITY BAY

A Thesis

by

HENRY LLOYD MULLINS

Approved as to style and content by:

William B. Wilson

(Chairman of Committee)

(Head of Department)

Sammy M. Ray

(Member)

Kirk Strawn

(Member)

August 1979

ABSTRACT

The Effects of Power Plant Effluents on the Growth of Phytoplankton in Adjacent Areas of Trinity Bay (August 1979)

Henry Lloyd Mullins, B.S., Stephen F. Austin State University

Chairman of Advisory Committee: Dr. William B. Wilson

The effect of cooling water discharges from the Houston Lighting and Power Company's Ceday Bayou Electric Power Station near Baytown, Texas, on the growth of phytoplankton in adjacent Trinity Bay was investigated from October 1972 through April 1974. Surface water temperature, salinity and pH were recorded each month at 11 stations located in Cedar Bayou, the plant's cooling system and Trinity Bay. Monthly chlorophyll _a_ concentrations and primary productivity rates were determined from sample waters collected at each station. Monthly bioassays were conducted with sample waters from 8 of the stations to evaluate the suitability of those waters for the growth of _Skeletonema costatum_, a standard culture organism, and the natural phytoplankton populations contained in the sample waters. Fluorometric measurements were made at the beginning and termination of the 4-day assay period to obtain the increase in relative chlorophyll _a_ of assay organisms.

Chlorophyll _a_ concentrations and primary productivity rates were lower in samples of water taken at locations in the plant's discharge system than in waters from the plant's intake and other Cedar Bayou stations. But, chlorophyll _a_ concentrations and primary productivity

rates determined for waters collected at the cooling pond discharge location were similar to those determined at the control station and higher than those determined for other Trinity Bay stations and the plant's intake. Bioassay results indicate that waters from the cooling pond discharge location had a higher suitability for assay organisms than did waters from other Trinity Bay stations. Thus, it appeared that power plant effluents enhanced the suitability of Trinity Bay waters, in the adjacent discharge area, for phytoplankton growth.

ACKNOWLEDGMENTS

This research was funded by the Houston Lighting and Power Company through the Department of Wildlife and Fisheries Sciences and Texas Agriculture Experiment Station Project 1869.

I wish to express my appreciation to Dr. William B. Wilson, my committee chairman, for his patience, encouragement and suggestions throughout the study and during the preparation of this thesis. Thanks are also extended to Drs. Sammy Ray and Kirk Strawn for their critical review of this thesis.

Special thanks go to John Kelsey, Tom Bullington, Gerald Loyd, Gail Marlatt and Anita Aldrich for their help in the field and laboratory. My most sincere thanks go to my wife, Linda, for her patience, encouragement and understanding during this period of our lives.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The increasing demand of modern industry for public waters has created a sense of concern in regard to possible deleterious environmental changes. The largest single industrial usage of waters is for cooling purposes (Cairns 1956). The steam-electric generating industry is the major user of cooling water (Mihursky 1969). Reports by Adams (1969) and North and Adams (1969) indicate that as much as 85% of the energy used by certain states is produced by steam-electric generating plants. Based on our present usage of water for cooling purposes and our growing demand for electricity, Sorge (1969) has estimated that by the year 2000 we will need an annual supply of cooling water equivalent to twice the national freshwater runoff. The current trend in regards to meeting the increased demand of water for cooling purposes, has been the increased use of estuarine waters. According to Picten (1960) 32% of our power plants will be on estuaries by 1980 compared to 22% in 1950. This accelerated use of our estuarine waters has created an urgent need for knowledge concerning the effects of power plant effluents in aquatic ecosystems (Grimes 1971).

Since power plant discharge water might have a deleterious effect on the survival and growth of estuarine organisms, the Houston Lighting and Power Company supported studies to determine the effects of the discharge water from their Cedar Bayou Generating Station on certain

---

The citations follow the style and format of the journal, Limnology and Oceanography.

estaurine organisms. This project included studies on natural plankton and benthic populations in Trinity Bay and mariculature possibilities of certain economically important estuarine organisms.

The suitability of the discharge water from the Cedar Bayou Generating Station for the survival and growth of local estuarine organisms might be affected by the source of the cooling water, by chemical changes of the cooling water due to passage through the plant and by the discharge water temperature. A portion of this plant's cooling water is drawn from Tabbs Bay which is approximately 3 km from the Houston Ship Channel. Tabbs Bay waters have been observed to contain abnormally high levels of industrial and domestic wastes (Metyko 1951, Carter 1970). Because of the proximity of these two areas, cooling water taken from this location might contain unusually high levels of nutrient and/or toxic substances. Activities associated with normal power plant operations which might affect the suitability of discharge water from this plant for the survival and growth of local estuarine organisms could include chemical additions to reduce fouling of plant facilities (Beauchamp 1969, Brook and Baker 1972), and the introduction of heavy metals due to the passage of water through the plant (Roessler 1971). Increased cooling water temperatures, due to passage through power plants, could result in the elimination of some species of estuarine and marine organisms in the discharge area and could affect the reproduction and growth rate of other organisms (Naylor 1965).

This thesis deals with the effects of discharge water from this plant on phytoplankton populations in Trinity Bay. The objectives were as follows:

(1) To determine the effects, if any, of water passage through the Cedar Bayou generating plant on the phytoplankton standing crop and primary production rates in adjacent areas of Trinity Bay.

(2) To determine whether or not passage of water through the Cedar Bayou generating plant affects its suitability for the survival and growth of phytoplankton in adjacent areas of Trinity Bay.

DESCRIPTION OF THE STUDY AREA

This study was conducted in the intake and discharge areas of the Houston Lighting and Power Company's Cedar Bayou plant and in the adjacent Trinity Bay area of the Galveston Bay complex (Fig. 1). The plant is approximately 13 km inland from Cedar Point and is adjacent to a small stream, Cedar Bayou (Fig. 2). During this study period, from October 1972 to April 1974, the plant was operated with two 750 megawatt units with a circulating capacity of approximately 25 million liters (700,000 gallons) per minute.

Water used for cooling purposes was taken from Cedar Bayou. The normal downstream flow of Cedar Bayou was insufficient to satisfy the cooling water demands of the plant. As a result, the flow of that portion of Cedar Bayou between the plant and Galveston Bay was reversed. To insure that sufficient quantities of cooling water could be drawn through Cedar Bayou, a man-made canal connecting Tabbs Bay with the lower portion of Cedar Bayou was dredged in November 1970.

After the cooling water passed through the plant it coursed through a 9.7 km discharge canal into and through a 1053-ha (2600 acre) cooling pond prior to discharge into Trinity Bay. The cooling pond is approximately 2 m deep with a flow rate through the cooling system of 90,000 to 120,000 cubic meters (300,000 to 400,000 cubic feet) per minute.

Trinity Bay is a secondary bay of the Galveston Bay system. It contains approximately 260 square km (1600 square miles) of the 900 square km (5500 square miles) of the Galveston Bay system. Fisher et al.

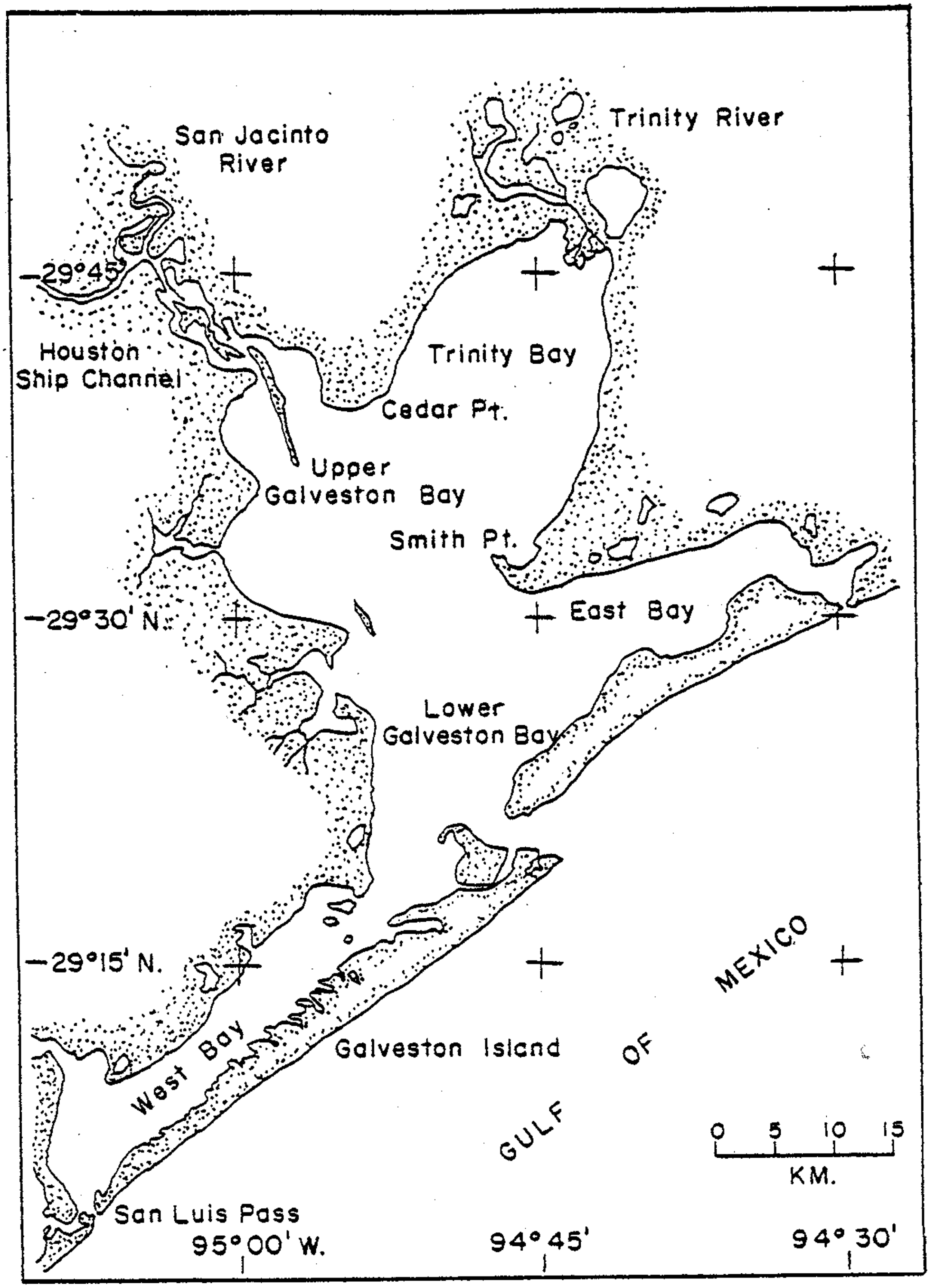

Fig. 1. Map of Galveston Bay complex.

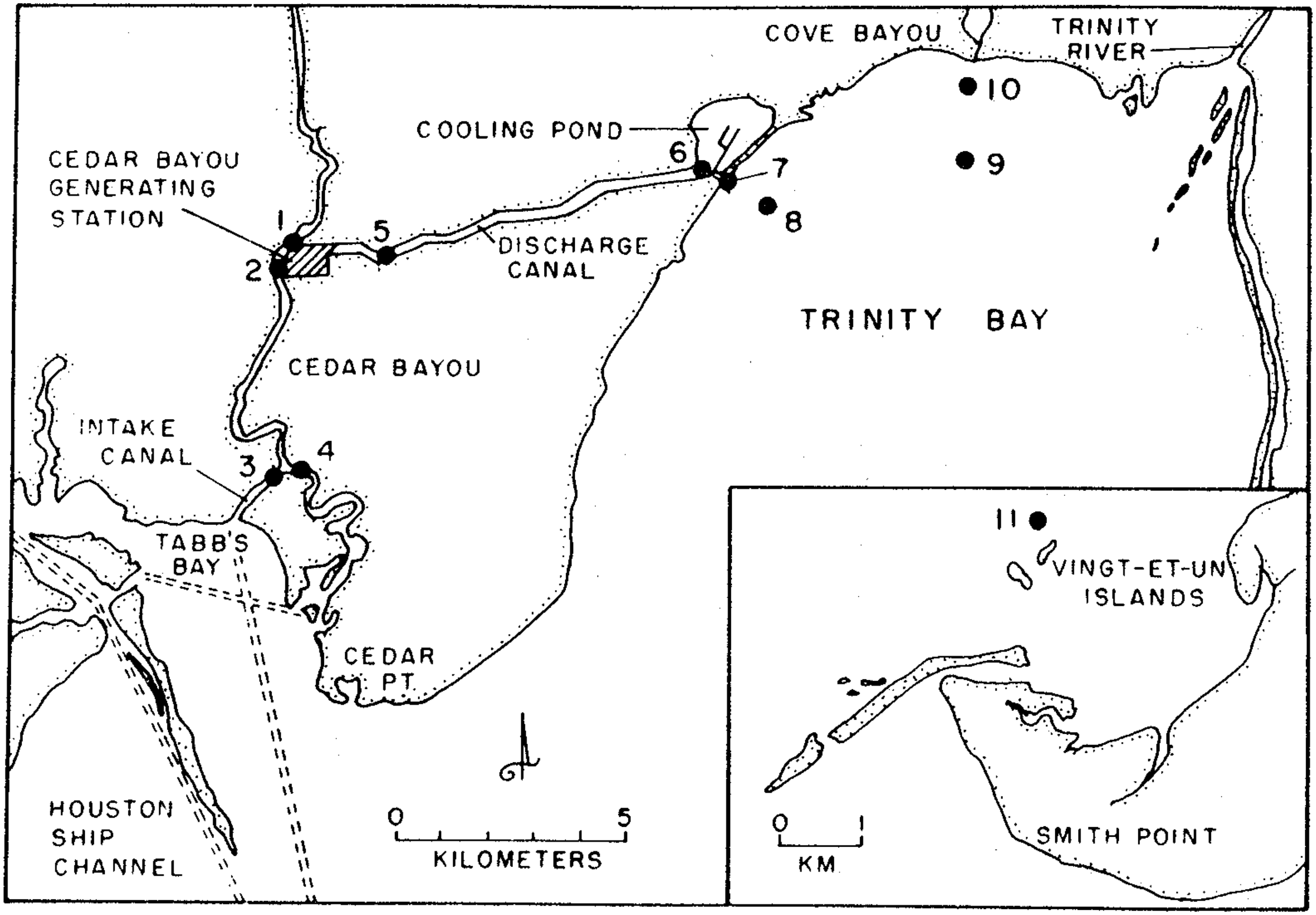

Fig. 2. Map of Cedar Bayou area indicating sampling station locations for the phytoplankton study. Smith Point and station 11 (inset) are located in the southeastern extremity of Trinity Bay.

(1972) describes Trinity Bay as a shallow, low salinity estuary which is dominated by the Trinity River. They also state that the bottom of this bay is primarily mud with water depths not exceeding 3 m, but subject to wind-driven tides which may cause water level fluctuations of as much as 1 m or more.

LITERATURE REVIEW

Effects of Power Plants on Plankton

Stresses are placed on aquatic organisms when water is used for cooling purposes by a steam-electric generating station (Morgan and Stross 1969). Four of the principal stresses are (1) increased temperatures, (2) introduction of chemicals for fouling control, (3) increased pressure and turbulence due to pumping the cooling water through the condenser tubes, and (4) the introduction of metals due to the passage of water through the condenser tubes (Coutant 1970, Markowski 1959).

Organisms in the cooling water that pass through power plants are subjected to harsh conditions that often result in growth inhibition or death. Mihursky and Cronin (1967) examined plankton net samples collected from the intake and discharge waters of a Patuxent River estuary power plant and reported that as much as 95% of the phytoplankton and zooplankton were destroyed by passage through the plant. Fox and Moyer (1973) found that the average production of phytoplankton contained in the discharge waters of a Florida generating station was 25.9% less than the phytoplankton contained in the intake waters. Morgan and Stross (1969) determined that the primary production in water which had passed through a Maryland power plant was only 15% of the intake area primary production. From these results they speculated that this loss of production could result in a loss of as much as 424 tons of photosynthesized carbon per summer. On the other hand, Markowski (1959) found that the passage of cooling water through an English power plant had no effects on the zooplankton contained in the water.

Increased water temperatures can result in a depression of primary production and the replacement of one algal population by another. Warinner and Brehmer (1966) found that depression of primary production in discharge waters was directly proportional to the rise in temperature produced by a generating plant. Rises in water temperatures can result in the replacement of diatoms and green algae by blue-green algae (Patrick 1968, Cairns 1972). Patrick (1968) reported a shift in the dominant algal form occurred when incubation temperatures of culture media containing Sabine River, Texas, algal populations were gradually increased from 20°C to 40°C. She found diatoms to be the most abundant form between 20°C and 30°C, green algae between 31°C and 35°C and blue-green algae at incubation temperatures above 35°C. Cairns (1967) states that this shift in algal types would be of enormous importance in the aquatic community because he believes much indirect evidence suggests that diatoms are more highly regarded as a food source by most fresh-water consumer species than are blue-green algae.

The periodic addition of chlorine to cooling water to combat fouling has been shown to produce harmful effects on phytoplankton. Periods of no C^{14} uptake by phytoplankton in cooling waters were shown by Morgan and Stross (1969) to coincide with additions of chlorine. They also found that chlorine additions caused a decrease in chlorophyll _a_ concentrations. Brook and Baker (1972) determined that the addition of chlorine depressed primary production by as much as 90%. They indicated that chlorination of the cooling water depresses the photosynthetic rate to a much greater extent than does a sudden temperature increase of 8-10°C which is normally associated with power plant operations.

Primary Productivity

Phytoplankton primary productivity has been measured and evaluated by a variety of methods. Two methods used to determine primary productivity are the determination of oxygen production (Gaarden and Gran 1927) and the uptake of radioactive carbon (Steeman-Nielsen 1952).

Descriptions of the C^{14} uptake method have been given by Steeman-Nielsen (1952, 1955, 1964) and Ryther and Vaccaro (1954). In this method the rate of uptake of radioactive carbon by the phytoplankton is determined by adding small quantities of C^{14} to water samples then filtering the water samples to remove the plankton followed by the measurement of radioactive carbon assimilated by the organisms.

Steeman-Nielsen (1964) considers the C^{14} technique, when properly used, to be the most reliable technique available. Although this method may be the best method available, it must be realized that it still has limitations. Under-estimates of phytoplankton productivity using this method can occur due to breakage of fragile phytoplankton cells during filtration (Lasker and Holmes 1957, Arthur and Rigler 1967). As a result the C^{14} which had been assimilated by the phytoplankton passes through the filter pad. Steeman-Nielsen (1964) and Arthur and Rigler (1967) report that the extent of error due to cell breakage can be significantly reduced by gently filtering small sample volumes. Steeman-Nielsen warns that if accurate productivity measurements are to be made, incubations must employ conditions approaching those found in the organisms' natural environment. Also, since in situ incubations more closely approach natural conditions, he considers that they should be employed in preference to laboratory or simulated in situ methods. However, a comparison of laboratory and in situ incubations by McAllister et al. (1960) showed that there was fair agreement between the two techniques if laboratory conditions were adjusted to approximate conditions at the time of sampling.

Primary productivity in estuarine waters is generally much greater than in oceanic waters (Stross and Stottlemeyer 1965). Malone (1971) reported that phytoplankton productivity in the Peru current was between 1 and 5 mg C/m^3/hr. McAllister et al. (1960) repeated a "typical" in situ primary productivity rate of 0.82 mg C/m^3/hr. from surface waters taken from a northern Pacific sampling station. They also reported primary productivity values of from 1 mg C/m^3/day, determined at a location near the equator, to 50 mg C/m^3/day determined for waters taken from a station located near the Aleutian Islands. On the other hand, Stross and Stottlemeyer (1965) reported that primary productivity values determined from Patuxent River estuary waters were from 2.3 to 148.5 mg C/m^3/hr. They found that primary productivity rates determined at the head of that estuary (mean rate of 58.3 mg C/m^3/hr.) were generally three times greater than those determined at the mouth of that estuary (mean rate of 17.5 mg C/m^3/hr.).

Chlorophyll a

The measurement of plant pigments, especially chlorophyll a, is one of the few rapid chemical methods available to estimate the amount of living plant matter (Flemer 1969). Odum et al. (1958) reported that attempts to use chlorophyll as a measure of the overall photosynthetic function in ecological systems began with Harvey (1934), who used visual estimates of green pigments extracted from marine planktonic communities as an estimate of phytoplankton biomass. After this early beginning chlorophyll a has been widely used to determine biomass of phytoplankton populations (Loftus and Carpenter 1971).

Concentrations of chlorophyll a are normally determined either spectrophotometrically or fluorometrically. Holm-Hansen et al. (1965) report that fluorometric determinations are reproducible and can be made quicker and with a higher sensitivity than can spectrophotometric determinations. Fluorometric techniques are recommended if only small sample volumes are available or if extremely high concentrations of inorganic particles make it difficult to filter large water samples (Yentsch and Menzel 1963; Holm-Hansen et al. 1965).

Chlorophyll a concentrations are normally much lower in oceanic than in estuarine waters. Lorenzen (1966) found chlorophyll a concentrations between 0.04 and 2.0 mg Chla/m^3 off the coast of Baja California. Riley (1941) reported that the maximum chlorophyll a concentration of oceanic waters near Georges Bank was 27.2 mg Chla/m^3 and that chlorophyll a concentrations in Long Island Sound waters were as high as 62.0 mg Chla/m^3 during spring phytoplankton blooms. Steidinger (1973) reported a maximum chlorophyll a concentration of 90 mg Chla/m^3 during a phytoplankton bloom in Oyster Bay, Jamaica. Marshall (1956) reported that the highest chlorophyll a concentrations usually occurred at the head of an estuary and that concentrations were generally lower toward the mouth. He attributed this difference to the low dispersal rates of phytoplankton in the upper reaches of the estuary and the mixing of benthic algae into the plankton in the shallow head waters.

Chlorophyll a concentrations of estuarine waters are subject to both seasonal and diurnal fluctuations. Seasonal fluctuations may be caused by variations of light, nutrients, temperatures, turbulence, turbidity and grazing (Raymont 1963). Atkins and Parke (1951) found that chlorophyll a values in the English Channel varied from a low of 0.36 mg $Chla/m^3$ in August to a high of 4.30 mg $Chla/m^3$ in June. Marshall (1956) reported that in Alligator Harbor, Florida, the maximum spring and fall chlorophyll a values were 13-14 mg $Chla/m^3$ compared to a winter maximum of 3-4 mg $Chla/m^3$. Diurnal chlorophyll a variations of up to 20.0 mg $Chla/m^3$ were observed in estuarine waters near Beaufort, North Carolina (Odum et al. 1958). Diurnal maxima in chlorophyll a values have been reported at dawn (Yentsch and Ryther 1957, Shimada 1958), in the afternoon (Odum et al. 1958), and at night (Yentsch and Scagel 1958). Minimum values have been reported to occur at midday (Yentsch and Ryther 1957) and in the early evening (Yentsch and Scagel 1958).

Bioassay Methods

Bioassays for water quality evaluation may be of considerable value in the study of specific water masses. Johnston (1963) found the growth of phytoplankton under assay conditions paralleled the productivity of phytoplankton in nature. The results of Wilson (1966) and Collier et al. (1969) suggest that water suitability bioassays may provide a method of determining water suitability for phytoplankton organisms.

The three most important bioassay procedures are (1) continuous-flow (chemostat) assays, (2) batch assays, and (3) in situ assays (Middlebrook et al. 1969). Of these three methods the batch assay method is the simplest, least expensive, most reproducible and most applicable to practice (Oswald and Gaonkar 1969). Briefly described, the batch assay method is as follows: The batch assay candidate test algae are added to the sample and following incubation under specified conditions the growth of the algal crop is determined on a daily schedule. Thus, the daily algal biomass can be determined from which a provisional growth rate can be derived.

The reproducibility of the batch test algal assay procedure was evaluated by Weiss and Helms (1971). Results from eight laboratories were compared. The participating laboratories were required to follow a set of prescribed procedures using common materials and cultures to determine the interlaboratory variations in results of the assay method. The results indicated that although there were marked interlaboratory variations, precision within each laboratory was remarkably good. They concluded that small differences in phytoplankton growth potential of various media could be detected by employing algal assays.

Skeletonema costatum

Skeletonema costatum (Creville) Cleve is a widely distributed estuarine and neritic diatom (Steidinger 1964). Curl and McLeod (1961) report this species occurs wherever phytoplankton have been studied, except in the Arctic and Antarctic. Although Curl and McLeod report this species to be abundant in the Gulf of Mexico in the spring and autumn, they indicate that it is seldom, if ever, a numerically dominant species. Smayda (1973) found that factors regulating the growth rate and standing crop of this species can include light, temperature, salinity, nutrient concentration and degree of zooplankton grazing.

S. costatum has been reported to be eurythermal (Steidinger 1964). Matsue (1954) found the maximum experimental temperature tolerated by this species was 40°C. This is a higher maximum temperature than in the 1.7°C to 29.0°C temperature range reported by Steidinger (1964). Moderate populations of this species have been reported from Norwegian fjords at temperatures of 1 to 4°C (Braarud 1963). From this and other field observations Braarud concludes that minimum temperatures do not restrict the distribution of *S. costatum* except possibly when temperatures were below 0°C. Curl and McLeod (1961) Jitts et al. (1964), Jorgensen (1966) and Uno (1971) have reported good growth in laboratory experiments if cultures were maintained between 19° and 21°C.

Steidinger (1964) reported *S. costatum* to be euryhaline and that it occurs in waters with salinity levels between 10.6 and 33.8 ppt. Curl and McLeod (1961) reported that photosynthesis of *S. costatum* continued in waters with salinity levels as low as 5 ppt, but the photosynthetic rate per cell at 5 ppt was only 10% of the maximum rate which occurred at 15 ppt.

S. costatum cultures have been maintained in light intensities ranging from approximately 300 foot-candles (Jorgensen 1966) to approximately 4,000 foot-candles (Jitts et al. 1964). Curl and McLeod (1961) and Uno (1971) report good growth when cultures of this species were maintained in light intensities between 1,000 and 1,500 foot-candles.

S. costatum has been employed as an assay organism in studies evaluating the quality of different water masses for phytoplankton growth (Johnston 1963, 1964, Smayda 1970 and others). These investigators reported marked differences of water masses in regard to their suitability for the growth of *S. costatum*. As a result of *S. costatum* assays, Johnston (1964) considered that the supply of chelating substances was frequently the most crucial aspect of phytoplankton nutrition in seawater.

MATERIALS AND METHODS

Sampling Stations

Eleven stations were established for this study (Fig. 2). Samples were collected at stations 1, 2, 3, 4, 6, 7, 8 and 11 for water suitability assays. Temperature, salinity, pH, cholorophyll a, and primary productivity were measured at all stations.

Stations 1 through 4 were located in Cedar Bayou. Station 1 was located approximately 300 m north of the plant. Station 4 was located approximately 5.4 km south of the plant in the original bayou channel and station 3 was located in the artificially constructed canal approximately 5.6 km south of the plant. Station 2 was located adjacent to a boat barrier at the plant's intake. Due to the reverse flow of that portion of Cedar Bayou south of the plant, stations 3 and 4 were selected in order to determine the suitability of waters drawn into the intake canal and lower Cedar Bayou, for phytoplankton growth. Station 1 was selected in order to evaluate the suitability of the water, for phytoplankton gorwth, from the portion of Cedar Bayou north of the plant. Station 2 was selected to determine the suitability of the water for phytoplankton growth at the point where cooling water entered into the plant.

Stations 5 and 6 were located in the discharge system. Station 5 was in the discharge canal approximately 50 m downstream from the point of cooling water discharge from the plant. This station was employed to evaluate the effects of entrainment on phytoplankton in the cooling water. Station 6 was located near the terminus of the discharge canal approximately 50 m below the drop structure. This station was employed to evaluate the effects of passage through the discharge canal on the phytoplankton contained in the cooling water.

Stations 7 through 11 were located in Trinity Bay. Station 7 was adjacent to a boat barrier at the point that the water was discharged from the cooling pond into Trinity Bay. Stations 8 and 9 were established at locations in Trinity Bay approximately 2 and 5 km, respectively, from station 7. Station 10 was located approximately 6 km northeast of station 8 and approximately 50 m from shore. A control station (station 11) was located in the southeastern portion of Trinity Bay near Smith Point at a distance of approximately 3 km from shore. This station was chosen as a control site because it was considered to be a sufficient distance from the discharge site so that it was not influenced by the plant operations and because the temperature, salinity, total dissolved nitrogen and phosphorus concentrations were similar to those in the Trinity Bay area adjacent to the cooling pond (Pullen et al. 1969).

Sampling Procedure

Monthly surface water samples were collected at each station beginning in October 1972 and continuing through April 1974. All water samples were collected by submerging the mouth of the collection bottle just beneath the surface and allowing surface water to enter the bottle. Sterile 1-liter Erlenmeyer flasks cleaned by the method described by Kelsey (1974) were used to collect water samples at stations 1, 2, 3, 4, 6, 7, 8 and 11. Water samples from stations 5, 9 and 10 were collected using sterilized 500 ml nalgene bottles. All samples were collected between 9:00 AM and 2:00 PM. Water samples were maintained in the dark at approximately the same temperature as the water temperature at the time of sampling during transport to the Texas A&M Marine Laboratory in Galveston, Texas. Carbon-14 uptake, chlorophyll a measurements and suitability bioassays were conducted at the Galveston laboratory. Carbon-14 uptake and chlorophyll a measurements were made within 12 hours and suitability bioassys were begun within 24 hours after water sample collection.

Chlorophyll a

Chlorophyll a was determined with a Turner Model 111 Fluorometer as described by Yentsch and Menzel (1963), and were recorded in mg Chl a/m^3. This measurement was employed to evaluate the phytoplankton standing crop.

Primary Productivity

The C-14 uptake method (Steeman-Nielsen 1952) was used to estimate the primary productivity at each station. Radioactive carbon solution ($Na_2C^{14}O_3$) was diluted with an artificial seawater medium (Table 1), to obtain a concentration of 1 microcurie per milliliter. One ml of this solution was pipetted into each of 33 Pyrex 22 x 175 mm test tubes with ground glass stoppers. Test tubes that served as "dark bottles" were enclosed in black electricians tape. One dark tube and 2 clear tubes were filled (64 ml) with sample water from each station. Sample portions

Table 1. Composition of artificial seawater (NH-15) employed in suitability assays as reported by Gates and Wilson (1960).

NH-15 medium(1) -- Salinity ~ 28 ppt			
NaCl	24.0 g	EDTA(3)	10.0 mg
KCl	0.6 g	B-12	1.0 µg
$MgCl_2 \cdot 6H_2O$	4.5 g	Thiamin	10.0 mg
$MgSO_4 \cdot 7H_2O$	6.0 g	Biotin	0.5 µg
$CaCl_2 \cdot 2H_2O$	0.7 g	Sulfides mix(4)	5.0 ml
K_2HPO_4	10.0 mg	Vitamins-8 mix(5)	0.1 ml
KNO_3	10.0 mg	Metals-T mix(6)	5.0 ml
Tris buffer(2)	0.4 mg	Adenine Sulfate	1.0 mg

(1) Additions per 1000.0 ml of distilled water

(2) 10 g of 2-Amino-2(hydroxymenthyl)-1, 3-propanediol per 100 ml of distilled water adjusted to pH 8.1-8.2 with HCl

(3) Disodium Ethylenediaminetetraacetate

(4) Sulfides mix (per 1000.0 ml)

NH_4Cl	0.2 g	NaHCO	0.2 g
KH_2PO_4	0.1 g	$Na_2S \cdot 9H_2O$	0.5 g
$MgCl_2$	0.04 g		

(5) Vitamins-8 mix (per 100.0 ml)

Thiamin	20.0 mg	Choline (chloride)	50.0 mg
Biotin	50.0 g	Inositol	100.0 mg
B-12	5.0 g	Putrescine	0.8 mg
Folic acid	0.25 mg	Riboflavin	0.5 mg
PABA	1.0 mg	Pyridoxine	4.0 mg
Nicotinic acid	10.0 mg	Pyrodoxamine (dihydrochloride)	2.0 mg
Thymine	80.0 mg	Orotic acid	26.0 mg

(6) Metals-T mix (per 1000.0 ml)

$FeCl_3 \cdot 6H_2O$	28.0 g	$MnCl_2$	3.7 g
H_3BO_3	30.0 g	TiO_2	8.3 g
H_2SeO_3	1.0 g	$Na_2SiO_3 \cdot 9H_2O$	50.0 g
NH_4SO_3	1.2 g	$2nOCl_2$	4.0 g
K_2CrO_4	1.1 g	$BaCl_2$	1.5 g

were incubated in a constant temperature water bath for 1 hour. The water temperature employed during this incubation was the mean of the water temperatures of all stations on each sampling date. Sample portions were placed approximately 8 cm from 2 cool-white, 20-watt fluorescent lights which provided an incubation light intensity of approximately 800 foot-candles. A Gossen Luna-Pro Electronic exposure meter was used to determine all light intensity values. After incubation and during filtration, samples were maintained in the dark for a period not exceeding 2 hours. Ten-ml sub-samples from each test tube were filtered with Whatman 2.4 cm GF/A glass fiber filters. Filter pads were placed on planchets and allowed to dry for approximately 12 hours at room temperature prior to making counts with a Nuclear-Chicago model 1042 gas scintillation counter. The carbon assimilated (mg $C/m^3/hr$) was calculated by use of the equation of Strickland and Parsons (1968).

Bioassay Procedure

A bioassay was employed to evaluate the suitability of the water from stations 1, 2, 3, 4, 6, 8 and 11 for phytoplankton growth. Two media types were used for each sampling station and date. One type consisted of filtered sample water (FSW) from each station. The second medium consisted of equal parts of an artificial seawater medium (Gates and Wilson 1960) and the filtered sample water from each station. The artificial seawater medium was employed as a standard control.

The water samples were sterilized and particulate matter was removed by filtration through a series of filters of progressively smaller pore sizes. Water samples were filtered into 1-liter Erlenmeyer filtration flasks using a millipore filtration apparatus. Separate filters, filter holders and filter flasks were employed for samples from each station. The filter series included Whatman 4.25 6F/A glass fiber filters and 47 mm millipore filters with 0.8μ, 0.45μ and 0.22μ pore sizes. A final filtration was made through sterilized 0.22μ millipore filters into sterile 2,000 ml modified aspirator bottles (Fig. 3). Occasional bacterial sterility tests were conducted to monitor filtrate sterility. For these tests 1-ml portions of filtrate were transferred into each of 2 media. One medium contained 10 ml of peptone seawater broth, the other a 10 ml peptone seawater agar slant (Spencer 1952). Tests were incubated at 37.5°C for 10 days. Aspirator bottles and millipore filters employed in the final filtration were sterilized by dry autoclaving for 20 minutes at 121°C.

Phytoplankton assay organisms consisted of natural phytoplankton (NP) populations of each station and sampling data and a bacteria-free culture of _Skeletonema costatum_. _S. costatum_ was chosen as a standard assay organism because it frequently occurs in samples collected, from the study area and considerable information is available in regard to its physiology, growth and culture requirements. Prior to filtration, 50-ml portions of each water sample were transferred into sterile 125 ml Erlenmeyer flasks to obtain natural phytoplankton population inoculants. The _S. costatum_ inoculant was obtained by aseptic transfer of approximately 10 ml of culture into 150 ml of sterilized NH-15 medium contained in 250 ml Erlenmeyer flasks 5 days prior to its use for assay inoculation. Thus the culture was in the exponential growth phase at the time

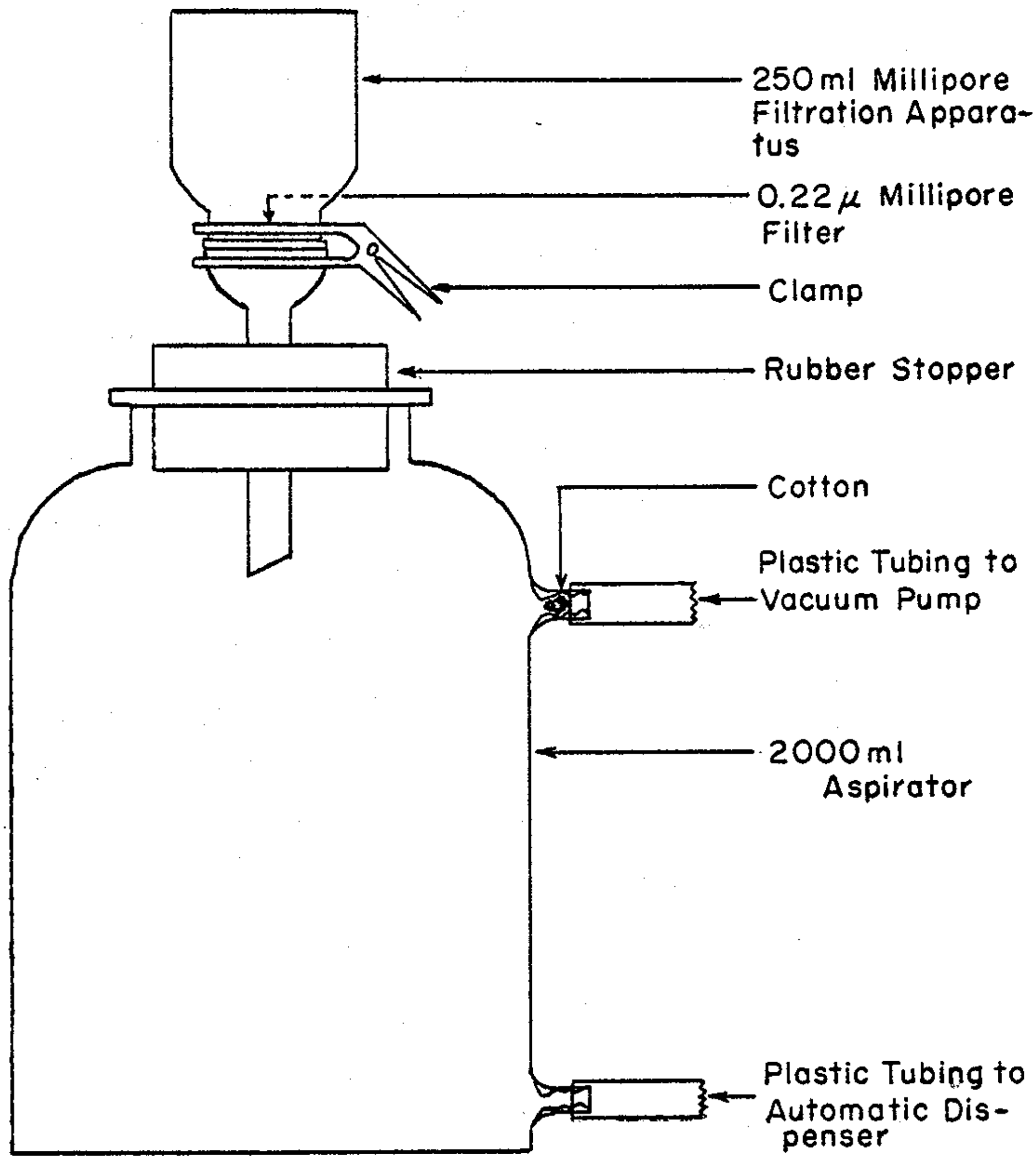

Fig. 3. Diagram of modified aspirator bottle assembly employed in final sample water filtration.

of inoculation.

Ten-ml portions of each medium were delivered with a Harvard Automatic Dispenser to Kimble 16 x 125 mm disposable glass test tubes. All tubes were covered with disposable Kim-Kap polypropylene caps. Ten-ml portions of the NH-15 medium were delivered to each of 54 culture tubes and 5-ml portions of this media were delivered to each of 96 culture tubes. These media portions were then sterilized by autoclaving for 15 minutes at 121°C. The sample waters were aseptically dispensed in 10-ml portions into sterile culture tubes and in 5-ml portions into the culture tubes which had previously received 5-ml portions of NH-15 medium. The aseptic transfer of sample waters and assay organism inoculations were made in a laminar flow hood. Sterile, 1.0 ml, Kimble serological, plastic, disposable pipetts were employed to transfer 0.1 ml of the inoculum into the culture tubes.

All assay portions were incubated in a constant temperature vault. Two incubation temperatures were employed for the assay. A total of 123 assay portions, which was 50% of the combined assay portions from all stations, were incubated in a constant temperature vault maintained at 20°C ± 2°C. The other 123 assay portions were incubated in a constant temperature vault maintained at the mean (± 2°C) of the water temperature observed at the stations at the time of sampling. Three replicate portions of each medium-organism-temperature combination were employed in the assay. All portions were incubated 4 days and were positioned approximately 5 cm from 2 cool-white, 40-watt fluorescent lights with an intensity of approximately 1,800 foot-candles.

Relative growth of the assay organisms were determined by measuring the _in vitro_ relative chlorophyll _a_ with a Turner Model 111 Flurometer. Flurometric measurements of the contents of each culture tube were recorded immediately after inoculation and after a 4-day incubation period. All values greater than 100 were measured with the 1 x, 3 x or 10 x fluorometer windows and multiplied by the appropriate factor for comparisons with the 30 x window readings. The relative growth of the phytoplankton was determined by comparing the pre-incubation measurements with measurements taken after the 4-day incubation period.

The analysis of variance and student t-test were employed for the examination of assay results.

Hydrological Methods

Air temperatures, surface water temperature, salinity and pH measurements were made at each station at the time water samples were collected. Water and air temperatures were measured to the nearest 0.5°C. Prior to November 1972 the water temperature was measured with a thermister probe of an ARA Hydrolab II, portable water quality analyzer. Afterwards temperatures were taken with a YSI Model 33 S-C-T meter. Air temperature measurements were made with an alcohol filled pocket Fahrenheit thermometer. Prior to November 1972 surface salinity was determined from electrical conductivity measurements made with the ARA Hydrolab II. Afterwards a YSI model 33 S-C-T meter was used to measure salinity. Surface pH readings, to the nearest 0.05 unit, were determined at all stations each month. Prior to January 1973 pH values were determined with a Beckman Expandomatic SS-2 pH meter after the water samples were transported to the laboratory in Galveston. Afterwards, in situ determinations were made with a portable Beckman Electromate pH meter.

RESULTS

Hydrology

The surface water salinity determined at sampling stations during this study were from 0.0 to 22.0 ppt (Table 2). The maximum salinity at each station was recorded during the first 3 months of the study (Oct.-Dec. 1972). From March 1973 to termination of the study all sampling stations in Trinity Bay had salinities below 10 ppt. Low salinity values (below 8.0 ppt) were determined in Trinity Bay during the periods of March 1973 to June 1973 and from October 1973 to March 1974. Cedar Bayou salinity levels approached 0 ppt in April and May 1973 and January 1974. The mean salinity at the plant's intake (station 2 - 5.6 ppt) and discharge (station 5 - 8.6 ppt) differed by 3 ppt. On all but 2 occasions (January and February 1974) the salinity was lower at the plant's intake than at the plant's discharge. The salinity at the control station (station 11) was generally higher than those of other Trinity Bay stations, except the cooling pond discharge station (station 7).

Surface water temperatures followed seasonal trends. The highest value for each station was recorded during the summer months (June, July and August) and the lowest value was recorded during the winter months (December, January and February). Maximum temperatures at all stations, excluding stations in the discharge canal (station 5) and cooling pond (station 6), occurred in July and August 1973 and minimum

Table 2. Surface salinity (ppt) measured at each sampling station from October 1972 to April 1974.

Month	Stations										
	1	2	3	4	5	6	7	8	9	10	11
Oct.	14.5	14.5	17.5	17.0	17.0	17.5	17.0	17.0	16.0	16.5	18.5
Nov.	1.0	1.0	6.0	6.0	8.0	9.0	22.0	19.5	19.0	16.5	19.0
Dec.	10.5	12.5	16.0	16.5	17.0	10.0	12.0	10.0	10.0	8.0	13.0
Jan.	1.0	1.5	7.0	7.5	6.5	6.0	8.5	2.0	4.0	1.5	13.0
Feb.	5.0	3.5	7.0	6.5	7.5	7.0	11.5	6.5	6.5	4.0	13.0
Mar.	4.0	4.0	4.5	4.5	5.5	5.5	3.0	0.0	0.0	0.0	2.0
Apr.	1.0	1.0	1.5	1.5	7.0	3.5	3.0	0.0	0.0	0.0	3.0
May	1.5	1.5	1.5	1.5	5.0	5.5	5.5	1.0	0.5	0.5	2.0
Jun.	3.0	3.5	3.0	2.5	5.5	5.5	5.0	0.5	0.0	0.5	0.5
Jul.	6.0	6.5	8.5	6.5	9.5	9.0	5.5	3.5	0.5	1.5	3.5
Aug.	10.0	10.0	14.5	12.5	13.5	12.0	9.5	5.5	6.0	5.0	8.5
Sep.	10.5	8.0	9.0	8.5	11.5	10.0	8.0	4.5	0.0	0.5	6.5
Oct.	2.5	2.5	2.0	2.0	3.0	3.5	3.5	0.5	0.5	0.0	3.0
Nov.	10.5	9.0	12.5	12.0	16.0	12.5	3.5	0.5	0.5	0.5	1.0
Dec.	7.0	7.5	9.5	9.5	8.0	7.0	5.5	1.0	0.5	1.0	7.5
Jan.	1.0	0.5	0.5	0.5	0.5	1.0	5.0	0.5	0.5	0.5	0.5
Feb.	8.0	9.5	10.5	10.5	9.5	9.0	4.5	0.5	0.5	0.5	4.0
Mar.	1.0	2.0	8.5	5.5	5.0	4.0	4.0	2.0	0.5	0.5	6.0
Apr.	7.5	7.5	10.0	9.0	8.5	8.0	8.5	3.5	5.0	2.5	8.0
Station mean	5.6	5.6	7.9	7.4	8.6	7.7	7.6	4.1	3.7	3.2	7.0

temperatures occurred in February and December 1973. Maximum temperatures for stations in the discharge canal and cooling pond occurred in June and July 1973 and minimum values occurred in December 1972.

An increase in cooling water temperature occurred after passage through the power plant (Table 3). The mean temperature at the plant's discharge (station 5) was 8.8°C higher than at the plant's intake (Fig. 4). This increased heat load dissipated during passage through the discharge system so that at the point of discharge from the cooling pond (station 7) the mean water temperature was similar to the mean water temperature at the plant's intake (station 2). On the other hand, the mean water temperature at the cooling pond discharge location (station 7) was approximately 1°C higher than the mean water temperature of the other Trinity Bay stations (stations 8, 9, 10 and 11).

Surface pH values determined during the study period varied from 7.20 to 9.00 (Table 4). Values determined in Cedar Bayou (stations 1, 2, 3 and 4) and Trinity Bay (stations 8, 9, 10 and 11) were generally higher than values determined at the stations of the discharge system (stations 5, 6 and 7). The lowest median pH values determined in the study area were determined at stations 5, 6 and 7 (8.00, 7.75 and 7.95 respectively).

Phytoplankton Standing Crop

Chlorophyll a concentrations at Cedar Bayou stations located between the plant and Tabbs Bay (stations 3 and 4) were usually higher than values determined at stations above the plant and at the plant's intake (stations 1 and 2). Mean chlorophyll a concentrations for

Table 3. Monthly surface water temperature measurements (°C) determined at each sampling station from October 1972 to April 1974.

Month	Stations										
	1	2	3	4	5	6	7	8	9	10	11
Oct.	28.0	28.0	27.5	27.5	35.5	34.5	28.0	23.5	26.5	27.0	26.0
Nov.	16.5	16.0	18.0	18.0	26.0	24.0	14.0	14.0	14.5	14.5	14.0
Dec.	14.5	14.5	13.5	13.5	20.5	13.0	19.0	12.0	12.0	11.0	12.0
Jan.	14.0	14.0	14.0	16.0	22.0	20.0	14.5	14.0	13.0	15.5	12.0
Feb.	13.0	12.5	12.5	13.0	22.5	18.5	13.0	11.5	10.5	11.0	11.0
Mar.	19.0	19.0	19.0	19.0	27.0	25.0	19.0	18.0	18.0	18.0	18.0
Apr.	18.0	20.0	20.0	19.5	28.0	26.0	22.0	18.0	21.0	20.0	21.0
May	19.5	19.5	20.5	20.5	27.0	26.0	21.0	20.5	21.0	21.0	19.0
Jun.	22.5	23.0	23.0	22.5	38.0	38.0	25.0	22.0	21.5	21.5	24.0
Jul.	31.0	31.0	31.0	31.0	40.0	39.0	28.5	29.0	30.0	31.0	28.0
Aug.	31.0	31.0	31.0	31.0	37.0	37.0	28.5	29.0	29.5	29.5	27.5
Sep.	28.5	28.0	28.5	28.5	37.0	35.0	26.0	28.0	27.5	27.0	27.0
Oct.	23.5	23.5	23.0	23.5	31.0	31.0	24.5	23.0	23.0	23.0	22.0
Nov.	22.0	22.0	21.0	21.0	28.5	27.0	19.0	18.0	18.0	18.0	19.0
Dec.	11.5	10.0	9.0	9.0	24.0	20.0	10.0	9.0	8.5	8.0	10.5
Jan.	17.0	18.0	16.5	15.0	29.0	25.5	15.0	15.0	14.0	12.5	15.0
Feb.	20.0	20.0	20.5	20.0	31.0	25.5	19.5	19.0	20.0	19.0	18.0
Mar.	21.0	19.5	20.0	20.0	26.0	25.0	20.0	19.0	19.0	20.0	21.0
Apr.	25.0	25.5	26.0	25.5	33.0	31.0	25.0	24.5	24.0	24.0	24.0
Station Mean	20.8	20.8	20.8	20.5	29.6	27.4	20.6	19.3	19.6	19.6	19.4

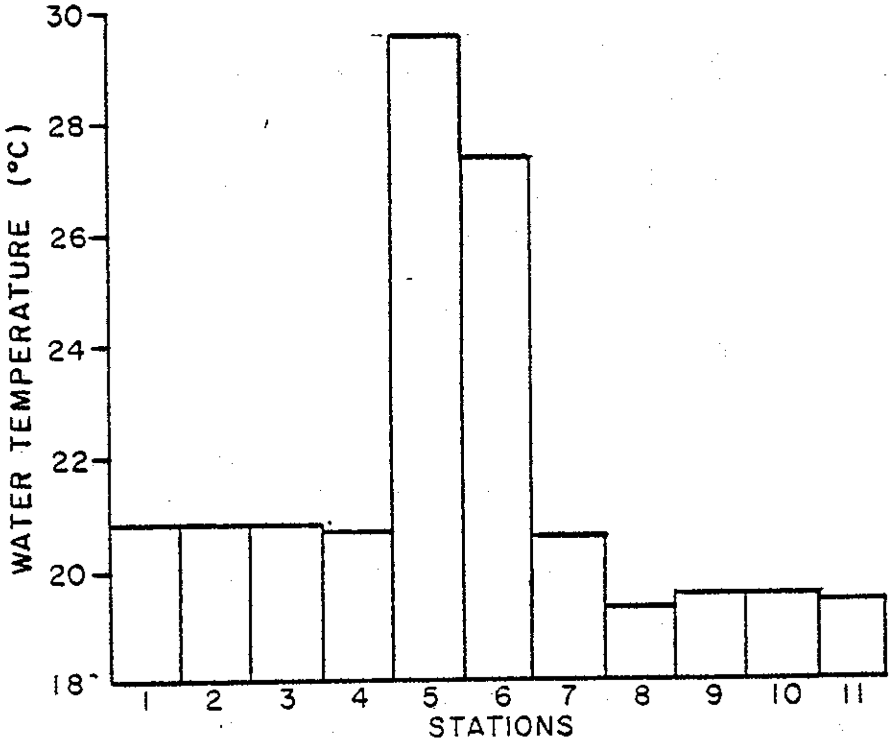

Fig. 4. Mean water temperatures determined for sampling stations for the period of October 1972 through April 1974.

Table 4. Monthly surface pH measurements determined at each sampling station from October 1972 to April 1974

Month	Stations										
	1	2	3	4	5	6	7	8	9	10	11
Oct.	8.60	8.60	8.80	8.65	8.40	8.10	7.40	8.60	8.55	8.60	8.35
Nov.	7.80	7.45	7.85	8.00	7.45	7.75	8.70	8.75	8.65	8.70	8.50
Dec.	7.95	8.00	8.35	8.30	8.15	8.10	7.90	8.75	8.75	8.65	8.65
Jan.	8.15	8.05	8.75	8.85	8.40	8.00	7.85	8.35	8.25	8.55	8.45
Feb.	8.45	8.35	8.20	8.40	8.15	8.20	8.35	8.30	8.60	8.55	8.80
Mar.	7.90	7.65	7.70	7.75	7.65	7.70	7.95	8.35	8.20	8.00	8.60
Apr.	8.00	8.10	8.25	8.15	7.50	7.70	7.60	8.15	8.40	8.35	8.50
May	8.40	8.45	8.55	8.70	8.20	8.50	8.75	8.55	8.25	8.30	8.10
Jun.	8.95	8.80	9.00	8.85	8.75	8.45	8.20	8.20	8.05	7.95	8.70
Jul.	8.25	8.40	8.65	8.60	8.25	8.25	8.30	8.65	8.25	8.30	8.05
Aug.	7.95	8.10	8.50	8.55	8.10	7.80	8.25	8.40	7.95	8.35	8.45
Sep.	8.00	8.30	7.50	8.45	8.00	7.65	8.05	7.75	7.55	7.35	7.75
Oct.	7.65	7.55	7.65	7.70	7.45	7.60	7.30	7.75	7.75	7.65	7.95
Nov.	7.85	7.70	7.90	7.75	7.50	7.35	7.85	7.85	7.95	8.10	8.45
Dec.	7.75	7.65	7.70	7.85	7.60	7.40	7.80	8.20	8.20	8.00	7.40
Jan.	8.25	8.55	8.30	8.30	8.30	8.45	7.75	8.40	8.50	8.25	8.30
Feb.	8.30	8.65	8.70	8.55	7.60	7.25	7.20	7.90	7.65	8.10	7.65
Mar.	8.10	8.15	7.50	7.70	7.65	7.55	7.95	8.05	8.20	8.15	7.50
Apr.	7.95	7.95	8.10	8.05	7.80	7.70	8.05	8.20	8.10	8.05	7.80
Station Median	8.10	8.10	8.25	8.30	8.00	7.75	7.95	8.30	8.20	8.25	8.35

stations 3 and 4 were 18.3 and 17.5 mg Chl*a*/m^3, respectively, whereas values for stations 1 and 2 were 10.6 and 10.8 mg Chl*a*/m^3, respectively, (Fig. 5). Chlorophyll *a* values for the Cedar Bayou stations were from 0.6 mg Chl*a*/m^3 at station 1 in November 1972 to 69.9 mg Chl*a*/m^3 at station 3 in January 1973 (Table 5).

Mean chlorophyll *a* concentrations at the plant's intake (station 2) and discharge (station 5) indicate that there was little difference in chlorophyll *a* concentrations at these 2 stations. The mean chlorophyll *a* value at the plant's intake (station 2) was 10.8 mg Chl*a*/m^3 as compared to 10.1 mg Chl*a*/m^3 at the plant's discharge (station 5). The mean chlorophyll *a* concentration (14.5 mg Chl*a*/m^3) at the mouth of the cooling pond (station 7) was almost double the mean concentration at the head of the cooling pond (7.6 mg Chl*a*/m^3 - station 6).

The chlorophyll *a* concentrations at the control station (station 11) were generally higher than or similar to values at the other Trinity Bay stations (stations 8, 9 and 10). On only 17 of 57 occasions (30% of the time) were the monthly chlorophyll *a* values at stations 8, 9 and 10 more than 33% higher than the values determined at the control station.

Primary Productivity Rate

Primary productivity rates measured during this study varied from 0.0 to 189.3 mg C/m^3/hr. (Table 6). The mean primary productivity values determined for the sampling stations were from 12.8 to 53.5 mg C/m^3/hr. (Figure 6). Maximum primary productivity rates were

Table 5. Surface chlorophyll a concentrations (Mg Chla/M^3) measured at each sampling station from October 1972 to April 1974.

Month	Stations										
	1	2	3	4	5	6	7	8	9	10	11
Oct.	57.1	32.2	26.7	16.1	17.0	10.3	3.6	21.6	24.4	25.7	9.5
Nov.	0.6	1.3	8.1	5.3	5.1	2.7	42.8	28.1	10.2	9.0	11.9
Dec.	1.9	2.6	13.9	12.2	7.0	4.6	7.3	23.5	10.7	15.7	37.7
Jan.	2.7	6.3	69.9	48.3	19.5	16.0	7.2	12.4	10.9	7.3	33.6
Feb.	1.2	3.0	23.4	23.4	8.6	5.1	5.8	23.0	14.4	7.7	48.3
Mar.	1.8	8.0	9.2	35.0	9.0	12.9	5.4	11.2	7.8	8.8	4.8
Apr.	5.8	4.2	10.4	11.9	2.8	3.7	2.2	4.6	4.2	6.8	13.8
May	17.9	15.9	22.5	15.6	14.2	4.8	29.0	26.2	19.3	17.0	13.2
Jun.	26.2	25.7	11.9	13.3	18.8	3.9	10.5	6.8	14.2	10.2	12.4
Jul.	6.8	11.2	13.6	10.7	8.5	5.6	10.0	12.0	4.2	5.1	11.9
Aug.	6.0	7.7	37.5	30.0	18.4	11.2	10.9	5.8	5.8	7.3	9.5
Sep.	8.7	34.5	36.8	31.1	15.3	6.0	23.1	15.1	8.0	11.9	7.9
Oct.	4.5	2.7	5.6	6.8	2.2	2.3	5.1	9.5	10.0	9.6	11.3
Nov.	5.8	6.9	6.2	7.4	5.2	5.4	18.4	4.5	4.2	4.4	11.5
Dec.	3.9	5.0	3.7	20.6	6.9	7.1	26.8	7.3	7.6	6.0	12.0
Jan.	1.4	1.7	1.3	1.0	0.9	1.2	12.1	3.3	5.2	4.2	6.6
Feb.	23.3	18.2	19.3	15.5	20.6	25.6	22.5	14.2	30.8	17.4	13.6
Mar.	1.7	1.5	10.3	16.8	3.1	1.8	18.4	16.0	16.1	22.0	11.0
Apr.	24.3	17.4	17.4	11.9	9.2	3.9	17.6	9.4	8.8	7.4	6.1
Station Mean	10.6	10.8	18.3	17.5	10.1	7.1	14.7	13.4	11.4	10.7	15.1

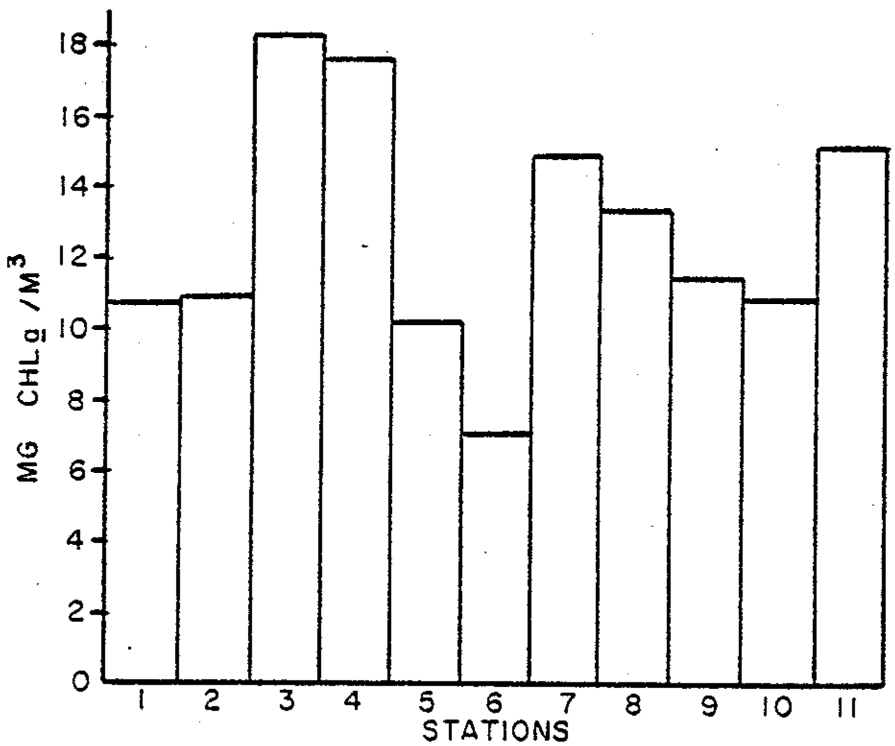

Fig. 5. Mean chlorophyll a concentrations determined from samples taken October 1972 through April 1974.

Table 6. Surface primary productivity rates (mg C/M^3/hr) determined at each sampling station from October 1972 to April 1974

Month	Stations 1	2	3	4	5	6	7	8	9	10	11
Oct.	60.7	86.5	56.9	41.3	8.5	6.1	2.6	22.5	28.4	26.1	11.9
Nov.	29.7	26.7	53.3	62.7	26.7	0.5	128.3	64.5	19.7	65.1	89.3
Dec.	0.0	2.6	13.5	10.7	8.6	5.4	5.4	15.5	22.1	11.7	23.4
Jan.	43.0	20.9	165.0	162.2	47.9	46.7	70.4	34.9	58.2	38.4	161.8
Feb.	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1
Mar.	3.4	33.4	44.6	136.3	0.0	4.1	11.5	55.0	28.9	45.5	24.4
Apr.	37.9	14.8	31.9	20.1	3.1	4.9	1.4	9.3	12.1	14.1	39.5
May	54.4	64.9	61.5	27.9	32.3	1.5	16.2	45.7	57.2	101.1	39.9
Jun.	55.1	52.9	24.2	21.3	3.6	3.5	14.1	11.2	33.5	18.4	21.9
Jul.	8.9	5.9	13.0	11.1	0.0	6.1	6.1	5.0	0.0	4.9	9.8
Aug.	47.4	65.7	172.7	120.3	43.7	1.7	42.4	0.8	26.8	19.7	41.1
Sep.	22.6	78.1	90.1	43.3	11.3	2.7	76.1	35.4	27.6	19.5	11.7
Oct.	0.0	0.0	0.0	1.1	0.0	0.4	0.0	2.0	5.0	6.5	2.7
Nov.	15.6	36.7	35.9	24.3	13.7	13.5	39.2	8.7	14.7	15.4	51.5
Dec.	5.0	6.4	25.7	39.3	22.4	12.3	124.0	17.9	20.4	17.2	36.2
Jan.	5.7	9.5	2.8	2.2	1.0	3.6	25.5	12.0	15.6	11.9	17.8
Feb.	77.8	138.4	189.3	102.6	67.8	104.7	95.7	26.4	162.9	49.3	91.6
Mar.	10.2	4.5	2.9	39.0	0.0	20.9	59.8	40.5	40.5	65.9	33.7
Apr.	70.6	85.5	32.8	25.7	34.9	5.0	90.7	20.2	45.2	26.3	13.1
Station Mean	28.8	38.6	53.5	43.1	17.1	12.8	42.6	22.5	32.6	29.3	38.0

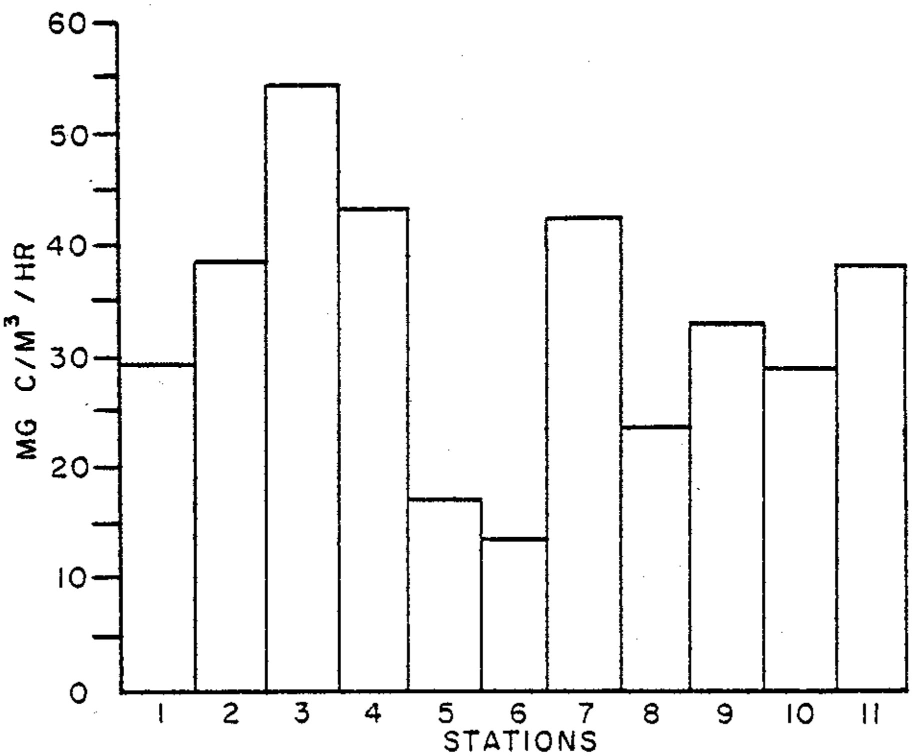

Fig. 6. Mean phytoplankton primary productivity rates determined for samples taken October 1972 through April 1974.

measured at station 3 (189.3 mg $C/m^3/hr.$, February 1974 and 172.7 mg $C/m^3/hr.$, August 1973).

Primary productivity rates in the discharge canal were generally lower than rates at other stations (Table 6). Primary productivity rates at the plant's discharge (station 5) and the terminus of the discharge canal (station 6) were generally similar to or lower than values determined for the plant's intake waters (station 2). On 4 occasions (November 1972, September 1973, December 1973 and April 1974), primary productivity rates at the cooling pond discharge location (station 7) were at least 70 mg $C/m^3/hr.$ more than the rate determined at the head of the cooling pond (station 6).

The mean productivity rates determined for cooling water after passage through the plant were lower than the mean rates calculated for waters taken at the remaining stations in the study area (Fig. 6). The mean rate at the plant's intake (station 2) was 38.6 mg $C/m^3/hr.$ as compared to 17.1 mg $C/m^3/hr.$ at the plant's discharge (station 5) and 12.8 mg $C/m^3/hr.$ at the terminus of the discharge canal (station 6). On the other hand, the mean rate at the cooling pond discharge location (station 7) was higher than those determined at the plant's intake (station 2) and the other Trinity Bay stations (stations 8, 9, and 10) including the control station (station 11).

Assimilation Ratio

An assimilation ratio, which relates the productivity rate to the chlorophyll a concentration (Ryther and Yentsch, 1957), was calculated from the results of each station's monthly chlorophyll a and primary productivity analysis. The ratios determined for this study varied from 0.0 to 49.5 mg C/m^3/hr. : mg Chl*a*/m^3 (Table 7); but only one value (station 1, November 1972) exceeded 20.5 mg C/m^3/hr : mg Chl*a*/m^3.

The mean assimilation ratios for the sample stations in the discharge system (stations 5 and 6) were lower than ratios determined for any other station in the study area (Fig. 7). The mean ratio determined for the plant's discharge waters (station 5, 1.6 mg C/m^3/hr.: mg Chl*a*/m^3) was only one-third that of the intake waters (station 2, 4.3 mg C/m^3/hr.: mg Chl*a*/m^3). With the exception of station 8 (1.8 mg C/m^3/hr. : mg Chl*a*/m^3) the ratio of 2.5 mg C/m^3/hr. : mg Chl*a*/m^3 for the cooling pond discharge location (station 7) was less than those ratios for other Trinity Bay stations (station 9 - 2.8, station 10 - 2.8, and station 11 - 2.9).

Assay Results

Medium suitability tests were conducted to determine the suitability of water samples collected in the study area for phytoplankton growth. A standard organism (*S. costatum*) inoculated into NH-15 medium and incubated at 20°C served as a control to compare relative growth values between months. The results of an analysis of variance for the relative growth of this organism at these control conditions indicated that the variations between months were significant (Table 8).

productivity analysis. The ratios determined for this study varied from 0.0 to 49.5 mg C/m^3/hr. : mg Chl<u>a</u>/m^3 (Table 7); but only one value (station 1, November 1972) exceeded 20.5 mg C/m^3/hr : mg Chl<u>a</u>/m^3.

The mean assimilation ratios for the sample stations in the discharge system (stations 5 and 6) were lower than ratios determined for any other station in the study area (Fig. 7). The mean ratio determined for the plant's discharge waters (station 5, 1.6 mg C/m^3/hr.: mg Chl<u>a</u>/m^3) was only one-third that of the intake waters (station 2, 4.3 mg C/m^3/hr.: mg Chl<u>a</u>/m^3). With the exception of station 8 (1.8 mg C/m^3/hr. : mg Chl<u>a</u>/m^3) the ratio of 2.5 mg C/m^3/hr. : mg Chl<u>a</u>/m^3 for the cooling pond discharge location (station 7) was less than those ratios for other Trinity Bay stations (station 9 - 2.8, station 10 - 2.8, and station 11 - 2.9).

Assay Results

Medium suitability tests were conducted to determine the suitability of water samples collected in the study area for phytoplankton growth. A standard organism (<u>S. costatum</u>) inoculated into NH-15 medium and incubated at 20°C served as a control to compare relative growth values between months. The results of an analysis of variance for the relative growth of this organism at these control conditions indicated that the variations between months were significant (Table 8).

Table 7. Monthly assimilation ratio (mg $C/M^3/hr$: mg $Chl\underline{a}/M^3$) determined at each sampling station from October 1972 to April 1974.

Month	Stations										
	1	2	3	4	5	6	7	8	9	10	11
Oct.	1.1	2.4	2.1	2.6	0.5	0.6	0.7	1.0	1.2	1.0	0.3
Nov.	49.5	20.5	6.6	11.8	5.2	0.2	2.9	2.3	1.9	7.2	7.5
Dec.	0.0	1.0	1.0	0.9	1.2	1.2	0.7	0.7	2.1	0.7	0.6
Jan.	15.9	3.3	2.4	3.6	2.5	2.9	9.8	2.8	5.3	5.3	4.3
Feb.	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Mar.	1.9	4.2	4.8	3.9	0.0	0.3	2.1	4.9	3.7	5.2	5.1
Apr.	6.5	4.7	3.1	1.7	1.1	1.3	0.6	2.0	2.9	2.1	2.9
May	3.0	4.1	2.7	1.8	2.3	0.3	0.6	1.7	3.0	5.9	3.1
Jun.	2.1	2.1	2.0	1.6	0.2	0.9	1.8	1.6	2.4	1.8	1.8
Jul.	1.3	0.5	1.0	1.0	0.0	1.1	0.6	0.4	0.0	1.0	0.8
Aug.	1.9	8.5	4.6	4.0	2.4	0.2	3.9	0.1	4.6	2.7	4.3
Sep.	2.6	2.3	2.4	1.4	0.7	0.4	3.3	2.3	3.4	1.6	1.5
Oct.	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.2	0.5	0.7	0.2
Nov.	2.7	5.3	5.8	3.3	2.6	2.5	2.1	1.9	3.5	3.5	4.5
Dec.	1.3	1.3	6.9	1.9	3.2	1.7	4.6	2.4	2.7	2.9	3.1
Jan.	4.1	5.6	2.2	2.2	1.1	3.0	2.1	3.6	3.0	2.8	2.7
Feb.	3.3	7.6	9.8	6.6	3.3	4.1	4.3	1.4	5.3	2.8	6.7
Mar.	6.0	3.0	0.3	2.3	0.0	11.6	3.2	2.5	2.5	3.0	3.1
Apr.	2.9	4.9	1.9	2.2	3.5	1.3	5.1	2.2	5.1	3.6	2.1
Station Mean	5.9	4.3	3.1	2.8	1.6	1.8	2.5	1.8	2.8	2.8	2.9

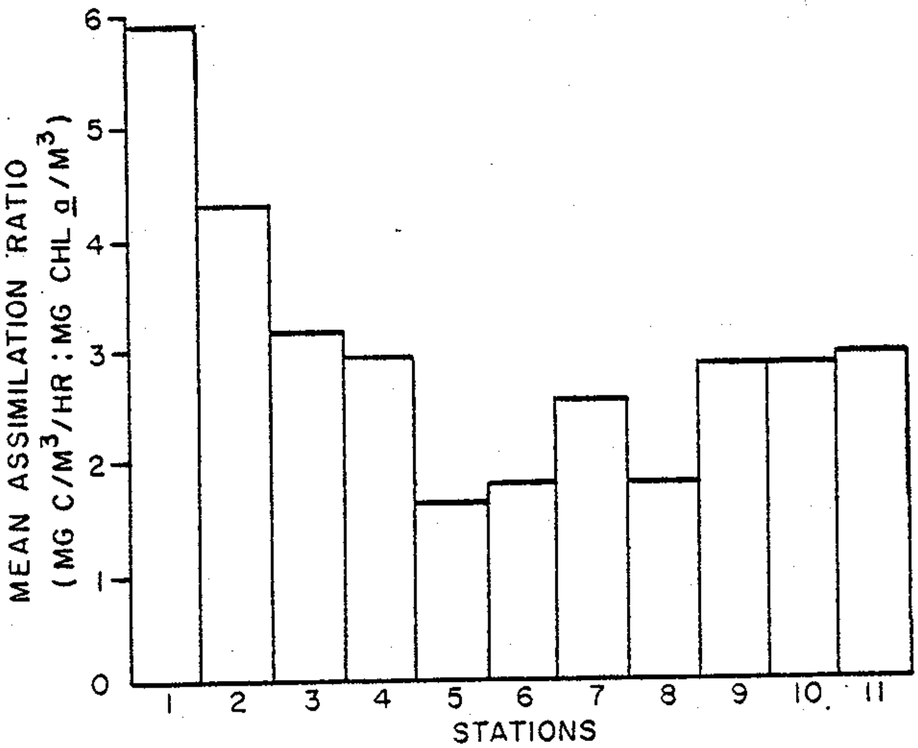

Fig. 7. Mean assimilation ratios calculated from samples taken October 1972 through April 1974.

Table 8. Analysis of variance for relative growth of S. costatum in NH-15 at 20°C among months.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Among months	18	146265	8126	15.09*
Within months	38	20461	538	
Total	56	166726		

*Significant at 1% level

Although an attempt was made to assure that the control organism was in a stage of exponential growth and that like quantities of inoculum were introduced each month, no technique was employed to insure a similar number of control organisms for each monthly inoculum. Possible differences in the number of control organisms inoculated at the start of each monthly assay could have resulted in the variations of S. costatum populations observed at the end of each assay period. Because of the significant difference in the relative growth values in the monthly controls, comparisons among months were not analyzed. The following analyses were based on comparisons within each month.

The sources and effects of cooling water discharges on the suitability of waters, for phytoplankton growth, was determined by evaluating t-test results which compared stations as follows:

1. Stations 1, 2, 3 and 4 vs. station 6.
2. Station 2 vs. stations 7 and 11.
3. Station 7 vs. stations 8 and 11.
4. Station 8 vs. station 11.
5. Station 3 vs. station 4.

Totals of t-test results, at the 5% confidence level, for a particular assay organism-media were grouped into 3 categories (A > B, A < B and A = B). A percentage of the whole for each category was calculated. Differences in categories of a particular group were deemed significant if the percentage of a particular category exceeded 50% of the total for the group.

The results of t-test for the suitability of FSW and 50/50 medium for the growth of S. costatum and NP between station 6 and stations 1, 2, 3 and 4 indicated that higher mean relative growth values of NP were most frequently determined from water samples taken at stations 2, 3 and 4 than for samples taken at station 6 (Table 9). In more cases similar mean relative growth values were determined for S. costatum in the 50/50 medium prepared with station 6 samples than were determined for 50/50 media prepared with samples from either stations 1, 2, 3 or 4 (55%, 65%, 64% and 60% of the assays, respectively). Although results from 44% of the assays indicated that similar mean values of NP were determined for 50/50 media from stations 1 and 6, higher mean values were determined more frequently in 50/50 media prepared with station 1 samples than from station 6 samples (36% compared to 20% of the assays, respectively). No conclusions can be made from the FSW/NP assay results for stations 1 and 6.

The results of the t-test for the suitability of FSW and 50/50 media for the growth of S. costatum and NP between stations 2, 7 and 11 indicated that higher NP mean relative growth values were determined from water samples taken at station 2 than from samples taken at

Table 9. Summary of t-test results for the suitability of field sample water (FSW) and 50/50 medium for the growth of S. costatum and natural phytoplankton (NP) between station 6 and stations 1, 2, 3 and 4. μ = mean relative growth value determined from replicates. Values listed represent total number of tests fitting a category.

	Skeletonema costatum	NP	
	50/50 medium	FSW	50/50 medium
$\mu1 > \mu6$	4	7	13
$\mu1 < \mu6$	9	7	7
$\mu1 = \mu6$	16	13	16
$\mu2 > \mu6$	4	10	13
$\mu2 < \mu6$	8	3	8
$\mu2 = \mu6$	22	16	15
$\mu3 > \mu6$	4	11	11
$\mu3 < \mu6$	8	5	7
$\mu3 = \mu6$	21	12	19
$\mu4 > \mu6$	5	10	12
$\mu4 < \mu6$	9	6	4
$\mu4 = \mu6$	20	13	21

< > indicates one tail test significant at 5% level
= indicates not significant at 5% level

stations 7 and 11 (Table 10). These results also indicate that mean values determined for S. costatum in 50/50 medium prepared from station 2 samples waters were similar to mean values determined in 50/50 media prepared from stations 7 and 11 samples.

Results of the t=test for the suitability of filtered sample water medium (FSW) and 50/50 medium for the growth of S. costatum and NP between stations 7, 8 and 11 show that higher mean relative growth values for both S. costatum and NP were more frequently obtained using water samples from station 7 than with samples from station 8 (Table 11).

Table 10. Summary of t-test results for the suitability of field sample water (FSW) and 50/50 medium for the growth of S. costatum and natural phytoplankton (NP) between station 2 and stations 7 and 11. μ = mean relative growth value determined from replicates. Numbers represent total number of tests fitting a category.

	Skeletonema costatum	NP	
	50/50 medium	FSW	50/50 medium
$\mu2 > \mu7$	10	14	15
$\mu2 < \mu7$	6	4	9
$\mu2 = \mu7$	16	12	13
$\mu2 > \mu11$	8	17	14
$\mu2 < \mu11$	7	4	7
$\mu2 = \mu11$	19	9	15

< > indicates one tail test significant at 5% level
= indicates not significant at 5% level

Table 11. Summary of t-test results for the suitability of field sample water (FSW) and 50/50 medium for the growth of S. costatum and natural phytoplankton (NP) between station 7, 8 and 11. μ = mean relative growth value determined from replicates. Values listed represent total number of tests fitting a category.

	Skeletonema costatum	NP	
	50/50 medium	FSW	50/50 medium
$\mu7 > \mu11$	8	11	10
$\mu7 < \mu11$	8	3	8
$\mu7 = \mu11$	18	7	18
$\mu7 > \mu 8$	13	11	14
$\mu7 < \mu 8$	3	1	8
$\mu7 = \mu 8$	16	6	15
$\mu8 > \mu11$	2	3	8
$\mu8 < \mu11$	8	6	12
$\mu8 = \mu11$	23	5	17

< > indicates one tail test significant at 5% level
= indicates not significant at 5% level

In most cases higher NP relative growth values were determined for station 7 FSW media than for the control station's (station 11) FSW media (52% and 14% of the assays, respectively). On the other hand, similar mean values for S. costatum were most frequently determined from 50/50 medium prepared with stations 7 and 11 samples (53% of the cases). In most cases (70% of the cases) similar mean values for S. costatum were determined for 50/50 media from stations 8 and 11. No conclusions can be made comparing the assay results of NP in either FSW of 50/50 media between stations 8 and 11.

The results of the t-test indicated that similar mean relative growth values were determined for S. costatum and NP inocula in water samples from stations 3 and 4 (Table 12).

Table 12. Summary of t-test results from the suitability of field samples water (FSW) and 50/50 medium for the growth of S. costatum and natural phytoplankton (NP) between stations 3 and 4. μ = mean relative growth value determined from replicates. Numbers represent total number of tests fitting a category.

	Skeletonema costatum	NP	
	50/50 medium	FSW	50/50 medium
$\mu 3 > \mu 4$	8	5	6
$\mu 3 < \mu 4$	3	7	11
$\mu 3 = \mu 4$	22	14	21

< > indicates one tail test significant at 5% level
= indicates not significant at 5% level

DISCUSSION

Cooling water temperature increases are normally associated with power plant operations (Markowski 1959, 1960, Roessler 1971, and Fox and Moyer 1973). Markowski (1960) found an increase of 8°C between the intake and discharge water temperatures of an English generating plant, and temperatures were elevated 6-7°C at 2 Florida power plants (Roessler 1971, Fox and Moyer 1973). In this study, power plant operations during the study period resulted in a mean water temperature increase of 8.8°C between the temperature of water just prior to entering the plant (station 2) and the temperature of water immediately upon discharge from the plant (station 5). But, the difference between the mean water temperatures at the cooling pond discharge location and the other Trinity Bay stations was only about 1.0°C. This small difference indicates that most of the heat increase due to passage through the plant dissipated during passage through the discharge canal and cooling pond. Therefore, the temperature of cooling waters discharged into Trinity Bay was not considered to be a significant factor in this study.

Low salinity levels were observed in Trinity Bay during the study period. Pullen et al. (1971) indicated that salinity levels of Trinity Bay waters were inversely related with Trinity Bay discharges. The highest salinity measured during this study was in the first 3 months of the study period (October, November and December 1972). From January 1973 to the termination of the study, salinity values recorded for the Trinity Bay stations did not exceed 6.5 ppt. Periods of near freshwater conditions (below 1.5 ppt) were observed at the upper Trinity Bay stations (stations 8, 9 and 10) from March 1973 to June 1973, and from October 1973 to January 1973. These low salinity levels could have resulted from seasonal flooding of the Trinity River.

The mean surface water salinity level at the cooling pond discharge station (station 7) was 3 ppt. higher than surface salinity at the intake station (station 2). Hammerschmidt (1973) reported that a layer of industrial brine was often present near the bottom of upper Cedar Bayou. The uptake of cooling waters, by the plant, which contained this brine layer and the subsequent mixing of this layer with other less saline waters from both upper and lower Cedar Bayou could have resulted in this salinity increase. As a result, the mean salinity of water samples from the cooling and discharge station (station 7) was higher than at the other Trinity Bay stations.

Maximum chlorophyll a concentrations and primary productivity rates determined for the Trinity Bay area were higher than maximum values reported for other marine areas. Steidinger (1973), in a review of the literature on phytoplankton chlorophyll a concentrations in oceanic and estuarine areas, presented results of a number of previous studies that indicated that maximum chlorophyll a concentrations determined in most of those studies were from 2 to 44 mg Chl$\underline{a}$/m^3. Chlorophyll a concentrations in the Trinity Bay area exceeded 44 mg Chl$\underline{a}$/m^3 on 4 occasions with a maximum value of 69.9 mg Chl$\underline{a}$/m^3 (station 3 - January 1973). McAllister et al. (1960) reported primary productivity rates from less than 1 to approximately 50 mg C/m^3/day for stations located in the Pacific Ocean and the maximum rate reported by Stross and Stottlemeyer

(1965) for the Patuxent River Estuary was 148.5 mg C/m^3/hr. In the present study primary productivity rates exceeding 148.5 mg C/m^3/hr. occurred on 6 occasions with a maximum rate determined in the study area of 189.3 mg C/m^3/hr. (station 3 - February 1974).

Primary productivity rates were not consistently observed to be directly associated with chlorophyll a concentrations. Ryther and Yentsch (1957) reported that chlorophyll was not an infallible indicator of photosynthetic capacity. Although, in this study, many instances of high primary productivity rates were measured at times of high chlorophyll a concentrations and low primary productivity rates were normally associated with low chlorophyll a concentrations there were some exceptions. For example, a high chlorophyll a concentration determined at the control station in February 1973 (48.3 mg Chla/m^3) coincided with a low primary productivity rate (0.1 mg C/m^3/hr.). Also a low chlorophyll a concentration was measured at station 1 in January 1973 (2.7 mg Chla/m^3) when a high primary productivity rate (43.0 mg C/m^3/hr.) was determined.

Chlorophyll a concentrations and primary productivity rates of discharge waters were lower than those that occurred in intake waters. Similar chlorophyll a reductions in cooling waters after passage through power plants were also reported by Kelsey (1974) and Hamilton et al. (1970). In the present study the progressively lower mean chlorophyll a values calculated for the plant's intake, discharge, and discharge canal terminus could indicate that, between the plant's discharge and the terminus of 9.7 km discharge canal, a degradation of chlorophyll a occurred in the phytoplankton cells killed during passage through the plant. The mean primary productivity of discharge waters was 56% lower than the mean rate at the plant's intake. Morgan and Stross (1969) and Fox and Moyer (1973) reported reductions in cooling water phytoplankton productivity of 85 and 29%, respectively, after passage through power plants. Adverse effects such as increased heat, chlorination and mechanical stress due to passage through the plant could have caused this decrease in chlorophyll a concentrations and primary productivity rates of discharge waters compared to that of intake waters (Morgan and Stross 1969).

An increase in the productivity of cooling water phytoplankton resulted when the temperature of the intake water (station 2) was 16°C or less and a decrease resulted when the intake water temperature was above 16°C. On 13 of 14 occasions when the intake water temperature was above 16°C, a decrease in the productivity of discharge water (station 5) phytoplankton was observed (a productivity rate of 0.0 mg C/m^3/hr was determined for both the intake and discharge stations in October 1973). Primary productivity rates in the discharge waters were higher than in the intake waters on 3 of 5 occasions when the intake water temperature was 16°C or less. On the other 2 occasions the productivity rates at the 2 stations were similar. Morgan and Stross (1969) also observed an increase in the primary productivity rate of cooling water phytoplankton when intake water temperatures were 16°C of less, but a decrease was observed only when the intake water temperature reached 23°C or higher.

A comparison of the assimilation ratios, a value which relates the productivity rate to the chlorophyll a concentration, between the plant's intake (station 2) and discharge (station 5) also indicated that passage through the power plant had an adverse effect on phytoplankton contained in the cooling waters. On 13 of the 19 occasions when assimilation ratios were determined for phytoplankton from these 2 locations, values determined from the plant's discharge waters were at least 50% lower than values determined for intake waters. On only 1 of the remaining 6 occasions (December 1973) were the discharge water ratio significantly higher (greater than 0.2 mg C/m^3/hr.:mg $Chla/m^3$) than the intake water ratio.

Assay results indicate that sample waters from the stations located in Cedar Bayou (stations 1 - 4) were equal to or slightly more suitable for the growth of assay organisms than were sample waters from the discharge canal terminus (station 6). The addition of chlorine, to reduce fouling, is a common practice in routine power plant operations. Although no information was available on the frequency of chlorine additions during the study period, this reduction in suitability could have been associated with periodic chlorine additions. Brook and Baker (1972) found that chlorine additions, in cooling waters of a Minnesota power plant, reduced photosynthesis from 50% to 90% compared to that of control samples. They determined that this high reduction in photosynthesis of chlorinated cooling waters was much greater than the 5 to 15% reduction associated with unchlorinated cooling water.

Waters collected at the lower Cedar Bayou stations (stations 3 and 4) may have originated from the same source. Results from chlorophyll *a*, primary productivity, hydrological and bioassay determinations indicated that water samples from these 2 stations were similar and could have come from the same water body. This source could have been the Houston Ship Channel. Copeland et al. (1970) suggested that the reversal of flow of lower Cedar Bayou could bring polluted waters from the Houston Ship Channel into the lower Cedar Bayou.

The transfer of polluted waters from the Houston Ship Channel into lower Cedar Bayou could have enriched the lower Cedar Bayou waters and, therefore, enhanced these waters for phytoplankton growth. The highest mean chlorophyll *a* concentrations and mean primary productivity rates in the study area were determined for sample waters collected at the lower Cedar Bayou stations (stations 3 and 4). These high values could be due to high levels of industrial and domestic wastes contained in lower Cedar Bayou waters (Copeland et al. 1970).

The plant's uptake and subsequent discharge of nutrient-rich cooling waters into Trinity Bay could have increased the quality of Trinity Bay waters for phytoplankton growth. The enhancement of Trinity Bay water quality is evidenced by assay results which indicate that sample waters taken at the cooling pond discharge location supported higher relative chlorophyll *a* values than did sample waters taken at the other Trinity Bay stations. Also higher mean chlorophyll *a* concentrations and primary productivity rates were determined for samples collected at this location than at all other Trinity Bay stations, except the control station, which had a mean chlorophyll *a* concentration similar to that determined for the cooling pond discharge location.

The discharge of higher salinity waters into Trinity Bay also could have improved Trinity Bay waters for phytoplankton growth. The mean surface water salinity at the cooling pond discharge location was 3-4 ppt. higher (Table 2, p. 28) than mean salinity levels observed at other Trinity Bay stations (stations 8, 9 and 10). The discharge of this higher salinity water, either alone or in combination with high nutrient levels, could have stimulated phytoplankton populations in the discharge area. The discharge of these higher salinity waters could have been especially important to Trinity Bay phytoplankton populations due to the near freshwater conditions that existed throughout much of the study period.

The improvement of Trinity Bay water quality, for phytoplankton growth, was probably restricted to the area between stations 7 and 8. This restricted enhancement was suspected because no increase in water quality was apparent in water samples collected at the remaining Trinity Bay stations including station 8 (located approximately 2 km east of the cooling pond discharge location).

Because of the low salinity observed during the study period _S. costatum_ was not a suitable standard assay organism. Naturally occurring phytoplankton populations (NP) and _S. costatum_, a common estuarine diatom, were used as assay organisms to assess the suitability of waters in the project for phytoplankton growth. The results of _S. costatum_/FWS assays indicate that the lack of growth of this organism could have been due to the low salinity of sample waters. Curl and McLeod (1961) reported that _S. costatum_ exhibited maximum photosynthesis in enriched seawaters with salinity levels of 15 ppt. A salinity decrease below this level reduced photosynthesis, and in waters with a salinity of 5 ppt. the photosynthetic rate was reduced by 90%.

The addition of NH-15 medium to sample waters improved the suitability of those waters for both S. costatum and NP growth. The addition of this high salinity (28 ppt.) enriched artificial seawater would have increased the salinity and could have increased the nutrient levels of sample waters. This salinity increase and nutrient enrichment could have resulted in the higher mean relative growth values determined for assay organisms in those media than in the FSW alone.

CONCLUSIONS

The increase in discharge water temperature, due to passage through the plant, was not considered to have a significant impact on phytoplankton in Trinity Bay. A mean water temperature increase of 8.8°C between the plant's intake and discharge areas dissipated after passage through the discharge canal and cooling pond, so that, in most cases water temperatures recorded at the cooling pond discharge location were only slightly higher (approximately 1°C) than those recorded at the other Trinity Bay stations.

Chlorophyll a concentrations and primary productivity rates were determined to be lower in waters collected in the discharge system (stations 5 and 6) than in intake waters (stations 1 through 4). The intake water temperature could be a factor in the reduction of the primary productivity rate of the plant's discharge waters.

The low salinity levels of study area waters resulted in a lack of growth of the standard assay organism (S. costatum) in those waters, and could have adversely affected the suitability of Trinity Bay waters for naturally occurring phytoplankton populations.

The discharge of cooling waters from the Cedar Bayou Generating Station improved the water quality of Trinity Bay for phytoplankton growth. This improvement was apparent at the cooling pond discharge station, but not at 2 km from that location. This local improvement in Trinity Bay water quality could have been due to the higher salinity and/or the higher nutrient levels of discharge waters compared to other Trinity Bay waters.

REFERENCES

ADAMS, J. R. 1969. Ecological investigations around some thermal power stations in California tidal waters. Chesapeak Science 10: 145-154.

ARTHUR, C. R. and F. H. RIGLER. 1967. A possible source of error in the C^{14} method of measuring primary productivity. Limnol. Oceanog. 12: 121-124.

ATKINS, W. R. G. and M. PARKE. 1951. Seasonal changes in the phytoplankton as indicated by chlorophyll estimations. Jour. Mar. Biol. Assoc. 29: 609-618

BEAUCHAMP, R. S. A. 1969. The use of chlorine in the cooling water system of coastal power stations. Chesa. Sci. 10: 380.

BRAARUD, T. 1963. Species distribution in marine phytoplankton. Jour. Ocean. Soc. Japan. 20th Ann. Vol.: 628-649.

BROOK, A. J., and A. L. BAKER. 1972. Chlorination at power plants: Impact on phytoplankton productivity. Science 176: 141-1415.

CAIRNS, J., JR. 1956. Effects of increased temperature on aquatic organisms. Indus. Wastes 1: 150-152.

CAIRNS, J. JR. 1967. The use of quality control techniques in the management of aquatic ecosystems. Water Resources Bull. 3: 47-53.

CAIRNS, J., JR. 1972. Coping with heated waste water discharges from steam-electric power plants. Biosciences 23: 411-420.

CARTER, L. J. 1970. Galveston Bay: Test case of an estuary in crisis. Science. 167: 1102-1108.

COLLIER, A., W. B. WILSON, AND M. BORKOWSKI. 1969. Responses of *Gymnodinium breve* Davis to natural waters of diverse origin. Jour. of Phycology. 5: 168-172.

COPELAND, B. J., E. G. FRUH, AND F. MOSELEY. 1970. Biological and ecological studies on Cedar Bayou generating station diversion. Report to Houston Lighting & Power Co, Houston, Texas.

COUTANT, C. C. 1970. Thermal pollution - biological effects. A review of the literature of 1969. Battelle Mem. Inst. Pacif. Northwest Lab., Richland, Wash. :90p.

CURL, H. JR., AND G. C. McLEOD. 1961. The physilogical ecology of a marine diatom, Skeletonema costatum (Grev.) Clevel. Journ. Mar. Res. 19: 70-88.

FISHER, W. L., J. H. McGOWEN, L. F. BROWN, JR., AND C. G. GROAT. 1972. Environmental geologic atlas of the Texas coastal zone: Galveston-Houston area. Univ. Texas Bur. Econ. Geol. Publ., Austin, Tx. 91p.

FLEMER, D. A. 1969. Chlorophyll analysis as a method of evaluating the standing crop phytoplankton and primary production. Chesapeake Science 10: 301-306.

FOX. J. L. AND M. S. MOYER. 1973. Some effects of a power plant on marine microbiota. Chesapeak Science 14: 1-10.

GAARDEN, T. AND H. H. GRAN. 1927. Investigation of the production of plankton in the Oslo Fjord. Rapp. at Proc.-Verb., Cons. Int. Explor. Mar. 42: 1-48.

GATES, J. A., AND W. B. WILSON. 1960. The toxicity of Gonyaulax monilata Howell to Mugil cephalus. Limnol. Oceanogr. 5: 171-174.

GRIMES, C. B. 1971. Thermal addition studies of the Crystal River steam electric station. Fla. Dept. Nat. Resources Mar. Res. Lab., Prof. Pup. Ser. 11: 53p.

HAMILTON, D. H., D. A. FLEMER, C. W. KEEFER, and J. A. MIHURSKY. 1970. Power plants: Effects of chlorination on estuarine primary production. Science 169: 197-198.

HAMMERSCHMIDT, P. C. 1973. The use of fishes in cages as biological monitors of the quality of water passing through a power plant. MS Thesis, Texas A&M Univ. 120 p.

HARVEY, H. W. 1934. Measurement of phytoplankton population. Jour. Mar. Biol. Assoc. U.K. 19: 761-773.

HOLM-HANSEN, O., C. J. LORENZEN, R. W. HOLMES and J. S. H. STRICKLAND. 1965. Fluorometric determination of chlorophyll. Jour. Cons. perm. Int. Explor. Mer. 30: 219-223.

JITTS, H. R., C. D. McALLISTER, K. STEPHENS and J. D. H. STRICKLAND. 1964. The cell division rates of some marine phytoplankters as a function of light and temperature. Jour. Fish. Res. Bd. Can. 21: 139-157.

JOHNSTON, R. 1963. Sea water, the natural medium of phytoplankton. I. General features. Jour. Mar. Biol. Assoc. U.K. 43: 427-456.

JOHNSTON, R. 1964. Sea water, the natural medium of phytoplankton. II. Trace metals and chelation, and general discussion. Jour. Mar. Biol. Assoc. U.K. 44: 87-109

JORGENSEN, E. G. 1966. Photosynthetic activity during the life cycle of synchromous *Skeletonema* cells. Physiol. Plant. 19: 789-799.

KELSEY, J. A. 1974. The effects of a steam-electric generating plant on suitability of adjacent estuarine waters for growth of phytoplankton. MS Thesis, Texas A&M Univ. 109 p.

LASKER, R. and R. W. HOLMES. 1957. Variability in retention of marine phytoplankton by membrane filters. Nature. 180: 1295-1296.

LOFTUS, M. E. and J. H. CARPENTER. 1971. A fluorometric method for determining chlorophylls *a*, *b* and *c*. Jour. Mar. Res. 29: 319-338.

LORENZEN, C. J. 1966. A method for the continuous measurement of *in vivo* chlorophyll concentration. Deep-Sea Res. 13: 223-227.

MALONE, T. C. 1971. The relative importance of nannoplankton and netplankton as primary producers in tropical oceanic and neritic phytoplankton communities. Limnol. Oceanogr. 16: 633-639.

MARKOWSKI, S. 1959. The cooling water of power stations: A new factor in the environment of marine and freshwater invertebrates. Jour. Anim. Ecol. 28: 243-258.

MARKOWSKI, S. 1960. Observations of the response of some benthic organisms to power station cooling water. Jour. Anim. Ecol. 29: 349-357.

MARSHALL, N. 1956. Chlorophyll *a* in the phytoplankton in coastal waters of the eastern Gulf of Mexico. Jour. Mar. Res., 15: 14-32.

MATSUE, Y. 1954. On the culture of the marine plankton diatom *Skeletonema costatum* (Grev.) Clevel. Rev. Fish. Sci. Japan. Jour. Soc. Adv. Sciences: 1-40.

McALLISTER, C. D., T. R. PARSONS AND J. D. H. STRICKLAND. 1960. Primary productivity at station "P" in the Northeast Pacific Ocean. Jour. Conser. Expl. Mer. 25: 240-259.

METYKO, F. J. 1951. Industrial effluents and marine pollution. Tex. Jour. Sci. 1: 45-52.

MIDDLEBROOK, E. J., T. E. MALONEY, C. F. POWERS, AND L. M. KAACK. 1969. Proceedings of the Eutrophication-biostimulation assessment workshop. Berkeley, Calif. June 19-21, 1969 Symposium. i.v. 281p.

MIHURSKY, J. A. 1969. Patuxent thermal studies: summary and recommendations. Md. Nat. Res. Inst. Ref. No. 69-2, Univ. Md., College Park. Md, 20p.

MIHURSKY, J. A. AND L. E. CRONIN. 1967. Problems and progress in thermal pollution in Maryland. Nat. Res. Inst. Univ. Md., College Park. Md., Ref. No. 67-122: 15p.

MORGAN, P. R., II, AND R. G. STROSS. 1969. Destruction of phytoplankton in the cooling water supply of a steam electric station. Chesapeake Science 10: 165-167.

NAYLOR, E. 1965. Biological effects of a heated effluent in locks at Swansea, S. Wales. Proc. 2nd Soc. London. 144: 253-268.

NORTH, W. J. AND J. R. ADAMS. 1969. The status of thermal discharge on the Pacific coast. Chesa. Sci. 10: 139-144.

ODUM, H. T., McCONNELL, W. AND W. ABBOTT. 1958. The chlorophyll a of communities. Pub. Inst. Mar. Sci., 5: 65-96.

OSWALD, W. J. AND S. A. GAONKAR. 1969. Batch assays for determination of algal growth potentials. pp. 23-38. In, Middlebrook. E. J.,

T. E. Maloney, C. F. Powers and L. M. Kaach (eds.) Proceedings of the Eutrophication-biostimulation assessment workshop. Berkeley, Calif., June 1921, 1969 Symposium. i.v. 281p.

PATRICK, R. 1968. Some effects of temperature on freshwater algae. In: Biological aspects of thermal pollution. Ed. Krentel, P. A., and E. L. Parker. Proc. Nat. Symp. in Ther. Poll., Portland, Ore., Vanderbilt Univ. Press: 161-185.

PICTEN, W. L. 1960. Water use in the United States, 1900-1980. Bus. Def. Serv. Adm., U. S. Dept. Comm. 45p.

PULLEN, E. J., W. L. TRENT and G. B. ADAMS, 1971. A hydrographic survey of the Galveston Bay system, Texas. 1963-1966. NOAA Tech. Rep. NMFS SSRF-639. 13p.

RAYMONT, J. E. G. 1963. Plankton and Productivity in the Oceans. Pergamon Press, Oxford. 660 p.

RILEY, G. A. 1941. Plankton studies. IV. Georges Bank. Bull. Bingham Oceanogr. Coll. 7: 1-73.

ROESSLER, J. A. 1971. Environmental changes associated with a Florida power plant. Mar. Poll. Bull. 2: 87-90.

RYTHER, J. H., and R. F. VACCARO. 1954. A comparison of the oxygen and C^{14} methods of measuring marine photosynthesis. Jour. du Cons. 20: 25-34.

RYTHER, J. H., and C. S. YENTSCH. 1957. The estimation of phytoplankton production in the ocean from chlorophyll and light data. Limnol. Oceanogr. 2: 281-294.

SHIMADA, B. M. 1958. Diurnal fluctuations in photosynthetic rate and chlorophyll a content of phytoplankton from Eastern Pacific waters. Limnol. Oceanog., 3: 336-339.

SMAYDA, T. J. 1970. Growth potential bioassay of water masses using diatom cultures: Phosphorescent Bay (Puerto Rico) and Carribbean waters. Helgolander Wiss. Meeresunters 20: 172-194.

SMAYDA, T. J. 1973. The growth of Skeletonema costatum during a winter-spring bloom in Narragansett Bay, Rhode Island. Norwegian Jour. of Botany. 20: 219-247.

SORGE, E. V. 1969. The status of thermal discharges east of the Mississippi River. Chesa. Sci. 10: 131-138.

SPENCER, C. P., 1952. On the use of antibiotics for isolating bacteria-free cultures of marine phytoplankton organisms. Jour. Mar. Biol. Assoc. U.K. 31: 97-106.

STEEMAN-NIELSEN, E. 1952. The use of indicative carbon (C^{14}) for measuring organic production in the sea. Jour. Cons., Cons., Perm. Int. Explor. Mer. 18: 117-140.

STEEMAN-NIELSEN, E. 1955. The interaction of photosynthesis and respiration and its importance for the determination of C^{14} discrimination in photosynthesis. Physiol. Plant. 8:945-953.

STEEMAN-NIELSEN, E. 1964. Recent advances in measuring and understanding marine primary production. Jour. Ecol. 52: 119-130.

STEIDINGER, K. A. 1964. Skeletonema costatum (Greville) Cleve, Fla. Bd. Conser., Mar. Lab. Leaflet Ser. 1: No. 2.

STEIDINGER, K. A. 1973. Photoplankton ecology: A conceptual review based on Eastern Gulf of Mexico research. CRC Critical Reviews in Microbiology. 3: 49-68.

STRICKLAND, J. D. H., and T. R. PARSONS. 1968. A practical handbook of seawater analysis. Fish. Res. Bd. Can. Bull. 167. 311p.

STROSS, R. G., and J. R. STOTTLEMEYER. 1965. Primary production in the Patuxent River. Chesapeake Science 6: 125-140.

UNO, S. 1971. Turbidometric continuous culture of phytoplankton constructions of the apparatus and experiments on the daily periodicity in photosynthetic activity of Phaeodactylum tricornutum and Skeletonema costatum. Plank. Soc. of Japan Bull. 18: 14-27.

WARINER, J. E. and M. L. BREHMER 1966. Effects of thermal effluents on marine organisms. Int. Jour. Air Wat. Pollut., 10: 272-289.

WEISS, C. M. and R. W. HELMS. 1971. The interlaboratory precision test: An eight laboratory evaluation of the provisional algal assay procedure bottle test. Dept. of Environ. Sci. and Engineering School of Public Health. Univ. North Carolina. at Chapel Hill. 70p.

WILSON, W. B. 1966. The suitability of sea-water for the survival and growth of Gymodinium breve Davis; and some effects of phosphorus and nitrogen on its growth. Fla. Bd. Consv., Salt Water Fish. Div., Prof. Paper Series. No. 7. 42 p.

YENTSCH, C. S., and D. W. MENZEL. 1963. A method for the determination of phytoplankton chlorophyll and phaephyton by fluorescence. Deep-Sea Res. 10: 221-231.

YENTSCH, C. S. and J. H. RYTHER . 1957. Short term variations in phytoplankton chlorophyll and their significance. Limnol. Oceanogr. 2: 140-142.

YENTSCH, C. S., and R. F. SCAGEL. 1958. Diurnal study of photosynthetic pigments. An *in situ* study in East Sound, Washington. J. Mar. Res., 17: 567-584.

APPENDIX

Table 13. Relative chlorophyll a values of Skeletonema costatum assays of seawater samples, NH-15 and 50/50 medium incubated 4 days at 20°C for the period of October 1972 to April 1974.

Station	October 1972			November 1972			December 1972			January 1973			February 1973		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
1	138	61	0	56	0	0	84	0	0	189	9	0	172	47	0
	74	0	0	38	0	0	196	0	0	168	8	0	171	75	0
	178	0	0	22	0	0	150	0	0	176	0	0	203	61	0
2	-	42	0	-	31	0	-	0	0	-	0	0	-	48	0
		56	0		30	0		9	0		0	0		96	0
		71	0		0	0		0	0		0	0		220	0
3	-	70	15	-	54	6	-	5	0	-	20	0	-	32	8
		84	28		47	3		1	0		20	0		70	0
		110	36		42	0		0	0		15	0		66	0
4	-	103	33	-	62	26	-	100	0	-	0	0	-	50	71
		116	13		78	18		61	0		0	0		-	-
		162	76		40	6		8	0		0	0		207	28
6	-	249	22	-	40	0	-	0	0	-	0	0	-	143	0
		228	29		31	0		0	0		4	0		136	0
		221	18		39	0		40	0		13	0		122	0
7	-	136	162	-	116	28	-	0	0	-	0	0	-	46	0
		146	117		177	27		0	0		0	0		28	0
		144	0		133	48		0	0		0	0		30	0
8	-	48	0	-	96	13	-	15	0	-	0	0	-	151	4
		65	4		68	30		3	0		0	0		188	14
		96	4		70	20		-	0		0	0		20	18
11	-	52	1	-	109	29	-	53	16	-	30	0	-	56	5
		89	6		173	40		39	29		41	0		44	6
		93	4		72	35		28	23		29	0		55	5

Table 13. (continued)

Station	March 1973			April 1973			May 1973			June, 1973			July 1973		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	183	0	0	168	24	0	224	54	0	199	130	0	183	0	0
1	174	0	0	187	25	0	175	75	0	238	146	0	204	0	0
	171	0	0	172	26	0	175	82	0	245	174	0	232	0	0
		31	0		28	0		74	0		30	0		0	0
2	-	55	0	-	34	0	-	79	0	-	16	0	-	0	0
		29	0		30	0		67	0		26	0		0	0
		207	0		19	0		60	0		44	0		0	0
3	-	15	0	-	23	0	-	95	0	-	37	0	-	0	0
		198	0		26	0		113	0		53	0		0	0
		210	0		28	0		58	0		17	0		0	0
4	-	211	0	-	27	0	-	61	0	-	22	0	-	0	0
		217	0		19	0		80	0		21	0		0	0
		0	0		33	0		69	0		16	0		0	0
6	-	0	0	-	30	0	-	74	0	-	29	0	-	0	0
		0	0		25	0		80	0		40	0		0	0
		7	0		9	0		58	4		7	0		0	0
7	-	9	0	-	10	0	-	60	8	-	8	0	-	0	0
		61	0		13	0		50	12		0	0		0	0
		56	0		23	0		71	0		14	0		0	0
8	-	45	0	-	25	0	-	52	0	-	8	0	-	0	0
		52	0		23	0		42	0		10	0		0	0
		0	0		20	0		46	0		20	0		0	0
11	-	19	0	-	27	0	-	74	0	-	18	0	-	0	0
		8	0		28	0		78	0		17	0		0	0

Table 13. (continued)

Station	August 1973			September 1973			October 1973			November 1973			December 1973		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	196	98	0	166	69	0	216	187	0	138	221	0	181	53	0
1	211	123	0	180	78	0	220	121	0	142	254	0	156	86	0
	215	64	0	183	71	0	218	126	0	132	287	0	161	59	0
		5	0		64	0		92	0		89	0	-	38	0
2	-	7	0	-	156	0	-	99	0	-	91	0	-	41	0
		14	0		81	0		65	0		102	0		33	0
		20	33		109	0		108	0		28	16		32	0
3	-	30	38	-	134	0	-	129	0	-	36	18	-	65	0
		16	35		119	0		91	0		19	21		71	0
		28	4		95	0		79	0		32	15		54	0
4	-	25	7	-	97	0	-	54	0	-	39	13	-	50	0
		32	3		92	0		105	0		34	14		64	0
		25	0		156	0		143	0		9	7		36	0
6	-	20	0	-	36	0	-	143	0	-	8	9	-	54	0
		33	0		176	0		118	0		8	11		91	0
		0	0		106	0		115	0		46	0		26	0
7	-	0	0	-	75	0	-	89	0	-	33	0	-	18	0
		0	0		117	0		75	0		45	0		24	0
		25	0		97	0		27	0		4	0		0	0
8		10	0	-	96	0	-	33	0	-	2	0	-	1	0
		10	0		101	0		34	0		6	0		0	0
		25	0		94	0		64	0		37	0		56	7
11		16	0	-	107	0	-	87	0	-	43	0	-	48	6
		16	0		105	0		49	0		45	0		71	9

Table 13. (continued)

Station	January 1974			February 1974			March 1974			April 1974		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	152	0	0	152	55	0	137	0	0	31	19	0
1	162	0	0	162	49	0	132	20	0	33	1	0
	195	0	0	195	89	0	129	1	0	30	23	0
		115	0	-	48	0		20	0	-	210	0
2	-	130	0		45	0	-	62	0		124	0
		85	0		48	0		92	0		177	0
		100	0		38	0		61	0		30	6
3	-	0	0	-	40	0	-	5	0	-	54	10
		11	0		55	0		1	0		67	8
		23	0		61	0		93	0		43	0
4	-	157	0	-	58	0	-	95	0	-	42	0
		55	0		70	0		92	0		37	14
		59	0		158	0		51	0		160	22
6	-	29	0	-	126	0	-	27	0	-	173	20
		12	0		133	0		0	0		203	18
		128	0		3	0		55	0		57	53
7	-	57	0	-	0	0	-	56	0	-	62	56
		119	0		1	0		53	0		65	53
		53	0		0	0		21	0		27	0
8	-	57	0	-	0	0	-	31	0	-	20	0
		54	0		21	0		38	0		30	0
		16	0		0	0		46	0		50	23
11	-	32	0	-	0	0	-	48	0	-	42	26
		11	0		3	0		42	0		34	23

Table 14. Relative chlorophyll a values of Skeletonema costatum assays of seawater samples, NH-15 and 50/50 medium incubated 4 days at the monthly temperature indicated for the period of October 1972 to April 1974.

Station	October 1972 (28°C)			November 1972 (16°C)			December 1972 (13°C)			January 1973 (15°C)			February 1973 (14°C)		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	169	361	0	4	0	0	3	0	0	0	0	0	33	12	0
1	151	84	0	0	0	0	6	0	0	2	0	0	23	2	0
	54	85	0	0	0	0	6	0	0	3	0	0	33	23	0
		78	0		0	0		0	0		0	0		0	0
2	-	86	0	-	0	0	-	0	0	-	0	0	-	0	0
		102	0		25	0		0	0		0	0		0	0
		92	24		6	0		0	1		0	0		6	0
3	-	58	33	-	32	0	-	0	2	-	0	0	-	0	0
		61	68		70	0		0	1		-	0		4	0
		103	53		67	2		0	0		0	0		0	0
4	-	0	68	-	63	2	-	0	0	-	0	0	-	0	0
		6	6		45	0		0	0		-	0		5	0
		226	18		0	0		2	0		0	0		1	0
6	-	182	21	-	24	0	-	0	0	-	0	0	-	0	0
		0	0		0	0		0	0		0	0		6	0
		187	121		69	30		0	0		0	0		16	0
7	-	12	159	-	42	25	-	-	0	-	0	0	-	23	0
		26	219		37	28		-	-		0	0		32	0
		48	2		117	28		0	1		0	0		0	0
8	-	104	3	-	86	35	-	0	1	-	0	0	-	0	0
		6	11		62	31		-	-		0	0		6	0
		51	4	-	63	-		0	0		0	0		0	0
11	-	70	7		66	-	-	1	0	-	0	0	-	1	0
		113	9		69	-		1	0		0	0		3	0

Table 14. (continued)

Station	March 1973 (19°C) NH-15 medium	March 1973 (19°C) 50/50 medium	March 1973 (19°C) sample medium	April 1973 (21°C) NH-15 medium	April 1973 (21°C) 50/50 medium	April 1973 (21°C) sample medium	May 1973 (20°C) NH-15 medium	May 1973 (20°C) 50/50 medium	May 1973 (20°C) sample medium	June 1973 (27°C) NH-15 medium	June 1973 (27°C) 50/50 medium	June 1973 (27°C) sample medium	July 1973 (30°C) NH-15 medium	July 1973 (30°C) 50/50 medium	July 1973 (30°C) sample medium
	88	0	0	69	23	0	153	69	0	231	40	0	2	0	0
1	73	0	0	67	21	0	154	72	0	243	59	0	3	–	0
	74	0	0	66	14	0	136	61	0	231	54	0	3	0	0
		9	0		9	0		77	0		33	0		0	0
2	–	0	0	–	12	0	–	53	0	–	25	0	–	0	0
		6	0		11	0		32	0		56	0		0	0
		50	0		9	0		67	0		43	0		0	0
3	–	0	0	–	20	0	–	54	0	–	46	0	–	0	0
		3	0		12	0		61	0		27	0		0	0
		0	0		20	0		47	0		60	0		0	0
4	–	0	0	–	20	0	–	71	0		44	0	–	0	0
		58	0		14	0		68	0		30	0		0	0
		0	0		23	0		118	0		196	0		0	0
6	–	0	0	–	20	0	–	120	0	–	33	0	–	0	0
		0	0		24	0		97	0		52	0		0	0
		0	0		18	0		80	0		31	0		0	0
7	–	7	0	–	7	0	–	59	0	–	39	0	–	0	0
		0	0		3	0		88	0		35	0		0	0
		0	0		23	0		42	0		29	0		0	0
8	–	0	0	–	25	0	–	45	0	–	0	0	–	0	0
		0	0		23	0		42	0		31	0		0	0
		13	0		20	0		97	0		23	0		0	0
11	–	3	0	–	27	0	–	87	0	–	24	0	–	0	0
		0	0		28	0		44	0		12	0		0	0

Table 14. (continued)

Station	August 1973 (31°) NH-15 medium	August 1973 (31°) 50/50 medium	August 1973 (31°) sample medium	September 1973 (28°) NH-15 medium	September 1973 (28°) 50/50 medium	September 1973 (28°) sample medium	October 1973 (24°C) NH-15 medium	October 1973 (24°C) 50/50 medium	October 1973 (24°C) sample medium	November 1973 (20°C) NH-15 medium	November 1973 (20°C) 50/50 medium	November 1973 (20°C) sample medium	December 1973 (12°C) NH-15 medium	December 1973 (12°C) 50/50 medium	December 1973 (12°C) sample medium
	86	0	0	221	82	0	221	179	0	126	198	0	1	0	0
1	185	0	0	242	89	0	213	179	0	115	206	0	1	0	0
	152	0	0	245	98	0	201	196	0	134	231	0	1	0	0
		20	0		70	0		160	0		171	0		0	0
2	–	16	0	–	83	0	–	93	0	–	168	0	–	0	0
		16	0		69	0		109	0		193	0		0	0
		121	11		72	0		171	0		52	4		0	0
3	–	152	40	–	88	0	–	181	0	–	54	2	–	0	0
		156	43		93	0		200	0		49	2		0	0
		75	12		42	0		149	0		22	13		0	0
4	–	80	5	–	70	0	–	139	0	–	28	12	–	0	1
		117	6		70	0		140	0		31	14		0	1
		20	0		186	0		182	0		44	6		0	0
6	–	22	0	–	322	0	–	192	0	–	36	11	–	0	0
		32	0		257	0		193	0		46	9		0	0
		35	11		79	0		131	0		41	0		0	1
7	–	24	13	–	70	0	–	132	0	–	42	0	–	0	2
		42	7		82	0		148	0		36	0		0	2
		25	0		68	0		73	0		11	0		0	1
8	–	29	0	–	93	0	–	98	0	–	10	0	–	0	2
		38	0		125	0		81	0		15	0		0	1
		40	2		102	0		124	0		19	0		3	3
11	–	–	11	–	180	0	–	111	0	–	23	0	–	3	3
		–	11		109	0		112	0		46	0		2	2

Table 14. (continued)

Station	January 1974 (17°C) NH-15 medium	January 1974 (17°C) 50/50 medium	January 1974 (17°C) sample medium	February 1974 (21°C) NH-15 medium	February 1974 (21°C) 50/50 medium	February 1974 (21°C) sample medium	March 1974 (20°C) NH-15 medium	March 1974 (20°C) 50/50 medium	March 1974 (20°C) sample medium	April 1974 (25°C) NH-15 medium	April 1974 (25°C) 50/50 medium	April 1974 (25°C) sample medium
	58	1	0	92	57	0	143	24	0	33	42	0
1	25	0	0	75	62	0	157	2	0	33	94	0
	15	0	0	73	50	0	132	29	0	48	11	0
		0	0		56	0		22	0		250	0
2	-	10	0	-	64	0	-	62	0	-	142	0
		10	0		54	0		20	0		102	0
		0	0		75	0		8	0		44	0
3	-	0	0	-	92	0	-	4	0	-	55	0
		0	0		85	0		0	0		63	0
		9	0		63	0		79	0		21	24
4	-	0	0	-	66	0	-	80	0	-	41	5
		10	0		38	0		93	0		26	0
		17	0		70	0		58	0		175	0
6	-	2	0	-	27	0	-	54	0	-	148	0
		1	0		6	0		0	0		126	0
		38	0		2	0		66	0		49	47
7	-	38	0	-	5	0	-	72	0	-	53	42
		20	0		20	0		84	0		57	42
		24	0		0	0		51	0		21	0
8	-	0	0	-	0	0	-	51	0	-	34	0
		12	0		0	0		52	0		37	0
		29	0		4	0		46	0		62	13
11	-	26	0	-	2	0	-	55	0	-	31	7
		1	0		1	0		30	0		4	12

Table 15. Relative chlorophyll a values of natural phytoplankton assays of seawater samples, NH-15 and 50/50 medium after incubation for 4 days at 20°C for the period from October 1972 to April 1974.

Station	October 1972			November 1972			December 1972			January 1973			February 1973		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	7	54	264	73	2	0	114	72	33	1	0	0	1	0	0
1	96	48	171	19	0	4	3	33	30	1	0	0	0	0	0
	23	76	35	17	27	51	163	51	18	1	0	0	0	0	0
	51	107	236	52	54	55	163	56	135	1	0	0	68	264	158
2	23	194	189	16	59	62	215	64	146	2	0	0	34	337	133
	24	124	171	10	43	63	193	73	157	1	0	0	68	241	108
	22	13	0	237	207	74	185	107	181	225	68	0	244	161	201
3	33	13	0	165	194	127	211	96	197	248	95	0	151	141	198
	24	58	0	143	267	202	269	106	227	255	109	0	195	148	206
	38	2	13	207	182	66	65	28	39	158	93	12	55	109	48
4	17	28	11	190	309	93	47	32	39	208	124	11	38	62	44
	40	90	10	188	284	135	45	35	39	205	72	14	24	104	28
	25	114	208	34	34	31	159	186	222	127	244	0	324	514	172
6	36	48	205	21	21	36	183	113	251	90	50	0	274	378	128
	29	170	172	49	18	43	207	141	279	125	29	0	235	378	177
	109	187	109	139	166	27	159	140	168	184	289	0	53	102	145
7	137	128	105	130	215	59	60	49	3	238	282	0	36	141	142
	137	95	95	159	222	51	38	-	169	216	271	0	44	96	155
	57	26	0	125	79	11	155	85	7	5	38	2	102	235	47
8	132	57	3	160	95	25	193	29	3	6	20	1	82	225	52
	86	124	5	89	109	19	183	-	-	6	8	2	150	251	59
	114	55	8	159	101	16	185	99	16	174	210	7	70	54	15
11	131	85	17	195	124	16	199	122	22	185	157	7	65	50	8
	158	55	17	202	180	20	222	101	37	177	121	11	23	142	12

Table 15. (continued)

Station	March 1973			April 1973			May 1973			June 1973			July 1973		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	3	45	0	44	34	0	141	159	0	222	131	6	44	144	0
1	6	110	5	45	43	0	130	155	0	269	183	7	57	251	0
	1	48	12	48	43	0	137	152	0	265	-	11	43	144	5
	205	386	250	51	52	0	181	164	0	229	415	0	144	176	3
2	259	261	190	45	30	0	107	174	0	208	360	0	214	230	0
	265	313	204	52	42	0	146	159	0	196	347	0	159	201	8
	246	528	102	46	35	0	133	207	0	18	93	0	38	67	0
3	221	473	91	46	35	0	137	188	0	29	126	0	40	65	0
	229	547	116	42	31	0	133	170	0	27	123	0	30	60	0
	151	219	193	43	23	0	99	143	0	33	238	0	21	99	0
4	174	101	139	47	28	0	97	146	0	38	133	1	17	126	0
	232	271	208	42	37	0	93	155	0	28	179	0	17	118	0
	0	0	0	43	67	0	92	93	0	2	0	0	0	0	0
6	1	0	0	42	57	0	121	169	0	2	0	0	1	0	0
	3	16	0	44	43	0	46	166	0	5	0	0	1	0	0
	6	260	48	26	22	0	78	103	14	4	21	0	4	13	0
7	4	153	39	26	40	0	67	103	5	7	22	0	1	14	0
	0	68	37	29	17	0	58	86	16	3	22	0	1	16	0
	30	194	12	4	7	0	23	128	0	1	49	0	1	6	0
8	24	15	13	2	22	0	12	140	0	4	59	0	1	8	0
	24	166	12	2	16	0	20	144	0	1	61	0	1	11	0
	21	48	0	29	26	0	3	69	0	0	52	0	6	34	0
11	24	56	0	30	19	0	2	144	0	2	63	0	5	26	0
	18	56	0	33	25	0	2	125	0	2	57	0	4	33	0

Table 15. (continued)

Station	August 1973			September 1973			October 1973			November 1973			December 1973		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	239	304	0	312	219	56	237	279	4	146	261	23	235	237	209
1	257	300	4	348	135	34	258	300	0	137	342	17	202	237	218
	268	332	6	365	194	45	263	290	2	196	320	26	211	266	185
	245	387	0	294	268	72	222	283	69	116	193	8	116	259	93
2	256	334	0	322	273	43	226	179	75	99	261	17	118	337	91
	231	328	0	337	234	65	236	246	39	126	295	15	118	341	78
	232	195	0	308	233	16	180	226	4	156	143	12	155	182	124
3	263	156	0	297	195	5	180	146	5	51	156	13	147	148	120
	233	216	0	322	185	19	210	204	0	178	132	15	160	176	30
	172	287	0	222	272	8	139	270	0	134	148	24	212	263	67
4	222	292	0	330	285	5	142	202	2	147	165	29	128	267	74
	218	248	0	222	250	6	146	179	0	165	148	27	141	243	61
	163	290	0	308	235	0	142	179	17	104	127	12	100	214	69
6	188	281	0	315	144	0	154	186	0	112	108	23	143	199	78
	193	266	0	272	297	0	179	164	4	96	96	16	194	335	94
	4	0	0	229	251	15	32	168	0	61	78	0	14	179	0
7	3	0	0	235	273	6	41	177	0	78	63	0	8	133	0
	2	0	0	220	242	7	70	182	0	54	62	0	10	68	0
	1	10	0	201	334	0	0	111	0	1	76	0	0	4	0
8	1	7	0	189	315	0	0	139	0	2	59	0	0	0	0
	1	9	0	172	302	0	0	148	0	0	89	0	0	21	0
	3	0	0	79	200	0	10	185	0	16	38	0	55	144	0
11	2	0	0	69	218	0	12	187	0	23	29	0	34	113	0
	4	0	0	82	208	0	10	167	0	21	39	0	49	154	0

Table 15. (continued)

Station	January 1974			February 1974			March 1974			April 1974		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	207	234	34	258	287	5	5	118	0	79	93	92
1	237	211	36	242	264	7	0	123	0	91	100	43
	238	318	18	250	178	11	1	4	0	95	121	51
	226	185	84	124	96	17	60	0	7	93	164	105
2	229	202	71	138	117	11	0	68	0	97	199	88
	281	265	62	111	104	8	29	28	3	109	207	56
	123	118	24	152	144	5	160	175	218	87	112	0
3	270	177	37	160	194	3	140	186	267	100	111	0
	177	227	42	165	186	7	149	177	230	96	102	0
	131	296	39	165	280	7	141	303	92	150	262	0
4	101	296	38	172	215	5	137	260	94	154	189	0
	142	238	46	127	287	18	141	210	81	118	193	4
	0	0	0	351	216	0	96	219	0	124	126	0
6	0	0	0	294	186	0	100	219	0	116	151	0
	0	0	0	308	169	0	67	229	0	141	168	0
	57	238	1	128	322	0	96	156	0	13	162	0
7	45	250	4	107	343	0	98	159	0	9	122	0
	69	204	2	97	263	0	94	154	0	9	158	0
	2	236	0	71	98	0	75	137	0	0	93	0
8	0	143	0	130	80	0	80	120	0	0	178	0
	16	158	0	35	74	0	80	123	0	29	183	0
	20	56	0	45	205	0	143	93	0	0	93	0
11	22	91	0	38	164	0	143	86	0	5	60	0
	9	85	0	45	222	0	152	89	0	3	93	0

Table 16. Relative chlorophyll a values of natural phytoplankton assays of seawater samples, NH-15 and 50/50 medium incubated 4 days at the monthly temperature indicated for the period from October 1972 to April 1974.

Station	October 1972 (28°C)			November 1972 (16°C)			December 1972 (13°C)			January 1973 (15°C)			February 1973 (14°C)		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
1	54	78	93	0	7	30	0	0	0	0	0	0	0	0	0
	27	158	111	0	0	21	0	2	0	0	0	0	0	0	0
	14	190	80	0	0	26	0	0	0	0	0	0	0	0	0
2	50	107	236	2	28	45	10	9	3	1	0	0	1	0	0
	23	194	189	0	0	48	7	16	2	1	0	0	1	0	0
	22	124	171	0	13	20	5	7	2	1	0	0	1	0	0
3	18	11	0	234	262	145	99	43	15	2	0	0	58	10	91
	56	42	10	176	174	250	55	27	22	2	0	0	32	15	67
	41	27	8	108	274	238	40	19	10	1	0	0	13	13	107
4	14	0	0	179	334	138	65	28	39	2	0	0	13	40	53
	25	8	0	99	322	172	47	32	39	5	2	0	36	50	53
	47	0	0	70	321	202	45	35	39	-	0	0	12	83	43
6	11	15	146	5	15	59	6	2	2	9	0	0	11	13	42
	25	10	140	12	12	44	7	6	4	11	0	0	9	26	44
	22	0	139	5	6	49	9	12	9	7	0	0	11	46	36
7	48	52	152	143	164	52	1	0	0	27	6	0	2	0	10
	71	54	144	145	175	49	2	0	0	30	2	0	3	0	13
	31	85	156	151	191	52	2	1	0	27	0	0	2	0	14
8	3	8	0	72	146	22	4	1	1	0	0	0	3	0	3
	5	1	0	51	121	20	5	0	-	0	0	0	2	0	0
	5	27	1	39	100	22	5	-	-	0	0	0	2	10	1
11	46	54	7	36	150	22	36	17	9	3	0	0	1	0	1
	90	21	15	29	88	30	27	21	7	3	0	0	1	0	0
	32	66	21	34	143	33	29	11	5	2	0	0	1	0	1

Table 16. (continued)

Station	March 1973 (19°C)			April 1973 (21°C)			May 1973 (20°C)			June 1973 (27°C)			July 1973 (30°C)		
	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium	NH-15 medium	50/50 medium	sample medium
	0	0	0	37	28	0	70	161	0	222	167	0	32	32	28
1	0	0	0	38	32	0	64	173	0	175	100	0	37	29	0
	0	0	0	43	29	0	74	177	0	147	202	0	17	21	0
	50	305	251	42	56	0	76	129	0	231	422	3	200	54	40
2	76	405	244	40	53	0	79	153	0	179	263	0	107	38	13
	27	429	237	43	47	0	39	163	0	116	150	0	181	58	9
	63	51	137	29	30	0	80	163	0	109	180	0	34	15	1
3	103	46	132	25	38	0	111	149	0	87	203	2	94	11	0
	64	61	150	25	35	0	106	167	0	101	211	0	57	9	2
	171	90	88	37	52	0	88	169	0	129	133	0	193	38	1
4	169	219	110	38	50	0	82	169	0	120	160	1	151	73	1
	143	336	130	34	51	0	96	160	0	131	208	1	64	44	0
	0	0	0	43	54	0	10	191	0	25	31	47	20	9	34
6	0	0	0	40	41	0	11	213	0	34	13	14	13	2	40
	0	0	0	41	47	0	20	139	0	20	18	6	28	1	32
	12	236	34	42	45	0	125	110	29	124	52	1	22	19	0
7	6	84	44	40	48	0	123	98	30	209	50	8	29	27	2
	6	211	31	43	-	0	110	102	35	184	52	0	15	13	0
	0	63	3	2	6	0	58	170	0	16	74	0	31	20	0
8	0	61	1	1	15	0	33	170	0	13	145	0	22	19	0
	0	27	2	2	0	0	33	171	0	13	107	0	22	16	3
	16	26	0	43	64	0	1	107	0	127	149	3	251	54	0
11	21	28	0	37	57	0	1	64	0	71	154	0	75	29	0
	22	71	0	36	52	0	2	117	0	67	184	5	32	38	0

Table 16. (continued)

Station	August 1973 (31°C) NH-15 medium	August 1973 (31°C) 50/50 medium	August 1973 (31°C) sample medium	September 1973 (28°C) NH-15 medium	September 1973 (28°C) 50/50 medium	September 1973 (28°C) sample medium	October 1973 (24°C) NH-15 medium	October 1973 (24°C) 50/50 medium	October 1973 (24°C) sample medium	November 1973 (20°C) NH-15 medium	November 1973 (20°C) 50/50 medium	November 1973 (20°C) sample medium	December 1973 (12°C) NH-15 medium	December 1973 (12°C) 50/50 medium	December 1973 (12°C) sample medium
1	132	288	89	370	197	72	117	242	0	106	205	0	0	0	0
	141	111	44	460	175	83	126	238	0	84	178	0	0	0	0
	116	145	65	431	212	82	132	242	0	96	221	0	0	0	0
2	168	240	19	448	0	52	124	255	16	146	261	8	3	2	0
	147	231	0	345	5	46	104	248	14	138	295	11	3	1	0
	234	134	5	391	0	47	106	270	26	159	271	7	3	0	0
3	139	0	0	258	32	54	149	273	0	98	163	0	8	12	17
	116	48	0	229	275	58	128	277	0	87	147	0	9	1	20
	118	45	0	322	179	63	116	266	0	103	135	0	9	-	22
4	248	202	0	276	215	17	150	220	0	146	134	11	3	6	14
	226	153	0	273	134	21	143	219	0	201	147	14	4	5	19
	229	188	0	301	0	64	145	212	0	173	164	12	3	5	14
6	266	358	5	27	65	93	115	229	17	124	142	10	4	4	2
	280	293	0	243	46	81	100	221	9	116	140	14	3	0	2
	269	320	3	70	63	47	94	221	0	131	126	8	4	1	3
7	191	56	0	302	258	11	105	177	0	28	93	0	0	0	1
	144	64	0	305	199	30	89	187	0	25	101	0	2	0	1
	161	62	0	279	257	19	101	199	0	33	105	0	3	0	2
8	25	71	0	266	310	0	0	113	0	2	98	0	1	0	0
	28	91	0	309	115	0	0	74	0	1	113	0	2	0	0
	33	103	0	266	380	0	0	117	0	0	76	0	2	0	1
11	-	199	0	410	342	16	16	214	0	48	82	0	1	1	2
	-	197	0	409	298	12	18	208	0	41	63	0	2	2	2
	-	226	0	417	320	14	20	209	0	32	45	0	2	1	2

Table 16. (continued)

Station	January 1974 (17°C) NH-15 medium	50/50 medium	sample medium	February 1974 (21°C) NH-15 medium	50/50 medium	sample medium	March 1974 (20°C) NH-15 medium	50/50 medium	sample medium	April 1974 (25°C) NH-15 medium	50/50 medium	sample medium
	2	19	0	146	226	0	15	1	0	73	172	16
1	3	60	0	162	164	2	16	0	0	81	132	54
	2	50	0	192	134	2	2	0	0	86	128	8
	12	0	8	66	120	0	2	1	0	113	200	104
2	14	0	0	56	96	0	3	13	0	109	103	75
	11	0	3	52	117	0	1	49	0	103	128	141
	1	7	3	111	110	5	146	241	41	160	100	0
3	2	0	5	182	134	7	153	206	42	173	–	0
	2	14	1	160	158	10	154	209	25	101	95	0
	4	1	0	105	234	0	171	289	81	162	100	0
4	6	8	0	97	236	1	73	289	108	92	102	0
	3	0	0	113	139	2	157	264	69	172	96	0
	0	0	0	337	169	0	24	231	0	66	265	17
6	0	0	0	365	185	2	26	256	0	63	160	11
	0	0	0	279	247	0	17	248	0	88	126	24
	8	149	0	128	322	0	111	159	0	18	79	0
7	11	118	0	107	343	0	113	151	0	15	145	0
	12	248	0	97	263	0	103	140	0	18	152	0
	0	10	0	60	42	0	97	119	0	95	110	0
8	0	4	0	48	50	0	69	114	0	87	88	0
	0	1	0	37	77	0	55	110	0	137	86	0
	2	5	0	43	104	0	175	33	2	161	110	0
11	2	6	0	40	91	0	164	30	2	166	110	0
	3	7	0	30	102	0	173	32	1	167	113	0

Table 17. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum between station 7 and station 11, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a for triplicate test portions and is applicable for Tables 5-34.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
7	142.0	75.0	142.0	49.3	0	0.6	0	-	34.7	26.7	25.7	2.3	10.7	9.3
11	78.0	78.0	118.0	66.0	40.0	0	33.3	-	51.7	1.3	9.3	5.3	25.0	25.0
df	4	4	4	4	4	3	4	-	4	4	4	4	4	4
t	4.77*	0.05	0.69	1.65	5.52*	1.53	8.67*	-	2.47	4.75*	0.88	0.65	5.13*	3.04†

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
7	56.0	75.7	5.0	35.0	-	-	0	-	99.3	77.0	93.0	137.0	41.3	39.7
11	66.0	76.0	18.3	19.7	-	-	19.0	-	102.0	130.3	66.7	115.7	41.7	29.3
df	4	4	4	4	-	-	4	-	4	4	4	4	4	4
t	0.95	0.01	5.00*	3.41†	-	-	6.33*	-	0.20	2.11	1.63	3.08†	0.06	1.19

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
7	22.7	0	101.3	32.0	1.3	9.0	54.7	74.0	61.3	53.0
11	58.3	2.7	19.7	18.7	1.0	2.3	45.3	43.7	42.0	32.3
df	4	4	4	4	4	4	4	4	4	4
t	4.98*	7.98*	3.52†	1.24	0.24	1.15	4.75*	3.36†	3.75†	1.22

† Significant at 5% level

* Significant at 1% level

Table 18. *Comparison of t-test results of the suitability of FSW for the growth of NP between station 7 and station 11, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.*

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
7	103.0	150.7	45.7	51.0	111.7	0	0	-	147.3	12.3	41.3	36.3	-	-
11	14.0	14.3	17.3	28.3	25.0	7.0	8.3	-	11.7	0.7	0	0	-	-
df	4	4	4	4	4	4	4	-	4	4	4	4	-	-
t	17.34*	25.36*	2.91†	6.60*	1.58	6.05*	6.24*	-	30.67*	9.35*	12.21*	9.24*	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
7	11.7	31.3	-	3.0	-	0.7	-	-	9.3	20.0	-	-	-	-
11	0	0	-	2.7	-	0	-	-	0	14.0	-	-	-	-
df	4	4	-	4	-	4	-	-	4	4	-	-	-	-
t	3.44†	16.88*	-	0.11		0.99	-	-	3.27†	1.06	-	-	-	-

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
7	-	1.3	2.3	-	-	0.7	-	0	-	-
11	-	2.0	0	-	-	0	-	1.7	-	-
df	-	4	4	-	-	4	-	4	-	-
t	-	2.00	2.64	-	-	0.99	-	4.98*	-	-

†Significant at 5% level
*Significant at 1% level

Table 19. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 7 and station 11 for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
7	136.7	63.7	201.0	176.7	94.5	0.3	280.7	2.7	113.0	-	160.3	177.0	26.3	46.5
11	65.0	47.0	135.0	127.0	107.3	16.3	162.7	0	82.0	-	53.3	41.7	23.3	57.7
df	4	4	4	4	3	4	4	4	4	-	4	4	4	3
t	2.49	0.97	2.24	2.35	0.36	5.46 *	4.47†	1.50	0.93	-	1.92	2.74	0.40	2.41

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
7	97.3	103.3	21.7	51.3	14.3	19.7	-	60.7	255.3	238.0	175.5	187.7	67.7	99.7
11	112.7	96.0	57.3	162.3	31.0	40.3	-	207.3	208.7	320.0	179.7	210.3	35.3	80.0
df	4	4	4	4	4	4	-	4	4	4	4	4	4	4
t	0.66	0.44	11.15*	10.13*	6.25*	2.47	-	15.19*	4.41†	3.52†	0.52	3.42†	5.32*	1.97

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
7	126.7	0	230.7	171.7	309.3	309.3	156.3	150.0	147.3	125.3
11	137.0	1.3	77.3	6.0	197.0	99.0	89.3	31.7	82.0	111.0
df	4	4	4	4	4	4	4	4	4	4
t	0.29	3.98†	8.75*	4.22†	3.80†	8.66*	26.85*	21.21*	3.88†	0.61

†Significant at 5% level
*Significant at 1% level

Table 20. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 7 and station 8, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.*

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
7	142.0	75.0	142.0	49.3	0	-	-	-	34.7	23.7	25.7	2.3	10.7	9.3
8	69.7	52.7	78.0	88.3	9.0	-	-	-	119.7	2.0	51.0	0	23.7	23.7
df	4	4	4	4	3	-	-	-	4	4	4	4	4	4
t	5.03*	0.35	3.15†	2.07	2.01	-	-	-	1.65	4.29†	1.41	0.99	9.45*	3.16†

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
7	56.0	75.5	5.0	35.0	-	-	0	33.7	99.3	77.0	93.0	137.0	41.3	39.7
8	55.0	43.0	10.7	20.0	-	-	15.0	30.7	98.0	95.3	31.3	84.0	4.0	12.0
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	0.11	3.75†	1.84	1.45	-	-	2.99†	0.46	0.10	1.08	5.17*	5.75*	8.61*	11.51*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
7	22.7	-	101.3	32.0	1.3	9.0	54.7	74.0	61.3	53.0
8	0.3	-	54.7	12.0	7.0	0	30.0	51.3	25.7	30.7
df	4	-	4	4	4	4	4	4	4	4
t	9.20*	-	2.08	2.18	0.8	1.61	4.92*	4.27†	9.45*	4.11†

†Significant at 5% level

*Significant at 1% level

Table 21. Comparison of t-test results of the suitability of FSW for the growth of NP between station 7 and station 8, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
7	103.0	150.7	45.7	51.0	111.7	–	0	–	147.3	12.3	41.3	36.3	–	–
8	2.7	0.3	18.3	21.3	5.0	–	1.7	–	52.7	1.3	12.3	2.0	–	–
df	4	4	4	4	3	–	4	–	4	4	4	4	–	–
t	22.75*	42.42*	2.61	24.68*	1.51	–	4.93*	–	18.03*	7.37*	8.53*	8.64*	–	–

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
7	11.7	31.3	–	3.0	–	0.7	–	–	9.3	20.0	–	–	–	–
8	0	0	–	0	–	1.0	–	–	0	0	–	–	–	–
df	4	4	–	4	–	4	–	–	4	4	–	–	–	–
t	3.44†	16.88*	–	1.19	–	0.27	–	–	3.27†	3.63†	–	–	–	–

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
7	–	1.3	2.3	–	–	–	–	–	–	–
8	–	0.3	0	–	–	–	–	–	–	–
df	–	4	4	–	–	–	–	–	–	–
t	–	2.12	2.64	–	–	–	–	–	–	–

†Significant at 5% level

*Signicifant at 1% level

Table 22. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 7 and station 8 for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	21°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
7	136.7	63.7	201.0	176.7	94.5	0.3	280.7	2.7	113.0	0	3.3	177.0	26.3	46.5
8	69.0	12.0	94.3	122.3	57.0	0.5	22.0	0	237.0	3.3	26.0	50.3	15.0	7.0
df	4	4	4	4	2	3	4	4	4	4	4	4	4	3
t	1.71	3.91†	5.43	3.52†	0.70	0.29	25.43*	1.50	7.74*	0.99	8.50*	2.61	1.37	6.88*

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
7	97.3	103.3	21.7	51.3	14.3	19.7	0	60.7	255.3	238.0	175.7	187.7	67.7	99.7
8	137.3	170.3	56.3	108.7	8.3	18.3	8.7	88.3	317.0	268.3	132.7	101.3	74.7	95.7
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	5.38*	18.90*	9.30*	2.79	3.53†	0.31	9.82*	2.87†	4.71*	0.37	3.62†	5.71*	0.69	0.35

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
7	126.7	–	230.7	171.7	309.3	309.3	156.3	150.0	147.3	125.3
8	8.0	–	179.0	5.0	84.0	56.3	126.7	114.3	151.3	94.7
df	4	–	4	4	4	4	4	4	4	4
t	3.62†	–	1.61	4.24†	9.01*	9.66*	5.45*	5.85*	0.12	1.25

†Significant at 5% level

*Significant at 1% level

Table 23. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 8 and station 11, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
8	69.7	52.7	78.0	88.3	9.0	-	0	-	119.7	2.0	51.0	0	23.7	23.7
11	78.0	78.0	118.0	66.0	40.0	-	33.3	-	51.7	1.3	9.0	5.3	25.0	25.0
df	4	4	4	4	3	-	4	-	4	4	4	4	4	4
t	0.43	0.74	1.29	1.39	2.99	-	8.67*	-	1.33	0.30	6.58*	1.35	0.51	0.51

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
8	55.0	43.0	10.7	20.0	-	-	15.0	-	98.0	95.3	31.3	84.0	4	12.0
11	66.0	76.0	18.3	19.7	-	-	19.0	-	102.0	130.3	66.7	115.7	41.7	29.3
df	4	4	4	4	-	-	4	-	4	4	4	4	4	4
t	0.83	2.02	3.88†	0.03	-	-	0.68	-	0.92	1.17	3.13†	3.73†	14.12*	2.02

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
8	0.3	0	54.7	12.0	7.0	0	30.0	51.3	25.7	30.7
11	58.3	2.7	19.7	18.7	1	2.3	45.3	43.7	42.0	32.3
df	4	4	4	4	4	4	4	4	4	4
t	8.59*	7.98*	5.42*	0.59	0.84	2.64	2.92	1.04	2.97†	0.09

†Significant at 5% level

*Significant at 1% level

Table 24. Comparison of t-test results of the suitability of FSW for the growth of NP between station 8 and station 11, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
8	2.7	0.3	18.3	21.3	5.0	-	1.7	-	52.7	3.3	12.3	2.0	-	-
11	14.0	14.3	17.3	28.3	25.0	-	8.3	-	11.7	0	0	0	-	-
df	4	4	4	4	3	-	4	-	4	4	4	4		-
t	3.40†	3.44†	0.25	2.08	2.45	-	4.85*	-	10.17*	0.99	36.98*	3.45†	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
8	-	-	-	0	-	-	-	-	-	0	-	-	-	-
11	-	-	-	2.7	-	-	-	-	-	14.0	-	-	-	-
df	-	-	-	4	-	-	-	-	-	4	-	-	-	-
t	-	-	-	1.83	-	-	-	-	-	12.12*	-	-	-	-

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
8	-	0	-	-	-	-	-	0	-	-
11	-	2.0	-	-	-	-	-	1.7	-	-
df	-	4	-	-	-	-	-	4	-	-
t	-	5.00	-	-	-	-	-	4.98*	-	-

† Significant at 5% level

* Significant at 1% level

Table 25. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 8 and station 11 for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
8	69.0	12.0	94.3	122.3	57.0	0.5	22.0	-	237.0	3.3	125.0	50.3	15.0	7
11	65.0	47.0	135.0	127.0	107.3	16.3	162.7	-	82.0	0	53.3	41.7	23.3	57.7
df	4	4	4	4	3	3	4	-	4	4	4	4	4	4
t	0.13	2.25	1.62	0.19	2.19	4.19†	5.15*	-	5.00*	0.99	1.28	0.46	1.70	9.08*

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
8	137.3	170.3	56.3	108.7	8.3	18.3	8.7	88.3	317.0	268.3	132.7	101.3	74.7	95.7
11	112.7	96.0	57.3	162.3	31.0	40.3	0	207.3	208.7	320.0	179.7	210.3	35.3	80.0
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	1.07	4.57†	0.20	2.30	7.80*	2.96†	9.82*	9.00*	10.17*	0.64	3.66†	7.87*	4.25†	1.10

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
8	8.0	0	179.0	5.0	84.0	56.3	126.7	114.3	151.3	94.7
11	137.0	1.3	77.3	6.0	197.0	99.0	89.3	31.7	82.0	111.0
df	4	4	4	4	4	4	4	4	4	4
t	9.36*	3.98†	3.30†	0.36	6.05*	3.76†	6.64*	30.07*	2.22	2.10

†Significant at 5% level

*Significant at 1% level

6.64* 30.07* 2.22 2.10

Table 26. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 1 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.*

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
1	20.3	176.7	0	0	-	-	5.7	-	61.0	12.3	-	-	25.0	19.3
6	232.7	136.0	36.7	8.0	-	-	5.7	-	133.7	2.3	-	-	29.3	22.3
df	4	4	4	4	-	-	4	-	4	4	-	-	4	4
t	9.64*	0.35	12.87*	0.99	-	-	0.00	-	7.14*	1.57	-	-	1.80	1.00

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
1	70.3	67.3	150.0	51.0	-	-	95.0	0	72.7	89.7	144.7	184.7	254.0	211.7
6	74.3	111.7	28.3	93.7	-	-	26.0	24.7	122.7	255.0	134.7	189.0	8.3	42.0
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	0.44	5.50*	8.32*	0.82	-	-	3.94†	6.64*	1.14	4.18†	0.43	0.64	12.89*	16.31*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
1	66.0	-	0	0.3	64.3	56.3	-	18.3	14.3	49.0
6	60.3	-	33.3	6.7	139.0	34.3	-	37.3	178.7	149.7
df	4	-	4	4	4	4	-	4	4	4
t	0.22	-	2.42	1.22	4.72*	1.14	-	0.92	11.39*	3.58†

† Significant at 5% level

* Significant at 1% level

Table 27. Comparison of t-test results of the suitability of FSW for the growth of NP between station 1 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
1	156.7	94.7	30.3	25.7	1.0	0	–	–	0	0	5.7	–	–	–
6	195.0	141.7	36.7	50.7	114.0	5.0	–	–	159.0	40.7	0	–	–	–
df	4	4	4	4	4	4	–	–	4	4	4	–	–	–
t	0.56	5.08*	0.39	4.88*	9.40*	2.39	–	–	10.21*	16.91*	1.62	–	–	–

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
1	–	–	8.0	0	–	9.3	3.3	66.0	45.0	79.0	2.0	0	22.0	0
6	–	–	0	27.3	–	35.3	0	2.7	0	73.7	7.0	8.7	17.0	10.7
df	–	–	4	4	–	4	4	4	4	4	4	4	4	4
t	–	–	5.23*	1.77	–	2.69	1.88	4.84*	7.08*	0.37	0.95	1.76	1.20	6.04*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
1	204.0	0	29.3	–	7.7	1.3	–	–	62.0	26.0
6	77.3	2.3	0	–	0	0.7	–	–	0	17.3
df	4	4	4	–	4	4	–	–	4	4
t	9.10*	6.98*	5.14*	–	4.34†	0.70	–	–	4.08†	0.59

† Significant at 5% level
* Significant at 1% level

Table 28. *Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 1 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
1	59.3	142.0	9.7	2.3	52.0	0.7	0	-	0	0	67.7	-	40.0	29.7
6	110.7	8.3	24.3	11.0	146.7	6.7	107.7	-	423.3	28.3	5.3	-	55.7	47.3
df	4	4	4	4	4	4	4	-	4	4	4	-	4	4
t	1.41	3.97†	1.46	2.45	3.93†	2.01	1.57	-	9.33*	2.95†	2.85†	-	2.06	4.47*

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
1	155.3	170.3	157.0	156.3	179.7	30.7	312.0	181.3	182.7	194.7	289.7	240.7	307.7	201.3
6	142.7	181.0	0	20.7	0	4.0	279.0	323.7	225.3	58.0	176.3	223.7	110.3	136.0
df	4	4	3	4	4	4	4	4	4	4	4	4	4	4
t	0.50	0.47	8.11*	4.46†	5.03*	4.58†	2.69	2.47	0.85	11.09*	12.75*	5.70*	7.64*	4.85*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	25°C	
1	246.7	0	254.3	43.0	243.0	174.7	8.17	0.3	104.7	144.0
6	249.3	1.7	0	0	190.3	198.7	222.3	245.0	148.3	183.7
df	4	4	4	4	4	4	4	4	4	4
t	0.06	1.38	7.82*	3.48†	1.46	0.65	3.60†	33.15*	2.94†	0.89

† Significant at 5% level

* Significant at 1% level

Table 29. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 2 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	56.3	88.7	20.3	8.3	3.0	0	0	-	121.3	0	38.3	5.0	30.7	10.7
6	232.7	136.0	36.7	8.0	13.3	0.7	5.7	-	133.7	2.3	0	0	29.3	22.3
df	4	4	4	4	4	4	4	-	4	4	4	4	4	4
t	14.85*	0.63	1.54	0.02	0.75	0.99	1.47	-	0.23	1.25	4.58†	1.88	0.45	7.82*

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	73.3	54.0	24.0	38.0	-	-	8.7	17.3	100.3	74.0	85.3	120.7	94.0	177.3
6	74.3	111.7	28.3	93.7	-	-	26.0	24.7	122.7	255.0	134.7	189.0	8.3	42.0
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	0.21	3.86†	0.53	1.06	-	-	3.71†	1.85	0.42	4.57†	3.70†	3.33†	21.12*	16.01*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	37.3	-	110.7	6.7	47.0	58.0	58.0	34.7	170.3	164.7
6	60.3	-	33.6	6.7	139.0	34.3	26.0	37.3	178.7	149.7
df	4	-	4	4	4	4	4	4	4	4
t	1.40	-	4.14*	0.00	9.47*	1.24	1.25	0.11	0.29	0.32

† Significant at 5% level
* Significant at 1% level

Table 30. Comparison of t-test results of the suitability of FSW for the growth of NP between station 2 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	198.7	198.7	60.0	37.7	146.0	2.3	-	-	133.0	0	2.47	244.0	-	-
6	195.7	141.7	36.7	50.7	250.7	5.0	-	-	159.0	40.7	0	0	-	-
df	4	4	4	4	4	4	-	-	4	4	4	4	-	-
t	0.16	2.92†	5.43*	1.31	5.93*	1.26	-	-	1.22	16.91*	11.84*	60.37*	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	-	-	-	1	3.7	20.7	-	8.0	60.0	48.3	61.0	18.7	13.3	8.7
6	-	-	-	27.3	0	35.3	-	2.7	0	73.7	7.0	8.7	17.0	10.7
df	-	-	-	4	4	4	-	4	4	4	4	4	4	4
t	-	-	-	1.69	1.57	1.46	-	0.90	6.86*	1.82	4.40†	1.62	0.86	0.93

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	87.3	0	72.3	3.7	12.0	0	3.3	-	83.0	106.7
6	77.3	2.3	0	0	0	0.7	0	-	0	17.3
df	4	4	4	4	4	4	4	-	4	4
t	0.91	6.99*	11.32*	1.57	4.53†	0.99	1.64	-	5.77*	4.58†

† Significant at 5% level

* Significant at 1% level

Table 31. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 2 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	141.7	141.7	52.0	13.7	64.3	10.7	0	-	280.7	0	320.0	379.7	41.3	52.0
6	110.7	8.3	24.3	11.0	146.7	6.7	107.7	-	423.3	28.3	5.3	0	55.7	47.3
df	4	4	4	4	4	4	4	-	4	4	4	4	4	4
t	0.70	4.94*	4.05†	0.31	3.77†	1.00	1.57	-	2.65	2.95†	8.58*	9.99*	1.52	1.01

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	165.7	148.3	374.0	278.3	207.3	50.0	349.7	201.7	258.3	1.7	236.0	257.7	249.7	275.7
6	142.7	181.0	0	20.7	0	4.0	279.0	323.7	225.3	58.0	176.3	223.7	110.3	136.0
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	0.91	1.35	17.94*	3.25†	12.96*	6.96*	3.53†	3.14†	0.71	9.00*	1.91	4.84*	4.44	12.38*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	312.3	1.0	217.3	-	105.7	111.0	32.0	21.0	190.0	143.7
6	249.3	1.3	0	-	190.3	198.7	222.3	245.0	148.3	183.7
df	4	4	4	-	4	4	4	4	4	4
t	1.24	0.22	8.93*	-	5.62*	3.36†	9.51*	13.82*	2.31	0.78

†Significant at 5% level

*Significant at 1% level

Table 32. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 3 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
3	88.0	70.3	47.7	36.0	2.0	-	18.3	-	56.0	3.3	140.0	17.7	22.7	13.7
6	232.7	136.0	36.7	8.0	13.3	-	5.7	-	133.7	2.3	0	0	29.3	22.3
df	4	4	4	4	4	-	4	-	4	4	4	4	4	4
t	10.02*	6.93*	2.44	1.38	0.84	-	3.02†	-	5.73*	0.39	2.23	1.09	2.15	2.47

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
3	89.3	60.7	44.7	38.7	-	-	22.0	143.0	120.7	84.3	109.3	184.0	27.7	51.7
6	74.3	111.7	28.3	93.7	-	-	26.0	24.7	122.7	255.0	134.7	189.0	8.3	42.0
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	0.94	6.17*	1.95	1.06	-	-	0.71	10.14*	0.04	4.29*	1.83	0.54	3.92†	2.85†

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
3	56.0	-	37.0	0	44.3	84.0	22.3	4.0	50.3	54.0
6	60.3	-	33.3	6.7	139.0	34.3	26.0	37.3	178.7	149.7
df	4	-	4	4	4	4	4	4	4	4
t	0.21	-	0.10	1.28	8.53*	2.55	0.15	1.76	7.67*	6.29*

† Significant at 5% level

* Significant at 1% level

Table 33. Comparison of t-test results of the suitability of FSW for the growth of NP between station 3 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
3	0	6.0	134.3	211.0	201.7	15.7	-	-	201.7	88.3	103.0	139.7	-	-
6	195.0	141.7	36.7	50.7	250.7	5.0	-	-	159.0	40.7	0	0	-	-
df	4	4	4	4	4	4	-	-	4	4	4	4	-	-
t	16.90*	36.11*	2.61	4.78*	2.30	2.63	-	-	2.71	4.01†	14.23*	26.03*	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
3	-	-	-	0.7	-	1.0	-	0	13.3	58.3	3.0	0	13.3	0
6	-	-	-	22.3	-	35.3	-	2.7	0	73.7	7.0	8.7	17.0	10.7
df	-	-	-	4	-	4	-	4	4	4	4	4	4	4
t	-	-	-	1.72	-	13.88*	-	1.83	3.13†	1.09	0.74	1.76	1.10	6.04*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
3	91.3	19.7	34.3	3.0	5.0	7.3	238.3	36.0	-	0
6	77.3	2.3	0	0	0	0.7	0	0	-	17.3
df	4	4	4	4	4	4	4	4	-	4
t	0.43	11.62*	6.39*	7.59	4.32†	4.17†	16.16*	6.55*	-	4.61*

†Significant at 5% level

*Significant at 1% level

Table 34. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 3 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
3	28.0	26.7	222.7	236.7	103.0	29.7	90.7	-	150.0	12.7	516.0	52.7	33.7	34.3
6	110.7	8.3	24.3	11.0	146.7	6.7	107.7	-	423.3	28.3	5.3	0	55.7	47.3
df	4	4	4	4	4	4	4	-	4	4	4	4	4	4
t	2.15	1.83	8.61*	7.13*	2.02	3.01†	0.24	-	5.97*	1.61	22.37*	11.94*	3.10†	2.93†

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°c	24°C	20°C	20°C
3	188.3	159.7	114.0	198.0	64.0	11.7	189.0	31.0	204.3	162.0	192.0	272.0	143.7	148.3
6	142.7	181.0	0	20.7	0	4.0	279.0	323.7	225.3	58.0	176.3	223.7	110.3	136.0
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	1.68	0.94	10.82*	16.52*	30.74*	2.49	4.75*	11.98*	0.44	1.46	0.63	11.57*	2.92†	1.29

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
3	168.7	6.5	174.0	7.0	176.7	134.0	179.3	218.7	108.3	97.5
6	249.3	1.7	0	0	190.3	198.7	222.3	245.0	148.3	183.7
df	4	3	4	4	4	4	4	4	4	3
t	1.82	1.10	5.52*	1.73	0.75	2.26	9.05*	1.96	3.17†	1.59

† Significant at 5% level

* Significant at 1% level

Table 35. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 4 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Marc.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
4	127.3	36.3	60.0	58.3	56.3	0	0	-	128.5	1.7	212.7	19.3	24.7	18.0
6	232.7	136.0	36.7	8.0	13.3	0.7	5.7	-	133.7	2.3	0	0	29.3	22.3
df	4	4	4	4	4	4	4	-	3	4	4	4	4	4
t	5.34*	1.29	2.05	4.80*	1.44	0.99	1.47	-	0.08	0.26	97.29*	0.99	1.26	1.83

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
4	66.3	62.0	20.0	44.7	-	-	28.3	90.7	94.7	60.7	79.3	142.7	35.0	27.0
6	74.3	111.7	28.3	93.7	-	-	26.0	24.7	122.7	255.0	134.7	189.0	8.0	42.0
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	1.05	4.71*	1.17	0.93	-	-	0.54	4.79*	0.64	4.81*	3.27†	9.78*	12.64*	3.71†

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
4	56.0	-	78.3	6.3	63.0	55.7	93.3	84.0	40.7	29.3
6	60.3	-	33.3	6.7	139.0	34.3	26.0	37.3	178.7	149.7
df	4	-	4	4	4	4	4	4	4	4
t	0.25	-	1.05	0.05	7.35*	1.02	4.56†	2.42	10.72*	7.81*

† Significant at 5% level
* Significant at 1% level

Table 36. Comparison of t-test results of the suitability of FSW for the growth of NP between station 4 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
4	11.3	0	98.0	170.7	39.0	39.0	12.3	-	40.0	49.7	180.0	109.3	-	-
6	195.0	141.7	36.7	50.7	250.7	5.0	0	-	159.0	40.7	0	0	-	-
df	4	4	4	4	4	4	4	-	4	4	4	4	-	-
t	15.87*	64.81*	3.01	6.31*	12.86*	16.33*	13.98*	-	7.11*	2.18	8.59*	9.01*	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
4	-	-	-	0.7	-	0.7	-	0	6.3	34.0	0.7	0	23.3	12.3
6	-	-	-	22.3	-	35.3	-	2.7	0	73.7	7.0	8.7	17.0	10.7
df	-	-	-	4	-	4	-	4	4	4	4	4	4	4
t	-	-	-	1.72	-	14.28*	-	1.83	7.17*	1.94	1.22	1.76	1.59	0.84

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
4	67.3	15.7	41.0	-	10.0	1.0	89.0	86.0	1.3	0
6	77.3	2.3	0	-	0	0.7	0	0	0	17.3
df	4	4	4	-	4	4	4	4	4	4
t	0.95	7.84*	16.29*	-	2.47	0.37	22.02*	7.45*	0.99	4.61*

† Significant at 5% level
* Significant at 1% level

Table 37. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 4 and station 6, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
4	40.0	2.7	258.3	325.7	31.7	31.7	96.3	-	91.7	57.7	197.0	215.0	29.3	51.0
6	110.7	8.3	24.3	11.0	146.7	6.7	107.7	-	423.3	28.3	5.3	0	55.7	47.3
df	4	4	4	4	4	4	4	-	4	4	4	4	4	4
t	1.61	1.09	5.97*	63.64*	5.38*	7.05*	0.16	-	6.95*	1.81	3.78†	3.02†	3.26†	0.96

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°c	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
4	148.0	164.3	183.3	167.0	114.3	51.7	275.7	181.0	269.0	116.3	217.0	217.0	170.3	148.3
6	142.7	181.0	0	20.7	0	4.0	279.0	323.7	225.3	58.0	176.3	223.7	110.3	136.0
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	0.21	0.75	6.03*	6.48*	14.27*	4.29†	0.21	5.98*	0.95	0.92	1.44	1.81	3.48†	1.22

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
4	257.7	5.3	276.7	3.0	260.7	199.7	257.7	280.7	214.7	99.3
6	249.3	1.7	0	0	190.3	198.7	222.3	245.0	148.3	183.7
df	4	4	4	4	4	4	4	4	4	4
t	0.19	2.94	14.31*	1.19	2.63	0.02	1.30	3.20†	2.48	2.01

† Significant at 5% level
* Significant at 1% level

Table 38. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 3 and station 4, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
3	88.0	70.3	47.7	36.0	2	-	18.3	-	56.0	3.3	140.0	17.7	22.7	13.7
4	127.0	36.3	60.0	58.3	56.3	-	0	-	128.5	1.7	212.7	19.3	24.7	18.0
df	4	4	4	4	4	-	4	-	3	4	4	4	4	4
t	1.82	0.96	1.06	1.12	2.03	-	10.99*	-	1.19	0.68	1.16	0.06	0.57	1.12

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
3	89.3	60.7	44.7	38.7	-	-	27.0	143.0	120.7	84.3	109.3	184.0	27.7	51.7
4	66.3	62.0	20.0	44.7	-	-	28.3	90.7	94.7	60.7	79.3	142.7	35.0	27.0
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	1.35	0.15	5.05*	0.57	-	-	1.36	3.03†	3.50†	2.09	1.63	4.55†	1.37	8.17*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
3	56.0	-	37.0	0	44.3	84.0	22.3	4.0	50.3	54.0
4	56.0	-	78.3	6.3	63.0	55.7	93.3	84.0	40.7	29.3
df	4	-	4	4	4	4	4	4	4	4
t	0.00	-	0.80	1.99	2.88†	2.79†	3.66†	15.79*	0.87	3.02†

†Significant at 5% level

*Significant at 1% level

Table 39. Comparison of t-test results of the suitability of FSW for the growth of NP between station 3 and station 4, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
3	0	6.0	134.3	211.0	201.7	15.7	0	-	201.7	83.3	103.0	139.7	-	-
4	11.3	0	98.0	170.7	39.9	39.0	12.3	-	40.0	49.7	180.0	109.3	-	-
df	4	4	4	4	4	4	4	-	4	4	4	4	-	-
t	12.84*	1.96	0.86	1.06	12.06*	6.70*	13.98*	-	24.71*	3.19†	3.47†	2.28	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
3	-	-	-	0.7	-	1.0	-	-	13.3	58.3	3.0	-	13.3	0
4	-	-	-	0.7	-	0.7	-	-	6.3	34.0	0.7	-	23.3	12.3
df	-	-	-	4	-	4	-	-	4	4	4	-	4	4
t	-	-	-	0.00	-	0.50	-	-	1.61	1.59	1.40	-	4.00†	13.98*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
3	91.3	19.7	34.3	3.0	5.0	7.3	238.3	36.0	-	-
4	67.3	15.7	41.0	0	10.0	1.0	89.0	86.0	-	-
df	4	4	4	4	4	4	4	4	-	-
t	0.77	1.80	1.12	2.59	1.18	4.05†	9.76*	3.91†	-	-

† Significant at 5% level

* Significant at 1% level

Table 40. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 3 and station 4, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
3	28.0	26.7	222.7	236.7	103.0	29.7	90.7	0	150.0	12.7	516.0	52.7	33.7	34.3
4	40.0	2.7	258.3	289.0	31.7	31.7	96.3	0.7	91.7	57.7	197.0	215.0	29.3	51.0
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	0.39	2.57	0.79	1.15	17.59*	0.27	0.29	0.99	3.64†	3.44†	5.80*	2.28	1.00	6.93*

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
3	188.3	159.7	114.0	198.0	64.0	11.7	189.0	31.0	204.3	162.0	192.0	272.0	143.7	148.3
4	148.0	164.3	183.3	181.7	114.3	51.7	275.7	181.0	269.0	116.3	217.0	217.0	170.3	148.3
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	3.57†	0.77	2.15	0.96	6.08*	3.65†	3.86†	7.04*	3.62†	0.48	0.68	13.47*	1.64	0.00

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
3	168.7	6.5	174.0	7.0	174.7	134.0	179.3	218.7	108.3	99.5
4	257.7	5.3	276.7	3.0	260.7	199.7	257.7	280.7	214.7	99.3
df	4	3	4	4	4	4	4	4	4	3
t	6.93*	0.28	2.77	0.84	3.10†	1.96	2.89†	4.44†	4.44†	0.07

†Significant at 5% level

*Significant at 1% level

Table 41. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 2 and station 7, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	56.3	88.7	20.3	8.3	3.0	-	-	-	121.3	0	38.3	17.7	30.7	10.7
7	142.0	75.0	142.0	49.3	0	-	-	-	34.7	23.7	25.7	2.3	10.7	9.3
df	4	4	4	4	4	-	-	-	4	4	4	4	4	4
t	9.61*	0.28	5.84*	3.16†	0.99	-	-	-	1.68	5.10*	0.64	0.93	9.37*	0.29

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	73.3	54.0	24.0	38.0	-	-	8.7	17.3	100.3	74.0	85.3	120.7	94.0	177.3
7	56.0	75.7	5.0	35.0	-	-	0	33.7	99.3	77.0	93.0	137.0	41.3	39.7
df	4	4	4	4	-	-	4	4	4	4	4	4	4	4
t	3.74†	1.38	3.90†	0.31	-	-	3.17†	3.02†	0.05	0.51	0.79	0.78	9.06*	17.00*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	37.3	-	110.0	6.7	47.0	58.0	58.0	34.7	170.3	164.7
7	22.7	-	101.3	32.0	1.3	9.0	54.7	74.0	61.3	53.0
df	4	-	4	4	4	4	4	4	4	4
t	4.37†	-	0.33	3.69	34.25*	7.71*	0.15	2.68	4.33†	2.52

† Significant at 5% level
* Significant at 1% level

Table 42. Comparison of t-test results of the suitability of FSW for the growth of NP between station 2 and station 7, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	198.7	198.7	60.0	37.7	146.0	2.3	-	-	159.7	0	214.7	244.0	-	-
7	103.0	150.7	45.7	51.0	111.7	0	-	-	147.3	12.3	41.3	36.3	-	-
df	4	4	4	4	4	4	-	-	4	4	4	4	-	-
t	4.82*	2.43	1.44	1.49	0.62	0.98	-	-	0.40	16.25*	9.40*	36.83*	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	0	0	-	1.0	3.7	20.7	-	8.0	60.0	48.3	61.0	18.7	13.3	8.7
7	11.7	31.3	-	3.0	0	0.7	-	0	9.3	20.0	0	0	0	0
df	4	4	-	4	4	4	-	4	4	4	4	4	4	4
t	3.44*	16.88	-	0.73	1.57	2.04	-	1.40	5.51*	4.87*	5.47*	5.02*	4.88*	7.20*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	87.3	0	72.3	3.7	12.0	-	3.3	-	83.0	106.7
7	0	1.3	2.3	0	0	-	0	-	0	0
df	4	4	4	4	4	-	4	-	4	4
t	18.57*	3.98†	10.85*	1.57	4.53†	-	1.64	-	5.77*	5.58*

† Significant at 5% level
* Significant at 1% level

Table 43. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 2 and station 7 for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	15°C	20°C	21°C
2	141.7	141.7	52.0	13.7	64.3	10.7	0	0	280.7	-	520.0	379.7	41.3	52.0
7	136.7	63.7	201.0	176.7	94.5	0.3	280.7	2.7	113.0	-	160.3	177.0	26.3	46.5
df	4	4	4	4	3	4	4	4	4	-	4	4	4	2
t	0.13	2.71	8.16*	14.47*	0.87	3.75†	53.57*	1.50	5.20*	-	2.40	3.35†	1.58	1.53

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	165.7	148.3	374.0	278.3	202.3	50.0	349.7	201.7	258.3	1.7	136.0	257.7	249.7	275.7
7	97.3	103.3	21.7	51.3	14.3	19.7	0	60.7	255.3	138.0	175.7	187.7	6.77	99.7
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	9.51*	4.21	16.90*	2.87†	12.01*	4.13†	18.66*	4.14†	0.19	12.07*	1.96	7.70*	5.98*	16.46*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	312.3	1.0	217.3	0	105.7	111.0	32.0	21.0	190.0	143.7
7	126.7	0	230.7	171.7	309.3	309.3	156.3	150.0	147.3	125.3
df	4	4	4	4	4	4	4	4	4	4
t	4.43†	1.72	0.47	4.37	8.24*	7.89*	6.25*	8.35*	2.32	0.49

† Significant at 5% level
* Significant at 1% level

Table 44. Comparison of t-test results of the suitability of 50/50 medium for the growth of Skeletonema costatum *between station 2 and station 11, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll* a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	56.3	88.7	20.3	8.3	3.0	0	0	-	121.3	0	38.3	5.0	30.7	10.7
11	78.0	78.0	118.0	66.0	40.0	0.7	33.3	-	51.7	1.3	9.0	5.3	25.0	25.0
df	4	4	4	4	4	4	4	-	4	4	4	4	4	4
t	1.39	0.54	3.12†	6.77*	4.72*	1.99	8.67*	-	1.35	1.50	2.93†	0.07	1.84	5.37*

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	73.3	54.0	24.0	38.0	-	-	8.7	-	100.3	74.0	85.3	120.7	94.0	177.3
11	66.0	76.0	18.3	19.7	-	-	19.0	-	99.3	130.3	66.7	115.7	41.7	29.3
df	4	4	4	4	-	-	4	-	4	4	4	4	4	4
t	0.68	1.05	1.33	1.82	-	-	2.54	-	0.03	2.22	1.23	0.24	11.12*	12.83*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	37.3	0	110.0	6.7	47.0	58.0	58.0	34.7	170.3	164.7
11	58.3	2.7	19.7	18.7	1.0	2.3	45.3	43.7	42.0	32.3
df	4	4	4	4	4	4	4	4	4	4
t	2.94†	7.98*	6.15*	1.26	32.53*	17.50*	0.60	0.58	5.03*	2.79†

†Significant at 5% level

*Significant at 1% level

Table 45. Comparison of t-test results of the suitability of FSW for the growth of NP between station 2 and station 11, for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	15°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	198.7	198.7	30.3	37.7	146.0	2.3	0	-	133.0	0	214.7	244.0	-	-
11	14.0	14.3	17.3	28.3	25.0	7.0	8.3	-	11.7	0.7	0	0	-	-
df	4	4	4	4	4	4	4	-	4	4	4	4	-	-
t	9.41	9.31	0.83	0.98	13.58	3.88	6.24	-	8.32	1.99	11.84	60.37	-	-

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	28°C	24°C	20°C	20°C
2	-	-	-	1.0	3.7	20.7	-	63.0	60.0	48.3	61.0	18.7	13.3	8.7
11	-	-	-	0	0	0	-	0	0	0	0	0	0	0
df	-	-	-	4	4	4	-	4	4	4	4	4	4	4
t	-	-	-	0.99	1.57	2.12	-	0.99	6.86	15.70	5.47	5.00	4.83	7.20

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	87.3	0	72.3	3.7	12.0	-	3.3	0	83.0	106.7
11	0	2.0	0	0	0	-	0	1.7	0	0
df	4	4	4	4	4	-	4	4	4	4
t	18.57	45.82	11.32	1.57	4.53	-	1.64	4.98	5.77	5.58

Table 46. Comparison of t-test results of the suitability of 50/50 medium for the growth of NP between station 2 and station 11 for the period of October 1972 through April 1974. Numbers listed are mean increase of relative Chlorophyll a.

	Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	28°C	20°C	16°C	20°C	13°C	20°C	15°C	20°C	14°C	20°C	19°C	20°C	21°C
2	141.7	141.7	52.0	13.7	64.3	10.7	0	-	280.7	-	310.0	379.7	41.3	52.0
11	65.0	47.0	135.0	33.0	107.3	16.3	162.7	-	82.0	-	53.3	41.7	23.3	57.7
df	4	4	4	4	4	4	4	-	4	-	4	4	4	4
t	2.69	3.17†	3.46†	2.31	4.86*	1.42	6.29*	-	4.76*	-	7.33*	8.30*	2.67	1.29

	May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	
	20°C	20°C	20°C	27°C	20°C	30°C	20°C	31°C	20°C	28°C	20°C	24°C	20°C	20°C
2	165.7	148.3	374.0	278.3	102.3	50.0	349.7	201.7	258.3	1.7	236.0	257.7	249.7	275.7
11	112.7	96.0	57.3	162.3	31.0	40.3	0	207.3	208.7	320.0	210.0	210.0	35.3	80.0
df	4	4	4	4	4	4	4	4	4	4	4	4	4	4
t	2.31	2.73	15.02*	1.45	10.81*	1.01	18.65*	0.16	3.73†	24.84*	1.81	7.01*	7.10*	14.26*

	Dec.		Jan.		Feb.		Mar.		Apr.	
	20°C	12°C	20°C	17°C	20°C	21°C	20°C	20°C	20°C	25°C
2	312.3	1.0	217.3	0	105.7	111.0	32.0	21.0	190.0	143.7
11	137.0	1.3	77.3	6.0	197.0	99.0	89.3	31.7	82.0	111.0
df	4	4	4	4	4	4	4	4	4	4
t	5.96*	0.49	5.25*	10.38*	4.99*	1.40	2.89†	0.73	6.28*	1.12

†Significant at 5% level

*Significant at 1% level

VITA

Name: Henry Lloyd Mullins

Date of Birth: August 15, 1950

Place of Birth: Plainview, Texas

Address: 301 North Houston Street, Aransas Pass, Texas

Marital Status: Married

Parents' Name: Henry L. and Thelma D. Mullins

Parents' Address: 1414 Mockingbird Lane, Beeville, Texas

Educational Background:

1. A. C. Jones High School, Beeville, Texas. Graduated: 1968
2. Stephen F. Austin State University, Nacodoches, Texas. B. S.: 1972

Professional Experience:

1. Graduate Research Assistant, Texas A&M University, 1972-1974
2. Research Assistant, University of Texas, Marine Science Institute, Port Aransas, Texas, 1974-1975
3. Coastal Biologist, State of Texas, General Land Office, 1975-1979

The typist for this thesis was Marion R. Lundberg.