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# COLLECTION OF HIGH ENERGY YIELDING STRAINS OF SALINE MICROALGAE FROM SOUTHWESTERN STATES

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# COLLECTION OF HIGH ENERGY YIELDING STRAINS OF SALINE MICROALGAE FROM SOUTHWESTERN STATES

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## ABSTRACT

Microalgal and water samples were obtained from 87 sites in Arizona, California, Nevada, New Mexico, Texas and Utah. Collected waters ranged in temperature from 17.8° to 39°C, in specific conductance from 447 uS/cm to 474,000 uS/cm and from 6.1 to 10.2 in pH. Ionic analysis of the waters revealed that the relative anion and cation composition of the surface waters sampled was relatively similar to the artificial SERI Type I and Type II Media that has been used as the standardized media for growth rate experiments. Approximately 1,400 individual isolates of microalgae were obtained from surface waters in the Southwest. Of the initial 23 algae screened for growth characteristics, the majority grew best at the lower salinities in both SERI Type I and Type II Media. Growth rates for selected strains approached three doublings per day.

## INTRODUCTION

Collection and screening efforts designed to isolate and characterize lipid accumulating microalgae have been restricted primarily to specific geographic locations. Thomas et al. (1983, 1984, 1985) have collected and characterized selected microalgae

from saline waters in eastern California and western Nevada. Barclay (1984) and Barclay et al. (1985) have collected and screened microalgae from Colorado and Utah, and Tadros (1985) has isolated organisms from marine habitats on the Gulf Coast of Alabama, Florida, and Mississippi. Lewin (1985) and Ryther (per. comm.) have also made collections from marine and saline habitats.

The Southwestern United States have been identified as possessing the requisite resources and characteristics such as abundant land, saline water, high incident solar radiation and mild temperatures that would be advantageous in the development of microalgal biomass technology (McIntosh, 1984). Since an abundance of microalgal species exist in the diverse aquatic habitats of the Southwest, they represent a large and varied assemblage of autotrophic microorganisms that have adapted to utilize the growing conditions available. It is logical, therefore, that microalgal species which either dominate or are found in abundance in the region would represent likely candidates for mass culture using natural waters of the area.

This investigation was designed primarily to enlarge the pool of microalgal raw material from which the more desirable strains could be selected, manipulated or ultimately genetic modified. Previous attempts to mass culture microalgae has focused on increased yield through improvements in culture management rather than on improvements resulting from the selection of more desirable strains.

The specific objectives were to:

(1) collect microalgal species/strains from a diversity of saline habitats at numerous locations in the desert Southwest.

(2) isolate and identify strains that grow well at elevated salinities and light intensities, and to characterize selected strains for lipid and carbohydrate accumulation.

(3) characterize the gross physico-chemistry of the habitats from which microalgae were collected.

To accomplish these objectives, microalgae were obtained from 87 aquatic habitats of diverse salinities and temperatures in Arizona, California, Nevada, New Mexico, Texas and Utah and were screened for their ability to grow rapidly in dense culture under elevated salinities and light intensities and to accumulate lipid and carbohydrate storage products.

## MATERIALS AND METHODS

Six separate sampling trips to saline surface waters supporting algal growth in the arid Southwest were conducted from 19 April to 27 July 1985 (Fig. 1 and Table 1). Before algal samples were taken at a given aquatic site, specific conductance of the water was measured and if it exceeded 2000 uS/cm, a sample was collected. Conductance was not the sole criterion used to determine whether samples were to be taken. Sites exhibiting lower conductivity, yet abundant algal growth were also sampled.

At each site several field measurements were recorded. Air temperature was measured in the shade with a mercurial thermometer. Water temperature and specific conductance were determined with a Yellow Spring Instruments (YSI) Model 33 S-C-T salinity meter. Conductance was corrected to 25°C (Wetzel and Likens, 1979). Water depth was recorded at the point of sample collection. Hydrogen ion concentrations were measured with a portable Orion Model 407A pH meter.

One liter of water was collected for microalgal isolation and media preparation and another liter obtained from subsequent water chemistry analyses. In addition to these planktonic samples, neustonic and benthic samples were collected at sites exhibiting visible algal growth. Neustonic samples were collected in a quiescent area by sweeping a Whatman No. 42 filter across the water surface with a forceps. If abundant algal growth was present around the margin of the pond or stream a benthic sample was also collected. Samples were kept near collection temperatures by placement in an insulated chest in the dark until returning to the laboratory.

At all sites where planktonic samples were collected, water was obtained for determination of ionic composition (Ca, Mg, Na, K, OH, $CO_3$, $HCO_3$, $SO_4$, Cl) and total filterable residue (TFR). Water samples were collected by bottle immersion below the surface, placed on ice and kept in the dark until processed. Following filtration of the water through pre-rinsed Whatman GF/C

filters (1.2 um pore size), anionic composition and TFR were determined. Alkalinity was measured by titration to phenolphthalein and bromcresol green-methyl red end points (APHA et al., 1985), chloride by mercuric nitrate titration (USEPA, 1979) and sulfate by the turbidimetric method (APHA et al., 1985) in 2.5 cm curvettes with a Coleman Model 54 spectrophotometer. Total filterable residue was determined gravimetrically after drying at 105°C to a constant weight (APHA et al., 1985). Cationic concentrations were measured after membrane filtration (0.45 um pore size) and nitric acid preservation of samples by direct aspiration atomic absorption spectroscopy with a Perkin-Elmer Model 403 (USEPA, 1979). Lanthanum and cesium were added to the samples and an air-acetylene flame used. All glassware and bottles used for collection and storage of water samples were soaked in 6 N HCl and throughly rinsed with distilled and deionized water.

Planktonic samples were divided into four aliquots to isolate and characterize the microalgae (Fig. 2). A portion was preserved with Lugol's solution to provide a record of the taxonomic diversity for each site and to give an indication of total cell numbers. An aliquot of the sample was enriched with nutrients and maintained as a living collection. All nutrient additions were similar to Guillard's F1 Medium (Guillard and Ryther, 1962) without thiamine, biotin, or $B_{12}$. Samples were enriched to: $NaNO_3$, 146.9 mg/l; $NaH_2PO_4 \cdot H_2O$, 9.794 mg/l;

$Na_2SiO_3 \cdot 9H_2O$, 9.794 mg/l; $Na_2EDTA$, 8.541 mg/l; $FeCl_2 \cdot 6H_2O$, 6.170 mg/l; $CuSO_4 \cdot 5H_2O$, 19.59 ug/l; $ZnSO_4 \cdot 7H_2O$, 43.10 ug/l; $CoCl_2 \cdot 6H_2O$, 19.59 ug/l; $MnCl \cdot 4H_2O$, 35.26 ug/l; and $NaMoO_4 \cdot 2H_2O$, 12.73 ug/l. Two approaches were used for preliminary screening and iolation. In one approach samples were streaked directly onto 1.5% agar plates with conductivities similar to that recorded in the field (Fig. 2). Plates were made with filter sterilized (0.22 um pore size) Solar Energy Research Institute (SERI) Type I or II Media (Barclay et al., 1985), seawater, or natural site water, all enriched with nutrients. Isolated colonies were removed and placed into test tubes (16 x 150 mm) containing 2 ml of liquid medium of the type used to prepare the plates. The pH of SERI Media or seawater was not adjusted since small acid or base additions resulted in precipitation. Average pH of the media of 10, 40 and 70 mS/cm conductance was: SERI Type I(10), 7.78; SERI Type II(10), 8.56; SERI Type I(40), 7.34; SERI Type II(40), 8.80; SERI Type I(70), 7.25; SERI Type II(70), 8.80; seawater, 7.79. In the second approach samples were enriched and placed in large culture tubes (25 x 150 mm) on a rotary culture device similar to that described by Barclay et al. (1985) (Fig. 3). The cultures were exposed to the following conditions: constant temperature of 25°C, irradiance of 1500 $uE/m^2/sec$ and 12 h light 12 h dark (12L:12D) photoperiod. Light intensity was measured with a LI-Cor Model LI-185 Meter and LI-192S Quantum Sensor. The rotary culture device was placed inside an environmental chamber (National Appliance Co., Portland, OR) to maintain a constant

temperature which was continuously recorded with a Model 594 hygro-thermograph (Bendix Corp., Baltimore, MD). Samples were placed in the rotary device for 7 to 19 days and then samples streaked and isolated as above.

Sediment and filters containing neustonic samples were placed into tubes containing SERI Type I or II Media enriched with nutrients. After visible growth occurred the sample was streaked onto agar plates and algal clones isolated.

Microalgal samples generated from the two isolation approaches were examined microscopically (Fig. 4). If the samples were not unialgal they were restreaked onto agar plates and checked again. Portions of the unialgal sample were placed on agar slants and 10 ml of media added to the test tubes. These samples were precultured at 25°C in enriched SERI Type I and Type II Media of 40 mS/cm conductance, 200 uE/$m^2$/sec irradiance, and a 12L:12D cycle. Once significant cell numbers were achieved and while the culture was in logarithmic growth, samples were inoculated (0.5 ml) into culture tubes (25 ml) containing enriched SERI Type I and II Media at 10, 40 and 70 mS/cm and enriched seawater, and placed in the rotary culture device. Initial growth rate measurements were made at 30°C, 500 uE/$m^2$/sec and 12L:12D cycle. Growth rates of promising strains will be determined later at different temperatures and light intensities. Rotary culture device tubes were inserted directly into a Coleman Model 54 spectrophotometer and optical density values recorded at 750 nm (2.2 cm path length) for 10 days. Values were transformed

to logarithm base 2 and growth rates calculated from the slope of a linear regression of time (total light and dark period) and optical density (Sorokin, 1973).

Nile Blue A (CI 51180) and Oil Red O (CI 26125) stains were used to evaluate the presence of intracellular lipids in selected strains of microalgae. Samples were cultured in nutrient sufficient or deficient SERI Type I or II media under conditions of 25°C, 200 uE/$m^2$/sec, and a 12L:12D cycle. Once a dense culture was produced cells were stained and rated from zero, for no microscopically visible lipid droplets, to three pluses for droplets nearly filling the entire cell volume. Cells were washed in distilled water and fixed by passing a microscope slide, containing a drop of sample, through a flame to evaporate the liquid. While the slide was hot Nile Blue A (40 mg/100 ml distilled water) or Oil Red O (750 mg/100 ml dimethyl sulfoxide) were added and allowed to remain for about 30 sec. Slides treated with Nile Blue A were washed and destained with 1 M Tris-HCl buffer (pH 8.5) and Oil Red O stained cells were washed with 60% isopropanol. Wet mounts were prepared and viewed with moderate light at 1000x magnification.

The chemical composition of algal strains showing either good growth or lipid accumulation via the staining methods was determined. Algae were grown in one-liter flasks containing appropriate SERI Media or seawater. Once significant cell numbers were achieved the batch cultures were harvested by filtration or centrifugation. Total carbohydrates were

determined by the phenol-sulfuric acid method (Kochet, 1978) with a glucose standard and total proteins by the heated biuret-Folin assay (Dorsey et al., 1978) with a bovine serum albumen (BSA) standard. Total lipids were determined according to Bligh and Dyer (1959). Dry weight was found by concentrating an algal sample onto a tared precombusted Whatman CF/C filter and drying at 105°C to a constant weight. Ash-free dry weight was obtained by igniting the above filter at 500°C for one hour. The filter was cooled, wetted with distilled water and brought to a constant weight after drying at 105°C. Chemical composition was expressed as a percentage of the ash-free dry weight.

## RESULTS AND DISCUSSION

Samples of natural water containing microalgae were obtained from 87 aquatic habitats in the Southwest representing a broad range of conductivities and temperatures (Fig. 5). Twenty samples were from natural waters with temperatures of 30°C or greater. Another 19 sites had water temperatures between 28 and 29.9°C at the time of collection. Mean water temperature for all the samples was 26.6°C, ranging from 17.8°C in the Salt River Canyon (Site no. SRC-3) to 39.0°C at LaVerkin Springs (LVS-3). Specific conductance ranged from 447 uS/cm in the Salt River Canyon of Arizona (SRC-11) to 474,000 uS/cm in Salt Lake in New Mexico (SL-1) and averaged 24,900 uS/cm. Approximately one-third of the habitats had a conductance greater than 10,000 uS/cm. Specific conductivity was measured at 74 additional sites but was

either too low (< 2000 uS/cm) or the extremely turbid nature of the water due to suspended particulates precluded sample collection. Measurements of specific conductance in the field were used to match the sample to the appropriate SERI Media during initial screening and isolation. Other field parameters are summarized in Table 2. Water depths ranged from 1 cm at Wilcox Playa (WP-1/2) to 76 cm in the Buckeye Irrigation District (B-4). A seep in the Salt River Canyon (SRC-3) exhibited the pH low of 6.1 with a high pH of 10.2 recorded at Wilcox Playa (WP-1).

Ionic composition of waters sampled during the summer of 1985 is given in Table 3. In the calculation of anionic composition, alkalinity was calculated as the sum of OH, $CO_3$, and $HCO_3$. Trilinear plots of relative anionic and cationic compositions of the various waters is given in Figures 6 and 7. From the anionic plot (Fig. 6) it is apparent that the waters from the Southwest were dominated by Cl. Exceptions include several sites in the Pecos River Valley of Texas, with high proportions of $SO_4$ and samples collected from central Arizona possessing high alkalinities. Elevated proportions of Na + K were apparent in the cationic plot (Fig. 7). A number of samples (16 of 88) contained a high relative Ca concentration with all samples noticably deficient in Mg.

These results are generally similar to those obtained by Thomas et al. (1984) for saline waters sampled in California and Nevada. Based on an average of relative anionic compositions for

23 sites sampled a higher proportion (6 of 23) of their sample sites contained water high in alkalinity. Analyses of cationic compositions yielded a very dense cluster in the Na + K apex of a trilinear plot. The Salton Sea (Imperial-Riverside Counties, California), in April 1983 contained the lowest proportion of Na + K at 73.9%.

Most waters of the arid southwest are controlled by evaporation-precipitation processes (Gibbs, 1970) resulting in high Na and Cl levels. Proportions of these ions in saline waters can be modified by temperature, precipitation, evaporation, basin sediments, nature of influent waters, lithology of the drainage basin, and biotic effects (Cole, 1968). Results from our work and that of Thomas et al. (1984) corroborate the expected high levels of Na and Cl in southwestern surface waters. When field data is compared to the SERI artificial media good agreement with the anionic composition is apparent (Fig. 6). Most of the sites had a relative anionic composition that is distributed evenly between Type I and II Media with some samples having a proportionally higher alkalinity. The relative cationic composition of the sites do not follow SERI Type I Media (Fig. 7). The high proportion of Mg (38.1 to 45.6% meq/l) causes this medium formulation to appear as an outlier on the trilinear plot. Most of our samples contained only about 17% meq Mg/l whereas Thomas et al. (1984) obtained

about 5% meq Mg/l. In extreme stages of concentration Mg salts can predominate over less soluble Na compounds, but surface waters of this type are uncommon in the Southwest.

A compilation of ionic water chemistry and its potential correlation with promising microalgae might be used later to predict water conditions that favor algal species that are able to thrive in mass culture in the Southwest and subsequently produce desirable products. Differences in algal floras between lakes are frequently correlated with ionic characteristics of the water. Moss (1973) reported that pH and inorganic carbon concentrations in five southern Michigan lakes were important in explaining differences in algal composition. A positive correlation between Ca and chlorophyll-a concentrations was reported by Bierhuizen and Prepas (1985) in saline lakes of Alberta and Barica (1978) found that high salinity decreased maximum summer chlorophyll-a levels. This information on ionic composition can therefore be used to refine artificial media formulations for future culture work.

Specific conductance proved to be a good predictor of total filterable residue (TFR) in the waters sampled (Fig. 8). Total filterable residue concentrations determined by evaporation averaged 23,226 mg/l (range 273 to 506,166 mg/l) and can be related to conductivity by the following linear regression equation:

$$\log (TFR) = 1.0255(\log SC) - 0.2789$$

$$r^2 = 0.9487, \; n = 88.$$

As an analytical check TFR was calculated as the sum of dominate ions (Ca, Mg, Na, K, OH, $CO_3$, $HCO_3$, $SO_4$ and Cl) and compared to evaporative TFR. Ratios of evaporative to summation TFR were close to unity with only a few aberrations (Table 8). Divergent values might have resulted from occluded water remaining in the dishes after drying at 105°C. Depth at the sample site was recorded but this parameter does not appear to contain much predictive value (cf. Barclay et al., 1985).

A total of 151 samples were collected for the isolation of microalgae (Table 4). Most of the collections (63.6%) were of planktonic material. The large number of sites samples and the dual approaches employed to isolate algae produced a very large quantity of isolates. Only a small fraction of these isolates have been characterized with regard to growth and chemical composition. The thrust of our current and future efforts will be directed toward the methodical examination of this large reservoir of algal samples.

A list of 51 isolated algal genera is given in Table 5. To date 14 different genera have been identified, with several represented by multiple strains. This list will be expanding as more isolates are identified from existing cultures. Dunaliella, the most halophilic eukaryotic organism known (Brock, 1976) composes the largest portion (15 of 51) of the algae isolated. This genus was collected from six sites with high conductivities ranging from 72,900 to 52,900 uS/cm. Blue-green algae were the next most abundant (13 of 51) organisms isolated. Seven strains

of Oscillatoria and six strains of Chroococcus were isolated. Many genera of blue-green algae thrive in saline waters (Borowitzka, 1981) with Microcoleus, Oscillatoria, Phormidium, and Spirulina being common filamentous representatives. Aphanothece halophytica, which is closely related to Chroococcus, is reported to be common in warm, saline lakes. Nine strains of Cymbella were isolated from sites of generally low conductivity (ranging from 912 to 29,900 uS/cm). Only one strain of each of the remaining ten genera has been identified. An additional 47 unialgal cultures have been obtained but await identification.

During nutrient-sufficient growth 12 isolates were stained with Oil Red O (Table 6). Only Trebouxia (ASU0132) demonstrated significantly elevated levels of intracellular lipids. Four other strains had detectable lipid aggregations with the remainder giving no reaction. These cultures will be allowed to senesce and stained again to evaluate lipid accumulation under nutrient deficiency.

During the initial set of growth rate experiments three genera were used to evaluate the procedure. Growth rates were determined for Carteria and Pleurochloris from the Arizona State University (ASU) culture collection and Platymonas (S/Platy-1) from SERI.

Platymonas was reported to be a profilic alga and two strains from the ASU collection are thought to have potential as biomass producers. Platymonas grew in all media (Table 7) with a growth rate ranging from 0.231 doublings/day (doub/d) in SERI I(40)

Medium to 0.901 doub/d in SERI II(40) Medium. These rates are slightly lower than those obtained by Laws (1985) who reported about one doubling per day for Platymonas grown in laboratory scale experiments. Carteria and Pleurochloris grew in low salinity SERI Media (Table 7) at an average of 0.304 doub/d and 0.410 doub/d, respectively. Pleurochloris grew at a rate 0.717 doub/d in SERI I(70), the most saline media used during these growth rate experiments.

A total of 23 growth rate determinations have been completed (Table 7). Most of these initial rates are from samples collected in the Salt River Canyon. Dunaliella (ASU0002) showed high doubling rates in all media used except SERI Type II(70) (Fig. 9). Growth rates for this alga were calculated from two separate experiments and agreement between results was good. Both determinations indicated that Dunaliella (ASU0002) grew best in SERI Type I(10). Eremosphaera (ASU0048), Nannochloris (ASU0068) and Trebouxia (ASU0132) from the Salt River Canyon exhibited rapid growth in several SERI Media of low conductivity (Fig. 10). A rate of 2.038 and 3.263 doub/d were recorded for Trebouxia and Eremosphaera in SERI Type I(10). A single sample of Asteroccous (ASU0061) from the Verde River showed a similar pattern with high growth rates in the less concentrated SERI Media and seawater (Fig. 15). Rapid growth was apparent (0.767 to 1.101 doub/d) in all SERI Type I Media and seawater (2.576 doub/d) for Dunaliella (ASU0038) collected from Salt Creek in Texas. Two algae from LaVerkin Springs and one from Lower

Chevelon Creek exhibited very rapid growth in most of the media used (Fig. 13). Chlorococcum (ASU0093) from Lower Chevelon Creek grew rapidly in low salinity SERI Media and seawater (maximum 1.723 doub/d in SERI Type I(40)). Rates ranging from 0.501 in SERI Type I(70) to 2.313 doub/d in seawater were reported for Chroococcus (ASU0071 and ASU0075) from LaVerkin Springs. Growth for the other strains is depicted in Figures 11, 12 and 14.

Most of the rapid growth rates were observed in SERI Media Type I and II at 10 mS/cm. This may have resulted from the fact tnat most (11 of 19) of these initial field samples were isolated into low conductance media. These algae are apparently intolerant of large changes in salinity, however Brown (1985) was able to transfer Nannochloris from 7% to 200% artificial seawater (ASW) with an intermediate incubation in 100% ASW. There appears to be no major differences in growth rates between SERI Type I and II Media with the exception of the paucity of growth seen in Type II Medium at 70 mS/cm. Only two algae (Platymonas and Chroococcus (ASU0071)) were able to demonstrate appreciable growth in this concentrated medium.

Initial growth rates obtained from algae collected in the Southwest appear similar to those found by other workers in the Aquatic Species Program. Since other workers have previously used different media, culturing devices, light intensities, and methods of calculating and expressing growth rates, results are not always strictly comparable.

Thomas et al. (1984) initially estimated algal growth visually but later (Thomas et al., 1985) determined growth rates for 31 "good" and "intermediate" growing strains at 30°C. Growth ranged from 0.10 doub/d for a green flagellate (56R80-1) in Standard I Moderate TDS Medium to 2.48 doub/d for Chlorella ellipsoidea (BL-6) in Standard II Low TDS Medium. The average rate was 0.68 doub/d for the 31 strains tested. In later experiments Thomas et al. (1985) determined growth rates for six algal strains at 30°C in five different Standard Media. Chaeroceros (OL-12) grew the best at 1.72 doub/d in Standard II Moderate TDS Medium.

Barclay et al. (1985) reported exponential growth rates (per day) for Ankistrodesmus and Boekelovia (Chryso/F1) on salinity-temperature gradients. Exponential growth rates in excess of 2.0/day (ca. 3.5 doub/d) were obtained for both species.

Maximum doubling times of 18 h (= 1.33 doub/d) were reported for Dunaliella salina and Phaeodactylum tricornutum by Ben-Amotz (1985). These growth rates are not directly comparable to our results since the cultures were grown at different temperatures.

## CONCLUSIONS

Algal and water samples were collected from a large number of sites in the Southwest exhibiting a broad range of environmental conditions. Analyses of cationic and anionic compositions indicate that the SERI Artificial Media are reasonably good approximations of southwestern surface waters. The major

exception is the elevated levels of magnesium present in SERI Type I Media. Approximately 1400 algal cultures have been generated and only a small portion of these have been examined in detail. Fifty-one unialgal cultures, growing in saline medium, have been tentatively identified. These isolates were dominated by Dunaliella, unicellular and filamentous blue-green algae, and Cymbella. Using Oil Red O stain, 12 isolates have been tentatively evaluated for the production of intracellular lipids. During nutrient-sufficient growth Trebouxia (ASU0132) demonstrated high levels of lipid accumulation. Growth rate measurements have been completed for 21 unialgal samples using SERI Media and seawater. Most algae grew well in SERI Type I and II Media with low conductivities. Dunaliella (ASU0038), Chroococcus (ASU0075), Chlorococcum (ASU0093), and Trebouxia (ASU0132) grew at about two doub/d while Eremosphaera (ASU0048) doubled three times per day.

Efforts are currently directed toward obtaining a more detailed characterization of growth parameters for selected species and analysis of chemical composition of the most promising strains.

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Table 1. Sampling sites in Arizona, California, Nevada, New Mexico, Texas and Utah.

| Site No. | Date | State | County | Latitude | Longitude | Elev. | Topographic map |
|---|---|---|---|---|---|---|---|
| KP-1 | 5/19/85 | AZ | Maricopa | 332230 | 1115619 | 380 | Guadalupe, Ariz. 7.5 min (1982) |
| TL-1 | 5/19/85 | AZ | Maricopa | 332238 | 1115707 | 380 | Tempe, Ariz. 7.5 min (1973) |
| DL-1 | 5/19/85 | AZ | Maricopa | 332153 | 1115325 | 385 | Guadalupe, Ariz. 7.5 min (1982) |
| IBW-1 | 5/19/85 | AZ | Maricopa | 332705 | 1115447 | 360 | Tempe, Ariz. 7.5 min (1973) |
| TC-1 | 5/19/85 | AZ | Maricopa | 332653 | 1115610 | 380 | Tempe, Ariz. 7.5 min (1973) |
| PZ-1 | 5/19/85 | AZ | Maricopa | 332657 | 1115403 | 385 | Tempe, Ariz. 7.5 min (1973) |
| SR-1 | 5/19/85 | AZ | Maricopa | 332555 | 1115617 | 345 | Tempe, Ariz. 7.5 min (1973) |
| SRC-1 | 5/30/85 | AZ | Gila | 334753 | 1103001 | 1025 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-2 | 5/30/85 | AZ | Gila | 335054 | 1103320 | 965 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-3 | 5/30/85 | AZ | Gila | 335016 | 1113321 | 975 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-4 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-5 | 5/30/85 | AZ | Gila | 335423 | 11113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-6 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-7 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-8 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-9 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-10 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-11 | 5/30/85 | AZ | Gila | 334947 | 1103424 | 950 | Blue House Mtn., Ariz. 15 min (1946) |
| SRC-12 | 5/30/85 | AZ | Gila | 335423 | 1113631 | 1000 | Blue House Mtn., Ariz. 15 min (1946) |
| FC-1 | 6/13/85 | AZ | Yavapai | 342412 | 1113702 | 1150 | Strawberry, Ariz. 7.5 min (1967) |
| FC-2 | 6/13/85 | AZ | Yavapai | 342524 | 1113425 | 1290 | Strawberry, Ariz. 7.5 min (1967) |
| FC-2A | 6/13/85 | AZ | Yavapai | 342524 | 1113425 | 1290 | Strawberry, Ariz. 7.5 min (1967) |
| FC-3 | 6/13/85 | AZ | Yavapai | 342515 | 1113431 | 1285 | Strawberry, Ariz. 7.5 min (1967) |
| FC-4 | 6/13/85 | AZ | Yavapai | 342515 | 1113431 | 1285 | Strawberry, Ariz. 7.5 min (1967) |
| VR-1 | 6/13/85 | AZ | Yavapai | 342118 | 1114233 | 805 | Verde Hot Springs, Ariz. 7.5 min (1967) |
| VR-2 | 6/13/85 | AZ | Yavapai | 342118 | 1114233 | 805 | Verde Hot Springs, Ariz. 7.5 min (1967) |
| VR-2A | 6/13/85 | AZ | Yavapai | 342118 | 1114233 | 805 | Verde Hot Springs, Ariz. 7.5 min (1967) |
| B-1 | 7/2/85 | AZ | Mariopa | 332142 | 1123420 | 260 | Buckeye, Ariz. 7.5 min (1958) |
| B-2 | 7/2/85 | AZ | Mariopa | 332119 | 1123555 | 255 | Buckeye, Ariz. 7.5 min (1958) |
| B-3 | 7/2/85 | AZ | Mariopa | 332051 | 1123813 | 250 | Buckeye, Ariz. 7.5 min (1958) |
| B-4 | 7/2/85 | AZ | Mariopa | 331958 | 1124036 | 245 | Buckeye, Ariz. 7.5 min (1958) |
| HR-1 | 7/2/85 | AZ | Mariopa | 332054 | 1124318 | 250 | Hassayampa, Ariz. 7.5 min (1958) |
| GD-1 | 7/2/85 | AZ | Mariopa | 331334 | 1124559 | 220 | Spring Mtn., Ariz. 7.5 min (1973) |
| PC-1 | 7/2/85 | AZ | Mariopa | 335702 | 1124156 | 225 | Gila Bend, Ariz. 15 min (1951) |
| BP-1 | 7/2/85 | AZ | Mariopa | 330448 | 1130117 | 170 | Dendora Valley, Ariz. 15 min (1951) |
| WM-1 | 7/2/85 | AZ | Yuma | 324221 | 1140454 | 70 | Wellton, Ariz. 7.5 min (1965) |
| WM-2 | 7/2/85 | AZ | Yuma | 324508 | 1142516 | 50 | Laguna Dam, Ariz. 7.5 min (1955) |
| GL-1 | 7/3/85 | AZ | Yuma | 333008 | 1114740 | 25 | Gadsden, Ariz. 7.5 min (1965) |
| MD-1 | 7/3/85 | AZ | Yuma | 322919 | 1144717 | 25 | Gadsden, Aiz. 7.5 min (1965) |
| PV-1 | 7/3/85 | CA | Imperial | | | | |
| PV-2 | 7/3/85 | CA | Imperial | | | | |
| GR-1 | 7/15/85 | AZ | Graham | 330302 | 1095755 | 815 | Thomas, Ariz. 15 min (1960) |
| GR-2 | 7/15/85 | AZ | Graham | 330258 | 1095753 | 815 | Fort Thomas, Ariz. 15 min (1960) |
| CC-1 | 7/15/85 | AZ | Graham | 325928 | 1095432 | 835 | Thatcher, Ariz. 15 min (1960) |
| CM-1 | 7/15/85 | AZ | Greenlee | 330316 | 10911750 | 1070 | Clifton, Ariz. 15 min (1962) |

Table 1. (continued)

| Site No. | Date | State | County | Latitude | Longitude | Elev. | Topographic map |
|---|---|---|---|---|---|---|---|
| WP-1 | 7/16/85 | AZ | Cochise | 320847 | 1-94635 | 1260 | Cochise, Ariz. 15 min (1958) |
| WP-2 | 7/16/85 | AZ | Cochise | 320844 | 1094630 | 1260 | Cochise, Ariz. 15 min (1958) |
| FH-1 | 7/17/85 | TX | El Paso | | | | |
| T-1 | 7/17/85 | TX | El Paso | 312449 | 1060347 | 1145 | Tornillo, Tex. 7.5 min (1972) |
| T-2 | 7/17/85 | TX | El Paso | 312508 | 1060308 | 1145 | Tornillo, Tex. 7.5 min (1972) |
| DC-1 | 7/17/85 | TX | Hudspeth | 315622 | 1051125 | 1115 | Dell City, Tex. 7.5 min (Prov. ed. 1984) |
| DC-2 | 7/17/85 | TX | Hudspeth | 315611 | 1051026 | 1115 | Dell City, Tex. 7.5 min (Prov. ed. 1984) |
| DC-3 | 7/17/85 | TX | Hudspeth | 315341 | 1050855 | 1110 | Dell City, Tex. 7.5 min (Prov. ed. 1984) |
| SC-1 | 7/18/85 | TX | Culberson | 315108 | 1041404 | 1050 | Screw Bean Draw, West; Tex. 7.5 min (1973) |
| 14 | 7/18/85 | TX | Reeves | 314921 | 1040032 | 885 | Screw Bean Draw, West; Tex. 7.5 min (1973) |
| 15 | 7/18/85 | TX | Reeves | 315300 | 1035508 | 850 | Red Bluff, Tex. 7.5 min (1968) |
| RBR-1 | 7/18/85 | TX | Reeves | 315404 | 1035437 | 865 | Red Bluff, Tex. 7.5 min (1968) |
| PR-1 | 7/18/85 | TX | Loving | 315403 | 1035434 | 840 | Red Bluff, Tex. 7.5 min (1968) |
| 18 | 7/18/85 | TX | Reeves | | | | |
| DR-1 | 7/18/85 | NM | Eddy | 320124 | 1040315 | 885 | Malaga, New Mex. 15 min (1945) |
| WL-1 | 7/18/85 | NM | Eddy | 321107 | 1040404 | 900 | Malaga, New Mex. 15 min (1945) |
| 21 | 7/18/85 | NM | Eddy | | | | |
| SL-1 | 7/18/85 | NM | Eddy | 321807 | 1040043 | 910 | Carlsbad, New Mex. 15 min (1971) |
| SLC-1 | 7/18/85 | NM | Eddy | 321841 | 1040225 | 900 | Carlsbad, New Mex. 15 min (1971) |
| MLS-1 | 7/18/85 | NM | Chaves | 332012 | 1041954 | 885 | Bottomless Quadrangle, New Mex. 7.5 min (1950) |
| MLN-1 | 7/18/85 | NM | Chaves | 332012 | 1041954 | 885 | Bottomless Quadrangle, New Mex. 7.5 min (1950) |
| DI-1 | 7/18/85 | NM | Chaves | 332007 | 1041954 | 885 | Bottomless Quadrangle, New Mex. 7.5 min (1950) |
| FBS-1 | 7/18/85 | NM | Chaves | 332003 | 1041953 | 885 | Bottomless Quadrangle, New Mex. 7.5 min (1950) |
| FBN-1 | 7/18/85 | NM | Chaves | 332003 | 1041953 | 885 | Bottomless Quadrangle, New Mex. 7.5 min (1950) |
| LL-1 | 7/18/85 | NM | Chaves | 332113 | 1042026 | 1055 | Bottomless Quadrangle, New Mex. 7.5 min (1950) |
| BL-1 | 7/18/85 | NM | Chaves | 332828 | 1042404 | 1060 | Bitter Lake, New Mex. 7.5 min (1962) |
| SH19-1 | 7/18/85 | NM | Chaves | 332905 | 1042438 | 1065 | Bitter Lake, New Mex. 7.5 min (1962) |
| SH21-1 | 7/18/85 | NM | Chaves | 332912 | 1042439 | 1070 | Bitter Lake, New Mex. 7.5 min (1962) |
| SH37-1 | 7/18/85 | NM | Chaves | 332900 | 1042458 | 1070 | Bitter Lake, New Mex. 7.5 min (1962) |
| SH11-1 | 7/18/85 | NM | Chaves | 332920 | 1042504 | 1070 | Bitter Lake, New Mex. 7.5 min (1962) |
| U7-1 | 7/18/85 | NM | Chaves | 332608 | 1042428 | 1060 | Bitter Lake, New Mex. 7.5 min (1962) |
| LW155 | 7/25/85 | NV | Clark | 360514 | 1145910 | 470 | Henderson Quadrangle 15 min (1952) |
| LW048 | 7/25/85 | NV | Clark | 360508 | 1145910 | 470 | Henderson Quadrangle 15 min (1952) |
| LW048 | 7/25/85 | NV | Clark | 360517 | 1145852 | 470 | Henderson Quadrangle 15 min (1952) |
| LVS-1 | 7/25/85 | UT | Washington | 371124 | 1131618 | 940 | Hurricane Quadrangle 15 min (1954) |
| LVS-2 | 7/25/85 | UT | Washington | 371118 | 1131601 | 940 | Hurricane Quadrangle 15 min (1954) |
| LVS-3 | 7/25/85 | UT | Washington | 371118 | 11131608 | 940 | Hurricane Quadrangle 15 min (1954) |
| ZSL-1 | 7/26/85 | NM | Catron | 342708 | 1084609 | 1895 | Zuni Salt Lake, New Mex. 7.5 min (1972) |
| ZSL-2 | 7/26/85 | NM | Catron | 342643 | 1084607 | 1895 | Zuni Salt Lake, New Mex. 7.5 min (1972) |
| SJR-1 | 7/27/85 | NM | Valencia | 350347 | 11074228 | 1895 | McCarty's Quadrangle 7.5 min (1957) |

Table 1. (continued)

| Site No. | Date | State | County | Latitude | Longitude | Elev. | Topographic map |
|---|---|---|---|---|---|---|---|
| LCC-1 | 7/27/85 | AZ | Navejo | 345525 | 1103143 | 1495 | Hibbard, Ariz. 7.5 min (1970) |
| LCC-2 | 7/27/85 | AZ | Navejo | 345525 | 1103143 | 1495 | Hibbard, Ariz. 7.5 min (1970) |
| MP-1 | 7/27/85 | AZ | Navejo | 345808 | 1103835 | 1485 | Clear Creek Reservoir, Ariz. 7.5 min (1970) |
| MW-1 | 7/27/85 | AZ | Yavepai | 343827 | 1114606 | 1075 | Lake Montezuma, Ariz. 7.5 min (1969) |

Table 2. General characteristics of sampling site.

| Site No. | Date | Time | Air | $H_2O$ | % | EC | pH | Evap | Sum | E/S |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 KP-1 | 5.19 | 950 | | 29.0 | 49 | 679 | 8.4 | | 468.8 | |
| 2 TL-1 | 5.19 | 1015 | | 28.0 | 33 | 955 | 8.1 | | 713.9 | |
| 3 DL-1 | 5.19 | 1030 | | 27.9 | 49 | 570 | 8.2 | | 412.7 | |
| 4 IBW-1 | 5.19 | 1100 | | 27.8 | 21 | 722 | 8.4 | | 443.4 | |
| 5 TC-1 | 5.19 | 1115 | | 25.1 | 47 | 460 | 8.1 | | 376.7 | |
| 6 PZ-1 | 5.19 | 1145 | | 28.3 | 40 | 523 | 8.2 | | 411.85 | |
| 7 SR-1 | 5.19 | 1200 | | 29.0 | 19 | 558 | 9.1 | | 365.8 | |
| 8 SRC-1 | 5.30 | 1010 | 23 | 18.0 | 20 | 901 | 7.6 | 573 | 610.2 | 0.939 |
| 9 SRC-2 | 5.30 | 1102 | 24 | 18.3 | 3 | 912 | 6.6 | 614 | 701.3 | 0.876 |
| 10 SRC-3 | 5.30 | 1125 | 24 | 17.8 | 27 | 1454 | 7.5 | 947 | 930.9 | 1.017 |
| 11 SRC-4 | 5.30 | 1505 | 24 | 22.0 | 6 | 41040 | 8.4 | 29528 | 27867.72 | 1.060 |
| 12 SRC-5 | 5.30 | 1520 | 24 | 22.0 | 12 | 29700 | 7.6 | 20204 | 21607.2 | 0.935 |
| 13 SRC-6 | 5.30 | 1540 | | 22.0 | 9 | 45360 | 7.9 | 30523 | 30417.7 | 1.003 |
| 14 SRC-7 | 5.30 | 1541 | | 19.0 | 5 | 1925 | 8.1 | 11037 | 1071.4 | 0.968 |
| 15 SRC-8 | 5.30 | 1601 | | 24.5 | 5 | 29700 | 6.4 | 19848 | 21061.1 | 0.942 |
| 16 SRC-9 | 5.30 | 1611 | 25 | 24.0 | 35 | 52920 | 6.1 | 38672 | 37324.2 | 1.036 |
| 17 SRC-10 | 5.30 | 1620 | 24 | 19.0 | 40 | 1089 | 7.8 | 631 | 589.2 | 1.071 |
| 18 SRC-11 | 5.30 | 1720 | 24 | 20.0 | 12 | 447 | 7.9 | 273 | 376.09 | 0.726 |
| 19 SRC-12 | 5.30 | 1515 | | 19.0 | | 1265 | 7.5 | 673 | 732.8 | 0.918 |
| 20 FC-1 | 6.13 | 1420 | 33 | 25.0 | 14 | 4600 | 7.6 | 374 | 599.58 | 0.624 |
| 21 FC-2 | 6.13 | 1610 | | 22.9 | 61 | 754 | 7 | 448 | 591.84 | 0.757 |
| 22 FC-2A | 6.13 | 1615 | | 22.5 | | 718 | 7.3 | 432 | 606.49 | 0.712 |
| 23 FC-3 | 6.13 | 1645 | | 22.9 | 37 | 1300 | 7 | 6334 | 605.17 | 10.466 |
| 24 FC-4 | 6.13 | 1649 | 35 | 22.0 | 20 | 666 | 7.5 | 385 | 588.5 | 0.654 |
| 25 VR-1 | 6.13 | 1850 | 34 | 28.2 | 27 | 1150 | 6.8 | 693 | 696.6 | 0.995 |
| 26 VR-1A | 6.13 | 1853 | | 40.0 | | 4357 | 6.8 | 3176 | 4205.2 | 0.755 |
| 27 VR-2 | 6.12 | 1855 | | 29.2 | 4 | 4464 | 7.9 | 33119 | 4372.9 | 0.759 |
| 28 BBC-1 | 6.20 | 1635 | | 31.0 | 4 | 1710 | | 579 | 710.2 | 0.815 |
| 29 B-1 | 7.2 | 745 | | 21.7 | 20 | 4691 | 7.5 | 3331 | 3114.3 | 1.070 |
| 30 B-2 | 7.2 | 800 | | 23.5 | 46 | 5810 | 7.7 | 3866 | 3481 | 1.111 |
| 31 B-3 | 7.2 | 810 | 30 | 24.5 | 25 | 3700 | 7.6 | 2705 | 2565.2 | 1.054 |
| 32 B-4 | 7.2 | 840 | 33 | 26.0 | 76 | 3773 | 8.2 | 2570 | 2452.4 | 1.048 |
| 33 HR-1 | 7.2 | 920 | 34 | 28.7 | 10 | 3116 | 8 | 1564 | 1409.9 | 1.109 |
| 34 GD-1 | 7.2 | 1015 | | 28.5 | 10 | 41185 | 9.5 | 2648 | 2603 | 1.017 |
| 35 PC-1 | 7.2 | 1045 | 43 | 28.5 | | 3395 | 8.5 | 2341 | 2106.7 | 1.111 |
| 36 BP-1 | 7.2 | 1215 | 45 | 31.9 | 30 | 6942 | 8.3 | 3449 | 3295.5 | 1.047 |
| 37 WM-1 | 7.2 | 1630 | 44 | 28.0 | | 4465 | 7.9 | 3129 | 3110.5 | 1.006 |
| 38 WM-2 | 7.2 | 1805 | 42 | 28.2 | | 4750 | 8 | 3270 | 3293.4 | 0.993 |
| 39 BL-1 | 7.3 | 1200 | 42 | 28.1 | 30 | 3681 | 7.8 | 2972 | 2709.8 | 1.097 |
| 40 MD-1 | 7.3 | 1220 | | 28.0 | | 2470 | 7.9 | 1725 | 1652.4 | 1.044 |

Table 2. (continued)

| Site No. | Date | Time | Air | $H_2O$ | % | EC | pH | Evap | Sum | E/S |
|---|---|---|---|---|---|---|---|---|---|---|
| 41 PV-1 | 7.3 | 1650 | 42 | 28.9 | | 2418 | 7.9 | 1457 | 2011.2 | 0.724 |
| 42 PV-2 | 7.3 | 1700 | 46 | 34.1 | 10 | 10875 | 8.3 | 6218 | 7417.8 | 0.838 |
| 43 GR-1 | 7.15 | 1106 | | 30.0 | 15 | 6440 | 8.2 | 3724 | 3081.5 | 1.209 |
| 44 GR-2 | 7.15 | 1115 | | 34.0 | 3 | 9890 | 8.1 | 8137 | 6060.4 | 1.343 |
| 45 CC-1 | 7.15 | 1205 | 39 | 32.0 | 10 | 3805 | 9.3 | 2203 | 1756.5 | 1.254 |
| 46 CM-1 | 7.15 | 1720 | 35 | 32.0 | 15 | 8455 | 7.7 | 4216 | 3402.2 | 1.239 |
| 47 WP-1 | 7.16 | 1150 | | 33.0 | 1 | 7830 | 10.2 | | 5806.6 | 0.000 |
| 48 WP-2 | 7.16 | 1212 | 39 | 32.0 | 1 | 9078 | 9.9 | | 5297.7 | 0.000 |
| 49 FH-1 | 7.17 | 1125 | | 23.0 | 25 | 3484 | 7.7 | 1391 | 2379.6 | 0.585 |
| 50 T-1 | 7.17 | 1435 | | 25.1 | | 2310 | 7.2 | | 1503.7 | 0.000 |
| 51 T-2 | 7.17 | 1445 | 39 | 30.0 | | 4370 | 7.8 | 3199 | 2605.5 | 1.228 |
| 52 DC-1 | 7.17 | 1935 | 29 | 20.0 | 13 | 7150 | 9.6 | 6004 | 4322.4 | 1.389 |
| 53 DC-2 | 7.17 | 1950 | | 18.0 | 53 | 7980 | 6.7 | 7473 | 5472.3 | 1.366 |
| 54 DC-3 | 7.17 | 2000 | | 24.9 | 10 | 7000 | 7.4 | 5665 | 4393.2 | 1.289 |
| 55 SC-1 | 7.18 | 730 | | 22.5 | 25 | 4274 | 7.6 | 5542 | 4554.7 | 1.217 |
| 56 14 | 7.18 | 800 | | | | 36652 | 7.6 | 15395 | 26812.9 | 0.574 |
| 57 15 | 7.18 | 834 | | 22.8 | 41 | 3016 | 7.1 | 24568 | 21504.8 | 1.142 |
| 58 RBR-1 | 7.18 | 840 | | 24.0 | 61 | 10404 | 7.5 | 7316 | 6311.9 | 1.159 |
| 59 PR-1 | 7.18 | 900 | 31 | 24.0 | 25 | 10098 | 7.2 | 7305 | 6260 | 1.167 |
| 60 18 | 7.18 | 945 | | 26.1 | 10 | 29400 | 7.7 | 14075 | 18953.2 | 0.743 |
| 61 DR-1 | 7.18 | 1015 | | 26.4 | 13 | 3430 | 7.5 | 2273 | 2947.8 | 0.771 |
| 62 WL-1 | 7.18 | 1040 | | 26.9 | 23 | 5432 | 8.1 | 3339 | 3912 | 0.854 |
| 63 21 | 7.18 | 1115 | | 32.5 | 10 | 86900 | 8.1 | 69040 | 64304.2 | 1.074 |
| 64 SL-1 | 7.18 | 1222 | | 31.0 | 71 | 474240 | 6.8 | 506166 | 345362.9 | 1.466 |
| 65 SLC-1 | 7.18 | 1245 | | 27.9 | 75 | 5510 | 7.6 | 5012 | 3432.1 | 1.460 |
| 66 MLS-1 | 7.18 | 1555 | | 27.0 | 61 | 14550 | 8 | 11973 | 9785 | 1.224 |
| 67 MLN-1 | 7.18 | 1556 | | 29.5 | 20 | 37260 | 8 | 42001 | 27801.5 | 1.511 |
| 68 DI-1 | 7.18 | 1615 | | 16.0 | 15 | 6860 | 7.6 | 3944 | 4973.9 | 0.793 |
| 69 FBS-1 | 7.18 | 1635 | | 29.0 | | 35340 | 8.4 | 32343 | 32164.6 | 1.006 |
| 70 FBN-1 | 7.18 | 1636 | | 27.1 | | 25220 | 8.6 | 29519 | 19606.3 | 1.506 |
| 77 LL-1 | 7.18 | 1705 | | 25.8 | | 33320 | 9.2 | 35122 | 25500.5 | 1.377 |
| 72 BL-1 | 7.18 | 1635 | | 30.0 | | 73236 | 8.8 | 84175 | 53936 | 1.561 |
| 73 SH19-1 | 7.18 | 1845 | 35 | 30.0 | | 73776 | 8.2 | 75514 | 52907.3 | 1.427 |
| 74 SH21-1 | 7.18 | 1902 | | 30.5 | | 82680 | 8.2 | 71994 | 59273.3 | 1.216 |
| 75 SH37-1 | 7.18 | 1935 | | 27.9 | | 19000 | 7.7 | 15624 | 14098.2 | 1.108 |
| 76 SH11-1 | 7.18 | 1937 | | 29.0 | | 41385 | 7.8 | 37105 | 32354.1 | 1.147 |
| 77 U7-1 | 7.18 | 2005 | | 28.0 | | 11400 | 7.5 | 8589 | 6283.8 | 1.367 |
| 78 LW155 | 7.25 | 1125 | 39 | 30.8 | 8 | 12420 | 7.6 | 9024 | 7566.8 | 1.193 |
| 79 LW048 | 7.25 | 1200 | 40 | 28.0 | 25 | 14250 | 7.4 | 10827 | 10098.8 | 1.072 |
| 80 LW-3 | 7.25 | 1215 | | 32.0 | 8 | 2421 | 8.8 | 1758 | 1905.8 | 0.922 |
| 81 LVS-1 | 7.25 | 1830 | | 37.9 | 38 | 121180 | 6.3 | 5247 | 6953.3 | 0.755 |
| 82 LVS-2 | 7.25 | 1930 | | 30.2 | 8 | 11040 | 6.5 | 6531 | 6808.7 | 0.959 |
| 83 LVS-3 | 7.25 | 1941 | 34 | 39.0 | 46 | 10624 | 6.5 | 4409 | 5661.2 | 0.779 |
| 84 ZSL-1 | 7.26 | 1900 | 25 | 26.5 | 15 | 427900 | 7.2 | 345713 | 301822.1 | 1.145 |
| 85 ZSL-2 | 7.26 | 1935 | 24 | 23.0 | 20 | 195800 | 7.9 | 141150 | 128601.5 | 1.098 |
| 86 RSJ-1 | 7.27 | 955 | 28 | 21.0 | 15 | 2052 | 8.2 | 1317 | 784.3 | 1.658 |
| 87 LCC-1 | 7.27 | 1850 | 27 | 23.0 | 23 | 2808 | 7.8 | 2832 | 1568.4 | 1.806 |

Table 2. (continued)

| Site No. | Date | Time | Air | $H_2O$ | % | EC | pH | Evap | Sum | E/S |
|---|---|---|---|---|---|---|---|---|---|---|
| 88 LCC-2 | 7.27 | 1855 | | 23.2 | 8 | 4732 | 8.2 | 2485 | 2750.3 | 0.904 |
| 89 MP-1 | 7.27 | 1935 | 24 | 22.9 | | 1938 | 8.1 | 3157 | 1111.3 | 2.841 |
| 90 MW-1 | 7.27 | 2345 | 23 | 24.0 | 23 | 957 | 6.4 | 694 | 804 | 0.863 |

Air = air temperature, C $H_2O$ = water temperature, C Z = water depth, cm EC = electrical conductivity, uS/cm at 25 C pH = hydrogen ion activity TDS = total dissolved solids, mg/1 Evap = evaporative TDS at 150 C sum = summation TDS from ionic analysis, E/S = ratio (w/w) of Evap to Sum TDS.

Table 3. Ionic composition of the waters sampled for microalgae.

| | meq/l [Cations] | | | | meq/l [Anions] | | | | | Sum | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site No. | Ca | Mg | Na | K | OH | $CO_3$ | $HCO_3$ | $SO_4$ | Cl | Cations | Anions | C/A |
| KP-1 | 1.68 | 1.33 | 3.52 | 0.10 | 0.00 | 0.24 | 1.51 | 1.32 | 4.85 | 6.61 | 7.91 | 0.838 |
| TL-1 | 1.81 | 1.85 | 7.31 | 0.12 | 0.00 | 0.17 | 2.54 | 1.82 | 6.62 | 11.08 | 11.16 | 0.993 |
| DL-1 | 1.25 | 1.42 | 3.64 | 0.13 | 0.00 | 0.16 | 1.53 | 1.32 | 3.39 | 6.43 | 6.40 | 1.005 |
| IBW-1 | 1.73 | 2.07 | 3.72 | 0.10 | 0.00 | 0.36 | 0.98 | 1.32 | 4.52 | 7.63 | 7.17 | 1.064 |
| TC-1 | 1.80 | 1.09 | 2.57 | 0.13 | 0.00 | 0.22 | 1.90 | 0.97 | 2.67 | 5.59 | 5.75 | 0.972 |
| PZ-1 | 1.71 | 1.28 | 3.18 | 0.05 | 0.00 | 0.24 | 2.04 | 1.09 | 2.91 | 6.22 | 6.27 | 0.991 |
| SR-1 | 1.12 | 1.17 | 3.41 | 0.06 | 0.00 | 0.62 | 0.66 | 1.11 | 3.85 | 6.75 | 6.23 | 0.923 |
| SRC-1 | 1.66 | 0.84 | 6.79 | 0.16 | 0.00 | 0.07 | 1.58 | 0.79 | 7.57 | 9.44 | 10.01 | 0.943 |
| SRC-2 | 4.04 | 3.95 | 2.00 | 0.11 | 0.00 | 0.00 | 5.09 | 2.73 | 2.27 | 10.10 | 10.09 | 1.001 |
| SRC-3 | 4.84 | 3.13 | 4.83 | 0.14 | 0.00 | 0.13 | 3.05 | 4.60 | 7.57 | 12.94 | 15.35 | 0.843 |
| SRC-4 | 6.99 | 20.16 | 404.99 | 3.22 | 0.00 | 0.22 | 11.21 | 20.30 | 462.10 | 435.35 | 493.84 | 0.882 |
| SRC-5 | 9.68 | 13.66 | 344.09 | 3.53 | 0.00 | 0.00 | 19.58 | 15.12 | 318.16 | 370.95 | 352.86 | 1.051 |
| SRC-6 | 19.31 | 31.27 | 430.65 | 4.09 | 0.00 | 0.15 | 13.57 | 21.54 | 499.97 | 485.32 | 535.24 | 0.907 |
| SRC-7 | 1.81 | 1.29 | 13.88 | 0.16 | 0.00 | 0.00 | 2.34 | 0.86 | 14.39 | 17.14 | 17.59 | 0.974 |
| SRC-8 | 16.32 | 2.00 | 311.03 | 2.61 | 0.00 | 0.00 | 29.47 | 16.41 | 303.01 | 331.95 | 348.90 | 0.951 |
| SRC-9 | 18.31 | 18.43 | 528.53 | 5.29 | 0.00 | 0.00 | 38.47 | 25.10 | 590.88 | 570.56 | 652.44 | 0.875 |
| SRC-10 | 1.45 | 0.72 | 7.31 | 0.13 | 0.00 | 0.00 | 1.56 | 0.42 | 7.43 | 9.61 | 9.40 | 1.022 |
| SRC-11 | 2.45 | 2.06 | 0.42 | 0.05 | 0.00 | 0.16 | 3.65 | 0.97 | 0.45 | 4.97 | 5.24 | 0.950 |
| SRC-12 | 1.81 | 0.91 | 9.31 | 0.13 | 0.00 | 0.00 | 1.76 | 0.56 | 9.37 | 12.15 | 11.69 | 1.039 |
| FC-1 | 4.19 | 3.04 | 0.57 | 0.03 | 0.00 | 0.08 | 7.00 | 0.52 | 0.28 | 7.83 | 7.88 | 0.994 |
| FC-2 | 3.69 | 2.88 | 0.59 | 0.03 | 0.00 | 0.00 | 7.10 | 0.55 | 0.25 | 7.19 | 7.89 | 0.912 |
| FC-2A | 4.04 | 2.88 | 0.44 | 0.03 | 0.00 | 0.00 | 7.24 | 0.60 | 0.25 | 7.38 | 8.09 | 0.913 |
| FC-3 | 4.29 | 2.88 | 0.45 | 0.03 | 0.00 | 0.00 | 7.17 | 0.54 | 0.27 | 7.66 | 7.97 | 0.960 |
| FC-4 | 4.74 | 3.54 | 0.48 | 0.04 | 0.00 | 0.17 | 6.511 | 0.57 | 0.24 | 8.80 | 7.48 | 1.176 |
| VR-1 | 2.73 | 3.54 | 4.32 | 0.15 | 0.00 | 0.00 | 5.28 | 2.02 | 2.10 | 10.75 | 9.40 | 1.143 |
| VR-1A | 17.22 | 4.44 | 35.93 | 1.02 | 0.00 | 0.00 | 28.29 | 13.30 | 16.23 | 58.61 | 57.82 | 1.014 |
| VR-2 | 4.34 | 5.68 | 48.72 | 0.95 | 0.00 | 0.72 | 27.18 | 15.98 | 17.28 | 59.69 | 61.15 | 0.976 |
| BBC-1 | 5.34 | 2.06 | 2.50 | 0.02 | 0.00 | 0.15 | 4.05 | 2.23 | 4.54 | 9.91 | 10.98 | 0.903 |
| B-1 | 8.98 | 7.16 | 26.84 | 1.79 | 0.00 | 0.00 | 5.27 | 14.72 | 311.93 | 44.77 | 51.92 | 0.862 |
| B-2 | 9.88 | 7.90 | 32.67 | 1.20 | 0.00 | 0.00 | 5.40 | 17.22 | 34.77 | 51.65 | 57.39 | 0.900 |
| B-3 | 8.03 | 6.58 | 21.84 | 2.17 | 0.00 | 0.00 | 2.96 | 14.05 | 24.88 | 38.83 | 41.89 | 0.922 |
| B-4 | 7.58 | 6.01 | 21.53 | 2.35 | 0.00 | 0.00 | 3.80 | 11.39 | 24.31 | 37.48 | 39.49 | 0.949 |
| HR-1 | 5.44 | 3.62 | 11.79 | 2.35 | 0.00 | 0.00 | 3.22 | 3.42 | 15.04 | 23.20 | 21.68 | 1.070 |
| GD-1 | 6.69 | 5.92 | 25.53 | 2.99 | 0.00 | 0.00 | 1.58 | 113.07 | 27.34 | 41.14 | 41.99 | 0.980 |
| PC-1 | 8.68 | 4.11 | 18.79 | 2.15 | 0.00 | 0.00 | 2.04 | 7.37 | 25.06 | 33.74 | 34.47 | 0.979 |
| BP-1 | 8.33 | 6.58 | 31.36 | 2.91 | 0.00 | 0.00 | 2.31 | 14.94 | 38.22 | 49.19 | 55.47 | 0.887 |
| WM-1 | 8.23 | 5.68 | 27.80 | 1.87 | 0.00 | 0.00 | 5.53 | 19.70 | 24.85 | 43.57 | 50.08 | 0.870 |
| WM-2 | 9.13 | 6.17 | 28.58 | 2.05 | 0.00 | 0.11 | 5.71 | 20.69 | 26.89 | 5.93 | 53.39 | 0.860 |
| GL-1 | 7.63 | 6.83 | 21.66 | 5.80 | 0.00 | 0.00 | 2.22 | 17.9 | 21.81 | 41.93 | 41.52 | 1.010 |

Table 3. (continued)

| Site No. | Ca | Mg | Na | K | OH | $CO_3$ | $HCO_3$ | $SO_4$ | Cl | Cations | Anions | C/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MD-1 | 7.09 | 4.03 | 11.70 | 1.30 | 0.00 | 0.00 | 4.24 | 11.33 | 9.56 | 24.12 | 25.12 | 0.960 |
| PV-1 | 6.69 | 6.01 | 15.36 | 1.25 | 0.00 | 0.00 | 4.87 | 12.32 | 14.54 | 29.20 | 31.73 | 0.920 |
| PV-2 | 7.39 | 6.01 | 91.79 | 3.30 | 0.00 | 0.00 | 8.99 | 38.43 | 72.31 | 108.48 | 119.73 | 0.906 |
| GR-1 | 7.29 | 4.38 | 38.45 | 0.40 | 0.00 | 0.24 | 6.82 | 4.97 | 37.27 | 50.50 | 49.29 | 1.025 |
| GR-2 | 11.88 | 10.78 | 86.13 | 0.92 | 0.00 | 0.00 | 6.80 | 7.51 | 81.81 | 109.71 | 96.12 | 1.141 |
| CC-1 | 1.94 | 2.96 | 26.19 | 0.28 | 0.00 | 0.63 | 1.86 | 0.25 | 26.07 | 31.37 | 28.811 | 1.089 |
| CM-1 | 12.43 | 1.44 | 38.28 | 1.61 | 0.00 | 0.00 | 2.46 | 0.93 | 56.36 | 53.76 | 59.75 | 0.900 |
| WP-1 | 2.00 | 8.89 | 125.28 | 1.48 | 0.00 | 0.00 | 0.00 | 35.19 | 29.07 | 137.65 | 64.26 | 2.142 |
| WP-2 | 2.40 | 5.27 | 107.88 | 0.87 | 0.00 | 0.00 | 0.00 | 19.86 | 48.46 | 116.41 | 68.32 | 1.704 |
| FH-1 | 7.78 | 1.97 | 7.90 | 0.87 | 0.00 | 0.00 | 27.39 | 1.36 | 6.98 | 18.52 | 35.73 | 0.518 |
| T-1 | 6.29 | 2.03 | 12.79 | 0.23 | 0.00 | 0.00 | 4.16 | 8.08 | 11.51 | 21.34 | 23.75 | 0.899 |
| T-2 | 11.23 | 4.77 | 24.80 | 0.31 | 0.00 | 0.48 | 6.52 | 10.43 | 23.33 | 41.11 | 40.76 | 1.009 |
| DC-1 | 20.06 | 22.63 | 24.14 | 0.21 | 4.94 | 2.73 | 0.00 | 40.13 | 27.87 | 67.04 | 75.67 | 0.888 |
| DC-2 | 31.94 | 22.22 | 24.14 | 0.18 | 0.00 | 0.34 | 3.13 | 43.98 | 47.56 | 78.48 | 95.02 | 0.826 |
| DC-3 | 24.10 | 16.38 | 26.06 | 1.07 | 0.00 | 0.48 | 4.32 | 32.19 | 35.15 | 67.61 | 72.14 | 0.937 |
| SC-1 | 43.91 | 12.01 | 8.57 | 0.64 | 0.00 | 0.00 | 0.96 | 63.82 | 5.16 | 65.14 | 69.94 | 0.931 |
| 14 | 56.89 | 41.97 | 338.21 | 1.53 | 0.00 | 0.00 | 1.54 | 70.87 | 390.14 | 438.60 | 462.55 | 0.948 |
| 15 | 57.39 | 28.80 | 253.61 | 1.10 | 0.00 | 0.00 | 2.16 | 80.43 | 285.96 | 340.89 | 368.55 | 0.925 |
| PBR-1 | 22.50 | 14.89 | 54.38 | 1.20 | 0.00 | 0.00 | 1.94 | 32.43 | 76.36 | 92.98 | 110.73 | 0.840 |
| PR-1 | 22.41 | 13.66 | 56.99 | 1.10 | 0.00 | 0.00 | 1.94 | 33.20 | 72.75 | 94.15 | 107.89 | 0.873 |
| 18 | 50.40 | 27.98 | 207.50 | 1.20 | 0.00 | 0.00 | 1.28 | 49.35 | 291.66 | 287.07 | 342.27 | 0.839 |
| DR-1 | 33.98 | 6.17 | 6.00 | 0.17 | 0.00 | 0.00 | 2.00 | 36.27 | 5.16 | 45.33 | 43.43 | 1.067 |
| WL-1 | 28.34 | 10.78 | 16.70 | 0.24 | 0.00 | 0.00 | 1.20 | 41.09 | 21.81 | 56.06 | 64.10 | 0.875 |
| 21 | 59.88 | 72.42 | 965.70 | 25.31 | 0.00 | 0.20 | 1.50 | 83.86 | 984.78 | 1123.31 | 1070.34 | 1.049 |
| SL-1 | 1.07 | 2822.55 | 2731.80 | 45.26 | 0.00 | 0.00 | 2.50 | 1151.39 | 5388.59 | 5600.67 | 6542.48 | 0.856 |
| SLC-1 | 20.31 | 14.24 | 22.62 | 0.18 | 0.00 | 0.00 | 1.52 | 25.01 | 29.08 | 57.34 | 55.62 | 1.031 |
| MLS-1 | 44.41 | 28.33 | 95.27 | 0.40 | 0.00 | 0.00 | 1.82 | 46.44 | 113.63 | 166.41 | 161.89 | 1.028 |
| MLN-1 | 52.40 | 88.87 | 296.23 | 1.25 | 0.00 | 0.71 | 1.76 | 106.65 | 382.56 | 438.76 | 491.68 | 0.892 |
| DI-1 | 44.91 | 13.99 | 23.84 | 0.22 | 0.00 | 0.00 | 2.00 | 43.66 | 31.82 | 82.96 | 77.48 | 1.071 |
| FBS-1 | 41.92 | 207.37 | 257.96 | 2.20 | 0.00 | 1.70 | 2.30 | 213.27 | 348.48 | 509.44 | 565.75 | 0.900 |
| FBN-1 | 42.91 | 122.61 | 163.56 | 1.18 | 0.00 | 1.39 | 0.92 | 135.42 | 193.18 | 330.26 | 330.91 | 0.998 |
| LL-1 | 55.39 | 106.98 | 244.04 | 1.74 | 0.08 | 1.58 | 0.00 | 149.05 | 287.85 | 408.14 | 438.57 | 0.931 |
| BL-1 | 75.85 | 153.88 | 661.20 | 2.07 | 0.00 | 1.07 | 0.60 | 173.70 | 757.52 | 893.00 | 932.89 | 0.957 |
| SH19-1 | 60.88 | 126.73 | 681.20 | 1.84 | 0.00 | 0.55 | 2.20 | 169.46 | 749.96 | 850.65 | 922.18 | 0.922 |
| SH21-1 | 64.87 | 134.13 | 691.65 | 1.92 | 0.00 | 0.83 | 1.86 | 194.64 | 871.15 | 892.57 | 1068.48 | 0.835 |
| SH37-1 | 56.39 | 32.92 | 143.11 | 0.40 | 0.00 | 0.00 | 1.70 | 54.65 | 184.32 | 232.82 | 240.67 | 0.967 |
| SH11-1 | 57.39 | 86.40 | 372.26 | 0.95 | 0.00 | 0.24 | 2.08 | 121.76 | 439.37 | 5117.10 | 563.44 | 0.918 |
| U7-1 | 28.20 | 13.17 | 73.95 | 0.23 | 0.00 | 0.00 | 2.08 | 15.72 | 84.86 | 113.54 | 102.65 | 1.106 |
| LW155 | 40.92 | 29.62 | 68.30 | 1.69 | 0.00 | 0.00 | 3.68 | 22.12 | 97.72 | 140.53 | 123.52 | 1.138 |
| LW048 | 47.41 | 37.03 | 83.52 | 2.12 | 0.00 | 0.00 | 4.72 | 40.60 | 125.76 | 170.08 | 171.08 | 0.994 |
| LW-3 | 10.68 | 6.58 | 8.22 | 0.61 | 0.00 | 0.32 | 0.94 | 22.14 | 7.57 | 26.10 | 30.97 | 0.843 |
| LVS-1 | 38.42 | 10.29 | 69.60 | 0.38 | 0.00 | 0.00 | 17.80 | 12.88 | 77.27 | 118.9 | 107.94 | 1.100 |
| LVS-2 | 38.93 | 9.63 | 60.90 | 3.38 | 0.00 | 0.00 | 16.50 | 21.30 | 67.42 | 110.83 | 105.22 | 1.053 |

Table 3. (continued)

| Site No. | Ca | Mg | Na | K | OH | $CO_3$ | $HCO_3$ | $SO_4$ | Cl | Cations | Anions | C/A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LVS-3 | 28.49 | 7.98 | 47.85 | 2.78 | 0.00 | 0.00 | 18.00 | 11.52 | 63.64 | 87.09 | 91.16 | 0.955 |
| ZSL-1 | 18.01 | 255.10 | 4283.00 | 19.69 | 0.00 | 0.00 | 5.34 | 492.28 | 4954.27 | 4555.80 | 5451.88 | 0.836 |
| ZSL-2 | 29.14 | 116.03 | 1831.35 | 8.18 | 0.00 | 1.03 | 3.18 | 193.87 | 2105.93 | 1984.70 | 2303.99 | 0.861 |
| RSJ-1 | 3.69 | 2.55 | 4.22 | 0.13 | 0.00 | 0.44 | 3.78 | 4.94 | 3.02 | 10.60 | 12.16 | 0.871 |
| LCC-1 | 2.85 | 2.47 | 17.40 | 0.16 | 0.00 | 0.00 | 3.28 | 1.44 | 22.74 | 22.87 | 27.46 | 0.833 |
| LCC-2 | 3.99 | 4.03 | 32.67 | 0.19 | 0.00 | 0.40 | 3.50 | 5.03 | 39.38 | 40.88 | 48.30 | 0.846 |
| MP-1 | 2.23 | 1.79 | 12.70 | 0.05 | 0.00 | 0.16 | 2.90 | 0.67 | 15.15 | 16.78 | 18.87 | 0.889 |
| MW-1 | 5.74 | 2.80 | 2.04 | 0.15 | 0.00 | 0.00 | 9.16 | 0.01 | 1.21 | 10.73 | 10.38 | 1.033 |

C/A = ratio (meq/meq) of cations to anions

Table 4. Summary of types of samples collected during 1985.

| Location | Date | Neustonic | Planktonic | Benthic | Misc |
|---|---|---|---|---|---|
| Phoexix (Metropolitan area) | 5/19 | 7 | 7 | - | - |
| Salt River | 5/30 | 2 | 12 | - | - |
| Fossil/Verde | 6/13 | 2 | 6[a] | - | - |
| Yuma | 7/02 to 7/03 | 3 | 14 | 4 | 3 |
| AZ-NM-TX | 7/15 to 7/18 | 10 | 35 | 9 | 2 |
| AZ-NV-UT-NM | 7/25 to 7/27 | 4 | 13 | 3 | 2 |
| | | 28 | 87[b] | 16 | 11 |

Total Samples Collected by ASU = 142

Planktonic samples collected by associates = 9

151 GRAND TOTAL

[a] samples from FC-2A and VR-1A for water chemistry only

[b] One sample collected from Big Bug Creek (BBC-1) on 20 July

Table 5. Genera, isolate number and collection site for algae isolated during 1985.*

| Genera | Isolate No. | Site No. |
|---|---|---|
| Dunaliella | ASU0001 | SRC-6 |
| Dunaliella | ASU0002 | SRC-6 |
| Dunaliella | ASU0005 | SRC-6 |
| Dunaliella | ASU0006 | SRC-9 |
| Dunaliella | ASU0010 | SRC-6 |
| Dunaliella | ASU0011 | SRC-6 |
| Dunaliella | ASU0012 | SRC-6 |
| Dunaliella | ASU0013 | SRC-6 |
| Dunaliella | ASU0015 | SRC-8 |
| Dunaliella | ASU0017 | SRC-8 |
| Oscillatoria | ASU0023 | F8S-1 |
| Dunaliella | ASU0025 | SRC-D |
| Cymbella | ASU0030 | DC-2 |
| Borodinella | ASU0031 | DC-3 |
| Cymbella | ASU0032 | MLS-1 |
| Dunaliella | ASU0034 | SC-1 |
| Dunaliella | ASU0035 | SC-1 |
| Dunaliella | ASU0038 | SC-2 |
| Cymbella | ASU0039 | RBR-1 |
| Cymbella | ASU0040 | SRC-B |
| Cymbella | ASU0041 | SRC-8 |
| Cymbella | ASU0042 | SRC-2 |
| Cymbella | ASU0043 | SRC-2 |
| Dunaliella | ASU0044 | SC-1 |
| Ctenocladus | ASU0045 | SRC-12 |
| Cymbella | ASU0046 | SRC-2 |
| Synedra | ASU0047 | SRC-4 |
| Eremosphaera | ASU0048 | SRC-B |
| Oscillatoria | ASU0050 | SRC-C |
| Oocystis | ASU0054 | SRC-12 |
| Oscillatoria | ASU0055 | DI-1 |
| Nannochloris | ASU0060 | SRC-3 |
| Asterococcus | ASU0061 | VR-1 |
| Chlorosarcina | ASU0062 | SRC-3 |
| Borodinella | ASU0064 | SRC-2 |
| Chlorosarcina | ASU0065 | SRC-2 |
| Osillatoria | ASU0068 | MW-1 |
| Chroococcus | ASU0071 | LVS-1 |
| Chroococcus | ASU0073 | LVS-1 |
| Chroococcus | ASU0074 | LVS-1 |
| Chroococcus | ASU0075 | LVS-1 |
| Cymbella | ASU0077 | LVS-2 |
| Oscillatoria | ASU0078 | MW-1 |
| Oscillatoria | ASU0079 | MP-1 |
| Chroococcus | ASU0080 | LCC-2 |
| Chroococcus | ASU0081 | LCC-2 |

Table 5. (continued)

| Genera | Isolate No. | Site No. |
|---|---|---|
| Synedra | ASU0082 | LCC-1 |
| Oscillatoria | ASU0084 | MP-1 |
| Chlorococcum | ASU0093 | LCC-1 |
| Trebouxia | ASU0132 | SRC-1 |
| Borodinella | ASU0134 | SRC-3 |
| Chlorococcum | ASU0139 | LCC-1 |
| Chlorococcum | ASU0143 | LCC-1 |

* Identification of algal genera is tentative and subject to revision.

Table 6. Oil Red O staining results for nutrient-sufficient cultures of selected algal genera.

| Genera | Isolate No. | Reaction |
|---|---|---|
| Dunaliella | ASU0038 | 0 |
| Eremosphaera | ASU0048 | 0 |
| Nannochloris | AsU0060 | 0 |
| Asterococcus | ASU0061 | 0 |
| Borodinella | ASU0064 | + |
| Chlorosarcina | ASU0065 | 0 |
| Chroococcus | ASU0071 | + |
| Trebouxia | ASU0132 | ++ |
| Borodinella | ASU0134 | + |
| Chlorococcum | ASU0139 | 0 |
| Chlorococcum | ASU0143 | 0 |

Table 7. Summary of growth rates for algal isolates.

| Isolate No. | Genus | Date | Med | doub/d | OD max | $r^2$ |
|---|---|---|---|---|---|---|
| - | Carteria | 9.29 | I(10) | 0.317 | 0.032 | 0.862 |
| | | | II(10) | 0.319 | 0.026 | 0.841 |
| | | | I(40) | 0.276 | 0.019 | 0.905 |
| | | | II(40) | | 0.004 | |
| | | | I(70) | | 0.004 | |
| | | | II(70) | | 0.003 | |
| | | | SW | | 0.002 | |
| - | Platymonas | 9.29 | I(10) | 0.510 | 0.120 | 0.916 |
| | | | II(10) | 0.826 | 0.153 | 0.970 |
| | | | I(40) | 0.231 | 0.080 | 0.920 |
| | | | II(40) | 0.901 | 0.150 | 0.978 |
| | | | I(70) | 0.484 | 0.066 | 0.923 |
| | | | II(70) | 0.336 | 0.022 | 0.715 |
| | | | SW | 0.322 | 0.129 | 0.986 |
| - | Pleurochloris | 9.29 | I(10) | 0.435 | 0.065 | 0.972 |
| | | | II(10) | 0.487 | 0.113 | 0.947 |
| | | | I(40) | 0.308 | 0.043 | 0.977 |
| | | | II(40) | | 0.004 | |
| | | | I(70) | 0.717 | 0.069 | 0.977 |
| | | | II(70) | | 0.004 | |
| | | | SW | | 0.010 | |
| 2 | Dunaliella | 9.29 | I(10) | 0.377 | 0.129 | 0.871 |
| | | | II(10) | 0.859 | 0.141 | 0.969 |
| | | | I(40) | 0.259 | 0.227 | 0.863 |
| | | | II(40) | 0.444 | 0.026 | 0.981 |
| | | | I(70) | 0.539 | 0.265 | 0.804 |
| | | | II(70) | | 0.003 | |
| | | | SW | 0.347 | 0.163 | 0.881 |
| 11 | Dunaliella | 9.29 | I(10) | 0.843 | 0.012 | 0.855 |
| | | | II(10) | | 0.003 | |
| | | | I(40) | 0.608 | 0.025 | 0.911 |
| | | | II(40) | | 0.002 | |
| | | | I(70) | 0.471 | 0.021 | 0.942 |
| | | | II(70) | | 0.000 | |
| | | | SW | 0.285 | 0.018 | 0.628 |
| 12 | Dunaliella | 9.29 | I(10) | 0.375 | 0.105 | 0.776 |
| | | | II(10) | 0.431 | 0.139 | 0.667 |
| | | | I(40) | 0.335 | 0.280 | 0.897 |
| | | | II(40) | 0.553 | 0.093 | 0.975 |
| | | | I(70) | 0.387 | 0.229 | 0.884 |
| | | | II(70) | | 0.001 | |
| | | | SW | 0.484 | 0.248 | 0.761 |

Table 7. (continued)

| Isolate No. | Genus | Date | Med | doub/d | OD max | $r^2$ |
|---|---|---|---|---|---|---|
| 2 | Dunaliella | 11.22 | I(10) | 0.650 | 0.205 | 0.910 |
| | | | II(10) | 0.754 | 0.075 | 0.879 |
| | | | I(40) | 0.605 | 0.242 | 0.886 |
| | | | II(40) | | 0.003 | |
| | | | I(70) | 0.532 | 0.239 | 0.838 |
| | | | II(70) | | 0.002 | |
| | | | SW | 0.469 | 0.246 | 0.808 |
| 38 | Dunaliella | 11.22 | I(10) | 0.991 | 0.100 | 0.876 |
| | | | II(10) | 0.542 | 0.112 | 0.965 |
| | | | I(40) | 0.767 | 0.275 | 0.845 |
| | | | II(40) | | 0.004 | |
| | | | I(70) | 1.101 | 0.125 | 0.979 |
| | | | II(70) | | 0.004 | |
| | | | SW | 2.576 | 0.226 | 0.843 |
| 48 | Eremosphaera | 11.22 | I(10) | 1.300 | 0.237 | 0.950 |
| | | | II(10) | 3.263 | 0.198 | 0.936 |
| | | | I(40) | 0.839 | 0.196 | 0.842 |
| | | | II(40) | | 0.004 | |
| | | | I(70) | | 0.006 | |
| | | | II(70) | | 0.005 | |
| | | | SW | | 0.015 | |
| 60 | Nannochloris | 11.22 | I(10) | 0.528 | 0.153 | 0.987 |
| | | | II(10) | 1.159 | 0.123 | 0.988 |
| | | | I(40) | | 0.005 | |
| | | | II(40) | | 0.007 | |
| | | | I(70) | | 0.002 | |
| | | | II(70) | | 0.003 | |
| | | | SW | | 0.004 | |
| 61 | Asterococcus | 11.22 | I(10) | 1.521 | 0.166 | 0.986 |
| | | | II(10) | 1.145 | 0.173 | 0.953 |
| | | | I(40) | 0.967 | 0.097 | 0.935 |
| | | | II(40) | | 0.002 | |
| | | | I(70) | | 0.002 | |
| | | | II(70) | | 0.006 | |
| | | | SW | 1.313 | 0.022 | 0.866 |
| 75 | Chroococcus | 11.22 | I(10) | 0.836 | 0.220 | 0.919 |
| | | | II(10) | 1.713 | 0.250 | 0.956 |
| | | | I(40) | 1.050 | 0.335 | 0.892 |
| | | | II(40) | 1.731 | 0.235 | 0.977 |
| | | | I(70) | 1.163 | 0.395 | 0.953 |
| | | | II(70) | | 0.007 | |
| | | | SW | 2.313 | 0.394 | 0.775 |

Table 7. (continued)

| Isolate No. | Genus | Date | Med | doub/d | OD max | $r^2$ |
|---|---|---|---|---|---|---|
| 93 | Chlorococcum | 11.22 | I(10) | 1.153 | 0.201 | 0.908 |
| | | | II(10) | 0.988 | 0.090 | 0.976 |
| | | | I(40) | 1.723 | 0.015 | 0.995 |
| | | | II(40) | | 0.012 | |
| | | | I(70) | | 0.007 | |
| | | | II(70) | | 0.006 | |
| | | | SW | 1.479 | 0.026 | 0.807 |
| 132 | Trebouxia | 11.22 | I(10) | 1.970 | 0.071 | 0.995 |
| | | | II(10) | 2.038 | 0.154 | 0.986 |
| | | | I(40) | 0414 | 0.064 | 0.978 |
| | | | II(40) | 1.260 | 0.012 | 0.940 |
| | | | I(70) | | 0.004 | |
| | | | II(70) | | 0.001 | |
| | | | SW | 2.094 | 0.029 | 0.746 |
| 139 | Chlorococcum | 12.12 | I(10) | 0.518 | 0.162 | 0.887 |
| | | | II(10) | | 0.004 | |
| | | | I(40) | | 0.005 | |
| | | | II(40) | | 0.001 | |
| | | | I(70) | | 0.002 | |
| | | | II(70) | | 0.003 | |
| | | | SW | | 0.005 | |
| 143 | Chlorococcum | 12.12 | I(10) | 0.923 | 0.093 | 0.939 |
| | | | II(10) | | 0.006 | |
| | | | I(40) | | 0.010 | |
| | | | II(40) | | 0.005 | |
| | | | I(70) | | 0.003 | |
| | | | II(70) | | 0.001 | |
| | | | SW | | 0.006 | |
| 134 | Borodinella | 12.12 | I(10) | 0.616 | 0.052 | 0.985 |
| | | | II(10) | 0.685 | 0.058 | 0.945 |
| | | | I(40) | | 0.005 | |
| | | | II(40) | | 0.003 | |
| | | | I(70) | | 0.004 | |
| | | | SW | | 0.007 | |
| 65 | Chlorosarcina | 12.12 | I(10) | | 0.005 | |
| | | | II(10) | | 0.004 | |
| | | | I(40) | | 0.002 | |
| | | | II(40) | | 0.002 | |
| | | | I(70) | | 0.002 | |
| | | | II(70) | | 0.004 | |
| | | | SW | | 0.005 | |

Table 7. (continued)

| Isolate No. | Genus | Date | Med | doub/d | OD max | $r^2$ |
|---|---|---|---|---|---|---|
| 64 ? | | 12.12 | I(10) | 0.578 | 0.030 | 0.933 |
| | | | II(10) | | 0.004 | |
| | | | I(40) | | 0.007 | |
| | | | II(40) | | 0.005 | |
| | | | I(70) | | 0.004 | |
| | | | II(70) | | 0.000 | |
| | | | SW | | 0.006 | |
| 47 ? | | 12.12 | I(10) | | 0.011 | |
| | | | II(10) | 0.374 | 0.014 | 0.791 |
| | | | I(40) | | 0.011 | |
| | | | II(40) | | 0.003 | |
| | | | I(70) | | 0.002 | |
| | | | II(70) | | 0.000 | |
| | | | SW | | 0.006 | |
| 71 | Chroococcus | 12.12 | I(10) | 0.985 | 0.103 | 0.946 |
| | | | II(10) | 0.834 | 0.113 | 0.919 |
| | | | I(40) | 0.851 | 0.086 | 0.724 |
| | | | II(40) | 1.289 | 0.321 | 0.982 |
| | | | I(70) | 1.439 | 0.298 | 0.981 |
| | | | II(70) | 0.501 | 0.026 | 0.717 |
| | | | SW | 0.542 | 0.145 | 0.934 |
| 50 | Osillatoria | 12.12 | I(10) | | 0.019 | |
| | | | II(10) | | 0.006 | |
| | | | I(40) | | 0.000 | |
| | | | II(40) | 0.600 | 0.056 | 0.967 |
| | | | I(70) | | 0.019 | |
| | | | II(70) | | 0.000 | |

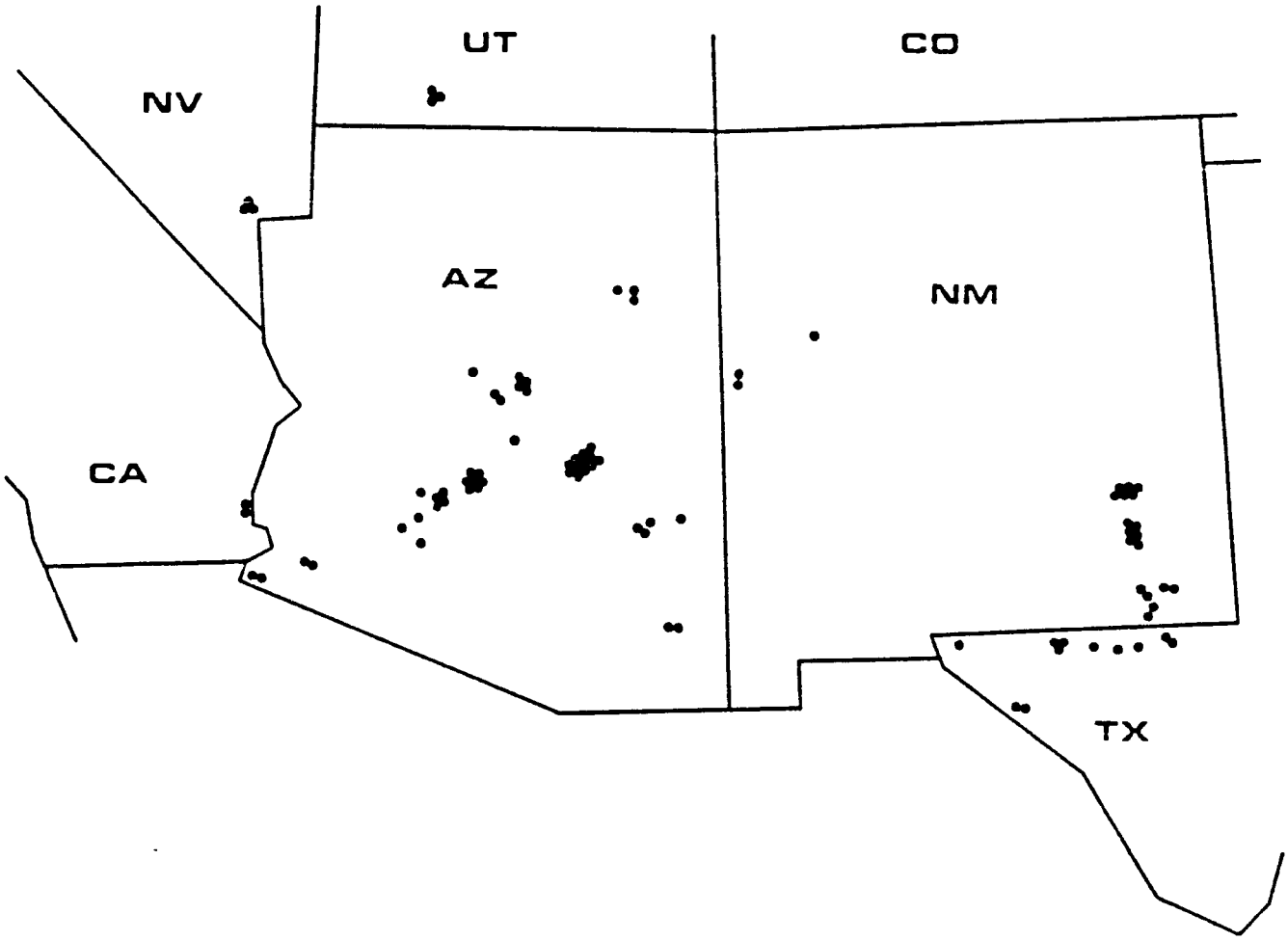



Figure 1. Sampling locations for microalgae in the desert southwest.

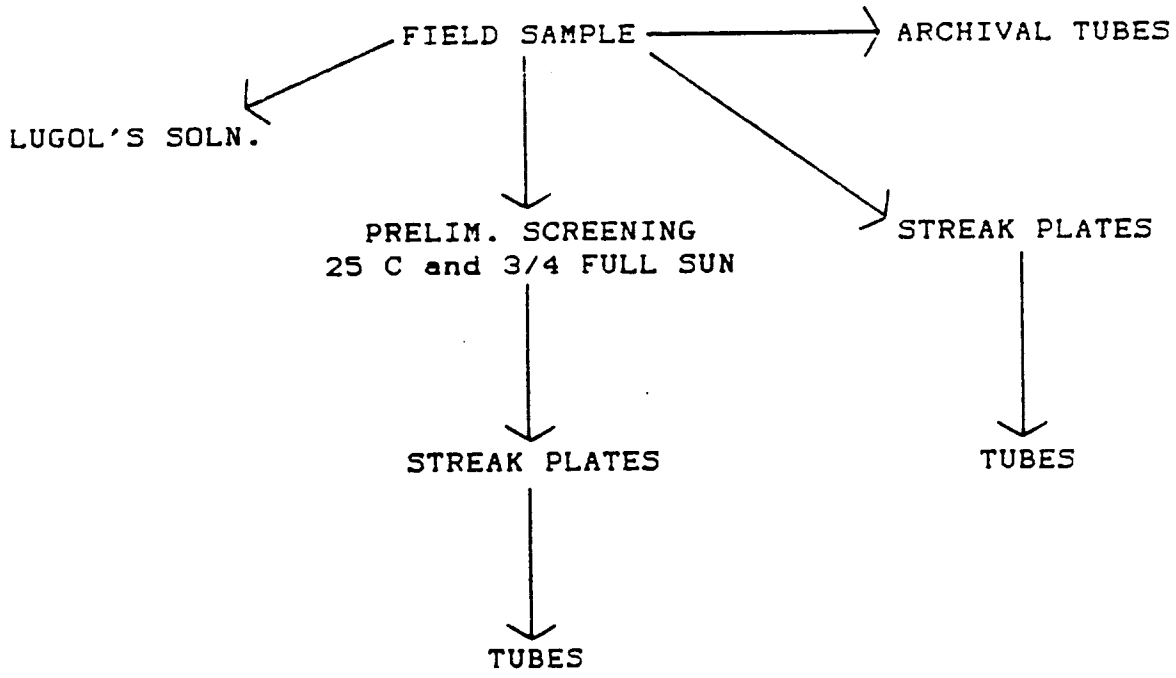



Figure 2. Summary of protocol used to screen, isolate and maintain record of microalgae collected.

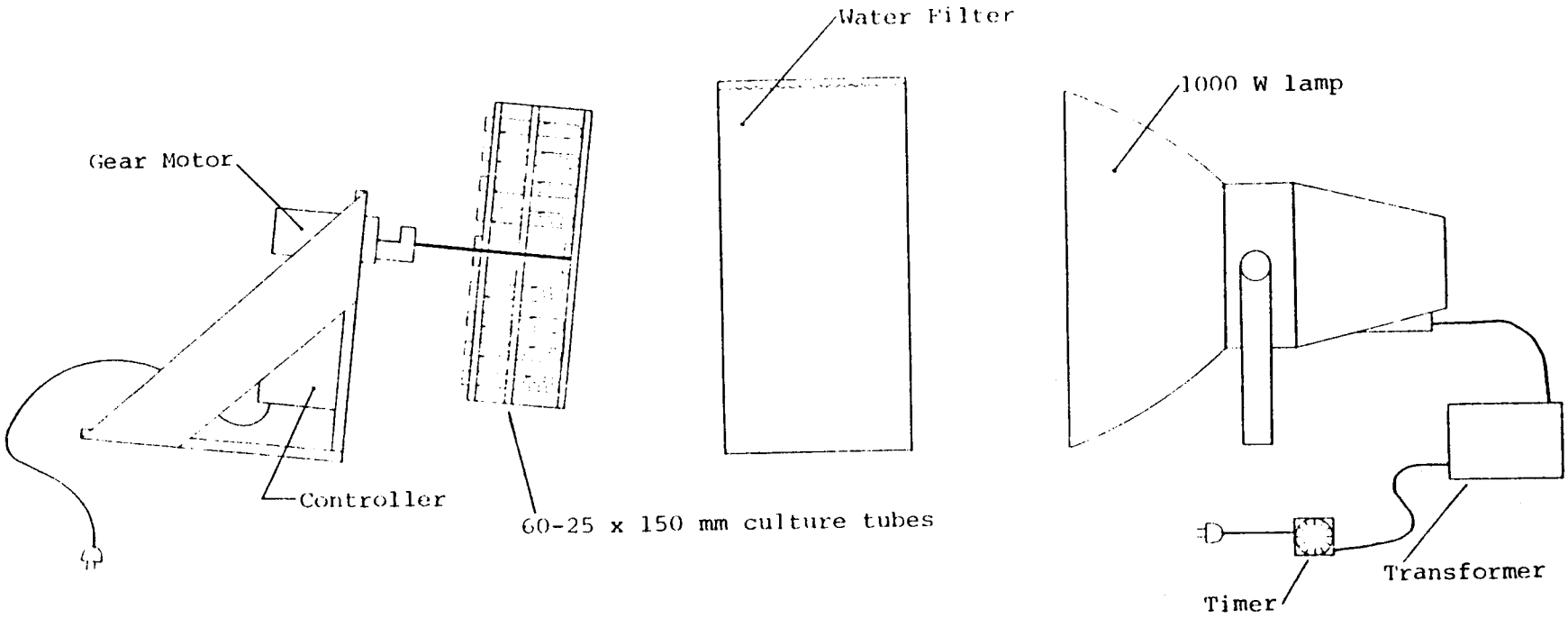



**Figure 3.** Schematic diagram of rotary culture device (RCD) used to screen field samples and for growth characterization. Light source was a Sylvania model M1000/BD lamp with a Westinghouse model MH1000 BU/4 1000 watt bulb. Culture tubes were rotated at ca. 15 rpm.

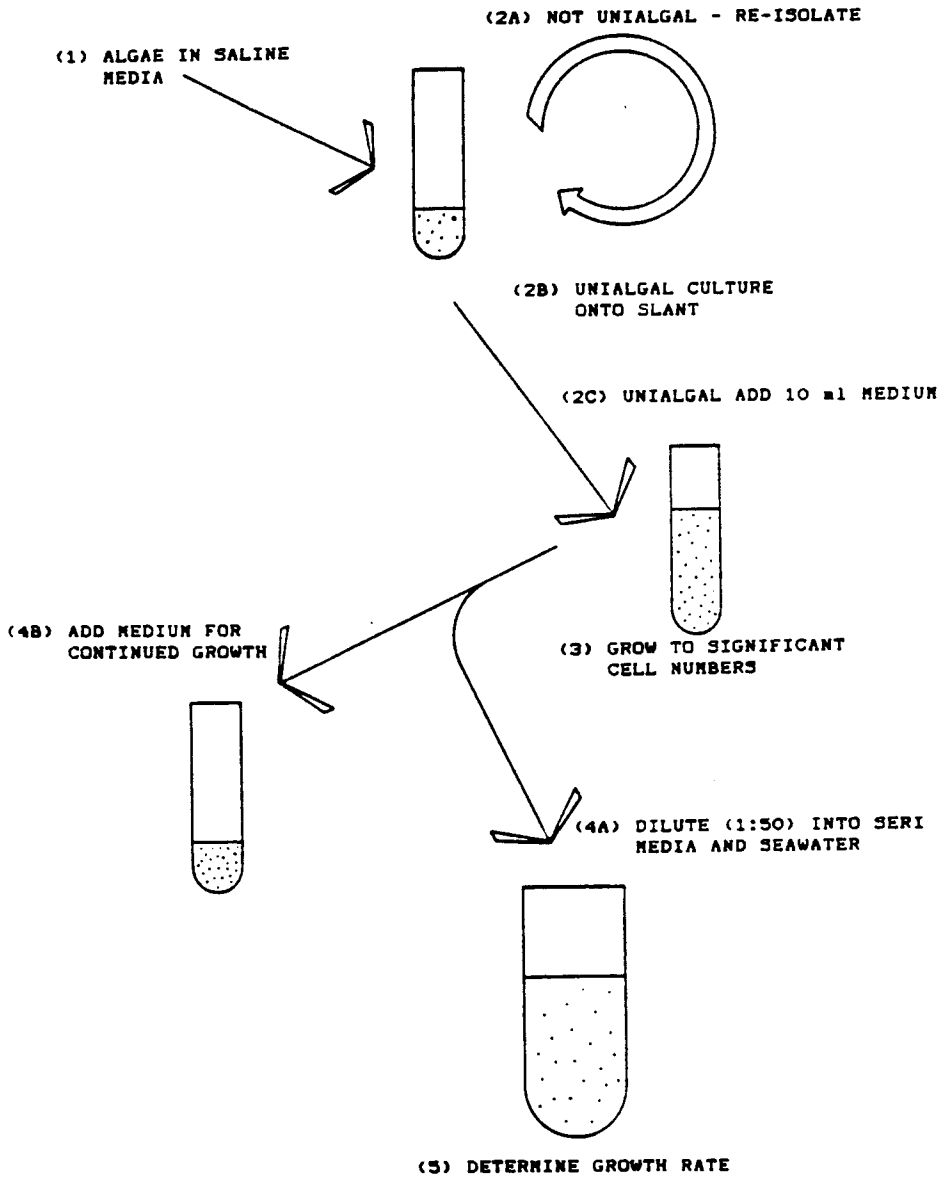



Figure 4. Summary of procedure used to evaluate growth rates in microalgae isolated from nature.

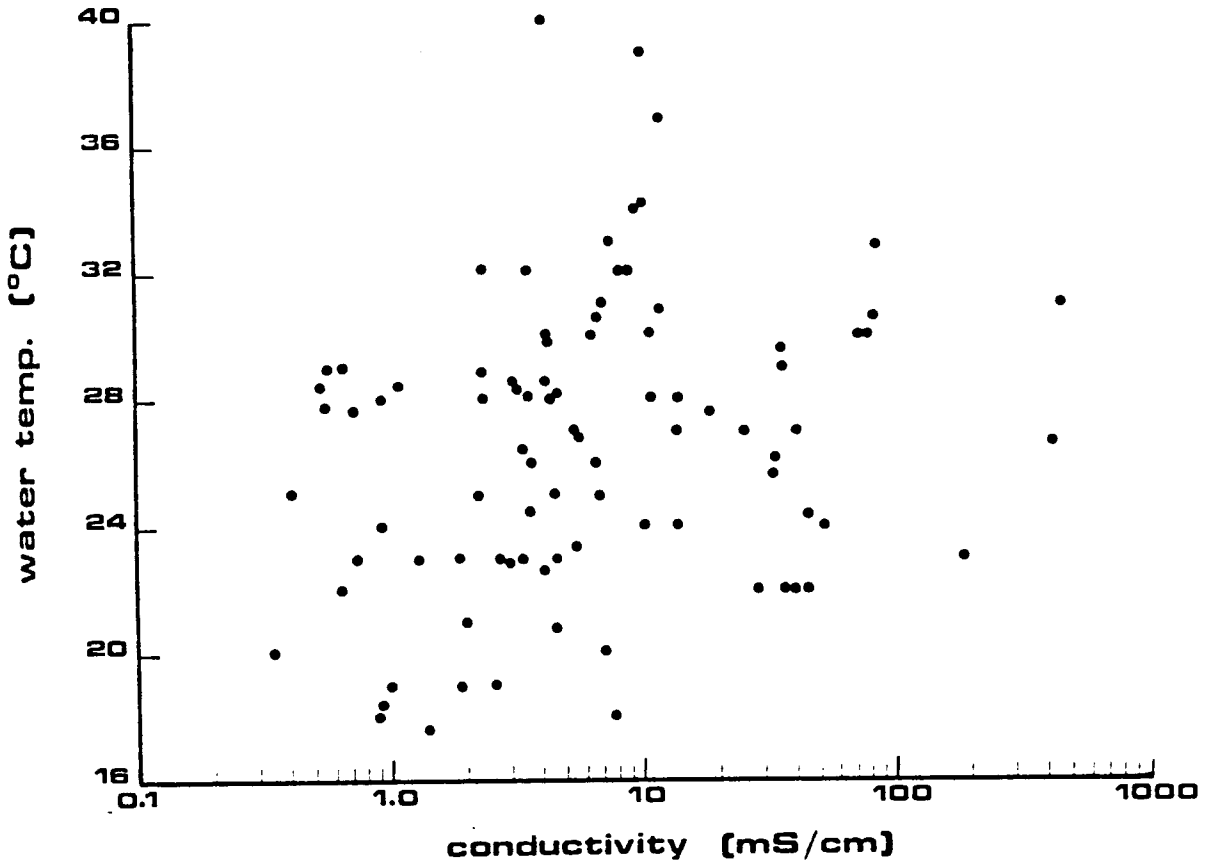



Figure 5. Water temperature and specific conductance of sampling sites for microalgae.

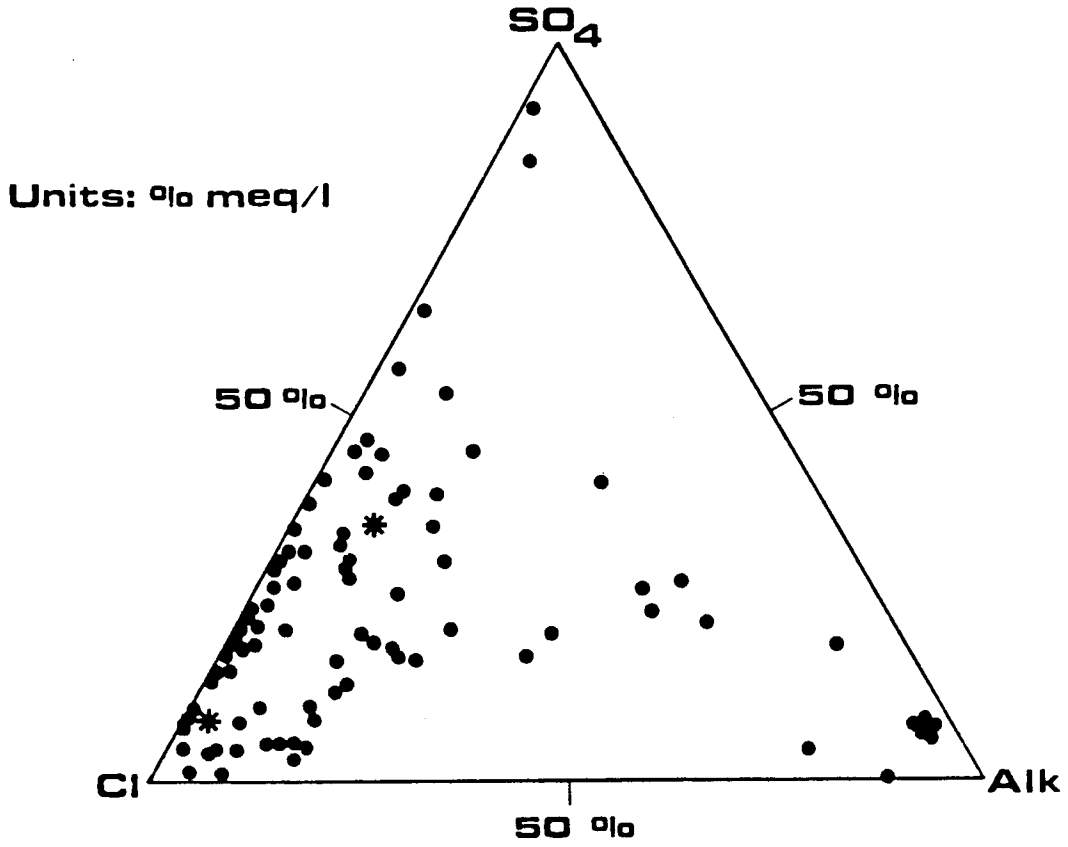



Figure 6. Relative anion composition for waters sampled for microalgae. Each dot represents a sampling site. Asterisks indicate relative anion composition of SERI Type I and II Media.

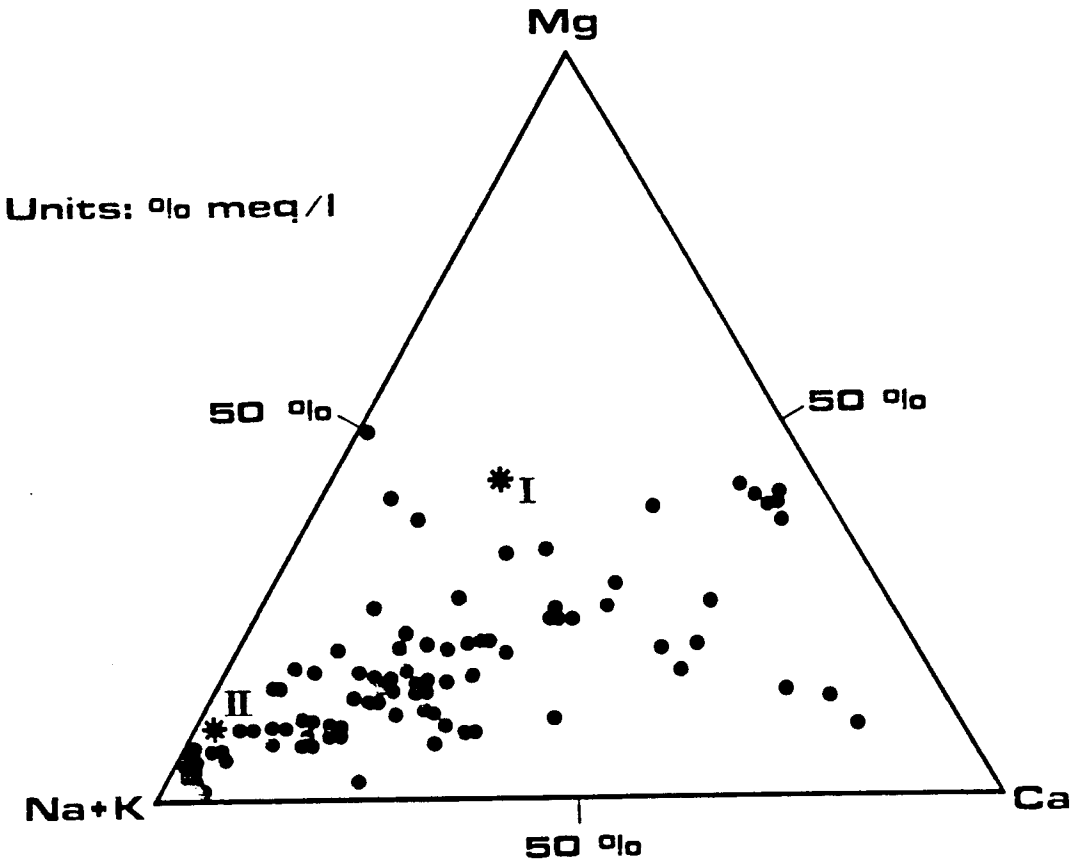



Figure 7. Relative cation composition for waters sampled for microalgae. Each dot represents a sampling site. Asterisks indicate relative cation composition of SERI Type I and II Media.

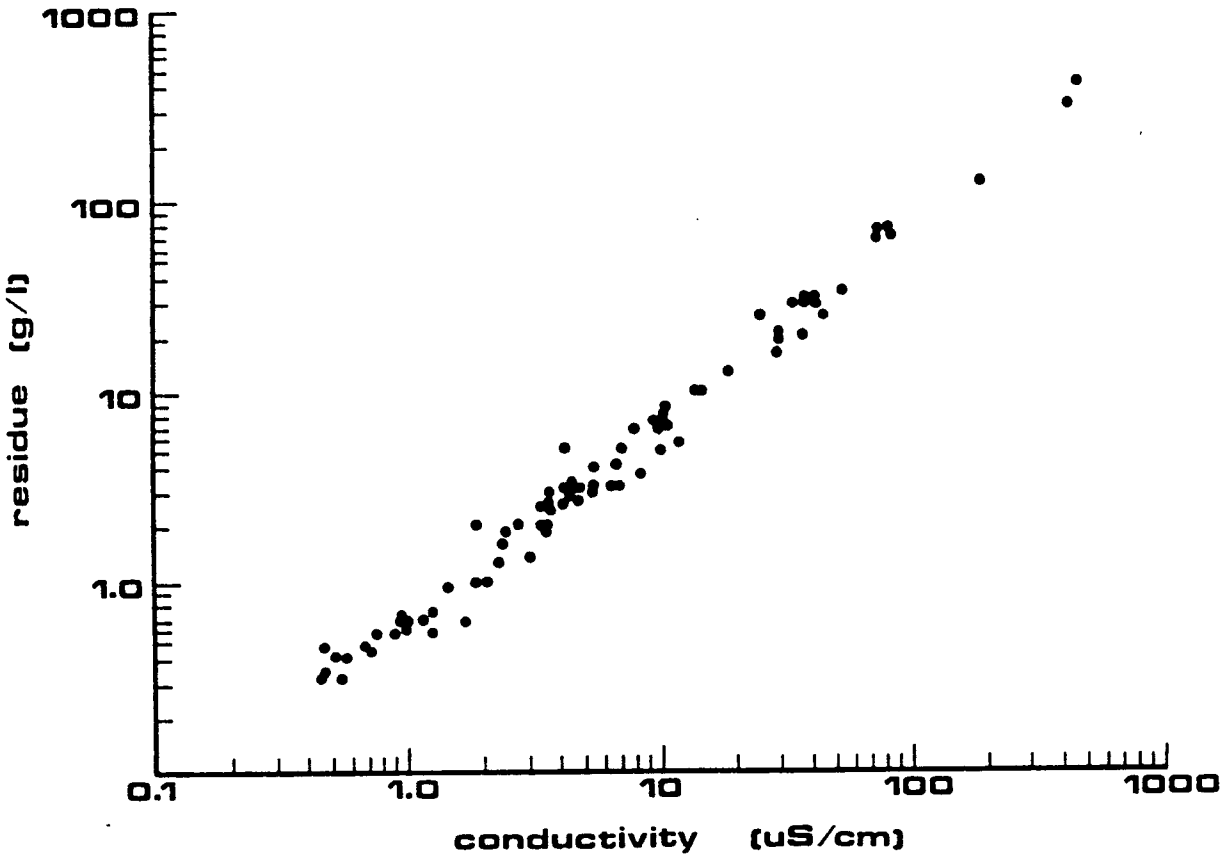



Figure 8. Relationship between specific conductance and total filterable residue in the waters sampled for microalgae

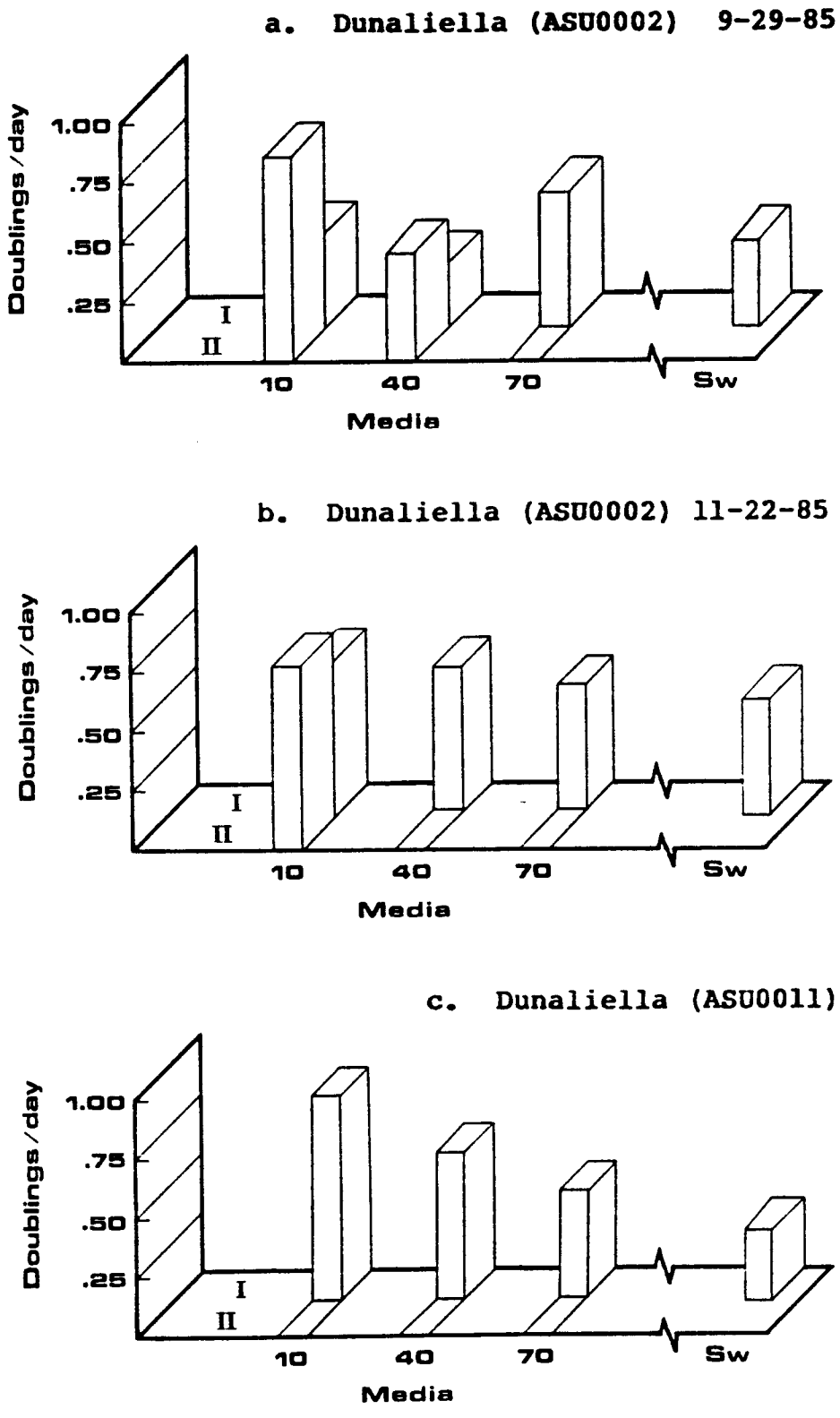



Figure 9. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).

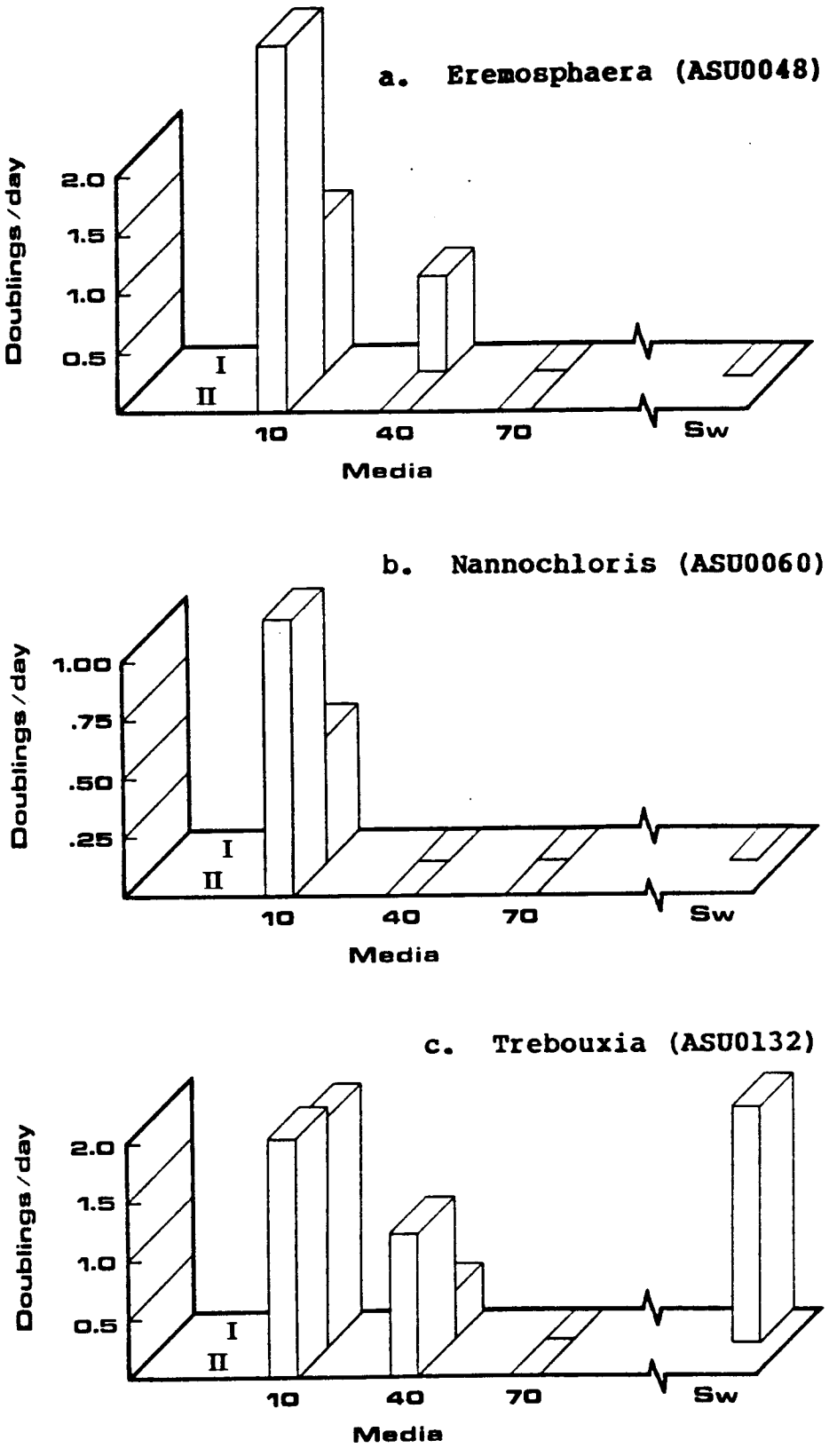
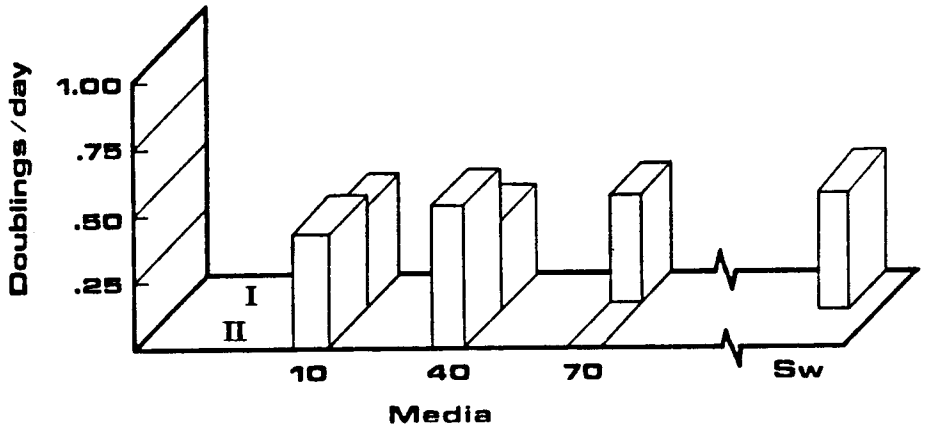
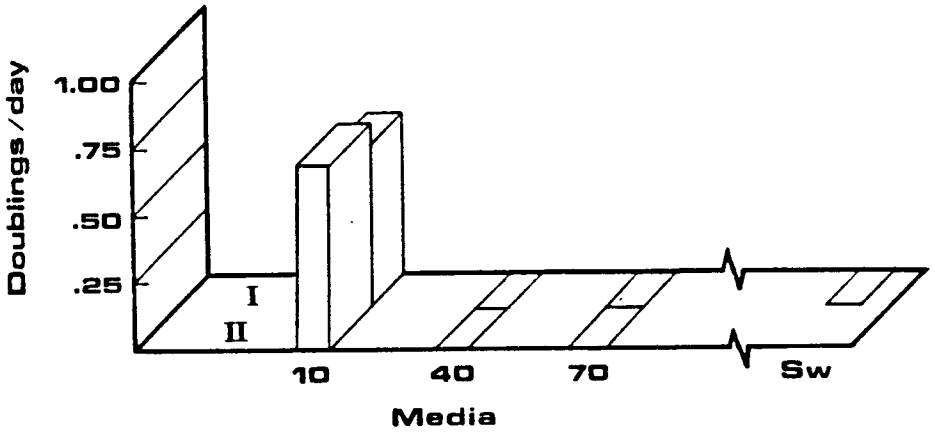



Figure 10. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).

a. Dunaliella (ASU0012)




b. Borodinella (ASU0134)




c. Borodinella (ASU0064)

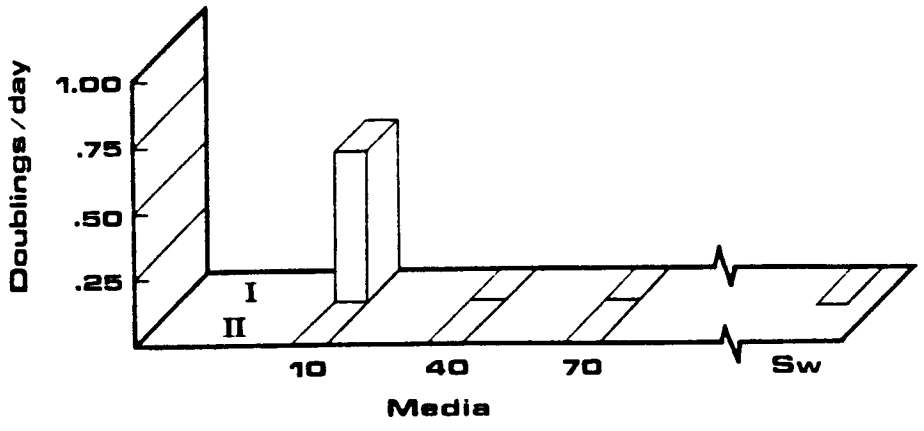



Figure 11. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).

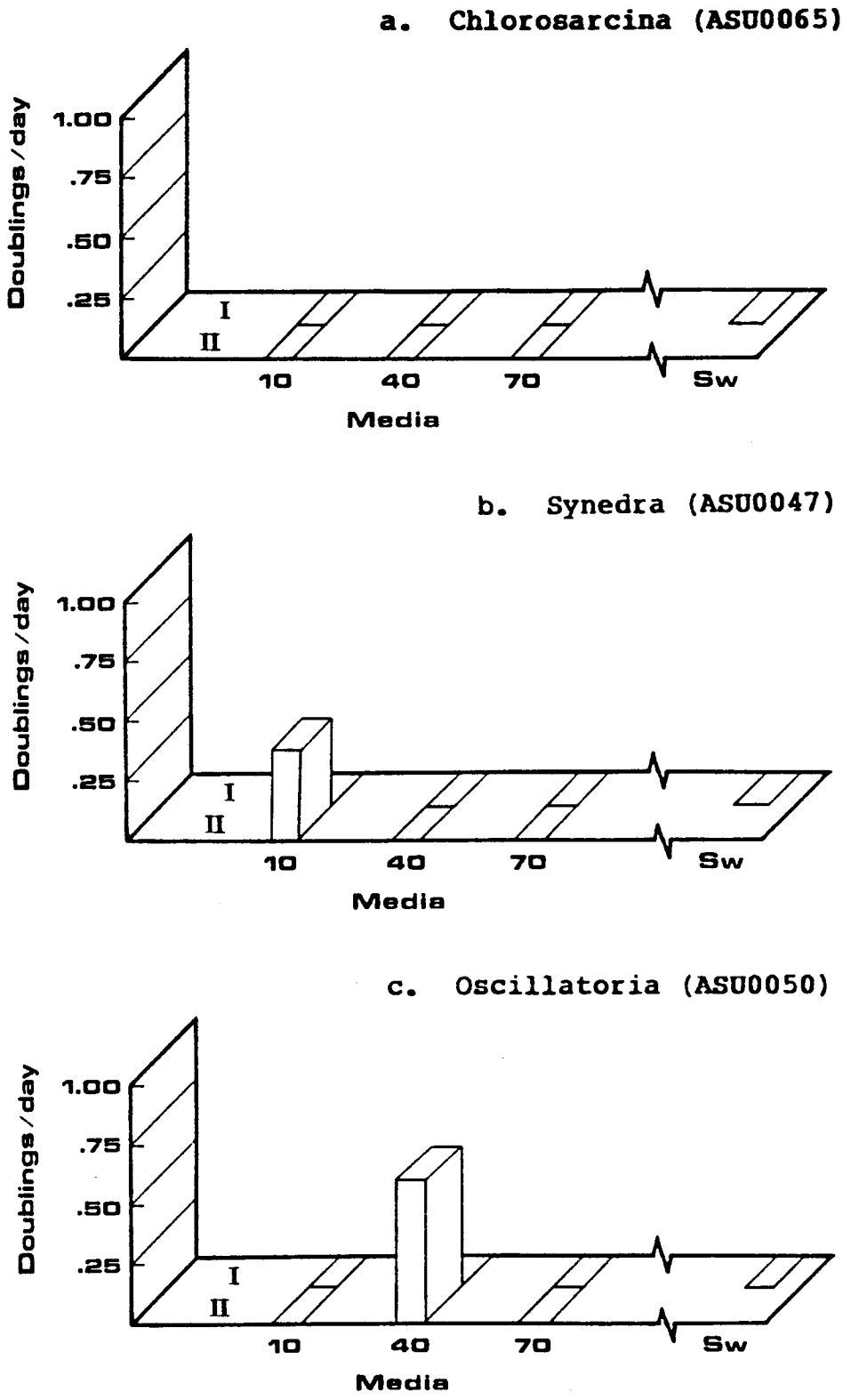



Figure 12. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).

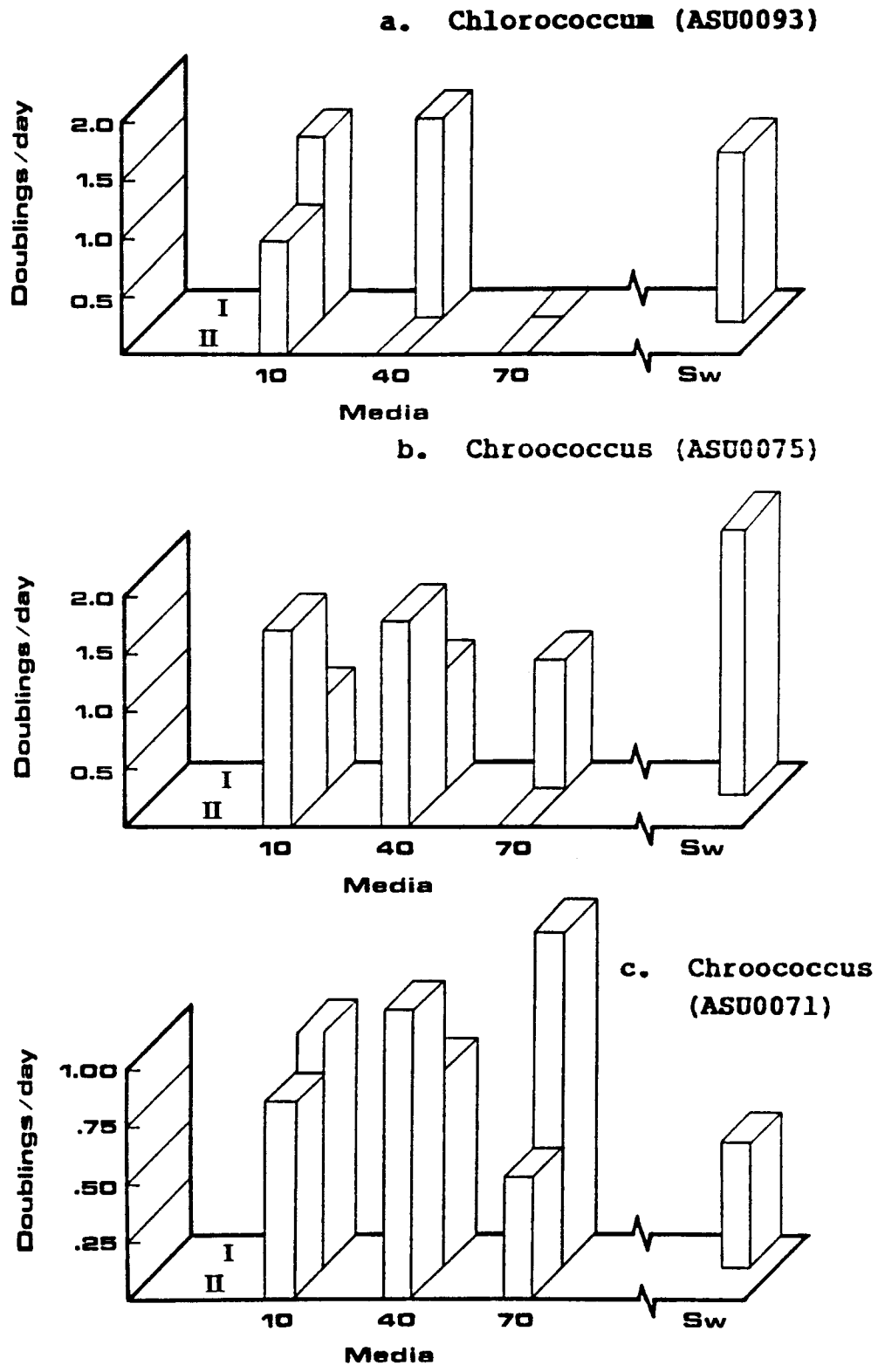



Figure 13. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).

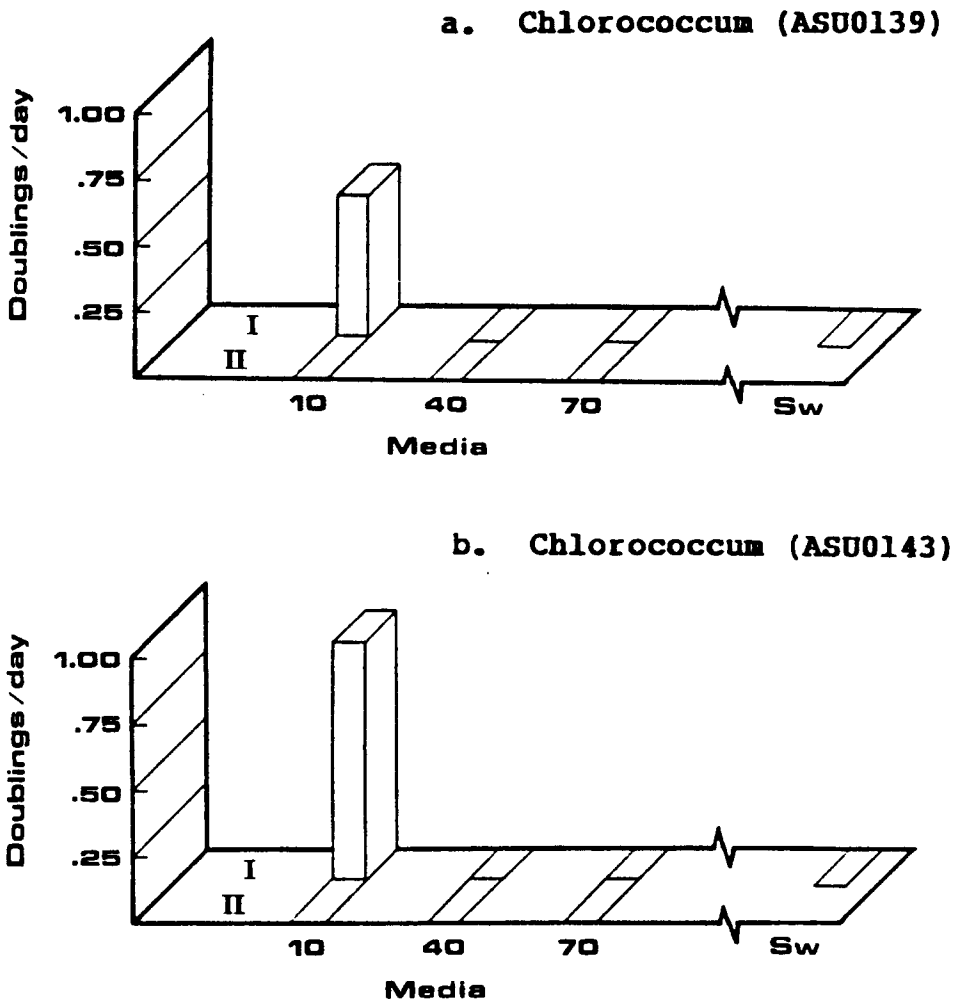



Figure 14. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).

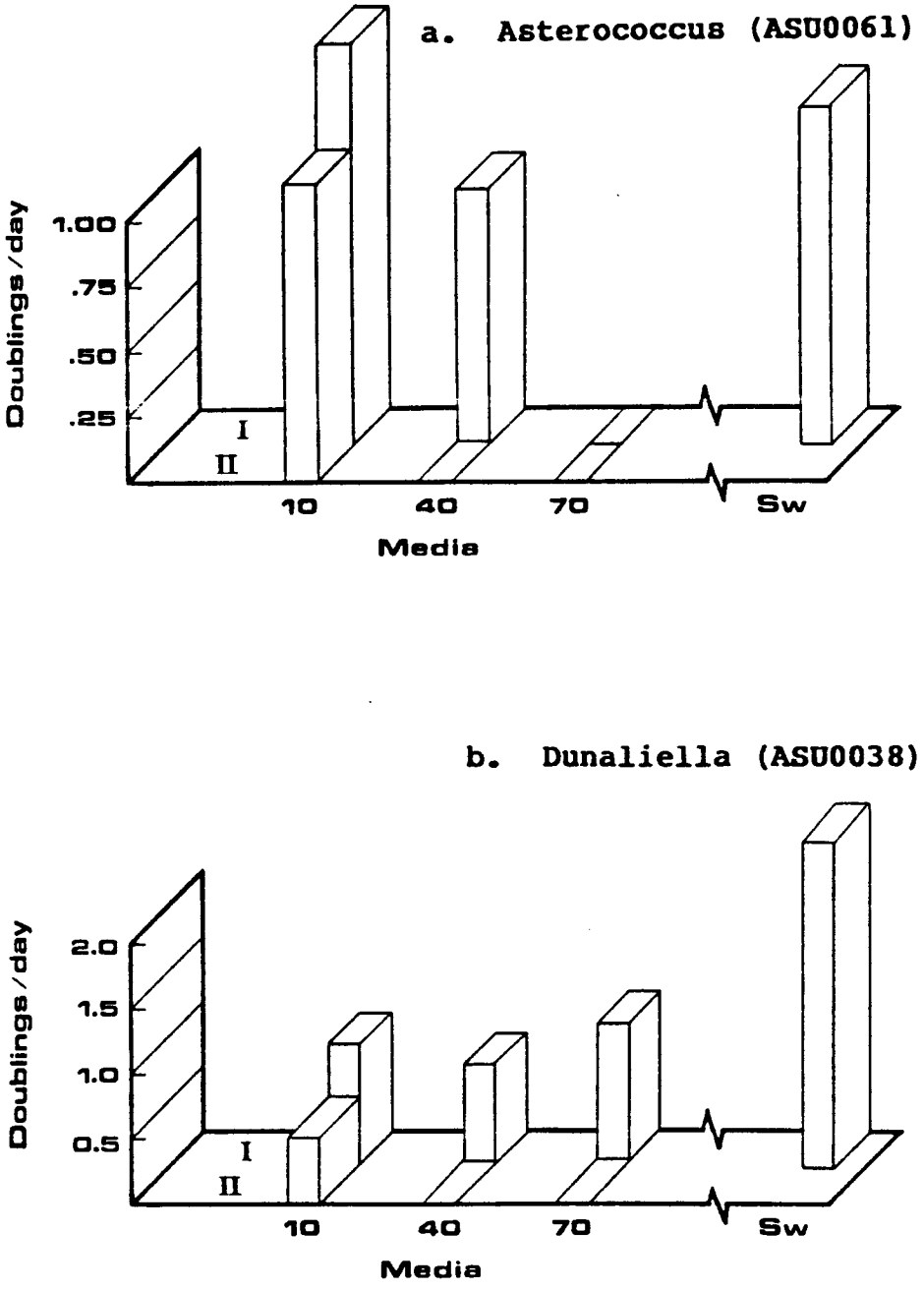



Figure 15. Growth rates for microalgae isolates in SERI Type I and II Media of 10, 40 and 70 mS/cm specific conductance and in seawater (SW).