THE MARINE ENVIRONMENT OF MARINA DEL REY, CALIFORNIA

A BASELINE SURVEY

JULY 1976 TO JUNE 1979

A REPORT TO
THE DEPARTMENT OF SMALL CRAFT HARBORS
COUNTY OF LOS ANGELES

BY

HARBORS ENVIRONMENTAL PROJECTS
DOROTHY F. SOULE AND MIKIHIKO OGURI, EDITORS

Published by

Allan Hancock Foundation and The Office of Sea Grant Programs
Institute for Marine and Coastal Studies
University of Southern California Los Angeles, California 90007

USCSG-TR-03-80

MARINE STUDIES OF SAN PEDRO BAY, CALIFORNIA PART 18

JUNE 1980

Study Site, Marina del Rey, California

(base map, courtesy of Automobile Club of Southern California)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

WATER QUALITY

Water quality in Marina del Rey is determined by both the oceanographic conditions prevailing in the adjacent open coastal oceanic waters and the factors superimposed on those conditions associated with the rainfall, urban runoff and general usages of the marina waters. Due to the seasonal and annual variations in rain and runoff the pollutant load discharged into the marina and the resultant water quality also show strong variations. This creates an environment that is suitable only for organisms capable of surviving a wide range of salinity, temperature and dissolved oxygen and the presence of a variety of metals and other pollutants.

The limited measurements of metals and chlorinated hydrocarbons that have been made in the marina waters and sediments suggest that many of the water-borne pollutants may originate in deflection of storm flows from Ballona Creek back into the marina and in storm drain flow.

The marina would be an excellent area for study of the impact of non-point source flow, but thus far such a project has not been undertaken.

SEDIMENT GRAIN SIZE AND POLLUTANTS

Sediment grain size showed a dominance of sand in stations near the entrance to the marina, with silt and clay tending to appear as a greater portion of the total in the inner areas of the marina. The distribution within the marina at the various stations was variable, suggesting that natural sorting mechanisms varied considerably. Following periods of heavy runoff the sorting appeared to be more graded, with the finer sediments dominating in the inner slips and along the channel extending northward.

This suggests that sand may originate in flows from Ballona Flood Control Channels, as well as being carried from the beach by prevailing winds and storms. Sand settles out near the entrance in the southern part of Marina del Rey. The finer material would tend to deposit in areas where reduced turbulence would permit settling. Heavy runoff would tend to resuspend and sweep the finer sediments out of the marina.

Metals found in the sediments, in general, were similar in concentration to those in sediments of Los Angeles Harbor. However, chlorinated hydrocarbons did not appear to be present in 1978. Sources of metals in the non-industrial area are unknown and concentrations were higher than expected.

PHYTOPLANKTON

The fertility of the waters in the marina was assessed by measurements of phytoplankton population density, expressed in terms of chlorophyll *a* concentration and the productivity of these organisms. In general, the marina waters were usually more productive than the adjacent coastal waters but followed the same cyclic seasonal patterns. The area most consistently high in productivity and chlorophyll *a* was the middle portion of the main channel. Stations located in basins yielded data reflecting the localized patterns of use of the waterways and ranged from high values to extremely low ones. The primary productivity of the waters of the marina was quite variable, but was fairly high. There were no episodes suggesting the existence of eutrophic conditions and relatively few instances in which bio-inhibition was indicated. The impact of flushing from above-normal rainfall and runoff may have been responsible for the fact that 1977-1978 was the poorest of the three years for phytoplankton productivity.

ZOOPLANKTON

The dominant zooplankter found in Marina del Rey during this study was *Acartia californiensis*, which comprised approximately 95% of the total zooplankton sampled there. This species is known to prefer shallower, warmer and more turbid waters and to be tolerant of environmental stress. It also dominates the plankton populations of the inner harbor areas in Los Angeles-Long Beach Harbors. The high level of dominance of this species resulted in an extremely low Shannon-Wiener index of diversity of 0.44 for zooplankton.

The zooplankton were comprised primarily of copepods, 98.5%, with no other group of organisms contributing even 1% to the total population. Ichthyoplankton, fish eggs and larvae, constituted only 0.04% of the total, suggesting that the marina is not a center of fisheries reproduction. Temporal distribution of the zooplankton showed that there were minimal populations in late summer, fall and winter. Higher levels occurred in the early spring, increasing to maximal levels in late spring and early summer. Since this was the *Acartia* pattern, and it was the dominant species, it masked other seasonal patterns.

Zooplankton abundance was high, about 3.5 times the levels found in Los Angeles-Long Beach, but since it was composed of very few species it may not be attractive to fish species. Conversely, reduced numbers of fish predators might be responsible for the higher zooplankton numbers. The highest concentrations of zooplankton were found in the inner harbor and lower concentrations near the entrance of the marina.

BENTHIC FAUNA

Over 115,400 benthic animals representing more than 300 taxa were found in the marina in the three-year study. Benthic organisms showed clear patterns of distribution, based on the dominant species. Ballona Creek fauna (station 1) differed from that of station 2, the marina entry, from station 3, a shelly "reef" at the Ballona Lagoon tide gates and station 4 at the inner end of the entrance channel. But the main channel and basins differed greatly from the outer four stations. The numbers of species also showed a consistent, clear separation between the outermost stations 1-4 with means of 42-61 species per m^2, the middle stations 5-7 with 31-32 species/m^2, and inner stations 8-11 with 21-28 species/m^2. The station pattern for numbers of individuals showed means above 10,000/m^2 -- 24,679 at stations 2, 3, 4 and 7, and below 10,000/m^2 at the others. Station 11 was lowest in species and in numbers.

The species diversity index was best at station 4 and indices were generally better than those in Los Angeles-Long Beach Harbor. The peak period for numbers of individuals was September 1977, when the numbers of taxa were lowest. The means of taxa for the entire marina ranged from 29 to 42, and means of individuals from 6,790 to 22,733.

MEROPLANKTON

Meroplankton, representing sessile species with planktonic larval stages, were collected on settling racks at eight locations. They showed good diversity of species and of higher taxa. The most diverse site was station 4 at the inner end of the entrance channel. All stations showed seasonality as well as severe impacts during the storm period of January-February of 1978. The impacts at inner marina stations were greater where species diversity was lower, and impacts lasted much longer before recovery. Non-point source flow should be studied to determine whether pollutants entering through drainage can be reduced.

FISH FAUNA

The fish surveys in the marina found a total of 35 species using otter trawl, gill net, diver survey, beach seine, and other visual sighting. This is about half the number of species known from King Harbor, but the latter has been subject to intensive fish surveys. Experiments with caged fish indicated that runoff was not lethal to them, but fish may be swept from or leave the harbor during intensive runoff periods. Low oxygen episodes also caused fish to leave. The numbers were highest in June of 1977 and 1978, low in winter, and lowest in January 1978.

POTENTIAL MODIFICATIONS OF THE MARINA

Modification of the marina might be undertaken for at least three purposes: for improvement of water quality, for improvement of habitat and for increased accommodation of recreational boating. The economic, social and political implications of changes do not fall within the scope of this study, although it is recognized that these factors may override ecological concerns. While there are waiting lists for recreational boating accommodations throughout southern California, the capital outlay needed for new marinas has risen with inflation, and increased public pressure to preserve or restore wetlands places construction of large new marinas, or large-scale modifications of existing ones, in doubt.

Flushing

The practice of marina design has been directed toward protection of boats by obtaining the least amount of water movement possible and the largest number of accommodations in the space available. The results of these design criteria are generally poor water quality and hence poor biological quality.

Flushing in Marina del Rey is much lower in the slip basins than in the main channel and entrance channel. Brandsma, Lee and Bowerman (1973) tested the flushing characteristics of pollutants injected at various sites and tidal stages by computer methods. They concluded that placement of pollutant injection points such as storm drains at constructed ends of basins should have been avoided. Solid boundaries severely restrict convective and dispersive transport of pollutants.

It is unfortunate that storm drains in the marina were located at the inner ends of basins rather than on the channels or diverted into Ballona Creek Flood Control Channel altogether. The impacts of storm waters on water quality and biota have been severe, as discussed elsewhere in this report and in Soule and Oguri (1977). Additional drainage to the existing sites would probably not alter appreciably the destructive effects inherent to intermittent freshwater storm loadings.

Ballona Lagoon

Prior to construction of the marina, Ballona Lagoon was connected to Ballona Creek by tide gates and extended to the Venice canals tide gates. There it turned inland and branched: one arm extended over to a drainage basin called Lake Los Angeles, which is now part of the beach area of Basin D; the other arm extended back toward Ballona Creek, roughly parallel to the lagoon, and many branches and drainage channels extended into the area now occupied by the marina (Figure I 2) At the turn of the century (Figure I 1), water and wetland areas were much more extensive. Drainage was effected for various purposes including oil field development, for mosquito and other insect control, and for farming.

It is most unfortunate that the connection between the Venice canals junction of Ballona Lagoon and Lake Los Angeles (Basin D) was not retained. If some connection could be restored, tidal flushing of the marina and the lagoon would be much improved. Basins B and C are closer to Ballona Lagoon and would probably provide the only links possible at the present time. Proposals to open Ballona Lagoon to boating might be feasible if such a connection could be made. Tide gates to the Venice Canals area could then be structured to flush that area more effectively as well.

If such construction were undertaken, the Ballona Lagoon habitat might well be enhanced over the present conditions of debris accumulation and highly organic muds. Banks should be sloped to allow a natural intertidal biota; it is possible that a bird island could also be created.

Ballona Creek

Historically, wetlands extended through Venice, southwest through La Ballona, and inland to Machado, a stop on the Santa Monica Railroad, later the Pacific Electric Railway, and south, roughly to the present Culver Boulevard area. Channelizing of Ballona Creek Flood Control Channel in the 1930's extended to the shoreline. Proposals have been considered for the privately owned land south of the Marina from Fiji Way to Ballona Creek, and on the south side of Ballona Creek, to break out the concrete channel entirely and create a large lagoon system. Although this could be used to create wetland habitat and support recreation as well, the catchment of storm debris would be a major problem, and the cost would probably be prohibitive. Reaching agreement among private entities, the public, and public agencies on how to construct such habitats would probably present even more difficulties than funding. Regardless of which design were selected, it is essential that natural sediment banks and slopes be contoured to provide the estuarine habitat typical of an area such as lower Newport Bay, rather than the primarily vertical substrates typical of marina construction.

Construction of any interior channels, extending the Basin H area to the south of Fiji Way, would create very poor water quality, unless a connection could be made to Ballona Creek. The creek would have to be deepened to achieve tidal flushing, and protection from debris designed. Deepening might enhance wetland restoration on the south side of Ballona Creek.

Improvements in the marina water quality could be made by increasing flushing via either Ballona Lagoon or Ballona

Creek.

Non-point source control of the input of high oxygen-demand or toxic materials which enter the storm drain system is needed. The storm waters themselves probably serve an important function to flush the inner basins and aid in maintaining a relatively diverse ecosystem in an area that is naturally a low-diversity habitat.

INTRODUCTION

HISTORICAL BACKGROUND

Marina del Rey is a small craft recreational harbor encompassing some 403 acres of waterways, slips and berthing basins. A similarly sized land area, adjacent to the waterways, provides support facilities, about one-third of which are operated directly by the Los Angeles County Department of Small Craft Harbors. The remainder are under lease to private entities which provide slip and dock accommodations, and amenities such as shops, restaurants, apartments and hotel facilities (Soule and Oguri, 1977).

The marina is entirely manmade, created in 1960-1962 from lands that were formerly part of the Ballona Creek wetlands. Ballona Creek was concretized in the 1930's, draining a large portion of the urban area inland to central Los Angeles. Figure 1 shows the Los Angeles basin and wetlands at the turn of the century. The wetlands were progressively drained for farming and oil production and other industry, as well as for vector control of mosquitos and other public health nuisances.

The history of construction design and funding was reviewed by the Department of Small Craft Harbors in 1976; Reish in Soule and Oguri (1977) provided information on biological colonization during the construction period of the marina as it became inundated. Other studies relating to the physical variables in the marina include Bowerman and Chen (1971); Brandsma, Lee and Bowerman (1973); Chen and Lu (1974). Information on adjacent Ballona Lagoon includes Bakus (1975) and Ford and Collier (1976).

SCOPE OF THE STUDY

The present investigation began in July 1976, to study the biological, physical and chemical aspects of the marina, which had not previously been undertaken. Thirteen sites were selected for establishing stations representative of the diverse environmental conditions in the marina (Figure 2; Table 4). Of these sites stations 1-11 are marine and could be sampled by boat. Station 12, in Ballona Creek, was sampled from the footbridge, and station 13 was in the bird sanctuary and was sampled from land.

Parameters measured are listed in Table 1 along with references associated with the methods. Each section of the volume discusses methods and frequency of sampling. Table 2 presents the limits of detection for the chemical analysis of sediments, and Table 3 gives conversions from scientific, metric units to English units.

Monitoring Program

Monthly monitoring was done from the Department of Small Craft Harbors boats. Temperature, salinity, dissolved oxygen and pH were measured at 1 m intervals through the water column. Turbidity was measured by two transmissometers which malfunctioned so frequently that Secchi discs had to be substituted.

Water samples were taken for nutrient chemistry and for phytoplankton productivity determinations, including chlorophyll *a* and assimilation ratios.

Zooplankton tows were made and the species and numbers determined per cubic meter.

Settling racks were suspended at two-month intervals in the marina studies to determine species and numbers of meroplanktonic fouling fauna.

Benthic fauna were sampled seasonally by Campbell grab, which takes 0.10 m^2 of surface, and sediments screened for organisms.

Fish surveys were made about twice a year, by otter trawl, gill netting, diver census and other visual sightings.

Sediment from the grab samples and water samples were taken for analysis of trace metals and chlorinated hydrocarbons. Sediments were analyzed once a year; water was examined during storm sequences.

Data storage and analysis was by IBM 370 computer using Harbors Environmental Projects programs. The CalComp plotter was used for multigraphs and the Symap program was used for IBM data mapping.

The principal investigators, associates, staff and consultants for Harbors Environmental Projects during the field and laboratory investigations in Marina del Rey are listed on the following pages.

EMPLOYEES OR ASSOCIATES OF HARBORS ENVIRONMENTAL PROJECTS - 1978/1979

MANAGEMENT BIOLOGISTS

Director: Dorothy F. Soule, Ph.D., Senior Research Scientist, Institute for Marine and Coastal Studies, Adjunct Professor of Environmental Engineering; Marine Biology.

Associate Director: Mikihiko Oguri, M.S., Research Scientist, Institute for Marine and Coastal Studies; Phytoplankton Ecology, Marine Biology.

Associate Director: John D. Soule, Ph.D., Professor of Histology and Biology, USC, and Research Associate, Allan Hancock Foundation; Histology, Pathology, Marine Invertebrates.

PRINCIPAL INVESTIGATORS/CONSULTANTS

B. C. Abbott, Ph.D. Director, Allan Hancock Foundation; Chairman, Department of Biological Sciences. Phytoplankton, red tide toxins, biostimulation. (Ph.D. Cambridge Univ.).

K. Y. Chen, Ph.D. Chairman, Environmental Engineering, USC. Trace metal chemistry, amplification, sanitation engineering. (Ph.D. Harvard Univ.).

John Dawson, M.A. Research Scientist, Harbors Environmental Projects, USC. Zooplankton fauna, ecology. (M.S. Cal.St.U.Humboldt).

Ethan D. Churchill, Ph.D. Research Associate, Terrestrial Botany, Harbors Environmental Projects, USC. (Ph.D. Catholic Univ. Amer.).

C. Robert Feldmeth, Ph.D. Associate Professor, Biology, Claremont Colleges, and Research Scientist, Harbors Environmental Projects, USC. Marine ecology (Ph.D. Univ. Toronto).

Patricia Kremer, Ph.D. Research Scientist, Harbors Environmental Projects, USC. Estuarine ecology, computer modelling, oxygen budgets. (Ph.D. Rhode Island).

J. J. Lee, Ph.D. Associate Professor, Civil Engineering, USC. Ocean Engineering, Ocean engineering, hydrodynamics, modelling, computer. (Ph.D. Cal Tech).

John McDonald, M.A. Lecturer, Geography, USC. Computer mapping, sociogeography. (U.S. Army and M.A. Cal State Northridge).

Mikihiko Oguri, M.S. Associate Director, Harbors Environmental Projects, IMCS-USC. Phytoplankton, productivity, physical water quality, radioisotopes. (M.S. Univ. Hawaii).

Dennis Power, Ph.D. Director, Santa Barbara Museum of Natural History. Associate for Ornithology. (Ph.D. Univ. Kansas).

Donald J. Reish, Ph.D. Professor of Biological Sciences, Calif. State Univ. Long Beach, and Research Associate, Harbors Environmental Projects, USC. Benthic ecology, bioassay. (Ph.D. USC).

Robert Smith, Ph.D. Research Scientist, Harbors Environmental Projects, USC. Benthic ecology, computer ecosystem analysis. (Also independent consultant, BLM, Los Angeles City, Texas A&M, etc.). (Ph.D. USC).

Dorothy F. Soule, Ph.D. Director, Harbors Environmental Projects and Harbor Research Laboratory, Senior Research Scientist, IMCS-USC, and Allan Hancock Foundation. Invertebrates, ecology. (Ph.D., Claremont Grad. School).

John D. Soule, Ph.D. Professor of Histology and Biology, USC, and Research Associate, Allan Hancock Foundation. Histology, pathology, marine invertebrates. (Ph.D. USC).

John S. Stephens, Jr., Ph.D. James Irvine Professor of Biology, Occidental College and Research Associate, Harbors Environmental Projects, USC. Ichthyology, marine ecology. (Ph.D. UCLA).

Cornelius W. Sullivan, Ph.D. Assistant Professor, Biological Sciences, USC. Marine microbiology, biogeochemistry, phytoplankton ecology. (Ph.D.UCSD).

Gary Troyer, M.S. Associate Professor, Claremont Colleges, and Research Consultant, Harbors Environmental Projects, USC. Ecological assessment, diver surveys. (M.S. Univ. Redlands).

Louis C. Wheeler, Ph.D. Professor Emeritus, USC, Associate for Terrestrial Botany. (Ph.D. Harvard Univ.).

Mary Wicksten, Ph.D. Research Scientist, Harbors Environmental Projects, USC. Marine ecology, crustacean biology, literature surveys. (Ph.D. USC).

Charles Woodhouse, Ph.D. Marine Mammalogist, Santa Barbara Museum of Natural History. Consultant.

ASSOCIATE INVESTIGATORS

Kent Adams, M.S. Research Assistant, Harbors Environmental Projects, USC. Bioassay, Environ. Engineering. (M.S. USC).

Scott Brady, Ph.D. Research Assistant, Harbors Environmental Projects, USC. Biochemistry. (Ph.D. USC).

Margaret Callahan, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Zooplankton.

Paul Collins, Santa Barbara Museum of Natural History. Vertebrate biology (UCSB).

Richard Hammer, M.S., Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Zooplankton, crustacean biology. (M.S. Texas A&M).

Clyde Henry, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Benthic ecology, computer ecosystems analysis. (M.A., Texas A&M).

Anne L. Holmquist, Ph.D.(cand.) Research Scientist, Harbors Environmental Projects, USC. Phytoplankton productivity.

David Krempin, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Radioisotopes, microbiology.

Larry Randall McGlade, M.S. Research Assistant, Harbors Environmental Projects, USC. (M.S., Cal. St.U.Long Beach).

Sarah McGrath, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Radioisotopes, microbiology.

Gregory Morey-Gaines, Ph.D.(cand.). Research Assistant, Biological Sciences, USC. Phytoplankton, biostimulation, food webs.

T.J. Mueller, Ph.D.(cand.). Consultant in statistical analysis, USC.

Marianne Ninos, Ph.D.(cand.). Research Assistant, ichthyoplankton, HEP, USC.

Robert Osborn, M.S. Research Assistant, Harbors Environmental Projects, USC. Benthic fauna, polychaete biology. (M.S., Cal.St.U.Long Beach).

Scott Ralston, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Ichthyology, developmental biology.

Timothy Sharp, M.S. Research Technician, Harbors Environmental Projects, USC. Microbiology, radioisotopes.

Sarah Swank, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Phytoplankton, bioassay, ecology.

Gordon Taylor, Ph.D.(cand.). Research Assistant, Harbors Environmental Projects, USC. Microbiology, radioisotopes.

TECHNICAL SUPPORT STAFF

Charles Robert Bostick
James Bryan
Debra Bright
Clairessa Cantrell
John Dmohowski
James Dorsey
Frank Edmands
Donna Eto
Melanie Hunter
Maria Lorente
Alawia Mahgoub
Vanessa McGlade
Steve Petrich
Roseanne Ruse
David Schomisch
James Shubsda
Joanne Woodcock

ADMINISTRATIVE STAFF

Lona Proffitt
Ruth Steiger
Mary Jim
Anita Lai
Sophia Ng

OTHER CONSULTANTS

Donna Cooksey
Kevin Green
Kirk M. Herring
Ronald Hill
Christine Jadomska
Steve Ziemba
Robert Watkins
Valerie Raco
Thomas McDonnell
Mark McMahan
Steve Petrich
Jill D. Sadler
Mary Siroky
Michelle Smith
Carol Stepien
Evelyn McDonald

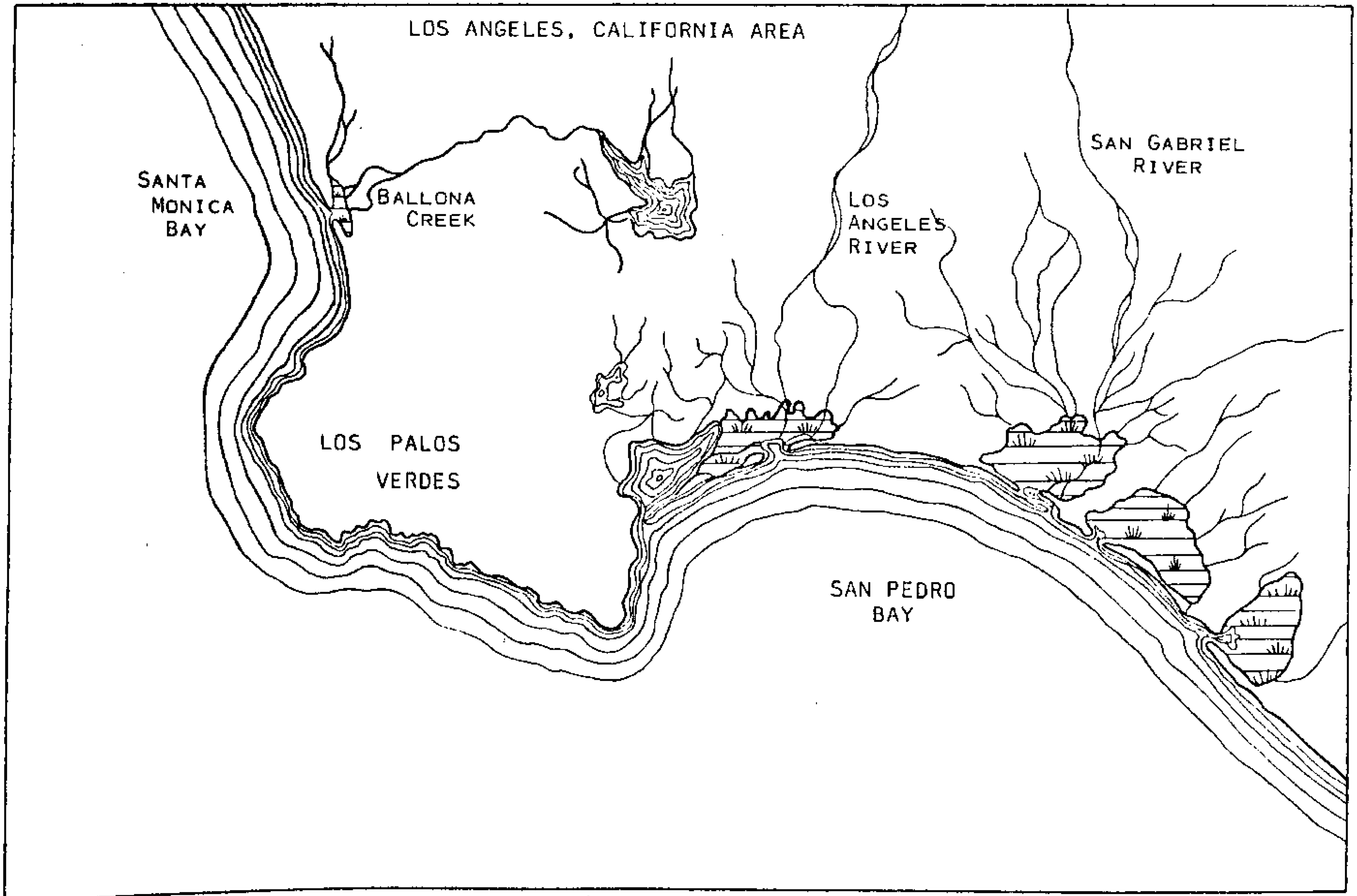


Figure 1. Los Angeles Area Wetlands, circa 1900.

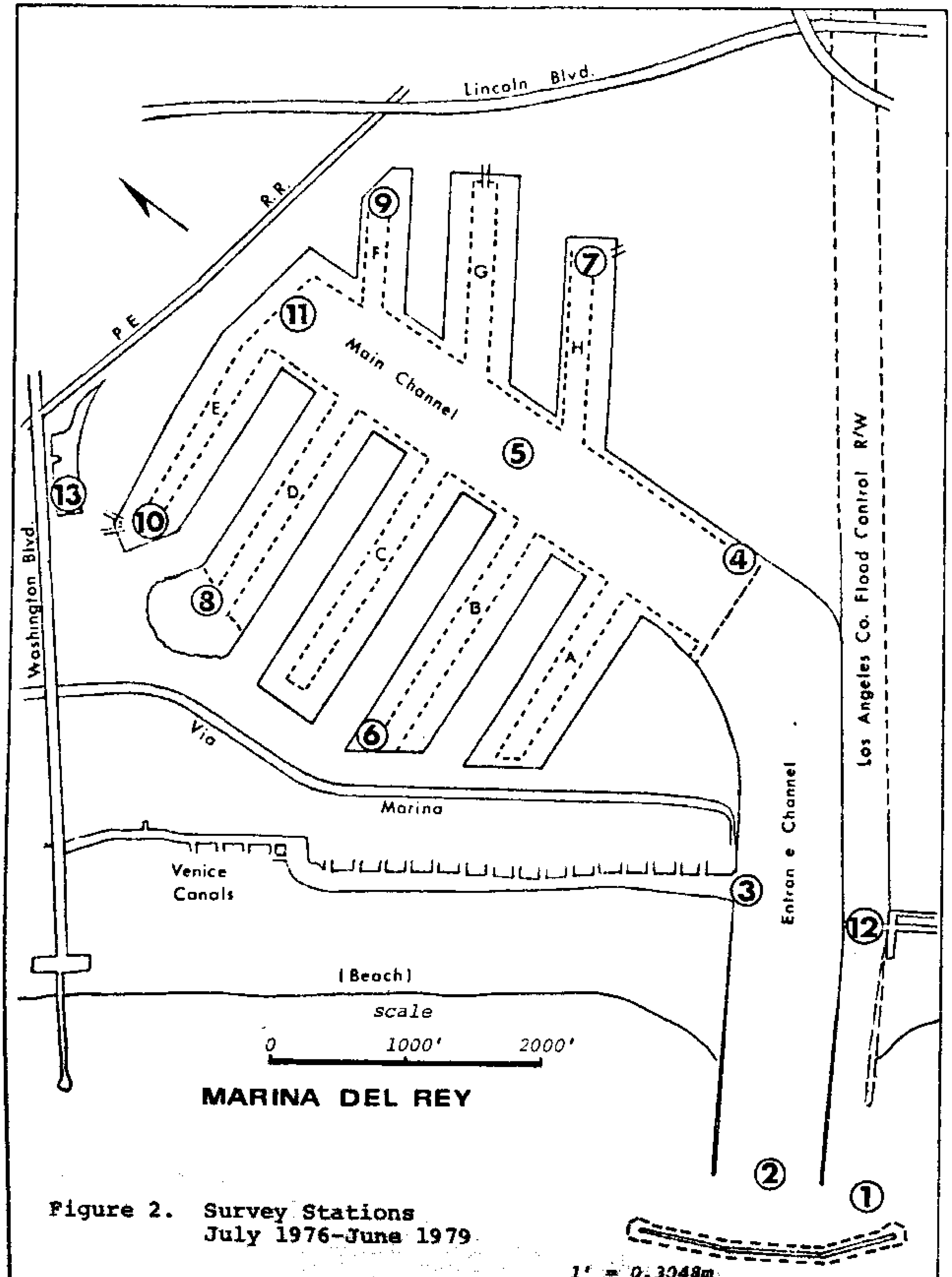


Figure 2. Survey Stations
July 1976-June 1979

Table 1. Parameters Measured in Marina del Rey

A. MONTHLY MONITORING	METHOD
1. Abiotic Parameters	
a. Temperature b. Salinity c. Dissolved Oxygen d. pH	Martek electronic remote probe, at 1m intervals through the water column
e. Light transmittance	Hydroproducts Transmissometer, remote probe with self-contained light path, at 1m intervals through depth
f. Ammonia	Solorzano (1969)
g. Nitrite	Strickland and Parsons (1968)
h. Nitrate i. Phosphate	Modified Strickland and Parsons (AHF, 1976)
2. Biotic Parameters	
a. Primary Productivity,	Modified Steeman-Neilsen (1952) ^{14}C light and dark bottles, standard light source incubator with ambient water temperature
b. Chlorophyll	Spectrophotometry, Strickland and Parsons (1968) equations
c. Assimilation ratio	
d. Zooplankton species	253µm net surface tow with flow meter
e. Water column fouling fauna, larvae and juveniles	Glass microscope slides in wood frame rack, plastic screened, suspended at 3m depth (bimonthly)
B. PERIODIC MONITORING	
1. Abiotic Parameters	
a. Sediment grain size	Pettijohn (1957), Felix (1969) Gibbs (1971), AHF (1976)
b. Trace metals chlorinated pesticides	Amer. Publ. Health (1976)
2. Biotic Parameters	
a. Benthic Fauna	Campbell grab 0.5mm screen
b. Fish species	Otter trawl, gill netting, diver census

TABLE 2

UNIVERSITY OF SOUTHERN CALIFORNIA

Sediment Analysis
- Variation and Detection Limit

Constituent	Error %	Det. Limit	Constituent	Error %	Det. Limit
Moisture %	0.5	0.01%	Arochlor 1242	5	1×10^{-10} gm
Dry Matter (%)	0.1	0.01%	Arochlor 1254	5	1×10^{-10} gm
COD	5	0.25 ppm	Arochlor 1260	5	5×10^{-11} gm
TOC	4	0.001%	Lindane	5	5×10^{-13} gm
TVS	1	0.01%	BHC	5	4×10^{-12} gm
IOD	5	0.25 ppm	Heptachlor	5	4×10^{-12} gm
Oil & Grease	5	10 ppm*	Aldrin	5	4×10^{-12} gm
Kjeldahl N	5	0.2 ppm	Heptachlor Epoxide	5	4×10^{-12} gm
Norg	5	0.2 ppm	Kelthane	5	5×10^{-11} gm
P	4	0.05 ppm	Methoxychlor	5	2×10^{-11} gm
Sulfide	5	2 ppm	Chlordane	5	8×10^{-12} gm
Hg	5	0.001 ppm	Toxaphene	5	1×10^{-10} gm
Pb	1.5	0.05 ppm	Dieldrin	5	4×10^{-12} gm
Zn	0.5	0.005 ppm	DDE	5	3×10^{-12} gm
As	6	0.005 ppm	DDD	5	6×10^{-12} gm
Cd	0.5	0.005 ppm	o, p', DDT	5	8×10^{-12} gm
Ni	1	0.025 ppm	p, p', DDT	5	8×10^{-12} gm
Cu	1	0.02 ppm	Total DDT		--
Fe	0.1	0.2 ppm	Endrin	5	1×10^{-10} gm
Cr	2	0.01 ppm	Others (name)		--

* **Based on 10 grams of dry sediment**

TABLE 3

CONVERSION TABLE

(Metric Units to English Units)

Temperature (Values marked E = exact °F, others rounded)

°C	E	1	2	3	4	5E	6	7	8	9
0	32	34	36	37	39	41	43	45	46	48
10	50	52	54	55	57	59	61	63	64	66
20	68	70	72	73	75	77	79	81	82	84
30	86	88	90	91	93	95	97	99	100	102

Area

1 Hectare	=	2.471	Acres
1 Square Meter	=	1.196	Square Yards
1 Square Meter	=	10.76	Square Feet

Distance

1 Kilometer	=	0.6214	Mile
1 Meter	=	1.094	Yards
1 Meter	=	3.281	Feet
1 Centimeter	=	0.3937	Inch

Volume

1 Cubic Meter	=	1.308	Cubic Yards
1 Cubic Meter (liquid)	=	264.17	Gallons
1 Liter	=	0.2642	Gallons

Pressure

1 Newton/Square Meter	=	0.000148	Pound/Square Inch

Power

1 Kilocalorie	=	3.9685	British Thermal Units (BTU's)

Weight

1 Metric Ton	=	1.1	Short Tons
1 Kilogram	=	2.205	Pounds

Table 4. Description of Stations

MDR-1
1. Located at buoy at east entrance to Marina.
2. Off mouth of Ballona Creek, some protection from breakwater but subject to currents along coast.
3. Subject to discharge from Ballona Creek, especially after rains.
4. Depth 23 ft (7m).

MDR-2
1. At entrance of Marina, midway between the two jetties.
2. Protection by breakwater but subject to currents along coast.
3. Depth 16 ft (5m).

MDR-3
1. Located on west side of main channel in front of tide gate at entrance to the old Venice canal.
2. Protected by jetties and breakwater.
3. Subject to discharge from Venice canal on ebb tides and after rains.
4. Depth 10 ft (3m), variable.

MDR-4
1. At Administration dock on east side of main channel.
2. Subject to heavy boating use.
3. Protected from surge but exposed to strong westerly winds.
4. Depth 16 ft (5m).

MDR-5
1. Located in the center of the main channel.
2. Subject to heavy boating traffic.
3. Depth 16 ft (5m).

MDR-6
1. At very back of Basin B.
2. Protected from winds by concrete sea wall.
3. Depth 10 ft (3m).

MDR-7
1. At work yard dock, back of Basin H.
2. Exposed to afternoon westerly winds.
3. Storm drain opening present.
4. Depth 10 ft (3m).

MDR-8
1. At center buoy outside swimming beach in Basin D.
2. Exposed afternoon winds.
3. Depth 10 ft (3m).

MDR-9
1. At very back of Basin F.
2. Protected by slips and sea wall.
3. Storm drain present.
4. Depth 6.6 ft (2m).

Table 4. (continued)

MDR-10	1. At very back of Basin E. 2. Subject to daily flow from adjacent tide gate from Bird Conservation Area. 3. Subject to storm drain runoff after rains due to Bird Conservation Area. 4. Depth 10 ft (3m).
MDR-11	1. At end of main channel. 2. Storm drain present. 3. Depth 10 ft (3m).
MDR-12	1. On Ballona Creek at Pacific Avenue bridge. 2. Subject to daily discharge along Ballona Creek as well as storm runoff after rains. 3. Depth 10 ft (3m).
MDR-13	1. At tide gate in Bird Conservation Area. 2. Subject to daily flushing via tide gate. 3. Storm drain runoff present after rains. 4. Depth 6 ft (2m).

Depths vary according to tidal stage and due to scouring of shallow bottoms by propellor wash, storm drains or tide gate flow.

SYSTEMS INFLUENCING THE WATER QUALITY OF MARINA DEL REY

OCEANOGRAPHY OF THE SOUTHERN CALIFORNIA BIGHT

The California coastal waters are influenced by the California Current, which flows southward from the Gulf of Alaska, Washington and Oregon carrying remnants of waters from the northward-flowing Japanese (Kuroshio) Current, the northern mid-Pacific gyre(s) and some subarctic waters from the counter-clockwise gyre in the Gulf of Alaska (Reid, 1960).

The water conditions within Marina del Rey are governed by the coastal water regime between the southern California mainland and the Channel Islands, the area called the Southern California Bight. In addition, waters of the marina are affected by solar heating and impacted by storm runoff, some of which enter the slips through large storm drains (Figure 8 , map). Also, runoff from Ballona Creek Flood Control Channel is carried into the marina by tidal exchange or deflected into the marina by the breakwater.

The lower salinity cool water warms gradually as it flows south. The current passes mainly outside the Channel Islands and a series of small, counter-clockwise gyres or eddies develop along the coast (Jones, 1971) which bring northern water to the shores.

The Davidson Countercurrent (undercurrent) moves upcoast from Baja California during the winter months for variable lengths of time and for variable distances. It generally surfaces in the bight south of Pt. Conception but has in some years flowed as far north as Ft. Bragg. The higher salinity tropical water flowing northward in the winter may cause the intermediate and some surface waters to be warmer during November-February than they are in March-May, depending on the strength and duration of the countercurrent (Soule, 1974; Soule and Oguri, 1979a,b).

Marina del Rey opens onto Santa Monica Bay, a broad, relatively shallow and unprotected bay bounded by submarine canyons to the north and south.

Oceanic Temperatures

Water temperatures along the Pacific coast from Neah Bay, Washington to Balboa, California were compiled by Harbors Environmental Projects for the years 1972 through 1978, based largely on Scripps Institute of Oceanography data.

Figures 1 through 7 (Soule and Oguri, 1979b) show that temperatures are usually warmest at Ventura and Santa Monica Bay, but they are lower at Pt. Dume to the north of Santa Monica Bay, and at Los Angeles Harbor, to the south and east. The lower temperatures perhaps indicate areas of upwelling, or the direction of the local shallower water gyres.

Mean temperatures at Santa Monica Bay were warmer in 1976 than they were in 1977 and 1978, although the extreme high temperatures were slightly higher in 1977. North of Morro Bay and Pt. Lobos, waters were cooler in 1976 than in 1977 and 1978. All three years were warmer than the 1972-1975 period, which demonstrates the large-scale variation in coastal ocean temperatures. The data shown are based on annual means.

Marina Annual Mean Temperatures

Temperatures in the marina were measured monthly in the present study, from July 1976 to June 1979, at 1 meter intervals through the water column at 13 stations (Figure 8) using a Martek remote probe. Complete Martek data are presented in Appendix A for reference, beginning in July 1977 (See Soule and Oguri, 1977, for 1976-77 data).

Figures 9, 10 and 11 present yearly averages for 1976-77, 1977-78, and 1978-79, starting each year in July. The legends are given as histograms on the facing page, showing distribution of the means for the 13 stations. Comparisons show that mean temperatures were higher in 1976-77 (Figure 9) than in 1977-78 and were considerably lower in 1978-79.

The warmest area of the marina shifted as well, for it was warmest at the inner end of the main channel (station 11) the first year, in the bird sanctuary (station 13) the second year, and in Slip F (station 9) the third year.

Seasonal Trends

The peak temperature recorded was 23°C in the summer of 1976, in the bird sanctuary (station 13). Locally, seasonality generally falls into natural groups of June, July and August as the summer quarter; September, October and November as autumn; December, January and February as winter; and March, April and May as spring. There are some variations based on when shifts in southern or northern water masses occur, but these groupings have been consistent. Figures 12 to 23 show the seasonal means.

The summer of 1976 (Figure 12) was the hottest of the three years, with six stations showing means in the 22-23°C range, and five in the 21-22°C range. In 1977 (Figure 13) 12 stations fell a degree lower in the 20-22°C range and none were above that. In 1978 the range was wider, between 18.87 and 20.8°C (Figure 14).

Autumn mean temperatures shifted downward to a 19-21° range in 1976 (Figure 15), but that year remained warmer than subsequent years which ranged from 18.13-19.73°C in 1977 (Figure 16) and 18.17-19.70°C in 1978 (Figure 17).

The winter of 1976-77 remained warmer (Figure 18) than normal, with means at most stations in the 16-17°C range, whereas means of all stations were in the 15-16°C range in winter 1977-78 (Figure 19). The 1978-79 winter showed more "normal" mean temperatures in a range of 12.8-14.13°C (Figure 20).

The spring periods seemed to show the most variation (Figures 21-23). After the warmest summer, autumn and winter in 1976, the spring of 1977 was coolest; the range of means was 15.70-18.30°C. In 1978, following intermediate seasonal temperatures the spring was the warmest, with a range of 17.05-20.67°C. And in 1979, following the coldest winter, spring means ranged more narrowly between 16.3 and 18.37°C.

There are thus shifts between mean seasonal highs of about 6-8°C throughout the years and shifts in lows of approximately 4-6°C. Lowest temperatures usually occur in the winter, but in the warmer 1976 the lowest temperatures were in the spring.

The thermal regime is most important to fish species, which receive reproductive cycle cues for food storage and subsequent maturation of eggs and sperm. Without a sufficient cool period, reproduction seems to be impaired in some species. This may also relate to timing of phytoplankton and zooplankton blooms, on which the newly hatched larvae must feed to survive.

Temperature is also related to rainfall and runoff, which can best be noted in salinity variations, discussed below.

<u>Ocean Salinities</u>

Salinities in oceans range between 33 ppt and 37 ppt, with an average of 35 ppt used for convenience (Sverdrup, Johnson and Fleming, 1946). Off southern California they are likely to range from 33.0 to 34.5 ppt.

Marina Annual Mean Salinities

There were distinct differences in the mean annual salinities for the three years, as shown in the histograms (Figures 24-26), since 1976-77 was a dry year, the fifth consecutive year that rainfall in the basin had ranged from 7 inches to 15 in. (Table 1). In contrast, in 1977-78 a total of 37.61 in. fell in the central Los Angeles basin, and in 1978-79 22.63 in. fell (unofficial records by J.D. Soule). Such intensive periods of rainfall create very heavy runoff in the Ballona Creek Flood Control Channel; runoff in turn is deflected into the marina by the breakwater and carried in by tides. (See Table 1, p IIA 136).

The range of mean salinities in the marina in 1976-77 was from 29.69 ppt to 32.64 ppt, but only Ballona Creek (Station 12) showed the lowest of concentrations. In 1977-78, the range of means was 26.22 ppt to 31.02 ppt with the bird sanctuary the lowest and the outer channel the highest. The median was at the 29-30 ppt level. In 1978-79, the range was only slightly higher: 26.89 ppt to 31.38 ppt. All stations in the outer and main channel were in the higher range and Ballona Creek was the lowest, followed by the bird sanctuary. Warmer oceanic waters from the south are generally of higher salinity than cooler, northern waters.

Seasonality

Seasonal salinity patterns are shown in Figures 27-38 for the three year period. The summer of 1976 (Figure 27) showed almost uniformly high salinities, up to 33.5 ppt at most stations. This was a period without rainfall. In contrast, a tropical storm dropped more than 2 in. of rain in August 1977, which created a more varied pattern for that summer (Figure 28). A low of 21.7 ppt occurred in the sancturary, and the other stations clustered between 27.86 and 31.84 ppt. In the summer of 1978 (Figure 29) there was no rainfall and salinity was uniform except in Ballona Creek. The top reading was 30.7 ppt, however, considerably below the 1976 levels, which suggests a pattern of cooler northern waters.

Autumn 1976 (Figure 30) had a range of mean salinities from 30.50 to 32.73 ppt; some 4 in. of rainfall occurred in that period. Since storm runoff can be quite swift, monthly monitoring may not catch the transitory extremes, but a wide range of variation was still evident. In contrast, the range of means in autumn 1977 (Figure 31) was 31.97-33.77 ppt, a period with only 0.1 in. rainfall. Autumn 1978 showed a salinity range of 29.5 to 32.2 ppt, but means at most stations lay between 30.8 and 31.8 ppt.

The winter period showed the most dramatic contrasts. In 1976-77 (Figure 33) mean salinities were uniformly high, up to 34.33 ppt, although there was a storm period in January that was not reflected in the monitoring. The winter quarter of 1977-78 (Figure 34) had more than 23 in. of rain and this is clearly reflected by the range of 16.15-28.20 ppt. The low salinity flow from Ballona Creek is deflected back into the outer marina channel, so that the inner slips have higher salinities than the outer channel. This flow is also a source of debris and pollutants. The winter of 1978-79 (Figure 35) had more than 13 in. of rainfall, but the range of mean salinities was more broad, from 18.53 to 31.2 ppt, and the intrusion of Ballona Creek water seemed not to be as intense as in the previous year. Light rains may cause a freshwater lens to form, but during heavy rains, mixing is more general.

The spring of 1977 reflected most of the rainfall for 1976-77, with a range of 27.87-31.37 ppt (Figure 36). In 1978, although the range was 25.47-30.93 and there were about 9 in. of rainfall, much of the marina was uniform in salinity, in the 29.85-30.85 ppt range (Figure 37). In sharp contrast, the spring of 1979 showed higher salinities, with a range of 31.17-33.40 ppt, the higher values being outside the marina (Figure 38).

Dissolved Oxygen in the Ocean

Along the local open coast, dissolved oxygen (DO) levels generally have ranged between 6.0 and 8.5 ppm, although the saturation point of oxygen is dependent upon temperature and salinity. The presence of phytoplankton aggregations can result in elevated dissolved oxygen levels (Sverdrup et al., 1946), as can turbulent mixing, which may sometimes produce temporarily supersaturated levels. Regulatory agencies such as the State Water Quality Control Board, California Department of Fish and Game and the Environmental Protection Agency have arbitrarily set 5 ppm as the minimum acceptable limit; below about 3 ppm fish show considerable stress, although many invertebrates are capable of withstanding much lower levels.

Most of the dissolved oxygen in the sea is produced by single-celled phytoplankton as a byproduct of photosynthesis. The phytoplankton at times contains certain species which produce a reddish or brownish coloration to the water when a sufficient density of cells (a bloom) is attained. The bloom conditions occurred at times in the 1973-1975 period all along the open coast as well as in harbors and estuaries (AHF, 1976). In subsequent years, only patchy, localized blooms occurred, during which times oxygen will exceed saturation and reach as high as 16 ppm.

Marina Oxygen Levels Annual Means

The maps of annual means of surface values for dissolved oxygen do not give an accurate indication of the episodes of extreme low or high dissolved oxygen. Legends for Figures 39, 40 and 41 show the histograms respectively for July 1976 to June 1977, July 1977 to June 1978, and July 1978 to June 1979. The 1976-77 range of surface means (Figure 39) was 5.69 to 7.27 ppm, whereas in the following year the range was higher, 6.97-8.51; in 1978-79 the range was again low, from 5.58 to 6.99. Comparison with Table 2 shows that there were fewer episodes of low DO in 1977 or 1979 (p IIA 137).

Seasonal Means

In the three years, the summer periods (June, July and August) showed a general progression downward in means; the lows decreased from 7.25 ppm to 5.00 ppm which approaches the regulatory minimum, referred to previously (Figures 42-44).

The three autumn periods (September, October, November) showed ranges of means of 3.27-7.57 ppm in 1976 (Figure 45); levels were much improved to a range of 6.70-9.37 in 1977 (Figure 46) but means were again decreased to 3.30-6.40 in 1978 (Figure 47).

The winter periods (December, January and February) differed considerably (Figures 48-50) with 1976-77 showing a very low range of means of 2.20-5.70 ppm, while the 1977-78 range was high, 6.15-9.33 ppm. Mean levels in 1978-79 were intermediate, between 4.37 and 7.17 ppm. It is of course possible that monthly monitoring was not sufficiently frequent to show potentially greater short-term variation.

The spring periods, like the summers, were characterized by high means, but the means and extremes of means shifted downward over the three year period (Figures 51-53).

Anomalous Patterns

Examination of the raw data in Soule and Oguri (1977) and in Appendix A of the present volume reveals some anomalous patterns wherein DO's were much higher, well above saturation, near the bottom rather than in the surface waters. This was particularly evident during the winter of 1977-78 during and after heavy rains, and also in August 1978, when 16.4 ppm was encountered at station 1. A similar pattern was seen in April 1979.

These patterns were not similar to those seen in the high-COD storm waters that flushed the marina in the winter of 1976-1977, which constituted the first heavy flushing of the urban area for several years, nor in the winter rains of 1978-79.

As reported in Soule and Oguri (1977), dissolved oxygen (DO) levels in July and August 1976 were near saturation and a bloom was beginning. However in September a tropical storm brought heavy rains to the Los Angeles basin, the early opening of a rainy season following four years of low rainfall or actual drought. The DO levels were near zero in the bird sanctuary and below 4 ppm in many slips.

Substantial rainfall continued from September 1976 through January 1977 and DO continued to be depressed through February 1977 (Table 2).

Chemical oxygen demand (COD) in runoff waters measured during and after another storm in March 1977 showed very high COD levels (172-204 ppm) but the marina had apparently been flushed of the dry weather build-up and DO values were not extremely low. It may be significant that phytoplankton blooms followed in April and May 1977 (See Section IIIA on Phytoplankton Productivity).

The causative factors for triggering blooms have often been thought to be associated with terrestrial runoff, and this may be one possibility. However, in July and August 1976, strong blooms occurred near the entrance of the marina, and very little rain had fallen prior to that.

In 1977, substantial rains fell in May and August; DO's were depressed in August - September at stations 10 and 11 and were extremely low at station 13, the bird sanctuary. High DO's indicative of blooms occurred patchily throughout the winter 1977-78 but no further extreme lows were observed. A general bloom occurred in April, with some low DO's in May, and an outer marina bloom occurred in August.

Low DO's occurred in September-December 1978, coincident with the rainy season. In January 1979, a general bloom occurred but few low DO's were observed except for one very low reading at station 8.

Conclusions cannot be based on monthly data alone; it is possible to miss many episodes of low or high DO unless monitoring takes place at least twice a week. However, special tests carried out before, during and after rainfall -- especially rainfall that occurs after a prolonged dry spell -- show that clearly depression in oxygen levels may occur. Oxygen readings were always taken in the morning hours.

Because the marina receives an influx of storm waters from Ballona Creek, as well as through five major storm drains, the marina is completely vulnerable to the impacts of rapidly changing salinities and oxygen depletion. The low circulation in slips also encourages the build-up of patchy phytoplankton blooms, which first create excess oxygen and then deplete dissolved oxygen when the bloom dies and bacteria biodegrade the phytoplankton cells.

Hydrogen Ion Concentration (pH)

Marine pH

The usual range of pH encountered in the open sea is about 7.5 to 8.4 (Sverdrup et al., 1946); the higher values occur near the surface and in areas of photosynthetic activity. Higher pH values may be found in bays and estuaries, due to phytoplankton utilization of CO_2. Lower values below 7.0 may be found associated with anoxic sediments where H_2S is produced.

Marina pH patterns

The marina had several periods where pH values were higher then 8.5. This occurred in October 1977 through much of the marina, as well as occurring consistently in parts of the marina in January-May 1979 (See Table 3, p IIA 138). Intensive phytoplankton growth in the spring of 1979 may have been a factor in elevating pH, but in other periods, no blooms were present. From August 1976 through January 1977, pH was low (below 8.0) throughout the marina, and coincided with extensive low dissolved oxygen values (below 5 ppm).

In October 1977, pH was high (above 8.5) in all but the outer stations, where very high DO's occurred (above 9 ppm). Conversely in November 1977 and January 1978 low pH occurred throughout the marina but high DO's occurred in November-December 1977 and in February and April, 1978. The high DO's were frequently confined to the deeper waters, especially in April 1978, as mentioned above. These periods were not characterized by high productivity which was measured in surface samples only. It is difficult to explain these complex interactions of physical and biological properties. Excessively high air temperatures were recorded, along with a heavy and lengthy rainy season and extreme variability and salinity.

Patterns subsequently changed, with both high pH and high DO's characterizing January-February 1979 and April 1979.

Annual Means

Annual pH means are shown for the three years in Figures 54-57. There are small differences among them, with 1977-78 having the lowest range of 7.93-8.08, and 1978-79 the highest, mostly in the 8.18-8.30 range.

Seasonal Means

Of the summer seasons (Figures 57-59), 1976 showed the lowest means. The ranges were not very different, however.

The autumn seasons differed, with the lowest range of means in 1976 of 7.73-8.04 (Figure 60); the range in 1977 was widest and highest, from 7.87-8.37 (Figure 61), and in 1978 it was 7.83-8.19 (Figure 62).

The winter seasons shifted patterns somewhat, with 1976-77 (Figure 63) showing a range of means of 7.85-8.11. Whereas pH means were highest in Autumn 1977, they were lowest in the winter 1977-78 (Figure 64). A shift to higher pH values occurred in the winter of 1978-79 (Figure 65) which was similar to spring values.

The spring period in 1977 (Figure 66) showed high mean values of 8.23-8.34. In 1978, the spring range was 8.07-8.22 (Figure 67). The spring of 1979 was anomalous, with a range of 7.67-8.76 but most stations were above 8.3.

Periods of low pH may reflect stirring of the bottom during the winter and possible release of H_2S from decay of organic detritus, the reduction in salinity from runoff, low phytoplankton levels, or other, unrecognized, conditions.

Pollutants

Storm Water Runoff

Oil and Grease. Oil and grease from surface streets is washed into the marina during heavy rains, contributing to the impact of such non-point source flow. The freshwater influx alone will physically carry some animals out of their habitats in the basins and channels, leaving the areas temporarily depauperate. While many intertidal and subtidal species are euryhaline and can tolerate sudden changes in salinity, the fact that the marina is entirely of marine salinity in summer will lead to departure or death of stenohaline species during winter runoff.

The pollutant loadings vary with the length of the preceding dry period and the flow rate of runoff. Total oil and grease were measured in water samples during three consecutive storms, on December 28, 1977, January 12, 1978 and Febraury 6, 1978. Concentrations on the first date ranged from 0.32 to 2.64 ppm; on the second date the range was 0.957 to 2.127 ppm; while on the third date the range was 0.311 to 2.25 ppm. The mean dropped from 1.341 to 0.024 ppm (Table 4). However, the distribution pattern changed considerably, with concentrations increasing at the storm drains in Basin E (station 10) and Basin H (station 7) but decreasing at most other stations sampled (p IIA 139).

Chlorinated Pesticides. The level of chlorinated hydrocarbons were found to be below detection limit during the storm-water runoff in one liter water samples taken in the marina basins. Examination of Los Angeles County Flood Control data from water samples taken in Ballona Creek at Sawtelle Blvd. showed the presence of several chlorinated hydrocarbons (Table 5) but there were no indications that these were carried back into the marina in detectable concentrations. Table 2 in Section I, p 9 gives limits of detection for USC analyses carried out in the Environmental Engineering laboratories.

Trace Metals. Data from two sampling periods is presented in Table 6 (p IIA, 141), comparing water samples from the marina following a one-day tropical storm in August 1977 and water samples taken at the end of December 1977, following a week of rainfall.

Arsenic levels were similar in waters throughout the marina in August 1977 with a range of 0.002 to 0.004 ppm. They increased by an order of magnitude at stations 1 and 2 at the mouth of Ballona Creek and at the storm drain, station 7, in December.

Cadmium was lowest at the entry with 0.0001 ppm at stations 1 and 2, on Ballona Creek (station 12) and at station 8, and ranging up to 0.0004 ppm at stations 4 and 11 on the main channel, reaching 0.0009 ppm in the bird sanctuary, station 13, in August 13. In December, levels increased about an order of magnitude at the entrance, but were still an order of magnitude below the levels found by the Los Angeles County Flood Control District in Ballona Creek at Sawtelle Boulevard near the San Diego Freeway, about four miles inland (data courtesy of Mr. John Mitchell, LACyFCD).

Chromium levels were highest in August 1977 at stations 1 through 4 and station 12, suggesting the external source of Ballona Creek. Largest increases occurred at stations 1, 2, 6 and 7 in December, where amounts were similar to the Ballona Creek level. The August range was 0.007 to 0.014 ppm; in December the range was 0.014 to 0.048 ppm, with 0.03 ppm in the creek.

Iron levels were lowest in August at stations 8, 9 and 10, and the range was from 0.007 to 0.017 ppm. The anomalous pattern indicated an increased of up to three orders of magnitude at the creek mouth, station 1. Yet the LACyFCD data showed only 0.07 ppm while the range in the marina was from 0.22 to 19.40 ppm. The storm drain station 7 was high also.

Mercury levels ranged from being not detectable at nine stations to 0.0001 ppm at the entry and storm drain in August. It increased to being detected at all stations sampled in December with a range of 0.0031 ppm to 0.0056 ppm. This was similar to the LACyFCD data. Highest levels were at stations 1 and 6.

Manganese levels ranged from a low of 0.10 at the creek mouth to 0.9 ppm at stations 4 and 12 in August. Levels increased in December at station 1 but decreased at all other stations measured, by about an order of magnitude in some sites. The LACy readings were an order of magnitude lower in December, suggesting flushing had taken place.

Nickel levels were uniformly low in August, ranging from 0.001 to 0.0002 ppm. Increases were highest at the entry and station 8, and lowest at stations 4, 5 and 7, with a range of 0.008 to 0.020 ppm. The LACy reading was 0.03 ppm.

Lead levels were fairly uniform in August, ranging from 0.003 ppm at stations 10 and 13 to 0.005 at stations 5, 7 and 11. Increases in lead occurred at all stations sampled in December with a range of 0.008 to 0.070 ppm, an order of magnitude at most stations. The greatest increases were at stations 1 and 2.

Zinc levels were low in August 1977, ranging from 0.0001 ppm at the entry, station 2, to 0.0045 ppm at station 13, a wide range. Levels were about an order of magnitude higher at all stations other than stations 1, 2 and 3. Significant increases of up to 3 orders of magnitude occurred in December at stations 1, 2 and 3 and about two orders of magnitude elsewhere. The LACy levels in the creek were 0.23 ppm, similar to stations 1 and 2, and the lowest was 0.145 ppm.

Levels of sediment pollutants were discussed in Soule and Oguri (1977) and in Section IIB of the present report.

Discussion and Conclusions

Since the general oceanic regime governs the marina waters in terms of large-scale, seasonal and annual temperatures, it accordingly governs the species carried into the marina for colonization. However, the effects of rainfall and urban runoff and the associated pollutant burden appear to have more impact on the marina environment. Intertidal and subtidal inshore organisms have been historically selected in favor of those capable of withstanding a great deal of natural variation in temperature and salinity. The widespread channelizing of large volumes of water through the urban area have led to much faster runoff, more debris and heavier pollutant loads, which impact the organisms rapidly; there is less percolation of rain into soil for slower, longer-term drainage to maintain more uniform salinities.

The data suggest that the associated increased chemical and biological oxygen demand results in decreased dissolved oxygen during or after most rainstorm episodes.

Heavy metal concentrations increased in the water column following heavy rainfall runoff, except for manganese which increased only at station 1. The increases may reflect a combination of increased stirring of contaminated sediments and the loadings in Ballona Creek and the storm drains. Table 7 shows the changes in range and the change in patterns of concentrations to reflect the creek and marina entry (station 1 and 2, and the storm drain at station 7).

It is unfortunate that more metals and pesticide and analyses could not be carried out due to lack of funds available. It was strongly recommended that some EPA-SCAG funds for non-point source be directed to this area because drainage patterns can be well identified, but this was not done.

It is difficult to determine, on the basis of such few samplings, whether marina activities contribute significantly to heavy metals contaminations. Only chromium and iron appeared to occur at higher levels in the marina than were recorded in the Los Angeles County Flood Control data from Ballona Creek and Sawtelle Blvd. in the only comparable period.

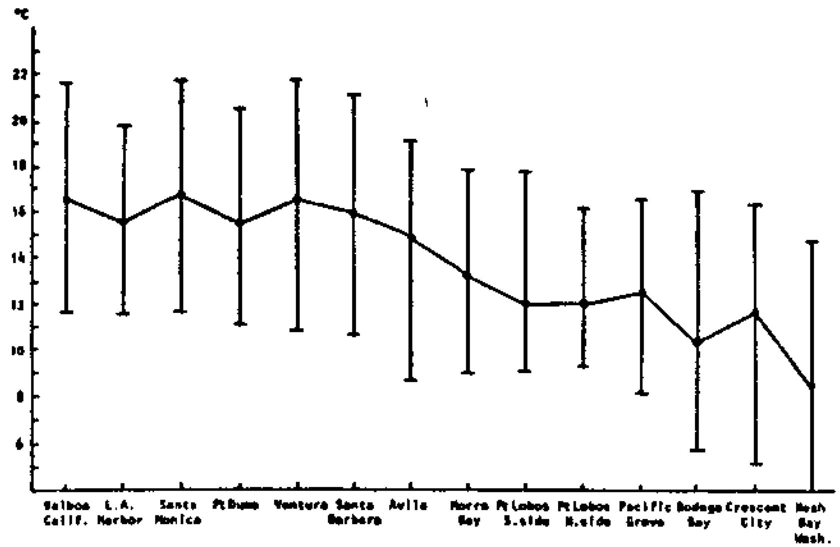


FIGURE 1. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1972.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

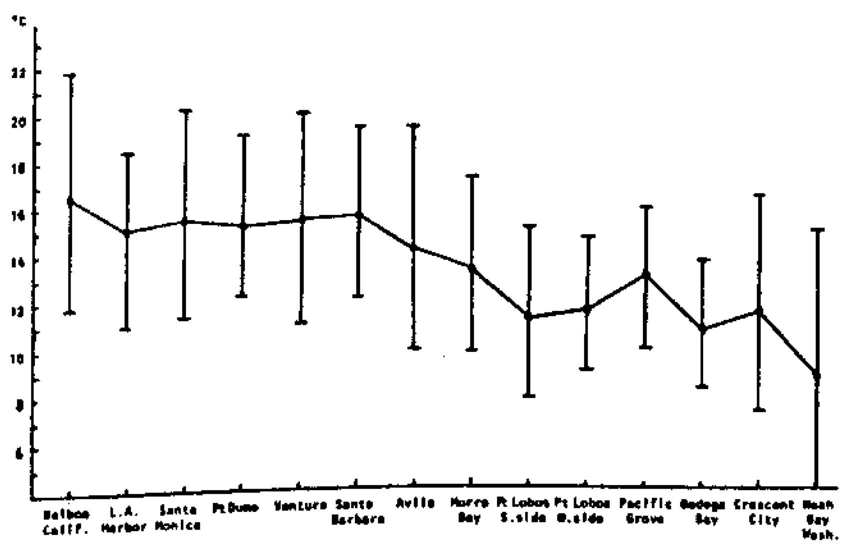


FIGURE 2. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1973.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

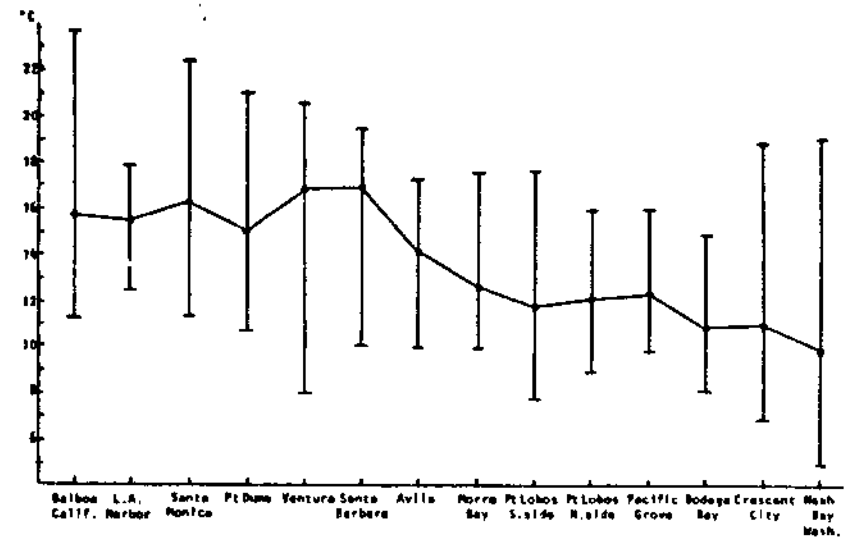


FIGURE 3. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1974.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

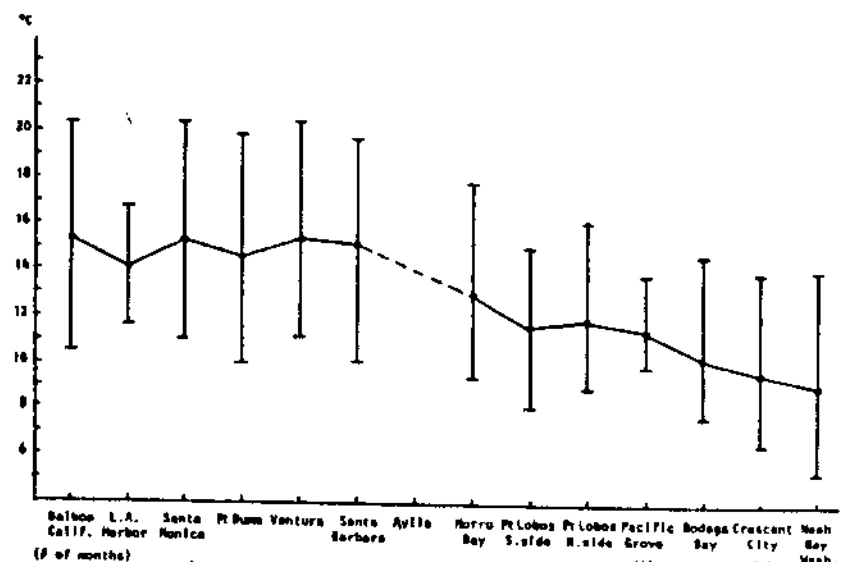


FIGURE 4. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1975.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

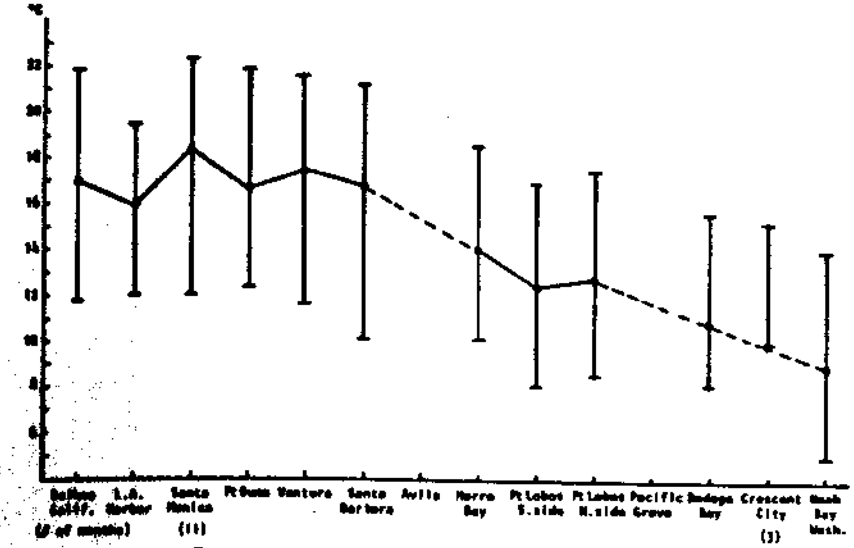


FIGURE 5. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1976.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

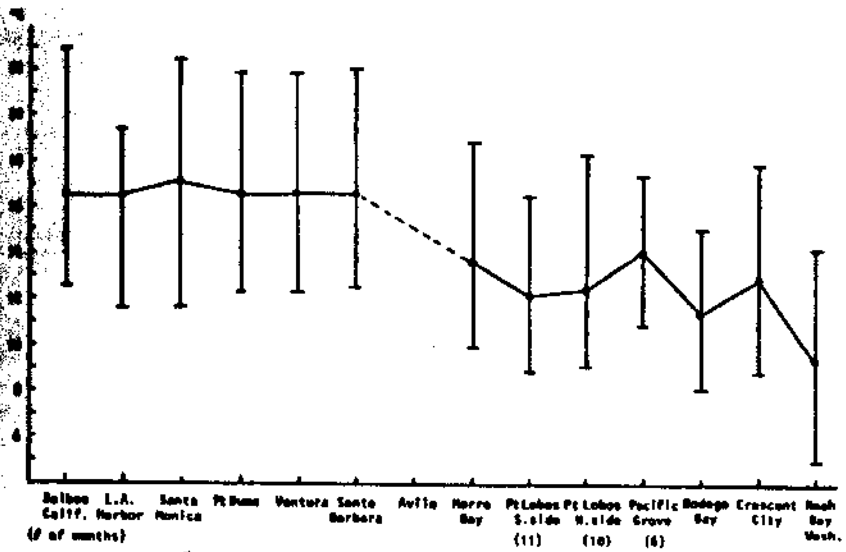


FIGURE 6. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1977.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

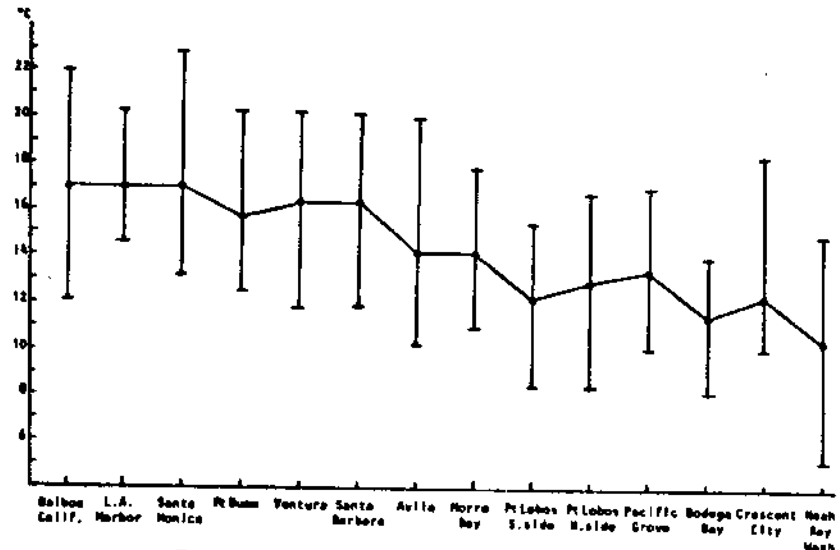


FIGURE 7. ANNUAL HIGH, LOW AND MEAN SURFACE WATER TEMPERATURES, EASTERN PACIFIC STATIONS, 1978.
(LA Harbor, HEP Sta A1; all other data courtesy SIO)

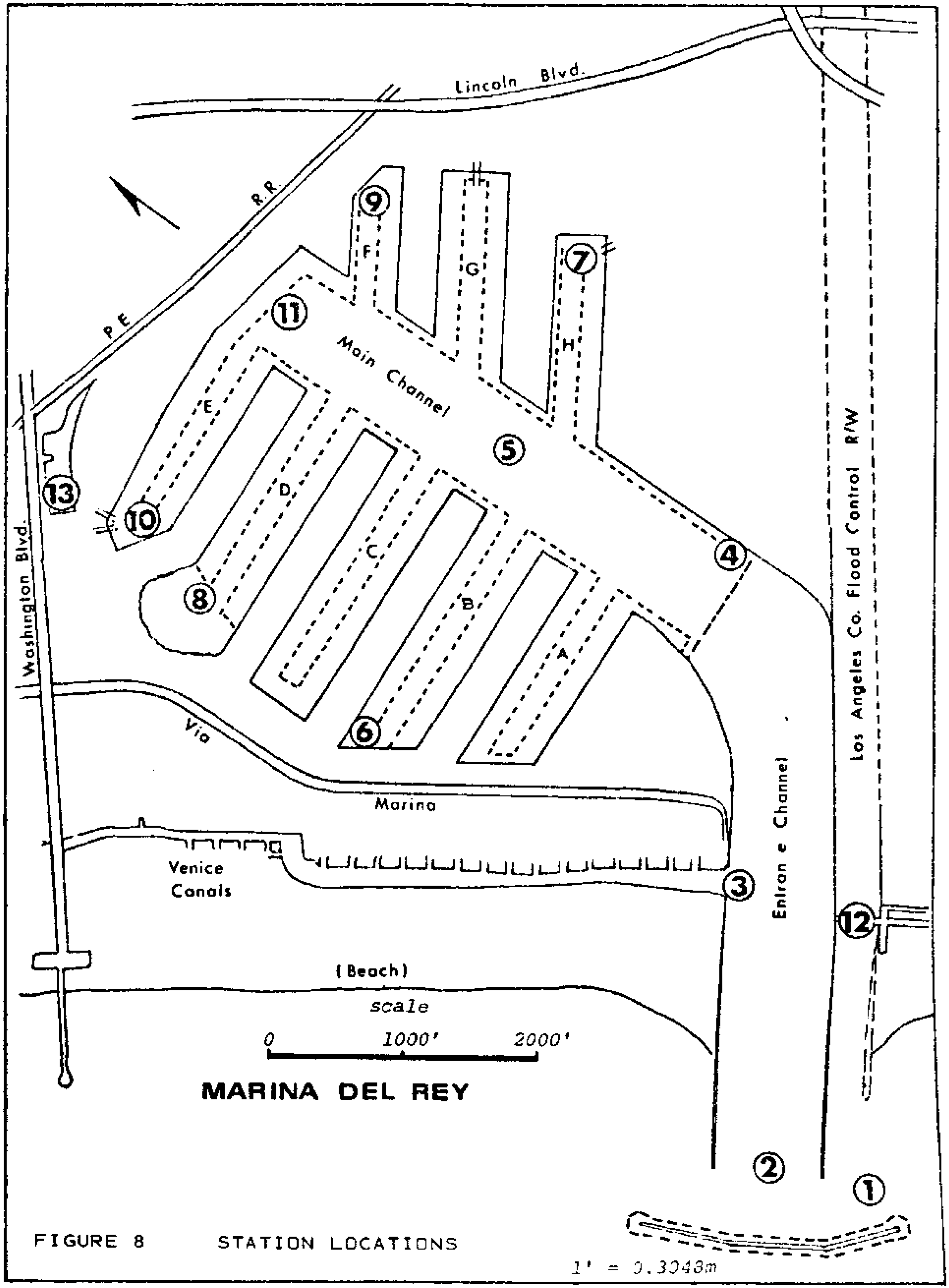


FIGURE 8 STATION LOCATIONS

1' = 0.3048m

FIGURE 9 LEGEND

TEMPERATURE -- YEARLY AVERAGE
1976 - 1977

DATA VALUE EXTREMES ARE 17.93 19.52

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	16.25	16.93	17.42	18.00	18.29	18.88	19.46
MAXIMUM	16.25	16.93	17.42	18.00	18.29	18.88	19.46	19.65

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

81.86	3.43	2.45	2.94	1.47	2.94	2.94	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8
         =========================================================================================
         .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########  #########
         .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########  #########
SYMBOLS  ....1....  ''''2''''  ++++3++++  XXXX4XXXX  000050000  @@@@6@@@@  ####7####  ####8####
         .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########  #########
         .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########  #########
         =========================================================================================
FREQ.        0          0          0          1          1          6          4          1
     1                                   IXX4XXI    I00500I    I@@6@@I    I##7##I    I##8##I
     2                                                         I@@6@@I    I##7##I
     3                                                         I@@6@@I    I##7##I
     4                                                         I@@6@@I    I##7##I
     5                                                         I@@6@@I
     5                                                         I@@6@@I
```

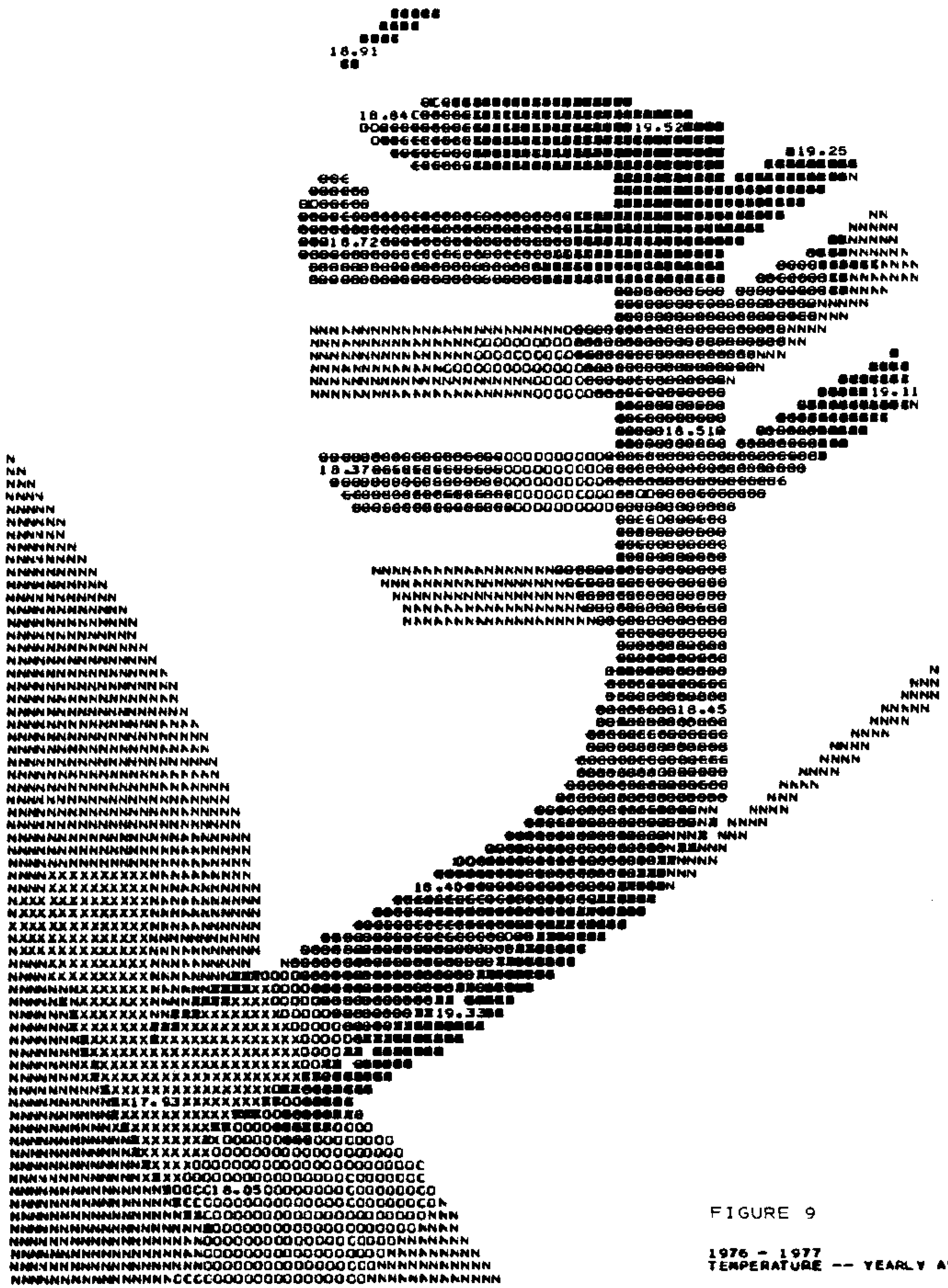


FIGURE 9

1976 - 1977
TEMPERATURE -- YEARLY AVERAGE

FIGURE 10 LEGEND

TEMPERATURE -- YEARLY AVERAGE
1977 - 1978

```
DATA VALUE EXTREMES ARE        17.58        19.85


ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
      ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

  MINIMUM      0.0     16.25     16.93     17.42     18.00     18.29     18.88     19.46
  MAXIMUM    16.25     16.93     17.42     18.00     18.29     18.88     19.46     19.85

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

             81.86      3.43      2.45      2.94      1.47      2.94      2.94      1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
  LEVEL          1         2         3         4         5         6         7         8
             ------------------------------------------------------------------------------
             .........  '''''''''  +++++++++ XXXXXXXXX 000000000 ######### ######### #########
             .........  '''''''''  +++++++++ XXXXXXXXX 000000000 ######### ######### #########
  SYMBOLS    ....1....  ''''2''''  ++++3++++ XXXX4XXXX 000050000 ####6#### ####7#### ####8####
             .........  '''''''''  +++++++++ XXXXXXXXX 000000000 ######### ######### #########
             .........  '''''''''  +++++++++ XXXXXXXXX 000000000 ######### ######### #########
             ------------------------------------------------------------------------------
  FREQ.          0         0         0         2         2         4         4         1
           1                             [XX4XX]   I00500I   I##6##I   I##7##I   I##8##I
           2                             [XX4XX]   I00500I   I##6##I   I##7##I
           3                                                 I##6##I   I##7##I
           4                                                 I##6##I   I##7##I
```

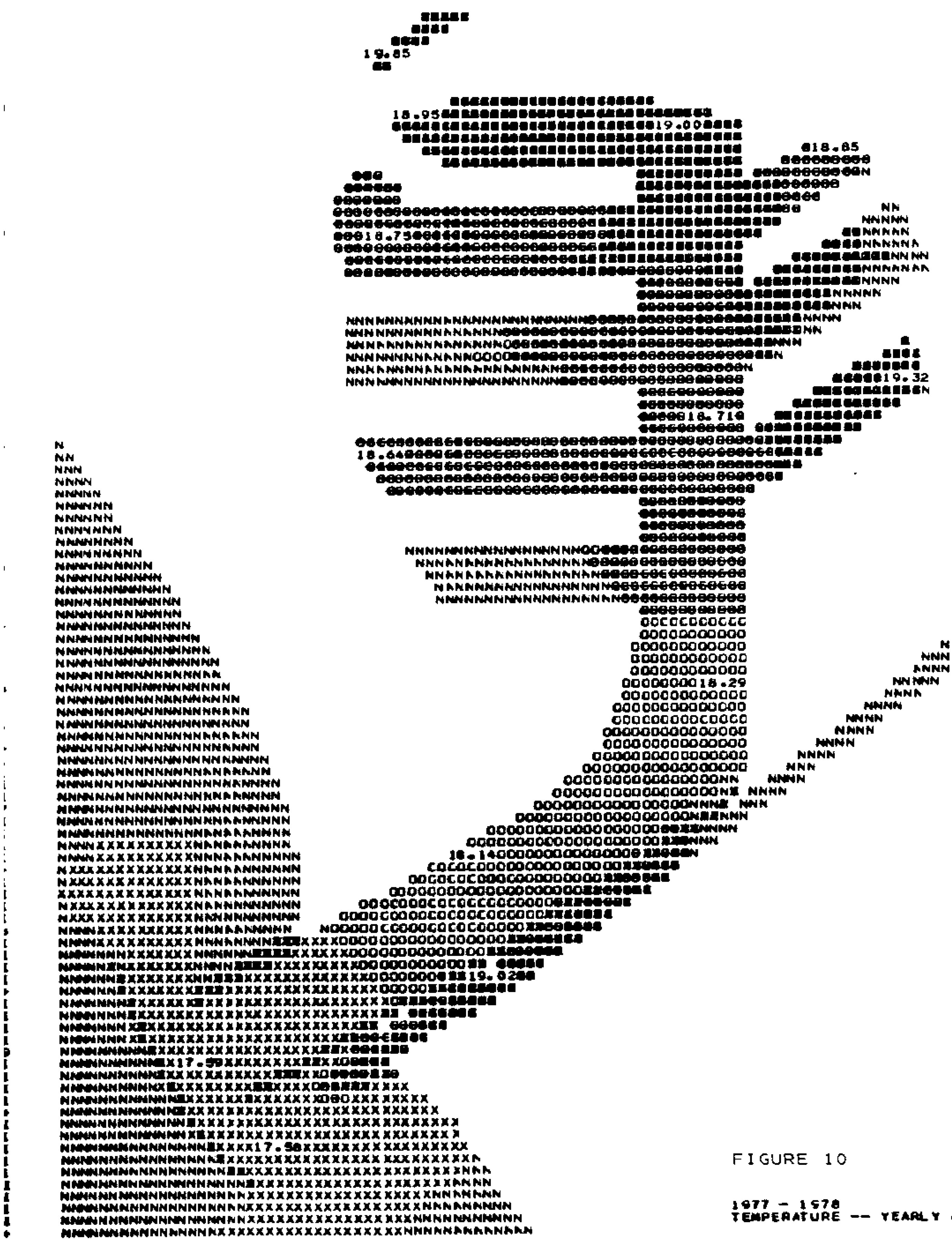


FIGURE 10

1977 - 1978
TEMPERATURE -- YEARLY AVERAGE

FIGURE 11 LEGEND

TEMPERATURE -- YEARLY AVERAGE
1978 - 1979

DATA VALUE EXTREMES ARE 16.70 18.40

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	16.25	16.93	17.42	18.00	18.29	18.88	19.46
MAXIMUM	16.25	16.93	17.42	18.00	18.29	18.88	19.46	19.85

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

81.86	3.43	2.45	2.94	1.47	2.94	2.94	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8
         ==========================================================================================
          .........  '''''''''  +++++++++  XXXXXXXXX  CCOOOCOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOCOOOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOO5COOO  @@@@6@@@@  @@@@7@@@@  @@@@8@@@@
          .........  '''''''''  +++++++++  XXXXXXXXX  CCOCOOOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOCOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
          .........
         ==========================================================================================
FREQ.        0          2          2          4          2          3          0          0
     1               I''2''I    I++3++I    IXX4XXI    IOO5OOI    I@@6@@I
     2               I''2''I    I++3++I    IXX4XXI    IOO5OOI    I@@6@@I
     3                                     IXX4XXI               I@@6@@I
     4                                     IXX4XXI
```

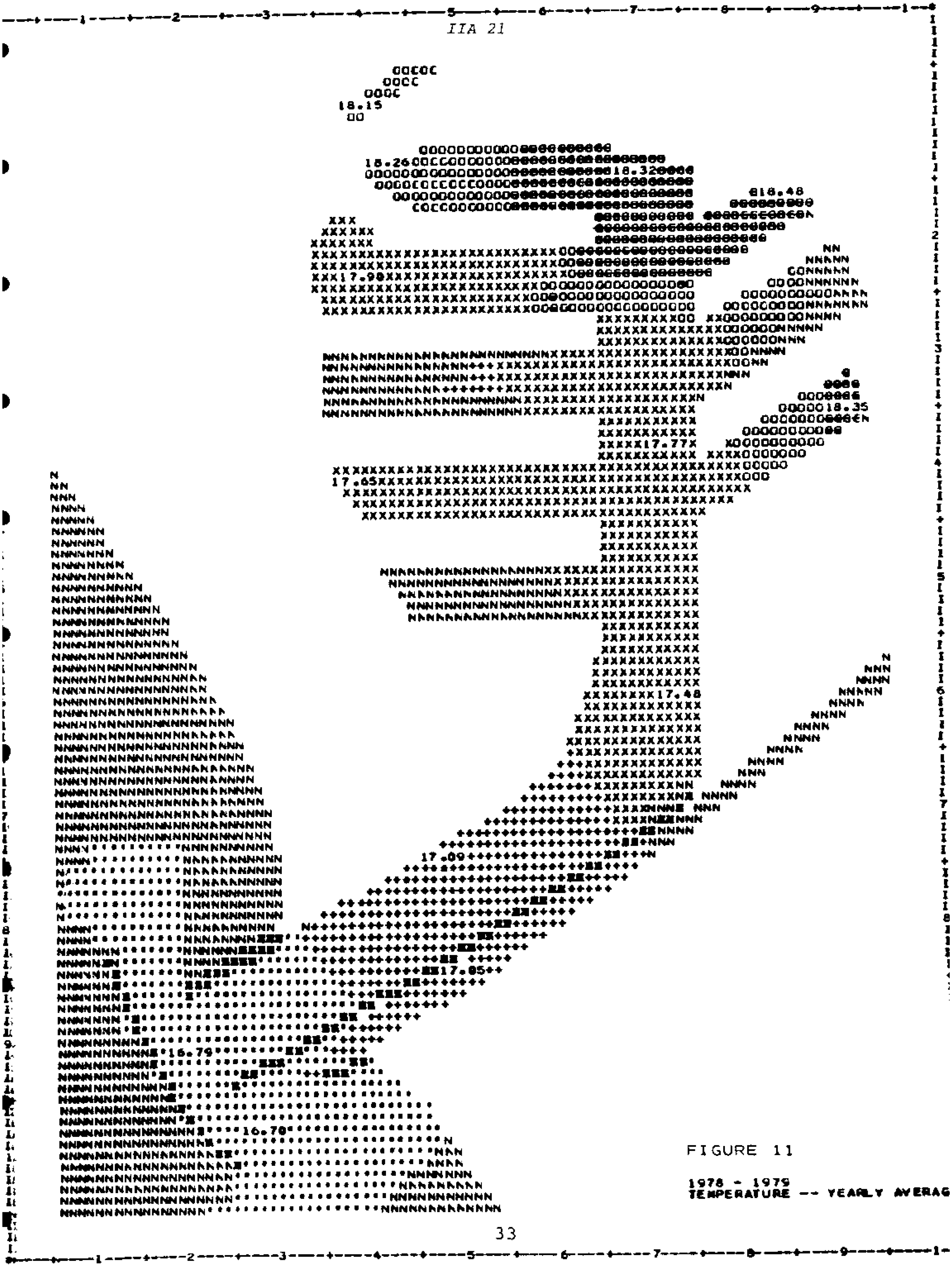


FIGURE 11

1978 - 1979
TEMPERATURE -- YEARLY AVERAG

FIGURE 12 LEGEND

AVERAGE TEMPERATURE: DEGREES C
SUMMER 1976

DATA VALUE EXTREMES ARE 20.30 23.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

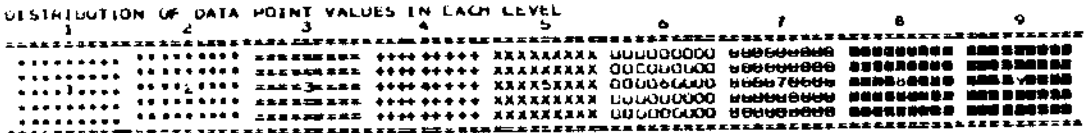
PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9

SYMBOLS



FREQ.	0	0	0	0	0	0	2	5	6

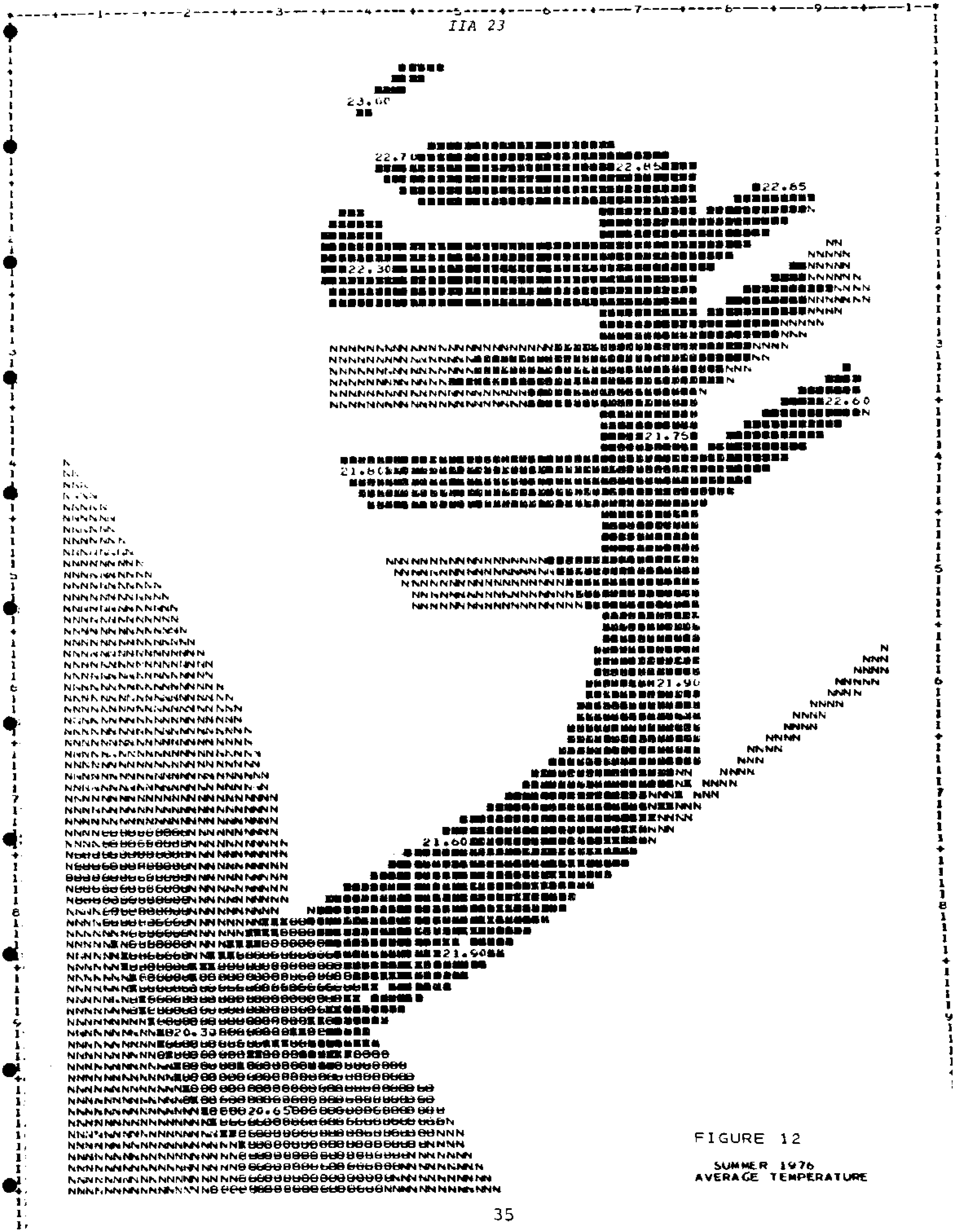


FIGURE 12

SUMMER 1976
AVERAGE TEMPERATURE

FIGURE 13 LEGEND

AVERAGE TEMPERATURE: DEGREES C
SUMMER 1977

DATA VALUE EXTREMES ARE 19.82 21.98

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.05	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

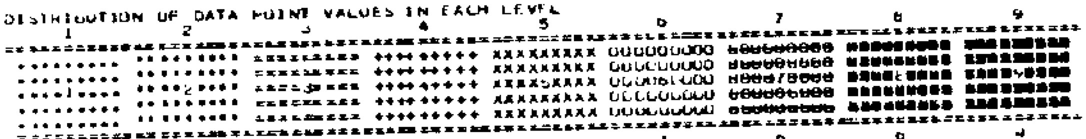
LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS									
FREQ.	0	0	0	0	0	1	6	6	4

FIGURE 13

SUMMER -- 1977
AVERAGE TEMPERATURE

FIGURE 14 LEGEND

AVERAGE TEMPERATURE; DEGREES C
SUMMER 1978

DATA VALUE EXTREMES ARE 18.87 22.80

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■	■■■■■■■■■
FREQ.	0	0	0	0	1	2	2	6	2

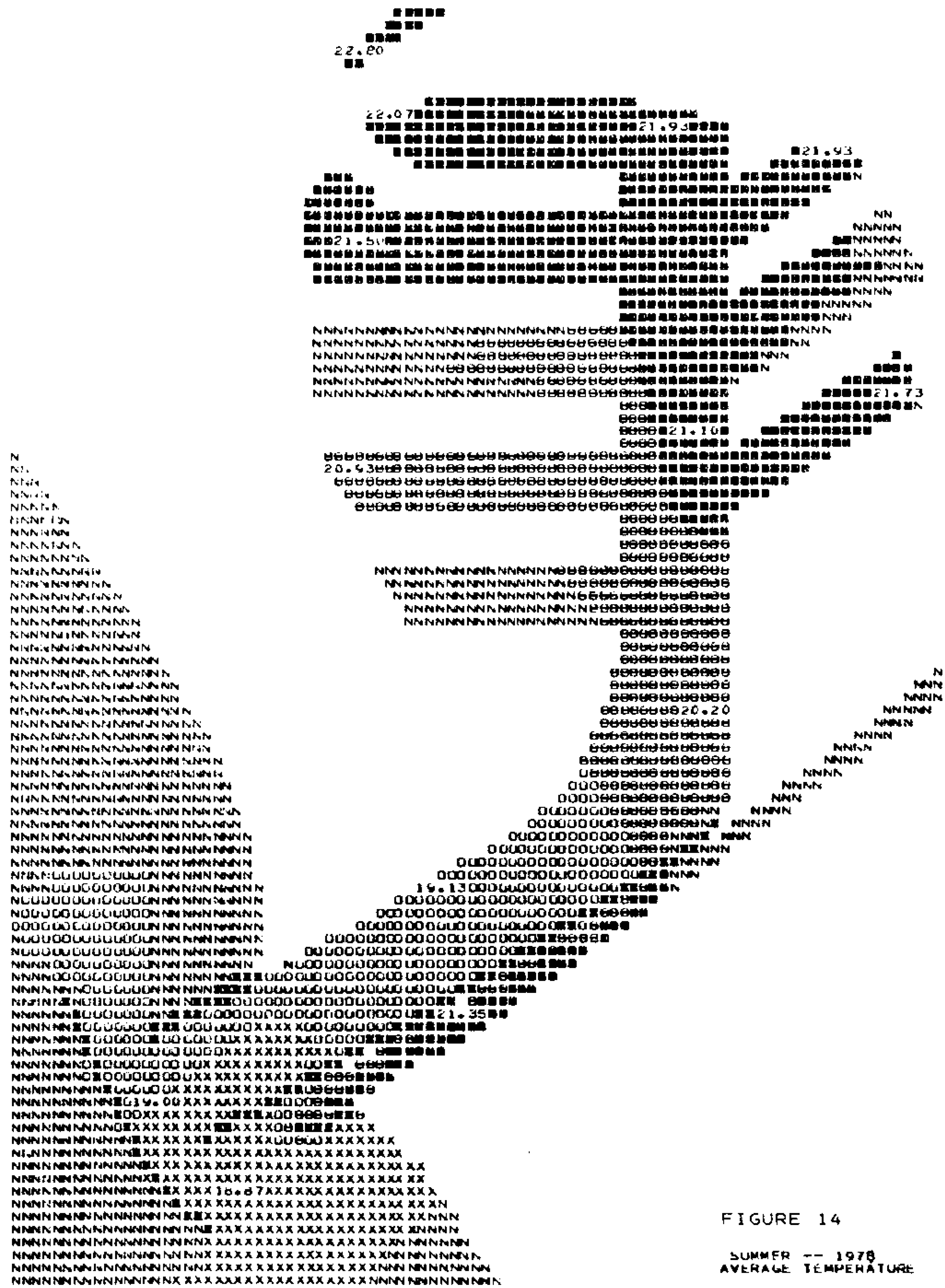


FIGURE 14

SUMMER -- 1978
AVERAGE TEMPERATURE

FIGURE 15 LEGEND

AVERAGE TEMPERATURE: DEGREES C
AUTUMN 1976

DATA VALUE EXTREMES ARE 19.33 20.87

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	.	'	=	+	X	O	Ø	▪	■
FREQ.	0	0	0	0	0	6	7	0	0

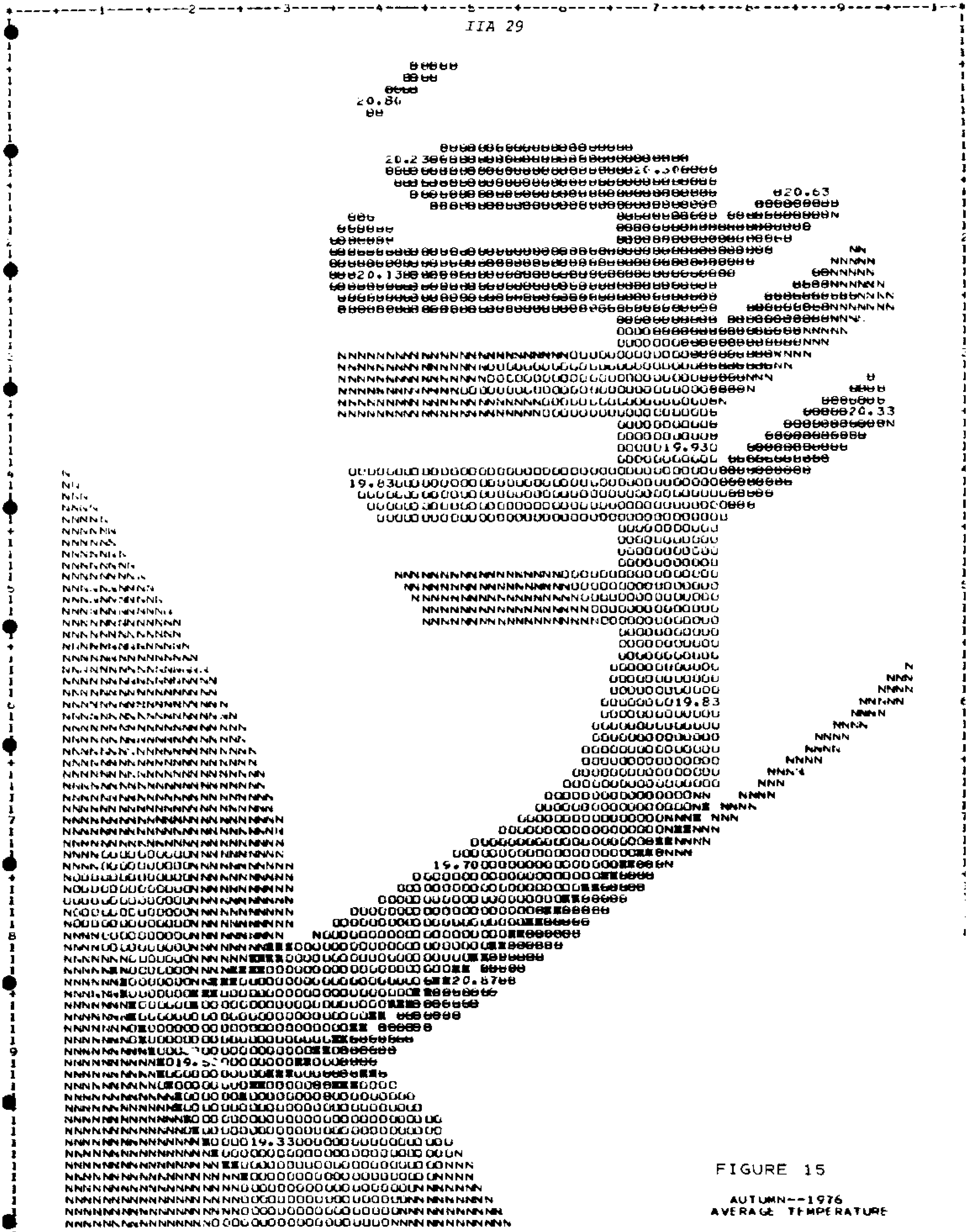


FIGURE 15

AUTUMN--1976
AVERAGE TEMPERATURE

FIGURE 16 LEGEND

AVERAGE TEMPERATURE: DEGREES C
AUTUMN 1977

DATA VALUE EXTREMES ARE 18.13 19.73

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9
MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1	2	3	4	5	6	7	8	9
65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	.....	'''''	=====	+++++	XXXXX	OOOOO	ØØØØØ	■■■■■	■■■■■
FREQ.	0	0	0	0	4	9	0	0	0
1					IXX5XXI	IOO6OOI			
2					IXX5XXI	IOO6OOI			
3					IXX5XXI	IOO6OOI			
4					IXX5XXI	IOO6OOI			
5						IOO6OOI			
6						IOO6OOI			
7						IOO6OOI			
8						IOO6OOI			
9						IOO6OOI			

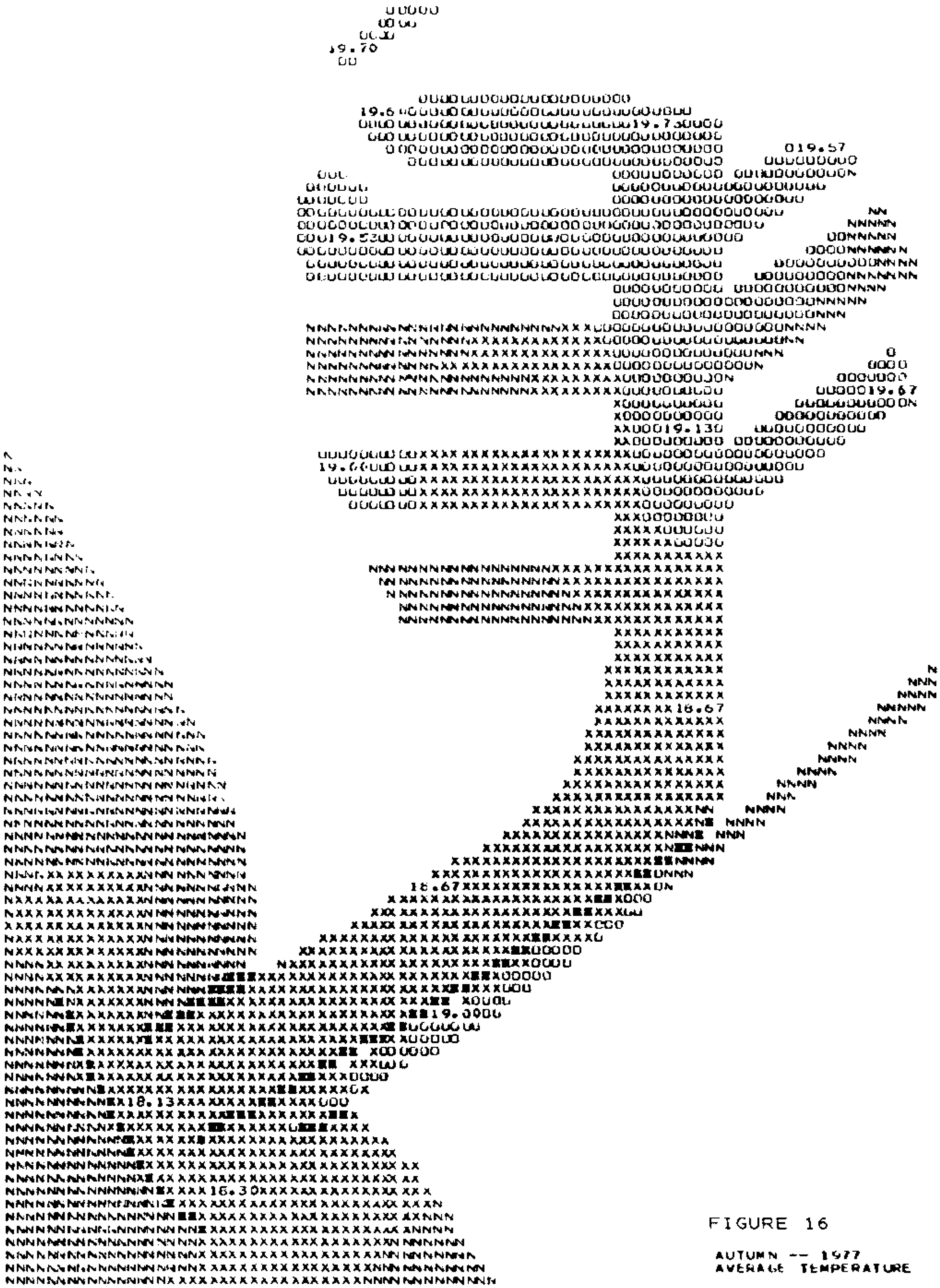


FIGURE 16

AUTUMN -- 1977
AVERAGE TEMPERATURE

FIGURE 17 LEGEND

AVERAGE TEMPERATURE: DEGREES C
AUTUMN 1978

DATA VALUE EXTREMES ARE 18.17 19.70

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	■■■■8■■■■	■■■■9■■■■
FREQ.	0	0	0	0	5	8	0	0	0

```
            5          8
1        IXX5XXI    IOO6OOI
2        IXX5XXI    IOO6OOI
3        IXX5XXI    IOO6OOI
4        IXX5XXI    IOO6OOI
5        IXX5XXI    IOO6OOI
6                   IOO6OOI
7                   IOO6OOI
8                   IOO6OOI
```

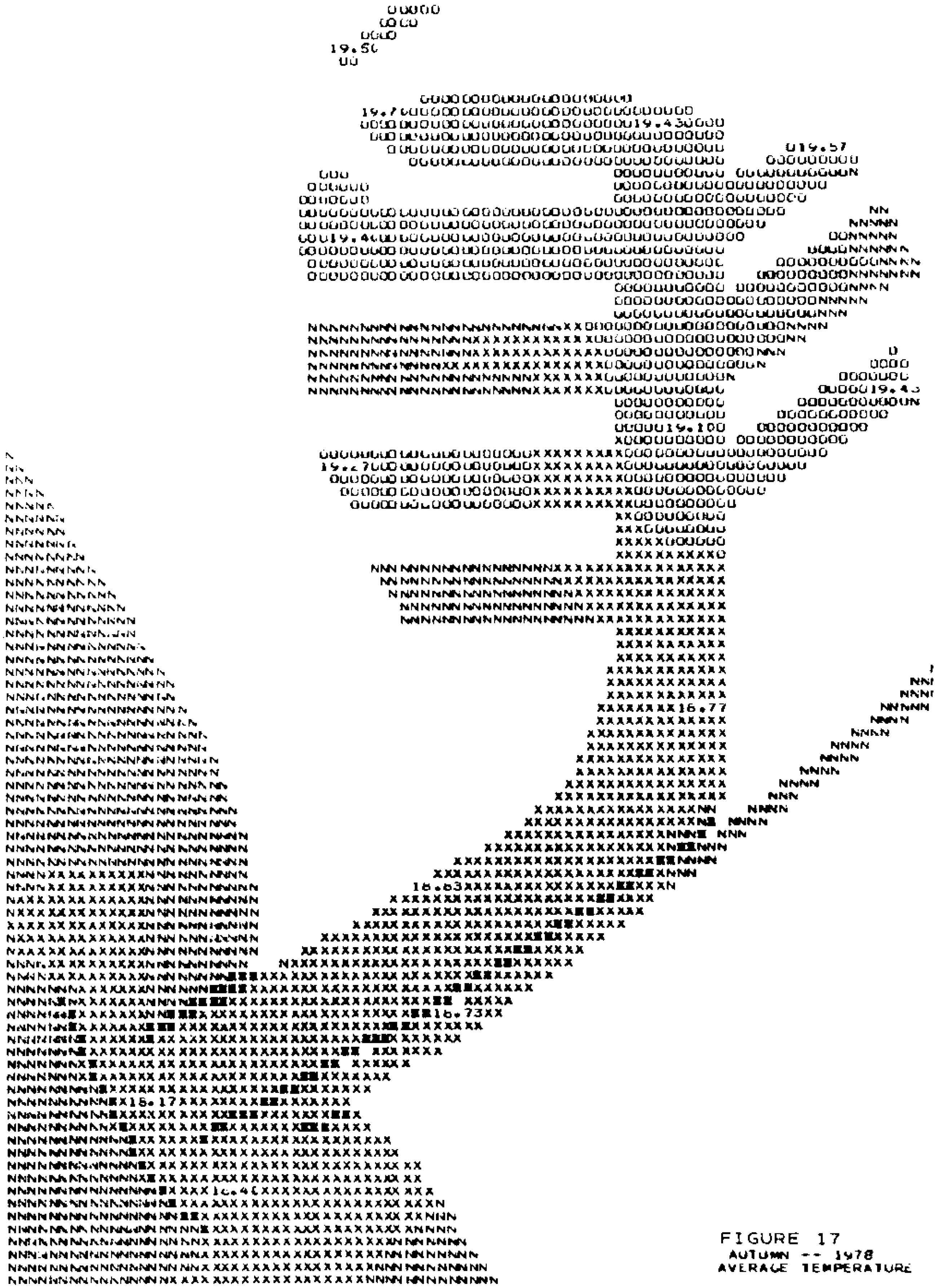


FIGURE 17
AUTUMN -- 1978
AVERAGE TEMPERATURE

FIGURE 18 LEGEND

AVERAGE TEMPERATURE: DEGREES C
WINTER 1976-1977

DATA VALUE EXTREMES ARE 15.97 18.25

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1         2         3         4         5         6         7         8         9
          ------------------------------------------------------------------------------------------
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  888888888  #########  #########
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  888888888  #########  #########
SYMBOLS   ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  8888788888  ####8####  ####9####
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  888888888  #########  #########
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  888888888  #########  #########
          ------------------------------------------------------------------------------------------
FREQ.        0         1         9         2         1         0         0         0         0
```

```
      1              I''2''I   I==3==I   I++4++I   IXX5XXI
      2                        I==3==I   I++4++I
      3                        I==3==I
      4                        I==3==I
      5                        I==3==I
      6                        I==3==I
      7                        I==3==I
      8                        I==3==I
      9                        I==3==I
```

FIGURE 18

WINTER -- 1976-1977
AVERAGE TEMPERATURE

FIGURE 19 LEGEND

AVERAGE TEMPERATURE: DEGREES C
WINTER 1977-1978

DATA VALUE EXTREMES ARE 15.60 15.90

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.01	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL          1          2          3          4          5          6          7          8          9
          =========================================================================================================
           ......... ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO 888888888 ######### ■■■■■■■■■
           ......... ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO 888888888 ######### ■■■■■■■■■
SYMBOLS    ....1.... ''''2'''' ====3==== ++++4++++ XXXX5XXXX OOOO6OOOO 8887888 ####8#### ■■■■9■■■■
           ......... ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO 888888888 ######### ■■■■■■■■■
           ......... ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO 888888888 ######### ■■■■■■■■■
          =========================================================================================================
FREQ.          0         13          0          0          0          0          0          0          0
          1          I''2''I
          2          I''2''I
          3          I''2''I
          4          I''2''I
          5          I''2''I
          6          I''2''I
          7          I''2''I
          8          I''2''I
          9          I''2''I
         10          I''2''I
         11          I''2''I
         12          I''2''I
         13          I''2''I
```

FIGURE 19

WINTER — 1977-1978
AVERAGE TEMPERATURE

FIGURE 20 LEGEND

AVERAGE TEMPERATURE: DEGREES C
WINTER 1978-1979

DATA VALUE EXTREMES ARE 12.80 14.13

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	...2....	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	8888788888	[illegible]	[illegible]
FREQ.	13	0	0	0	0	0	0	0	0

```
 1  I..I..I
 2  I..I..I
 3  I..I..I
 4  I..I..I
 5  I..I..I
 6  I..I..I
 7  I..I..I
 8  I..I..I
 9  I..I..I
10  I..I..I
11  I..I..I
12  I..I..I
13  I..I..I
```

FIGURE 20

WINTER — 1978-1979
AVERAGE TEMPERATURE

FIGURE 21 LEGEND

AVERAGE TEMPERATURE: DEGRESS C
SPRING 1977

DATA VALUE EXTREMES ARE 15.70 18.30

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

P'RCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	...2...	===3===	+++4+++	XXXX5XXXX	OOOO6OOOO	■■■7■■■	■■■8■■■	■■■9■■■
FREQ.	0	2	3	4	4	0	0	0	0

```
    1         I..2..I   I==3==I   I++4++I   IXX5XXI
    2         I..2..I   I==3==I   I++4++I   IXX5XXI
    3                   I==3==I   I++4++I   IXX5XXI
    4                             I++4++I   IXX5XXI
```

FIGURE 21

SPRING -- 1977
AVERAGE TEMPERATURE

FIGURE 22 LEGEND

AVERAGE TEMPERATURE: DEGREES C
SPRING 1978

DATA VALUE EXTREMES ARE 17.05 20.67

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
        ==========================================================================================
          .........  ++++++++  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  ØØØØØØØØØ  ■■■■■■■■■  ■■■■■■■■■
          .........  ++++++++  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  ØØØØØØØØØ  ■■■■■■■■■  ■■■■■■■■■
SYMBOLS   ....1....  ++++2+++  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  ØØØØ7ØØØØ  ■■■■8■■■■  ■■■■9■■■■
          .........  ++++++++  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  ØØØØØØØØØ  ■■■■■■■■■  ■■■■■■■■■
          .........  ++++++++  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  ØØØØØØØØØ  ■■■■■■■■■  ■■■■■■■■■
          .........
        ==========================================================================================
FREQ.        0          0          0          4          5          2          2          0          0
     1                                   I++4++I    IXX5XXI    IOO6OOI    IØØ7ØØI
     2                                   I++4++I    IXX5XXI    IOO6OOI    IØØ7ØØI
     3                                   I++4++I    IXX5XXI
     4                                   I++4++I    IXX5XXI
     5                                              IXX5XXI
```

FIGURE 22

SPRING -- 1978
AVERAGE TEMPRATURE

FIGURE 23 LEGEND

AVERAGE TEMPERATURE: DEGREES C
SPRING 1979

DATA VALUE EXTREMES ARE 16.30 18.37

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00
MAXIMUM	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

65.22	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1         2         3         4         5         6         7         8         9
         ==========================================================================================
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  ■■■■■■■■■  ■■■■■■■■■
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  ■■■■■■■■■  ■■■■■■■■■
SYMBOLS  ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  0000700000  ■■■■8■■■■  ■■■■9■■■■
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  ■■■■■■■■■  ■■■■■■■■■
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  ■■■■■■■■■  ■■■■■■■■■
         ==========================================================================================
FREQ.        0         0         4         5         4         0         0         0         0
   1                          I==3==I   I++4++I   IXX5XXI
   2                          I==3==I   I++4++I   IXX5XXI
   3                          I==3==I   I++4++I   IXX5XXI
   4                          I==3==I   I++4++I   IXX5XXI
   5                                    I++4++I
```

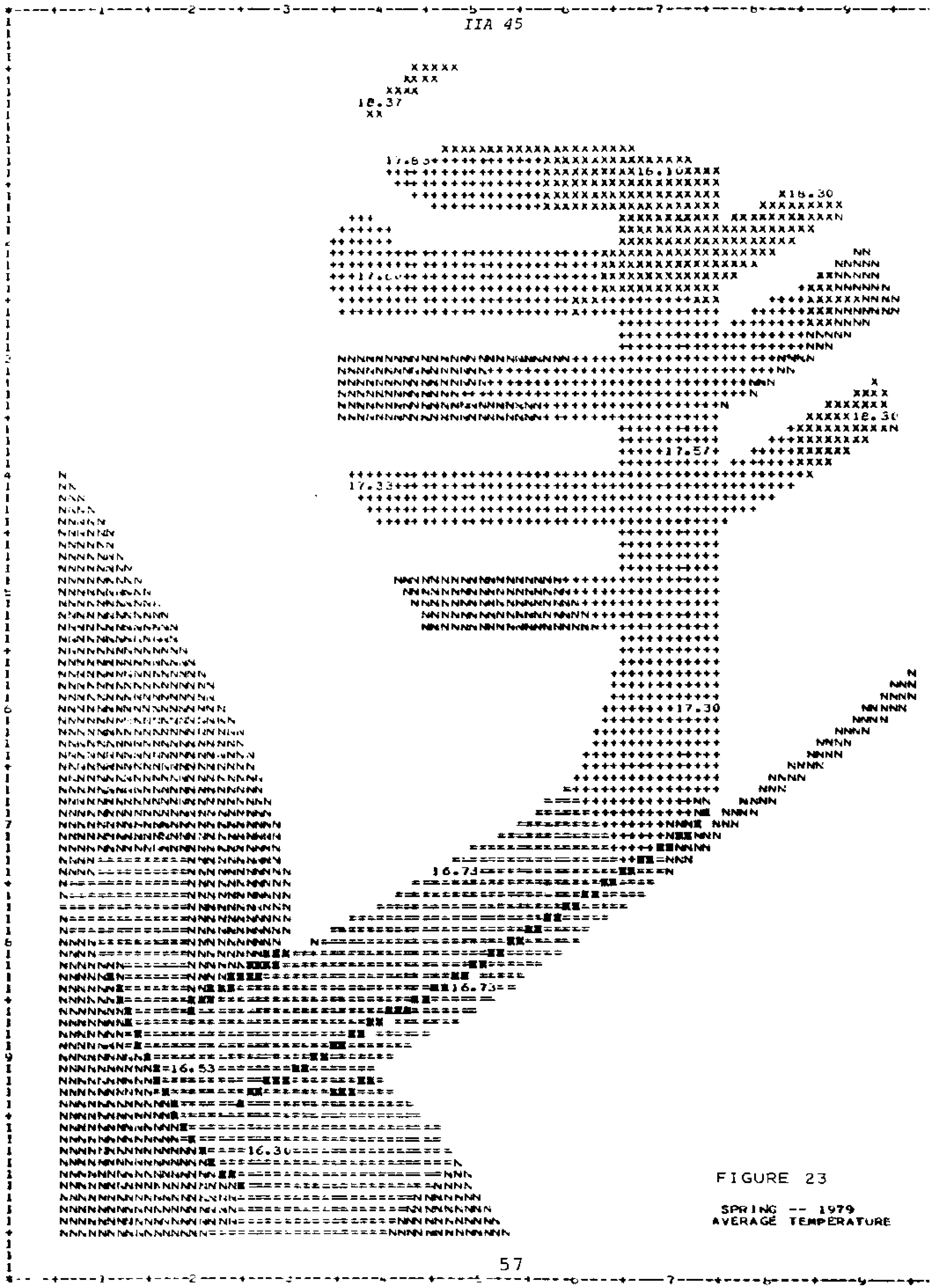


FIGURE 23

SPRING -- 1979
AVERAGE TEMPERATURE

FIGURE 24 LEGEND

SALINITY -- YEARLY AVERAGE
1976 - 1977

DATA VALUE EXTREMES ARE 29.69 32.64

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

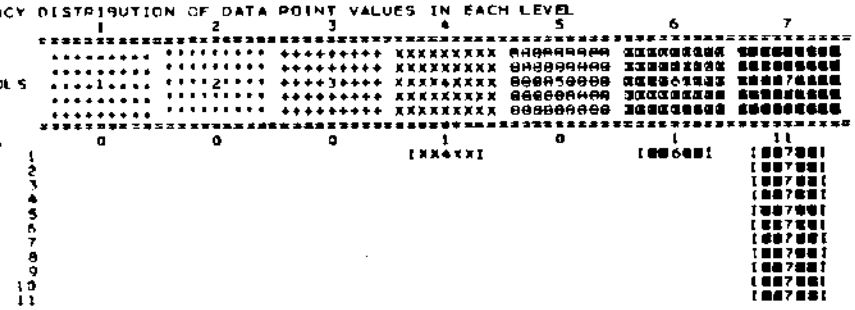
MINIMUM	0.0	26.00	27.00	29.00	30.00	31.00	32.00
MAXIMUM	26.00	27.00	29.00	30.00	31.00	32.00	32.64

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

79.66	3.06	6.13	3.06	3.06	3.06	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7
SYMBOLS							
FREQ.	0	0	0	1	0	1	11



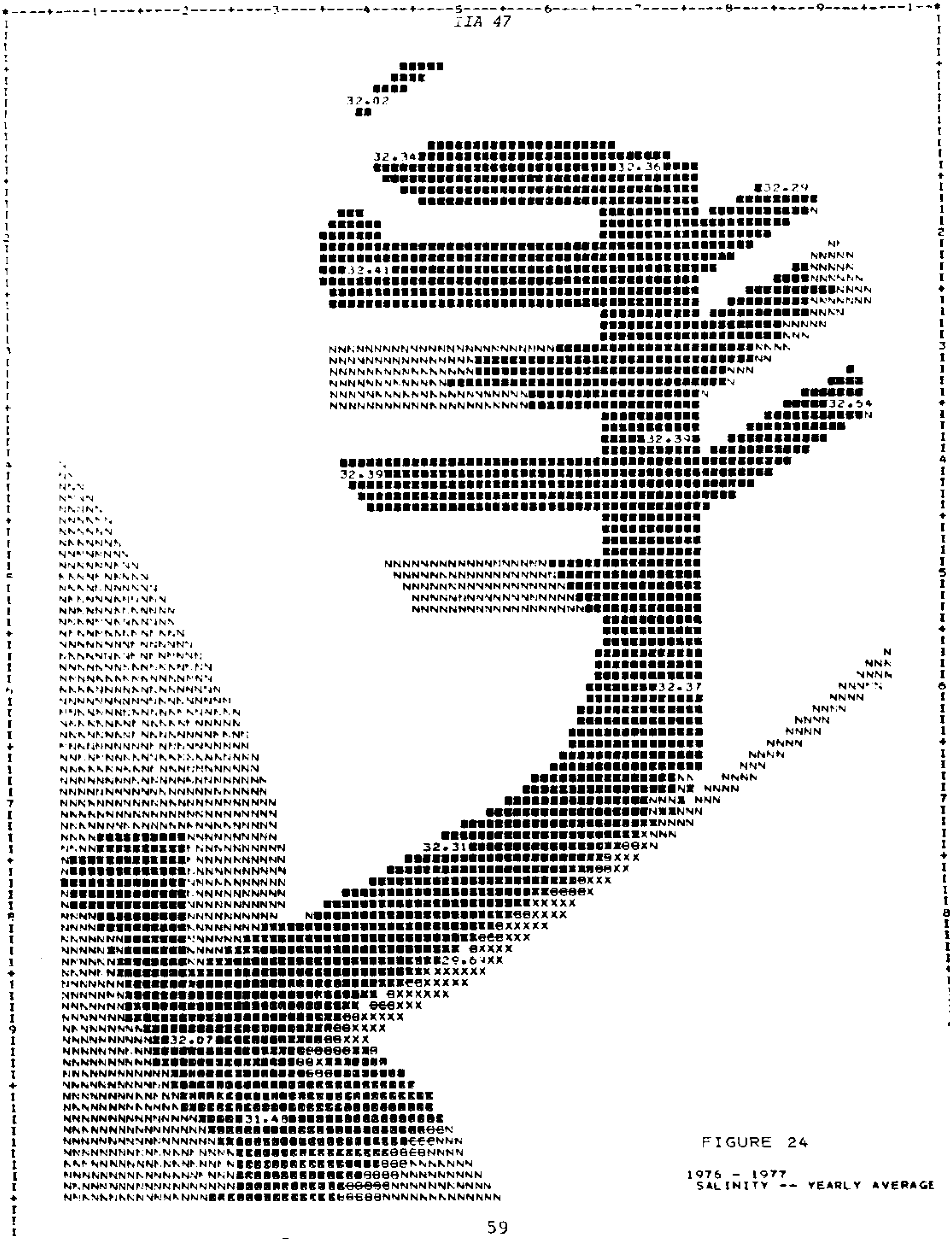


FIGURE 24

1976 - 1977
SALINITY -- YEARLY AVERAGE

FIGURE 25 LEGEND

SALINITY -- YEARLY AVERAGE
1977 - 1978

DATA VALUE EXTREMES ARE 26.22 31.02

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	26.00	27.00	29.00	30.00	31.00	32.00
MAXIMUM	26.00	27.00	29.00	30.00	31.00	32.00	32.64

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

79.66	3.06	6.13	3.06	3.06	3.06	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL         1          2          3          4          5          6          7
          ==========================================================================
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  0000500000 ####6####  ####7####
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
          ==========================================================================
FREQ.         0          1          4          3          4          1          0
        1             I''2''I    I++3++I    IXX4XXI    I00500I    I##6##I
        2                        I++3++I    IXX4XXI    I00500I
        3                        I++3++I    IXX4XXI    I00500I
        4                        I++3++I               I00500I
```

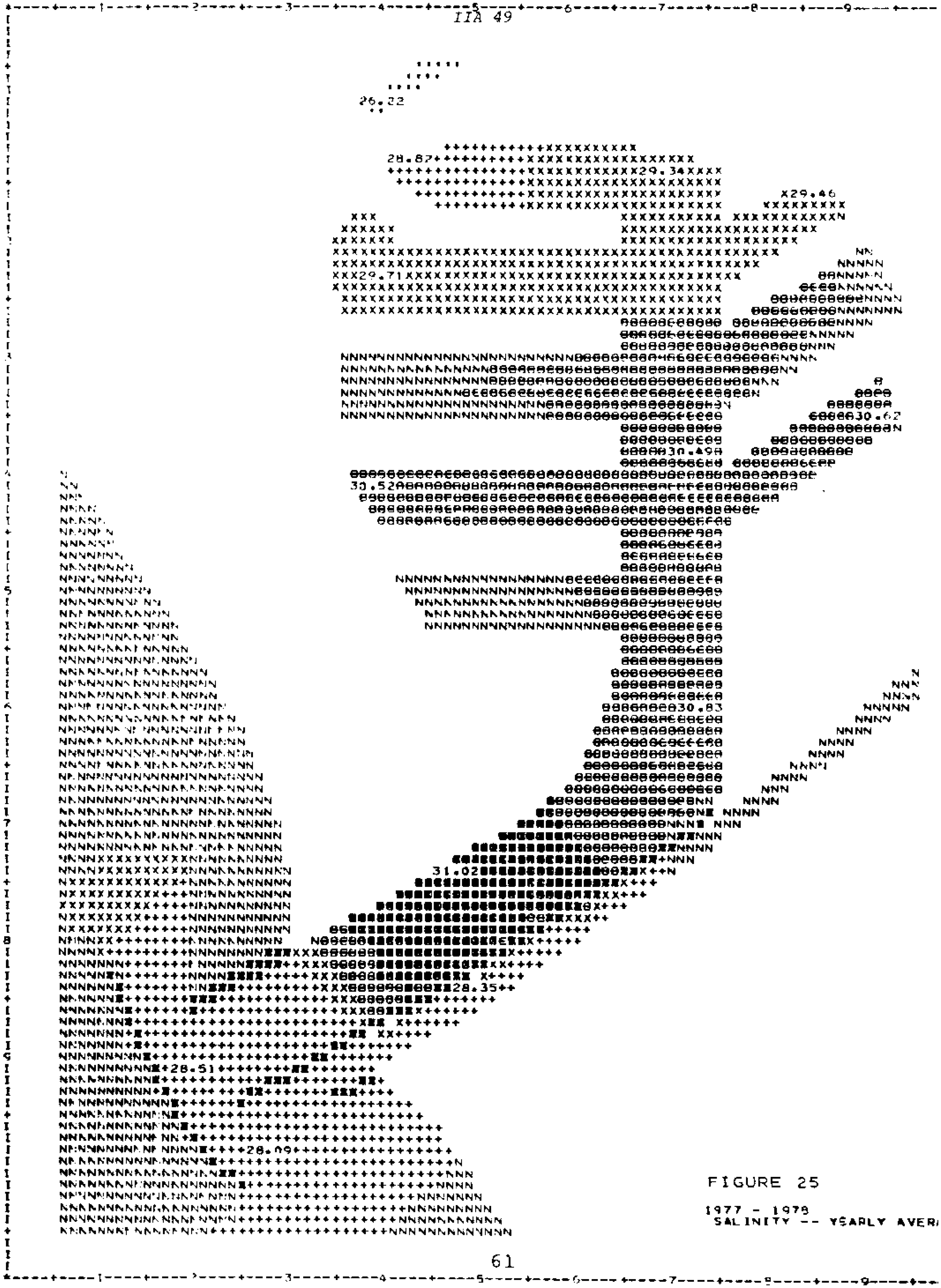


FIGURE 25

1977 - 1979
SALINITY -- YEARLY AVER

FIGURE 26 LEGEND

SALINITY -- YEARLY AVERAGE
1978 - 1979

DATA VALUE EXTREMES ARE 26.89 31.38

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	26.00	27.00	29.00	30.00	31.00	32.00
MAXIMUM	26.00	27.00	29.00	30.00	31.00	32.00	32.64

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

79.66	3.06	6.13	3.06	3.06	3.06	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	00005000	■■■6■■■	■■■7■■■
FREQ.	0	1	1	2	3	6	0

```
     FREQ.    0       1         1          2          3          6        0
       1           I''2''I   I++3++I   IXX4XXI    I00500I    I■■6■■I
       2                               IXX4XXI    I00500I    I■■6■■I
       3                                          I00500I    I■■6■■I
       4                                                     I■■6■■I
       5                                                     I■■6■■I
       6                                                     I■■6■■I
```

FIGURE 26

1978 - 1979
SALINITY -- YEARLY AVERAGE

FIGURE 27 LEGEND

AVERAGE SALINITY
SUMMER 1976

DATA VALUE EXTREMES ARE 30.00 33.50

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.88	22.87	26.84	27.84	28.83	29.83	30.82	31.81
MAXIMUM	19.88	22.87	26.84	27.84	28.83	29.83	30.82	31.81	34.30

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	6.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	0000700000	88888888	99999999
FREQ.	0	0	0	0	0	0	1	1	11
1							I887I	I888I	I999I
2									I999I
3									I999I
4									I999I
5									I999I
6									I999I
7									I999I
8									I999I
9									I999I
10									I999I
11									I999I

IIA 53

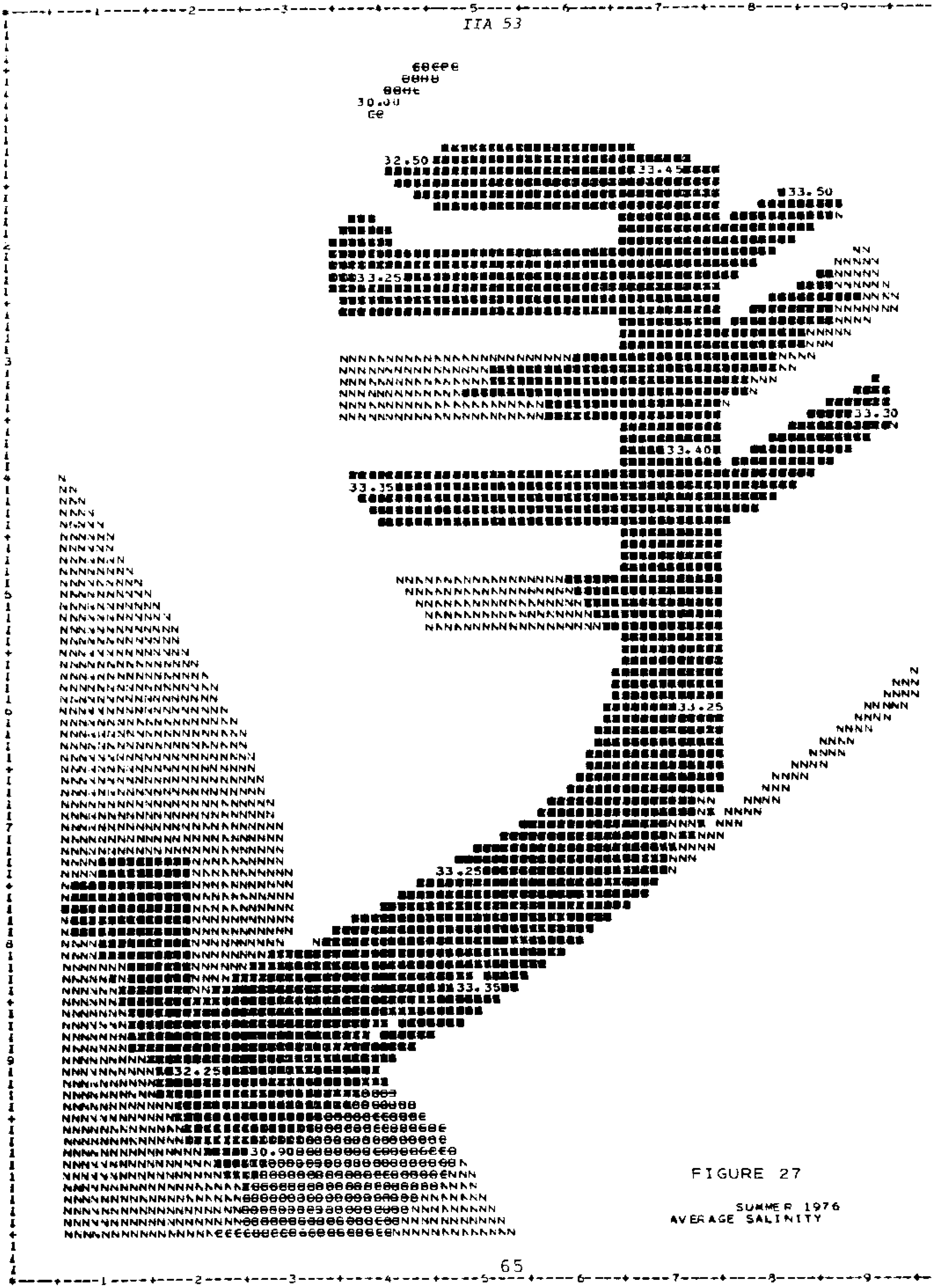


FIGURE 27

SUMMER 1976
AVERAGE SALINITY

FIGURE 28 LEGEND

AVERAGE SALINITY
SUMMER 1977

DATA VALUE EXTREMES ARE 21.70 31.50

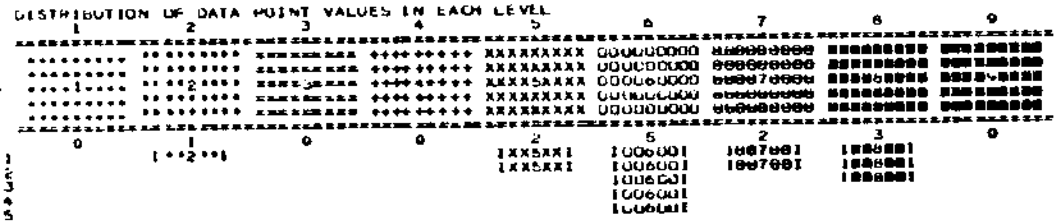
ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.69	26.67	27.86	28.86	29.65	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS									
FREQ.	0	1	0	0	2	5	2	3	0

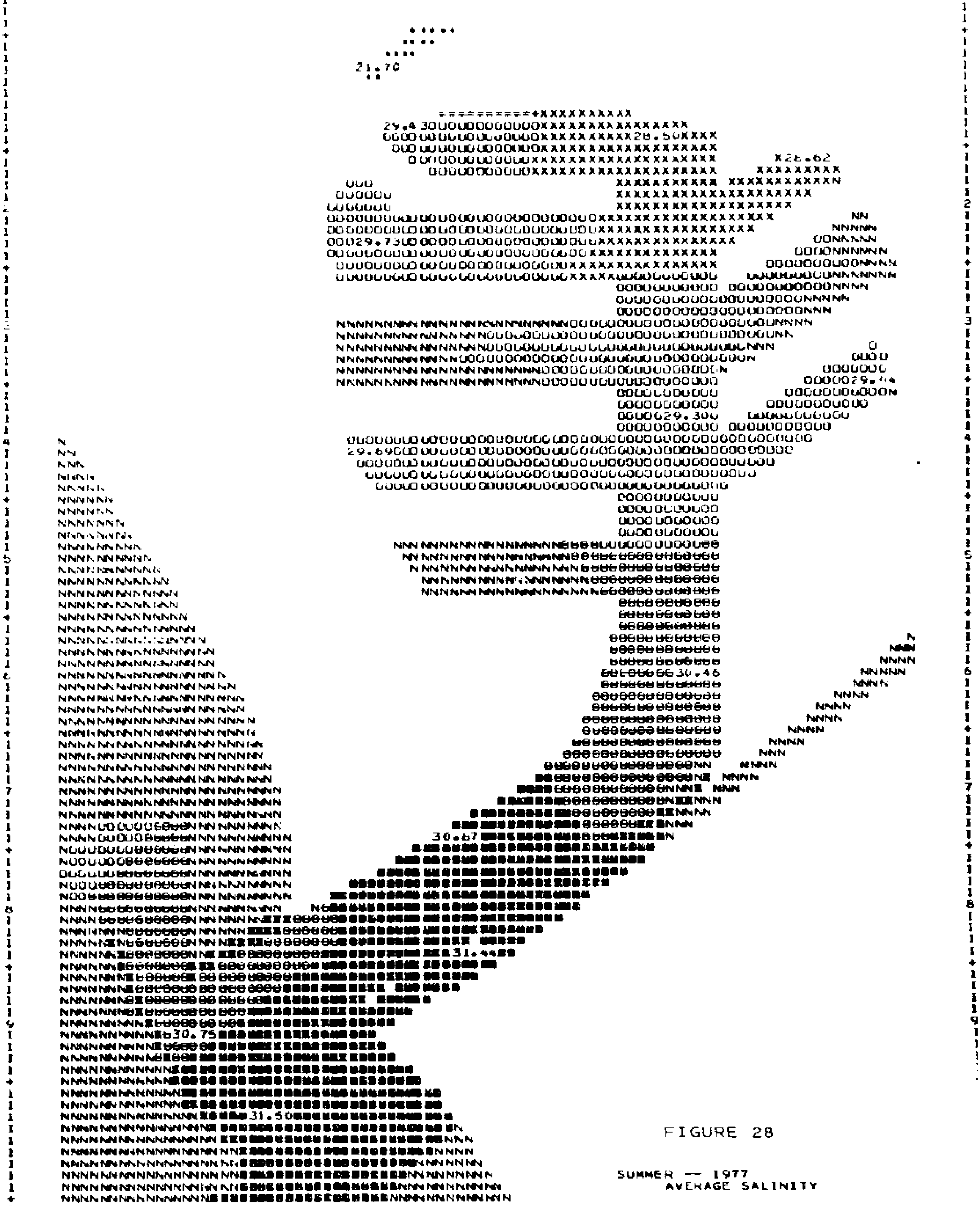


FIGURE 28

SUMMER — 1977
AVERAGE SALINITY

FIGURE 29 LEGEND

AVERAGE SALINITY
SUMMER 1978

DATA VALUE EXTREMES ARE 28.00 30.70

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
        ==========================================================================================
        .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
        .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
SYMBOLS ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  ■■■■8■■■■  ■■■■9■■■■
        .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
        .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
        ==========================================================================================
FREQ.        0          0          0          0          1          0         12          0          0
   1                                                  IXX5XXI              I@@7@@I
   2                                                                       I@@7@@I
   3                                                                       I@@7@@I
   4                                                                       I@@7@@I
   5                                                                       I@@7@@I
   6                                                                       I@@7@@I
   7                                                                       I@@7@@I
   8                                                                       I@@7@@I
   9                                                                       I@@7@@I
  10                                                                       I@@7@@I
  11                                                                       I@@7@@I
  12                                                                       I@@7@@I
```

IIA 57

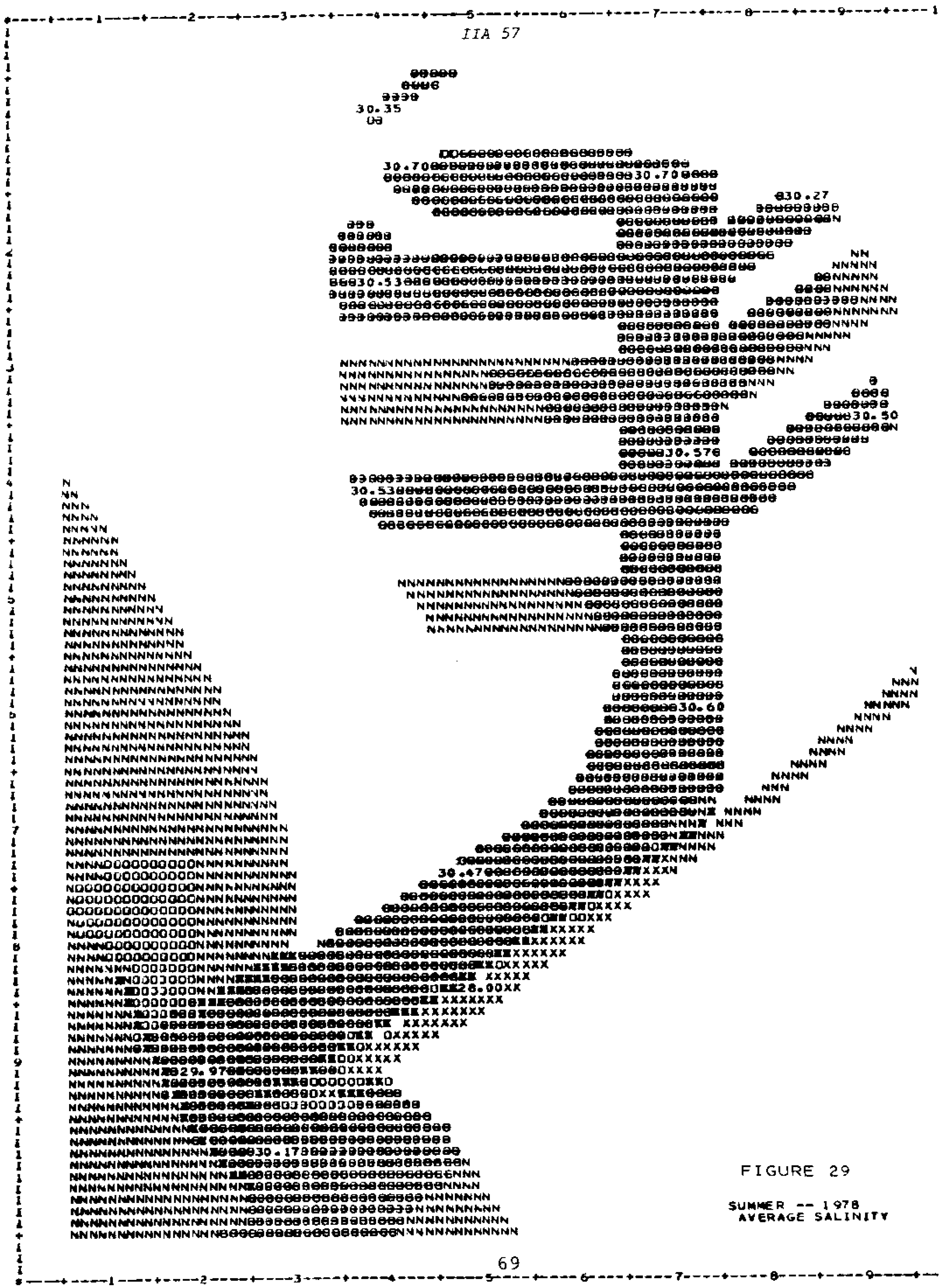


FIGURE 29

SUMMER -- 1978
AVERAGE SALINITY

FIGURE 30 LEGEND

AVERAGE SALINITY
AUTUMN 1976

DATA VALUE EXTREMES ARE 30.50 32.73

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
          ****************************************************************************************************
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  IIIIIIIII  ■■■■■■■■■
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  IIIIIIIII  ■■■■■■■■■
SYMBOLS   ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  0000700000 IIII8IIII  ■■■■9■■■■
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  IIIIIIIII  ■■■■■■■■■
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  000000000  IIIIIIIII  ■■■■■■■■■
          ****************************************************************************************************
FREQ.        0          0          0          0          0          0          2          6          5
     1                                                                     I007001I   I■■8■■I    I■■9■■I
     2                                                                     I007001I   I■■8■■I    I■■9■■I
     3                                                                                I■■8■■I    I■■9■■I
     4                                                                                I■■8■■I    I■■9■■I
     5                                                                                I■■8■■I    I■■9■■I
     6                                                                                I■■8■■I
```

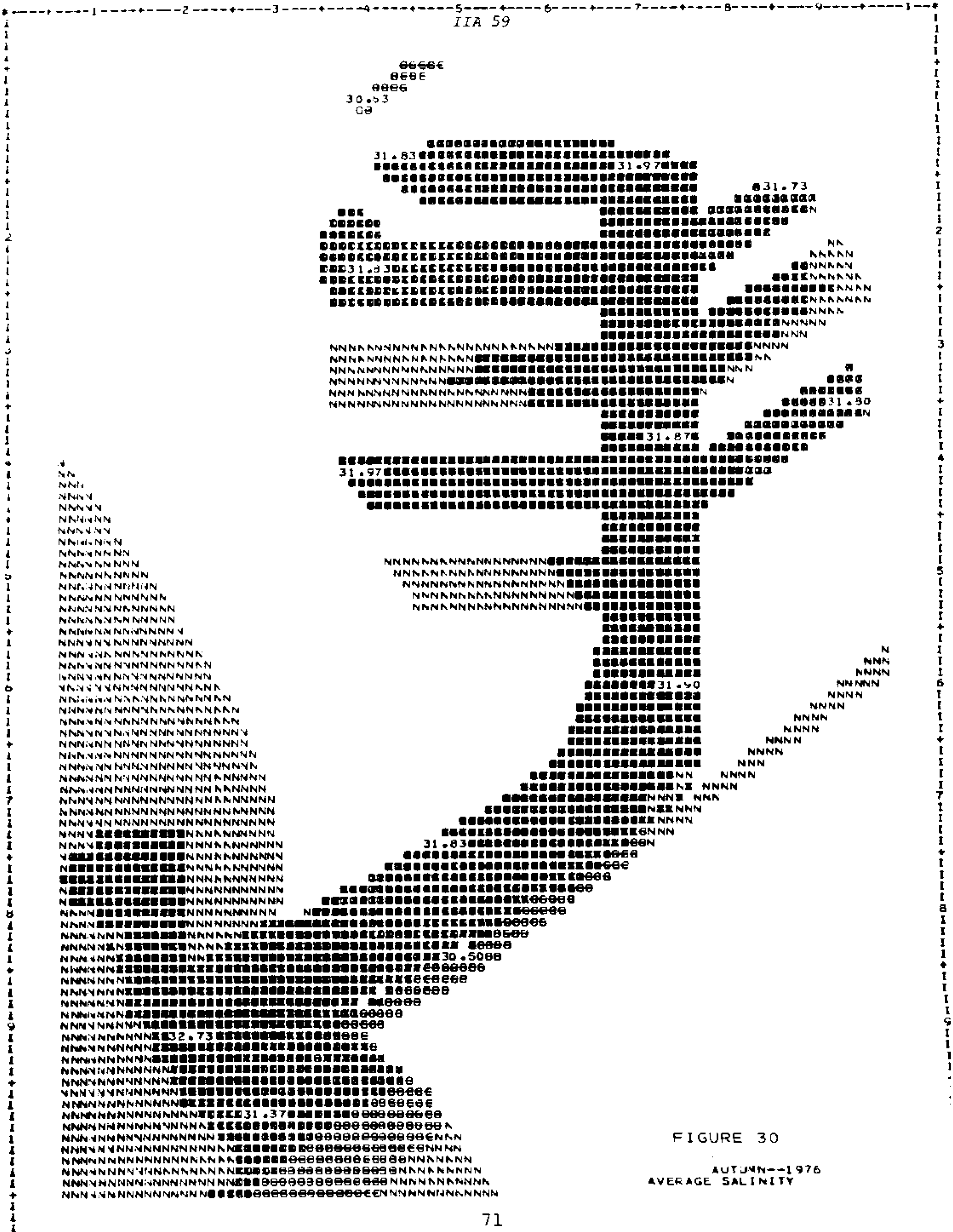


FIGURE 30

AUTUMN--1976
AVERAGE SALINITY

FIGURE 31 LEGEND

AVERAGE SALINITY
AUTUMN 1977

DATA VALUE EXTREMES ARE 31.97 33.77

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOOOOOOO	0000700000	████8████	████9████
FREQ.	0	0	0	0	0	0	0	0	13

1
2
3
4
5
6
7
8
9
10
11
12
13

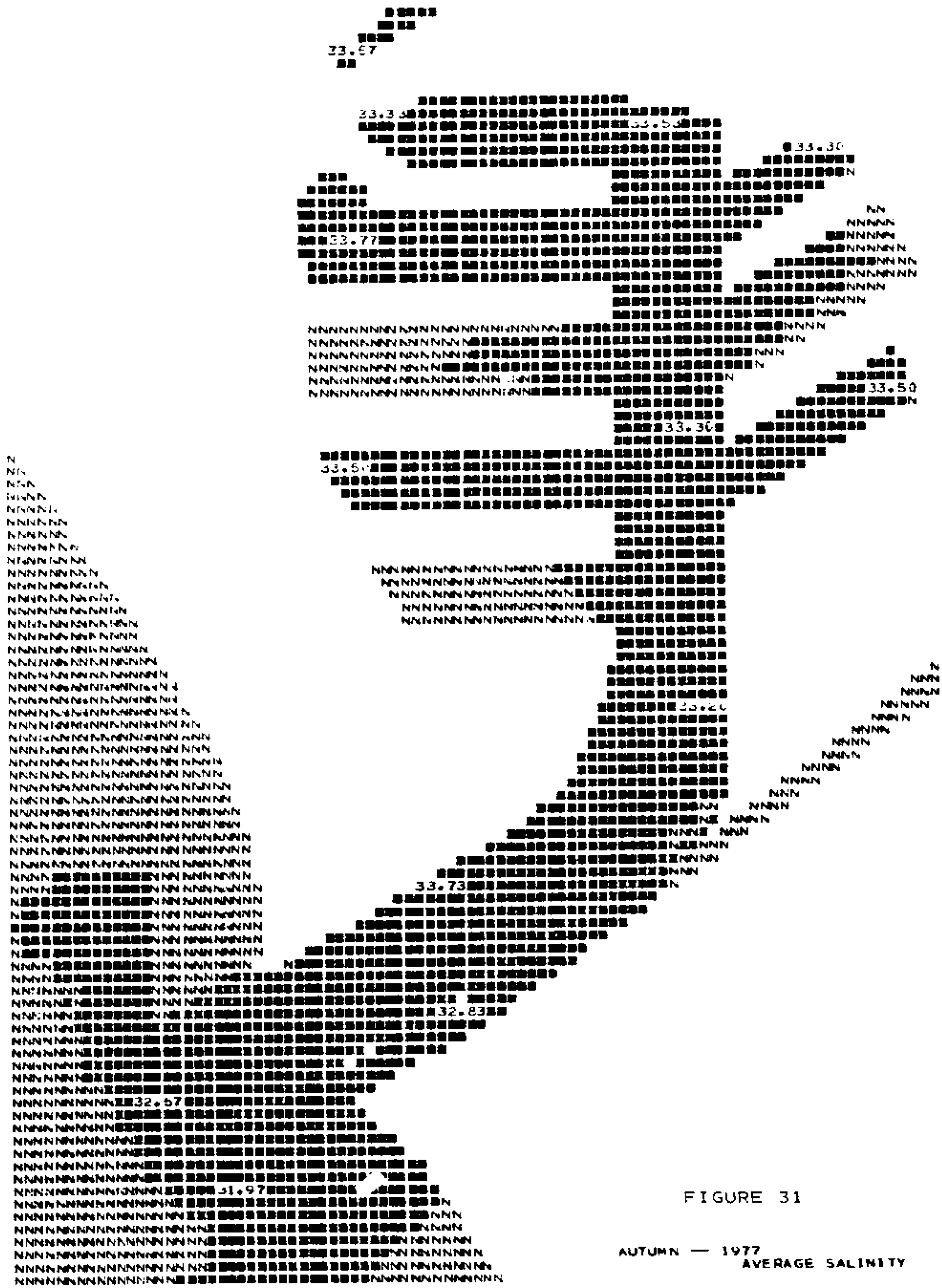


FIGURE 31

AUTUMN — 1977
AVERAGE SALINITY

FIGURE 32 LEGEND

AVERAGE SALINITY
AUTUMN 1978

DATA VALUE EXTREMES ARE 29.50 32.20

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.86	22.87	26.84	27.84	28.83	29.63	30.82	31.61
MAXIMUM	19.86	22.87	26.84	27.84	28.83	29.63	30.82	31.81	34.30

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

67.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	····1····	++++2++++	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	8888 7 8888	####8####	####9####
FREQ.	0	0	0	0	0	1	0	11	1
1						IOO6OOI		I##8##I	I##9##I
2								I##8##I	
3								I##8##I	
4								I##8##I	
5								I##8##I	
6								I##8##I	
7								I##8##I	
8								I##8##I	
9								I##8##I	
10								I##8##I	
11								I##8##I	

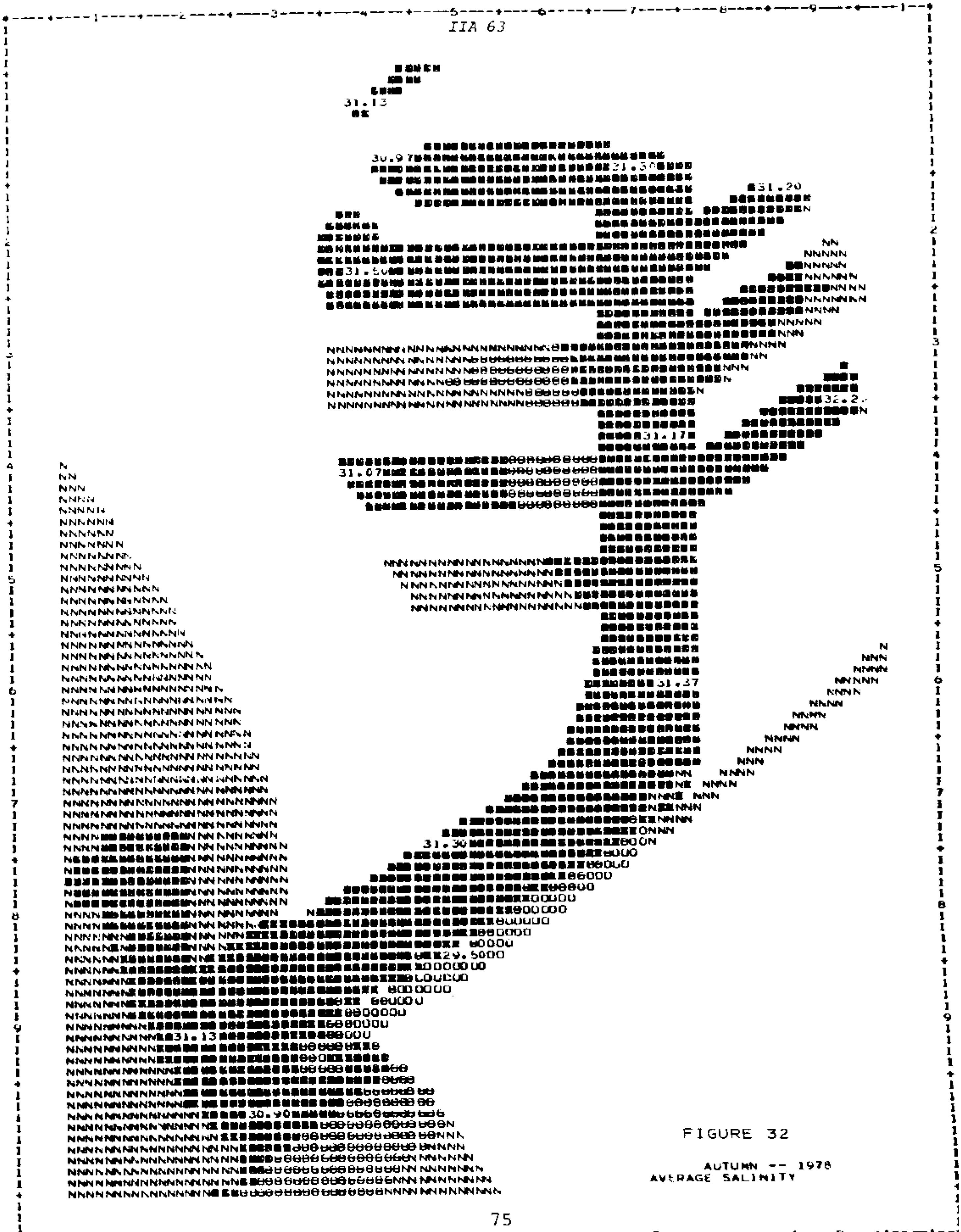


FIGURE 32

AUTUMN -- 1978
AVERAGE SALINITY

FIGURE 33 LEGEND

AVERAGE SALINITY
WINTER 1976-1977

DATA VALUE EXTREMES ARE 30.90 34.33

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	@@@@7@@@@	■■■■8■■■■	■■■■9■■■■
FREQ.	0	0	0	0	0	0	0	1	12

1
2
3
4
5
6
7
8
9
10
11
12

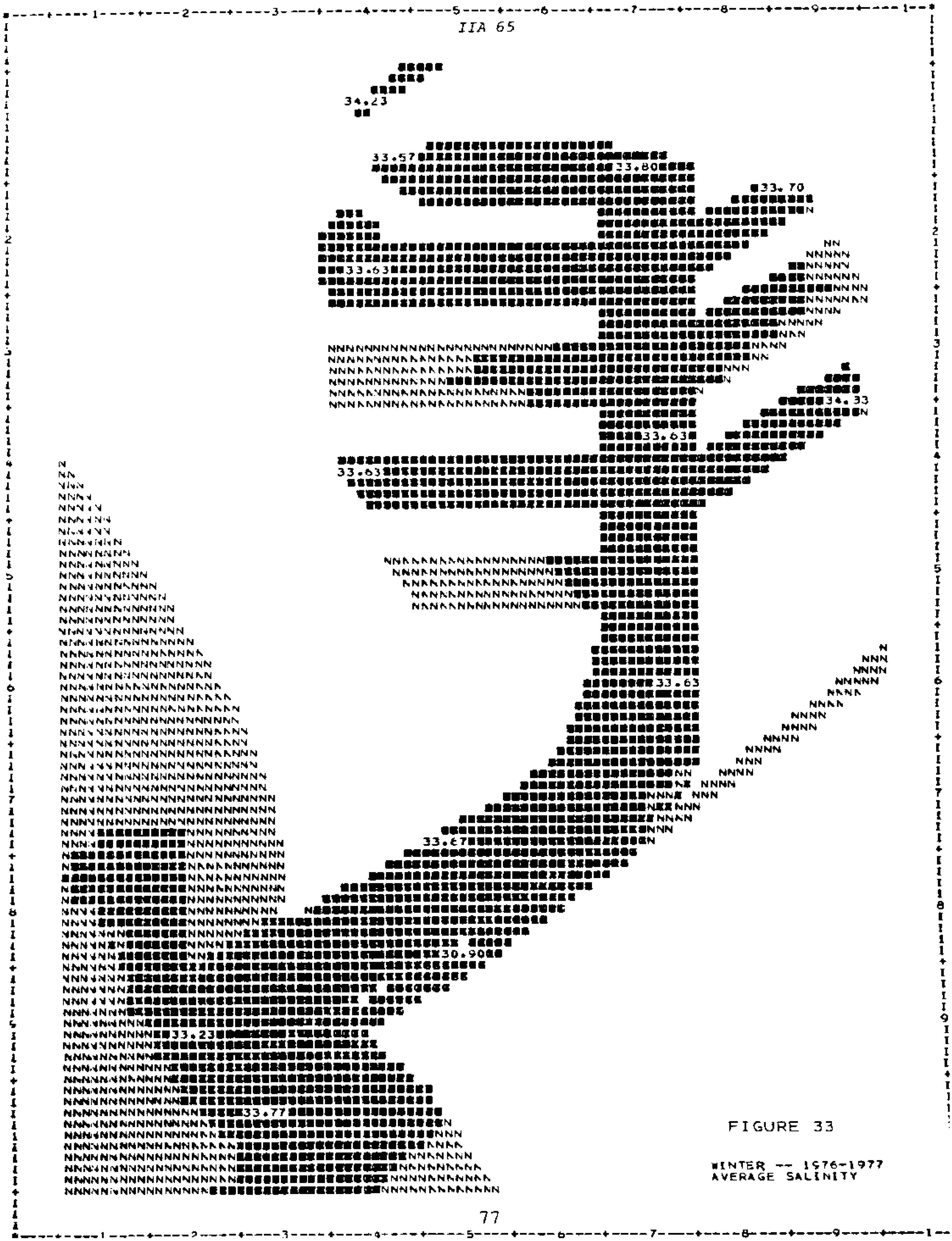


FIGURE 33

WINTER -- 1976-1977
AVERAGE SALINITY

FIGURE 34 LEGEND

AVERAGE SALINITY
WINTER 1977-1978

DATA VALUE EXTREMES ARE 16.15 28.20

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.88	22.87	26.84	27.84	28.83	29.83	30.82	31.81
MAXIMUM	19.88	22.87	26.84	27.84	28.83	29.83	30.82	31.81	34.30

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
         ====================================================================================================
          .........  '''''''''  =========  ++++ +++++ XXXXXXXXX  OOOOOOOOO  OOOOOOOOO  ■■■■■■■■■  ■■■■■■■■■
          .........  '''''''''  =========  ++++ +++++ XXXXXXXXX  OOOOOOOOO  OOOOOOOOO  ■■■■■■■■■  ■■■■■■■■■
SYMBOLS   ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  OOOO7OOOO  ■■■■8■■■■  ■■■■9■■■■
          .........  '''''''''  =========  ++++ +++++ XXXXXXXXX  OOOOOOOOO  OOOOOOOOO  ■■■■■■■■■  ■■■■■■■■■
          .........  '''''''''  =========  ++++ +++++ XXXXXXXXX  OOOOOOOOO  OOOOOOOOO  ■■■■■■■■■  ■■■■■■■■■
         ====================================================================================================
FREQ.        2          3          3          3          2          0          0          0          0
     1   I..1..I    I''2''I    I==3==I    I++4++I    IXX5XXI
     2   I..1..I    I''2''I    I==3==I    I++4++I    IXX5XXI
     3              I''2''I    I==3==I    I++4++I
```

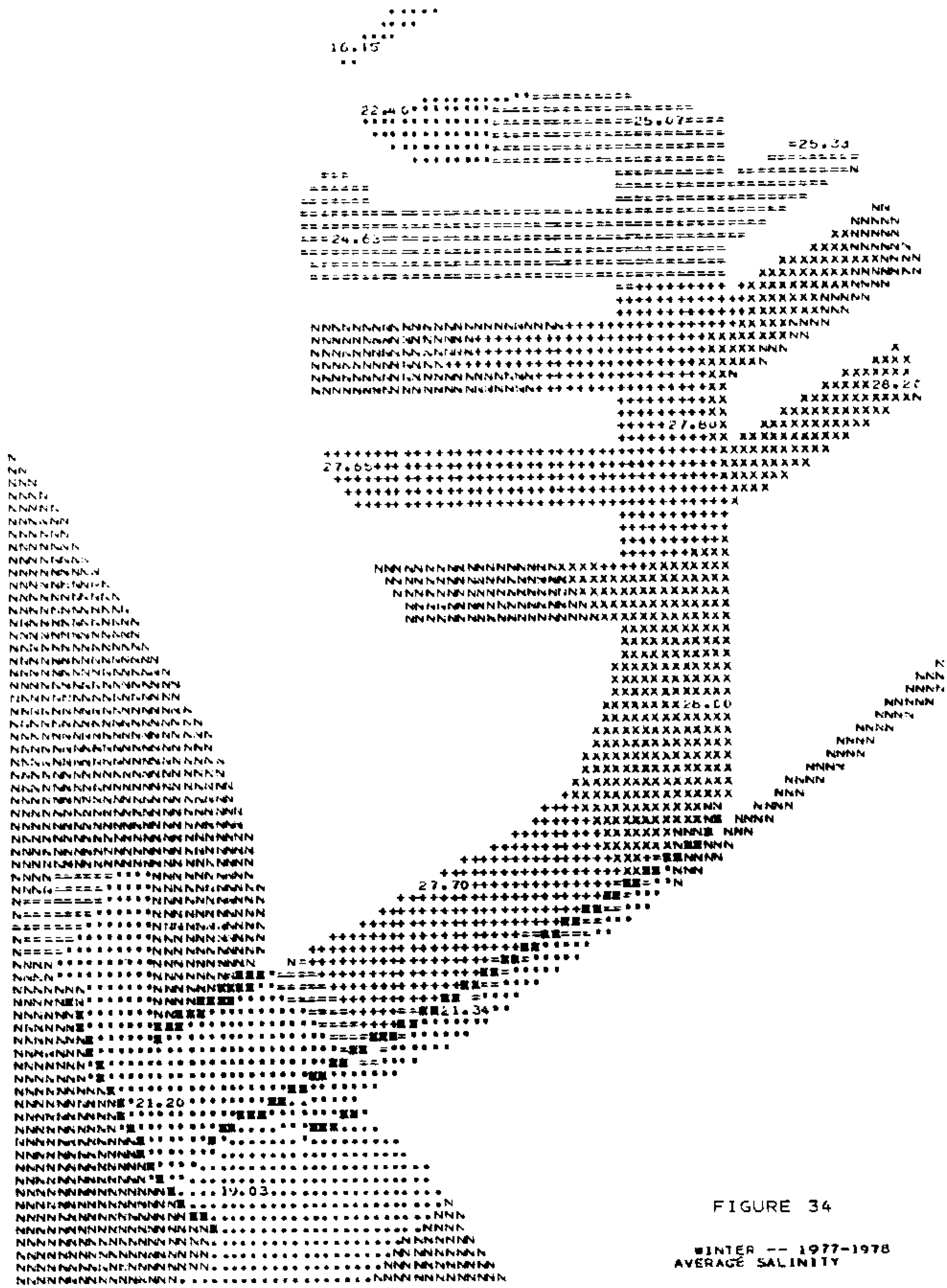


FIGURE 34

WINTER -- 1977-1978
AVERAGE SALINITY

FIGURE 35 LEGEND

AVERAGE SALINITY
WINTER 1978-1979

DATA VALUE EXTREMES ARE 18.53 31.20

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM* INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	8888788888	████8████	████9████
FREQ.	2	0	1	1	0	1	5	3	0
1	I..1..I		I==3==I	I++4++I		IOO6OOI	I887881	I██8██I	
2	I..1..I						I887881	I██8██I	
3							I887881	I██8██I	
4							I887881		
5							I887881		

FIGURE 35

WINTER — 1978-1979
AVERAGE SALINITY

FIGURE 36 LEGEND

AVERAGE SALINITY
SPRING 1977

DATA VALUE EXTREMES ARE 27.87 31.37

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.88	22.87	26.84	27.84	28.83	29.83	30.82	31.81
MAXIMUM	19.88	22.87	26.84	27.84	28.83	29.83	30.82	31.81	34.30

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL           1          2          3          4          5          6          7          8          9
         ==========================================================================================
          .........  ''''''''' ========= +++++++++ XXXXXXXXX 000000000 @@@@@@@@@ ######### #########
          .........  ''''''''' ========= +++++++++ XXXXXXXXX 000000000 @@@@@@@@@ ######### #########
SYMBOLS   ....1....  ''''2'''' ====3==== ++++4++++ XXXX5XXXX 0000600000 @@@@7@@@@ ####8#### ####9####
          .........  ''''''''' ========= +++++++++ XXXXXXXXX 000000000 @@@@@@@@@ ######### #########
          .........  ''''''''' ========= +++++++++ XXXXXXXXX 000000000 @@@@@@@@@ ######### #########
         ==========================================================================================
FREQ.           0          0          0          0          1          1          3          8          0
       1                                             IXX5XXI    I0060OI    I@@7@@I    I##8##I
       2                                                                   I@@7@@I    I##8##I
       3                                                                   I@@7@@I    I##8##I
       4                                                                              I##8##I
       5                                                                              I##8##I
       6                                                                              I##8##I
       7                                                                              I##8##I
       8                                                                              I##8##I
```

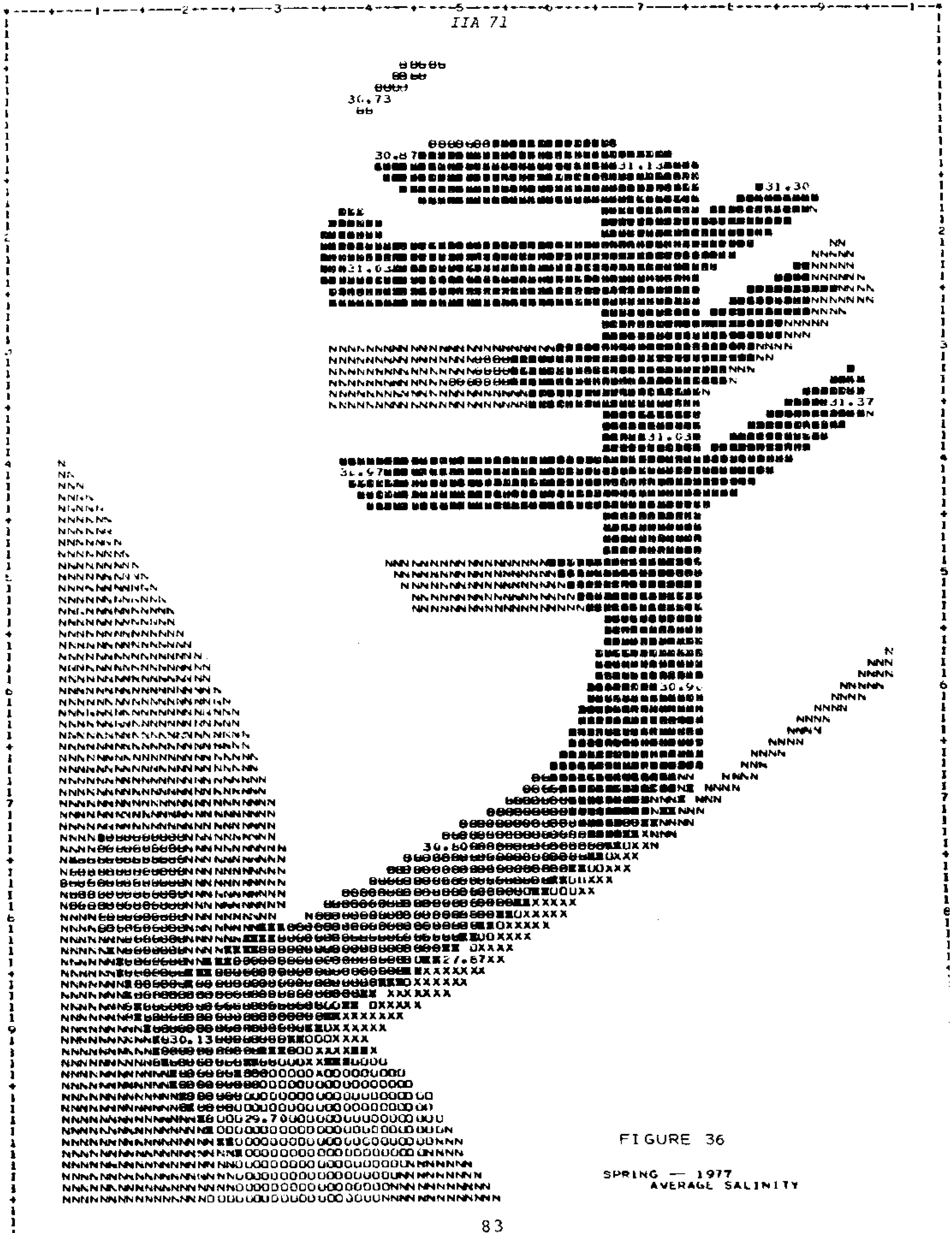


FIGURE 36

SPRING — 1977
AVERAGE SALINITY

FIGURE 37 LEGEND

AVERAGE SALINITY
SPRING 1978

DATA VALUE EXTREMES ARE 25.47 30.93

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.85	31.84	34.33

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	00005 0000	[illegible]	[illegible]	[illegible]
FREQ.	0	0	1	0	0	1	10	1	0
1			I==3==I			I006001	I007001	I[illegible]I	
2							I007001		
3							I007001		
4							I007001		
5							I007001		
6							I007001		
7							I007001		
8							I007001		
9							I007001		
10							I007001		

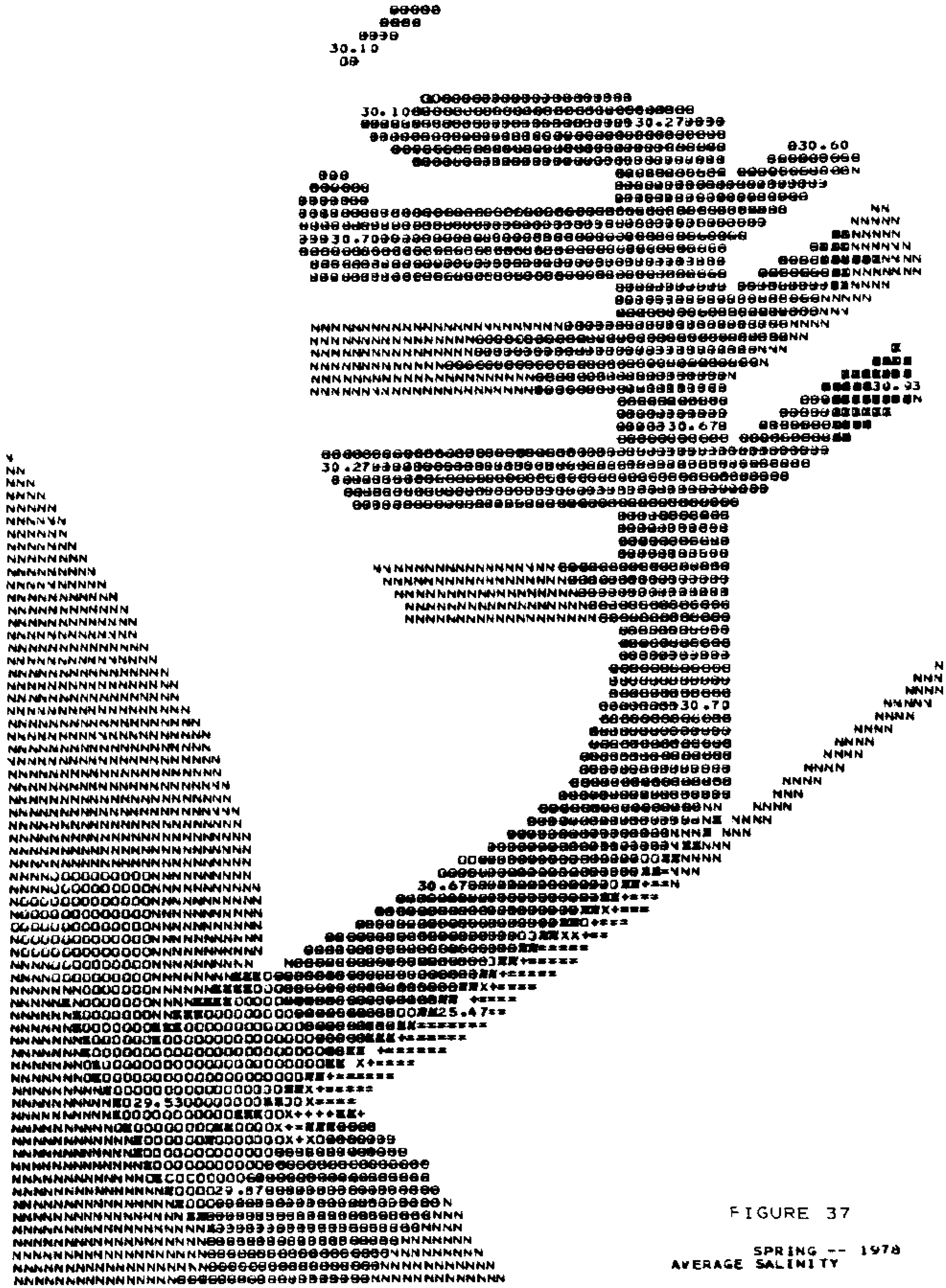


FIGURE 37

SPRING -- 1978
AVERAGE SALINITY

FIGURE 38 LEGEND

AVERAGE SALINITY
SPRING 1979

DATA VALUE EXTREMES ARE 31.17 33.40

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	19.90	22.89	26.87	27.66	28.86	29.65	30.85	31.84
MAXIMUM	19.90	22.89	26.87	27.86	28.86	29.85	30.65	31.84	34.33

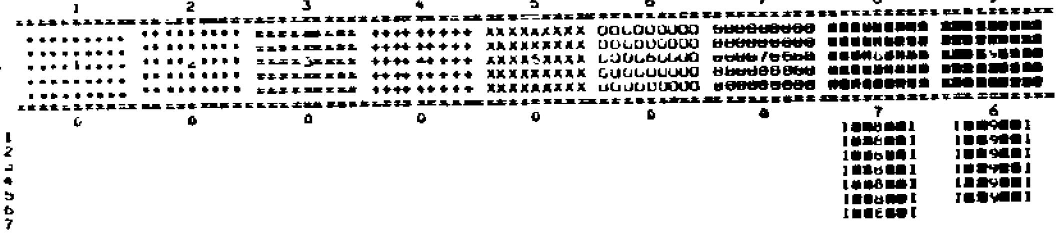
PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

57.97	8.70	11.59	2.90	2.90	2.90	2.90	2.90	7.25

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
FREQ.	0	0	0	0	0	0	0	7	6

SYMBOLS



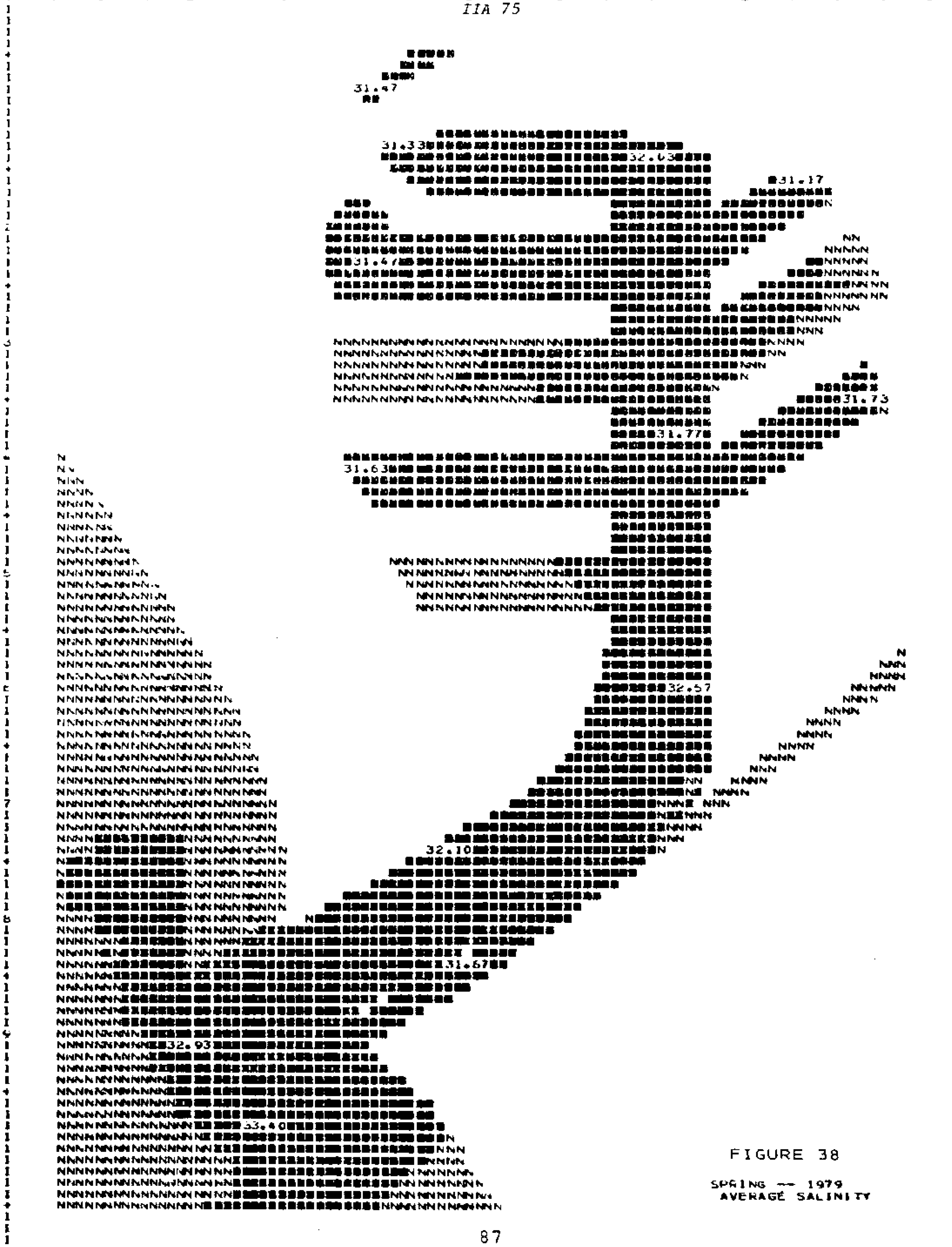


FIGURE 38

SPRING -- 1979
AVERAGE SALINITY

FIGURE 39 LEGEND

DISSOLVED OXYGEN -- YEARLY AVERAGE
1976 - 1977

DATA VALUE EXTREMES ARE 5.69 7.27

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	5.52	5.93	6.42	6.92	7.41	8.01	8.40
MAXIMUM	5.52	5.93	6.42	6.92	7.41	8.01	8.40	8.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

64.81	4.88	5.81	5.81	5.81	6.97	4.65	1.28

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	...1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	6666	7777	8888
FREQ.	0	1	5	5	2	0	0	0

```
FREQ.   1            I''2''I  I++3++I  IXX4XXI  IOO5OOI
        2                     I++3++I  IXX4XXI  IOO5OOI
        3                     I++3++I  IXX4XXI
        4                     I++3++I  IXX4XXI
        5                     I++3++I  IXX4XXI
```

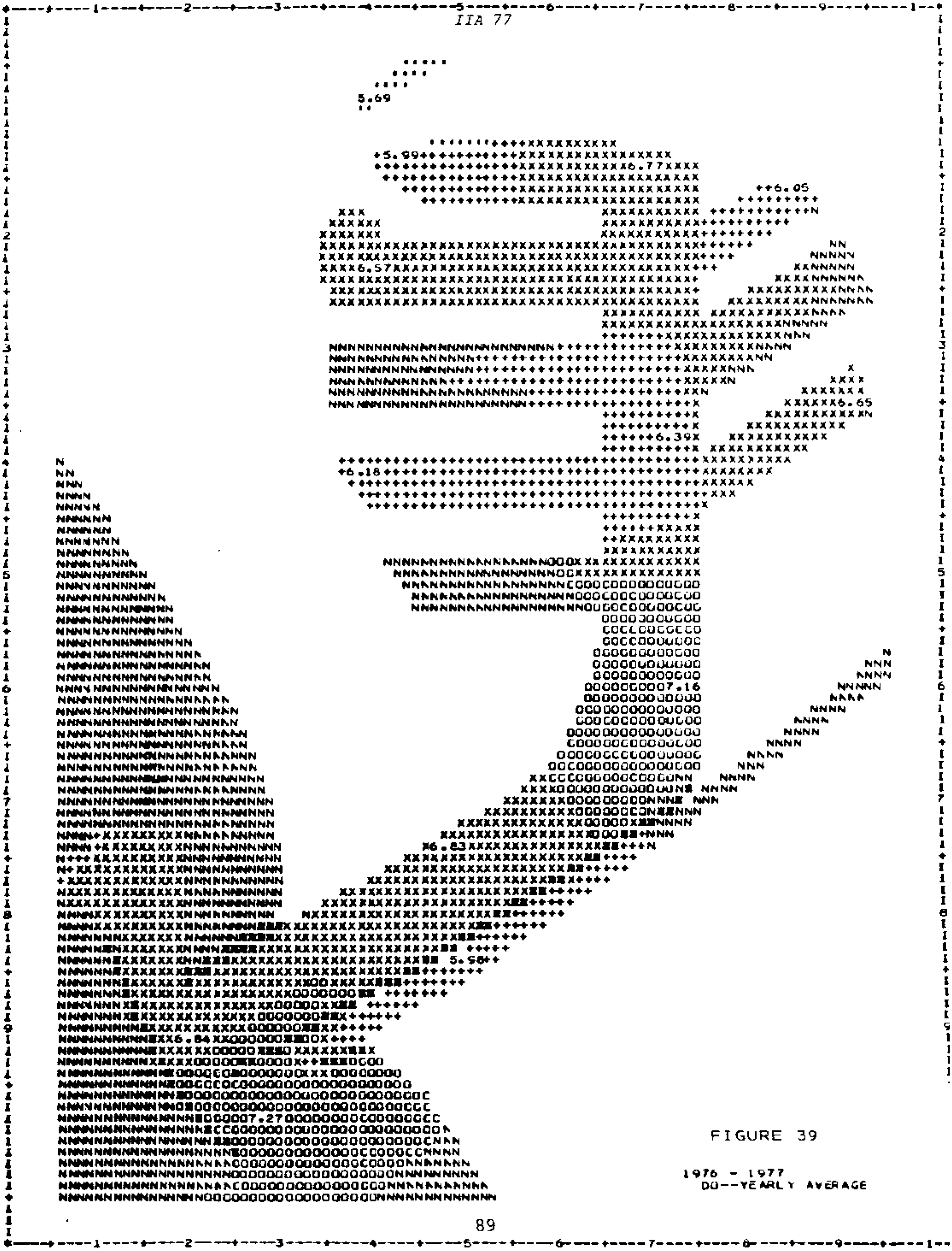


FIGURE 39

1976 - 1977
DO--YEARLY AVERAGE

FIGURE 40 LEGEND

DISSOLVED OXYGEN -- YEARLY AVERAGE
1977 - 1978

DATA VALUE EXTREMES ARE 6.97 8.51

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	5.52	5.93	6.42	6.92	7.41	8.01	8.40
MAXIMUM	5.52	5.93	6.42	6.92	7.41	8.01	8.40	8.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

64.81	4.88	5.81	5.81	5.81	6.97	4.65	1.28

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	····1····	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	ØØØØ6ØØØØ	████7████	████8████
FREQ.	0	0	0	0	3	5	3	2
1					I00500I	I00600I	I00700I	I00800I
2					I00500I	I00600I	I00700I	I00800I
3					I00500I	I00600I	I00700I	
4						I00600I		
5						I00600I		

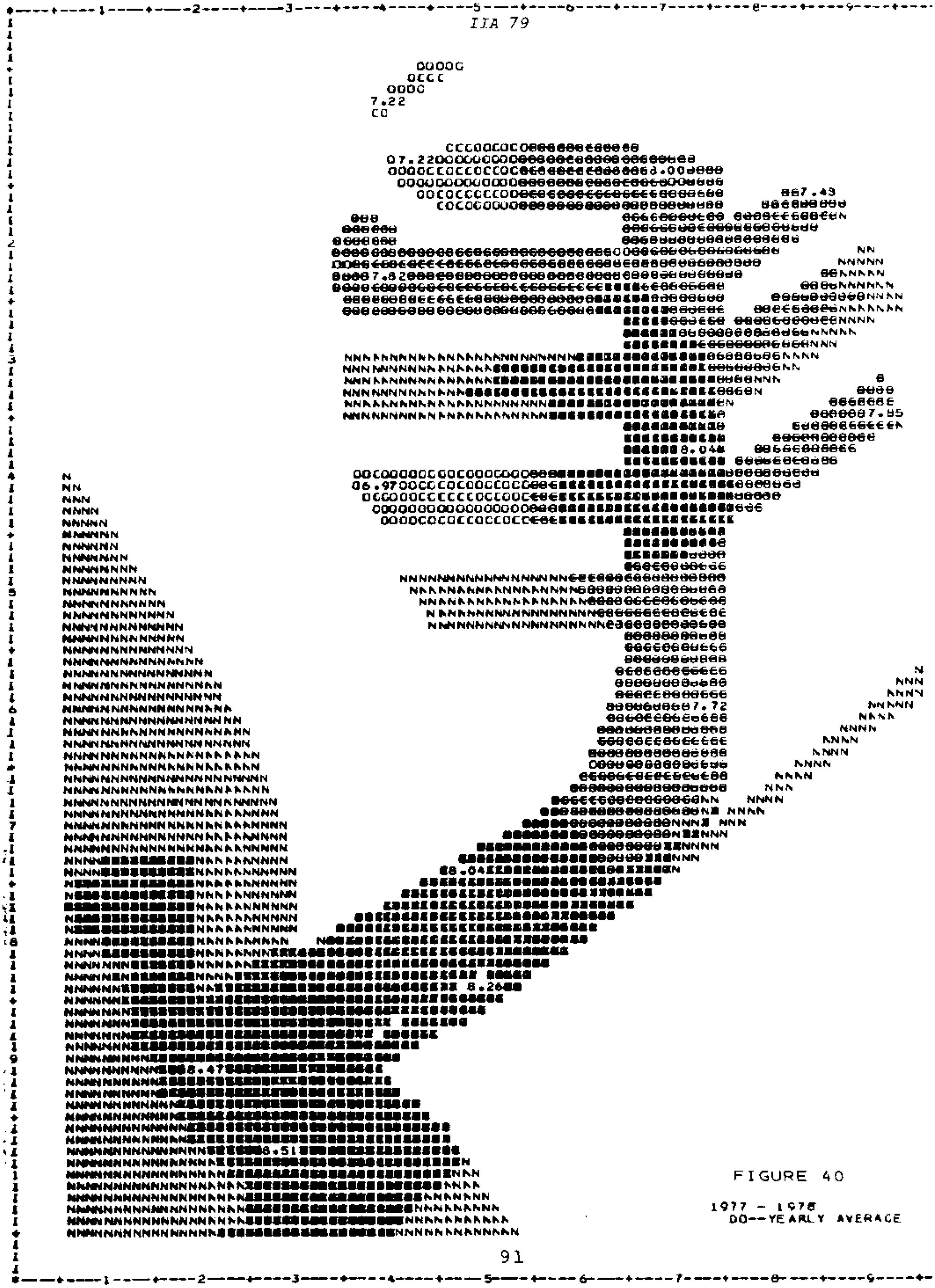


FIGURE 40

1977 - 1978
DO--YEARLY AVERAGE

FIGURE 41 LEGEND

DISSOLVED OXYGEN -- YEARLY AVERAGE
1978 - 1979

DATA VALUE EXTREMES ARE 5.56 6.99

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	5.52	5.93	6.42	6.92	7.41	8.01	8.40
MAXIMUM	5.52	5.93	6.42	6.92	7.41	8.01	8.40	8.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

64.81	4.88	5.81	5.81	5.81	6.97	4.65	1.28

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8
        ==========================================================================================
         .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
SYMBOLS  ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOO5OOOO  @@@@6@@@@  ####7####  ####8####
         .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
        ==========================================================================================
FREQ.        0          3          7          1          2          0          0          0
      1             I''2''I    I++3++I    IXX4XXI    IOO5OOI
      2             I''2''I    I++3++I               IOO5OOI
      3             I''2''I    I++3++I
      4                        I++3++I
      5                        I++3++I
      6                        I++3++I
      7                        I++3++I
```

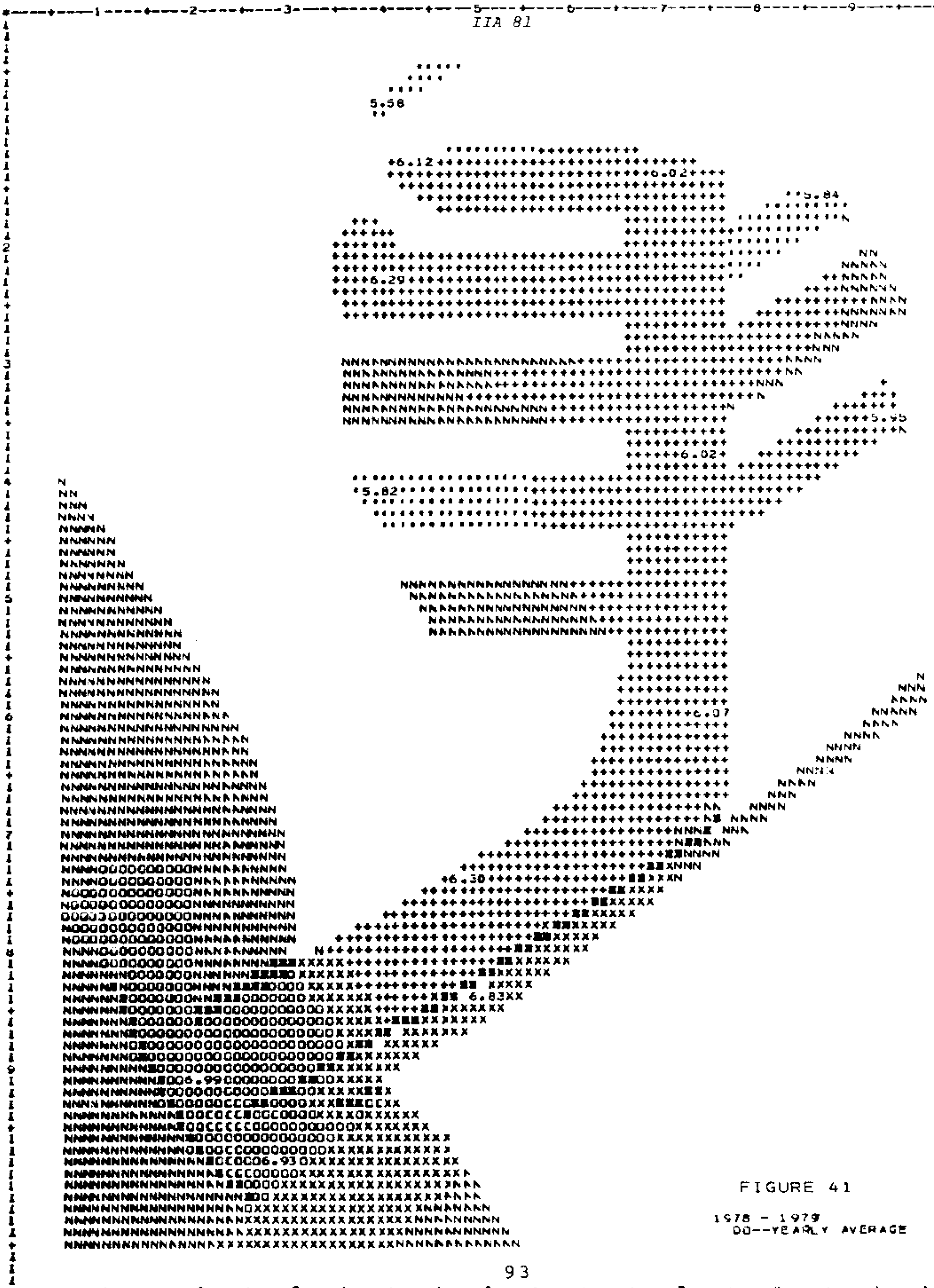


FIGURE 41

1978 - 1979
DO--YEARLY AVERAGE

FIGURE 42 LEGEND

DISSOLVED OXYGEN
SUMMER 1976

DATA VALUE EXTREMES ARE 7.25 9.10

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	@@@@6@@@@	@@@@7@@@@	████8████
FREQ.	0	0	0	0	0	5	7	1

```
FREQ.     0        0        0        0        0       5         7         1
  1                                               I@@6@@I   I@@7@@I   I@@8@@I
  2                                               I@@6@@I   I@@7@@I
  3                                               I@@6@@I   I@@7@@I
  4                                               I@@6@@I   I@@7@@I
  5                                               I@@6@@I   I@@7@@I
  6                                                         I@@7@@I
  7                                                         I@@7@@I
```

IIA 83

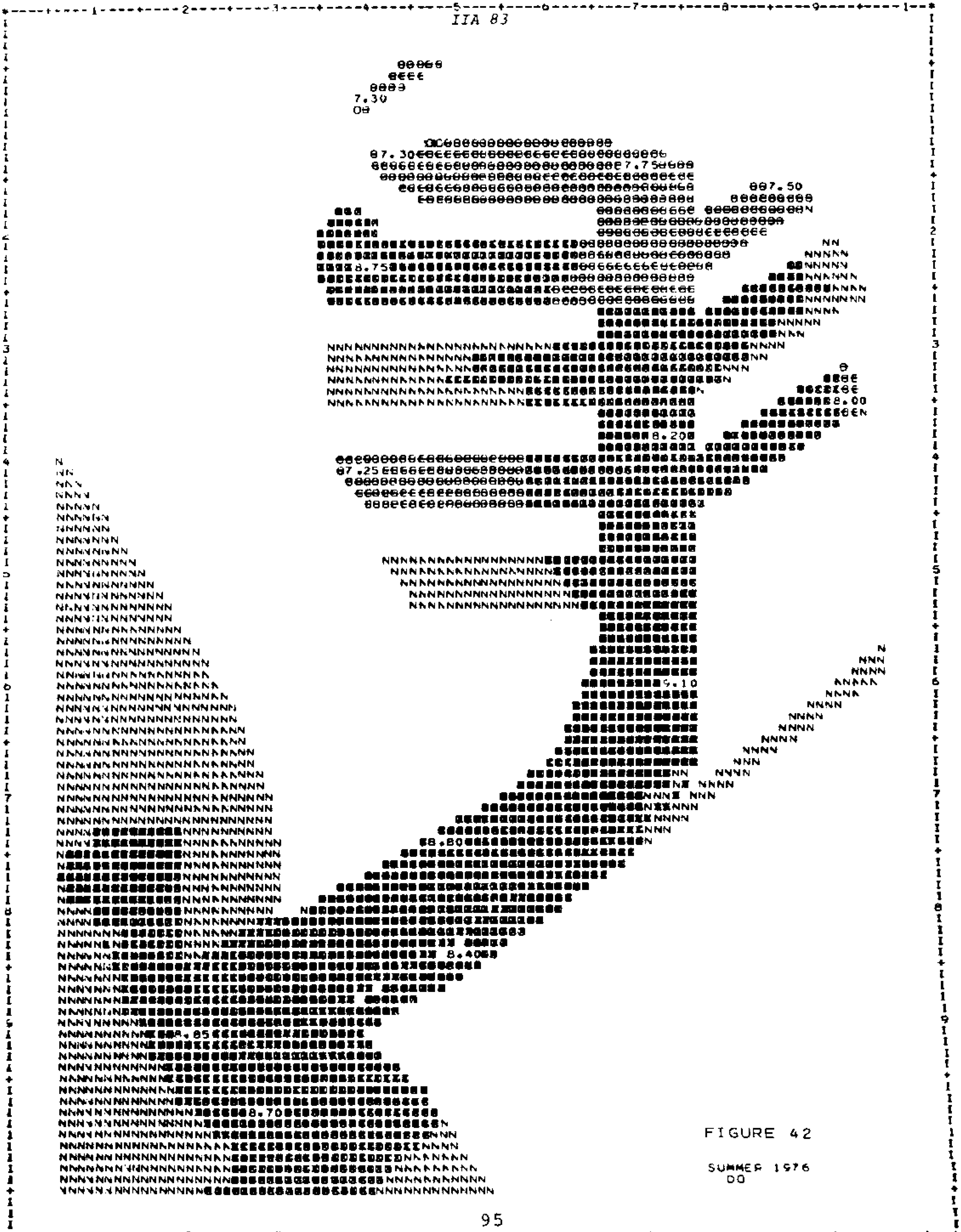


FIGURE 42

SUMMER 1976
DO

FIGURE 43 LEGEND

DISSOLVED OXYGEN
SUMMER 1977

DATA VALUE EXTREMES ARE 5.40 9.37

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

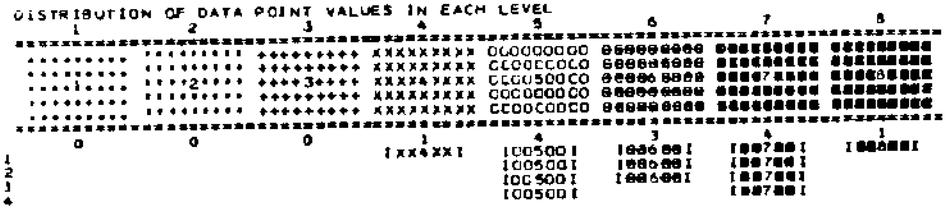
MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS								
FREQ.	0	0	0	1	4	3	4	1



IIA 85

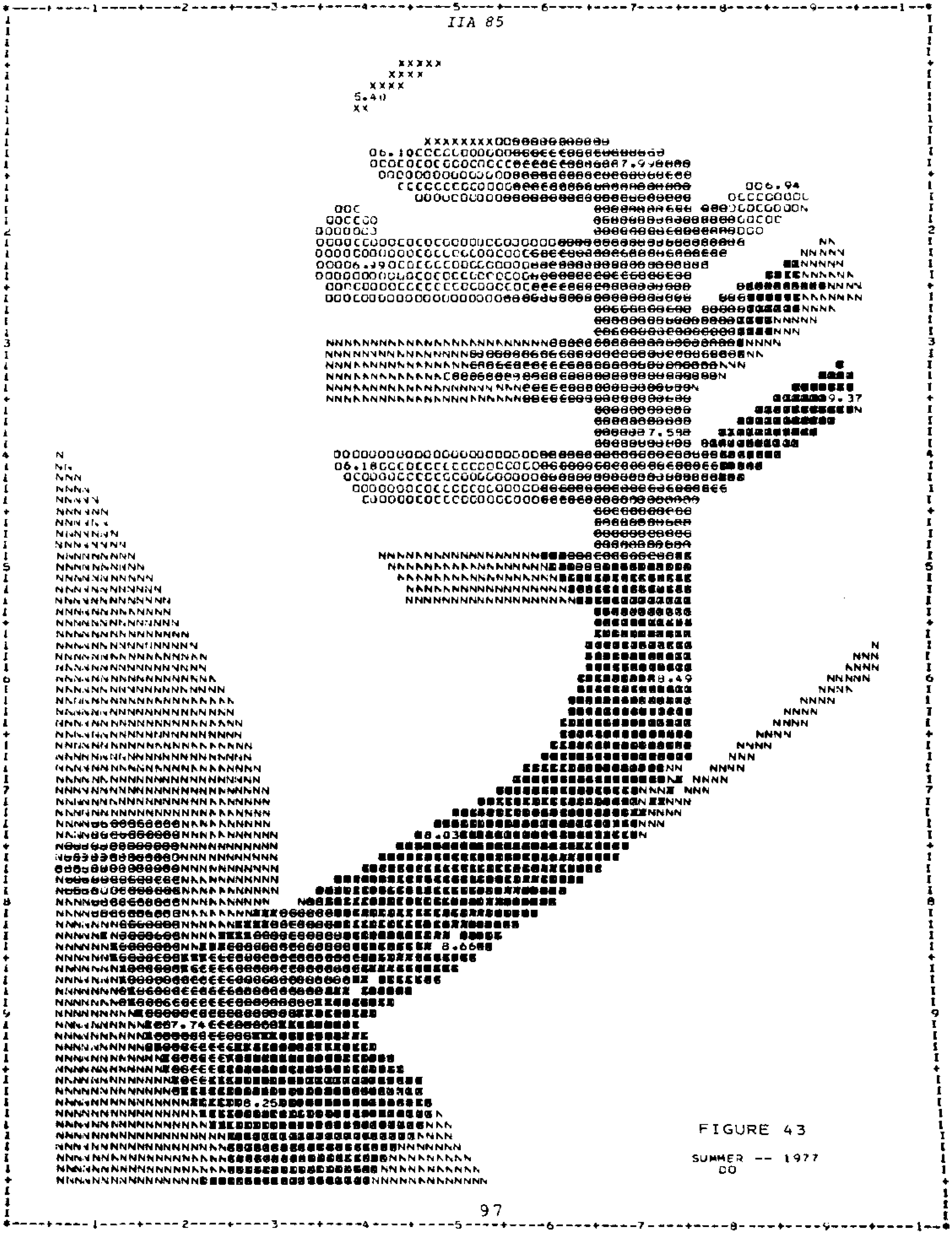


FIGURE 43

SUMMER -- 1977
CO

FIGURE 44 LEGEND

DISSOLVED OXYGEN
SUMMER 1978

```
DATA VALUE EXTREMES ARE          5.00          8.23


ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
      ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

  MINIMUM      0.0       3.00       4.00       5.00       6.00       7.00       8.00       9.00
  MAXIMUM      3.00      4.00       5.00       6.00       7.30       8.00       9.00       9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

               31.48     10.49      10.49      10.49      10.49      10.49      10.49      5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
  LEVEL          1          2          3          4          5          6          7          8
           =========================================================================================
             .........  '''''''''  +++++++++  XXXXXXXXX  CCOCOOOOO  000000000  #########  #########
             .........  '''''''''  +++++++++  XXXXXXXXX  CCCOCOOOO  000000000  #########  #########
  SYMBOLS    ....1....  ''''2''''  ++++3++++  XXXX4XXXX  CCCO50000  000060000  ####7####  ####8####
             .........  '''''''''  +++++++++  XXXXXXXXX  CCOCOOOCO  000000000  #########  #########
             .........  '''''''''  +++++++++  XXXXXXXXX  COOOCOOOO  000000000  #########  #########
           =========================================================================================
  FREQ.          0          0          0          2          6          3          2          0
         1                                    IXX4XXI    IOO5OOI    I00600I    I##7##I
         2                                    IXX4XXI    IO05OOI    I00600I    I##7##I
         3                                               ICC5OOI    I00600I
         4                                               IOO5OOI
         5                                               ICO5COI
         6                                               IOO5OOI
```

IIA 87

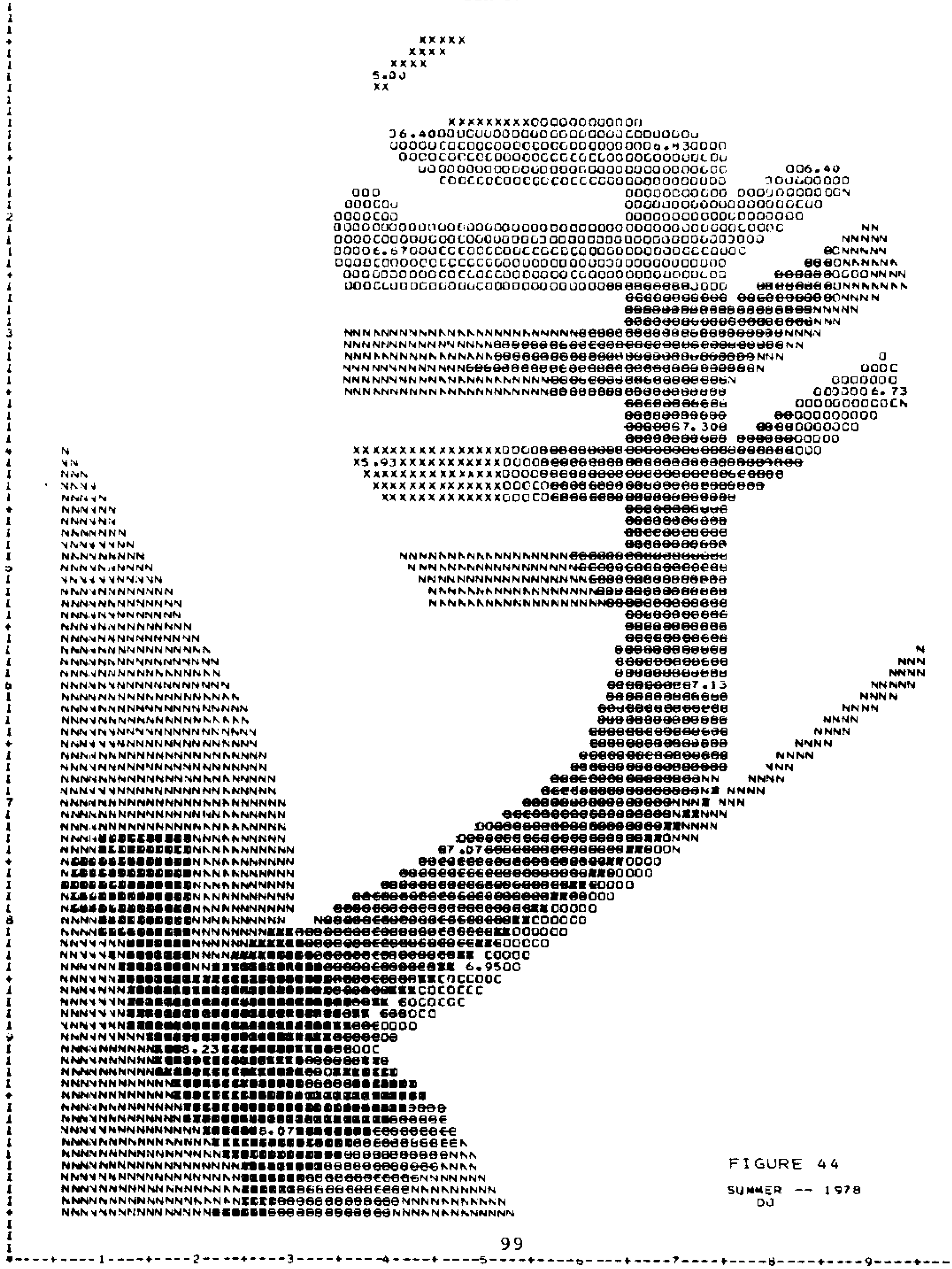


FIGURE 44

SUMMER -- 1978
DJ

FIGURE 45 LEGEND

DISSOLVED OXYGEN
AUTUMN 1976

DATA VALUE EXTREMES ARE 3.27 7.57

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.45	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■	■■■■■■■■■
	....	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■	■■■■■■■■■
	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	ØØØØ6ØØØØ	■■■■7■■■■	■■■■8■■■■
	....	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■	■■■■■■■■■
	....	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	■■■■■■■■■	■■■■■■■■■
FREQ.	0	1	5	3	1	3	0	0
1		I''2''I	I++3++I	IXX4XXI	IOO5OOI	IØØ6ØØI		
2			I++3++I	IXX4XXI		IØØ6ØØI		
3			I++3++I	IXX4XXI		IØØ6ØØI		
4			I++3++I					
5			I++3++I					

IIA 89

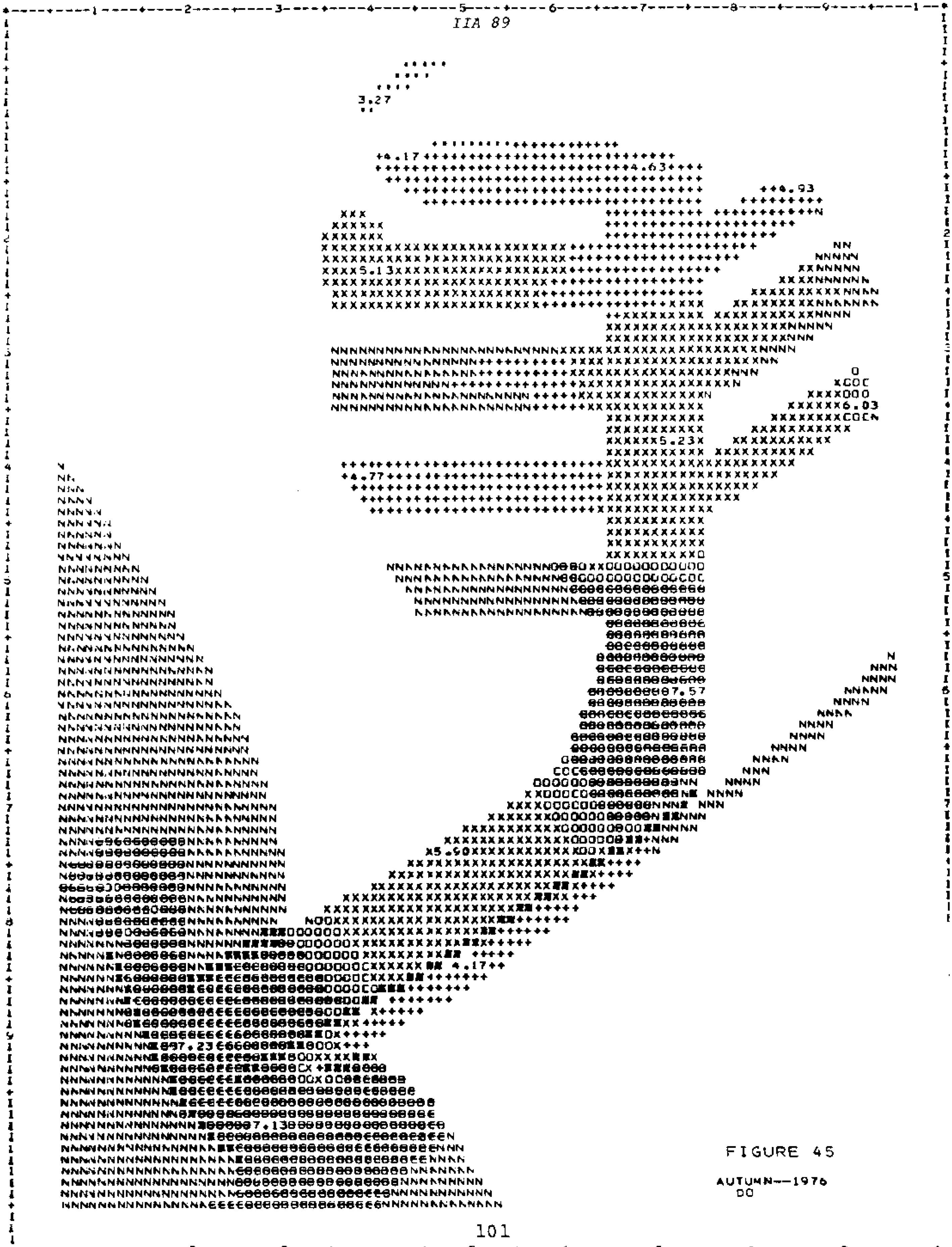


FIGURE 45

AUTUMN--1976
DO

FIGURE 46 LEGEND

DISSOLVED OXYGEN
AUTUMN 1977

DATA VALUE EXTREMES ARE 6.70 9.37

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	[illegible]	[illegible]	[illegible]
FREQ.	0	0	0	0	2	5	4	2

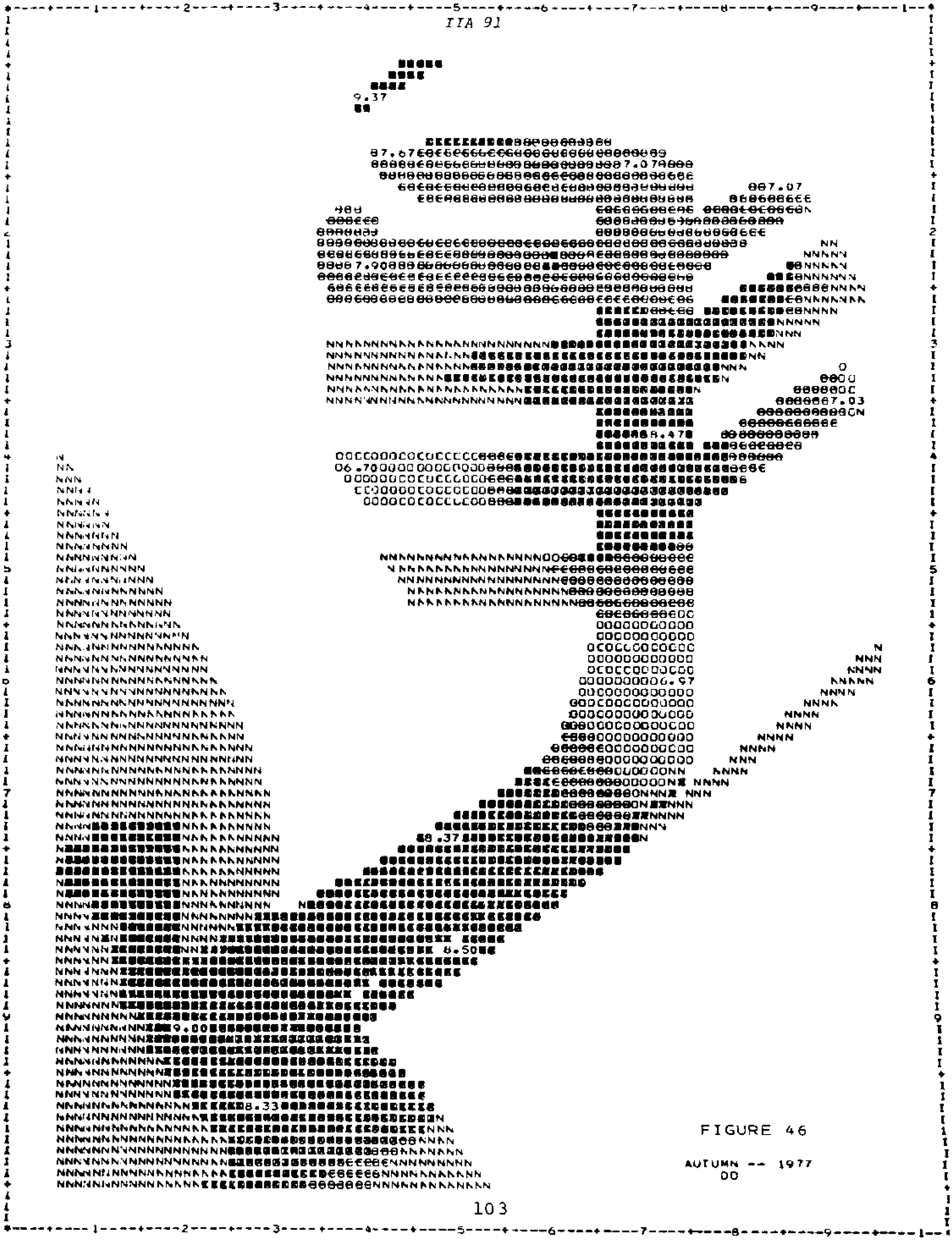


FIGURE 46

AUTUMN -- 1977
OO

FIGURE 47 LEGEND

DISSOLVED OXYGEN
AUTUMN 1978

DATA VALUE EXTREMES ARE 3.30 6.40

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	ØØØØ6ØØØØ	████7████	████8████
FREQ.	0	1	6	3	3	0	0	0

```
FREQ.      0        1         6         3         3        0        0        0
   1             I''2''I   I++3++I   IXX4XXI   IOO5OOI
   2                       I++3++I   IXX4XXI   IOO5OOI
   3                       I++3++I   IXX4XXI   IOO5OOI
   4                       I++3++I
   5                       I++3++I
   6                       I++3++I
```

IIA 93

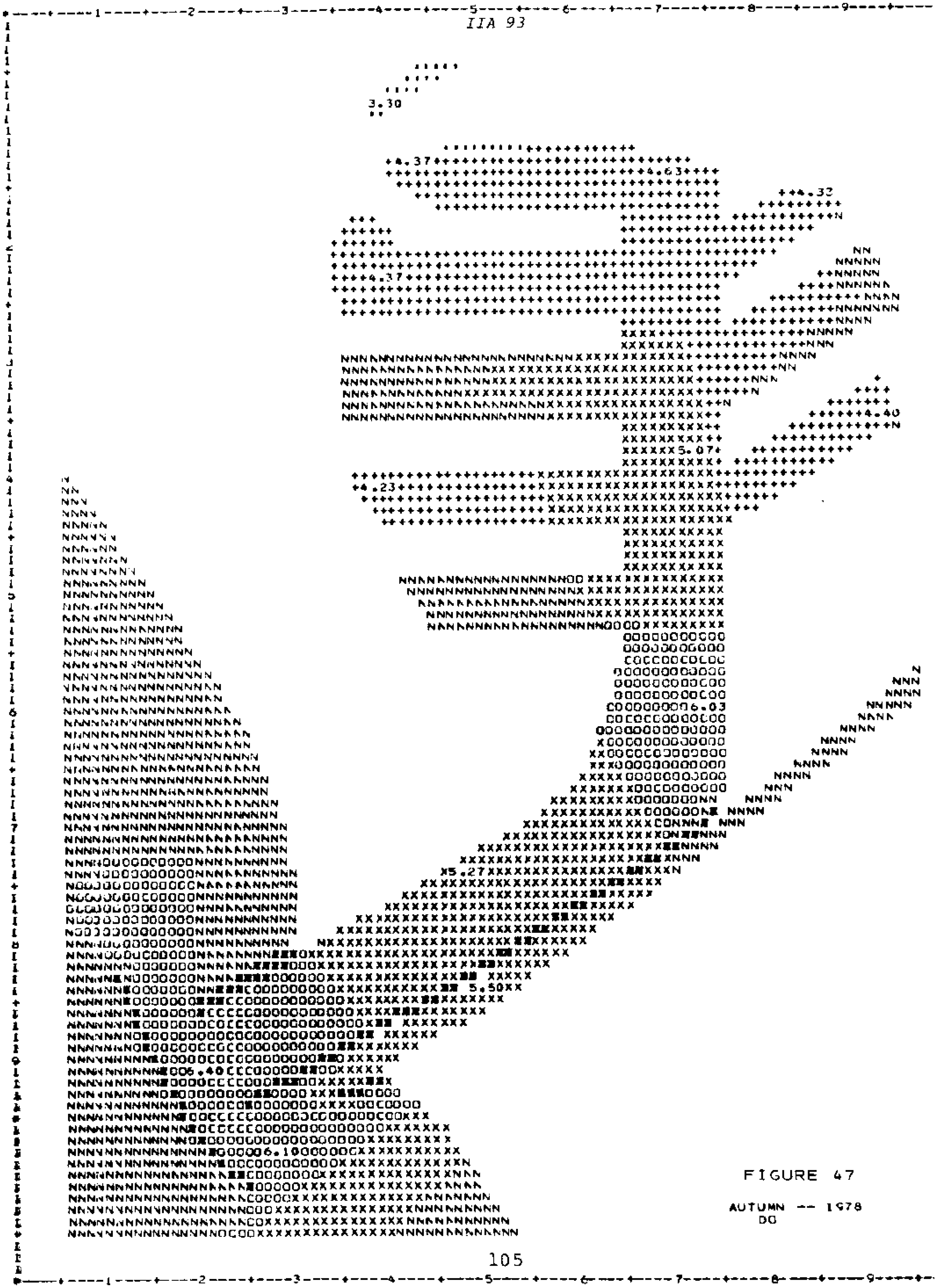


FIGURE 47

AUTUMN -- 1978
DO

FIGURE 48 LEGEND

DISSOLVED OXYGEN
WINTER 1976-1977

DATA VALUE EXTREMES AGE 2.20 5.70

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL          1          2          3          4          5          6          7          8
         ==========================================================================================
           .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........  '''''''''  +++++++++  XXXXXXXXX  OOOO5OOOO  @@@@6@@@@  ####7####  ####8####
SYMBOLS    ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........
         ==========================================================================================
FREQ.          5          6          1          1          0          0          0          0
       1   I..1..I    I''2''I    I++3++I    IXX4XXI
       2   I..1..I    I''2''I
       3   I..1..I    I''2''I
       4   I..1..I    I''2''I
       5   I..1..I    I''2''I
       6              I''2''I
```

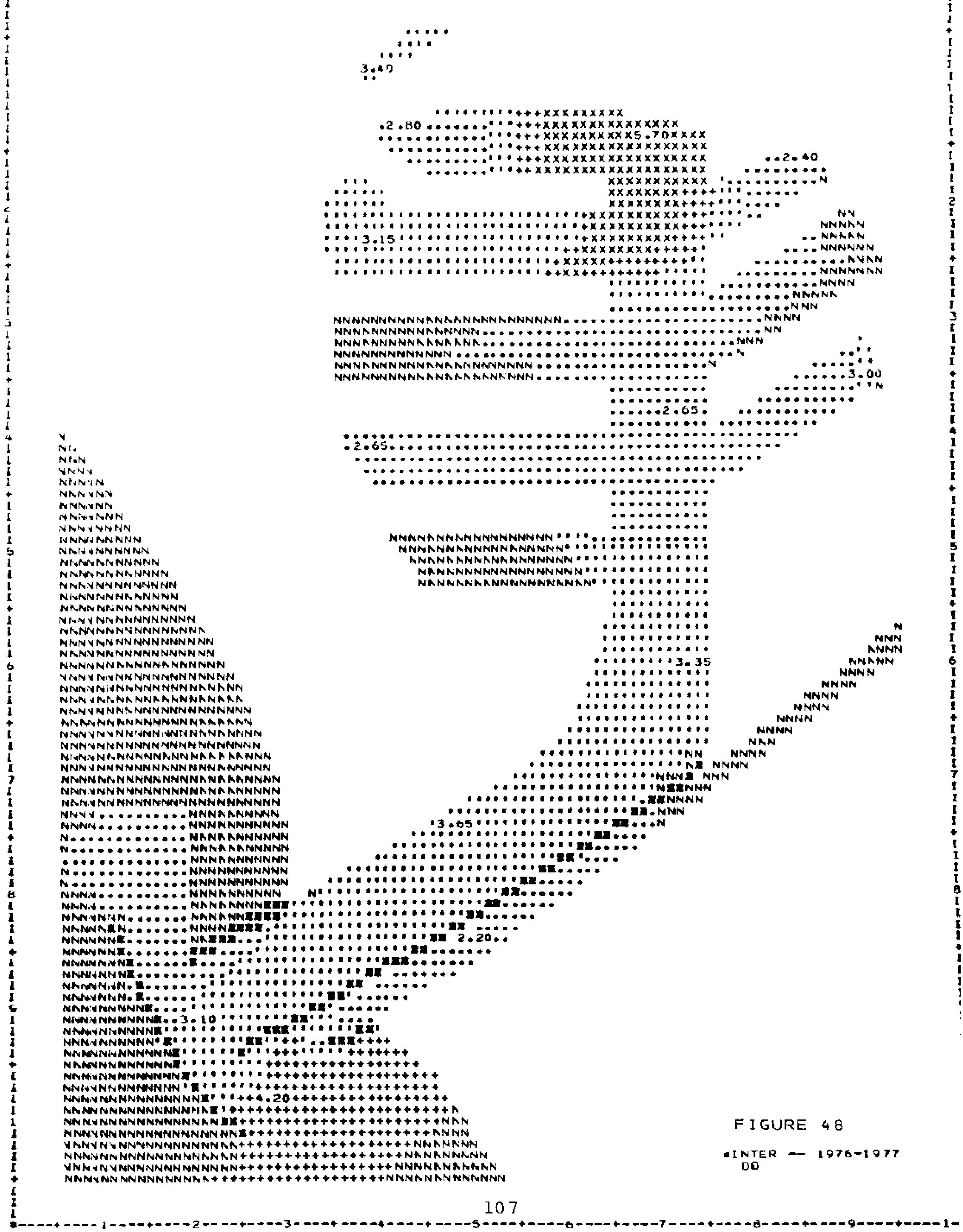


FIGURE 48

WINTER -- 1976-1977
DO

FIGURE 49 LEGEND

DISSOLVED OXYGEN
WINTER 1977-1978

DATA VALUE EXTREMES ARE 6.15 9.33

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
FREQ.	0	0	0	0	1	5	4	3

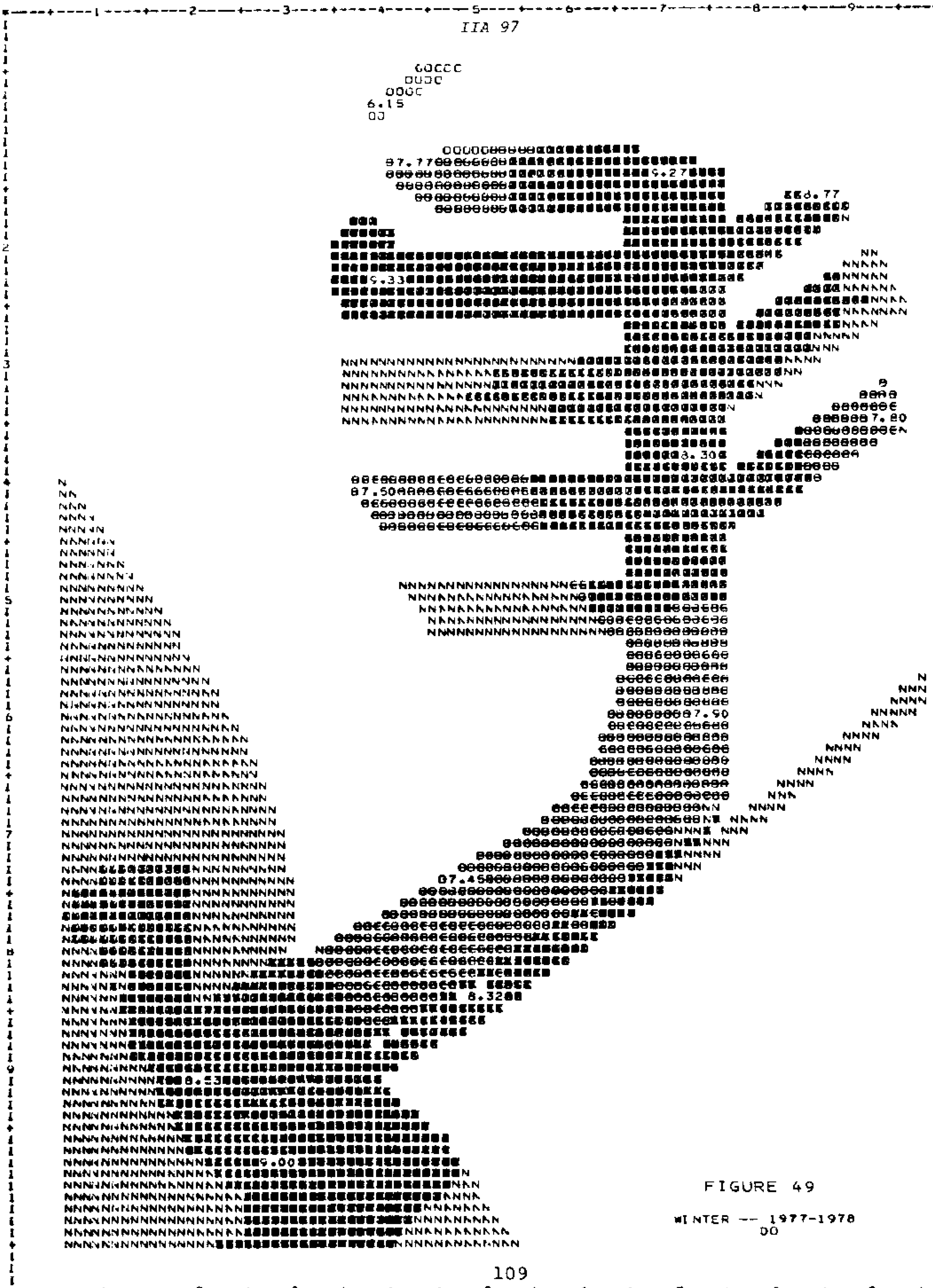


FIGURE 49

WINTER -- 1977-1978
DO

FIGURE 50 LEGEND

DISSOLVED OXYGEN
WINTER 1978-1979

DATA VALUE EXTREMES ARE 4.37 7.17

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	@@@@6@@@@	@@@@7@@@@	@@@@8@@@@
FREQ.	0	0	2	2	6	3	0	0
1			I++3++I	IXX4XXI	IOO5OOI	I@@6@@I		
2			I++3++I	IXX4XXI	IOO5OOI	I@@6@@I		
3					IOO5OOI	I@@6@@I		
4					IOO5OOI			
5					IOO5OOI			
6					IOO5OOI			

IIA 99

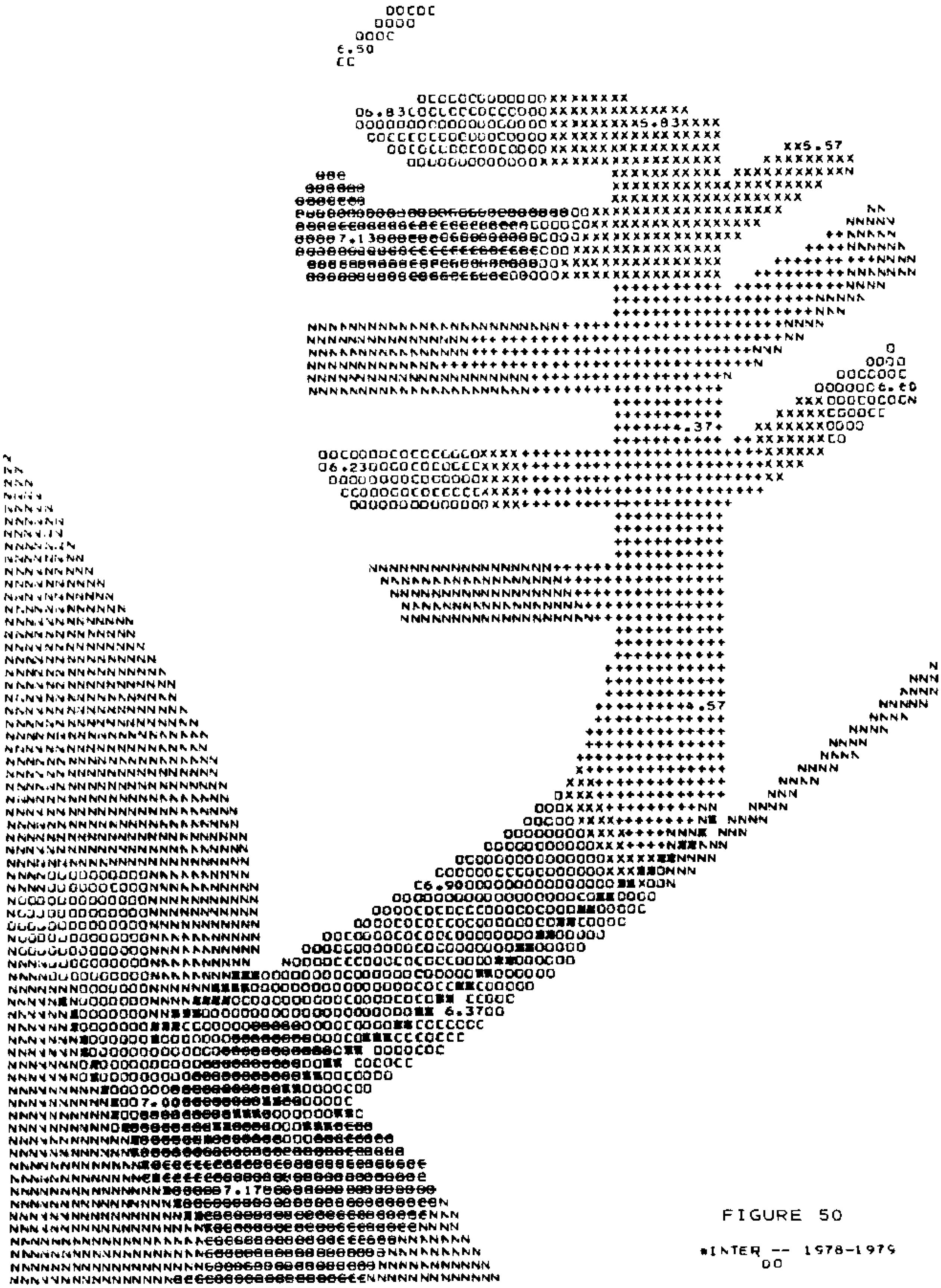


FIGURE 50

*INTER -- 1978-1979
DD

FIGURE 51 LEGEND

DISSOLVED OXYGEN
SPRING 1977

DATA VALUE EXTREMES ARE 7.43 9.53

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

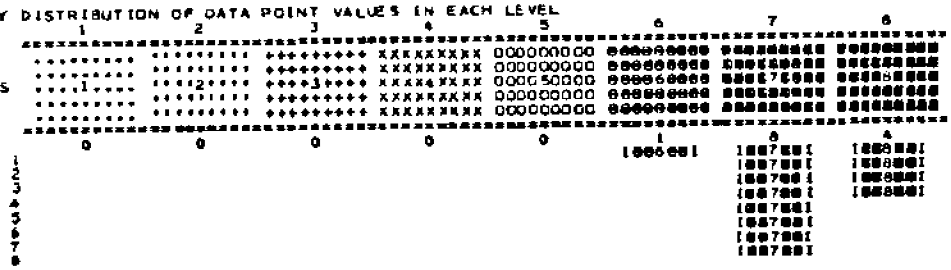
MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
FREQ.	0	0	0	0	0	1	8	4



IIA 101

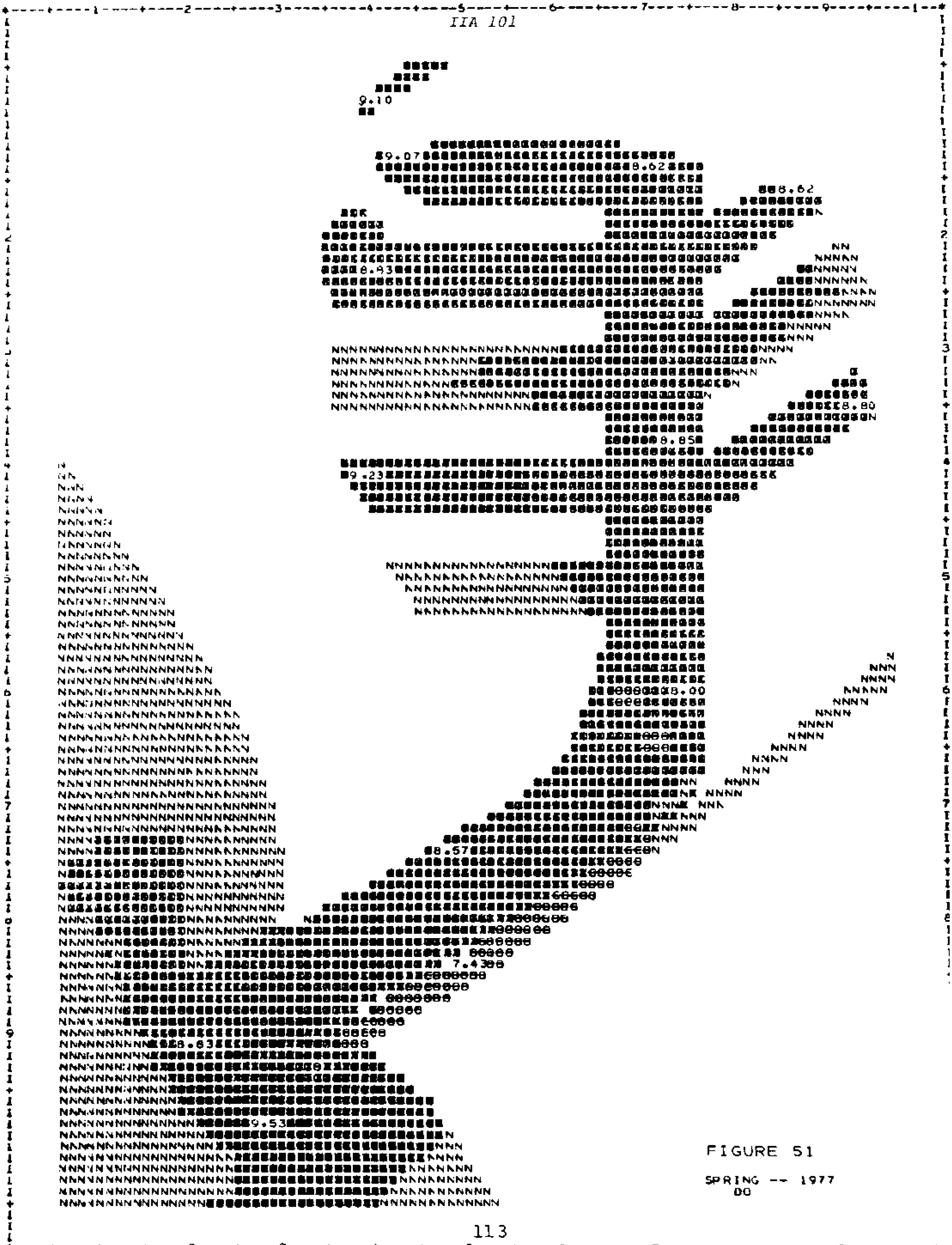


FIGURE 51

SPRING -- 1977
DO

FIGURE 52 LEGEND

DISSOLVED OXYGEN
SPRING 1978

DATA VALUE EXTREMES ARE 7.07 8.60

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	66666	7	8
FREQ.	0	0	0	0	0	10	3	0
1						I006001	I007001	
2						I006001	I007001	
3						I006001	I007001	
4						I006001		
5						I006001		
6						I006001		
7						I006001		
8						I006001		
9						I006001		
10						I006001		

IIA 103

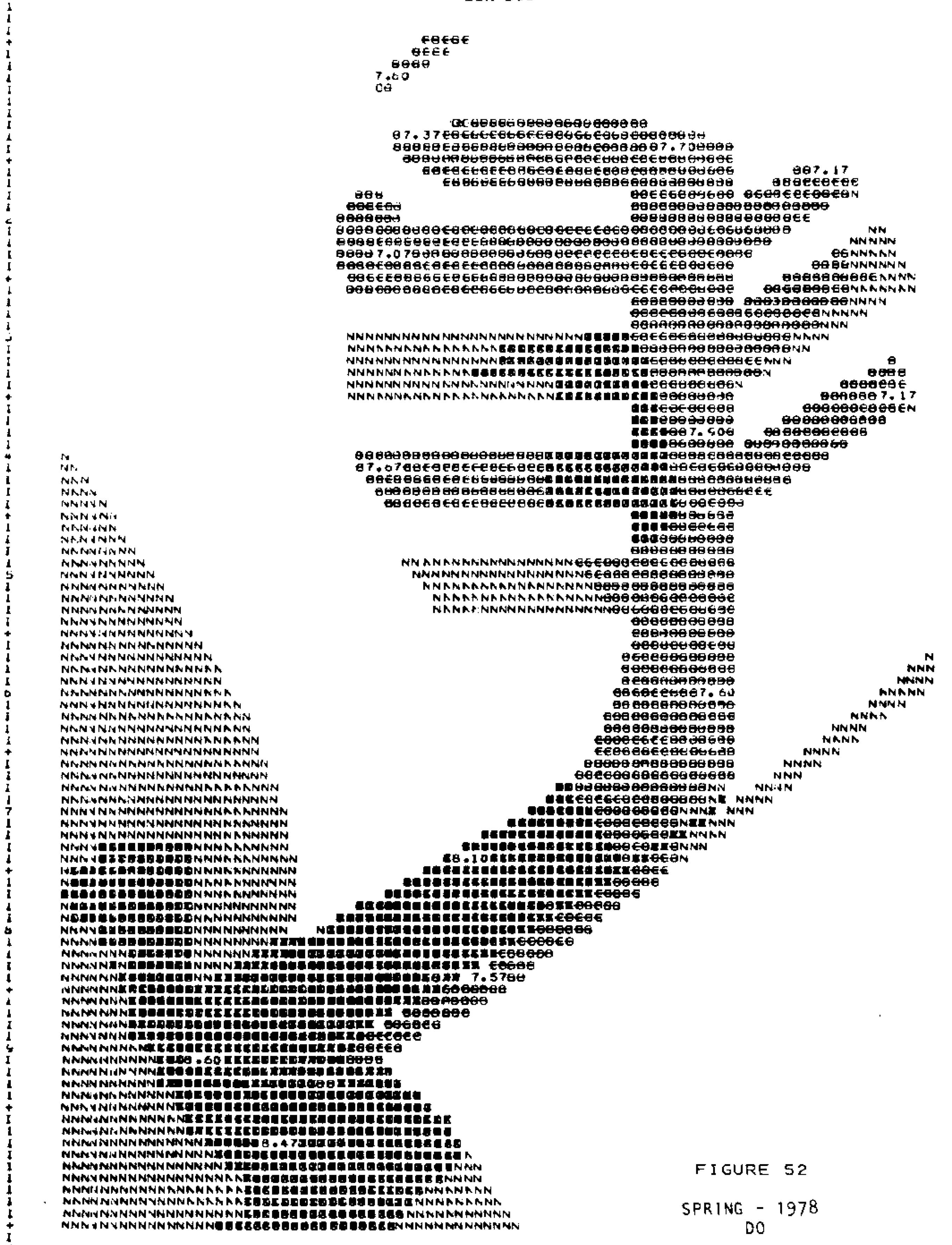


FIGURE 52

SPRING - 1978
DO

FIGURE 53 LEGEND

DISSOLVED OXYGEN
SPRING 1979

DATA VALUE EXTREMES ARE 5.97 8.10

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM* INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	3.00	4.00	5.00	6.00	7.00	8.00	9.00
MAXIMUM	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

31.48	10.49	10.49	10.49	10.49	10.49	10.49	5.56

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8
       *****************************************************************************************
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOO5OOOO  @@@@6@@@@  ####7####  ####8####
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
       *****************************************************************************************
FREQ.        0          0          0          1          7          4          1          0
       1                                 IXX4XXI    IOO5OOI    I@@6@@I    I##7##I
       2                                            IOO5OOI    I@@6@@I
       3                                            IOO5OOI    I@@6@@I
       4                                            IOO5OOI    I@@6@@I
       5                                            IOO5OOI
       6                                            IOO5OOI
       7                                            IOO5OOI
```

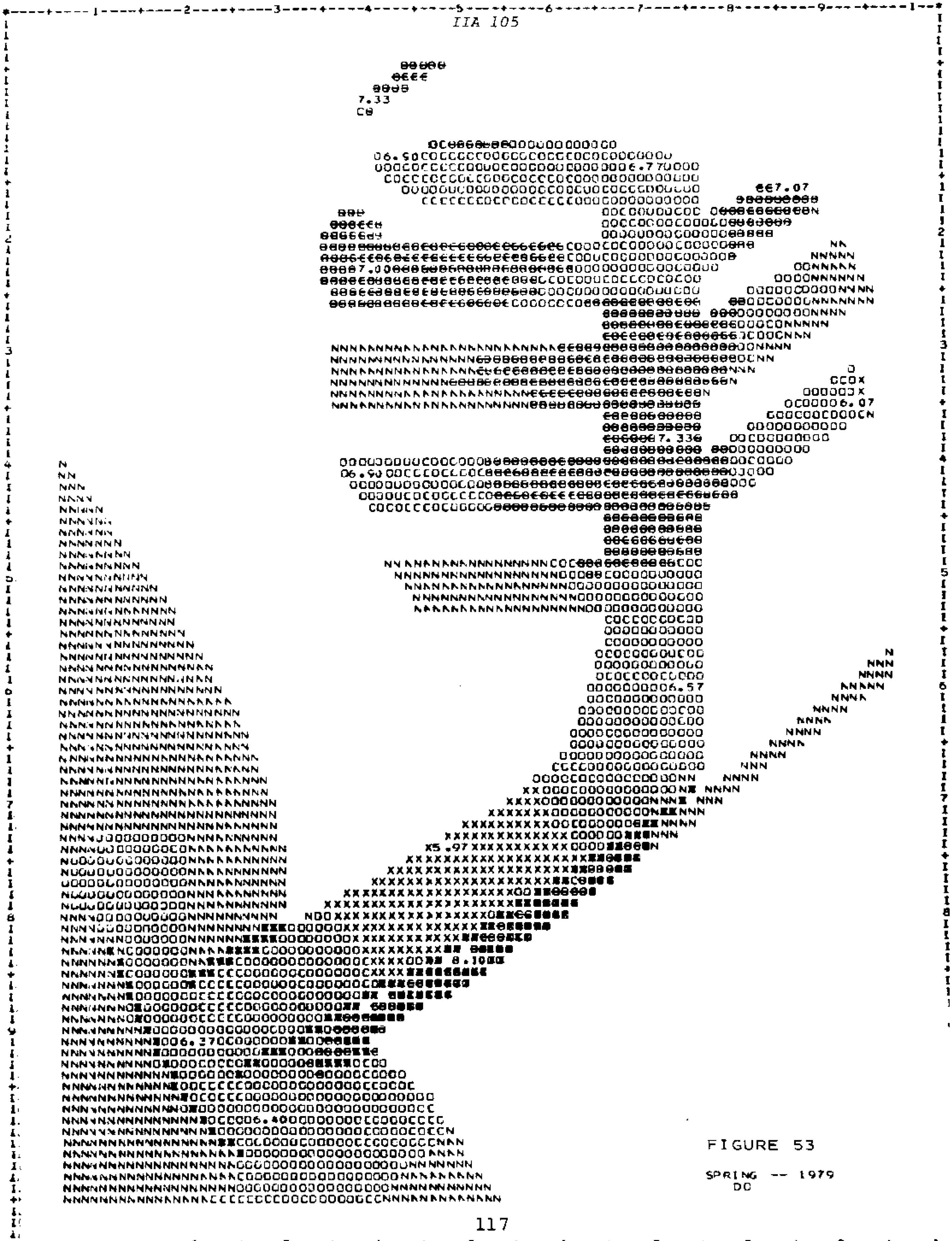


FIGURE 53

SPRING -- 1979
DO

FIGURE 54 LEGEND

PH -- YEARLY AVERAGE
1976-1977

DATA VALUE EXTREMES ARE 7.97 8.17

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	8.0	7.93	7.97	8.00	8.03	8.10	8.18	8.30
MAXIMUM	7.93	7.97	8.00	8.03	8.10	8.18	8.30	8.34

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

95.08	0.48	0.36	0.36	0.84	0.96	1.44	0.48

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8
          ...................................................................................
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  [illegible] [illegible]
SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOO5OOOO  @@@@6@@@@  [illegible] [illegible]
          .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  [illegible] [illegible]
          ...................................................................................
FREQ.        0          0          1          2          6          4          0          0
     1                          I++3++I    IXX4XXI    IOO5OOI    I@@6@@I
     2                                     IXX4XXI    IOO5OOI    I@@6@@I
     3                                                IOO5OOI    I@@6@@I
     4                                                IOO5OOI    I@@6@@I
     5                                                IOO5OOI
     6                                                IOO5OOI
```

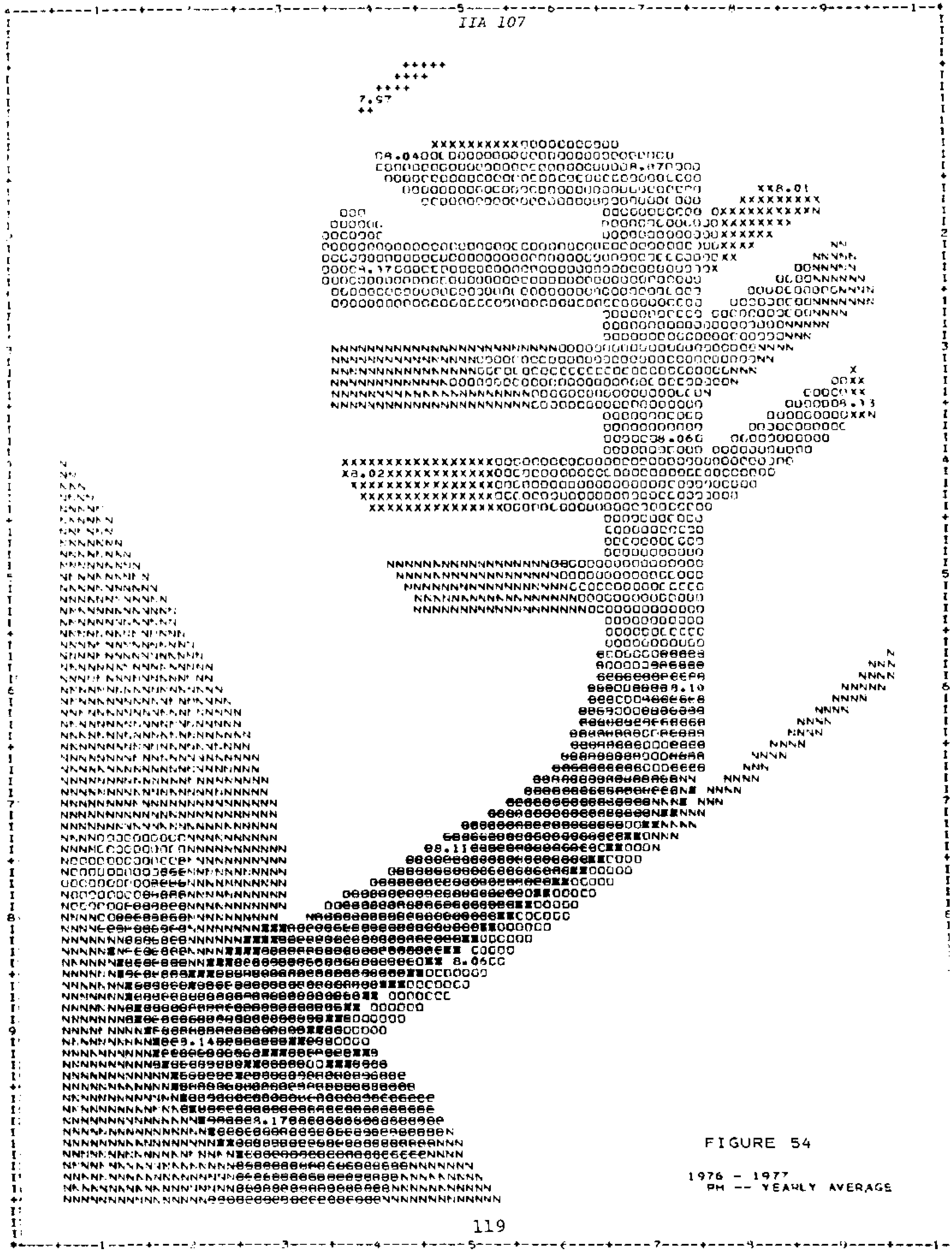


FIGURE 54

1976 – 1977
PH -- YEARLY AVERAGE

FIGURE 55 LEGEND

PH -- YEARLY AVERAGE
1977-1978

```
DATA VALUE EXTREMES ARE          7.93         8.08


ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
      ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

  MINIMUM      0.0       7.93       7.97       8.00       8.03       8.10       8.18       8.30
  MAXIMUM      7.93      7.97       8.00       8.03       8.10       8.18       8.30       8.34

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

              95.08      0.48       0.36       0.36       0.84       0.96       1.44       0.48

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
  LEVEL          1          2          3          4          5          6          7          8
           *****************************************************************************************
            .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  [illegible]  [illegible]
            .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  [illegible]  [illegible]
  SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOO5OOOO  @@@@6@@@@  [illegible]  [illegible]
            .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  [illegible]  [illegible]
            .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  [illegible]  [illegible]
           *****************************************************************************************
  FREQ.          0          4          3          2          4          0          0          0
          1             I''2''I    I++3++I    IXX4XXI    IOO5OOI
          2             I''2''I    I++3++I    IXX4XXI    IOO5OOI
          3             I''2''I    I++3++I               IOO5OOI
          4             I''2''I                          IOO5OOI
```

FIGURE 55

1977 - 1978
PH -- YEARLY AVERAGE

FIGURE 56 LEGEND

PH -- YEARLY AVERAGE
1978-1979

DATA VALUE EXTREMES ARE 0.00 8.34

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.93	7.97	8.00	8.03	8.10	8.18	8.30
MAXIMUM	7.93	7.97	8.00	8.03	8.10	8.18	8.30	8.34

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

95.88	0.48	0.36	0.36	0.84	0.96	1.44	0.48

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	OOOO5OOOO	9999699999	■■■■7■■■■	■■■■8■■■■
FREQ.	0	0	0	1	0	0	9	3

	1	2	3	4	5	6	7	8
1				IXX4XXI			I■■7■■I	I■■8■■I
2							I■■7■■I	I■■8■■I
3							I■■7■■I	I■■8■■I
4							I■■7■■I	
5							I■■7■■I	
6							I■■7■■I	
7							I■■7■■I	
8							I■■7■■I	
9							I■■7■■I	

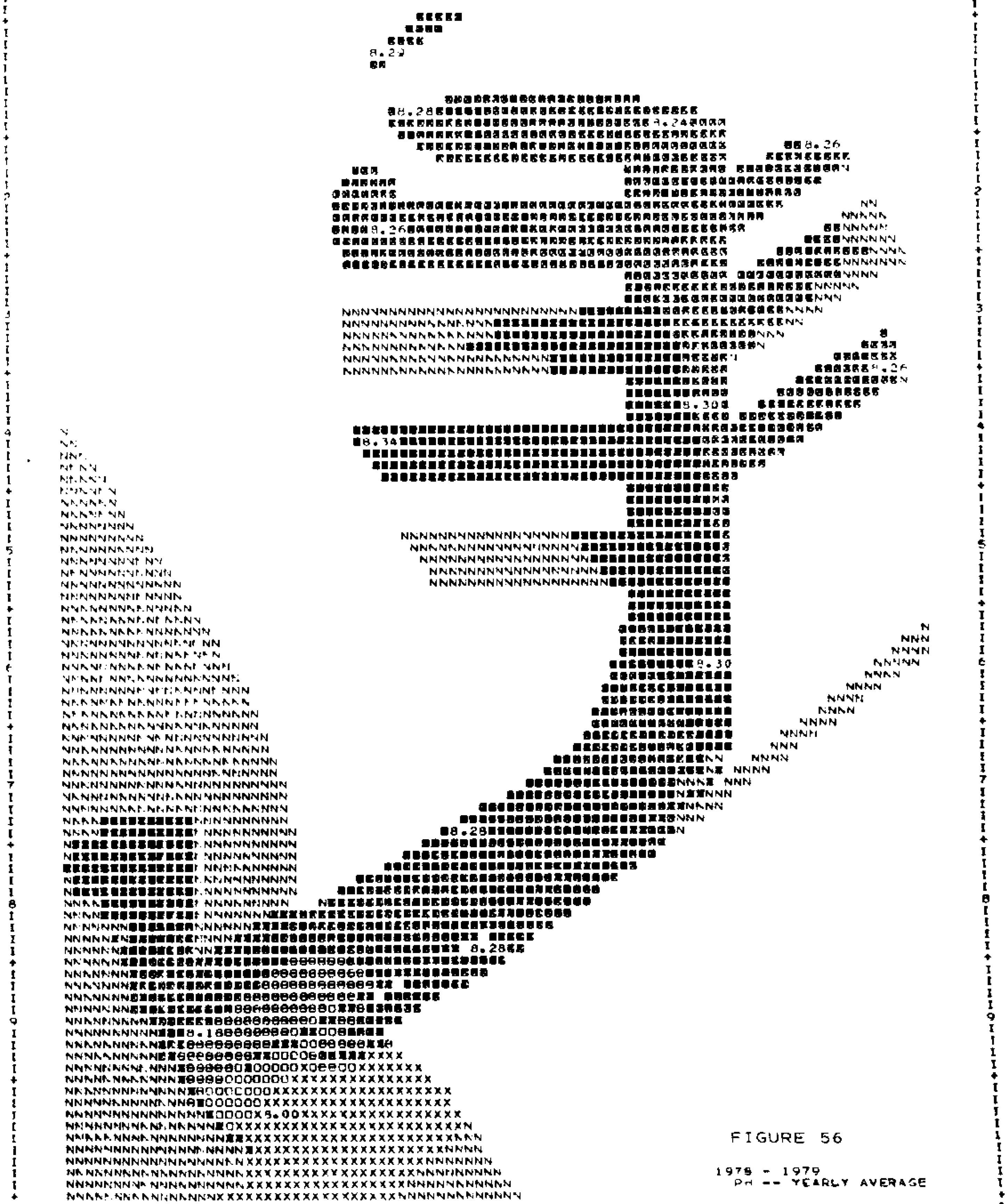


FIGURE 56

1979 - 1979
PH -- YEARLY AVERAGE

FIGURE 57 LEGEND

AVERAGE PH
SUMMER 1976

DATA VALUE EXTREMES ARE 8.00 8.21

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	####8####	####9####
FREQ.	0	0	0	0	3	7	3	0	0
1					IXX5XXI	IOO6OOI	I06780I		
2					IXX5XXI	IOO6OOI	I06780I		
3					IXX5XXI	IOO6OOI	I06780I		
4						IOO6OOI			
5						IOO6OOI			
6						IOO6OOI			
7						IOO6OOI			

IIA 113

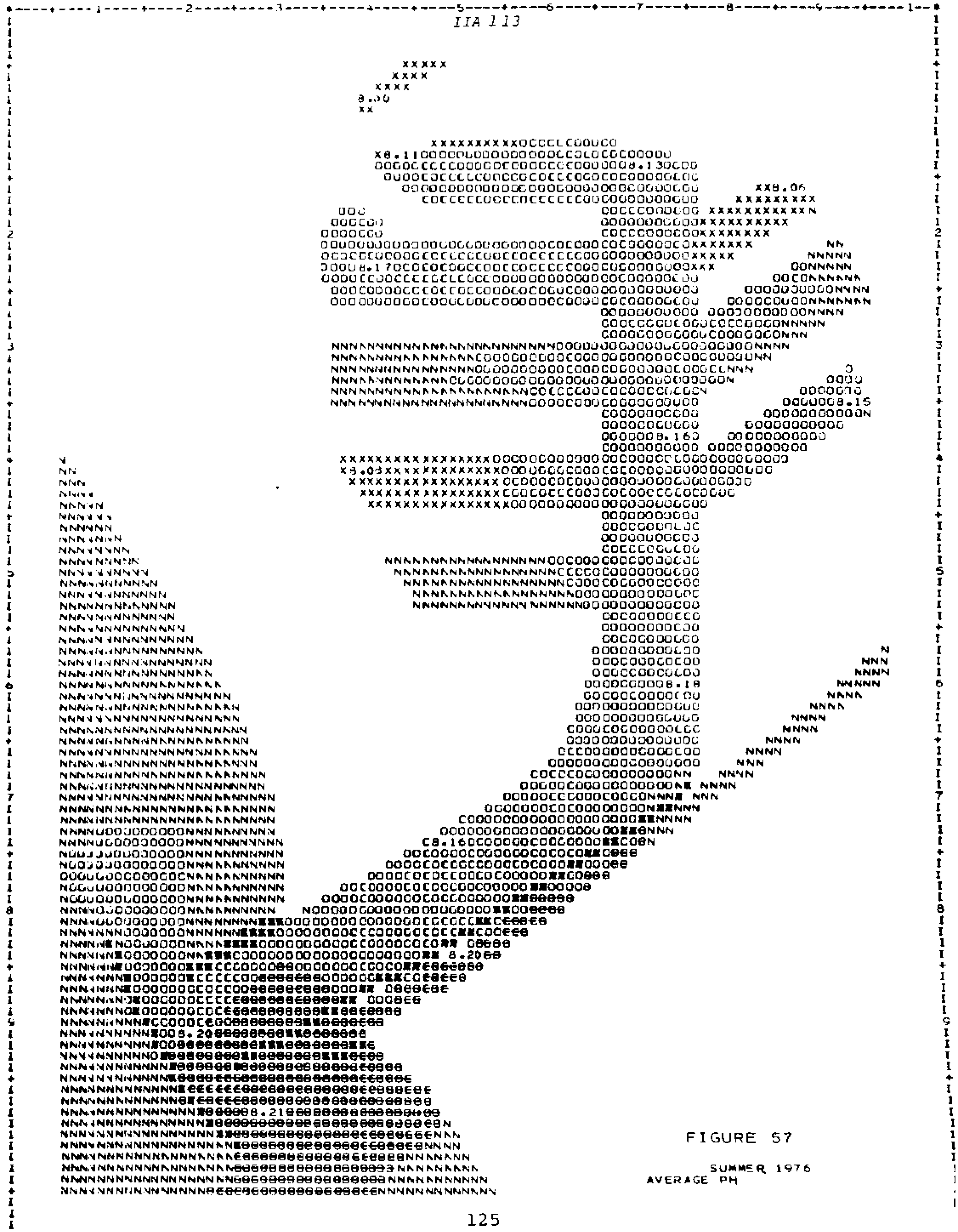


FIGURE 57

SUMMER 1976
AVERAGE PH

FIGURE 58 LEGEND

AVERAGE PH
SUMMER 1977

DATA VALUE EXTREMES ARE 8.09 8.36

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	▒▒▒▒▒▒▒▒▒	█████████
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	▒▒▒▒▒▒▒▒▒	█████████
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	▒▒▒▒8▒▒▒▒	████9████
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	▒▒▒▒▒▒▒▒▒	█████████
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	▒▒▒▒▒▒▒▒▒	█████████
FREQ.	0	0	0	0	2	2	6	3	0
1					IXX5XXI	IOO6OOI	IØØ7ØØI	I▒▒8▒▒I	
2					IXX5XXI	IOO6OOI	IØØ7ØØI	I▒▒8▒▒I	
3							IØØ7ØØI	I▒▒8▒▒I	
4							IØØ7ØØI		
5							IØØ7ØØI		
6							IØØ7ØØI		

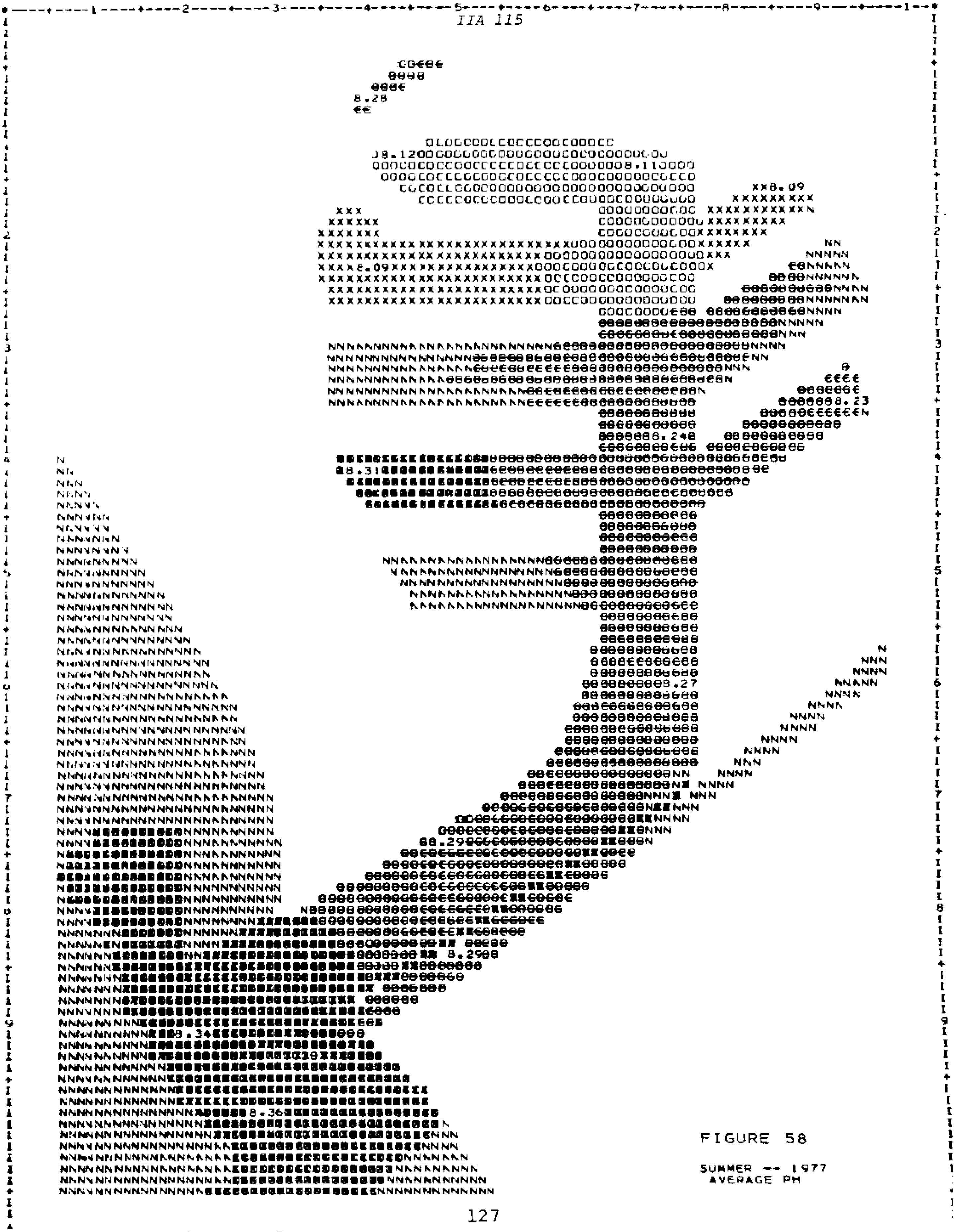


FIGURE 58

SUMMER -- 1977
AVERAGE PH

FIGURE 59 LEGEND

AVERAGE PH
SUMMER 1978

DATA VALUE EXTREMES ARE 8.07 8.32

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

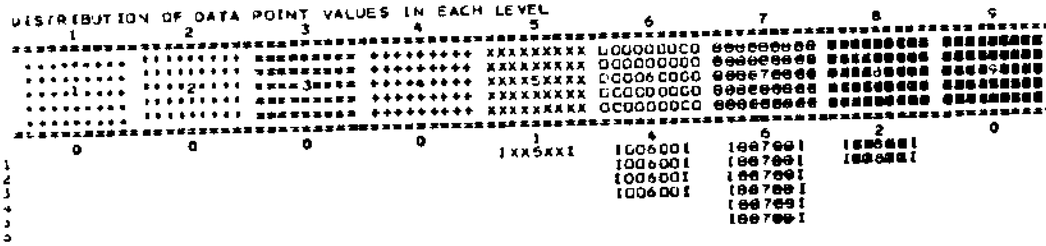
PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
FREQ.	0	0	0	0	1	4	6	2	0

SYMBOLS



IIA 117

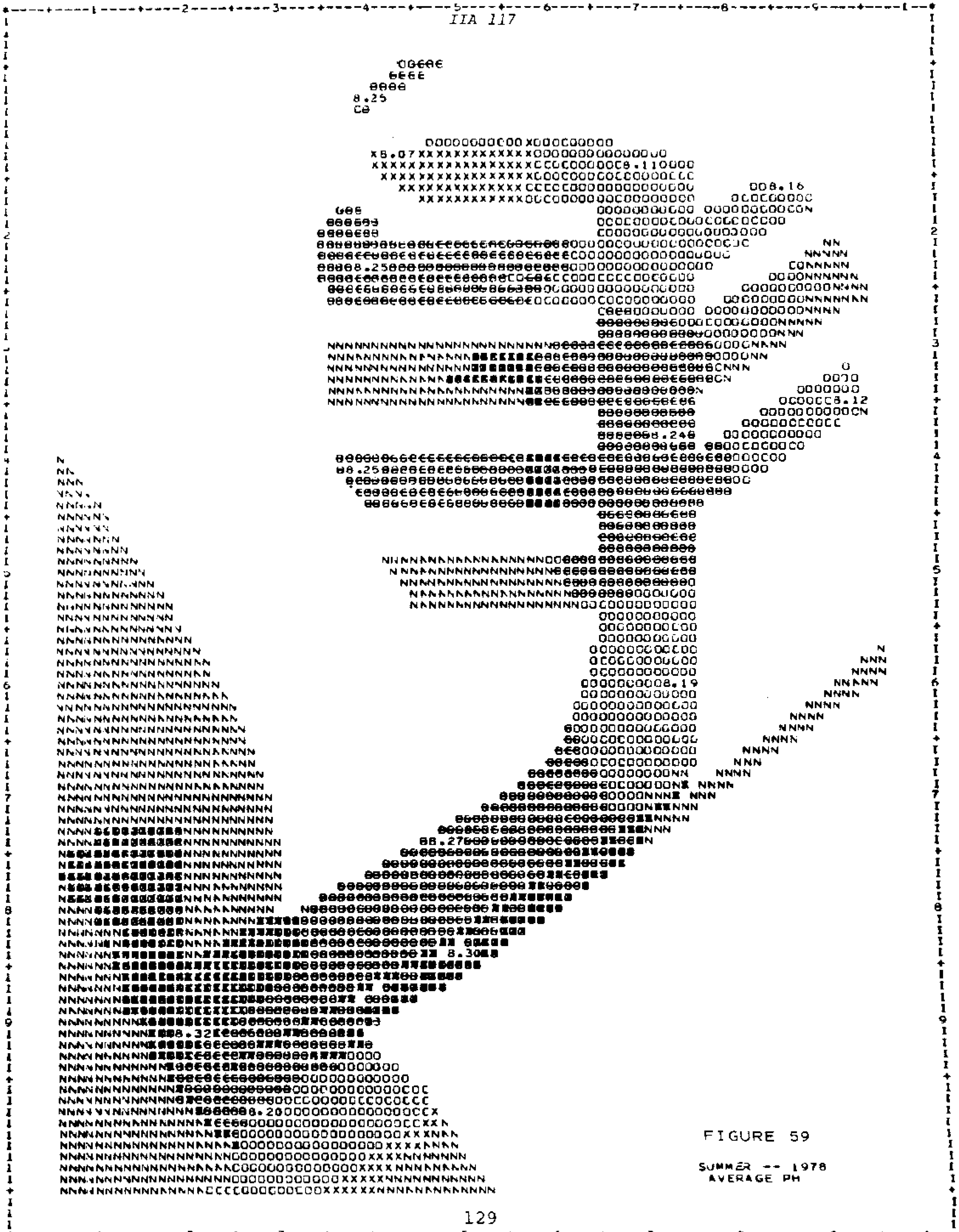


FIGURE 59

SUMMER -- 1978
AVERAGE PH

FIGURE 60 LEGEND

AVERAGE PH
AUTUMN 1976

DATA VALUE EXTREMES ARE 7.73 8.04

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	····1····	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	(overprinted) 7	(overprinted) 8	(overprinted) 9
FREQ.	0	0	1	9	3	0	0	0	0

```
FREQ.       0         0         1         9         3         0         0         0         0
    1                        I==3==I   I++4++I   IXX5XXI
    2                                  I++4++I   IXX5XXI
    3                                  I++4++I   IXX5XXI
    4                                  I++4++I
    5                                  I++4++I
    6                                  I++4++I
    7                                  I++4++I
    8                                  I++4++I
    9                                  I++4++I
```

IIA 119

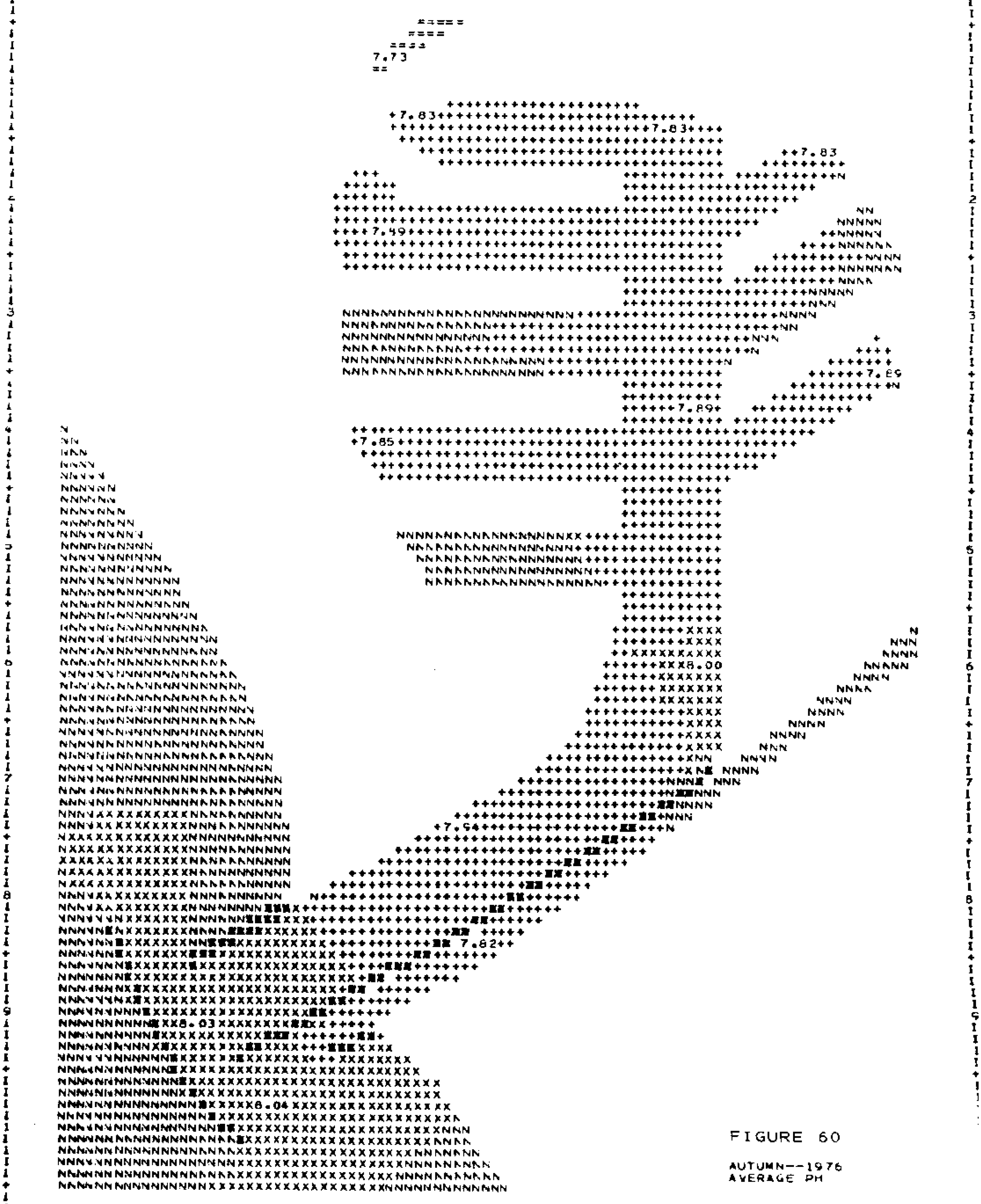


FIGURE 60

AUTUMN--1976
AVERAGE PH

FIGURE 61 LEGEND

AVERAGE PH
AUTUMN 1977

DATA VALUE EXTREMES ARE 7.87 8.37

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1         2         3         4         5         6         7         8         9
        ******************************************************************************************
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  █████████  █████████  █████████
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  █████████  █████████  █████████
SYMBOLS  ....1....  ''''2''''  ====3====  +++++++++  XXXX5XXXX  OOOO6OOOO  ████7████  ████8████  ████9████
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  █████████  █████████  █████████
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  █████████  █████████  █████████
        ******************************************************************************************
FREQ.        0         0         0         4         4         3         1         1         0
       1                              I++4++I    IXX5XXI    IOO6OOI    I██7██I    I██8██I
       2                              I++4++I    IXX5XXI    IOO6OOI
       3                              I++4++I    IXX5XXI    IOO6OOI
       4                              I++4++I    IXX5XXI
```

0.207550 MINUTES FOR HISTOGRAM

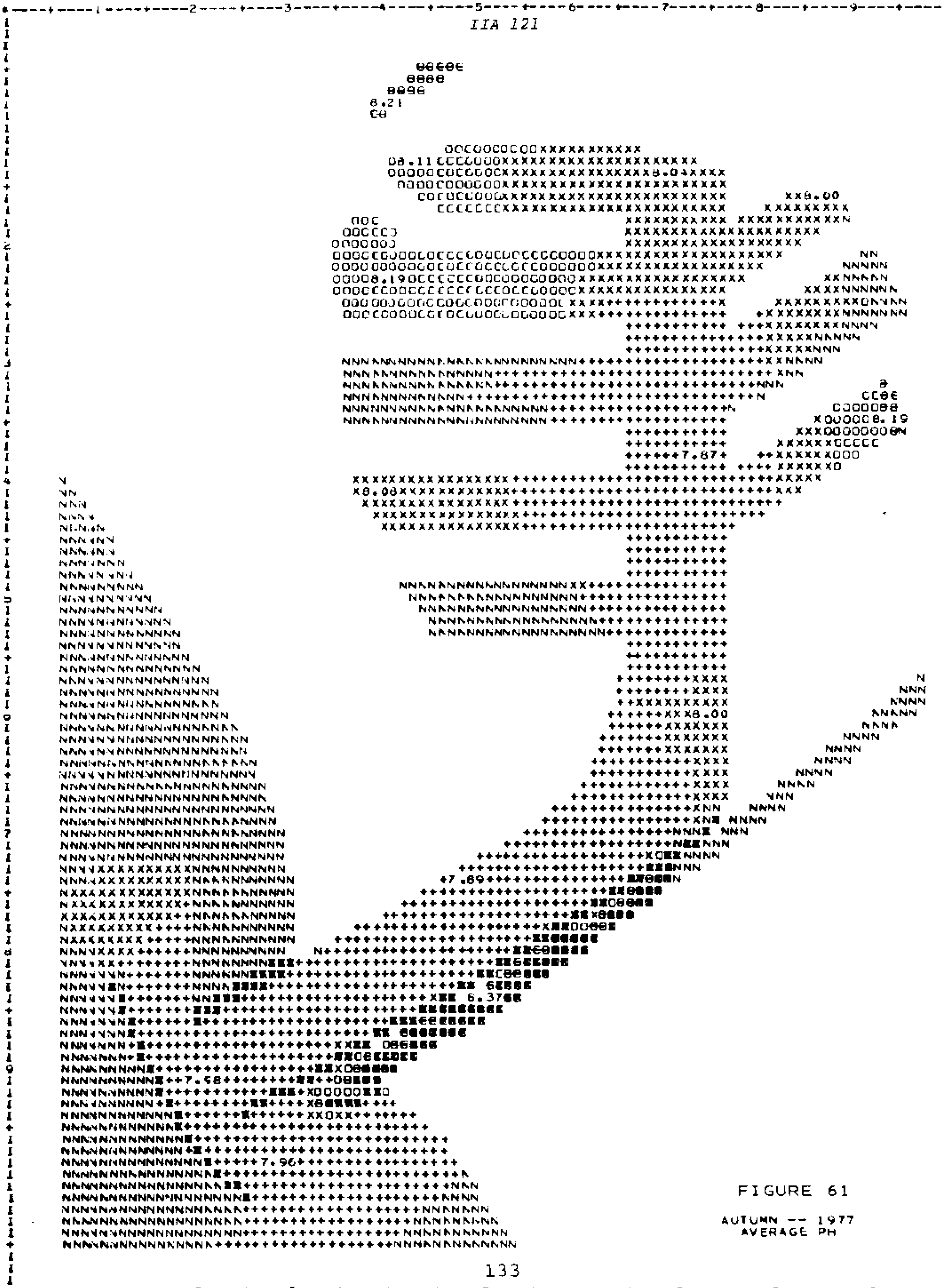


FIGURE 61

AUTUMN -- 1977
AVERAGE PH

FIGURE 62 LEGEND

AVERAGE PH
AUTUMN 1978

DATA VALUE EXTREMES ARE 7.83 8.19

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL       1          2          3          4          5          6          7          8          9
        *****************************************************************************************************
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ ######### #########
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ ######### #########
SYMBOLS  ....1....  ''''2'''' ====3==== ++++4++++ XXXX5XXXX OOOO6OOOO @@@@7@@@@ ####8#### ####9####
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ ######### #########
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ ######### #########
        *****************************************************************************************************
FREQ.       0          0          0          1          3          9          0          0          0
      1                                   I+++++I    IXX5XXI    IOO6OOI
      2                                              IXX5XXI    IOO6OOI
      3                                              IXX5XXI    IOO6OOI
      4                                                         IOO6OOI
      5                                                         IOO6OOI
      6                                                         IOO6OOI
      7                                                         IOO6OOI
      8                                                         IOO6OOI
      9                                                         IOO6OOI
```

IIA 123

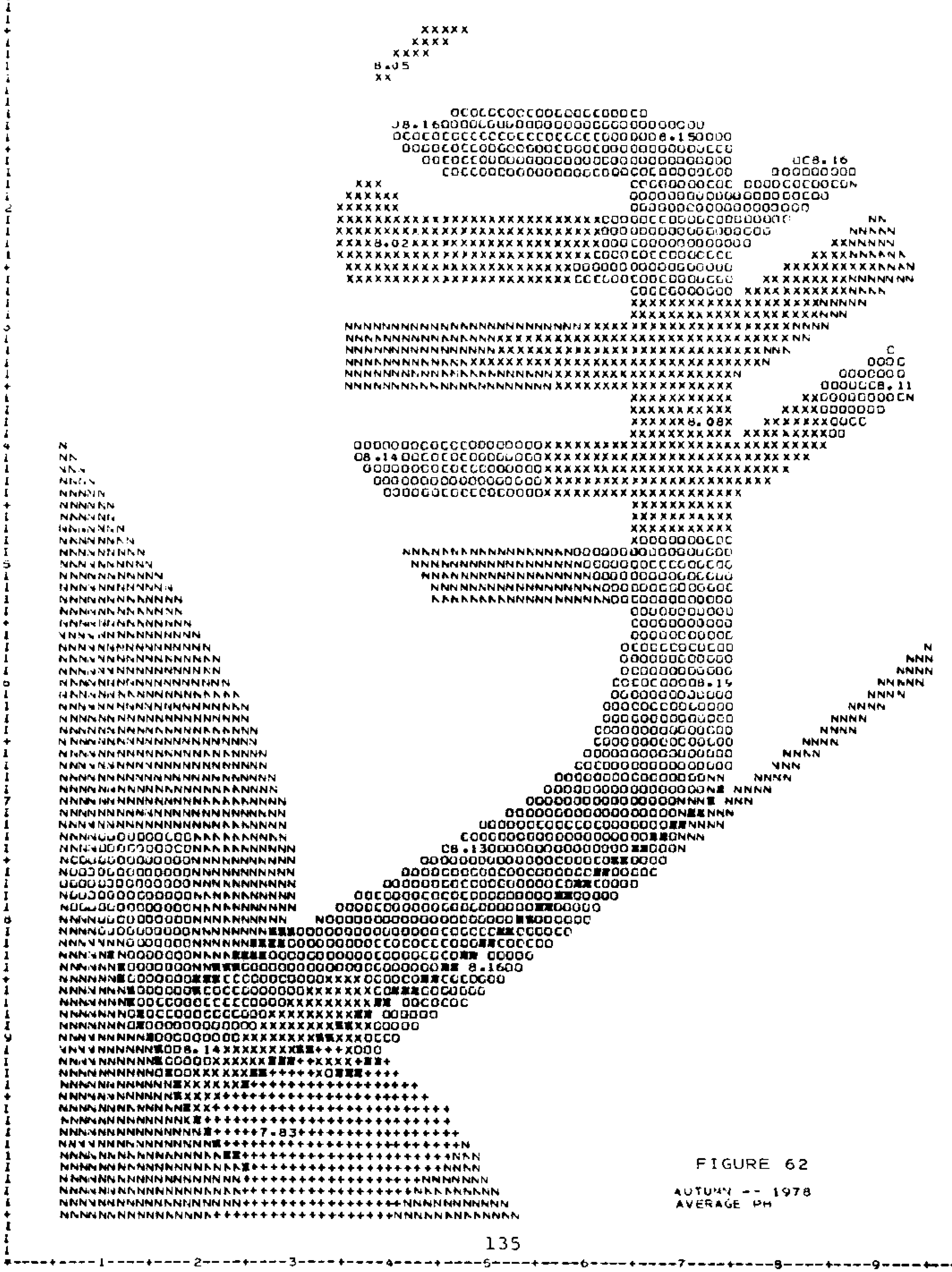


FIGURE 62

AUTUMN -- 1978
AVERAGE PH

FIGURE 63 LEGEND

AVERAGE PH
WINTER 1976-1977

DATA VALUE EXTREMES ARE 7.85 8.11

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
        ****************************************************************************************************
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
SYMBOLS  ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  ####8####  ####9####
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
        ****************************************************************************************************
FREQ.        0          0          0         10          2          1          0          0          0
    1                                     I++4++I    IXX5XXI    IOO6OOI
    2                                     I++4++I    IXX5XXI
    3                                     I++4++I
    4                                     I++4++I
    5                                     I++4++I
    6                                     I++4++I
    7                                     I++4++I
    8                                     I++4++I
    9                                     I++4++I
   10                                     I++4++I
```

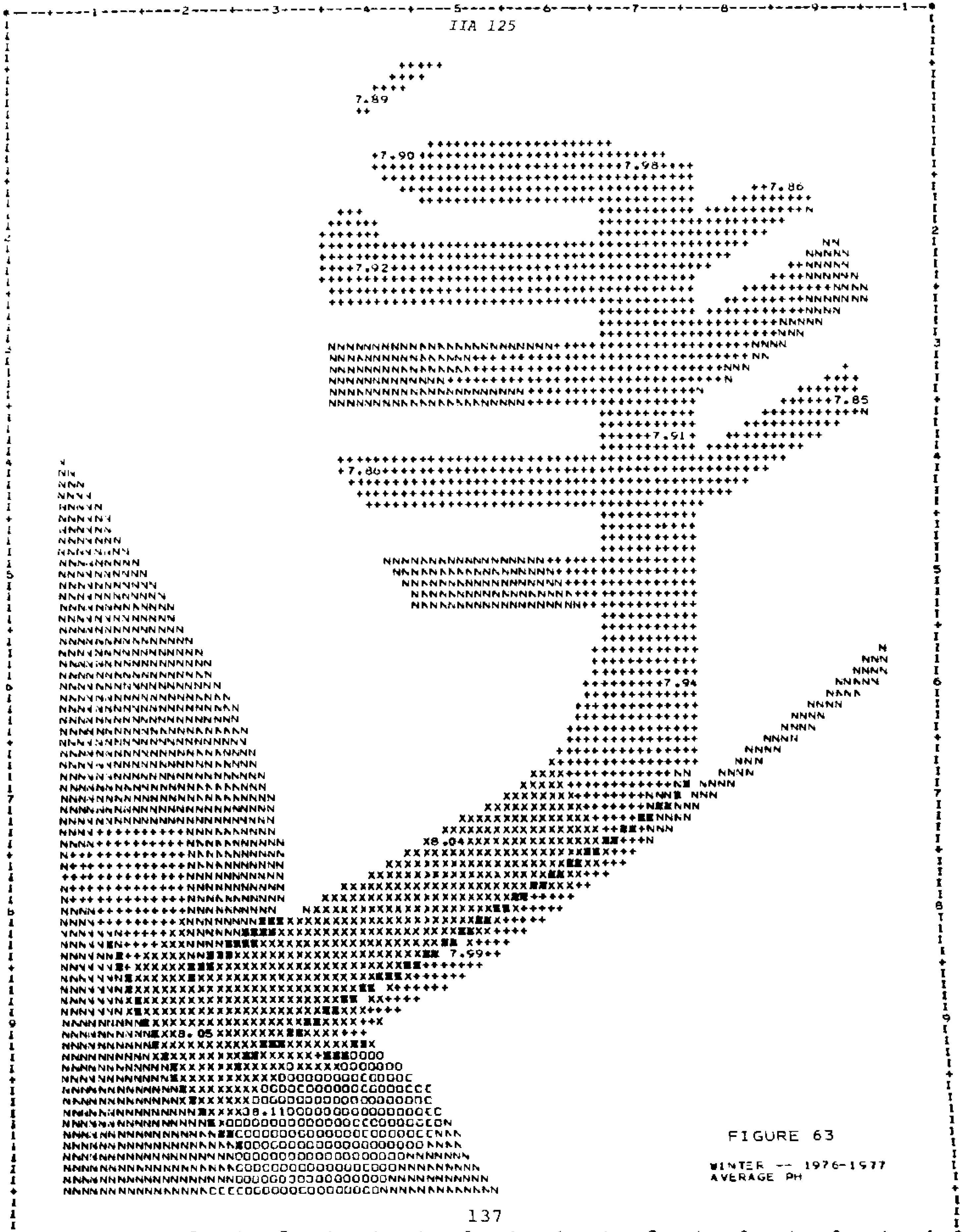


FIGURE 63

WINTER -- 1976-1977
AVERAGE PH

FIGURE 64 LEGEND

AVERAGE PH
WINTER 1977-1978

DATA VALUE EXTREMES ARE 7.00 7.73

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

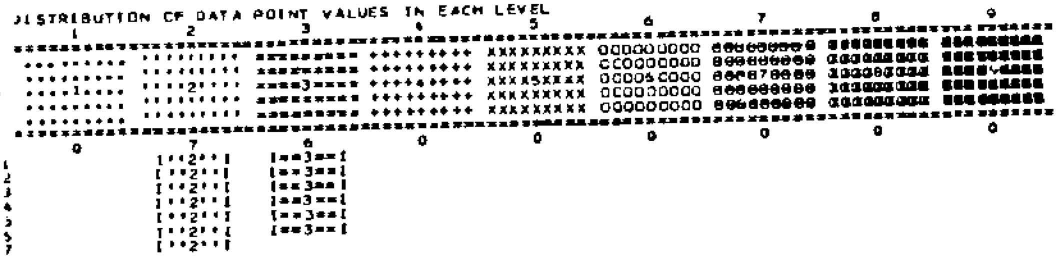
MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.90

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS									
FREQ.	0	7	6	0	0	0	0	0	0



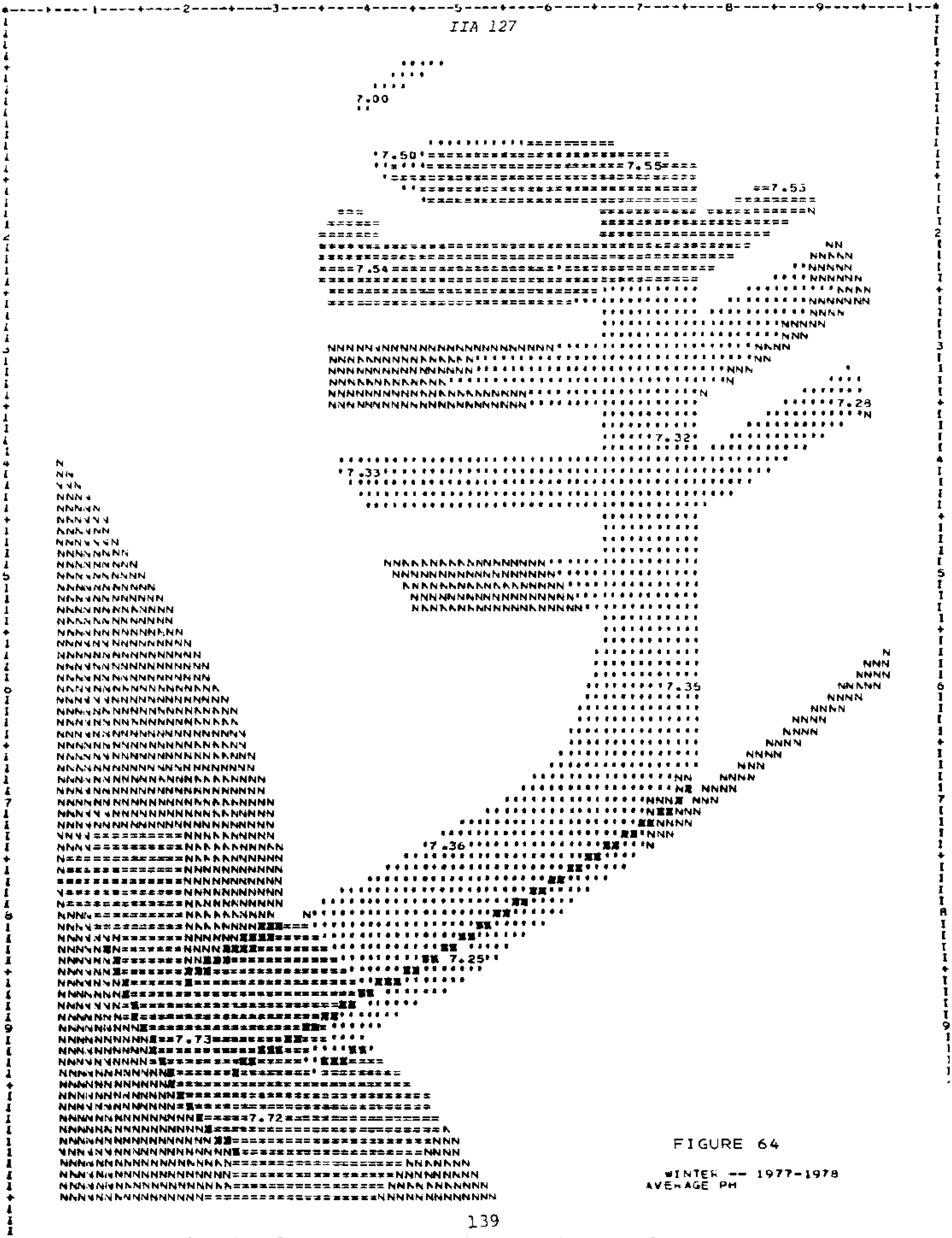


FIGURE 64

WINTER -- 1977-1978
AVERAGE PH

FIGURE 65 LEGEND

AVERAGE PH
WINTER 1978-1979

DATA VALUE EXTREMES ARE 8.10 8.46

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

90.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	.	'	=	+	X	O	@	[illegible]	[illegible]
FREQ.	0	0	0	0	0	3	3	7	0

```
        6          7
   1  I00600I   I00700I
   2  I00600I   I00700I
   3  I00600I   I00700I
   4
   5
   6
   7
```

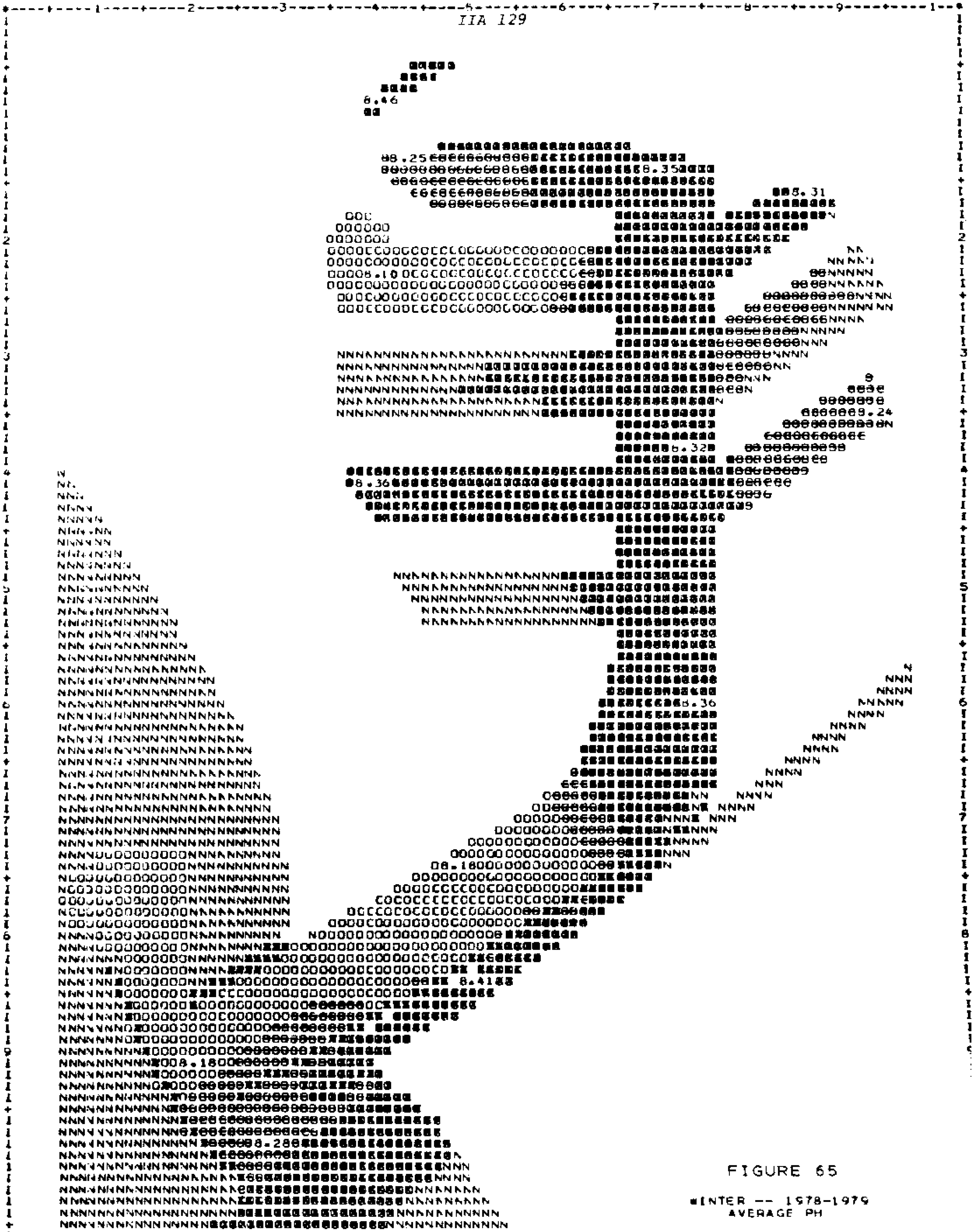


FIGURE 65

WINTER -- 1978-1979
AVERAGE PH

FIGURE 66 LEGEND

AVERAGE PH
SPRING 1977

DATA VALUE EXTREMES ARE 8.23 8.34

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

LEVEL	1	2	3	4	5	6	7	8	9
MINIMUM	3.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.57

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	1	2	3	4	5	6	7	8	9
	80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++++++++	XXXX5XXXX	OOOO6OOOO	8887888	[illegible]	####9####
FREQ.	0	0	0	0	0	0	6	7	0

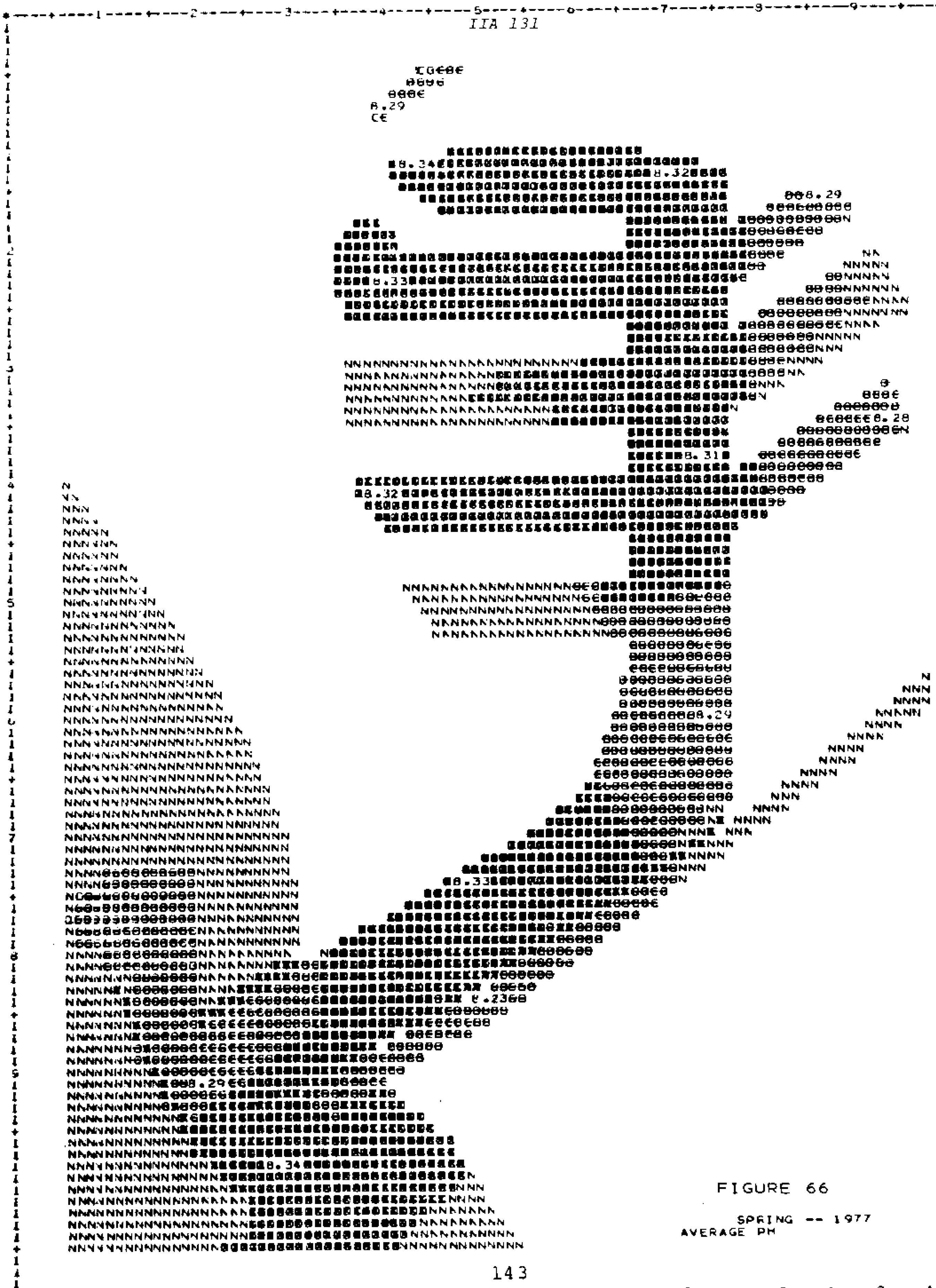


FIGURE 66

SPRING -- 1977
AVERAGE PH

FIGURE 67 LEGEND

AVERAGE PH
SPRING 1978

DATA VALUE EXTREMES ARE 8.07 8.22

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
FREQ.	0	0	0	0	3	8	2	0	0

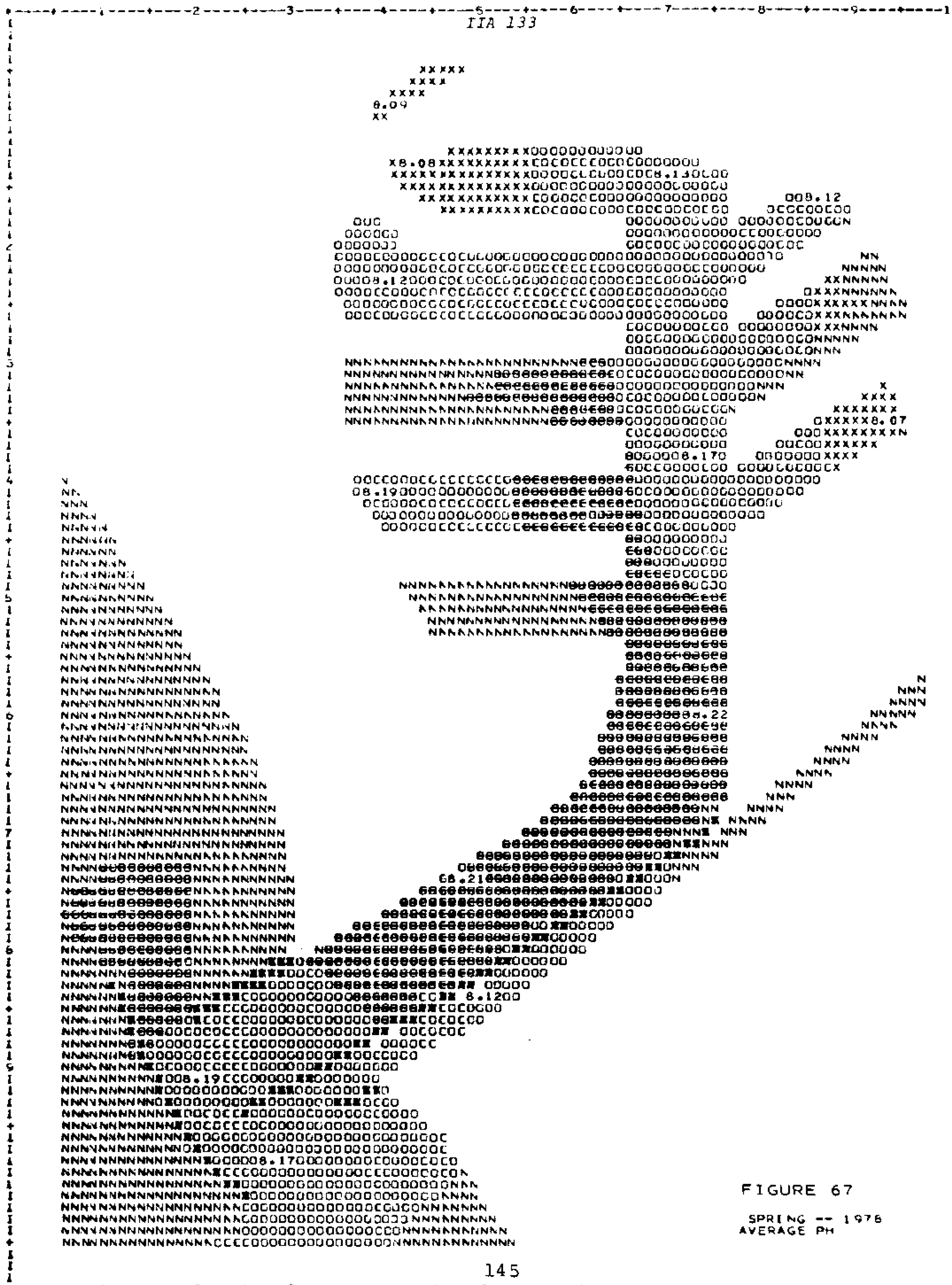


FIGURE 67

SPRING -- 1976
AVERAGE PH

FIGURE 68 LEGEND

AVERAGE PH
SPRING 1979

DATA VALUE EXTREMES ARE 7.67 8.67

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50
MAXIMUM	7.00	7.50	7.75	8.00	8.10	8.20	8.30	8.50	8.67

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

80.74	5.77	2.88	2.88	1.15	1.15	1.15	2.31	1.96

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++++++	XXXX5XXXX	OOOO6OOOO	@@@@7@@@@	8	9
FREQ.	0	0	1	0	1	0	1	4	6

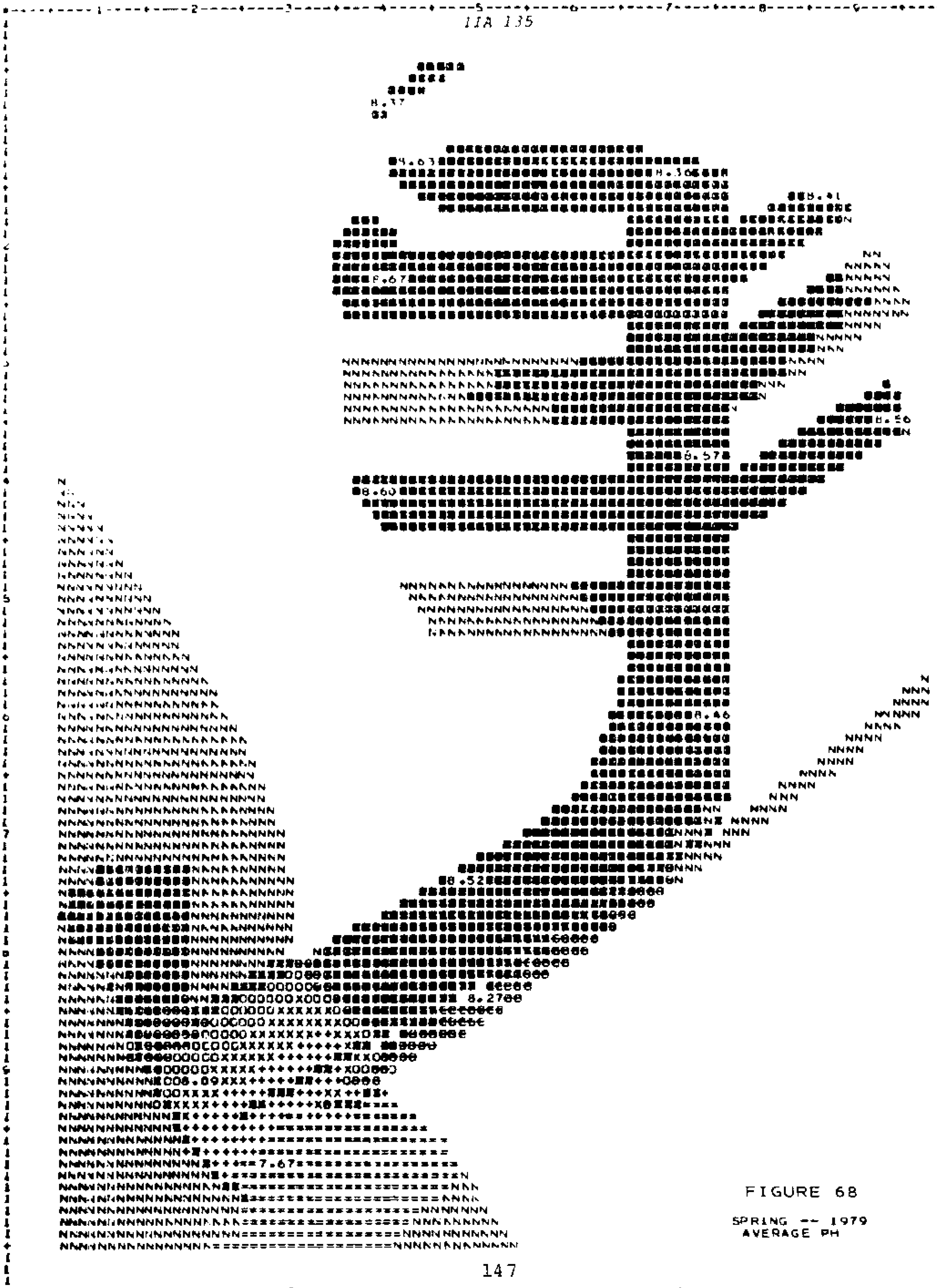


FIGURE 68

SPRING -- 1979
AVERAGE PH

Table 1. Unofficial Rainfall Figures from Los Angeles Basin*

RAINFALL
(inches)

YEAR

Month	1972	1973	1974	1975	1976	1977	1978	1979
Jan	NR	2.67	9.60	0.00	0.00	3.89	7.25	7.55
Feb	NR	+	0.00	2.60	4.23	0.15	10.66	3.35
Mar	NR	2.70	4.20	3.90	1.70	2.10	8.90	6.70
Apr	NR	0.00	0.00	1.60	0.45	0.00	3.00	0.00
May	NR	0.00	0.00	0.00	0.10	3.60	0.10	0.05
Jun	NR	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Winter Cycle		72/73 7.19	73/74 14.55	74/75 12.36	75/76 7.40	76/77 14.84	77/78 37.61	78/79 22.63
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.32	0.00	0.00	0.00	0.00	2.20	0.00	0.00
Sept	0.00	0.00	0.00	0.00	2.30	0.00	0.58	0.00
Oct	0.00	0.00	0.66	0.00	1.10	0.00	0.10	0.80
Nov	0.00	+	0.00	0.00	1.10	0.10	1.90	0.00
Dec	1.50	0.75	3.60	0.36	0.60	5.40	2.40	0.10
Annual Total	(Inc) 1.82	6.12	18.06	8.46	11.68	17.44	34.89	18.55

*Records from inland Los Angeles Basin by John D. Soule.

\+ = trace

Table 2. Dissolved Oxygen Extremes in Marina del Rey 1976-1979 (+ = above 9 ppm; – = below 5 ppm; B = bottom only, N = No data).

	1976						1977												1978												1979				
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
1		+					– –	–		+				+		+	+B	+		+B	+B					++B			–	–	–				
2		+					–	–		+				+		+	+	+		+B		+				+B			–	–	+				
3							–	–		+	+			+		+	+	N	+B			+				+B			–	–	+			+B	
4				+			–	N		+				+				N		+B		+				+B			–	–	+			+B	
5			–	–	–	–	–	N								+	+	N		+		+						–		–	–				
6			–	–	–	–	–	N		+	+				–			N		+B		+	–					–	–	–	–				
7			–	–	–	–	–	N		+	+	++											–				–	–	– –	– –	+	+			
8			–	–	–	–	–			+	+						+	+		+B		+	–				–	–	–	–	+	+			– –
9			–	–	–	–	–					–						+					–				–		–	–	+			+B	
10			–	–	–		–			+	+			–			+	+				+			–		–	–	–	–	+		–	+	
11			–	–	–		–	–		+	+				–			+		+B											+			+B	
12			–	–	–	–	–	–						+B		+	+													– –		+			
13			– – –	–	–		– – –				+			– – –		+	+				+B					–	– – –	– –	– – –	– –					–

Table 3. pH Extremes in Marina Del Rey, 1976-1979 (+ = above 8.5; - = below 8)

	1976					1977												1978												1979				
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
1			-			-						+				-		-								-	-	-						-
2			-			-										-		-										-						-
3		-	-	-		-										-		-													+			+
4		-		-	-	-									+	-		-												+	+			
5		-	-	-	-	-							-			-		-										-	+		+		+	+
6	-	-	-	-	-	-						+	-	-	+	-		-												+	+		+	+
7		-	-	-	-	-							-	-	+	-		-		-		+							-	+	+		+	
8	-	-	-	-	-	-							-	-	+	-	-	-				-				-		-	-		+		+	
9	-	-	-	-	-	-							-	-	+	-		-											-					
10	-	-	-	-	-	-							-	-	+	-	-	-	-			-	-										+	+
11	-	-	-	-	-								-	-	+	-		-				-												
12		-	-	-	-										+	-		-	-			-												
13		-	-	-	-	-								-	+	-		-	-			-								-	+		+	

Table 4 . Total Oil and Grease Concentrations in Storm Water Runoff Samples (in ppm).

Station \ Date	12/28/77	1/12/78	2/6/78
1	2.64	-	-
2	1.52	-	-
3	0.53	1.14	0.52
4	1.09	1.16	0.53
5	0.65	-	-
6	1.16	0.98	0.61
7	0.55	1.38	2.51
8	0.32	1.81	0.43
9	-	2.13	0.31
10	-	1.18	2.25
11	-	0.96	-
$\bar{x}$ =	1.06	1.34	1.02

Notations

12/28/77: samples taken during rain, following a week of rainfall.

1/12/78 : samples taken 2 days after a week of rainfall.

2/6/78 : samples taken during rain, following more than 7" of rain in January.

All stations could not be reached for sampling on each date.
Note heavy oil and grease at mouth of Ballona Creek, Stations 1 and 2.
Note increase in oil and grease at storm drain locations, Stations 7 and 10.

Table 5. Concentration of Chlorinated Hydrocarbons and Pesticides in Runoff Water Samples (in nanograms per liter).

	USC-HEP Samples Marina del Rey* 12/18/77	LACyFCD** 12/27/77
op DDE	none detected	132
pp DDE	"	72
op DDD	"	K10
pp DDD	"	K10
op DDT	"	42
pp DDT	"	53
PCB 1242	"	K10
PCB 1254	"	K10
PCB 1260	"	–
Chlordane	"	–
Dieldrin	"	K10
BHC	–	51
Heptaepox	–	41
Lindane	–	116

** LACyFCD = Data courtesy of the Los Angeles County Flood Control District. Collected samples from Ballona Creek at Sawtelle Blvd., about 4 miles inland.

— = not analyzed

K = below 10, limits of detection

* = Detection limits listed in Table 2, p I9

Table 6 . Heavy Metal Concentrations in Storm Water Runoff Samples (in ppm)

MDR Station Parameter		1	2	3	4	5	6	7	8	9	10	11	12	13	LACy FCD
As	a	0.003	0.002	0.003	0.003	0.004	0.003	0.003	0.003	0.002	0.003	0.004	0.004	0.003	-
	b	0.018	0.020	0.006	0.012	0.008	0.016	0.025	0.009	0.008	0.007	0.010	-	-	0.064
Cd	a	0.0001	0.0001	0.0002	0.0004	0.0002	0.0002	0.0002	0.0001	0.0002	0.0003	0.0004	0.0001	0.0009	-
	b	0.0023	0.0014	0.0012	0.0012	0.0009	0.0008	0.0018	0.0004	0.0005	0.0018	0.0009	-	-	K0.03
Cr	a	0.013	0.014	0.010	0.015	0.008	0.008	0.009	0.008	0.008	0.007	0.006	0.013	0.007	-
	b	0.048	0.033	0.014	0.016	0.012	0.028	0.027	0.014	0.016	0.026	0.010	-	-	0.03
Cu	a	0.008	0.009	0.009	0.008	0.010	0.012	0.014	0.010	0.014	0.016	0.013	0.008	0.005	-
	b	0.035	0.028	0.013	0.014	0.012	0.019	0.026	0.017	0.010	0.021	0.014	-	-	0.06
Fe	a	0.014	0.015	0.011	0.017	0.009	0.014	0.011	0.008	0.007	0.008	0.010	0.013	0.015	-
	b	19.40	9.1	2.5	2.04	1.41	0.22	8.90	0.85	0.91	0.89	0.86	-	-	0.07
Hg	a	0.0001	0.0001	ND	ND	ND	ND	0.0001	ND	0.0001	ND	ND	ND	ND	-
	b	0.0056	0.0042	0.0038	0.0042	0.0031	0.0056	0.0042	0.0032	0.0056	0.0030	0.0054	-	-	0.005
Mn	a	0.10	0.80	0.40	0.90	0.60	0.50	0.50	0.40	0.60	0.40	0.40	0.90	0.30	-
	b	0.27	0.20	0.10	0.095	0.080	0.086	0.160	0.090	0.070	0.080	0.075	-	-	K0.02
Ni	a	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	-
	b	0.020	0.015	ND	0.008	0.008	0.016	0.008	0.020	0.003	0.016	0.008	-	-	0.03
Pb	a	0.004	0.004	0.004	0.004	0.005	0.004	0.005	0.004	0.004	0.003	0.005	0.004	0.003	-
	b	0.070	0.053	0.008	0.011	0.010	0.014	0.017	0.016	0.017	0.023	0.016	-	-	K0.10
Zn	a	0.0002	0.0001	0.0002	0.0033	0.0025	0.0024	0.0026	0.0025	0.0033	0.0033	0.0044	0.0013	0.0045	-
	b	0.245	0.200	0.175	0.150	0.145	0.175	0.180	0.150	0.125	0.180	0.175	-	-	0.23

LACyFCD = Los Angeles County Flood Control District Samples 12/28/77 Ballona Creek at Sawtelle Blvd., about 4 miles inland.

ND = not detected
– = not sampled in December 1977

Sample a = 8/18/77 following 2" rainfall
b = 12/28/77 during rain, following a week of rainfall
K = below limits of detection LACyFCD

Table 7 . Changes in Heavy Metal Ranges and Extremes Following Rainfall.

Parameter	August 1977 Range (ppm)	Station Low	Station High	December 1977* Range (ppm)	Station Low	Station High
As	0.002-0.004	2,9	5,11,12	0.006-0.025	3	2,7
Cd	0.0001-0.0009	1,2 8,12	13	0.0004-0.0023	8	1
Cr	0.006-0.015	11,10, 13	4,2,1	0.012-0.048+	5	1,2,7
Cu	0.005-0.016	13	10,7,9	0.010-0.035	9	1,2,7
Fe	0.007-0.017	9	4,2,13	0.22-19.40+	6	1,2,7
Hg	ND-0.001	-	1,2,7,9	0.0031-0.0056	5	1,6,9
Mn	0.10-0.90	1	4,12	0.80-0.27	5,10	1,2
Ni	0.0001-0.0002	-	5,12	ND-0.02	3	1,8
Pb	0.003-0.005	10,13	5,7,11	0.008-0.070	3	1
Zn	0.0001-0.0045	2,1,3	11,13	0.125-0.245	9	1,2

* Stations 9-13 not sampled in December, 1977

ND - not detected

\+ Levels higher than the LACy Flood Control District Samples

SEDIMENT GRAIN SIZE AND POLLUTANTS

INTRODUCTION

The composition and distribution of surface sediments in the marina are governed by a number of factors: the historic estuarine watershed of the Los Angeles River caused deposition on unconsolidated sediments throughout the low lying area; the channelizing of Ballona Creek as a County Flood Control Channel in the 1930's resulted in heavy, sediment-laden, storm runoff; and increased urbanization led to increased pollutant loads. In addition, the coastal currents, tides and prevailing winds carry sands into the entrance channel, and some portions of the land that was excavated for the marina is characterized by older strand sands or sandy soil.

Because the character of the sediments governs the nature of the benthic biota to a large extent, the HEP research group chose to carry out grain size analyses in order to relate those physical and biological parameters. Accordingly, during ten benthic biota sampling cruises, sediment samples were also taken and the percentages of sand, silt and clay determined. Samples for ten periods from March 1977 through June 1979 were analyzed.

While funds were not available for chemical analyses of sediments for heavy metals and pesticides in each period, analyses were carried out in March 1977 (Soule and Oguri, 1977) and in March 1978. More frequent water analyses were carried out to determine whether pesticides were transported into the marina by wet or dry weather drainage flow.

Sediment Size Analysis Methods

Sediment samples were taken from the research vessel with a Campbell grab (modified Van Veen grab) which samples a $0.1 m^2$ surface area. Duplicate subsamples for analysis of grain size and pollutants were taken with plastic containers from the center of the grab sample to prevent contamination. Samples were chilled and transported to the laboratory, where they were frozen. Water samples were stored in plastic bottles for metals analysis and in glass for pesticides.

For grain size analysis, each sample was thawed, stirred thoroughly, and a split taken, varying in size according to estimated sand content. Hydrogen peroxide (30%) was then added to the sample to remove organic material. The sample was next washed three times in tap water and three times in distilled water to remove salt. The sample was then wet-screened through a 62μm screen and the material passed through was collected in a 1000 ml cylinder. Material retained on the screen was collected in a 50 ml beaker and oven-dried. The dried material was rescreened on a dry

60μm screen because some material can be retained hydraulically by the screen when wet. The additional material that passed through the dry screen was added to the cylinder, and the material retained on the screen was weighed to 0.1 mg. A deflocculant, 0.3ml of 20% NH_4OH, was added to the cylinder and the contents analyzed by the standard pipette method of Pettijohn (1957). The coarse fraction, greater than 62μm, was analyzed by settling tube (Felix, 1969) and calibrated according to Gibbs, Matthews and Link (1971).

Marine sediments consist of discrete particle groupings that tend to show log-normal size distributions, which permits comparisons according to grain size. Although there are a number of sediment characterizations by composition and size, only the major divisions of sand, silt and clay were analyzed in the present study. These are identified according to the Phi Scale, the log of the diameter of the sediment grain, and by grain size in millimeters as follows:

Grain Type	Grain Size in Ø	Grain Size in mm
Sand	$\leq$4Ø	0.0625 to 1.0000
Silt	4Ø - 8Ø	0.0039 to 0.0625
Clay	$\geq$8Ø	.0039

Results of Grain Size Analysis

Changes in the percentages and distribution of the major sediment types occurred seasonally and also annually, according to the analyses carried out (Figures 1 through 10). It must be recognized that a single grab sample at each station may well miss significantly different substrates nearby.

Sorting takes place in nature due to the interactions between the natural or man-made influences on the transport medium and the size, shape and specific gravity of the sediment particles. If the velocity of currents decreases slowly, sorting takes place over a longer space, with heavier, larger and more rounded particles dropping out first. The lighter, smaller, more irregular particles tend to remain in suspension until the velocity decreases. If velocity decreases rapidly, both modes occur over a short space, resulting in poor sorting (Twenhofel, 1950).

Areal Distribution

Sand was predominant at the mouth of Ballona Creek (Station 1) and in the entrance channel of the marina (stations 2, 3, and 4). In the main channel (stations 5 and 11) silt predominated, with sand present in significant amounts only in September 1978 at station 11.

Among the slips, only slip B (station 6) was consistently and predominately sand.

Slip E (station 10) was predominately sand only in June and December 1977, and was mixed sand, silt and clay in varying proportions in the other periods. Sand had almost disappeared in December 1978 and April 1979.

Slip F (station 9) showed sand predominating in June, September and December 1977, and September and December 1978. The sand had almost disappeared in April 1979.

Slip D (station 8) is the recreational beach, but the area is predominately silt and had substantial amounts of sand only in June and September 1978. The entire inner part of the marina was mostly silt and clay in April 1979. By June 1979 sand had returned to Slip E.

Seasonal and Annual Differences

In 1977 the percentage of sand increased at the mouth of Ballona Creek (station 1) from March to June and peaked in September, but decreased in December. Sand increased at the marina entrance (station 2) from March to peak in June 1977, and decreased in September but increased in December 1977, perhaps due to the high tides of November.

In 1978, the percentage of the sand at Ballona Creek was as high as the peak of September 1977 for the entire year, decreasing only slightly in December 1978 and April 1979. Sands at the marina mouth were high in June 1977 and were highest in June 1978 (Figure 6). By April 1979, the sand had decreased greatly in that location.

While the percentages sand, silt and clay varied considerably throughout the marina, only the April 1979 pattern of distribution showed decreased sand throughout the inner marina and the mouth, except in Slip B and at the Ballona Lagoon tide gate (station 3). This is the only period when sediments appeared to be well sorted.

SEDIMENT POLLUTANTS

Patterns of sediment contaminants were presented in Soule and Oguri (1977) for March 17, 1977 (Table 1 herein). Samples were taken again, on March 30, 1978 (Table 2). In both instances subsamples were taken from the benthic biological grab samples, stored in plastic containers, and frozen until chemical analysis was carried out in the USC Environmental Engineering laboratory.

Comparison of the data from the two sampling periods is made in Table 3, giving ranges of concentrations. In Table 3a, Bowerman and Chen's (1971) data are compared, but improved analytical techniques may make some earlier values doubtful.

Results

The peak loadings in 1977 occurred at station 10 for seven parameters, suggesting that deposition from the storm drains and bird sanctuary has occurred there and also at station 11. Station 7 also showed high loadings. The lowest levels occurred almost uniformly at station 3 in 1977, but in 1978 that station was never the lowest. Station 1, at the mouth of Ballona Creek, was the lowest in most instances.

DISCUSSION AND CONCLUSION

The results suggest that the exceedingly heavy rainfall of the winter season in 1978, amounting to over 23 in. in the basin, had swept sediments deposited in the drier years out to sea. The inner marina basins also showed decreases in most parameters, except for station 3 . It seems probable that sulfide and other pollutants may have been carried from the Venice Canal system and Ballona Lagoon into the entrance channel due to the excessive runoff.

Although the Ballona Lagoon is considered by some to be a good biological habitat, the muds appear to be highly organic and may act as a sink for a number of pollutants. Heavy flushing action probably does not occur during tidal change but does occur when runoff disturbs the bottom sediments (Ford and Collier, 1976).

The impacts of the storm drains are apparent, although sediment loads decreased, again probably due to heavy runoff. The incidence of pollutants in the water column is discussed in section IIA on water quality. The limits of detection for chemical parameters are given in Section I, Table 2. As was noted earlier, no evidence of pesticides was found in 1978 samples.

Comparison of sediment data with that of Los Angeles-Long Beach Harbors is of interest (Table 4, Soule and Oguri, 1980). Immediate Oxygen Demand (IOD) at Marina del Rey station 8 exceeded the maximum in Los Angeles Harbor at the mouth of Dominguez Slough, the most polluted site in the harbors! Chemical Oxygen Demand (COD) was similar in 1977 at the marina stations 2 and 10 to the oil dock in Los Angeles Harbor. Quantities decreased in the marina in 1978 at station 10 to levels near those in inner Los Angeles West Basin. Levels of Total Organic Carbon (TOC) and sulfide at station 10 were similar to those in inner Los Angeles Harbor. The Total Volatile Solids (TVS) levels at station 10 were similar to those at the Terminal Island Treatment Plant outfall station; oil and grease levels at MDR station 7 were also similar to the treatment plant values. The minima were much lower in Marina del Rey than at harbor stations, emphasizing the impact of runoff at stations 10 and 7. This clearly has a serious impact on such a small water mass as compared with the large harbors. Phosphorus levels were comparable with levels in outer Los Angeles Harbor and main channel.

Among the trace metals, arsenic levels were almost an order of magnitude lower in the marina than in the harbor, as were those of cadmium. The maximum chromium level at MDR station 5 approached that of the outer harbor oil terminal, but elsewhere levels were much lower in the marina.

Upper levels of copper at station 8 approached levels at Dominguez Slough in the inner harbor, and the lower levels were similar to those in the outer harbor. The iron levels in the marina were similar in range to outer Los Angeles-Long Beach levels, and the range of mercury levels was also similar.

The higher manganese concentrations in the harbors exceeded marina levels at station 10, but the intermediate and low levels were similar.

In the case of nickel, the marina range exceeded the harbor range considerably. Nickel and iron were also metals that apparently increased in the marina in 1978.

Lead levels in the marina were similar to the harbor range, except for Dominguez Slough, which had a much higher level at 401 ppm compared with 88.5 ppm at MDR station 1. Zinc levels in the marina were similar to harbor levels except for Dominguez Slough and another inner harbor station, where levels were much higher.

It is unfortunate that the expense of metal and hydrocarbon analysis is so great that the data are rarely taken. The costs of replicates for statistical analysis were beyond the scope of the present study and therefore minor differences among levels cannot be considered significant. It was unexpected to find such high levels of pollutants in the marina, attesting to the important impact of runoff in that environment.

Heavy metals exert various effects on animals; depending upon concentration they act as biocides, or may inhibit reproduction or respiration. Of the metals in the marine environment, only cadmium, some forms of mercury and iron seem to bioaccumulate in food chains to levels that might be hazardous to human health. Apparently no studies on levels of metals have been done on food chain organisms in the marina. Pesticides and PCB's also inhibit organisms and have the disadvantage of not being biodegradable. It is fortunate that these are not a problem in the marina.

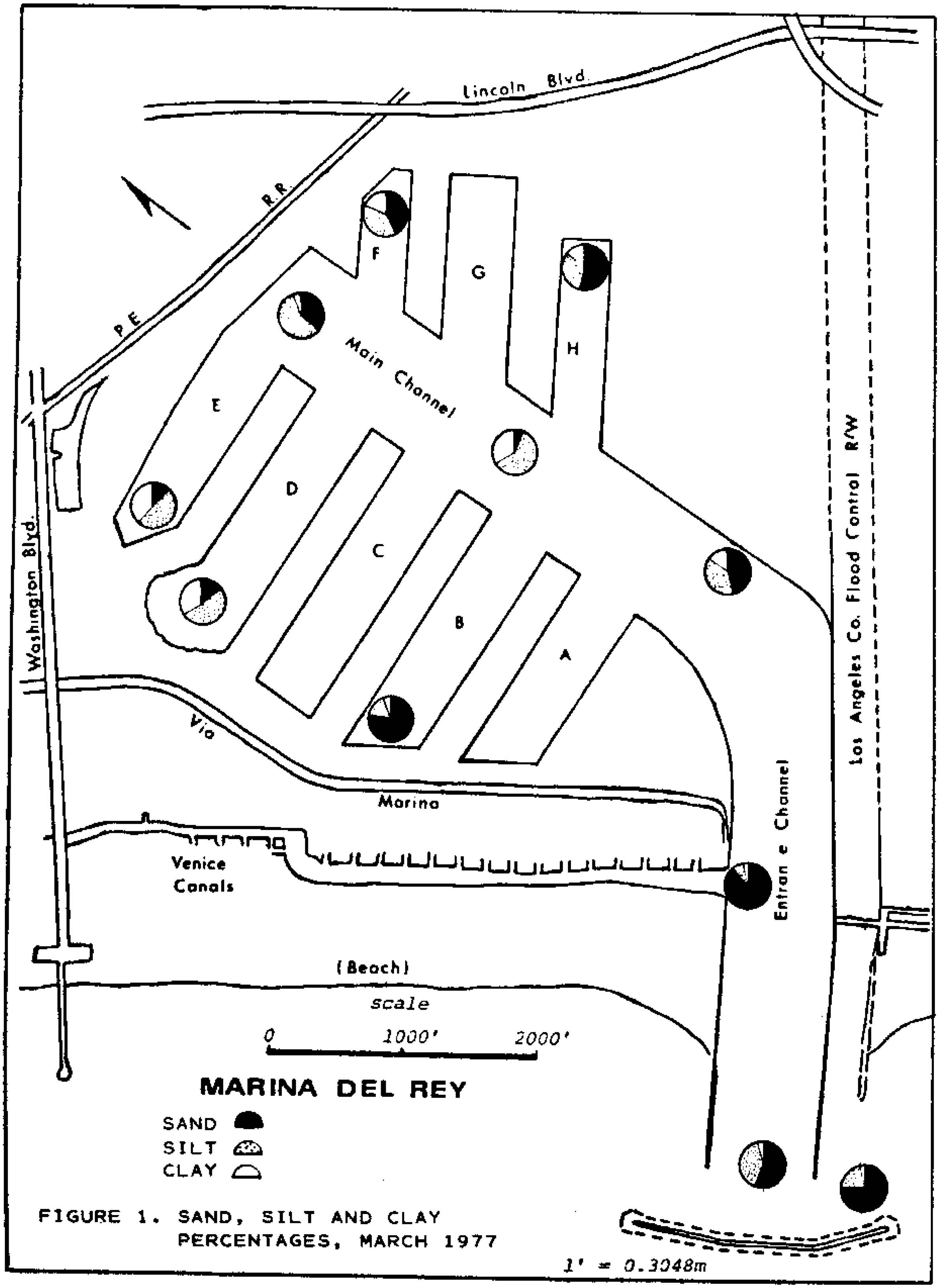


FIGURE 1. SAND, SILT AND CLAY PERCENTAGES, MARCH 1977

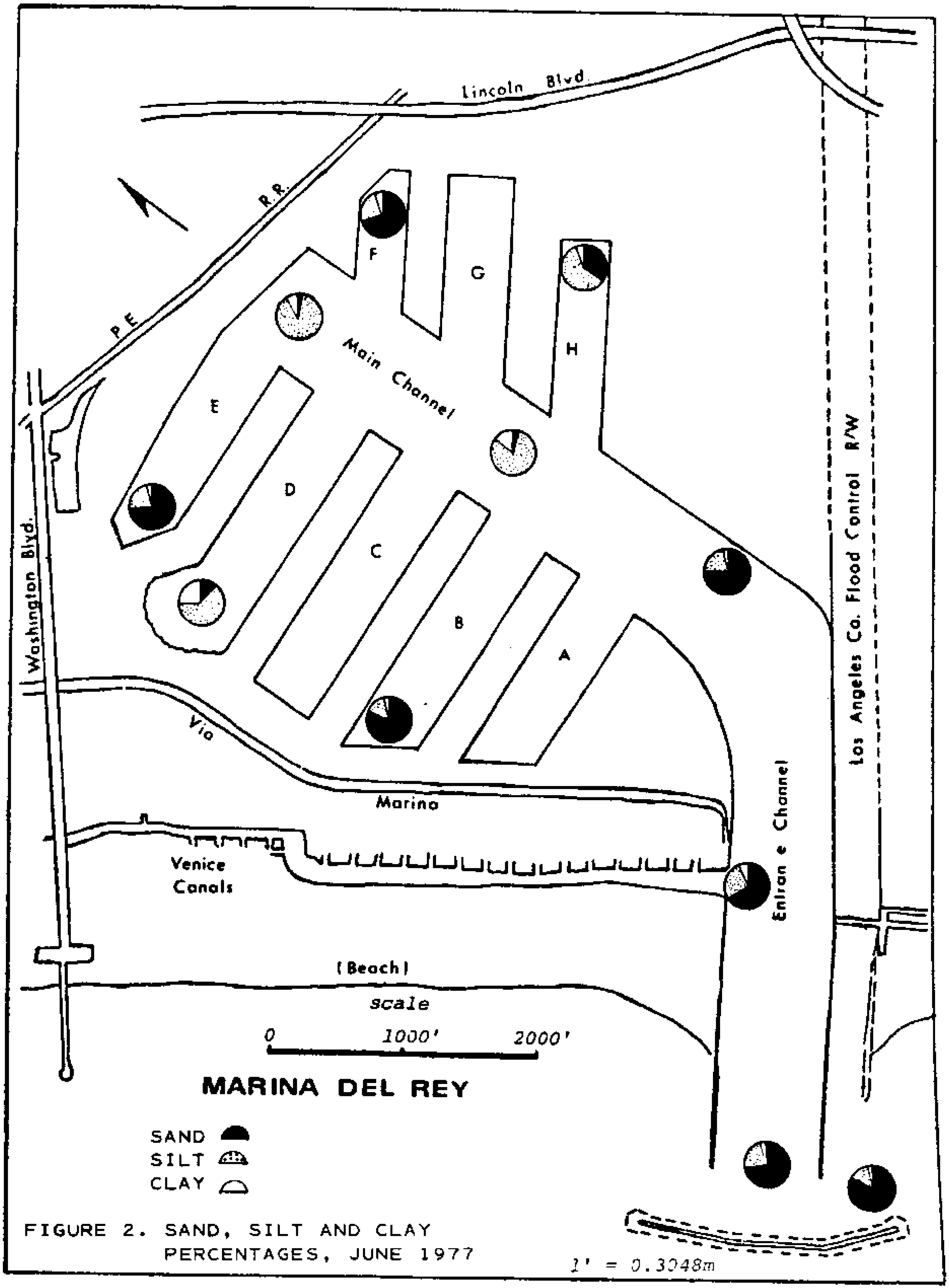


FIGURE 2. SAND, SILT AND CLAY PERCENTAGES, JUNE 1977

1' = 0.3048m

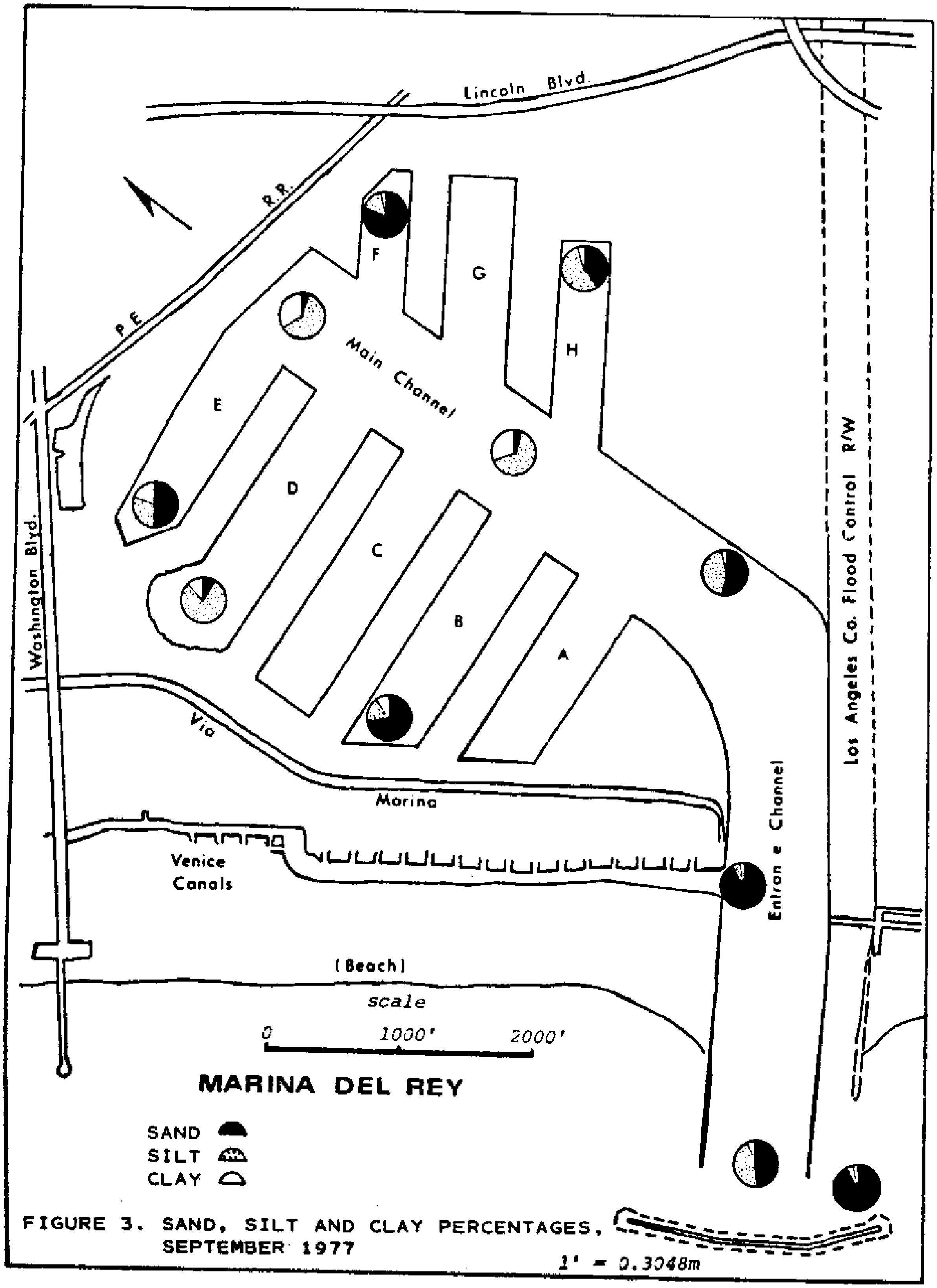


FIGURE 3. SAND, SILT AND CLAY PERCENTAGES, SEPTEMBER 1977

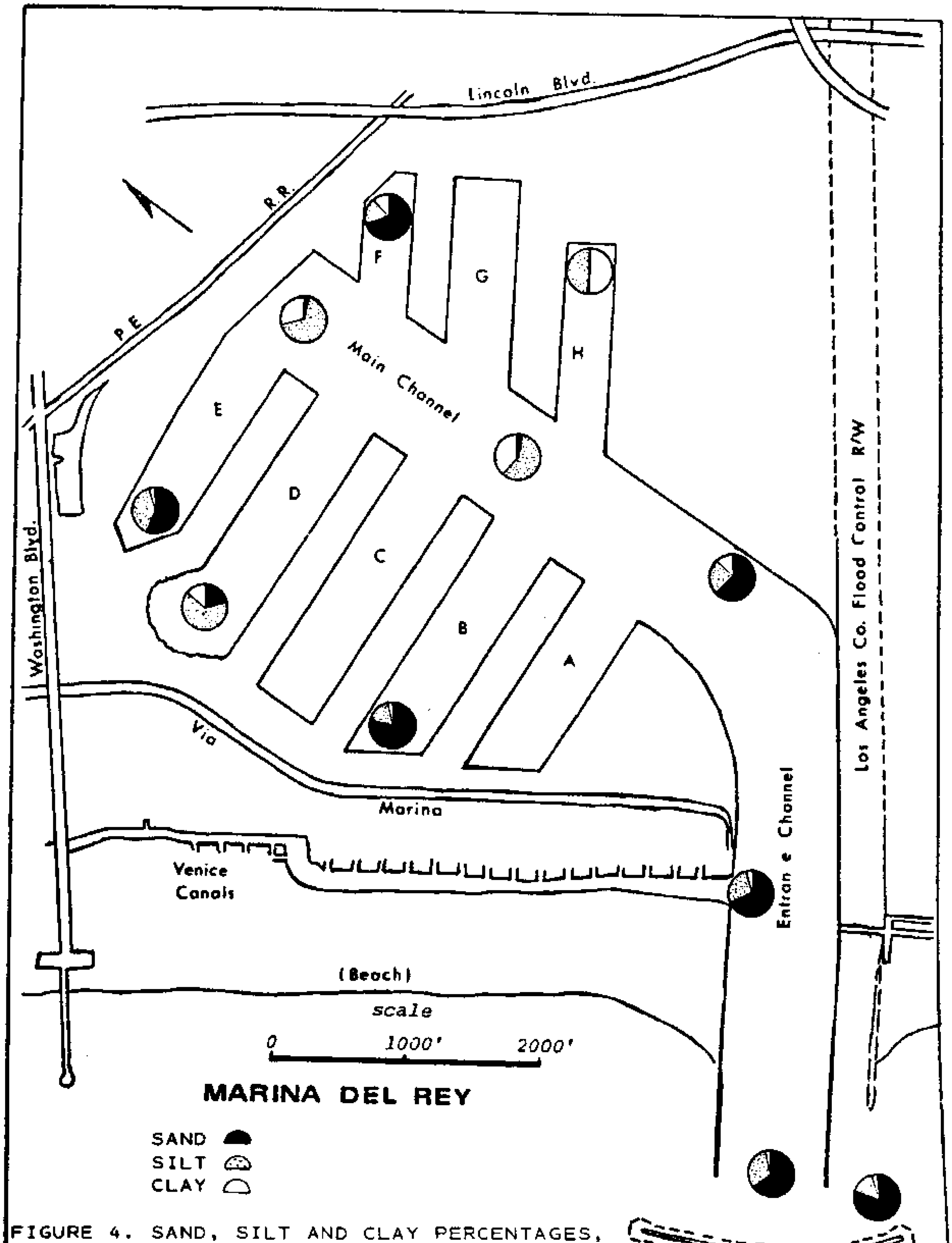


FIGURE 4. SAND, SILT AND CLAY PERCENTAGES, DECEMBER, 1977

1' = 0.3048m

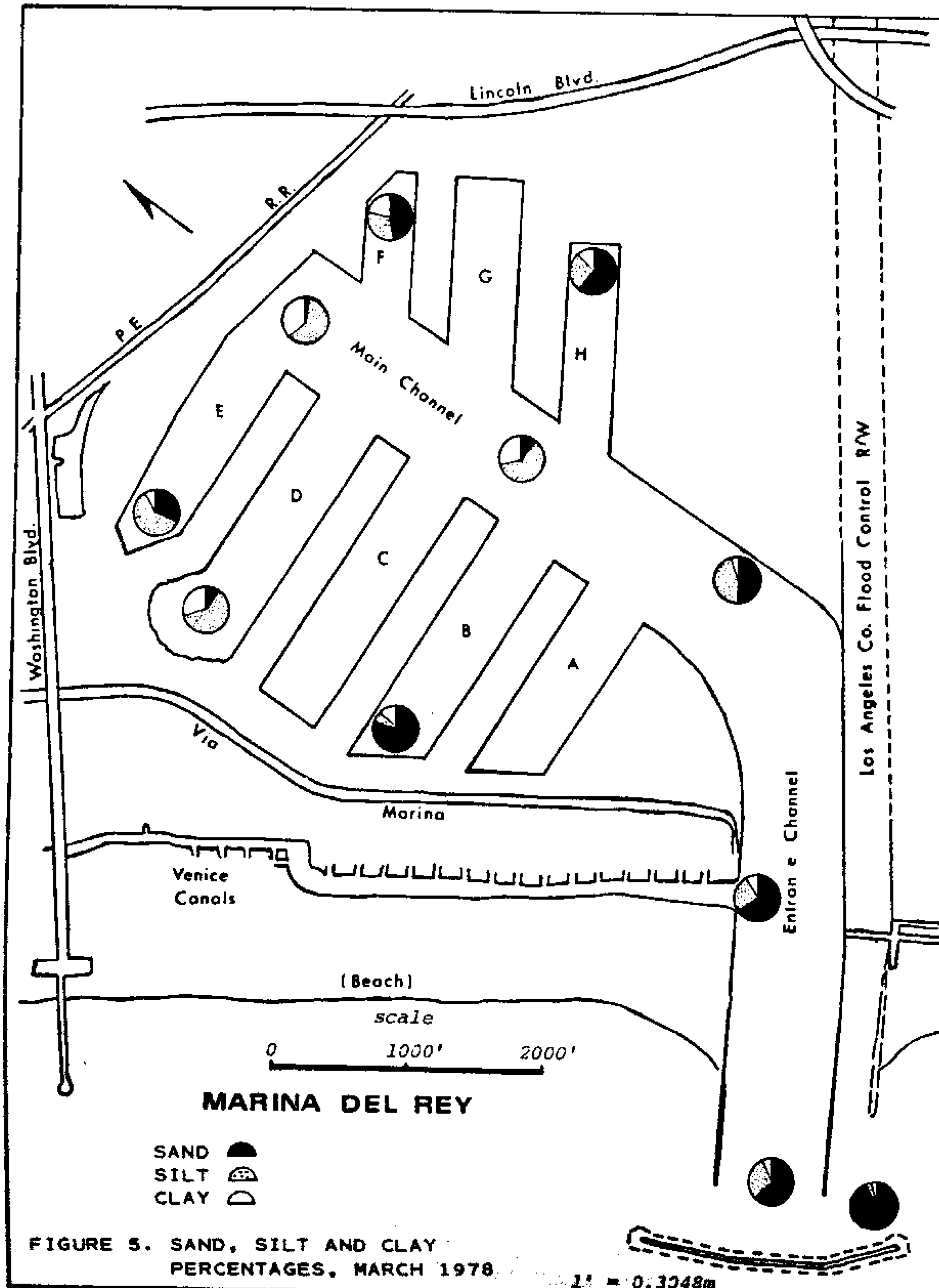


FIGURE 5. SAND, SILT AND CLAY PERCENTAGES, MARCH 1978

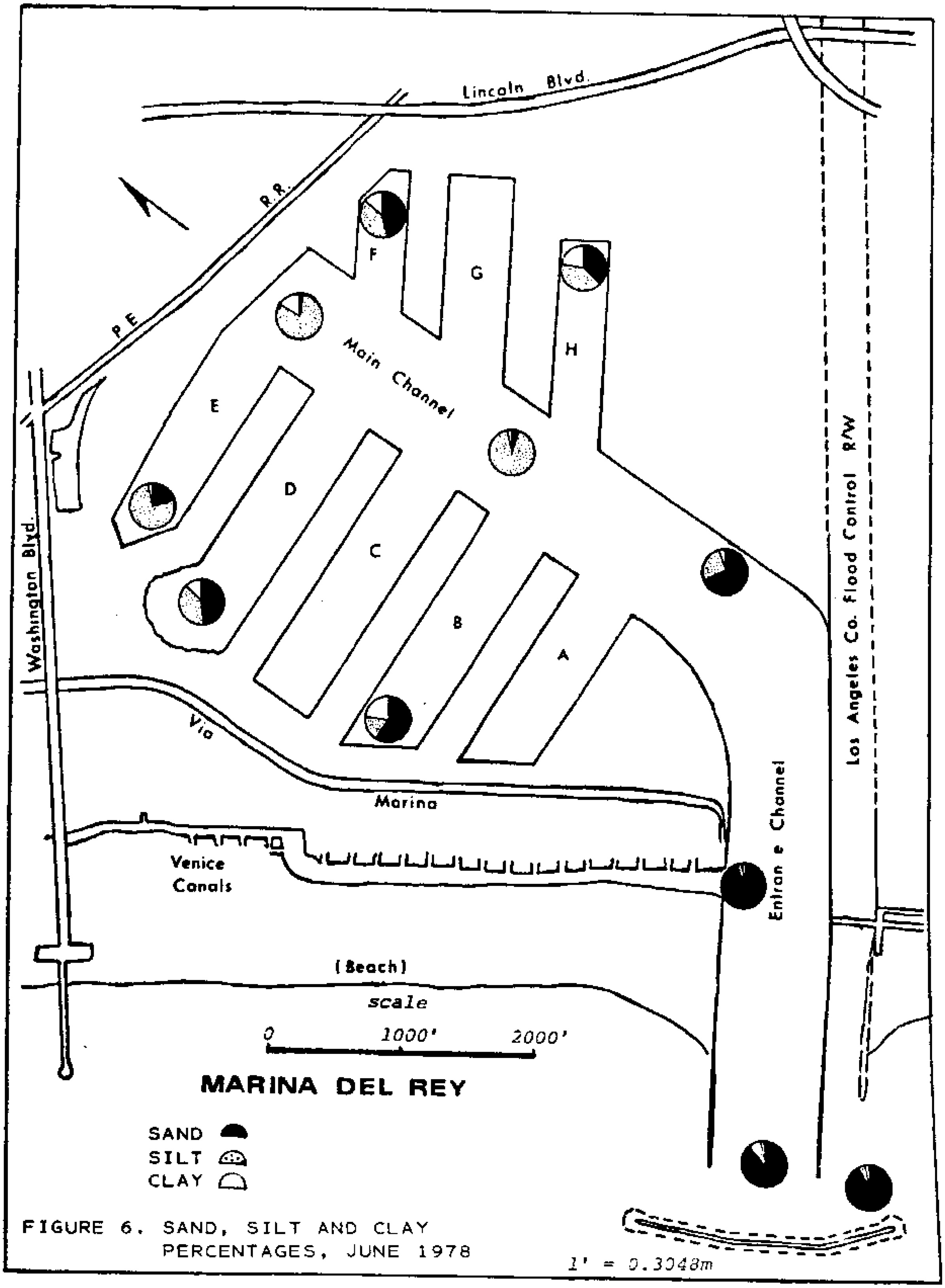


FIGURE 6. SAND, SILT AND CLAY PERCENTAGES, JUNE 1978

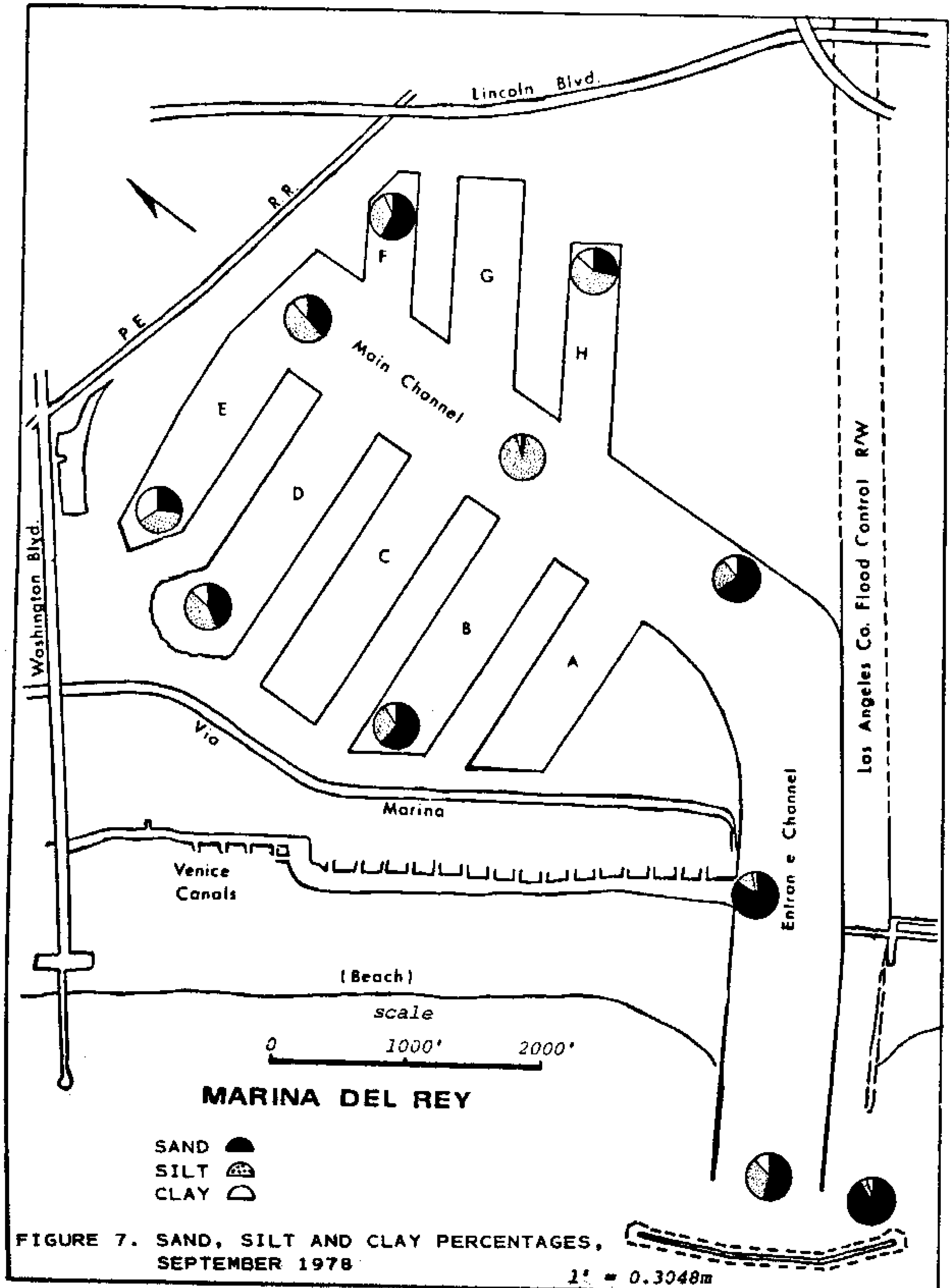


FIGURE 7. SAND, SILT AND CLAY PERCENTAGES, SEPTEMBER 1978

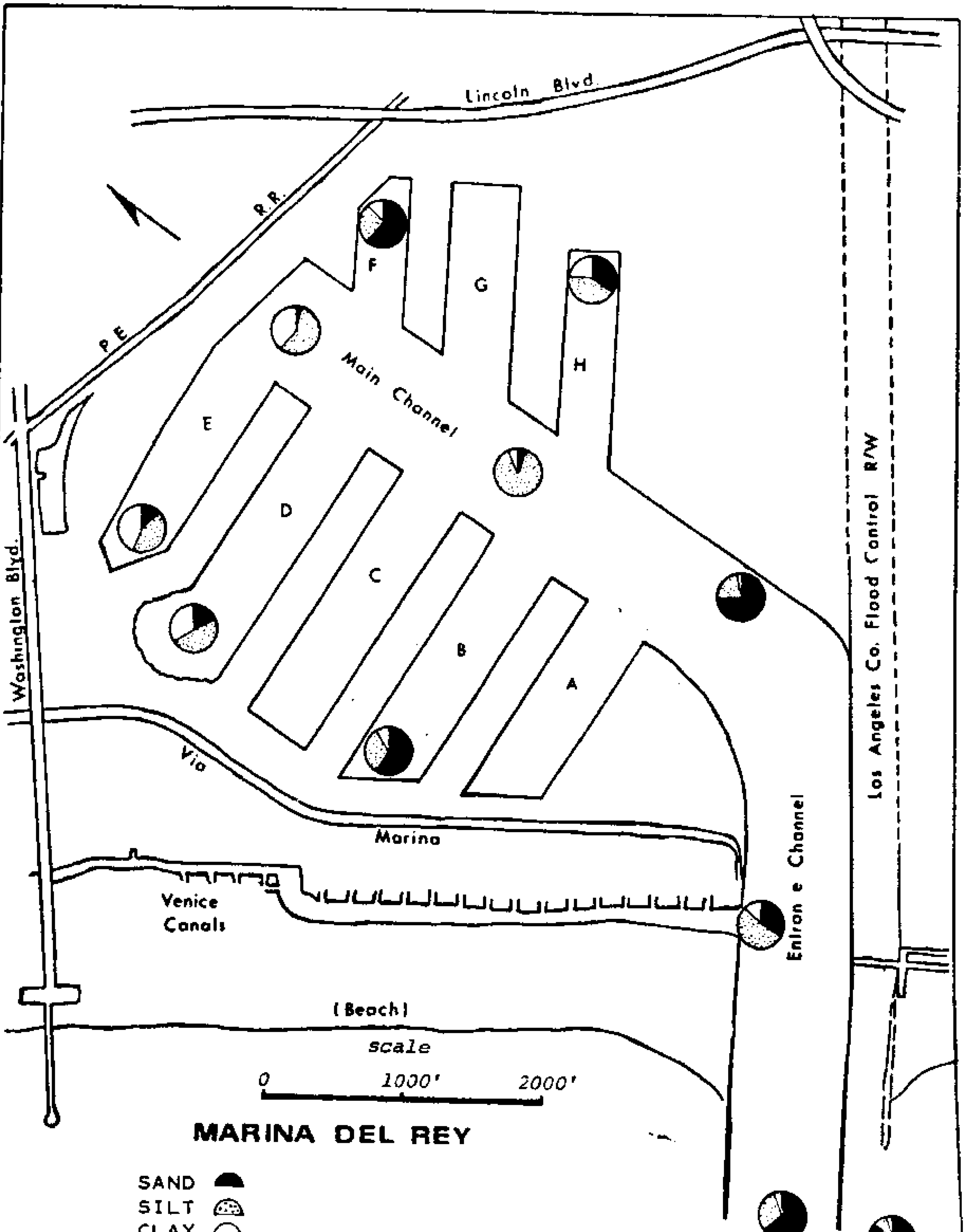


FIGURE 8. SAND, SILT AND CLAY PERCENTAGES, DECEMBER 1978

1' = 0.3048m

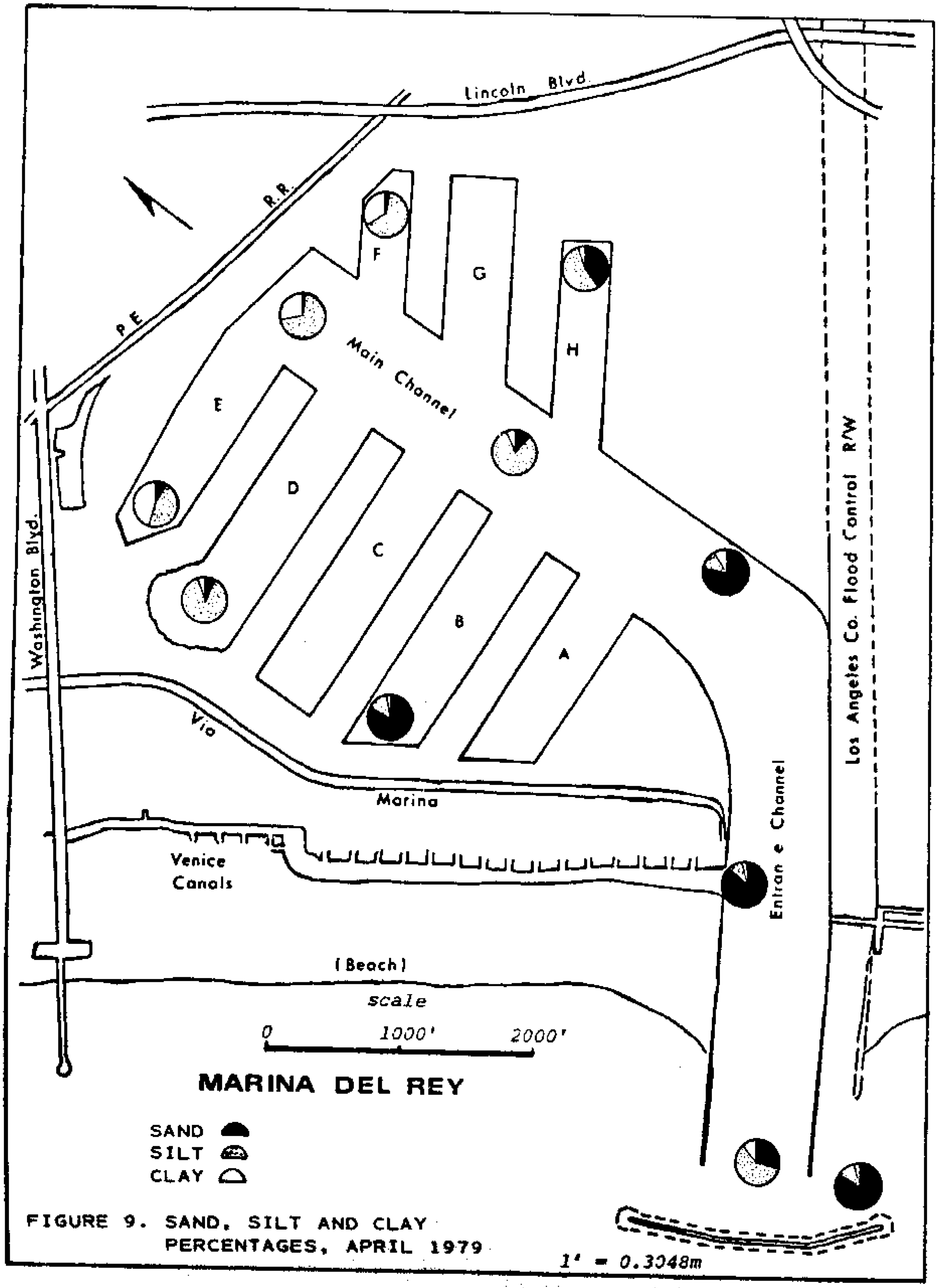


FIGURE 9. SAND, SILT AND CLAY PERCENTAGES, APRIL 1979

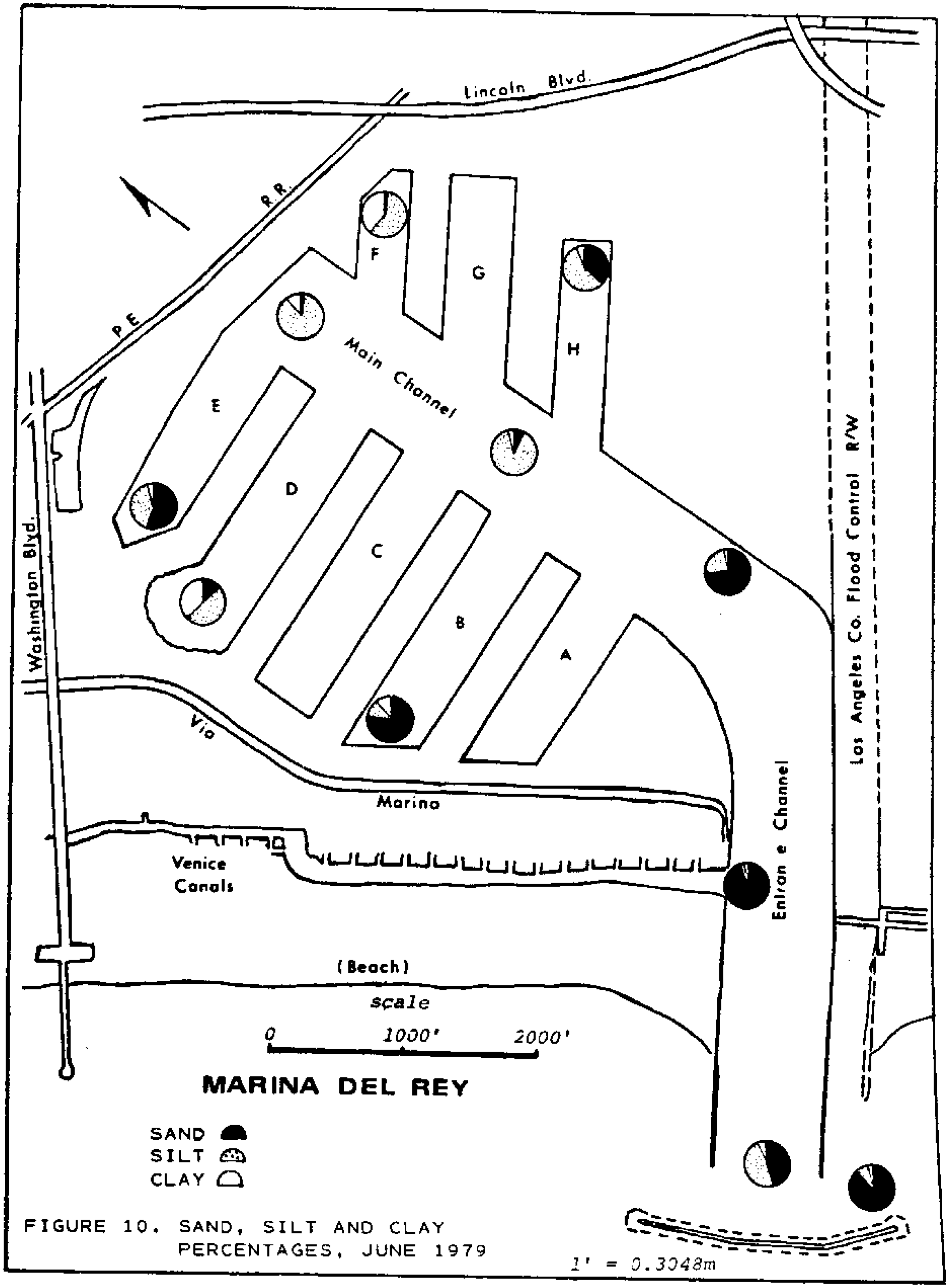


FIGURE 10. SAND, SILT AND CLAY PERCENTAGES, JUNE 1979

1' = 0.3048m

Table 1. Sediment Analysis, Marina del Rey, 17 March 1977
(from Marine Studies of San Pedro Bay California Part 13, 1977)

Station / Parameter	MDR 1	MDR 2	MDR 3	MDR 4	MDR 5	MDR 6	MDR 7	MDR 8	MDR 9	MDR 10	MDR 11
MC %	30.49	44.28	21.44	32.68	52.09	50.45	62.08	50.96	50.98	40.27	51.33
DM %	69.51	59.72	78.56	67.42	47.91	49.55	37.92	49.04	49.02	59.73	48.67
TOC %	2.12	3.94	0.21	0.76	0.94	0.48	1.35	0.60	0.70	0.80	0.66
COD	41900	108900	14500	29800	52800	41800	66700	45500	34100	92700	44800
IOD	1260	1460	629	744	2370	715	5010	1230	1520	1530	1500
TVS %	5.56	8.55	1.87	4.05	8.01	5.41	9.57	6.94	5.98	10.29	8.32
$S^{=}$	870	2070	6	23	395	305	2430	360	158	2430	122
Oil & Grease	6920	6300	1050	1180	3010	1830	2030	1460	1580	5170	1440
Org-N	860	1200	3.2	665	730	775	1950	890	1050	1080	780
Total-N	860	1200	3.2	665	730	775	1950	890	1050	1080	780
P	721	776	391	677	1050	591	880	938	1070	910	1170
As	5.25	6.27	2.72	5.56	21.6	10.1	13.9	20.8	15.3	22.9	17.6
Cd	1.12	1.19	0.132	0.589	0.666	0.426	0.621	0.588	0.308	1.03	0.611
Cr	88.1	96.9	27.1	70.6	122	69.8	95.5	94.1	84.8	128	129
Cu	46.3	67.8	10.9	51.8	141	105	161	118	107	270	125
Fe	14800	16900	5230	18700	34400	19800	24800	32300	33100	38100	39100
Hg	0.350	0.426	0.355	0.489	1.140	2.43	2.04	1.45	1.56	1.60	1.43
Mn	216	257	86	259	397	255	310	382	342	333	441
Ni	22.0	32.8	9.1	29.8	56.1	27.2	52.4	46.3	41.6	64.8	59.8
Pb	56.0	74.5	33	96.5	150	63.9	112	63.7	108	359	94.1
Zn	298	393	32	117	227	139	232	195	206	449	218

All units in ppm unless specified.

Table 2. Sediment Analysis, Marina del Rey, 3 March 1978

	MDR-1	MDR-2	MDR-3	MDR-4	MDR-5	MDR-6	MDR-7	MDR-8	MDR-9	MDR-10	MDR-11
MC(%)	27.2	29.3	38.2	44.6	47.5	34.9	33.1	46.0	52.4	48.1	57.3
DM(%)	72.8	70.7	61.8	55.4	52.5	65.1	66.9	54.0	47.6	51.9	42.7
COD	3290.4	7286.0	20,510	13,668	23,902	12,036	20,744	18,272	17,368	33,918	22,420
TOC(%)	0.099	0.18	0.762	0.717	1.055	0.354	0.725	0.772	0.753	1.464	1.05
IOD	43	382	1210	490	2310	2190	2890	4590	1060	2080	1960
OIL & GREASE	708	1000	1550	2790	1870	785	4620	2270	2480	1740	3610
$\Sigma S^=$	68.68	70.73	129.44	162.45	304.76	179.37	287.03	294.11	211.94	351.21	278.53
p	629	643	670	1000	1100	542	1650	920	1080	953	1160
Org. N	110	163	357	473	827	417	630	725	529	818	765
Kj-N	195	269	498	607	1203	741	840	1134	790	1243	1006
TVS(%)	0.35	1.32	2.407	3.48	4.55	2.55	3.2	3.7	3.1	5.7	5.3
As	2.76	3.05	11.0	10.4	9.86	11.5	13.7	12.1	9.47	10.6	11.3
Cd	0.231	0.158	0.575	0.386	0.417	0.539	0.768	0.675	0.650	0.631	0.502
Cr	38.4	33.4	60.9	53.9	82.1	29.3	63.3	56.5	55.3	52.9	65.7
Cu	8.9	20.6	36.5	70.8	109	61.5	123	201	127	82.7	127
Fe	14,500	13,400	16,760	20,200	31,000	14,400	15,100	27,000	26,800	33,000	43,800
Hg	0.32	0.28	0.57	0.54	0.96	1.75	1.89	1.35	1.27	1.42	1.28
Mn	318	265	167	188	191	164	151	191	255	374	290
Ni	53.1	54	42.6	96	63.8	29.4	34.3	86.4	89	99	145
Pb	88.5	118	70	47	38.8	11.3	23	60.9	19.6	27.8	32.8
Zn	73.8	69.4	130	152	196	85	178	147	178	182	274

Table 3. Comparison of peak concentration

	3/17/77			3/30/78		
		Stations			Stations	
Parameter	Range	Low	High	Range	Low	High
% Moisture	21.44-62.08	3	7	27.2-57.3	1	11
% Dry Matter	37.92-78.56	7	3	42.7-72.8	11	1
% TOC	0.21-3.94	3	1	0.099-1.46	1	10
COD	14,500-108,900	3	2,10	7286-33,918	2	10
IOD	629-5010	3	5	43-4590	1	8
% TVS	1.87-0.29		10,7	0.35-5.7	1	10
ΣS	6-2430	3	10,7	68.68^{+}-351.21	1	10
Oil & Grease	1050-6920	3	7	708-4620	1	7
Org N	3.2-1950	3	7	110^{+}-827	1	5
Total N	3.2-1950	3	7	195^{+}-1243	1	10
P	391-1170	3	11,9	542-1650^{+}	6	7
As	2.72-22.9	3	10	2.76-13.7	1	7
Cd	0.308-1.19	9	2	0.158-0.768	2	7
Cr	27.1-129	3	11,10	29.3-82.1	6	5
Cu	10.9-270	3	10	8.9-201	1	8
Fe	5230-39100	3	11	$13,400^{+}$-$43,800^{+}$	2	11
Hg	0.35-2.43	1,3	6	0.28-1.89	2	7
Mn	86-441	3	11	151^{+}-374	7	10
Ni	9.1-64.8	3	10	29.4^{+}-145^{+}	6	11
Pb	33-359	3	10	11.3-88.5	6	1
Zn	32-449	3	10	69.4^{+}-274	2	11

+ increase in 1978 over 1977

Table 3a. Comparison of Peak Pollutants in Sediments in 1971 (Bowerman and Chen, 1971)

Parameter	Range
Cd*	1.19+ - 7.79+
Fe	20600+ - 43800
Hg	0.064^{-} - 1.14^{-}
Mn	0.10^{-} - 54.4^{-}
Pb	37.8^{+} - 220

- lower than 1977-78 concentrations + higher than 1977-78 concentrations

* improved analytical techniques make comparison of these data questionable

Table 4. 1978 Sediment Pollutants Compared with 1973-74 (in ppm unless indicated) in Los Angeles-Long Beach Harbors.

1978 increase ↑ decrease ↓		1978 Ranges	1973-74 Ranges**
	% moisture content	62.6-26.09	57.56-21.94
	% Dry Matter	73.91-37.4	78.06-47.40
↑	% Total Volatile Solids	14.4-2.0	10.16-2.19
↑	Immediate O_2 Demand*	3560-647	1698-190
↓	% Total Organic Carbon*	1.67-0.26	2.239-0.302
-	Chemical O_2 Demand	125,000-9,580	128,502-11,050
↑	Oil and Grease	21,500-85	4,260-1,020
↑	Total Phosphorus	5,400-246	2,300-910
↑	Organic Nitrogen	2,730-65.7	953-107
↓	Sulfide*	473-113	4,216-86
↑	Arsenic*	121-21.6	17.0-1.01
↓	Cadmium	2.62-0.30	6.56-1.26
↑↓	Chromium	221-16	170-34.6
↓	Copper	233-15.8	296-36.4
↑	Iron	69,600-13,800	45,370-12,310
↓	Mercury*	0.134-0.09	4.17-0.10
↑	Manganese	842-177	489-210
↓	Nickel	106.8-8.2	148-17.3
↓	Lead	401-<3.6	413-38.4
↑	Zinc	1,317-53.1	516-61.0
↑↓	Total DDT	0.589-0.000	0.047-0.018
↓	Total PCB	1.247-0.000	5.728-0.222

* incomplete data
** AHF, 1976.

PHYTOPLANKTON PRODUCTIVITY AND NUTRIENTS

INTRODUCTION

The phytoplankton is composed of single-celled algae, plants which provide dissolved oxygen to marine waters and a source of carbon to the food web. Primary productivity measurement is an assessment of the interaction of the phytoplankton organisms and their environment, resulting in the photosynthetic production of biological material from non-living nutrients. As with terrestrial plants, the phytoplankton utilize the energy of sunlight in this conversion. In turn, the phytoplankton can be consumed by grazers present in the biota, which serve as the next trophic level in the food webs of the natural environment.

The rate of production is partly governed by the size of the population capable of photosynthesis, and the nutrients available to these organisms. Other environmental conditions, such as the presence of stimulatory, toxic, or inhibitory substances, will also be reflected in the rate of production.

The assessment of phytoplankton productivity and the estimation of the size of the photosynthetic population by measurement of Chlorophyll *a* was carried out as a part of the Marina del Rey studies to aid in assessing the status of the biology and water quality of the area.

METHODS

The methods used in this study have not changed from those given earlier (Soule and Oguri, 1977) and are as follows:

Samples of surface water were collected monthly at stations 1 through 11 for determination of phytoplankton productivity and pigments. The data are shown in Tables 1-3. In the tables, three numbers are shown for each date and station values are: productivity as milligrams of carbon fixed per hour of incubation per cubic meter (P), chlorophyll *a* as milligrams per liter (C), and assimilation ratio (A) which is derived by dividing productivity by the Chlorophyll concentration. Assimilation ratio gives information on the amount of biological material that can be produced (productivity) per unit of standing crop (Chlorophyll *a*). A high assimilation ratio indicates efficient production and a low one suggests environmental stress.

Primary productivity was determined by measuring the amount of radioactively labeled carbon (^{14}C) incorporated by the phytoplankton when incubated under controlled illumination for about three hours in seawater at ambient temperature. Standing crop, the number of phytoplankters present per volume of water, was determined by filtration of all plankton in one liter of water through Millipore HA filters, followed by extraction of the pigments chemically. The amount of chlorophyll *a* is determined by spectrophotometry. Since chlorophyll *a* pigment is directly proportional to the biomass of phytoplankton, a measure of standing crop can be obtained accurately.

Data were averaged for each of the three 12-month periods to give annual differences and shown in Figures 1 to 9. Seasonal averages of the same data are presented in Figures 10 through 48.

RESULTS

Annual Variation

Productivity for the 1976-77 year averaged substantially higher than in the subsequent years. The lowest average productivity in 1976-77, 10.88 $mgC/hr/m^2$ at station 8, was higher than the highest averaged values in either 1977-78 (9.83 at station 6) or in 1978-79 when the highest found were 9.98 at station 5 and 9.91 at station 7. The year 1976-77 was also the only year in which average productivities at the entrance to Marina del Rey stations 1 and 2 were among the highest values found in the area. This suggests that during this year substantial phytoplankton blooms had occurred in Santa Monica Bay.

The distribution of these values within the marina suggest that lower productivity values will usually occur in the northernmost stations 9, 10 and 11 and in the southerly stations, 1, 2 and 3. Stations in the middle were usually higher in productivity, while stations 6, 7 and 8, in basins B, H and D respectively, were more variable than those along the main channel (Figures 1, 2 and 3).

Chlorophyll *a* values, averaged for each of the 12 month periods (Figures 4, 5 and 6), showed a similarity to the productivity data. The first year, 1976-77, had the highest values, indicating that phytoplankton populations were high. The bimodal distribution of values for chlorophyll *a* concentration shown in the histogram for 1977-78 and the high values shown in the histogram and Figure 5 for that year reflect extremely high values found in June 1979 for station 7 and in July for stations 2 and 3, as shown in Tables 1 and 2.

If the three highest values noted for the second year are ignored, the data suggest that the marina contained somewhat more phytoplankton than occurred in the entrance waters and, presumably, in Santa Monica Bay. Consistent patterns of distribution within the marina were not apparent.

Assimilation ratios, based on the productivity and chlorophyll *a* values, are presented in Figures 7, 8 and 9 for each of the three 12-month periods of this study.

The averaged assimilation ratio data were highest in 1976-77 and lowest in 1978-79. Only in the first year did high assimilation occur in the waters at the entrance to the marina, bearing out the earlier noted possibility of blooms in Santa Monica Bay during that year.

Values for assimilation in all years tended to be higher in the middle of the marina, particularly at stations 4 and 5 in the main channel. Lower values occurred at the entry, at station 3 and in the inner marina, at stations 9, 10 and 11.

Seasonal Variation

The seasonal averages were calculated with June, July and August as summer months; September, October and November as autumn or fall; December, January and February as winter; and March, April and May as spring. Inspection of the data in Tables 1-3 supports this definition of the seasons but leads to the first "summer" of this project consisting of data only for July and August of 1976 and the last summer consisting only of June of 1979. The seasons are consistent with the analytical system used for the other parameters and other HEP studies (Soule and Oguri, 1979a, b).

Productivity values found during the summer months, shown in Figures 10-13, were generally the highest seasonal values found. For the most part, they showed the greatest range, with the high values usually found in the main channel and at station 8 near the beach. Values at station 10 were usually among the lowest. In all but the summer of 1978, high productivity was found at one or both stations 1 and 2, nearest the entry into the marina, also suggesting that blooms, possibly of red tide organisms had occurred in Santa Monica Bay.

Summer chlorophyll *a* values (Figures 14-16) show that the standing crop of phytoplankton in 1978 was the lowest of the three-year periods sampled.

In both 1976 and 1977 the highest values were found near the entrance to the marina, suggesting that the phytoplankton in the marina originated in Santa Monica Bay in those years. Station 8, near the beach in Basin D, consistently showed relatively high levels of chlorophyll *a*, and stations 6 and 10 in the basins had low values.

Summer assimilation values were moderate and variable in 1976, high and fairly uniform in 1977 and 1979, and low in 1978. Values at station 8 tended to be high, suggesting biostimulation in that area, and station 11 values were always low, suggesting that inhibition of phytoplankton was taking place at that station.

Autumn productivity average values for 1976, 1977 and 1978 are shown in Figures 22-24. In 1976, values were similar to those found in the summer and a distribution of values was also similar to those described. High values were found at the entrance to the marina, stations 1 and 2, in the middle section of the main channel, station 5, and near the beach in Basin D, station 8. The lowest values in 1976, which were approximately equal to the highest values found in subsequent years, occurred at stations 7 and 9. In autumn 1977, low and relatively uniform productivity values were found throughout the area. The highest values occurred at station 5, and were found at station 3, near the Ballona Lagoon tide gates, and at stations 6, 7, 9 and 10, in the basins. The autumn 1978 values were higher on average than those for 1977, but lower than those for 1976. Highest values occurred throughout the main channel and in the basins at stations 3, 4, 5, 7 , 8 and 9. Stations 6, 10 and 11 had low values.

The autumn chlorophyll values, shown in Figures 25-27 for the three years, essentially parallel the average levels noted for productivity values. Autumn 1976 values were highest and 1977 values were lowest. The 1978 values were intermediate.

In 1976 the chlorophyll *a* values were highest at the entry, extending to station 4 in the main channel. High values were also noted in the basins at stations 6, 7 and 8. The lowest values were found at stations 10 and 11. In 1977 the highest values occurred at the entrance to the marina with lower values occurring at all other stations, although station 5 had somewhat higher values than the other inner stations. In 1978 higher values than those at the entrance were found at both the southern end of the main channel, stations 3 and 4, and at the northern end, station 11. Lowest values occurred at stations 6 and 10.

The autumn assimilation values (Figures 28-30) were, on average, similar in 1977 and 1978. However, in autumn 1976 values appeared to be higher generally, and it was the only autumn in which high assimilation ratios occurred at the entrance to the marina.

In all three years the middle of the marina showed generally higher values than occurred to the south, near station 3, or to the north near station 10. Station 6 tended to have lower values and station 8 tended to have higher ones.

Winter values for productivity, shown in Figures 31-33, were the lowest for each year. In the winter of 1976-77, substantially more productivity was measured than in subsequent years and the range of values was considerable. The highest productivity was found at stations 6, 7, 8 and 9 in the basins, and the lowest at stations 1 and 2, at the entrance and near the Ballona Lagoon tide gates, and at station 10 near the bird sanctuary drainage. In the two subsequent years productivity was uniform and low throughout the entire marina area.

The winter chlorophyll *a* values, shown in Figures 34-36, were similar in pattern to the productivity values for this season. In the winter of 1976-77, more chlorophyll was present and a wider range of values was found than was noted in the two subsequent years. Higher values were found at basin stations 6, 7, 8 and 9. Low values occurred at channel stations 3 and 5. In both subsequent winter seasons the values found were lower and more uniform in distribution.

The assimilation values for the three winters are shown in Figures 37-39. The winter of 1976-77 showed highest assimilation rates and 1978-79 the lowest. In all three years the stations inside the marina tended to show higher rates of assimilation than occurred at the entrance, with higher values generally noted in stations along the main channel and at station 8, in Basin D.

Productivity values in the spring, shown in Figures 40-42, were substantially higher than those for the winter, reflecting the usual spring bloom. Spring of 1977 and 1979 productivity values were about three times higher than those found in 1978. In all three years the range of values was narrow, with higher values occurring at the inner stations as compared to those near the entrance to the marina.

The pattern of spring chlorophyll values presented in Figures 43-45, is similar to that of the productivity values. The values in the spring of 1978 are lower than those for 1977 and 1979. The range of values for each spring is not quite as restricted as for productivity but is narrow. In all three years the values found were higher at the inner stations than near the entrance.

Assimilation values for the spring seasons are presented in Figures 46-48. In 1977 a broad range of values was found, with high values occurring along the main channel, particularly near stations 4 and 5 in the middle of the channel. Low values were found at station 6, Basin B and station 10, Basin E.

In 1978 low values occurred at stations 1, 2 and 3 nearest the entrance. Values of assimilation increased with distance from the entrance. In 1978 assimilation was generally less than in 1977 or 1979.

In the spring of 1979 the range of values found was narrower than in the preceding years. Generally higher values were found near the entrance and at station 7, Basin H, and station 11 at the north end of the main channel. Basin D, station 8, had the lowest value.

DISCUSSION

The seasonal pattern of events in the occurrence and productivity of the phytoplankton in Marina del Rey is similar to the patterns occurring elsewhere in the coastal waters of Southern California. Winter lows in productivity, population (chlorophyll *a*) and assimilation ratios are usually followed by spring blooms in all of these parameters. Secondary blooms usually occur in the summer and fall which, in Marina del Rey, were more intense than the spring bloom.

In the marina, a similar pattern was seen during the first year of this study. Summer and fall high levels was followed by lower values in the winter of 1976-77. Spring and summer blooms occurred, with high levels of productivity, chlorophyll *a* and assimilation. However, the fall of 1977 through winter of 1978-79 showed levels of productivity that were about one-third that of the period from the summer of 1976 through the summer of 1977 and levels of chlorophyll *a* that were about one-half those of the earlier period. The spring and June of 1979 showed a return to the higher levels of the first year.

The patterns of distribution of the phytoplankton productivity and population indicator, the chlorophyll concentration, shown in the Figures suggest that during the 1976-77 period the higher levels of phytoplankton productivity and chlorophyll *a* also occurred outside the marina. In the two subsequent years the values found near the entrance to the marina for productivity were always among the lowest. Chlorophyll *a* concentrations at stations 2 and 3 in 1977-1978 (Figure 5) were high largely because of unusually high values found in July of 1977 at those two stations. If these high values were not considered, the average at station 2 would drop from 5.56 to 2.01 and the average at station 3 would drop from 4.33 to 1.61. With this change the same statement would apply to the chlorophyll *a* data.

This suggests that during the 1976-77 year a substantial contribution to the high levels of phytoplankton productivity and populations may have originated in contributions from populations in Santa Monica Bay. In subsequent years this contribution was lower. Inspection of the rainfall data presented in Section IIA of this report suggests that increased rainfall and the timing of it may have affected the exchange of waters with Santa Monica Bay. In 1976, a low rainfall year, rainfall occurred only in fall and winter. The late spring and summer months were dry. In 1977, rainfall in significant quantities was reported almost every other month. This rainfall and subsequent runoff could serve to promote a heavier net flow of water out of the marina than would otherwise occur. This explanation is conjectural since the tidal flushing rate of the marina and the runoff volumes are not known.

The pattern of rainfall occurrence in 1978 showed a massive increase in winter and early spring precipitation followed by a long dry spell of about 5 months. During this year both productivity and chlorophyll values increased within the marina but the values at the entry remained low.

A sharp decline in productivity and chlorophyll *a* values was reported for 1978 in Los Angeles-Long Beach Harbors (Soule and Oguri, 1979a, b). However, this occurrence did not coincide in time with the 1977-78 drop in those values at Marina del Rey. The proximate cause of the events in Los Angeles Harbor appeared to be more related to patterns in artificial enrichment of that area.

Within Marina del Rey several patterns can be seen in the data. The summer high values in the vicinity of the bathing beach near station 8 suggest that body contact sports are a factor in locally enhancing the fertility of the waters. An opposite effect, possible inhibition, seems to occur in the waters near Ballona Lagoon tide gate at station 3 and to a lesser extent at station 10 near the bird sanctuary gate. Stations 6, 7 and 9 located in Basin B, H and F, were variable in productivity and chlorophyll *a*, sometimes showing high values and other times showing low ones. This suggests strongly that the use of the waters in the various locations results in the input of both bioinhibitory and biostimulatory substances. Examples of such input include the exchange of waters with Ballona Lagoon and the Venice Canals, and the bird sanctuary, the hosing down of walks and lawns observed near station 6, illegal releases from boats and ships, cloroxing of boat hulls to remove fouling and the possible input of various wastes at the public launching facility near station 7. These, together with the restricted water flow and exchange in blind end slips and basins, represent possible bioregulating mechanisms. It is noteworthy in this regard that stations 4 and 5, which consistently show relatively high levels of phytoplankton productions, are the most isolated from these factors mentioned above. Given the low flushing characteristics, the runoff and the high level of usuage, the conditions in the marina appear to be remarkably good.

NUTRIENTS

INTRODUCTION

Monthly analyses were made of surface water samples at each station to determine the concentration of nitrate, nitrite, ammonia and phosphate. These are frequently referred to as nutrient salts and are essential for the growth of phytoplankton. Their concentration in open oceanic waters is usually quite low, similar to the values shown in Tables 4, 5, 6 and 7 for 1976-1977. In open oceanic waters the nutrient quantities available are low and are limiting to phytoplankton production.

Their routine measurement in Marina del Rey was undertaken in part to establish the relationship to the measurements of phytoplankton activity, and also to delineate some of the parameters of water quality in the area.

METHODS

Samples were collected in plastic buckets, filtered through 0.45µm pore size Millipore filters, and stored under conditions appropriate for the substance being analyzed. Analytical methods used were the standard techniques listed in Table 1, Section I in the Introduction.

RESULTS

The data for the measurements taken are listed in Tables 4, 5, 6 and 7 for nitrate, nitrite, ammonia and phosphate respectively. For all four of the nutrients the concentrations during the first year, 1976-77 were very low, approximating the values reported for open ocean waters. These low values persisted into August 1977 and then showed sharp increases to maximum values in the winter of 1977-1978. Values then decreased to lows through the spring and summer of 1978 and then rose again to higher fall and winter values. The values then dropped in the spring and summer of 1979. The lowest values noted occurred in the first year, 1976-1977, and the highest in the second year, 1977-1978. Higher values in the winter are thought to represent lower uptake from the smaller phytoplankton crop and low values in summer would represent greater utilization.

The patterns of distribution of nutrients indicated that higher levels of nitrate tended to occur in the main channel, particularly at the entrance, than occurred in the basins and at the head of the main channel. This pattern was reversed for the distribution of ammonia concentrations and, to a lesser degree, the phosphate concentrations.

DISCUSSION

The seasonal variation in values for nutrient salt concentrations is similar to that found elsewhere in waters off southern California. The values during the first year were low and uniform throughout the year. In subsequent years values were 1 to 2 orders of magnitude greater, and showed a distinct pattern of fall and winter highs, with lower values in spring and summer. Seasonal runoff probably contributed markedly to this pattern.

The distribution of the data suggests that some of the nitrate may originate through mineralizing and deposition from flushing or from the adjacent ocean entering the marina on the tidal cycles. The ammonia and phosphate most likely originate from terrigenous, urban sources including storm drains and boats in the marina.

A crude inverse relationship is apparent between nutrient concentrations and phytoplankton productivity. In 1976-1977 productivity was extremely high and nutrients were minimal, perhaps limiting. In 1977-1978 productivity was minimal and nutrients were high, particularly during fall and winter. In 1978-1979 the nutrient cycle was the expected, with fall and winter highs and spring and summer lows. The heavy rainfall during the last two years of the study would result in increased nutrients entering the marina in the runoff.

FIGURE 1 LEGEND

PRODUCTIVITY -- YEARLY AVERAGE
1976-1977

DATA VALUE EXTREMES ARE 10.88 20.57

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	4.27	6.00	7.00	8.00	9.00	10.00	12.00	15.00
MAXIMUM	4.27	6.00	7.00	8.00	9.00	10.00	12.00	15.00	20.57

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

20.76	8.41	4.86	4.86	4.86	4.86	9.72	14.58	27.05

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++++++	XXXX5XXXX	OOOO6OOOO	[illegible] 7	[illegible]	[illegible]
FREQ.	0	0	0	0	0	0	3	4	4

1
2
3
4

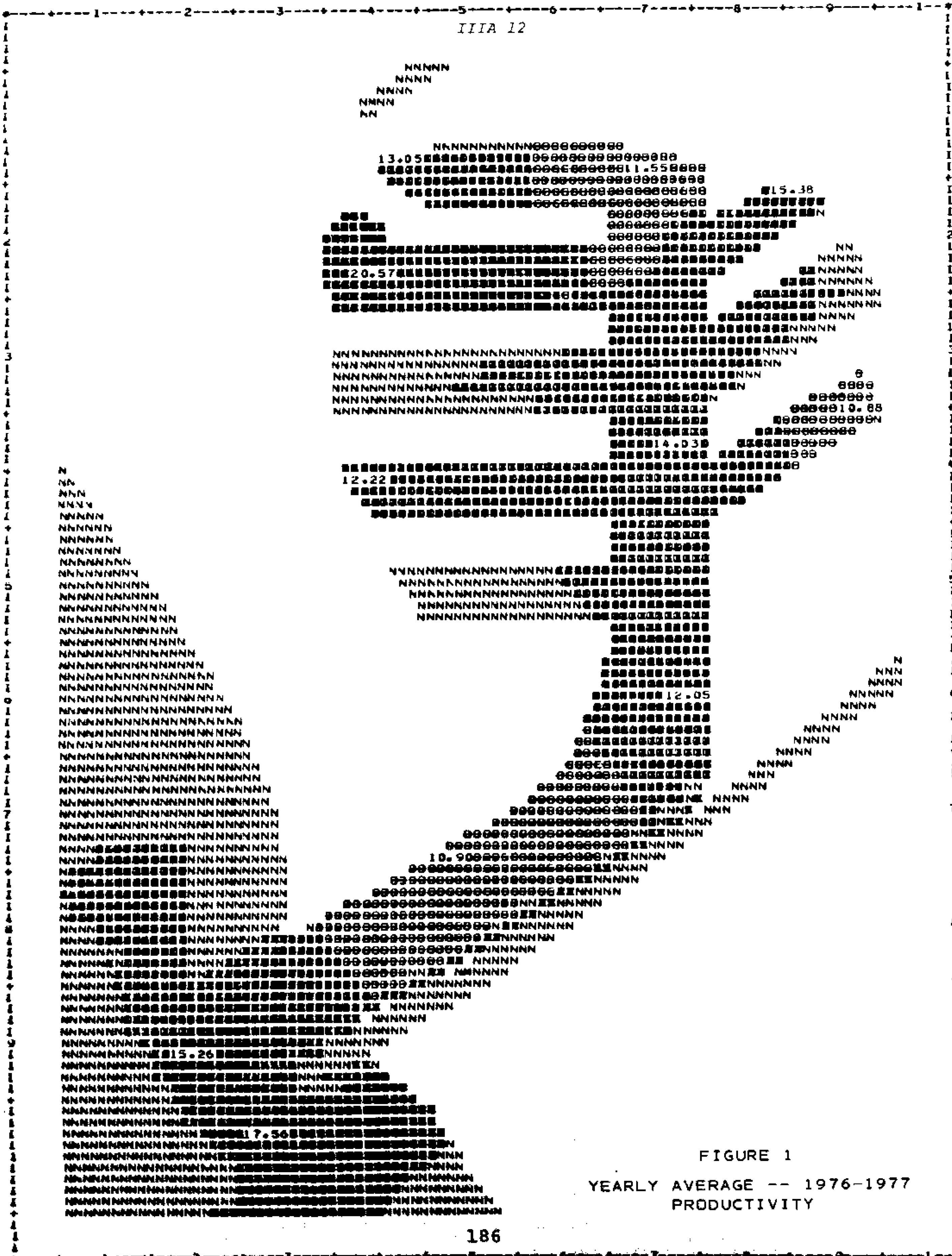


FIGURE 1

YEARLY AVERAGE -- 1976-1977 PRODUCTIVITY

FIGURE 2 LEGEND

PRODUCTIVITY -- YEARLY AVERAGE
1977-1978

DATA VALUE EXTREMES ARE 4.27 9.83

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	4.27	6.00	7.00	8.00	9.00	10.00	12.00	15.00
MAXIMUM	4.27	6.00	7.00	8.00	9.00	10.00	12.00	15.00	20.57

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

20.76	8.41	4.86	4.86	4.86	4.86	9.72	14.58	27.08

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	[illegible]	[illegible]	[illegible]
FREQ.	0	3	2	3	1	2	0	0	0
1		I''2''I	I==3==I	I++4++I	IXX5XXI	IOO6OOI			
2		I''2''I	I==3==I	I++4++I		IOO6OOI			
3		I''2''I		I++4++I					

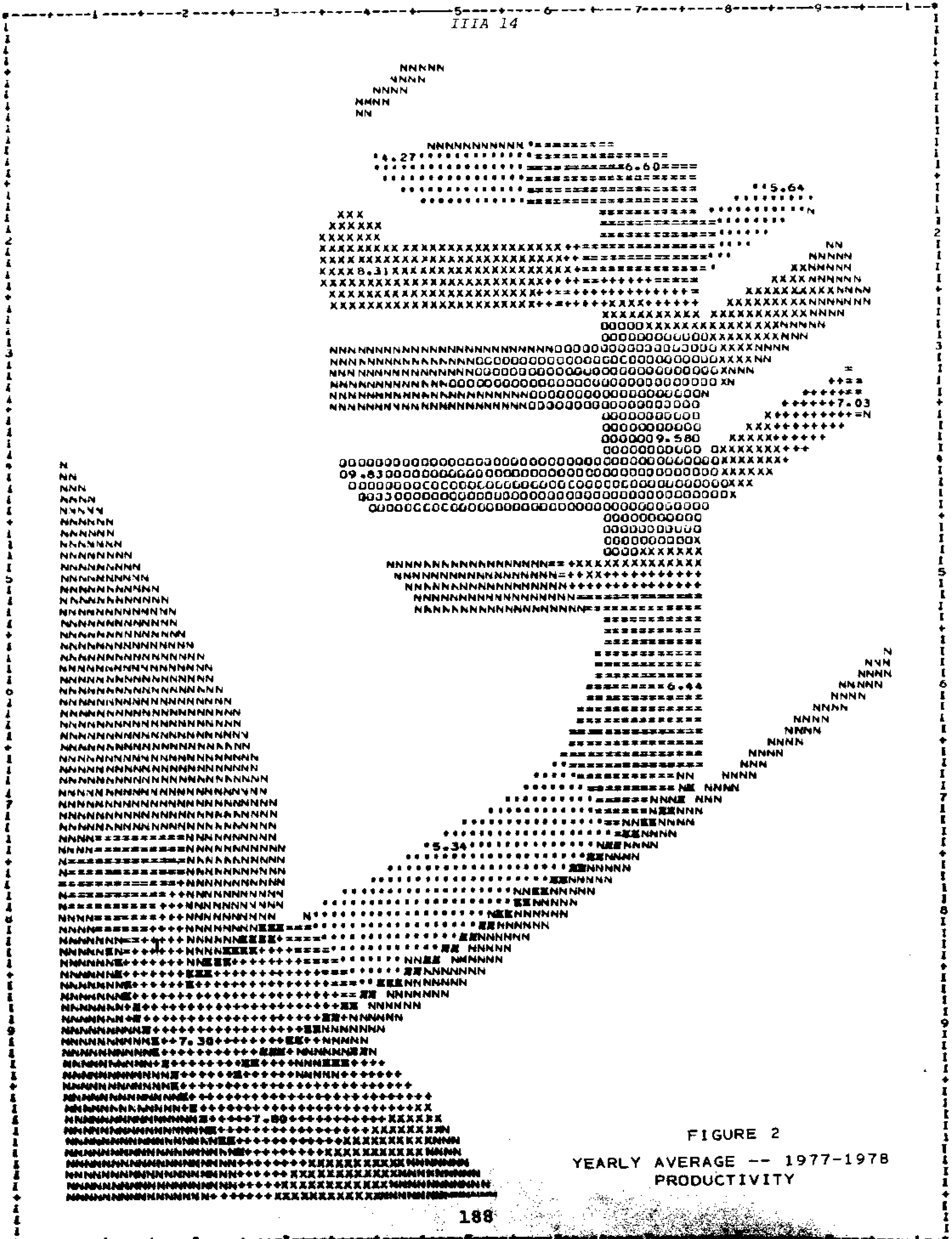


FIGURE 2

YEARLY AVERAGE -- 1977-1978
PRODUCTIVITY

FIGURE 3 LEGEND

PRODUCTIVITY -- YEARLY AVERAGE
1978-1979

DATA VALUE EXTREMES ARE 5.47 9.98

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	4.27	6.00	7.00	8.00	9.00	10.00	12.00	15.00
MAXIMUM	4.27	6.00	7.00	8.00	9.00	10.00	12.00	15.00	20.57

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

20.76	8.41	4.86	4.86	4.86	4.86	9.72	14.58	27.08

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	[illegible]	[illegible]	[illegible]	[illegible]	XXXX5XXXX	OOOO6OOOO	[illegible]	[illegible]	[illegible]
FREQ.	0	1	3	2	2	3	0	0	0
1		I''2''I	I==3==I	I++4++I	IXX5XXI	IOO6OOI			
2			I==3==I	I++4++I	IXX5XXI	IOO6OOI			
3			I==3==I			IOO6OOI			

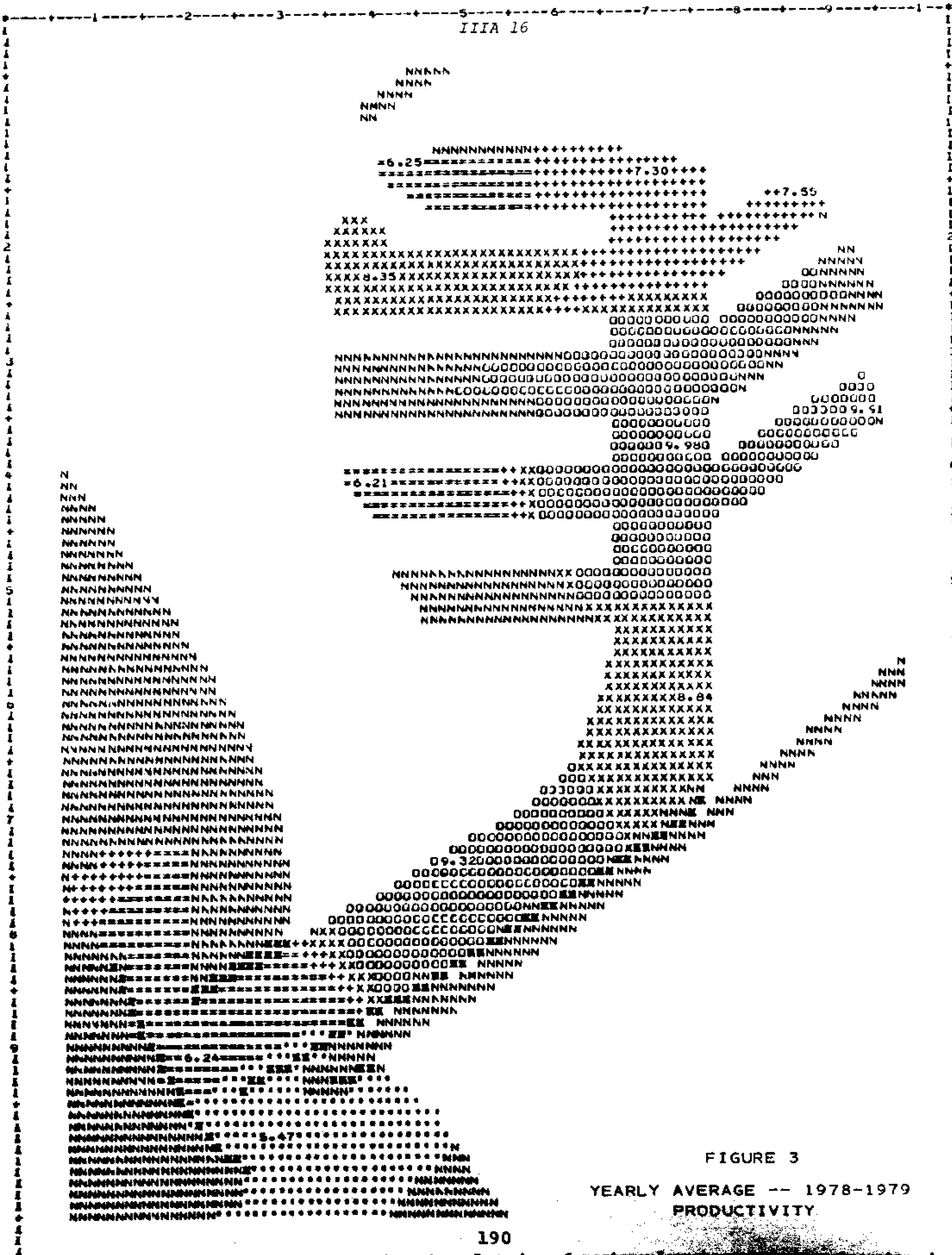


FIGURE 3

YEARLY AVERAGE -- 1978-1979

PRODUCTIVITY

FIGURE 4 LEGEND

CHLOROPHYLL A – YEARLY AVERAGE
1976–1977

```
DATA VALUE EXTREMES ARE          2.65         5.44


TOTAL MISSING DATA POINTS IS          2


ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
       ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

  MINIMUM       0.0        1.07       2.00       2.50       3.00       4.00       5.00
  MAXIMUM       1.07       2.00       2.50       3.00       4.00       5.00       5.56

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

               19.24      16.73       8.99       8.99      17.99      17.99      10.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
  LEVEL           1          2          3          4          5          6          7
            ===========================================================================
             .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@
             .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@
  SYMBOLS    ....1....  ''''2''''  ++++3++++  XXXX4XXXX  OOOO5OOOO  @@@@6@@@@  @@@@7@@@@
             .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@
             .........  '''''''''  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@
            ===========================================================================
  FREQ.           0          0          0          3          4          3          1
            1                                 IXXX4XXXI  IOOO5OOOI  I@@@6@@@I  I@@@7@@@I
            2                                 IXXX4XXXI  IOOO5OOOI  I@@@6@@@I
            3                                 IXXX4XXXI  IOOO5OOOI  I@@@6@@@I
            4                                            IOOO5OOOI
```

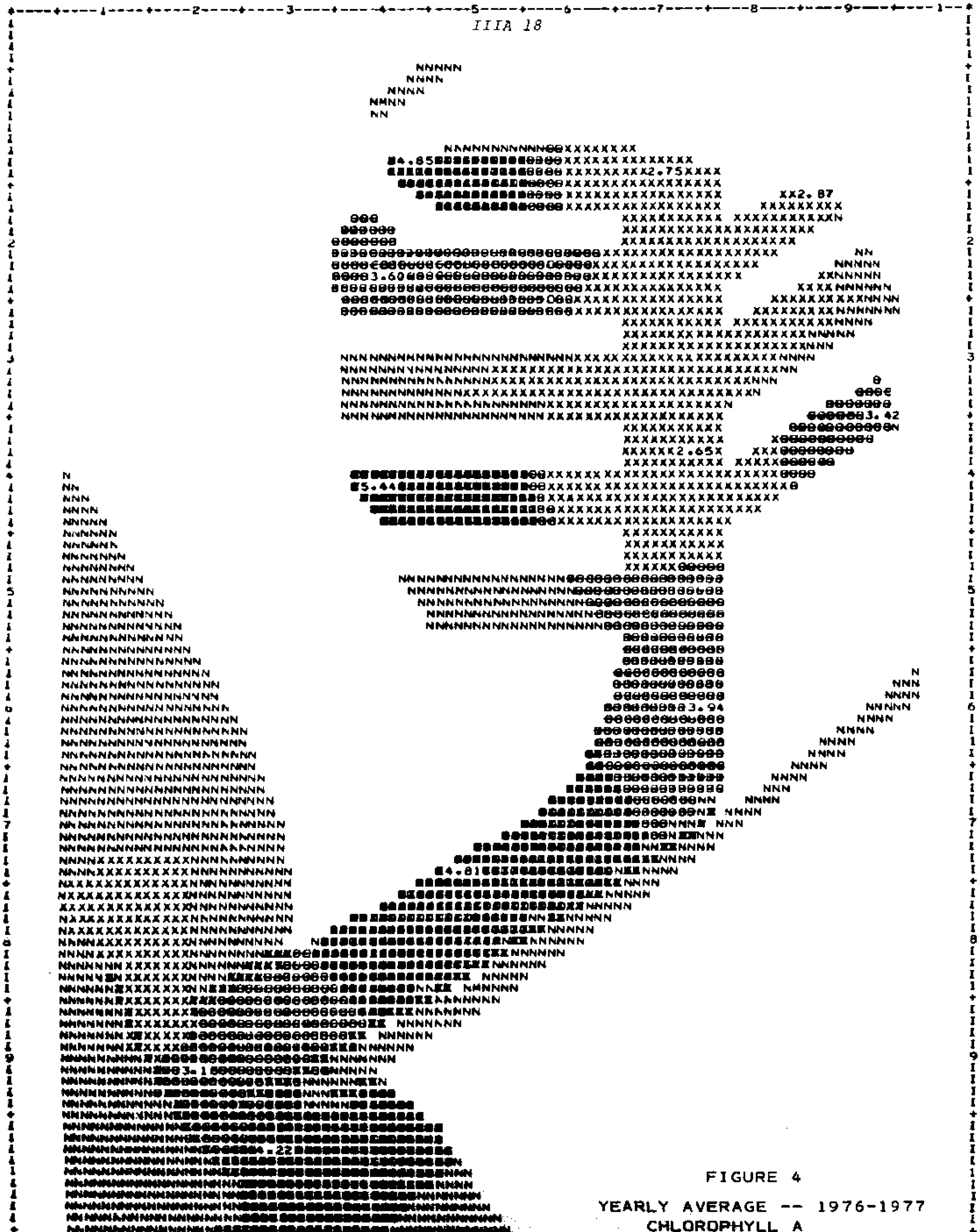


FIGURE 4

YEARLY AVERAGE -- 1976-1977
CHLOROPHYLL A

FIGURE 5 LEGEND

CHLOROPHYLL A - YEARLY AVERAGE
1977-1978

```
DATA VALUE EXTREMES ARE          1.07        5.56


TOTAL MISSING DATA POINTS IS         2


ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
       ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

  MINIMUM      0.0       1.07       2.00       2.50       3.00       4.00       5.00
  MAXIMUM      1.07      2.00       2.50       3.00       4.00       5.00       5.56

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

              19.24      16.73      8.99       8.99       17.99      17.99      10.07


FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
  LEVEL          1          2          3          4          5          6          7
           ===================================================================================
            .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
            .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
  SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  0000500000 ####6####  ####7####
            .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
            .........  '''''''''  +++++++++  XXXXXXXXX  000000000  #########  #########
            .........
           ===================================================================================
  FREQ.          0          7          1          0          0          2          1
        1                I''2''I    I++3++I                         I##6##I    I##7##I
        2                I''2''I                                    I##6##I
        3                I''2''I
        4                I''2''I
        5                I''2''I
        6                I''2''I
        7                I''2''I
```

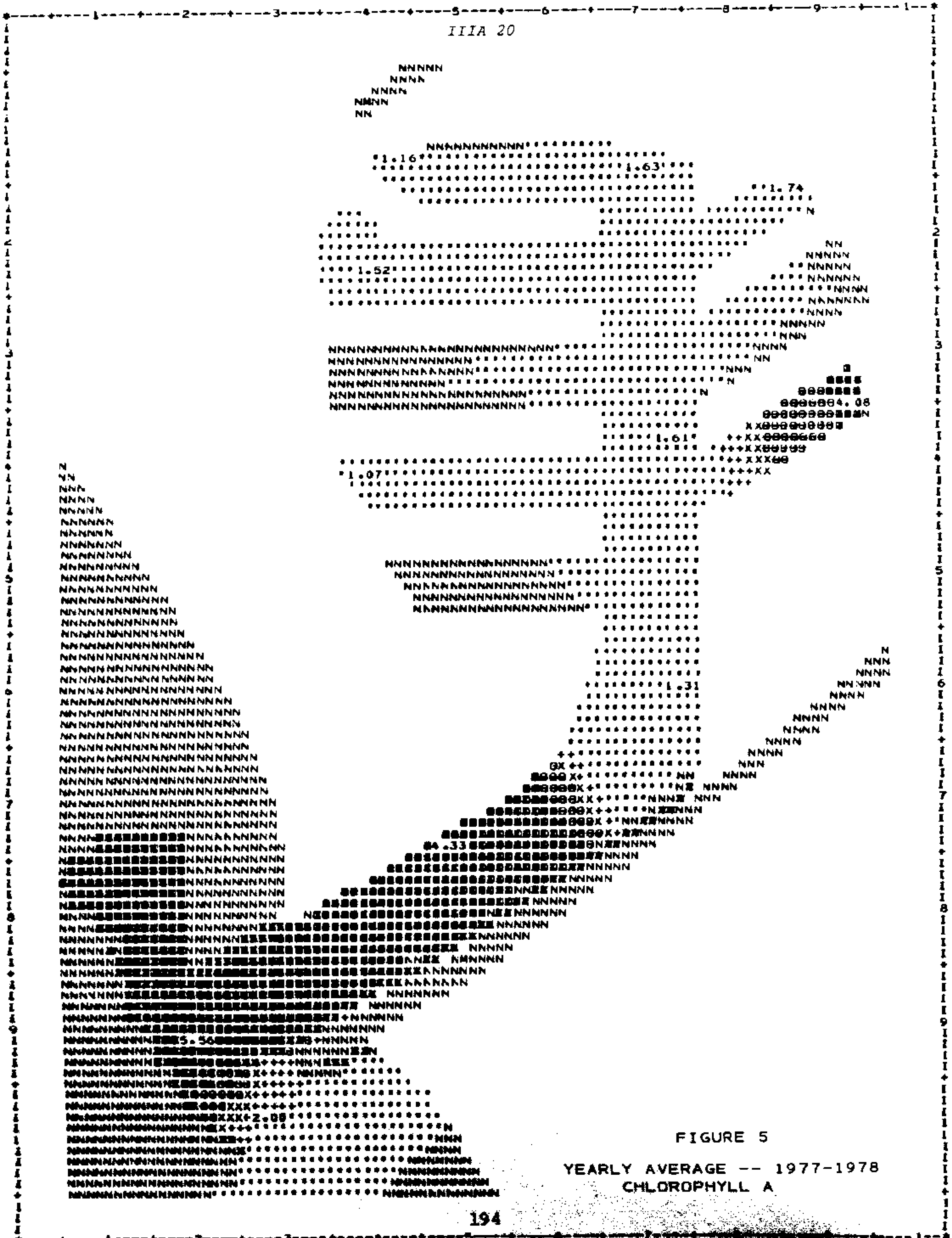


FIGURE 5

YEARLY AVERAGE -- 1977-1978
CHLOROPHYLL A

FIGURE 6 LEGEND

CHLOROPHYLL A - YEARLY AVERAGE
1978-1979

DATA VALUE EXTREMES ARE 1.93 2.94

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	1.07	2.00	2.50	3.00	4.00	5.00
MAXIMUM	1.07	2.00	2.50	3.00	4.00	5.00	5.56

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

19.24	16.73	8.99	8.99	17.99	17.99	10.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL          1          2          3          4          5          6          7
         ==========================================================================
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########
SYMBOLS   ....1....  ''''2''''  ++++3++++  XXXX4XXXX  0000500000 @@@@6@@@@  ####7####
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########
          .........  '''''''''  +++++++++  XXXXXXXXX  000000000  @@@@@@@@@  #########
          .........
         ==========================================================================
FREQ.          0          1          6          4          0          0          0
      1                I''2''I    I++3++I    IXX4XXI
      2                           I++3++I    IXX4XXI
      3                           I++3++I    IXX4XXI
      4                           I++3++I    IXX4XXI
      5                           I++3++I
      6                           I++3++I
```

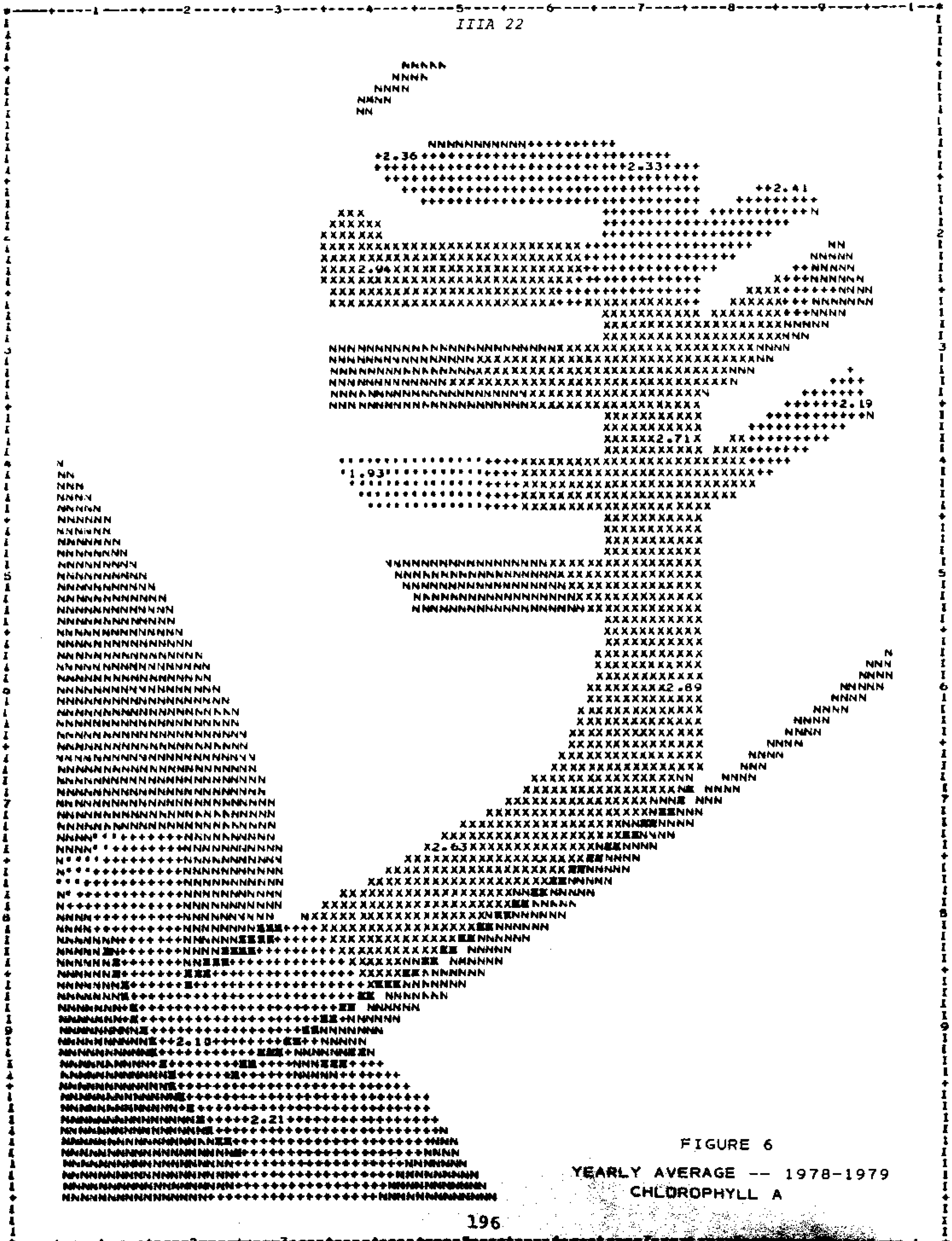


FIGURE 6

YEARLY AVERAGE -- 1978-1979
CHLOROPHYLL A

FIGURE 7 LEGEND

ASSIMILATION RATIO -- YEARLY AVERAGE
1976-1977

DATA VALUE EXTREMES ARE 3.34 7.13

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	2.10	2.50	2.70	3.50	4.00	5.00	5.50	6.00
MAXIMUM	2.10	2.50	2.70	3.50	4.00	5.00	5.50	6.00	7.13

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

29.45	5.61	2.81	11.22	7.01	14.03	7.01	7.01	15.85

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	[illegible]	[illegible]	[illegible]
FREQ.	0	0	0	1	2	1	2	3	2

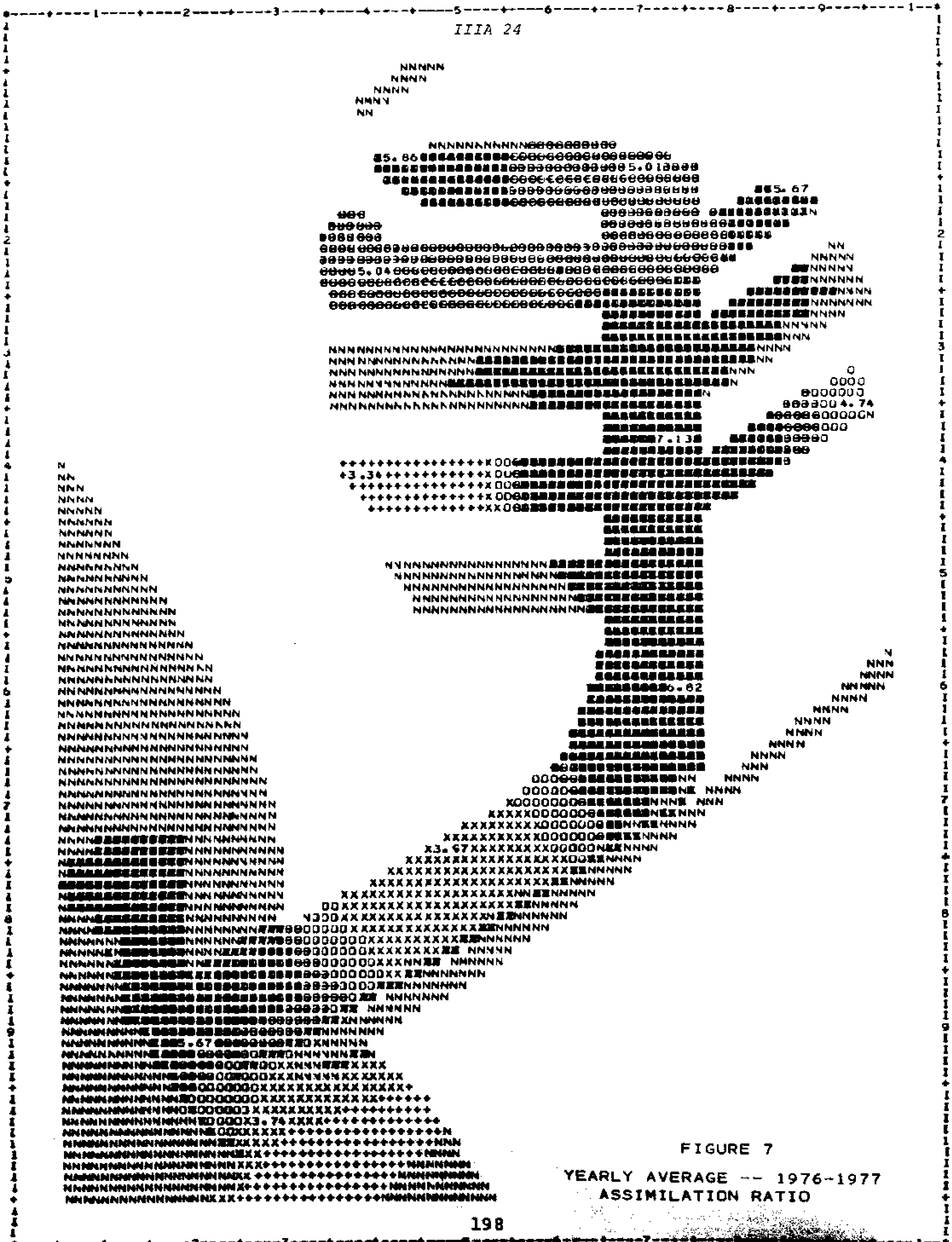


FIGURE 7

YEARLY AVERAGE -- 1976-1977
ASSIMILATION RATIO

FIGURE 8 LEGEND

ASSIMILATION RATIO -- YEARLY AVERAGE 1977-1978

DATA VALUE EXTREMES ARE 2.68 5.95

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	2.10	2.50	2.70	3.50	4.00	5.00	5.50	6.00
MAXIMUM	2.10	2.50	2.70	3.50	4.00	5.00	5.50	6.00	7.13

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

29.45	5.61	2.81	11.22	7.01	14.03	7.01	7.01	15.85

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
FREQ.	0	0	1	0	2	4	3	1	0

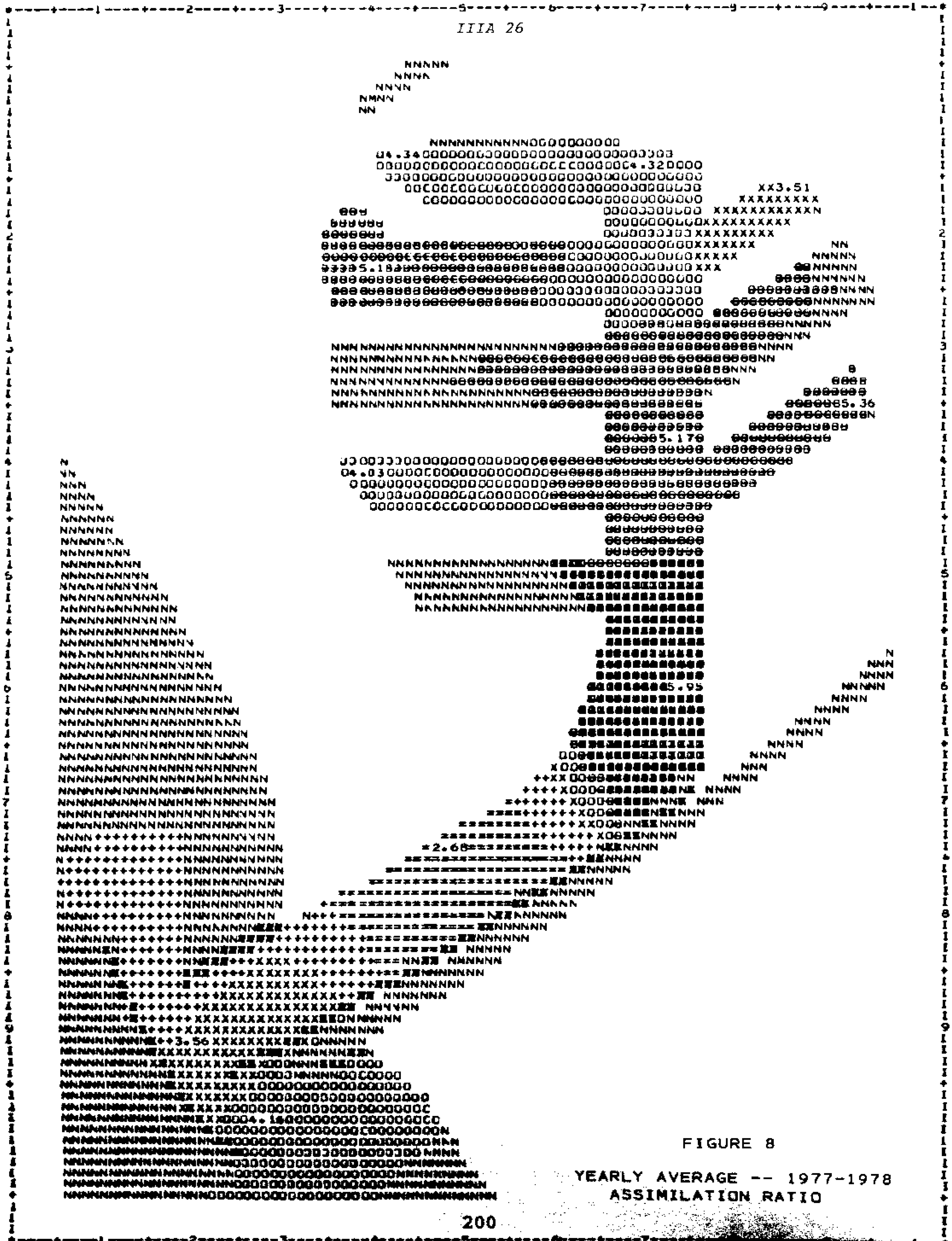


FIGURE 8

YEARLY AVERAGE -- 1977-1978
ASSIMILATION RATIO

FIGURE 9 LEGEND

ASSIMILATION RATIO -- YEARLY AVERAGE
1978-1979

DATA VALUE EXTREMES ARE 2.10 3.85

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	2.10	2.50	2.70	3.50	4.00	5.00	5.50	6.00
MAXIMUM	2.10	2.50	2.70	3.50	4.00	5.00	5.50	6.00	7.13

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

29.45	5.61	2.81	11.22	7.01	14.03	7.01	7.01	15.85

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	0000600C0	00087000	[illegible]	[illegible]
FREQ.	0	1	3	5	2	0	0	0	0

```
FREQ.
1      I''2''I   I==3==I   I++4++I   IXX5XXI
2                I==3==I   I++4++I   IXX5XXI
3                I==3==I   I++4++I
4                          I++4++I
5                          I++4++I
```

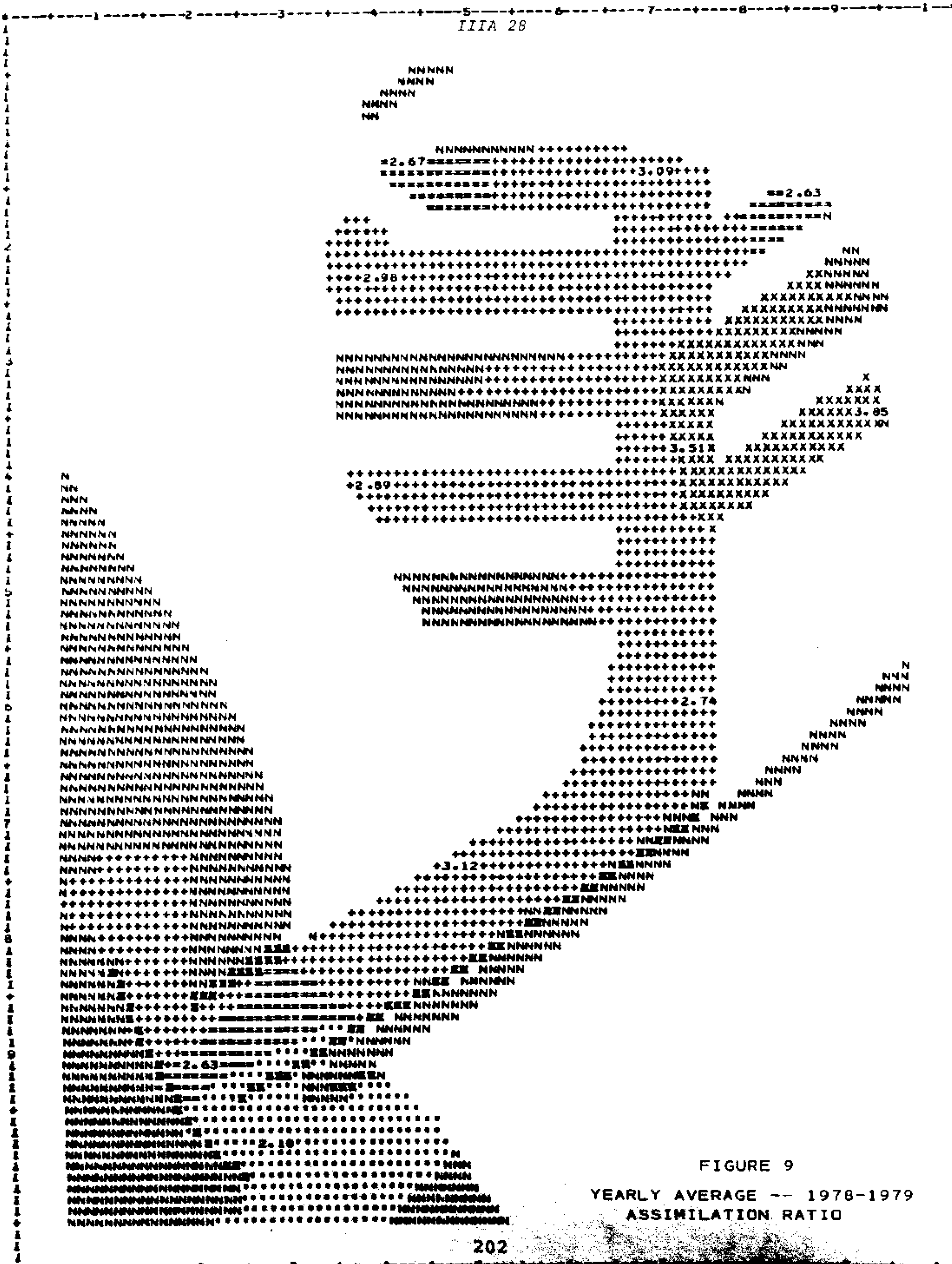


FIGURE 9

YEARLY AVERAGE -- 1978-1979
ASSIMILATION RATIO

FIGURE 10 LEGEND

PRODUCTIVITY
SUMMER 1976

DATA VALUE EXTREMES ARE 4.69 49.05

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9
MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	4.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++++++	XXXX5XXXX	OOOO6OOOO	[illegible] 7	[illegible] 8	[illegible] 9
FREQ.	0	0	0	1	1	3	2	2	2
1				I++++I	IXX5XXI	IOO6OOI	I@@7@@I	[illegible]	[illegible]
2						IOO6OOI	I@@7@@I	[illegible]	[illegible]
3						IOO6OOI			

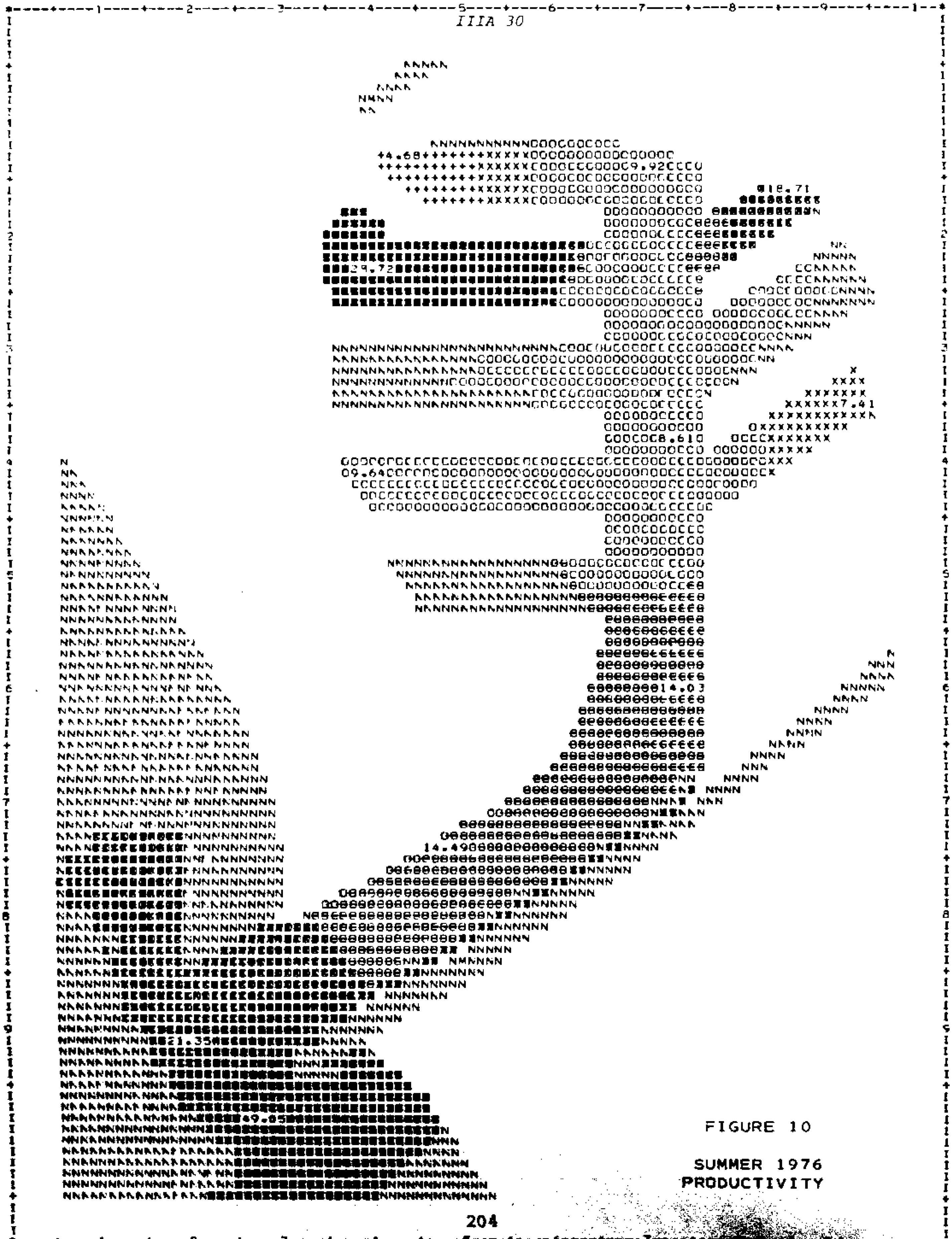


FIGURE 10

SUMMER 1976
PRODUCTIVITY

FIGURE 11 LEGEND

PRODUCTIVITY
SUMMER 1977

DATA VALUE EXTREMES ARE   8.44   30.98

TOTAL MISSING DATA POINTS IS   2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9
MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.59	5.00	8.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1	2	3	4	5	6	7	8	9
1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
FREQ.	0	0	0	0	0	1	2	7	1

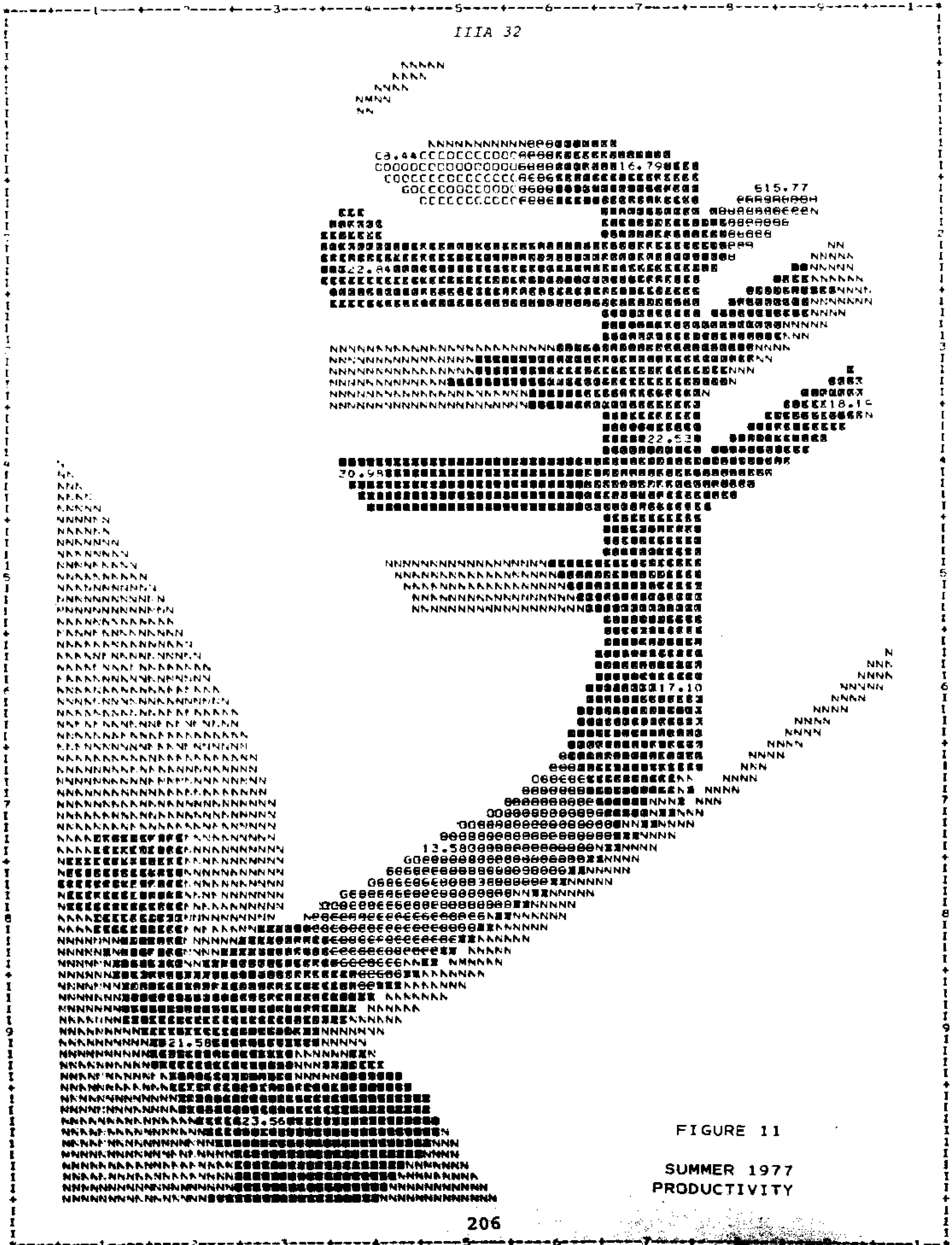


FIGURE 11

SUMMER 1977
PRODUCTIVITY

FIGURE 12 LEGEND

PRODUCTIVITY
SUMMER 1978

```
DATA VALUE EXTREMES ARE          2.42         9.74


TOTAL MISSING DATA POINTS IS          2


ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
       ('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

  MINIMUM      0.0       0.85      2.00      3.50      5.00      8.00     13.00     16.00     24.00
  MAXIMUM      0.85      2.00      3.50      5.00      8.00     13.00     16.00     24.00     49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

               1.73      2.34      3.06      3.06      6.12     10.19      6.12     16.31     51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL
  LEVEL          1         2         3         4         5         6         7         8         9
          ==========================================================================================
            .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
            .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
  SYMBOLS   ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  ####8####  ####9####
            .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
            .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
          ==========================================================================================
  FREQ.          0         0         2         4         3         1         0         0         0
        1                        I==3==I   I++4++I   IXX5XXI   IOO6OOI
        2                        I==3==I   I++4++I   IXX5XXI
        3                        I==3==I   I++4++I   IXX5XXI
        4                                  I++4++I
```

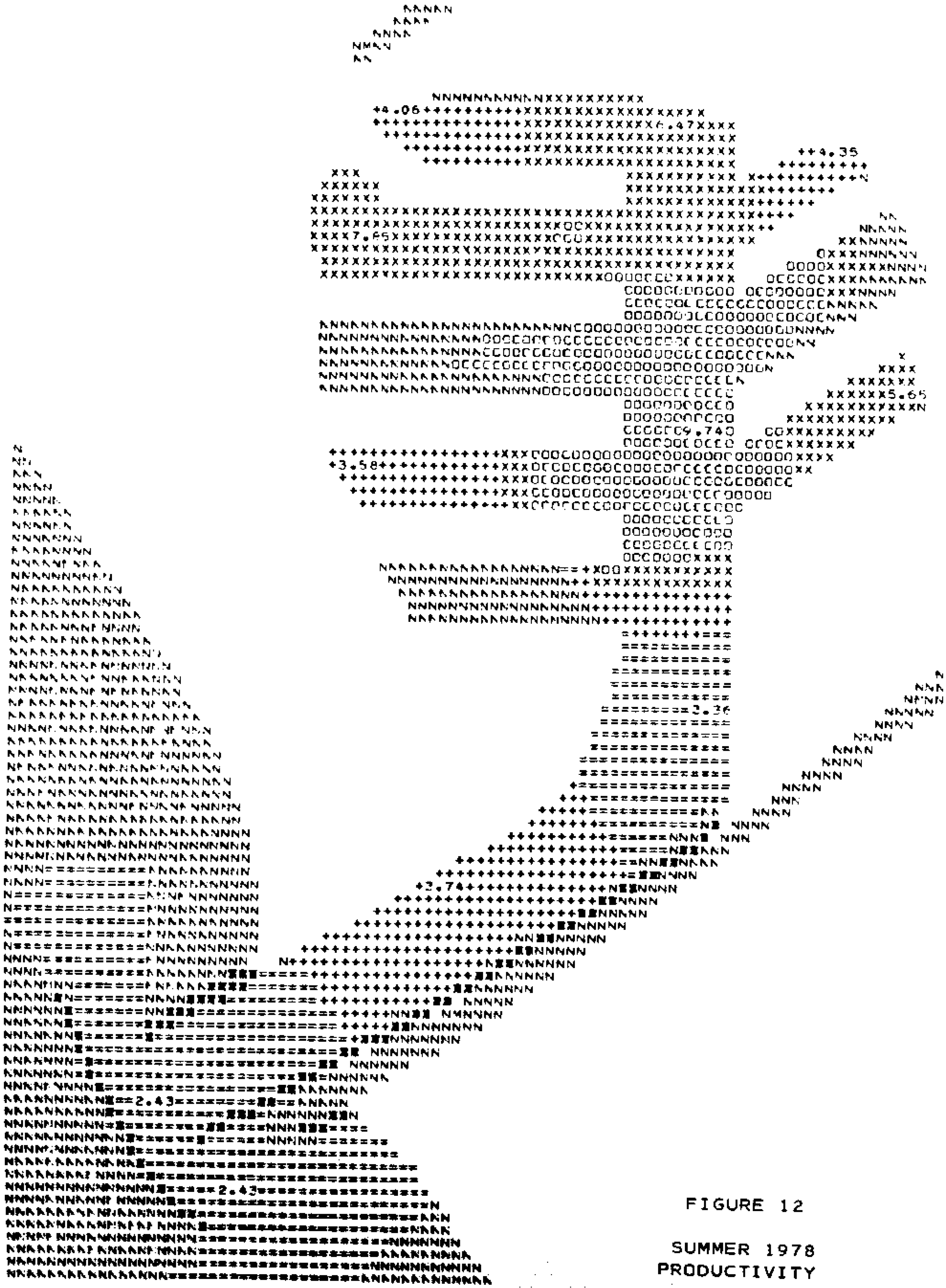


FIGURE 12

SUMMER 1978
PRODUCTIVITY

FIGURE 13 LEGEND

PRODUCTIVITY
SUMMER 1979

DATA VALUE EXTREMES ARE 7.10 43.81

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	[illegible]

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	.....	'''''	=====	+++++	XXXXXXXXX	CCCCCCCCC	@@@@@@@@@	#########	#########
	.....	'''''	=====	+++++	XXXXXXXXX	CCCCCCCCC	@@@@@@@@@	#########	#########
	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	CCCC6CCCC	@@@@7@@@@	####8####	####9####
	.....	'''''	=====	+++++	XXXXXXXXX	CCCCCCCCC	@@@@@@@@@	#########	#########
	.....	'''''	=====	+++++	XXXXXXXXX	CCCCCCCCC	@@@@@@@@@	#########	#########
FREQ.	0	0	0	0	1	1	2	5	2
1					IXX5XXI	ICO6OOI	I@@7@@I	I##8##I	I##9##I
2							I@@7@@I	I##8##I	I##9##I
3								I##8##I	
4								I##8##I	
5								I##8##I	

IIIA 36

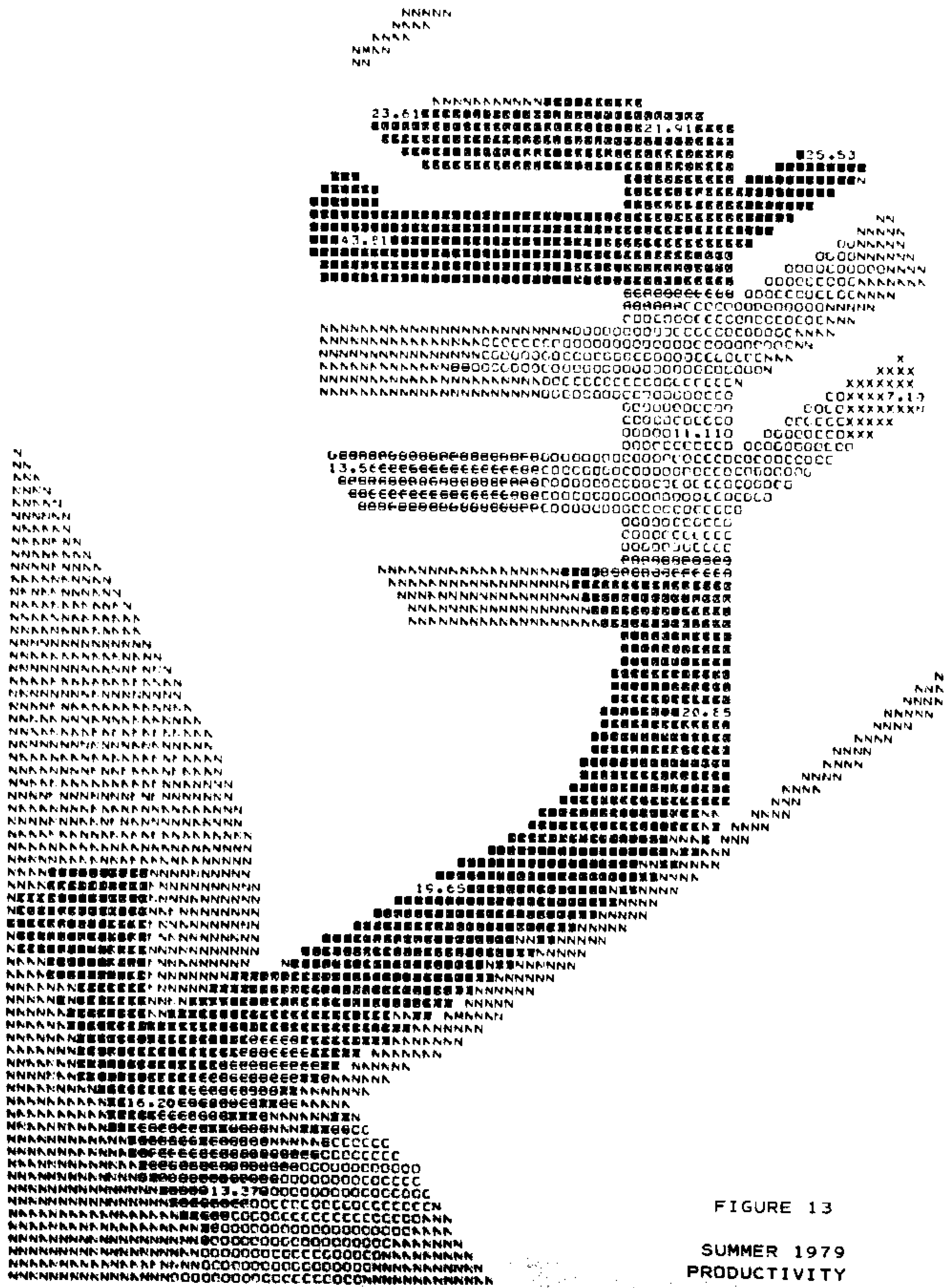


FIGURE 13

SUMMER 1979
PRODUCTIVITY

FIGURE 14 LEGEND

CHLOROPHYLL A
SUMMER 1976

DATA VALUE EXTREMES ARE 2.10 13.24

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL         1          2          3          4          5          6          7          8          9
         ================================================================================================
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ @@@@@@@@@ @@@@@@@@@
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ @@@@@@@@@ @@@@@@@@@
SYMBOLS  ....1....  ''''2'''' ====3==== ++++4++++ XXXX5XXXX OOOO6OOOO @@@@7@@@@ @@@@8@@@@ @@@@9@@@@
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ @@@@@@@@@ @@@@@@@@@
         .........  ''''''''' ========= +++++++++ XXXXXXXXX OOOOOOOOO @@@@@@@@@ @@@@@@@@@ @@@@@@@@@
         ================================================================================================
FREQ.         0          0          0          0          1          0          3          5          2
      1                                              IXX5XXI               I@@7@@I    I@@8@@I    I@@9@@I
      2                                                                    I@@7@@I    I@@8@@I    I@@9@@I
      3                                                                    I@@7@@I    I@@8@@I
      4                                                                               I@@8@@I
      5                                                                               I@@8@@I
```

FIGURE 14

SUMMER 1976
CHLOROPHYLL A

FIGURE 15 LEGEND

CHLOROPHYLL A
SUMMER 1977

DATA VALUE EXTREMES ARE 1.53 13.51

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	8886788888	8888888888	8888988888
FREQ.	0	0	0	2	1	1	3	1	3
1				I++4++I	IXX5XXI	IOO6OOI	I887 88I	I888 8I	I8 9 8I
2				I++4++I			I887 88I		I8 9 8I
3							I887 88I		I8 9 8I

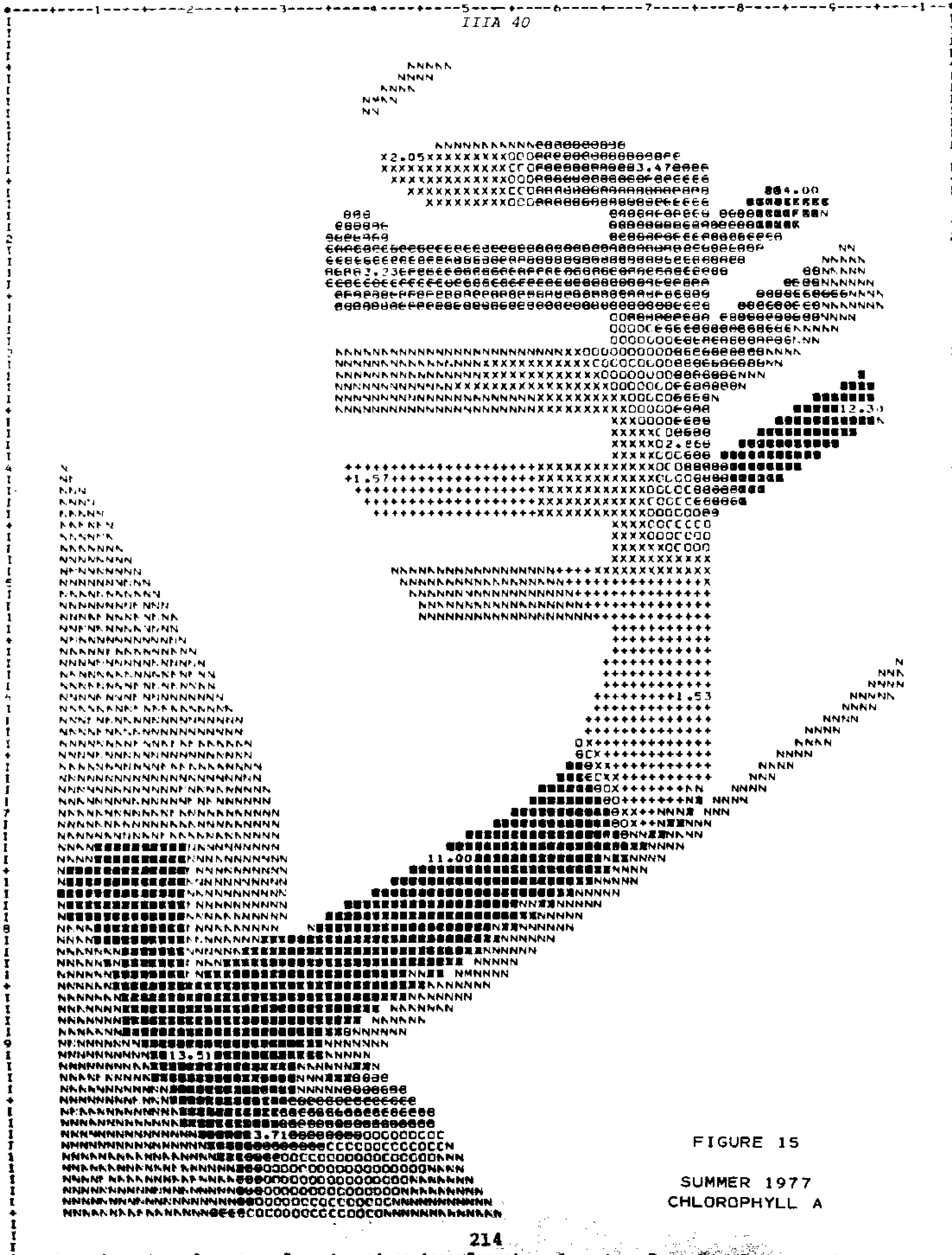


FIGURE 15

SUMMER 1977
CHLOROPHYLL A

FIGURE 16 LEGEND

CHLOROPHYLL A
SUMMER 1978

DATA VALUE EXTREMES ARE 1.69 3.14

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	43.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL          1          2          3          4          5          6          7          8          9
          =========================================================================================================
           .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
SYMBOLS    ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  #########  ####7####
           .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
           .........
          =========================================================================================================
FREQ.          0          0          0          4          3          3          1          0          0
      1                                     I++4++I    IXX5XXI    IOO6OOI    I@@7@@I
      2                                     I++4++I    IXX5XXI    IOO6OOI
      3                                     I++4++I    IXX5XXI    IOO6OOI
      4                                     I++4++I
```

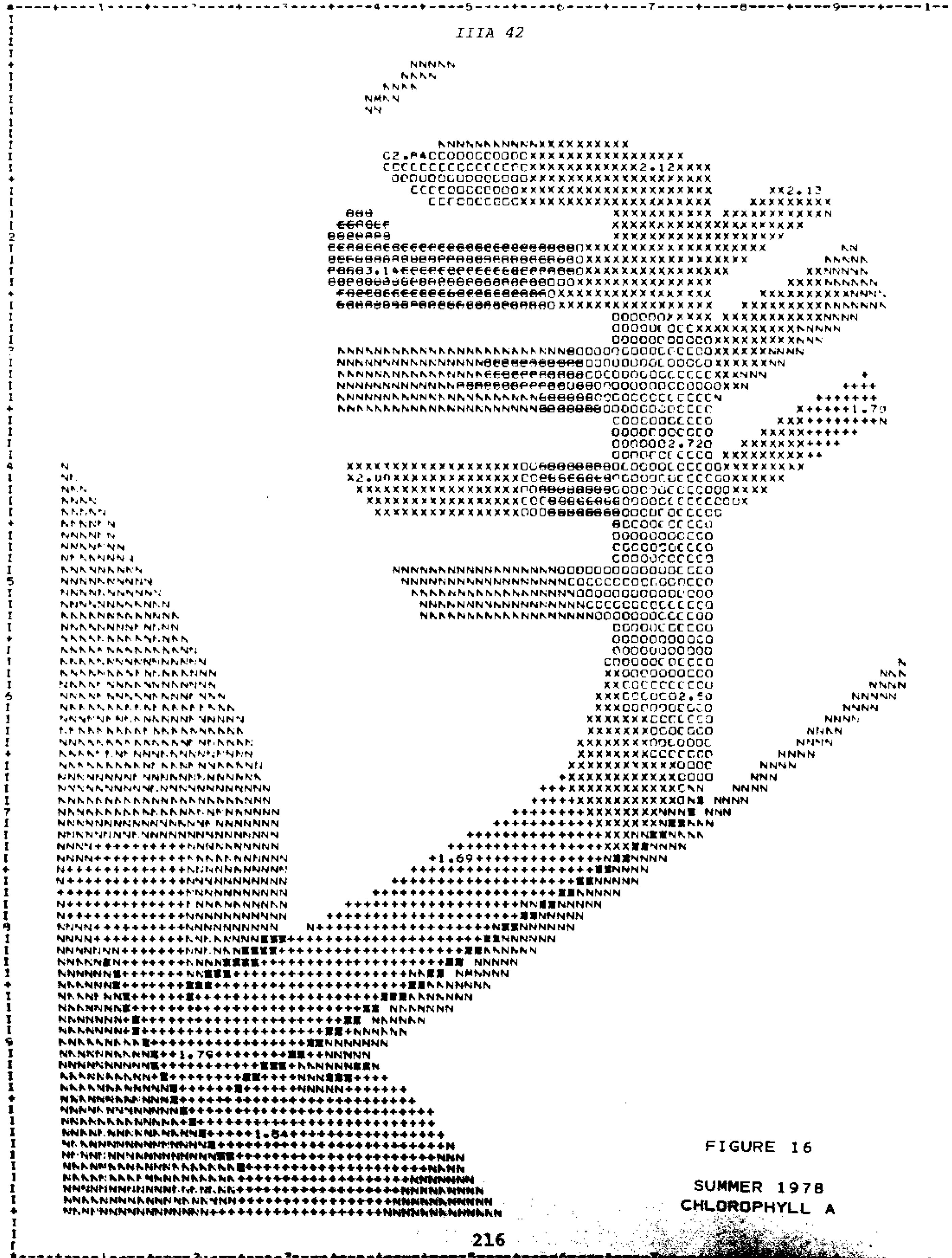


FIGURE 16

SUMMER 1978
CHLOROPHYLL A

FIGURE 17 LEGEND

CHLOROPHYLL A
SUMMER 1979

DATA VALUE EXTREMES ARE 1.40 8.11

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	····1····	····2····	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ΦΦΦΦ7ΦΦΦΦ	■■■■8■■■■	■■■■9■■■■
FREQ.	0	0	1	3	2	3	1	1	0

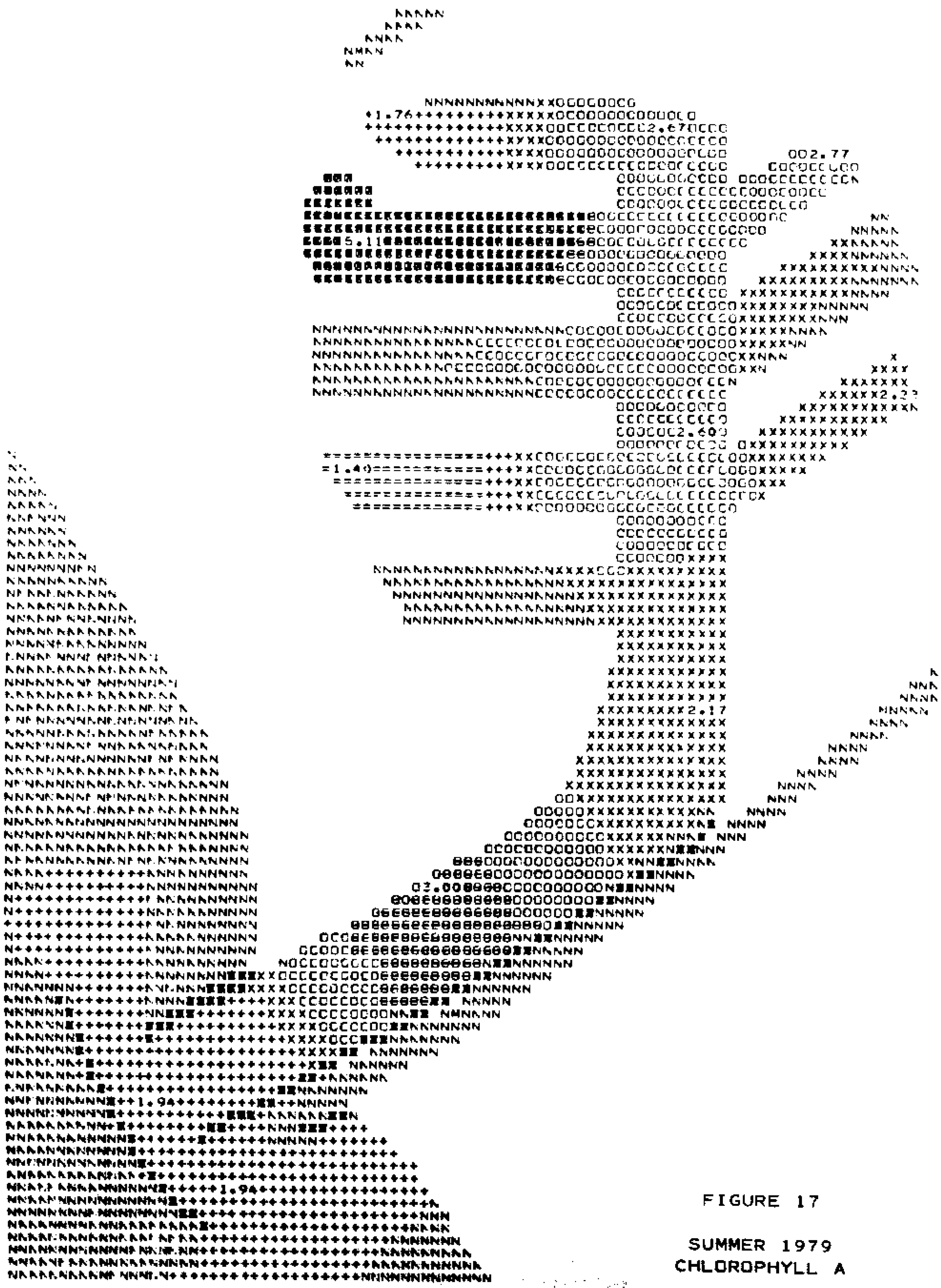


FIGURE 17

SUMMER 1979
CHLOROPHYLL A

FIGURE 18 LEGEND

ASSIMILATION RATIO
SUMMER 1976

DATA VALUE EXTREMES ARE 1.39 8.77

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.16

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9          10
       =========================================================================================================
         .........  '''''''''  ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  ---------  =========  +++++++++  XXXXXXXXX  OOOO7OOOO  @@@@8@@@@  ####9####  ####*####
SYMBOLS  ....1....  ''''2''''  ----3----  ====4====  ++++5++++  XXXX6XXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........
       =========================================================================================================
FREQ.        0          1          1          3          1          1          1          2          1          0
     1              I''2''I    I--3--I    I==4==I    I++5++I    IXX6XXI    IOO7OOI    I@@8@@I    I##9##I
     2                                    I==4==I                                     I@@8@@I
     3                                    I==4==I
```

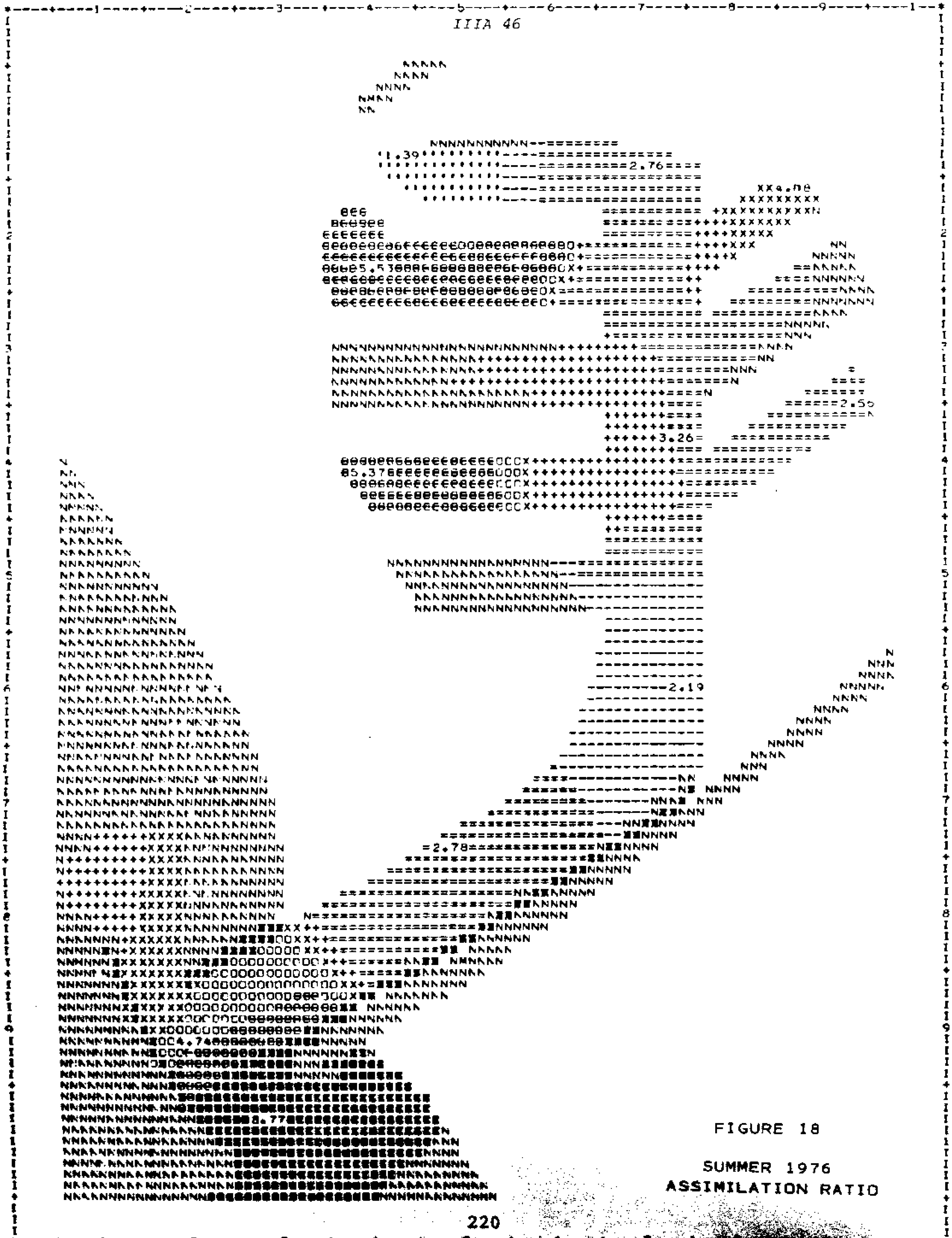


FIGURE 18

SUMMER 1976
ASSIMILATION RATIO

FIGURE 19 LEGEND

ASSIMILATION RATIO
SUMMER 1977

DATA VALUE EXTREMES ARE 3.46 13.18

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOC7OOOO	8888@8888	■■■■9■■■■	■■■■*■■■■
FREQ.	0	0	0	0	1	1	1	1	6	1

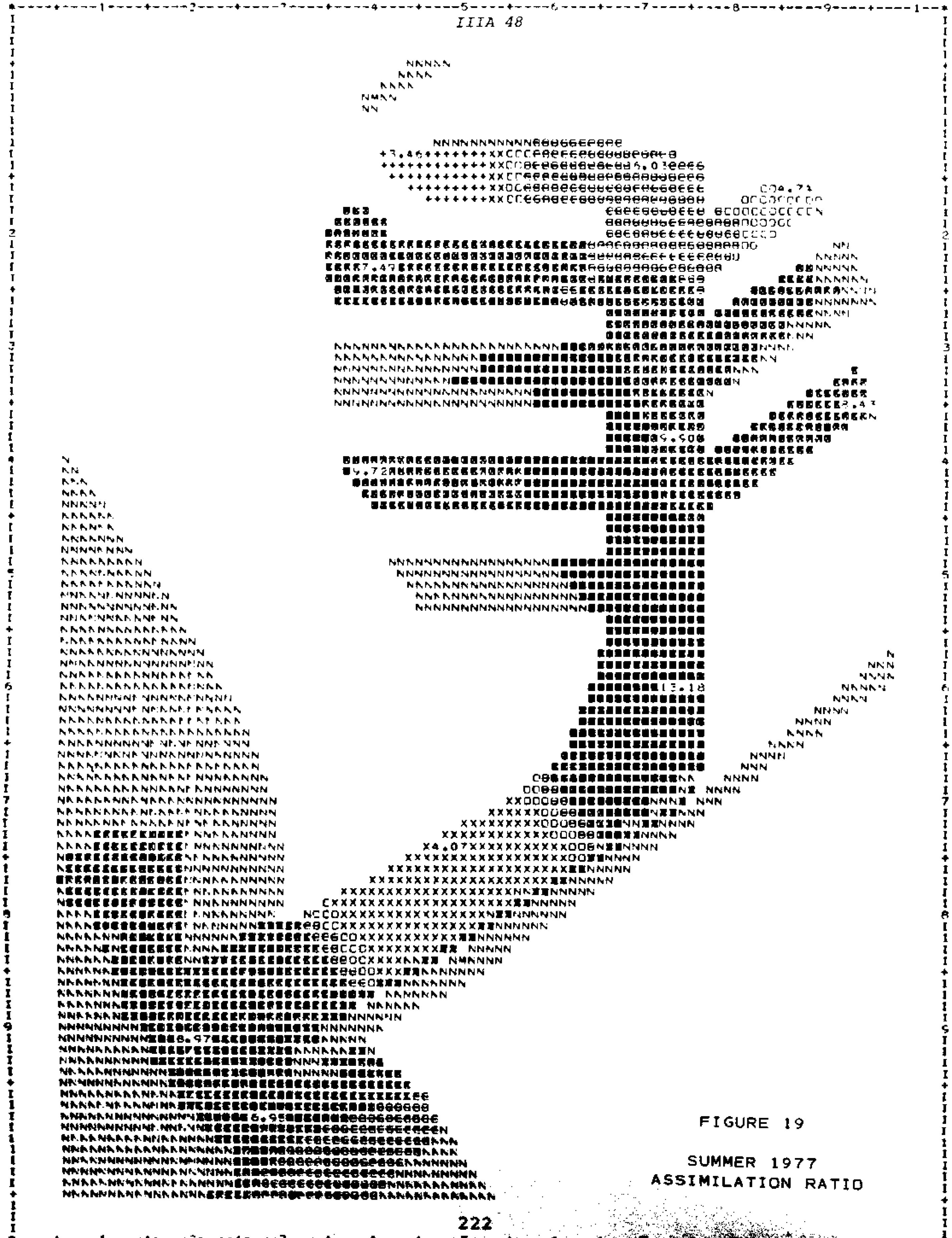


FIGURE 19

SUMMER 1977
ASSIMILATION RATIO

FIGURE 20 LEGEND

ASSIMILATION RATIO
SUMMER 1978

DATA VALUE EXTREMES ARE 1.20 3.64

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.65	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL       1          2          3          4          5          6          7          8          9          10
        ==========================================================================================================
         .........  ''''''''' ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
         .........  ''''''''' ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
SYMBOLS  ....1....  ''''2'''' ----3----  ====4====  ++++5++++  XXXX6XXXX  OOOO7OOOO  @@@@8@@@@  @@@@9@@@@  @@@@*@@@@
         .........  ''''''''' ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
         .........  ''''''''' ---------  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  @@@@@@@@@  @@@@@@@@@
        ==========================================================================================================
FREQ.       0          4          3          2          2          0          0          0          0          0
     1              I''2''I    I--3--I    I==4==I    I++5++I
     2              I''2''I    I--3--I    I==4==I    I++5++I
     3              I''2''I    I--3--I
     4              I''2''I
```

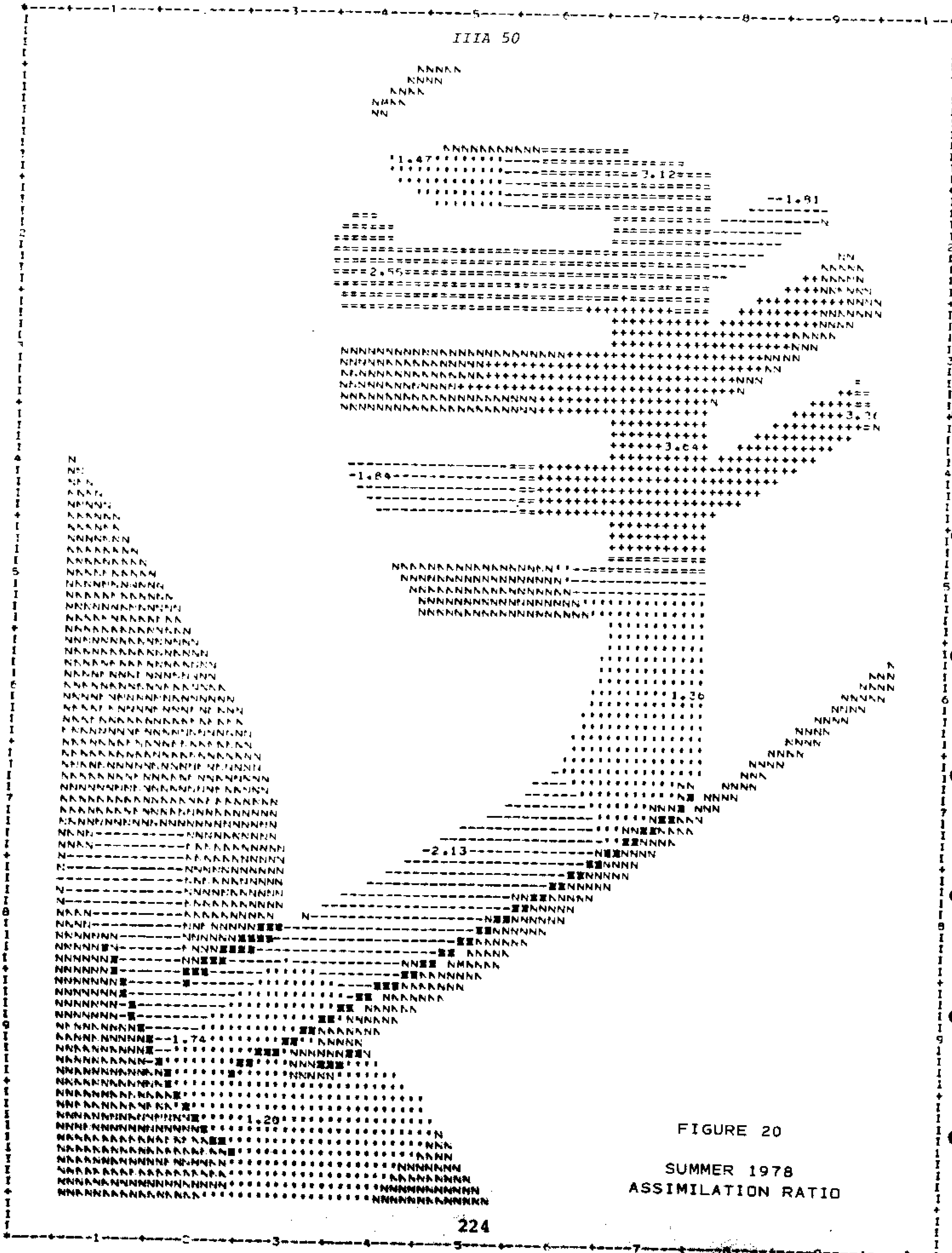


FIGURE 20

SUMMER 1978
ASSIMILATION RATIO

FIGURE 21 LEGEND

ASSIMILATION RATIO
SUMMER 1979

DATA VALUE EXTREMES ARE 3.19 13.42

TOTAL MISSING DATA POINTS IS 2

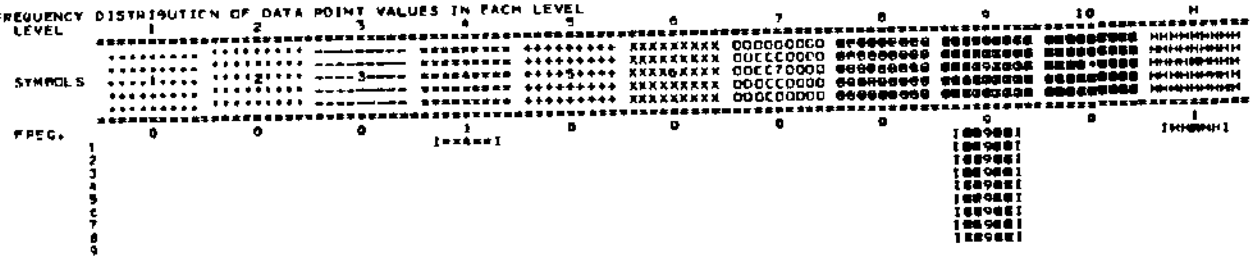
ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9	10	
MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	ABOVE 13.18
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18	

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1	2	3	4	5	6	7	8	9	10
3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL



LEVEL	1	2	3	4	5	6	7	8	9	10	H
FREQ.	0	0	0	1	0	0	0	0	9	0	1

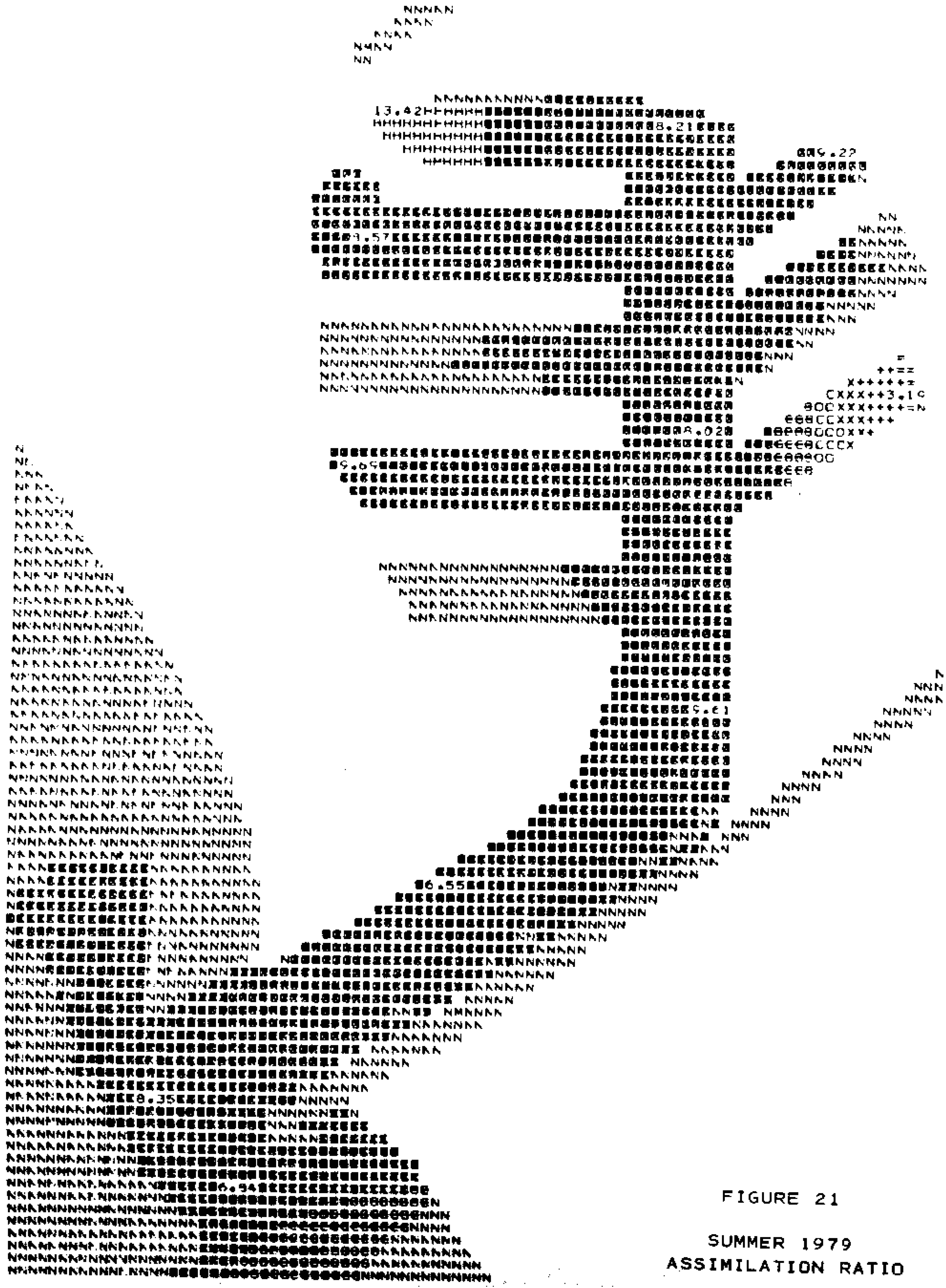


FIGURE 21

SUMMER 1979
ASSIMILATION RATIO

FIGURE 22 LEGEND

PRODUCTIVITY
AUTUMN 1976

DATA VALUE EXTREMES ARE 9.01 27.62

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.35	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	40.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
FREQ.	0	0	0	0	0	2	3	4	2

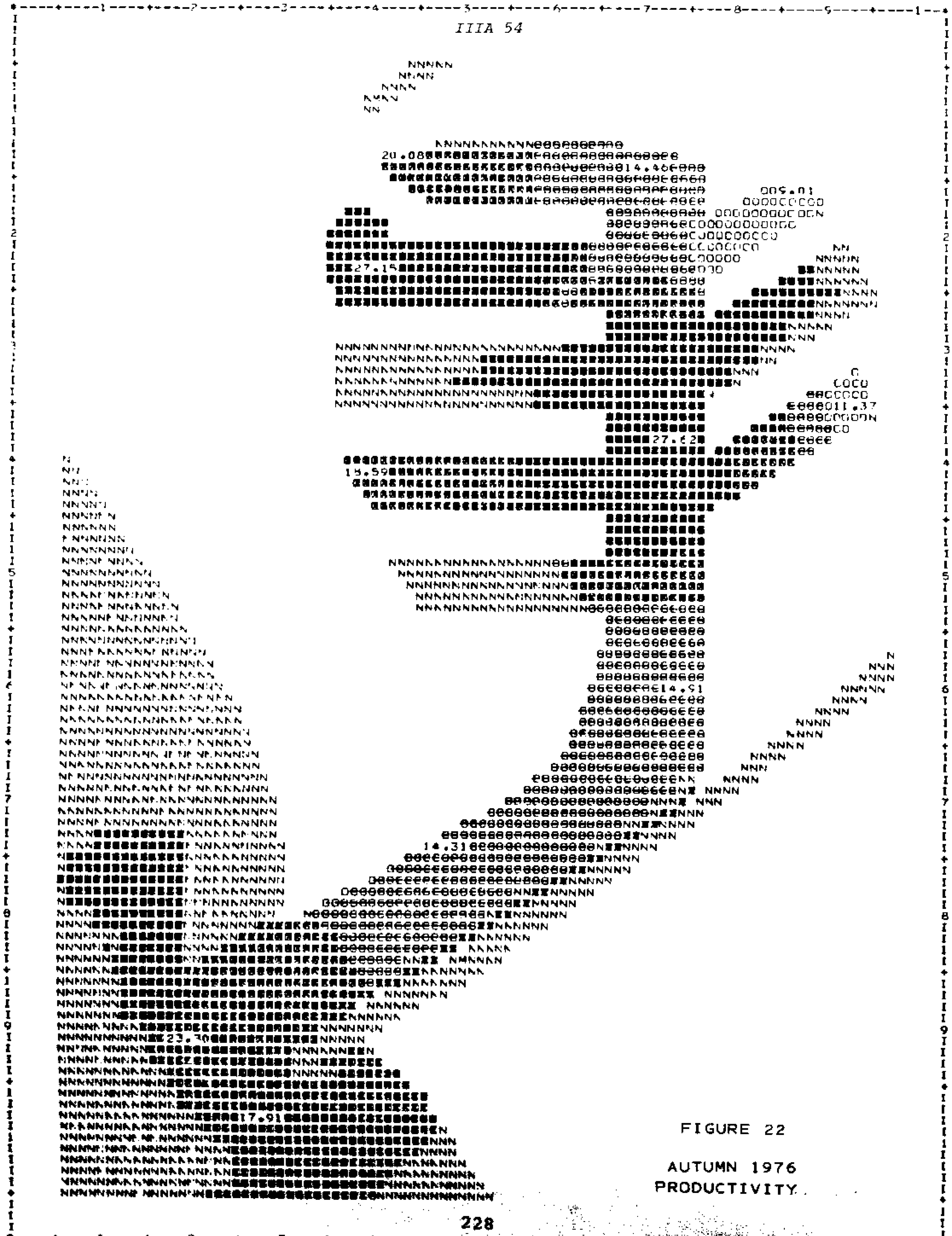


FIGURE 22

AUTUMN 1976
PRODUCTIVITY

FIGURE 23 LEGEND

PRODUCTIVITY
AUTUMN 1977

DATA VALUE EXTREMES ARE 2.71 5.93

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	9.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	9.00	13.00	16.00	24.00	45.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
 LEVEL       1          2          3          4          5          6          7          8          9
          ==========================================================================================
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
 SYMBOLS  ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  ####8####  ####9####
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
          ==========================================================================================
 FREQ.       0          0          5          5          0          1          0          0          0
        1                       I==3==I    I++4++I               IOO6OOI
        2                       I==3==I    I++4++I
        3                       I==3==I    I++4++I
        4                       I==3==I    I++4++I
        5                       I==3==I    I++4++I
```

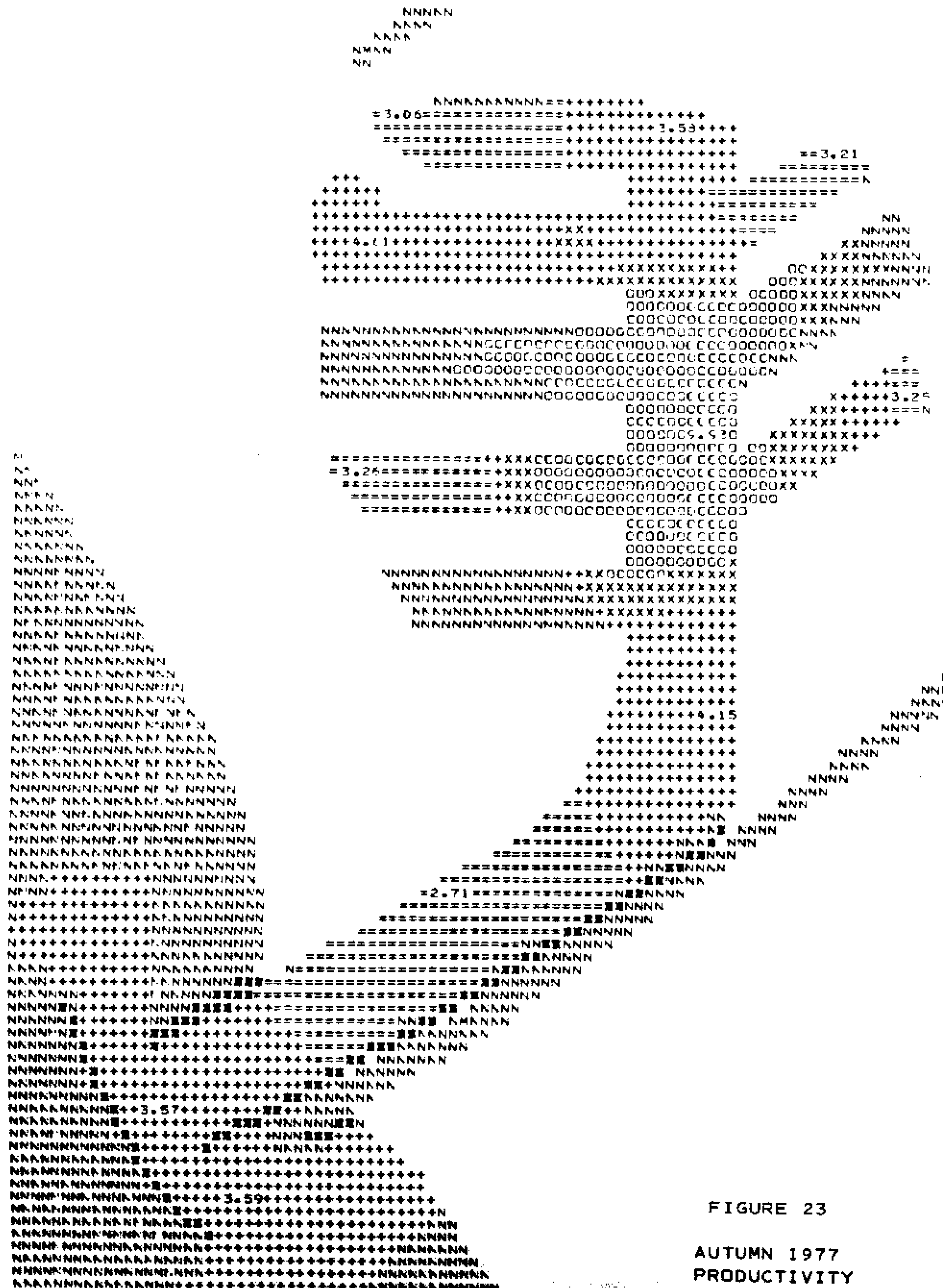


FIGURE 23

AUTUMN 1977
PRODUCTIVITY

FIGURE 24 LEGEND

PRODUCTIVITY
AUTUMN 1978

DATA VALUE EXTREMES ARE 3.40 12.01

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	45.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	████8████	████9████
FREQ.	0	0	1	2	2	6	0	0	0

```
      FREQ.
  1           I==3==I  I+++++I  IXX5XXI  IOO6OOI
  2                    I+++++I  IXX5XXI  IOO6OOI
  3                                      IOO6OOI
  4                                      IOO6OOI
  5                                      IOO6OOI
  6                                      IOO6OOI
```

IIIA 58

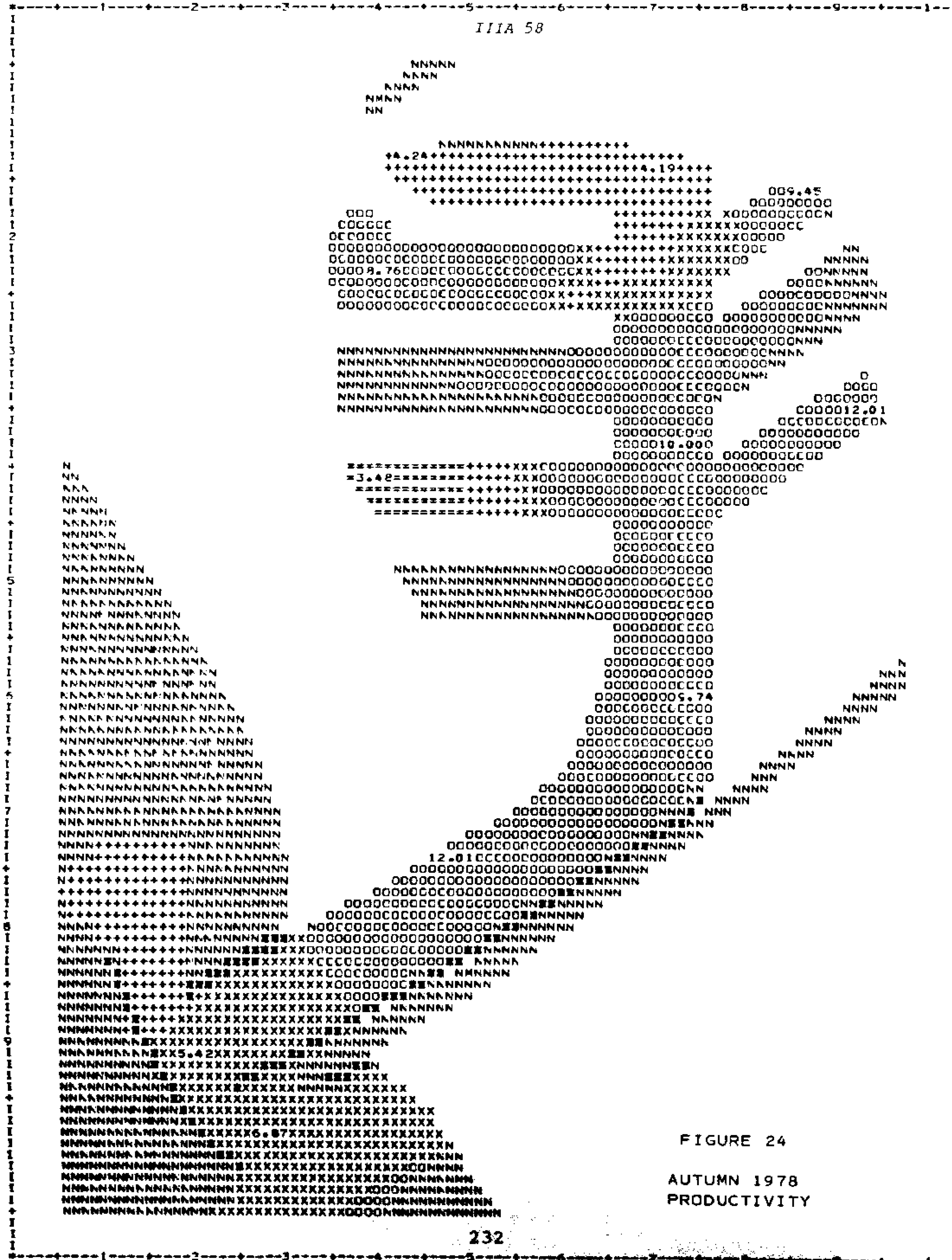


FIGURE 24

AUTUMN 1978
PRODUCTIVITY

FIGURE 25 LEGEND

CHLOROPHYLL A
AUTUMN 1976

DATA VALUE EXTREMES ARE 1.80 11.57

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
          ******************************************************************************************
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
SYMBOLS   ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  ■■■■8■■■■  ■■■■9■■■■
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
          .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  ■■■■■■■■■  ■■■■■■■■■
          .........
          ******************************************************************************************
FREQ.        0          0          0          1          0          1          2          6          1
      1                                 I+++4++I              IOO6OOI   I@@7@@I    I■■8■■I    I■■9■■I
      2                                                                 I@@7@@I    I■■8■■I
      3                                                                            I■■8■■I
      4                                                                            I■■8■■I
      5                                                                            I■■8■■I
      6                                                                            I■■8■■I
```

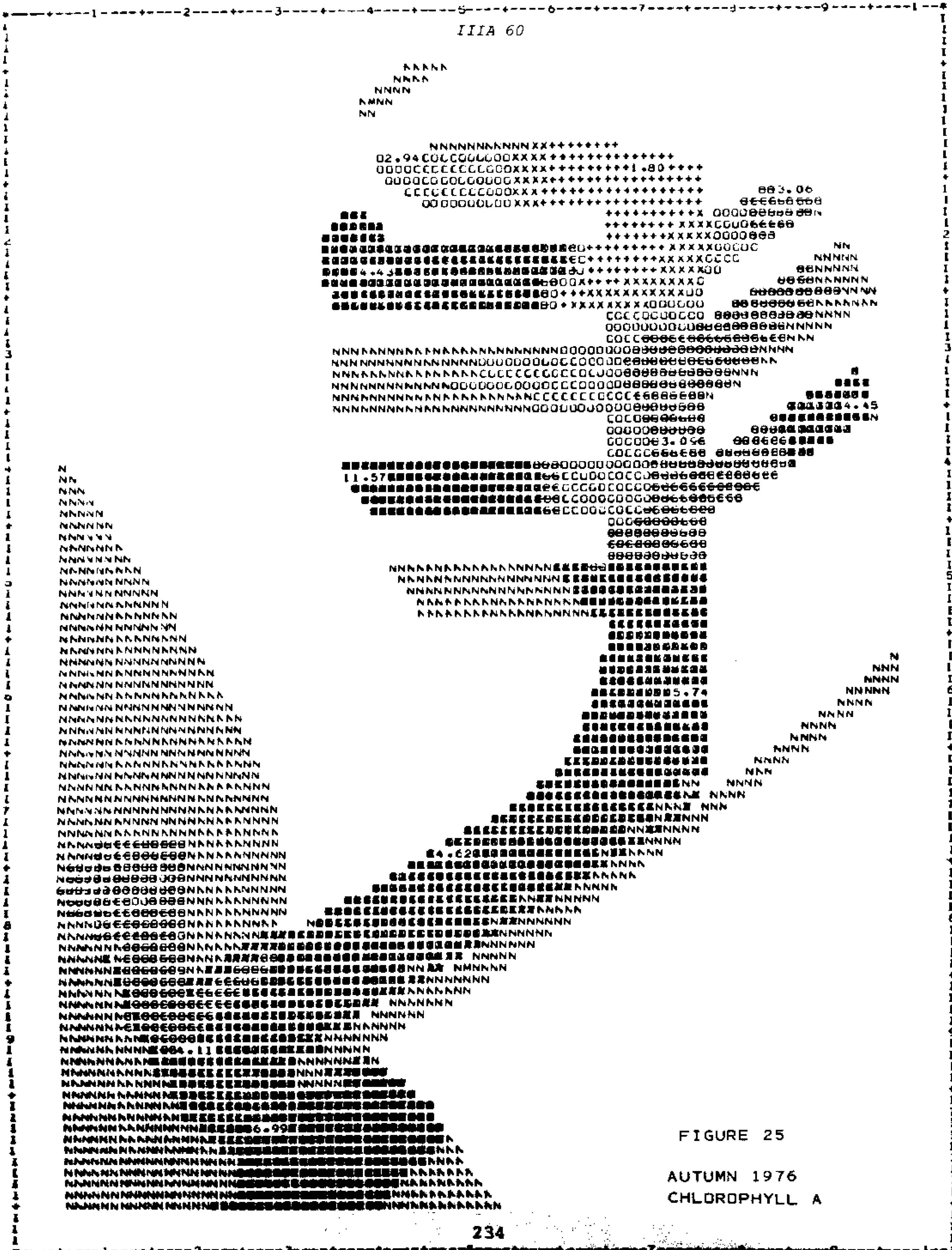


FIGURE 25

AUTUMN 1976
CHLOROPHYLL A

FIGURE 26 LEGEND

CHLOROPHYLL A
AUTUMN 1977

DATA VALUE EXTREMES ARE 0.47 3.31

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.30
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
         ***************************************************************************************************
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  CCOOCCCCC  000000000  #########  #########
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  CCOCOOCCO  000000000  #########  #########
SYMBOLS  ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  CCOC6OOOO  00007000O  ####8####  ####9####
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  CCOOOOOCO  000000000  #########  #########
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  CCOOOOOCO  000000000  #########  #########
         ***************************************************************************************************
FREQ.        0          7          3          0          0          0          1          0          0
    1               I''2''I    I==3==I                                      I0070OI
    2               I''2''I    I==3==I
    3               I''2''I    I==3==I
    4               I''2''I
    5               I''2''I
    6               I''2''I
    7               I''2''I
```

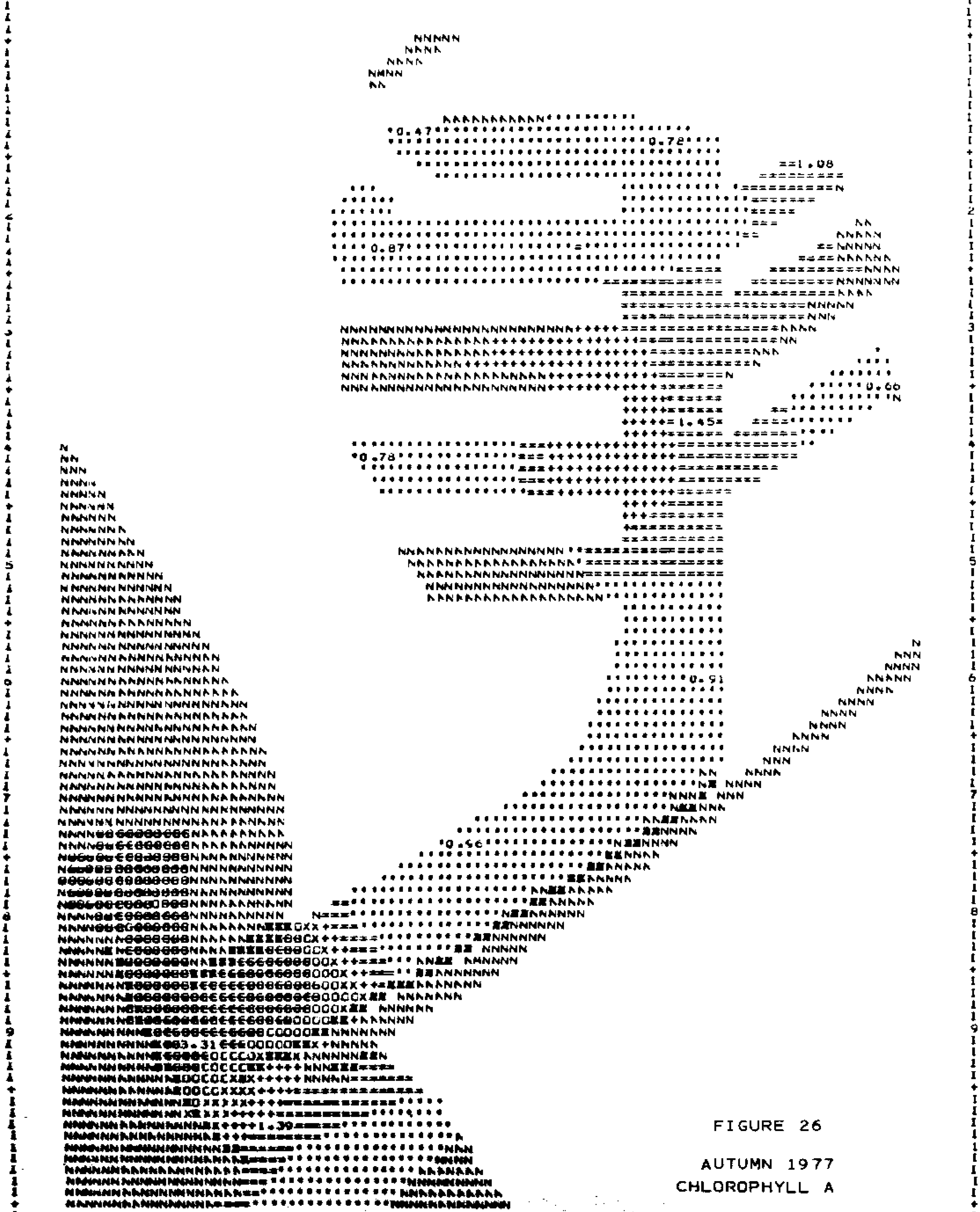


FIGURE 26

AUTUMN 1977
CHLOROPHYLL A

FIGURE 27 LEGEND

CHLOROPHYLL A
AUTUMN 1978

DATA VALUE EXTREMES ARE 0.97 2.91

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL         1          2          3          4          5          6          7          8          9
        ==========================================================================================
          .........  +++++++++  =========  +++++++++  XXXXXXXXX  CCCCCCCCC  @@@@@@@@@  IIIIIIIII  #########
          .........  +++++++++  =========  +++++++++  XXXXXXXXX  CCCCCCCCC  @@@@@@@@@  IIIIIIIII  #########
SYMBOLS   ....1....  ++++2++++  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  IIII8IIII  ####9####
          .........  +++++++++  =========  +++++++++  XXXXXXXXX  CCCCCCCCC  @@@@@@@@@  IIIIIIIII  #########
          .........  +++++++++  =========  +++++++++  XXXXXXXXX  OCCOCOOOO  @@@@@@@@@  IIIIIIIII  #########
          .........
        ==========================================================================================
FREQ.         0          1          1          3          3          3          0          0          0
      1               I++2++I    I==3==I    I++4++I    IXX5XXI    IOO6OOI
      2                                     I++4++I    IXX5XXI    IOO6CCI
      3                                     I++4++I    IXX5XXI    IOO6COI
```

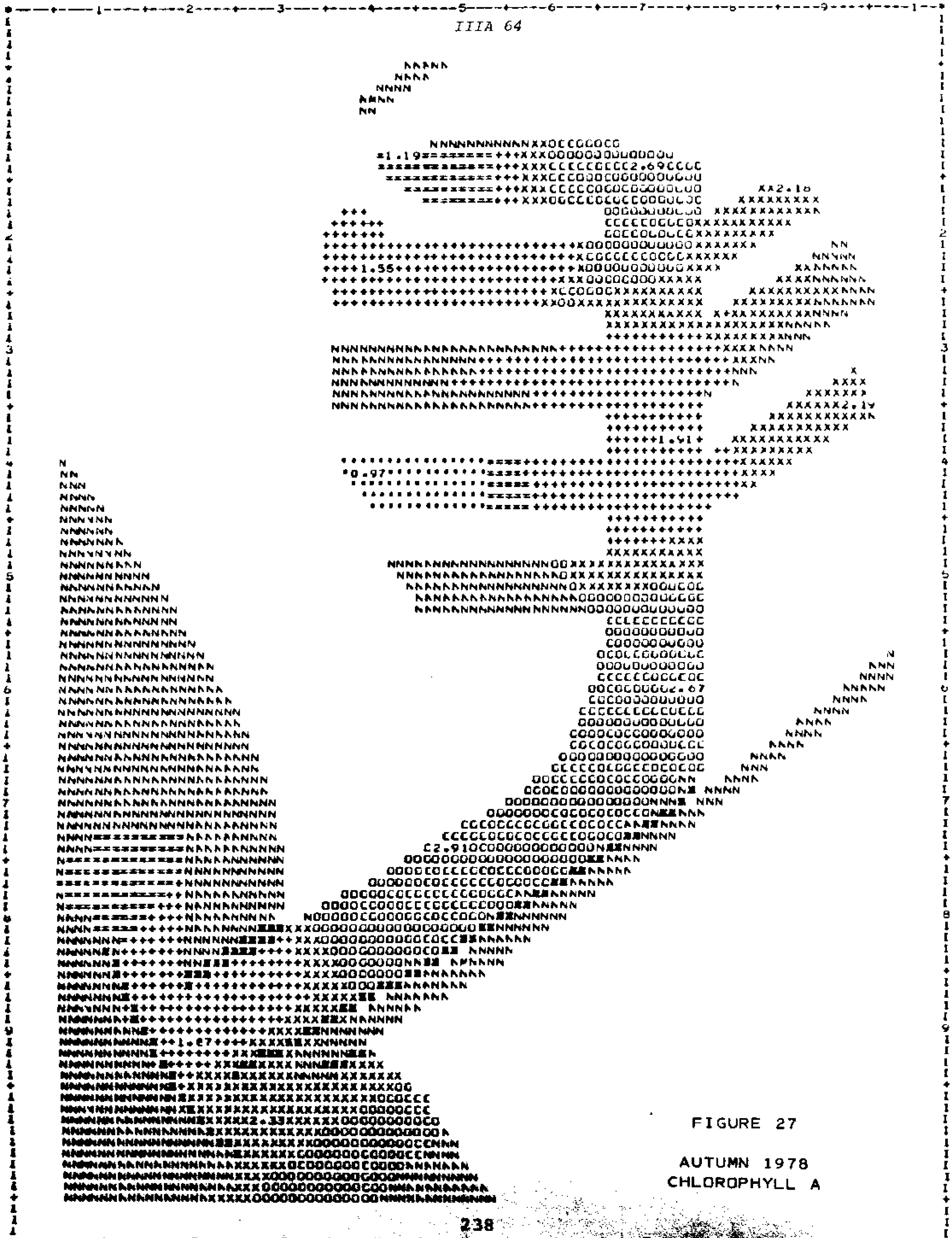


FIGURE 27

AUTUMN 1978
CHLOROPHYLL A

FIGURE 28 LEGEND

ASSIMILATION RATIO
AUTUMN 1976

DATA VALUE EXTREMES ARE 3.05 11.72

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	@@@@8@@@@	####9####	####*####
FREQ.	0	0	0	2	1	1	2	1	1	3
1				I==4==I	I++5++I	IXX6XXI	IOO7OOI	I@@8@@I	I##9##I	I##*##I
2				I==4==I			IOO7OOI			I##*##I
3										I##*##I

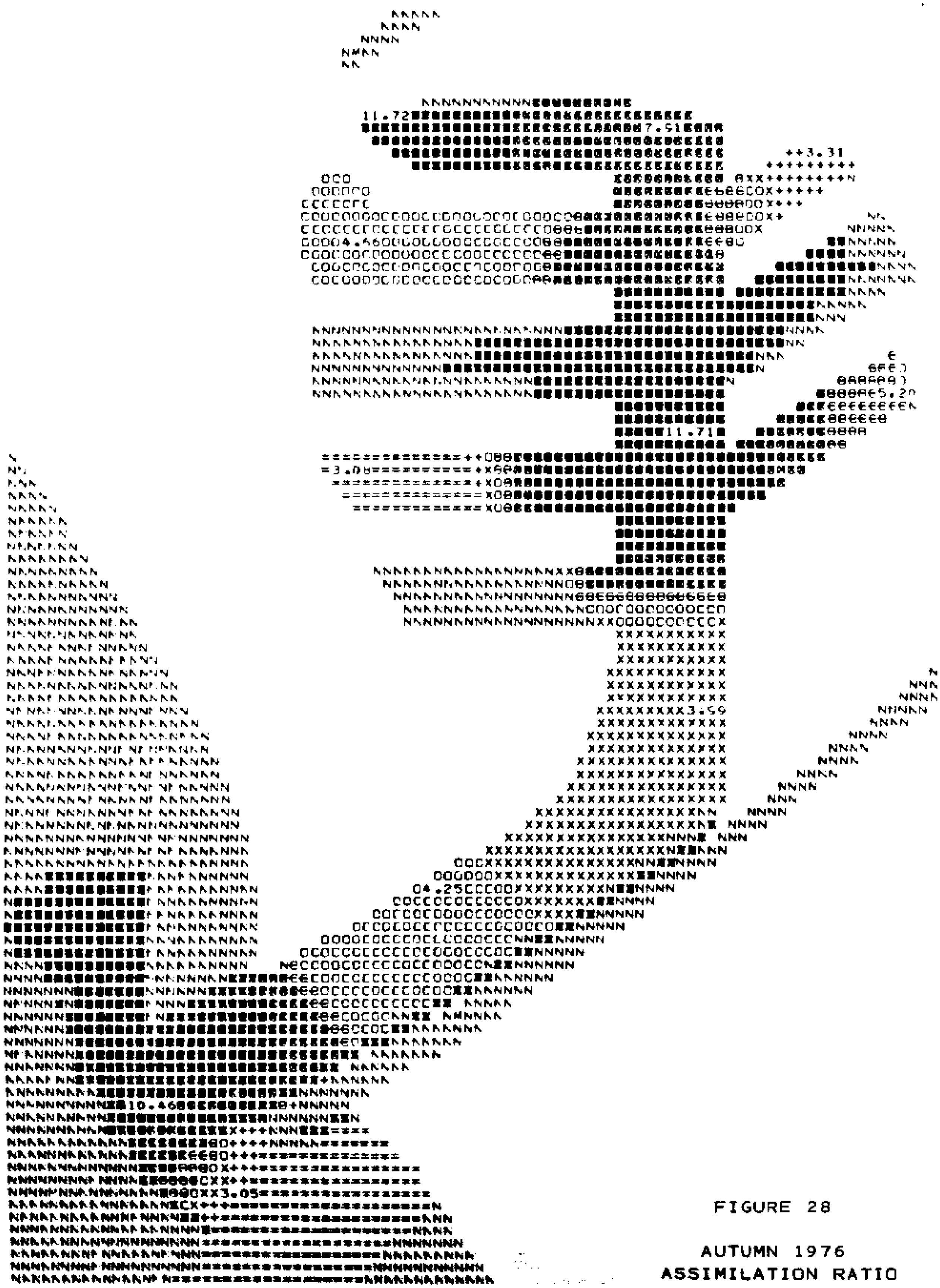


FIGURE 28

AUTUMN 1976
ASSIMILATION RATIO

FIGURE 29 LEGEND

ASSIMILATION RATIO
AUTUMN 1977

DATA VALUE EXTREMES ARE 1.09 6.16

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9	10
MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	1	2	3	4	5	6	7	8	9	10
	3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	1	2	3	4	5	6	7	8	9	10
FREQ.	0	1	1	0	0	1	3	5	0	0

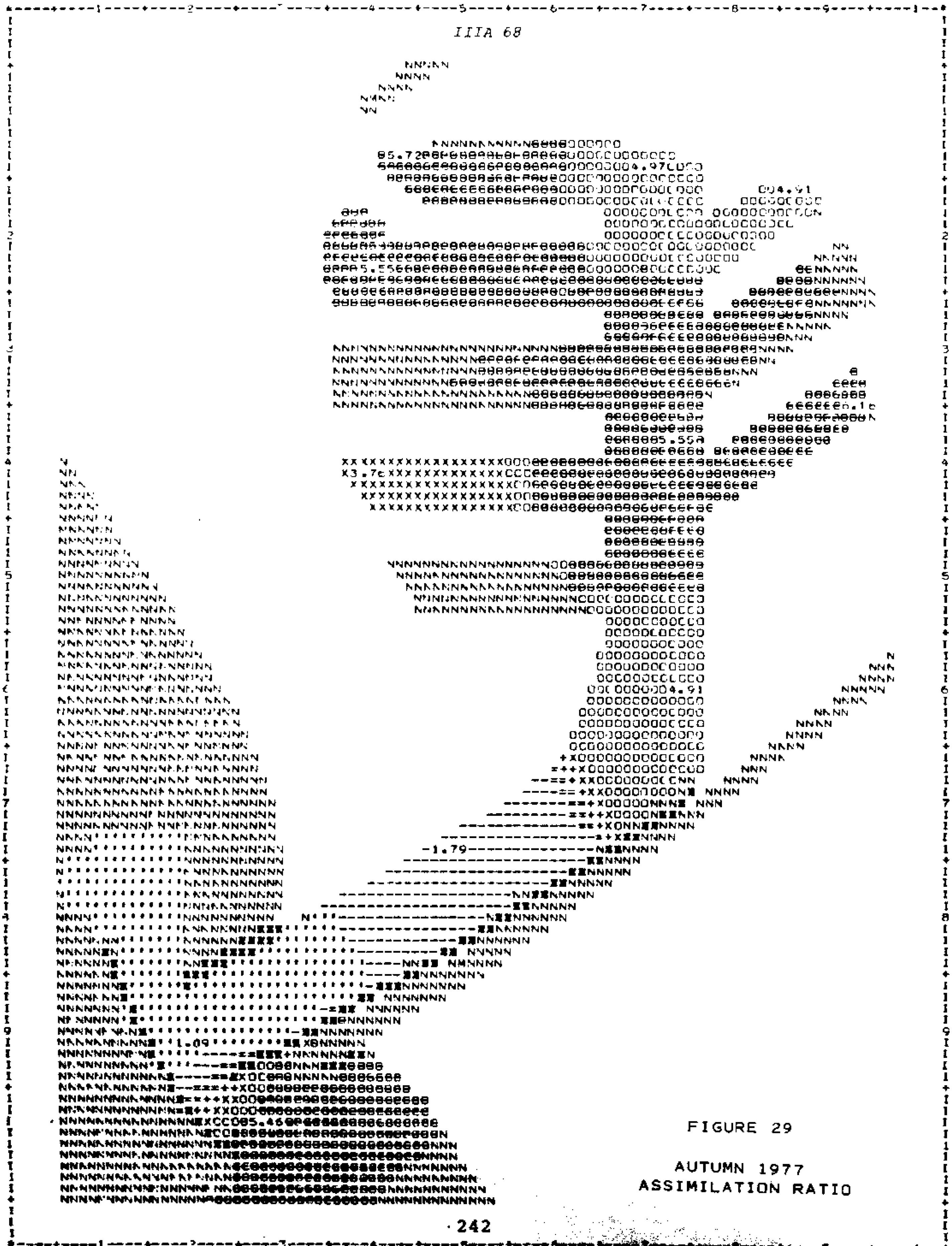


FIGURE 29

AUTUMN 1977
ASSIMILATION RATIO

FIGURE 30 LEGEND

ASSIMILATION RATIO
AUTUMN 1978

DATA VALUE EXTREMES ARE 2.30 5.05

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.10

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	@@@@8@@@@	[illegible]	[illegible]
FREQ.	0	0	1	2	2	3	1	2	0	0
1			I--3--I	I==4==I	I++5++I	IXX6XXI	IOO7OOI	I@@8@@I		
2				I==4==I	I++5++I	IXX6XXI		I@@8@@I		
3						IXX6XXI				

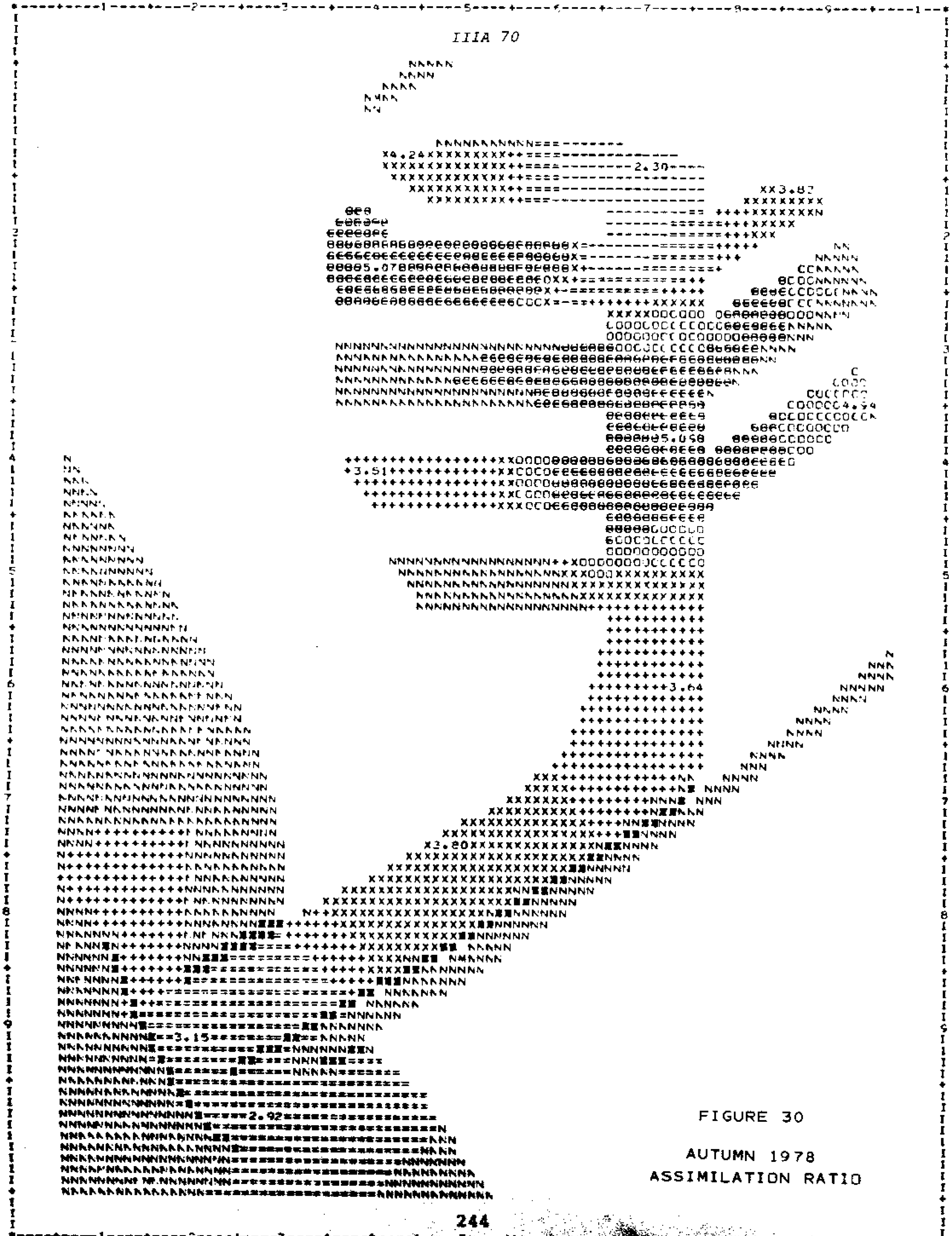


FIGURE 30

AUTUMN 1978
ASSIMILATION RATIO

FIGURE 31 LEGEND

PRODUCTIVITY
WINTER 1976-1977

DATA VALUE EXTREMES ARE 2.34 12.99

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1          2          3          4          5          6          7          8          9
         ==========================================================================================
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
SYMBOLS  ....1....  ''''2''''  ====3====  ++++4++++  XXXX5XXXX  OOOO6OOOO  @@@@7@@@@  ####8####  ####9####
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         .........  '''''''''  =========  +++++++++  XXXXXXXXX  OOOOOOOOO  @@@@@@@@@  #########  #########
         ==========================================================================================
FREQ.        3          0          2          1          4          4          0          0          0
     1                          I==3==I    I++4++I    IXX5XXI    IOO6OOI
     2                          I==3==I               IXX5XXI    IOO6OOI
     3                                                IXX5XXI    IOO6OOI
     4                                                IXX5XXI    IOO6OOI
```

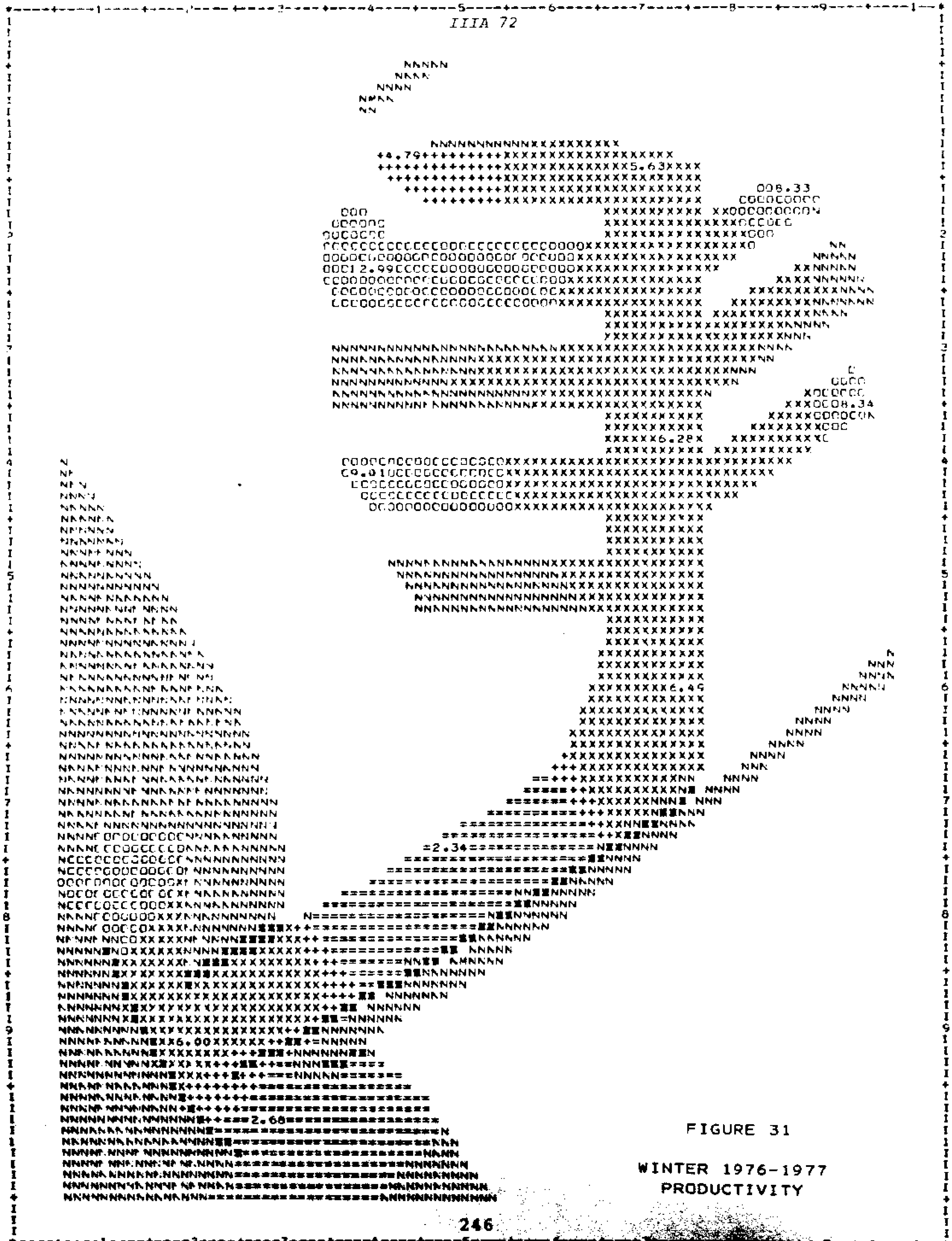


FIGURE 31

WINTER 1976-1977
PRODUCTIVITY

FIGURE 32 LEGEND

PRODUCTIVITY
WINTER 1977-1978

DATA VALUE EXTREMES ARE 0.85 1.37

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

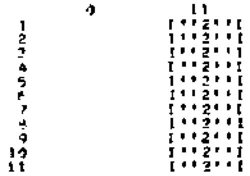
MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	1	2	3	4	5	6	7	8	9
FREQ.	0	11	0	0	0	0	0	0	0



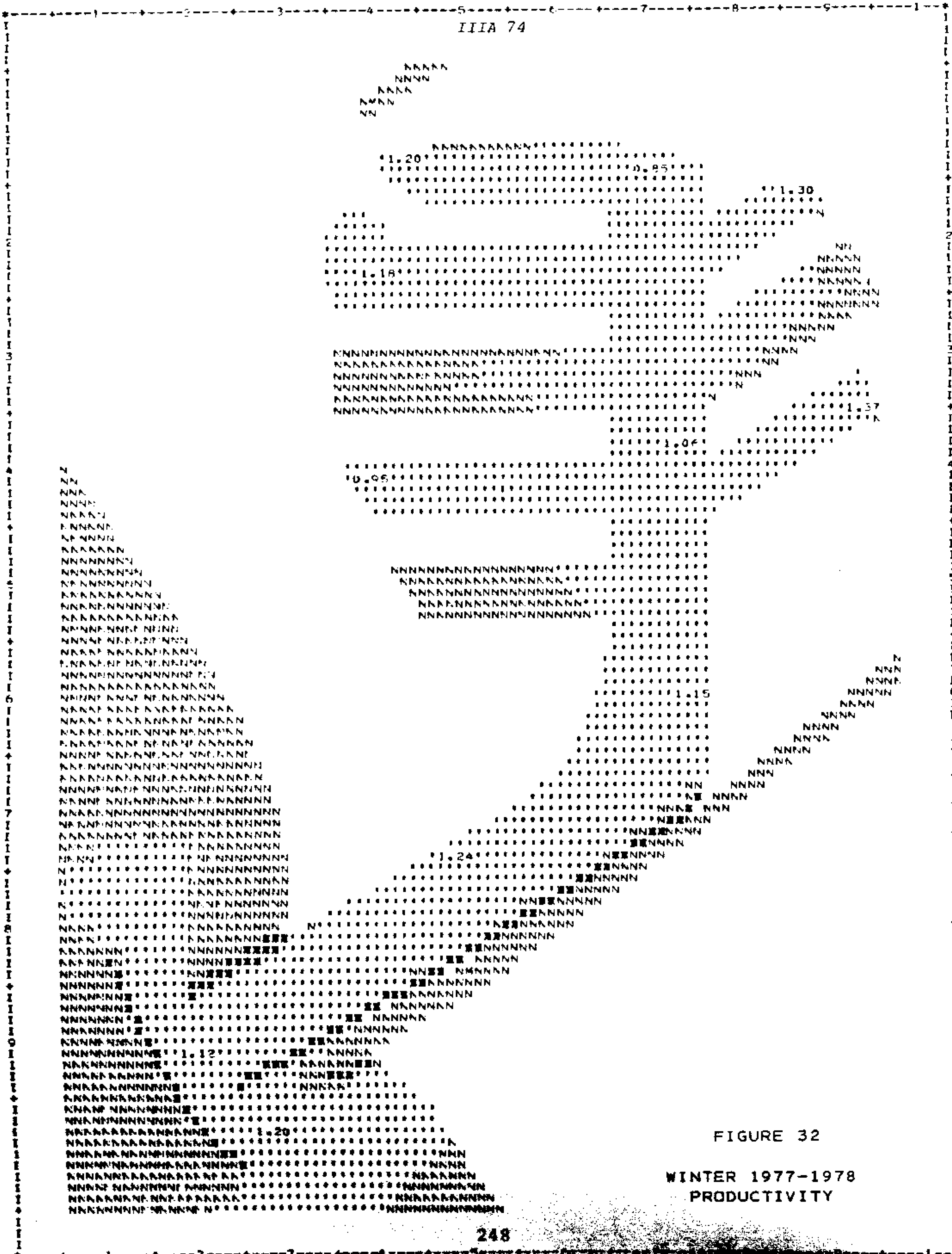


FIGURE 32

WINTER 1977-1978
PRODUCTIVITY

FIGURE 33 LEGEND

PRODUCTIVITY
WINTER 1978-1979

DATA VALUE EXTREMES ARE 1.12 2.92

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	@@@@7@@@@	▮▮▮▮8▮▮▮▮	▮▮▮▮9▮▮▮▮
FREQ.	0	8	3	0	0	0	0	0	0

```
      1   [''2'']  [==3==]
      2   [''2'']  [==3==]
      3   [''2'']  [==3==]
      4   [''2'']
      5   [''2'']
      6   [''2'']
      7   [''2'']
      8   [''2'']
```

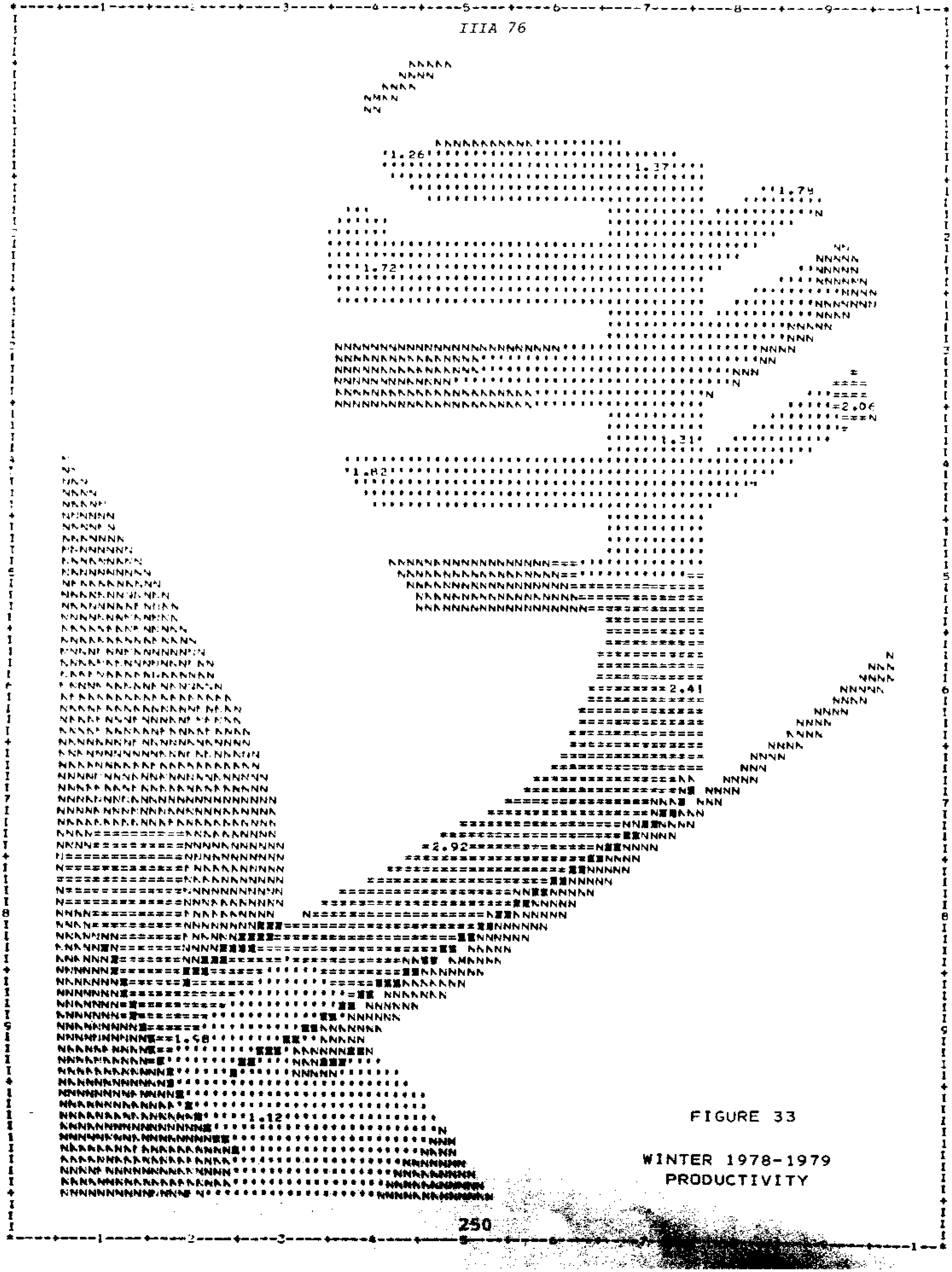


FIGURE 33

WINTER 1978-1979
PRODUCTIVITY

FIGURE 34 LEGEND

CHLOROPHYLL A
WINTER 1976-1977

DATA VALUE EXTREMES ARE 1.32 2.74

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	0000700000	[illegible]	[illegible]
FREQ.	0	0	2	2	4	3	0	0	0
1			I==3==I	I++4++I	IXX5XXI	IOO6OOI			
2			I==3==I	I++4++I	IXX5XXI	IOO6OOI			
3					IXX5XXI	IOO6OOI			
4					IXX5XXI				

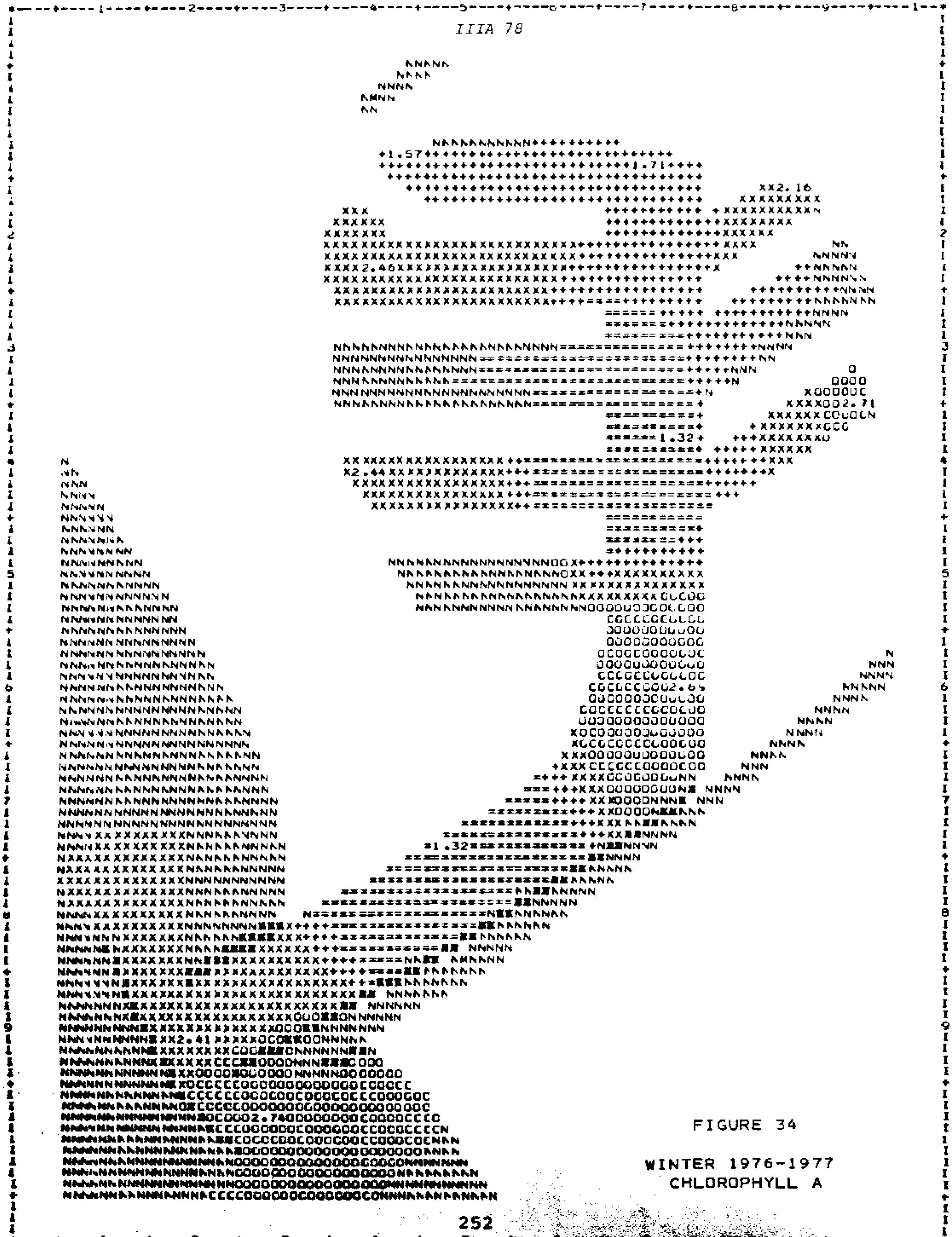


FIGURE 34

WINTER 1976-1977
CHLOROPHYLL A

FIGURE 35 LEGEND

CHLOROPHYLL A
WINTER 1977-1978

DATA VALUE EXTREMES ARE 0.50 1.15

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	[illegible]	[illegible]
FREQ.	0	9	2	0	0	0	0	0	0

```
       1   I''2''I   I==3==I
       2   I''2''I   I==3==I
       3   I''2''I
       4   I''2''I
       5   I''2''I
       6   I''2''I
       7   I''2''I
       8   I''2''I
       9   I''2''I
```

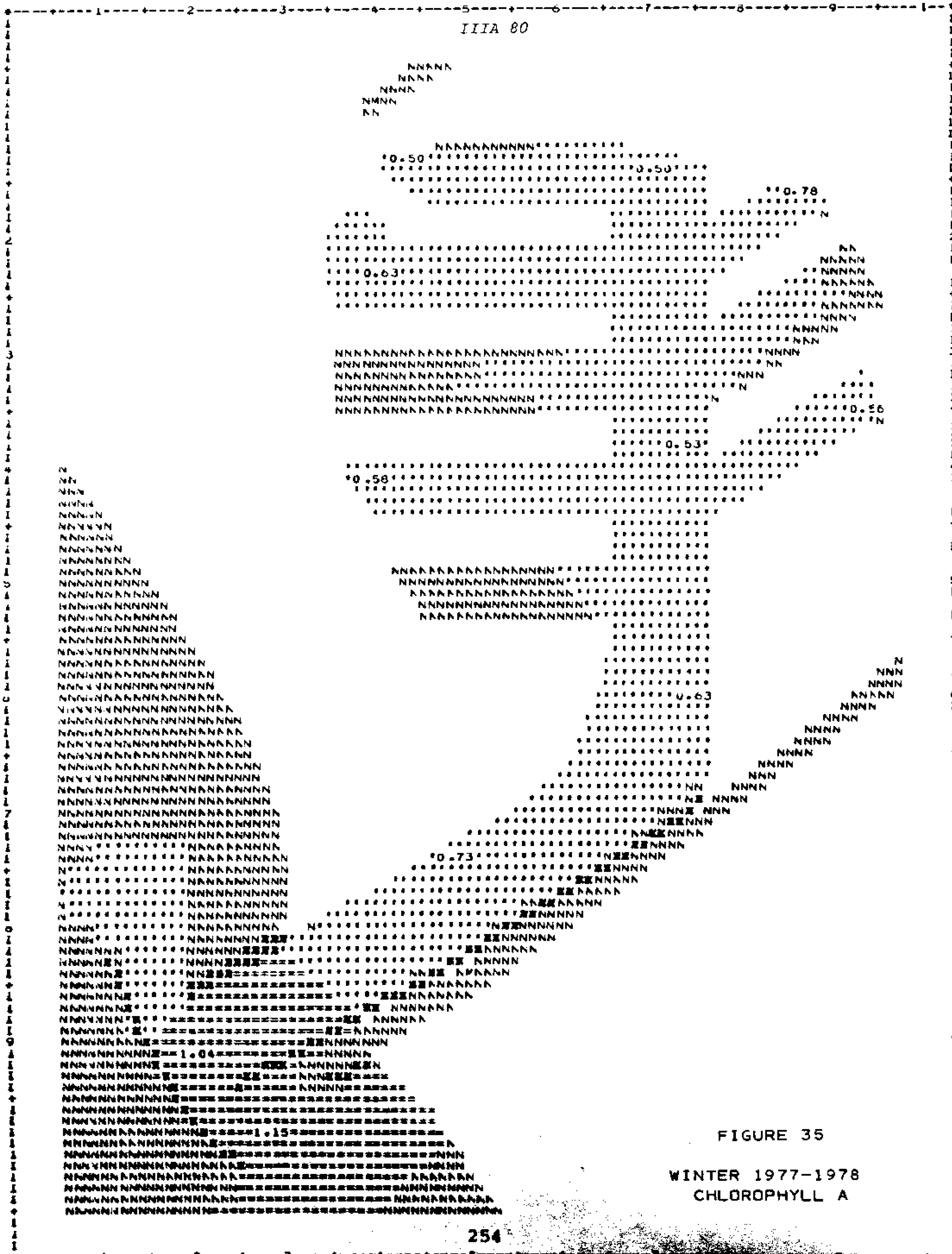


FIGURE 35

WINTER 1977-1978
CHLOROPHYLL A

FIGURE 36 LEGEND

CHLOROPHYLL A
WINTER 1978-1979

DATA VALUE EXTREMES ARE 0.93 1.98

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	. . . 1 . . .	' ' ' 2 ' ' '	= = = 3 = = =	+ + + + + + + + +	XXXX5XXXX	CCCC6CCCC	[illegible]	[illegible]	[illegible]
FREQ.	0	2	5	4	0	0	0	0	0

```
FREQ.
 1          I''2''I   I==3==I   I+++4++I
 2          I''2''I   I==3==I   I+++4++I
 3                    I==3==I   I+++4++I
 4                    I==3==I   I+++4++I
 5                    I==3==I
```

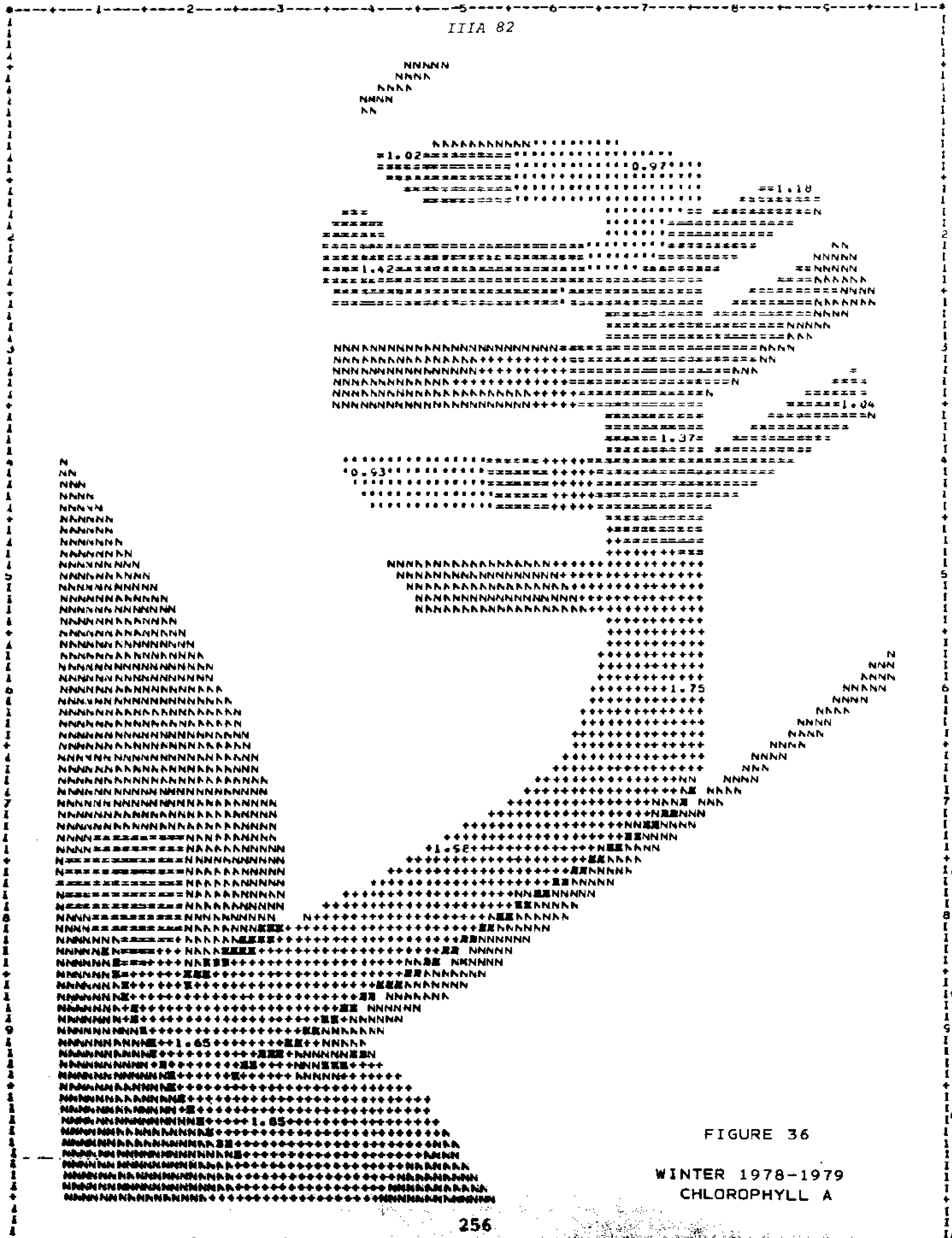


FIGURE 36

WINTER 1978-1979
CHLOROPHYLL A

FIGURE 37 LEGEND

ASSIMILATION RATIO
WINTER 1976-1977

DATA VALUE EXTREMES ARE 1.17 6.52

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.55	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOC7OOOO	0000000000	■■■■9■■■■	■■■■■■■■■
FREQ.	0	1	2	1	2	2	1	1	1	0
1		I''2''I	I--3--I	I==4==I	I++5++I	IXX6XXI	ICC7CCI	I88888I	I■■9■■I	
2			I--3--I		I++5++I	IXX6XXI				

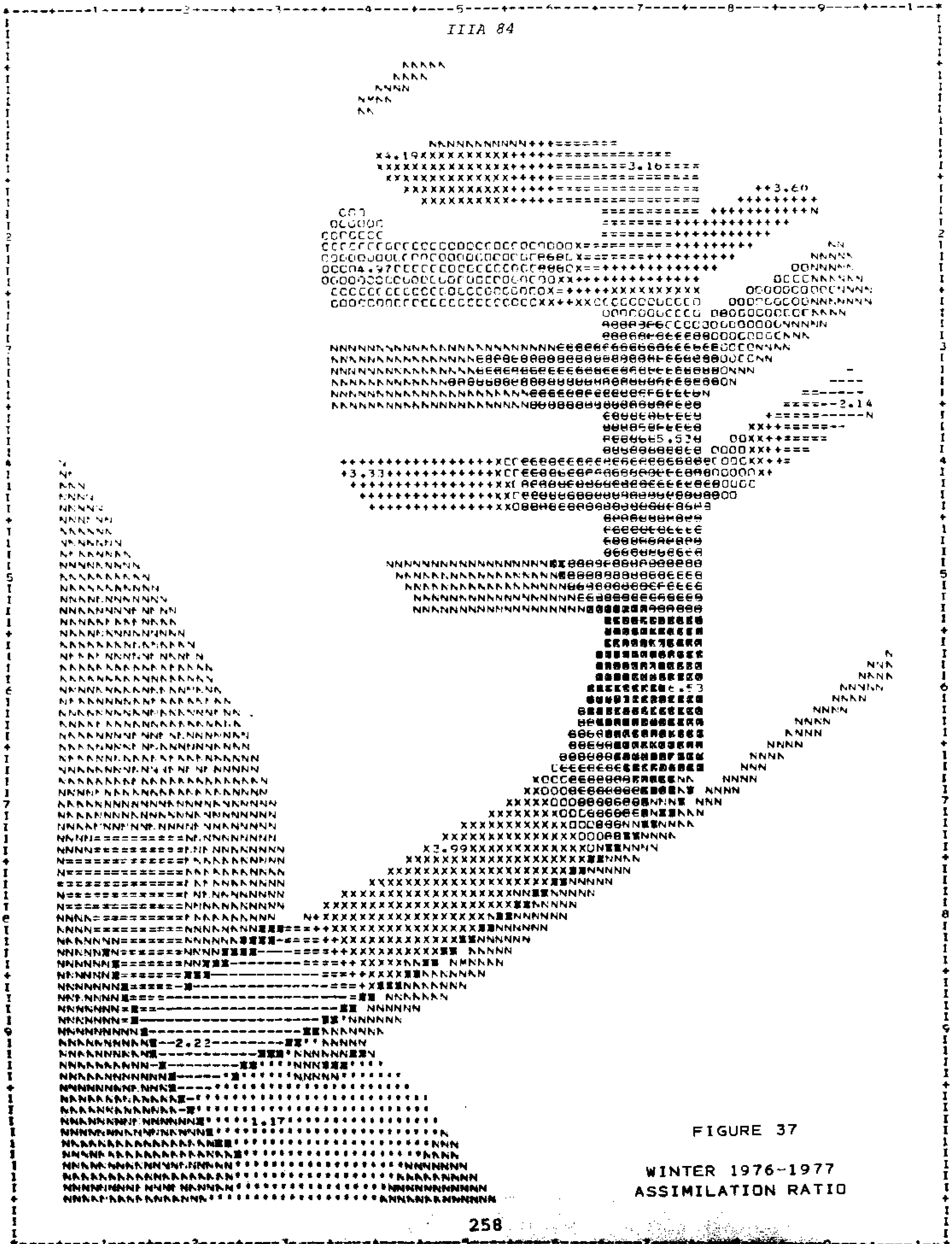


FIGURE 37

WINTER 1976-1977
ASSIMILATION RATIO

FIGURE 38 LEGEND

ASSIMILATION RATIO
WINTER 1977-1978

DATA VALUE EXTREMES ARE 1.23 4.24

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.16

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.55	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	····1····	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	88888888	■■■■9■■■■	■■■■·■■■■
FREQ.	0	2	3	4	0	2	0	0	0	0

```
FREQ.
 1          I''2''I   I--3--I   I==4==I          IXX6XXI
 2          I''2''I   I--3--I   I==4==I          IXX6XXI
 3                    I--3--I   I==4==I
 4                              I==4==I
```

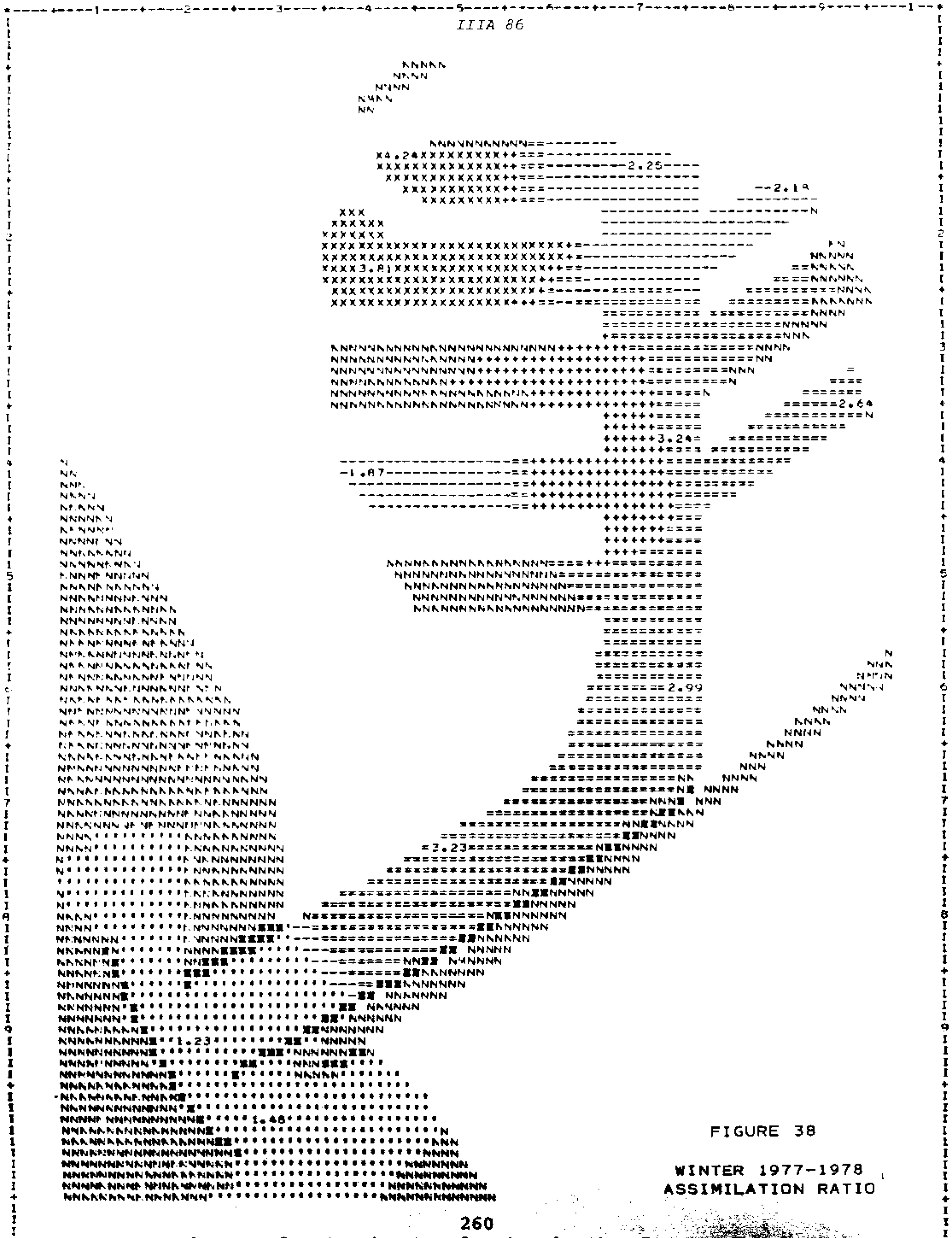


FIGURE 38

WINTER 1977-1978
ASSIMILATION RATIO

FIGURE 39 LEGEND

ASSIMILATION RATIO
WINTER 1978-1979

DATA VALUE EXTREMES ARE 0.51 2.31

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9	10
MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	1	2	3	4	5	6	7	8	9	10
	3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	.	'	-	=	+	X	O	@	[illegible]	[illegible]
FREQ.	1	6	4	0	0	0	0	0	0	0

```
FREQ.
 1   I..1..I   I''2''I   I--3--I
 2             I''2''I   I--3--I
 3             I''2''I   I--3--I
 4             I''2''I   I--3--I
 5             I''2''I
 6             I''2''I
```

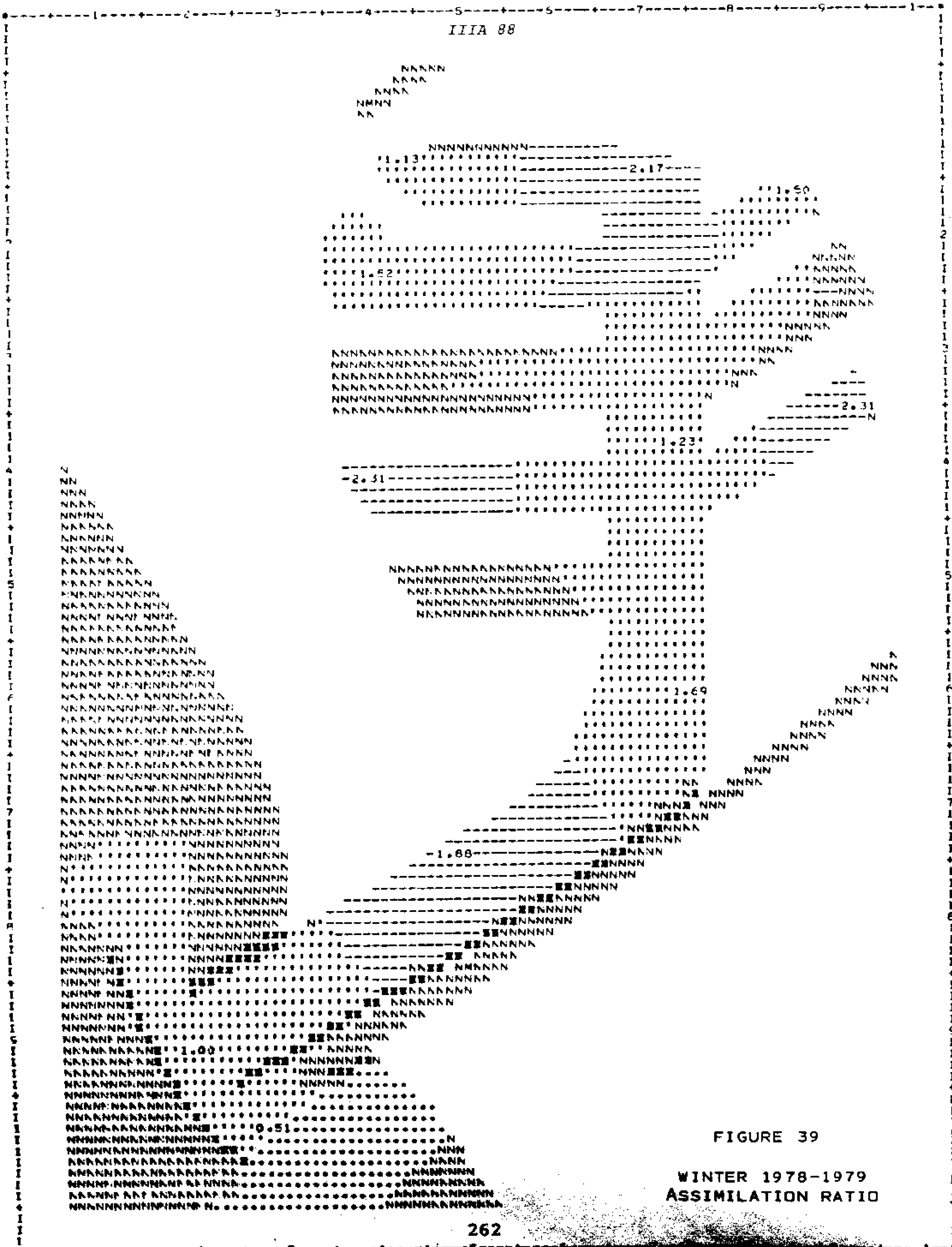


FIGURE 39

WINTER 1978-1979
ASSIMILATION RATIO

FIGURE 40 LEGEND

PRODUCTIVITY
SPRING 1977

DATA VALUE EXTREMES ARE 10.78 24.24

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	████8████	████9████
FREQ.	0	0	0	0	0	4	5	1	1

```
  1      I006OOI   I007ØØI   I008██I   I009██I
  2      I006OOI   I007ØØI
  3      I006OOI   I007ØØI
  4      I006OOI   I007ØØI
  5                I007ØØI
```

IIIA 90

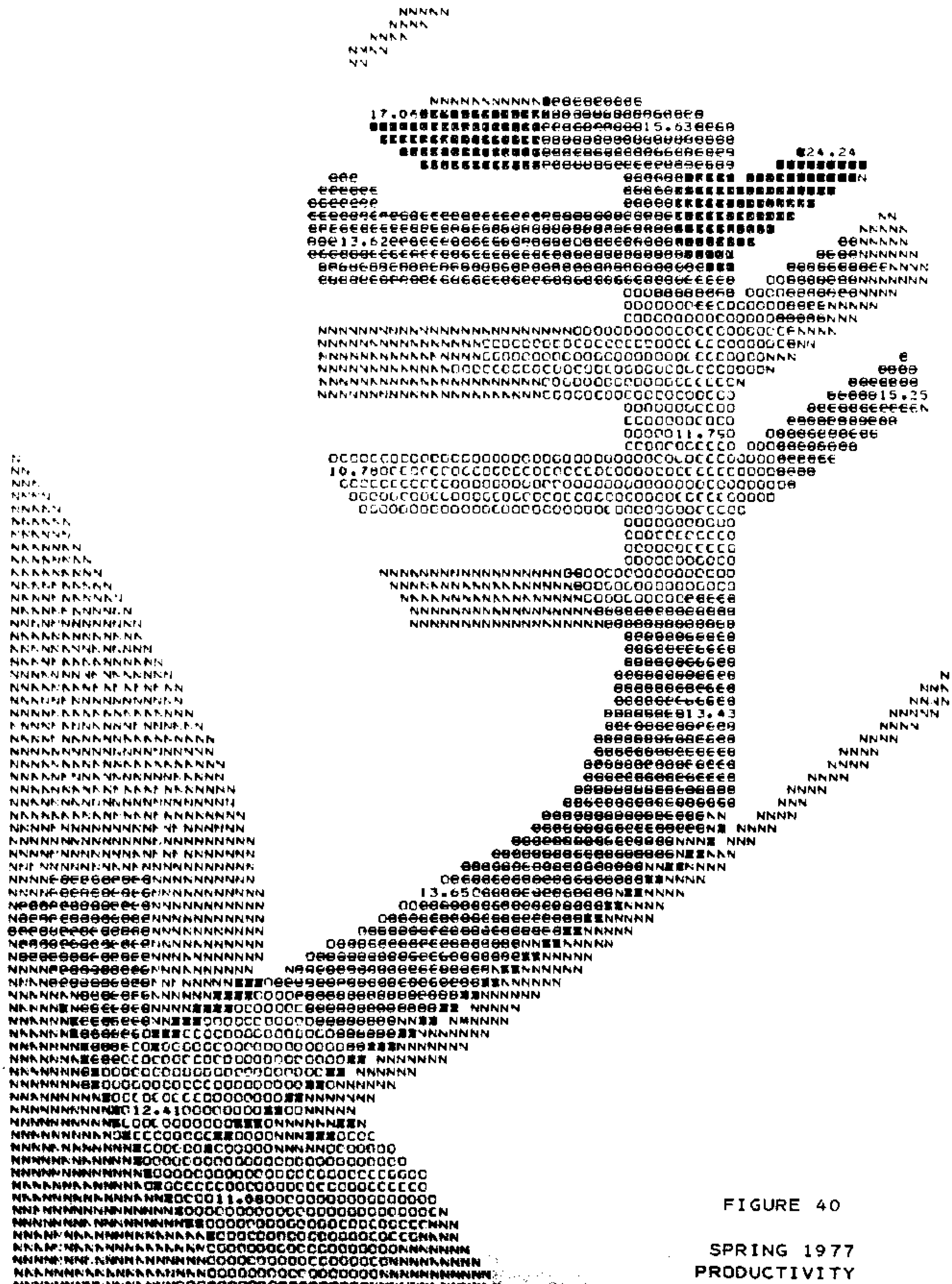


FIGURE 40

SPRING 1977
PRODUCTIVITY

FIGURE 41 LEGEND

PRODUCTIVITY
SPRING 1978

DATA VALUE EXTREMES ARE 2.26 5.31

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	8.00	13.00	16.00	24.00	46.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.15	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVEL        1         2         3         4         5         6         7         8         9
       =============================================================================================
         ......... ''''''''' ========= +++++++++ XXXXXXXXX CCCCCCCCC 666666666 ######### ▓▓▓▓▓▓▓▓▓
         ......... ''''''''' ========= +++++++++ XXXXXXXXX CCCCCCCCC 666666666 ######### ▓▓▓▓▓▓▓▓▓
SYMBOLS  ....1.... ''''2'''' ====3==== ++++4++++ XXXX5XXXX CCCC6CCCC 6666 7666 ####8#### ▓▓▓▓9▓▓▓▓
         ......... ''''''''' ========= +++++++++ XXXXXXXXX CCCCCCCCC 666666666 ######### ▓▓▓▓▓▓▓▓▓
         ......... ''''''''' ========= +++++++++ XXXXXXXXX CCCCCCCCC 666666666 ######### ▓▓▓▓▓▓▓▓▓
       =============================================================================================
FREQ.        0         0         4         5         2         0         0         0         0
     1                        I==3==I   I++4++I   IXX5XXI
     2                        I==3==I   I++4++I   IXX5XXI
     3                        I==3==I   I++4++I
     4                        I==3==I   I++4++I
     5                                  I++4++I
```

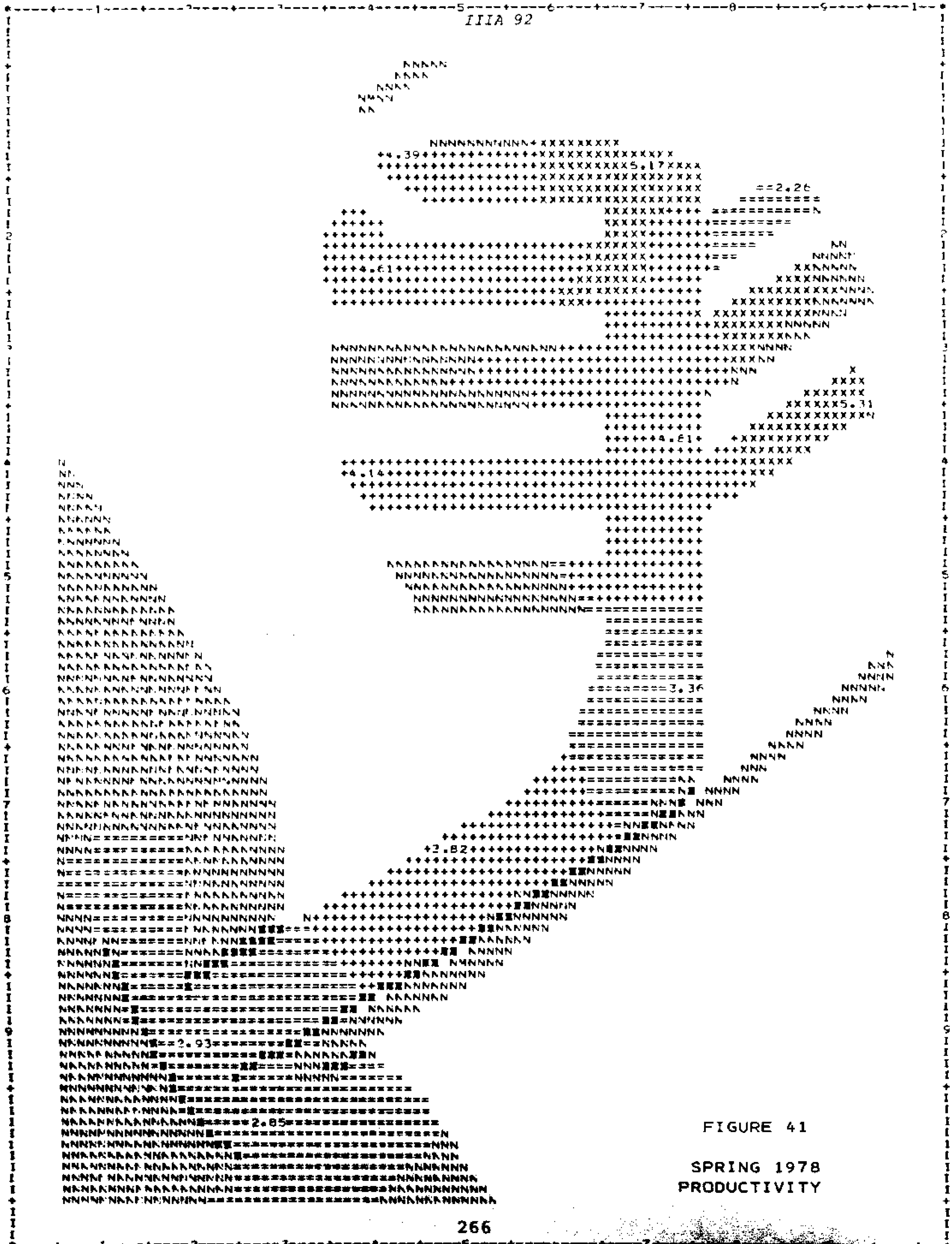


FIGURE 41

SPRING 1978
PRODUCTIVITY

FIGURE 42 LEGEND
PRODUCTIVITY
SPRING 1979

DATA VALUE EXTREMES ARE 11.48 19.00

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.85	2.00	3.50	5.00	9.00	13.00	16.00	24.00
MAXIMUM	0.85	2.00	3.50	5.00	9.00	13.00	16.00	24.00	49.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1.73	2.34	3.06	3.06	6.12	10.19	6.12	16.31	51.07

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	████████	████████
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	████████	████████
	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	ØØØØ7ØØØØ	████8████	████9████
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	████████	████████
	....	'''''''''	=========	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	████████	████████
FREQ.	0	0	0	0	0	1	5	5	0
1						IO76OOI	I667881	I██8██I	
2							I667881	I██8██I	
3							I667881	I██8██I	
4							I667881	I██9██I	
5							I667881	I██8██I	

FIGURE 42

SPRING 1979
PRODUCTIVITY

FIGURE 43 LEGEND

CHLOROPHYLL A
SPRING 1977

DATA VALUE EXTREMES ARE 1.46 5.65

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
	....	'''''''''	=========	+++++++++	XXXXXXXXX	000000000	888888888	■■■■■■■■■	■■■■■■■■■
	....	'''''''''	=========	+++++++++	XXXXXXXXX	000000000	888888888	■■■■■■■■■	■■■■■■■■■
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	000060000	888878888	■■■■8■■■■	■■■■9■■■■
	....	'''''''''	=========	+++++++++	XXXXXXXXX	000000000	888888888	■■■■■■■■■	■■■■■■■■■
	....	'''''''''	=========	+++++++++	XXXXXXXXX	000000000	888888888	■■■■■■■■■	■■■■■■■■■
FREQ.	0	0	1	0	1	3	3	3	0
1			I==3==I		IXX5XXI	I00600I	I88788I	I■■8■■I	
2						I00600I	I88788I	I■■8■■I	
3						I00600I	I88788I	I■■8■■I	

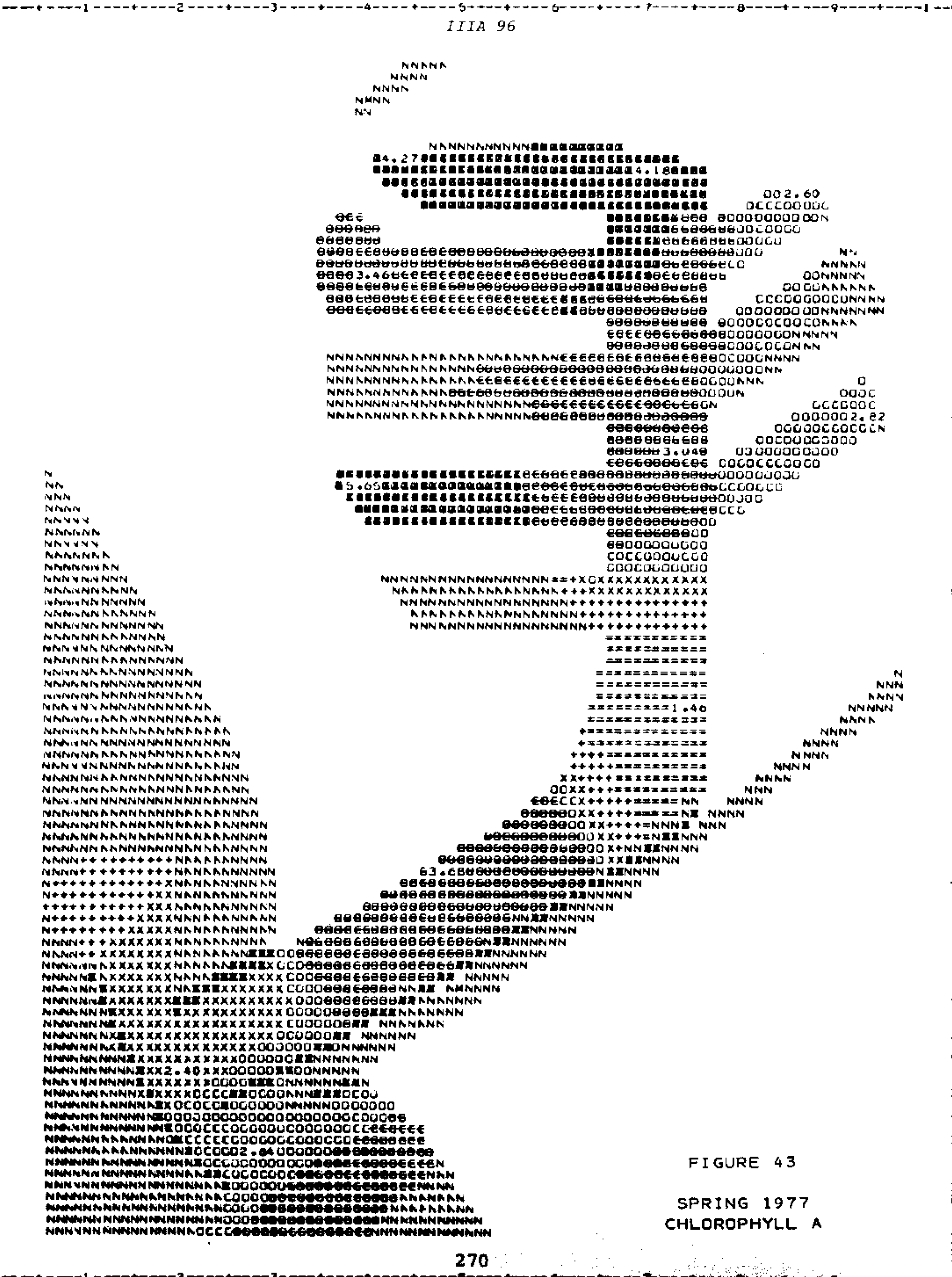


FIGURE 43

SPRING 1977
CHLOROPHYLL A

FIGURE 44 LEGEND

CHLOROPHYLL A
SPRING 1978

DATA VALUE EXTREMES ARE 1.10 2.31

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	2.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	8888788888	■■■■8■■■■	ЖЖЖЖ9ЖЖЖЖ
FREQ.	0	0	3	6	2	0	0	0	0

```
        3          6          2
    I==3==I    I+++++I    IXX5XXI
    I==3==I    I+++++I    IXX5XXI
    I==3==I    I+++++I
               I+++++I
               I+++++I
               I+++++I
```

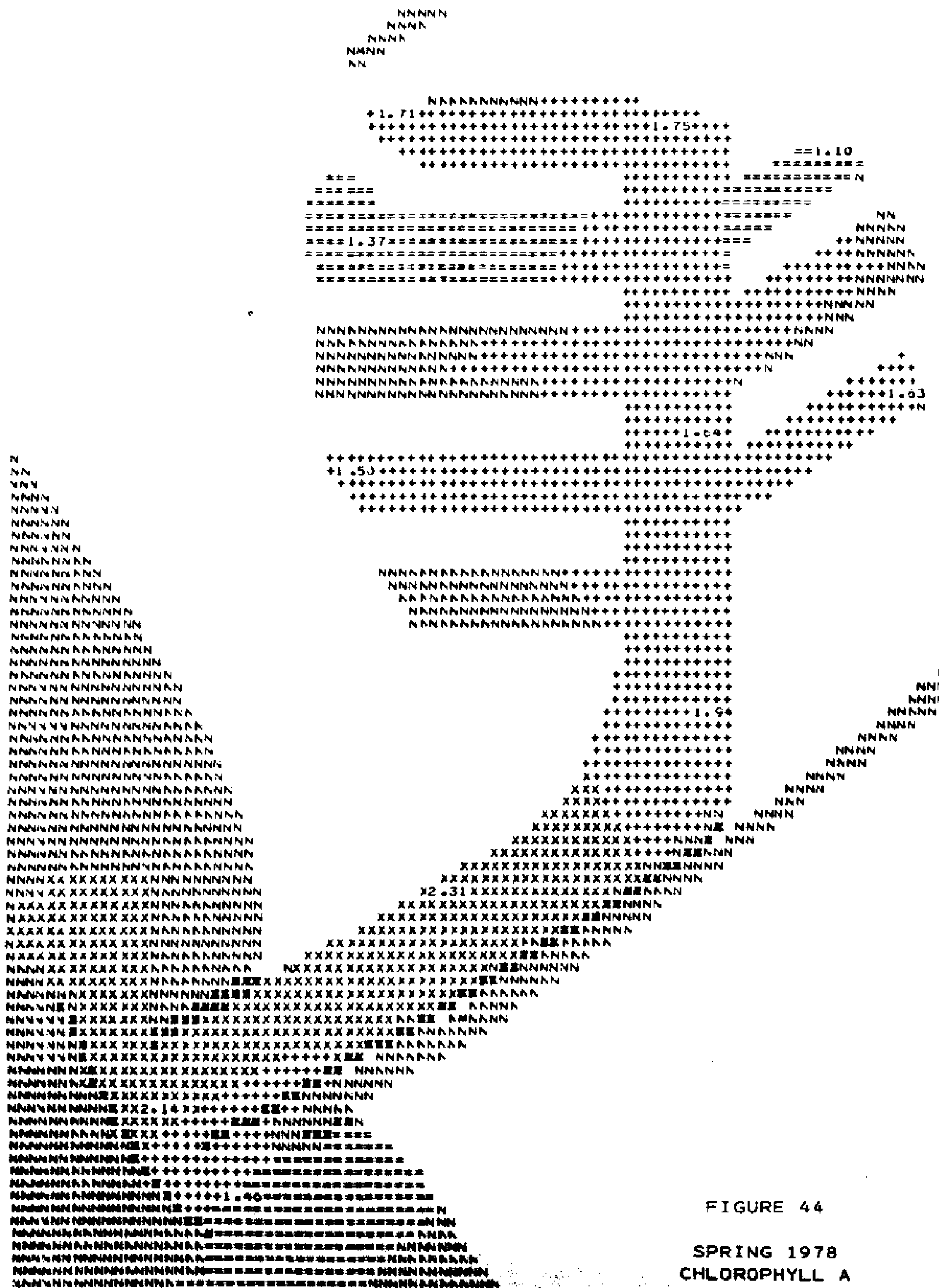


FIGURE 44

SPRING 1978
CHLOROPHYLL A

FIGURE 45 LEGEND

CHLOROPHYLL A
SPRING 1979

DATA VALUE EXTREMES ARE 2.83 5.67

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00
MAXIMUM	0.47	1.00	1.50	2.00	2.50	3.00	4.00	7.00	13.51

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.48	3.92	3.70	3.70	3.70	3.70	7.40	22.21	48.19

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9
SYMBOLS	....1....	''''2''''	====3====	++++4++++	XXXX5XXXX	OOOO6OOOO	[illegible]	[illegible]	[illegible]
FREQ.	0	0	0	0	0	1	5	5	0
1						ICC6CCI	[illegible]	[illegible]	
2							[illegible]	[illegible]	
3							[illegible]	[illegible]	
4							[illegible]	[illegible]	
5							[illegible]	[illegible]	

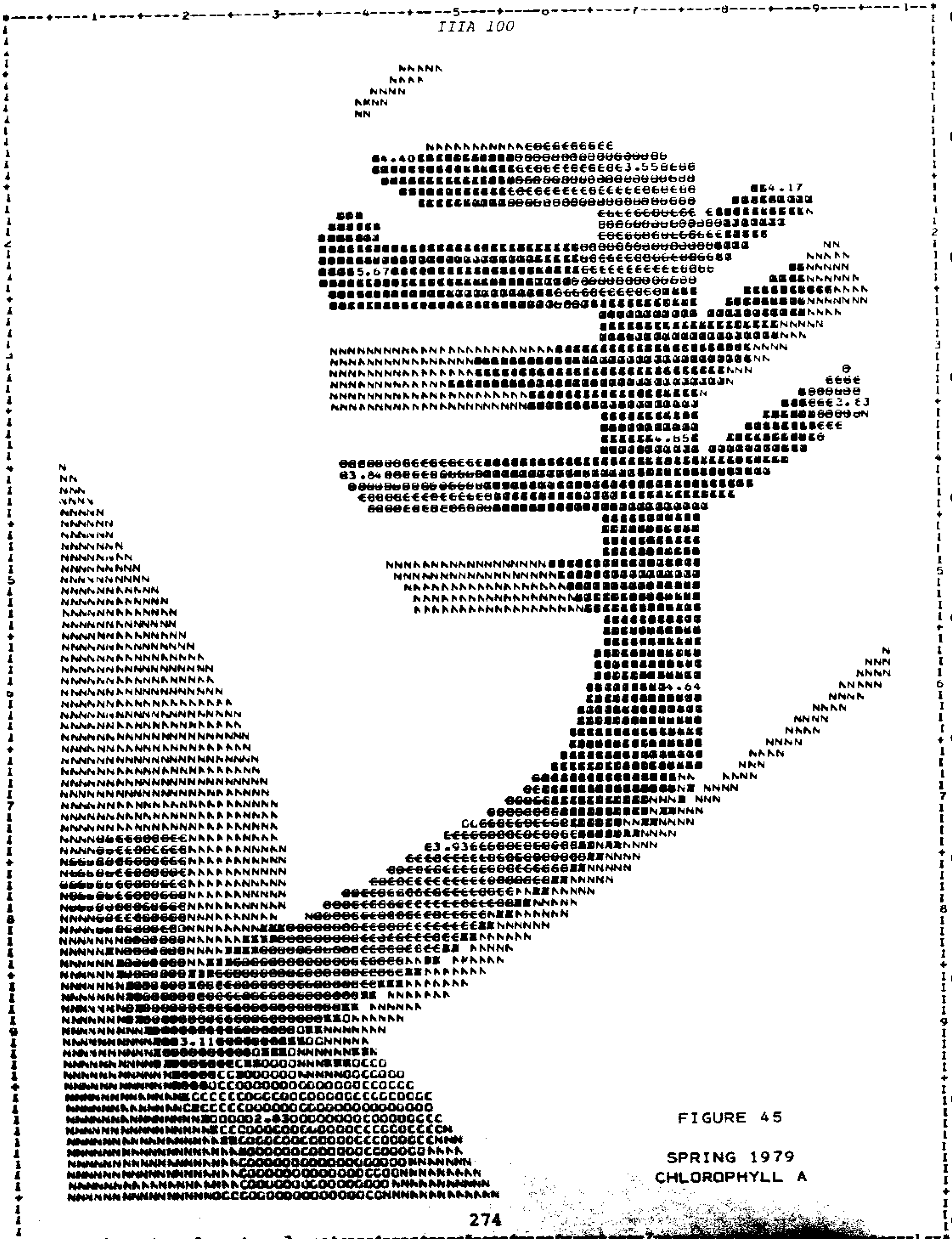


FIGURE 45

SPRING 1979
CHLOROPHYLL A

FIGURE 46 LEGEND

ASSIMILATION RATIO
SPRING 1977

DATA VALUE EXTREMES ARE 1.58 13.02

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	····1····	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	████8████	████9████	████*████
FREQ.	0	1	1	0	1	0	2	2	3	1

1
2
3

IIIA 102

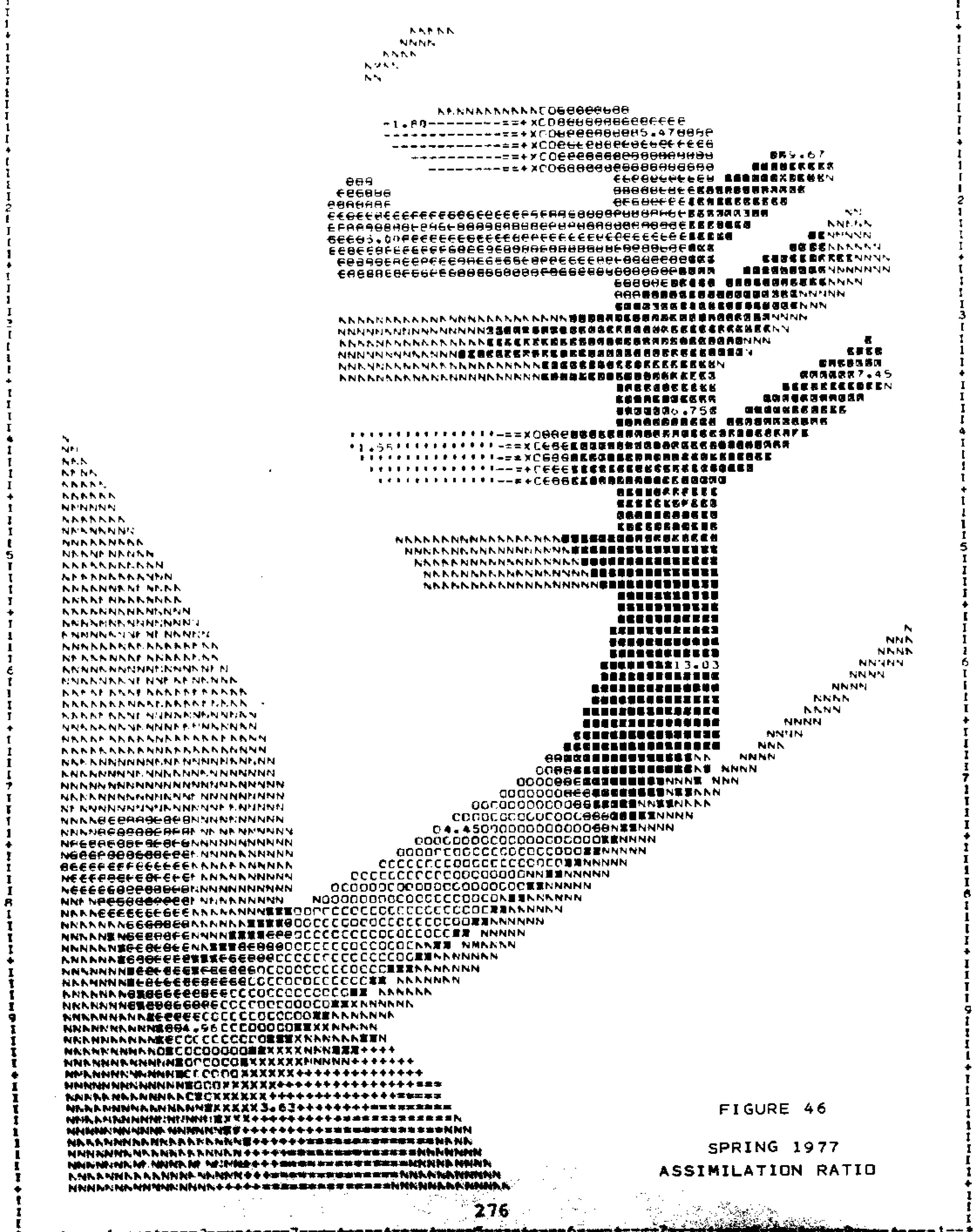


FIGURE 46

SPRING 1977

ASSIMILATION RATIO

FIGURE 47 LEGEND

ASSIMILATION RATIO
SPRING 1978

DATA VALUE EXTREMES ARE 1.35 4.02

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

	1	2	3	4	5	6	7	8	9	10
MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

1	2	3	4	5	6	7	8	9	10
3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOC7OOOO	@@@@8@@@@	[illegible]	[illegible]
FREQ.	0	3	2	2	2	2	0	0	0	0

```
FREQ.
  1            I''2''I  I--3--I  I==4==I  I++5++I  IXX6XXI
  2            I''2''I  I--3--I  I==4==I  I++5++I  IXX6XXI
  3            I''2''I
```

IIIA 104

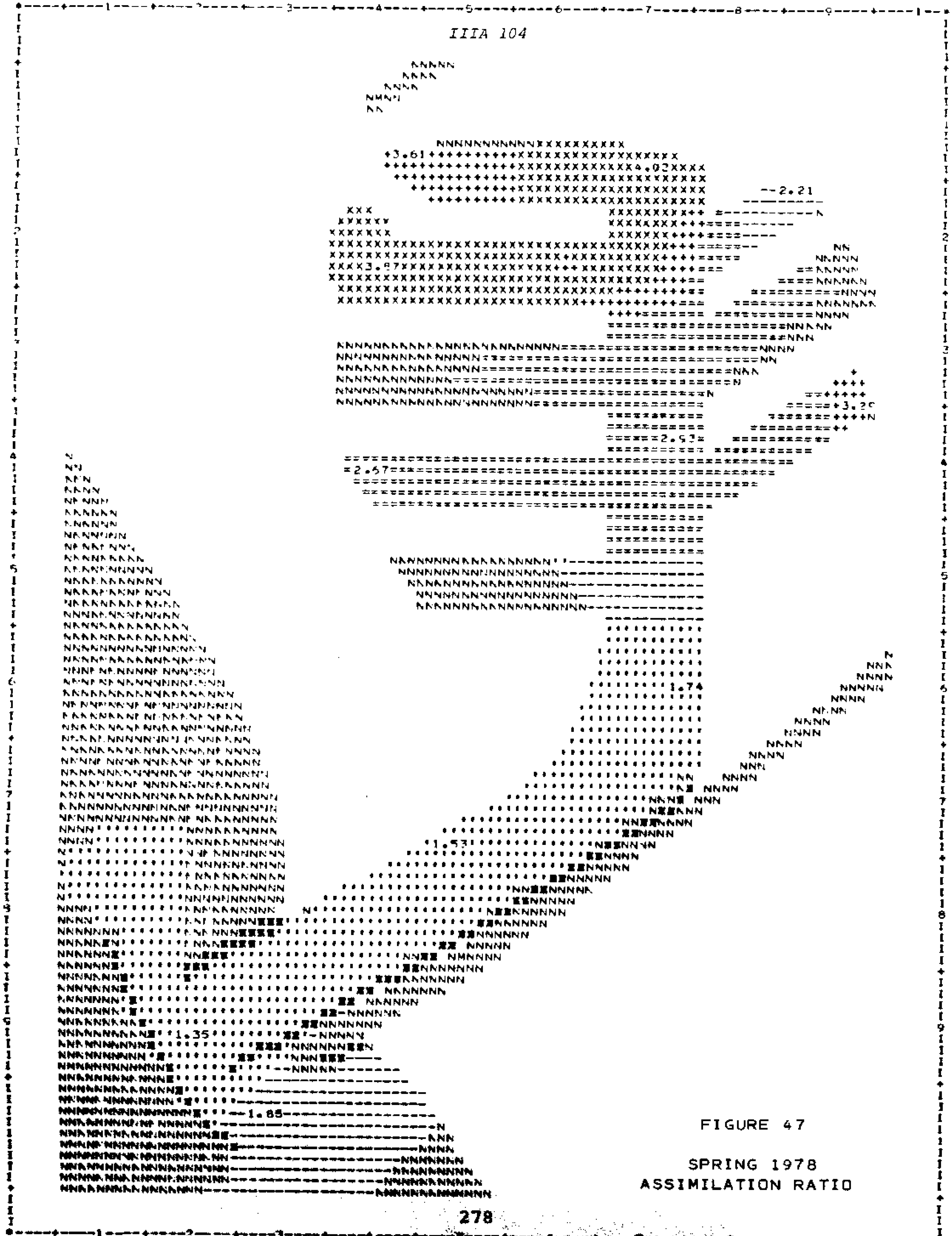


FIGURE 47

SPRING 1978
ASSIMILATION RATIO

SYMAP

5.175666 MINUTES FOR MAP

FIGURE 48 LEGEND

ASSIMILATION RATIO
SPRING 1979

DATA VALUE EXTREMES ARE 2.75 4.89

TOTAL MISSING DATA POINTS IS 2

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM* INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.0	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00
MAXIMUM	0.52	1.75	2.50	3.25	3.75	4.25	5.00	6.50	10.00	13.18

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

3.95	9.33	5.69	5.69	3.79	3.79	5.69	11.38	26.56	24.13

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	....2....	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	[illegible]	[illegible]	[illegible]
FREQ.	0	0	0	1	1	4	5	0	0	0

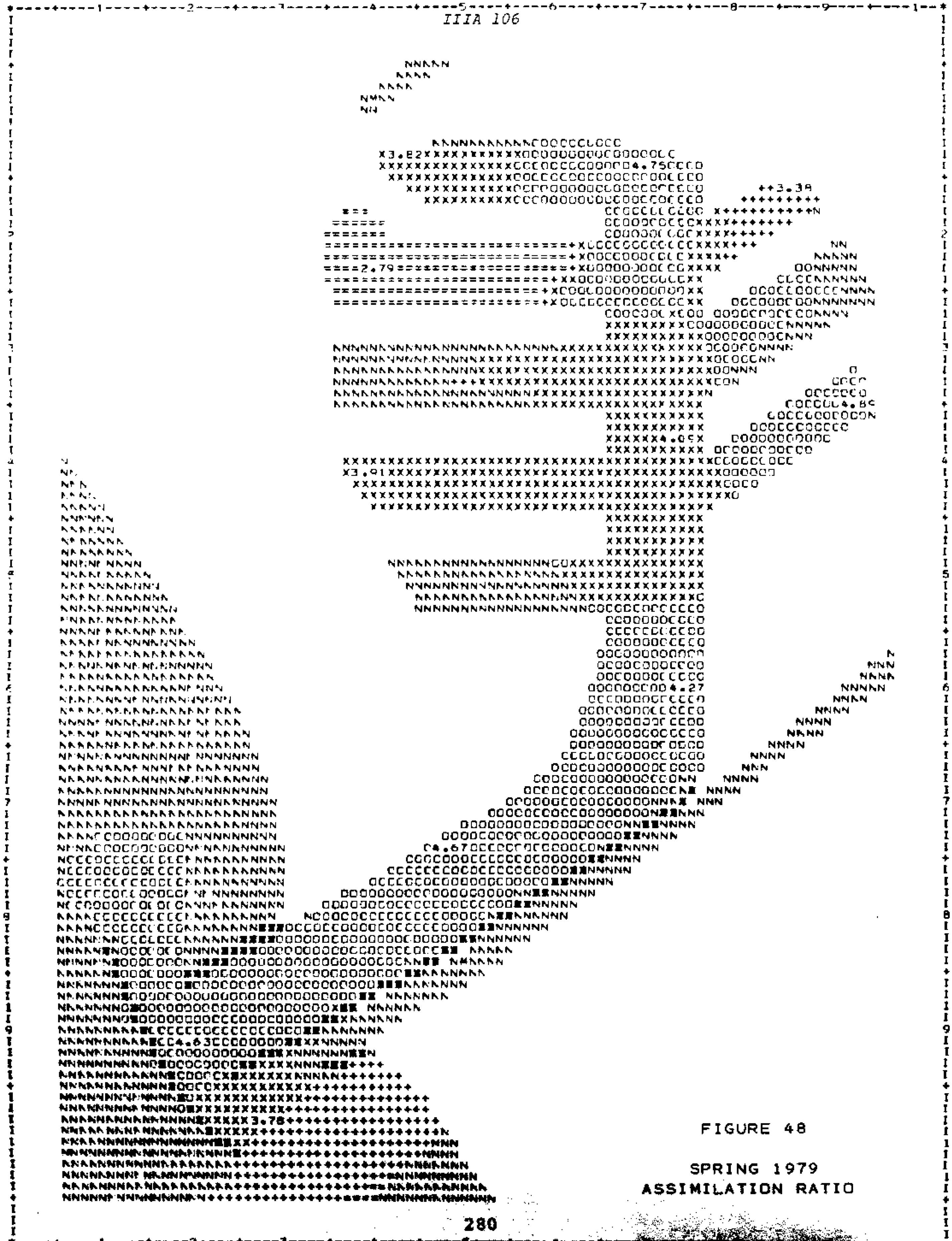


FIGURE 48

SPRING 1979
ASSIMILATION RATIO

Table 1. Phytoplankton Productivity, Chlorophyll *a* and Assimilation Ratio Based on Chlorophyll *a* in Marina del Rey.

Station		1976						1977					
	Date	7/29	8/19	9/16	10/14	11/19	12/16	1/20	2/17	3/17	4/21	5/19	6/23
1	P	89.85	8.25	16.15	16.75	20.84	2.20	3.05	2.80	3.04	18.20	11.99	32.53
	C	6.66	2.03	9.31	3.43	8.22	4.01	2.70	1.52	1.07	3.97	3.47	2.83
	A	13.49	4.06	1.73	4.88	2.54	0.55	1.13	1.84	2.84	4.58	3.46	11.49
2	P	34.68	8.03	32.66	18.89	18.35	2.09	3.00	12.90	4.74	18.35	14.15	27.90
	C	6.10	2.12	1.38	3.64	7.32	2.29	1.48	3.46	1.66	2.49	3.05	1.85
	A	5.69	3.79	23.67	5.19	2.51	0.91	2.03	3.73	2.86	7.37	4.64	15.08
3	P	11.74	17.25	5.90	27.41	9.62	2.74	1.92	2.34	3.96	30.20	6.79	8.69
	C	20.56	3.46	0.89	5.71	7.26	3.21	0.40	0.37	2.62	2.84	5.57	1.17
	A	0.57	4.99	6.63	4.80	1.33	0.85	4.80	6.32	1.51	10.63	1.22	7.43
4	P	17.88	10.18	8.01	23.57	13.16	3.01	3.18	13.28	1.71	23.27	15.32	22.51
	C	9.70	4.00	1.07	10.01	6.14	2.71	0.20	5.15	0.08	2.40	1.91	2.13
	A	1.84	2.55	7.49	2.35	2.14	1.11	15.90	2.58	21.38	9.70	8.02	10.57
5	P	14.94	2.29	10.44	62.83	9.58	3.53	4.51	10.79	4.35	13.60	17.43	33.55
	C	2.50	4.25	0.61	3.93	4.74	1.65	0.54	1.77	2.46	0.88	5.78	3.64
	A	5.98	0.54	17.11	15.99	2.02	2.14	8.35	6.10	1.77	15.45	3.02	9.22
6	P	4.59	14.69	12.63	34.98	8.17	1.17	5.76	20.11	3.66	16.18	12.49	60.54
	C	2.57	1.64	-	6.16	16.98	1.45	-	3.43	2.09	-	9.21	-
	A	1.79	8.96	-	5.68	0.48	0.81	-	5.86	1.75	-	1.36	-
7	P	0.18	14.64	5.66	24.92	3.53	3.93	14.43	6.65	2.00	23.44	20.30	12.51
	C	4.08	2.89	0.49	7.26	5.59	3.26	-	2.16	1.35	1.35	5.76	33.54
	A	0.04	5.08	11.55	3.42	0.63	1.21	-	3.08	1.48	17.36	3.52	0.37
8	P	50.52	6.93	46.14	22.40	12.91	-	5.04	20.95	3.40	22.06	15.39	6.43
	C	5.41	4.02	-	3.17	5.70	2.13	2.64	2.61	0.85	2.50	7.02	3.37
	A	9.34	1.72	-	7.07	2.26	-	1.91	8.03	4.00	8.82	2.19	1.91
9	P	31.08	6.34	9.88	12.13	5.01	-	5.45	11.21	2.40	37.95	32.38	22.52
	C	4.93	3.40	1.81	-	4.30	1.50	1.31	3.68	1.70	1.91	4.19	5.75
	A	6.30	1.86	5.46	-	1.17	-	4.16	3.05	1.41	19.87	7.73	3.92
10	P	-	4.68	9.96	41.77	8.52	3.05	5.83	5.48	0.02	33.75	17.41	14.82
	C	23.12	3.36	0.83	1.92	6.08	1.71	0.64	2.35	3.69	-	4.85	-
	A	-	1.39	12.00	21.76	1.40	1.78	8.45	2.33	0.01	-	3.59	-
11	P	9.41	10.43	11.67	25.24	6.48	3.06	5.10	8.72	3.94	21.47	21.48	23.14
	C	3.52	3.65	1.16	2.58	1.67	1.22	1.62	2.28	1.06	2.06	9.43	4.80
	A	2.67	2.86	10.06	9.78	3.88	2.51	3.15	3.82	3.72	10.42	2.28	4.82

P = Productivity (mg C/hr./m^3) C = Chlorophyll *a* (mg/l) A = Assimilation Ratio A (P/C)

Table 2. Phytoplankton Productivity, Chlorophyll *a* and Assimilation Ratio Based on Chlorophyll *a* in Marina del Rey.

Stn.	Date	1977 7/21	1977 8/18	1977 9/16	1977 10/21	1977 11/18	1977 12/28	1978 1/20	1978 2/17	1978 3/17	1978 4/21	1978 5/19	1978 6/16
1	P	22.74	15.42	6.06	2.18	2.52	1.24	1.62	0.75	0.86	4.64	3.06	3.06
	C	5.18	3.11	0.45	1.13	2.60	--	1.96	0.35	0.71	1.64	2.03	1.95
	A	4.39	4.96	13.47	1.93	0.97	--	0.83	2.14	1.21	2.83	1.51	1.57
2	P	23.29	13.55	3.67	3.17	3.86	0.91	1.73	0.71	0.34	6.01	2.45	0.99
	C	37.48	1.21	--	2.56	4.05	--	1.57	0.52	0.24	3.66	2.51	0.94
	A	0.62	11.20	--	1.24	0.95	--	1.10	1.37	1.42	1.64	0.98	1.05
3	P	19.90	12.14	4.72	1.86	1.56	0.46	1.83	1.42	2.24	7.30	1.92	1.94
	C	28.85	2.97	--	0.91	1.01	--	1.17	0.29	1.66	3.11	2.15	1.12
	A	0.69	4.09	--	2.04	1.54	--	1.56	4.90	1.35	2.35	0.89	1.73
4	P	15.49	13.29	9.60	1.43	1.43	0.39	1.25	1.81	1.96	5.38	2.73	3.37
	C	1.82	0.65	0.84	1.21	0.67	--	0.86	0.40	1.59	1.91	2.31	2.38
	A	8.51	20.45	11.43	1.18	2.13	--	1.45	4.53	1.23	2.82	1.18	1.42
5	P	11.93	22.12	22.86	1.90	5.02	0.46	1.20	1.52	2.65	9.98	1.81	14.06
	C	--	2.09	2.23	0.61	1.52	--	0.76	0.31	1.18	1.78	1.97	2.56
	A	--	10.58	10.25	3.11	3.30	--	1.58	4.90	2.25	5.61	0.92	5.49
6	P	5.83	26.56	6.07	0.89	2.81	1.67	0.11	1.06	1.65	8.14	2.64	3.34
	C	0.67	2.47	1.19	0.33	0.81	1.09	0.38	0.28	1.19	1.72	1.60	2.38
	A	8.70	10.75	5.10	2.70	3.47	1.53	0.29	3.79	1.62	4.73	1.65	1.40
7	P	24.28	17.78	4.48	1.95	3.32	1.71	1.37	1.02	5.09	8.68	2.17	7.32
	C	1.93	1.44	0.43	0.37	1.19	--	0.84	0.28	2.26	1.53	1.11	1.60
	A	12.58	12.35	10.42	5.27	2.79	--	1.63	3.64	2.25	5.67	1.95	4.58
8	P	14.98	47.12	6.46	1.19	6.17	0.99	1.13	1.43	1.64	8.89	3.29	9.42
	C	1.35	4.98	0.80	0.26	1.55	0.94	0.78	0.16	0.98	1.06	2.07	2.67
	A	11.10	9.46	8.08	4.58	3.98	1.05	1.45	8.94	1.67	8.39	1.59	3.53
9	P	7.35	17.44	5.66	1.63	2.35	1.07	1.25	1.58	1.41	3.70	1.68	7.09
	C	4.20	2.04	0.51	1.89	0.85	0.88	1.07	0.38	0.57	1.22	1.50	2.45
	A	1.75	8.55	11.10	0.86	2.76	1.22	1.17	4.16	2.47	3.03	1.12	2.89
10	P	7.22	3.29	6.08	0.63	2.47	1.37	1.07	1.15	3.03	9.37	0.77	4.42
	C	1.25	2.85	0.59	0.23	0.60	--	0.83	0.16	1.26	1.15	2.72	3.76
	A	5.78	1.15	10.31	2.74	4.12	--	1.29	7.19	2.40	8.15	0.28	1.18
11	P	17.39	9.85	5.75	1.68	3.30	0.65	0.96	0.93	3.35	6.98	5.18	11.75
	C	4.58	1.04	0.64	0.54	1.17	0.61	0.66	0.22	1.34	0.89	3.02	2.53
	A	3.80	9.47	8.98	3.11	2.82	1.07	1.45	4.23	2.50	7.84	1.72	4.64

P = Productivity (mg C/hr./m^3) C = Chlorophyll *a* (mg/l) A = Assimilation Ratio A (P/C)

Table 3. Phytoplankton Productivity, Chlorophyll *a* and Assimilation Ratio Based on Chlorophyll *a* in Marina del Rey.

Stn.	Date	1978						1979					
		7/21	8/18	9/21	10/20	11/17	12/15	1/19	2/23	3/30	4/27	5/31	6/28
1	P	3.65	0.57	5.95	10.20	4.47	2.67	0.44	0.26	6.01	7.84	20.58	13.37
	C	2.34	1.23	2.67	2.74	1.59	3.67	0.78	1.09	1.95	2.69	3.85	1.94
	A	1.56	0.46	2.23	3.72	2.81	0.73	0.56	0.24	3.08	2.92	5.35	6.89
2	P	3.65	2.64	4.30	7.53	4.43	4.62	0.42	0.90	12.92	5.25	27.27	16.20
	C	3.58	0.84	2.57	1.64	1.39	3.31	0.75	0.88	3.17	1.23	4.92	1.94
	A	1.02	3.14	1.67	4.59	3.18	1.40	0.56	1.03	4.08	4.27	5.54	8.35
3	P	4.05	5.23	9.17	22.83	4.02	4.79	1.41	2.56	20.47	9.04	26.31	19.65
	C	1.84	2.07	3.30	4.12	1.31	3.44	1.22	0.78	3.94	2.17	5.68	3.00
	A	2.14	2.53	2.78	5.54	3.07	1.22	1.15	3.28	5.20	4.17	4.63	6.55
4	P	4.94	1.77	7.89	16.27	5.05	4.56	0.63	2.05	23.06	11.57	24.89	20.85
	C	2.47	2.66	3.18	3.47	1.35	3.69	0.92	0.65	4.67	2.98	6.26	2.17
	A	2.00	0.67	2.48	4.69	3.74	1.24	0.68	3.16	4.94	3.88	3.98	9.61
5	P	9.14	6.01	8.39	17.40	4.21	2.42	0.32	1.20	24.02	9.10	23.49	20.85
	C	3.41	2.18	2.36	2.04	1.32	2.89	0.72	0.50	4.76	2.20	7.59	2.60
	A	2.68	2.76	3.56	18.53	3.19	0.84	0.45	2.40	5.05	4.14	3.09	8.02
6	P	4.02	3.38	1.57	6.73	2.15	2.94	0.74	1.79	21.47	5.88	20.57	13.56
	C	2.07	1.54	1.08	1.08	0.75	1.48	0.86	0.44	4.92	2.44	4.16	1.40
	A	1.94	2.19	1.45	6.23	2.86	1.99	0.86	4.07	4.36	2.41	4.95	9.69
7	P	7.06	2.58	8.31	23.91	3.82	1.68	0.77	3.74	23.97	7.68	28.06	7.10
	C	2.07	1.43	2.46	2.95	1.15	1.32	1.03	0.76	4.28	2.24	4.97	2.23
	A	3.41	1.80	3.38	8.11	3.32	1.27	0.75	4.92	5.60	3.43	5.65	3.19
8	P	9.30	4.82	4.18	18.65	3.45	1.28	0.89	3.00	26.06	8.04	11.11	43.81
	C	4.30	2.46	1.62	2.08	0.94	1.96	1.37	0.92	5.46	3.69	7.87	5.11
	A	2.16	1.96	2.58	8.97	3.67	0.65	0.65	3.26	4.77	2.18	1.41	8.57
9	P	5.90	0.07	3.29	21.35	3.71	2.15	1.06	2.12	9.90	10.11	23.80	25.53
	C	2.37	1.56	2.22	2.88	1.43	1.41	1.06	1.07	3.92	3.10	5.48	2.77
	A	2.49	0.04	1.48	7.41	2.59	1.52	1.00	1.98	2.53	3.26	4.34	9.22
10	P	2.93	4.83	1.16	7.25	4.31	0.72	0.44	2.63	16.96	9.92	19.48	23.61
	C	2.17	2.58	1.59	0.91	1.07	1.21	0.53	1.33	2.87	4.21	6.11	1.76
	A	1.35	1.87	0.73	7.97	4.03	0.60	0.82	1.98	5.91	2.36	3.19	13.42
11	P	0.89	6.78	2.69	6.71	3.16	1.50	0.32	2.28	20.47	8.12	22.91	21.91
	C	2.25	1.57	0.99	6.06	1.03	1.82	0.64	0.44	3.60	2.02	5.04	2.67
	A	0.40	4.32	2.72	1.11	3.07	0.82	0.51	5.18	5.69	4.02	4.55	8.21

P = Productivity (mg C/hr.m^3)   C = Chlorophyll *a* (mg/l)   A = Assimilation Ratio A (P/C)

Table 4

NITRATE DATA, MARINA DEL REY, 1976-1979
(µg·at/l)

1 9 7 6 - 1 9 7 7

Sta.	Jul'76	Aug'76	Sept'76	Nov'76	Dec'76	Jan'77	Feb'77	Apr'77	May'77	Jun'77
MDR-1	.421	.241	.083	.549	.167	.265	.371	.325	.342	.295
MDR-2	.400	.427	.082	.477	.287	.214	.219	.300	.391	.290
MDR-3	.129	.211	.180	.353	.144	.227	.198	.317	.401	.295
MDR-4	.320	.194	.193	.491	.261	.219	.270	.271	.330	.297
MDR-5	.632	.190	.213	.477	.208	.197	.257	.213	.279	.280
MDR-6	.581	.311	.283	.483	.221	.208	.247	.215	.262	.307
MDP-7	.113	.227	.224	.491	.300	.195	.213	.229	.274	.308
MDR-8	.475	.242	.179	.477	.328	.205	.253	.318	.280	.192
MDR-9	.733	.199	.310	.502	.414	.202	.270	.329	.290	.252
MDR-10	.297	.196	.168	.371	.301	.210	.308	.320	.219	.293
MDR-11	.293	.113	.208	.425	.442	.223	.290	.340	.227	.271

1 9 7 7 - 1 9 7 8

Sta.	Aug'77	Sept'77	Oct'77	Nov'77	Dec'77	Jan'78	Feb'78	Feb'78	Mar'78	Apr'78	May'78	Jun'78
MDR-1	.712	2.003	1.417	4.402	77.280	7.679	-	51.904	66.116	.303	.169	.910
MDR-2	.406	6.553	2.762	4.353	77.228	6.369	-	48.498	69.678	.019	.075	.000
MDR-3	0.690	1.465	3.271	4.341	35.007	5.885	9.837	3.929	2.401	.222	.485	.689
MDR-4	2.23	5.565	3.794	8.977	65.692	6.936	10.917	3.636	.861	.138	.046	.214
MDR-5	.425	2.385	2.291	9.970	24.721	5.068	-	5.516	1.529	-	1.515	.000
MDR-6	2.12	3.087	5.143	11.337	24.894	6.392	10.513	4.362	.443	.087	2.361	.224
MDR-7	1.74	2.252	5.360	9.732	39.511	4.529	24.629	13.993	3.418	.248	1.514	.452
MDR-8	2.13	1.794	6.513	10.397	32.301	-	10.809	5.369	1.693	.057	1.140	.231
MDR-9	2.32	6.349	7.665	13.612	24.412	9.868	77.866	9.078	41.816	19.832	6.786	33.009
MDR-10	1.51	4.649	5.459	13.981	37.336	11.816	31.558	29.623	6.776	.167	.000	.000
MDR-11	.724	4.456	7.891	-	36.712	-	-	5.827	1.754	.357	35.192	-

1 9 7 8 - 1 9 7 9

Sta.	Jul'78	Aug'78	Sept'78	Oct'78	Nov'78	Dec'78	Jan'79	Feb'79	Mar'79	Apr'79	May'79	Jun'79
MDR-1	1.253	.000	1.561	1.861	5.884	.735	10.261	16.628	.400	.811	.884	.503
MDR-2	.710	.030	.464	4.205	11.439	1.433	8.279	9.575	6.141	.137	.623	.463
MDR-3	.407	.636	2.400	2.726	3.409	8.241	3.648	5.944	3.813	.349	.476	.645
MDR-4	.814	.205	1.930	2.757	7.151	3.426	4.560	6.323	3.545	.051	.141	.960
MDR-5	.196	.000	4.068	2.741	8.822	4.443	5.873	7.912	4.330	.183	.000	1.124
MDR-6	9.179	.022	5.771	13.785	9.641	7.657	6.038	6.738	3.402	.178	.046	2.015
MDR-7	.000	.250	3.104	4.111	10.521	8.446	4.312	5.835	3.726	.085	.200	.315
MDR-8	1.007	.163	3.833	2.787	12.419	.392	5.942	6.831	3.175	.001	.237	.314
MDR-9	14.644	.674	8.830	4.589	11.212	8.551	13.727	11.857	12.929	13.987	19.058	11.221
MDR-10	1.768	20.098	4.288	3.682	10.683	9.063	8.816	7.404	5.991	.211	2.250	2.661
MDR-11	12.847	.744	4.675	3.274	10.465	8.323	4.738	8.095	5.335	.742	1.259	2.904

Table 5

NITRITE DATA, MARINA DEL REY, 1976–1979
(µg·at/l)

1 9 7 6 - 1 9 7 7

Sta.	Jul'76	Aug'76	Sept'76	Nov'76	Dec'76	Jan'77	Feb'77	Apr'77	May'77	Jun'77
MDR-1	.011	.066	.017	.152	.165	.127	.097	.200	.141	.147
MDR-2	.025	.035	.019	.098	.161	.091	.065	.113	.192	.099
MDR-3	.004	.010	.073	.123	.137	.077	.111	.190	.100	.084
MDR-4	.004	.027	.061	.100	.169	.035	.107	.127	.114	.076
MDR-5	.009	.031	.082	.140	.181	.091	.191	.100	.120	.131
MDR-6	.006	.030	.090	.132	.151	.111	.147	.095	.134	.101
MDR-7	.005	.020	.071	.149	.162	.114	.099	.088	.130	.104
MDR-8	.009	.024	.037	.165	.186	.107	.174	.142	.072	.099
MDR-9	.011	.031	.099	.156	.152	.126	.170	.150	.090	.089
MDR-10	.003	.024	.073	.091	.148	.100	.190	.136	.095	.087
MDR-11	.004	.019	.019	.165	.178	.097	.149	.144	.140	.094

1 9 7 7 - 1 9 7 8

Sta.	Aug'77	Sept'77	Oct'77	Nov'77	Dec'77	Jan'78	Feb'78	Feb'78	Mar'78	Apr'78	May'78	Jun'78
MDR-1	.058	.376	.147	.502	.339	.267	-	.417	.382	.073	.068	.123
MDR-2	.120	.393	.166	.492	.346	.201	-	.256	.288	.042	.054	.165
MDR-3	.174	.386	.147	.304	.348	.230	.242	.155	.104	.035	.056	.082
MDR-4	.272	.390	.262	.350	.503	.101	.365	.123	.090	.058	.050	.078
MDR-5	.216	.333	.202	.409	.556	.212	-	.163	.104	-	.092	.050
MDR-6	.243	.211	.322	.407	.431	.171	.258	.351	.313	.031	.112	.074
MDR-7	.343	.376	.245	.382	.387	.179	.740	.175	.119	.062	.078	.141
MDR-8	.250	.186	.262	.554	.781	.217	.339	.196	.094	.052	.054	.113
MDR-9	.384	.378	.163	.453	.326	.197	.133	.139	.125	.079	.086	.108
MDR-10	.339	.314	.151	.550	.479	.401	.950	.421	.186	.048	.124	.110
MDR-11	.395	.219	.260	-	.497	.206	-	.129	.121	.064	.058	.100

1 9 7 8 - 1 9 7 9

Sta.	Jul'78	Aug'78	Sept'78	Oct'78	Nov'78	Dec'78	Jan'79	Feb'79	Mar'79	Apr'79	May'79	Jun'79
MDR-1	.142	.247	.254	.090	.162	.073	.408	.773	.197	.220	.317	.135
MDR-2	.133	.153	.328	.163	.268	.101	.337	.564	.380	.240	.276	.135
MDR-3	.092	.105	.232	.123	.355	.065	.165	.464	.380	.215	.225	.225
MDR-4	.092	.220	.285	.146	.213	.126	.167	.489	.380	.256	.199	.225
MDR-5	.102	.203	.285	.158	.262	.152	.184	.534	.430	.189	.179	.293
MDR-6	.094	.161	.304	.242	.286	.203	.178	.519	.395	.230	.194	.332
MDR-7	1.849	.149	.297	.177	.288	.207	.149	.409	.380	.220	.199	.203
MDR-8	.106	.276	.338	.185	.320	.219	.188	.484	.385	.363	.179	.113
MDR-9	.104	.186	.288	.136	.272	.201	.165	.409	.395	.358	.256	.287
MDR-10	.144	.212	.384	.166	.302	.249	.295	.693	.516	.215	.276	.372
MDR-11	.112	.209	.242	.156	.282	.217	.180	.404	.425	.271	.220	.428

Table 6

AMMONIA DATA, MARINA DEL REY, 1976-1979

(μg·at/l)

1 9 7 6 - 1 9 7 7

Sta.	Jul'76	Aug'76	Sept'76	Nov'76	Dec'76	Jan'77	Feb'77	Apr'77	May'77	Jun'77
MDR-1	.006	.021	.084	.086	.094	.261	.049	.265	.241	.300
MDR-2	.005	.020	.099	.068	.061	.149	.071	.232	.247	.314
MDR-3	.007	.017	.127	.002	.066	.213	.149	.241	.209	.319
MDR-4	.003	.010	.121	.092	.061	.277	.238	.271	.201	.227
MDR-5	.005	.018	.139	.074	.058	.197	.211	.255	.194	.189
MDR-6	.004	.050	.157	.068	.058	.201	.207	.250	.260	.194
MDR-7	.005	.028	.192	.092	.055	.317	.200	.277	.257	.197
MDR-8	.018	.024	.143	.083	.057	.299	.194	.269	.237	.190
MDR-9	.007	.040	.200	.078	.050	.265	.179	.300	.341	.180
MDR-10	.001	.052	.242	.116	.051	.274	.199	.241	.279	.301
MDR-11	.007	.034	.246	.100	.061	.279	.196	.268	.275	.291

1 9 7 7 - 1 9 7 8

Sta.	Aug'77	Sept'77	Oct'77	Nov'77	Dec'77	Jan'78	Feb'78	Feb'78	Mar'78	Apr'78	May'78	Jun'78
MDR-1	.259	2.656	2.494	5.147	11.197	4.628	-	3.603	1.557	.621	.897	1.779
MDR-2	.166	3.399	10.208	6.141	7.877	4.628	-	3.983	1.661	.621	.947	2.298
MDR-3	.165	3.346	7.091	6.551	7.933	4.891	7.307	4.741	2.854	.395	1.446	3.484
MDR-4	.175	3.346	8.650	9.592	8.665	4.839	6.281	4.868	1.142	.564	.698	1.557
MDR-5	.157	4.355	9.663	9.299	7.202	5.890	-	5.121	1.246	.564	.847	1.779
MDR-6	.134	7.967	11.689	3.392	9.903	5.785	4.167	5.057	1.246	.564	.947	1.112
MDR-7	.226	5.736	11.845	17.780	8.215	6.048	9.058	6.069	1.557	.564	.947	1.927
MDR-8	.120	6.480	13.403	8.013	16.148	5.470	3.986	5.626	.986	.508	.897	1.260
MDR-9	.234	6.427	10.208	10.001	8.271	5.522	5.314	5.753	1.764	1.072	2.044	2.817
MDR-10	.259	7.967	7.403	8.890	11.703	8.099	16.305	10.115	2.024	.564	2.044	1.557
MDR-11	.310	6.692	14.806	10.177	10.690	5.470	-	5.374	1.557	.847	1.346	1.334

1 9 7 8 - 1 9 7 9

Sta.	Jul'78	Aug'78	Sept'78	Oct'78	Nov'78	Dec'78	Jan'79	Feb'79	Mar'79	Apr'79	May'79	Jun'79
MDR-1	1.075	1.126	1.992	2.253	3.054	1.790	6.218	14.959	2.459	3.318	4.574	2.394
MDR-2	1.383	.758	.797	4.097	5.236	2.558	5.447	8.138	3.115	2.063	2.063	2.271
MDR-3	.922	1.326	3.585	2.253	3.345	2.685	5.172	10.076	2.623	2.511	2.870	2.087
MDR-4	1.690	1.231	3.187	3.483	7.127	3.581	4.897	5.813	2.787	3.498	2.601	2.517
MDR-5	.461	1.137	6.905	2.458	8.726	4.731	5.777	7.286	2.295	1.883	2.063	2.087
MDR-6	1.997	1.137	6.772	7.784	9.744	5.754	5.172	6.045	2.459	1.614	2.601	2.762
MDR-7	1.075	.758	5.311	2.663	10.181	8.823	5.777	7.053	3.115	1.794	2.511	2.148
MDR-8	1.536	1.042	8.233	7.170	10.762	4.092	4.292	6.355	2.623	1.704	2.242	1.841
MDR-9	1.844	1.895	8.108	5.531	10.035	6.650	4.182	8.061	2.787	3.229	4.215	2.946
MDR-10	2.412	2.463	10.224	7.989	12.508	5.754	8.308	9.533	5.573	1.973	4.753	4.481
MDR-11	.615	1.895	7.303	3.073	10.762	5.499	5.722	8.836	3.770	1.973	3.139	3.008

Table 7

PHOSPHATE DATA, MARINA DEL REY, 1976-1979
(µg·at/l)

1976 - 1977

Sta.	Jul'76	Aug'76	Sept'76	Nov'76	Dec'76	Jan'77	Feb'77	Apr'77	May'77	Jun'77
MDR-1	.221	.113	.118	.172	.096	.261	.216	.265	.275	.217
MDR-2	.202	.079	.171	.220	.099	.237	.301	.313	.310	.199
MDR-3	.131	.114	.249	.254	.179	.192	.277	.321	.300	.194
MDR-4	.129	.127	.251	.296	.212	.087	.209	.300	.279	.208
MDR-5	.194	.087	.254	.289	.253	.239	.175	.271	.260	.106
MDR-6	.184	.111	.384	.295	.236	.360	.339	.279	.240	.119
MDR-7	.114	.096	.257	.312	.248	.321	.343	.325	.301	.127
MDR-8	.197	.113	.287	.330	.231	.277	.230	.320	.323	.182
MDR-9	.213	.138	.282	.371	.250	.276	.254	.317	.290	.152
MDR-10	.097	.099	.272	.387	.210	.240	.261	.199	.201	.211
MDR-11	.099	.146	.276	.334	.207	.252	.275	.175	.151	.229

1977 - 1978

Sta.	Aug'77	Sept'77	Oct'77	Nov'77	Dec'77	Jan'78	Feb'78	Feb'78	Mar'78	Apr'78	May'78	Jun'78
MDR-1	.280	.597	.227	1.522	6.762	1.105	-	.661	.679	.236	.780	.365
MDR-2	.136	.720	.502	1.699	5.786	1.066	-	.632	.679	.330	.434	.766
MDR-3	.469	.681	.788	1.087	3.904	1.310	1.345	.311	.898	.418	.653	.807
MDR-4	.458	.872	1.596	1.912	4.954	1.175	1.310	.846	.418	.325	.531	.431
MDR-5	.510	1.033	1.241	1.650	2.345	1.205	-	.938	.638	.325	.892	.421
MDR-6	.411	1.507	1.557	1.902	2.609	1.573	1.289	1.050	.474	.320	.638	.437
MDR-7	.583	1.143	1.557	1.887	4.880	1.160	2.294	1.050	.434	.600	.965	.482
MDR-8	.411	1.469	1.778	1.704	2.445	1.235	1.239	1.041	.571	.487	.672	.558
MDR-9	.704	1.384	1.645	1.971	2.041	1.185	2.112	.934	.668	.792	1.150	.772
MDR-10	.960	1.397	1.847	1.946	3.749	1.295	3.411	1.784	.878	.477	.677	.807
MDR-11	.481	1.410	1.759	2.105	2.355	1.150	-	1.016	.689	.482	1.096	.558

1978 - 1979

Sta.	Jul'78	Aug'78	Sept'78	Oct'78	Nov'78	Dec'78	Jan'79	Feb'79	Mar'79	Apr'79	May'79	Jun'79
MDR-1	.456	.471	.885	.517	.790	.370	1.404	1.854	.416	.399	.433	.472
MDR-2	.327	.404	.435	.928	1.267	.597	1.281	2.015	.610	.345	.364	.520
MDR-3	.465	.635	.609	.727	.682	.508	.867	1.171	.484	.507	.394	.472
MDR-4	.548	.532	.916	.883	1.092	.917	1.064	1.151	.610	.542	.236	.756
MDR-5	.649	.624	1.023	.878	1.360	.947	1.133	1.205	.503	.512	.300	.803
MDR-6	.847	.563	.911	1.359	1.321	1.366	1.108	1.176	.532	.822	.359	.709
MDR-7	.732	.553	.665	.873	1.433	1.509	1.074	1.317	.615	.547	.217	.661
MDR-8	.787	.875	1.213	1.294	1.599	1.337	1.034	1.098	.445	.714	.300	.567
MDR-9	.750	.906	1.208	1.148	1.462	1.475	1.217	1.146	.666	.881	.527	.709
MDR-10	1.501	.839	1.586	1.499	1.633	1.568	1.734	1.678	1.089	.861	.616	.803
MDR-11	.796	.814	1.366	1.063	1.462	1.430	1.241	1.293	.755	.739	.330	1.039

ZOOPLANKTON

INTRODUCTION

Zooplankton are those animals in the water column with such weak swimming ability that they are unable to hold their position against a current. Such organisms are carried from place to place by the prevailing currents and the individuals thus become transitory members of the fauna of a given site.

Members of the zooplankton which spend their entire life drifting in the water column are known as holoplankton. The most common holoplanktonic organisms include copepods, cladocerans, and larvaceans. Other organisms maintain a planktonic existence as immature or larval forms, metamorphose, and settle out on the bottom, becoming benthic. These are termed meroplanktonic and include brachyurans, molluscs, polychaete worms and bryozoans. Fish larvae may settle to the bottom, becoming part of the obligate benthic or demersal population or develop in swimming ability and become nektonic.

METHODS

Zooplankton samples were taken from a Los Angeles County Department of Small Craft Harbors maintenance barge in Marina del Rey. Samples were taken on a monthly basis for a total of three years, commencing in July 1976 and ending June 1979. Station locations of samples are shown in Figures 1 through 13. Single oblique tows were taken, using a ½ meter, 253 μm mesh nylon conical plankton net. The volume of filtered water was calculated from the revolutions on a flow meter positioned at the mouth of the plankton net halfway between the center and the rim. Following each tow the plankton net was washed down with sea water to the cod end and the plankton sample was decanted and preserved in 10% formalin in sea water.

Aliquots of the sample were made using a Folsom plankton splitter such that the subsample contained approximately 500-1000 organisms. The copepods and cladocerans from these samples were identified to species level and all other groups were identified to feasible taxonomic levels.

RESULTS

The zooplankton of Marina del Rey is dominated by copepods, comprising over 98.5% of the zooplankton, with cladocerans contributing only 0.84%. Other less significant groups include larvaceans (0.34%), brachyura zoea (0.14%), cirripedia nauplii (0.12%) and fish eggs and larvae (0.04%).

Among the copepods, *Acartia* spp. dominated, with 97.4% of the total zooplankton. This genus was composed mainly of *A. californiensis* (94.7%) and *A. tonsa* (2.7%). Other numerically less important copepods included *Paracalanus parvus* (1.0%) and *Corycaeus anglicus* (.10%).

The caldoceran populations were composed of four species. *Evadne nordmanni* was the most common (0.29%) followed by *Penilia avirostris* (0.22%), *Podon polyphemoides* (p.21%), and *Evadne spinifera* (0.12%).

SPATIAL DISTRIBUTION

The spatial distribution of the dominant zooplankton groups, as well as the total zooplankton and zooplankton diversity, were determined by calculating the mean concentration of zooplankton at each station over the three years of sampling. These mean areal concentrations are shown in Figures 1 through 13.

Acartia spp.

During the first two years of sampling, the dominant copepod in Marina del Rey was believed to be the calanoid copepod, *Acartia tonsa*. Early in the third year it was found that *A. tonsa* had been in fact composed of two species of *Acartia*: *A. tonsa* and *A. californiensis*. *Acartia californiensis* is a closely related species, nearly identical in appearance, which was described by Trinast (1976) from Newport Bay, California. Since then it has also been identified in Los Angeles-Long Beach Harbors (Soule and Oguri, 1979b) as a part of the "*A. tonsa*" collections.

The areal distribution of *Acartia* spp. over the three years is shown in Figure 1. It can be seen that the greatest concentration of this genus is in the inner portion of Marina del Rey, with a decrease in concentration in the entrance channel and just outside the entrance.

During the third year, *Acartia* spp. was separated into *A. tonsa* and *A. californiensis*. The areal distribution for these two species from July 1978 to June 1979 is shown in Figure 2.

While *Acartia californiensis* dominated the plankton numerically, the greatest concentrations of that species were found in the inner reaches of the harbor. Their dominance dropped off at the stations in the entrance channel and numbers were lowest at stations 1 and 2. Conversely, *A. tonsa* occurred in greatest concentrations at stations 1 and 2, declining in concentration at stations 3, 4, and 5. The lowest concentrations of *A. tonsa* were found in the slips.

Paracalanus parvus

Paracalanus parvus shows a distribution similar to that of *Acartia tonsa* (Figure 3). The greatest concentration of *P. parvus* occurred at the mouth of Marina del Rey and outer entrance channel station (station 3). Concentrations dropped in the main channel and were lowest in the inner slips (*i.e.*, stations 8, 9, 10).

Corycaeus anglicus

The cyclopoid copepod, *C. anglicus*, has its greatest concentrations at the mouth of the entrance channel (Figure 4). Concentrations diminished up the entrance channel and were found in low concentrations in the main channel and slips.

Podon polyphemoides

Podon polyphemoides had a distribution pattern in which the greatest concentration was at the mouth of Marina del Rey (Figure 5). The density of this species dropped to moderate levels in the entrance channel and main channel; the lowest concentrations occurred in the slips.

Evadne nordmanni

Evadne nordmanni also has its greatest concentrations at the mouth of the entrance channel (Figure 6). Only at station 3, at the Ballona Lagoon tide gate, was the density at an intermediate level. The remaining entrance and main channel stations, as well as the slips, had very low concentrations of this species.

Penilia avirostris

The cladoceran, *Penilia avirostris* (Figure 7), was distributed in a pattern similar to those of the previously discussed cladocerans, with the exception that the concentration at the entrance (station 2) was considerably greater than just outside the entrance (station 1). In this case there was nearly a two-fold difference between these closely spaced stations. The concentrations of this species in the rest of Marina del Rey were very low.

Larvacea

Larvacean distribution (Figure 8) was similar to that of *Evadne nordmanni*, with the principal concentration at the entrance of Marina del Rey. The concentrations declined in the entrance channel, and dropped further in the main channel. The lowest concentrations were found in the slips.

Brachyura zoea

The distribution of Brachyura zoea (Figure 9) was unique among the other zooplankton collected. They dominated at station 9, being nearly three-fold more numerous there than at the station with the next greatest concentration (station 7). Everywhere else, Brachyura zoea were not prevalent, and minimum values were found at stations 2, 8, and 11. The brachyurans include many crabs but the larval zoeal stages cannot generally be identified. Amphibious crabs are common in the intertidal rocks and on floats.

Cirripedia nauplius

Cirripedia nauplii (barnacle larvae) were most abundant in the channels of Marina del Rey (Figure 10). The greatest concentrations were found at stations 2, 3, 5 and 11. Station 4 had a somewhat reduced concentration of cirripedia nauplii. The slips represented by stations 6, 8 and 10 had the lowest concentration of this group.

Fish Eggs and Larvae

The distribution of fish eggs and larvae appeared to be more random within Marina del Rey than the distribution of other zooplankters discussed above. The greatest concentration was found at the entrance (Figure 11). Other moderate concentrations were found outside the entrance (station 1) and in the main channel (station 5) as well as in the slip where station 9 was located. The lowest concentration was at station 8, an area with the greatest human activity of boating and swimming.

Total Zooplankton

Because the zooplankton of Marina del Rey is dominated by the calanoid copepod *Acartia* spp., the areal distribution of total zooplankton (Figure 12) is very much like the distribution of *Acartia* spp. (see Figure 1). The higher concentrations are located in the inner portion, *i.e.*, the main channel and inner slips of Marina del Rey. The greatest concentration was found at station 9. The total zooplankton concentration decreased markedly in the entrance channel and was the lowest outside the mouth at station 1.

Shannon-Wiener Diversity Index

The areal distribution of Shannon-Wiener diversity index values (Figure 13) is clearly related to the distribution of the dominant species, *i.e.*, *Acartia californiensis*. In this case there is an inverse relationship. Where *A. californiensis* is dominant, the diversity is low and where it is not dominant the diversity index is high. This results in high diversity at the mouth (stations 1 and 2), with lower diversity as the stations progress up the entrance channel and main channel. The lowest diversity is found in the slips at stations 7, 9 and 10.

Temporal Distribution

The temporal distribution of the dominant zooplankton groups, the total zooplankton, and the zooplankton diversity is shown in Figures 14-16. Each year of sampling is plotted separately in order to show the variation between years. Some species (*Acartia* spp.) showed fairly consistent annual trends while others were quite variable.

Acartia spp.

The temporal distribution of the two species of *Acartia*, *A. tonsa* and *A. californiensis*, is shown in Figure 14A. Concentrations of *Acartia* spp. were generally low throughout summer from June and into the beginning of fall in October. In the fall and winter, populations showed increases, with one or two small peaks. Concentrations were at a maximum in the spring, in April of 1977 and 1978, and in May 1979.

Paracalanus parvus

Paracalanus parvus occurred in relatively low concentrations from June through December (Figure 14B). January and February were the peak months for this species in 1977 and 1978. Populations declined in March of 1977, and in April 1978, to relatively low levels. While *P. parvus* showed a peak of $924/m^3$ in January 1979, concentrations declined sharply in abundance in February but peaked for a second time in April, followed by a decline in May, 1979.

Corycaeus anglicus

Of the copepod species, *Corycaeus anglicus* showed the most variability between years (Figure 14C). During the first year of sampling, the major population increase of *C. anglicus* occurred in December, 1976 through February, 1977. In 1978, the increase occurred in the months of March and April. In the same year, a major peak occurred in November, 1978, flanked by lesser peaks in September and January, 1979. The timing and number of peaks seemed to vary widely, whereas those of *Acartia* spp. and *P. parvus* were more consistent.

Larvacea

Larvaceans exhibited the largest peak during the first year of sampling (Figure 14D). This peak lasted from December 1976 through February 1977. In the following year, sampling showed a relatively minor peak in January and another peak in March. The third year showed two major peaks, the first in November 1978 and a second in April 1979. It would appear that the time in which larvaceans show their greatest abundance is from November through April, but the timing of peaks is variable.

Podon polyphemoides

The cladoceran, *Podon polyphemoides*, shows abundance peaks that varied somewhat from year to year (Figure 15A). There was only a small peak in 1976 in November. In 1977, there were major peaks in February and July, while the peak occurrences in 1978 were in July and August. At all other times *P. polyphemoides* concentrations were relatively low.

Evadne spinifera

Evadne spinifera showed a peak similar to that of *P. Polyphemoides* in February 1977 (Figure 15B), but there was no other peak until September 1978. Thus, during the three years of sampling only two peak abundances of *E. spinifera* occurred.

Penilia avirostris

Penilia avirostris (Figure 15C) showed much more consistency in periods of abundance during the three years of sampling than did the other cladocerans, *P. polyphemoides* and *E. spinifera*. There were peaks in September, November and December, 1976; October through December, 1977; and November through December, 1978. Thus the major period of abundance for the three years was from September through December.

Fish Eggs and Larvae

During the years 1976 through 1978 the major period of abundance for fish eggs and larvae was in the winter, *i.e.*, December through February (Figure 15D). In 1976 and 1978 there were lesser peaks in August-September, but not in 1977. In 1979 there was a peak in February with a concentration approximately equal to those of the 1977 and 1978 levels followed by a much larger peak of $38/m^3$ in April, 1979, which had not appeared in the previous years.

Brachyura zoea

The seasonal distribution of brachyura zoea showed little variation between years of sampling (Figure 16A). The major peak abundance of brachyura zoea occurred from January through March, declining thereafter to minimal concentrations by June. The one exception to the pattern was in 1979, when a secondary peak occurred in May.

Cirripedia nauplii

The temporal distribution of cirripedia nauplii was extremely variable throughout the three years of sampling

(Figure 16B). Generally, however, August through November appeared to be a period of lower abundance, and January through May a period of abundance. Exceptions to this were peaks in October 1976 and in July 1977, and lows in January-March 1979.

Diversity Index

The temporal distribution of the Shannon-Wiener Diversity Index is shown in Figure 16C. Generally, the sampling year 1976-1977 had lower diversity indices than the following two years of sampling, with peaks in October 1976 and in February and June, 1977. During the latter two years, a peak in diversity occurred in August and in December-January. Following the winter peak, a spring decline in diversity occurred in March through April or May during all sampling years. The major drop in diversity in the spring coincided with the *Acartia* spp. bloom during that time, which dominates the zooplankton.

COMPARISONS OF ZOOPLANKTON WITH PHYSICAL PARAMETERS

The occurrences and distribution patterns of the major zooplankton species or groups are governed by a variety of factors, but within the confines of the marina the impact of changes in temperature, salinity and dissolved oxygen levels can be severe. The major species fluctuate seasonally in relation to one another, and vary with changing physical conditions as well.

Portrayal of biological changes coincident with physical changes has been undertaken by use of the CalComp plotter and Calform Mapping Program by John McDonald of the USC Geography Department and Evelyn McDonald.

Figures 17 through 27 present the data on the ten dominant zooplankton plotted for the three-year study. Immediately below the zooplankton data are plots of the diversity index data. Below those are graphs of dissolved oxygen in ml per liter, salinity (parts per 1000, PPT) and temperature (degrees Celsius).

The rainy season for 1976-1977 can be considered as "normal", when 14.84 inches fell on the Los Angeles Basin (unofficial records). In contrast, in 1977-1978 the total was 37.61 in., and in 1978-1979 the total was 22.63 inches. Typically, a few major storms provide most of the total, and the impact of runoff can be severe.

The Ballona Creek Los Angeles County flood control channel carries storm waters from central Los Angeles. It affects station 1 heavily and, depending on the tides, affects station 2 to a lesser extent. Also, there are major storm drains in the Marina in Slips E (station 10), G, and H (station 7). Lows in salinity can be seen in Figure 17 in December, 1977-January, 1978 and in February, 1979. Sharp declines in *Acartia* followed the 1977 rains but coincided with them in 1979. However, the lowest period of all in October 1978 did not coincide with low dissolved oxygen, reduced salinity or change in temperature. Probe malfunction in December, 1977 left data gaps at some stations, unfortunately. Low salinities in the inner channels in August, 1977 apparently resulted from a tropical storm that dropped over 2 in., an unusual summer event.

Near-zero oxygen levels occurred in January-February 1977. Since the previous several years had been low in rainfall, the depressed oxygen was attributed to high BOD (biological oxygen demand) and/or COD (chemical oxygen demand) materials flushed into the marina.

Acartia spp. are apparently detritivores, and winter runoff may in fact assist in producing the large spring blooms. Since several of the dominant zooplankton are fairly limited to the outer channels, storm waters would tend to sweep the populations out of the marina. *Acartia* appears to reproduce year around (Soule and Oguri, 1979a) and would thus be more rapidly replaced than species with limited reproductive periods.

The decrease in diversity can be seen in comparing the outer stations 1, 2 and 3 (Figures 17-19) with the channel stations 4 and 5 (Figures 20, 21) and the inner stations 6-11 (Figures 22-27).

DISCUSSION

The areal distribution of the species of *Acartia*, *A. tonsa* and *A. californiensis* is in some respects similar to that found by Harbors Environmental Projects for the Los Angeles-Long Beach Harbors (Soule and Oguri, 1979a, b) and in other respects is quite different. The similarity lies in the fact that *A. tonsa* is most abundant in the outer reaches of the harbors and *A. californiensis* has its greatest abundance in the inner portions of the harbors. The difference is that in Los Angeles-Long Beach Harbors the two species of *Acartia* are the dominant organism wherever each occurs in greatest abundance. In Marina del Rey *A. californiensis* is the dominant species throughout the harbor, occurring on the average of 20 to 50 times more frequently than *A. tonsa* (see legends on Figure 2).

Acartia californiensis appears to be dominant or abundant in Los Angeles-Long Beach Harbors in areas with apparently reduced circulation and/or heavier detrital loadings. These areas are in the inner harbor channels, at stations A10, D10 and A7 (HEP, 1979). Since Marina del Rey is a blind harbor, *i.e.*, with no flow-through ocean circulation, *A. californiensis* is more numerous than *A. tonsa*.

It has already been shown that *Acartia californiensis* makes up nearly 95% of the total zooplankton in Marina del Rey. Since this dominance is greatest in the inner portions of the harbor, it would be expected that most other zooplankton would have a pattern of very low abundance in the inner portion and greater abundance near and at the entrance of Marina del Rey. This is the type of pattern found in the other two abundant copepods, *Paracalanus parvus* and *Corycaeus anglicus*; the three dominant cladocerans, *Podon polyphemoides*, *Evadne nordmanni* and *Penilia avirostris*; and the larvaceans.

The temporal distribution of *Acartia* spp. in Marina del Rey showed a strong increase in numbers during the month of April for 1977-1978 and April-May in 1979. A similar spring increase was found by HEP (Soule and Oguri, 1979a, b) for *Acartia* spp. in the Los Angeles-Long Beach Harbors, but the increase reached its peak in June and declined in July and August. Thus it appears that the increase lasted two to three months longer in Los Angeles-Long Beach than it did in Marina del Rey. The difference in the species of *Acartia* that dominated the samples at each harbor facility may account for this. While *A. californiensis* represented 97% of the *Acartia* spp. in Marina del Rey, only the inner Los Angeles Harbor "C" stations showed a dominance of this species in Los Angeles Harbor. Thus, in overall collection, *A. tonsa* was dominant in more than two-thirds of the stations sampled in Los Angeles-Long Beach Harbors. The maximum abundance of *A. californiensis* in June was also found by Harbors Environmental Projects in Los Angeles-Long Beach Harbors at the inner harbor C stations, where *A. californiensis* dominated. At the outer Los Angeles-Long Beach Harbor stations, where *A. tonsa* dominated, the maximum seasonal abundance extended into July. This would account for the extended peak season.

Characteristically, Marina del Rey appeared to have greater concentrations of zooplankton than those found in Los Angeles-Long Beach Harbors. During the three years of sampling in Marina del Rey, the mean concentration of zooplankton was 3.5 times that of Los Angeles-Long Beach Harbors. Nearly all of the increased zooplankton concentration in Marina del Rey was due to the much greater concentration of *Acartia* spp., *i.e.*, seven times greater than that found in Los Angeles-Long Beach Harbors. While the *Acartia* spp. dominated in Marina del Rey, almost all other groups of zooplankton occurred in lower concentrations in the marina than in Los Angeles-Long Beach Harbors. The exception to this was the *Evadne* spp. (*E. nordmanni* and *E. spinifera*), which, with *Acartia* spp., also occurred in greater concentrations in the marina.

Because of the dominance of *Acartia* spp. and the relative paucity of other zooplankton groups, except for *Evadne* spp., as compared to Los Angeles-Long Beach Harbors, the Shannon-Wiener diversity index for the three years of marina sampling was much lower (.44) than it was in Los Angeles-Long Beach Harbors (1.11) in the 1978 sampling period.

The Los Angeles-Long Beach Harbors have two distinct types of planktonic habitat. These areas are the outer harbor waters, with relatively good ocean circulation, and the inner harbor channels, with poorer circulation, greater pollution, or greater variability in temperature, salinity, oxygen and pH. Each area has its dominant zooplanktonic organism and characteristic species diversity, the outer harbor with *A. tonsa* and high diversity, and the inner harbor with *A. californiensis* and lower species diversity. The results of the Marina del Rey studies showed an extreme dominance of *A. californiensis* and an extremely low species diversity (sometimes zero in the inner slips). These data point to the conclusion that Marina del Rey, particularly the inner portion, has higher levels of pollution, extremely poor ocean circulation, and/or a wide range of variability in water quality.

In previous studies extensive computer analysis has been carried out (AHF, 1976; Soule and Oguri, 1978; 1979a,b), but the resultant species and site dendrograms and classification maps require close inspection and interpretation. The computer plot program used in Figures 17-27 does not provide any analysis of statistical significance. However, it does better provide for visual inspection of the data in a direct fashion of parameters that are accepted as limiting factors.

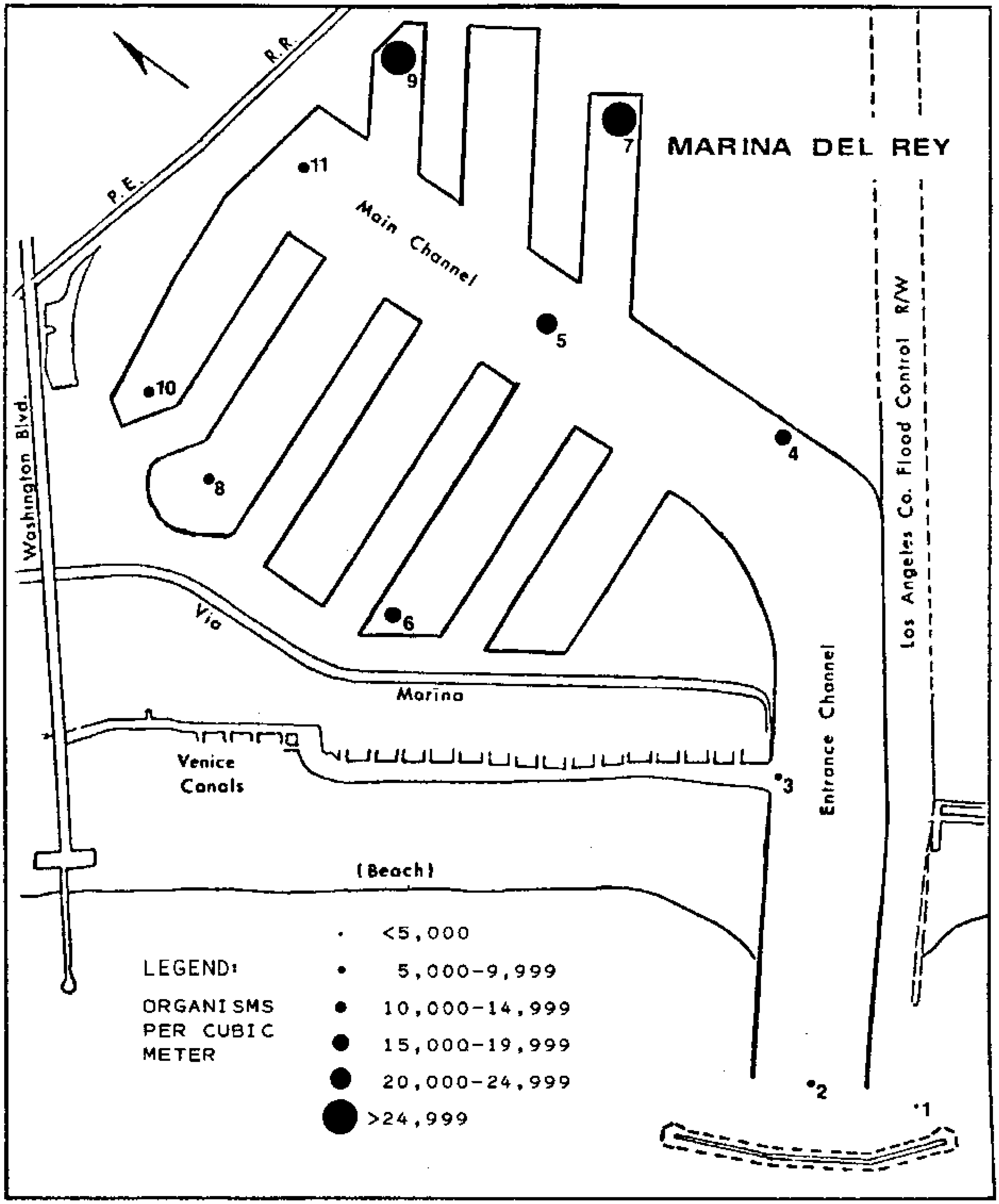


Figure 1. Mean spatial distribution of *Acartia* spp., July 1976-June 1979.

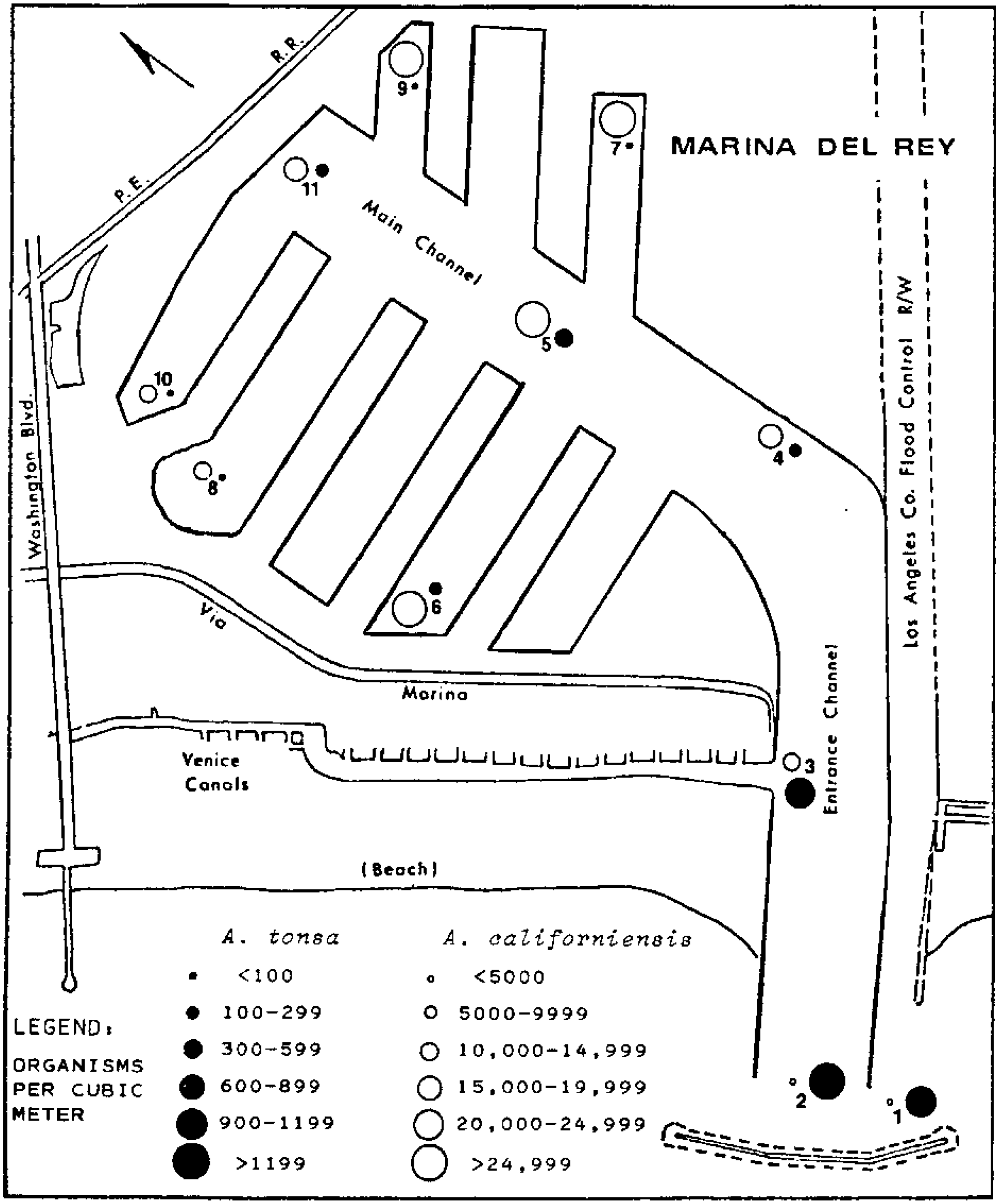


Figure 2. Mean spatial distribution of *Acartia tonsa* and *Acartia californiensis*, July 1978-June 1979.

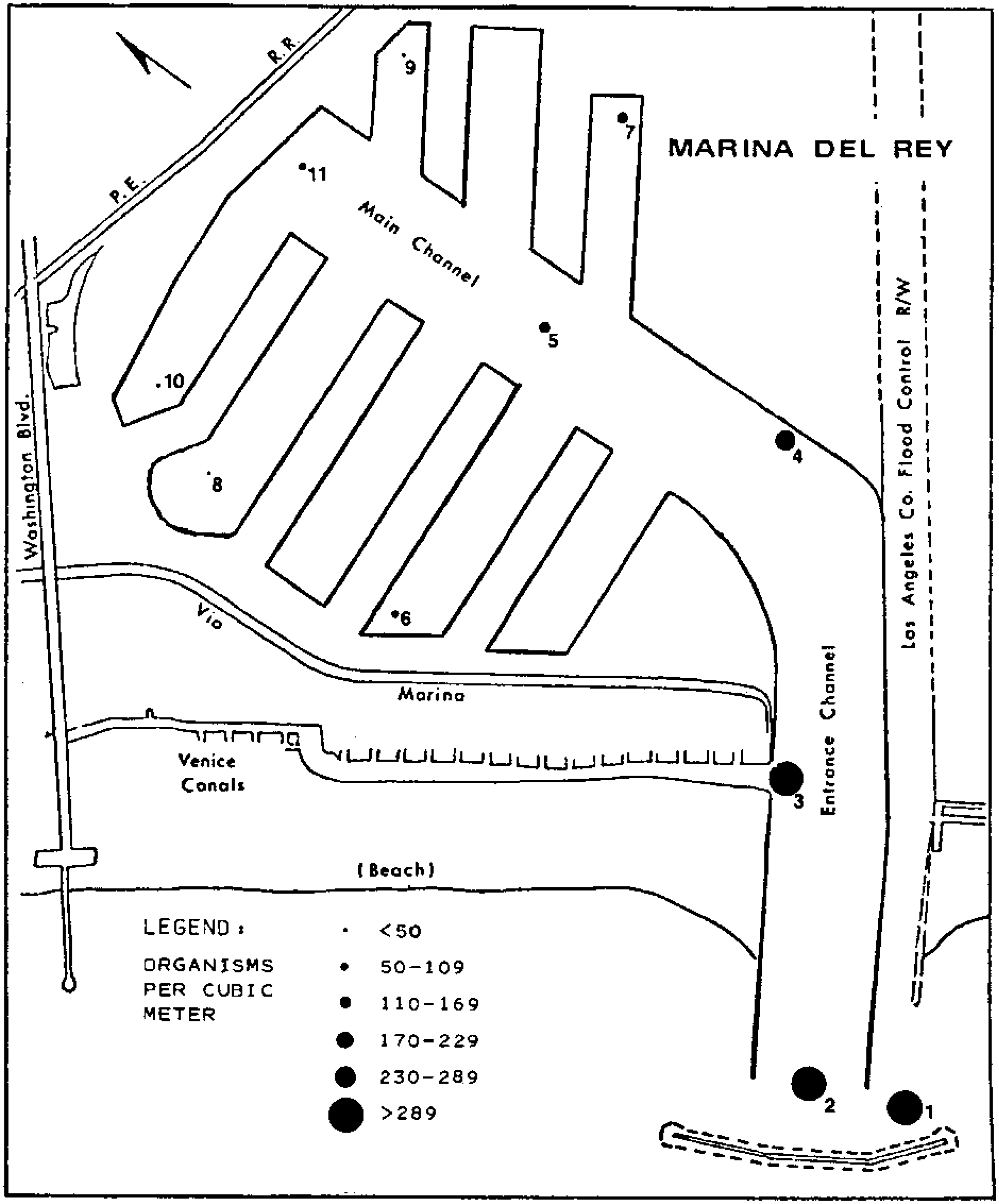


Figure 3. Mean spatial distribution of *Paracalanus parvus*, July 1976-June 1979.

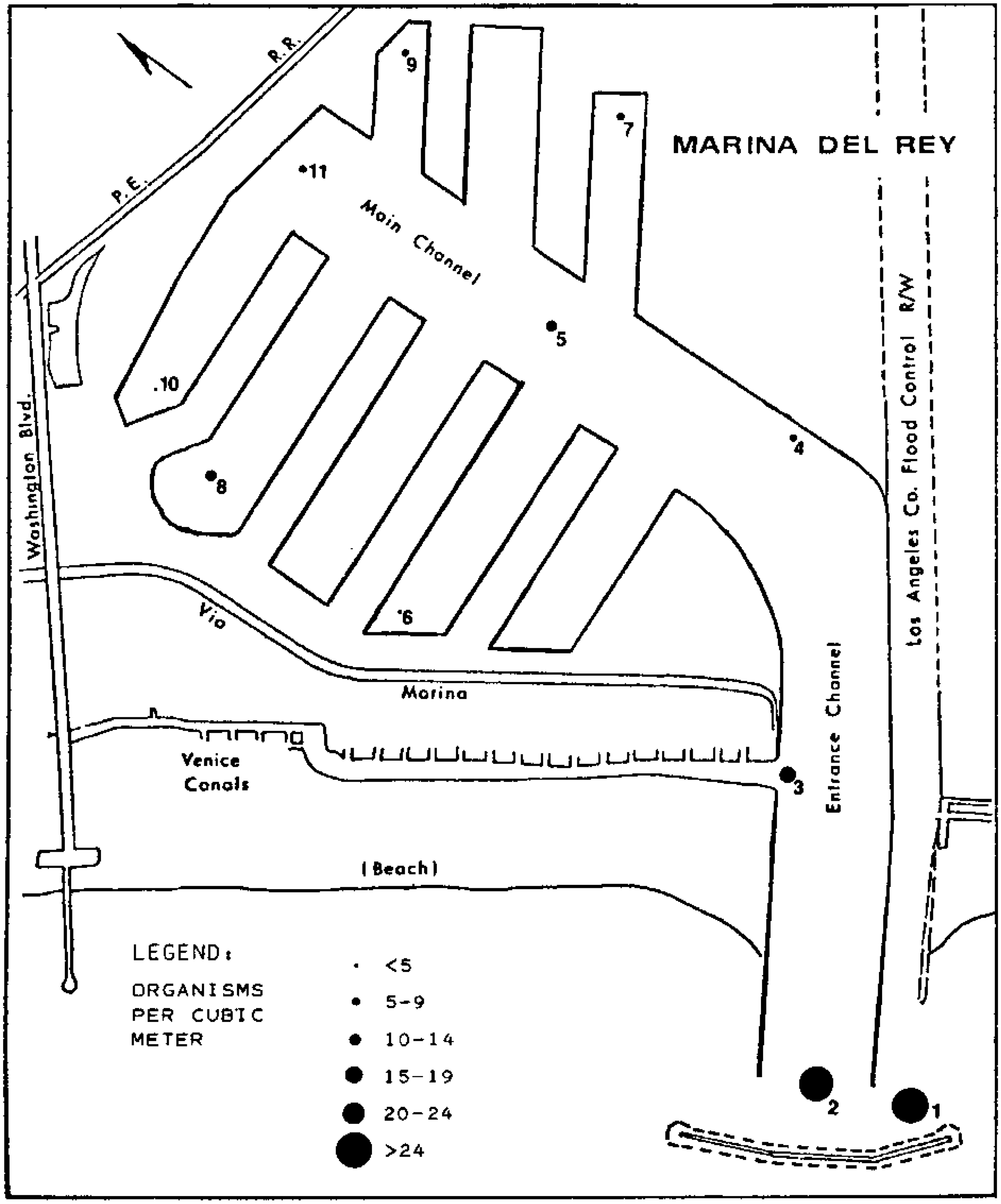


Figure 4. Mean spatial distribution of *Corycaeus anglicus*, July 1976-June 1979.

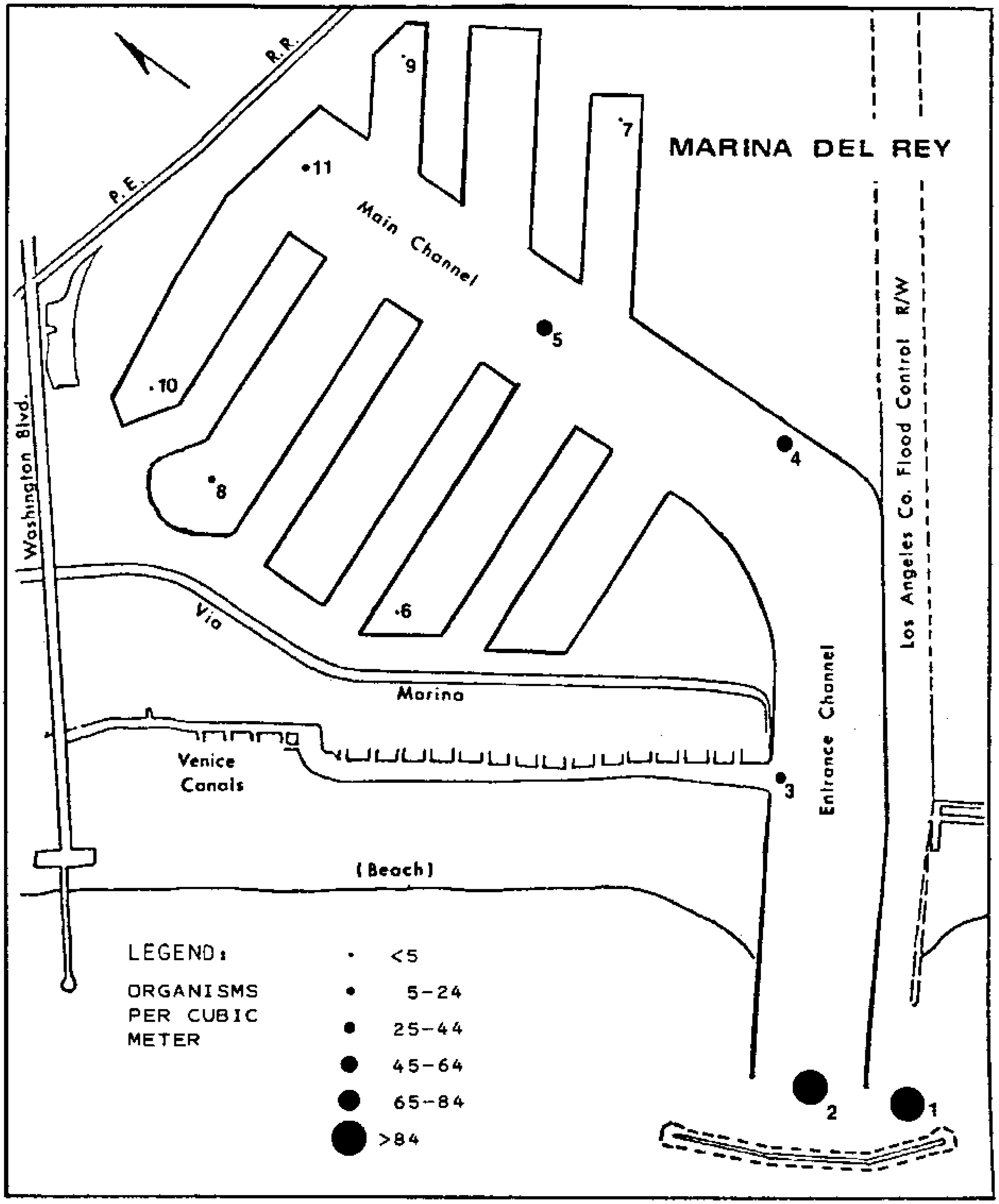


Figure 5. Mean spatial distribution of *Podon polyphemoides*, July 1976-June 1979.

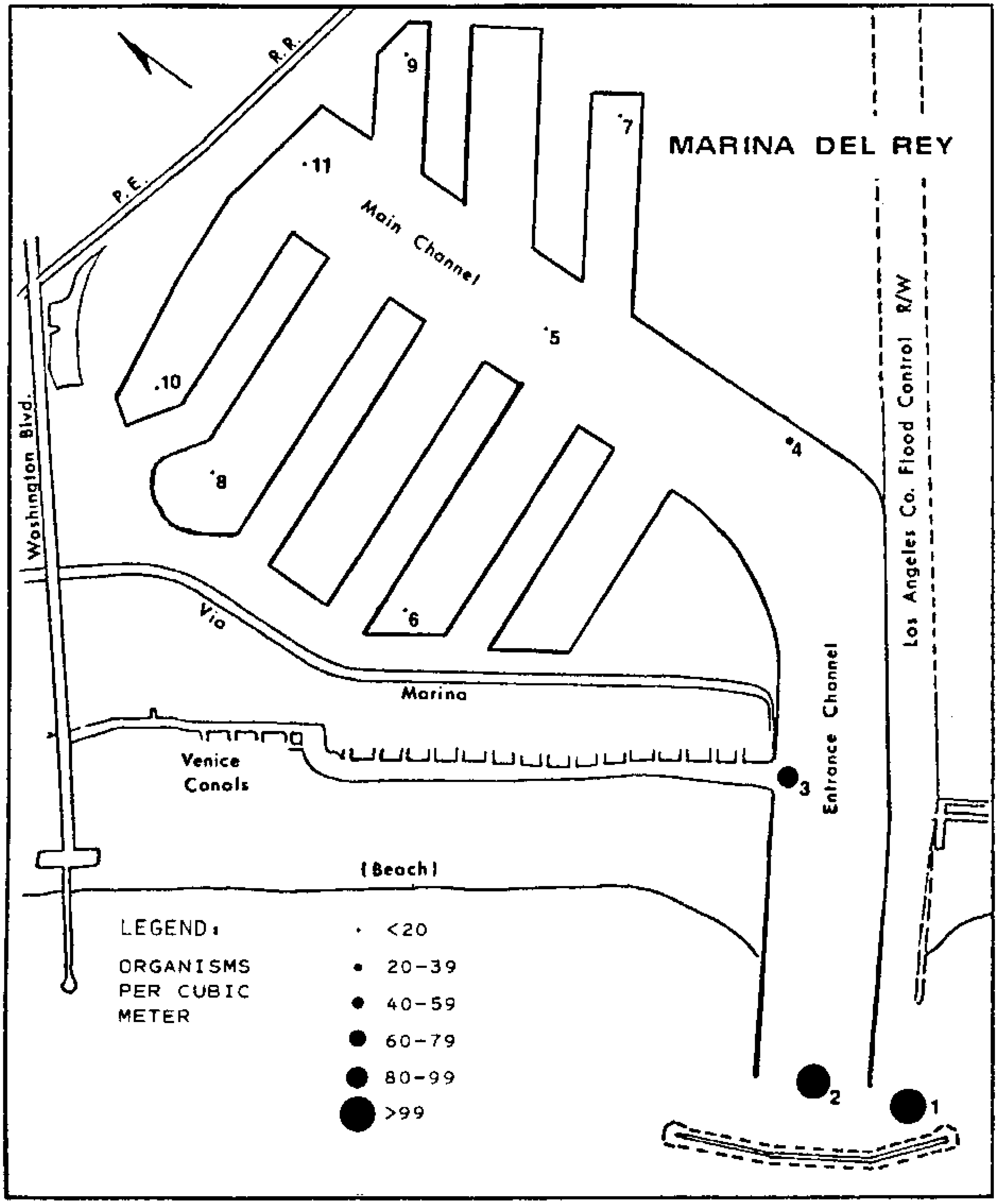


Figure 6. Mean spatial distribution of *Evadne nordmanni*, July 1976-June 1979.

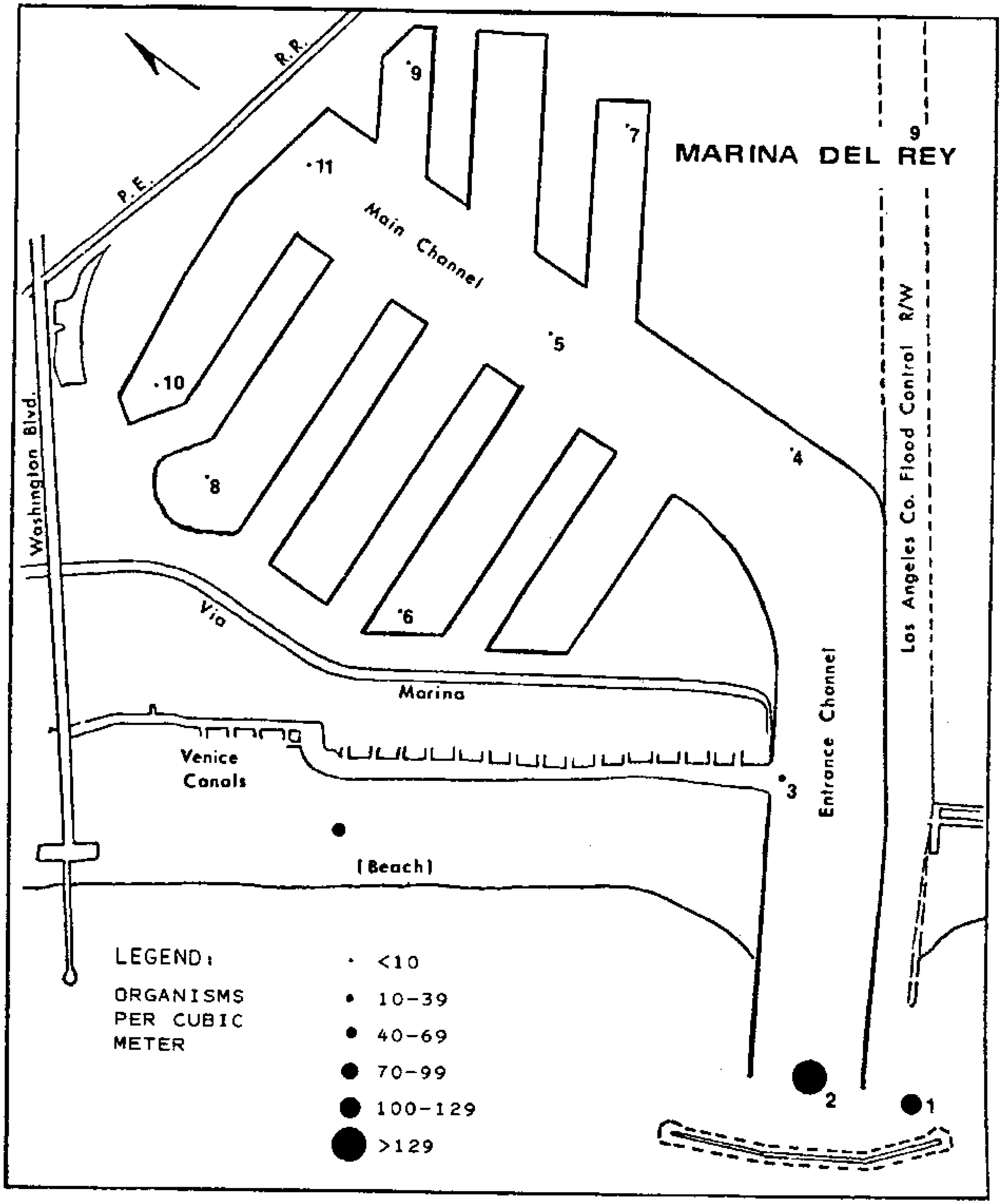


Figure 7. Mean spatial distribution of *Penilia avirostris*, July 1976-June 1979.

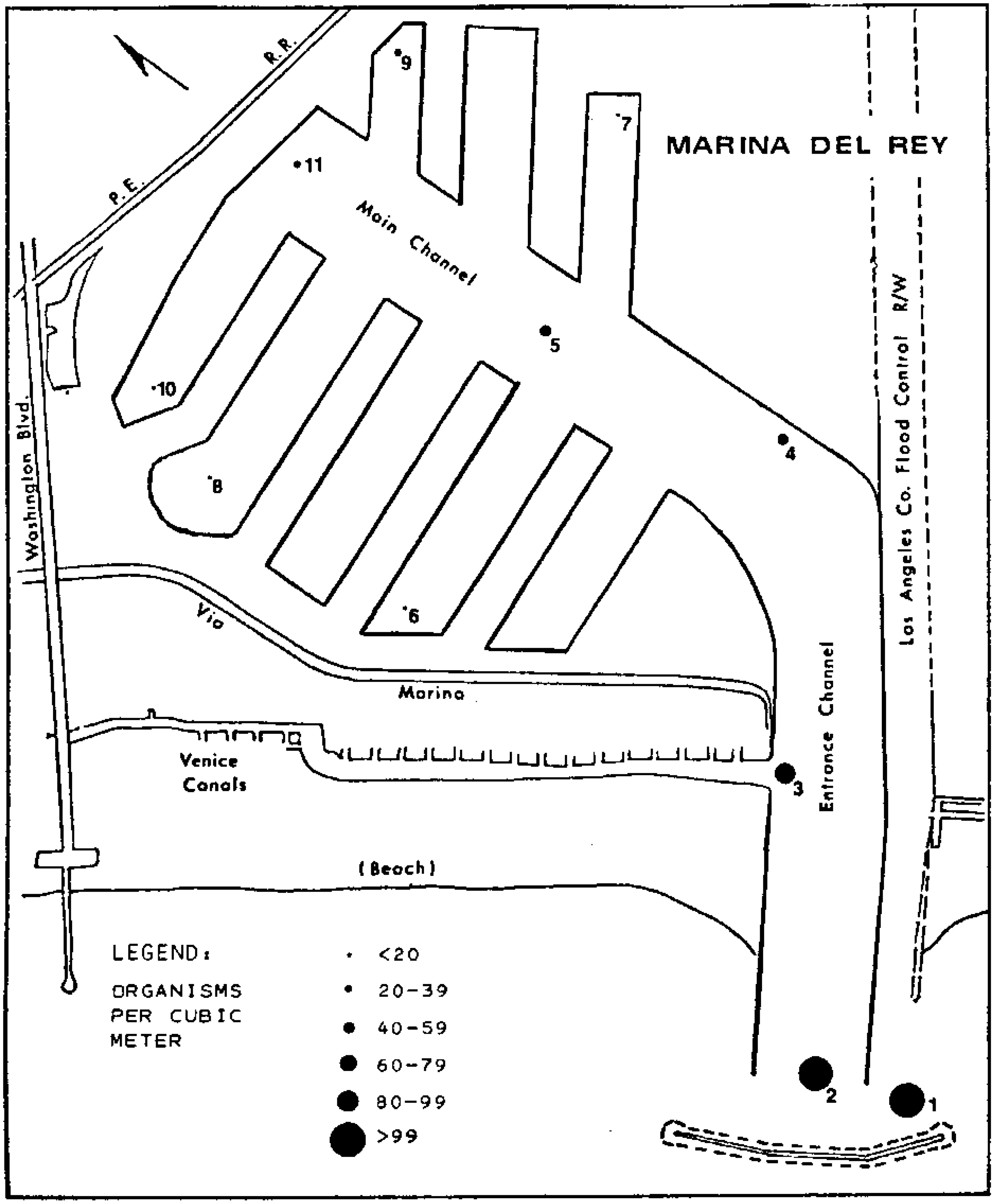


Figure 8. Mean spatial distribution of larvacea, July 1976-June 1979.

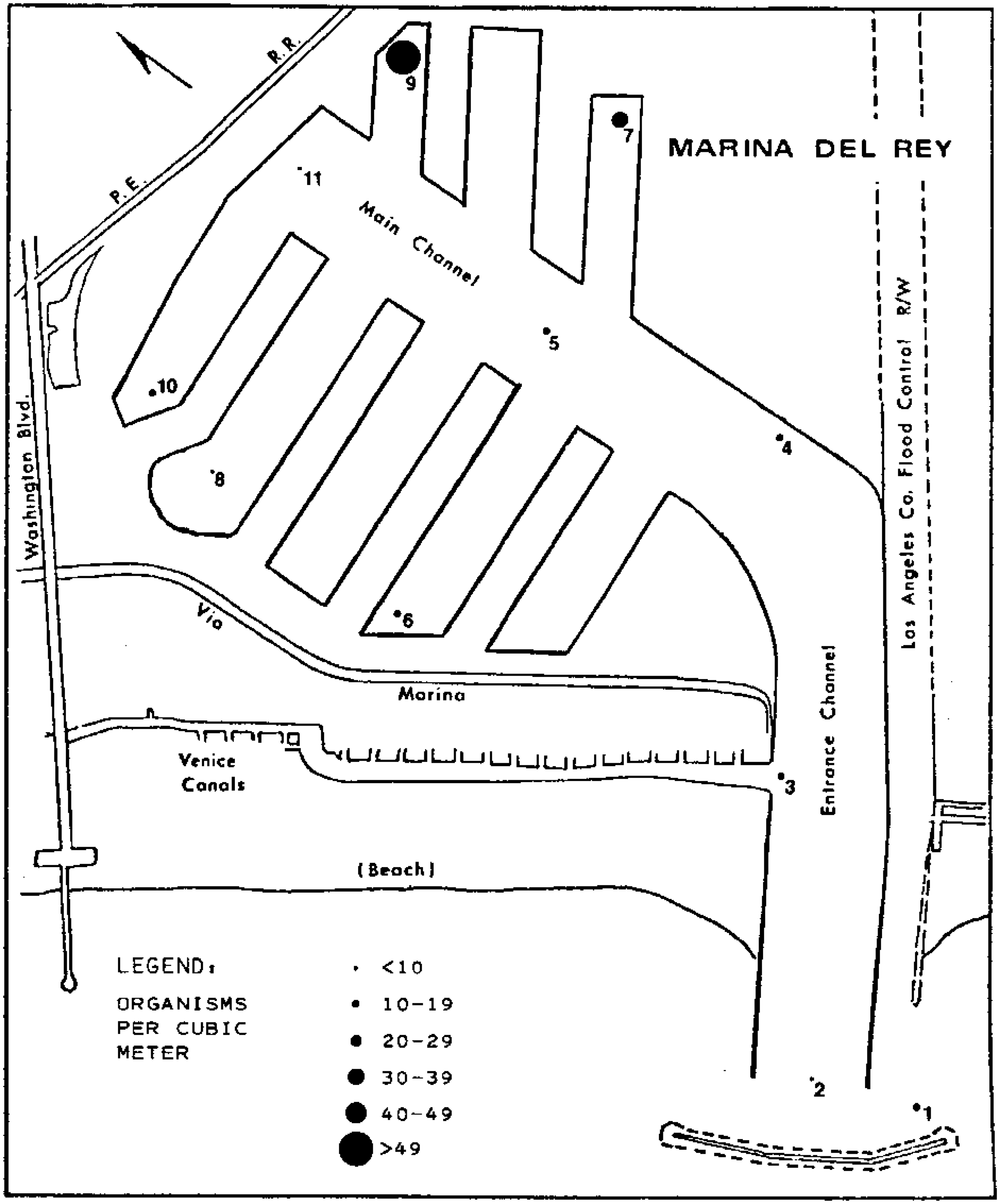


Figure 9. Mean spatial distribution of brachyura zoea, July 1976-June 1979.

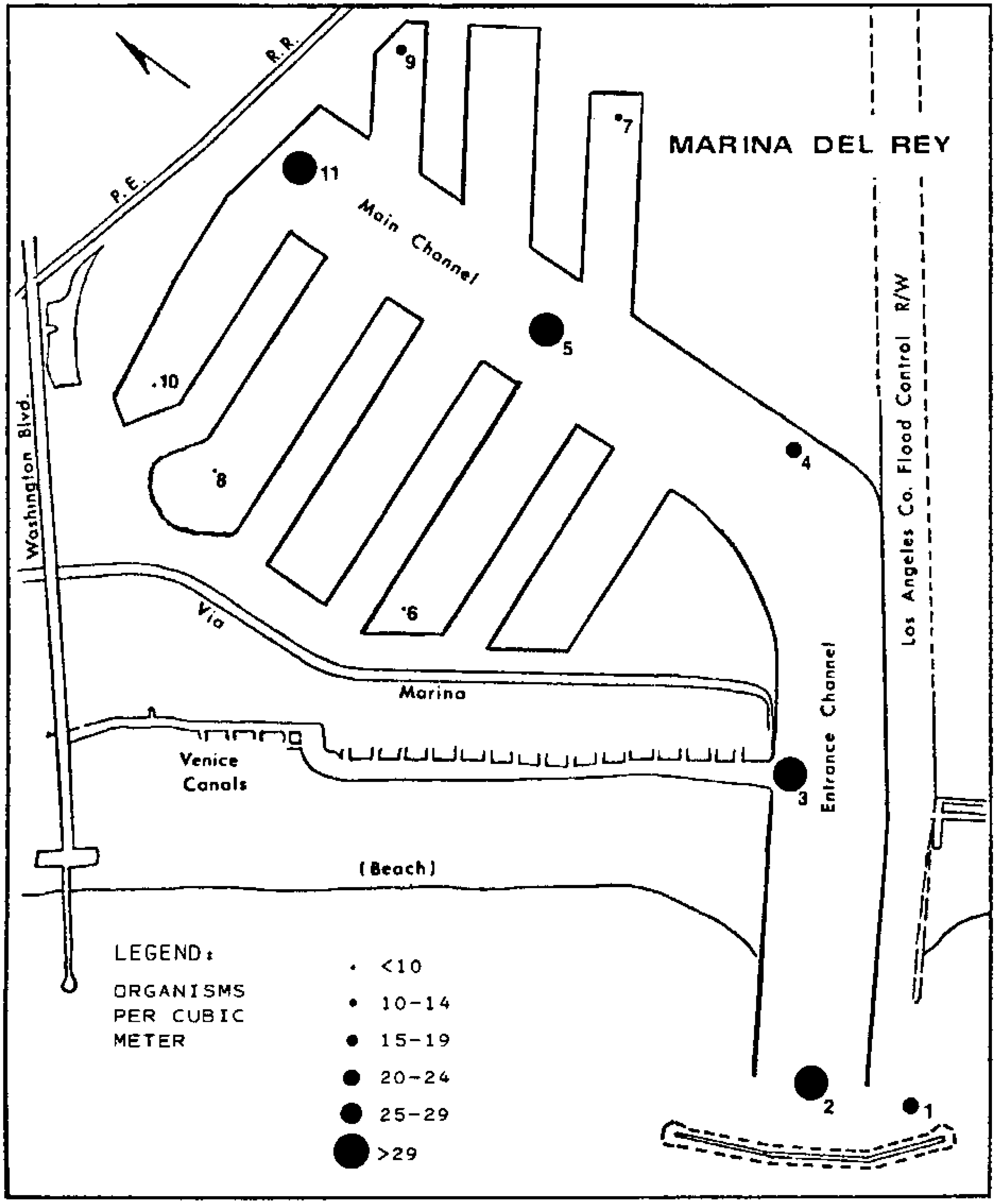


Figure 10. Mean spatial distribution of Cirripedia nauplius, July 1976-June 1979.

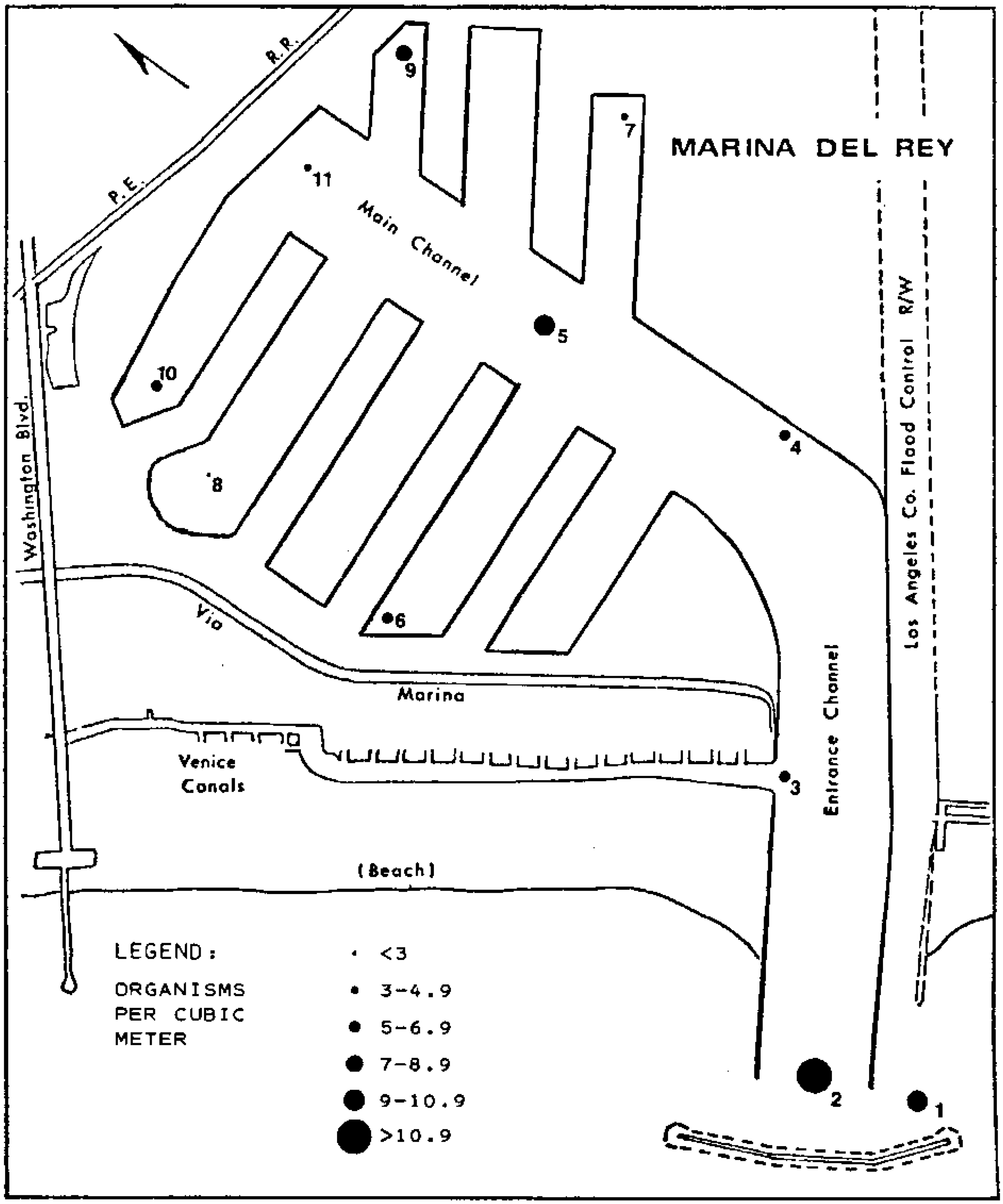


Figure 11. Mean spatial distribution of fish eggs and larvae, July 1976-June 1979.

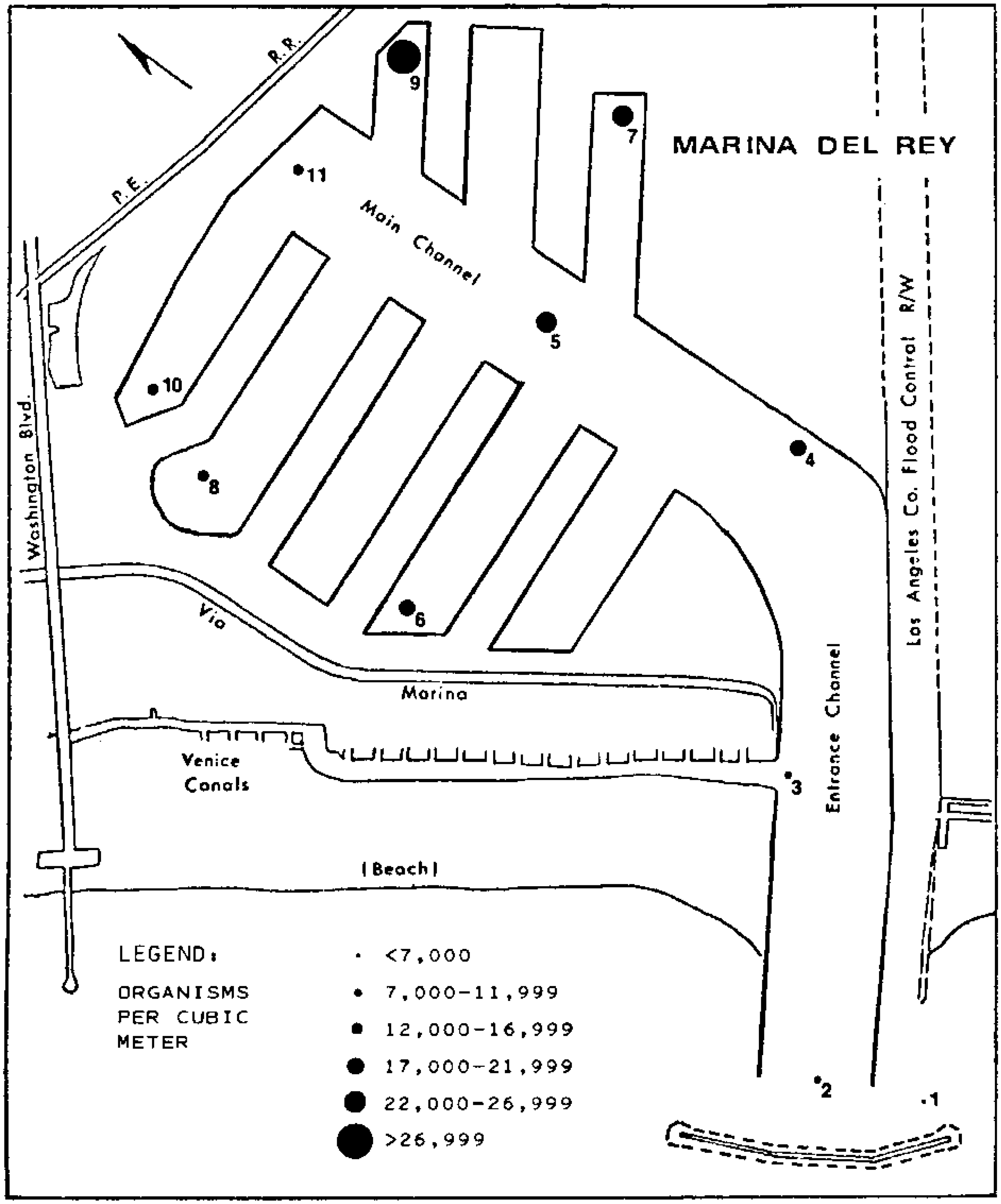


Figure 12. Mean spatial distribution of total zooplankton, July 1976 - June 1979.

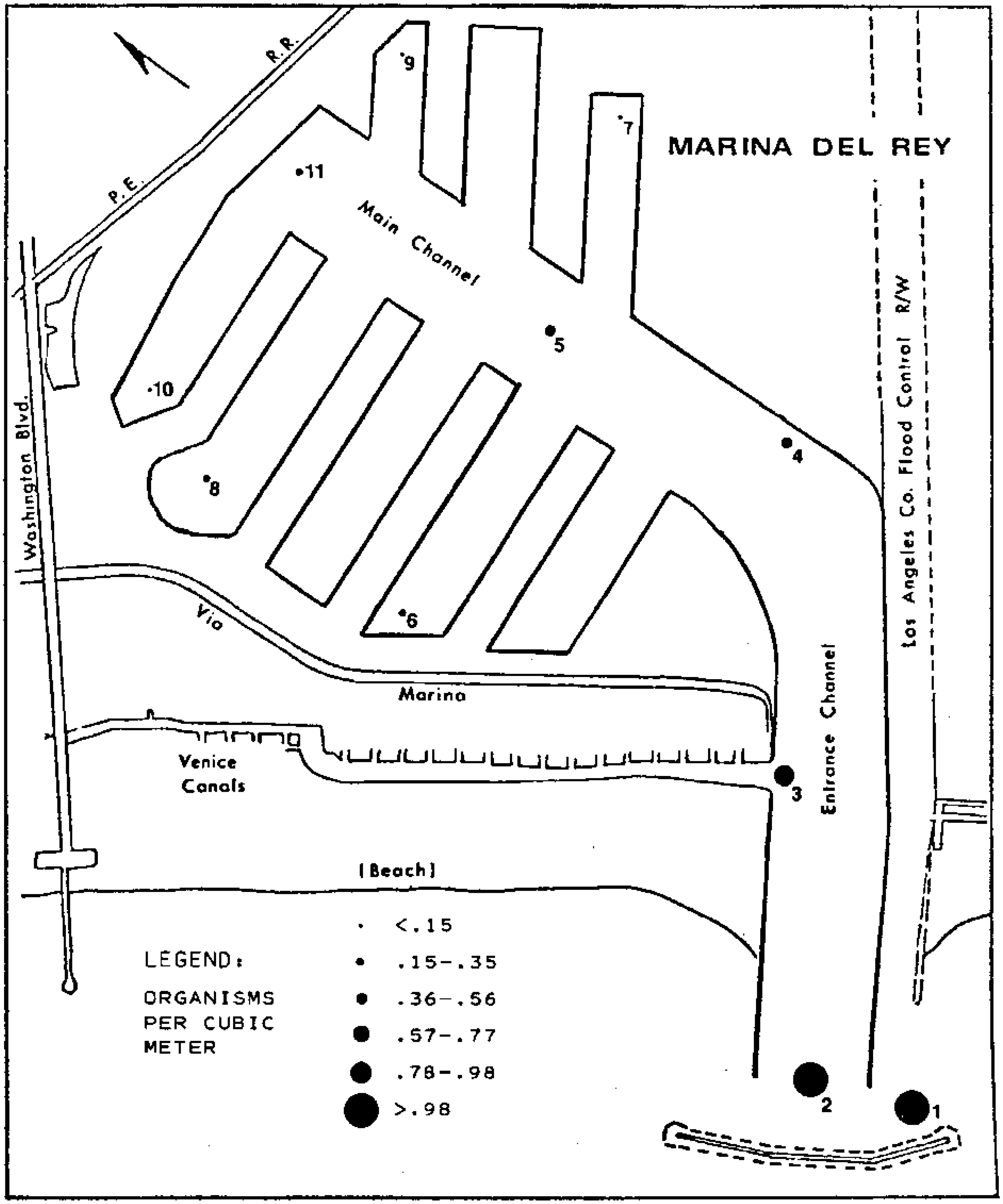


Figure 13. Mean spatial distribution of zooplankton Shannon Wiener Diversity Index, July 1976-June 1979.

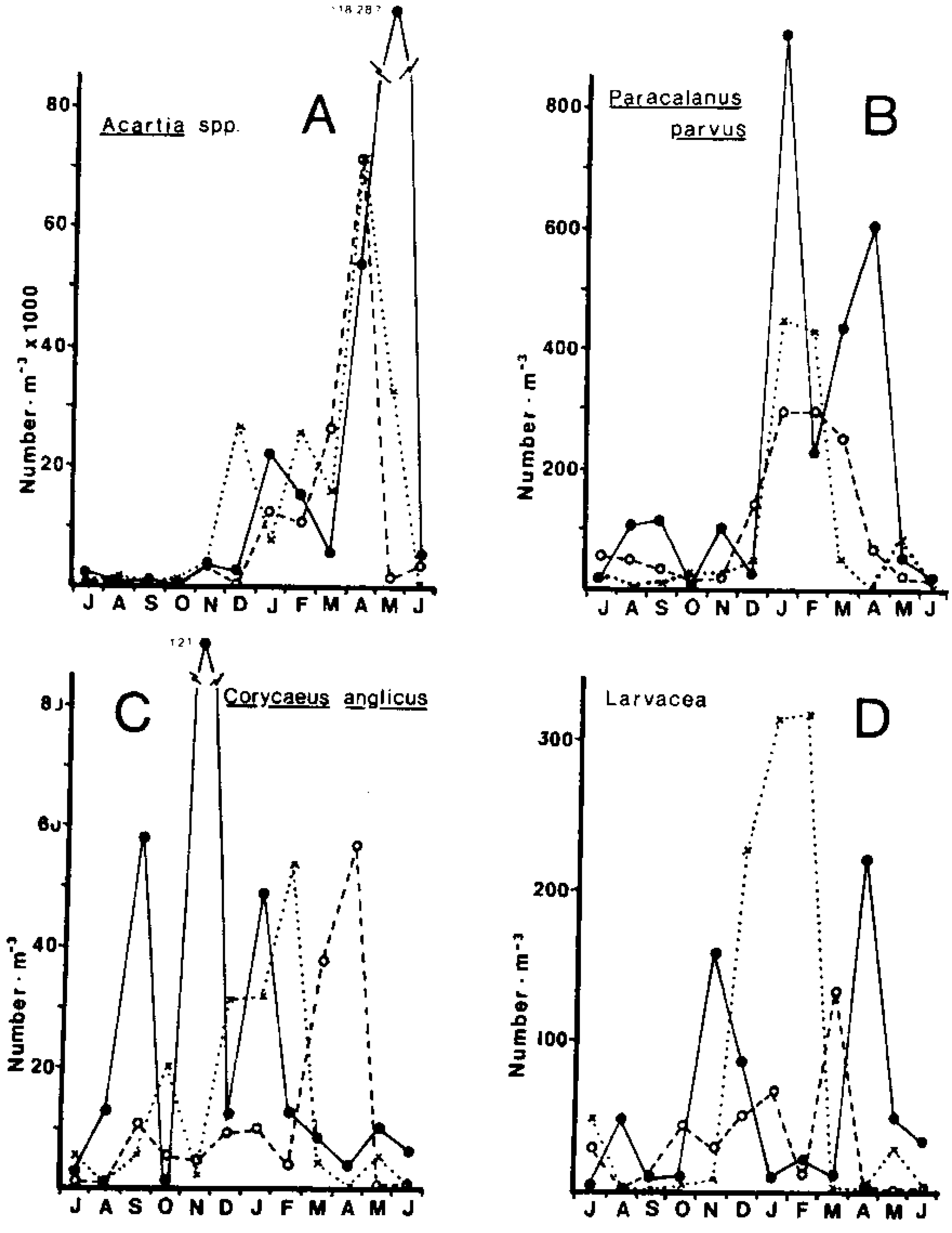


Figure 14. Temporal distribution of *Acartia* spp. (A); *Paracalanus parvus* (B): *Corycaeus anglicus* (C), and larvacea (D).
x····x : July 1976–June 1977; o---o: July 1977–June 1978; •——• : July 1978–June 1979.

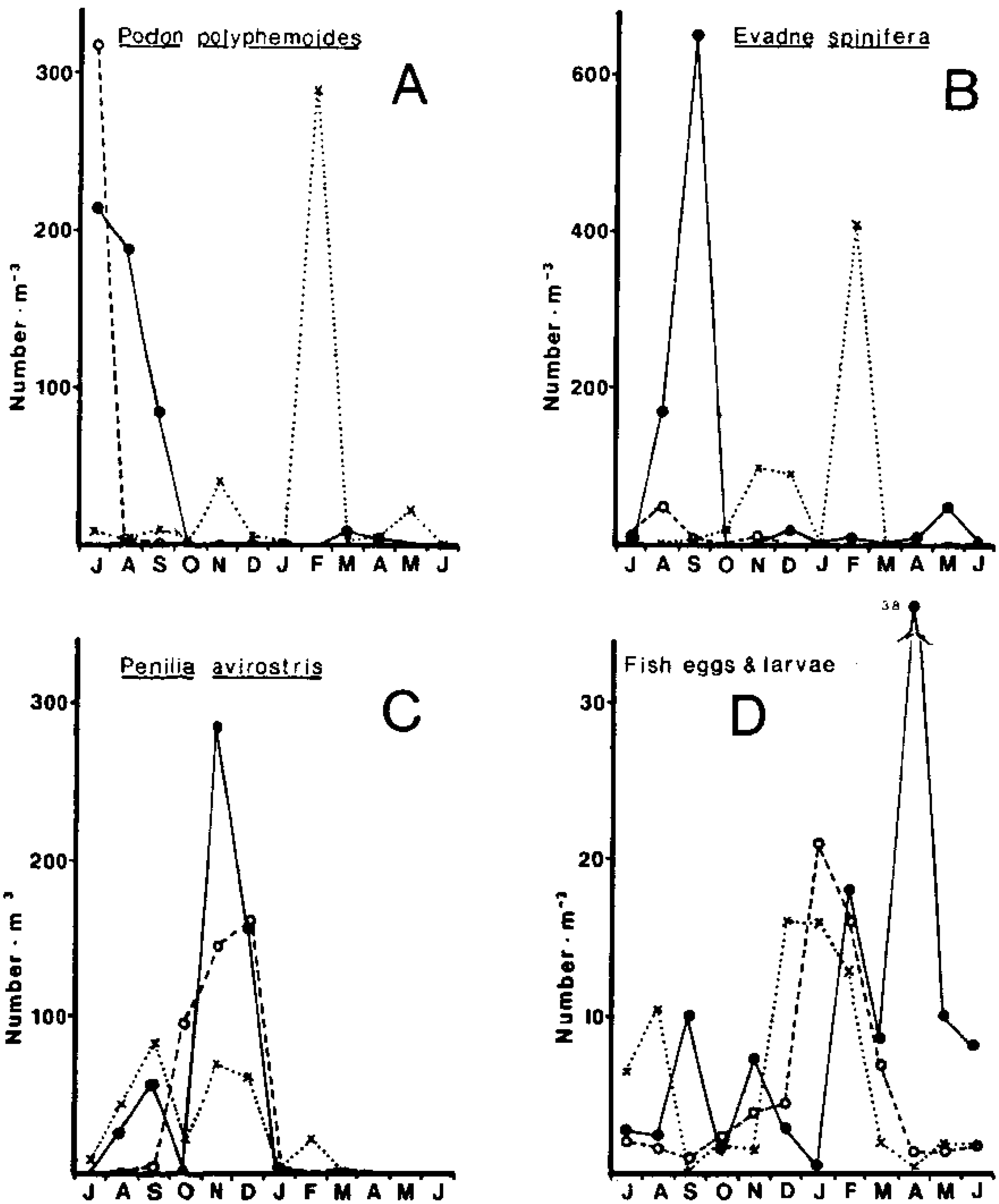


Figure 15. Temporal distribution of *Podon polyphemoides* (A); *Evadne spinifera* (B); *Penilia avirostris* (C); fish eggs and larvae (D).

x····x : July 1976-June 1977; o---o : July 1977-June 1978; ●—● : July 1978-June 1979.

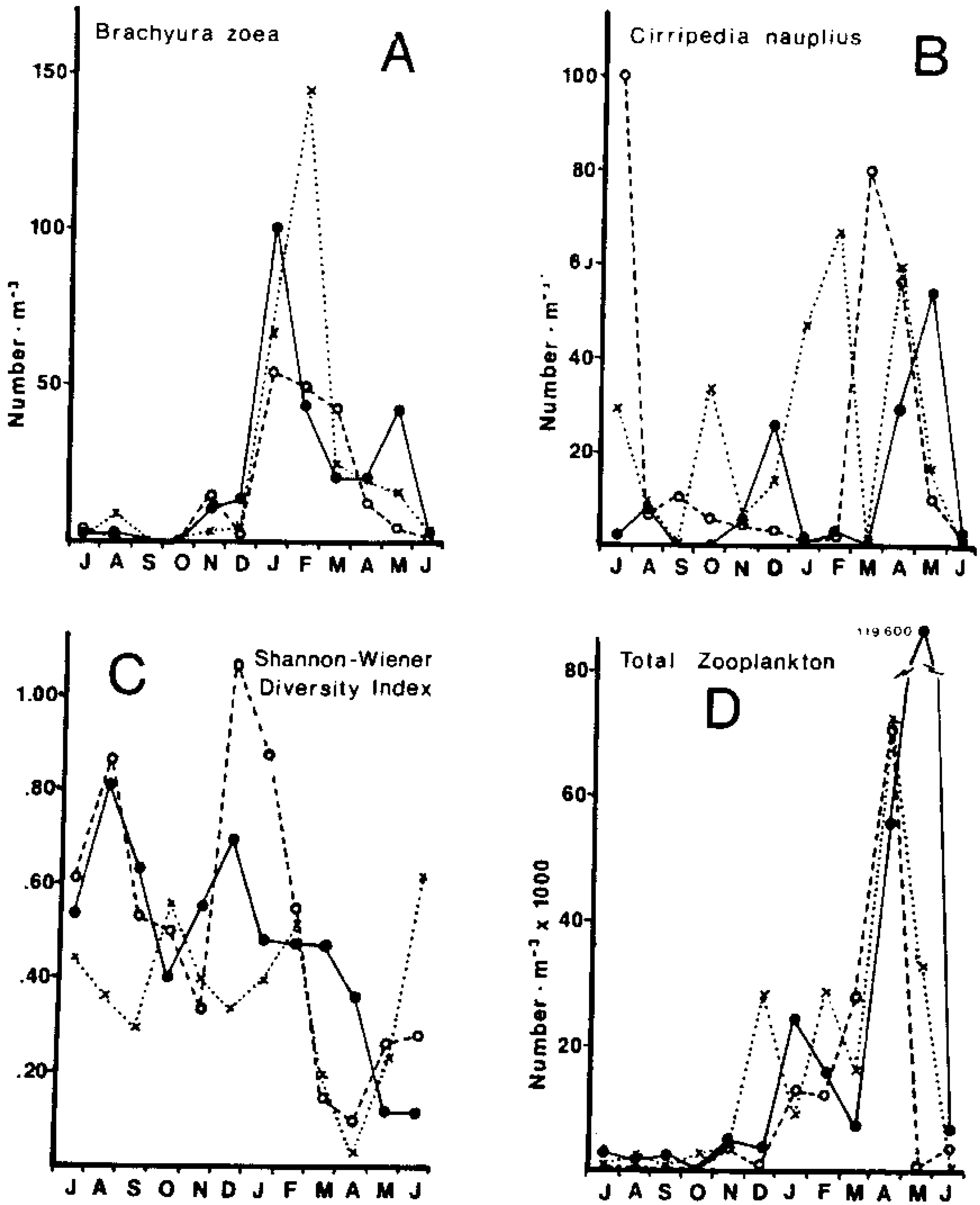


Figure 16. Temporal distribution of brachyura zoea (A); cirripedia nauplius (B); Shannon-Wiener diversity index (C); and total zooplankton (D).

x····x: July 1976-June 1977; o---o: July 1977-June 1978;
●——●: July 1978-June 1979.

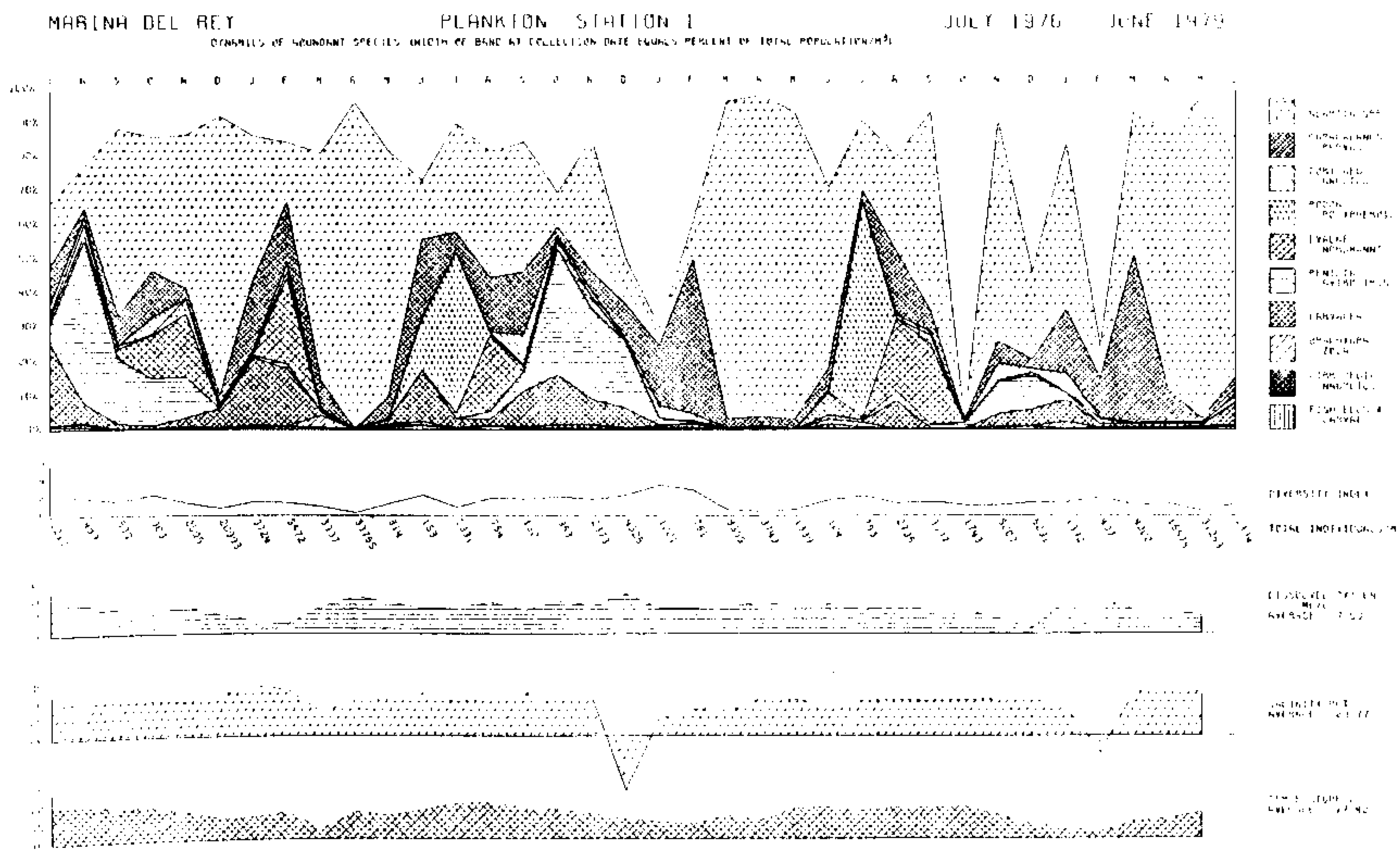


Figure 17. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

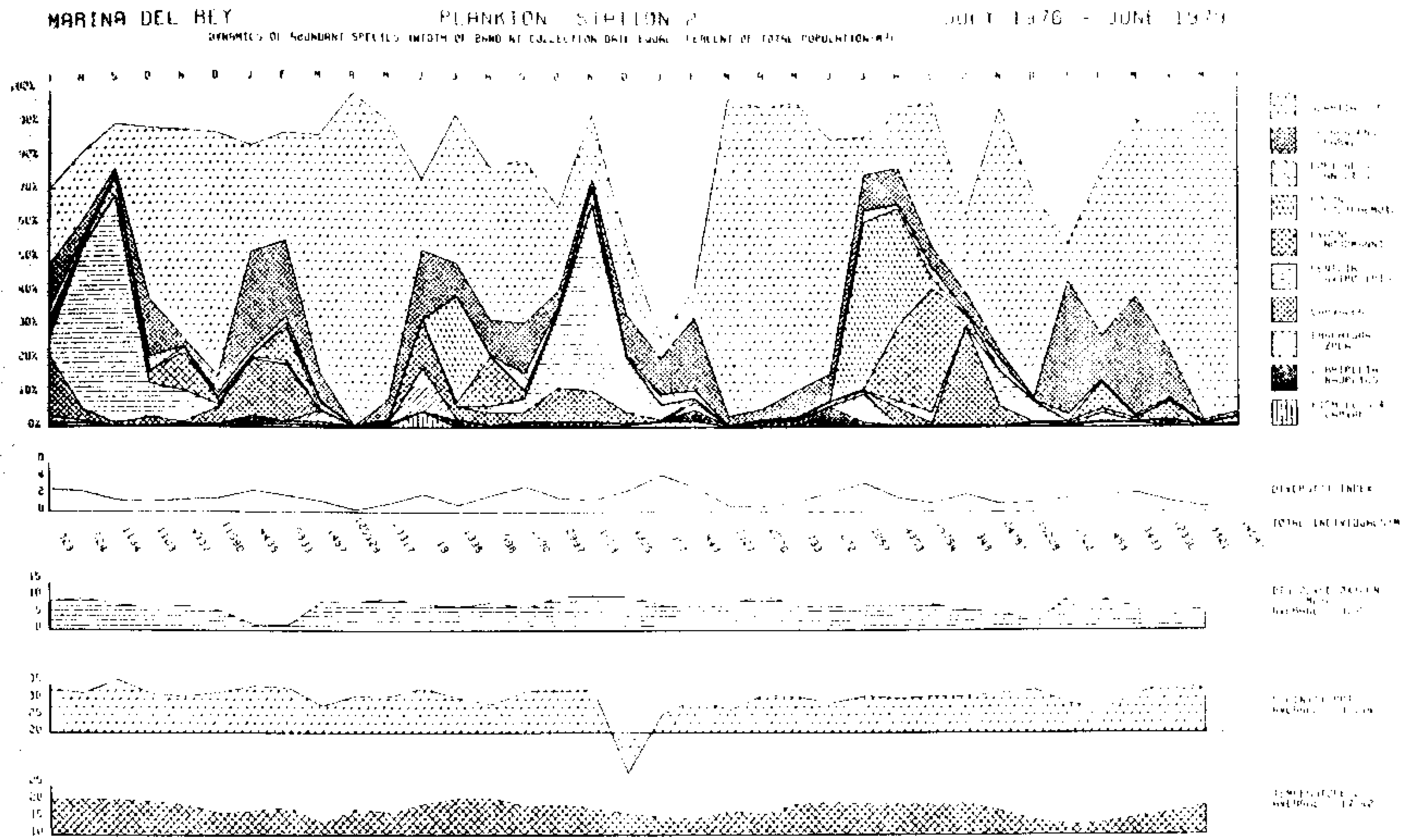


Figure 18. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

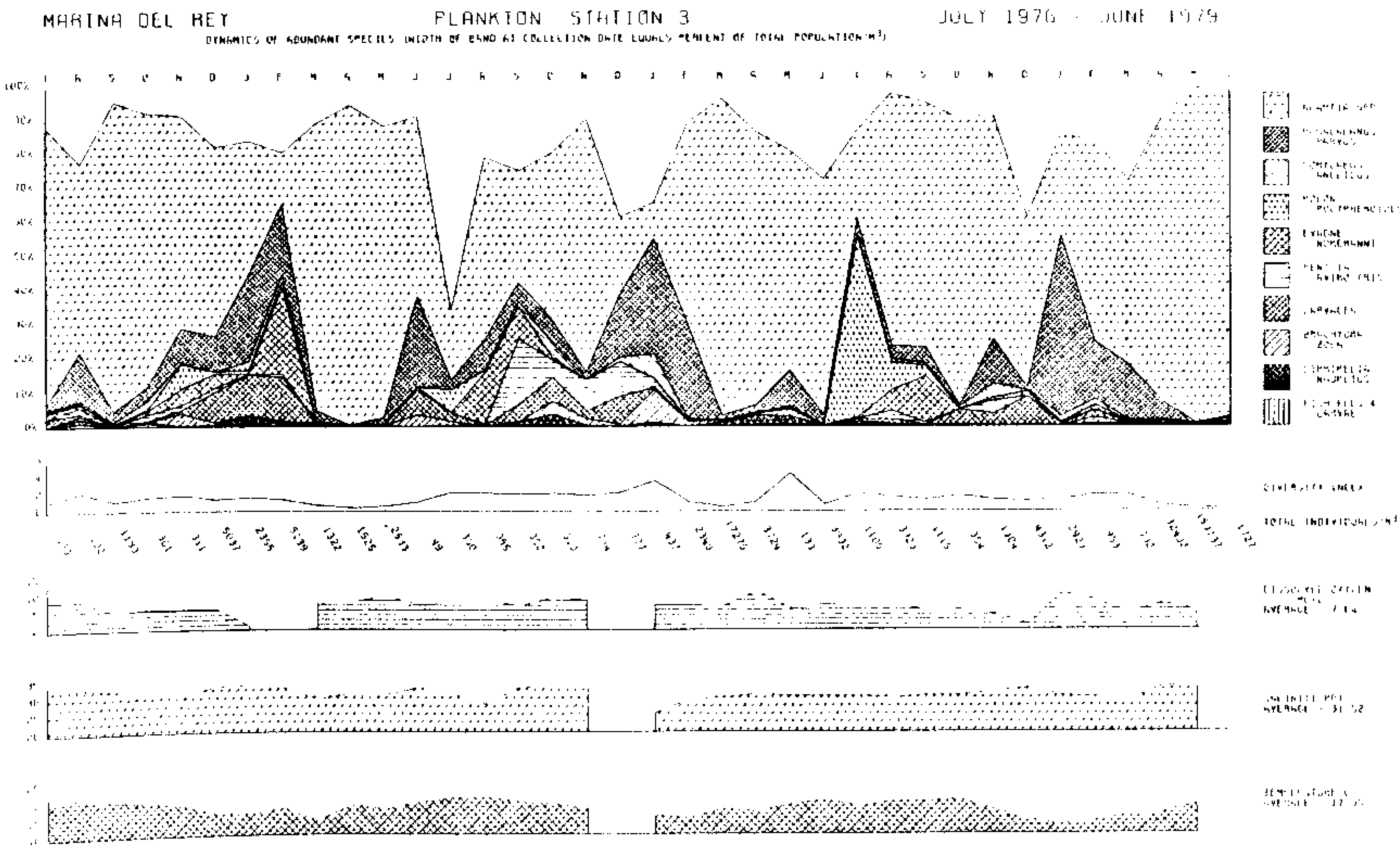


Figure 19. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m³, Diversity Index, Dissolved Oxygen, Salinity and Temoeratures.

(Percentages are cumulative for each species).

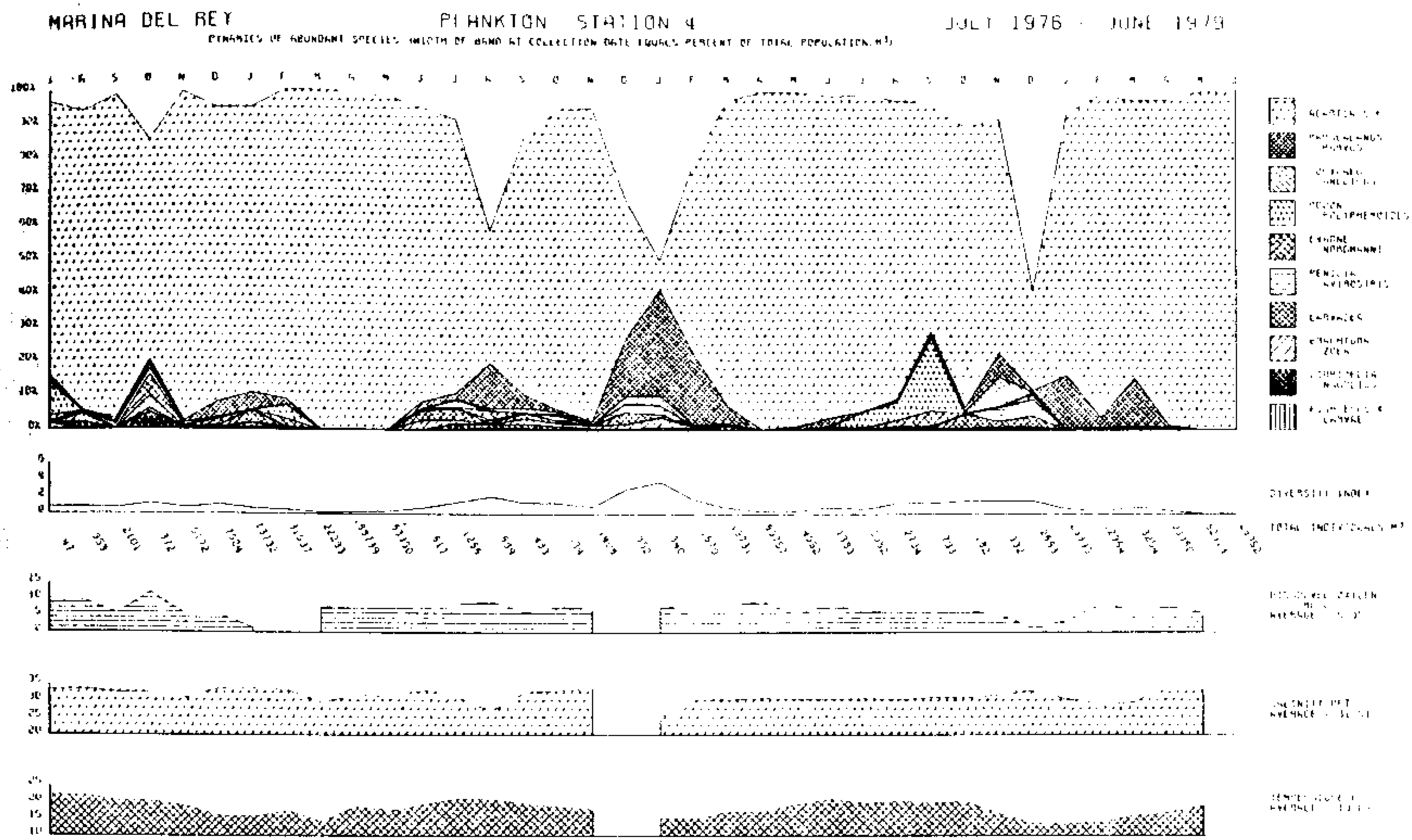


Figure 20. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m³, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

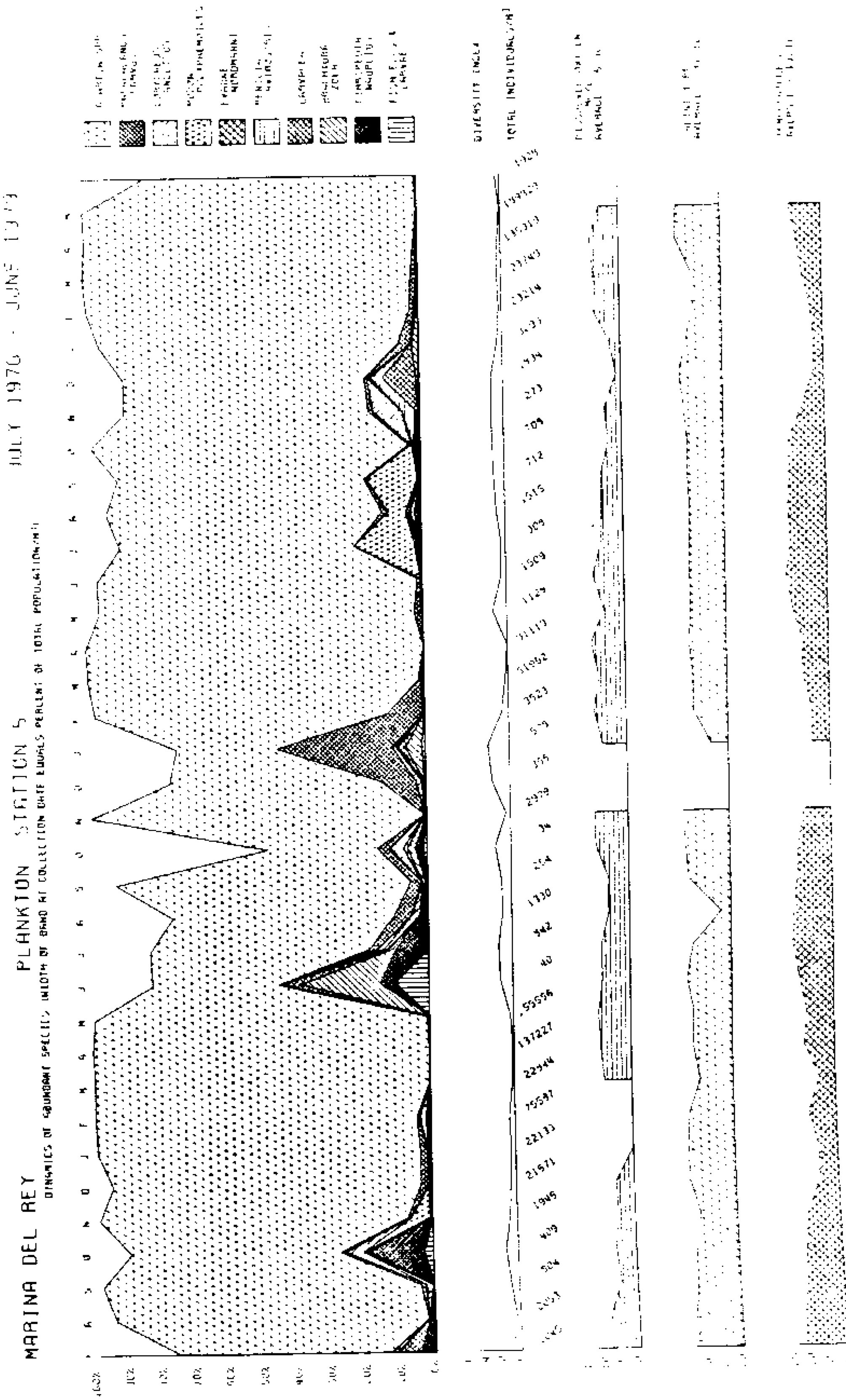


Figure 21. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

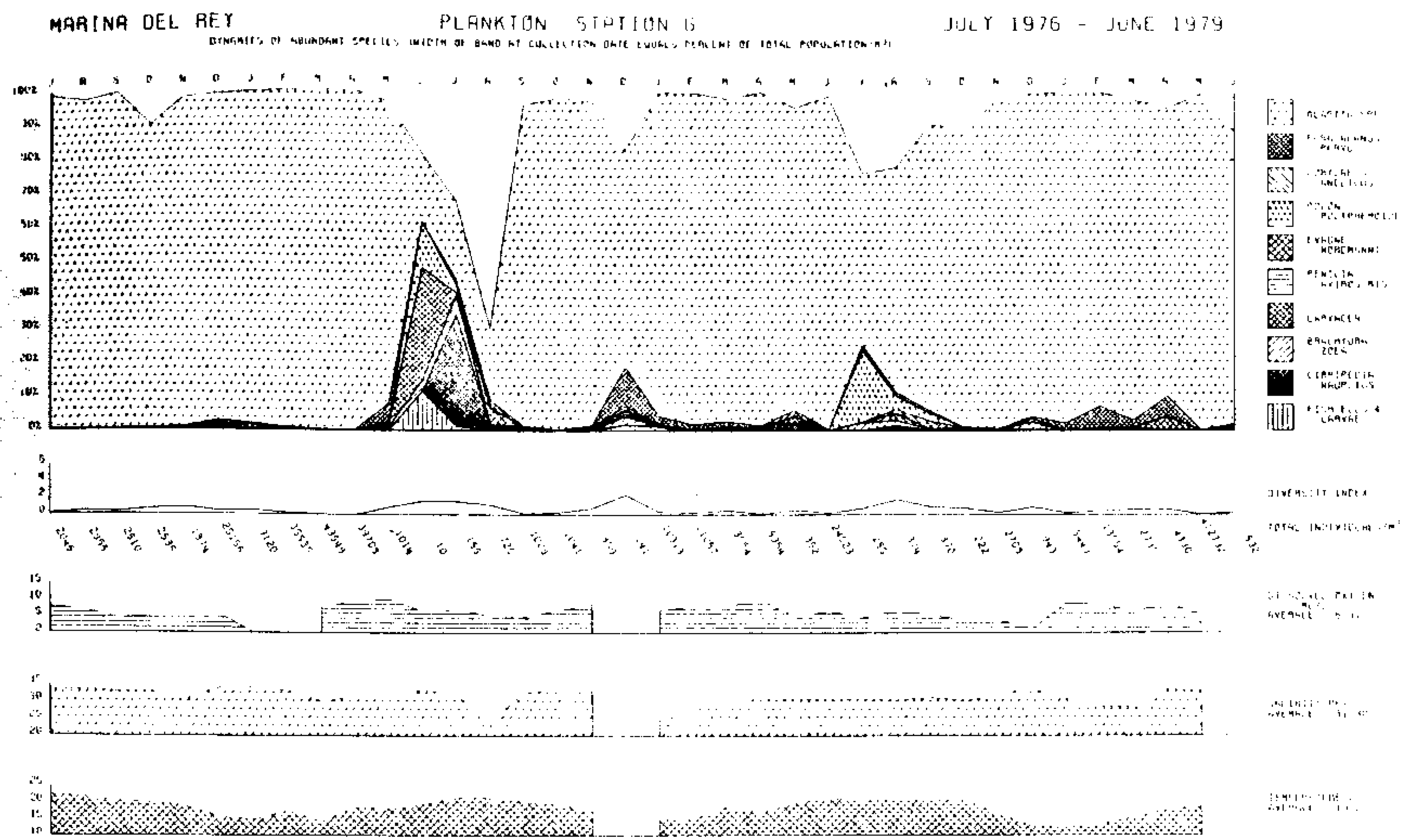


Figure 22. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

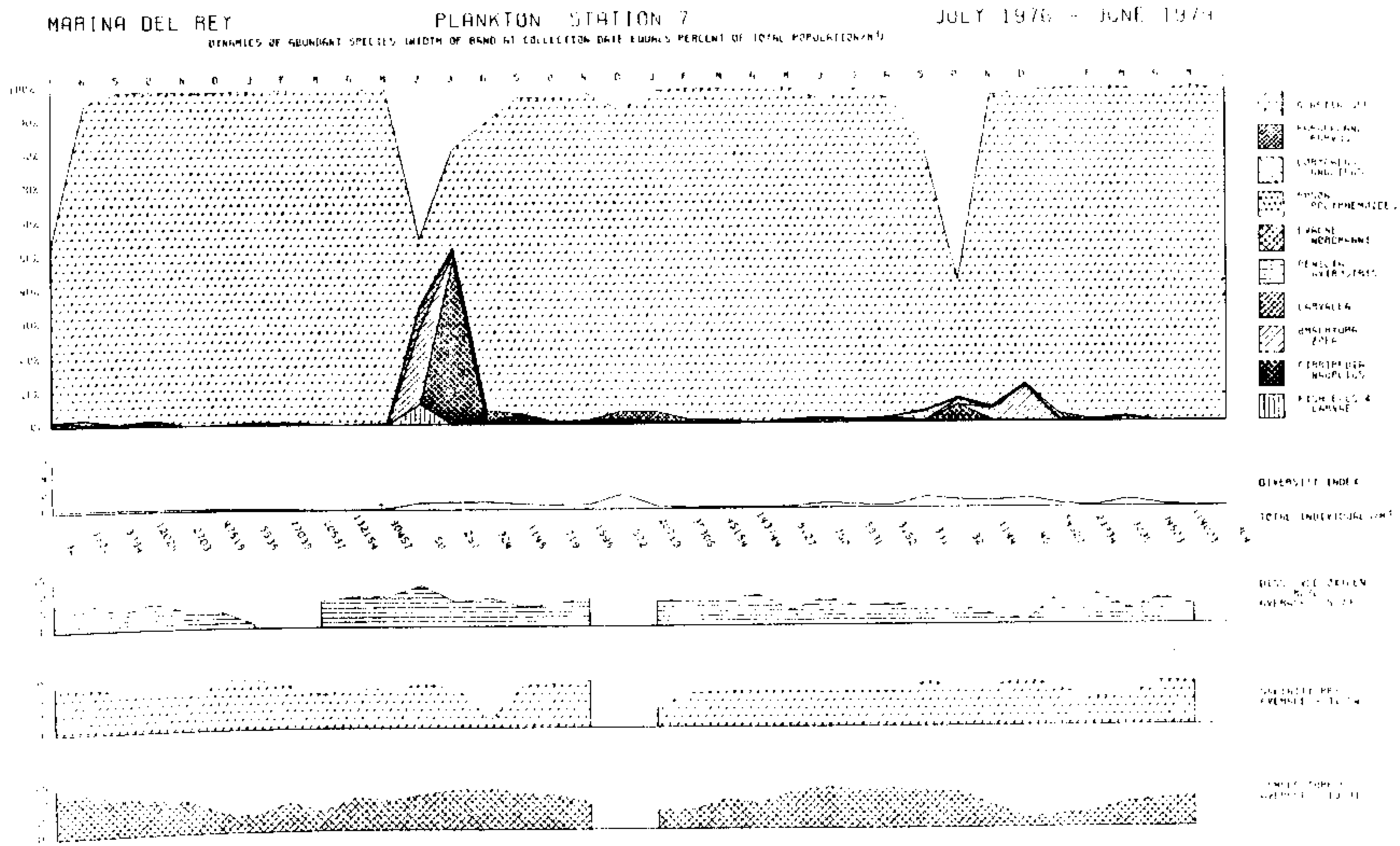


Figure 23. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolvec Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

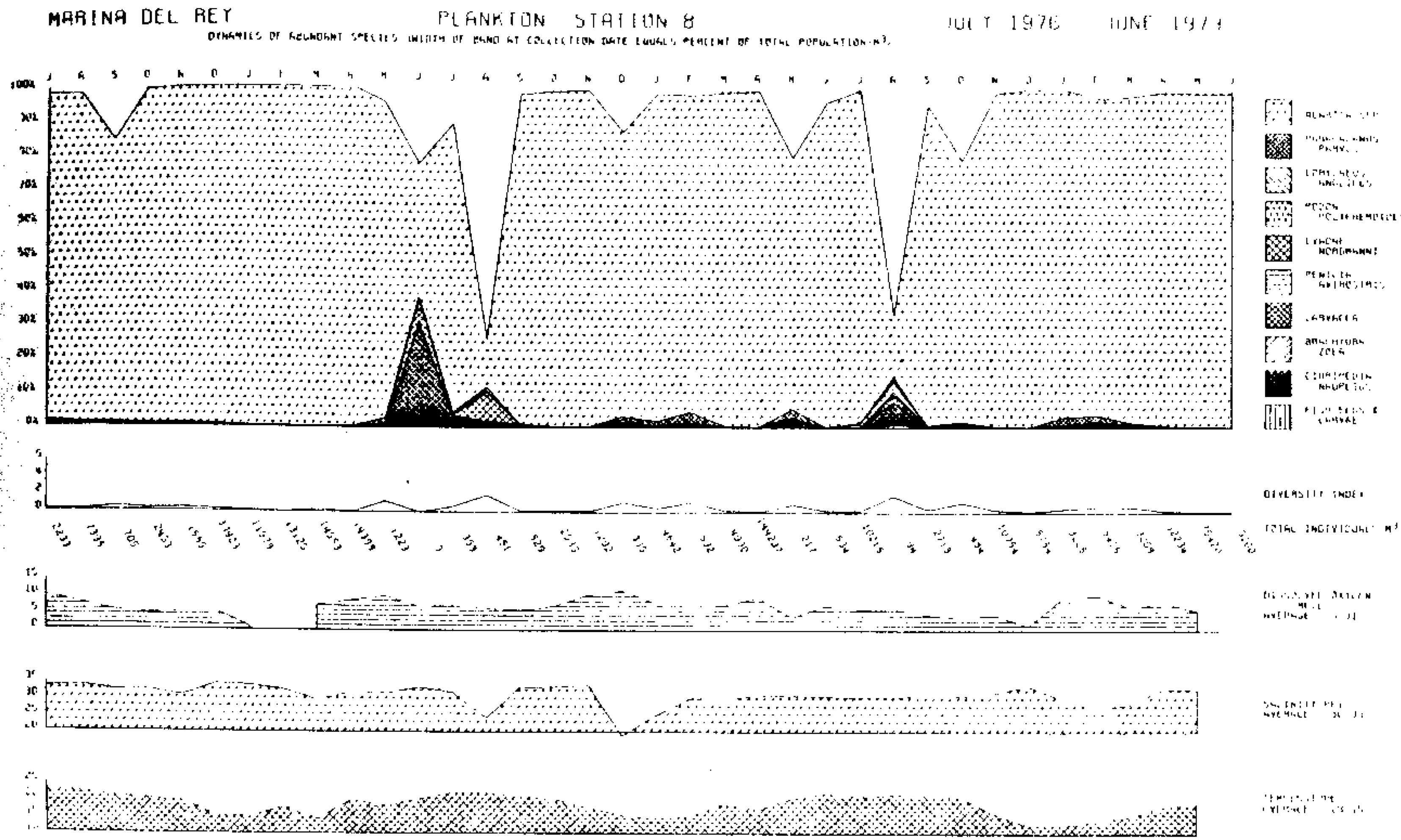


Figure 24. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentates are cumulative for each species).

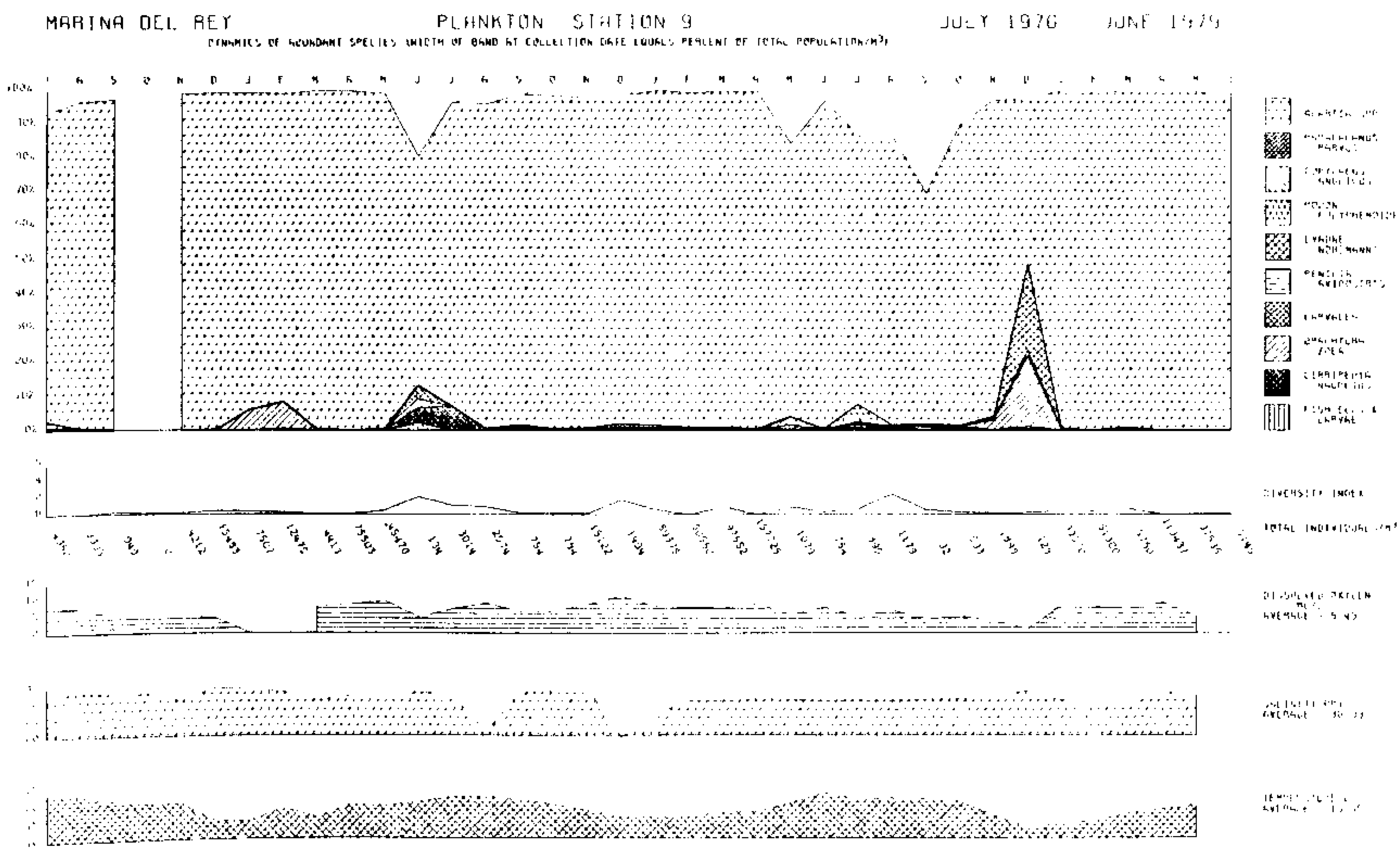


Figure 25. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

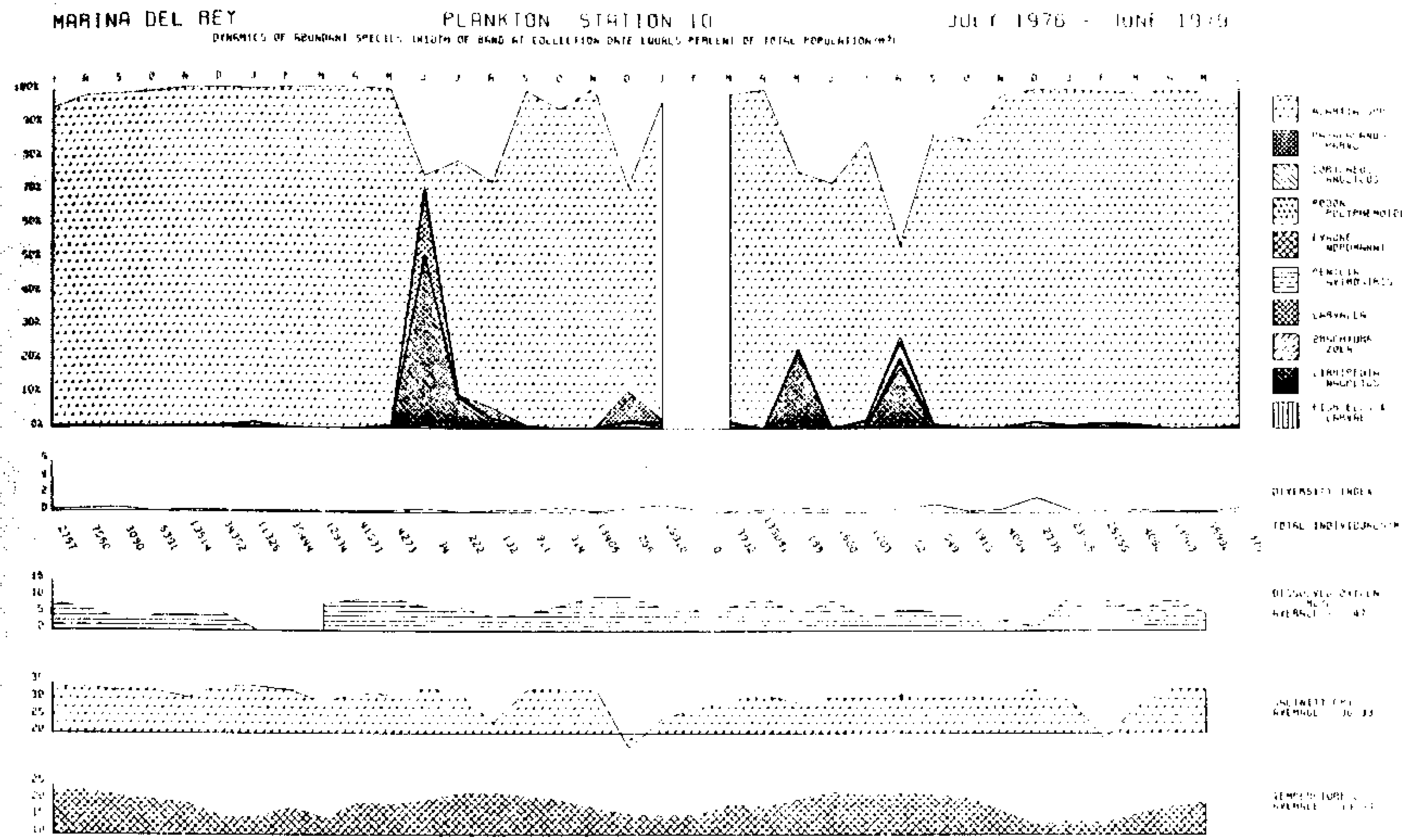


Figure 26. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

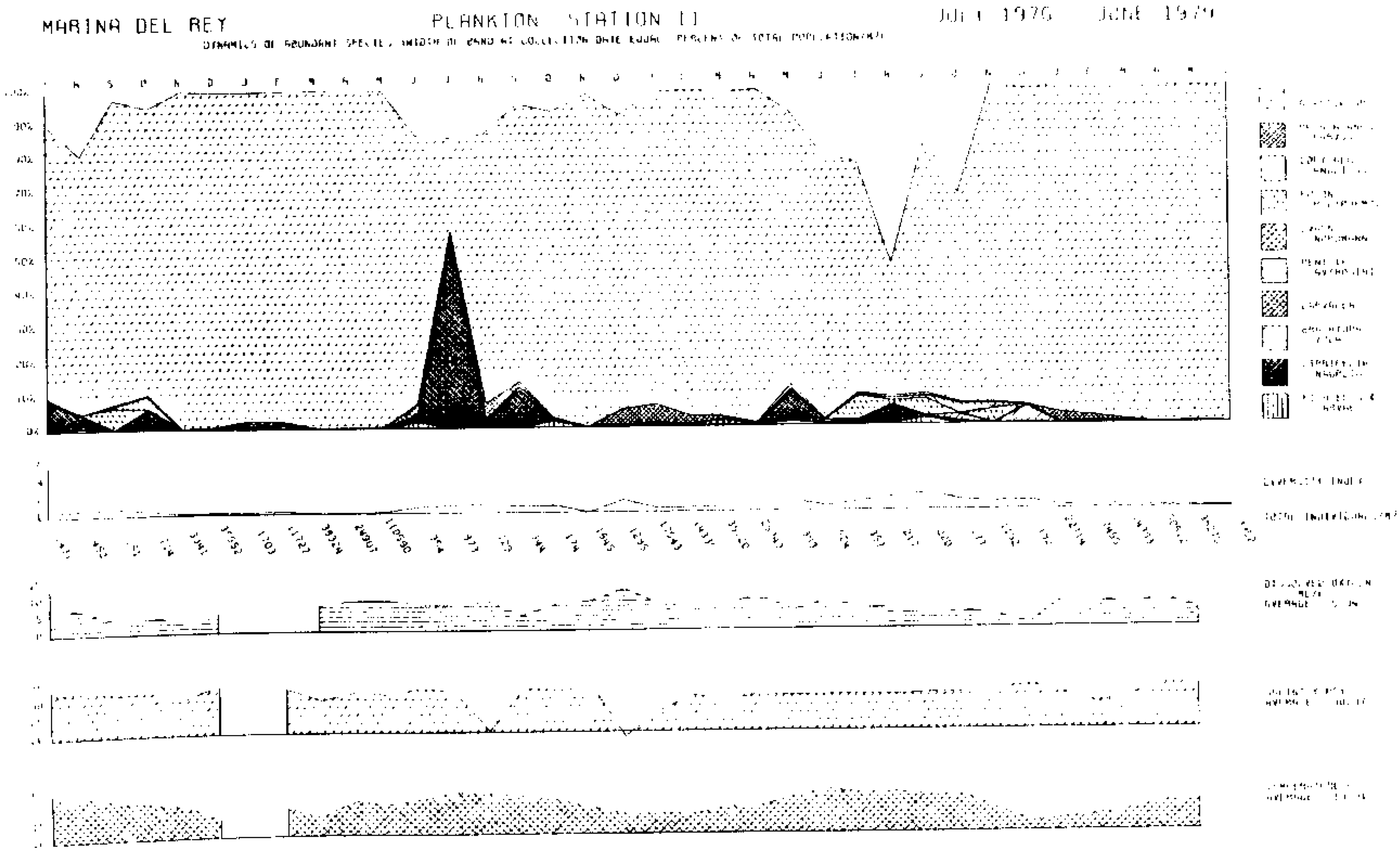


Figure 27. Percentages of Ten Dominant Zooplankton Species Compared with Numbers/m^3, Diversity Index, Dissolved Oxygen, Salinity and Temperatures.

(Percentages are cumulative for each species).

BENTHIC FAUNA

INTRODUCTION

The benthos of Marina del Rey varies from being predominantly sandy at the entrance to being largely silt or silt/clay in the inner basins and main channel. Furthermore, the character of the bottom sediments at a given location changes from season to season, as is illustrated in Section IIB, on sediments. The benthic species are those that live in or on the bottom substrate. As such, they are good indicators of relatively long-term environmental conditions, compared to the more transitory zooplankton.

Some benthic species have short reproductive periods of less than 30 days; some of these species are in reproduction the entire year and are thus able to recolonize an available substrate very rapidly. In soft bottom habitats, nematodes and polychaete worms are likely to dominate. Since most of the marine nematodes have not been described taxonomically for local waters, emphasis was placed on the polychaetes, which have been extensively described and utilized in nearshore surveys (AHF, 1976; Fauchald, 1977; Hartman, 1968, 1969; Soule and Oguri, 1977, 1979a, b).

METHODS

Biological and physical sampling in the Marina began in July 1976 and continued through June 1979 at the eleven stations in the marina. Benthic biological and sediment samples were collected at ten seasonal intervals during the three-year period. It was not possible to take benthic samples before October due to a breakdown of the Department of Small Craft Harbors work boat. Benthic biological samples were taken aboard the R/V Golden West or the Department of Small Craft Harbors work boat, using the Campbell grab, a modified Van Veen grab sampler which collects $0.1m^2$ of surface sediments with good depth penetration into the substrata. Replicate samples were taken at each of ten stations for each collection period. Stations 12 and 13 could not be sampled because they were not accessible by boat.

On deck, collected sediments were washed from the grab into a large plastic bin. Subsamples were removed for grain size determination and chemical analysis and the remaining sediments were placed into a washing box where they were suspended by running sea water and then gently washed through a 0.5mm mesh screen. Materials remaining on the screen were placed in glass jars, labeled and fixed in a 1:10 solution of buffered formaldehyde and sea water. Samples were stored in the fixative for approximately 48 hours.

In the laboratory, the samples were washed in fresh water to remove the formalin, and preserved for sorting in 70% ethanol. In the sorting process animals were separated from the sediments and debris and placed in small petri dishes for identification. Samples were first split into light and heavy fractions, using a running water flotation process. The heavy fraction containing sand, shell and large animals was sorted in pans using a large, lighted magnifying lens (∿3X). The lighter fraction, rich in animals and organic debris, was sorted in small lots under a dissecting stereomicroscope (10X or greater). It was both possible and practical for experienced sorters to identify and segregate the abundant taxa in this initial sorting. Fine sorting to species and verification of tentative identifications usually required higher magnifications and techniques appropriate for the animal being considered.

Animals were identified to lowest practical taxon, usually to species, and counted, stored in labeled vials containing 70% ethanol, and archived by station in the Allan Hancock Foundation Collections.

Data Analysis

Over 115,400 animals representing more than 300 taxa were found in the marina in the three-year survey (see Appendix B). In order to identify important species groups, the records were first scanned and all taxa occurring less than ten times in any one sample were excluded from consideration. Next, the remaining taxa were arranged by station and collection date and "abundant taxa" were identifed. Abundant taxa were considered to be those that represented over 10% of the individuals found in a sample. Next, the abundant taxa at each station were ranked by population, which each taxon represented over the entire survey. Since ranking was based on total numbers of individuals, a species that occurred in vast numbers in, for instance, two of the sampling periods at a station and then disappeared in the remaining eight collections, could be ranked first.

A modification of Gleason's Index ($\frac{S-1}{\log N}$ where S = total number of species; N = total number of individuals) was used to calculate species diversity (Margalef, 1968). In calculating diversity, animals identified at higher taxonomic levels were usually counted as species. These "unidentified species" fell into two categories: juveniles and fragments of individuals of species that would otherwise have been identified, and specimens of groups that were not identified. Therefore, in some instances a species was counted more than once, while animals belonging to several species may have been treated as a single species. Overall, the diversity values were obtained in a consistent manner with over and under counts tending to balance one another. The net effect was probably a slight understatement of actual species diversity.

At certain stations and times "artifact species" were encountered. These non-soft bottom animals were usually recently dislodged from overlying floats or attached to cans, bottles and other debris. Although artifact species were identified and counted, they were eliminated from analysis when possible. The adjustments mentioned above were made in the interest of producing the most internally consistent basis for temporal and spatial comparison of the data.

Finally, biological and physical data for each station were graphed and compared. Data points were plotted in a multigraph format with the months of the study period forming the common horizontal axis. Population dynamics of the abundant taxa were arranged as a stacked composite graph and placed over graphs of diversity, sediment grain size, dissolved oxygen, salinity and temperature. In this way changes in community structure and the physical environment could be readily identified and potential causal relationships suggested.

RESULTS

Spatial and Seasonal Patterns

Because benthic organisms are sedentary or of limited mobility, their distribution differed greatly from zooplankton patterns. Therefore comparisons are made on a station by station basis, with the important biological and physical parameters that were measured. These are illustrated in Figures 1-11. The population dynamics of each abundant animal was scrutinized and relationships between these and environmental conditions were suggested.

Station 1

Station 1, located at the mouth of Ballona Creek, was the deepest of the stations studied, 9m (29.6 ft). It generally had the highest average dissolved oxygen and lowest temperature levels, along with the highest percentage of sand in sediments. Diversity was comparatively high with averages of over 40 taxa and 8,560 individuals/m^2 (Figure 1). Chemical sediment data (Section IIB, Tables 2,3) reveals that total organic carbon there was lower then at inner marina stations by 2 or more orders of magnitude. Of major note was the virtual disappearance in March 1978 of three taxa (Nematoda, *Capitella capitata*, and *Peloscolix gabriellae*) that had tended to dominate earlier collections. This probably relates to a general lowering of salinity and to flushing due to heavy rainfall and runoff from the unprecedentedly wet spring. These species are well known to be associated with organically enriched areas. Increased freshwater flow from Ballona Creek probably flushed organics and organisms from the area. The reduction in organic load is indicated in Section IIB, Table 3.

The *Diastylopsis tenuis* population, which was prominent only at station 1, was seen to increase in June of both 1977 and 1978. Several other species were prominent only at station 1 or at stations 1 and 2 (Table 1, this section).

Station 2

Located at the Marina entrance channel, station 2 had high average dissolved oxygen, lower temperature than the rest of the marina, and relatively high diversity (Figure 2). The station had a high average number of taxa, 46, and the highest mean number of individuals, 24,679, about three times higher than at station 1. Since salinities were similar in both places, the effects of flushing in Ballona Creek must have caused the decline in populations at station 1. Station 2 differed from station 1 in generally having finer sediments, as well as different sub-dominant species. The early dominants, including Nematoda, *Capitella capitata*, and Oligochaeta (but not *Pelescolex*) disappeared or were depressed after March 1978. Nematoda made a comeback by December 1978, while oligochaetes were depressed, and *C. Capitata* did not reappear. The depression of the early dominants corresponds to rather dramatic rise in diversity. *Mediomastus californiensis* became a community dominant in December 1977 and remained so to the end of the study. There were no clear abiotic changes that would account for these population shifts, unless they were associated with decreased organic constant. Stations 1 and 2 became the "cleanest" stations in 1978.

Station 3

Station 3 was located along the western side of entrance channel next to the tide gates to Ballona Lagoon and the Venice canal system. Chemical sediment analysis showed this to be the "cleanest" station in the marina in 1977. This station was characterized by a shifting sandy silt bottom immediately adjacent to a small shell rubble "reef". In half of the collections made, a portion of the reef was sampled: Oct. 1976; June, Sept. and Dec. 1977; and Dec. 1978. The reef supported a rich hard bottom fauna, which contrasted sharply with the soft bottom community in the surrounding sediments. This situation presented a major stumbling block to community portrayal and therefore it was decided to separate the hard bottom fauna from the spatial analysis. As the hard bottom organisms are rather distinct this was a fairly easy task, except for one group, the unidentified Amphipoda.

The most striking shift in population structure appeared in September 1977 and was almost certainly artificially produced. The sample contained 25 taxa, 21 of which were eliminated as obvious hard bottom forms. Of the remaining animal groups, all but two individuals were amphipoda. Although these data were presented, they were not used for comparative purposes.

Thus a modified characterization of this station would be: high diversity with the principal species being *Mediomastus californiensis*, *prionospio heterobranchia*, Oligochaeta and *Lumbrineris* spp. There was a seasonal trend indicating that Oligochaete populations increased in March, which may fit the changes produced by the heavy rainy season.

Station 4

Station 4 is located at the south end of the main channel in front of the Administration Center. It had the next cleanest chemical sediment values and the sediments themselves were primarily sand-silt. Species diversity there was the highest in the marina, averaging 13,500 individuals/m^2 and 61 taxa per sample. The dominant species were *Mediomastus californiensis*, *lumbrineris* sp., and *Prionospio heterobranchia*. The graphs show these possible relationships: Populations of *P. heterobranchia* increased in summer and decreased in winter; *Cossura pygodactylata* increasing with finer sediment increase; and *Notomastus tenuis* increases coinciding with increased sand.

Station 5

Located midway along the main channel, station 5 had the least sand and highest silt content of the study sites. Of all the stations this had the lowest average dissolved oxygen levels, although the average was only slightly below that of stations 6 and 10. Diversity was lower than in the outer stations but there was less variation than at any of the study sites. Station 5 was dominated by the six species which constituted 81% of the population (Figure 5), with *Mediomastus californiensis* and *Pseudopolydora paucibranchiata* the most numerous. *Prionospio heterobranchia* showed low population levels in summer months and peaks in fall-winter sampling. Overall, diversity seemed to decrease as percent clay increased.

Station 6

At the closed end of Basin B, station 6 was the sandiest inner basin station. It had low dissolved oxygen and high average temperature which suggests poor flushing. The diversity was similar to that of station 5, averaging more than 6,500 individuals/m^2 and 31 taxa. *Pseudopolydora paucibranchiata* represented 24% of all individuals there. Eight species -- *Streblospio benedicti*, *Lumbrineris*, *Haploscoloplos elongatus*, *Tharyx*, *Schistomeringos longicornis*, *Prionospio heterobranchia*, *Mediomastus californiensis*, and *Acteocina inculta* -- were quite equal in occurrence, each representing from 6 to 8% of the total population. *Tharyx* and *P. Heterobranchia* percentages were depressed in summer months.

Station 7

Station 7 was off the boat ramp at the end of Basin H. It is heavily impacted by a storm drain and had low oxygen episodes and the highest mean temperature. Silt and sands occurred here in relatively equal amounts. *Cossura pygodactylata* and *Streblospio benedicti* were the overall dominant animals, accounting for 60% of the individuals collected, while *Tharyx* and *P. paucibranchiata* contributed 7% each. *Cossura pygodactylata* populations peaked in the fall and *Mediomastus californiensis* in spring months. Diversity was up in the summer.

Station 8

Located off the beach in Basin D, station 8 showed low diversity and high silt and clay levels. *Pseudopolydora paucibranchiata* constituted 38% of all individuals. *Acteocina inculta*, *Capitella capitata* and *Prionospio heterobranchia* each accounted for about 10% of the total animals. The *C. capitata* peak in December 1977 corresponded with high dissolved oxygen and low salinity readings, and populations of this species were low for summer months. *Exogone lourei* (spp?) had a trend of high numbers in spring and low numbers in summer. Diversity appeared to increase with lower temperatures.

Station 9

At the closed end of Basin F, this station is also adjacent to a storm drain effluent pipe. The principal species present were *Pseudopolydora paucibranchiata*, *Streblospio benedicti*, and *Capitella capitata*. *S. benedicti* and *C. capitata* tended to dominate the early spring collections, while *P. paucibranchiata* and *Acteocina inculta* prevailed in later months.

Station 10

Station 10 was located at the closed end of Basin E, near the drainage gate from the bird sanctuary. The sediments had the highest average clay content in the study area. Principal taxa here were *Streblospio benedicti*, *Pseudopolydora paucibranchiata*, *Capitella capitata*, Oligochaeta, and *Acteocina inculta*. All of these exhibited marked population fluctuations. Similar dynamics were seen in the populations of oligochaetes, *C. Capitata* and *Schistomeringos longicornis*, in that they all had spring peaks. *Polydora ligni* and *P. Paucibranchiata* patterns resembled one another but no seasonality existed. Populations of both *S. benedicti* and *Cossura pygodactylata* virtually disappeared in September 1977 and then reappeared in June 1978. The physical data presented no clear explanations for any of these events.

Station 11

Station 11, at the north end of the main channel, had sediments in the clay-silt range. This station had the lowest average diversity in the study area (21 taxa, 6,500 individuals/m^2). Through March 1978, *Pseudopolydora paucibranchiata* and *Streblospio* exchanged dominant positions. In June 1978 there was a sharp drop in diversity as most polychaete species either vanished or occurred in low numbers; the highest temperatures were recorded at this time. In the winter of 1978 and spring of 1979, *P. paucibranchiata* returned to a dominant position.

DISCUSSION AND CONCLUSIONS

The spatial distribution of the dominant species shown in Table 1 indicates the distinct differences in dominant species composition. While the dominant species at stations 1,2 and 3 differ distinctly from each other, there is a clear separation at station 4, with the remaining stations sharing many of the same species.

The most widespread species throughout the marina were *Mediomastus californiensis*, *Prionospio heterobranchia* and *Pseudopolydora paucibranchiata*. The dominance of *Capitella capitata* was limited to stations 1 and 2, and 8, 9 and 10, a rather peculiar distribution.

Total Numbers of Benthic Organisms

The averages for all 10 sampling periods in numbers of organisms and numbers of individuals/m^2 offer good comparisons for characterizing the environmental quality of each station.

Comparison of Mean Numbers of Species and Individuals/m^2
by Station, October 1976 - April 1979

Station	$\bar{x}$ number of species	$\bar{x}$ number of individuals
1	42	8,564
2	46	24,679
3	55	10,974
4	61	13,508
5	32	7,917
6	31	6,536
7	31	12,970
8	23	6,252
9	27	7,855
10	28	9,673
11	21	6,520

In terms of numbers of species, there is a clear break between the entry stations 1-4, the middle stations 5, 6 and 7, and the inner stations 8-11. In numbers of individuals, the pattern was not as clear. Station 2 had nearly twice as many individuals as the next ranked stations 4 and 7. Next came stations 3, 10 and 1, followed in rank by stations 5 and 9. Stations 6, 11 and 8 were all considerably lower in individuals/m^2.

It was coincidental that all sampling periods except June and September 1978 had been preceded by substantial rains within a month. The first period in October 1976 followed the first rainfall after a lengthy dry spell. The following tabulation of mean numbers of species and individuals/m^2 for the entire marina survey shows the substantial variation found between seasons and in the same season in different years.

Comparison of Mean Numbers of Species and Individuals/m^2
Summed for All Stations for Each Period Sampled

Date	10/28/76	3/17/77	6/23/77	9/16/77	12/28/77	
Mean Taxa & Individuals	41/9,585	32/12,631	38/10,310	29/22,733	34/6,790	
Date		3/17/78	6/16/78	9/21/78	12/15/78	4/13/79
Mean		36/8,108	37/7,062	37/9,040	42/8,594	37/9,760

Tables 2 and 3 give the total numbers of taxa and individuals/m^2 for each station and sampling period. The mean numbers appeared to be down in 1978 from 1977 levels, but it is difficult to attribute that to heavy rainfall long after rains had ceased in April 1978, unless the decrease in organic content of sediment is responsible.

The numbers of species and individuals can be compared with tabulations of benthic organisms in Los Angeles-Long Beach Harbors (Soule and Oguri 1979a, b). The numbers in the entrance channel are comparable with outer Los Angeles Harbor A stations, in 1978, while the inner marina stations are comparable with the inner harbor stations even though the depths are quite different.

The prominence of *Mediomastus californiensis* at marina stations parallels that dominance in 1978 in the harbors. Since the levels of pollutants in sediments and the grain sizes of the two areas are similar, as shown by the present study and Soule and Oguri (1979a, b), it is not surprising that there are similarities. There were a few species dominant in the marina that were not dominant in the harbors, including *Diastylopsis tenuis*, *Tellina modesta*, *Peloscolex gabriellae* and *Oxyurostylus pacifica*, all associated with the sandiest site, station 1.

Comparison of marina benthic data with other areas is difficult, because each station has important special physical conditions such as drainage or runoff which influence the biota. Comparison of the Los Angeles River plume stations D1, 2 and 3 (Soule and Oguri, 1979b) with MDR stations 1 and 2 meant comparing 1975 with 1978 for the river data, rather than 1976-77 with 1978, the only comparable data available.

The rainy years appeared to produce a three- to four-fold decrease in benthic populations.

Comparisons of station data from outer Los Angeles Harbor are obscured by the radical changes in effluent treatment between 1974 and 1978 (Soule and Oguri, 1979a). However, at station A2, near the entrance in Los Angeles Harbor, a 2.4-fold decrease occurred between 1977 and 1978, whereas at MDR station 3, the decrease was 1.8-fold. The greatest decrease in outer Los Angeles Harbor was between 1973 and 1978, a 3-fold decrease in benthic organisms, with only a 14% decrease occurring at the same stations between 1977 and 1978. The impact of runoff in that area is not as severe as it was in the Los Angeles River area (3-4-fold) or in the marina as a whole (32%). It was of interest to note that flushing of the innermost stations appeared to improve the benthic habitats in both areas; for example, at Dominguez Slough in Los Angeles Harbor (station C11) and at MDR station 10.

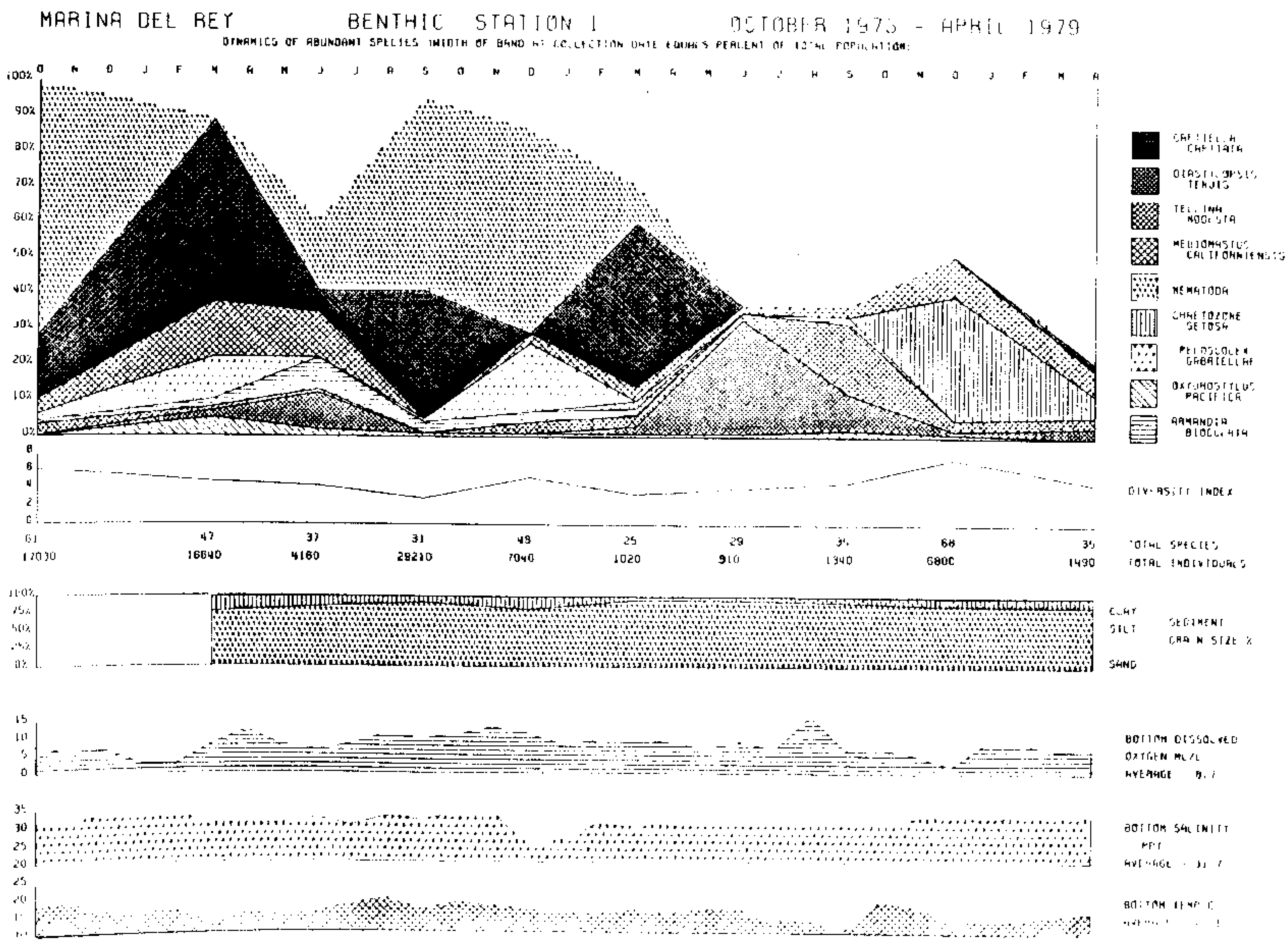


FIGURE 1. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

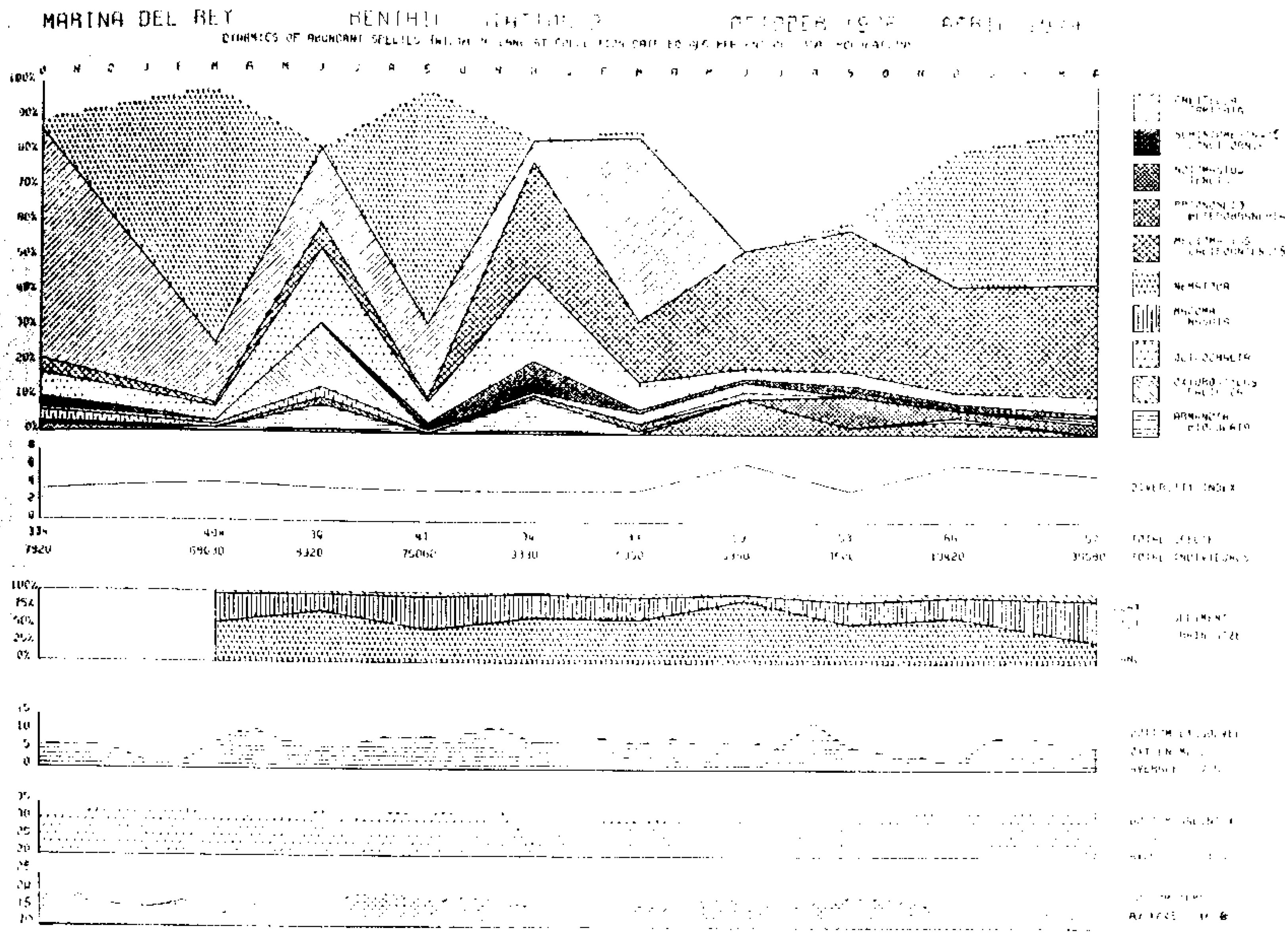


FIGURE 2. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

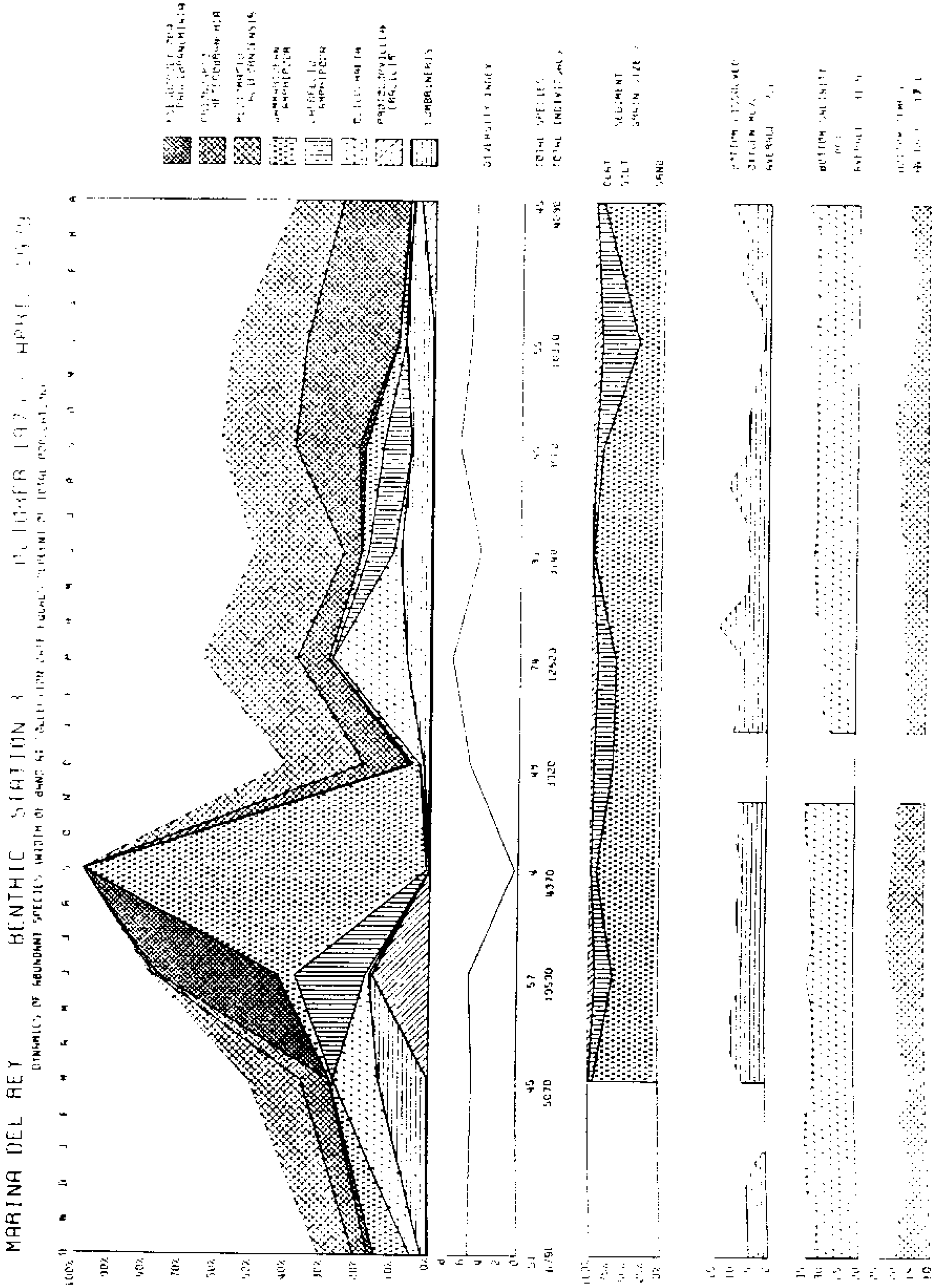


FIGURE 3. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

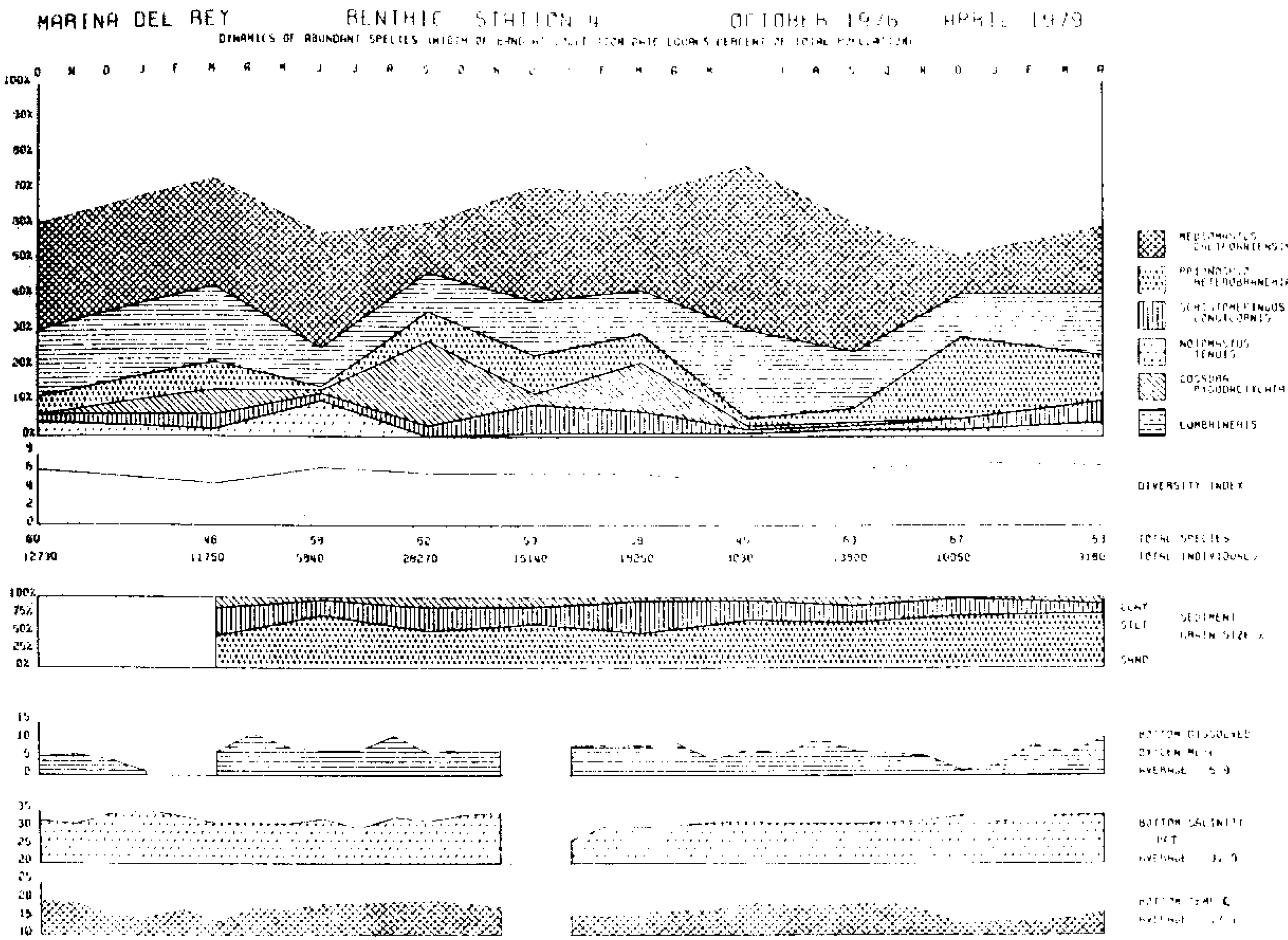


FIGURE 4. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

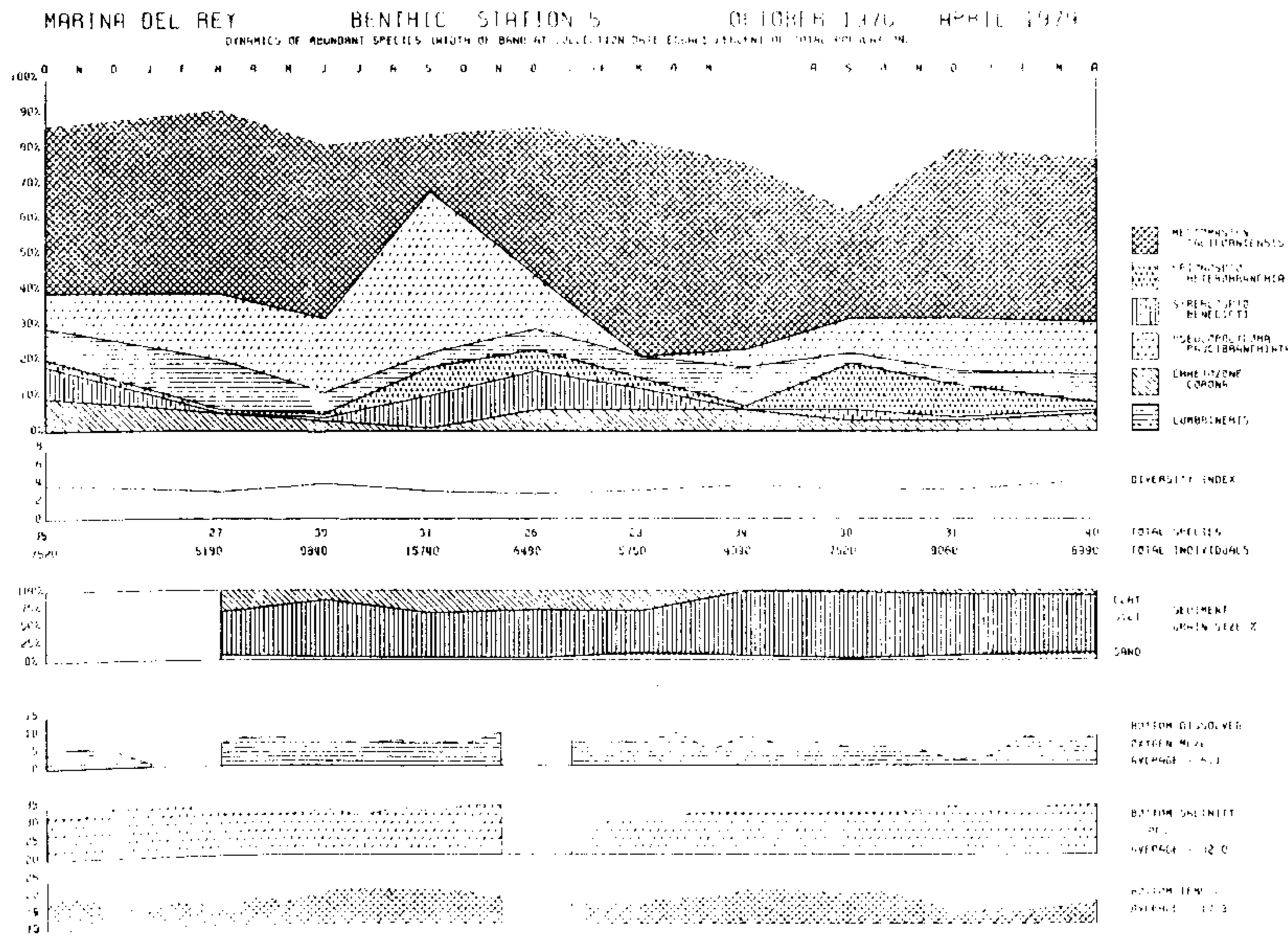


FIGURE 5. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

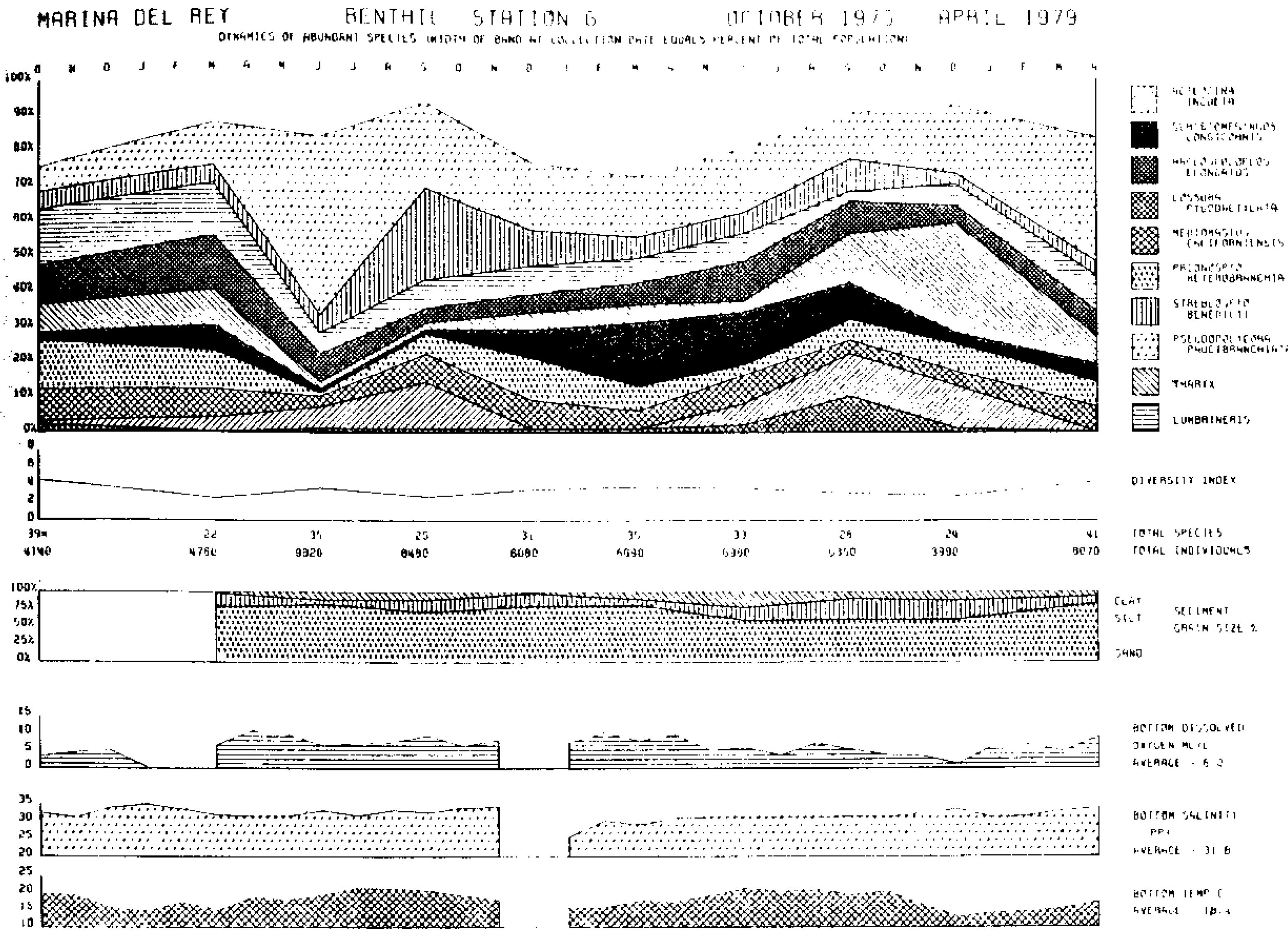


FIGURE 6. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

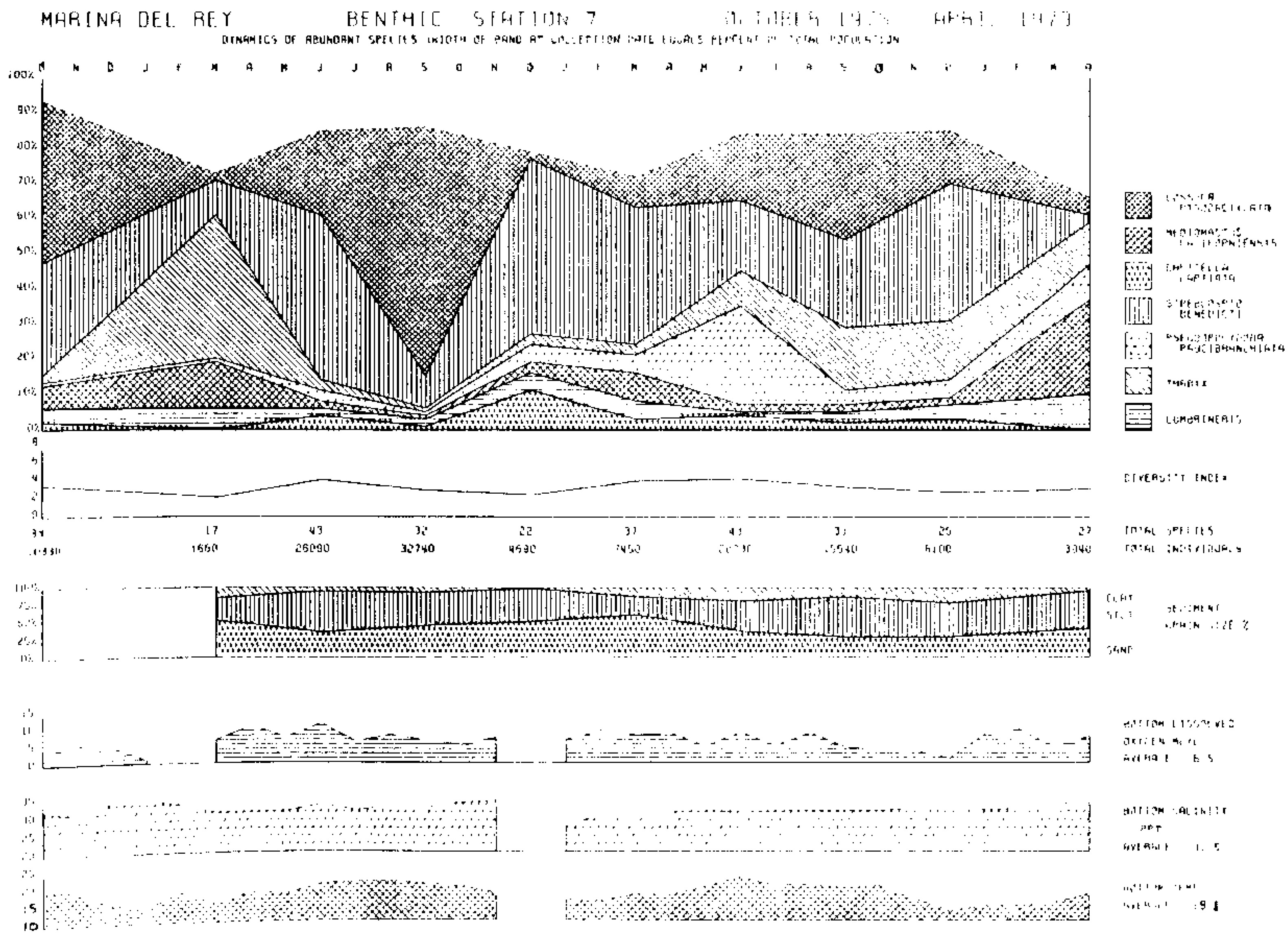


FIGURE 7. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

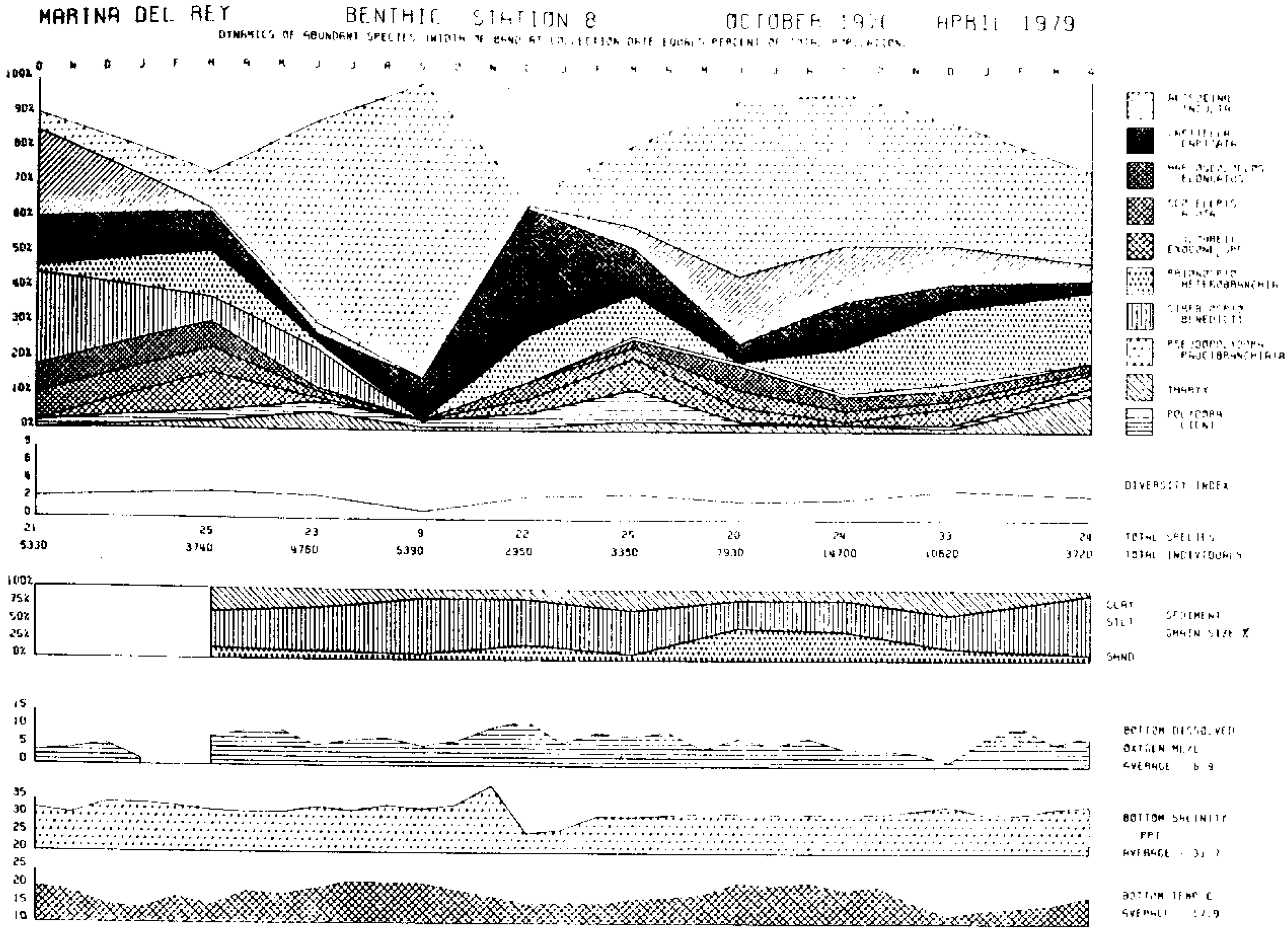


FIGURE 8. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

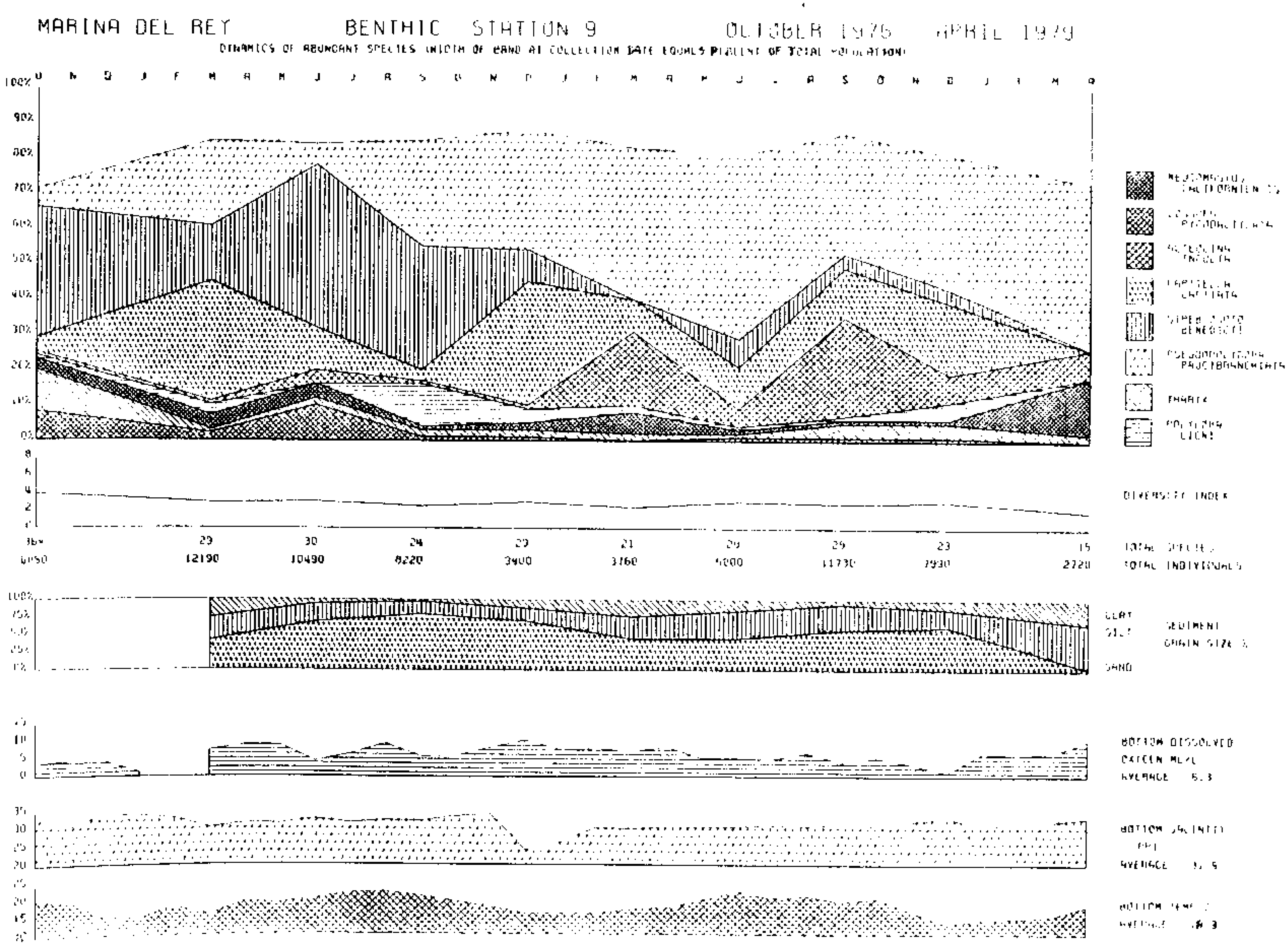


FIGURE 9. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

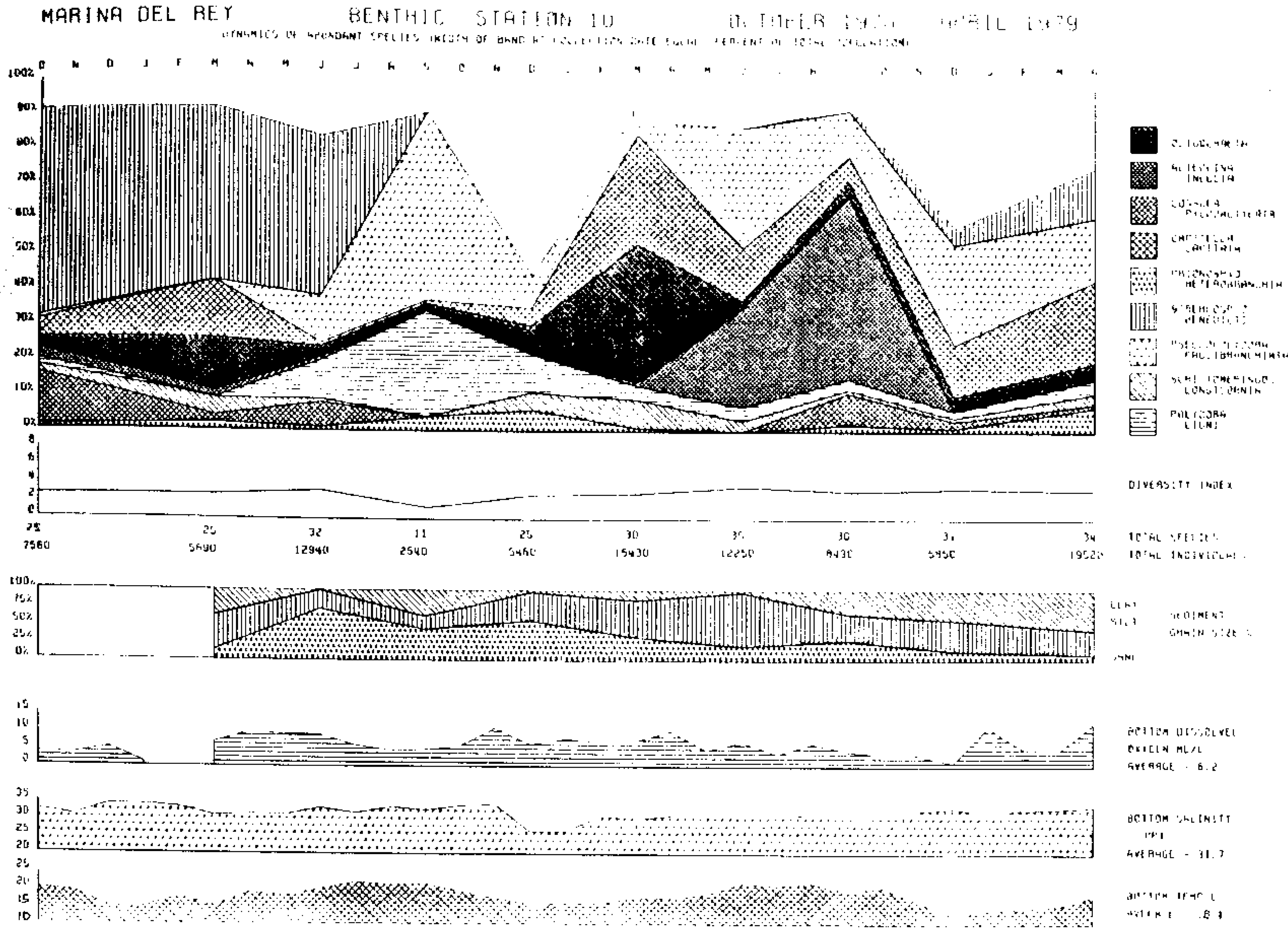


FIGURE 10. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

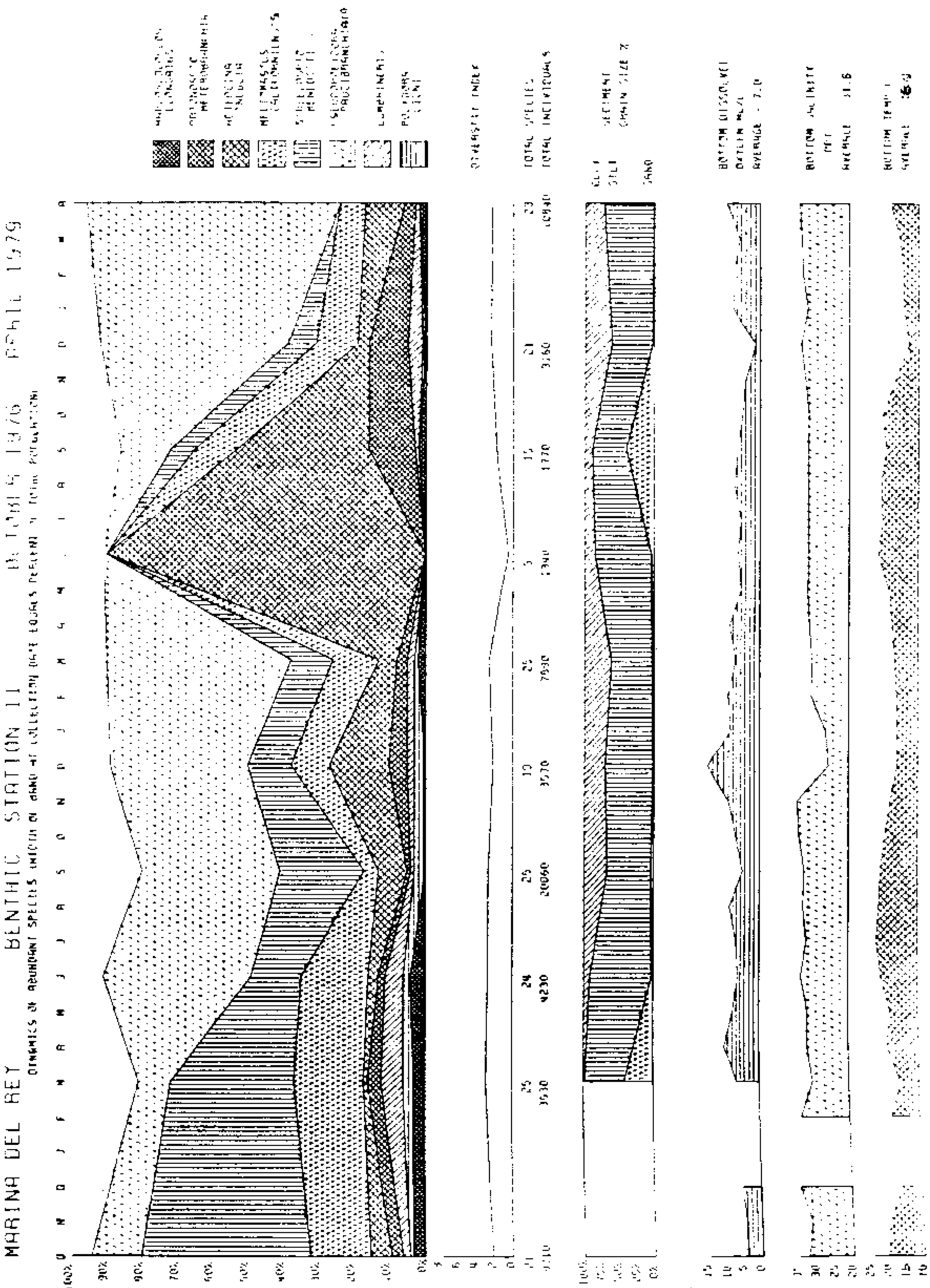


FIGURE 11. PERCENTAGES OF DOMINANT BENTHIC SPECIES COMPARED WITH NUMBERS/M^2, DIVERSITY INDEX, SEDIMENT GRAIN SIZE, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

Table 1. Spatial Distribution of Dominant Species.

	MDR Station										
	1	2	3	4	5	6	7	8	9	10	11
Capitella capitata	X	X					X	X	X	X	
Diastylopsis tenuis	X										
Tellina modesta	X										
Mediomastus californiensis	X	X	X	X	X	X	X		X		X
Nematoda	X	X									
Chaetozone setosa	X										
Peloscolex gabriellae	X										
Oxyurostylus pacificus	X	X									
Armandia bioculata	X	X									
Schistomeringos longicornis		X		X		X				X	
Notomastus tenuis		X		X							
Prionospio heterobranchia		X	X	X	X	X		X		X	X
Macoma nasuta		X									
Oligochaeta		X	X							X	
Pseudopolydora paucibranchiata			X		X	X	X	X	X	X	X
Gammarid			X								
Caprellid			X								
Protodorvillea gracilis			X								
Lumbrineris			X	X	X	X	X				X
Cossura pygodactylata				X		X	X		X	X	
Streblospio benedicti					X	X	X	X	X	X	X
Chaetozone corona					X						
Acteocina inculta						X		X	X	X	X
Haploscoloplos elongatus						X		X			X
Tharyx						X	X	X	X		
Scolelepis acuta								X			
Exogone lourei (spp)								X			
Polydora ligni								X	X	X	X

Table 2. Benthic Sampling, 1976-1979. Total Taxa/Individuals m^2

Station	28 Oct 76	17 Mar 77	23 June 77	16 Sept 77	28 Dec 77
MDR 1	61/17,030**	47/16,640*	37/ 4,160	31/29,210	48/ 7,040
MDR 2	33/ 7,920*	49/68,630*	36/ 8,920	41/75,060	34/ 9,330
MDR 3	80/17,750 (51/ 6,790)+	45/ 5,070	61/19,640 (57/19,530)+	25/23,920 (4/ 4,370)+	57/ 4,550 (48/ 3,920)+
MDR 4	67/12,990 (60/12,730)+	46/11,750	64/ 6,750 (58/ 5,840)+	67/28,700 (62/28,270)+	59/15,140
MDR 5	35/ 7,620	27/ 5,180	38/ 9,840	31/15,740	26/ 6,480
MDR 6	39/ 4,140*	22/ 4,760	35/ 9,820	25/ 8,480	31/ 6,080
MDR 7	33/10,330	17/ 1,660	43/26,090	32/32,740	22/ 4,690
MDR 8	21/ 5,330	25/ 3,740	23/ 4,760	9/ 5,390	22/ 2,950
MDR 9	36/ 6,050*	29/12,190	30/10,490	24/ 8,220	29/ 9,400
MDR 10	25/ 7,560	25/ 5,690	32/12,940	11/ 2,540	25/ 5,460
MDR 11	21/ 8,710	25/ 3,630	24/ 4,230	28/20,060	19/ 3,570

* Data represent average of 2 grabs
** Data represent average of 3 grabs
+ Totals adjusted to exclude hard bottom animals associated with rock and shell rubble in these samples; this is a conservative estimate of hard bottom effect.

Note: All samples are the first or "A" replicate of the two replicate samples taken per Station/Sampling date with Campbell grab.

Table 3. Benthic Sampling, 1978-1979. Total Taxa/Individuals m^2

Station	17 Mar 78	16 Jun 78	21 Sept 78	15 Dec 78	13 April 79
MDR 1	25/ 1,020	29/ 910	35/ 1,340	68/ 6,800	35/ 1,490
MDR 2	33/ 5,950	59/ 5,380	53/ 9,600	66/19,420	57/36,580
MDR 3	74/12,620	38/ 3,140	65/ 8,600	61/10,370 (55/10,310)+	45/ 4,080
MDR 4	59/18,250	45/ 8,030	63/13,800	71/10,260 (67/10,050)+	67/ 9,410 (63/ 9,160)+
MDR 5	29/ 5,750	34/ 4,990	30/ 7,520	31/ 9,060	40/ 6,990
MDR 6	35/ 6,690	33/ 6,980	28/ 6,350	24/ 3,990	41/ 8,070
MDR 7	37/ 7,450	43/20,730	33/15,540	25/ 6,100	27/ 3,940
MDR 8	25/ 3,380	20/ 7,930	24/14,700	33/10,620	24/ 3,720
MDR 9	21/ 3,760	28/ 6,000	28/11,730	29/ 7,990	16/ 2,720
MDR 10	30/16,430	36/12,250	30/ 8,490	31/ 5,850	34/19,520
MDR 11	25/ 7,890	5/ 1,340	15/ 1,770	21/ 3,160	23/10,840

+ Totals adjusted to exclude hard bottom animals associated with rock and shell rubble in these samples; this is a conservative estimate of hard bottom effect.

Note: All samples are the first of "A" replicate of the two replicate samples taken per Station/Sampling date with Campbell grab.

MEROPLANKTON (SETTLING RACK SPECIES)

INTRODUCTION

Many of the marine invertebrates that colonize rocks, pilings and benthos, as well as fouling organisms associated with boat hulls and docks, are sessile as adults but have plankton larval stages. The literature on fouling organisms is extensive because of the economic cost for maintenance for marine installations but less emphasis has been placed on larval transport and recolonization.

Settling racks, suspended for 1-2 month intervals, offer seasonal and areal evaluation of reproduction and colonization in the marina of these invertebrates.

METHODS

Settling racks are constructed of wooden slide box frames, screened front and back with plastic mesh, and containing 25 glass microscope slides. The technique is more fully discussed in AHF, 1976. Eggs, larvae and small adult organisms pass through the mesh and metamorphose or colonize on the horizontal glass substrate.

In the marina, eight stations were selected for bimonthly deployment of racks at the 3m depth. Stations 1, 3, 4, 6, 7, 8, 9 and 11 were surveyed but not all stations are represented in every period because rack losses do occur during storms or from vandalism.

RESULTS

The two dominant species in numbers of occurrences were *Corophium acherusicum* and *Elasmopus rapax*, both amphipods. *Hydroides pacificus*, a tube-building polychaete had the largest number of individuals, followed by another amphipod *Jassa falcata*. Table 1 presents rankings of the top 16 species in number of occurrences and in number of individuals. Amphipods occupied 7 of the top 15 places in numbers of occurrences and 6 places in numbers of individuals. As detrital feeders, amphipods would be important in the marina, where fine particulate matter abounds.

Ciona intestinalis, the large white tunicate, occupies an important place in both occurrences and numbers, usually in August to October.

More than 125 species were found on the racks, plus a number of taxa unidentified at species level. Fifteen phyla were represented.

Total counts of individuals are not given for many species because of coloniality. For important groups such as hydroids and bryozoans, the individuals are too small and too numerous in colonies to count. Data are presented in Appendix B as being present, or by wet weight, for those organisms for which individuals could not be counted. Because counts of other organisms alone would not reflect the true conditions, species diversity indices were not calculated.

Figures 1-6 present the percentages of the dominant species at the stations for which the most complete data were available.

Jassa falcata dominated at station 1, the mouth of Ballona Creek, for much of the 1976-1979 period sampled (Figure 1). It was especially prevalent during the summer months. In the winter and spring, *Mytilus edulis* occupied the dominant position. All fauna was greatly depleted in the winter of 1978, presumably due to the storms. This station had the lowest temperature and salinity at 3m depth, and highest dissolved oxygen.

At station 3, the entrance channel at the Ballona Lagoon tide gate, there was less obvious dominance (Figure 2). *Ericthonius brasiliensis*, an amphipod dominated for most of 1976-1977. After the general depletion in the winter of 1977, it was less prominent, but *Hydroides pacificus* and *Jassa falcata* increased.

At stations 4, 6, 9 and 11 mean temperatures were warmer than at the entry stations. *Hydroides pacificus* showed consistent summer peaks at all four stations. In 1977 it dominated in July, August and September with little competition until October, in 1978 there was little competition until November except at station 6.

At station 4, *Ciona intestinalis*, *Podocerus cristatus*, *Jassa falcata* and *Ericthonius brasiliensis* were about equally prevalent from the fall of 1976 through June 1977. This occurred again in the spring of 1978 after the winter destruction, accompanied by *H. pacificus*.

Such balance, or diversity, was not evident at stations 6, 9 and 11. At station 6, *Ciona intestinalis* peaked in October 1976, June 1977, October 1977, April 1978 and December 1978. It alternated to some extent with *Mytilus edulis* in 1977. At station 9, *Ciona* was prominent from

October 1977 through April 1978, peaked again in December 1978 and April 1979. At station 11 the peak was limited to June 1977, April 1978 and April 1979.

While *Jassa falcata* dominated station 1, it was less prevalent at the other stations. It occurs year around in the marina, however, which helps to account for its prominence. The same is true, for the most part, of the other amphipods, *Corophium acherusicum*, *Ericthonius brasiliensis* and *Podocerus cristatus*.

DISCUSSION AND CONCLUSIONS

Severe impact of the environment was evident at station 1 in January-February 1978 and perhaps in April 1979. At stations 3 and 4, in addition to the winter 1978 drop, a spring low occurred in 1977 and in winter-early spring 1979. At station 4, the low periods were in June 1977, February 1978 and February 1979, but were not as marked.

At the inner basin stations, 6 and 9, and at station 11, the spring of 1977 was depressed for a prolonged period, and the winter and spring periods from about October 1977 through May 1978 were depressed.

Conditions at station 6 declined very steeply from December 1978 through April 1979, in contrast to those at stations 9 and 11, which had December-March lows but rebounded well by April.

The seasonal disappearance of a number of species, present in summer and absent during winters, is a common local phenomenon. It may be based on temperatures, food supply, light and other natural causes. But in the marina the impacts can more directly be associated with the periods of heavy rainfall and runoff. The consequent lowering of salinity probably affects some number of species but most fouling species survive by virtue of tolerance to a wide range of conditions. Heavy flushing would carry away some of the adult populations, while eggs and larvae would probably be carried out to sea in runoff.

The so-called fouling community in the marina is not greatly different from that in Los Angeles-Long Beach Harbors (Soule and Oguri, 1979b) which was sampled by the same methods from 1971 to 1978. It probably constitutes a major food resource for browsing crustaceans, molluscs and worms in the intertidal-subtidal area. The lack of diverse substrates probably limits the community. As meroplankton, the species contribute to food for fish and holoplankton.

Diver Observations

While the invertebrate fouling community on the rocks was not surveyed, some diver observations were recorded during the fish surveys.

Dives were made on 24 January 1979 on either side of the entrance to Marina del Rey harbor, within ¼ mile of the entrance. An additional dive was made at the mid-point of the protected side of the outside breakwater. The dives lasted 15-25 minutes each at depths of 0-15 feet. Visibility was very poor, about 6 feet (2m) at best. The temperature of the water was 13.5°C (56°F). A pronounced halocline existed within 3 feet (about 1m) of the surface, although six days had passed since heavy rainfall. While the breakwater and sides of the jetties are of rock, most of the bottom is fine, easily-disturbed silt littered with mussel shells, dead leaves, bottles, cans, and paper.

Invertebrates were abundant, but limited in variety. Many large rock scallops (*Hinnites multirugosus*) coated the rocks. The attached pelecypod *Chama pellucida* was common. Also present were ascidians (*Pyura haustor* and *Styela montereyensis*), sponges, bryozoans (*Scrupocellaria* sp., *Bugula neritina*, and others), and hydroids. Along the outer breakwater, an unidentified sea anemone, the opisthobranch *Chelidoneura inermis*, and the nudibranch *Dialula sandiegensis* were seen. Also present were the carnivorous snails *Pteropurpura festiva* and *Ceratustoma nuttalli*. Shells of the clam *Saxidomus nuttalli* littered the bottom. The tube mollusc *Serpulorbis squamigerus* and tube-building polychaetes were common on some rocks.

Algae were generally scarce in Marina del Rey. Near the surface, the brown alga *Sargassum muticum* grew well but red algae of all kinds were scarce. A short green alga (?*Ulva* sp.) grew on intertidal rocks, where it was eaten by shore crabs (*Pachygrapsus crassipes*).

Two dives were made in Marina del Rey on 18 April 1979. The first was near the end of the south wall, from near the surface to 10 feet. Visibility was barely one meter. The second was along the inside of the outer breakwater, to 17 feet deep. Visibility here was about 1½m. Temperature was 16°C (60°F). The water was full of silt and disturbed debris.

Along the south wall, the molluscs *Serpulorbis squamigerus*, *Mytilus edulis*, *Chama pellucida*, and *Hinnites multirugosus* were abundant. Other common animals were the ascidian *Styela montereyensis*, encrusting pink bryozoans, the bryozoan *Bugula neritina*, Hydroids, and the starfishes *Pisaster* *ochraceus*. Also present were cerianthid anemones in the mud, the spider crab *Podochela hemphilli* on rocks, and the rock crab *Cancer anthonyi*. Subadult sheep crabs (*Loxorhynchus grandis*) were very common -- about 1 crab was encountered every 1½m of bottom. Few fishes were seen -- only about 10 topsmelt, one blenny, and a small barred sand bass. A wooly sculpin was present in the intertidal zone.

The outer breakwater had somewhat clearer water. Fishes present were black perch, juvenile barred sand bass and kelp bass, kelpfish (*Gibbonsia* sp.), and olive rockfish. *Mytilus edulis* occurred in great clumps, with *Hinnites multirugosus* and *Chama pellucida*. Also present were hydroids, sponges, the nudibranch *Flabellina iodinea*, the starfish *Pisaster brevispinus*, the gastropod *Ocenebra poulsoni*, and the sea cucumber *Parastichopus parvimensis*. The brown alga *Sargassum muticum* was common. No subadult sheep crabs were present here, but heavily decorated juveniles were abundant among algae and hydroids.

Most of the invertebrates observed during dives are either suspension feeders or predators on slow-moving or sessile prey. The sheep crabs, however, may be migratory, coming into the sheltered harbor to feed or mate.

The settling rack data represent the sessile, attached and sedentary species having planktonic larvae that colonize the available substrates in the marina. Although a number of species without planktonic larvae can only be surveyed by diver observation, templated scrapings and the like, the racks offer more accurate seasonal or episodic information than do the latter techniques. Both natural, seasonal and oceanographic changes and non-natural influences were observed in the marina by means of meroplankton.

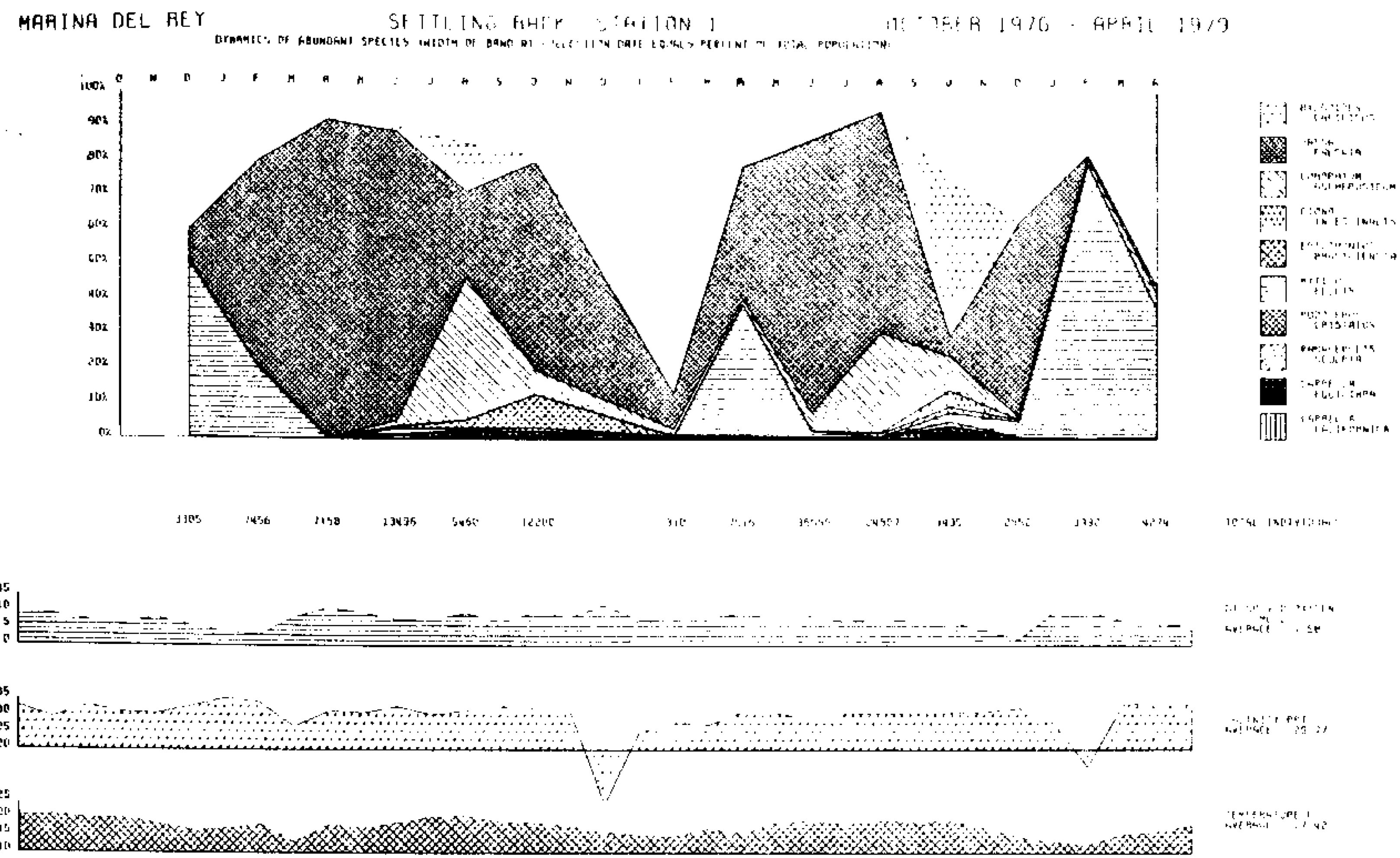


FIGURE 1. PERCENTAGES OF DOMINANT MEROPLANKTON SPECIES WITH NUMBERS PER STATION, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

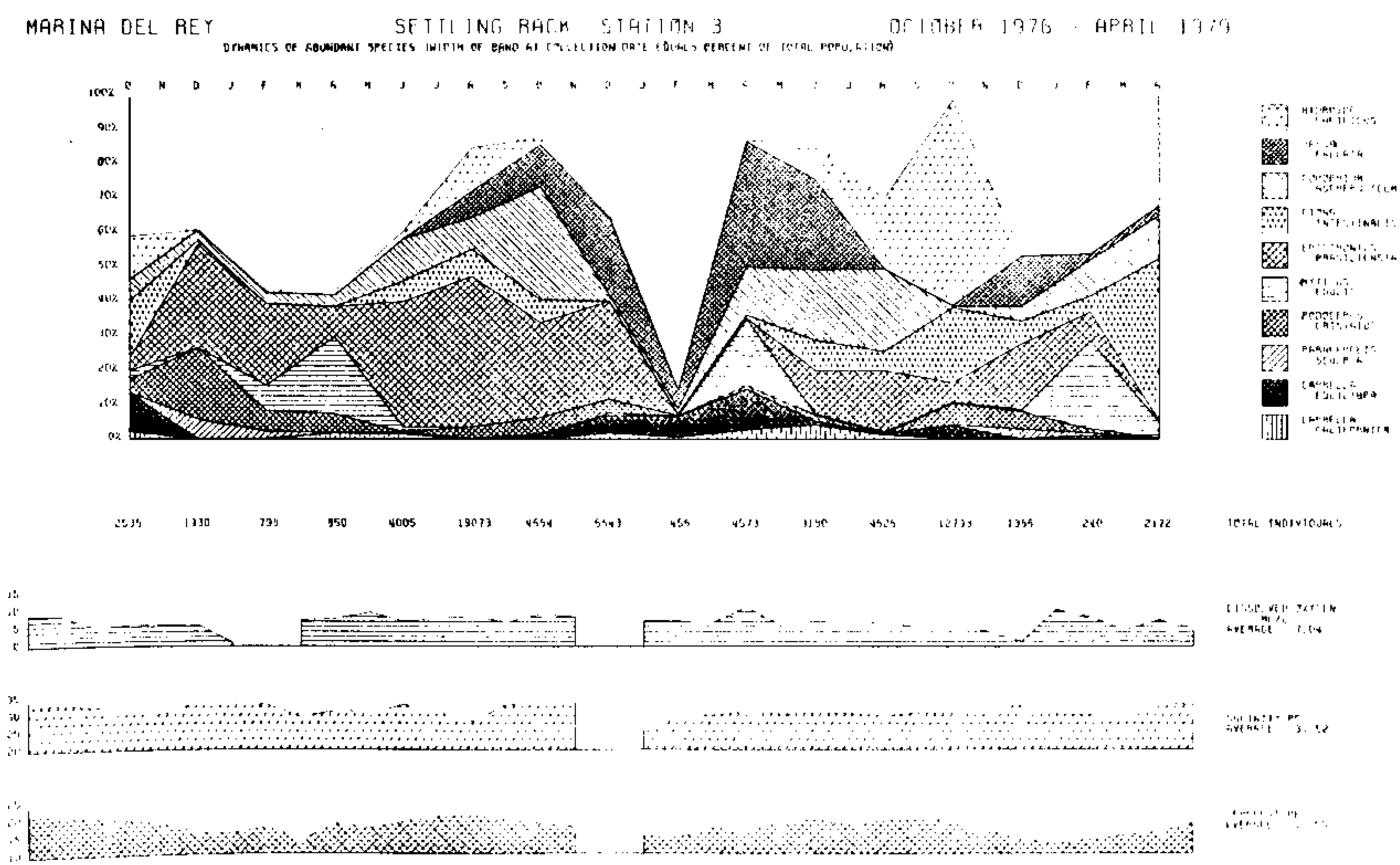


FIGURE 2. PERCENTAGES OF DOMINANT MEROPLANKTON SPECIES WITH NUMBERS PER STATION, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

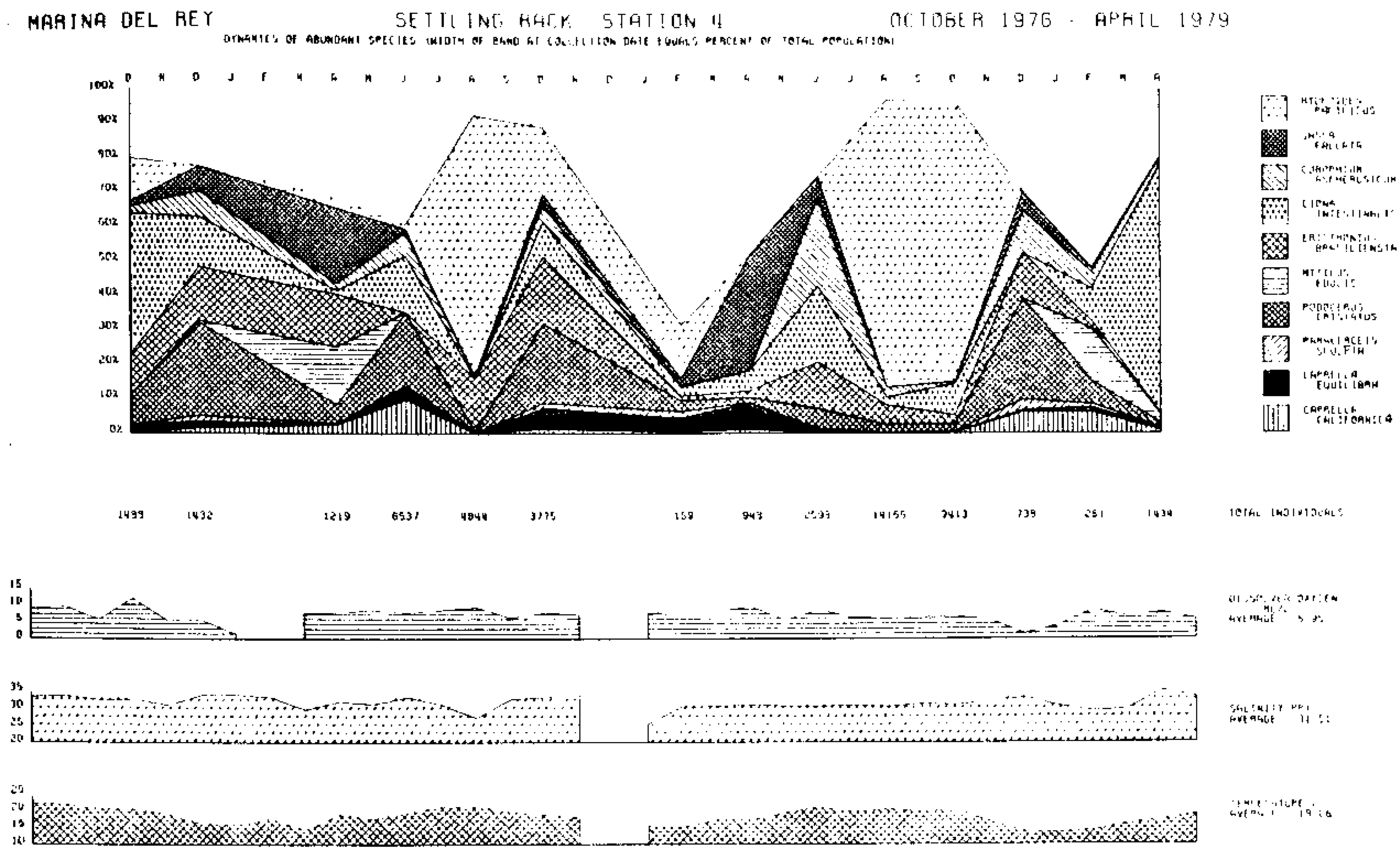


FIGURE 3. PERCENTAGES OF DOMINANT MEROPLANKTON SPECIES WITH NUMBERS PER STATION, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

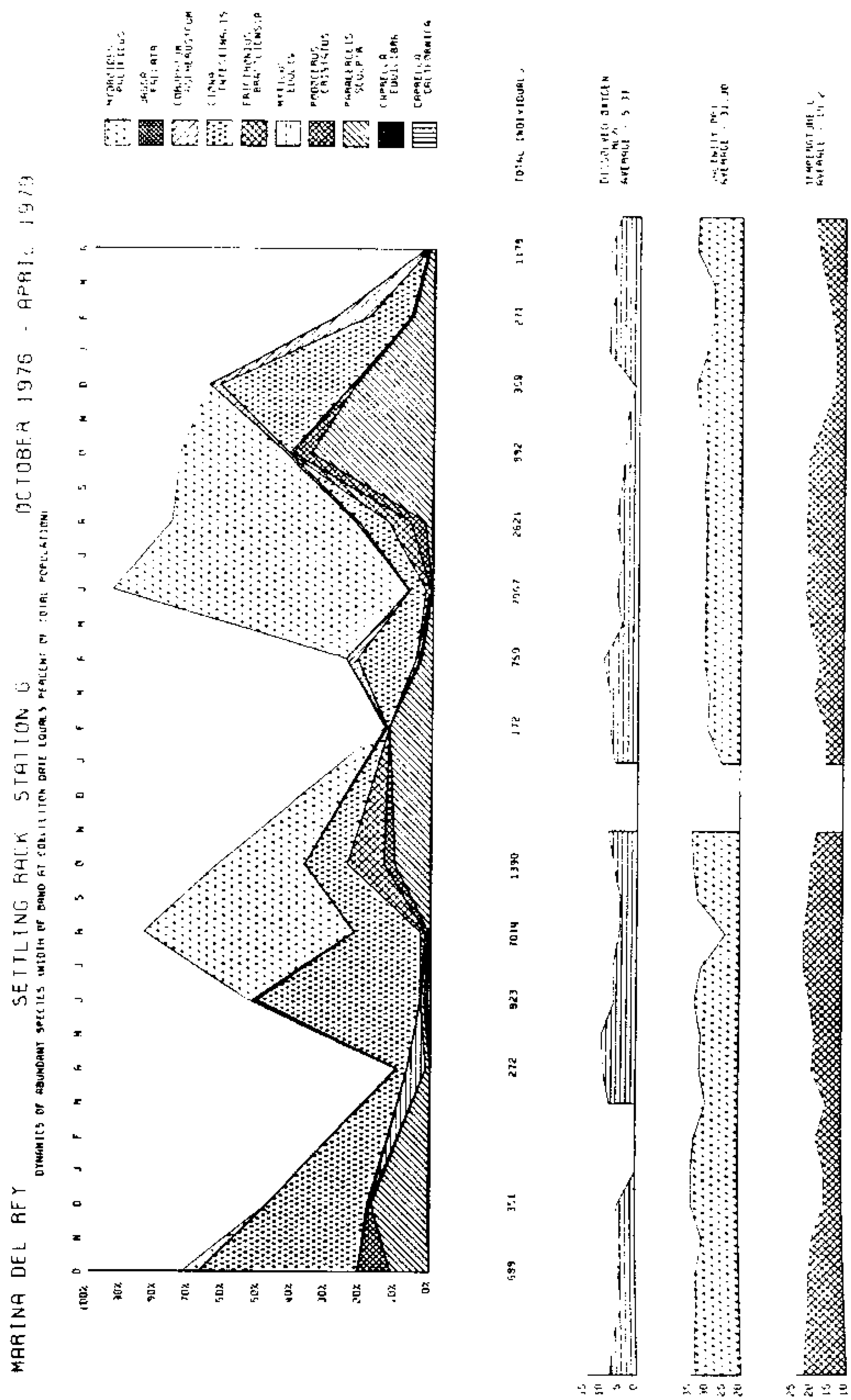


FIGURE 4. PERCENTAGES OF DOMINANT MEROPLANKTON SPECIES WITH NUMBERS PER STATION, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

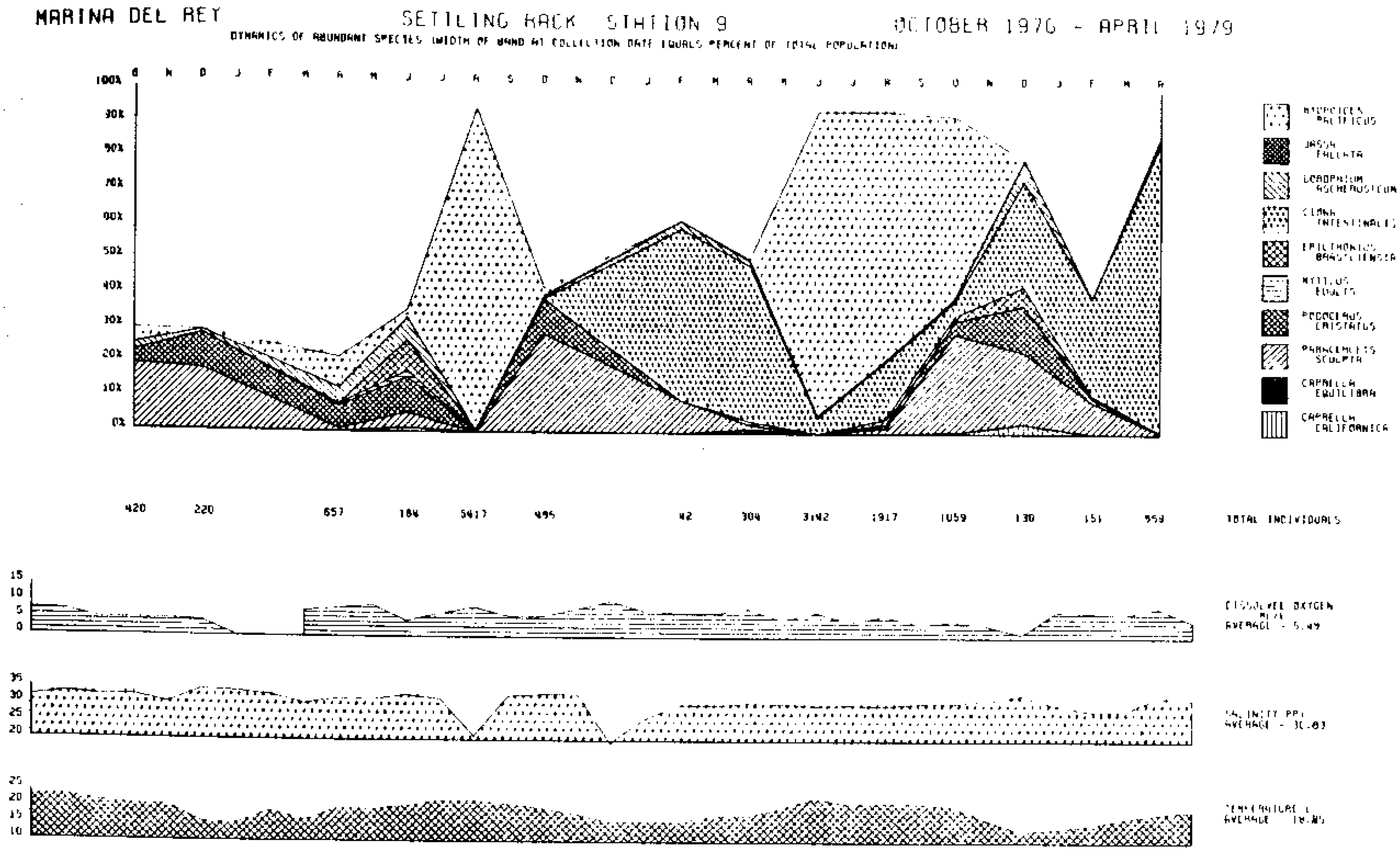


FIGURE 5. PERCENTAGES OF DOMINANT MEROPLANKTON SPECIES WITH NUMBERS PER STATION, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

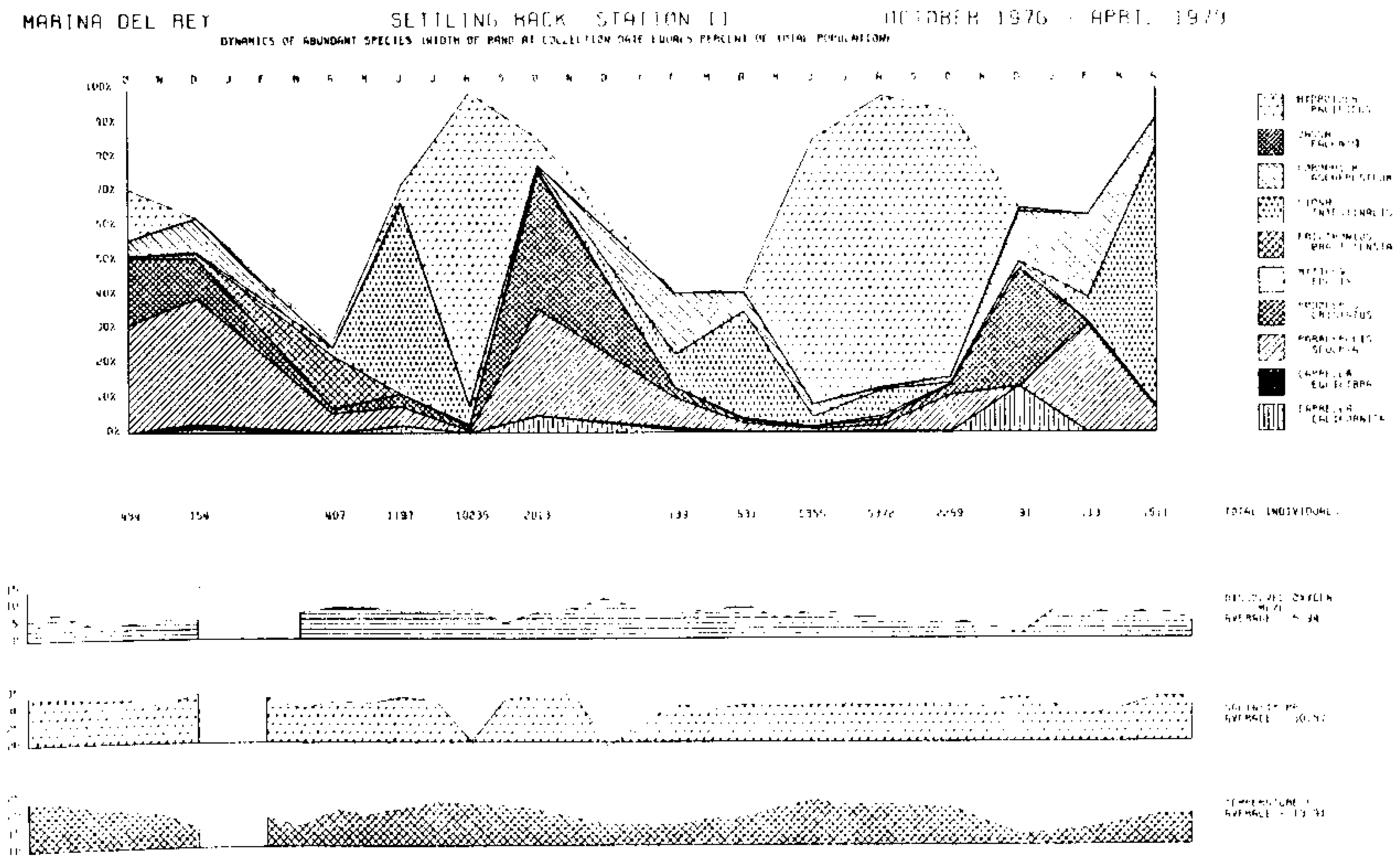


FIGURE 6. PERCENTAGES OF DOMINANT MEROPLANKTON SPECIES WITH NUMBERS PER STATION, DISSOLVED OXYGEN, SALINITY AND TEMPERATURE.

Table 1. Ranking of Dominant Settling Organisms, 1976 - 1979 Bimonthly Sampling

Number of Occurrences					Number of Individuals			
Rank	Species	Type	#Occurrences	x Annual	Rank	Species	#Individuals	x Annual #
1	*Corophium acherusicum*	Amphipod	97	32	1	*Hydroides pacificus*	125,783	41,928
2	*Elasmopus rapax*	Amphipod	91	30	2	*Jassa falcata*	69,139	23,046
3	*Ciona intestinalis*	Tunicate	90	30	3	*Corophium acherusicum*	39,336	13,112
4	*Paracerceis sculpta*	Isopod	85	28	4	*Ciona intestinalis*	26,292	8,764
5	*Podocerus cristatus*	Amphipod	83	28	5	*Ericthonius brasiliensis*	24,655	8,218
6	*Ericthonius brasiliensis*	Amphipod	78	26	6	*Mytilus edulis*	13,416	4,472
7	*Hydroides pacificus*	Polychaete	72	24	7	*Podocerus cristatus*	9,915	3,305
8	*Jassa falcata*	Amphipod	66	22	8	*Paracerceis sculpta*	4,853	1,618
9	*Polydora ligni*	Polychaete	65	22	9	*Caprella equilibra*	3,510	1,170
10	*Caprella californica*	Amphipod	62	21	10	*Caprella californica*	2,570	857
11	*Anatanais normani*	Tanaid	56	19	11	*Polyopthalmus pictus*	2,244	748
12	*Capitella capitata*	Polychaete	51	17	12	*Elasmopus rapax*	2,154	718
13	*Polyopthalmus pictus*	Polychaete	47	16	13	*Polydora ligni*	1,994	665
14	*Caprella equilibra*	Amphipod	46	15	14	*Anatanais normani*	1,881	627
15	*Mytilus edulis*	Mollusc	45	15	15	*Caprella verrucosa*	1,762	587

FISH FAUNA

INTRODUCTION

Marina del Rey is a man-made recreational marina with a total area of 165 hectares (407.6 acres). The marina was constructed in the early 1960's and lies adjacent to a large flood control channel (Ballona Creek). During rainy periods, stormwater runoff enters the marina both directly (Bowerman and Chen, 1971) via storm drains and indirectly by way of Ballona Creek (Brandsma, *et al.*, 1973). Bays and estuaries are considered to be valuable feeding and nursery grounds for fishes; hence it is important to ascertain the impact of pollutants upon the water quality and the biota of these areas. Since a large portion of western Los Angeles is drained by Ballona Creek, Marina del Rey might well be a natural sink for pollutants and hence an undesirable habitat for certain invertebrates and fishes.

The following study was carried out to determine if the fish fauna of Marina del Rey was a depauperate one compared to other local bays and small craft harbors in southern California. Horn and Allen (1976) determined that an equilibrium number of fish species is related to area for 13 bays and estuaries in California. No data on the fishes of Marina del Rey was available at that time and hence one purpose of this study was to determine whether an appropriate equilibrium is present as compared to other similar water bodies in southern California. If poor water quality within the marina makes it an undesirable habitat for fishes, the number of species present should be somewhat lower than would be expected.

As part of an analysis of the marina as a habitat for fishes, a thorough examination of the invertebrate biota along with physical and chemical parameters present was conducted, to determine the extent of impact that stormwater runoff had upon the water quality, and hence overall habitat, of Marina del Rey (Soule and Oguri, 1977). Water quality and habitat fitness studies can then be compared to fish population studies to obtain an overall assessment of the suitability of the marina as an environment for fishes.

To determine whether stormwater runoff caused direct mortality to fishes, large cages were placed in the marina and several species of fishes were held in them for a period of four months (February to May, 1978).

The present study thus sought to determine first, the nature of the fish fauna of the marina, and second, whether stormwater runoff caused poor enough water quality to prevent a normal assemblage of fishes from inhabiting Marina del Rey.

PROCEDURES

Fish Sampling

In order to obtain an adequate sampling of the fish fauna in Marina del Rey, otter trawls, gill net methods, diver survey and beach seining were employed. A 15-foot semi-balloon otter trawl was towed from the Los Angeles County workboat at a speed of 600 rmp's for periods of 10-15 minutes. The otter trawl was used to sample the main channel near the entrance (Trawl 1), adjacent to Chase Park (Trawl 2) and in Basin D (Trawl 3; see Figure 1). Otter trawl sampling was carried out in January and October of 1977 and in January and June of 1978.

To sample the larger, more rapidly swimming and non-benthic fish species, a multi-mesh size, 100 foot by 6 foot gill net was set in three locations for 45 minutes at each (stations 2, 5 and 6; Figure 1). Swimming species of all sizes that move into the area traversed by the gill net were thus caught. Gill net sampling occurred in June and October, 1977.

To determine what species occupy the main channel along the rock jetties, diver surveys were carried out (Figure 1) in January 1979 at three locations and in April 1979 at two locations.

Finally, the sand swimming beach (Basin D) was sampled with a 20 foot seine (mesh size 1/8 inch) in December of 1978.

Monthly sampling by Harbors Environmental Projects, University of Southern California, of the marina's biota and water quality over a three-year period has allowed for numerous casual observations of fishes within the marina. Periodic creel censuses of fishes caught by anglers from sea walls, jetties and the fishing dock were also made during the water quality monitoring studies.

Every attempt was thus made to sample the marina thoroughly so that an adequate analysis of the numbers of fish species would be obtained.

Fish Mortality Studies

Since storm water enters the marina and may be adversely affecting the habitat, an experiment was designed to determine whether poor water quality after rains caused mortality in marina fishes.

To test the impact of runoff water on fish, two large holding cages (4 ft by 4 ft by 10 ft) were constructed of ¼ inch Vexar mesh and placed alongside docks at stations 4 and 7. Station 4 includes the docks that are nearest to the marina entrance where water quality should be best, while inner slips E, F and G receive direct drain runoff. Two flatfishes, *Paralichthys californicus* (California halibut) and *Hypsopsetta* *guttulata* (diamond turbot) and one surfperch, *Phanerodon furcatus* (white surfperch) were chosen as test species.

In a study on the sequential mortality of 45 local fish species impounded during the construction of the Dana Point Marina, Waggoner and Feldmeth (1971) found surfperches to be least tolerant of low oxygen, while flatfishes were among the most tolerant. The species chosen for the present cage mortality studies thus represent the full spectrum of sensitivity to low dissolved oxygen.

The cages were placed in the water adjacent to a dock and 5 to 10 fish of each species were placed in both cages in February of 1978. The cages were checked weekly and the fishes were fed anchovies and squid.

RESULTS AND DISCUSSION

The fishes observed in Marina del Rey by the various sampling methods are presented in Table 1 and total 35 species. The otter trawl was the most productive sampling method, accounting for 18 species captured. Since the otter trawl was fished for approximately equal lengths of time (10-15 minutes) in three different locations in the marina, comparative data for species and numbers were tabulated (Table 2).

The trawls taken at the marina's entrance (Stations 2 to 3) yielded a total of 97 fishes, representing 13 species and a diversity index (Margalef, 1968) of 2.62. Trawl 2 was fished in the central and rear portions of the main channel (Stations 5 to 11) and produced 550 individuals representing 11 species and a diversity index of 1.58. Trawl 3 (Basin D, near Station 8) yielded 737 individuals representing 10 species and a diversity index of 1.36.

The numbers of fish caught in each trawl varied considerably according to season. The mean numbers of fishes captured during the summer sampling periods of June 1977 and June 1978 were 206 and 173, respectively (Table 2), while the mean number of fishes sampled in October 1977 was 70.7 and 12.7 in January 1978.

No mortality occurred to the fishes held in either of the cages during the test period of February to May, 1978.

Tables 3-8 present the data on the seasonal fish surveys according to catch methods.

Marina del Rey was opened in 1962 and has had ample time to be colonized by fishes. The mouth width of 275 m and a total area of 165 hectares should provide accessibility and habitat for the numerous bay and estuarine fish species present in southern California (Horn, 1974). Yet only 35 species of fish were found to be present, while similarly sized bays such as Alamitos Bay and Anaheim Bay provided habitat for 43 and 59 species, respectively (Allen, 1976; Lane and Hill, 1976).

Horn and Allen (1976) suggested that dumping of pollutants may be responsible for a reduction in species diversity of fishes in southern California bays. Marina del Rey experiences considerable impact from storm waters, as evidenced by surface debris, organic materials, oil, grease, pesticides and certain heavy metals, which may have a significant impact upon the habitat (Soule and Oguri, 1977). Even infrequent periods of poor water quality after heavy rains may bring about enough habitat degradation to cause some fish mortality as well as migration out of the adverse conditions. For example, on January 20, 1977 after a period of heavy rain, mean dissolved oxygen levels fell to 0.3 to 1.1 ppm for the inner portions of the marina and were only 2.3 to 3.3 ppm at the entrance. Waggoner and Feldmeth (1971) concluded that oxygen levels below 3.0 ppm might be fatal to fishes that are especially sensitive to low oxygen concentration, such as the surfperches (Family Embiotocidae). Also, numerous fish species have been observed to avoid water of low oxygen content, even oxygen levels that produced no acute respiratory distress (Whitmore, Warren and Doudoroff, 1960). Fishes are also known to leave areas of heavy influx of fresh water temporarily, such as would occur with the stormwater runoff. Bait fishermen who formerly fished for anchovy in Los Angeles-Long Beach Harbor (B. Verna, pers. comm.) know that anchovy would run to sea and deep water before large storms.

Other factors beside poor water quality may be responsible for the apparent depauperate fish fauna within Marina del Rey. Water depth is relatively uniform at approximately 10 to 15 feet. Vertical concrete sea walls bound the entire marina and hence substrate is relatively homogeneous. Only one sandy shore is present and its location (swimming beach in Basin D, near Station 8) at the end of a side channel is probably not a habitat conducive to estuarine intertidal invertebrate and fish species. Thus the physical environment present lacks diversity and may limit the marina as a suitable fish habitat.

However, in a comparison of the fish faunas of 13 bays and estuaries in California, Horn and Allen (1976) found a remarkably consistent correlation between size and number of species present. Their study included bays which were relatively pristine, such as Tijuana Estuary and Anaheim Bay, as well as heavily developed marinas such as Newport Bay and Alamitos Bay (Figure 2). The relationship between number of fish species and area in their study was best described by the curve $S=1.20A^{0.21}$ where S is the number of species and A is the area of the bay. From their equation a bay the size of Marina del Rey should be expected to have an equilibrium number of 46 species, 11 more than are present. The consistency of the correlation described by Horn and Allen for bay size versus species number for water bodies of considerable variability in size and habitat diversity is impressive. The relatively homogeneous habitat of Marina del Rey is thus probably not responsible for the low number of species; hence other factors such as water quality may well account for the paucity of fish species present.

Supporting the hypothesis that transitory episodes of poor water quality offer an explanation for the low species diversity of Marina del Rey fishes, is the comparison of numbers of fish caught in otter trawls in different seasons (Tables 3-8). During the dry summer months, water quality is not affected by storm waters, and dissolved oxygen generally remains normal (Soule and Oguri, 1977). As a result, large numbers of fishes were caught by the otter trawls in June of 1977 (mean=206) and 1978 (mean=173). In October of 1977 the mean catch fell to 70.7 individuals and reached its lowest point in January of 1978 (12.7 individuals). McErlean, *et al.* (1973), Haedrick and Haedrick (1974) and Haedrick (1975) have all correlated similar periods of seasonal abundance in fishes with times of poor water quality in bays and estuaries along the east coast of the United States. Thus it appears that bay fishes actively avoid areas of poor water quality.

The considerably lower diversity indices for the otter trawls made for the inner portion of the marina (Table 2) may also be due to avoidance of habitat with reduced food supply. Soule and Oguri (1977) also found lower diversity indices for zooplankton for the inner portions of Marina del Rey, as well as lower phytoplankton productivity and chlorophyll values with increased distance from the entrance. Productivity and chlorophyll values were 2-3 times lower in Marina del Rey in 1976 than in Los Angeles-Long Beach Harbors (AHF, 1976). The harbors had much lower values in 1978, following cessation of fish processing effluents and installation of secondary waste treatment (Soule and Oguri, 1979a). Marina levels were much lower in 1978 than in the two previous years.

Since no mortality occurred for either the flatfishes or surfperch in the test cages during a period of unusually wet weather (February to May, 1978), storm water may not directly cause mortality for the marina's fish fauna. However, the extremely low dissolved oxygen levels (to 0.0) measured during 1976 and 1977 did not occur again, although they reached 1.1 ppm in December of 1978. Water quality may also be variable enough in salinity and/or temperature to cause fish to migrate out of the marina during the winter, however, and explain the low numbers of fishes encountered in the January 1978 otter trawls. Lack of phytoplankton and zooplankton for food caused by the stormwater runoff could also cause the fish to move out of the marina; this might then explain the lack of mortality in the caged fish, which were fed. In the absence of stress from severe oxygen depletion, this factor may be more important.

An observation which seems to suggest an improvement of water quality and habitat conditions in 1978 involves the arrow goby, *Clevelandia ios*. This small fish lives in worm burrows in the bottom mud and probably cannot escape periods of extremely low oxygen by migrating out of the marina. In trawl 2 (station 5 to 11) no arrow gobies were present in June of 1977, two were present in October of 1977, 14 were present in January 1978 and 200 were present in June of 1978. Since the same otter trawl net, boat and crew were used and the sampling stations are easily identified with good landmarks, it would appear that sampling procedures were consistent. The poor water quality periods of the winter of 1977 may well have caused the arrow goby's demise, and its subsequent recovery occurred as water quality conditions improved in 1978.

CONCLUSION

In conclusion, Marina del Rey does indeed have a depauperate fish fauna which appears to be caused by periods of water quality degradation following rains and storm runoff. The low equilibrium number of fish species present is probably brought about by migration out of the marina during the rainy winter months when storm waters enter Marina del Rey. The probable presence of toxic substances brought into the marina by storm waters may also impact the phytoplankton and invertebrate members of the community so that the trophic structure necessary to support a normal assemblage of fishes does not develop. Such overall poor biotic habitat and instability of water quality due to periodic rains and subsequent runoff thus prevent a normal complement of fish species from populating the marina. Chemical analyses carried out by the Los Angeles County Flood Control District suggest either that fewer pollutants are now finding their way into the flood control channel, or that the pollutants which had accumulated in the channels during the dry years prior to 1977 have been flushed out of the marina.

The inherent design of the inner marina, with straight, vertical concrete walls and a soft, flat bottom, does not provide the diversity of habitat that would in turn encourage diversity of invertebrates and algae. The rock jetties better provide food and shelter for diverse fish species. A further analysis of bays and estuaries for slope, bottom contour and available substrates might add to the effectiveness of areal calculations.

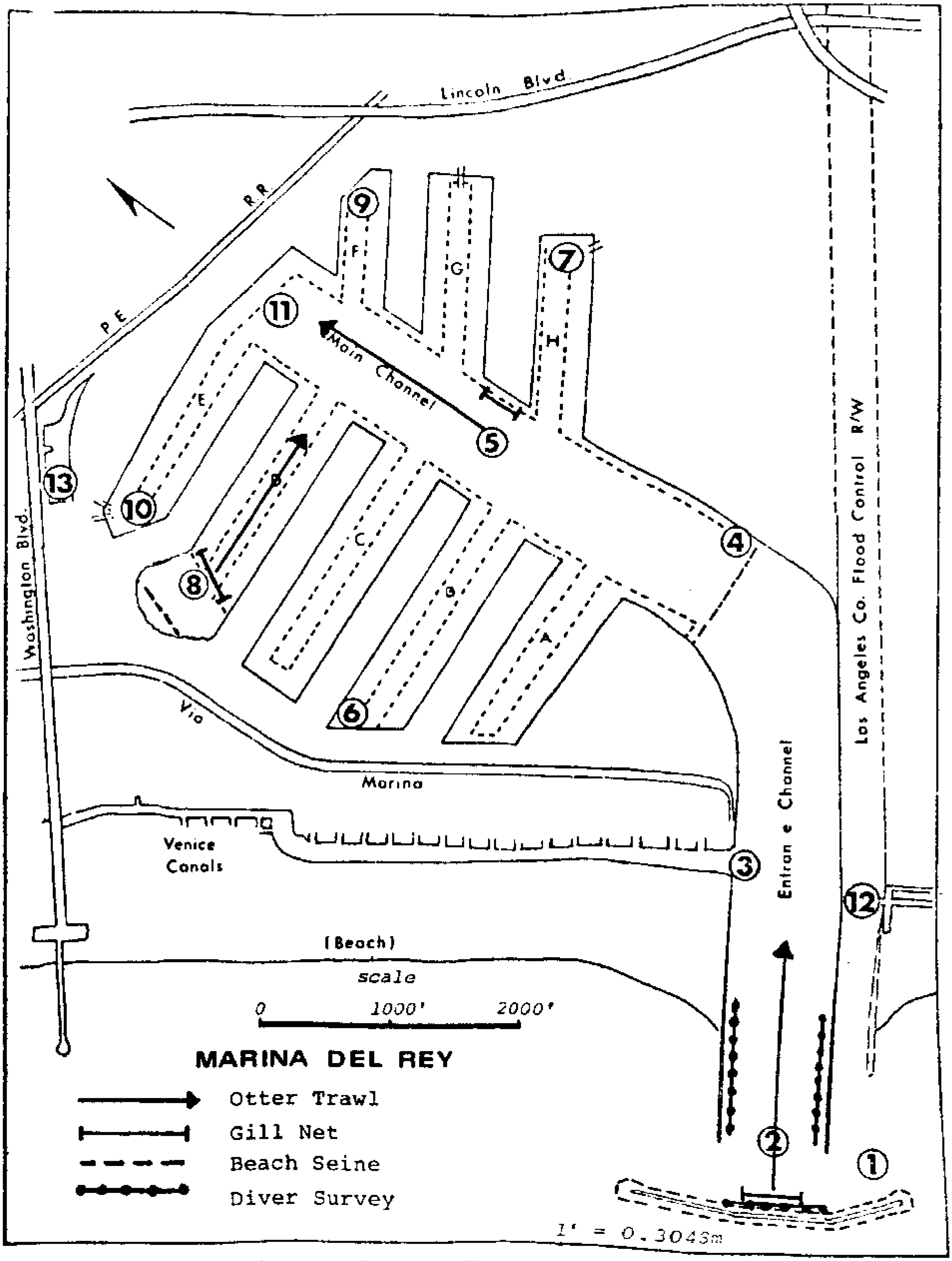


Figure 1. Fish sampling stations for Marina del Rey.

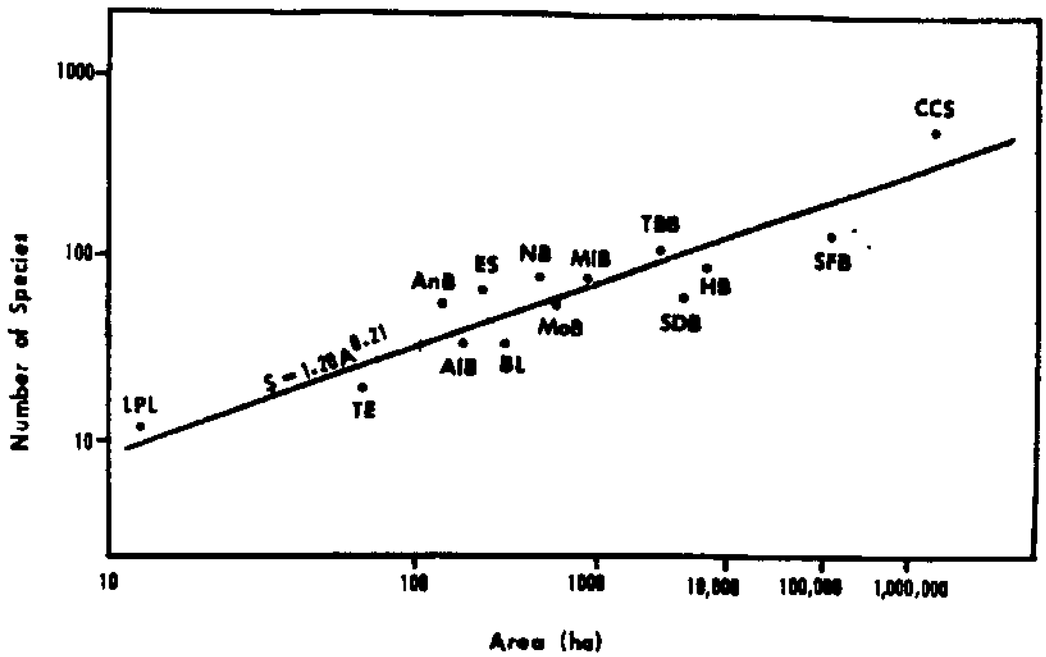


Figure 2. Relationship of numbers of species and surface area for 13 California bays and estuaries and the California continental shelf.

Tijuana Estuary (TE), *San Diego Bay* (SDB), *Mission Bay* (MiB), *Los Penasquitas Lagoon* (LPL), *Newport Bay* (NB), *Anaheim Bay* (AnB), *Alamitos Bay* (AlB), *Morro Bay* (MoB), *Elkhorn Slough* (ES), *San Francisco Bay* (SFB), *Bolinas Lagoon* (BL), *Tomales-Bodega Bay*)TBB), *Humboldt Bay* (HB) *and the California continental shelf* (CCS).

r=0.93 (P<.01) (Horn and Allen, 1976).

Table 1. Fish Caught in Marina del Rey, by Method

Species	Common Name	Sampling Method				
		otter trawl	gill net	diver survey	beach seine	visual sighting or creel census
Atherinops affinis	top smelt				X	
Atherinopsis californiensis	jack smelt		X			
Citharichthys stigmaeus	speckled sanddab	X				
Clevelandia ios	arrow goby	X				
Clinocottus analis	wooly sculpin			X		
Cymatogaster aggregata	shiner surfperch	X		X		
Embiotoca jacksoni	black surfperch	X		X		
Engraulis mordax	northern anchovy	X				
Fundulus parvipinnis	California killifish				X	X
Genyonemus lineatus	white croaker	X	X			
Gibbonsia sp.	kelp fish			X		
Girella nigricans	opaleye			X		
Hypsoblennius sp.	blenny			X		
Hypsopsetta guttulata	diamond turbot	X				
Hypsypops rubicundus	garibaldi			X		
Leptocottus armatus	staghorn sculpin	X				
Mustelus henlei	brown smoothhound					X
Myliobatis californica	bat ray	X				
Neoclinus stephensae	yellowfin fringehead			X		
Oxyjulis californica	senorita			X		
Paralabrax clathratus	kelp bass			X		
Paralabrax maculatofasciatus	spotted sand bass	X				
Paralabrax nebulifer	barred sand bass			X		
Paralichthys californicus	California halibut	X				
Phanerodon furcatus	white surfperch	X		X		X
Rhacochilus toxotes	rubberlip surfperch			X		
Rimicola muscarum	kelp clingfish	X				
Sarda chiliensis	Pacific bonito					X
Sebastes serranoides	olive rockfish			X		
Seriphus politus	queenfish	X				
Sphyraena argentea	California barracuda		X			
Symphurus atricauda	California tonguefish	X				
Syngnathus leptorhynchus	bay pipefish	X				
Synodus lucioceps	California lizardfish	X				
Urolophus halleri	round stingray	X				

Table 2. Seasonal Summary of Otter Trawl Data

Location	Species	Number and date caught 6/77	10/77	1/78	6/78	Total
Trawl 1	*Citharichthys stigmaeus*	0	1	0	0	1
	Cymatogaster aggregata	15	0	3	0	18
Stations 2-3	*Embiotica jacksoni*	1	0	0	1	2
	Engraulis mordax	0	8	0	0	8
	Genyonemus lineatus	0	0	1	3	4
	Hypsopsetta guttulata	1	0	1	3	4
	Paralichthys californicus	25	0	4	0	29
	Paralabrax maculatofasciatus	9	0	0	0	9
	Phanerodon furcata	0	4	0	0	4
	Rimicola muscarum	1	0	0	0	1
	Seriphus politus	0	12	0	2	14
	Symphurus atricauda	0	0	0	1	1
	Syngnathus leptorhynchus	1	0	0	0	1
	Total species = 13	53	25	9	10	97
				Div. index = 2.63		
Trawl 2	*Clevelandia ios*	0	2	14	200	216
	Cymatogaster aggregata	0	11	0	0	11
Stations 5-11	*Engraulis mordax*	15	108	0	6	129
	Genyonemus lineatus	35	8	2	4	49
	Hypsosetta guttulata	0	1	1	1	3
	Paralabrax maculatofasciata	3	3	0	1	7
	Paralichthys californicus	5	11	3	3	22
	Phanerodon furcatus	0	11	0	0	11
	Seriphus politus	0	29	0	70	99
	Synodus lucioceps	0	0	1	0	1
	Urolophus halleri	2	0	0	0	2
	Total species = 10	60	184	21	285	550
				Div. index = 1.58		
Trawl 3	*Citharichthys stigmaeus*	0	0	3	0	3
	Clevelandia ios	0	1	0	0	1
Station 8, Basin D	*Engraulis mordax*	500	1	0	0	501
	Genyonemus lineatus	3	1	0	15	19
	Hypsopsetta guttulata	1	0	1	0	2
	Leptocottus armatus	1	0	0	0	1
	Myliobatis californica	0	0	0	1	1
	Paralichthys californicus	0	0	1	5	6
	Seriphus politus	0	0	2	200	202
	Synodus lucioceps	0	0	1	0	1
	Total species = 10	505	3	8	223	737
				Div. index = 1.36		
	Total =	618	212	38	518	
	Mean =	206	70.7	12.7	173	

Table 3. Data for Fish Census, June 23, 1977

Otter Trawl No. 1 (10 min): From station 2 up-channel, mid-way between the two jetties.

Paralichthys californicus	California halibut	40-60 mm	15
		150-200 mm	10
Hypsopsetta guttulata	diamond turbot	180 mm	1
Embiotica jacksoni	black surfperch	150 mm	1
Syngnathus leptorhynchus	bay pipefish	300 mm	1
Cymatogaster aggregata	shiner surfperch	80-100 mm	3
		juveniles	12
Paralabrax maculatofasciatus	spotted sand bass	juveniles	9
Unidentified juvenile surfperch			1
Unidentified larvae			1
Rimicola muscarum	kelp clingfish	10 mm	1

Otter Trawl No. 2 (10 min): From station 5 toward station 11, main channel.

Genyonemus lineatus	white croaker	200-250 mm	10
		juveniles	25
Paralichthys californicus	California halibut	150-200 mm	5
Paralabrax maculatofasciatus	spotted sand bass	juveniles	3
Urolophus halleri	round stingray	450 mm	2
Engraulis mordax	northern anchovy	50-80 mm	15

Otter Trawl No. 3 (10 min): Basin D from station 8 outward

Paralichthys californicus	California halibut	150 mm	2
		450 mm	1
Genyonemus lineatus	white croaker	200-250 mm	3
Engraulis mordax	northern anchovy	50-80 mm	500 (estimate)
Leptocottus armatus	staghorn sculpin	100 mm	1
Hypsopsetta guttulata	diamond turbot	160 mm	1

Gill Net Sets (1 hour)

Gill Net Set 1. Parallel to breakwater at station 2, in at 0815 PDT

Atherinopsis californiensis	Jack smelt	320 mm	4
Genyonemus lineatus	White croaker	220 mm	1

Gill Net Set 2. Near station 5 parallel to sea wall of Park, in at 0935 PDT

Sphyraena argentea	California barracuda	450 mm	1

Gill Net Set 3. Near station 8 in Basin D, in at 1050 PDT

Genyonemus lineatus	White croaker	200 mm	1

13 species

630 individuals

Table 4. Data for Fish Census, October 21, 1977

Otter Trawl No. 1 (15 min): From station 2 up channel, mid-way between the two jetties. Time 12:45-1:00 p.m.

Citharichthys stigmaeus	Speckled sanddab	100 mm	1
Seriphys politus	Queenfish	50-80 mm	12
Genyonemus lineatus	White croaker	200 mm	1
Engraulis mordax	Northern anchovy	60-90 mm	1
Phanerodon furcatus	White surfperch	200-250 mm	4

Otter Trawl No. 2 (15 min): From station 5 toward station 11, main channel. Time 1:35-1:50 p.m.

Clevelandia ios	Arrow goby	25-30 mm	2
Paralichthys californicus	California halibut	200-250 mm	11
Hypsosetta guttulata	Diamond turbot	200 mm	1
Genyonemus lineatus	White croaker	250-300 mm	8
Paralabrax maculofasciata	Spotted sandbass	200 mm	3
Phanerodon furcatus	White surfperch	220-260 mm	11
Engraulis mordax	Northern anchovy	50-90 mm	108
Seriphus politus	Queenfish	50-80 mm	29
Cymatogaster aggregata	Shiner surfperch	60-100 mm	11

Otter Trawl No. 3 (20 min): Basin D from station 8 toward main channel. Time: 3:25-3:45 p.m.

Engraulis mordax	Northern anchovy	65 mm	1
Clevelandia ios	Arrow goby	35 mm	1

11 species
212 individuals

Table 5. Data for Fish Census, January 31, 1978
(followed 2 months of heavy rains)

Station 2. Fished trawl 15 min at 600 RPM on work boat.
Trawl begun 0913

Otter Trawl

Genyonemus lineatus	White croaker	200 mm	1
Cymatogaster aggregata	Shiner surfperch	90 mm	3
Paralichthys californicus	California halibut	100 mm	4
Hypsopsetta guttulata	Diamond turbot	230 mm	1
			9

Gill Net (Fished 0900-0940)

Phanerodon furcatus	White surfperch	200 mm	8
Sphyraena californica	California barracuda	350 mm	1
Atherinops californiensis	Jack smelt	250 mm	2
Genyonemus lineatus	White croaker	180 mm	1
			12

Station 5. Trawl begun 1014 (fished 15 min)

Otter Trawl

Genyonemus lineatus	White croaker	200 mm	2
Hypsopsetta guttulata	Diamond turbot	250 mm	1
Paralichtys californicus	California halibut	250,100,130mm	3
Clevelandia ios	Arrow goby	250 mm	14
Synodus lucioceps	California lizardfish	150 mm	1
			21

Gill Net (Fished 1000-1040)

No fish caught

Station 8.

Otter Trawl (Fished 1211-1226)

Citharichthys stigmaeus	Speckled sandab	150 mm	3
Paralichthys californicus	California halibut	350 mm	1
Synodus lucioceps	California lizardfish	200 mm	1
Seriphus politus	Queenfish	50 mm	2
Hypsopsetta guttulata	Diamond turbot	200 mm	1
			8

Gill Net (Fished 1209-1249)

No fish caught

Total species = 11
Total individuals = 50

Table 6. Data for Fish Census, June 16, 1978

Otter Trawl No. 1: From station 2 up channel, mid-way between the two jetties.
Time: 1:47-2:03 p.m.

Genyonemus lineatus	White croaker	200-230 mm	3
Hypsosetta guttulata	Diamond turbot	300-350 mm	3
Symphurus atricauda	California tonguefish	250 mm	1
Seriphus politus	Queenfish	200 mm	2
Embiotica jacksoni	Black surfperch	230 mm	1

Otter Trawl No. 2: From station 5 toward station 11. Time 2:40-2:55 p.m.

Genyonemus lineatus	White croaker	240-260 mm	4
Paralichthys californicus	California halibut	150-170 mm	3
Seriphus politus	Queenfish	140-170 mm	60
	(juveniles)	30-50 mm	10
Hypsosetta guttulata	Diamond turbot	200 mm	1
Paralabrax maculofasciata	Spotted sand bass	100 mm	1
Clevelandia ios	Arrow goby	30-35 mm	200
Engraulis mordax	Northern anchovy	100-150 mm	6

Otter Trawl No. 3: From station 8 (Basin D) out toward main channel.
Time 3:25-3:50 p.m.

Myliobatis californica	Bat ray	450 mm	1
Genyonemus lineatus	White croaker	150=200 mm	15
Seriphus politus	Queenfish	100-130 mm	200
Paralichthys californicus	California halibut	250-350 mm	5

10 species
516 individuals

Table 7. Diver Census, January 24, 1979
(followed 2-week rainy period)

Jetties

Atherinops affinis	top smelt	10*	
Embiotoca jacksoni	black surfperch	2	4 species
Oxyjulis californica	senorita	10*	24 individuals
Paralabrax nebulifer	barred sand bass	2	(* estimated)

Breakwater

Hypsypops rubicundus	garibaldi	1	
Paralabrax clathratus	kelp bass	5	4 species
Damalichthys vacca	pile surfperch	1	8 individuals
Neoclinus stephensae	yellowfin fringehead	1	

Table 8. Fish Census of April 18, 1979

Trawl Data

Otter Trawl No. 1 (10 min)

Cymatogaster aggregata	shiner surfperch	4	
Neoclinus blanchardi	sarcastic fringehead	1	
Hypsurus caryi	rainbow surfperch	2	6 species
Hypsopsetta guttulata	diamond turbot	1	10 individuals
Citharichthys stigmaeus	speckled sanddab	1	
Genyonemus lineatus	white croaker	1	

Otter Trawl No. 2 (10 min)

Genyonemus lineatus	white croaker	11	
Paralichthys californicus	California halibut	6	4 species
Hypsopsetta guttulata	diamond turbot	2	23 individuals
Clevelandia ios	arrow goby	4	

Otter Trawl No. 3 (10 min)

Genyonemus lineatus	white croaker	10 (2 juv.)	
Paralichthys californicus	California halibut	1	
	Unid. juv. surfperch	1	4 species
Clevelandia ios	arrow goby	4	18 individuals

8 species
49 individuals

Diver Census

East jetty (end to 100 yds north)

Clinocottus analis	wooly sculpin	1	
Hypsoblennius sp.	blenny	1	
Paralabrax nebulifer	barred sand bass	1	5 species
Atherinops affinis	top smelt	1	5 individuals
Leptocottus armatus	staghorn sculpin	1	

T-breakwater near station 2

Paralabrax nebulifer	barred sand bass	2	
Gibbonsia sp.	kelp fish	1	
Embiotica jacksoni	black surfperch	1	6 species
Paralabrax clathratus (juv)	kelp bass	3	9 individuals
Sebastes serranoides	olive rockfish	1	
Rhacochilus toxotes	rubberlip surfperch	1	

10 species
14 individuals

LITERATURE CITED

Allan Hancock Foundation. 1976. Environmental investigations and analyses, Los Angeles-Long Beach Harbors 1973-1976. Final report to the U.S. Army Corps of Engineers, Los Angeles District. Harbors Environmental Projects, Allan Hancock Found., Univ. So. Calif. 737 pp.

Allen, L.G. 1976. Additions to the list of fish species known from Alamitos Bay, California, based on studies in Colorado Lagoon. Calif. Dept. Fish and Game 62(4):299-303.

American Public Health Association. 1975. Standard Methods for the Examination of Water and Wastewater, 14th ed. New York. 1193 pp.

Bakus, G.J. 1975. Ballona Lagoon: Marine biology and water quality. Tetra tech Proposal TC 110-36. Tetra Tech, Inc., Pasadena, Calif. 27 pp.

Bowerman, F.R. and K.Y. Chen. 1971. Marina del Rey: A study of environmental variables in a semi-enclosed coastal water. Univ. So. Calif. Sea Grant Program USC-SG-4-71. 59 pp.

Brandsma, M.G., J.J. Lee and F.R. Bowerman. 1973. Marina del Rey: Computer simulation of pollutant transport in a semi-enclosed water body. Univ. So. Calif. Sea Grant Program USC-SG-1-73. 113 pp.

Chen, K.Y. and J.C.S. Lu. 1974. Sediment compositions in Los Angeles-Long Beach Harbors and San Pedro Basin. In Marine Studies of San Pedro Bay, California. D. Soule and M. Oguri (eds.). Part 7. Allan Hancock Found. and Sea Grant Program, Univ. So. Calif. 177 pp.

Fauchald, K. 1977. The polychaete worms; definitions and keys to the orders, families and genera. Nat. Hist. Museum of Los Angeles County, Science Series. 28:1-190.

Felix, D.W. 1969. An inexpensive recording settling tube for analysis of sands. J. Sed. Petrol. 39(2):777-780.

Ford, R.F. and G. Collier. 1976. An ecological evaluation of Ballona Lagoon. Center for Marine Studies, San Diego State Univ. 76 pp.

Gibbs, R.J., M.P. Matthews, and D.A. Link. 1971. The relationship between sphere size and settling velocity. J. Sed. Petrol. 41(1):7-18.

Haedrick, R.L. 1975. Diversity and overlap as measures of environmental quality. Water Research 9:945-952.

Haedrick, R.L. and S.D. Haedrick. 1974. A seasonal survey of the fishes in the Mystic River, a polluted estuary in downtown Boston, Massachusetts. Estuar. Coast. Mar. Sci. 2:59-73.

Harbors Environmental Projects. 1979. Bioassay investigations of sediments for the Pier J Completion Project EIR, Port of Long Beach, California. Harbors Environ. Proj., Univ. So. Calif. 116 pp.

Hartman, O. 1968. Atlas of the errantiate polychaetous annelids from California. Allan Hancock Found., Univ. So. Calif. 828 pp.

Hartman, O. 1969. Atlas of the sedentariate polychaetous annelids from California. Allan Hancock Found., Univ. So. Calif. 812 pp.

Horn, M.H. 1974. Fishes, Chapter 11. In A summary of knowledge of the southern California coastal zone and offshore areas. Vol. II. Biological environment. (M.D. Dailey, B. Hill and N. Lansing, eds.). South. Calif. Ocean Stud. Consort. for Div. Mar. Minerals, Bureau of Land Management, U.S. Dept. Interior, Contract No. 08 550 - CT 4-1, 124 pp.

Jones, J.H. 1971. General circulation and water characteristics in the southern California bight. Southern Calif. Coastal Water Res. Proj. 37 pp.

Lane, E.D. and C.W. Hill (eds). 1976. Marine resources of Anaheim Bay. Calif. Dept. Fish Game Fish Bull. 195 pp.

Margalef, D.R. 1968. Perspectives in Ecological Theory. Univ. of Chicago Press, Chicago. 111 pp.

McErlean, A.J., S.G. O'Conner, J.A. Mihursky and C.I. Gibson. 1973. Discussion of the status of knowledge concerning sampling, variation, physiologic tolerance and possible change criteria for bay organisms. Chesapeake Sci. 13: 542-554.

Neilsen, E. Steeman. 1952. The use of radioactive carbon (^{14}C) for measuring organic production in the sea. Rapp. Cons. Explor. Mer 144:92-95.

Pettijohn, F.J. 1957. Sedimentary Rocks. 2nd ed. Harper and Row, New York. 718 pp.

Reid, J.L. 1960. Oceanography of the northeastern Pacific Ocean during the last ten years. Calif. Coop. Ocean Fish. Invest. Repts. 7:77-90.

Solorzano, L. 1969. Determination of ammonia in natural waters by the phenolhypochlorite method. Limnol. Oceanogr. 14(5):799-801.

Soule, D.F. 1974. Thermal effects and San Pedro Bay. In Marine Studies of San Pedro Bay, California. D. Soule and M. Oguri (eds). Part 3. Allan Hancock Found. and Sea Grant Prog., Univ. So. Calif., Los Angeles. pp 1-20.

Soule, D.F. and M. Oguri. 1977. The marine ecology of Marina del Rey Harbor, California. In Marine Studies of San Pedro Bay, California. Part 13. Allan Hancock Found. and Sea Grant Prog., Instit. Mar. Coast. Stud., Univ. So. Calif. 424 pp.

Soule, D.F. and M. Oguri. 1978. Biological investigations. Marine Studies of San Pedro Bay, California. Part 14. Allan Hancock Found. and Sea Grant Prog., Instit. Mar. Coast. Stud., Univ. So. Calif., Los Angeles. 164 pp.

Soule, D.F. and M. Oguri. 1979a. Ecological changes in outer Los Angeles-Long Beach Harbors following initiation of secondary waste treatment and cessation of fish cannery waste effluent. Marine Studies of San Pedro Bay, California. Part 16. Allan Hancock Found. and Sea Grant Prog., Univ. So. Calif., Los Angeles. 597 pp.

Soule, D.F. and M. Oguri. 1979b. The marine environment in Los Angeles and Long Beach Harbors during 1978. Marine Studies of San Pedro Bay, California. D. Soule and M. Oguri (eds.). Part 17 (draft). Allan Hancock Found. and Sea Grant Prog., Instit. Mar. Coast. Stud., Univ. So. Calif., Los Angeles. 667 pp.

Strickland, J.D.H. and T.R. Parsons. 1968. A Practical Handbook of Seawater Analysis. Fish. Res. Bd. Canada Bull. 167. 311 pp.

Sverdrup, H.U., M.W. Johnson and R.H. Fleming. 1946. The Oceans. Prentice-Hall, New York. 1087 pp.

Trinast, E.M. 1976. A preliminary note on *Acartia californiensis*, a new calanoid copepod from Newport Bay, California. Crustaceans 31:54-58.

Twenhofel, W.H. 1950. Principles of Sedimentation. McGraw-Hill Book Co., Inc., New York. 673 pp.

Waggoner, J.P. and C.R. Feldmeth. 1971. Sequential mortality of the fish fauna impounded in construction of a marina at Dana Point, California. Calif. Fish and Game Bull. 57(3):167-176.

Whitmore, C.M., C.E. Warren and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentration. Trans. Amer. Fish. Soc. 89:17-26.