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PHYTOPLANKTON PRODUCTIVITY IN A SOUTHEASTERN COOLING RESERVOIR: TEMPORAL AND SPACIAL VARIABILITY

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ABSTRACT

DOCUMENTING THE TEMPORAL AND SPATIAL DYNAMICS OF PHYTOPLANKTON PRODUCTIVITY IN RESERVOIRS IS ESSENTIAL TO UNDERSTANDING THE FUNCTIONING OF THESE ECOSYSTEMS AND DEVELOPING APPROPRIATE MANAGEMENT SCHEMES. FEW SUCH DATA HAVE BEEN PUBLISHED FOR SOUTHEASTERN RESERVOIRS. A RECORD OF PRODUCTIVITY MEASUREMENTS SPANNING 19 YEARS EXISTS FOR PAR POND, A 1000 ha COOLING RESERVOIR LOCATED ON THE DEPARTMENT OF ENERGY'S SAVANNAH RIVER SITE IN SOUTH CAROLINA. FROM 1965 TO 1984, MEAN ANNUAL PRODUCTIVITY RANGED FROM 118 TO 777 mg C/m2/day. DIFFERENCES AMONG YEARS CORRELATED STRONGLY WITH FLUCTUATIONS IN MEAN CONDUCTIVITY. CONDUCTIVITY, IN TURN, WAS INFLUENCED BY CHANGES IN THE VOLUME AND QUALITY OF SAVANNAH RIVER WATER ADDED TO PAR POND TO COMPENSATE FOR EVAPORATIVE LOSSES. TO CHARACTERIZE THE VARIABILITY OF PRODUCTIVITY IN THIS SYSTEM, STATISTICAL AND GRAPHICAL SUMMARIES ARE PRESENTED FOR DIFFERENT TEMPORAL AND SPATIAL SCALES.

INTRODUCTION AND OBJECTIVES

CARPENTER AND KITCHELL (1987) DISCUSS THE ENVIRONMENTAL FACTORS THAT INFLUENCE LIMNETIC PRIMARY PRODUCTIVITY IN FRESHWATERS AND EMPHASIZE THAT KNOWING THE MAGNITUDE OF NATURAL VARIATION OF PRODUCTIVITY IS CRUCIAL TO BOTH THEORETICAL AND APPLIED INVESTIGATIONS OF LAKES AND OTHER AQUATIC SYSTEMS. RELATIVELY LITTLE PRODUCTIVITY DATA HAVE BEEN PUBLISHED FOR LARGE RESERVOIRS IN THE SOUTHEASTERN U.S. IT IS UNCERTAIN HOW WELL GENERALIZATIONS BASED PRIMARILY ON DATA FROM OTHER REGIONS OF NORTH AMERICA APPLY TO THIS PORTION OF THE COUNTRY.

PAR POND IS ONE OF THE MOST INTENSIVELY STUDIED LARGE SOUTHEASTERN RESERVOIRS (WILDE AND TILLY 1985). SINCE 1965, A VARIETY OF ECOLOGICAL AND LIMNOLOGICAL INVESTIGATIONS HAVE BEEN CONDUCTED ON THIS SYSTEM INCLUDING MONTHLY MEASUREMENTS OF PHYTOPLANKTON PRIMARY PRODUCTIVITY IN A NUMBER OF YEARS (CHIMNEY ET AL. 1985; MARSHALL AND TILLY 1971; TILLY 1973, 1974). WE HAVE REEXAMINED THESE DATA WITH THE INTENT OF DOCUMENTING THE TEMPORAL AND SPATIAL VARIABILITY OF PRODUCTIVITY IN PAR POND AS A CONTRIBUTION TO BETTER UNDERSTANDING ECOSYSTEM PROCESSES IN SOUTHEASTERN RESERVOIRS.

S AND STUDY SITE

ND IS A 1000 ha RESERVOIR LOCATED ON THE
IENT OF ENERGY'S SAVANNAH RIVER SITE IN
CAROLINA (FIG. 1). THIS IMPOUNDMENT WAS
UCTED IN 1958 TO RECIRCULATE COOLING WATER
WO OF THE NUCLEAR REACTORS ON SITE. WATER
HE SAVANNAH RIVER ("MAKE-UP WATER") WAS ADDED
POND TO COMPENSATE FOR EVAPORATIVE LOSS AND
A CONSTANT LAKE LEVEL. PAR POND HAS A
TH OF 6.2 m, A MAXIMUM DEPTH OF 16 m, A
F 62,000,000 m3, AND A SHORELINE LENGTH OF
ILLY 1973).

TIVITY MEASUREMENTS WERE MADE AT LEAST MONTH-
ELAGIC STATIONS (FIG. 1) USING SHORT-TERM
) MID-DAY INCUBATIONS (LIGHT/DARK BOTTLE) OF
COLLECTED FROM VARIOUS DEPTHS. IN 1965, THE
-CHANGE METHOD WAS EMPLOYED TO ESTIMATE PRODUC-
WHILE CARBON-14 UPTAKE WAS USED IN ALL FOLLOWING
VARIATIONS IN FIELD AND LABORATORY TECHNIQUES
OT LARGE ENOUGH TO INVALIDATE YEARLY COMPARI-
ND ARE DISCUSSED IN TILLY (1975).

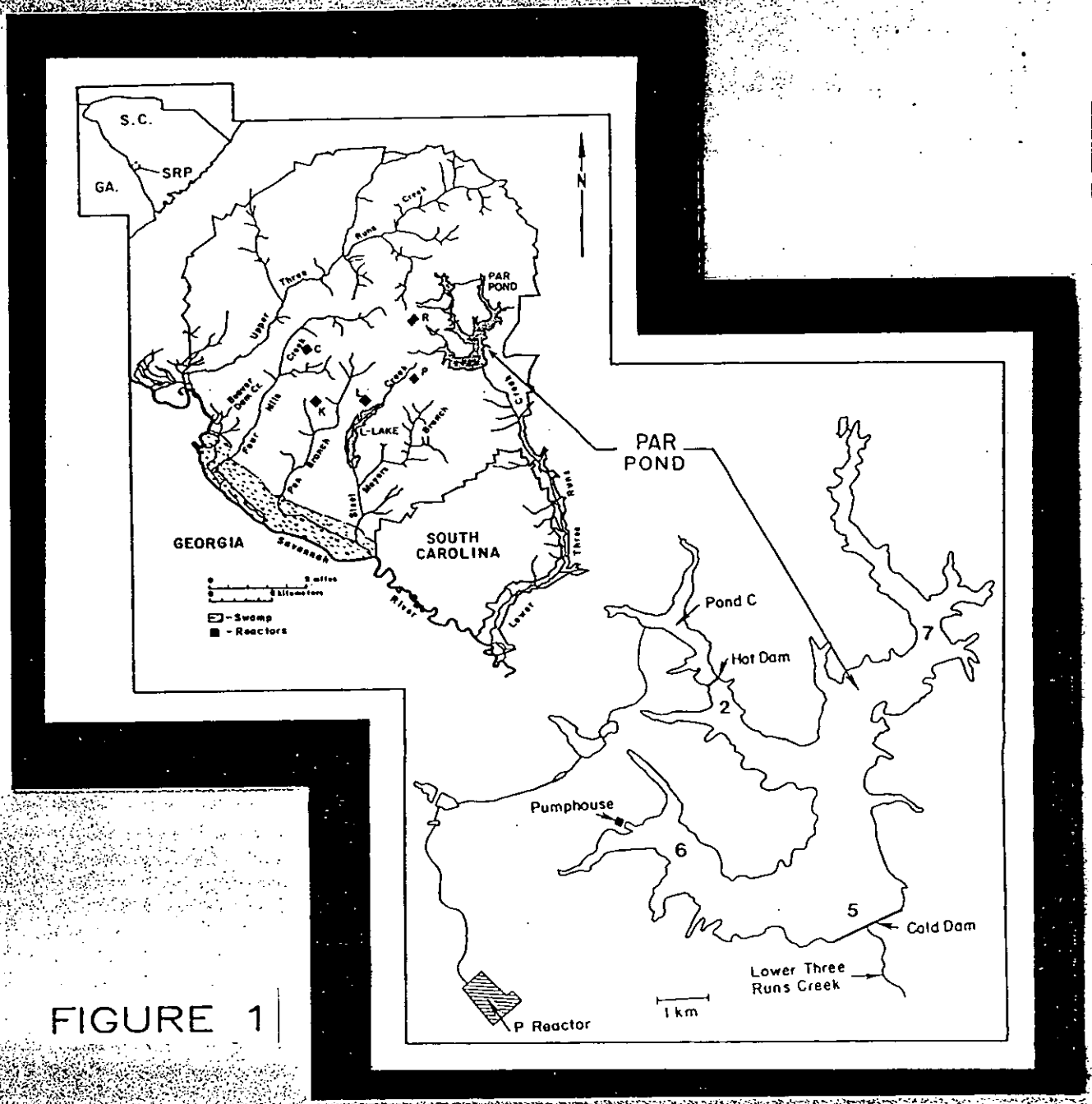
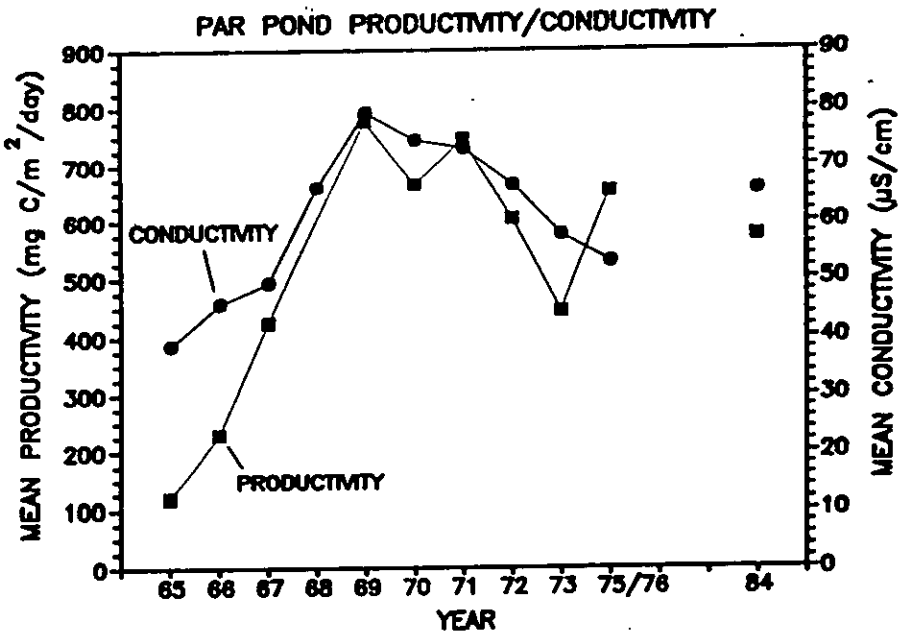


FIGURE 1

TEMPORAL VARIABILITY

MEAN ANNUAL PRIMARY PRODUCTIVITY IN PAR POND RANGED FROM 118 TO 777 mg C/m2/day (FIG. 2). VARIATION IN PRODUCTIVITY WAS STRONGLY CORRELATED WITH CHANGES IN MEAN ANNUAL CONDUCTIVITY (r=0.8967). THE IONIC COMPOSITION AND DISSOLVED SOLUTE CONCENTRATIONS OF PAR POND CLOSELY RESEMBLED THAT OF THE SAVANNAH RIVER DUE TO THE VOLUME OF MAKE-UP WATER ADDED. CHANGES IN WATER QUALITY IN THE SAVANNAH RIVER WERE ASSOCIATED WITH LEVELS OF INDUSTRIAL AND MUNICIPAL POLLUTION UPSTREAM OF THE SRS (TILLY 1975).



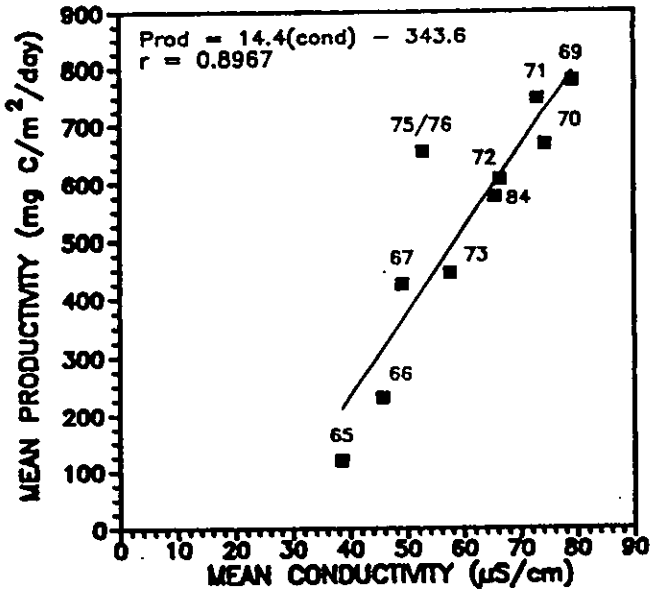


FIGURE 2

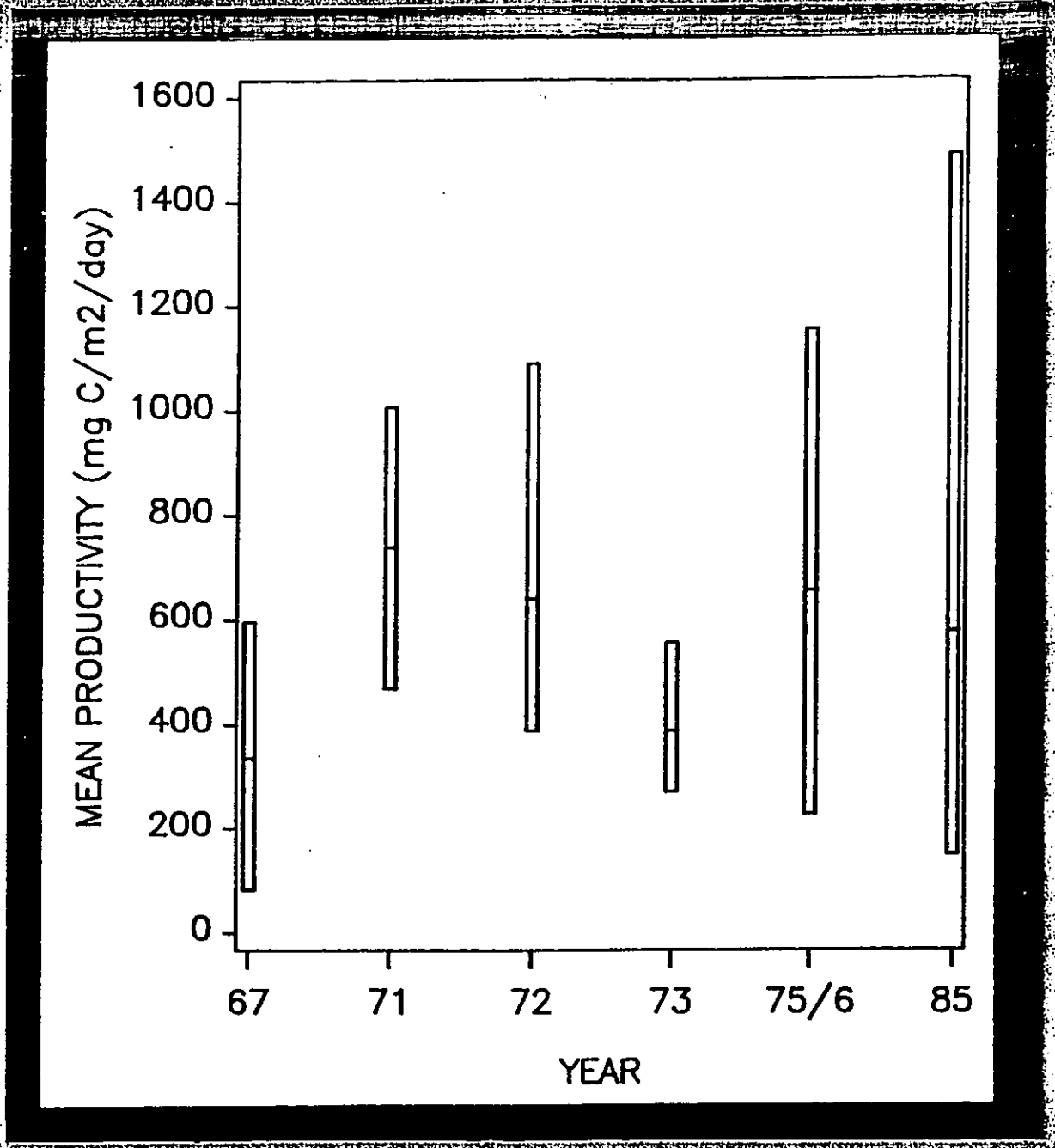


FIGURE 3

MONTHLY MEAN PRODUCTIVITY RANGED FROM ABOUT 100 TO 1500 mg C/m2/day FROM 1967 THROUGH 1984 (FIG. 3). MINIMUM AND MAXIMUM VALUES WITHIN A GIVEN YEAR DIFFERED BY FACTORS OF FROM TWO TO TEN.

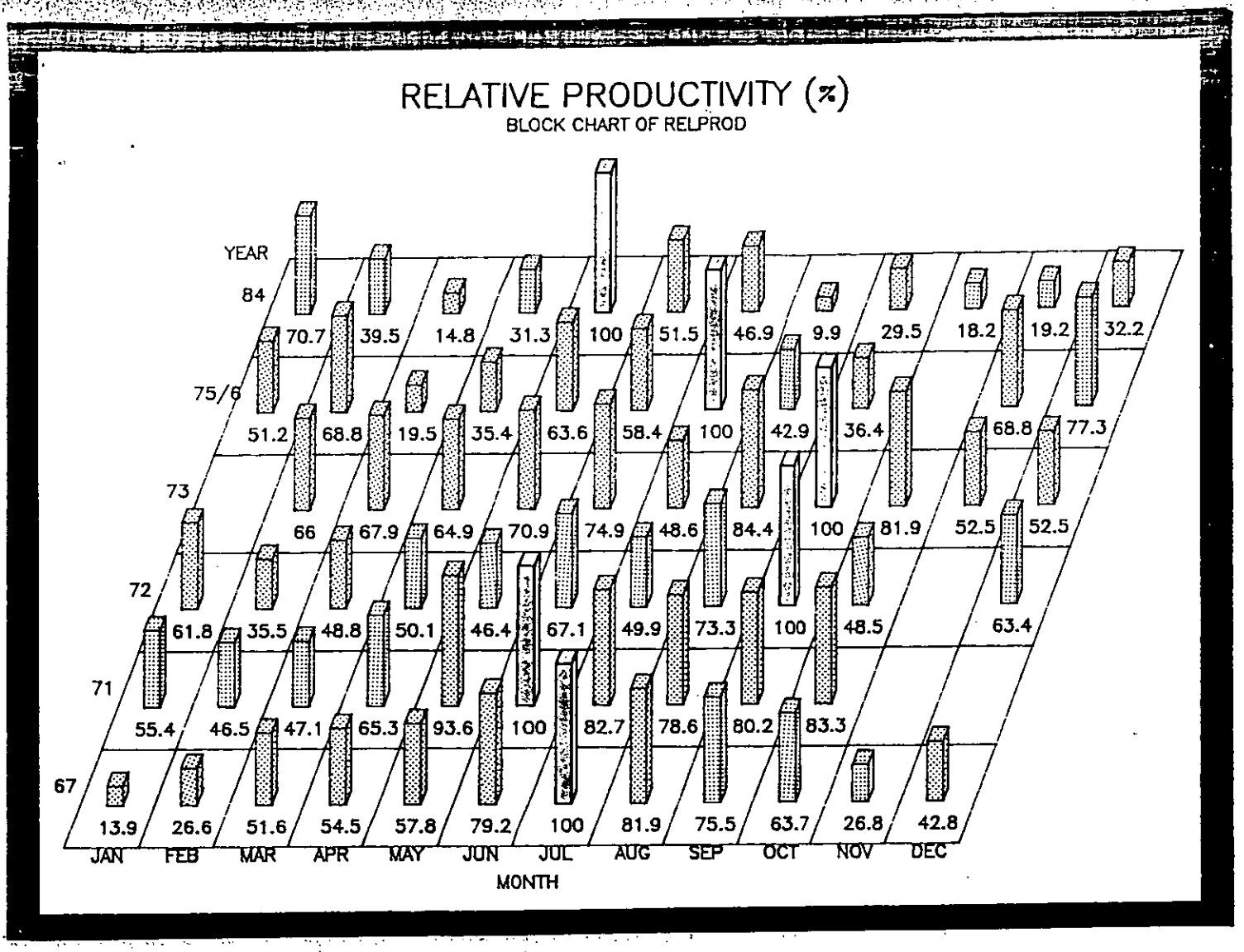


FIGURE 4

PRODUCTIVITY DATA HAVE BEEN RESCALED TO ILLUSTRATE SEASONAL TRENDS. ALL VALUES WITHIN A GIVEN YEAR WERE NORMALIZED RELATIVE TO THE HIGHEST MONTHLY VALUE FOR THAT YEAR AND EXPRESSED AS A PERCENT (FIG. 4). MAXIMUM PRODUCTIVITY OCCURRED DURING A FIVE MONTH PERIOD FROM MAY THROUGH SEPTEMBER. HOWEVER, LOW VALUES (CA. 10-50% OF THE MAXIMUM) WERE ALSO RECORDED DURING THIS PERIOD (e.g., 1973 AND 1984).

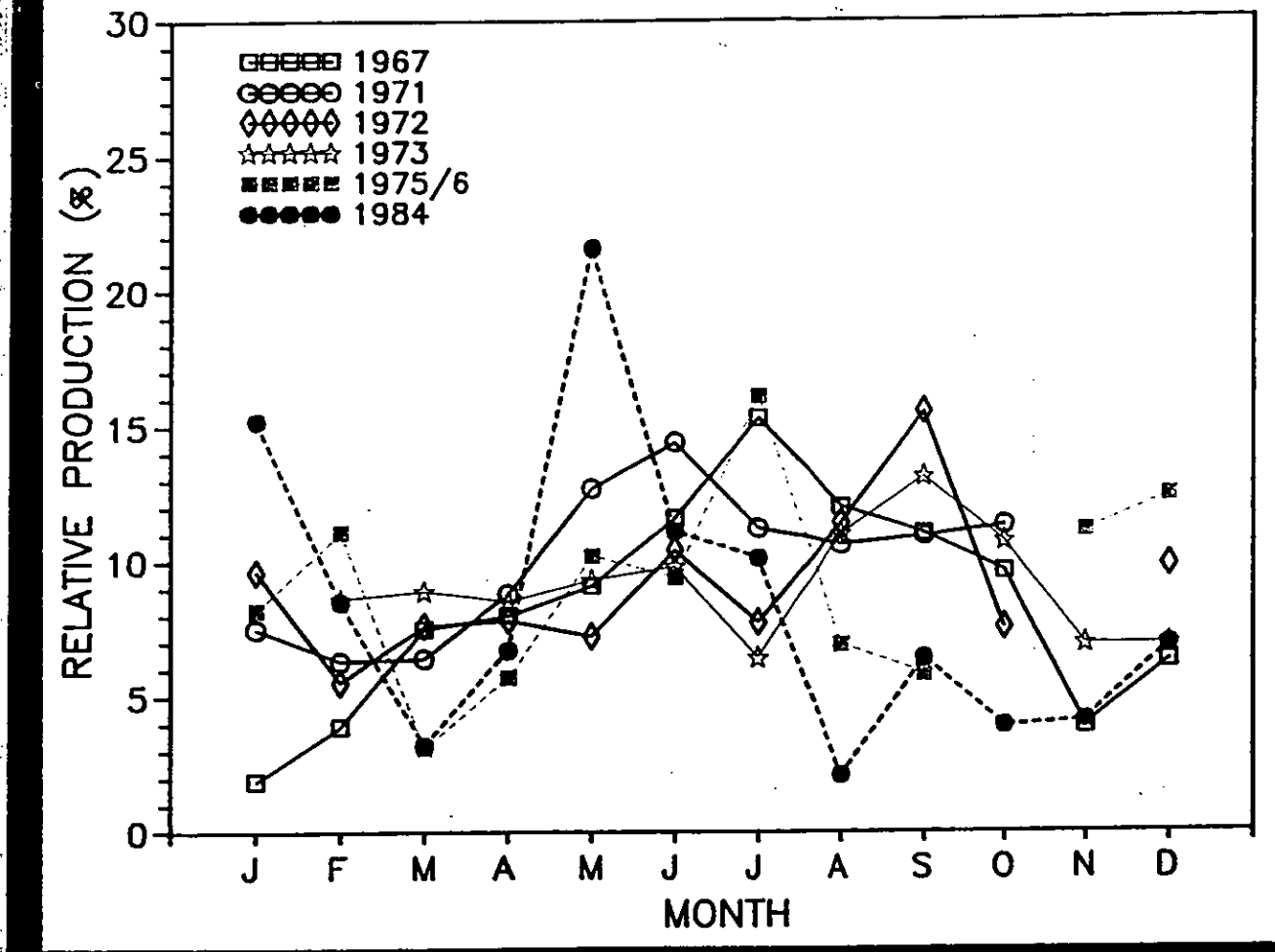


FIGURE 5

MONTHLY PRODUCTION VALUES WERE DERIVED FROM ESTIMATES OF PRODUCTIVITY AND SUMMED TO PRODUCE YEARLY PRODUCTION VALUES. THE CONTRIBUTION OF EACH MONTH'S PRODUCTION TO THE YEARLY TOTAL HAS BEEN EXPRESSED AS A PERCENT ("RELATIVE PRODUCTION"; FIG. 5). THE HIGHEST MONTHLY PRODUCTION VALUES WERE GENERALLY ONLY 13 TO 17% OF THE YEARLY TOTAL (NOTE EXCEPTION IN 1984).

SPATIAL VARIABILITY

MONTHLY MEAN PRODUCTIVITY (mg C/m2/day) AT A THERMALLY INFLUENCED SITE (MAX. TEMP OF CA. 40 C) AND A SITE THAT WAS LITTLE AFFECTED BY REACTOR EFFLUENT (STATIONS 2 AND 5, RESPECTIVELY; FIG. 1) WERE COMPARED FOR YEARS IN WHICH SUFFICIENT DATA WERE AVAILABLE (FIG. 6). THERE WERE NO CONSISTENT DIFFERENCES BETWEEN LOCATIONS. PRODUCTIVITY WAS HIGHER MORE OFTEN AT THE COOLER STATION AND DID NOT APPEAR TO BE THERMALLY IMPACTED.

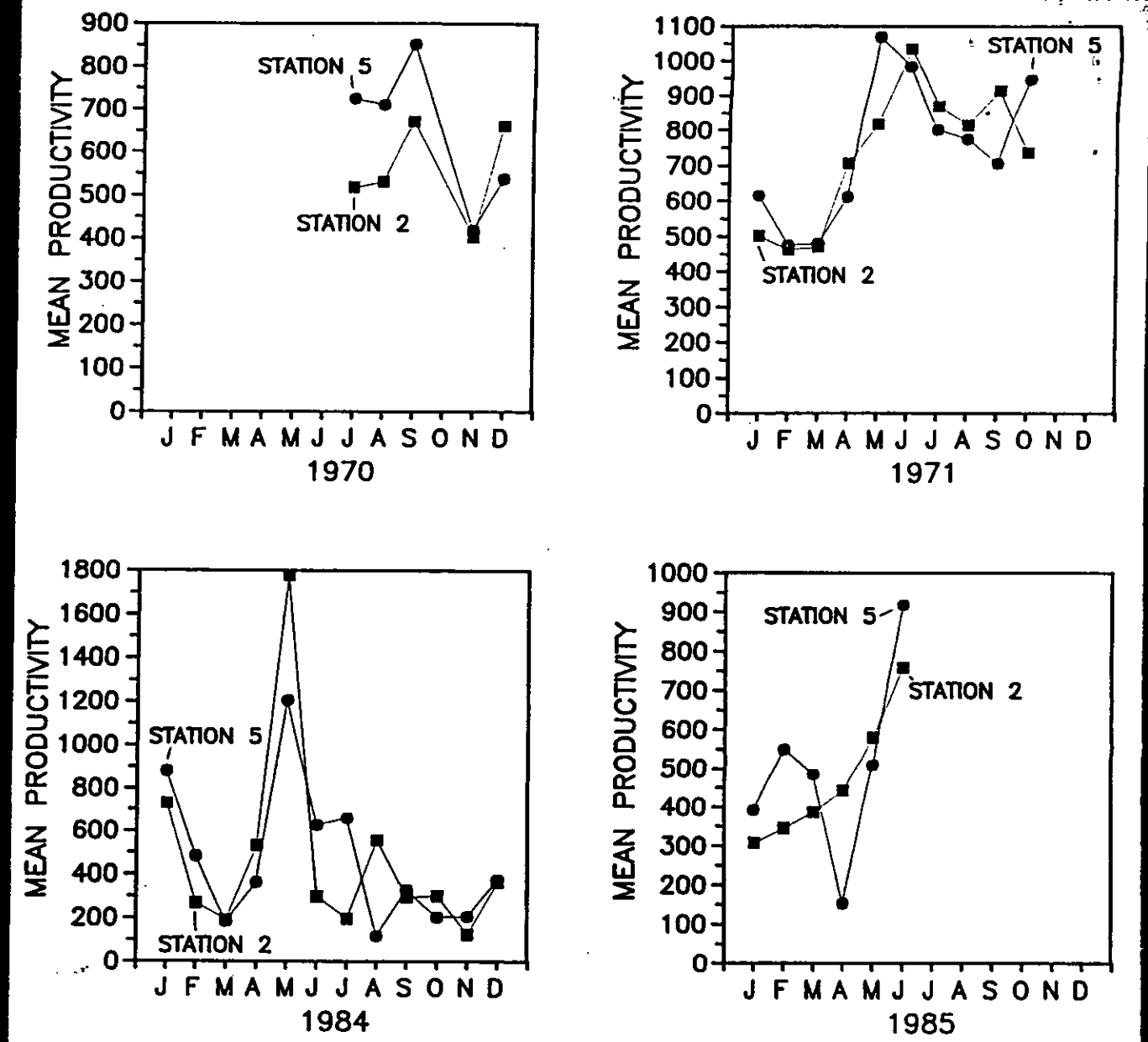


FIGURE 6

COEFFICIENTS OF VARIATION FOR PRIMARY PRODUCTIVITY AT SEVERAL TEMPORAL AND SPATIAL SCALES IN PAR POND

SPATIAL SCALE	TEMPORAL SCALE	MEASUREMENT	CV
STATIONS POOLED	WITHIN YEAR	INTEGRATED SUM	28-78
INDIVIDUAL STATIONS	WITHIN YEAR	INTEGRATED SUM	23-95
STATIONS POOLED	WITHIN MONTH	INTEGRATED SUM	4-71
DEPTHS THROUGHOUT WATER COLUMN	WITHIN DAY	SINGLE VALUES	14-204
INDIVIDUAL DEPTHS	WITHIN YEAR	SINGLE VALUES	36-118

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