EVERYTHING YOU ALWAYS WANTED TO KNOW ABOUT SEA ANEMONES*

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DISCOVERY BAY MARINE LAB
DISCOVERY BAY JAMAICA, WI

Tom & Tom:
An impressive well-integrated study. Well thought-out and creative. You've provided some good new interesting data. Your results are nicely presented and discussed.

John

* YOU HAD TO ASK

ABSTRACT

AGGRESSION NETWORKS ARE KNOWN AMONG MANY CORAL REEF SPECIES. THIS STUDY UNCOVERED A NETWORK AMONG THE THREE MAJOR SPECIES OF SEA ANEMONES FOUND AT DISCOVERY BAY, JAMAICA: CONDYLACTIS GIGANTEA, HETERACTIS LUCIDA, AND STOICHACTIS HELIANTHUS. C. GIGANTEA DOMINATES H. LUCIDA WHICH DOMINATES S. HELIANTHUS WHICH, IN TURN, DOMINATES C. GIGANTEA. INTRASPECIFIC SPACING IS OBSERVED WHEN SPACE IS LIMITING BUT LITTLE INTRASPECIFIC AGGRESSION OCCURS.

TRANSECT STUDIES REVEALED THAT H. LUCIDA POPULATION DENSITIES ARE HIGHEST AT DEPTHS BETWEEN FIFTEEN AND TWENTY-FIVE FEET AND STEADILY DECLINE WITH ADDITIONAL DEPTH. S. HELIANTHUS IS ONLY FOUND ON THE REEF CREST WHERE PHYSICAL STRESS IS HIGH AND COMPETITION FOR SPACE IS MINIMAL. QUALITATIVE OBSERVATIONS OF THE FEEDING BEHAVIOR WAS RECORDED AND LATER RELATED TO THE NUMBER OF NEMATOCYSTS PER UNIT AREA ON THE TENTACLES. A PRELIMINARY GUT CONTENT ANALYSIS WAS ALSO PERFORMED.

INTRODUCTION

THE CORAL REEF ECOSYSTEM IS IN A CONSTANT STATE OF FLUX. COLONIES OF TINY CORAL POLYPS ARE CONSTANTLY BUILDING THE CALCIUM CARBONATE CONDOMINIUMS WHICH WE CALL THE CORAL REEF. IN THE MEANTIME PHYSICAL STRESS, BIOEROSION AND PREDATION VIGOROUSLY TAX THESE COMMUNITIES CAUSING A STEADY STATE OF NEWLY CLEARED SUBSTRATUM FOLLOWED BY REGROWTH. DESPITE THIS CONTINUAL EMERGENCE OF AVAILABLE SITES TO SETTLE, THERE ARE A SIGNIFICANT NUMBER OF PAPERS THAT SUGGEST SPACE IS STILL A LIMITING RESOURCE (LOYA 1972, PORTER 1972, CONNELL 1973, GRIGG AND MARAGOS 1974).

CONSIDERING SPACE AS A LIMITING RESOURCE IT IS LOGICAL TO EXPECT A FAIR AMOUNT OF COMPETITION AND/OR AGGRESSION BETWEEN SPECIES COMPETING FOR THE SAME SITE. SEVERAL EXTENSIVE STUDIES ON THIS AGGRESSION AND THE UNDERLYING COMPETITIVE HEIRARCHIES HAVE BEEN CARRIED OUT ON SPONGES (JACKSON AND BUSS, 1975), CORALS (PORTER, 1972a) AND BENTHIC ALGAE (CONNELL, 1973). HOWEVER, WE FOUND A DEARTH OF INFORMATION REGARDING AGGRESSION AND THE SEA ANEMONE (PHYLUM: CNIDARIA, CLASS: ANTHOZOA, ORDER: ACTINARIA).

WE BEGAN OUR STUDY WITH THE IDEA OF OBSERVING AGGRESSIVE INTERACTIONS BETWEEN ANEMONES IN THE LAB AND IN THE FIELD AND HOPED TO ARRIVE AT SOME SORT OF COMPETITIVE

HEIRARCHY OR NETWORK. AS ADDED EMBELLISHMENT WE DECIDED TO LOOK AT SEVERAL NEGLECTED ASPECTS OF SEA ANEMONE INTERACTIONS AND PREFERENCES.

WE ENDEAVORED TO SUBSTANTIATE SEBENS' WORK ON SUBSTRATE PREFERENCE THROUGH FIELD OBSERVATIONS (SEBENS, 1976). WE ALSO DECIDED TO STUDY THE CHANGE OF SPECIES DENSITIES WITH DEPTH AND THE CORRESPONDING CHANGES IN THE PHYSICAL ENVIRONMENT. WE SUSPECTED STOICHACTIS HELIANTHUS TO BE LESS COMPETITIVE THAN THE OTHER ANEMONE SPECIES AND THEREBY TO BE EXILED TO THE SURFACES OF ROCKS WHERE IT WOULD BE UNDER CONTINUAL PHYSICAL STRESS. WITH DEPTH THIS STRESS WOULD DIMINISH, ALLOWING THE MORE "AGGRESSIVE" SPECIES, SUCH AS CONDYLACTIS GIGANTEA AND HETERACTIS LUCIDA, TO OUTCOMPETE S. HELIANTHUS. THUS WE HOPED TO OBSERVE A CONSTANT LOWER LIMIT TO S. HELIANTHUS GROWTH. WE ALSO EXPECTED SOME RELATIONSHIPS BETWEEN THE DENSITIES OF OTHER SPECIES BUT COULD NOT PREDICT THEM APRIORI.

ANOTHER ASPECT OF SEA ANEMONE LIFE WHICH INTRIGUED US WAS THEIR FEEDING BEHAVIOR. JAYNE SEYMOUR STUDIED THE FEEDING STRATEGIES OF C. GIGANTEA AND S. HELIANTHUS IN 1979. HER RESEARCH WAS CARRIED OUT IN THE LAB AND WE HOPED TO SUBSTANTIATE HER WORK ON PREY SUSCEPTIBILITY TO CAPTURE WITH STOMACH CONTENT ANALYSIS FROM FIELD SAMPLES.

WITH THESE OBJECTIVES SET FORTH WE DESIGNED AND CARRIED OUT SEVERAL EXPERIMENTS IN AN EFFORT TO SATISFY OUR SCIENTIFIC GOALS.

METHODS

IN AN EFFORT TO STUDY THE SEA ANEMONES' AGGRESSIVE BEHAVIOR, DATA AND OBSERVATIONS WERE COLLECTED BETWEEN 2/24/81 AND 3/2/81. FIELD OBSERVATIONS WERE MADE USING SCUBA AND SKIN DIVING, WHILE LABORATORY OBSERVATIONS WERE MADE, AND MANIPULATIONS PERFORMED, AT THE DISCOVERY BAY MARINE LABORATORY, DISCOVERY BAY JAMAICA. FOR CLARITY AND CONCISENESS BOTH THE FIELD AND LABORATORY PORTIONS OF THIS PROJECT WILL BE PRESENTED IN A PIECEMEAL FASHION.

FIELD WORK

TRANSECTS: TRANSECTS WERE MADE AT MOORING ONE AND AT THE LONG TERM STUDY SITE (LTS). EACH TEN FOOT WIDE TRANSECT STARTED AT A DEPTH OF SIXTY FEET AND WAS TAKEN NORMAL TO THE SHORE UP TO THE REEF CREST (APPROXIMATELY TWO FEET DEEP). THE LTS TRANSECT WAS STOPPED AT TWENTY FEET DUE TO HEAVY SURGE. DURING THE TRANSECT, WHENEVER AN ANEMONE WAS FOUND, THE SIZE, DEPTH, SUBSTRATE (CREVICE, SAND, EXPOSED), ADJACENT CORALS, POSSIBLE DAMAGE

TO THE ADJACENT CORAL, AND GENERAL OBSERVATIONS WERE RECORDED. CORAL DAMAGE WHICH FOLLOWED THE OUTLINE OF OUTSTRETCHED ANEMONE TENTACLES WAS CONSIDERED TO BE ATTRIBUTABLE TO THE ANEMONE. THESE PARAMETERS WERE RECORDED IN AN EFFORT TO SUBSTANTIATE SEBENS' FINDINGS ON SUBSTRATE PREFERENCE (SEBENS AND DERIEMER, 1977) AND TO SHOW POTENTIAL PATTERNS IN ANEMONE POPULATIONS AS A FUNCTION OF DEPTH.

TRANSPLANTATIONS: THE MAJOR PORTION OF OUR PROJECT CENTERED ON THE AGGRESSIVE BEHAVIOR BETWEEN ANEMONES. IN THE FIELD WE STUDIED THE EFFECTS OF INTRA-SPECIFIC AND INTERSPECIFIC AGGRESSIVE INTERACTIONS BY PLACING ANEMONES OF THE SAME AND DIFFERING SPECIES NEXT TO ONE ANOTHER ON THE FORE REEF NEAR LTS. WE BELIEVED THIS WOULD ELICIT SOME AGGRESSION OR MOVEMENT WHICH WE WOULD OBSERVE AND RECORD AFTER TWENTY-FOUR HOURS HAD ELAPSED. THE COMBINATIONS OF ANEMONES PAIRED TOGETHER WERE AS FOLLOWS:
1) C. GIGANTEA - C. GIGANTEA, 2) H. LUCIDA - H. LUCIDA, 3) S. HELIANTHUS - S. HELIANTHUS, 4) C. GIGANTEA - H. LUCIDA, 5) C. GIGANTEA - S. HELIANTHUS AND, 6) H. LUCIDA - S. HELIANTHUS. THE FIRST THREE PAIRS INVOLVED INTRA-SPECIFIC AGGRESSION OR SPACING AND THE LAST THREE INVOLVED INTERSPECIFIC INTERACTIONS.

FEEDING: JAYNE SEYMOUR (1979) CONDUCTED A STUDY ON THE FEEDING STRATEGIES OF C. GIGANTEA AND S. HELIANTHUS. HAVING FOUND THIS INTERESTING WE OBSERVED THE FEEDING ACTIVITIES OF ANEMONES DURING THE DAY AND DURING THE NIGHT AT THE EAST BACK REEF, SEVERAL SPECIMENS WERE COLLECTED FOR GUT CONTENT ANALYSIS IN THE LAB.

COLLECTIONS: IN ORDER TO OBSERVE THE ANEMONES' AGGRESSIVE TENDENCIES IN A CONTROLLED SITUATION, SEVERAL OF EACH OF THE DOMINANT SPECIES WERE BROUGHT BACK TO THE LAB. C. GIGANTEA AND H. LUCIDA WERE COLLECTED AT LTS WHILE THE S. HELIANTHUS SAMPLES WERE COLLECTED AT EBR. SINCE THE S. HELIANTHUS INHABIT A ZONE OF GREAT WAVE ACTION THEY WERE SECURELY ANCHORED TO THE SUBSTRATE. WE FOUND IT EASIER TO REMOVE THE SUBSTRATE ALONG WITH THE ANEMONE. REMOVAL WAS AIDED BY THE USE OF A DIVE KNIFE. THE ANEMONES WERE KEPT IN A MESH COLLECTING BAG UNTIL WE REACHED THE BOAT WHERE THEY WERE TRANSFERRED TO A BUCKET FILLED WITH SEA WATER AND RUSHED TO THEIR EXPERIMENTAL SITES IN THE LAB.

LAB MANIPULATIONS

INTRASPECIFIC AGGRESSION MANIPULATION: THE NEWLY COLLECTED ANEMONES WERE PLACED IN A PLASTIC HOLDING TUB ON THEIR ORIGINAL SUBSTRATES. AFTER SEVERAL HOURS, WHEN THE ANEMONES HAD ACCLIMATIZED, WE PLACED THE SUBSTRATES SO THAT THE TENTACLES OF THE TWO ANEMONES WERE WITHIN EACH OTHERS "ARM-SPAN". WE ALSO PLACED SEVERAL ROCKS AROUND THE EXPERIMENTAL PAIR SO THEY COULD RETREAT IF THEY SO DESIRED. ANY MOVEMENT OR UNUSUAL BEHAVIOR WAS RECORDED DURING THE NEXT TWENTY-FOUR HOURS AS EVIDENCE OF AGGRESSIVE INTERACTIONS. THE PAIRS TESTED WERE: 1) C. GIGANTEA - C. GIGANTEA, 2) H. LUCIDA - H. LUCIDA, AND 3) S. HELIANTHUS - S. HELIANTHUS.

INTERSPECIFIC AGGRESSION MANIPULATION: THE SAME PROCEDURE THAT WAS USED FOR THE INTRASPECIFIC MANIPULATIONS WAS EMPLOYED HERE. THE DIFFERENT ANEMONE SPECIES PAIRS WERE AS FOLLOWS: 1) C. GIGANTEA - S. HELIANTHUS, 2) C. GIGANTEA - H. LUCIDA, AND 3) S. HELIANTHUS - H. LUCIDA.

AGGRESSION AGAINST CORALS MANIPULATION: DURING OUR TRANSECTS WE NOTICED THAT ANEMONES THAT OCCUR ON LIVING CORALS HAVE KILLED ALL THE CORAL POLYPS THAT COME INTO CONTACT WITH THE ANEMONES' TENTACLES. SEBENS DID A

PRELIMINARY STUDY OF THIS IN HIS PAPER ENTITLED: THE ECOLOGY OF CARIBBEAN SEA ANEMONES IN PANAMA: UTILIZATION OF SPACE ON A CORAL REEF, (1976). WE ATTEMPTED TO QUANTIFY THIS AGGRESSIVE BEHAVIOR FOR C. GIGANTEA, H. LUCIDA AND S. HELIANTHUS AGAINST FOUR SPECIES OF CORAL: ISOPHYLLIA SINUOSA, PORITES PORITES, AGARICIA AGARICITES, AND SIDERASTREA SIDERASTREA. WE PLACED A NEWLY COLLECTED ANEMONE FROM EACH OF THE THREE DOMINANT SPECIES IN A HOLDING TANK AND ALLOWED IT TO ACCLIMATIZE FOR SEVERAL HOURS. THEN WE SURROUNDED IT WITH THE FOUR AFOREMENTIONED CORALS. HALF OF EACH CORAL WAS WITHIN A TENTACLE SPAN AND SERVED AS OUR EXPERIMENTAL SAMPLE WHILE THE OTHER HALF SERVED AS A CONTROL. THE CORALS WERE REMOVED AFTER A WEEK AND EXAMINED FOR DAMAGE CAUSED BY THE ANEMONE.

GUT CONTENT ANALYSIS: GUT CONTENTS WERE EXTRACTED FROM THE C. GIGANTEA, H. LUCIDA, AND S. HELIANTHUS COLLECTED DURING DAY AND NIGHT DIVES. THESE EXTRACTIONS WERE PERFORMED BY PLACING A SYRINGE THROUGH THE ORAL OPENING AND INTO THE INTERNAL CAVITY OF ANEMONES AND THEN SUCTION WAS EMPLOYED TO REMOVE THE CONTENTS. TWO SLIDES WERE PREPARED FROM THESE EXTRACTS FOR EACH SPECIES FOR EACH TIME (DAY AND NIGHT) TOTALLING FOUR SLIDES FOR EACH SPECIES. THESE SLIDES WERE

THEN OBSERVED UNDER A COMPOUND MICROSCOPE AT A POWER OF ONE HUNDRED TIMES NORMAL IN AN ATTEMPT TO IDENTIFY THE REMAINS OF THE ANEMONES' PREY. THESE REMAINS, WHETHER WHOLE OR PARTIAL, WERE SUBSEQUENTLY RECORDED.

AS A FOLLOW UP TO OUR STUDY OF FEEDING BEHAVIOR WE ATTEMPTED TO CORRELATE FEEDING EFFICIENCY TO THE ABUNDANCE OF NEMATOCYSTS IN THE TENTACLES OF EACH OF THE DOMINANT ANEMONES. WE PREPARED TWO SLIDES FROM THE TENTACLES OF C. GIGANTEA, H. LUCIDA, AND S. HELIANTHUS. THEN USING A COMPOUND MICROSCOPE AT A POWER OF ONE HUNDRED TIMES NORMAL, WE COUNTED THE NUMBER OF NEMATOCYSTS IN FIVE FIELDS FOR EACH SLIDE.

RESULTS AND DISCUSSION

THIS STUDY WAS DIVIDED INTO SIX DISTINCT PORTIONS EACH OF WHICH WAS PERFORMED FOR A SPECIFIC PURPOSE. BEARING THIS IS MIND THE AUTHORS FEEL IT BEST, FOR CLARITY AND CONCISENESS, TO ADDRESS EACH PORTION SEPARATELY AND THEN FINISH WITH SEVERAL CONCLUDING GENERALIZATIONS.

THE TRANSECTS: IN 1977 SEBENS AND DE RIEMER STATED THAT ANEMONES IN THE WILD HAVE DEFINITE SUBSTRATE PREFERENCES. DURING OUR TRANSECTS WE RECORDED SUBSTRATE PREFERENCE FOR

THE EXPLICIT REASON OF TESTING THIS. WE FOUND THAT C. GIGANTEA AND H. LUCIDA PREFER CREVICES AND HOLES WHILE S. HELIANTHUS WAS ALWAYS FOUND ON THE SURFACES OF SHALLOW ROCKS. WE OCCASIONALLY ENCOUNTERED LEBRUNIA DANAE AND BARTHOLOMEA ANNULATA WHICH ALWAYS INHABITED A ROCKY CREVICE. ALL THESE FINDINGS SUPPORT SEBENS AND DERIEMERS LABORATORY WORK EXCEPT B. ANNULATA. THEY STATE THAT THIS ANEMONE PREFERS HOLES WITH SANDY BOTTOMS. OUR CONFLICTING EVIDENCE WARRANTS FURTHER INVESTIGATION BUT CANNOT NEGATE THEIR WORK DUE TO OUR SMALL SAMPLE SIZE.

DESTRUCTION OF CORALS BY SEA ANEMONES WAS ANOTHER PROPOSITION EXAMINED IN OUR TRANSECT STUDY. DESPITE THE DISTURBED STATE OF THE REEF IN 1981, DUE TO HURRICANE ALLEN IN AUGUST 1980, WE FOUND MANY ANEMONES GROWING ON OR AROUND LIVING CORAL. IN MOST CASES THERE WAS VISIBLE DAMAGE TO THE CORAL WHICH WAS APPARENTLY CAUSED BY THE NEIGHBORING ANEMONE. WE OBSERVED DAMAGE TO AGARICIA, PORITES, AND MONTASTRAEA BY C. GIGANTEA AND DAMAGE TO MONTASTRAEA BY L. DANAE. ALL SPECIMENS OF H. LUCIDA WERE FOUND IN CREVICES FORMED BY THE LITHIFICATION OF DEAD ACROPORA CERVICORNIS. THESE FINDINGS WERE QUANTIFIED FURTHER IN THE LAB.

THE TRANSECT PORTION WAS ALSO DESIGNED TO ILLUMINATE ANY PATTERNS OF SEA ANEMONE DIVERSITY, DENSITY, ETC. WHICH MAY OCCUR IN

NATURE. WE EXPECTED TO FIND AN UPPER LIMIT TO C. GIGANTEA GROWTH BUT COULD NOT CONCLUSIVELY SHOW THIS OR ANY OTHER PATTERN OF C. GIGANTEA GROWTH DUE TO AN EXCEEDINGLY SMALL NUMBER OF INDIVIDUALS ENCOUNTERED (ONLY THIRTEEN IN BOTH TRANSECTS). ONLY FIVE INDIVIDUALS OF S. HELIANTHUS WERE FOUND ON THE FORE REEF. ALL OF THESE INDIVIDUALS WERE FOUND ON THE SURFACES OF ROCKS IN TEN FEET OF WATER OR LESS. THIS FINDING, COUPLED WITH THEIR ABUNDANCE ON THE REEF CREST AT THE EAST BACK REEF, SUGGEST THAT THEY THRIVE IN AREAS OF HIGH PHYSICAL STRESS. UNFORTUNATELY, THIS QUALITATIVE OBSERVATION CANNOT BE CONCLUSIVELY SUPPORTED BY A PAULTRY FIVE DATA POINTS.

H. LUCIDA WAS FOUND IN LARGE NUMBERS AND, CONSEQUENTLY, SEVERAL PATTERNS OF POPULATION GROWTH WERE TESTED. FIGURE 1 SHOWS THE AVERAGE NUMBER OF INDIVIDUALS FOUND WITHIN TEN FOOT DEPTH RANGES. IT IS OBVIOUS THAT H. LUCIDA HAS TROUBLE SURVIVING IN THE SHALLOW TURBID WATERS (LESS THAN FIFTEEN FEET), HOWEVER, THEIR MAXIMUM POPULATION DENSITY OCCURS BETWEEN FIFTEEN AND TWENTY-FIVE FEET AND FALLS STEADILY FROM THIS POINT. THIS SUGGESTS A HIGH DEGREE OF DEPENDENCE ON SYMBIOTIC ZOOXANTHELLAE. WE WERE UNABLE TO TEST THIS PROPOSAL.

THE SECOND PATTERN WE HOPED TO FIND WAS BETWEEN DEPTH AND SIZE. THESE DATA POINTS (FOR H. LUCIDA) ARE GRAPHICALLY REPRESENTED IN FIGURE 2.

NO TEST FOR LINEAR FIT WAS PERFORMED DUE TO MOTHER NATURE'S GENERATION OF A RANDOM NUMBERS GRAPH.

FIGURE 3 IS A SIZE DISTRIBUTION GRAPH FOR H. LUCIDA. THE DATA POINTS FORM A NORMAL CURVE AS WOULD BE EXPECTED. WE SUSPECT THAT THE POPULATION IS DOMINATED BY RAPIDLY GROWING YOUTHS WHICH ACCOUNT FOR A RAPID INCREASE IN SIZE TO A MAXIMAL POINT. FROM THIS POINT FORTH THEIR SIZE POSITIVELY CORRELATES WITH DESIRABILITY TO PREDATORS AND CONSEQUENTLY THEIR NUMBERS STEADILY DECREASE.

INTERSPECIFIC TRANSPLANTATIONS: THE RESULTS OF OUR IN SITU (LTS) EXPERIMENTS DESIGNED TO ELICIT INTERSPECIFIC AGGRESSION ARE SHOWN BELOW IN TABLE 1:

TABLE 1

ANEMONE PAIR	OBSERVATIONS
S. HELIANTHUS - H. LUCIDA	S. HELIANTHUS MOVED TO ROCKY SURFACE JUST OUT OF REACH OF H. LUCIDA - MAY HAVE MOVED TO PREFERRED SITE RATHER THAN AS A RESULT OF AN AGGRESSIVE INTERACTION.
C. GIGANTEA - H. LUCIDA	C. GIGANTEA MOVED TO A NEARBY CREVICE. TENTACLES MAY STILL OVERLAP BUT H. LUCIDA HAS WITHDRAWN TENTACLES - APPARENTLY TO AVOID CONTACT.
C. GIGANTEA - S. HELIANTHUS	S. HELIANTHUS IS DEAD (PHARYNX DISTENDED). THIS COULD BE THE RESULT OF THE SHOCK OF TRANSPLANTATION.

SINCE THESE FIELD EXPERIMENTS WERE NOT REPEATED THEY ARE NOT, BY THEMSELVES, SIGNIFICANT, THEY SUGGEST AN AGGRESSION HIERARCHY WITH C. GIGANTEA ON TOP AND S. HELIANTHUS ON THE BOTTOM.

C. GIGANTEA → H. LUCIDA → S. HELIANTHUS

STRICTLY CONSIDERING THIS DATA WE MAY ASSUME THAT C. GIGANTEA IS THE DOMINANT SEA ANEMONE IN A STABLE REEF. H. LUCIDA WOULD THEN BE A FUGITIVE SPECIES WHICH RECOLONIZES DISTURBED AREAS. PERHAPS THIS IS WHY THEY ARE SO ABUNDANT ON THE REEF AT THIS POINT IN TIME. FINALLY, S. HELIANTHUS IS AN OUTCAST WHICH HAS BEEN EXILED TO THE UNDESIRABLE HABITATS (ie. THOSE UNDERGOING CONSTANT PHYSICAL STRESS.)

INTRASPECIFIC TRANSPLANTATIONS: THE RESULTS OF OUR INTRA-SPECIFIC TRANSPLANTATION EXPERIMENTS DESIGNED TO ELICIT AGGRESSION ARE SHOWN BELOW IN TABLE 2:

TABLE 2

TYPE OF ANEMONE	OBSERVATIONS
C. GIGANTEA	THEY SPREAD OUT TO ADJACENT CREVICES WHERE THEIR TENTACLES BARELY OVERLAP. BOTH APPEAR TO ACCEPT THE OTHERS PRESENCE.
H. LUCIDA	THEY SPREAD OUT TO ADJACENT CREVICES WHERE THEIR TENTACLES OVERLAP TO A FAIR EXTENT. NO AGGRESSION IS APPARENT.
S. HELIANTHUS	NEITHER ANEMONE SHOWS ANY SIGN OF AGGRESSION EVEN THOUGH THEY ARE CONTIGUOUS.

IN THE DISTURBED REEF HABITAT SPACE MAY NO LONGER BE A LIMITING FACTOR. THIS MAY EXPLAIN THE REPOSITIONING OF CONSPECIFICS WITH LITTLE OR NO AGGRESSIVE ACTS. AT ANY RATE THE ANEMONES PREFER MIGRATION RATHER THAN OUTWARD AGGRESSION.

FEEDING BEHAVIOR: THE FEEDING BEHAVIOR OF C. GIGANTEA, S. HELIANTHUS, AND H. LUCIDA WAS OBSERVED BOTH IN THE FIELD AND IN THE LAB. OUR CURSORY OBSERVATIONS ARE IN COMPLETE AGREEMENT WITH JAYNE SEYMOUR'S OBSERVATIONS (1979).

C. GIGANTEA: AS SOON AS A TENTACLE COMES INTO CONTACT WITH A ZOOPLANKTON IT IS IMMEDIATELY CONTRACTED. SEVERAL OF THE ADJACENT TENTACLES DRAW THE PREY TO THE ORAL OPENING. THIS ANEMONE IS BY FAR THE QUICKEST OF THE ANEMONES TO REACT TO PREY CONTACT.

S. HELIANTHUS: WHEN A FOOD ITEM COMES INTO CONTACT WITH THE STICKY TENTACLES OF S. HELIANTHUS A SMALL INDENTATION AROUND IT IS FORMED. THIS GIVES S. HELIANTHUS A BETTER GRIP AS IT SLOWLY ROLLS ITS ORAL DISC OVER, BRINGING THE PREY INTO ITS ORAL CAVITY. OFTEN S. HELIANTHUS WILL ALLOW SEVERAL PREY ITEMS TO BECOME TRAPPED BEFORE BRINGING THEM TO THE MOUTH. THIS IS AN OBVIOUS ADVANTAGE SINCE IT IS A RELATIVELY SLOW FEEDER.

H. LUCIDA: THIS ANEMONE FOLLOWS THE SAME GENERAL FEEDING PATTERN AS C. GIGANTEA BUT IT LACKS SPEED. WHEN A TENTACLE

ENCOUNTERS A FOOD ITEM, IT AND SEVERAL OTHER TENTACLES SECURE THE ITEM AND SLOWLY BRING IT TO THE MOUTH.

EACH ANEMONE EMPLOYS NEMATOCYSTS TO IMMOBILIZE THE PREY. WE THOUGHT THAT THE NUMBER OF NEMATOCYSTS PER UNIT AREA MIGHT CORRELATE WITH THE TOTAL HANDLING TIME OF A PREY ITEM, FROM CAPTURE TO INGESTION, AND FOUND THIS TO BE TRUE. C. GIGANTEA, THE FASTEST FEEDER, HAD AN AVERAGE OF TWO-HUNDRED AND TWENTY NEMATOCYSTS PER FIVE MICROSCOPE FIELDS (AT 100x). H. LUCIDA, WITH AN INTERMEDIATE RATE, HAD SIXTY-SEVEN NEMATOCYSTS PER FIVE FIELDS WHILE S. HELIANTHUS, THE SLOWEST, ONLY HAD FIFTY NEMATOCYSTS PER FIVE FIELDS. THESE DATA SUGGEST THAT A GREATER QUANTITY OF NEMATOCYSTS ENABLE FASTER IMMOBILIZATION OF PREY WHICH IN TURN TRANSLATES TO A FASTER FEEDING RATE. THE NUMBER OF NEMATOCYSTS ALSO CORRELATES WITH THE AGGRESSION HIERARCHY FOUND IN THE FIELD BUT MAKES LITTLE SENSE WHEN CONSIDERING THE AGGRESSION NETWORK WHICH AROSE IN OUR LABORATORY EXPERIMENTS.

COLLECTION: THE ACTUAL PROCESS OF COLLECTING ANEMONES HAS NO SCIENTIFIC RELEVANCE BUT RELATED FIELD OBSERVATIONS DO. WHILE COLLECTING ANEMONES WE ENCOUNTERED MANY MORE SPECIES THAN DURING OUR TRANSECTS. THE ANEMONES SEEN AND IDENTIFIED, BUT NOT STUDIED WERE: LEBRUNIA DANAE, LEBRUNIA CORALLIGENS, BARTHOLOMEA ANNULATA, AND BUNDOSOMA GRANULIFERA.

LABORATORY MANIPULATIONS

INTRASPECIFIC AGGRESSION: C. GIGANTEA VERSUS C. GIGANTEA. IN THE LAB WE SIMULATED A HABITAT WHERE SPACE WAS SOMEWHAT LIMITING. UNDER THESE CRAMPED CONDITIONS THE C. GIGANTEA INDIVIDUALS SPACED THEMSELVES OUT IN AN EFFORT TO UTILIZE ALL OF THE AVAILABLE SPACE. AFTER SPACING HAD OCCURRED NO EVIDENCE OF AGGRESSION WAS OBSERVED EVEN THOUGH THE TENTACLES WERE OVERLAPPING. THIS LABORATORY RESULT IS IN COMPLETE AGREEMENT WITH FIELD MANIPULATIONS AND GENERAL OBSERVATIONS.

S. HELIANTHUS VERSUS S. HELIANTHUS. WE PLACED THREE INDIVIDUALS COLLECTED FROM DIFFERENT PORTIONS OF THE BACK REEF STILL IN CLOSE PROXIMITY TO ONE ANOTHER. THREE INDIVIDUALS WERE USED TO MINIMIZE THE CHANCE OF TESTING CLONES INSTEAD OF GENETICALLY DIFFERENT INDIVIDUALS. HOWEVER, VERY LITTLE ACTION OCCURRED. IF ANY MOVEMENT AT ALL OCCURRED IT WAS ONLY TO MOVE CLOSER TO ONE ANOTHER. POPULATIONS OF CONTIGUOUS INDIVIDUALS WERE ALSO OBSERVED IN THE FIELD. PERHAPS BY COMPLETELY COVERING THE TERRAIN THEY DIMINISH THE CHANCE OF COLONIZATION BY OTHER ORGANISMS. THIS IDEA HAS BEEN SUGGESTED BY FRANCIS FOR THE CLONAL FORM OF ANTHOPLEURA ELEGANTISSIMA ON THE WEST COAST OF THE UNITED STATES. (FRANCIS, 1979). IF THIS IS IN FACT THE CASE THEN A COMMUNITY DOMINATED BY S. HELIANTHUS MAY BE CONSIDERED IN A CLIMAX STATE.

H. LUCIDA VERSUS H. LUCIDA. ONCE AGAIN THREE INDIVIDUALS WERE PLACED TOGETHER IN THE HOPE OF ELICITING AN AGGRESSIVE RESPONSE. ONCE AGAIN IT DID NOT. EACH INDIVIDUAL WAVED ITS TENTACLES IN AN APPARENT ATTEMPT TO WARD OFF ITS NEIGHBOR. THIS AGGRESSION GRADUALLY SUBSIDED AND WITHIN THE TWENTY-FOUR HOUR PERIOD OF OBSERVATION THEY ALL COEXISTED WITH EACH OTHER, TENTACLES ENTWINED WITH NO FURTHER EXTERNAL SIGNS OF AGGRESSION.

PERHAPS THE EARLY AGGRESSIVE BEHAVIOR PROVES TO ~~EACH~~ THAT THEY ARE EQUAL IN DEFENSES THEREBY MAKING AN EQUITABLE PARTITIONING OF THE AVAILABLE SPACE MOST PROFITABLE FOR ALL INVOLVED.

INTERSPECIFIC AGGRESSION: C. GIGANTEA VERSUS H. LUCIDA. THIS WAS OUR FIRST LABORATORY MANIPULATION WITH BLATANT AGGRESSIVE BEHAVIOR. C. GIGANTEA CONSUMED H. LUCIDA OVERNIGHT. THIS EXPERIMENT WAS THEN REPEATED TWICE WITHOUT CARNIVOROUS RESULTS BUT STILL WITH DECISIVE AGGRESSION. IN THE BEGINNING BOTH ANEMONES STING THE OTHER WITH ~~ITS~~ THEIR TENTACLES, BUT IN TIME H. LUCIDA ALWAYS BEGINS TO RETREAT. THIS OBSERVATION SUPPORTS OUR FIELD TRANSPLANTATION EXPERIMENT.

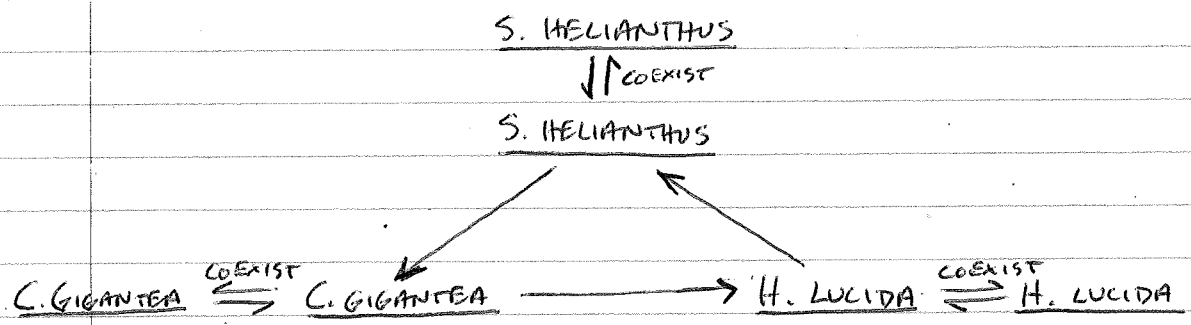
H. LUCIDA VERSUS S. HELIANTHUS. IN ALL THREE TRIALS OF THIS MANIPULATION H. LUCIDA WAS THE CLEAR CUT WINNER. IT WAVES ITS TENTACLES

AND STINGS S. HELIANTHUS APPARENTLY WITH MINIMAL RETALIATION. WITHIN TWENTY-FOUR HOURS S. HELIANTHUS HAS MOVE BEYOND THE REACH OF H. LUCIDA'S TENTACLES, BUT IN THE MEANTIME IT ROLLED UP THE EDGE OF THE ORAL DISC FACING H. LUCIDA. EVIDENTLY THIS MOTION IS AN EFFORT TO ESCAPE THE NEMATOCYST CLAD TENTACLES OF H. LUCIDA. THESE OBSERVATIONS ARE IN COMPLETE COMPLIANCE WITH OUR FIELD OBSERVATIONS.

C. GIGANTEA VERSUS S. HELIANTHUS. THIS INTERACTION WAS MARKED BY LITTLE OUTRIGHT AGGRESSION BUT A RAPID RETREAT BY C. GIGANTEA. WHEN PLACED TOGETHER NEITHER SPECIES SEEMED EXTREMELY DISTURBED BUT WITHIN TWENTY-FOUR HOURS C. GIGANTEA HAD ALWAYS MOVED SEVERAL INCHES SO THAT ITS TENTACLES COULD NOT TOUCH S. HELIANTHUS. ON ONE OCCASSION THIS MEANT LEAVING THE PREFERED NATURAL SUBSTRATE FOR THE SAFETY OF THE SIDES OF THE PLASTIC TUB. WE WERE UNABLE TO ASCERTAIN HOW S. HELIANTHUS DROVE C. GIGANTEA AWAY BUT WE KNOW IT TO BE EFFECTIVE.

THE REPLICABILITY OF THE LABORATORY MANIPULATIONS INDICATE AN AGGRESSION NETWORK INSTEAD OF THE AGGRESSION HIERARCHY SUGGESTED BY THE FIELD TRANSPLANTATION STUDY. SINCE THE FIELD STUDIES WERE ONLY PERFORMED ONCE WE CAN DISMISS THE OVERPOWERING OF S. HELIANTHUS BY C. GIGANTEA. THE NETWORK OF AGGRESSIVE

BEHAVIOR BY ANEMONES IS GRAPHICALLY DISPLAYED BELOW:



THE FORMATION OF AN AGGRESSION NETWORK LEADS TO HIGH SPECIES DIVERSITY, THIS NETWORK, COUPLED WITH A REEF THAT IS IN A CONSTANT STATE OF FLUX, CAN EXPLAIN THE LARGE NUMBER OF ANEMONE SPECIES FOUND ON ANY ONE REEF.

AGGRESSION AGAINST CORALS: IT WAS OBSERVED IN THE FIELD THAT ANEMONES CAN AND DO DAMAGE THE CORALS WHICH SURROUND THEIR ROCK LAIRS, TO QUANTIFY WHICH ANEMONES DAMAGE WHICH CORALS WE ARTIFICIALLY PLACED CORALS AROUND ANEMONES IN THE LAB AND OBTAINED THE FOLLOWING RESULTS LISTED IN TABLE 3:

TABLE 3

	DAMAGE TO CORALS			
ANEMONE TYPE	AGARICIA — CONTROL	ISOPHYLLIA - CONTROL	PORITES - CONTROL	SIDESTREA - CONTROL
S. HELIANTHUS	YES — NO	YES — YES	YES — NO	YES — NO
C. GIGANTEA	YES — NO	YES — NO	YES — NO	YES — NO
H. LUCIDA	YES — NO	YES — NO	NO — NO	YES — NO

IN GENERAL EACH ANEMONE IS CAPABLE OF DAMAGING VIRTUALLY ANY CORAL WITH WHICH IT COMES INTO CONTACT. THERE ARE TWO POSSIBLE EXCEPTIONS TO THIS. S. HELIANTHUS MAY OR MAY NOT BE ABLE TO DESTROY ISOPHYLLIA SINCE THERE WAS NO DISCERNIBLE DIFFERENCE BETWEEN THE EXPERIMENTAL AND CONTROL PORTIONS OF THIS CORAL. DAMAGE TO THE CONTROL DUE TO THE STRESS OF REMOVAL AND RELOCATION PROBABLY CLOUDED OUR RESULTS. THE SECOND EXCEPTION INVOLVED H. LUCIDA AND PORITES. NEITHER THE CONTROL NOR THE EXPERIMENTAL PORTION WERE DAMAGED. THIS APPARENTLY IS DUE TO THE FACT THAT HETERACTIS CHANGED ITS POSITION DURING THE STUDY AND WAS NO LONGER ABLE TO REACH THE PORITES SAMPLE. CONSEQUENTLY THIS INTERACTION CAN NOT BE DEEMED SIGNIFICANT.

THE GENERAL TREND APPEARS TO BE THAT ANEMONES CAN COLONIZE ANY CREVICE AND ARE CAPABLE OF KILLING OFF ADJACENT CORAL COLONIES. IF THIS WERE TRUE, ANEMONES WOULD ONLY BE LIMITED BY THE NUMBER OF INHABITABLE CREVICES AND WE WOULD PREDICT A POPULATION BOOM OCCURRING ON THIS, A RECENTLY DISTURBED REEF. PERHAPS THE RELATIVE ABUNDANCE OF H. LUCIDA REFLECTS THIS PHENOMENA BUT WITHOUT PRE-DISTURBANCE DATA, NO VALID CONCLUSIONS CAN BE DRAWN AT THIS TIME.

GUT CONTENT ANALYSIS: EVEN THOUGH THE INTERON CONTENTS WERE EXTRACTED IMMEDIATELY AFTER REMOVAL FROM THE FIELD MOST OF THEM WERE INDISTINGUISHABLE. THE IDENTIFIABLE CONTENTS ARE LISTED BELOW IN TABLE 4:

TABLE 4

DAY SAMPLES	C. GIGANTEA	H. LUCIDA	S. HELIANTHUS
LARVACEA	4	–	3
PTEROPOD	1	–	–
NAUPLII	1	–	–
TROCHOPHORE	2	–	–
POLYCHAETE	2	–	–
COPEPOD	2	–	–
TOTAL	12	0	3

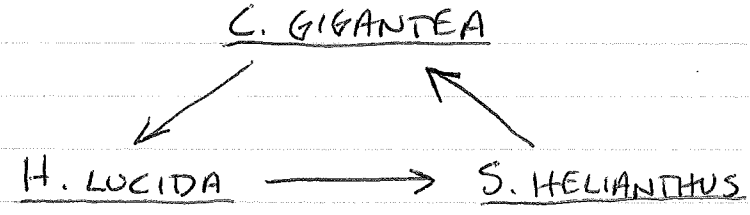
NIGHT SAMPLES	C. GIGANTEA	H. LUCIDA	S. HELIANTHUS
LARVACEA	2	6	4
NAUPLII	–	1	–
TROCHOPHORE	1	2	–
POLYCHAETE	2	4	1
COPEPOD	3	3	–
PROTOZOAN	1	–	–
AMPHIPOD	3	4	1
GASTROPOD VELIGER	–	–	1
CRUSTACEAN APPENDAGE	11	13	9
TOTAL	23	33	16

THE FIRST AND MOST OBVIOUS PATTERN IS THAT ANEMONES ARE MORE EFFECTIVE ZOOPLANKTON FEEDERS DURING THE NIGHT. THIS IS PROBABLY A RESULT OF THE INCREASED NUMBER OF ZOOPLANKTON DUE TO THE DEMERSAL RISE.

THE SECOND APPARENT PATTERN ARISING IS A PREDOMINANCE (50% OR GREATER) OF CRUSTACEAN PREY ITEMS IN THE DIETS OF ALL THREE ANEMONES. AT FIRST THIS MAY APPEAR TO BE SELECTIVE FEEDING BUT EXAMINATION OF THE PROPORTION OF CRUSTACEA FOUND IN THE NOCTURNAL ZOOPLANKTON COMMUNITY IS ALSO APPROXIMATELY 50% (LABORATORY, 1981). THIS SUGGESTS THAT THE ANEMONES ARE PASSIVE FEEDERS CAPTURING ANY SUFFICIENTLY SMALL PREY ITEM WHICH HAS THE MISFORTUNE OF ENCOUNTERING THEIR TENTACLES.

CONCLUSION

THIS STUDY HAS QUANTIFIED THE AGGRESSIVE BEHAVIOR OF SEVERAL SPECIES OF ANEMONES. ANEMONES ARE CAPABLE OF DAMAGING CORAL COLONIES THEREBY SECURING MUCH SOUGHT AFTER NICHES. IF, PERCHANCE, TWO ANEMONES COME ACROSS EACH OTHER IN THE FIELD WE HAVE SHOWN THAT CERTAIN PATTERNS ARISE: 1) IF THE ANEMONES ARE OF THE SAME SPECIES THEY BOTH OCCUPY THE CREVICE AND DIVIDE THEIR SPATIAL RESOURCE EQUALLY. 2) IF THE ANEMONES ARE OF DIFFERING SPECIES ONE SPECIES ALWAYS DOMINATES. THE SPECIES KEEP EACH OTHER IN CHECK VIA AN AGGRESSION NETWORK PICTURED BELOW:



SEVERAL OTHER ASPECTS OF THE ANEMONE WERE ALSO STUDIED. WE FOUND TWO DISTINCT METHODS OF FOOD PROCUREMENT WERE EMPLOYED BUT NO PREY SELECTION WAS OBSERVED. WE NOTED A PREDOMINANCE OF S. HELIANTHUS ON THE REEF CRESTS AND H. LUCIDA AT DEPTHS BETWEEN FIFTEEN AND TWENTY-FIVE FEET. SUBSTRATE PREFERENCE, AS SUGGESTED BY SEBENS (1977), WAS ALSO SUBSTANTIATED.

OUR STUDIES ON THE AGGRESSIVE BEHAVIOR OF THE SEA ANEMONE WERE INTERESTING TO CARRY OUT AND HAVE LAID THE GROUNDWORK FOR FUTURE STUDIES. ADDITIONS AND CONVOLUTIONS OF OUR BASIC NETWORK LIE ONLY AN FSP PROJECT AWAY.

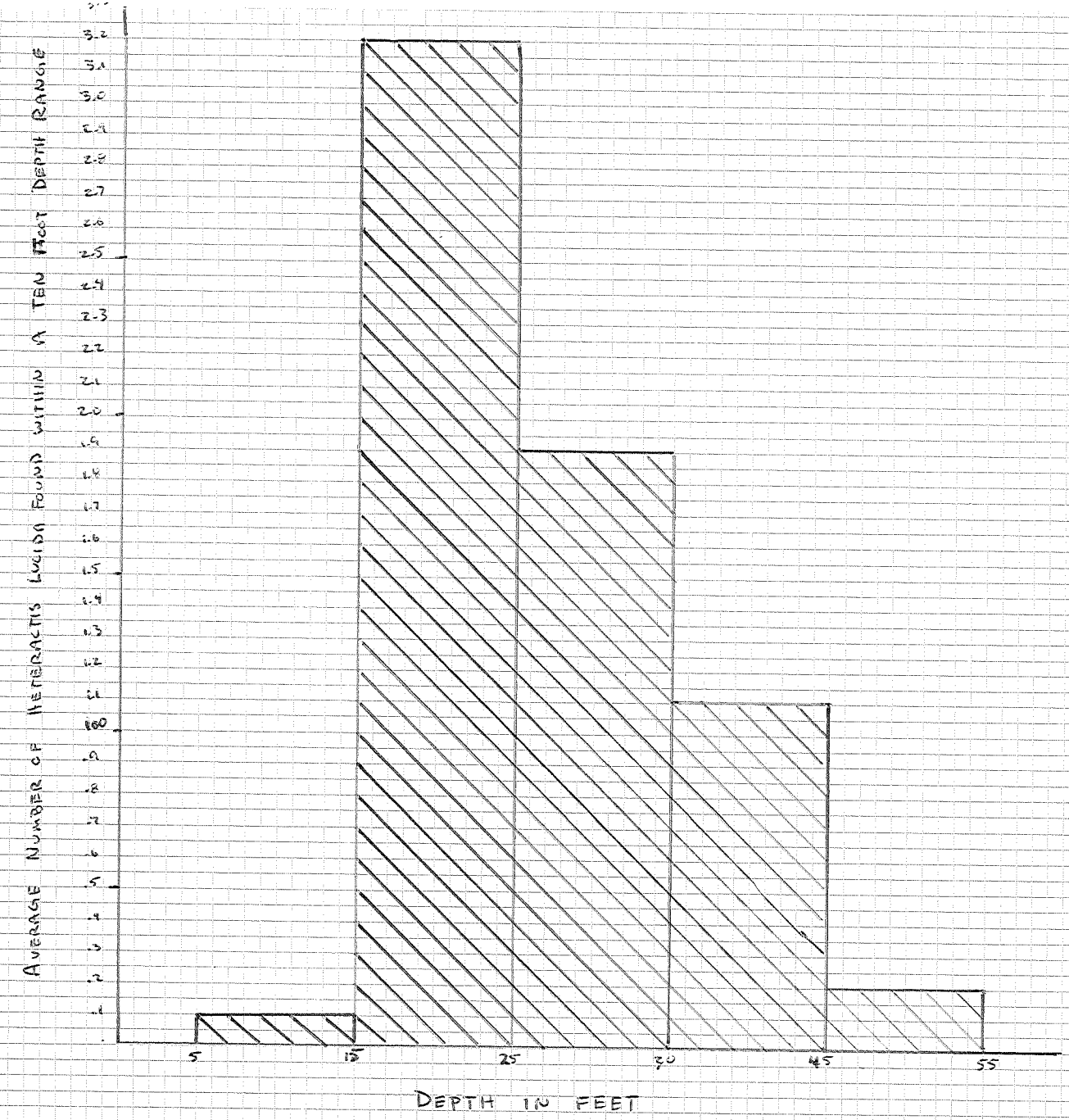


FIGURE 1. HISTOGRAM SHOWING AVERAGE NUMBER OF HETERACTIS LUCIDA FOUND WITHIN TEN FOOT DEPTH RANGES AS A FUNCTION OF DEPTH.

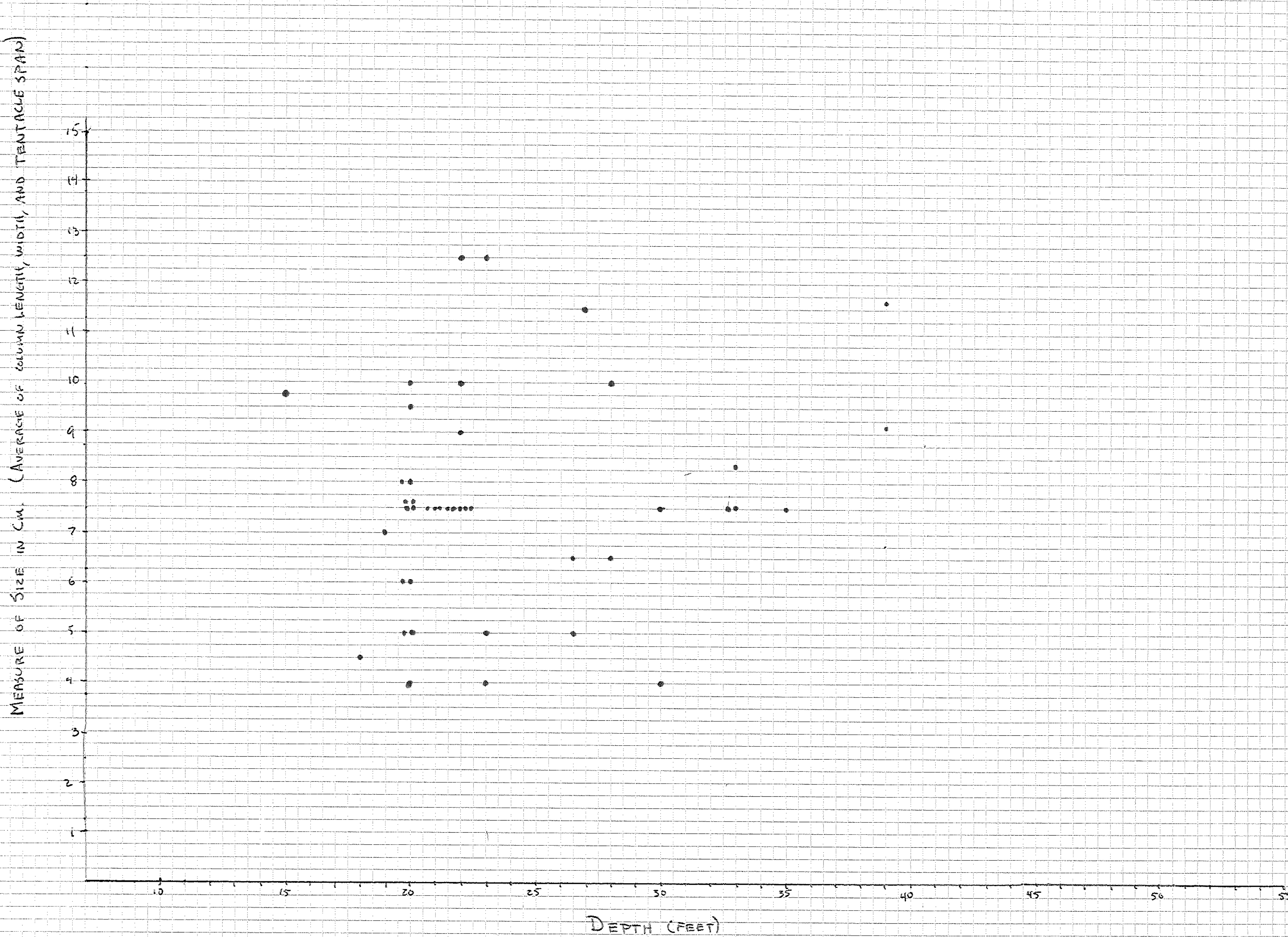


Figure 2. Graph of size of Heteractis lucida individuals found as a function of depth

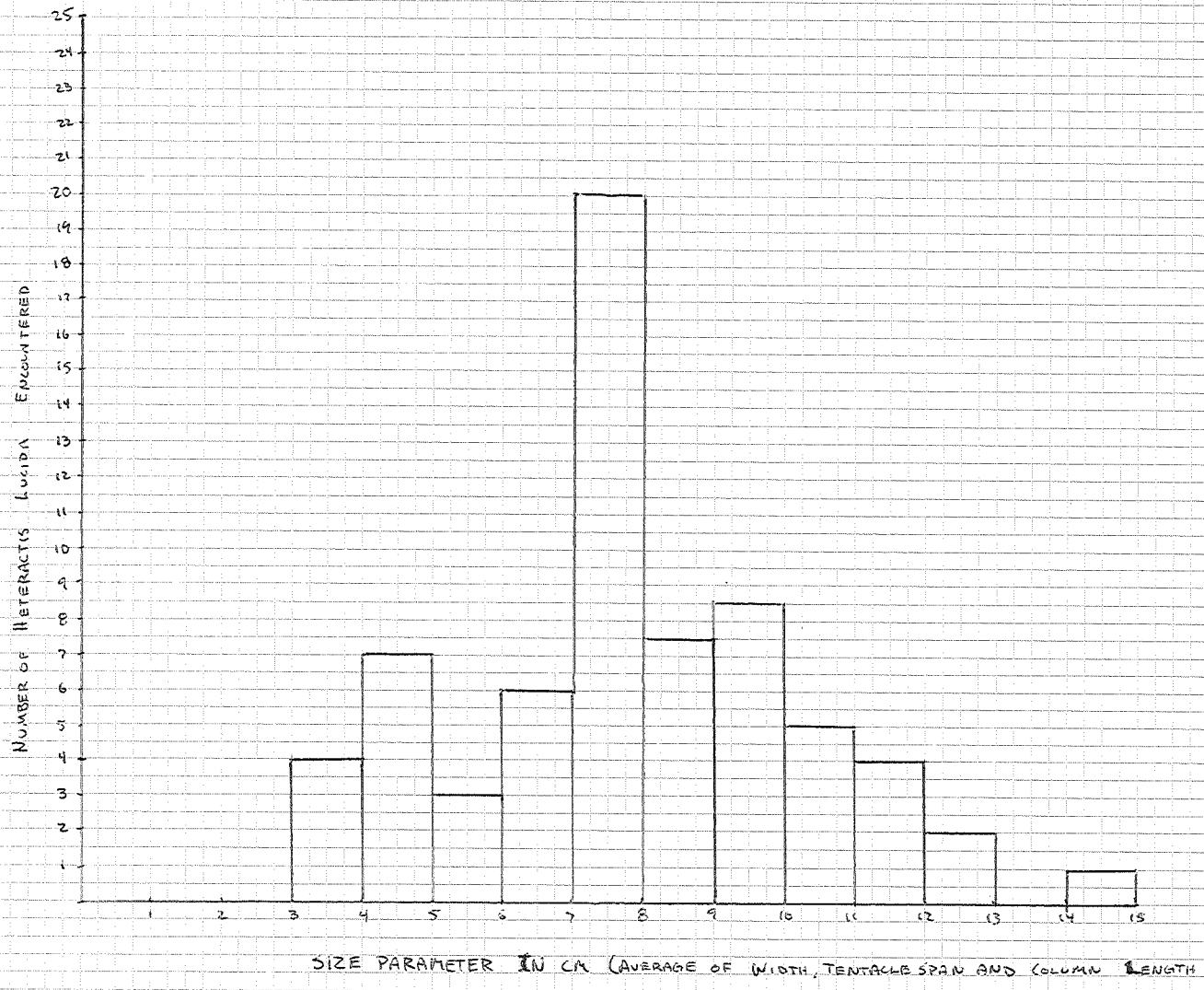


FIGURE 3. SIZE DISTRIBUTION GRAPH OF HETERACTIS LUCIDA

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