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The Management

Cruise Report

W-45

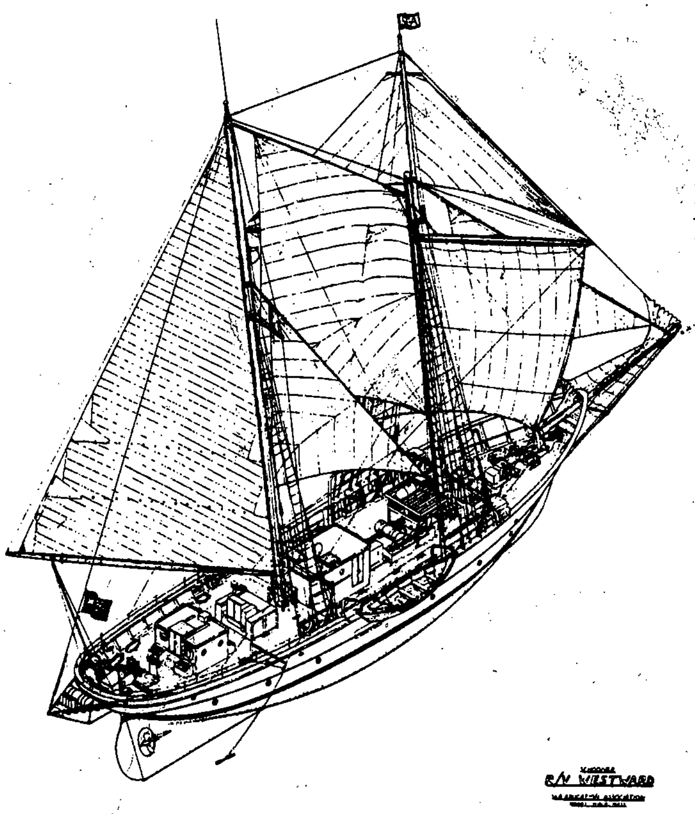
Scientific Activities

Undertaken Aboard

R/V Westward

Key West - Woods Hole

April 11 - May 23, 1979



(R. Long)

Sea Education Association - Woods Hole, Massachusetts

Cruise Report

W-45
(The Strombus Expedition)

Key West - Woods Hole

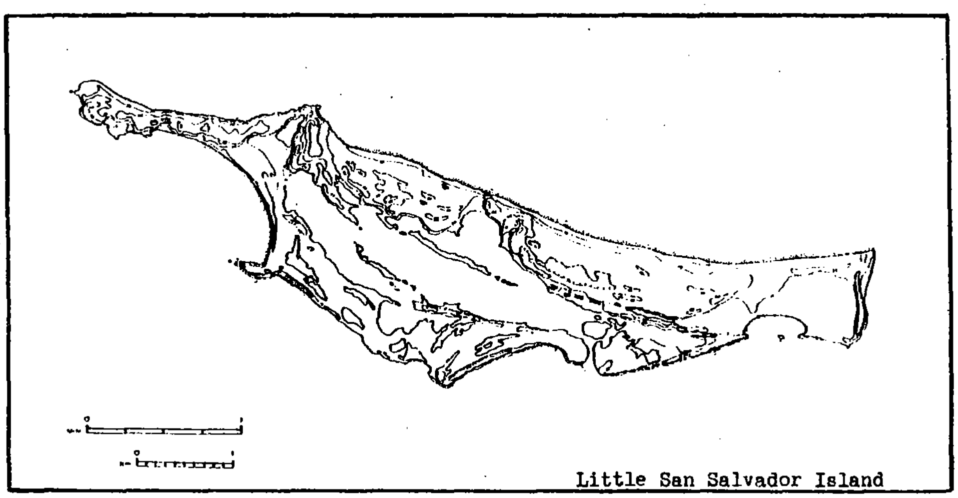
April 11 - May 23, 1979

R/V Westward

Sea Education Association

Woods Hole, Massachusetts

SHIPBOARD DRAFT



PREFACE

This cruise report outlines the scientific activities for the Strombus Expedition, the forty-fifth cruise of the R/V Westward. These activities fall into two separate categories which, however, serve each other: a traditional academic program offered purely and directly for the students' scholastic benefit; and, a program of research and student projects in which the students' skill and drive and curiosity determined the scope and benefit of their participation.

The Strombus Expedition differed from other Westward cruises during the past few years in that nearly one-third of the six weeks was devoted to examination of an island, Little San Salvador, where we engaged in shallow water and terrestrial studies. This difference, a very active Visiting Staff program and the inevitable vagaries of weather made W-45 a logistically complicated cruise which depended upon the especial persistence and dedication of the staff.

Ms. M. Abby Ames was in charge of the shipboard laboratory and, carried an additional burden normally assigned to a second full-time assistant. She also supervised the open ocean studies on leg 2 of the cruise. I am deeply grateful for her very central contribution to W-45.

Dr. Carol Reinisch of Harvard Medical School accompanied us on leg 1 of the cruise, including the island work, and in the course of her immunology study supervised 20% of the class on individual projects. I am sure the students benefited from her counsel, example and energy as other classes and I have on former cruises.

Mr. David Moss of the University of Delaware, College of Marine Studies came on leg 2 of the cruise, with principal responsibility for the Delaware Bay program. His firsthand knowledge of this estuary, his effectiveness in supervising students and his carefully prepared series of seminars made David's participation especially valuable.

Mr. Rob Moir joined us for the last leg of the cruise from Philadelphia to Woods Hole. His energetic addition to a weary staff and his marine mammal and pelagic bird expertise was most welcome. I thank him for his patience with all of us.

A number of visitors to the science program enlarged our range of expertise at Little San Salvador Island, including Mr. Roderick Attrill (Bahamas natural history), Bahamas National Trust; Ms. Dale Brown (phycology), Graduate School of Oceanography, U.R.I.; and two former colleagues, Dr. Mary Gillham (botany), University College, Cardiff; and Mr. Sheldon Pratt (benthic ecology), Graduate School of Oceanography, U.R.I.

The nautical staff of the Westward took on added work and responsibility to make this cruise successful. Mr. Gary Manter was in charge of photography and processing, Mr. Donald Thomson was Shipboard Information Officer and, with Mr. Richard Waterhouse, supervised the bathymetric survey in the island lagoon.

As Chief Scientist, I am indebted and grateful to Captain Wallace Stark whose skill and judgment were as important as my own abilities in the eventual success of the overall scientific program.

Arthur G. Gaines, Jr.
Chief Scientist
Woods Hole, MA
June 3, 1979

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CRUISE SUMMARY

This offering of Introduction to Marine Science Laboratory 1/ was structured about ship-based studies at an uninhabited Bahamas island, Little San Salvador Island, and Westward's transect of the Western North Atlantic Ocean and the Delaware Bay estuary. The course included 20 seminars, 150 contact hours of supervised field and laboratory work and an individual project for each student. The content of the course, therefore, reflects the skills and interests of the visiting and permanent staff and the students as well as the opportunities for inquiry inherent to the ship's track.

Leg 1 focused on studies of Little San Salvador Island where a shore laboratory and camp were established for visiting scientists. Lagoon studies dealt with bathymetry, sediment composition and distribution, benthic habitats, hydrography, phytoplankton and zooplankton. Aquaculture-oriented work on *Strombus gigas* in the lagoon included a census of life stages and studies on physiology, food sources and natural predators of the conch. Terrestrial surveys treated vegetative zonation; bird census, and the occurrence of amphibians and reptiles. Two hypersaline ponds were examined briefly for biota and water characteristics.

During leg 2 hydrographic work was conducted in cooperation with an OTEC 2/ project. The Sargassum community was examined for species composition and diversity and primary productivity. Neuston samples and mesopelagic fauna were collected and examined. A series of hydrocasts from the Sargasso Sea to upper Delaware Bay were analysed for temperature, salinity and nutrients, and student projects were carried out on light penetration, the dissolved copper concentration, particulate carbon and phytoplankton and zooplankton associated with surface water at these stations.

The results of the cruise were discussed at a one day meeting at the University of Pennsylvania in Philadelphia, the port marking the end of leg 2.

During leg 3, the planned intensification of our marine mammal and pelagic bird observations was hampered by fog.

Throughout the cruise NOAA weather observations were transmitted ashore. All processing of samples and data, including photographic records was completed and discussed in written Shipboard Reports prior to our arrival at Woods Hole, Westward's home port and the terminus for W-45.

1/ Boston University, NS CLX 225

2/ Ocean Therman Energy Conversion

INTRODUCTION

Introduction to Marine Sciences Laboratory is one of two offerings aboard Westward [1/] and is based in part upon a prerequisite course offered at Woods Hole, Massachusetts (Introduction to Marine Science) which also runs for six weeks.

Three areas - seminars, supervised laboratory and field work (Science watch), and student projects - make up the course. The first two are described briefly below and results of the third constitute the bulk of this report. While the structure of Introduction to Marine Science remains fixed over the years, the exact contents of each offering depend upon interests and abilities of the staff and students (Table 1) and the agreed upon itinerary and cruise track (Fig. 1 , Table 2). On W-45 three areas of work defined our program:

Little San Salvador Island, Bahamas

This small uninhabited, privately owned island represents an unmodified island - fringing reef - lagoon complex and as such holds considerable scientific interest. The owners are presently considering the possibility of aquaculture of the queen conch (*Strombus gigas*) in the lagoon and expressed interest in our evaluation of this idea. Our work here, therefore, included both basic and applied aspects.

Sargasso Sea Studies

Contributions were made to ongoing surveys of pelagic tar and other constituents of the neuston and to an ongoing study of the trophic structure of the Sargassum weed community as Westward made her way north on the open sea. Measurements on open ocean water samples also provided a contrast with those in coastal or inshore waters and helped to characterize this environment.

Delaware Bay Studies

The purpose of the Delaware Bay work was to illustrate some of the basic features of the estuary through analysis of certain key variables. Delaware Bay, one of the largest American estuaries, displays a gradient of shoreline-use in addition to the natural features.

1/ The other is Introduction to Nautical Science Laboratory.

Table 1 W-45 Ship's Complement.

Nautical Staff

Wallace C. Stark, J.D.	Captain
Donald M. Thomson, Jr., B.S.	Chief Mate
Ronald H. Harelstad, B.S.	Second Mate
Richard E. Waterhouse, M.A.	Third Mate
Gary Manter, A.M.S.	Chief Engineer
David H. Martin (leg 3)	Engineer
Gale Gryska, B.A.	Steward

Scientific Staff

Melinda A. Ames, B.S.	Scientist-2
Arthur G. Gaines, Jr., Ph.D.	Chief Scientist
Rob Moir, M.A.T. (leg 3)	Scientist-3
David E. Moss, M.S. (leg 2)	Scientist-3
Carol L. Reinisch, D.Sc. (leg 1)	Scientist-3

Visiting Staff (partial, leg 1)

Roderick Attrill, B.S., Bahamas National Trust
Dale Brown, B.S., University of Rhode Island
Corwith Cramer, M.S., Sea Education Association
Mary Gillham, Ph.D., The University of Wales, Cardiff
James Millinger, Ph.D., Redlands University
Sheldon Pratt, B.S., University of Rhode Island

Students	College	Home
Scott E. Bovard	Iowa State University, IA	Mason City, IA
Gwen M. Burzycki	Cornell University, NY	Alfred, NY
Peter A. Cataldo	University of Vermont, VT	Worcester, MA
Lynn Collins	Colby College, ME	Eastham, MA
Thomas C. DeCarlo	Dartmouth, NH	Provincetown, MA
Laura E. Ellis	Middlebury College, VT	Menands, NY
Dennis E. Fitzpatrick	Cornell University, NY	Delmar, NY
Laura E. Gentile	Cornell University, NY	Staten Island, NY
Grace K. Hornor	Smith College	Osterville, MA
Barbara J. Johnson	Loyola University, MD	Severna Park, MD
Nicholas P. LaFond	St. John's University, MN	St. Joseph, MN
William J. McMahon	Boston College, MA	Watertown, MA
Paul O. Miniter	Middlebury College, VT	Belmont, MA
Celeste H. Nadworny	Florida State University, FL	Stony Brook, NY
Robert P. O'Neil	Univ. of New Hampshire, NH	Arlington, MA
Barbara A. Polan	Cornell University, NY	Clifton Springs, NY
Christopher B. Rich	University of Rhode Island, RI	Carmel, NY

Students	College	Home
Gretchen R. Rich	Univ. of New Hampshire, NH	Slingerlands, NY
Judy Seligson	Oberlin College, OH	Steamboat Springs, CO
David B. Siebert	Princeton University, NJ	Manasquan, NY
Janice Silverstein	Cornell University, NY	Bayside, NY
Mark J. Tedesco	Tufts University, MA	Winchester, MA
Robert L. Visnick	Univ. of New Hampshire, NH	Rockport, MA
Martha C. Wilson	Amherst College, MA	Bethesda, MD

Table 2 W-45 Itinerary 1979

Leg	Depart	Date	Arrive	Date
1	Key West, FL	04/12/79	Nassau, Bahamas 1/	04/16/79
	Nassau	04/17/79	Little San Salvador	04/19/79
	Little San Salvador 2/	04/21/79	Cape Eleuthera, Eleutera	04/21/79
	Cape Eleuthra	04/21/79	Little San Salvador	04/22/79
	Little San Salvador 2/	04/25/79	Nassau	04/27/79
	Nassau	04/27/79	Little San Salvador	04/29/79
	Little San Salvador	04/29/79	Nassau 1/	05/01/79
2	Nassau	05/01/79	Wilmington, DE 1/	05/14/79
	Wilmington	05/15/79	Philadelphia, PA	05/15/79
3	Philadelphia	05/18/79	Woods Hole, MA	05/23/79

1/ Customs

2/ Addition to proposed itinerary, owing to heavy weather, for transfer of personnel and equipment

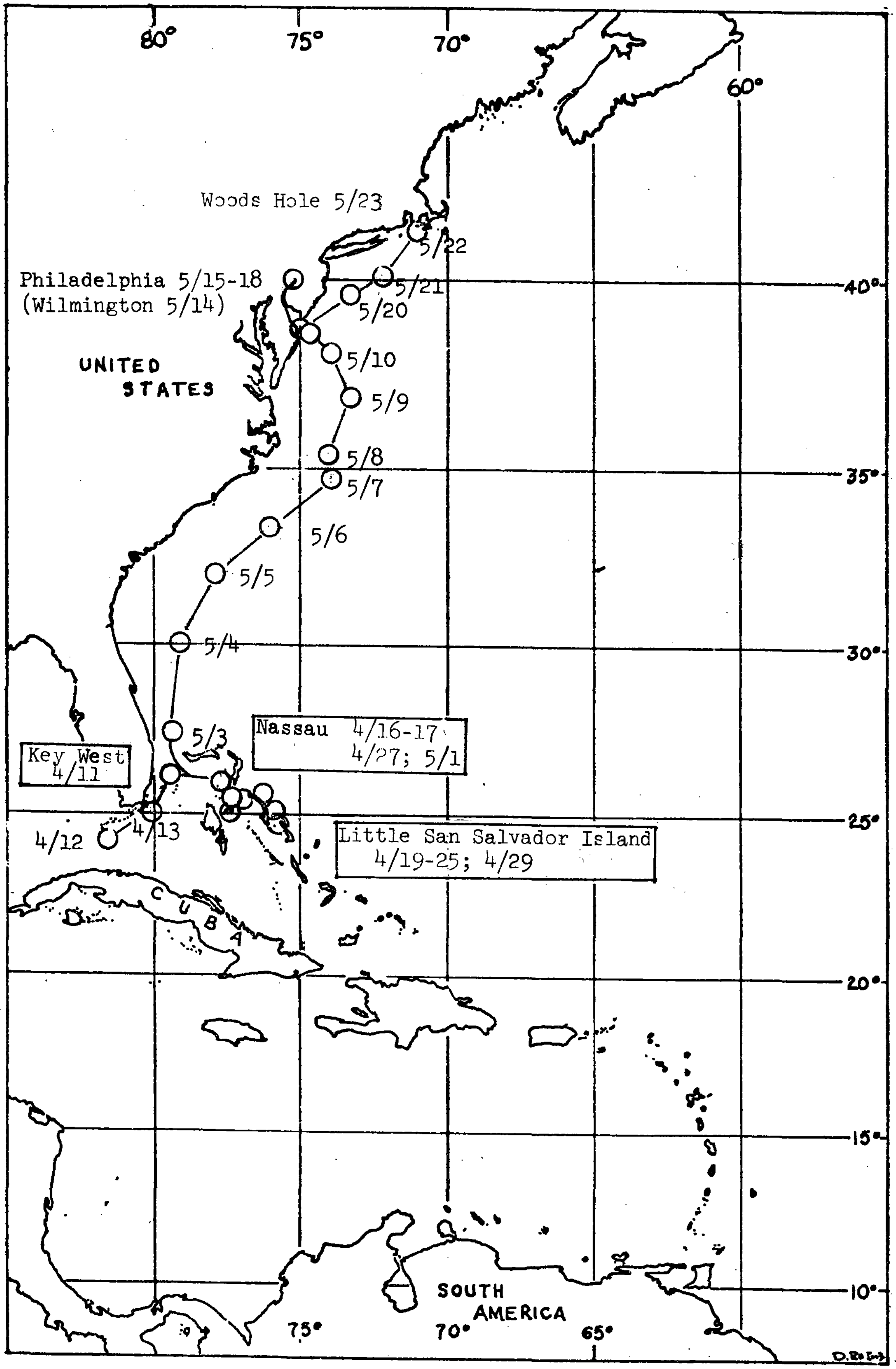

Fig. 1 W-45 Cruise track. Noon positions (LAN).

Student projects are defined ashore at Woods Hole, carried out at sea, and discussed in Shipboard Reports. The contents of this report, therefore, reflects the inevitable limitations imposed by restricted time, library facilities and reflection. From the viewpoint that writing coincides with an essential stage of the thought process it can be argued that these limitations are of secondary concern.

Studies conducted during W-45 partly represent ongoing work of individuals and agencies that have extended their help to our students. Material reported here should not be cited or excerpted without written permission of the Chief Scientist.

ACADEMICS

Lectures

Like the rest of the Marine Science program the seminars and lectures (Table 3) reflect Westward's location and research activities. Evaluation of student performance in this was by means of a written final examination {Appendix A }.

Science Watch

A scheduled 24-hour science watch consisting of a staff or visiting scientist and two or three students was maintained throughout the seagoing portions of the cruise.

Activities during watch involved execution or assistance in execution of the scientific program (Table 4) and maintenance of a scientific log. Time on watch also assured the opportunity for personal instruction on any aspect of the cruise work and assistance in individual project work. Staff members were encouraged to conduct demonstrations or carry out exercises during watch time not otherwise committed.

A collection of demonstration organisms representing many phyla and ecological life types was assembled during watch and served as a basis for a practical examination included in the final exam. Evaluation in Science Watch depended upon a subjective evaluation by the scientists on watch during the cruise and the student's record of weather observations, chemical determinations and participation in other watch responsibilities (Table 4).

Individual Projects

Students were required to define an individual project while ashore at Woods Hole. Any topic was regarded as acceptable which a) takes advantage of a special opportunity afforded by the Westward cruise; and b) is conducted and presented in a scientific manner. The majority of projects

Table 3 Seminars and Class Meetings for W-45- Marine Science

1.	Standing watch: protocol in the laboratory	Gaines
2.	Little San Salvador observations - Day 1	Gaines
3.	Little San Salvador observations - Day 2	Gaines
4.	The geology and natural history of the Bahamas: I	Attrill
5.	The geology and natural history of the Bahamas: II	Attrill
6.	Chemistry of the salinity determination	Gaines
7.	Chemistry of the Winkler dissolved oxygen determination	Gaines
8.	Temperature sensing - the bathythermograph	Ames
9.	Mangrove communities	Ames
10.	Sampling with nets and filters	Gaines
11.	The Sargassum community	Ames
12.	Colorimetric methods of analysis: PO_4; $Si(OH)_4$, NH_3.	Gaines
13.	Results of the OTEC hydrocast	Ames
14.	Mesopelagic faunal assemblages	Ames
15.	Estuaries: definition, classification, geology	Moss
~~16.~~	~~The Delaware Bay estuary: nutrient flux~~	~~Moss~~
17.	Evaluating coastal resources	Moss
18.	Life salvage in American Admiralty Courts	Moss
19.	Marine mammals	Moir
20.	Pelagic bird observations	Moir

Table 4 Scientific Operations on W-45 Involving General Science Watch Participation

Operation	Numbers performed or deployed
Bathythermographs	19
Zooplankton tows	19
Bongo net	7
Meter net	2
Neuston net	10
Phytoplankton tows	10
Hydrocasts	9
Chemical determinations	
Salinity titrations	404
Oxygen titrations	508
Reactive phosphorus	154
Silica	72
Ammonia	152
Oxidizable particulate carbon	43
Chlorophyll	24
Dissolved copper	24
Shallow water cores	5
Photometer stations	13
Cetacean watch	29 hours
Isaacs Kidd midwater trawl	1
NOAA weather observations	46
Otter trawl	1

selected are traditional problems in a natural science but occasionally an applied or engineering project is chosen instead.

A complete written Shipboard Report is required of each student prior to leaving the ship. In addition, during our Philadelphia port stop each student presented a short verbal report or status report at the College of Engineering and Applied Science, University of Pennsylvania, a new affiliate of SEA (Appendix B).

COOPERATIVE PROGRAMS

Cooperative Ship Weather Observation Program (NOAA)

The R/V Westward is certified by NOAA to gather weather observations for the U.S. National Weather Service in conjunction with the Organization Meteorologique Mondiale. The data, which are collected at 0600 and 1200 GMT are transmitted to Coast Guard stations ashore and constitute part of a global weather observation network.

On W-45 46 sets of observations were compiled of which 59% were successfully transmitted. Of these 63% were copied by NMN Portsmouth, VA, 33% were copied by NMG New Orleans and 4% by NMF Boston.

For our own purposes these observations (Table 5) comprise a sea surface and meteorolgoical record for the cruise.

Ichthyoplankton Neuston Sampling (National Marine Fisheries Service)

Ten neuston samples collected on W-45 (Table 12) will be forwarded to the National Marine Fisheries Service - Miami, where they will be examined for larval fish content. This cooperative program coordinated by Dr. William Richards is directed at clarifying the life histories of important sport fisheries species.

Comparative Invertebrate Immunology

Carol L. Reinisch, Harvard Medical School

Invertebrates such as Echinoderms are known to have nonspecific defense mechanisms. Specifically, animals such as sea stars have the capacity to reject sheep red blood cells, innoculations of bacteria, xenografts from other Echinoderms, etc. However, what is not known is whether in vitro assays can be utilized to quantitate the precise cellular mechanism which underlies rejection of foreign material.

Table 5 W-45 Ship's Weather Observations.

$99L_aL_aL_a$	$Q_cL_oL_oL_o$	$YYGGi_w$	Nddff	VVwwW	PPPTT	$N_hC_LhC_MC_H$	D_sv_sapp	$OT_sT_sT_dT_d$	$1T_wT_wT_w{}^tT$	$3P_wP_wH_wH_w$	$d_wd_wP_wH_wH_w$
99243	70810	13063	60924	98030	15426	623//	11400	00125	12650	30604	/////
99249	70803	13123	50915	98022	15124	523//	11203	05322	12605	30503	/////
99247	70799	14063	21915	99012	16125	21/3/	42402	00021	12500	30302	/////
99253	70795	14123	81405	99031	16224	4221/	81307	05221	12555	30000	14501
99260	70787	15063	31803	99010	15524	20/16	21705	00021	12550	30000	00/00
99259	70779	15123	31905	98030	15024	24/54	31207	01816	12582	30201	99/01
99253	70773	16063	42305	98011	15024	0//58	41400	05025	12485	30501	/////
99256	70771	18063	30000	98010	20822	21300	11400	05319	12459	30000	00/00
99256	70765	18123	10707	98012	21123	16005	31003	05005	12405	30101	05503
99235	70759	19063	30513	96021	19922	0/559	31711	05516	12450	30501	/////
99245	70759	19123	40513	97030	20022	11332	00201	05514	12460	30000	00100
99255	70760	26063	82015	97506	13023	75528	71705	00508	12358	30302	22508
99258	70766	26123	62008	97032	12223	13290	61205	05121	12385	30100	12604
99256	70774	27063	03602	99010	12924	00900	00400	00323	12305	30000	/////
99256	70769	28123	10000	99010	14824	11200	12206	00223	12355	30301	/////
99252	70760	29063	31603	98130	16124	143//	41702	00124	12458	30000	/////
99245	70760	29123	83620	96802	17522	73211	00215	05421	12455	30101	36501
99250	70761	30063	30503	98021	18024	113/8	71207	05023	12453	30000	05///
99255	70762	30123	40906	98030	18124	42400	72204	00122	12407	30000	08803
99253	70772	31063	01606	98011	16124	00000	00400	00025	12488	30000	00000
99255	70773	02063	50210	98002	15025	55400	71203	00522	12450	30301	00000
99258	70775	02123	60406	97012	15221	12276	72403	05223	12500	30101	11501
99263	70787	03063	42202	98020	18624	21220	71205	05321	12550	3////	/////
99267	70793	03123	10913	98001	18923	18106	72212	05419	12688	30101	09501
99293	70793	03063	10909	97000	19524	1156/	82400	05219	12550	30202	09504
99297	70791	04123	60915	98031	19324	43310	12208	05421	12600	30302	14703
99313	70793	05063	31112	98020	15124	284//	82713	05721	12725	30302	20503
99317	70785	05123	81719	97258	15024	874//	11205	05322	12636	30500	21704
99326	70765	06063	80000	98132	12924	864//	11703	05520	12640	3////	09504
99329	77611	06083	80509	96032	14523	61120	21005	0//20	12685	30501	07302
99342	70755	07053	21105	98011	19822	21300	11803	0//21	12655	30201	09503
99347	70745	07123	21105	98010	21224	11510	32212	05114	12485	30101	11501
99346	70740	08063	31908	98020	21923	21471	00400	05217	12380	30501	14501
99348	77410	08123	22104	99010	22322	11310	00106	05517	12450	30401	21501
99365	77345	09063	02301	99000	23121	00900	81707	00815	11935	3////	23501
99368	77350	10123	10000	97020	23519	11400	81210	00317	11815	30000	18501
99373	77360	10063	12109	97020	20517	00801	81720	00217	11655	30401	25501
99379	70737	10123	72706	96030	19915	66009	81400	00813	11186	30000	21500
99382	70740	11123	72501	96424	16015	9////	71400	00215	11445	30501	25501
99387	70747	12063	91104	90454	17117	9/0//	00230	00615	11400	39901	99/00
99142	77475	12123	91405	90454	16915	9/0//	00102	00815	11429	30201	99501
99391	70740	20063	90906	96515	17013	9////	86706	05113	11351	30302	/////
99393	70733	20123	90605	93454	18211	9////	81204	05012	11208	30100	06502
99399	70723	21063	90310	90494	16011	9////	11706	05111	11154	3////	/////
99400	70721	21123	90606	94444	15211	9////	81703	05012	11165	30201	14501
99401	70715	22063	92708	97032	14512	91044	11203	00214	11155	30101	00000

Key: $L_aL_aL_a$= latitude in degrees and tenths; Q_c= quadrant of globe; $L_oL_oL_o$ = longitude in degrees and tenths; YY = day of month; GG = Greenwich Mean Time; i_w = wind indicator; N = total cloud amount; dd = wind direction; ff = wind speed; VV = visibility; ww = present weather; W = past weather; PPP = sea level pressure; TT = air temp.; N_h = amount of lowest clouds; C_L = type of low cloud; h = height of lowest clouds; C_M = type of middle cloud; C_H = type of high cloud; D_s = course of ship; v_s = speed of ship; a = character of pressure change; pp = amount of pressure change; T_s = air-sea temp difference; T_d = dew point; T_w = sea temp.; ${}^tT$ = tenths of air temp.; P_w and H_w = wind wave period and height; d_w = swell direction.

On W-45, the purpose of the research carried out under my direction was to determine if we could employ an in vitro assay designed to determine whether a difference in cellular responses can be detected in animals which have previously been inoculated with erythrocytes when compared to uninoculated controls. Five students carried out research on Little San Salvador Island, taking advantage of collections of two species of Echinoderms, Strongylocentrotus and Diadema, which are abundant in the lagoon there. The sheep erythrocytes (SRBC) were brought from Boston and refrigerated throughout the experimentation. The results, abstracted below, show that cells obtained from animals which received a previous injection of sheep erythrocytes, have an increased capacity to both bind and phagocytose erythrocytes in vitro.

Evidence of immunological memory in sea urchins

Paul Miniter

Abstract

Evidence of immunological memory in invertebrate cellular defense systems is limited. Bang (1975) encountered decreasing clearance times of Anophrys protozoa from Asterias (sea stars) upon repeated inoculations with the antigen. Our experiment using sea urchins inoculated with SRBC antigens are consistent with Bang's findings of increased rates of clearance upon repeated exposures to antigens. Coelomocytes from Strongylocentrotus previously inoculated with SRBC, exhibted increased relative amounts of single coelomocytes with entrapped SRBC's upon a second in vitro exposure to SRBC's as compared to coelomocytes from normal sea urchins. Similar experiments with Diadema sea urchins were inconclusive.

Memory response: A study of the phagocytic defense system in Diadema and Strongylocentrotus

Mark Tedesco

Abstract

Two species of Echinoids, Diadema (sp.) and Strongylocentrotus (sp.), were used to study the memory response of their phagocytic defense systems. The evolutionary background of the vertebrate

immune system may be the invertebrate phagocytic system. We challenged host coelomocytes with antigenic sheep erythrocytes in both normal and preinoculated situations. In *Strongylocentrotus*, a secondary response of a much greater magnitude (3-12 times) than the primary response was witnessed. This is evidence of a memory response in the organism. In *Diadema*, cell counts gave no conclusive evidence as to whether or not this animal had a memory response.

Invertebrate memory: A case study using the sea urchin, *Strongylocentrotus*

Dennis Fitzpatrick

Abstract

Seven specimens of the Sea Urchin, *Strongylocentrotus* were collected in the Little San Salvador lagoon. Three were inoculated with sheep red blood cells; four were not. Sheep red blood cells were then introduced in each animal in vitro. The reaction of the two groups was observed, compared, and quantitated. The result was that sensitized *Strongylocentrotus* coelomocytes recognized the antigen faster than the unsensitized coelomocytes indicating an immunological memory.

Memory in the internal defense mechanism of *Strongylocentrotus*

Nicholas LaFond

Abstract

The purpose of this experiment was to show whether or not a memory exists in the internal defense mechanism of the echinoderm *Strongylocentrotus*. Although it is not absolutely certain, I think these data show that the probability is quite high that it does exist, and if nothing else, they demand more research be done to either substantiate them or refute them. Actually, under the working conditions and unfamiliarity and inexperience with the techniques, ? I would say we did a good job in slide preparation and elucidation of the data. I would also like to give Paul Miniter a good amount of credit in helping us all understand what was going on and doing a lot of the cell counts for our

"good" data. So, all in all, the experiment was definitely a success.

Immunological studies on invertebrates collected at Little San Salvador Island

Lynn Collins

Abstract

Cell recognition and response of the invertebrate to foreign particles was studied in vivo and in vitro. It was found that responses involve a type of memory as indicated by a higher level of uptake of non-self cells by sensitized cells.

Ocean Thermal Energy Conversion

At the request of the Bahamas Electric Corporation *Westward* carried out a hydrocast in the Tongue of the Ocean. Ocean Thermal Energy Conversion (OTEC) is a possible approach to generating electricity from the thermal gradient that exists in the ocean. To be feasible, this requires a sharp and relatively shallow permanent thermocline among other engineering considerations.

The results of the hydrocast (Table 6) indicate a source of cold water (5.6°C, probably antarctic intermediate water) within 820 meters of the surface. This would provide engineers with a temperature gradient of about 20°C to work with.

Deep water brought to the surface for generation of electricity contains high nutrient levels and may then be useful for aquaculture.

Table 6 OTEC hydrostation in the Tongue of the Ocean, Bahamas. April 30, 1979. 2210. W-45

<table>
<tr><th>Corrected Depth (M)</th><th>Temp (°C)</th><th>Salinity (0/00)</th><th>O_2 (ml/L)</th><th>NH_3 (µM/L)</th><th>PO_4 (µM/L)</th></tr>
<tr><td>0</td><td>25.42</td><td>36.4</td><td>4.50</td><td rowspan="12">not detectable</td><td>0.16</td></tr>
<tr><td>80</td><td>-</td><td>36.5</td><td>4.61</td><td>0.16</td></tr>
<tr><td>165</td><td>22.48</td><td>36.8</td><td>4.36</td><td>0.20</td></tr>
<tr><td>245</td><td>-</td><td>36.8</td><td>4.39</td><td>0.11</td></tr>
<tr><td>325</td><td>17.57</td><td>36.5</td><td>4.04</td><td>0.41</td></tr>
<tr><td>410</td><td>-</td><td>36.4</td><td>4.15</td><td>0.39</td></tr>
<tr><td>490</td><td>-</td><td>36.1</td><td>3.79</td><td>0.67</td></tr>
<tr><td>575</td><td>11.27</td><td>35.2</td><td>3.13</td><td>1.14</td></tr>
<tr><td>661</td><td>-</td><td>35.0</td><td>3.35</td><td>0.15 (?)</td></tr>
<tr><td>820</td><td>5.64</td><td>34.9</td><td>4.60</td><td>1.36</td></tr>
<tr><td>1135</td><td>-</td><td>-</td><td>4.69</td><td>1.04</td></tr>
<tr><td>1302</td><td>4.47</td><td>-</td><td>5.03</td><td>1.20</td></tr>
</table>

LONG TERM INTERNAL PROGRAMS

Marine Mammals

Rob Moir

Records of cetacean sightings have been kept on all Westward cruises for the past several years. For W-45 it was anticipated that densest populations of whales would occur along leg 3, in the mid-Atlantic bight, and therefore, intensive structured "whale watch" was limited to this leg.

From Cape Henelopen to Woods Hole observers stood watch on deck in pairs (20.5 hrs) or singly (8.5 hrs) during daylight hours when visibility exceeded 35 meters. Dense fog prevailed and there were no sightings of marine mammals.

Spot observations by the Science Watch for the preceding legs are given in Figure 2 and Table 7 . Cetaceans were most abundant among the Bahamas Islands and off Cape Hatteras, on both sides of the north wall of the Gulf Stream.

Pelagic Bird Observations

Barbara Johnson and Rob Moir

Twenty-seven 10-minute bird watching stations were kept on the high sea from Key West to Woods Hole (Fig. 3). Most of the 26 species observed were oceanic birds but some were land birds (Table 8) apparently blown out to sea by storms. Individual sightings, outside regular 10-minute stations (Table 9), brought the number of pelagic sightings to 30 species of which 9 landed aboard the ship.

Between Cape Henelopen and Woods Hole an intensive bird watch was maintained during daylight hours. More than 85 sightings were made, despite dense fog, including 14 species (Table 10).

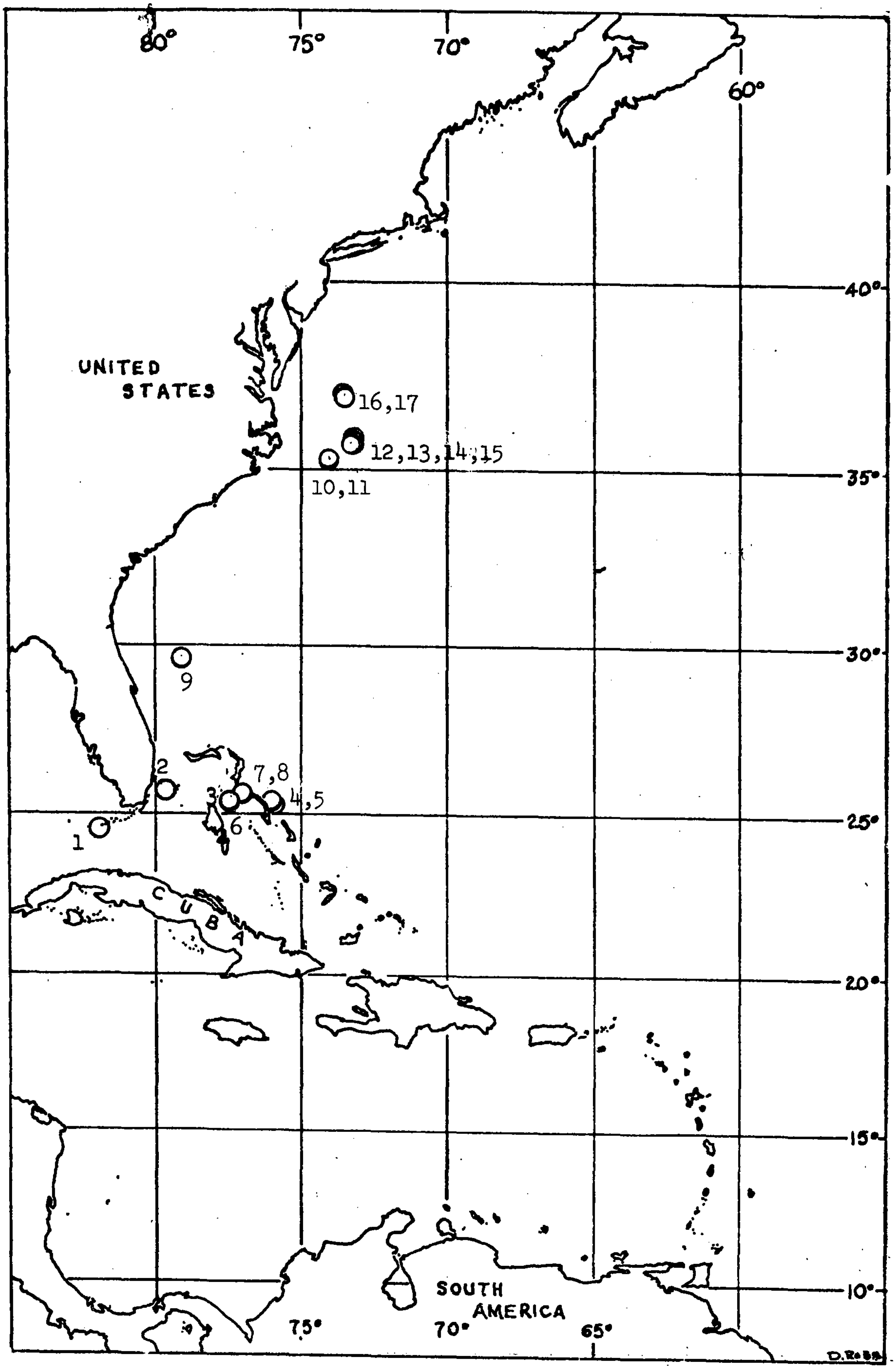

Fig. 2 Marine mammal sightings. W-45. See Table 7.

Table 7 <u>Marine Mammals Sighted During W-45</u>

Obs #	Common Name	Scientific Name	I.D./1	#	Date	Time	Location
1	(dolphin)	---	-	1	04/12	0240-0800	(mooring basin Key West)
2	Sperm whale	*Physetes catadon*	2	1	04/14	0845	26°26'N 79°20'W
3	Saddleback dolphin	*Delphinus delphis*	2	(14)	04/17	1115	25°14'N 77°27'W
4	Pilot whale	*Globicephala macrorhynchus*	3	(8)	04/18	1300	25°26'N 76°17'W
5	(dolphins)	---	-	(20)	04/18	1225	25°28'N 76°17'W
6	(dolphins)	---	-	(13)	04/30	0720	25°15'N 77°10'W
7	(dolphins)	---	-	(11)	05/02	0830	25°45'N 77°30'W
8	Pigmy killerwhale	*Feresa attenuata*	3	1	05/02	0830	25°45'N 77°30'W
9	Atlantic bottlenosed dolphins	*Tursiops truncatus*	3	5	05/04	0900	29°55'N 79°07'W
10	(dolphins)	---	-	25	05/08	1600	35°35'N 73°50'W
11	Spinnery dolphin	*Stenella longirostris*	3	30-60	05/08	1645	35°37'N 73°47'W
12	Atlantic bottlenosed dolphin	*Tursiops truncata*	3	5	05/08	1927	36°11'N 73°20'W
13	(dolphins)	---	-	-	05/09	0515	36°20'N 73°27'W
14	Saddleback dolphin	*Delphinus delphis*	3	(6)	05/09	0700	36°26'N 73°28'W
15	Saddleback dolphin	*Delphinus delphis*	3	(14)	05/09	0745-0930	36°30'N 73°28'W
16	Saddleback dolphin	*Delphinus delphis*	3	(25)	05/09	1830	37°00'N 73°30'W
17	(dolphins)	---	-	-	05/10	0230	37°18'N 73°35'W

1/ 1=authoritative identification; 2=likely identification; 3=possible identification.

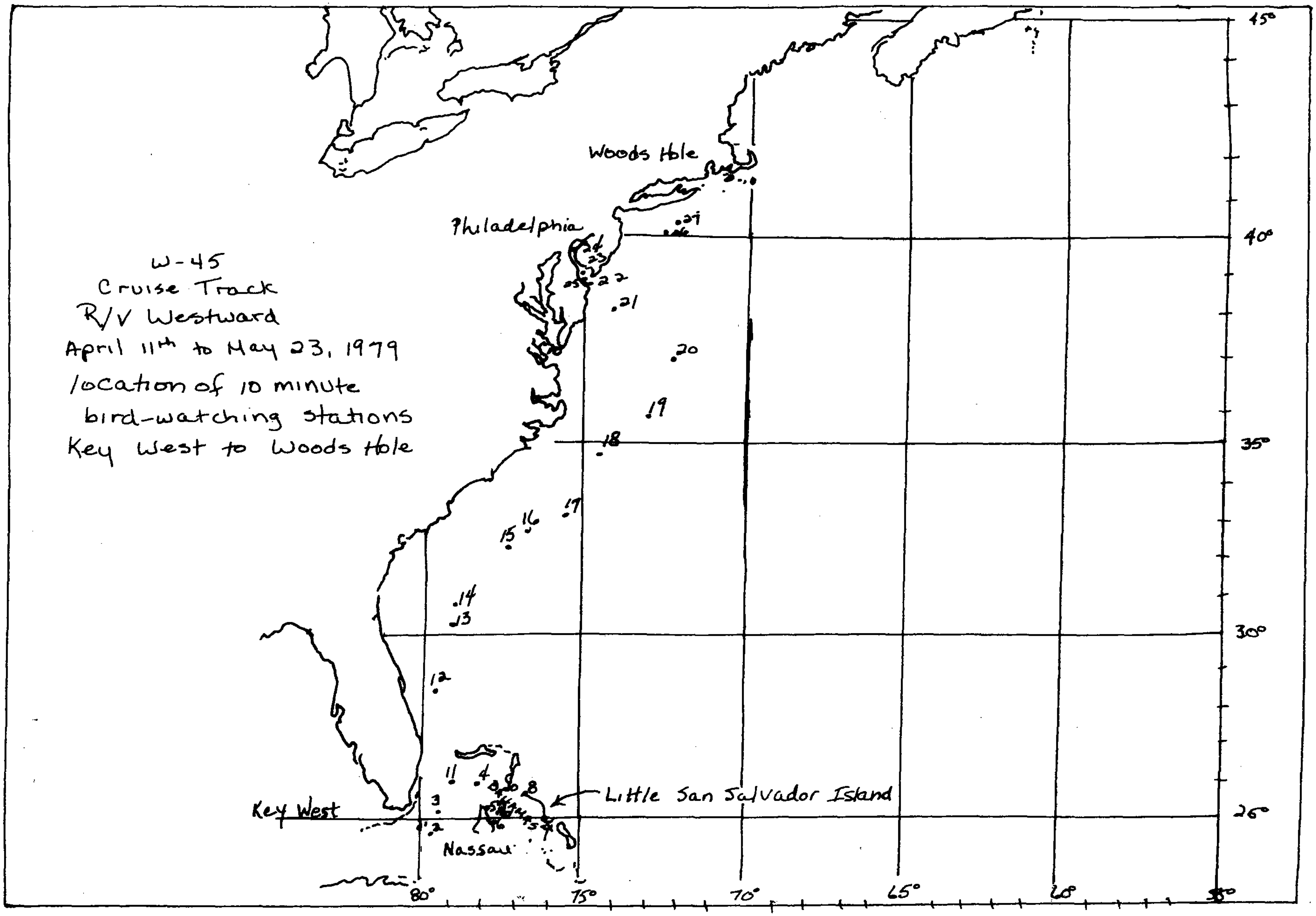

Fig. 3 Locations of high seas 10-minute bird watching stations on W-45. (see Table 8)

Table 8 Birds sighted on the high seas during 10-minute bird watching stations on W-45 (see Fig. 3).

Number	Date	Time	Sightings
1.	4/13/79	1650-1700	2 Noddy Terns
2.	4/13/79	1810-1820	no birds observed
3.	4/14/79	1105-1115	no birds observed
4.	4/15/79	0805-0815	5 Laughing Gulls
			1 Noddy Tern
5.	4/15/79	1705-1715	4 Laughing Gulls
6.	4/17/79	1200-1210	no birds observed
7.	4/17/79	1345-1355	2 Parasitic Jaegers
			2 Laughing Gulls
8.	4/28/79	1535-1545	20 Sooty Terns
9.	4/30/79	1215-1225	no birds observed
10.	4/30/79	1825-1835	1 Wilson's Petrel
11.	5/2/79	1930-1940	no birds observed
12.	5/3/79	1130-1140	no birds observed
13.	5/4/79	1130-1140	1 Warbling Vireo
14.	5/4/79	1700-1710	2 Herring Gulls
15.	5/5/79	1545-1555	1 Audubon Shearwater
16.	5/5/79	1800-1820	1 Cattle Egret
			1 Yellow Throat Warbler
			1 Palm Warbler
			(all landed on board)
17.	5/6/79	1240-1250	2 Wilson's Petrels
18.	5/7/79	1645-1655	1 Greater Shearwater
			1 Wilson's Petrel
19.	5/8/79	1325-1335	no birds observed
20.	5/9/79	1250-1300	no birds observed
21.	5/10/79	1330-1340	1 Herring Gull

Number	Date	Time	Sightings
22.	5/11/79	1215-1225	1 Barn Swallow
			1 Mourning Warbler
23.	5/10/79	1500-1515	1 Scarlet Tanager
			1 Magnolia Warbler
			3 Herring Gulls
24.	5/13/79	1915-1925	1 Herring Gull
			30-40 Cormorants
25.	5/19/79	1315-1325	7 Herring Gulls
			3 Common Terns
26.	5/20/79	1120-1130	20-30 Fulmars
			1 Parasitic Jaeger
			1 Greater Shearwater
27.	5/21/79	0920-0930	3 Fulmars
			1 Sooty Shearwater

Table 9 Sightings of birds on th high seas on W-45 (Johnson).

Common Loon	Skua
Sooty Shearwater	Herring Gull
Audubon's Shearwater	Laughing Gull
Greater Shearwater	Common Tern
Fulmar	Noddy Tern
Leach's Petrel	Sooty Tern
Wilson's Petrel	Bridled Tern
Blue-Faced Booby	Barn Swallow
Double-Crested Cormorant	Warbling Vireo
Cattle Egret	Pine Warbler
Canada Goose	Yellow Throat
Parasitic Jaeger	Magnolia Warbler
Scarlet Tanager	Swamp Sparrow

BIRDS WHICH LANDED ABOARD WESTWARD

1 Audubon Shearwater

2 Cape May Warblers

2 Yellow Throat Warblers

1 Palm Warbler

1 Magnolia Warbler

1 Warbling Vireo

4 Barn Swallows

1 Scarlet Tanager

1 Cattle Egret

Table 10 Bird Sightings Aboard R.V.Westward, May 20 to May 22,1979
during intensive bird watching (Moir).

Date	Time	Species	Number	Location	Wind Direction	and Force
5/20	915	greater shearwater	1	39°38'N 73°23'W	NE	3
	930	d.c. cormorant	1	39°39'N 73°22'W	NE	3
	1330	wilson's petrel	2	39°51'N 73°01'	ENE	3
	1330	fulmar	4	39°51'N 73°01'W	ENE	3
	1630	fulmar	20+	40°01'N 72°47'W	ENE	3
		gulls	12			
	1630	wilson's petrel	1	40°01'N 72°47'W	ENE	3
	1700	greater shearwater	1	40°02'N 72°46'W	ENE	3
	1715	sooty shearwater	1	40°02'N 72°45'W	ENE	3
	1725	jaegar	1	40°03'N 72°44'W	ENE	3
	1800	fulmars	3	40°03'N 72°43'W	ENE	3
5/21	0810	fulmar	1	40°05'N 72°08'W	NE	2
	0835	petrel	1	40°05'N 72°09'W	NE	2
	0945	petrel	1	40°06'N 72°11'W	NNE	1
	0950	herring gull	1	40°06'N 72°11'W	NNE	1
	1005	fulmar	2	40°07'N 72°13'W	calm	-
	1210	fulmar	1	40°07'N 72°17'W	calm	-
	1310	fulmar	1	40°09'N 72°18'W	calm	-
	1415	fulmar	1	40°10'N 72°19'W	calm	-
	1945	skua	1	40°35'N 71°52'W	WSW	1
5/22	0450	gannet	1	41°07'N 71°16'W	W	2
	0455	loon	1	41°07'N 71°16'W	W	2
	0520	yellow throat warbler	1	41°07'N 71°13'W	W	2
	0600	gannets	3	41°10'N 71°11'W	NW	2
	0613	black backed gull	1	41°11'N 71°10'W	NW	2
	0640	red breasted merganser	6	41°12'N 71°08'W	NW	1
	1000	phalaropes	12	41°21'N 70°58'W	NW	1
	1305	d.c. cormorant	3	41°26'N 70°48'W	calm	-

Turtle Sightings

Robert Visnick

Westward cruises often go by without a single turtle sighting, but 3 were made on W-45 (Table 11). The Ridley turtle sighted at Little San Salvador Island was about 50 m. offshore in shallow water and snorklers were able to view it quite closely. The Loggerhead sighted on April 30, while the ship was on station, stayed close alongside for more than 20 minutes.

Table 11 Turtles observed on W-45

Date	Time	Species	Number	Position
04/12	0955	Loggerhead	1-2	off Key West
04/22	0800	Ridley	1	West Bay, Little San Salvador Island
04/30	2225-2245	Loggerhead	1	25°22.1N 77°12.2W

Neuston Studies

The neuston, or "surface dwellers," is a category of plankton which has received attention only for the past 15-20 years. Since the air-sea interface tends to concentrate certain pollutants the neuston has recently been regarded as a potential "early warning system" for environmental degradation. The air-sea interface also represents an environment with special properties and is of considerable interest in itself.

For more than two years *Westward* cruises have routinely conducted neuston sampling and certain shipboard analysis of the catch. On W-45 we had the opportunity to sample an area of the Western North Atlantic from which we have relatively few previous measurements. All samples were examined for *Sargassum* weed, pelagic tar balls, the marine insect *Halobates* and blades of the angiosperms *Syringodium* and *Thalassia* (Table 12 ; Fig. 4).

Pelagic Tar

Tar balls are believed to originate from crude oil lost during tanker washings (Butler *et al*. 1973. Bermuda Biol. Sta. Spec. Pub. 10) and have a lifetime at sea of from several months to several years. Their distribution would reflect tanker activity, movement by marine and atmospheric processes and deterioration of the tar.

As usual, on W-45 we observed great variability in the tar catch ($\bar{x}$ = 1.1mg/M^2; S.D. = 1.4). Regardless, the mean and range are lower than those for tows in the Sargasso Sea from W-36 ($\bar{x}$ = 11.4) and W-42 ($\bar{x}$ = 3.5) and may justify the statement that tar concentrations are lower in the Gulf Stream than in the Sargasso Sea.

Sargassum Weed

Sargassum weed is of interest to us in connection with an ongoing study on trophic dynamics in the community associated with this drifting brown seaweed.

Table 12 Summary of W-45 Neuston Tow Results /1

Tow #	Date	Time	Position (N&W)		Tarballs mg m^{-2}	Sargassum /2 mg m^{-2}	Halobates $10^3 Km^{-2}$	Thalassia /2 mg m^{-2}	Syringodium /2 mg m^{-2}
1	05/01	1954	25 15	77 10	0	6.9	0.6	10.4	109
2	05/02	1135	25 58	77 49	0	82.9	0	26.2	351
3	05/02	2030	26 06	78 08	–	–	–	–	–
4	05/03	1135	30 08	79 03	1.9	723	–	–	–
5	05/04	2000	30 35	79 20	3.0	4,520	1.9	0	–
6	05/05	1135	31 58	77 44	3.2	217	1.9	0	0
7	05/05	2003	32 27	76 51	0	7.8	8.4	0	0
8	05/06	1115	33 16	75 53	–	–	–	–	–
9	05/06	1949	33 56	75 41	0.6	1,840	0	0	0
10	05/09	2000	37 00	73 30	0	0	0	0	0
				mean	1.1	850	1.8	–	–
				standard deviation	1.4	1,608	3.0	–	–
				range	3.2	4,520	8.4	26.2	351

1/ Quantities calculated on the basis of 1544m^2 filtered (=2.5 kts for 20 min.)

2/ Wet weight

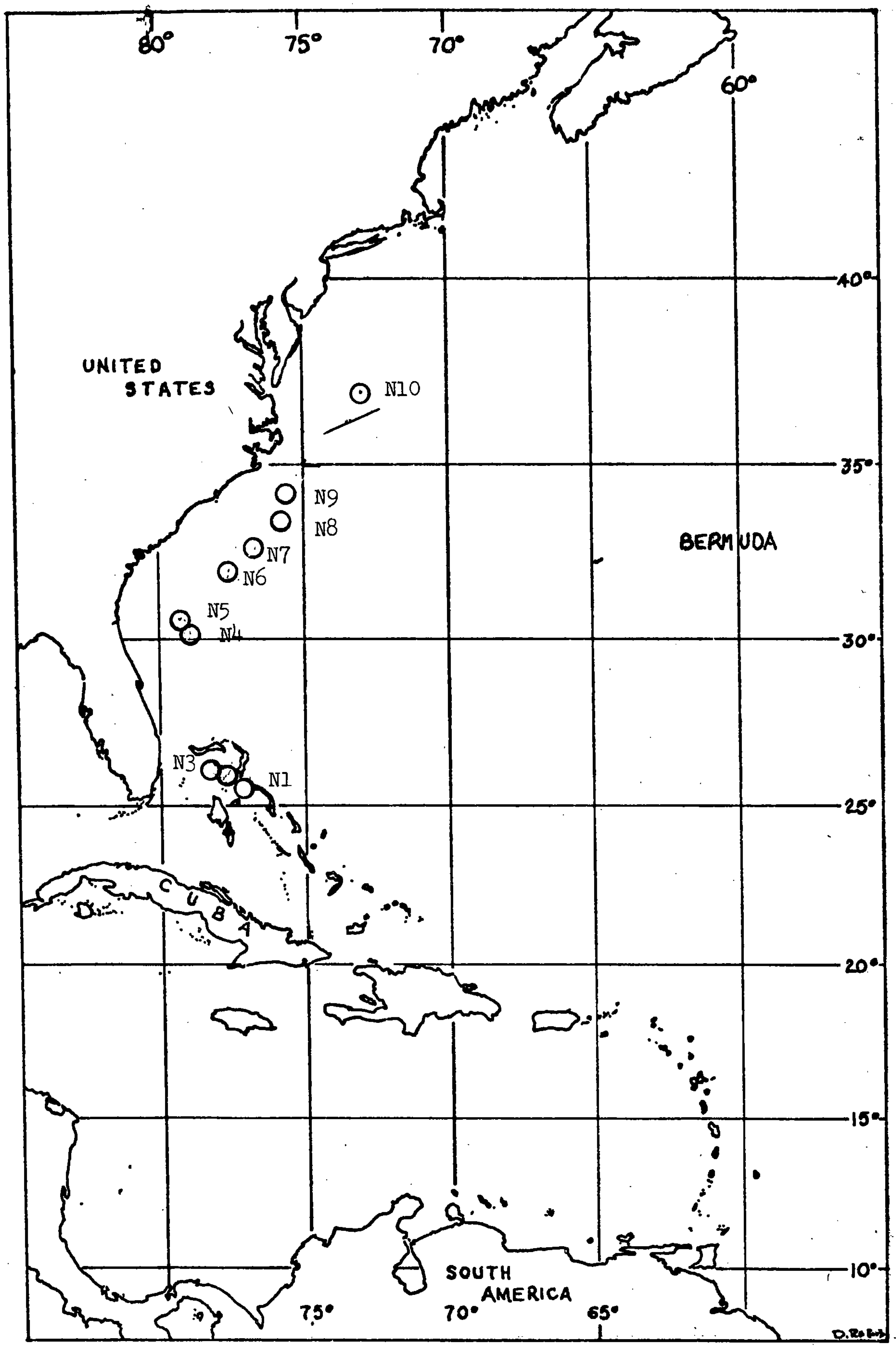

Fig. 4 Neuston tows taken on W-45. The north wall of the Gulf Stream was crossed at about 37N, 73W.

Considering only the nine stations within the Gulf Stream or Sargasso Sea, the mean standing crop is 0.944 mg wet weight/M^2 (= 0.142 mg dry weight/M^2 using the conversion factor of Robinson, 1978). This is more than an order of magnitude greater than our values for the Sargasso Sea and Caribbean (W-36, W-42, W-44) and is comparable with the value given for the Gulf Stream in the classical paper by Parr (1939).

From observations on W-45, including numerous entries in the log of massive windrows of Sargassum it can be stated that, relative to the Sargasso Sea, Sargassum weed was very abundant in the Gulf Stream, the Northwest and Northeast Providence Channels and along the east side of Eleuthera.

Halobates

Halobates micans, a marine water strider, is almost unique among insects in that it carries out its life cycle entirely at sea. The mean abundance for W-45 was 1,800/Km^2 versus 8,500 and 3,900/Km^2 for W-42 and W-36 in the central Sargasso Sea, which numbers are not different on the basis of normal statistics.

Thalassia and Syringodium

The export of marsh grasses to temperate estuarine and coastal waters is well known. During recent cruises we have become aware that blades of tropical marine grasses may also be abundant at the surface near islands or in coastal continental waters. On W-45 we measured both Thalassia and Syringodium in neuston samples from Tongue of the Ocean and Northwest Providence Channel.

Sargassum Community Studies

Drifting Sargassum seaweed is a sometimes conspicuous primary producer in the North Atlantic gyre. The brown algae reproduces vegetatively and can support a highly diverse assemblage of organisms known as the Sargassum community. For several cruises we have been examining the trophic structure of this "displaced benthic community," as it has been referred to.

Primary Productivity

Primary productivity was determined using the light-dark bottle oxygen change method . Branch tips (ca.1 g. wet weight) from a freshly collected Sargassum natans clump were added to 6 replicate light and 6 replicate dark B.O.D. bottles. Initial oxygen levels were determined to within 1% by replicate titrations of quadruplicate initial samples. The bottles were incubated at ambient seawater temperature in a seawater bath on the deck. Incident light was measured periodically during the incubation using a Kahlisco irradiometer.

After the incubation, Sargassum tips were removed and placed in numbered recepticals for weighing (±10%, determined in a water balance) and the oxygen samples were fixed immediately. No attempt was made to remove epiphytes or epizooites from the Sargassum although actively growing tips which are relatively uncolonized (except by hydroids) were selected. Thus, the values obtained from these measurements include an unknown component associated with the attached biota. Branch tips used typically averaged 36 "leaves" (14-61) and 19 floats (13-26).

The results of determinations on 3 days (Table 13) show averages for net productivity of + 0.272 ml O_2/gSargassum/hr; for respiration of -0.112 ml O_2/gSargassum/hr; and for gross productivity of 0.384 ml O_2/gSargassum/hr, expressed on a wet weight basis.

Differences among determinations on the three days probably result from differences inherent to the plants used, rather than to temperature or light variation within the range we observed.

Our values agree reasonably well with those of former cruises using identical methods (Table 14) but are high compared with measurements of Carpenter and Cox (1974).

Table 13 Results of Sargassum Productivity Measurements. W-45, Gulf Stream Samples

	1	2	3
Net productivity			
(mlO_2/g/hr) 1/	0.205{±0.040}	-0.401{±0.036}	0.211{±0.030}
(mgC/g/hr)	2.54	5.01	2.61
Respiration 2/			
(mlO_2/g/hr)	-0.100{±0.020}	-0.105{±0.013}	-0.131{±0.028}
(mgC/g/hr)	1.24	1.30	1.62
Gross productivity			
(mlO_2/g/hr)	0.305	0.506	0.342
(mgC/g/hr)	3.78	6.27	4.23
LB incubation interval	10^{02}-13^{10}	13^{30}-17^{00}	09^{50}-14^{45}
T (°C)	26.2 ±0.8	27.3	25.0 ±1.0
Light Intensity ($10^4 \mu W cm^{-2}$)	7.2 ±2.7	3.4 ±3.0	6.2 ±2.0
Date	05/04/79	05/05/79	05/07/79
Position	30°07N 79°03W	33°29N 75°47W	34°44N, 73°53W
Weight of experimental material (g)	0.69 ±0.28	1.0 ±0.21	0.53 ±0.09

1/ expressed on a wet weight basis

2/ expressed on a dry weight basis
(D.W. = 0.15 W.W.; Robinson 1978)
$mgC = mlO_2 \times (\frac{32}{22.4})(1.3 mgC/mMC) = mlO_2 \times 1.86$

Table 14 Productivity values for *Sargassum*

	Net Productivity mlO_2/gd.w./hr.	Respiration mlO_2/gd.w./hr.	Gross Productivity mlO_2/gd.w./hr.
This report	.205	-0.100	0.305
	.401	-0.105	0.506
	.211	-0.131	0.342
Robinson, 1978 (W-36) 1/	.158	-0.066	0.226
Wilson, 1978 (W-42)	-	-0.330	-
	-	-0.270	-
Welsh, 1977 (W-33)	.069	-0.138	0.207
	.095	-0.074	0.169
	.081	-0.056	0.137
Carpenter and Cox, 1974 1/	.034	-0.015	0.055

1/ Values given are mean of several determinations.

Species Diversity of the *Sargassum* Community

On May 7 an extensive "windrow" of *Sargassum* was sighted. The accumulation consisted of a chain of rafts approximately 5-10 meters wide and extending many miles in length -- *Westward*'s course paralleled it for nearly 20 miles. The accumulation included *Physalia* and other floating items as well.

At 35°15'N, 74°53'W we hove to and divers brought a raft measuring *ca* 70 m^2 aboard ship in nets and buckets. Invertebrates were removed and identified and a species roster is being compiled by Ms. Abby Ames. Preliminary determinations of diversity ($D = \frac{S-1}{\log N}$) give a value of 18 (N = 930; S = 55) which is far higher than the diversity of a south central Sargasso Sea raft examined on W-36 (D = 1.8) in which 4 decapods (2 crab species and 2 shrimps) and one hydroid made up the community.

LITTLE SAN SALVADOR ISLAND STUDIES

INTRODUCTION

Little San Salvador Island is an uninhabited and undeveloped private island in the Bahamas (Figs. 5, 6). The Westward is only one of the very many vessels which have stopped there regularly over the years, although the island is otherwise virtually inaccessible. The idea for this study arose during a stop in 1977 when it became obvious that the island represented a litte-disturbed complex of tropical environments within a geographically small area, that presented unique educational and scientific opportunities.

The work proposed for W-45 (Appendix C) followed discussions with the island owners, the Bahamian Government and the Bahamas National Trust. The island owners' interest in the aquaculture potential of the queen conch in the Lagoon served to focus a portion of our work and led to our designation of the cruise, the "Strombus Expedition," in honor of this gentle, noble beast (*Strombus gigas*).

The trip was a logistically complex one. With the visiting scientists it involved more people than Westward is certified to carry and, therefore, establishment of a shore camp, ancillary means of transportation and field laboratory facilities. Westward's two dories would not be sufficient for the Lagoon studies. The work would need to mesh with the other education program conducted aboard ship and, finally, it had to be conducted within the normal operating budget.

We never lost sight of the fact that weather could wreak havoc with our plans. It plagued Agassiz' Bahamas work on Wild Duck in 1893 and disrupted the Bahamas Expedition of 1905 on Van Name, a 100-ton schooner; in fact, weather remains an important factor in the operation of much larger modern oceanographic vessels. On the Strombus Expedition bad weather drove us to our last contingency plans.

The success in our island work very much depended upon a remarkable group of students who rose to the occasion.

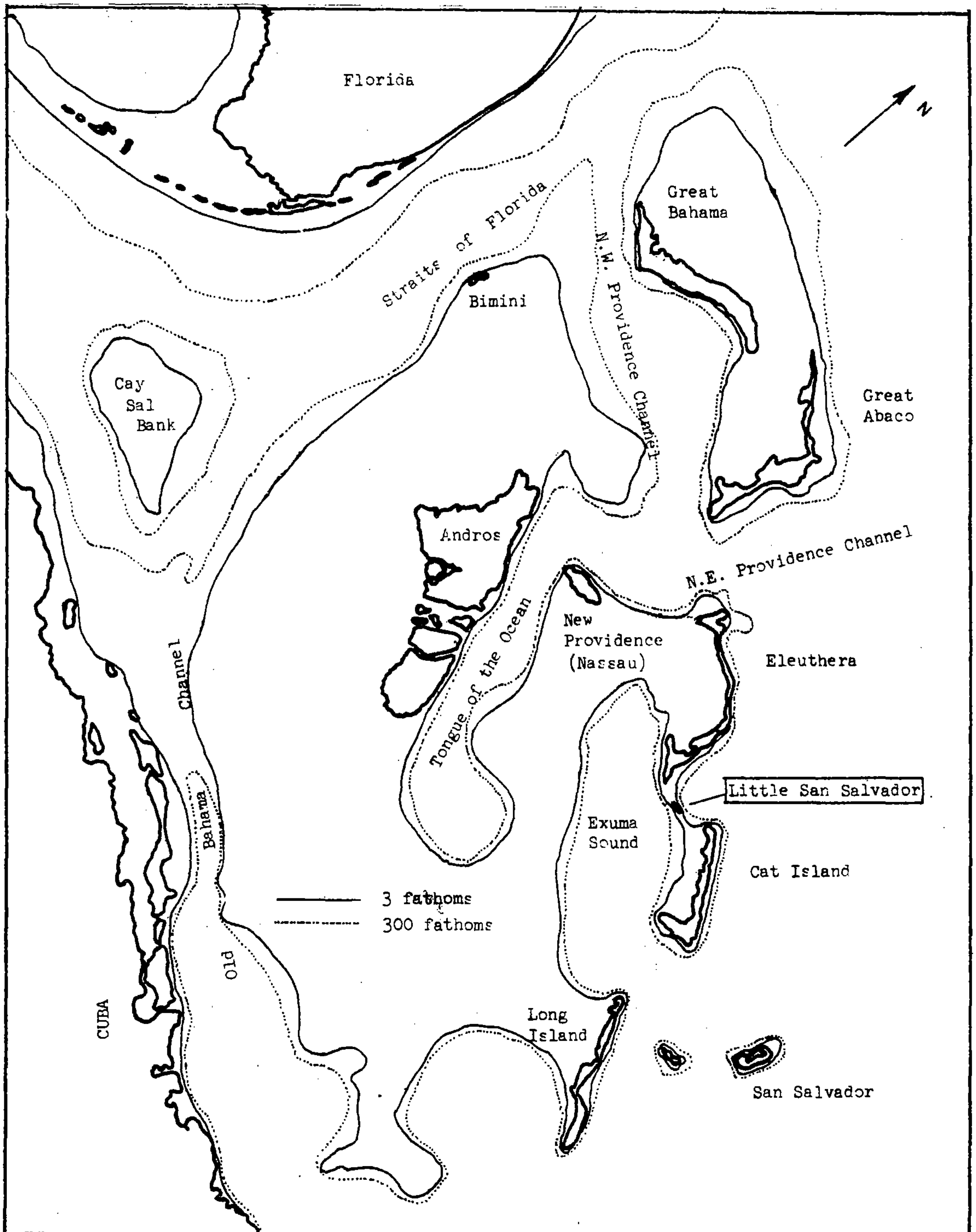

Fig. 5. The Northern Bahamas

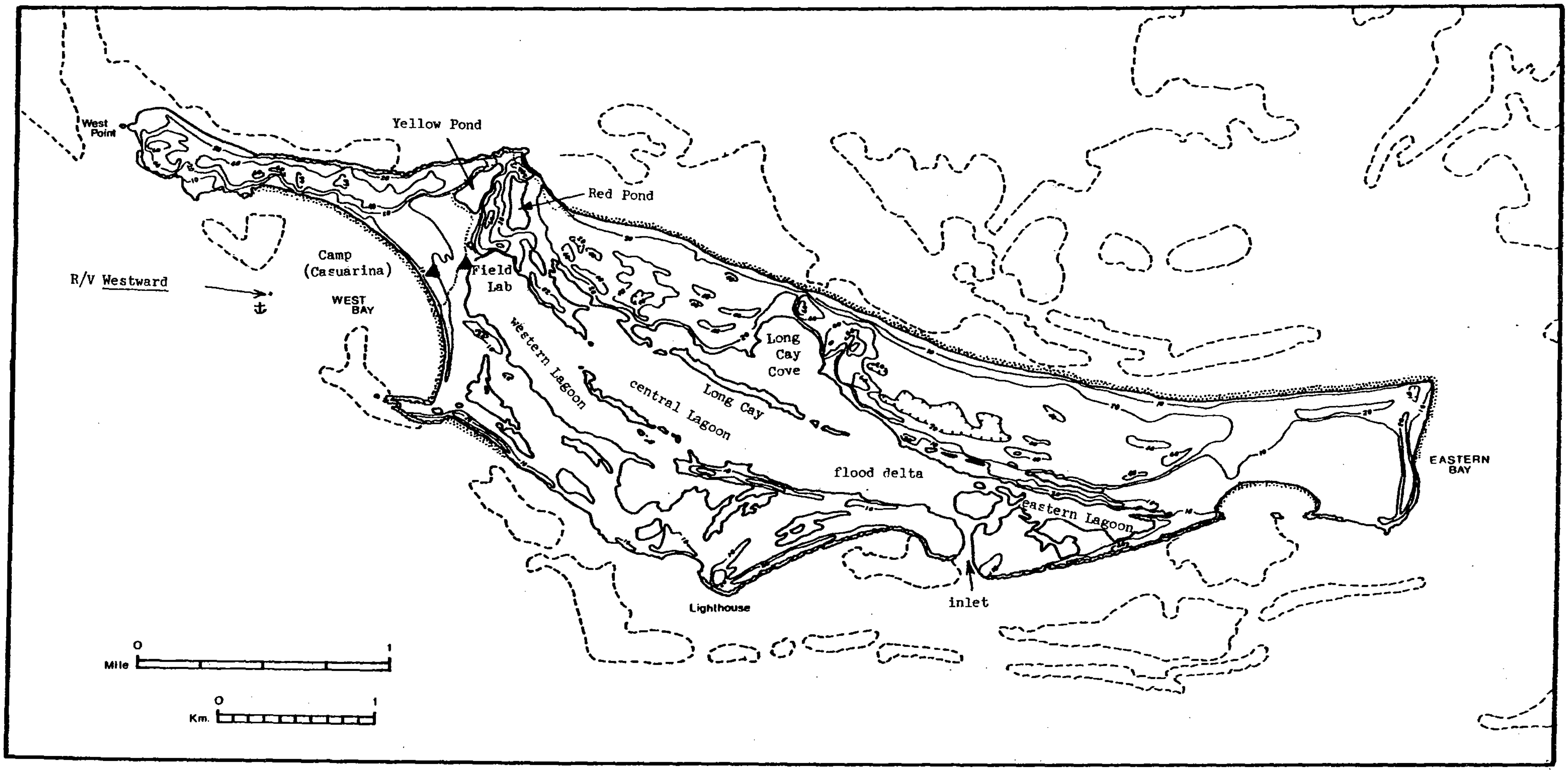

Fig. 6. Little San Salvador Island. Place names are those used in this report.

TERRESTRIAL STUDIES

Geology

Arthur Gaines

The essential ideas behind the geology of the Bahamas islands, per se, were spelled out by A. Agassiz (1893).[1/] He recognized that, a) above sea level these calcareous islands have an aeolian origin; b) they have been modified by marine erosion; and, c) they have, within geologically recent times, been influenced by a sea level change of 300 ft.

Many of the comments of Shattuck (1905) [2/] apply specifically to the geology of Little San Salvador Island:

> Dunes occur with great frequency along the sea-shores, where the winds have an opportunity to blow the calcareous sand up into heaps dazzling in the sunlight. These bear the characteristic vegetation and consolidate rapidly into soft rock, so that the tendency is to grow in height rather than to migrate inland. These dunes are distributed generally throughout the archipelago, but perhaps they are well developed as anywhere along the eastern side of Eleuthera fronting the ocean. There appears to be no very well defined line of separation between those half consolidated dunes, and the ridges of hard rock. Both have the same origin, as well as a similar topography, and one passes into the other with insensible gradations. The oldest dunes are hard rock, while the youngest are loose sand, and there is every intermediate stage. These ridges cross the islands in ranks like the dunes, and where an island has suffered severely from erosion, are frequently the only remaining features to mark the once more continuous land surface. The highest of these ridges are met within Cat Island, where they rise to about 400 feet, but this is uncommon. They are usually low, rolling hills, scarcely high enough to break the monotony of the landscape.

Dunes of varying ages and lithification form Little San Salvador Island. Currently active ones show an orientation that reflects prevailing winds, exposure to waves and the geometry of existing resistant headlands. The older ridges, now removed from a sand supply, show a different orientation that presumably relates to conditions of an earlier time. The orientation of older dunes appears to strike NW to SE along a curving axis (Fig. 7) and

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1/ Agassiz, A. 1893. Observations on the West Indies Am. J. Sci. 45:358-362.

2/ Shattuck, G.B. 1905. The Bahamas Islands. p 12. The Geographical Society of Baltimore. Macmillan, London. 630 pp.

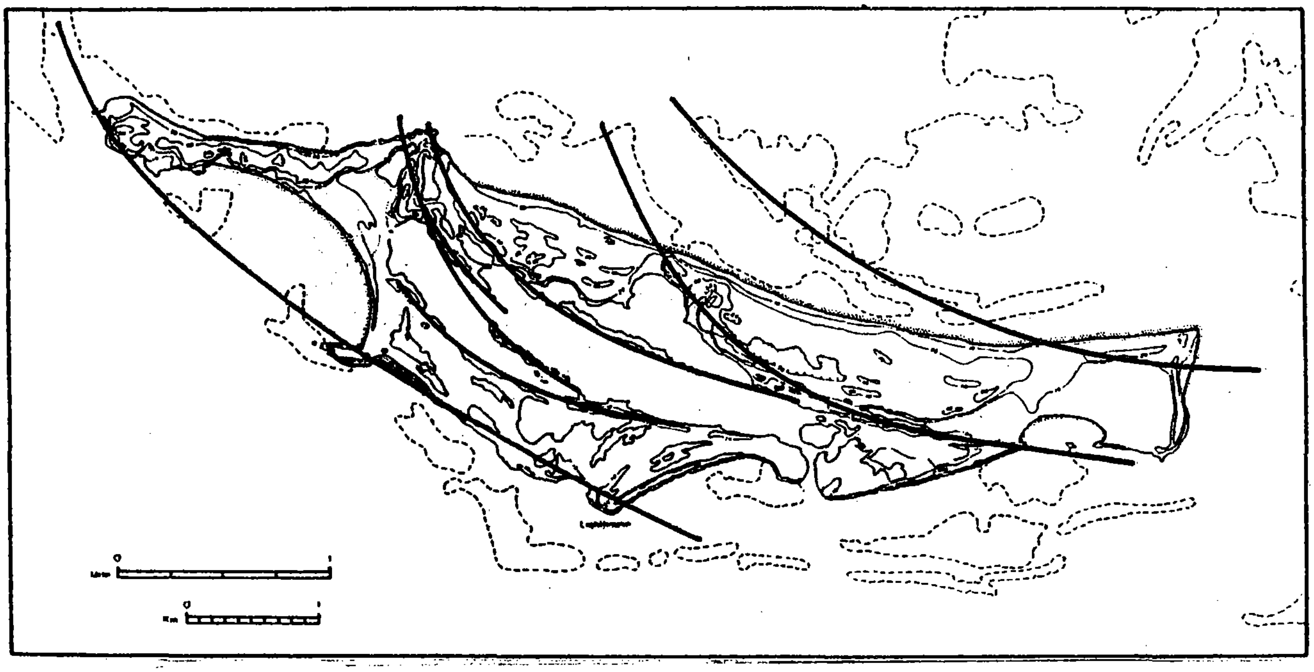


Fig. 7   Possible orientation of ancient dune ridges on
Little San Salvador Island.

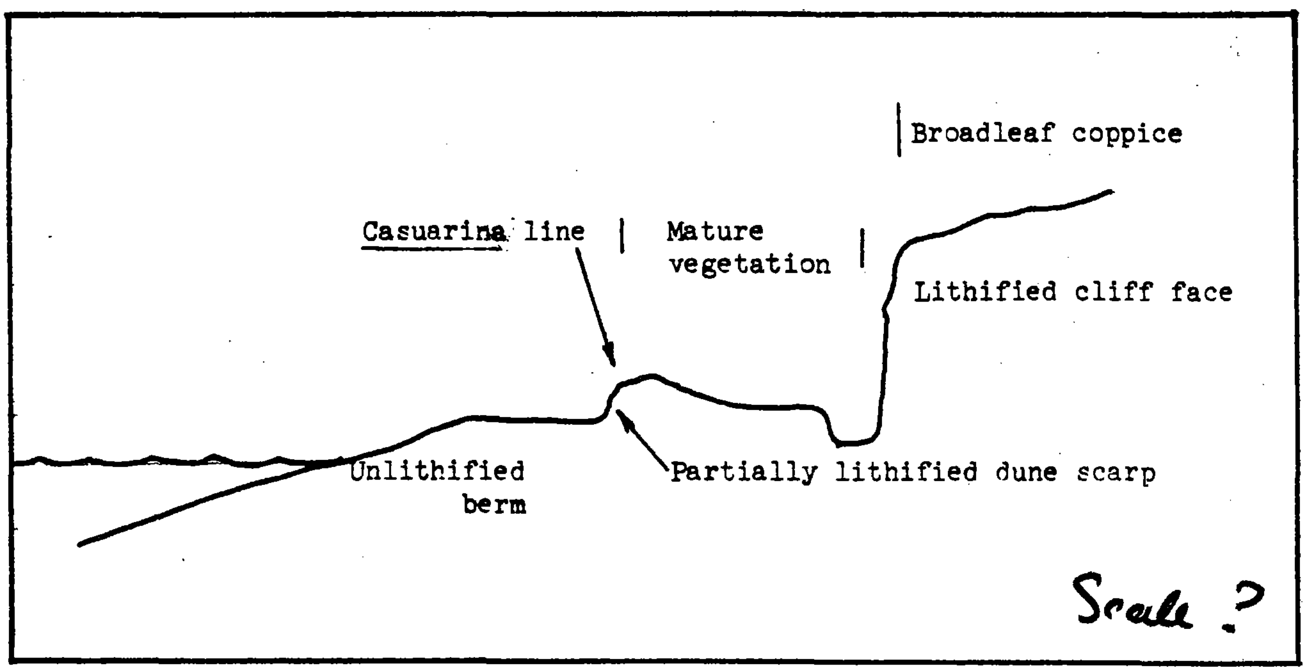


Fig. 8   The typical shore profile along the eastern section
of the north shore of Little San Salvador Island.

is most conspicuous where the drowned dune ridges or their remnants diagonally cross the lagoon. This pattern may also be reflected in the orientation of "reefs" off the northern shore, the implication being that these reefs follow older dune ridges. Dunes, beach ridges and vegetative (mangrove) bands of younger age intersect these old ridges dramatically along the south shore and elsewhere. At some locations younger dune formations unconformably overlie older ones, such as at the lighthouse point, or north of Yellow Pond where dune formation is active.

The lithification of calcereous aeolian sands is represented in many stages at Little San Salvador. On West Bay beach a very new and presumably abiotic lithification process produces distinct bedding crusts in the dune scarp. North of Yellow Pond initial stages of cementation seem to accompany colonization by lichens (see Gillham, this report) followed by production of a nearly identical spotted gray rock which lacks the lichen. It is easily crushed by hand and shown to consist of a thin crust binding dune sand. The next stage is a darker, sometimes pitted, more resistant rock which can be broken but with greater difficulty, to reveal a loosely cemented dune sand interior. This rock characterizes "dunes" with modern orientation at many places on the island shore that connect older, more resistant headlands. Since the lithification process appears to proceed from the surface downward, dunes which are subjected to laterial erosion by the sea sometimes become hollow as the uncemented interior is easily washed out. This is conspicuous at the lighthouse point.

Beach deposits along the north shore are interrupted along a section north of the hypersaline ponds, where dramatic cliffs drop into the surf, dividing the windward beach into a western section lying on West Point and an eastern section comprised of 3-1/2 miles of breathtaking beauty, diminished only by the abundance of tar distributed along its length. The profile of the eastern beach for at least half its length has a characteristic form that presumably reflects deposits of increasing age landward (Fig. 8).

In three places there is evidence of breaching of the north coast by storm waves. Two of these are "passes" of less than 10 ft. elevation leading to the large hypersaline ponds, Red Pond and Yellow Pond (discussed by Gaines and by Pratt, this report) which show evidence of episodic flooding by seawater. The third location, near the center of the north shore is presently a prominent gap, which lies between old dune ridges, blocked by a partially lithified dune of perhaps 25 ft. elevation (Fig. 6).

Judging from oblique aerial photos 1/ and field inspection it appears that most sediments entering the Lagoon may have come through this breach, presumably during severe storms. It is well documented that a dune ridge of 25 feet is easily demolished by waves accompanying hurrican force winds. // Why?

The existing inlet to the Lagoon represents a dynamic environment (discussed in this report by Pratt and by Gentile, among others). As would be expected the shallowest depths here occur immediately offshore and immediately within the Lagoon in the flood delta. The gut itself is 1.4 meters maximum depth at low water (see Silverstein, this report).

Along the east shore of the inlet, formations of marine sedimentary rocks are exposed near sea level underlying the aeolian ridge which directly faces the ocean. These formations contain broken fossils of mollusks which according to Dall (1905) 2/ are now found living. Shells of Strombus gigas were conspicuous in this regard. An overlying, possibly marine, unit lacked identifiable fossil remains.

1/ Provided by Mr. L. Brown, Nassau

2/ Baltimore Geographical Society, op cit.

In 1883 Agassiz wrote that sea level change "explains satisfactorily the cause of the present configuration of the Bahamas but teaches us nothing in regard to the substration upon which the Bahamas were built." 1/ With regard to the origin of the Bahamas platform, Emery and Uchupi (1972) state, "Less is known about the origin of the Bahama Banks than about any other comparably large area of the Atlantic margin of North America." 2/ Such salient aspects as the convolute outline of the banks, with their deep indentations; the steep escarpments with evident relation to the Blake Escarpment; and a carbonate section in excess of 10 km thick, have no agreed upon explanation.

1/ Agassiz, op cit. pp 358-362

2/ Emery, K. O. and E. Uchupi 1972. Western North Atlantic Ocean. p 204. Memoir 17. Amer. Assoc. Pet. Geol. Tulsa. 532pp

Vegetation

Grace Hornor

Abstract

In 1972 vegetation on Little San Salvador Island was mapped as 4 floral zones at a scale of 1:25,000 on the basis of aerial photos. 1/ The purpose of my study was to taxonomically characterize the dominant flora of these assemblages and, where possible, to improve upon the map by field inspections.

Correll considers 10 ecological groups appropriate to distinguish major Bahamian habitats. Some of these represent ecotones which could not be mapped at 1:25,000 scale, while others represent subdivisions of units mapped in 1972. On Little San Salvador Correll's "Tidal Flats and Salt Marshlands" and his "Mangrove Community" are mapped as "Permanent Marsh." Still other divisions, e.g. "Pinelands," are missing from the island entirely.

Any attempt to group the more than 1000 plant species in the Bahamas (or doubtless, several hundred on the island) will not be free of difficulties.

1/ Cat Island and Little San Salvador Island. Sheet 1. BLS Series 318 Edition 1, Scale 1:25,000. Lands and Surveys Department, Nassau, Bahamas 1972.

Birds

Barbara Johnson

Abstract

A survey of birds was made between April 19 and April 25, 1979 using the method of ten-minute stations (Table 15 ; Fig. 9) augmented by routine identification of all birds spotted (Table 16 ; Fig. 9). In all, 47 species are regarded as positively identified. The most abundant birds on the island are the Bahama Bananaquit, the Bahama Mockingbird and the White Crowned pigeon.

"Bird-nip?"

Barbara Johnson

Agave americana is a flowering succulent plant found along the north shore of Little San Salvador Island. From its thick broad-leaved base grows a thick center stalk which extends 20 to 30 feet in the air. At the top are located several flowering branches. Something about these branches seemed to have a curious effect on the Bahama Bananaquits (*Coereba bahamensis*) of the island.

At first observation, it appeared as though these trees were dropping fruit, or very large seeds; a closer look revealed that many of the branches were lined with Bananaquits who would seem to hurl themselves straight down from the limbs to the base of the tree. They did not appear to be flying, but almost free-falling straight down. When these birds feed, they have an unusual habit of hanging upside-down at times. From observation it appeared as though they let go of the branches on which they had been perched.

The birds' flight back up was just as odd. These creatures seemed to be flying straight up -- not at an angle to the branch as they normally fly. It was, in fact, this return flight up which initially focused the author's attention to the fact that the objects were birds, and not the fruit of the plant.

This odd behavior was noted to be occurring on several of the Agave plants along the shore during the afternoon. The most populated plant had 20-30 Bananaquits associated with it. Sometimes only 5 or 6 birds would be associated with a tree, but this strange behavior was noted only to be involving this one bird species and the branches of the flowering Agave americana. An investigation into what is causing this species to act in such an unusual manner may be in order.

Hypersaline Ponds

Arthur Gaines

The Red and Yellow ponds of approximately 10 acre size were examined briefly and found to be hypersaline and markedly different from each other. Pratt's observations on Yellow Pond are given elsewhere.

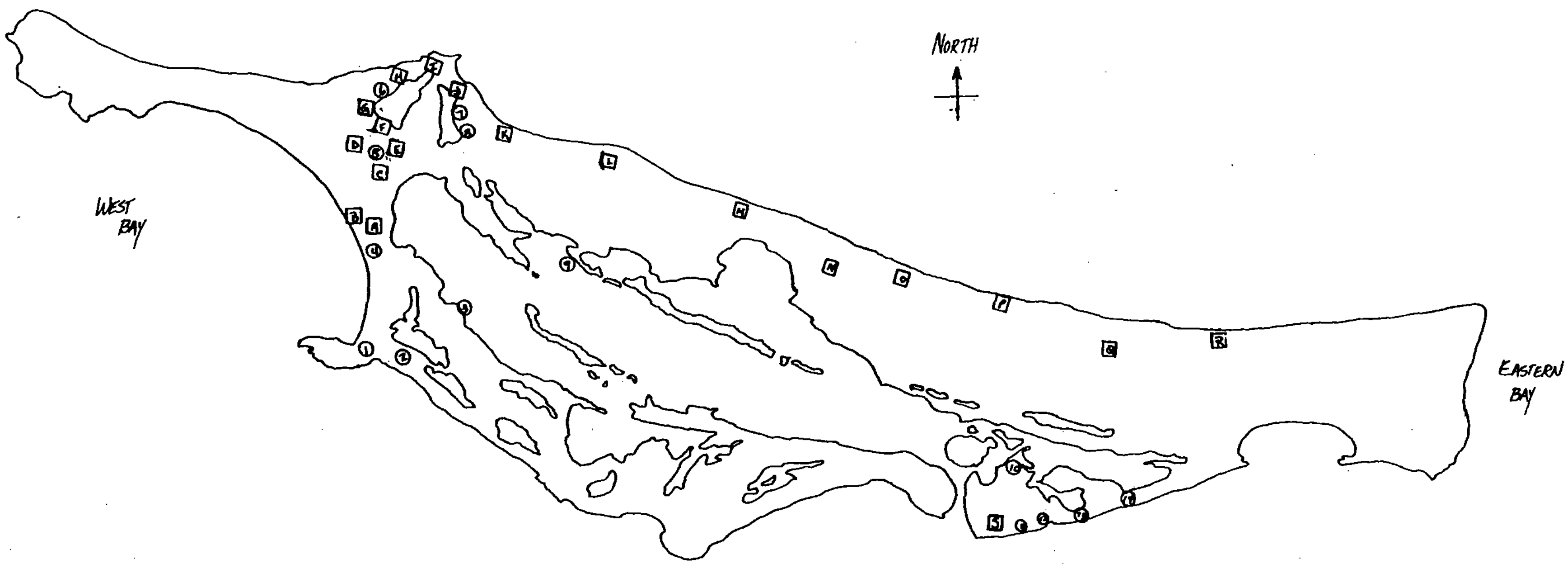
The striking color of the Red Pond results from a thin gelatinous algal mat which lines its submerged bottom (salt crust lined the emerged bottom around the margins). Preliminary observations suggest the causative agent is a coccoid blue-green alga, with minor occurrence of a filamentous blue-green alga and a diatom. Analysis of the water shows it has nearly 6x the salinity of seawater and has precipitated certain of its salts. Both silica and ammonia are present but phosphorus is low and probably limiting.

Seawater probably enters the shallow basin episodically across the narrow iron shore passage which separates it from the sea, and then concentrates through evaporation. The presence of salterns along the west shore inidcates men have attempted to manage the salt resource. Water seeping into the Pond along its shore is brackish (15-52 $^{o}/oo$) because of contamination by evaporites in the sediments. The island ground water has a salinity of 0.9 $^{o}/oo$.

Besides the algae, Red Pond appears to support a population of small flying insects and the birds and lizards which feed on them along its shore. During our visit foam was present as an accumulation along the lee shore.

Results of analyses of pond and well water from Little San Salvador April 1979.

	Salinity opt. ref. o/oo	Cl o/oo	Knudsen 1.8065xCl	Nutrients NH_4 (µM)	PO_4 (µM)	$Si(OH)_4$ (µM)	pH
Red Pond	194	120.1	216.9	2.71	0.01	13.6	8.10
Yellow Pond	95	-	-				-
West Bay	37.4	20.4	36.8	0.00	0.18-0.31	7.04	8.16
Island well	0.0	0.5	0.9	44.4	-	82.61	-



Barbara Johnson
W-45

Fig. 9 Bird sighting locations at Little San Salvador Island. · = ten minute stations. O = sightings of interest. April 1979. W-45.

Table 15 Key to Ten-minute Bird Watching Stations on Little San Salvador, April 1979 (see Fig. 9).

Station	Date	Time	Sightings
A	4/19/79	1410-1420	1 Bahama Swallow 1 Bahama Mockingbird 3 Unidentified birds
B	4/19/79	1330-1340	2 Bahama Bananaquits 1 Indigo Bunting 1 Bahama Mockingbird
C	4/21/79	0955-1005	1 Brown Thrasher 6 White Crown Pigeons 8 Ground Dove 4 Bahama Bananaquits 1 Mourning Dove 3 Unidentified birds
D	4/19/79	1515-1525	14 White Crown Pigeons 1 Unidentified bird
E	4/21/79	0905-0915	3 Unidentified birds 1 Bahama Bananaquit 1 Brown Rooster
F	4/19/79	1540-1550	3 Northern Water Thrush 10-15 Bahama Bananaquits
G	4/24/79	0755-0805	2 Black-Necked Stilts 1 Snowy Egret 2 Ruddy Turnstones
H	4/24/79	0825-0835	2 Bahama Ducks(White-checked pintail) 5 White Crowned Pigeons 2 Black-Necked Stilts 1 Bahama Mockingbird 1 Brown Thrasher
I	4/24/79	0855-0905	no birds observed
J	4/24/79	0925-0935	1 Lesser Yellowlegs 1 Clapper Rail 1 Bahama Duck 1 Ovenbird 2 Unidentified birds
K	4/24/79	1045-1055	1 Bahama Bananaquit 2 Bahama Mockingbirds 2 Osprey

Table 15 (cont.)

Station	Date	Time	Sightings
L	4/24/79	1125-1135	2 Bahama Mockingbirds 1 Unidentified bird
M	4/24/79	1215-1225	20-30 Bahama Bananaquits
N	4/24/79	1455-1505	1 Osprey 2 Unidentified birds
O	4/24/79	1300-1310	1 Bahama Mockingbird 2 Bahama Bananaquits
P	4/24/79	1330-1340	no birds observed
Q	4/24/79	1430-1440	2 White Crown Pigeons 3 Bahama Bananaquits 2 Ovenbirds
R	4/24/79	1400-1410	no birds observed
S	4/24/79	1555-1605	1 Osprey 2 Yellow-Billed Tropic Birds 1 Burrowing Owl

Table 16 Key to Bird Sightings of Interest on Little San Salvador, April 1979 (see Fig. 9)

1. Clapper Rail
2. Black and White Warbler
3. Great Blue Heron
4. Black - Faced Grassquit
5. White Crowned Pigeons
6. Black - Necked Stilts
7. Bahama Duck
8. Lesser Yellowlegs
9. Belted Kingfisher
10. Snowy Egret's Nest
11. Burrowing Owl
12. Yellow-Billed Tropic Bird
13. Osprey
14. Tropic Bird's Nest

Table 17 **Bird Species Sighted on Little San Salvador Island, Bahamas April 19-25, 1979.**

	MG	RA	BJ	Others
1. Audubon's Shearwater F: Procellariidae G: Puffinus S: griseus	X		X	
2. Wilson's Petrel F: Hydrobatidae G: Oceanites S: oceanicus oceanicus	X	X	X	
3. Yellow - Billed Tropic Bird F: Phaethonidae G: Phaëthon S: lepturus catesbyi		X	X	X
4. Man - O - War Bird F: Fregatidae G: Fregata Magnificens Rothschildi	X	X		X
5. Great Blue Heron F: Ardeidae G: Ardea S: herodias	X	X	X	X
6. Snowy Egret F: Ardeidae G: Leucophoyx S: thula thula		X	X	X
7. Reddish Egret F: Ardeidae G: Dochromanassa S: rufescens rufescens		X		
8. Green Heron F: Ardeidae G: Butorides S: virescens virescens	X			
9. White Cheeked Pintail F: Anatinae G: Anaas S: bahamensis	X	X	X	X
10. Osprey F: Pandionidae G: Pandion S: halioetus carolinensis	X	X	X	X
11. Domestic Chickens and Roosters F: Tetraonidae G: S:	X			X
12. Clapper Rail F: Rallidae G: Rallus S: longirostris	X	X	X	
13. American Oystercatcher F: Haematopodidae G: Hoematopus S: palliatus palliatus			X	X
14. Ruddy Turnstone F: Charadridae G: Arenaria S: interpres morinella	X	X	X	X
15. Killdeer F: Charadriidae G: Charadrius S: vociferus vociferus	X			
16. Willet F: Scolopacidae G: Catoptrophorus S: semipalmatus	X			
17. Lesser Yellowlegs F: Scolopacidae G: Totanus S: flavipes			X	X
18. Semipalmated Sandpiper F: Scolopacidae G: Ereunete S: pusillus	X	X	X	X
19. Black - Necked Stilt F: Recurvirostridae G: Himantopus S: mexicanus	X	X	X	X
20. Herring Gull F: Larinae G: Larus S: argentatus	X			
21. Laughing Gull F: Larinae G: Larus S: atricilla	X	X	X	X
22. Royal Tern F: Sterninae G: Thalasseus S: maximus maximus	X	X		
23. Cabot's Tern F: Sterninae G: Thalasseus S: sandvicensis acuflavidus.		X		

Key to Sighting Authorities: MG = Dr. Mary Gillham; RA = Rod Attrill; BJ = Barbara Johnson; Others = Shore Party

Table 17 (cont.)

	MG	RA	BJ	Others
24. Bridled Tern F: Sterninae G: Sterna S: anoethetus	X		X	
25. White Crowned Pigeon F: Columbidae G: Columba S: leucocephala	X	X	X	X
26. Mourning Dove F: Columbidae G: Zenaidura S: macroura	X	X	X	
27. Ground Dove F: Columbidae G: Columbigallina S: passerina passerina	X	X		
28. Zenaida Dove F: Columbidae G: Zenaida S: aurita	X	X	X	
29. Key West Quail Dove F: Columbidae G: Oreopeleia S: chrysia		X		
30. Burrowing Owl F: Tytonidae G: Speotyto S: cunicularia	X	X		X
31. Bahama Woodstar (Hummingbird) F: Trochilidae G: Calliphlox S: evelynae	X		X	X
32. Northern Water Thrush F: Turdidae G: Seiurus S: noveboracensis	X		X	
33. Bahama Mockingbird F: Mimidae G: Mimus S: gundlachi	X	X	X	X
34. Catbird F: Mimidae G: Dumetella S: carolinensis		X	X	
35. Brown Thrasher F: Mimidae G: Toxostoma S: rufum rufum			X	X
36. Black and White Warbler F: Paruludae G: Mniotilta S: varia	X	X		
37. Yellow Warbler F: Paruludae G: Dendroica S: petechia		X		
38. Cape May Warbler F: Paruludae G: Dendroica S: tigrina	X		X	X
39. Parula Warbler F: Parulidae G: Parula S: americana	X			
40. Bahama Yellow - Throated Warbler F: Parulidae G: Dendroica S: dominica	X			
41. Palm Warbler F: Parulidae G: Dendroica S: palmarum	X	X	X	X
42. Oven-Bird F: Parulidae G: Seiurus	X	X	X	X
43. Indigo Bunting F: Fringillidae G: Passerina S: cyanea	X		X	X
44. Bahama Swallow F: Hirundinidae G: Callichelidon S: cyaneoviridis	X		X	
45. Bahama Bananaquit F: Coerebidae G: Coereba S: flaveola	X	X	X	X
46. Black - Faced Grassquit F: Fringillidae G: Tiaris S: bicolor	X	X		
47. Belted Kingfisher F: Alcedinidae G: Megaceryle S: alcyon alcyon		X		

THE LAGOON

Bathymetry

Tom DeCarlo

A bathymetric map of Little San Salvador Lagoon was prepared using lead-line soundings, oblique aerial photos and field inspection of shallow areas. Navigation in the field was by means of horizontal sextent angles on markers surveyed in with reference to the LSS4 lighthouse. The resulting map (Fig. 11) is considered approximate but is probably the best available.

Tidal Flushing in Little San Salvador Lagoon

Janice Silverstein

Abstract

The residence time of water in the lagoon is estimated at 4.9 days. This estimate is based on two independent approaches for calculating tidal exchange. The first method depends on a measurement of the semidiurnal tidal range (22.5 cm at the west end) and estimation of the lagoon surface area (2.53 km^2) and gives at tidal prism of 5.69 x 10^5 M^3. Thus 10.5 tides or 5.4 days of exchange are required to equal the high tide lagoon volume (estimated at 6.0 x 10^6 M^3 from the bathymetry of DeCarlo).

The second method depends upon a measurement of water flow through the inlet using a current meter. Transport was calculated from a determination of the cross-sectional area at the site of the current measurement (Fig. 12) which averaged 28.45 M^2 and varied in time as a sine wave with an amplitude of half the tidal range (the variation of cross-sectional area with tidal height was found to be linear). The flow rate in the inlet between flood and ebb slack averaged 1.34 M/sec (= 2.57 kts) and was nearly constant with time. Transport associated with one tide therefore was about 7.15 x 10^5 M^3 resulting in a residence time of 8.4 tide cycles or 4.3 days.

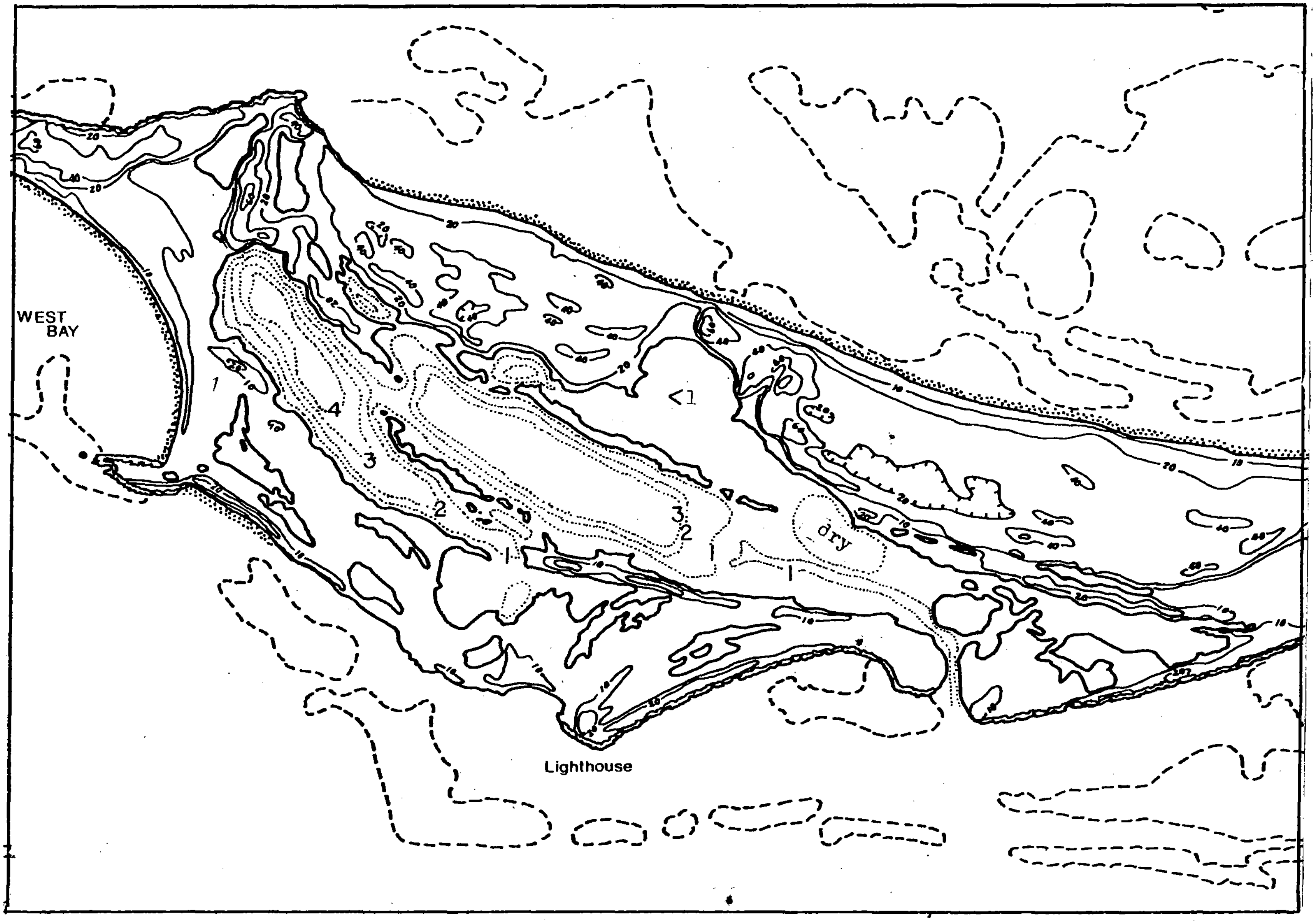


Fig. 11 The bathymetry of Little San Salvador Lagoon. April 1979.

Hydrography

Scott Bovard, Martha Wilson

Abstract

Samples from the deepest part of Little San Salvador Lagoon and from West Bay were analysed for certain dissolved substances. The results (Table 18) show that the lagoon is slightly hypersaline but is not appreciably stratified in either temperature or salinity. Dissolved oxygen was near saturation at all depths. Phosphorus, nitrogen and silica were present in higher quantities in the lagoon than in West Bay, where nitrogen was generally not detectable and was probably limiting to plant growth.

Increases in the three nutrients between 4/24 and 4/25 cannot be explained although they may be related to runoff from the island or perturbation of sediments associated with a severe storm accompanied by heavy rain during that interval.

While additions of ground water to the lagoon might help explain the tenfold increase in silica,[1/] it would not be consistent with the simultaneous increase in salinity of 0.5 $^{o}/oo$.

Light Penetration

William J. McMahon

Abstract

The extinction of light in Little San Salvador Lagoon was measured with a Kohlsico Submarine Irradiometer. The attenuation coeffecient, α, calculated over 3 M depth varied from 0.32 m^{-1} to 0.37 m^{-1}, which is comparable with open ocean values for white light. This suggest that the submarine "haze" visible to divers in the lagoon does not appreciably absorb light energy.

1/ Well water on the island contained 82 µM/L of silica.

Table 8 Results of Chemical Determinations at Little San Salvador Island April 1979. W-45.

A) Lagoon Samples (Western Lagoon)

Depth (M)	T (^{o}C)		S $^{o}/oo$		O_2 (ml/L)		PO_4 (μM/L)			NH_3 (μM/L)			Silica (μM/L)			Particulate carbon (mg/M^3)	
	4/20	4/29	4/20	4/29	4/20	4/24	4/20	4/24	4/29	4/20	4/24	4/29	4/20	4/24	4/29	4/20	4/29
0	24.8	27.8	38.6	39.1	4.82	5.04	0.10	0.15	0.25	N.D.	0.24	0.28	1.82	1.23	9.46	430	340
2	24.8	-	38.6	-	4.74	-	0.13	-	-	0.28	-	-	N.D.	-	-	560	-
4	24.8	-	38.5	-	4.76	-	0.14	-	-	0.38	-	-	1.28	-	-	420	230
5	24.8	27.3	38.7	39.4	4.88	5.02	0.15	0.09	0.31	0.05	-	0.49	1.02	0.97	12.6	440	-

B) West Bay Samples

0	-	26.0	37.2	38.5	4.92	-	0.053	0.098	0.248	0.02	N.D.	N.D.	-	-	7.04	230	64.0
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	640	-
5	-	-	-	-	4.96	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	4.95	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	4.94	-	-	-	-	-	-	-	-	-	-	-	-

N.D. = below detection level of the method.

Phytoplankton

Gwen Burzycki

Abstract

Phytoplankton composition and productivity of the lagoon and the coastal waters of Little San Salvador Island, Bahamas, were measured using net tows, light-dark bottle productivity estimates, and chlorophyll "a" analysis. The open waters were found to be diverse (d = 10.8), with 19 species of diatoms and 14 species of dinoflagellates reported, and unusually large numbers of a single diatom species, Striatella unipunctata (53.6% of the total, Table 19). Productivity was not measurable using the oxygen change method, and chlorophyll "a" values were low (0-.14 ug/1). In contrast, the western basin of the lagoon had low diversity (d = 5.5), with 2 diatom species and 6 dinoflagellate species reported. The samples were predominantly copepods (87.3%). Productivity was not measurable, and chlorophyll "a" values were considerably higher (1.09-4.79 ug/1), though this may in part represent plant material in the gut tracts of the zooplankton rather than live plant cells.

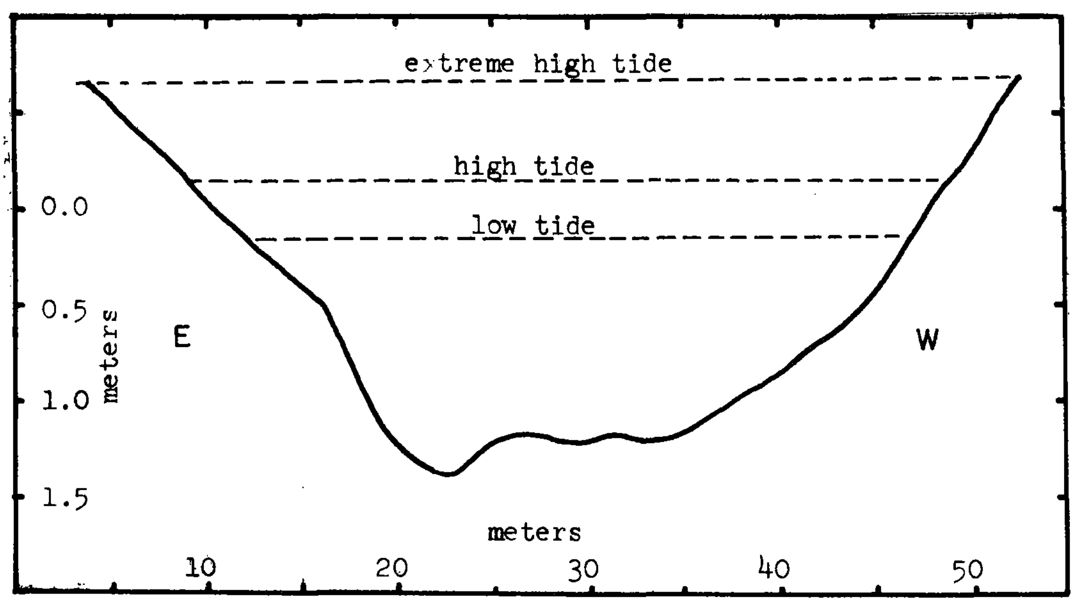


Fig. 12 The cross-section of Little San Salvador Lagoon inlet at its narrowest point.

Table 19 Species Composition of Net Tows at Little San Salvador April 29, 1979 #20 mesh. W-45

	West Bay		Western Lagoon	
	#'s of organisms	% of total	#'s of organisms	% of total
Striatella unipunctata	511	53.6	0	0.0
Copepod nauplii	44	4.5	530	51.4
Copepods	14	1.5	371	35.9
Ceratium furcas	1	0.1	0	0.0
C. fusus	6	0.5	6	0.6
C. gibberum	4	0.4	0	0.0
C. kofoidi	13	1.4	0	0.0
C. minutum	1	0.1	0	0.0
C. trichoceros	10	1.0	1	0.1
C. tripos	20	2.0	3	0.3
Cochlodinium pirum	2	0.2	0	0.0
Dinophysis sp.	0	0.0	12	1.2
Gymnodinium sp.	1	0.1	2	0.2
Ornithocercus sp.	1	0.1	1	0.1
Peridinium sp.	1	0.1	0	0.0
Peridinium sp. 2	1	0.1	0	0.0
Pyrophacus horologicum	4	0.4	1	0.0
Amphiprora sp.	19	2.0	0	0.0
Asterionella japonica	3	0.3	0	0.0
Chaetoceros sp.	1	0.1	0	0.0
Climacodium sp.	2	0.2	0	0.0
Climacosphenia moniligera	17	1.8	0	0.0
Coscinodiscus sp.	7	0.7	1	0.1
Fragilaria oceania	13	1.4	1	0.1
Gyrosigma sp.	1	0.1	0	0.0
Hemiaulus sp.	3	0.3	0	0.0
Isthmia nervosa	3	0.3	0	0.0
Nitzschia closterium	13	1.4	0	0.0
N. longissima	15	1.6	0	0.0
Pleurosigma sp.	2	0.2	0	0.0
Rhizosolenia sp. 1	18	2.0	0	0.0
Rhizosolenia sp. 2	5	0.5	0	0.0
Rhizosolenia sp. 3	3	0.3	0	0.0
Synedra undulata	15	1.6	0	0.0
Tropidoneis antarctica	6	0.5	0	0.0
filamentous blue-greens	27	2.9	0	0.0
filamentous greens-fragments	40	4.2	2	0.2
bivalve larvae	6	0.5	6	0.6
gastropod larvae	6	0.5	17	1.5
pteropod	4	0.4	0	0.0
foraminiferan	4	0.4	0	0.0
Globigerina sp.	6	0.5	2	0.2
pluteus larvae	2	0.2	1	0.1
polychaete larvae	1	0.1	0	0.0
radiolarians	3	0.3	0	0.0
tintinnids	37	3.9	1	0.1
eggs	2	0.2	18	1.7
egg masses	0	0.0	30	2.9
brown spheres	0	0.0	26	2.5
total	954		1032	

Zooplankton

Barbara Polan

Abstract

Differences in zooplankton composition and abundance were studied in net samples (0.333 mm mesh) from Little San Salvador Lagoon and West Bay. Decapod zoea made up 88% of the lagoon catch compared with less than 1% of the West Bay catch. Eggs identified as fish eggs predominated in the West Bay catch (96%) but were only 10% of the lagoon catch. The standing crop of zooplankton in the lagoon is estimated as 100 to 1000 times more concentrated than that in West Bay.

Initial Studies of Lagoonal Sediments of Little San Salvador Island

Laura Gentile

40 surface sediment samples were subjected to a textural analysis, as described by Pettijohn, Potter and Seiver (1972), and to an initial examination of constituents (Fig. 13). The large majority of sediments lie in the sand-size particle range, are calcareous and have a biogenic origin or display biological reworking.

The lagoon inlet, where tidal currents regularly attain a speed of 3 knots, is characterized by a sedimentary deposit of well sorted, coarse sand-sized particles, consisting of oolites and grapestone. The western deep end of the lagoon, which is not subject to currents, is characterized by poor sorting and medium sand-size particles of biogenic skeletal detritus. Other lagoon sediments where water depth and current velocities are intermediate are poorly sorted fine and medium sand-size carbonate particles.

Although Little San Salvador Lagoon is a heterogeneous depositional environment, some generalizations based on preliminary constituent analysis are possible:

a) the inlet is characterized by mobile ooid and grapestone sand. Quiescent areas behind small islands at the inlet are dominated either by pelletoids and shells occupied by snails or hermit crabs, or by nearly monospecific deposits of benthic foraminifera.

b) Pelletoids are the primary constituents of the currently active flood delta southeast of Long Cay.

c) In the shallows north and the deeper water south of Long Cay sediments are primarily pelletoid and possess a microtopography indicative of extensive reworking by the sand shrimp, Callianassa.

d) The sediment deposit of the western lagoon exhibits the greatest diversity of constituents, including skeletal fragments of green seaweeds which grow there.

The present lagoonal bathymetry reflects influx of sediment material from the ocean floor surrounding Little San Salvador. At the mouth of the inlet a mature delta deposit has been stabilized by a Mangrove population and a currently active delta has formed to the west of this, off Long Cay. The deep western lagoon is removed from any apparent external source of sediment and contains a modern sedimentary blanket less than one meter thick (Rich, this report). On the basis of active sediment transport it is difficult to explain the abundant sediment present north of Long Cay and at the eastern end of the lagoon. These deposits may result from formerly active breachways.

Sedimentary Foraminifera in Little San Salvador Lagoon

Gretchen Rich

Abstract

Sediment cores from the lagoon at Little San Salvador Island were examined for foraminifera. Special attention was paid to sampling the western lagoon where sediments are believed to be derived entirely from *in situ* biogenic process in the water column and sediment, and where foraminifera could be used as an index of environmental conditions and stability.

The maximum thickness penetrated was about 1 m, in the deepest part of the lagoon. This blanket of biogenic carbonates is underlain by an impenetrable surface associated with large bivalve shells, coral or coral fragments and fragments of carbonate rock. If this surface is correlative with that of the ancient dune ridges that form the island then the sediment may represent 1,000-2,000 years accumulaton.

A cursory examination of the sediment did not reveal discontinuities to suggest prolonged environmental change, although foraminifera in these samples will require considerable further attention to reach firm conclusions.

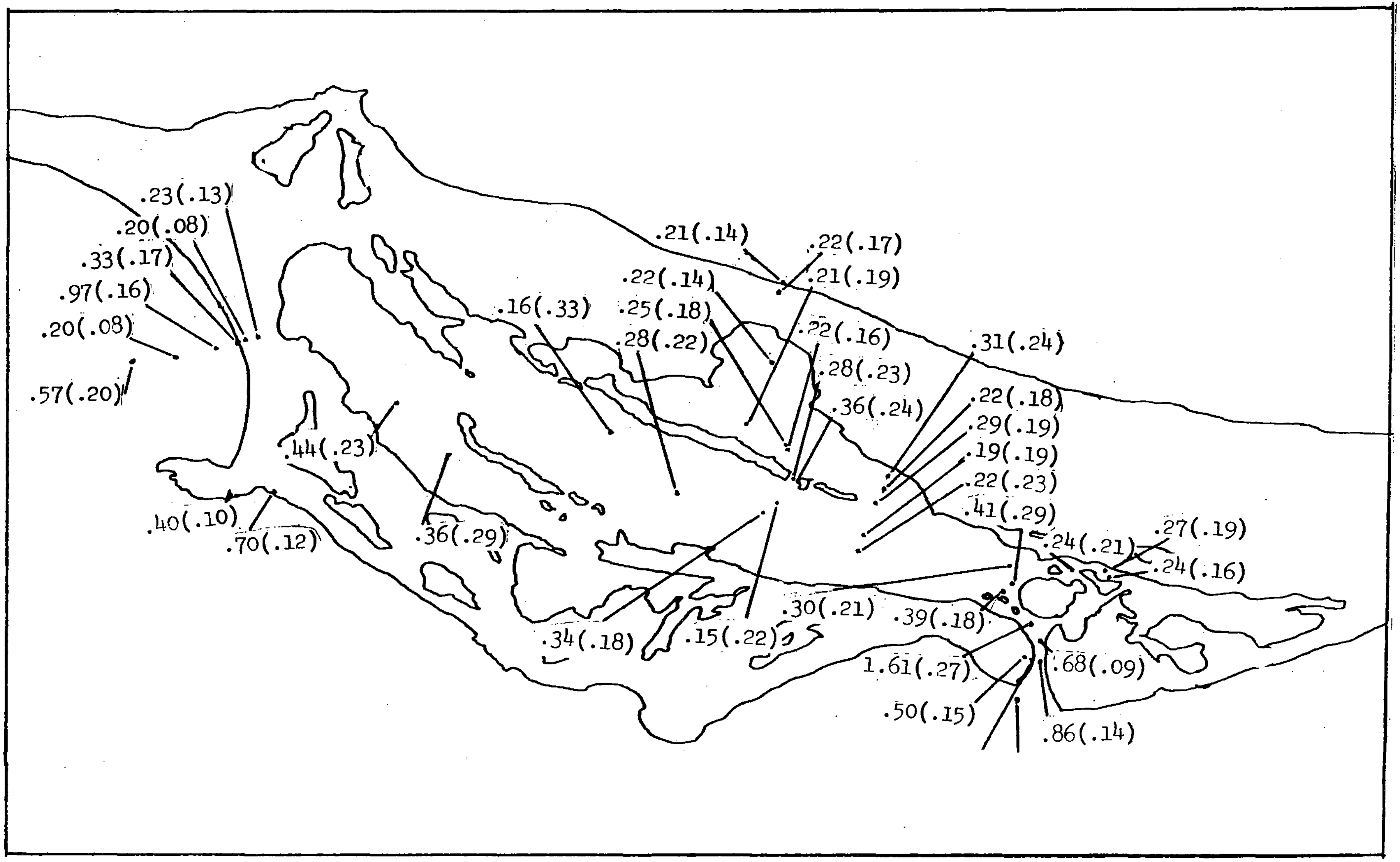


Fig. 13 Median sediment size and sorting coefficient (in parentheses) for surface sediments from Little San Salvador Island Lagoon (mm). W-45.

Sediment Reworking by the Sand Shrimp, *Callianassa*

Grace Hornor

Abstract

Extensive reworking of lagoonal sediments by *Callianassa* characterizes abou 17% of the Lagoon, north and south of Long Cay (Fig. 6). This activity produces a landscape consisting of individual hollows averaging 41 cm depth and 76 cm diameter at the top. Alignment of these hollows results in patterns of irregular ridges and troughs, which are submerged at high tide and in places become separate ponds of standing water at low tide.

The effect of this activity on sediments and on other organisms through the sediment mobility and the structured environment it creates would seem to bear significantly on the lagoonal environment of Little San Salvador.

STUDIES ON THE QUEEN CONCH (Strombus gigas) WITH A VIEW TOWARD ITS AQUACULTURE AT LITTLE SAN SALVADOR LAGOON

Introduction

Peter Cataldo

Strombus gigas, the queen conch, is the world's largest species of conch, growing to over 3 kg and 300 mm length. Twelve percent of the mature conch's total weight is marketable meat, that which can be sold for consumption. The shell also has high economic value. These considerations and its wide distribution in the Bahamas make the queen conch the base of the third most important industry in that archipelagic nation. Its commercial importance is only surpassed by that of the spiney lobster and the fishing industry.

Reproduction in the Strombus gigas occurs throughout most of the year, although in more northern areas reproduction stops in the winter months due to the cold water temperature. Fertilization is internal and the eggs are laid within 24 hours. They emerge as a long sticky tube to which sand adheres and evidently provides camouflage. The mass contains 385,000 to 750,000 eggs, and several egg masses are laid per breeding season. Fertilization seems to occur in shallow water with egg-laying in deeper water.

After 5 days, the free swimming larval form hatches. The larvae, called veligers, draw their name from their swimming organ, the vellum. It consists of two semicircular lobes with beating cilia to create movement. The veligers are suspension feeders, living mainly on phytoplankton. Phytoplankton is ingested by means of a subvellar food groove, also with beating cilia, which lead the food into the organism for ingestion.

Metamorphasis begins after 20 days during which the veliger assumes a more benthic form. The foot and eyes develop while the vellum begins to disappear. Shell formation begins slightly later. This metamorphasis ends at 28 to 33 days at which time the organism is totally benthic.

The conch will continue to grow in length and body weight until the age of about four years. At that time the organism reaches sexual maturity and changes its growth pattern, to add weight to the shell but very little meat. This is due primarily to the thicking of the lip of the shell. The conch shell harbors an assemblage of marine organisms which eat away at it. The continuous secretion of calcium carbonate along the lip counteracts this deterioration. The conch will continue to grow in this pattern until its death, the life expectancy being 5 to 7 years.

Strombus gigas generally inhabits the waters of Bermuda, the Bahamas, southern Florida, the Gulf of Mexico, and Brazil. Its preferred environment consists of shallow seagrass beds contiguous with a sandy bottom. Turtle grass, eel grass, and manatee grass are the major species with which Strombus gigas is found. The juveniles are found mainly in the more sandy areas and hide buried beneath the sand during the daylight hours. This is believed to be owing to their susceptibility to predation.

The Strombus gigas feeds mainly on epiphytic algae on the seagrasses and on benthic algae. Sediments and pieces of grasses have been found within the stomach of the queen conch, totally undigested, thus showing that the conch feeds only on the epiphytes and not on the grasses themselves.

The Occurrence and Distribution of the Queen Conch (*Strombus gigas*) in Little San Salvador Lagoon

Robert Visnick

Abstract

Approximately 75,000 m^2 of the lagoon floor (nearly 3%), including portions of all habitats present, was visually searched by snorklers or, in shallows, on foot (Fig. 14). Twenty-seven conchs were counted (Table 20) of which most were probably juveniles (not sexually mature). 89% of the conchs found were closely spaced at two areas (stations 3 and 9, Fig. 14). At one location (station 9) 17 juveniles were found in a sandy area of about 300 m^2, each conch being partially concealed under a brown-orange seaweed. All juveniles were found in water less than 0.1 m deep.

A concentrated search in a portion of the lagoon populated with turtle grass (*Thalassia*), which is a preferred habitat for conchs, produced a single adult (station 1). No attempt was made to survey at night when smaller juveniles would be expected to emerge from the sediments.

The dearth of the conch in the lagoon is believed to reflect overfishing on the basis of four considerations: 1) anecdotal accounts of former abundance; 2) large piles of holed shells along the shore which could have come from the lagoon; 3) the presence of juveniles, indicating a favorable environment; and 4) the relative ease with which conchs could be harvested in the lagoon.

The Occurrence and Significance of Natural and Human Predation on the Conch (*Strombus gigas*) in Little San Salvador Lagoon

Judy Seligson

Abstract

Of 22 species of animals listed by Randall (1964) and Hesse (1975) 1/

1/ In Stevely and Warner 1979. The biology and utilizations of the queen conch, *Strombus gigas*. Florida Cooperative Extension Service.

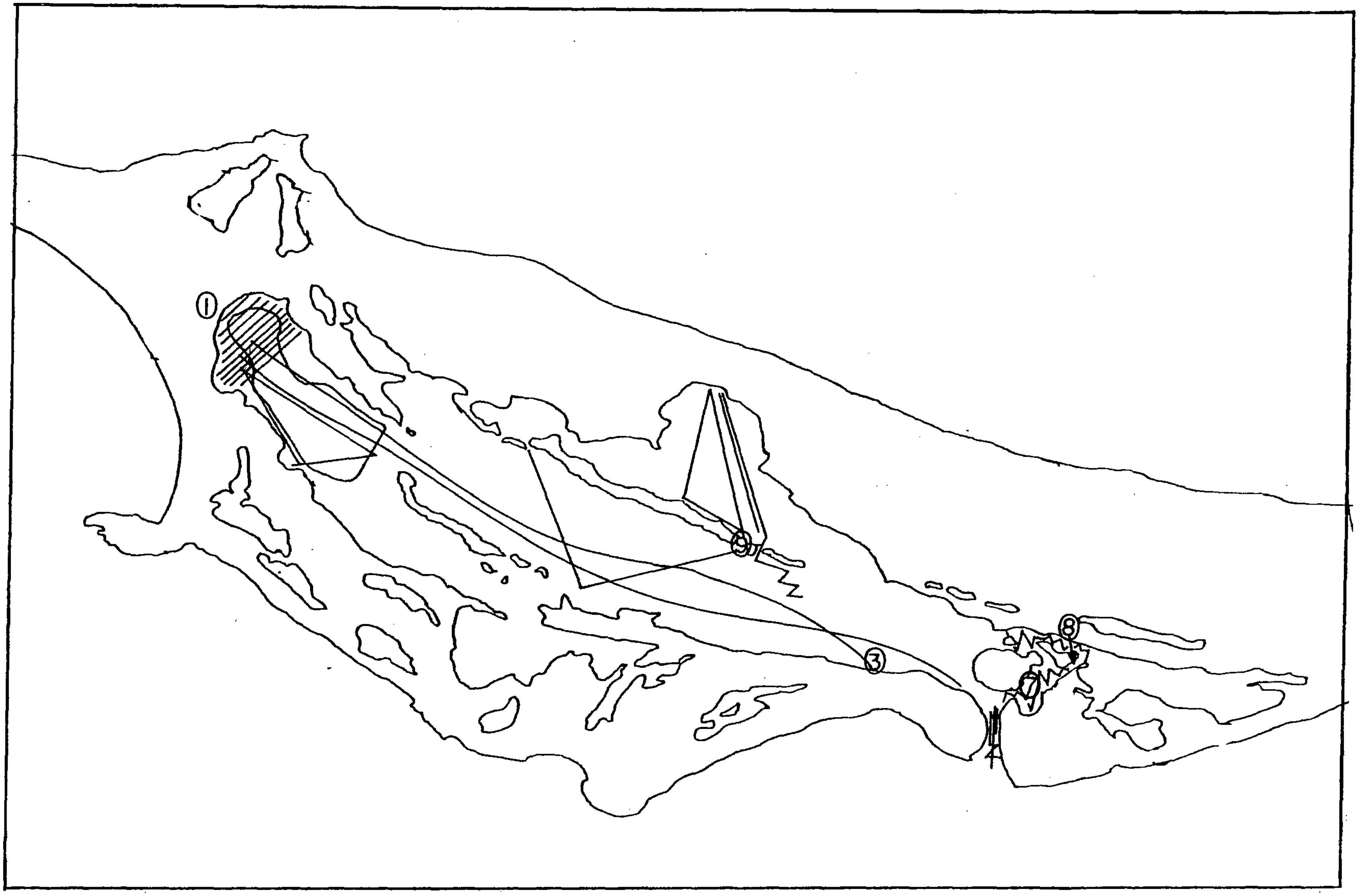


Fig. 14 Transect lines searched by snorklers or walkers for adult and juvenile conch. April 1979. W-45

as predators of adult and juvenile conchs, 3 were observed in the lagoon. These included the spotted eagle (?) ray (aetobatis narinari) ca. 4 individuals; the spiny lobster (Panularus argus) 1 sighting; and the nurse (?) shark (Ginglymostom curratum) 1 sighting. Another potential predator of adults, the large sea turtle, was sighted in West Bay. The hermit crab (Petrochirus) and a number of fish predators were also probably present.

Empty conch shells were examined in an attempt to identify the cause of mortality. 99.7% were distinctly killed by humans (holed shells generally in piles around the shoreline) and the remainder, all of which were found underwater, could have been killed by natural predators. A litter of shell rubble which floors the lagoon inlet was not accounted for in this study as an unknown number of individuals are involved and they merge in condition with fossil shells found in strata here.

Shell Heaps of Little San Salvador Island

Judy Seligson

Abstract

Piles of shells of Strombus gigas occur at many locations around the lagoon, but particularly on the shores and islands near the inlet. These piles contain varying numbers of shells, estimated at from 70 to several thousand. It is presumed, although by no means certain, that these conchs were removed from the lagoon. The age of the oldest piles is unknown.

Piles containing up to several hundred shells are believed to represent a single catch and display uniform characteristic with regard to the method of removing the meat, i.e., the shape of the spire hole (for cutting the animal free of the shell), the presence or absence of a lip hole (used for tying live animals together) or the removal of the spire (an alternative method for unattaching the meat). Shell piles lacking lip holes were always located a short distance inland.

Shell heaps showed significant differences in mean shell size (Table 21) and there may have been a trend for heaps of smaller shells to occur inland of larger ones. If shell heaps increase

Table 20 Results of Conch Census in Little San Salvador Lagoon (see Fig. 14). April 1979

Station Number	Length (cm)	Weight (g)	Age 1/ (yrs)
1	21.0	2500	2.8-4.0
2	21.0	-	2.8-4.0
	26.0	2300	> 4.0
West Bay not plotted	23.0	1400	> 4.0
	23.0	2500	> 4.0
	21.0	1600	1.8-4.0
	20.0	2000	2.8-4.0
3	13.5	110	1.4-1.8
	13.0	170	1.4-1.8
	15.0	140	1.5-1.9
	14.8	230	1.5-1.9
	14.4	170	1.2-1.6
	12.7	70	1.1-1.3
	18.0	260	2.2-2.8
7	15.5	110	1.5-1.9
8	19.0	340	2.8-4.0
9	17 "juveniles" noted but no further data obtained		

1/ From age length curve of Berg (1976).

in age B→C, E→D→F→A (Table 21) then differences in means could signify harvesting of smaller conchs as overfishing depleted the larger adults.

Data from the shell heaps could be extremely valuable for understanding growth of the conch here if means for dating the piles were achieved and the conch fishing practices of the Bahamians with regard to building shell heaps and holing shells was determined.

Table 21 Certain statistics for random samples of conch shells (n = 50) from six piles near the inlet of Little San Salvador Island Lagoon.

Pile	Mean size (cm)	Mean age 1/ (yrs)	Mode (cm)	# size 2/ classes	Standard Deviation (cm)
A	25	> 4	23	7	5.2
B	17	1.9	18	6	4.8
C	18	2.4	20	5	4.0
D	20	3.1	20	3	2.6
E	18	2.4	18	5	4.0
F	22	> 4	23	4	3.2

1/ Mean age of conch at the time of its death, determined from the Von Bertanlanffy growth curve given by Berg (1976) and Hesse (1975) in Stevely and Warner (1979).

2/ Shell length was rounded to the nearest inch and converted to cm. The size class interval was therefore 2.5 cm.

Studies on the Occurrence of Turtle Grass (Thalassia testudinum) in Little San Salvador Island Lagoon

Celeste Nadworny

Abstract

Thalassia is an important food and habitat for the conch and the occurrence and productivity of this grass (including epiphyte) is important to a consideration of aquaculture. The predominant grasses and seaweeds in 1 m^2 quadrants were determined for five stations in the western lagoon where macroscopic benthic vegetation is most abundant (Table 22). Values for stations 1 and 2 are probably most representative of the deep portion of the lagoon, and show domination by Thalassia (72% of all macroscopic vegetation). In shallower water the green alga Bataphora or the brown alga Padina predominated (these may also be suitable foods for Strombus).

The standing crop of Thalassia was mapped using these data, aerial photographs and spot checks in the field. It was estimated that the western lagoon had a standing crop of 678 g wet weight/m^2 (= 176 g dry weight/m^2) that the central lagoon supported 10% of that and Long Cay Cove and the eastern lagoon, 1%. The standing crop of Thalassia in the lagoon is therefore on the order of 5×10^5 kg dry weight. Productivity associated with Thalassia beds similar to those in the western lagoon is about 2×10^3 g/m^2/yr.[1/] Using similar assumptions as above, the productivity of Thalassia in the lagoon would be 1.6×10^6 kg/yr. At 10% ecological efficiency this could produce 2×10^5 kg of conch/yr (dry weight) or perhaps 8×10^6 conchs/yr (= 1 harvested per 3 square meters). More realistically, this suggests that the existing vegetation in Little San Salvador Lagoon could support a sizable population of conchs and that other limiting factors may be more important.

1/ Greenway, M. 1976. The grazing of Thalassia testudinum in Kingston Harbor, Jamaica. Aquatic Botany.

Table 22 Sea grasses and seaweeds at meter square quadrants in the Western Lagoon at Little San Salvador Island. April 1979. Wet weight 1 g.

	Station 1	2	3	4	5
Species					
Grasses					
Thalassia	505 (71%)[1/]	850 (73%)	44 (55%)	100 (12%)	148 (13%)
Seaweeds					
Penicillis	101 (14%)	55 (5%)[2/]		23 (3%)	67 (6%)
Bataphora			18.5(23%)	615 (75%)	
Padina					368 (32%)
Other algae			17 (22%)	40 (5%)	424 (35%)
Other	103 (15%)	255 (22%)		45 (5%)	168 (14%)

1/ dry weight determined on this sample was 26% of wet weight.

2/ dry weight determined on this sample was 44% of wet weight.

Table 23 Results of observations on movement of Strombus gigas in the Western Lagoon at Little San Salvador Island. April 22-24, 1979.

Conch	Sex	Length (cm)	Weight (g)	Distance Traveled (m)	Average/ day (m)
2	F	26	2270	80	26.6
3	F	23	1360	90	30.0
4	F	23	2490	125	41.7
5	M	21	1590	3	1.0 1/
6	F	20	2040	80	26.7
				average	31.2

1/ disregarded in calculating the average

Observations on the Mobility of *Strombus gigas*

David Siebert

Abstract

Five conchs placed in the Western Lagoon were marked with small floats on string attached to their shells and their movement recorded over three days. The average distance traveled was 31.2 meters/day (Table 23) and movement was toward deep water and toward *Thalassia* beds. This average speed is in the range of published values. It suggests that it would take a minimum of 131 days for a conch to move through the inlet to the Western Lagoon. Unless there were some strong signal to guide such directed movement it seems much more time would be required. This may partially explain why harvesting of conch in the lagoon could deplete the stock.

Physiological Studies on *Strombus gigas*: Oxygen Uptake, Ammonia Excretion and Phosphorus Excretion

Peter Cataldo

Abstract

The respiration rate of an adult conch averaged -1.2 μM/hr/g (Table 24). For an R.Q. of 1, this implies an annual respiration of only 50 g carbon or about 100 g dry weight of organic matter. If the conch typically achieves a meat weight of 100 g in 2.5 years (Berg, 1976) this implies a very efficient food:meat conversion by this animal.

The release rates of nitrogen and phosphorus occurred in the ratio $\Delta O_2 : \Delta NH_3 : \Delta PO_4 = 100:5:1$ which is close to the classical Redfield ratio (106:16:1) for the dissimilation of organic matter. The nitrogen release rate might be low because ammonia is only one form of released nitrogen.

Rates for oxygen uptake and ammonia release by juvenile conchs were higher by a factor of 2 to 3.

Table 24 Metabolic exchange rate of oxygen, phosphate and ammonia by *Strombus gigas*.

Expressed on a meat wet weight basis. 27°

Trial #	Sex	Weight (g)	Length (cm)	Oxygen (µM/hr/g)	Ammonia (µM/hr/g)	Phosphate (µM/hr/g)	O_2/N/P
1	F	395	25	-1.2	0.068	0.010	120:6.8:1
2	F	395	25	-1.2	0.048	0.015	80:3.2:1
3	F	40	13.5	-1.4	0.050	-	-
4	F	30	12.0	-3.9	0.091	-	-

Aquaculture of Strombus gigas in Little San Salvador Lagoon:
A Summary

1. Access to the literature on the ecology of *Strombus gigas* is provided by the recent review of Stevely and Warner (1979). The natural history of this animal is discussed by Randall (1964), among others, and considerations of its mariculture are treated by Berg (1976) and Brownell (1977). Stevely and Warner's review also includes a history of the commercial exploitation of conchs.

2. Adult conchs are presently absent from the lagoon, which we believe is owing to overfishing and a low recruitment rate inherent to the geometry of the lagoon and low mobility of the animal.

3. Small juveniles are present but their abundance could not be estimated from our census which was conducted during daylight when small juveniles are reported to bury themselves.

4. At least three large natural predator species of the conch are present in the lagoon.

5. *Thalassia* (turtle grass) densely covers about 160 acres (25%) of the lagoon providing a good habitat for conchs. In other large areas the activities of a burrowing shrimp (*Callianassa*) may inhibit the development of *Thalassia*, but may provide an environment suitable for small juvenile conchs.

6. The water in the lagoon showed high levels of oxygen, and higher ammonia, phosphate and silica than outside. No appreciable stratification of salinity or temperature was evident.

7. The water in the lagoon supports a high standing crop of zooplankton (especially larval forms) which may provide competition for veligers of *Strombus*, which are herbivorous. They may also include predators of the veliger.

8. Phytoplankton were inconspicuous compared with zooplankton and further sampling will be necessary to clarify their population dynamics. The high chlorophyll "a" concentration in lagoon water suggests a high standing crop but a fraction of this could have been from gut contents.

9. The tidal flushing time for the lagoon is about 5 days. This moderates extremes of temperature and salinity sometimes associated with lagoons, and probably insures a regular influx of veligers from surrounding populations.

10. Respiration measurements on the conch support the contention that growth of the animal is efficient in terms of incorporation of organic matter.

11. The geometry of the lagoon with its varied bathymetry, adjunct coves and well defined inlet make it amenable to management for aquaculture. There is evidence that storms have breached the the north and possibly the eastern coast, but the danger to *Strombus*, even if this happened, would be minimal.

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VISITING SCIENTISTS PRELIMINARY REPORTS 1/

Natural History Observations on Little San Salvador Island

Roderick Attrill, Bahamas National Trust

Presently uninhabited, this island has in the past been cultivated probably fairly extensively. My observations were limited to the eastern end of the island during the Strombus Expedition. Behind South West Beach, the narrow flat area between the sea and the Lagoon is covered with secondary growth, the dominant species being Pithicellobium and Acacia. Strangely no poisonwood (Metopium toxiferum) was observed on the western end of the island. To the west of the Lagoon much evidence of agriculture was found, especially the cultivation of sisal. The hills in this area have much Lignum vitae (Guaiacum sanctum) and gum-elemi (Bursera simaruba). Throughout this area white crowned pigeons were very common as was evidence of their nests. The island is in fact protected under the Wild Birds Protection Act. Despite this, shell cases were commonly seen.

The Lagoon is flushed by the sea in all parts and supports extensive Thalassia beds. At the eastern end algal reefs (with Porites) form interesting assemblages of species.

Mangrove development is not extensive although the red mangrove (Rhizophora mangle) where found was flourishing. Black mangrove, white mangrove, and buttonwood fringed the Lagoon, but were never as predominant as they would become at higher salinities.

Several species of wading birds were present, although, scattered and in small numbers. Nowhere was the algal mat sufficient to support flamingos. Egret nests were seen but not in large numbers. It is likely that only a few pairs of heron or egret nest on Little

1/ These reports are presented without editing or any attempt to fit them into related sections of student work.

San Salvador Island.

The southern coast, east of the inlet to the Lagoon is generally high and rocky, and favoured for the nesting of marine birds, in particular the white-tailed tropic bird and other burrowing seabirds such as Petrels and Shearwaters. A pair of Osprey had built their nest on one high crag, and at the time of our visit had one well-fledged young (Fig. 9).

The eastern end of the island was not visited, but appeared to be mixed broadleaf coppice with *Cocothrinax* and *Pseudophoenix* palms. *Metopium toxiferum*, was far more in evidence in the coppice at this end of the island.

Altogether Little San Salvador Island is one of the more unspoilt islands. Its topography is considerably more variable than most, from the comparatively steep hills to the Lagoon, and rocky south-eastern shore, but above all, its appeal lies in the absence of man's work.

Benthic Invertebrate Communities: Preliminary Observations

Sheldon D. Pratt, University of Rhode Island

The aquatic bottom environments of the island were examined over a three day period. A great diversity of habitats and associated fauna were found from splash pools, to mangrove thickets, turtle grass beds, and offshore reefs. Four habitats are discussed here. These discussions will be more fully developed when samples being returned aboard *Westward* are examined.

Hypersaline Ponds "Yellow Pond", (Fig.6), north of the base camp is a hypersaline pond at an apparently low stage due to dry weather. The area sampled had 2 cm of water overlying about 20 cm of fluid carbonate mud. The salinity was 94.7 ppt. The surface of the mud consisted of a 2 cm layer of soft tubes made by an oligochaete worm and a polychaete worm, *Capitella capitata*. Single species of gastropod and bivalve mollusks were present, while large numbers of the bivalve shells of ostracod crustaceans indicated they are important during periods of greater water depths.

Green (?) benthic algae on the mud probably provided food for the deposit-feeding animals. The presence of C. capitata in the pond is of particular interest. This species has been used as an indicator of stress or pollution in northern environments. Recently, it has been found that C. capitata is actually a group of species; each adapted for different environments and able to rapidly take advantage of "empty" habitats.

Coralline Algae Habitat In the west end of the Lagoon just below the low tide mark there is a dense growth of branched pink calcarious algae forming a small reef 10-20 cm high and 1-2 meters wide. The algae is tentatively identified as Goniolithon acropetum, but the Corallinacae has been called a "family perpetually aggravating to phycologists" needing critical histological study of fertile tetrasporangia for identification. A great density and variety of invertebrates were found in the meshwork of the algae. These included young individuals of species seen on the grass flats (sea cucumbers); attached filter feeders (mussels, sea squirts); large predatory and scavenging bristle worm polychaetes; and several species each of chitons and brittle stars. The brittle algae beds would need protection if the island was developed for tourism.

Lagoon Inlet High suspended sediment loads and temperature extremes make the lagoon unsuitable for most reef corals and many other reef organisms. However, an area of high current velocity and hard bottom just inside the lagoon entrance supports a colorful population of sponges, seafans, sea whips, and corals resistant to the effects of sedimentation (Porites porites, P. astreoides, Manicina areolata). Fish are relatively abundant here. The attached fauna is similar to that described in lagoon entrances at Abaco and Bimini islands.

Tidal Flats Extensive intertidal flats are found in both the east and west lagoon bays and north of "Long Island." Most of this area is dominated by the mounds and funnels constructed by a 5 cm long decapod crustacean "mud shrimp" (Callianessa sp.)

Callianessa lives in gallery-like burrows and obtains its food from sediment collected in the funnels and ejects sediment and fecal rods from the mounds. Researchers have discussed the negative effects of Callianessa activity on non-motile filter feeders.

The following speculations about the ecology of Callianessa may suggest future lines of research. It is likely that benthic micro-algae is the main source of food, although detritus from turtle grass and macro-algae trapped in the funnels may also be important. The effect of Callianessa on the makeup of benthic algal populations is indicated by the change in color from pink (from red algae) to white as the zone of mounds is entered. Animals co-occuring with Callianessa must be adapted for a shifting substrate. This may include the Dosinia clams which produce a feeding tube to the surface with a specialized foot. Callianessa makes up a large standing crop of relatively large animals which is normally not available to predators with the possible exception of rays. In other species of burrowing crustaceans the males leave the protection of the sediment to seek mature females and suffer high mortality from a variety of fish. The role of the mud shrimp galleries is unknown: they could serve for refuge during attack, oxygen and temperature control during low tide, or for bacterial breakdown of plant food. The activity of Callianessa may prevent buildup of flats above a level at which they would dry out, lithofacation of the sediment, or colonization by mangrove or turtle grass. Commensal species may share the tubes of mud shrimp as they do other large burrowers. Spatial distribution of adult Callianessa is very regular (about 1 m between mounds); there may be a high mortality of juveniles unable to hold space by aggression or interference.

Intertidal areas with slightly higher elevation than the Callianessa zone are dominated by small white hermit crabs. Adults are about 5 mm wide and occupy holes very regularly spaced, about 10 cm apart. Their feeding tracks make radial patterns around the hole at low tide. Gastropod snails, fiddler crabs in snail shells, and juvenile hermit crabs are also abundant in these areas. This zone is presently being colonized by white mangrove.

Reptiles and Amphibians of Little San Salvador Island

Roderick Attrill, Bahamas National Trust

The herpetofauna of Little San Salvador Island and adjacent islands is mainly of Cuban origin, the exceptions being the two sub-species of *Epicrates*, which owe their origin to the island of Hispaniola, and the greenhorse frog, *Eleutherodactylus planirostris*, which occurs in the continental United States.

During the Wisconsin Ice Age, the island of Little San Salvador was continuous with the islands of Eleuthera to the north, and Cat Island to the south. Since that time geographical isolation has resulted in the formation of sub-species of some species. *Epicrates striatus strigilatus* is the boa of Eleuthera and *E. s. ailutus* is the boa of Cat Island. *Eleutherodactylus p. planirostris* is the frog of Eleuthera and *E. p. rogersi*, the frog of Cat Island. In the case of *Epicrates* and *Eleutherodactylus* any sub-species formed may be separate from either Cat Island or Eleuthera forms and hence of particular interest.

In their checklist of reptiles and amphibians of the West Indies, Schwartz et al (1977) listed only one species for Little San Salvador. Evidently the island had been little studied. In the supplement to their checklist published December, 1978, a further six species were added. The Strombus expedition added one more species bringing the total to eight.

The Strombus expedition did not cover every part of the island, but certainly representative habitats were covered. The species seen or collected on the Strombus expedition are as follows.

Sphaerodactylus spp.

These small geikos live under leaf litter, particularly under the dead fronds of Cocothrinax palm. Two species were taken, both differing considerably in coloration. Identification of these will await expert consultation. Schwartz records S. nigropunctatus gibbus for Little San Salvador, and S. n. nigropunctatus for Eleuthera and Cat Island.

Leiocephalus carinatus hodsoni

This curly-tail lizard seems to be the most abundant species, being found in the sand dunes, on coastal rocks, and in both broadleaf coppice and Cocothrinax and Pseudophoenix dominated vegetation.

Anolis distichus dapsilis

The Bahama Bark Anole is common in the broadleaf coppice to the eastern end of the Lagoon.

A. sagrei ordinatus

The Cuban anole occurs in the same area as the above species.

A. smaragdinus smaragdinus

Although I did not observe this species, one of the students reported seeing a "green lizard" which could only have been this species. A. s. smaragdinus is morphologically similar to A. carolinensis which some authors believe to be the same species.

Ameiva auberi thoracia

This large teeid lizard is fairly widely distributed throughout dunes and coppice, but occurs nowhere in the same profusion as Leiocephalus.

Alsophus vudii vudii

The brown racer, endemic to the Bahamas, is a rear-fanged viper, although harmless. Several of these were observed in the secondary coppice behind South West Beach.

Eleutherodactylus planirostris

This frog was collected from around a waterhole (freshwater) in a disturbed, recently cultivated area. Previously unrecorded from Little San Salvador, this frog may have been introduced accidentally from Eleuthera or Cat Island, or more likely, have been merely overlooked by herpetologists. The subspecies has yet to be determined.

Terrestrial Investigations

Mary Gillham, University of Wales

The course of sand lithification was traced on the three parallel dune ridges behind West Bay, and followed through to high ground and iron shore. It seems that this is at least partly a biological process involving several species of lichen and one of moss, possibly also algae.

Dune ridges at increasing distances from the sea are progressively more lithified, the process being most active along the dune crests. None occurs under bushes where fallen leaves prevent growth of Cryptogams (and are stirred at intervals, along with surface sand, by Bahaman Mocking birds and lizards); nor does it occur under tufts of dune grass, which may be elevated on pedestals of original dune sand surrounded by grey, rock-like surface.

This process, like tufa formation by mosses, liverworts and algae in calcareous seepages, where plants actively extract carbon dioxide for photosynthesis from calcium bicarbonate, needs water, to release the $CaCO_3$ in soluble form available to the plants, and is likely to proceed most actively during summer rains. Sand grains lose their oolitic shape during this stage of weathering and, below the greying surface layer, retain the pink colour that is seen in sand churned by waves breaking on the shore (though not in dry sand).

A sequence of different lichen species is involved: the small, dark acrocarpous moss appears only in the early stage as far as could be ascertained. Material excavated from lizard burrows appearing to enter solid rock may be of pure sand, and plant roots penetrate such material with ease. Jigsaw cracking of the hardened surface on the third dune ridge by drying out and root expansion gives the typical clint and gryke formation of a limestone pavement, except that material flooring the gullies is sand in situ instead of accumulated detritus.

On both the iron shore and the hills, where lithified material has built up to great depths, many clints become detached and seesaw underfoot. Weathering in the taller "forest scrub," with its ground orchid (Epidendrum hodgianum), lignum vitae (Guaicum officinalis) and air plant (Tillandsia utriculata), is partly by other lichens, these playing their traditional role in the ecosystem as pioneers in the breakdown of rock to soil. On the ironshore, seawater plays a part in this, producing sharp edges and plant-like forms, possibly the calcified remains of old dune plants. Disturbance or cultivations would hinder and mask this process on the inhabited islands.

Transects were done on the four main types of shoreline.

a) Accreting sandy shore on the North Coast - Dwarf spurge (Euphorbia mesembrianthe mifolia), dune grasses and the goodeniacious (Scaevola plumieri) saplings stabilising embryo dunes below the seaweed (Sargassum) driftline; sea lavender (Mallatonia gnaphalodes, formerly Tournefourtia) and bay cedar (Suriana maritima) holding slighly larger ones below the fringe of Australian pine (Casuarina equisetifolia) and the scrub of mixed broad-leaved shrubs and siver-top palms (Cocothrinax argentea) behind.

b) Eroding sandy shore on West Bay - where there was cutting back of an oolitic sand clifflet area chemo-lithification in the absence of lichens had already begun. The arenicolous vegetation leading back from the crumbling edge contained more grasses and sedges including the striking sea oats (Uniola paniculata), Ernodea littoralis, Scaevola, creeping softly hairy Ambrosia hispida, and Suriana than the scrub behind.

c) Shore in South Bay where flat shelves of limestone - behind the beach supported silver-leaved buttonwood or britton mangrove

(Conocarpus erectus) and an admixture of rock and sand flora thickly entwined with dodder or woe-vine (Cassytha filiformis).

d) Ironshore on the headland - between here and West Bay, the east side of this was the more exposed, leading up from the heather-like Rachicallis americana (which is known as sand-fly-bush, hog-bush, salt-water bush, 'seaweed' or wild thyme), through a low scrub of pink-flowered strumpfia (Strumpfia maritima) and a broken belt of sea grape (Coccoloba uvifera), to seven-year apple (Casasia clusiaefolia). The west side has a series of high pools eroded out where hermit crabs (Coenobita) spend about 2 months between their aquatic larval phase and terrestrial adult phase, this passing straight back into rocky scrub with Conocarpus except towards the tip where the Rachicallis-Strumpfia dwarf scrub dominated.

Maps and records were made of zonation of plants and animals in relation to the proximity of water. In general terms the smaller ponds are zoned outwards from bare mud, sand or water in the centre → sand re-worked into pellets by fiddler crabs (Uca) → rat's tail grass (Sporobolus virginicus) → the succulent-leaved yellow daisy (Borrichia arborescens) → Uniola → Conocarpus → mixed scrub with pigeon plum (Coccoloba diversifolia), bread-and-cheese (Pithecellobium guadalupense), sapodilla (Manilkara bahamensis) and many others.

Salt resistant succulent herbs at the edge of the Lagoon included saltwort (Batis maritima), glasswort (Salicorina perennis) and pink-flowered sea purslane (Sesuvium portulacastrum). Most of the turtle-grass under water here was Thalassia restudinum but a little of the narrower-leaved Halodule wrightii was found.

The most varied ecosystem was that around the freshwater well where a banana-hole contained jumbey trees (Leucaena leucocephala) well grown, and the prevalent silver-topped palms were replaced by the larger, more water-loving cabbage palmetto (Sabal palmetto). As many as 40 white-crowned pigeons might erupt from the standing water in this little sink hole, and others such as zenaida doves were common here. Agrion and red-bodied dragonflies were seen only here, presumably from nymphs in the well. Frogs were found only here, living with freshwater Erapsid crabs in burrows excavated by land crabs. Yellow and orange butterflies and whites were seen only here, their larvae having fed, probably on the higher crab grass and other vegetation of this anomalous area. This is the site where the giant centipede was found.

Birds feeding round the red and yellow ponds were recorded to tie in with invertebrate studies on the food potential, (lizards here fed on flies hatched from aquatic larvae) and birds and insects dependent on sea grape nectar and Ernodea fruits were determined.

Chlorophyll "A" Determinations

Abby Ames

Chlorophyll "a" was determined in surface samples from coastal and open ocean stations. As one measure of the standing crop of photosynthetic organisms, the concentration of chlorophyll "a" is also an index of potential productivity.

Stations H-3 through B-3 (Fig. 15) represent a transect from the Sargasso Sea to the upper Delaware Bay and contrasts the very abundant algal standing crop of the estuary with the desert-like oceanic gyres.

The low lagoonal productivity implied by these data does not take into account the presence of benthic grasses and algae which are important there. Primary productivity in Delaware Bay, on the other hand, is probably mainly associated with the phytoplankton.

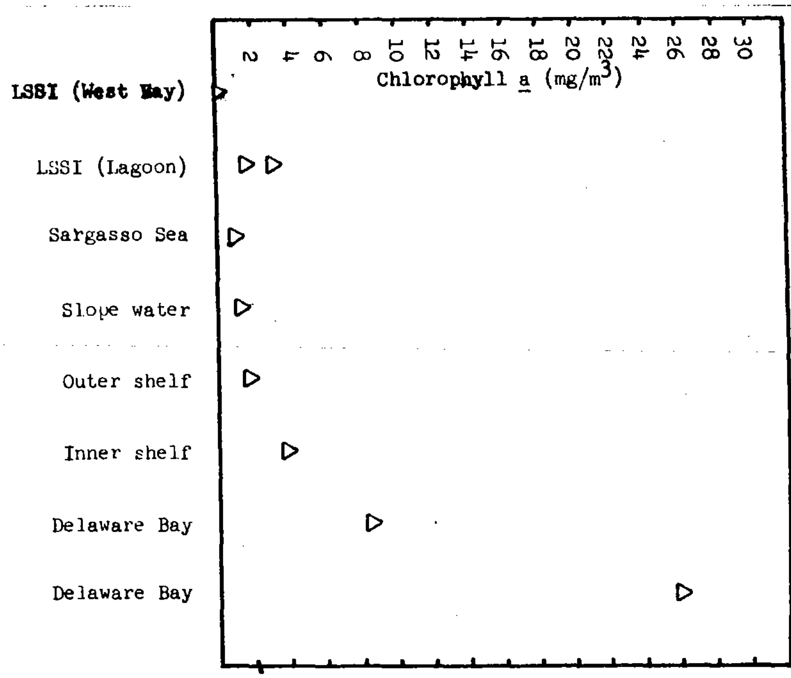


Fig. 15 Chlorophyll "a" concentrations for open ocean and coastal stations. W-45.

Observations on the West Wall of the Gulf Stream

At about 36°11'N, 73°28'W Westward crossed the west wall of the Gulf Stream. This was monitored by surface temperature (Fig. 16) and by a series of bathythermographs. We measured a drop in surface temperature of about 10°C in 17 nautical miles and a change in shipboard climate that made an impression on all aboard.

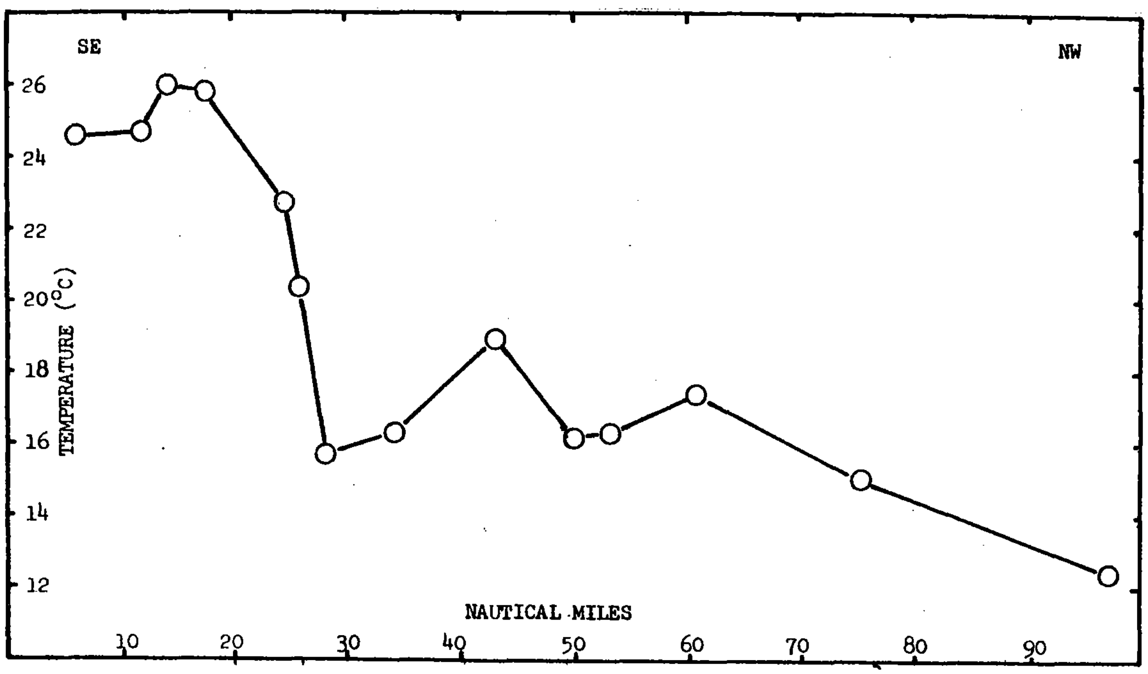


Fig. 16 Ocean surface temperatures associated with a transect across the west wall of the Gulf Stream. W-45

The attenuation of light in the ocean with special attention to the "sun burn" region of the ultraviolet

William McMahon

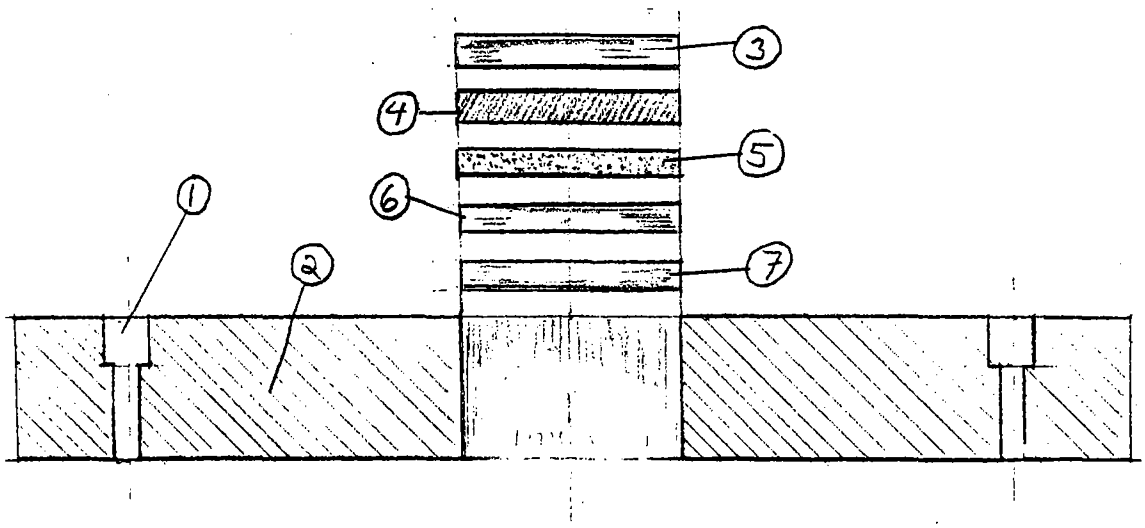
The so-called "sun burn" region of ultraviolet light (290-330 nm) has actinic properties and is therefore of biological significance. The attenuation of visible and UV light was measured at coastal and deep sea stations using a Kahlsico Submarine Irradiometer with a special modification, built by Dr. George Goldsmith of Boston College, for measuring the sun burn region (Fig. 17).

The results (Table 25) show that the UV energy penetrates deeper than energy associated with white light.

Table 25 Coefficients of attenuation for visible light and for ultraviolet calculated using data over a 3 meter seawater path length

Station #	Position		Visible	UV
1	Litte San		0.49	-
2	Salvador		0.49	-
3	26 N 79 W		-	0.45
4	30 N 79 W		1.73	0.75
5	35 N 74 W		0.28	-
6	36 N 73 W		0.35	-
7	37 N 73 W		0.30	0.05
8	37 N 73 W		-	0.05
9	38 N 74 W		0.33	-
10	Inner shelf	Delaware Bay	0.30	0.42
11	B-4	Delaware Bay	0.90	-
12	B-3	Delaware Bay	0.58	-
13	B-2	Delaware Bay	1/	-

1/ No detectable light at 3 meters. α for 2 meters was 5.9.



U.V. Transducer

1. Screw Hole (2)
2. Brass Flange
3. Quartz
4. UG-11
5. $MgWO_4$ Phosphor
6. Mylar (U.V. Absorbing)
7. Corning 4-96

Introduction

David Moss

The Delaware Bay estuary extends from the mouth of the Bay to Cape Henlopen and Cape May to Trenton. This 132 mile long system is a well mixed, coastal plain estuary with complex biological, chemical, and physical oceanographic qualities.

The estuary has endured short and long term biologic and geologic processes including: 1) tremendous suspended sediment movement, 2) sea level fluctuations, 3) tidal marsh buildup and degradation, 4) seasonal pulses of river discharge from 1200 cubic feet per second (CFS) to 14,000 CFS, and 5) fluctuation in speciation and abundance of biota. Historically, this unstable oceanographic environment has been the site of major commerce and shipping activities. The rich productivity of the waters is exemplified by large shellfish and finfish harvests, while the adjoining shorelands are characterized by rich farmlands and tidal marshlands.

A chemical and biological sampling program was undertaken by students aboard W-45 in the estuary. This work was designed to 1) add to the existing baseline data, and 2) introduce a system with oceanographic properties different from the open sea and tropical areas encountered during the first four weeks of W-45.

The data collected were used at the University of Pennsylvania seminar for comparing coastal estuarine systems and the open sea. Data obtained along a transect within the estuary (see Fig. 18) indicate possible effects of industrial and sewage effluents. The conflicting use of the Delaware estuary for recreation, commerce, and nature provided additional rationale for undertaking this research aboard Westward.

Discussion of Data

Salinity (5 0/00)

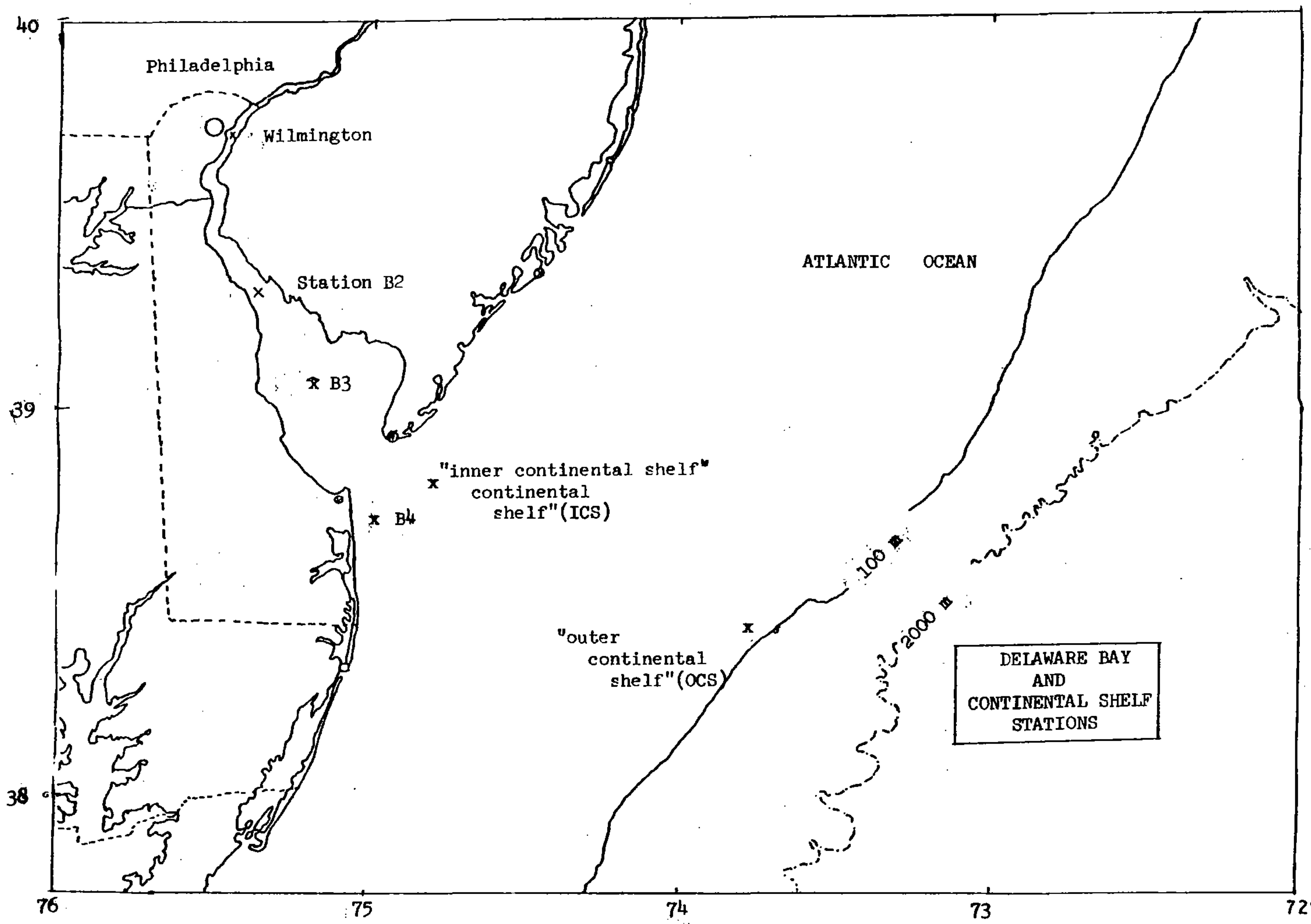
Salinity generally decreased along the transect from IS to B-2 (see Fig. 18). Values of 30 to 31 parts per thousand (ppt) at IS and B-4 were mostly uniform with depth and indicated dominance

Fig. 18 Data Table for Estuary Transect Delaware Bay W-45

Station	Depth (M)	Temp (°C)	Salinity (0/00)	DO (ml/l)	POC (μM)	NH_3 (μM)	PO_4 (μM)	Si (μM)
Inner shelf	0	14.1	30.22	6.90	540.93	0.00	0.00	0.00
	5	14.1	30.15	6.80	-	0.02	0.00	0.00
	10	14.0	30.40	6.80	-	0.01	0.00	0.00
	25	9.4	31.77	6.79	-	0.00	0.26	0.30
Bay 4	0	11.2	30.80	6.53	643.00	0.00	0.26	1.41
	5	10.4	31.00	6.38	-	0.00	0.16	1.17
	7	10.7	30.93	6.41	-	0.00	0.24	1.10
Bay 3	0	16.4	20.42	7.27	1261.00	0.17	0.05	0.97
	3	16.1	20.96	7.00	-	0.45	0.15	0.25
	5	15.7	22.12	6.79	-	0.47	0.19	1.48
Bay 2	0	18.6	5.77	5.33	-	2.52	3.10	44.20
	3	18.6	5.77	5.46	-	2.29	2.20	43.74
	6	18.6	5.71	5.43	-	2.61	2.87	43.23

Fig. 18a Description of Sampling Sites, Delaware Bay Estuary, W-45

Station	Position	Area	Distance (miles) from bay mouth	Station time (LST)	Tide	Remarks	Date
IS	$38^{\circ}12'$N $74^{\circ}45'$W	Inner shelf	43	0700		4 depths sampled	05/12/79
B-4	$38^{\circ}43.2'$N $75^{\circ}01'$W	Entrance to bay mouth	10	1300	Ebb	3 depths sampled	05/12/79
B-3	$39^{\circ}04'$N $75^{\circ}10'$W	Mid-bay	24	0700		3 depths sampled	05/13/79
B-2	$39^{\circ}19'$N $75^{\circ}24.5'$W	Upper bay	68	1815	Ebb	3 depths sampled	05/13/79


40
Philadelphia
Wilmington
Station B2
B3
39
"inner continental shelf"
continental
shelf"(ICS)
B4
ATLANTIC OCEAN
100 m
2000 m
"outer
continental
shelf"(OCS)
DELAWARE BAY
AND
CONTINENTAL SHELF
STATIONS
38
76
75
74
73
72

of ocean waters over Delaware river water flow. The B-3 station showed increased salinity with depth (surface = 20.42, bottom = 22.12) and is indicative of some mixing and layering of dense ocean waters below less dense river waters. The B-2 station had homogenously low values with depth, indicating dominance of river flow. Data taken in other years (Cronin, 1962) show that salinity can fluctuate within the estuary at each location as much as 5 ppt during each season. Our data indicates a winter and spring of heavy precipitation as evidenced by low salinity at B-2.

Temperature (^{o}C)

Slight surface warming was observed at all stations (see Fig. 18) except B-2 which was found to be homogenous with depth. The general increase in surface temperatures from IS to B-2 was expected although B-4 was considerably colder at three upper depths than the IS station. Colder waters at B-4 could have been due to the trapping of upwelled ocean waters inside the perimeter of Hens and Chickens Shoal at B-4. Decreased temperature at a depth of 5 meters at B-3 could be due to solar surface warming and warmer river and land runoff sources. Temperatures at IS, B-3, B-2 agreed well with data from previous investigations.

Dissolved Oxygen (DO)

DO values agreed well with past measurements (see Fig. 18). Slightly higher surface values at IS, B-4, and B-3 than at depth indicate greater photosynthetic activity and/or enrichment through atmospheric exchange . The average value of 5.41 ml/l at B-2 is considerably lower than values of Sharp (1977) and Cronin (1962). Decreased values could be indicative of biological oxygen demand (BOD) caused by detrital oxidation or industrial and sewage effluent loading.

Particulate Organic Carbon (POC)

Particulate Organic Carbon is a measure of live animals and plants as well as non-living detritus in the water column (see Fig. 18). In the estuary POC varies directly with detrital outflow from tidal marshes and blooms of phytoplankton and zooplankton. Composition of POC varies seasonally with living material dominating in summer and fall and detritus dominating in winter and spring.

A large increase in surface POC was recorded along the transect from IS to B-4 to B-3. This increase is due to a larger component of living material combined with increasing amounts of detritus. Although B-2 was not sampled for POC, a qualitative estimate revealed a much greater percentage of plant and animal detritus recently flushed out of the marshes. The reports of Ellis and C. Rich (this report) should be consulted for analysis of the living zooplankton and phytoplankton fractions along the transect.

Cronin (1962) found higher numbers of zooplanktons in the upper Bay area (similar to our B-2) in the spring over several years. Further study of the exact composition of POC in the estuary, i.e. living vs. detrital fractions, is needed. Examination in the future of seasonal variation in plankton abundance and speciation could be used as a baseline indicator of environmental perturbations.

Silicate ($SiOH_2$, $SiOH_4$)

Processes of mixing, dissolution, and biological uptake govern the concentration of reactive (dissolved) silicate in the water column (see Fig. 18). Data for B-4 and B-3 agree with previous measurements in spring (see Sharp, 1977). Undetectable concentrations at IS station indicate that silicate was a growth limiting factor during our sampling period. A recent bloom or slow mixing could account for the undetectable measurements. Extremely high values of >43 μM/l at B-2 is probably indicative of marsh sources derived from edaphic algae, diatoms and silica flagellates.

Ammonia and Phosphate (NH_4^+, PO_4) (see Fig. 18)

Ammonium and phosphate concentrations are regulated by biological uptake, decay, and water column mixing rates. When light is not limiting, the recycling of these and other nutrients to surface waters is the most important factor governing primary productivity. Estuaries generally have high productivity due to rapid resuspension of nutrients. Industrial and sewage effluents, however, can be a dominant source of NH_4 and PO_4.

Low values of PO_4 at IS and B-3 could indicate bio-limiting uptake rates. Very high values of 2.2 to 3.1 µM/l at B-2 could be due to marsh flushed sources but is also likely to be derived from an effluent source. Uptake rates by microzooplankters and phytoplankton were not sufficient to cause significant depletion in PO_4 . The range of PO_4 values at B-4 and B-3 correspond to previous data (Sharp, 1977). Values at IS and B-2 were lower and higher, respectively, than expected.

NH_4^+ is recycled at a slower rate than PO_4. Values in the ocean usually reflect surface depletion and deeper zone enrichment. NH_4^+ and NO_3^{-2} are the preferred forms of nitrogen for phytoplankton uptake, but NH_4 is the first breakdown product of particulate organic nitrogen (PON) by action of bacteria.

Low values of NH_4^+ at IS, B-4 and B-3 are indicative of biological uptake and oxidation of PON to other forms. Values of 2 to 3 µM/l at B-2 are plausible in nature but could be indicative of effluent sources.

Summary
Characterization of an entire estuarine system is not possible based on duplicate sampling over a two day period for nutrients, oxygen, salinity, temperature, zooplankton and phytoplankton. As a training exercise for Westward students, however, the sampling and analyses of estuarine waters provided preliminary baseline data of great value for comparative purposes with other cruise data.

Data at station B-2, with high PO_4 and NH_4 values, low DO values and high silicate values, could be indicating the presence of upper estuary industrial and sewage effluents. Low values of NH_4, PO_4 and $Si(OH)_2$ and higher DO at IS and B-4 stations seem to indicate biologically productive areas. The Bay and adjacent

oceanic waters continue to be viable, productive areas while upper estuary locations are affected by effluents and pertubations capable of altering the natural conservative - nonconservative properties of chemical constituents.

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Phytoplankton diversity along the Delaware Bay transect

Christopher Rich

Surface net samples (0.170 mm mesh) from Delaware Bay and the inner continental shelf were examined for phytoplankton. (Table 26). Greatest phytoplankton concentration occurred at the mouth of the Bay where *Biddulphia sp*. was a heavy dominant and diversity, therefore, was lowest of all stations sampled (Table 27). Phytoplankton concentrations at other Bay stations decreased up-estuary while the number of species and species diversity increased. The inner shelf station was characterized by intermediate diversity and relative evenness among the dominant species.

These data suggest a peak in environmental variability or stress at the mouth of the Bay.

Table 26 Dominant phytoplankton species in samples from the Delaware Bay transect. April 10-14. W-45

STATION	L	SPECIES LIST	#/liter
ISS	1)	Biddulphia sp.	12.8
	2)	Ceratium fusus	3.5
	3)	Ceratium tripos	1.6
	4)	Ceratium lineatum	0.2
	5)	Ceratium macroceros	0.2
B-4	1)	Biddulphia sp.	1255
	2)	Ceratium fusus	1.9
	3)	Ceratium tripos	0.9
	4)	Rhizosolenia sp.	0.9
	5)	Coscinodiscus sp.	0.9
	6)	Navicula sp.	0.5
	7)	Unknown A	0.5
B-3	1)	Unknown B	261.9
	2)	Biddulphia sp.	246.5
	3)	Rhizosolenia sp.	0.3
	4)	Coscinodiscus sp.	0.1
	5)	Asterionella japonica	0.1
	6)	Navicula sp.	0.1
	7)	Ceratium fusus	0.1
	8)	Ceratium tripos	0.1

Table 26 (cont.)

	1)	Unknown B	24
	2)	Coscinodiscus sp.	16
	3)	Scenedesnus sp.	8
	4)	Rhizosolenia sp.	8
B-2'	5)	Navicula sp.	8
	6)	pennate diatom #1	8
	7)	pennate diatom #2	8
	8)	Ceratium fusus	4.8
	9)	Ceratium tripos	4.8
	10)	Biddulphia regia	3.2

Table 27 Phytoplankton species diversity along the Delaware Bay transect.

Station	ISS	B-4	B-3	B-2
Total # of species (S)	5	7	8	10
Total individuals per liter	18.3	1260.1	509.2	92.8
Species diversity index	3.2	1.9	2.6	4.6
N/S	3.7	180.1	63.7	9.3

The distribution of brachyuryan crab larvae in Delaware Bay

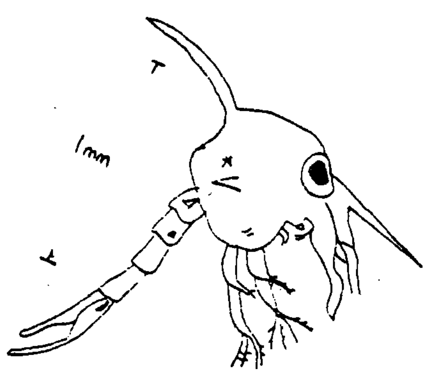
Laura Ellis

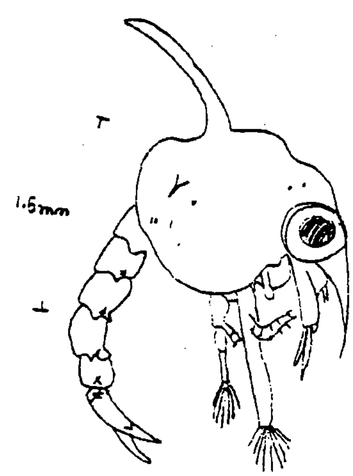
Abstract

The occurrence and distribution of brachuryan crab larvae was studied along a transect from the outer continental shelf up the Delaware estuary. Zooplankton samples were collected at five stations using a bongo plankton net with a mesh size of .333 mm. Hydrographic data including temperature and salinity was obtained at each station. Quantitative counts of the major constituents of each sample were made. Zoea, brachuryan larvae, were found at every station except the upper bay in salinities ranging from 33 0/00 to 22 0/00 (Table 28). The largest percentage of zoea was found at the inner shelf station where the catch consisted entirely of zoea.

Table 28 Results of zooplankton observations for the Delaware Bay transect. W-45.

Station	Date	Time	Volume of sample (cc/m^3)	Salinity (0/00)	Temp. (°C)	# Dominant species	Percentage zoea
Upper bay (B2)	05/13/79	1815	10.7	5.71	18.61	2	0
Mid bay (B3)	05/13/79	0700	4.1	22.12	15.70	3	30
Bay mouth (B4)	05/12/79	1300	1.4	31.00	10.40	4	3.4
Inner shelf (IS)	05/12/79	0700	3.0	30.15	14.10	1	100
Outer shelf (OCS)	05/10/79	1350	10.3	32.74	13.97	5	2.8





Dissolved copper along the Delaware Bay transect

Robert P. O'Neil

Water column copper concentrations were determined in samples from Baltimore Canyon (OCS) to Wilmington, Delaware (Table 29). The results indicate highest values at the mouth of the Bay (26 ppb) with decreasing values seaward and up-estuary. This distribution cannot be explained either in terms of dilution of pure seawater with contaminated freshwater or vice versa. The evenness of the gradient suggests a relatively constant source at the mouth of the Bay with dilution landward and seaward by mixing processes. It may be significant that the distribution of copper is inversely related to species diversity.

Table 29 Dissolved copper in samples from the Delaware Bay transect. April 10-15, 1979. W-45.

Sample #	Position of sample	Surface or Bottom	Depth of Bottom (meters)	Temp. of water (°C)	Salinity (ppt)	Flood or ebb	Dissolved Cu (ppb)
5 (OCS)	38 10.5 N	S		13.90	32.74		0
	73 52 W						0
3 (B4)	38 42.4 N	S		10.65	30.86	Ebb	26.0
	75 01.8 W						27.3
4 (B4)	38 42.0 N	B	5	11.18	30.92	Ebb	22.2
	75 01.8 W						21.0
1 (B3)	39 05.2 N	S		16.35	20.42	Flood	10.2
	75 10.3 W						10.2
2 (B3)	39 04.9 N	B	6	15.70	22.12	Flood	21.6
	75 10.3 W						21.0
7 (B2)	39 20.2 N	S		18.62	5.77	Flood	9.5
	75 26.3 W						8.3
6 (B2)	39 20.2 N	B	5	18.60	5.71	Flood	12.7
	75 26.3 W						13.3
9 (Wilm)	39 40.5 N	S		19.10	0.2	Ebb	12.7
	75 30.2 W						12.1
8 (Wilm)	39 40.5 N	B	5	19.02	0.2	Ebb	13.3
	75 30.2 W						13.3

ACKNOWLEDGEMENTS

Many people extended often critical help in the course of this cruise. Mr. Allen Butler, of Nassau, and Mr. Kingdon Gould of Washington, helped initiate our Little San Salvador Island plans and Mr. Oris Russell, Mr. Claude Smith and Mr. Colin Higgs played essential roles in our receipt of a Bahamian research clearance. I am indebted to Mr. Roderick Attrill of the Bahamas National Trust, for his logistical assistance and to Dr. Donovan Correll, Fairchild Tropical Gardens, whose guidance in planning the cruise was most useful. Dr. Arthur Humphrey, Dr. Britton Chance and Mr. Francis Ballard accommodated our needs at Philadelphia.

Students were assisted in planning their work by Dr. George Goldsmith, Boston College; Dr. Bruce Corliss and Dr. Robert Guillard of Woods Hole Oceanographic Institution; and Dr. Carl Berg and Mr. Allen Poole of the Marine Biological Laboratory.

On behalf of the participants in W-45 I wish to thank Ms. Judy Fenwick who produced this manuscript from our not always coherent shipboard reports.

APPENDICES

Appendix A Introduction to Marine Science
Final Examination: Part I - Essay
May 19, 1979, Harbor of Refuge, Cape Henelopen

Answer one of the following. Be as specific as possible and draw on as much of the lecture material of this course as applicable. Open book. Return this examination to the aft cabin before 12:30 (3-1/2 hours).

I. The existence of certain types of communities in otherwise barren or different areas depends upon the creation of a special environment by organisms themselves. Discuss this statement using the Sargassum community, the mangrove community or a community of your own choice. Define the environment created, the role of each organism in it and define characteristics or system characteristics that may account for stability of the community.

II. Many, or perhaps all, of the differences between the open ocean environment and those of the tropical lagoon and the estuary result directly or indirectly from geometrical aspects of the landform containing these coastal bodies of water. Using the estuary or lagoon as an example, discuss this statement. How does shape affect other properties of these physical, chemical, biological and geological systems relative to the open ocean.

III. Write and answer a question which draws on important and broad aspects of your scientific experience during the Strombus expedition. Include with your answer a justification of the question.

Appendix B

The Strombus Expedition

University of Pennsylvania Symposium
May 17, 1979
Towne Building

Morning Session A - Little San Salvador Island Studies

(Session Chairman - A. Gaines)

Introduction (Gaines)
Vegetation (Hornor)
Birds (Johnson)
The Lagoon
Bathymetry (DeCarlo)
Sediment geology (Gentile)
Sedimentary foraminifera (Rich)
Sediment reworking by infauna (Hornor)
Hydrography I: Oxygen, phosphorus and silica (Wilson)
Hydrography II: Salinity, ammonia and particulate organic matter (Bovard)
Hydrography III: Tidal flushing and residence time (Silverstein)
Light penetration
The phytoplankton (Burzycki)
The zooplankton (Polan)

Studies on the queen conch (Strombus gigas)

(Session Chairman - R. Visnick)

Introduction (Cataldo)
Census and population studies (Visnick)
Predators (Seligson)
Food sources (Nadworny)
Physiological studies (Cataldo)
Movement and motility (Siebert)

LUNCH

Afternoon Session A - Immunological Studies

(Session Chairman - C. Reinisch)

Titles to be announced. Papers by LaFond, Miniter, Fitzpatrick Collins and Tedesco.

Afternoon Session B - Open Ocean Studies

(Session Chairman - A. Ames)

Introduction (Ames)
Hydrostations
Tongue of the Ocean (OTEC) (Ames)
Deep ocean station (Sargasso Sea) (Burzycki)
Slope Water station
Outer Shelf station (Baltimore Canyon) (Wilson)
Inner Shelf station (Wilson)
Temperature structure (Johnson)

Sargassum Community Studies

- Neuston samples (Fitzpatrick)
- Biomass distributions (Fitzpatrick)
- Standing crop (Fitzpatrick)
- Primary productivity of Sargassum (Ames)
- Sargassum community population studies (Ames)

INTERMISSION

Afternoon Session C - Delware Bay Investigations

(Session Chairman - D. Moss)

- Introduction (Moss)
- Hydrography (Moss)
- Phytoplankton diversity (Rich)
- The distribution of brachyuran crab zoea (Ellis)
- Light attenuation (McMahon)
- Distribution of dissolved copper (O'Neil)

Appendix C W-45 research proposal for Little San Salvador Island (1/25/79).

RESEARCH PROPOSAL

Little San Salvador Island

Title: The Natural History of Little San Salvador Island (The Strombus Expedition)

Chief Scientist: Dr. Arthur G. Gaines, Jr., Sea Education Association, Woods Hole, MA 02543

Dates of Study: April 16-April 27, 1979

Statement of Objectives:

A multidisciplinary scientific investigation will be conducted at Little San Salvador Island with the following compatible objectives.

1. To offer an undergraduate field course in the marine and nautical sciences as part of Sea Semester. (NS 225 and NS 226 at Boston University)

2. To examine the occurrence and autecology of *Strombus gigas*, the queen conch, in Little San Salvador Lagoon with a view toward aquaculture potential.

3. To examine Little San Salvador Lagoon as a tropical marine environment.

4. To outline aspects of the terrestrial natural history of Little San Salvador Island.

5. To prepare herbarium specimens of the flora of Little San Salvador Island.

6. To study aspects of the immunology and physiology of tropical marine invertebrates.

Staff:

A. Sea Education Association (Academic Coordinator, Dr. Arthur Gaines)

Mr. Donald Thomson, Head of Nautical Science

Dr. Arthur Gaines, Chief Scientist
Ms. Abby Ames

Students - Twenty-four undergraduate students.

B. Visiting Scientists

Mr. Rod Attrill, The Bahamas National Trust
Dr. Donovan Correll, Fairchild Tropical Garden
Dr. Mary Gillham, The University of Wales, Cardiff, U.K.
Mr. Sheldon Pratt, The University of Rhode Island
Dr. Carol Reinisch, Harvard Medical School

Itinerary:

April 11	-	Westward departs Key West.
April 16	-	Westward arrives Nassau, enter customs. Visiting Scientists arrive at Nassau by plane. Meeting of staff. Reception for interested parties.
April 17	-	Westward departs Nassau.
April 19	-	Westward arrives at Little San Salvador Island. Visiting Scientists depart Nassau by plane and arrive at Little San Salvador Island. Set up shore base at Little San Salvador Island. Begin scientific work.
April 22	-	Westward departs Little San Salvador Island for coastal work. Visiting Scientists remain ashore.
April 24	-	Westward returns to Little San Salvador Island.
April 25	-	Complete scientific work and dismantle shore base. Visiting Scientists leave Little San Salvador Island by plane and arrive at Nassau. Westward departs Little San Salvador Island.
April 27	-	Westward arrives Nassau. Off loading of herbarium specimens. Clearing customs.
April 28	-	Westward departs Nassau.
May 23	-	Westward arrives at Woods Hole, Massachusetts, the terminal port.

Sampling:

The major sampling will be of terrestrial vegetation by Dr. Correll who hopes to make as complete a collection as possible of the flora on the island.

Other programs will involve limited sampling of sediments, plankton, benthic organisms, fishes and corals. Birds, reptiles, and mammals will not be sampled. All marine samples will be analysed aboard ship or used for immediate teaching purposes.

Reports and Data:

Copies of reports and papers arising from this research will be made available to the Bahamas Government, the island owners and the Bahamas National Trust.

Logistics:

All equipment and personnel, except Visiting Scientists, will be transported aboard the R/V Westward, a 220 ton schooner equipped for oceanographic research. Visiting Scientists will be transported between Nassau and the Island by amphibious plane. Alternatively they may travel between Nassau and Eleuthra by scheduled flight and between Eleuthra and the Island by chartered boat.

All personnel except Visiting Scientists will eat and sleep aboard ship. Visiting Scientists will camp on the Island in a temporary shore base established there and will be provided food from the ship or can dine on board.

A portion of the students and ship staff will spend days ashore participating in or assisting Visiting Scientists in scientific research and survey work.

The R/V Westward carries medical supplies and redundant communications facilities. Radio communication will be established between the ship and shore base and between the ship and Nassau (either directly by SSB or via the high seas operator).

att.

1/25/79

ORGANIZATION OF THE STROMBUS EXPEDITION