DOCUMENT RESUME

ED 207 844 SE 035 709

AUTHOR Schlenker, Richard M.; Perry, Constance M.
TITLE Writing Guide for Student Oceanography and Marine Biology Field Research Reports.
PUB DATE Apr 81
NOTE 112p.; Contains occasional light and broken type.

EDRS PRICE MF01/PC05 Plus Postage.
DESCRIPTORS *College Science; Environmental Research; Field Studies; *Guidelines; Higher Education; *Marine Biology; *Oceanography; *Research Reports; Science Education; Scientific Methodology; Scientific Research; Secondary Education; Secondary School Science; Student Research; *Technical Writing

ABSTRACT

Guidelines are presented for oceanography students and others who conduct field investigations to assist them in writing research reports. The discussion not only focuses on report writing but also emphasizes data gathering and library research techniques. Topics include introduction to research reports, conducting field research, tools and aids for report writing, and format. Three sample research problems and their associated reports are included which illustrate the procedures and guidelines. (DC)

WRITING GUIDE FOR STUDENT OCEANOGRAPHY AND MARINE BIOLOGY FIELD RESEARCH REPORTS

by

Richard M. Schlenker
Department of Arts & Science
Maine Maritime Academy
Castine, Maine 04421

Constance M. Perry
College of Education
University of Maine
Orono, Maine 04469

April 1981

Table of Contents

FORWARD

PURPOSE OF THE GUIDE. Students, generally speaking, conduct field research for four reasons. First, instructors use the conduct of research as a teaching method. That is, the research projects students conduct are designed to support and amplify conceptually important lecture material.

Second, field research affords students an opportunity to investigate problems in which they have strong interests. Research of this type is found in upper level undergraduate and graduate courses. It usually is conducted as an addendum to normal course work.

Students also conduct research because they must write honors papers, theses and dissertations respectively as parts of their bachelors, masters, and doctoral degrees. Except in the case of honors papers, such research is conducted independent of organized courses (except that a project may be designed as part of a graduate level research course).

Perhaps the final reason why college professors have their students conduct research is that it gives the students a chance to dabble in and experience the research process. The purpose here is to introduce students to some of the problems encountered when research projects are undertaken. A goal of this approach is to foster development by students of healthy respect for scientific evidence while at the same time maintaining a healthy skepticism for the same evidence.

Data gathering is a major portion of each research project. Information is gathered in this segment of each research project and serves as a point of departure. When data are evaluated, as many variables as possible are held constant while, if possible, a single parameter is allowed to vary. As the procedure continues different parameters are held constant while others are allowed to vary. Trends and relationships observed as the process proceeds theoretically lead students to either make generalizations regarding research questions under investigation or accept or reject hypotheses formulated prior to gathering the data. Whatever the case, when research projects are intended to be teaching methods, the generalizations drawn from data usually support concepts present in lectures. Once research generalizations and lecture material are integrated students have a more well-rounded picture of a subject than possible if either the lecture or the research was conducted in isolation.

Writing a research report is the final and perhaps most difficult step in any research project. The report includes information from library and other reference sources and interpretations and conclusions drawn from observations and data manipulations.

The objective of this guide is to provide Oceanography students with a number of aids which should help them in research report writing. In this regard, we stress not only aids to final report writing but also make suggestions about the data gathering and library research phases of a project.

Although this guide was written specifically for use by Oceanography students we feel its principles may be applied to field investigations and reports regardless of the discipline.

RMS
CMP

CHAPTER 1

INTRODUCTION TO RESEARCH REPORTS

I. Definitions of Research Reports

A. A Final Step. A research report or paper is the product of a long series of events. These events usually begin when an investigator seeks the answer to some perplexing question or questions. As answers are sought, the researcher, (1) reads the reports of other investigators who have conducted research in the same or similar areas of endeavor, (2) gathers data and, (3) evaluates and interprets his or her findings.

B. A Link. Once research has been reported the findings become another link in a research chain. The additional link allows those who follow to carry on where the particular piece of research terminated.

C. Method of Communication. Research reports are a method of communication. They notify readers of research findings and the way the findings were interpreted. As such these reports include a rationale or reasons why an investigation was conducted, methods that were used in data gathering, the actual data, a discussion of the findings and conclusions drawn as a result of the findings.

D. Complete Documents. Research reports are complete documents. Each must stand on its own. It must be understandable to its readers even though they may not be well versed in research conducted prior to the project being reported. In addition, a report must be understandable even though those who read it were not present when the data were gathered or had no knowledge of the project prior to reading the report.

II. Research Report Quality

Research reports which meet the few simple criteria outlined above are assets to the literature. The results of the research they report are valuable to both the research community and the general readership. They provide another link in man's understanding of the phenomenon which was investigated. Conversely reports that are vague or in some way incomplete are a waste of both the writer's and the reader's time. Research report writers, therefore, must always strive for excellence.

References

Schlenker, R.M. and Perry, C.M. A writing guide for student oceanography laboratory and field research reports. Resources in Education, ERIC Ed 178 332, March 1980.

CHAPTER 2

CONDUCT OF FIELD RESEARCH

Each research project has several phases. They include searching the literature, equipment setup, data gathering, data analysis and research report writing. The first four phases are discussed here.

I. Searching the Literature

The first step in conducting research of any kind is to search the literature. Literature searches are accomplished for several reasons. The most important reason, for beginning science students, is that they learn what other researchers and writers have to say about the problem under investigation. As the search proceeds students read text books, general articles and reports related to the problem they are investigating. The majority of citations germaine to a research project are located by consulting the card catalogues and abstracting services maintained by most libraries.

A. Card Catalogues. Card catalogues include references categorized by subject and author. Unless you desire to read something written by a specific author. However, it is most expedient to search for texts using subject name classifications. All students need do is consult the particular subject name in which they are interested (arranged alphabetically in the card catalogue). This should produce the reference numbers for all books of that subject held by a library.

B. Abstracting Services. Abstracting services publish periodic listings of articles and research reports (usually in specific academic area). Each list covers a specific time period reflected by the frequency with which the listing is issued. For example, let's consider Oceanic Abstracts, June 1980. First, the title suggests that the service deals with ocean related topics. Second the word "June" indicates the document is probably issued twelve times each year and this issue cites articles and reports published prior to the June publication date. Finally, 1980 indicates the year the particular issue of the abstract was published. But that's not the entire story; students must know more about abstracting services if the services are to be used to full advantage. They must know from whence citations in the Abstracting Service Listing originate and how they are categorized.

1. Origins of Citations. Documents cited by a particular service most often were published previously in some periodical. Students who do a through job literature searching are aware of the periodicals an abstracting service covers. A list of these periodicals is usually included in the first few pages of each issue published by the service. Periodicals not included in this list are not covered by the service. In Ocean Abstracts, June 1980, for example, you would expect to find citations of ocean realted documents published in the periodicals listed at the beginning of that issue.

Students interested in documents published in speicific periodicals should consult the periodical listing prior to using the service. A number of services dealing with marine oriented articles are listed at the end of this chapter.

2. Thoroughness of Search. It is often important to locate all documents published about a subject during a speicific time frame. This task may be accomplished by consulting a number of abstracting services. It is therefore imperative that students keep a list of periodicals abstracted by the services they use.

3. Technicality of Citations. Some services abstract highly technical

journals while other deal with more general and popularized periodicals. At this juncture researchers should note the type publications covered by abstracting services and then use those which fit their needs.

4. Finding Citations. Abstracting services list citations in several ways. Some of those in common use are by institutions, authors and key words. The key word method should be used by beginning student researchers.

a. Key Words. Key words, sometimes called descriptors, are words used to identify subjects or categories of subjects. Oceanography, for example may be divided into several subtopics, each with its own key word label. The subtopics in turn may be further divided by more narrowly defined key words. In 1979, Oceanic Abstracts used approximately 7400 different terms to categorize the documents it listed. They ranged from Abalones to Zygotes, dividing the ocean in almost every conceivable way.

There are at least three types of descriptors; broad terms, narrower .. ms and related terms.

i. Broad Terms. Broad terms identify the most general categories of classification. Key words such as navigation, reefs, sediments and ships are cons ered broad. All documents, published within a time period in periodicals abstrac.. y a service, which are somehow related to one of these descriptors are listed in the abstract issue under the respective broad term. An article about weather data gathering weather ships would be listed under ships.

ii. Related Terms. Related terms are terms somehow related to a broad topic. They direct researchers to other areas where useful information might be found. In addition, they identify subject headings under which some of the same aritcles listed under a main topic of interest are also listed. The article about weather ships, for example, might also be listed under the broad term, "weather" since weather and weather ships are related. Weather and Weather Ships, therefore, are related terms.

b. Citations are also listed under the authors' last names. As was mentioned in the Card File discussion citations so listed, are valuable to students interested in finding the work of specific authors.

c. Institutions. Articles are sometimes listed by the institutions from whence they originate. Such documents are often research reports relfecting work accomplished on large and often grant funded projects. In many cases the institutions are the authors of documents while individual authors and compilators remain anonymous.

d. References Sections of Other Papers. Each time a document is read the references section of the work should be checked. This is an extremely wealthy source of information, providing leads to work often missed when other literature searching strategies are used.

e. Researcher Thought Processes. Students must realize that it is easy to miss (not locate) a key article or text. Herein lies perhaps the biggest problem encountered by all beginning researchers. There is no absolute way to prevent its occurrence. The probability that key documents may be missed is, however, minimized if students spend a few moments outlining their searching strategies prior to the start of an actual literature search.

As outlines are developed, an attempt should be made to list all possible key words relevant to a project. The more able students are to divide a subject exactly as it was by the professional abstractor the more likely they are not to miss a paper critical to their own research.

II. Equipment Setup

Data gathering equipment setups are based upon the results of anticedent operations. When the scientific method is used to solve problems observations, literature searches and formulation of hypotheses preceed the actual investigation.

A. Observations. Observations are the first step in the research chain. It is through perceptions gained during one's observations that inquisition is stimulated. This occurs because the precepts suggest something in a setting to be odd, unusual or theretofore uninvestigated. Observations are motivators of literature searches.

B. Literature Search. Literature searches are conducted to gain insight. When conducted correctly they should locate information already known about questions which surface as a result of a researcher's observations. One might observe, as a result of a single Bathythermograph drop, for example, that water temperature in a channel decreases as depth increases. The observation might cause students to question whether such a relationship exists at other research stations or at other geographic locations. A literature search should locate research reports and articles dealing with the temperature depth relationship in areas similar to the one in which the initial observation was made.

C. Formulation of Hypotheses. Hypotheses are educated guesses about the answers to questions arising from a researcher's observations. Often, such questions cannot be answered completely by information found in the literature. Based upon the results of both the bathythermograph drop discussed above and the results of an associated literature search regarding the water temperature-depth relationship, a researcher might hypothesize; that water temperature in the channel under investigation decreases with increasing depth. Acceptance or rejection of the hypothesis then depends upon interpretation evidence gathered during the data collection phase of the project.

D. Research Setting. This is the geographic location where data are gathered. It therefore is the location at which data gathering equipment is setup.

The mark of all good research is that it can be replicated at some future date by someone other than the original investigator. Replication, depends upon the quality of the original final report. The production of high quality reports in turn depends upon all of the information gathered in the field. Ways in which equipment was setup should be part of that data bank.

Field notebooks are used specifically for the purpose of recording equipment setups, data gathered from the equipment and weather conditions at the time data were gathered.

1. Field Notebooks. Field notebooks are notebooks used in the field to record moment by moment observations. The notebooks are extremely important because they allow students to review the time spent in the field. They contain a handwritten collection of notes taken the moment observations were made. They should include all information relevant to an investigation or which might have some bearing upon an investigation's outcome. The section of a notebook dealing with a specific data gathering session probably includes the date and time of day data were gathered, weather conditions at the time data were gathered (including but not limited to air and water temperatures, height of tide, percent and type of cloud cover and sea conditions), equipment employed in the data gathering operation, how the equipment was employed (including sketches of equipment setups), numbers and names of people engaged in the investigation and the actual data collected during the session. Samples of suggested field notebook pages are located in Appendix A.

a. Timely Field Notebook Entries. Entries reflecting the events of a data gathering session should not be made after the session has concluded. Our memories fade rapidly. Recollections of the past are often vague.

Late entries often lack the crisp details of notes taken the moment an observation is made.

b. Use of Field Notebook Information. The information contained in the field notebook is the basis for the majority of an investigator's research report. Poorly and/or inadequately kept notebooks lead to final reports that are poor, inadequate or have some other unrectifiable problem which prevents the research from being replicated.

III. Gathering Data.

Raw data is recorded in a field notebook the moment it becomes available. Each datum is recorded as precisly as possible. It is from raw data that inferences are eventually drawn and extrapolations made. It behooves empiricists to make coeherent hand drawn Tables in their field notebooks before they begin recording data. Figrue 1 provides an example of such a Table.

Station	1/2 M² AREAS											
	1			2			3			4		
	C	S	R	C	S	R	C	S	R	C	S	R
1	20	0	12	25	2	4	25	4	0	30	8	0
2	19	0	7	20	1	6	24	3	0	21	9	0
3	15	0	16	22	3	4	20	6	0	19	10	0
4	11	0	10	21	2	7	22	8	0	28	11	0
5	12	0	17	18	0	2	19	7	0	15	7	0
6	10	0	10	20	1	1	23	9	0	19	8	0
7	14	0	3	22	2	6	24	5	0	24	12	0
8	29	0	8	24	1	7	27	8	0	26	14	0
9	10	0	16	20	3	5	30	4	0	28	12	0
10	24	0	5	21	3	3	15	7	0	19	13	0

Figure 1. An Example of a Hand Drawn Field Notebook Table.

Here, the researcher was interested in population numbers of common (C), rough (R) and smooth (S) periwinkles at four different heights (1, 2, 3, 4) within the intertidal zone. Population numbers were counted in a ½ meter square area at each height of ten different transects (1, 2, 3, 4, 5, 6, 7, 8, 9, 10). As Can be seen raw data recorded in this fashion is clear concise and coherent.

IV. Data Analysis.

Data analysis involves manipulation of parameters germane to a problem in an effort to establish trends. The process inasmuch as is possible calls for control of all but one variable in a problem while that parameter is allowed to vary from one station to another, one time to another and so on. When subsurface current patterns are investigated in an estuary, it is necessary first to systematically measure (a function of the research design) currents down through the water column at several different locations. The task is often accomplished using a remote current sensing device. To naive students, this process yields sufficient data from which to seek trends. They think that all one need do is compare the current at the same depth across several stations to establish trends. There is, however, a bit of falacious reasoning here. The depth of most oceanic water masses change continually as the tide ebbs and floods. Although depth at which sampling takes place is held constant the depth of observances from one station to another may be different when the surface is corrected to reflect mean high water. If a data evaluation is to be meaningful, all stations must be adjusted to mean high water before trends are sought. Then and only then is it possible to look at current directions or speeds at a given specific depth across a number of stations. Similar logic is used whenever data are manipulated.

A. Data Evaluation and Manipulation Aids.

1. Charts. A chart of the research area is essential to success. It allows research stations to be pinpointed and makes a variety of other information readily available. National Ocean Survey Charts of the east coast of the

United States, for example, provide water depths computed to mean low water.

2. <u>Tide Tables</u>. Tide tables, published annually by the U.S. Department of Commerce, National Ocean Survey, provide daily predictions for 196 reference ports and tidal difference data for about 6000 stations. The "Tide Tables, East coast of North and South America Including Greenland" includes six separate and different Tables. They are; (1) Daily Tide Predictions; (2) Tidal Differences and other Constants, (3) Height of Tide at any Time, (4) Local Mean Time of Sunrise and Sunset, (5) Preduction of Local Mean Time to Standard Time and, (6) Moonrise and Moonset. Tables 1, 2, and 3 are of specific interest to us here.

a. <u>Daily Tide Predictions</u>. Figure 2 shows a typical page from this Table. It is Page 32 of the 1979 tables of the East Coast. Here we find the predicted times and heights of the high and low water at the Portland, Maine reference station during January, February and March 1980. The complete table provides predictions for each day of the year at each reference station.

This Figure also includes several other data. Each day in the day column, is identified by letters and numbers reflecting the day of the week and the numerical day of the month. The times of each high and low tide are also included as well as the height of each tide above mean low water.

Tide heights are measured above mean low water, indicated as 0.0 ft. A low tide occured on Thursday, February 8, 1979 at 1503 and its height was 0.0 or mean low water. The low water figure indicates the lowest level to which the water falls during a tide at a reference station. Figures for high tide are indicated in feet above mean low water. Minus figures for low tides mean that the lowest water levels of the tides are the indicated number of feet below mean low water. The 1.1 ft. at 0623 on January 1, 1979 means during that low tide the water level will fall to -1.1 feet below mean low water (researchers

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

JANUARY						FEBRUARY						MARCH					
DAY	TIME h.m.	HT. ft.	DAY	TIME h.m.	HT. ft.	DAY	TIME h.m.	HT. ft.	DAY	TIME h.m.	HT. ft.	DAY	TIME h.m.	HT. ft.	DAY	TIME h.m.	HT. ft.
1	0024	9.8	16	0045	8.3	1	0152	10.2	16	0123	8.7	1	0036	10.6	16	0018	9.1
M	0623	-1.1	TU	0641	0.5	TH	0800	-1.2	F	0731	0.2	TH	0648	-1.7	F	0627	-0.2
	1238	11.0		1250	9.0		1413	10.2		1339	8.7		1259	10.6		1235	9.0
	1902	-2.2		1910	-0.3		2029	-1.4		1949	0.0		1913	-1.6		1843	-0.1
2	0118	9.9	17	0120	8.3	2	0247	9.9	17	0200	8.7	2	0126	10.4	17	0052	9.2
TU	0720	-1.0	W	0718	0.5	F	0900	-0.9	SA	0811	0.2	F	0741	-1.4	SA	0706	-0.2
	1332	10.7		1328	8.8		1511	9.5		1421	8.5		1354	10.0		1311	8.8
	1957	-1.9		1947	-0.1		2124	-0.8		2027	0.2		2003	-1.1		1919	0.1
3	0213	9.8	18	0158	8.3	3	0343	9.6	18	0243	8.7	3	0218	10.1	18	0129	9.2
W	0819	-0.8	TH	0800	0.6	SA	1002	-0.4	SU	0858	0.3	SA	0835	-1.0	SU	0744	-0.2
	1430	10.2		1406	8.6		1614	8.8		1504	8.2		1448	9.3		1356	8.6
	2053	-1.5		2023	0.1		2225	-0.2		2112	0.4		2055	-0.4		1958	0.2
4	0311	9.6	19	0237	8.2	4	0443	9.2	19	0328	8.7	4	0312	9.6	19	0211	9.2
TH	0920	-0.5	F	0843	0.7	SU	1106	-0.1	M	0949	0.4	SU	0933	-0.4	M	0831	-0.1
	1532	9.6		1451	8.3		1718	8.2		1559	7.9		1546	8.6		1443	8.4
	2151	-0.9		2105	0.4		2325	0.4		2204	0.6		2151	0.3		2043	0.4
5	0412	9.5	20	0321	8.2	5	0548	[illegible].0	20	0422	8.7	5	0409	9.1	20	0301	9.1
F	1026	-0.2	SA	0930	0.8	M	1214	0.1	TU	1047	0.3	M	1036	0.1	TU	0924	0.0
	1636	9.0		1538	8.0		1825	7.9		1657	7.8		1648	8.0		1533	8.2
	2254	-0.4		2151	0.[illegible]					2303	0.7		2252	0.8		2138	0.6
6	0515	9.3	21	0409	8.3	6	0029	0.7	21	0522	8.9	6	0511	8.7	21	0356	9.1
SA	1134	-0.1	SU	1024	0.8	TU	0648	8.8	W	1150	0.2	TU	1141	0.4	W	1021	0.0
	1745	8.6		1633	7.7		1316	0.2		1802	7.9		1754	7.6		1634	8.1
	2355	0.0		2242	0.7		1929	7.7					2355	1.1		2238	0.7
7	0617	9.2	22	0501	8.4	7	0129	0.8	22	0005	0.6	7	0614	8.4	22	0458	9.1
SU	1240	-0.1	M	1122	0.7	W	0748	8.8	TH	0627	9.2	W	1242	0.6	TH	1126	0.0
	1850	8.3		1731	7.7		1414	0.1		1256	-0.2		1858	7.5		1743	8.1
				2336	0.7		2025	7.8		1908	8.2					2346	0.6
8	0055	0.2	23	0557	8.7	8	0225	0.8	23	0109	0.3	8	0100	1.2	23	0605	9.3
M	0716	9.2	TU	1224	0.3	TH	0839	8.9	F	0729	9.6	TH	0716	8.4	F	1234	-0.3
	1341	-0.2		1833	7.8		1503	0.0		1359	-0.7		1342	0.5		1849	8.5
	1953	8.2					2115	7.9		2010	8.6		1954	7.6			
9	0154	0.4	24	0034	0.6	9	0311	0.7	24	0213	-0.2	9	0156	1.1	24	0053	0.3
TU	0812	9.3	W	0656	9.1	F	0926	9.0	SA	0830	10.1	F	0810	8.5	SA	0711	9.6
	1437	-0.3		1324	-0.1		1549	-0.1		1457	-1.3		1433	0.4		1338	-0.6
	2046	8.1		1933	8.1		2158	8.0		2110	9.2		2044	7.8		1953	9.0
10	024[illegible]	0.5	25	0133	0.3	10	0353	0.6	25	0313	-0.8	10	0245	0.9	25	0159	-0.2
W	0900	9.3	TH	0753	9.6	SA	1007	9.1	SU	0929	10.6	SA	0859	8.7	SU	0817	10.0
	1527	-0.4		1422	-0.7		1628	-0.2		1552	-1.8		1518	0.2		1438	-1.1
	2137	8.2		2033	8.5		2235	8.2		2204	9.8		2128	8.1		2052	9.6
11	0332	0.5	26	0231	-0.2	11	0432	0.4	26	0409	-1.3	11	0328	0.7	26	0259	-0.8
TH	0946	9.4	F	0849	10.2	SU	1043	9.2	M	1024	11.0	SU	0939	8.9	M	0914	10.4
	1611	-0.5		1518	-1.3		1703	-0.3		1644	-2.1		1558	0.1		1532	-1.5
	2220	8.2		2129	9.0		2312	8.4		2256	10.3		2205	8.3		2145	10.1
12	0414	0.5	27	0329	-0.6	12	0507	0.3	27	0502	-1.7	12	0408	0.4	27	0355	-1.3
F	1027	9.4	SA	0944	10.7	M	1118	9.2	TU	1116	11.1	M	1018	9.0	TU	1008	10.6
	1651	-0.5		1611	-1.8		1735	-0.4		1734	-2.2		1633	-0.1		1624	-1.7
	2259	8.2		2222	9.5		2344	8.5		2346	10.6		2240	8.5		2237	10.6
13	0453	0.4	28	0423	-1.1	13	0543	0.2	28	0555	-1.8	13	0445	0.2	28	0448	-1.7
SA	1104	9.3	SU	1039	11.1	TU	1153	9.2	W	1208	11.0	TU	1053	9.1	W	1101	10.7
	1727	-0.5		1702	-2.2		1808	-0.3		1824	-2.0		1707	-0.2		1713	-1.7
	2335	8.3		2315	10.0								2314	8.8		2325	10.8
14	0529	0.4	29	0516	-1.4	14	0017	8.6				14	0518	0.0	29	0539	-1.8
SU	1139	9.3	M	1131	11.2	W	0617	0.2				W	1127	9.1	TH	1151	10.5
	1800	-0.4		1754	-2.4		1226	9.1					1738	-0.2		1801	-1.5
							1840	-0.3					2347	9.0			
15	0009	8.3	30	0006	10.2	15	0049	8.7				15	0552	-0.1	30	0013	10.7
M	0604	0.4	TU	0610	-1.5	TH	0654	0.2				TH	1201	9.1	F	0628	-1.7
	1215	9.2		1224	11.1		1301	8.9					1811	-0.2		1241	10.2
	1836	-0.4		1845	-2.3		1913	-0.2								1847	-1.1
			31	0057	10.3										31	0059	10.5
			W	0705	-1.5										SA	0720	-1.4
				1318	10.7											1330	9.6
				1936	-1.9											1934	-0.5

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.
HEIGHTS ARE REFERRED TO MEAN LOW WATER WHICH IS THE CHART DATUM OF SOUNDINGS.

Figure 2. Typical Tide Table Page.

should also realize that soundings shown on East Coast National Ocean Charts reflect the water depth at mean low water).

b. <u>Tidal Difference and Constants</u>. Figure 3 is a typical page from this Table. The Table in its entirety includes data for 3860 subordinate reference stations. Data provided for each of the substations is applied to station data from the Daily Tide Predictions Table (see Figure 2) to derive tidal heights at the substation. The specific station for this page is listed at the top of the Figure as Portland, Maine. Information on this page, therefore, is applied to the figuresprovided in the Portland, Maine section of the Daily Tide Predictions Table (see "a" above and Table 1 in the tide tables 1979).

Table 2 includes several data. The number is the linear number of the particular substation. The numbers begin with one as the most northern substation. Each substation is named and the latitude and longitude of each is provided. The latitude and longitude respectively of Castine, Maine for example are 44^{0} 23'N and 68^{o} 48'W.

Two types of differences are provided in the table; a time difference and a heighth difference. Time differences are given in plus and minus minutes. Minus, for example, means the time of high or low tide is subtracted from the high or low tide time at the reference station (in this case Portland, Maine). The same procedure holds for heighth. Returning to Figure 2, on January 1, 1979 a high tide occured at reference station Portland, Maine at 0024. Its height above mean low water was 9.8 ft. Applying the information from Figure 3 for Castine, Maine 4 minutes is subtracted from the high tide time at Portland and 0.7 ft. added to the tide heighth. On January 1, 1979, therefore, a high tide occured in Castine at 0020 and its heighth was 10.7 ft. above mean low water. The same substation plus and minus figures are applied to reference station information regardless of the date. The ranges and the mean tide level are also

No.	Place	Position: Lat.	Position: Long.	Differences: Time: High water	Differences: Time: Low water	Differences: Height: High water	Differences: Height: Low water	Ranges: Mean	Ranges: Spring	Mean Tide Level
		° ′	° ′	h. m.	h. m.	feet	feet	feet	feet	feet
	MAINE — Continued	N.	W.	on PORTLAND, p.32						
	Time meridian, 75°W.									
665	Steele Harbor Island	44 30	67 33	-0 28	-0 20	+2.6	0.0	11.6	13.3	5.8
667	Jonesport, Moosabec Reach	44 32	67 36	-0 23	-0 17	+2.5	0.0	11.5	13.2	5.8
669	Gibbs Island, Pleasant River	44 33	67 45	-0 20	-0 11	+2.3	0.0	11.3	13.0	5.6
671	Addison, Pleasant River	44 37	67 45	0 00	+0 04	+2.8	0.0	11.8	13.6	5.9
673	Trafton Island, Narraguagus Bay	44 29	67 50	-0 23	-0 20	+2.1	0.0	11.1	12.8	5.5
675	Milbridge, Narraguagus River	44 32	67 53	-0 20	-0 05	+2.3	0.0	11.3	13.0	5.6
677	Pigeon Hill Bay	44 27	67 52	-0 21	-0 18	+2.1	0.0	11.1	12.8	5.5
678	Green Island, Petit Manan Bar	44 22	67 52	-0 28	-0 24	+1.6	0.0	10.6	12.2	5.3
679	Pinkham Bay, Dyer Bay	44 28	67 55	-0 23	-0 19	+1.9	0.0	10.9	12.5	5.4
681	Garden Point, Gouldsboro Bay	44 28	67 59	-0 23	-0 13	+1.8	0.0	10.8	12.4	5.4
683	Corea Harbor	44 24	67 58	-0 25	-0 20	+1.5	0.0	10.5	12.1	5.2
685	Prospect Harbor	44 24	68 01	-0 24	-0 15	+1.5	0.0	10.5	12.1	5.2
	Frenchman Bay									
701	Winter Harbor	44 23	68 05	-0 23	-0 09	+1.1	0.0	10.1	11.6	5.0
703	Eastern Point Harbor	44 28	68 10	-0 20	-0 11	+1.5	0.0	10.5	12.1	5.2
705	Sullivan	44 31	68 12	-0 10	-0 05	+1.5	0.0	10.5	12.1	5.2
707	Mount Desert Narrows	44 26	68 22	-0 08	-0 03	+1.5	0.0	10.5	12.1	5.3
	Mount Desert Island									
709	Salsbury Cove	44 26	68 17	-0 15	-0 12	+1.6	0.0	10.6	12.2	5.3
711	Bar Harbor	44 23	68 12	-0 22	-0 16	+1.5	0.0	10.5	12.1	5.2
713	Southwest Harbor	44 16	68 19	-0 22	-0 12	+1.2	0.0	10.2	11.7	5.1
715	Mount Desert	44 22	68 20	-0 16	-0 08	+1.6	0.0	10.6	12.2	5.3
717	Bass Harbor	44 14	68 21	-0 18	-0 11	+0.9	0.0	9.9	11.3	5.0
719	Pretty Marsh Harbor	44 20	68 25	-0 13	-0 13	+1.2	0.0	10.2	11.7	5.1
	Blue Hill Bay									
721	Union River	44 30	68 26	-0 09	-0 08	+1.4	0.0	10.4	11.9	5.2
723	Blue Hill Harbor	44 24	68 34	-0 13	-0 08	+1.1	0.0	10.1	11.6	5.0
725	Allen Cove	44 18	68 33	-0 12	-0 12	+1.3	0.0	10.3	11.8	5.1
727	Mackerel Cove	44 10	68 26	-0 20	-0 13	+1.0	0.0	10.0	11.5	5.0
729	Burnt Coat Harbor, Swans Island	44 09	68 27	-0 23	-0 13	+0.5	0.0	9.5	10.8	4.7
	MAINE, Penobscot Bay									
	Eggemoggin Reach									
731	Haskeag Harbor	44 14	68 33	-0 16	-0 14	+1.2	0.0	10.2	11.6	5.1
733	Center Harbor	44 16	68 35	-0 13	-0 07	+1.1	0.0	10.1	11.5	5.0
735	Sedgwick	44 18	68 38	-0 11	-0 06	+1.2	0.0	10.2	11.7	5.1
736	Isle Au Haut	44 04	68 38	-0 23	-0 19	+0.3	0.0	9.3	10.7	4.7
737	Head Harbor, Isle Au Haut	44 01	68 37	-0 20	-0 20	+0.1	0.0	9.1	10.4	4.6
739	Kimball Island	44 04	68 39	-0 20	-0 22	+0.6	0.0	9.6	10.9	4.8
741	Oceanville, Deer Isle	44 12	68 38	-0 18	-0 17	+1.1	0.0	10.1	11.5	5.0
743	Stonington, Deer Isle	44 09	68 40	-0 18	-0 17	+0.7	0.0	9.7	11.0	4.8
745	Northwest Harbor, Deer Isle	44 14	68 41	-0 12	-0 12	+1.1	0.0	10.1	11.5	5.0
747	Matinicus Harbor	43 52	68 53	-0 17	-0 12	0.0	0.0	9.0	10.4	4.5
749	Vinalhaven, Vinalhaven Island	44 03	68 50	-0 13	-0 06	+0.3	0.0	9.3	10.7	4.6
751	Iron Point, North Haven Island	44 08	68 52	-0 13	-0 13	+0.5	0.0	9.5	10.8	4.8
753	Pulpit Harbor, North Haven Island	44 09	68 53	-0 13	-0 15	+0.8	0.0	9.8	11.1	4.9
755	Castine	44 23	68 48	-0 04	-0 01	+0.7	0.0	9.7	11.1	4.8
757	Pumpkin Island, South Bay	44 25	68 44	+0 11	+0 20	+1.3	0.0	10.3	11.7	5.1
	Penobscot River									
759	Fort Point	44 28	68 49	-0 06	-0 05	+1.3	0.0	10.3	11.8	5.1
761	Bucksport	44 34	68 48	-0 02	-0 01	+2.0	0.0	11.0	12.5	5.5
763	South Orrington	44 42	68 49	+0 01	+0 04	+3.3	0.0	12.3	14.0	6.1
765	Hampden	44 45	68 50	+0 02	+0 06	+3.8	0.0	12.8	14.5	6.4
767	Bangor	44 48	68 46	+0 04	+0 13	+4.1	0.0	13.1	14.9	6.5
769	Belfast	44 26	69 00	-0 08	-0 01	+1.0	0.0	10.0	11.5	5.0
771	Camden	44 12	69 03	-0 12	-0 06	+0.6	0.0	9.6	10.9	4.8
773	Rockland	44 06	69 06	-0 16	-0 10	+0.7	0.0	9.7	11.2	4.8
775	Owls Head	44 0[illegible]	69 0[illegible]	-0 16	-0 13	+0.4	0.0	9.[illegible]	10.7	4.7
777	Dyer Point, Weskeag River	44 0[illegible]	69 07	-0 10	-0 10	+0.6	0.0	9.6	10.9	4.8

Figure 3. Tidal Differences and Constants Table Page.

provided. Researchers are referred to the actual tide table for a discussion of these parameters.

c. Heights of the Tide at Any Time. Figure 4 is an example of this table. It has two sections; duration of tidal rise or fall and range of tide. The former section is used first in computing tidal heighth at any time and includes times every twenty minutes from 4 hours 00 minutes to 10 hours 40 minutes. The procedure used in finding the heighth of tide at any time is as follows:

i. Find the high and low tide heighths and their times of occurrence at the reference station of interest (use Table 2). There is, for example, a low tide of -1.1 ft. at 0623 and a high tide of 11.0 at 1238 on January 1, 1980 at Portland, Maine. Now suppose you need tidal heighth at 1000.

ii. Compute the time required for the tide to change from low to high (1238-0623 = 6h 15m).

iii. Compute the tidal range (the algebraic difference between low and high tides; 11.0 ft.-1.1 ft. = 12.1 ft.).

iv. Compute the elapsed time between low tide and the time the heighth of the tide must be known (1000-0623 = 3h 37m). In other words, you want the tide heighth 3h 37m after low water.

v. Apply the derived time and range values (3h 37m, 12.1 ft.) to Figure 4. The top section, Duration of Rise and Fall, is entered first in the following manner. Find the 20 minute time segment in the extreme left hand column that is closest to the time required for the tide to change from low to high (6.20 in this case since 6h 15m are required for the change). Now, proceed horizontally to the figure closest the time after low tide when the tide heighth

Duration of rise or fall, see footnote	Time from the nearest high water or low water														
h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
4 00	0 08	0 16	0 24	0 32	0 40	0 48	0 56	1 04	1 12	1 20	1 28	1 36	1 44	1 52	2 00
4 20	0 09	0 17	0 26	0 35	0 43	0 52	1 01	1 09	1 18	1 27	1 35	1 44	1 53	2 01	2 10
4 40	0 09	0 19	0 28	0 37	0 47	0 56	1 05	1 15	1 24	1 33	1 43	1 52	2 01	2 11	2 20
5 00	0 10	0 20	0 30	0 40	0 50	1 00	1 10	1 20	1 30	1 40	1 50	2 00	2 10	2 20	2 30
5 20	0 11	0 21	0 32	0 43	0 53	1 04	1 15	1 25	1 36	1 47	1 57	2 08	2 19	2 29	2 40
5 40	0 11	0 23	0 34	0 45	0 57	1 08	1 19	1 31	1 42	1 53	2 05	2 16	2 27	2 39	2 50
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 57	3 10
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27	2 40	2 53	3 07	3 20
7 00	0 14	0 28	0 42	0 56	1 10	1 24	1 38	1 52	2 06	2 20	2 34	2 48	3 02	3 16	3 30
7 20	0 15	0 29	0 44	0 59	1 13	1 28	1 43	1 57	2 12	2 27	2 41	2 56	3 11	3 25	3 40
7 40	0 15	0 31	0 46	1 01	1 17	1 32	1 47	2 03	2 18	2 33	2 49	3 04	3 19	3 35	3 50
8 00	0 16	0 32	0 48	1 04	1 20	1 36	1 52	2 08	2 24	2 40	2 56	3 12	3 28	3 44	4 00
8 20	0 17	0 33	0 50	1 07	1 23	1 40	1 57	2 13	2 30	2 47	3 03	3 20	3 37	3 53	4 10
8 40	0 17	0 35	0 52	1 09	1 27	1 44	2 01	2 19	2 36	2 53	3 11	3 28	3 45	4 03	4 20
9 00	0 18	0 36	0 54	1 12	1 30	1 48	2 06	2 24	2 42	3 00	3 18	3 36	3 54	4 12	4 30
9 20	0 19	0 37	0 56	1 15	1 33	1 52	2 11	2 29	2 48	3 07	3 25	3 44	4 03	4 21	4 40
9 40	0 19	0 39	0 58	1 17	1 37	1 56	2 15	2 35	2 54	3 13	3 33	3 52	4 11	4 31	4 50
10 00	0 20	0 40	1 00	1 20	1 40	2 00	2 20	2 40	3 00	3 20	3 40	4 00	4 20	4 40	5 00
10 20	0 21	0 41	1 02	1 23	1 43	2 04	2 25	2 45	3 06	3 27	3 47	4 08	4 29	4 49	5 10
10 40	0 21	0 43	1 04	1 25	1 47	2 08	2 29	2 51	3 12	3 33	3 55	4 16	4 37	4 59	5 20

Range of tide, see footnote	Correction to height														
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5
1.5	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8
2.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
2.5	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2
3.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5
3.5	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.8
4.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0
4.5	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2
5.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.7	2.0	2.2	2.5
5.5	0.0	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.4	1.6	1.9	2.2	2.5	2.8
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.7	3.0
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9	2.2	2.6	2.9	3.2
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1	2.4	2.8	3.1	3.5
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.3	1.6	2.0	2.4	2.8	3.2	3.6	4.0
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9	3.4	3.8	4.2
9.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5	1.9	2.2	2.7	3.1	3.6	4.0	4.5
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3	3.8	4.3	4.8
10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5	4.0	4.5	5.0
10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	5.2
11.0	0.0	0.1	0.3	0.5	0.7	1.1	1.4	1.8	2.3	2.8	3.3	3.8	4.4	4.9	5.5
11.5	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.4	2.9	3.4	4.0	4.6	5.1	5.8
12.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.0	3.6	4.1	4.8	5.4	6.0
12.5	0.0	0.1	0.3	0.5	0.8	1.2	1.6	2.1	2.6	3.1	3.7	4.3	5.0	5.6	6.2
13.0	0.0	0.1	0.3	0.6	0.9	1.2	1.7	2.2	2.7	3.2	3.9	4.5	5.1	5.8	6.5
13.5	0.0	0.1	0.3	0.6	0.9	1.3	1.7	2.2	2.8	3.4	4.0	4.7	5.3	6.0	6.8
14.0	0.0	0.2	0.3	0.6	0.9	1.3	1.8	2.3	2.9	3.5	4.2	4.8	5.5	6.3	7.0
14.5	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.4	3.0	3.6	4.3	5.0	5.7	6.5	7.2
15.0	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.5	3.1	3.8	4.4	5.2	5.9	6.7	7.5
15.5	0.0	0.2	0.4	0.7	1.0	1.5	2.0	2.6	3.2	3.9	4.6	5.4	6.1	6.9	7.8
16.0	0.0	0.2	0.4	0.7	1.1	1.5	2.1	2.6	3.3	4.0	4.7	5.5	6.3	7.2	8.0
16.5	0.0	0.2	0.4	0.7	1.1	1.6	2.1	2.7	3.4	4.1	4.9	5.7	6.5	7.4	8.2
17.0	0.0	0.2	0.4	0.7	1.1	1.6	2.2	2.8	3.5	4.2	5.0	5.9	6.7	7.6	8.5
17.5	0.0	0.2	0.4	0.8	1.2	1.7	2.2	2.9	3.6	4.4	5.2	6.0	6.9	7.8	8.8
18.0	0.0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.7	4.5	5.3	6.2	7.1	8.1	9.0
18.5	0.1	0.2	0.5	0.8	1.2	1.8	2.4	3.1	3.8	4.6	5.5	6.4	7.3	8.3	9.2
19.0	0.1	0.2	0.5	0.8	1.3	1.8	2.4	3.1	3.9	4.8	5.6	6.6	7.5	8.5	9.5
19.5	0.1	0.2	0.5	0.8	1.3	1.9	2.5	3.2	4.0	4.9	5.8	6.7	7.7	8.7	9.8
20.0	0.1	0.2	0.5	0.9	1.3	1.9	2.6	3.3	4.1	5.0	5.9	6.9	7.9	9.0	10.0

Obtain from the predictions the high water and low water, one of which is before and the other after the time for which the height is required. The difference between the times of occurrence of these tides is the duration of rise or fall, and the difference between their heights is the range of tide for the above table. Find the difference between the nearest high or low water and the time for which the height is required.

Enter the table with the duration of rise or fall, printed in heavy-faced type, which most nearly agrees with the actual value, and on that horizontal line find the time from the nearest high or low water which agrees most nearly with the corresponding actual difference. The correction sought is in the column directly below, on the line with the range of tide.

When the nearest tide is high water, subtract the correction.

When the nearest tide is low water, add the correction.

Figure 4. Heights of the Tide at Any Time.

must be known (3h 10m in this case in the extreme right hand column is closest to 3h 37m). Since the times provided in this section of the table are times from nearest high or low water, reexamine the time difference figures to determine whether a time recomputation would provide figures which more closely match those presented in the Table. This is accomplished by computing the elapsed time between the time when the heighth of the tide must be known and the next high tide (1238-1000 = 2h 38m). Two hours and thirty minutes matches more closely a time presented in the table. The figure is again entered at 6.20 and the user proceeds to 2h 32m, three columns from the right side of the Table.

vi. Find the value closest to the range of the tide in the extreme left hand column of the Range of the Tide section (12.0 ft. in this case). To find the tidal difference factor, proceed horizontally across the 12 ft. row to the same column that contains the time difference in the top section (third column from the right). The value found here is the tidal difference factor (4.8 ft.).

vii. The actual tide heighth is computed by adding or subtracting the derived tidal difference factor from either high or low tide. Since 2h 38m was the time before the next high tide, 4.8 ft. must be subtracted from the tide heighth at the next high tide (11.0 ft. from Table 2 - 4.8 ft. = 6.2 ft.). On January 1, 1980 at 1000 the heighth of the water was 6.2 ft. above mean low water.

viii. Follow the same sequence of steps when determining tidal heighth at subordinate stations (those station in Figure 3). In the process, the computations discussed previously for Figure 3 (determining the times of high and low tide) are accomplished first followed by Figure 4 computations.

d. <u>Using Tide Table Data to Control Variables</u>. Let's suppose that on 1000 January 1, 1979 your research vessel was at the station X on the chart in Figure 5 to make a Nansen cast. Prior to the cruise it was decided to place Nansen bottles in this cast at depths of 15 ft., 30 ft., and 45 ft., below the surface.

As a researcher, you know that data from this cast must be corrected somehow if it is to be compared with data gathered on other days at other stations and at other tide levels. First you examine National Ocean Survey Chart 13309 and the Tidal Differences and Other Constants Table in Tide Tables 1979 to determine which subordinate tide prediction station is closest to research station X. Once the station is identified, tidal heighth is derived for the time the Nansen cast was made. Figure 6 shows that computation.

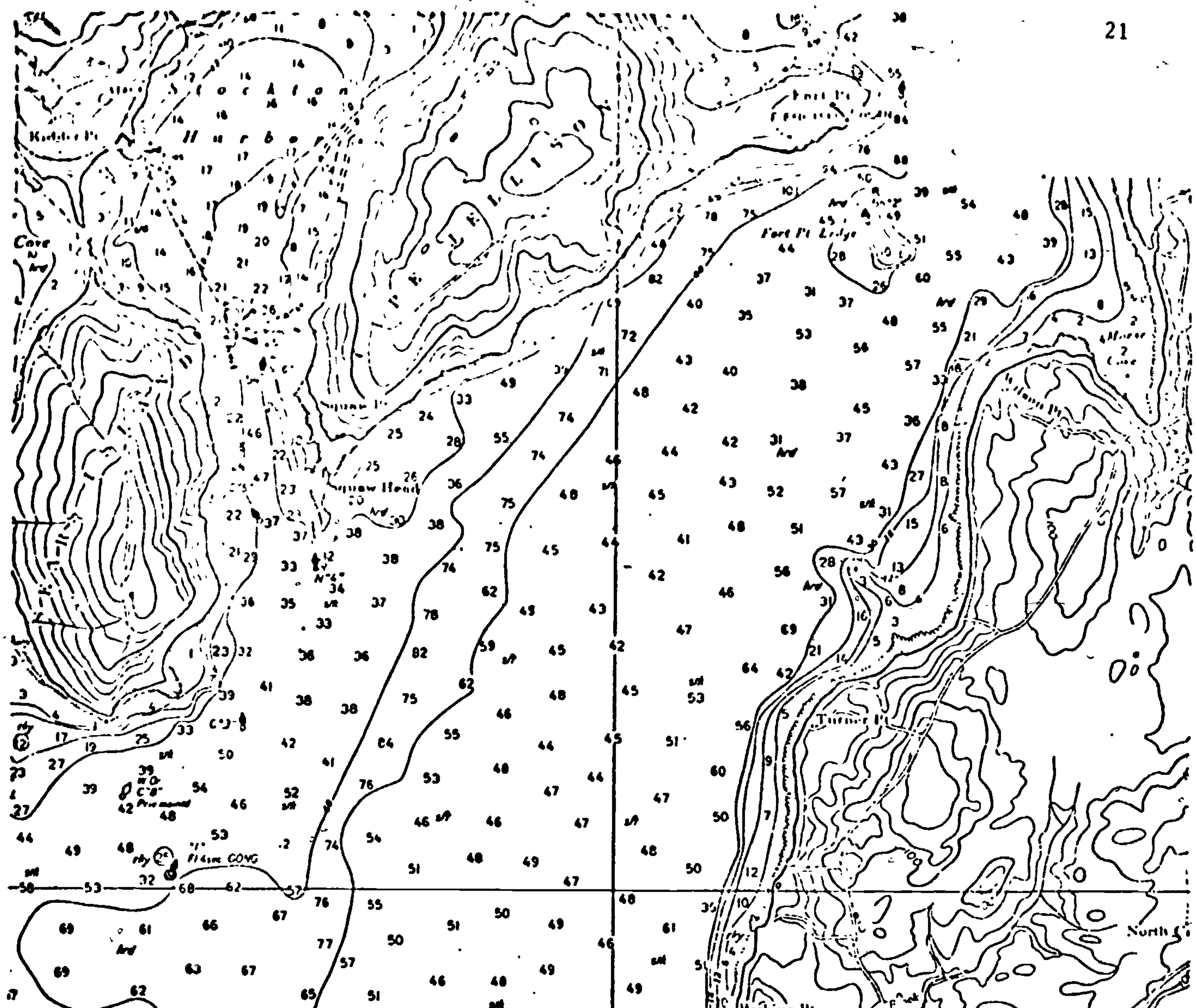


Figure 5. Nansen Cast Station.

SUBSTATION
TIDE PREDICTION SHEET

SUBSTATION FORT POINT, MAINE   DATE: 1 JANUARY 1979

REFERENCE STATION PORTLAND, MAINE

SUBSTATION HIGH WATER TIME DIFFERENCE -0h -6m

SUBSTATION LOW WATER TIME DIFFERENCE -0h 05m

SUBSTATION HIGH WATER HEIGHTH DIFFERENCE +1.3 ft.

SUBSTATION LOW WATER HEIGHTH DIFFERENCE 0.0 ft.

HIGH AND LOW WATER PREDICTIONS

	REFERENCE STATION INFORMATION (TABLE 1)		SUBSTATION INFORMATION (TABLE 2)	
	TIME (EST)	HEIGHTH (FT)	TIME (EST)	HEIGHTH (FT)
LW				
HW				
LW				
HW				
LW				
HW				

HEIGHTH OF WATER AT ANY TIME
SUBSTATION FORT POINT DATE 1 JAN 79 TIME 1000

DURATION OF TIDAL RISE OR FALL	(1232-0618) 6h 14m
TIME FROM NEAREST TIDE	(HW 1232-1000) 2h 32m
RANGE OF NEAREST TIDE	(11.1 -1.1) 12.2 ft.
HEIGHTH OF NEAREST TIDE	(HW) 11.1 ft.
CORRECTION FROM TABLE 3 (TIDE TABLES 1980)	4.1 ft.
HEIGHTH OF TIDE AT 1000	(11.1 - 4.1) 7.0 ft.
CHARTED DEPTH AT MEAN LOW WATER	(from NOS chart) 54 ft.
DEPTH OF WATER AT 1000	(54 + 7.0) 61 ft.

Figure 6. Typical Tide Prediction Sheet.

Without further manipulation of water level information, it is possible to determine immediately that the Nansen bottles are sampling at 16 ft. (54 ft. at MWL - 45 ft. = 9 ft. + 7 ft. = 16 ft.), 31 ft., and 46 ft. above the bottom. In addition, it is possible using the mean low water (MLW) figures from the National Ocean Survey chart and the mean tide range (for Fort Point, see Figure 5) figures (unless it happens to be a spring tide) to obtain a mean high water figures for the research site (54 ft. + 10.3 ft., = 64.3 ft.). When corrected to mean high water the Nansen bottles in this cast are set at 18.3 ft., 33.3 ft., and 48.3 ft. below the surface.

When research involving Nansen casts and Bathythermograph drops is conducted; (1) investigators are interested in firsthand knowledge of well-defined small areas, and; (2) researchers should make several casts or drops in the same area. When this is the case, the data which is collected must be reduced (controlled) to some common denominator. After such manipulations have been made, investigators can further evaluate their data. In the process they may look uniformities at specific depths within specific parameters. They may, for example, want to know whether; (1) isopleths, isohalines, isotherms or thermoclines exist at specific depths within the water mass; or (2) there is evidence suggesting the variables are effected somehow by coriolis forces.

i. <u>Effect of arometric Pressure on Tides</u>. The effect of barometric pressure upon tide heighth must also be taken into account when controlling variables. Tide tables are written at a barometric pressure of 29.92 inches of mercury (760 millimeters of mercury or 760 Torr). An atmospheric pressure decrease of 1 inch, 25.4 mmhg or 25.4 Torr causes an increase in tidal heighth of one foot. Other factors equal, water level is related linearly to atmospheric

PORTSMOUTH HARBOR ENTRANCE (OFF WOOD I.), N.H., 1979

F-FLOOD, DIR. 355° TRUE   E-EBB, DIR. 195° TRUE

JANUARY

DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
1	0217	0455	2.3F
M	0834	1048	1.8F
	1424	1723	2.6E
	2115	2322	1.7F
2	0305	0547	2.2E
TU	0927	1140	1.8F
	1516	1815	2.5E
	2207		
3		0015	1.7F
W	0401	0642	2.1E
	1026	1233	1.6F
	1611	1907	2.4E
	2301		
4		0105	1.6F
TH	0458	0736	2.0E
	1126	1326	1.4F
	1710	2001	2.2E
	2357		
5		0200	1.4F
F	0557	0833	1.9E
	1228	1422	1.2F
	1810	2059	2.0E
6	0054	0255	1.3F
SA	0657	0934	1.8E
	1332	1519	1.0F
	1912	2157	1.8E
7	0152	0352	1.2F
SU	0755	1044	1.8E
	1434	1619	0.9F
	2014	2258	1.7E
8	0249	0450	1.1F
M	0852	1210	1.8E
	1535	1758	0.7F
	2114		
9		0005	1.6E
TU	0344	0548	1.0F
	0945	1327	1.8E
	1631	2026	0.9F
	2209		
10		0108	1.6E
W	0435	0657	1.0F
	1035	1412	1.9E
	1722	2116	0.9F
	2301		
11		0154	1.6E
TH	0523	0725	1.0F
	1121	1445	1.9E
	1809	2118	0.9F
	2349		
12		0233	1.5E
F	0609	0806	1.1F
	1204	1508	1.9E
	1852	2119	0.9F
13	0034	0308	1.6E
SA	0652	0847	1.1F
	1245	1535	1.9E
	1933	2121	0.9F
14	0116	0347	1.6E
SU	0734	0928	1.2F
	1323	1610	2.0E
	2013	2158	1.0F
15	0156	0425	1.6E
M	0816	1012	1.2F
	1359	1649	2.0E
	2052	2241	1.1F

DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
16	0235	0509	1.6E
TU	0858	1055	1.2F
	1432	1730	2.0E
	2132	2324	1.1F
17	0313	0551	1.6E
W	0941	1138	1.2F
	1501	1811	1.9E
	2212		
18		0008	1.2F
TH	0349	0634	1.6E
	1026	1225	1.1F
	1526	1856	1.9E
	2254		
19		0051	1.2F
F	0427	0722	1.6E
	1115	1312	1.1F
	1554	1943	1.8E
	2337		
20		0142	1.2F
SA	0509	0811	1.6E
	1207	1401	1.0F
	1633	2032	1.7E
21	0024	0231	1.2F
SU	0558	0902	1.6E
	1303	1453	1.0F
	1727	2122	1.7E
22	0115	0320	1.2F
M	0654	0955	1.7E
	1400	1546	0.9F
	1843	2217	1.7E
23	0208	0413	1.3F
TU	0755	1052	1.8E
	1456	1643	1.0F
	2007	2312	1.7E
24	0302	0509	1.3F
W	0854	1148	1.9E
	1551	1742	1.1F
	2117		
25		0009	1.8E
TH	0356	0604	1.5F
	0950	1243	2.1E
	1644	1838	1.2F
	2219		
26		0104	1.9E
F	0449	0701	1.6F
	1045	1338	2.3E
	1735	1933	1.4F
	2316		
27		0200	2.1E
SA	0541	0754	1.7F
	1137	1431	2.5E
	1825	2028	1.6F
28	0010	0252	2.2E
SU	0633	0848	1.8F
	1228	1523	2.6E
	1914	2121	1.7F
29	0103	0346	2.3E
M	0725	0939	1.9F
	1319	1619	2.7E
	2003	2212	1.8F
30	0155	0437	2.4E
TU	0818	1032	1.9F
	1410	1704	2.7E
	2053	2302	1.8F
31	0247	0529	2.3E
W	0911	1121	1.8F
	1501	1754	2.6E
	2144	2353	1.7F

FEBRUARY

DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
1	0339	0620	2.3E
TH	1006	1212	1.6F
	1554	1845	2.4E
	2236		
2		0044	1.6F
F	0433	0713	2.1E
	1104	1304	1.4F
	1648	1937	2.2E
	2330		
3		0133	1.5F
SA	0529	0809	2.0E
	1203	1355	1.2F
	1746	2030	2.0E
4	0026	0224	1.3F
SU	0626	0906	1.8E
	1305	1450	1.0F
	1846	2127	1.7E
5	0123	0318	1.1F
M	0724	1009	1.7E
	1408	1545	0.8F
	1947	2227	1.6E
6	0221	0413	1.0F
TU	0821	1123	1.6E
	1509	1647	0.7F
	2048	2333	1.5E
7	0318	0510	0.9F
W	0916	1305	1.7E
	1606	2006	0.8F
	2144		
8		0042	1.4E
TH	0411	0603	0.9F
	1007	1356	1.7E
	1658	2054	0.8F
	2237		
9		0143	1.4E
F	0 1	0652	0.9F
	1055	1439	1.8E
	1744	2054	0.9F
	2325		
10		0214	1.5E
SA	0547	0740	1.0F
	1139	1442	1.8E
	1826	2054	0.9F
11	0009	0245	1.5E
SU	0630	0823	1.0F
	1220	1511	1.9E
	1906	2054	0.9F
12	0050	0323	1.6E
M	0712	0904	1.1F
	1259	1543	1.9E
	1944	2134	1.1F
13	0129	0402	1.7E
TU	0752	0947	1.2F
	1335	1622	2.0E
	2022	2213	1.2F
14	0205	0442	1.7E
W	0833	1030	1.2F
	1408	1701	2.0E
	2059	2256	1.2F
15	0239	0523	1.8E
TH	0914	1113	1.2F
	1436	1742	2.0E
	2137	2339	1.3F

DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
16	0311	0606	1.8E
F	0957	1156	1.2F
	1500	1825	1.9E
	2217		
17		0022	1.3F
SA	0342	0651	1.8E
	1042	1244	1.2F
	1526	1911	1.8E
	2258		
18		0109	1.3F
SU	0416	0740	1.8E
	1132	1331	1.1F
	1604	2000	1.8E
	2345		
19		0158	1.3F
M	0501	0831	1.8E
	1227	1424	1.1F
	1656	2051	1.7E
20	0038	0250	1.3F
TU	0601	0925	1.8E
	1325	1517	1.0F
	1810	2148	1.7E
21	0135	0343	1.3F
W	0712	1020	1.8E
	1425	1614	1.0F
	1940	2243	1.7E
22	0235	0440	1.3F
TH	0822	1119	1.9E
	1523	1714	1.1F
	2055	2345	1.8E
23	0333	0539	1.4F
F	0925	1218	2.1E
	1618	1813	1.3F
	2200		
24		0043	1.9E
SA	0430	0637	1.5F
	1024	1316	2.3E
	1711	1912	1.4F
	2258		
25		0141	2.1E
SU	0525	0734	1.6F
	1119	1410	2.4E
	1802	2007	1.6F
	2352		
26		0236	2.3E
M	0618	0829	1.8F
	1212	1504	2.6E
	1852	2101	1.7F
27	0044	0328	2.4E
TU	0709	0922	1.8F
	1303	1553	2.6E
	1941	2152	1.7F
28	0135	0419	2.4E
W	0301	1013	1.8F
	1353	1644	2.6E
	2029	2241	1.8F

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.

Figure 7. Typical Page from Daily Current Predictions Table.

pressure.

3. Current Tables. Another research tool published by the National Ocean Survey is titled Tidal Current Tables. It consists of five tables and explanations of several current relevant factors. They are; (1) daily current predictions; (2) current differences and other constants; (3) velocity of current at any time; (4) duration of slack; (5) rotary tidal currents; (6) the Gulf Stream; (7) wind driven currents; (8) the combination of currents; (9) current diagrams. Several of these are discussed below.

a. Daily Current Predictions. Figure 7 is a typical page from this table. Like the Table of Daily Tidal Predictions (Figure 2) this Table provides information for each day of the year at the reference station, (Portsmouth Harbor, NH entrance in this case). Users are also provided with the true (not magnetic) directions of ebb (E) and flood (F) tides, times of stack water and the times of maximum ebb and flood currents. On January 1, 1979, at Portsmouth Harbor entrance, slack water high occurred at 0212 and 1424 while slack water low occurred at 0834 and 2115. On the same day, maximum ebb tide currents occurred at 0455 and 1723 with velocities of 2.3 knots and 2.6 knots respectively.

b. Current Difference and Other Constants. Figure 8 is a typical page from the Current Differences and Other Constants table. This Table provides information that is applied to the current data in Figure 7 (Table 1 of the current tables) in the derivation of subordinate station tidal currents. Names of reference stations are printed in the right center of the table above their respective group of substations. Locations between Brazil Rock and Hat Island data are applied to Bay of Fundy Entrance currents when their ebb and flood currents are derived.

TABLE 2.—CURRENT DIFFERENCES AND OTHER CONSTANTS

No.	PLACE	POSITION		TIME DIFFERENCES		VELOCITY RATIOS		MAXIMUM CURRENTS			
								Flood		Ebb	
		Lat.	Long.	Slack water	Maximum current	Maximum flood	Maximum ebb	Direction (true)	Average velocity	Direction (true)	Average velocity
		° ′	° ′	h. m.	h. m.			deg.	knots	deg.	knots
	BAY OF FUNDY	N.	W.	on BAY OF FUNDY ENT., p.4							
	Time meridian, 60°W.										
1	Brazil Rock, 6 miles east of----------	43 22	65 18	-2 00	-2 00	0.4	0.4	275	1.0	050	1.0
5	Cape Sable, 3 miles south of----------	43 20	65 38	-2 10	-2 10	1.0	0.8	275	2.2	095	2.0
10	Cape Sable, 12 miles south of---------	43 11	65 37	-1 00	-1 00	0.7	0.7	235	1.7	090	1.6
15	Blonde Rock, 5 miles south of---------	43 15	65 59	-0 50	-0 50	0.9	0.8	310	2.0	125	2.0
20	Seal Island, 13 miles southwest of----	43 16	66 15	+0 10	+0 10	1.1	0.7	325	2.6	140	1.6
25	Cape Fourchu, 17 miles southwest of---	43 34	66 24	+0 45	+0 45	0.5	0.5	355	1.2	145	1.2
30	Cape Fourchu, 4 miles west of---------	43 47	66 15	0 00	0 00	0.9	0.7	000	2.0	175	1.7
35	Lurcher Shoal, 6 miles east of--------	43 52	65 21	+0 30	+0 30	0.9	0.8	355	2.0	175	1.8
40	Lurcher Shoal, 10 miles west of-------	43 46	66 42	+0 35	+0 30	0.6	0.7	000	1.4	160	1.6
45	Lurcher Shoal, 10 miles northwest of--	43 59	66 37	+0 30	+0 30	0.8	0.5	005	1.8	175	1.2
50	Brier Island, 5 miles west of---------	44 13	66 30	+0 50	+0 50	1.2	1.0	005	2.7	185	2.5
55	Brier Island, 15 miles west of--------	44 17	66 44	-0 15	-0 15	0.6	0.5	060	1.4	250	1.2
60	Gannet Rock, 5 miles southeast of-----	44 29	66 41	+0 30	+0 30	1.1	1.6	040	2.6	230	3.9
65	Boars Head, 10 miles northwest of-----	44 31	66 23	+0 55	+0 55	0.8	0.8	020	1.9	205	2.0
70	Prim Point, 20 miles west of----------	44 44	66 15	+0 45	+0 45	0.7	0.6	040	1.6	235	1.4
75	Cape Spencer, 14 miles south of-------	44 58	65 57	+0 55	+0 55	0.7	0.7	050	1.7	245	1.6
80	BAY OF FUNDY ENTRANCE-----------------	44 45	66 56	Daily predictions				030	2.3	210	2.4
	MAINE COAST										
	Time meridian, 75°W.										
85	Eastport, Friar Roads-----------------	44 54	66 59	0 00	0 00	1.2	1.2	210	3.0	040	3.0
90	Western Passage, off Kendall Head-----	44 56	67 00	+0 20	+0 25	1.4	1.3	320	3.2	140	3.1
95	Western Passage, off Frost Ledge------	44 58	67 02	+0 10	+0 10	0.9	0.7	330	2.1	150	1.7
100	Pond Point, 7.6 miles SSE. of---------	44 20	67 30	([1])	-0 10	0.2	0.5	015	0.5	215	1.2
105	Moosabec Reach, east end--------------	44 32	67 34	-3 00	-3 25	0.4	0.4	110	1.0	260	1.0
110	Moosabec Reach, west end--------------	44 31	67 39	-1 50	-1 45	0.4	0.5	090	1.0	255	1.2
115	Bar Harbor, 1.2 miles east of---------	44 23	68 10	([2])	+0 40	0.1	0.3	330	0.2	150	0.7
120	Casco Passage, E. end, Blue Hill Bay--	44 12	68 28	-1 25	-1 50	0.3	0.3	035	0.7	285	0.7
125	Hat Island, SE. of, Jericho Bay-------	44 08	68 30	-0 55	-1 00	0.4	0.5	320	0.9	125	1.3
				on PORTSMOUTH HBR. ENT., p.10							
130	Isle Au Haut, 0.8 mi. E. of Richs Pt--	44 05	68 35	-2 10	-1 45	1.2	0.8	335	1.4	140	1.5
135	West Penobscot Bay, off Monroe I------	44 05	69 00	-1 45	-1 20	0.2	0.3	005	0.3	160	0.6
140	Muscongus Sound-----------------------	43 56	69 27	*Current too weak and variable to be predicted.*							
145	Damariscotta River, off Cavis Point---	43 53	69 35	-1 05	-1 00	0.5	0.6	350	0.6	215	1.0
150	Sheepscot River, off Barter Island----	43 54	69 41	-1 00	-0 50	0.7	0.6	005	0.8	200	1.1
155	Lowe Pt., NE. of, Sasanoa River-------	43 51	69 43	-0 45	-0 10	1.4	1.0	325	1.7	150	1.8
160	Lower Hell Gate, Knubble Bay[3]---------	43 53	69 44	-0 35	+0 20	2.5	1.9	290	3.0	155	3.5
165	Upper Hell Gate, Sasanoa River--------	43 54	69 46	([2])	([2])	0.8	0.5	305	1.0	140	0.8
	KENNEBEC RIVER										
170	Hunniwell Point, northeast of---------	43 45	69 47	+0 05	+0 20	2.0	1.6	330	2.4	150	2.9
175	Bald Head, 0.3 mile southwest of------	43 48	69 49	+0 10	+0 25	1.3	1.3	320	1.6	155	2.3
180	Bluff Head, west of-------------------	43 51	69 48	+0 30	+0 40	1.9	1.9	015	2.3	185	3.4
185	Fiddler Ledge, north of---------------	43 53	69 48	+0 35	+1 00	1.6	1.4	265	1.9	115	2.6
190	Doubling Point, south of--------------	43 53	69 48	+0 25	+0 50	2.2	1.7	300	2.6	125	3.0
195	Lincoln Ledge, east of----------------	43 54	69 49	+0 30	+0 40	1.6	1.6	000	1.9	175	2.8
200	Bath, 0.2 mile south of bridge[4]-------	43 55	69 48	[5]+0 35	+0 55	0.8	0.8	005	1.0	175	1.5

[1]Flood begins, $+0^h 15^m$; ebb begins, $-1^h 35^m$.
[2]Times of slack are indefinite.
[3]Velocities up to 9.0 knots have been observed in the vicinity of The Boilers.
[4]Flood begins, $+3^h 30^m$; maximum flood, $+2^h 10^m$; ebb begins, $+1^h 20^m$; maximum ebb, $+2^h 05^m$.
[5]Current turns westward just before the end of the flood.

Figure 8. Typical Page from Current Differences and Other Constants Table.

Suppose it is necessary to determine the currents near Monroe Island in West Penobscot Bay on January 1, 1979. Figure 7 indicates high tides occur at 0212 and 1424 and low tides occur at 0834 and 2115 at Portsmouth Harbor entrance (the reference station) on this date. Figure 8 shows a time difference of -1h 45m for slack water Periods of slack water, therefore, occured January 1, 1979 off Monroe Island, Maine at 0027 (0212 -1h 45m), 0649, 1239 and 1930. The times of maximum currents are altered by-1h 20m, thus, 1h 20m is subtracted from 0455, 1048, 1723 and 2322, the times of maximum currents at Portsmouth Harbor entrance.

Velocity ratios are provided for maximum ebb and flood times. The ratios are multiplication factors used in determining maximum tidal current velocities. The velocity of maximum tidal current at a reference station is multiplied by the velocity ratio at the subordinate to derive the actual current speed at the station. In this case, maximum flood tides at the reference station were 1.8 and 1.7 knots, and the maximum ebb tides were 2.3 and 2.6 knots. Maximum flood and ebb tides at the subordinate station were therefore, 0.2 x 1.8; 0.2 x 1.7; 0.3 x 2.3 and; 0.3 x 2.6. This table also provides the true directions of ebb and flood currents. These directions may be somewhat different from the directions of maximum tides ac the reference station.

c. Velocity of Current at Any Time. This table is shown in Figure 9. The letter 'f' heads each column of the A portion. It means multiplication factor. The following stepwise sequence should be followed when using the table.

i. Before using this Table to determine the tidal current at a specific time at a subordinate station listed in Figure 8. The tidal prediction at the subordinate station must be obtained from the tide within which the specific time of interest falls (see ii below). Use the method described in the

TABLE 3.—VELOCITY OF CURRENT AT ANY TIME

TABLE A

Interval between slack and desired time	Interval between slack and maximum current													
	h. m. 1 20	h. m. 1 40	h. m. 2 00	h. m. 2 20	h. m. 2 40	h. m. 3 00	h. m. 3 20	h. m. 3 40	h. m. 4 00	h. m. 4 20	h. m. 4 40	h. m. 5 00	h. m. 5 20	h. m. 5 40
h. m.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.
0 20	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0 40	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
1 00	0.9	0.8	0.7	0.8	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3
1 20	1.0	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4
1 40	......	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4
2 00	......	......	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.5
2 20	......	......	......	1.0	1.0	0.9	0.9	0.9	0.8	0.7	0.7	0.7	0.6	0.6
2 40	......	......	......	......	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7
3 00	......	......	......	......	......	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7
3 20	......	......	......	......	......	......	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8
3 40	......	......	......	......	......	......	......	1.0	1.0	1.0	0.9	0.9	0.9	0.9
4 00	......	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0	0.9	0.9
4 20	......	......	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0	0.9
4 40	......	......	......	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0
5 00	......	......	......	......	......	......	......	......	......	......	......	1.0	1.0	1.0
5 20	......	......	......	......	......	......	......	......	......	......	......	......	1.0	1.0
5 40	......	......	......	......	......	......	......	......	......	......	......	......	......	1.0

TABLE B

Interval between slack and desired time	Interval between slack and maximum current													
	h. m. 1 20	h. m. 1 40	h. m. 2 00	h. m. 2 20	h. m. 2 40	h. m. 3 00	h. m. 3 20	h. m. 3 40	h. m. 4 00	h. m. 4 20	h. m. 4 40	h. m. 5 00	h. m. 5 20	h. m. 5 40
h. m.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.
0 20	[illegible]	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
0 40	0.8	0.7	0.8	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
1 00	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4
1 20	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5
1 40	......	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
2 00	......	......	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.6
2 20	......	......	......	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7
2 40	......	......	......	......	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.7
3 00	......	......	......	......	......	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8
3 20	......	......	......	......	......	......	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.8
3 40	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0	0.9	0.9	0.9
4 00	......	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0	0.9	0.9
4 20	......	......	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0	0.9
4 40	......	......	......	......	......	......	......	......	......	......	1.0	1.0	1.0	1.0
5 00	......	......	......	......	......	......	......	......	......	......	......	1.0	1.0	1.0
5 20	......	......	......	......	......	......	......	......	......	......	......	......	1.0	1.0
5 40	......	......	......	......	......	......	......	......	......	......	......	......	......	1.0

Use table A for all places except those listed below for table B.
Use table B for Cape Cod Canal, Hell Gate, Chesapeake and Delaware Canal and all stations in table 2 which are referred to them.

1. From predictions find the time of slack water and the time and velocity of maximum current (flood or ebb), one of which is immediately before and the other after the time for which the velocity is desired.
2. Find the interval of time between the above slack and maximum current, and enter the top of table A or B with the interval which most nearly agrees with this value.
3. Find the interval of time between the above slack and the time desired, and enter the side of table A or B with the interval which most nearly agrees with this value.
4. Find, in the table, the factor corresponding to the above two intervals, and multiply the maximum velocity by this factor. The result will be the approximate velocity at the time desired.

Figure 9. Velocity of Current at Any Time.

Current Differences and Other Constants section (b above) to accomplish this task.

ii. Suppose a researcher needed to know the tidal current off Monroe Island at 1000 January 1, 1979. Based on our previous computations there are slack water periods at 0649 and 1239 and a maximum flood tide of .36 knots from 005 degrees true at 0948 on that day.

iii. Find the time interval between slack water and the time of maximum velocity flood (0948 - 0649 = 2h 59m).

iv. Find the time interval between the desired time (1000) and slack water (1000 - 0649 = 3h 11m).

v. Enter Table A (Figure 9) in accordance with the directions provided under Table B. There are columns and rows. Find the vertical column with the heading nearest 2h 59m (use column times as the difference between slack water and maximum flood). Then find the horizontal line with a heading nearest 3h 11m (use lines for the time difference between slack water and the desired time). Once the proper line and column have been determined, enter the table at both and proceed to their intersection. The figure at the intersection is a tida- multiplication factor. Use it to calculate ~~tidal~~ velocity at the desired time.

When we enter the table in search of the multiplication factor for this problem a blank is found at the intersection. There is, however, a factor for every time between slack water periods. In this case we know intuitively that the factor is probably close to 1.0 but since the time of maximum velocity flood has passed, tidal velocity no doubt is decreasing toward the next slack water. The difference figures, therefore, must be recomputed using the time of the coming slack water period (1239). The recomputation column figure then becomes 2h 51m (1239-948) and the line figure 2h 38m (1239-1000). This time, intersection of the column and ine yields a factor of 1.0. Tidal velocity at 1000 is then .36 knots (1.0 x .36k).

d. Wind Driven Currents. When investigating surface currents it may be necessary to account for the effect of wind upon currents. Table 1 provides average wind driven current values.

TABLE 1

Average Wind Drive Current Values

Wind velocity (MPH)	10	20	30	40	50
Average current velocity (k)	0.2	0.3	0.4	0.5	0.6

MPH - miles per hour   k - knots

i. Tidal Currents plus Wind Currents. When the wind is in the same direction as the ebb or flood current, their current values add; the surface current so produced is the sum of the two.

ii. Tidal Currents Minus Wind Current. When wind driven currents oppose tidal currents, the effect is subtractive. The surface current is the difference between the two.

iii. Tidal Currents and Wind Currents from Different Directions. As is often the case, tidal currents and wind currents are from different directions. When this occurs, right angle trigonometry, the Pythagorean theorm or vector analysis must be used to find the resultant current.

The rules of trigonometry may be used at any time to solve any resultant current problem. This method requires the use of Trig tables and known angles. Angles are determined by knowing the true of magnetic direction of the tide and the direction from whence the wind blows.

The Pythagorean theorm method ($c = \sqrt{a^2 + b^2}$) is directly applicable only when tidal and wind currents are displaced by 90°.

The vector method requires the use of lines representing the magnitudes of tidal and wind currents. Here the lines are displaced by an angle equal to the actual current displacement in the environment and the lengths of the lines are to scale (for example 1 cm = 1 k). Figure 10 shows such a vector diagram. When these diagrams are made correctly the length of the resultant current vector (AC in the example) should be an accurate representation of both resultant current direction and velocity.

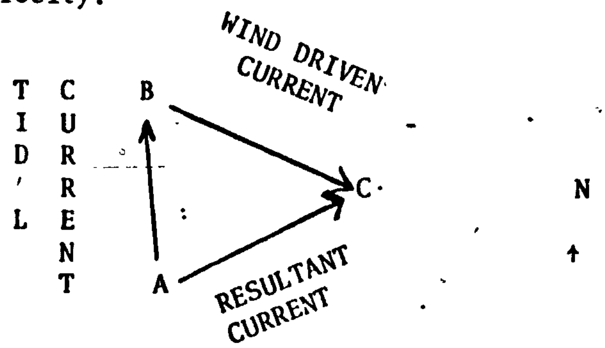


Figure 10. Vector Diagram Showing Combination of Tidal and Wind Driven Currents.

e. Substation Current Prediction Sheets. When attempting to control curent related variables while investigating such phenomena as the Ekman spiral, a current prediction sheet may be useful. One is shown in Figure 11.

SUBSTATION
CURRENT PREDICTION SHEET

LOCALLY - MONROE ISLAND, MAINE DATE: 1 JANUARY 1979

REFERENCE STATION - PORTSMOUTH HARBOR ENTRANCE

SUBSTATION TIME DIFFERENCES

A. SLACK WATER -h 45m

B. MAXIMUM CURRENT -1h 20m

SUBSTATION CURRENT VELOCITY RATIOS

A. MAXIMUM FLOOD 0.2

B. MAXIMUM EBB 0.3

SUBSTATION CURRENT DIRECTIONS

A. (TRUE) FLOOD 005

B. EBB 160

REFERENCE STATION INFORMATION (TABLE 1)		SUBSTATION INFORMATION (TABLE 2)	
TIME (EST)	VELOCITY (K)	TIME (EST)	VELOCITY (K)
0212	0		
0455	2.3 E		
0834	0		
1048	1.8 F		
1424	0		
1723	2.6 E		
2115	0		
2322	1.7 F		

VELOCITY OF CURRENT ANY TIME

SUBSTATION - MONROE ISLAND DATE: 1 JANUARY 1979
TIME: 1000

INTERNAL BETWEEN SLACK WATER AND DESIRED TIME ____________

INTERNAL BETWEEN SLACK WATER AND MAXIMUM TIME ____________

MAXIMUM CURRENT ____________

MULTIPLICATION FACTOR (TABLE 3) ____________

CURRENT VELOCITY ____________

CURRENT DIRECTION ____________

Figure 11. Typical Current Prediction Sheet

4. Other Data Manipulation Aids. There are many other data manipulation aids and methods of controlling variables than those presented here. Many are graphic. Although we have not called them aids as such in this guide they indeed are. We suggest you look closely at the graphic methods of date presentation discussed in Chapter 3. Much may be learned about a collection of data by putting it in some coherent graphic or tabular form.

V. Marine Related Abstracting Services.

Experienced researchers know that marine related literature is liable to appear in almost any abstracting service. Whether an article or paper is cited by one service or another depends upon its subject. Some services list only marine oriented documents while others list only an occasional article. There is, in all of the services cited here, a high probability of finding marine science oriented citations. In addition to the abstracting services, we have listed a few relevent periodic bibliographies:

A. Government Reports, Announcements and Index Publisher:

U.S. Government Printing Office

B. Scientific American Cumulative Index Publisher: Scientific American, Inc.

C. Ship Abstracts Publisher: The Ship Research Institute of Norway

D. Readers Guide to Periodical Literature Publisher: The H.W. WIlson Company

E. Oceanic Abstracts Publisher: Data Courier, Inc.

F. Poole's Index to Periodical Literature Publisher: Peter Smith

G. Pollution Abstracts Publisher: Data Courier, Inc.

H. Cumulative Book Index Publisher: The H.W. Wilson Company

I. Book Review Digest Publisher: The H.W. Wilson Company

J. Book Review Index Publisher: Gale Reserach Company

K. Applied Science & Technology Index Publisher: The H.W. Wilson Company

L. Access Publisher: John Gordon Burke, Inc.

M. The Environment Index Publisher: Environment Information Center, Inc.

References

Schlenker, R.M. and Perry, C.M., A writing guide for student oceanography laboratory and field research reports. Resourses in Education, ERIC ED 178 332, March 1980.

Shufeldt, H.H. and Dunlap, G.D., Piloting and Dead Reckoning. Annapolis, Maryland: Naval Institute Press, 1975.

U.S. Department of Commerce, Tidal Current Tables 1979. Washington, D.C.: U.S. Government Printing Office, 1978.

U.S. Department of Commerce, Tide Tables 1979. Washington, D.C.: U.S. Government Pringint Office, 1978.

CHAPTER 3

TOOLS AND AIDS FOR REPOFT WRITING

Students writing research reports apply literally thousands of concepts they have learned throughout their precollege and undergraduate school days. It might realistically be said that all the rules of grammer which apply to the native tongue must be used when writing reports. Although those rules cannot be recapitulated here, students are well advised to write with these rules in mind.

Chapter 3 is divided into two major sections. They are Writing Aids and Methods of Data Presentation.

I. Writing Aids.

Scientific research report writing is somewhat different from the theme and term paper writing students do in high school and college English courses. In science we deal with the scientific method and in so doing attempt to keep our views and thoughts objective. We base our writing upon empirical evidence gathered during our own work and upon the findings reported by other researchers.

Adherence to objectiveity is not difficult if writers follow a few simple steps as they proceed.

A. The Outline. Outlines are used whenever people attempt to write papers and reports. Outlines help ensure that the composition has a definite beginning, body and ending. The outlining procedure then is the first step writers take in constructing a report.

Chapter 4 includes a research report format. That format is the form in which the report should be when it is completed. In essence it is itself a topic outline of a report in that it signals readers as to what may be found under each heading. Before a report can be placed in that format, however, individual sections must be completed. Here, we suggest students use outlines.

Outlines should be written for each of the following report sections; Introduction; Methods; Data or Findings; Discussion and; Conclusions or Interpretations. Each outline should have a beginning, body and ending. The outlines should be a series of words that follow the traditional outline format. Once an outline has been written, the gaps are filled in with brief sentences; as a final step the outline is used as a point of departure when writing the final draft of a section.

In the example provided below, the Introduction section of a research report has been outlined. The hypothetical problem, to which the outline relates, dealt with the location of the fall line in the Penobscot River Estuary.

1. <u>Section Outline</u>

INTRODUCTION

I. Introduction
   A. Project Rationale
      1. Preproject observations
         a. Penobscot River salinity
            i. above Winterport
II. Body
   A. Estuarian Theory
      1. Possible Location
   B. Other Research Findings
      1. Penobscot Estuary
      2. Other Estuaries
III. Conclusions

A. Hypothesis

1. High Tide

2. Low Tide

a. Apogee

B. Rough Draft. When a section outline, necessary literature searching, reading and or data gathering have been completed a rough draft is written. Beginning researchers tend to write final drafts from their outlines. This procedure, however, should be avoided. Tough drafts allow writers to reflect upon their work and whenever necessary, make corrections.

C. Abbreviations. Some abbreviations may be used in specific research report writing. Those generally acceptable are abbreviations for distance, quantities and dimensions, such as millimeters (mm), cubic centimers (cm^3), kilometers (km) and the like. Others are not acceptable. While economy of space is important, clarity is more so. As a rule, abbreviations other than those listed above should not be used in the text of a report.

D. Person. When pronouns are used in a report, they should be in the third person. This practice aids in writing a clear and objective report (see Table 2).

Table 2

Division of Pronouns by Person, Chase, and Gender

	SINGULAR					PLURAL		
	First Person	Second Person	Third Person			First Person	Second Person	Third Person
NOMINATIVE	I	You	He	She	It	We	You	They
DATIVE	Me-to	You-for	Him	Her	It	Us	You	Them
ACCUSATIVE or OBJECTIVE	Me	You	Him	Her	It	Us	You	Them
GENITIVE or POSSESSIVE	It	Your	His	Hers	Its	Our	Your	Their

E. Citations. Whenever another scholar's work is quoted or otherwise used in a report it must be cited. That is, the original author must be given credit for the work. In scientific reports the process is accomplished in three ways.

1. References Section. Every reference cited in the context of a report must also be listed in the references section of the report (see References, Chapter 4).

2. Direct Referral to Author. When referring directly to the work of another author in the context of a report, the last name only of that author is used followed by the parenthetic inclusion of the date of publication. If one wants, for example to cite work published by Bell R. Buoy in 1980 it is accomplished as follows: Buoy (1980) found a direct relationship between depth and pressure in the water column.

3. Parenthetic Inclusion of Author and Date. The example used in 2 above may be cited in a slightly different manner. A direct relationship has been found between depth and pressure in a water column (Buoy, 1980).

F. Tense. Research reports deal with events that have taken place some time in the past (this applies to interm reports also). Since they deal (with the exception of intern reports) with investigations that have already been completed, they are always written in the past tense.

G. Second and Final Drafts. Once a first draft is completed and corrected, work is begun on a second draft. Second drafts may also be final drafts. This, however, is a somewhat dangerous precident for beginning writers to set. Second drafts should be read carefully, and then grammatical construction, spelling and other errors corrected. The report is then ready for proof and colleague reading.

1. Proof Reading. Proof reading is perhaps the most overlooked part of the writing process. Many beginning students tend to omit this segment all together.

Papers should be proof read after completion of a second draft. If done correctly, proof reading helps to locate additional mispellings, typographical errors, poor sentence structure and improper grammar, measurably increasing the quality of a report. Final drafts must also be maticulously proof read.

2. Colleague Reading. Colleague reading is the final step taken by beginning researchers prior to preparation of their final drafts. Here the report is given to a colleague to read. The person you choose should be someone who is generally unfamiliar with your investigation. If he or she understands what you have written and feels that based upon your writing, your research project can be replicated, your report will probably be clear to the general readership. It therefore, need not be modified further. Conversely, if your colleague has difficulty understanding your work, it should be changed accordingly.

a. Replication. As a guide to your colleague reader, one essential mark of well written scientific reports is that they allow the studies they describe to be replicated without additional information. This means the report has been so written that an identical research project could be conducted under the same conditions by a person other than the original investigator.

Reports which exemplify these few simple dicta are credits to their authors. Those not following these pronouncements cannot truly be called scientific research reports.

II. Methods of Data Presentation.

There are literally dozens of ways research data may be presented. Excepting one, they are all graphic. The one exception is a straight forward contextual description. Written descriptions of data or research findings are always provided in a paper. Figures and Tables, however, are luxuries used to provide readers with visual overviews of findings.

Certain rules must be followed when Figures and Tables are used. Each has its own unique number and they are always numbered consecutively. If, for example, three figures and four tables were included in a research report, they would be numbered as follows; Figure 1, Figure 2, Figure 3; Table 1, Table 2 and so on. The titles of Tables are placed above the tables and the titles of Figures are placed below the figures. Proper placement and use of titles are found in Chapter 5 and amongst the samples provided below.

A. Sample Tables.

1. Table 1 is an amalgamation of data collected during an intertidal population density study. Definitions of terms, letters and the like used in a table are provided in one of two ways. They may be provided in context or they may be provided in a list of notes at the bottom of the table. The latter method is used here; consult Chapter 5 for examples of the former method.

Table 1

Numbers of Periwinkles by Species Counted in 10 Transects

	1/2 METER ^{2}	1			2			3			4		
		SPECIES											
	STATION NO.	C	S	R	C	S	R	C	S	R	C	S	R
WEST	1	20	0	12	25	2	4	25	4	0	30	8	0
	2	19	0	7	20	1	6	24	3	0	21	9	0
	3	15	0	16	22	3	4	20	6	0	19	10	0
	4	11	0	10	21	2	7	22	8	0	28	11	0
TO	5	12	0	17	18	0	2	19	7	0	15	7	0
	6	10	0	10	20	1	1	23	9	0	19	8	0
	7	14	0	3	22	2	6	24	5	0	24	12	0
EAST	8	19	0	8	24	1	7	27	8	0	26	14	0
	9	10	0	16	20	3	5	30	4	0	28	12	0
	10	24	0	5	21	2	3	15	7	0	19	13	0

Notes: C = Common, S = Smooth, R = Rough

2. Table 2 shows a way of presenting data reflecting ionic concentrations in body fluids of some invertebrates.

Table 2

Concentrations of Ions in Body Fluids of Some Marine Invertebrates (g/kilo)

Seawater So/oo = 34.3	Na	K	Ca	Mg	Cl	SO_4
	10.6	0.38	0.40	1.27	19.0	2.65
Aurelia aureta	10.2	0.41	0.39	1.23	19.6	1.46
Arenicola marina	10.6	0.39	0.40	1.27	18.9	2.44
Carcinus maenas	11.8	0.47	0.52	0.45	19.0	1.52
Mytilus edulis	11.5	0.49	0.50	1.35	20.8	2.94
Phallusia mammillata	10.7	0.40	0.38	1.28	20.2	1.42

3. Table 3 presents a collections of bathythermograph data.

Table 3

BT Readings at Stations in Penobscot Bay, Maine

	Station Numbers (With Surface Temperatures ^0C)			
	1	2	3	4
	(18.6)	(18.9)	(20)	(21.8)
	Depths (meters)			
Temperatures (^0C)				
21.1	-	-	-	8
20	-	-	4	10
18.9	-	10	7	13
17.7	9	28	10	15
16.7	33	31	15	17
15.6	39	37	19	19
17.7	9	28	10	15
16.7	33	31	15	17
15.6	39	37	19	19
14.4	42	42	24	26
13.3	62	50	33	36
12.1	58	55	44	49
11.1	80	75	51	59
10	106	91	62	75

4. Table 4 shows a method of presenting salinity versus depth data.

Table 4

Salinities at Selected Depths and Locations in Penobscot Bay, Maine

Depth	Salinity (o/oo)				
(Feet) Stations	1	2	3	4	5
0	18.75	17.28	19.12	15.63	16.95
5	18.91	18.00	19.45	16.60	17.88
10	19.46	18.75	20.01	17.25	18.75
15	20.05	19.48	20.86	18.01	19.22
20	20.91	20.07	21.50	19.23	20.03
25	22.00	21.98	22.05	21.80	21.93
30	24.10	22.60	24.02	24.00	23.98

5. Table 5 presents surface salinities and temperatures.

Table 5

Surface Salinities and Temperatures at Selected Location in Penobscot Bay, Maine

Station Number	Longitude (degrees & minutes)	Latitude (degrees & minutes)	Surface Salinty (o/oo)	Surface Temperature (^0C)
1	68 45.6	44 20.8	33.20	11.2
2	68 45.4	44 20.6	32.90	12.5
3	68 45.5	44 20.4	33.10	14.8
4	68 45.6	44 10.2	33.20	14.8
5	68 45.4	44 20	33.50	15.0
6	68 45.5	44 19.8	33.45	15.8

6. Table 6 presents currents versus depth data.

Table 6

Salinity, Temperature, Direction and Speed of Currents in the Water Column at Selected Locations in the Penobscot, Maine Estuary

	STATION NUMBERS								
	1			2			3		
	Depths (Meters)								
	10	20	30	10	20	30	10	20	30
Direction (magnetic)	090	105	115	091	106	114	092	104	116
Speed (knots)	2.1	1.6	1.1	1.1	1.4	1.2	2.0	1.5	1.0
Temperature (^0C)	18.5	17.2	18.0	18.6	17.0	16.1	18.3	17.1	16.3
Salinity (oo/oo)	33.4	31.5	9.0	33.2	32[illegible]	29.1	33.1	31.8	29.0

B. Sample Figures.

1. Figure 1 presents North-South current data over a period of three tidal cycles.

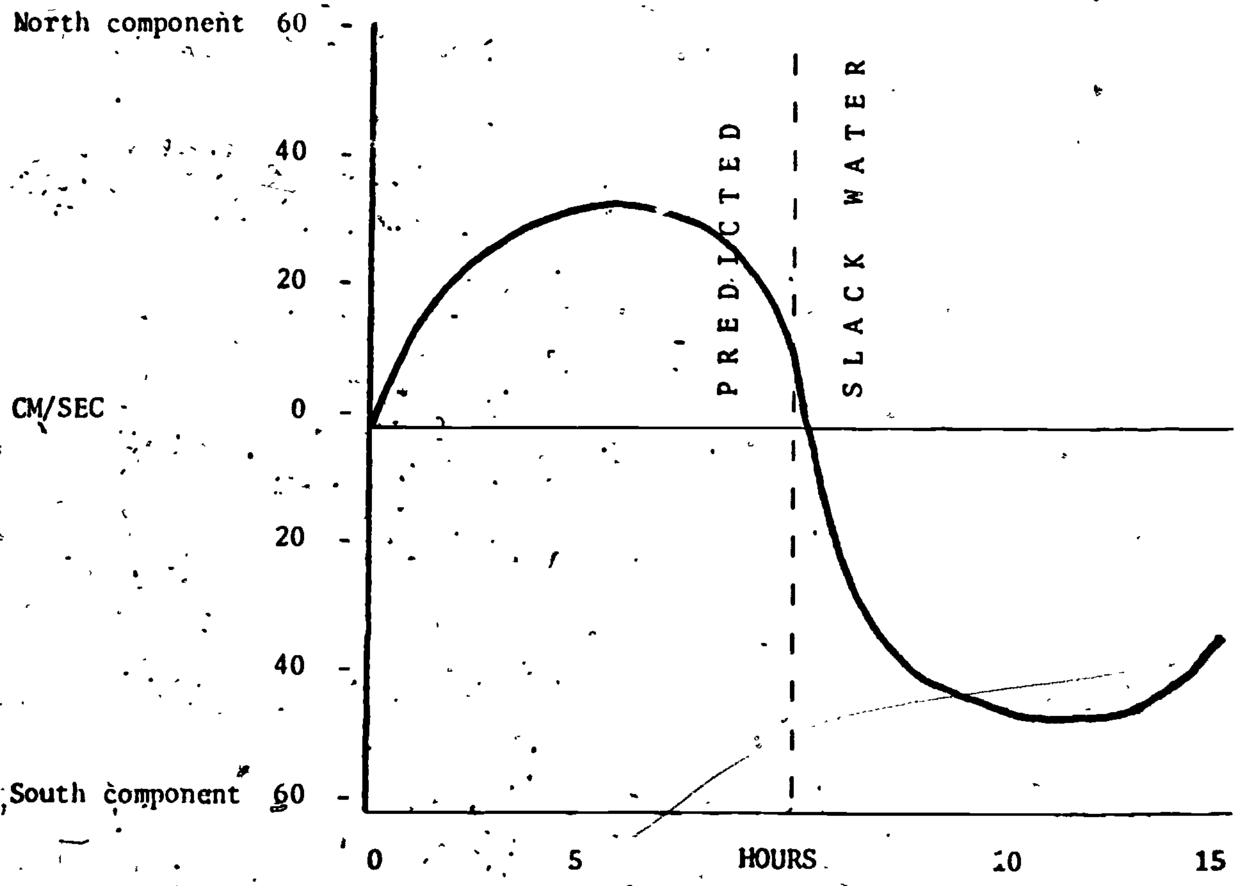


Figure 1. Best fit curve of plots of North-South current components for three tidal cycles at C1 in the Bagaduce River.

2. In Figure 2, temperature is compared with depth at a single research station.

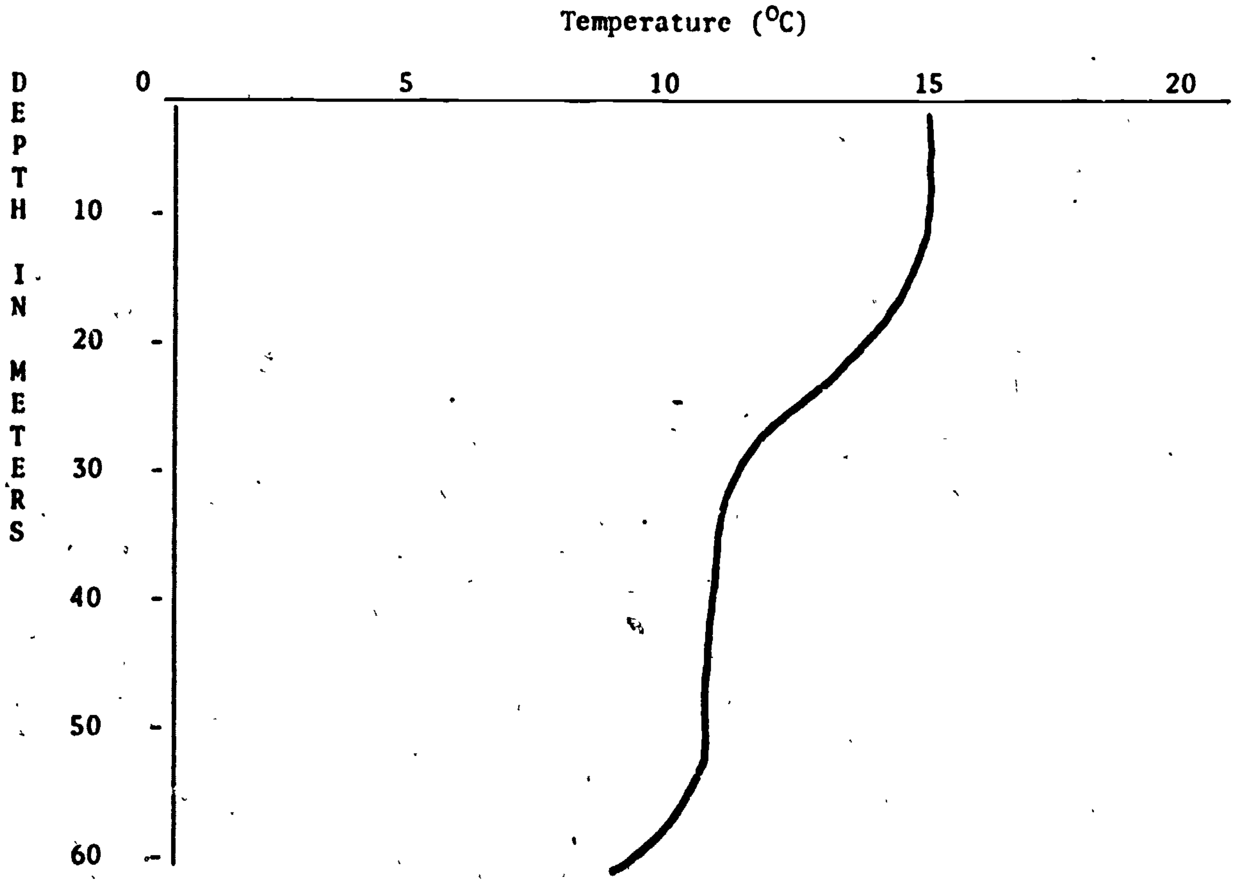
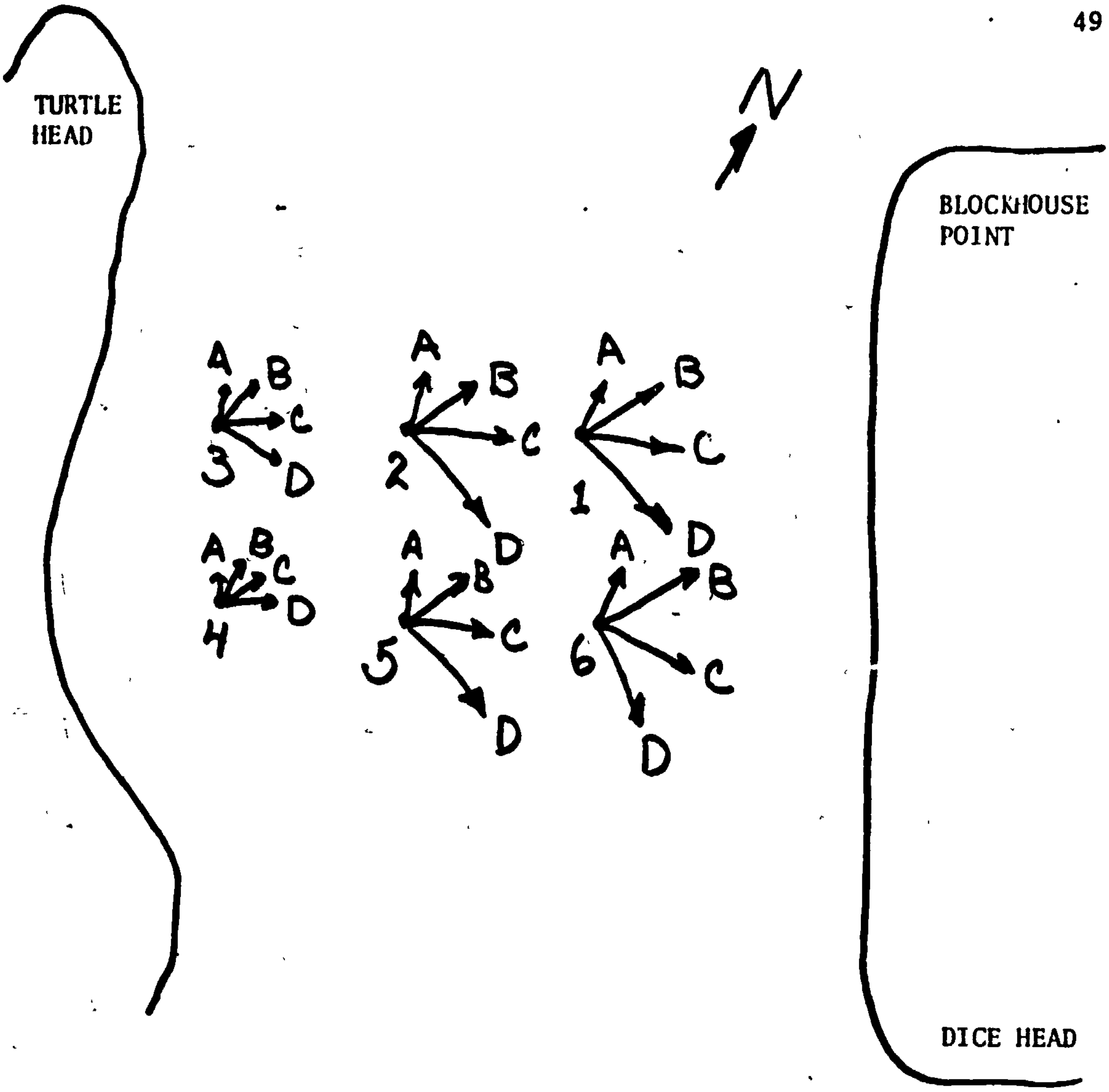


Figure 2. Temperature-depth profile at Station 2, October 8, 1980.

3. In Figure 3, current verses depth data is presented for six different research stations in a line between two points of land.



* 1 cm = .2 knots

** A = 5'

B = 10'

C = 15'

D = 20'

Figure 3. Current Direction and Speed with Depth at Stations 1-6, June 28, 1980.

4. The data from 4 different BT drops are present in Figure 4.

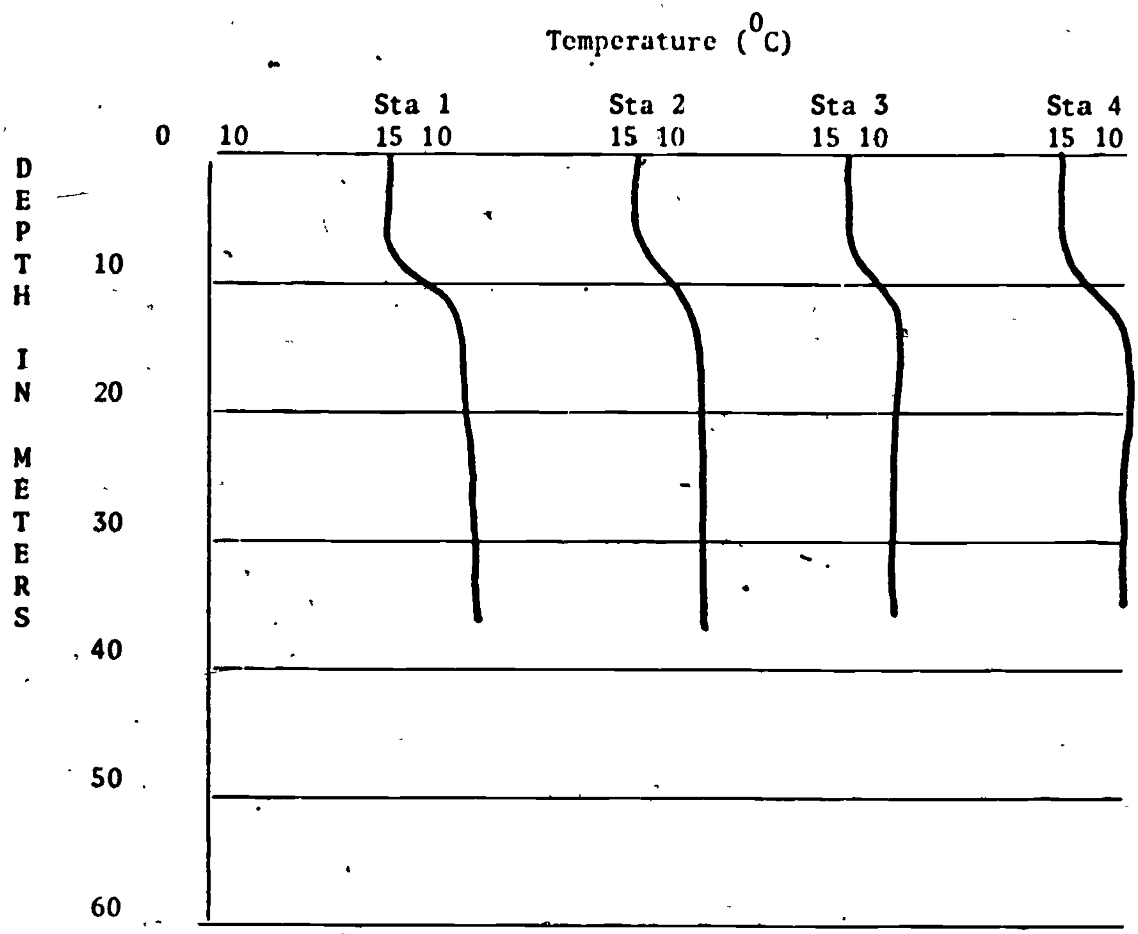
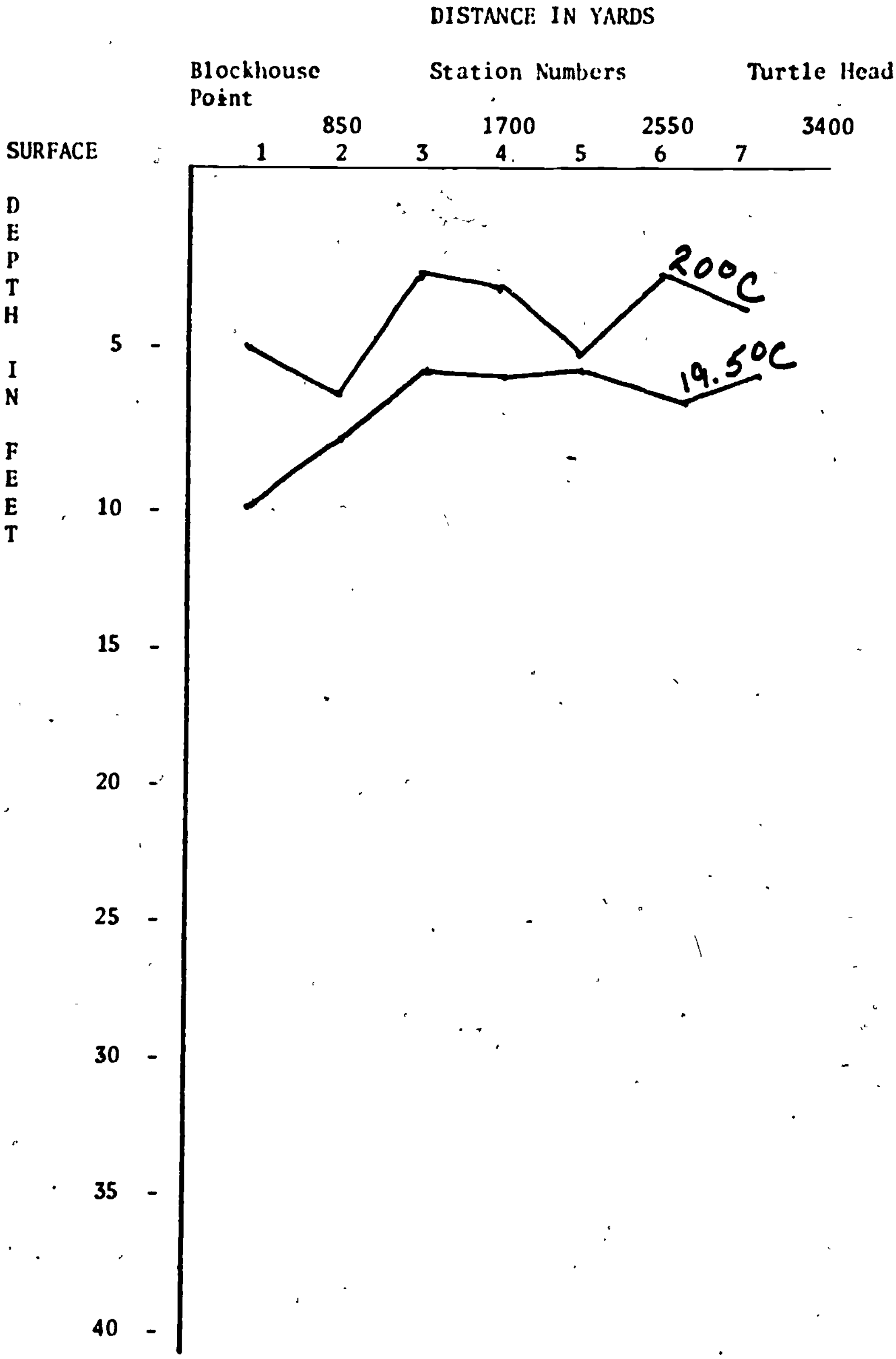


Figure 4. A Comparison of Bathythermograph readings at Stations 1-4 in the Penobscot, Maine Estuary.

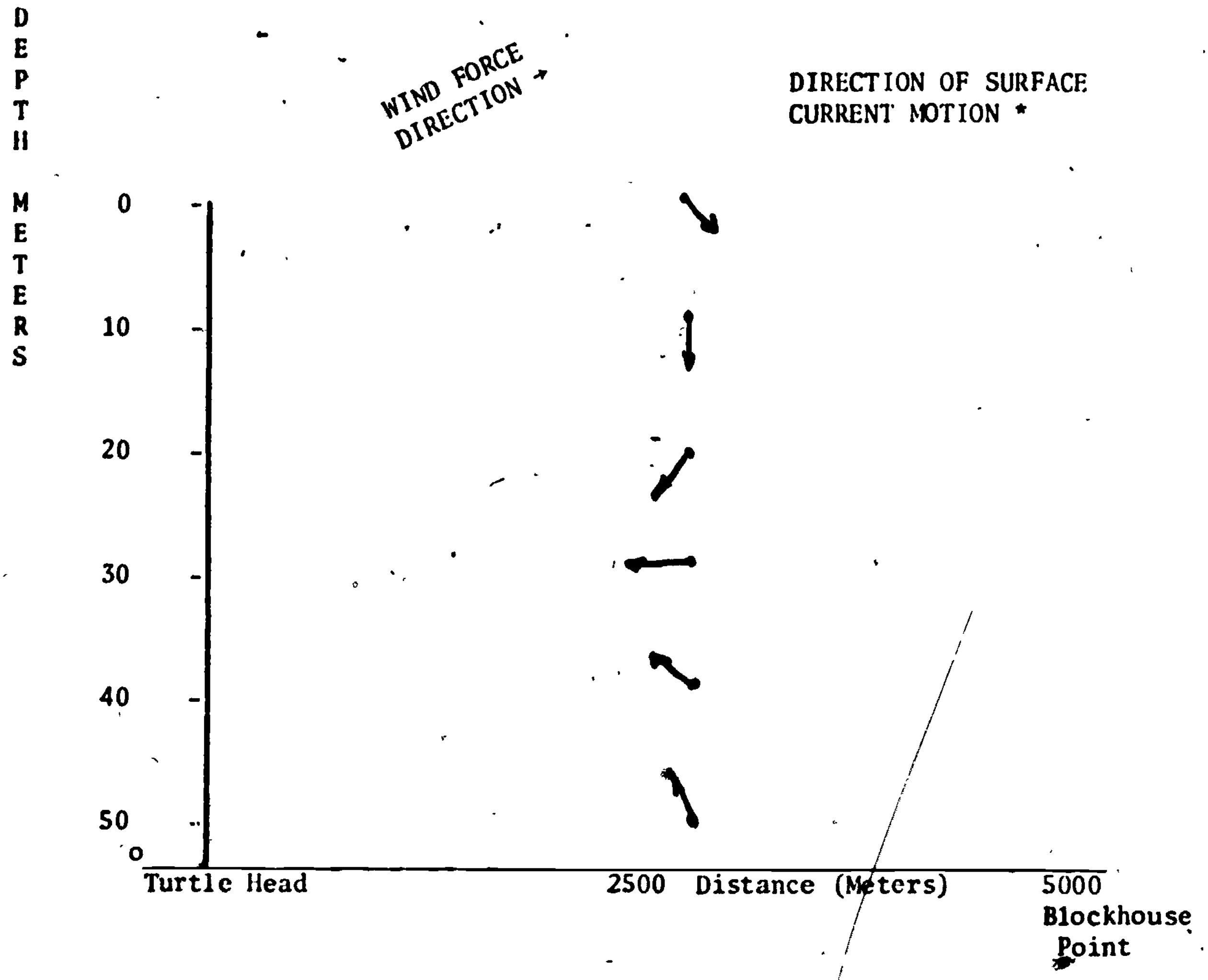
5. Lines of equal temperature between two geographic points are present in Figure 5.



* = Temp in °C.

Figure 5. Isotherms between 68° 44' 10" W. and 44° 28' 22" N and 44° 28' 22" W, 68° 42' 12" W (corrected to MLW) September 1980.

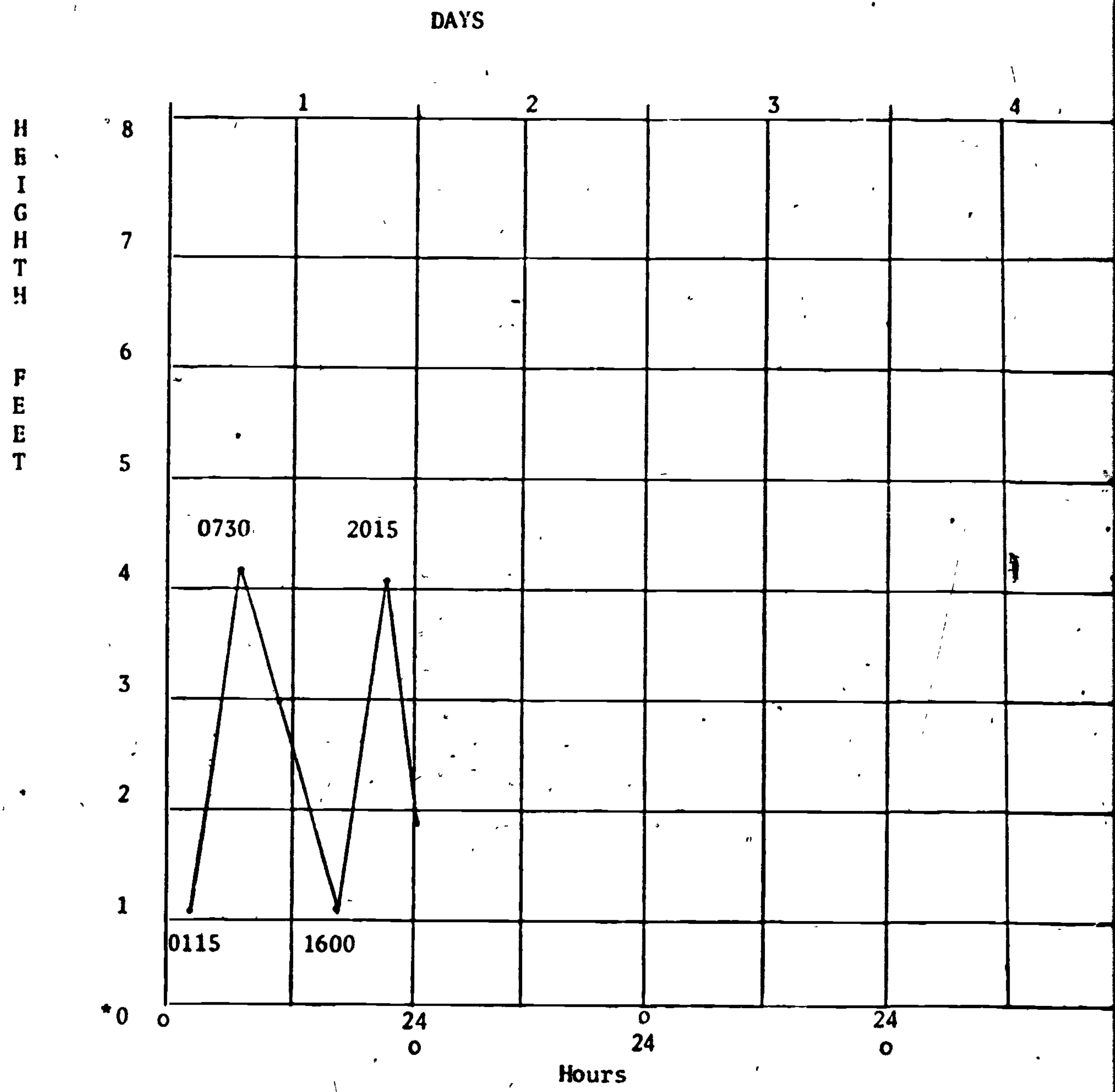
6. Ekman spiral data is presented in Figure 6.



* 1 cm = 1K

Figure 6. Remote Current Reading in the Water Column at Station 2, Penobscot Bay.

7. A method of showing visually daily tidal fluctuations is shown in Figure 7.



* MLW

Figure 7. A Graph of Tides in Penobscot Bay June 21, 1981.

8. Figure 8 shows one method of presenting sigma-t data.

SALINITY (PARTS PER THOUSAND)

TEMPERATURE DEGREES	26	27	28	29	30	31	32	33
12	22.74	23.52	24.28	25.06	25.83	26.61	27.38	
11								
10	23.08	23.86	24.64	25.41	26.19	26.97	27.75	
9								
8	23.38	24.16	24.94	25.73	26.51	27.29	28.08	
7								
6	23.63	24.42	25.21	26.00	26.79	27.57	28.36	
5								
4	23.84	24.63	25.43	26.22	27.01	27.81	28.60	
3								
2	24.00	24.80	25.60	26.39	27.19	27.99	28.79	
1								
0	24.10	24.91	25.71	26.52	27.32	28.13	28.93	

Figure 8. Temperature-Salinity Diagram Showing Sigma-t for Station 1.

9. Data reflecting salinity values at a variety of surface stations is presented in Figure 9.

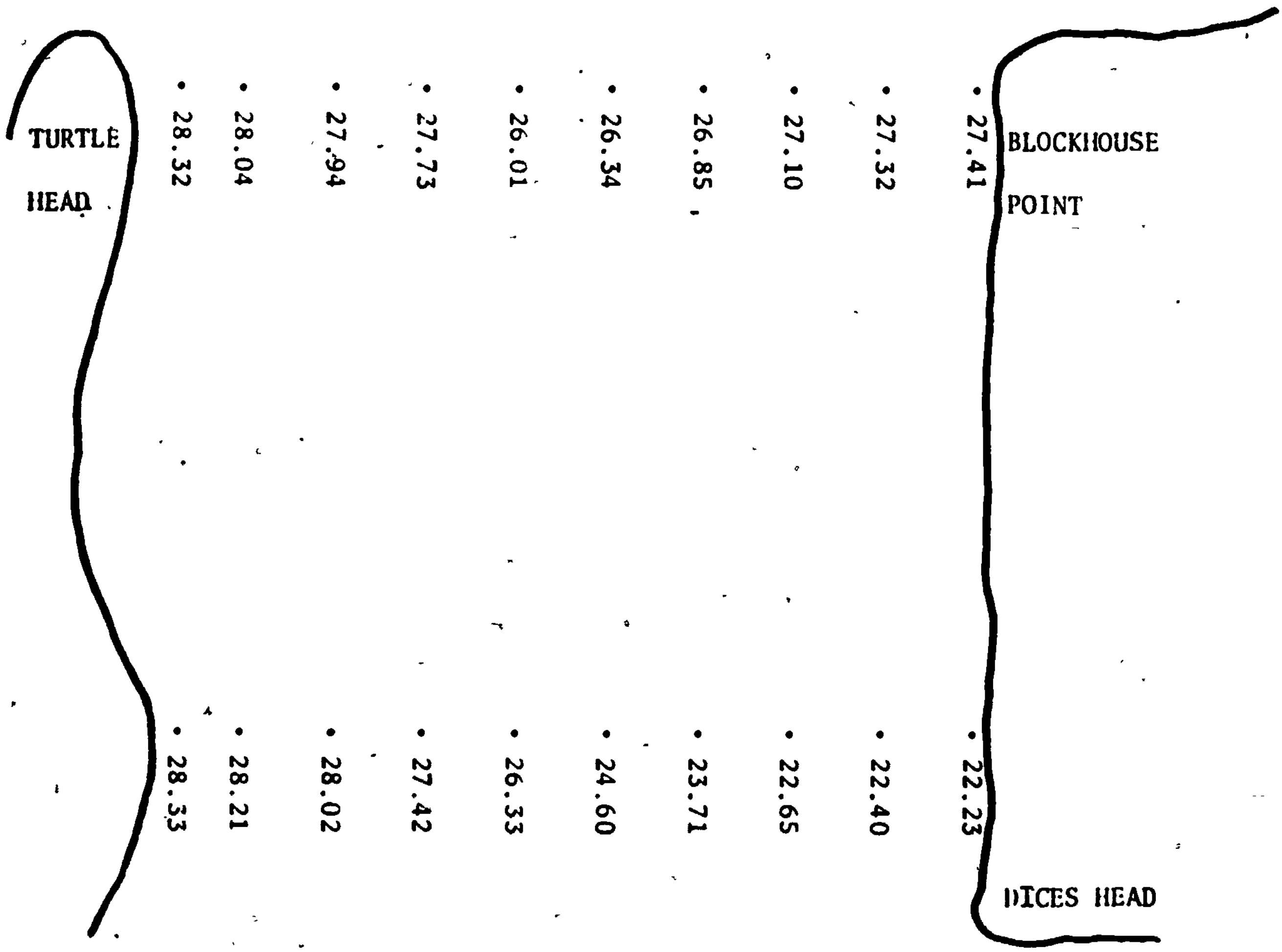


Figure 9. Surface Salinities taken at 20 Stations Bewteen Castine Maine and Islesboro Island (September 1 - October 1, 1980).

REFERENCES

Manheimer, L. Style Manual. New York: Marcel Dekker, 1973.

Gibaldi, V. and Achtert, W.S. MLA Handbook for Writers of Research Papers, Theses, and Dissertations. New York: Modern Language Association, 1977.

Schlenker, R.M. and Perry, C.M. A Writing Guide for Student Oceanography Laboratory and Field Research Reports. Resources Education, ERIC ED 178 332, 1980.

Pipkin, B.W. Gorsline, D.S., Casey, R.E., and Hammond, D.E. Laboratory Exercises in Oceanography. San Francisco: W.H. Freeman and Company, 1977.

Opkycke, J.B. Harpers English Grammar. New York: Popular Library, 1965.

Curme, G.O. English Grammar. New York: Barnes & Noble, 1966.

American Psychological Association Publication Manual of The American Psychological Association.

Tait, R.V. Elements of Marine Ecology an Introductory Course. London: Butterworth, 1968.

CHAPTER 4

RESEARCH REPORT FORMAT

Research reports should include the following sections; Title, Introduction, Methods, Data or Findings, Discussion, Conclusions, References and Summary or Abstract. Each section is discussed in the following paragraphs.

Except for the title, each section of a report is preceded by its respective section heading (Introduction, Methods, etc.). There are at least two acceptable locations for the placement of section headings. One is called a centered head. Centered heads are centered above the major division they name and written in capitol letters. An example of this type is shown below.

INTRODUCTION

The objective of this project was to compare two methods of bottom profile construction and determine which would provide oceanographers with the most accurate contour of the ocean floor. It was hypothesized that a recording fathometer would produce more accurate profile than could be obtained using soundings from a National Ocean Survey Chart to construct a profile of the same course travelled when the fathometer print was made.

METHODS

The second type heading is known as a free-standing sidehead. Free-standing sideheads are set flush with the left margin of the report and on a line by itself. It is underlined and only the first letter is capitalized. An example is shown below.

Introduction

Geological oceanographers often require highly accurate bottom profiles of study areas. The purpose of this research was to evaluate two methods of bottom profile construction in an attempt to determine which would produce the highest quality product.

Methods

I. Title

The title is (except when an Abstract is used-see Abstract or Summary section below) the first part of a report seen by prospective readers. It is the part which tells a reader whether, from his or her perspective, the report should be read. A title, therefore, must indicate the contents of a report. It must be clear, concise, percise and comprehensive.

Most reports have a seperate title page. The page includes the title of the report, the author's (student's) name, the name of the school or institution, with which the author is affiliated, location and the date (some style guide writer's suggest a course name and number be included if the report is written as part of a course requirements). An example title page is shown on the following page.

(Sample Title Page) Line

A Comparison of Two Methods
of Ocean Bottom Profiling 11

By 33

Boswain Midshipman 54
Maine Maritime Academy 55
Castine, Maine 04421 56
October 1980 57

II. Introduction

This is the what, why history and hypothesis section of a report. It is the place where researchers; (1) discuss what was done. The discussion includes the research question or questions that were to be answered or the problem that was to be solved and; (2) discuss the reasons why the project was undertaken.

A problem's history is also discussed here. Historical information is drawn from other research papers, text books and other library sources. The primary funtion of the historical discussion is to provide readers with background information related to the research being reported. In a sence, in telling readers what is already known about a problem, the historical discussion leads readers to the rationale (or why) for conducting the research.

When hypotheses are used as a part of the research design, they are usually included here. That is, hypotheses concerning the outcome of the investigation are listed in this section.

Written correctly, this section provides a logical link between the problem being investigated and the research methodology used to seek an answer or solution.

Readers are urged to consult the sample problems in Chapter 5 for examples of this section.

III. Methods

Although a separate part of a report, the methods section should be a natural continuation of the, Introduction. Here, a writer explains as specifically as possible, exactly how the data for a report were gathered. As guidance in writing this section students should remember that well written scientific research reports are specific enough that they allow others to reconduct a project solely from directions provided in the report's Methods section. If, for example, data were collected at a specific station readers must be told how to relocate the station. In this regard, two approaches are possible. First, if the station location was determined using the intersection of lines of position from known geographic features or aids to navigation, the names of the structures and their magnetic bearings from the station may be given. The second method requires only that the latitude and longitude of a station be identified. Examples of these approaches are provided below.

A. Approach A. Locations of the stations were established by intersecting lines of positions from the stations to known geographic and navigational structures. The lines of position were determined using a hand bearing compass. The structures used for station 1 and their respective bearings from the station were; Turtle Head, 324°; Islesboro Ledge Buoy, 215°; Hosmers Ledge Day Marker 094°.

B. Approach B. The first two sentences used with this approach are the same as those used above with Approach A. In the third sentence the writer might say, Station 1 was located at 44° 22' 38" N latitude and 68° 23' 32" W longitude.

Data gathering equipment must be identified in this section. It is not, however, necessary to explain the internal functionings of data-gathering equipment unless the equipment was used in some atypical manner. Readers, unfamiliar with the general functioning of Nansen bottles or some other piece of equipment for example are obligated to consult the literature of such information.

With one exception, a majority of the information in this section comes directly from the field notebook. When statistical and special data manipulation techniques are used they must be identified in this section.

IV. Data or Findings

The Data or Findings as the author chooses to call them are those things accumulated during the data gathering phases of a project. As was the case with the Methods section, information for this section comes directly from the field notebook.

Data or findings are always described in writing. In addition, findings may be presented using Tables and Figures. It is convention to lump all graphs, charts and diagrams in a single category called "figures."

A. Tables and Figures as Visual Aids. When Tables, Figures or both are used they add clarity to that described in context. Tables and Figures are only a visual representation or summary of what is written about project findings. They are not substitutes for a written description of project findings.

B. Table and Figure Numbers and Titles. Tables and Figures are numbered successively and each has its own title. If, for example, a report contains two tables and two figures they are numberes Table 1, Table 2, Figure 1 and Figure 2 and so on.

Table and Figure titles must be comprehensive. They should reflect as closely as possible, the exact contents of the Table or Figure.

Examples of table and figure numbering are found in the sample papers (see Chapter 5) and the examples of tables and figures in Chapter 3. Additional guidance may be found in writing style manuals.

V. Discussion

Research project findings are discussed in this section. Hypotheses formulated or research questions posed in the early stages of an investigation are considered here. This is also the place where the findings of the present study are compared with those studies conducted previously by other investigators. When the findings of other researchers are compared with yours, those of others must be cited in context and listed in the References section of your report (see Chapter 5).

The Discussion section should be concise, percise and straightforward. This is not the place to describe everything that transpired in the investigation.

Tables and Figures may be used in this section. If used, they should summarize the results of data manipulations or findings.

VI. Conclusions

Here researchers draw conclusions based upon their findings. The conclusions drawn here eminate from the comparisons made in the Discussion section, between information in the literature and the findings of the present study. A writer may wish to conclude, based upon interpretation of his findings, that his results support conclusions drawn previously by other investigators. In investigations designed to exemplify a theory, a conclusion might be that the present study either supports or disagrees with accepted theory. Where findings fail to support accepted theory exactly, students may wish to draw conclusions reflecting upon the possibility that experimental error contributed to said lack of support.

While beginning researchers tend to conclude that experiments worked nicely or were a success, the practice should be avoided at all costs. The readership decides upon the success or failure of investigations. Further, determinations of this nature normally depend upon a reader's evaluation of reserarch design quality, quality of data manipulations and the equality of presentation. Failure to mention experimental error or some other salinent feature of an investigation may lead readers to conclude the project ended in failure.

VII. References

This section is a list of all references cited in the context of the report. The citations are listed alphabetically by the authors' last names. The remainder of each citation should be in the same form as the ciatations included in the sample problems, Chapter 5.

VIII. Summary or Abstract

Summaries, generally speaking, preceed references sections while abstracts preceed titles. Which ever is used (a matter of author preference), the section contains but a few brief sentences describing the methods, findings and conclusions of an investigation.

REFERENCES

Schlenker, R.M. and Perry, C.M. A Writing Guide for Student Oceanography Laboratory and Field Research Reports. Resources in Education, ERIC ED 128-332, March 1980.

CHAPTER 5

SAMPLE PROBLEMS AND ASSOCIATED REPORTS

INTRODUCTION

Three sample research problems and their associated reports make up this chapter. The prereport writing process in each case follows the scientific method. Someone, usually the eventual researcher is cued to an oddity as the result of personal observations. Natural curosity leads the observer into the literature in search of what is already known about the observed phenomonon.

Once a literature search is complete one of two courses may be taken. Both are related to the original observation. Either research questions are asked about the observation or hypotheses are formulated regarding cause-effect relationships related to the oddity. Finally, either alternative takes the researcher into the field in search of casual relationships.

SAMPLE PROBLEMS

With each of the three sample problems readers are first presented with a situation. The situations reflect researchers perceptions resulting from observations made in situ. Following a description of the situation, we have included information which might have turned up as part of a literature search. This is followed by an overview of how the research study was conducted. Finally, we have included a report we feel adequately reflects the study.

I. Sample Problem One

A. The Situation. Three species of periwinkles have been observed in the vicinity of Castine, Maine. There appears to be a preponderence of the common periwinkle *Littorina littorea* and fewer numbers respectively of the smooth periwinkle *Littorina obtusata* and the rough periwinkle *Littorina saxatilis*. At two locations, however, there appeared to be fewer of the former species and greater numbers of the latter two species.

As a researcher, you seek to resolve the issue by answering two questions. They are: (1) Which species of periwinkle has the greatest population density in the Castine, Maine vicinity? (2) How do the findings related to the first question compare with population densities in the periwinkles' geographical range?

B. The Literature. The first step is to consult the literature. Here the researcher hopes to locate related findings of other researchers. During your search, two such related references were quickly located. They were: (1) Smith, A. B. and Jones, C.D. Population densities of three periwinkle species in the littoral zone at Penobscot, Maine. The Blue Hill Biological Review, 1896, 25 (8), 38-40. The authors concluded that the common periwinkle was the most prolific species at Penobscot, Maine, (2) Schultz and Schlitz, Biology of the Maine Coast. New York: MacMillan, 1977. The authors stated that the most prolific periwinkle in Maine's lower littoral zone is the common periwinkle.

C. The Study. A transect was made every 200 meters along the Castine, Maine shore line from west to east, with the first located at Dices Head. In all, 10 transects were made, each when the tide was mean low. Four equally spaced ½m square areas were sampled along each transect. The first of these 4 areas was situated adjacent the mean high-water mark and the fourth adjacent mean low-water mark. The second and third sampling areas were spaced equidistant from the first and fourth sampling areas and from each other. This meant the total numbers of periwinkles were counted at four different levels in the intertidal zone for each transect and the spacings between sampling areas were identical.

D. The Data. The table shown below includes data gathered during the study. It is a page from a Field Notebook.

Station	1/2 M^2 AREAS											
	1			2			3			4		
	C	S	R	C	S	R	C	S	R	C	S	R
1	20	0	12	25	2	4	25	4	0	30	8	0
2	19	0	7	20	1	6	24	3	0	21	9	0
3	15	0	16	22	3	4	20	6	0	19	10	0
4	11	0	10	21	2	7	22	8	0	28	11	0
5	12	0	17	18	0	2	19	7	0	15	7	0
6	10	0	10	20	1	1	23	9	0	19	8	0
7	14	0	3	22	2	6	24	5	0	24	12	0
8	29	0	8	24	1	7	27	8	0	26	14	0
9	10	0	16	20	3	5	30	4	0	28	12	0
10	24	0	5	21	3	3	15	7	0	19	13	0

E. The Report. This report includes a Summary Section rather than an Abstract. Although the title page is somewhat condensed here, actual spacing should be in accordance with the model provided in Chapter 4.

1. The Title Page.

Population Density of Three
Periwinkle Spices at
Castine, Maine

By

Allen B. Boswain
Maine Maritime Academy
Castine, Maine 04421
June 1981

2. The Introduction Section.

INTRODUCTION

For the past eighty years it has been known (Smith and Jones, 1896), that three species of periwinkles exist in Eastern Maine's intertidal zone. Which species, however, is most prolific throughout the zone remains in doubt (Smith and Jones, 1896; Schultz and Schlitz, 1977). Smith and Jones (1896) found the common periwinkle to be the largest group in the midule littoral zone at Penobscot, Maine while Schultz and Schiltz (1977) suggested this to be the most prolific species in the lower regions of the intertidal zone along Maine's coast.

Recent observations in the Castine, Maine area have suggested the common periwinkle population density to be greater, at all levels within the intertidal zone, than the population densities of either the smooth or rough periwinkles. Observations though at two locations have turned up greater numbers of smooth and rough rather than common periwinkles. It was, therefore, decided, using controlled conditions, to ascertain the validity of these observations. Is the common periwinkle indeed the most prolific of the periwinkle species? Further, the common periwinkle was hypothesized to be the most prolific species at all levels of the intertidal zone at Castine, Maine.

3. The Methods Section.

METHODS

The data were collected from 10 transects spaced 200 meters apart. The transects were numbered successively from west to east, extended from the mean high-water line to the mean low-water line (a distance of 4 meters at Castine) and transect number one was located at Dices Head.

Periwinkles were counted at four equally spaced $\frac{1}{2}m^2$ areas within each transect and the first $\frac{1}{2}m^2$ area was located adjacent to the mean high-water mark. In this manner, a total of 40 individual $\frac{1}{2}m^2$ areas were sampled during the conduct of the study.

4. The Data or Findings Section.

FINDINGS

The data are presented in Table 1. In the Table, the letter "C" represents the common periwinkle, "S" - the smooth periwinkle, and the letter "R" - the rough periwinkle. The one-half meter square are numbered from the shallowest to deepest. Number 1 is shallowest.

The common periwinkle exhibited the greatest population density at all levels within the intertidal zone. Smooth periwinkles were not found at the highest level within the zone but increased in numbers with increasing depth below the mean high-water mark. Members of the rough periwinkle species were not encountered in the lower portions of the zone. Further, their numbers were found to increase with decreasing depth below the mean high-water mark.

TABLE 1

Numbers of Periwinkles by Species Counted in 10 Transects

	1/2 METER^2	1			2			3			4		
		SPECIES											
	STATION NO.	*C	S	R	C	S	R	C	S	R	C	S	R
	1	20	0	12	25	2	4	25	4	0	30	8	0
WEST	2	19	0	7	20	1	6	24	3	0	21	9	0
	3	15	0	16	22	3	4	20	6	0	19	10	0
	4	11	0	10	21	2	7	22	8	0	28	11	0
TO	5	12	0	17	18	0	2	19	7	0	15	7	0
	6	10	0	10	20	1	1	23	9	0	19	8	0
EAST	7	14	0	3	22	2	6	24	5	0	24	12	0
	8	19	0	8	24	1	7	27	8	0	26	14	0
	9	10	0	16	20	3	5	30	4	0	23	12	0
	10	24	0	5	21	2	3	15	7	0	19	13	0

*C = Common, S = Smooth, R = Rough

5. The Discussion Section.

DISCUSSION

The original hypothesis was accepted. The common periwinkle was found to be the most prolific periwinkle species at Castine, Maine. The number of common periwinkles per unit area seems fairly constant throughout the intertidal zone. See Figure 1.

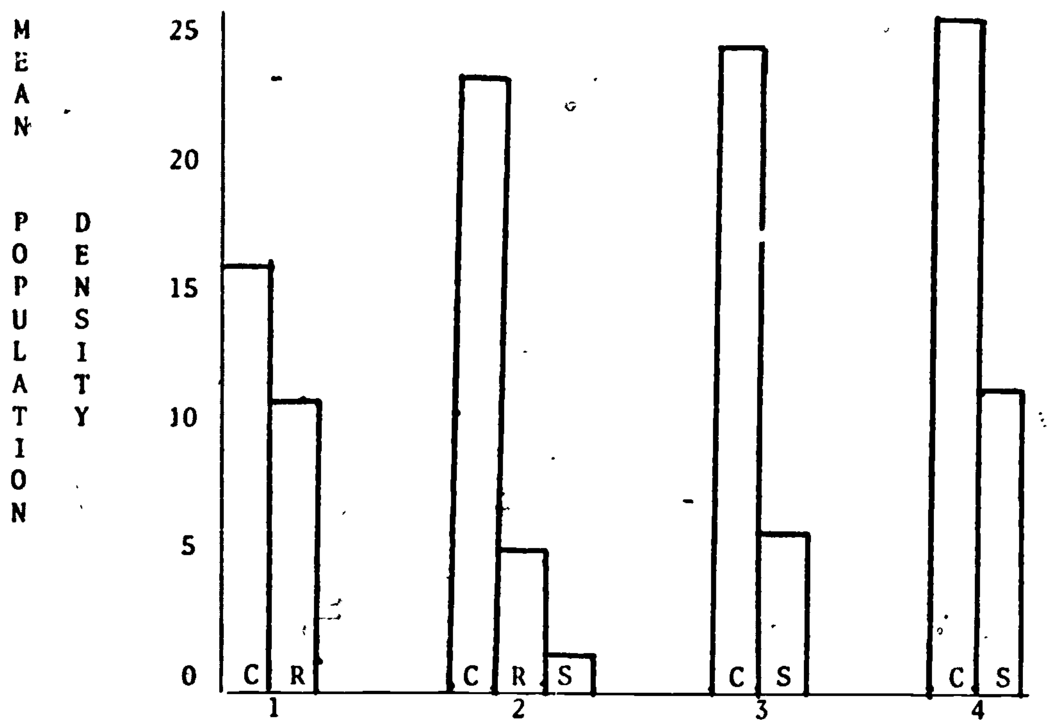


Figure 1. Mean Population Densities of Common, Rough, and Smooth Periwinkles At Four Depths Below The Mean High-Water Mark.

The findings suggest the second most abundant species in the higher intertidal zone to be the rough periwinkle and the smooth periwinkle in the lower portion of the zone. They also suggest the possible inability of rough periwinkles to survive the lower intertidal zone and smooth periwinkles to survive in the higher reaches of the zone.

6. The Conclusion Section.

CONCLUSIONS

The findings of this study were consistent with those of Smith and Jones (1896) and Schultz and Schlitz (1977). The common periwinkle is the most abundant spiecies in the middle and lower intertidal regions at Castine, Maine.

Four additional conclusions were drawn concerning periwinkle population densities at Castine. They were: (1) the most abundant species in the high intertidal zone is the common periwinkle; (2) the population of common periwinkles is equally dispersed throughout the intertidal zone; (3) the second most abundant species in the upper intertidal zone is the rough periwinkle; (4) the second most abundant periwinkle species in the lower intertidal zone is the smooth periwinkle.

Whether or not conclusions three or four are generalizable to a broader geographic area awaits additional research.

7. The Summary Section.

SUMMARY

Population densities of common, smooth and rough periwinkles were determined in the intertidal zone at Castine, Maine. The common periwinkles were found equally distributed throughout the zone. Rough periwinkles were found to inhabit the upper portion while smooth periwinkles were found to inhabit the lower portions of the intertidal zone.

8. The References Section.

REFERENCES

Schultz, A.B. & Schlitz, B.C. Biology of the Maine coast. New York: MacMillan, 1977.

Smith, A.B., & Jones, C.D. Population densities of three periwinkle species in the midlittoral zone at penobscot, maine. The Blue Hill Biological Review, 1896, 25 (8), 38-40.

II. Sample Problem Two.

A. The Situation. National Ocean Survey chart 13309 shows soundings in the Castine, Maine harbor to vary from one to another. These data, however, are not sufficient to allow maximum use of Castine Harbor. In order to afford mariners, fishermen and others the opportunity to use the harbor to its utmost a scale model of the harbor bottom is required. A search of the literature in this regard revealed the only work ever accomplished in Castine Harbor or the Bagaduce River estuary was reported on chart 13309. A preliminary study therefore, was conducted. The primary objective was to investigate problems which might be encountered in actually attempting to build a model of the Bagaduce River estuary area adjacent to Castine's town dock. The objective was accomplished by making one bottom profile leading away from the town dock at 90^{0} relative to the dock and then correcting that profile to mean low water.

B. The Report. This report includes an Abstract rather than a Summary Section. As was pointed out above, the Abstract preceeds the title.

1. The Abstract.

ABSTRACT

A preliminary study was conducted to determine what problems might be encountered in making a model of the bottom in Castine, Maine harbor. Weather conditions during the data gathering periods were found to render questionable the quality of the data gathered for model making purposes.

2. The Title Page.

Problems Encountered In Making A Single
Bottom Profile Across The Castine, Maine
Harbor and Adjacent Bagaduce Estuary Area

By

Bildge O. Water
Maine Maritime Academy
Castine, Maine 04421
June 1981

3. The Introduction Section

INTRODUCTION

Making maximum use of harbors and estuaries requires extensive knowledge of their bottom profiles as well as other parameters. While salinity, current and temperature data are available for Castine, Maine harbor and the adjacent Bagaduce Estuary the only information concerning bottom contours in the area are the National Ocean Survey soundings found on National Ocean Survey Chart 13309. While soundings are sufficient for general navigation they do not allow use of the harbor to the maximum extent possible. Town administrators, therefore, decided to investigate the feasibility of developing a model of the ocean bottom in the area.

The investigators felt efforts to complete a rapid feasibility study would be hampered in several ways. It was hypothesized that; (1) data collection would be hampered by tidal currents, wind speed and direction and wave height; (2) reduction of data to reflect mean low water (MLA) would be made difficult because of the amount of time required to transet the estuary while collecting bottom profiles.

4. The Methods Section.

METHODS

Preliminary study data were gathered in the following manner. A bottom profile was made across the estuary at 90° angle to the face of the Castine town dock using recording fathometer on the research vessel Panthalas.

The vessel was operated at its slowest possible speed and held on course by following maneuvering signals provided from ashore. Accordingly, a surveyor's transet was set upon the town dock ... lattitude 44° 23.7'N and longtitude 68° 47.6'W and sighted at an angle 52° west relative to nun buoy 2 in the Bagaduce River. The transet operator sighted on a transet staff fixed amidships at the stern of the research vessel. When the cross hair of the transet was on the transet staff the vessel was on its proper track line. When deviation occured the boat coxswain was signaled to modity his course.

Signaling was accomplished through the use of flags. Directions were given to the flagman by the transet operator. If the vessel deviated to the left of its intended course the flag operator held a flag to the right of his body and horizontal to the dock until the vessel resumed its proper course. Once a proper course was resumed the flag was held over the flagman's head in line with his body profile.

Tide data were collected from a tide staff whose zero mark was set at mean low water. The vessel's time of departure from the dock was noted and tide height reading taken at that moment. Similar readings were taken at the moment the vessel reached the opposite side of the estuary. The end positions of the track line were obtained by the intersection of sighting lines taken from the vessel. The sightings were taken with a hand bearing compass. The points of intersection on national ocean survey chart 13309 were used to compute actual latitude and longitude of the end points.

5. The Data of Findings Section.

DATA

Fifteen minutes were required to transet the course of 1.2 nautical miles. The tide was ebbing during the operation and found to drop 22 cm from its 2M above MLW at the time of the vessel's departure from the town dock.

Figure 1 shows the bottom profile obtained form the fathometer printout. The profile has been corrected to MLW. This profile is similar to that obtained on the return voyage when it was attempted to obtain a mirror image of the trip across the estuary.

INSERT FIGURE 1 HERE

The investigation was conducted beginning at 10:15 eastern standard time July 4, 1979. The sky was cloudless, the wind steady at 5 knots in an easterly direction and the surface of the water broken by a 15cm chop running east.

6. The Discussion Section.

DISCUSSION

Several problems were encountered while collecting the data. Although it was anticipated that an easterly wind and surface chop might have compensated for the westerly flow ebb tidal current, the vessel was found to wander to the west of its intended track line. Correction of westerly deviations caused the course to momentarily deviate east of the track line during each correction period. The result was a meandering which produced a somewhat sinusoidal rather than a straight track line with east west deviations greater to the west than the east.

Exact position location at the end of the track line was confounded by the ebbing tide. An attempt was made to hold the vessel in position while sightings were made but some westward drift was noted.

7. The Conclusions Section.

CONCLUSIONS

Weather conditions at the time data were gathered allow acceptance of the first hypothesis. No evidence however was accumulated leading to the acceptance of the second hypothesis. It was, therefore, rejected.

Prior to embarking upon data collection for the actual model building task an additional preliminary study should be conducted. A profile should be made during a slack water period. This would reduce interference from tidal current flow to a minimum. In this way the problems created by weather alone can best be evaluated. It may be that for accuracy sake the contours may be taken only on windless days and during slack water periods.

8. The References Section.

REFERENCES

National Ocean Survey Chart No. 13309.

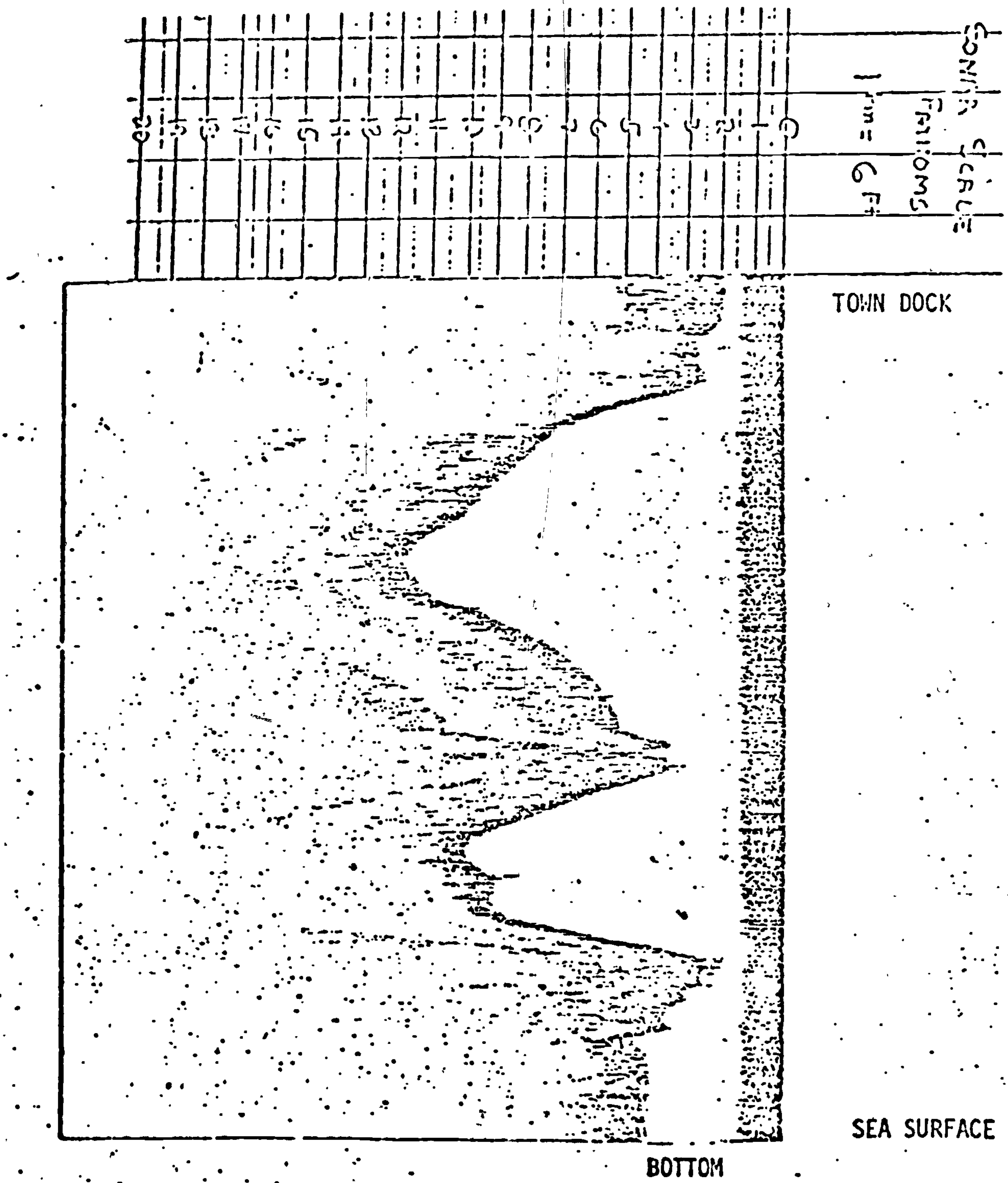


Figure 1. Bottom Profile of the Bagaduce Estuary Beginning at the Castine, Maine Town Dock.

III. Sample Problem Three

A. The Situation. Situation three involves an actual project conducted by student researchers. The report reflects that project. The objective of the project of the project was to describe hydrographically an area of Eastern Penobscot Bay (area located on National Ocean Survey Chart 13309).

B. The Report. The report is an edited version of that prepared by one student researcher. It includes a Summary Section rather than an Abstract.

1. The Title Page.

Assignment of Estuarine Type to Penobscot Bay

By

Marine C. Engineer
Maine Maritime Academy
Castine, Maine 04421
June 1981

2. The Introduction Section.

INTRODUCTION

The primary objective of the project was to evaluate the Penobscot Bay Estuary and subsequently assign it an estuarian classification.

The initial phase of the project involved becoming familiar with the oceanographic methods utilized to gather data, the problems associated with obtaining meaningful data and the actual gathering of raw data for the project. The second phase was designed to provide researchers the opportunity to select and combine or eliminate data to provide meaningful picture from which conclusions could be drawn.

The data verified that Penobscot Bay was an estuary. It however, was not immediately apparent what type of estuarine classification best described the pro ject area.

Ross (1970) defined an estuary as a semienclosed coastal body of water having a free connection with the open sea and within which sea water is diluted by fresh water derived from land drainage. It soon became apparent that there were considerable differences between estuaries and that several methods of classification existed.

It was hypothesized that the Penobscot Bay estuary was partially mixed.

3. The Methods Section.

METHODS

Temperature, salinity, depth and current data were collected at stations located between Blockhouse Point and Turtle Head. The data were collected over a period of several days by student research teams.

Temperature data was obtained from Nansen bottles and a bathythermograph. Temperature data obtained from resersing thermometer was not utilized in preparing temperature profiles because of failure by researchers to apply a necessary surface temperature correction to temperatures obtained. Salinity was determined using a conductivity type salinometer. Water depth was determined using a recording fathomometer. Current speeds were obtained with a remote reading current meter and through the use of current drogues. Current drogue data was not used because its quality was questionable.

4. The Data or Findings Section.

FINDINGS

Salinity and temperature versus data were evaluated to determine what, if any relationship existed between the two parameters and depth. The actual geographic locations of each salinity-depth station are included in Table 1. Each of these stations is located on National Ocean Survey Chart 13309.

TABLE 1

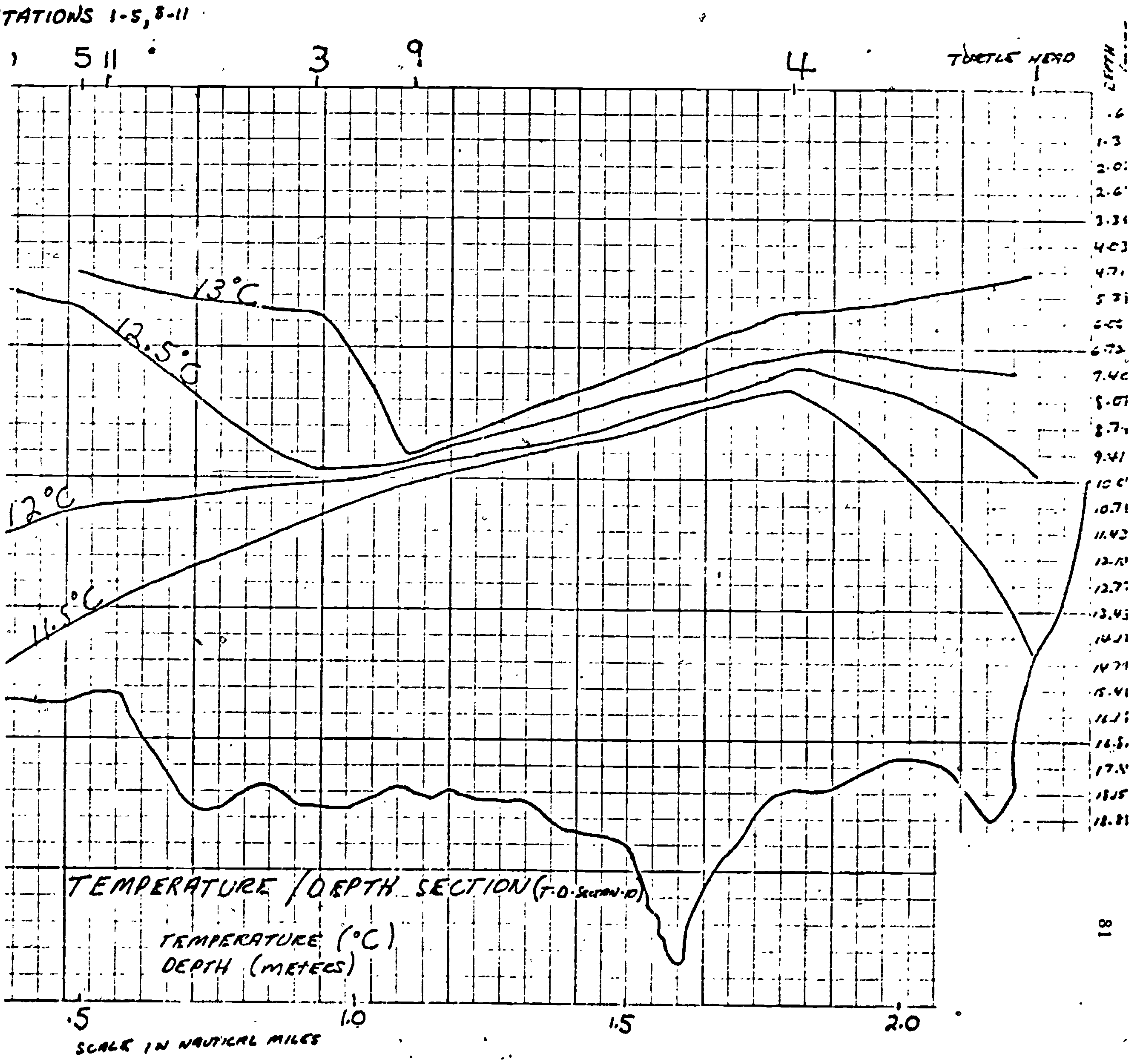
Geographic Locations of Temperature-Salinity Stations

STATION NUMBER	LATITUDE	LONGITUDE
1	44° 23' 38" N	68° 52' 29" W
2	44° 23' 35" N	68° 49' 21" W
3	44° 23' 28" N	68° 50' 36" W
4	44° 23' 34" N	68° 51' 53" W
5	44° 23' 35" N	68° 50' 18" W
8	44° 23' 35" N	68° 49' 28" W
9	44° 23' 23" N	68° 50' 55" W
10	44° 23' 32" N	68° 49' 11" W
11	44° 23' 30" N	68° 50' 03" W

Temperature verses depth data were combined to produce an isotherm (see Figure 1). Temperature was found to decrease with depth between 13°C at 4.71 meters to 11.8°C at 16.14 meters.

Salinity increased with depth from a low of 27.5 °/00 at a depth of 0.5 meters to a maximum of 31.5 °/00 at 18.0 meters (see Figure 2).

Figure 1. Temperature/Depth Section Between Blockhouse Point and Turtle Head.



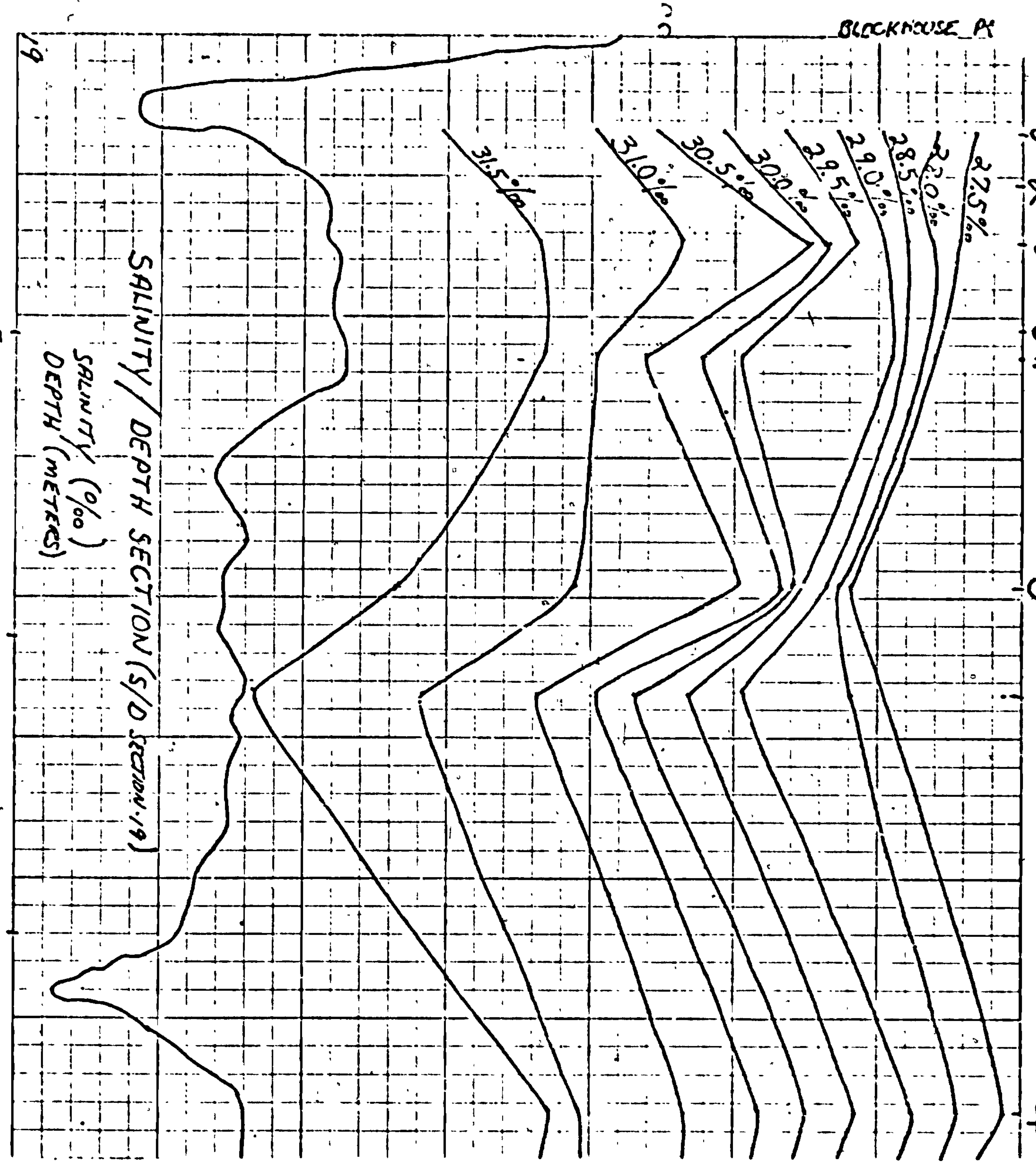


Figure 2. Salinity/Depth Section Between Blockhouse Point and Turtle Head.

The relationship between surface salinity and ebb and flood tides was evaluated to determine whether there was a significant salinity difference under the two conditions. The greatest salinity difference (28.2 °/00-22.6 °/00) between tides was found one nautical mile from Blockhouse Point (see Figure 3).

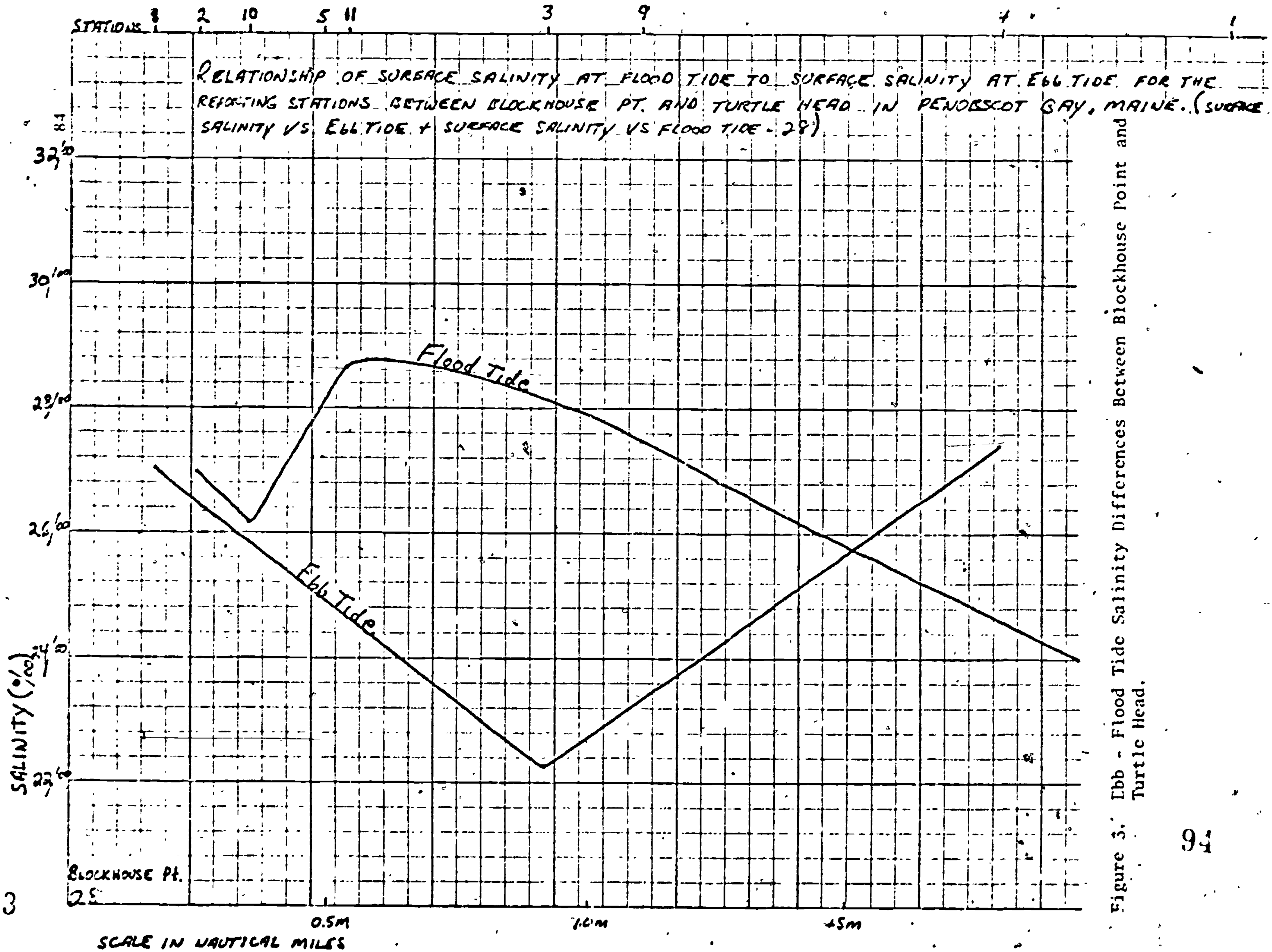


Figure 3. Ebb - Flood Tide Salinity Differences Between Blockhouse Point and Turtle Head.

A bottom contour map was constructed using bottom profiles from the recording fathometer (see Figure 4). The map was compared with National Ocean Survey Chart 13309 and found to contain more data than the NOS Chart (see Figure 4).

Current directions and speeds were evaluated at 10, 30, and 60 feet. Current speeds varied from 0.1K to 0.85K with the greatest current speed at 10 feet. Current direction varied at all depths in each water column sampled (see Table 2).