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ABSTRACT

This guide is intended to improve the writing and composition skills of oceanography students but it may be applied to other written scientific compositions. Discussed is the documenting of laboratory and field investigations during the activity. A suggested format for the research report is presented with discussions of each section. A segment is devoted to tips for writing a good report. Sample short reports are included in the guide. (RE)

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A WRITING GUIDE FOR STUDENT OCEANOGRAPHY LABORATORY AND FIELD RESEARCH REPORTS

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INTRODUCTION

A report or paper is the final step in a long series of events. These events usually begin when a researcher seeks to answer some perplexing question. As an answer is sought, the researcher reads the reports of others, gathers data, and evaluates and interprets his findings. Once reported, the researcher's findings become another link in a research chain allowing those who follow to pick up and carry on where he stopped.

The report is a method of communication. It notifies readers of research findings and the way the researcher interpreted them in the light of previous research and accepted theory. As such it includes a rationale or reasons why the investigation was conducted, methods used in gathering the data, the data, a discussion of the findings and conclusions drawn as a result of the findings.

Clearly, research reports are complete documents. Each must stand on its own and so must be understandable to its readers even though the readers may not be well versed in research conducted prior to the present project. Also, the report must be understandable to those who read it even though the readers were not present when the data were gathered or had no knowledge of the project prior to reading the report.

Reports or papers which meet these few and simple criteria are assets both to the research community and to the general readership. They provide another link in our understanding of that which is being investigated. Those which are vague or in some way incomplete are a waste of both the writer's and the reader's time. As a research report writer, therefore, you must always strive for excellence.

PURPOSE OF THE GUIDE

Generally, science content courses include a weekly laboratory session. During laboratory sessions students conduct experiments chosen to support and to amplify important conceptual material presented in lecture sessions.

A major portion of each experiment is the data-gathering phase. The data which are gathered become points of departure and theoretically lead students to generalizations supporting lecture material. Once integrated, laboratory generalizations and lecture material provide a more well-rounded picture of a subject than is possible if either were conducted in isolation. However, recent evidence suggests this schema to be idealistic. In reality many students, especially when required only to answer a few brief questions about laboratory exercises show little if any learning gain from laboratory experiences.

Additional problems seem to surface when students spend many laboratory sessions treating experiments superficially. Students show inability to manipulate data, interpret data, use library and other reference sources, draw conclusions based upon observations, present data in graphic formats, and paramount of all; inability to express themselves in writing. Yet, such skills are all objectives of a laboratory program.

Many of these deficiencies, however, are greatly reduced and the student's expertise concomitantly increased when a formal research report must be written following the completion of each laboratory activity.

This guide was specifically written for use by Oceanography students but its principles may be applied to all laboratory and field investigations.

CONDUCT OF LABORATORY AND FIELD INVESTIGATIONS

Periods of time spent in field and laboratory investigations generally are devoted to equipment setup and data gathering. It is important that investigators be able to review these periods after they are over. Field notebooks are kept specifically for this purpose.

Field notebooks are, as the name suggests, notebooks used in either the field or laboratory. They are a hand-written collection of notes taken at the moment observations are made. They should include all information relevant to an investigation or which might have some bearing upon an investigation's outcome. For example, a section covering a specific field or laboratory data gathering session might include the date, time of day observations were made, weather conditions at the time of the observations (temperature, height of the tide, cloud cover, sea conditions), equipment employed in data gathering tasks, how the equipment was employed (sketches of equipment setups), numbers and names of people engaged in the investigation and the actual data which were collected during the session. Field notebooks should not be written at some time after the data gathering has concluded. Recollections of the past are often vague, lacking the crisp details of the present.

The information contained in the field notebook becomes the basis for the majority of the investigator's field or laboratory research report. Poorly or inadequately kept field notebooks necessarily lead to poor or inadequate final reports.

RESEARCH REPORT FORMAT

Research reports should contain at least the following sections. Each section of each report should be preceeded by its respective heading.

TITLE: The title must be comprehensive, and reflect the contents of the report. This is the first item seen by a prospective reader (except when an abstract is included - see below), and that part which tells the reader whether from his or her perspective the report should be read.

INTRODUCTION: This section includes a rationale for the investigation (why was the research undertaken, what question or questions were to be answered, or what problem was to be solved), the history of the problem or question (what have other researchers found in this area - is there an accepted theory to be substantiated or disproved), and any hypothesis the investigator formulates concerning the final outcome of the investigation.

Information for much of the introduction section is obtained from other research papers, texts, and other library information. The section should provide a logical link between the problem being investigated and the research methodology used to seek a solution or answer.

METHODS: Here the writer explains exactly how his data were gathered. However, it is not necessary for the writer to explain the internal functionings of data-gathering equipments unless the equipments were made to function in an atypical manner. If a reader is unfamiliar with how a Nansen bottle or some other piece of equipment functions he is obligated to consult the literature for such information.

The information in this section of the report should come directly from the field notebook with exception that, when data manipulating and statistical techniques are used they must be described.

DATA: As was the case with the Methods section, information for this section should derive directly from the field notebook.

The data may be presented, using graphs, charts, tables, and diagrams, but it also must be described in writing. These aids are used only to provide a visual representation and to summarize that which is presented in context. For the sake of ease and clarity it is generally acceptable to lump all graphs, charts, and diagrams in a single category. The category known as "figures" is used.

When figures and tables are used they should be successively numbered and each should have its own title. If a report contains more than one table, the first is labeled Table 1, the second Table 2, and so on (the same is true of figures). Each title should reflect the exact contents of the table or figure and each should be drawn in accordance with the guidance of a style manual. Three such manuals are listed in the Reference section of this guide, and others may be found in the College Library.

DISCUSSION: The investigator's data are discussed in this section. Hypotheses formulated in the early stages of the investigation should be considered here. It may be advantageous here to compare your findings to those of others. If comparisons are made between your research and the findings of other investigators then those others must be cited in context and their respective reports listed in the References section of your report (see sample reports below). In any event, be as brief and straightforward as possible. This is not the place to describe everything that has transpired thus far in the investigation.

You may use tables and figures in this section; however, if used, they should summarize the results of data manipulations.

CONCLUSIONS: In this section student researchers should draw conclusions based upon their findings. The writer may wish to conclude, based upon interpretations of the study's data that the findings support those of other specific studies or agree with or disagree with accepted theory. In investigations designed to exemplify a theory, where the findings did not exactly support the theory the writer may wish to draw conclusions reflecting the possibility that experimental error contributed to a theory's lack of support.

Although beginning student laboratory and field investigators tend to conclude that experiments worked nicely or were a success. This practice should be avoided at all costs. Research report readers are the ones who decide upon the success or failure of an investigation. Further, determinations of this nature normally depend upon the quality of a presentation. Failure to mention experimental error or some other salient feature of an investigation may lead readers to conclude the research ended in failure.

REFERENCES: This section contains all references cited in context. Citations are listed alphabetically by authors' last names. The remainder of the citation should be consistent with a style manual (see examples provided below).

SUMMARY OR ABSTRACT: Generally speaking, summaries preceed references sections while abstracts preceed titles. Whatever the case, this section is but a few brief sentences describing the investigation's methods, findings, and conclusions.

AIDS TO WRITING A GOOD REPORT

Tense and Person. Reports are written in standard English. They should be written in the third person and since the writing concerns investigations already completed, the past tense is always used.

Abbreviations. While the use of some abbreviations such as those for millimeters, cubic centimeters, kilometers, and the like are generally acceptable in research report writing, others are not. As a guide, all words in the text of a report should be spelled out in full.

Proof Reading. Perhaps the most overlooked area by beginning student research report writers is that of proof reading. Proof reading helps to locate misspellings, typographical errors, poor sentence structure, and improper grammar - measurably increasing a report's quality.

Colleague Reading. Colleague reading is perhaps the final step prior to preparation of a final draft. In this step, your report is given to a colleague who is generally unfamiliar with your investigation. If that person can read and understand what you have done then the report will probably be clear to the general readership. If your colleague has difficulty with the report, it should be changed accordingly.

As a further guide to your colleague, remember one essential mark of a good written report is that it will allow the study to be replicated without additional information.

SAMPLE PROBLEMS

SITUATION 1. 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. However, at two locations 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. Those questions 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?

THE LITERATURE. The first step is to consult the literature. Here the researcher hopes to locate related findings of other researchers. 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 of this article concluded that in the midlittoral zone adjacent to Penobscot, Maine the common periwinkle was the most prolific species; (2) Schultz and Schlitz, Biology of the Maine Coast. New York: MacMillan, 1977. The authors of the text stated that the most prolific periwinkle in Maine's lower littoral zone is the common periwinkle.

THE STUDY. A transect was made every 200 meters along the Castine, Maine shoreline from west to east, with the first located at Dices Head. In all, 10 transects were taken, 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 to the mean high-water mark and the fourth adjacent to the 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.

THE DATA. C = Common Periwinkle. R = Rough Periwinkle. S = Smooth Periwinkle.

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

THE REPORT.

POPULATION DENSITIES OF THREE PERIWINKLE SPECIES AT CASTINE, MAINE

INTRODUCTION:

That three species of periwinkles exist in Eastern Maine's intertidal zone has been known for the past eighty years (Smith and Jones, 1896). However, which species 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 middle littoral zone at Penobscot, Maine while Schultz and Schlitz (1977) suggested this to be the most prolific species in the low portions 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 the rough periwinkle. However, observations at two locations have turned up greater numbers of smooth and rough rather than common periwinkles. Therefore, it was 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 periwinkle species at all levels of the intertidal zone at Castine, Maine.

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 1/2 m^2 areas within each transect and the first 1/2 m^2 area was located adjacent to the mean high-water mark. In this manner, a total of 40 individual

1/2 m^2 areas were sampled during the conduct of the study.

DATA:

The data are presented in Table 1. In the Table, "C" represents the common periwinkle, "S" - the smooth periwinkle, and "R" - the rough periwinkle.

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 as the depth below the mean high-water mark increased. Members of the rough periwinkle species were not encountered in the lower portions of the zone. Further, their numbers were found to increase as the depth below the mean high-water mark decreased.

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
	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

DISCUSSION:

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

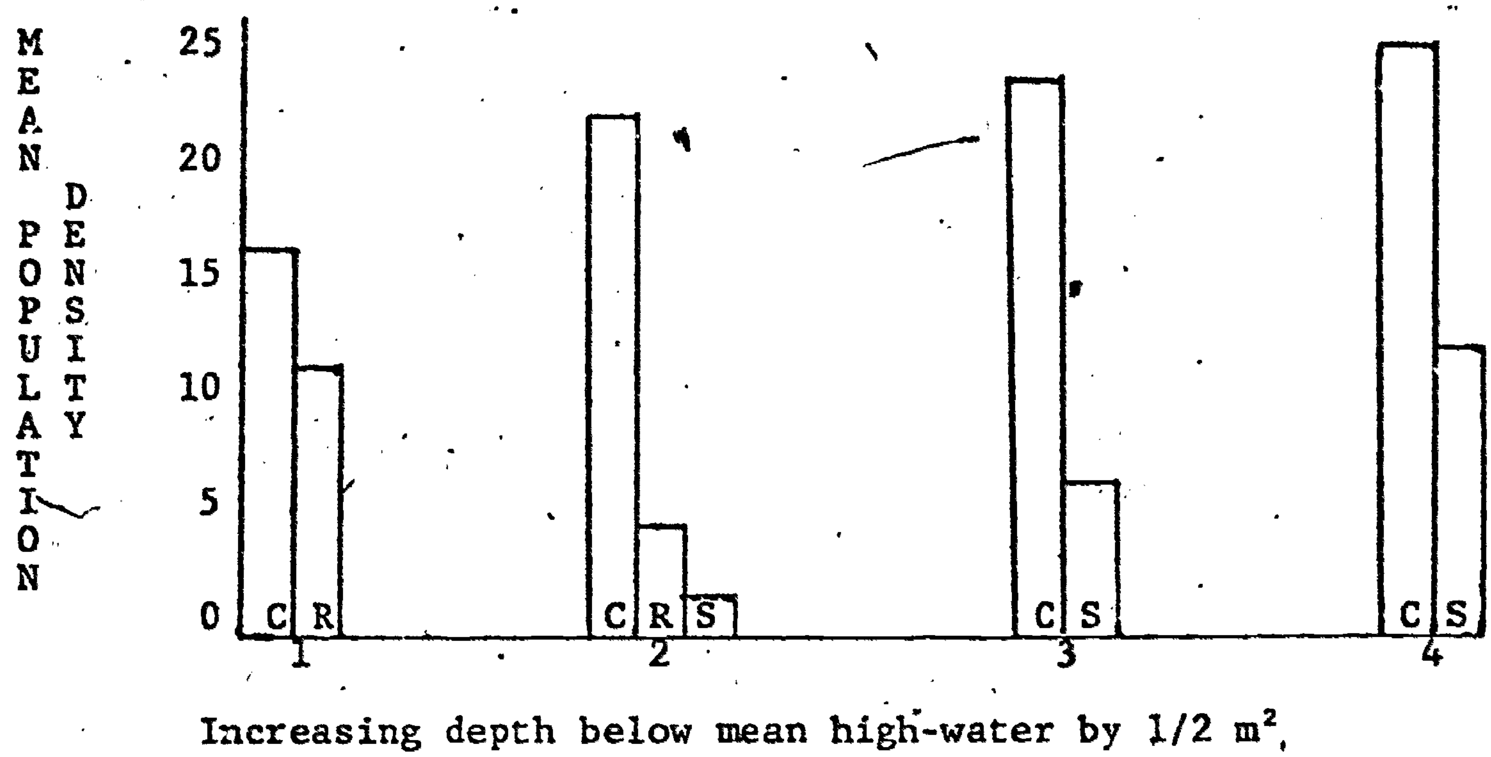

FIGURE 1

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. These findings also suggest an inability on the part of rough periwinkle to intrude into the lower intertidal zone and the smooth periwinkle to intrude into the higher reaches of the zone.

CONCLUSION:

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 further conclusions were drawn concerning periwinkle population densities at Castine: (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.

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.

SITUATION 2. National Ocean Survey chart 13309 shows soundings in the Castine, Maine harbor to vary from one to another, However, these data are not sufficient if maximum use is to be made 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 to have been accomplished in Castine Harbor or the Bagaduce River estuary was reported on chart 13309. Therefore, a preliminary study is to be conducted.

The primary objective in preliminary studies is 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 will be 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.

TITLE

PROBLEMS ENCOUNTERED IN MAKING A SINGLE BOTTOM PROFILE ON THE CASTINE, MAINE HARBOR AND ADJACENT BAGADUCE ESTUARY AREA

INTRODUCTION

Making maximum use of harbors and estuaries requires extensive knowledge of 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 this area derives from National Ocean Survey soundings. While soundings are sufficient for general navigation they do not allow the harbor to be used to the maximum extent possible. Therefore, town administrators 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 (MLW) would be made difficult by the amount of time required to transet the estuary while collecting bottom profiles.

METHODS

Preliminary study data were gathered in the following manner. A bottom profile was made across the estuary at an angle 90^{o} to the face of the Castine, Maine town dock by recording fathometer on the research vessel Panthalas.

The research vessel was operated at its slowest possible speed and held on course by following maneuvering signals provided from shore. Accordingly, a surveyor's transet was set up on the town dock at latitude 44^{o} 23'N and longtitude 68^{o} 47.6'W and sighted at an angle 52^{o} west relative to nun buoy 2 in the Bagaduce River. The transet operator sighted on a transet staff a 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 and when deviation occured the boat coxswain was signaled to modify 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 trackline 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.

DATA

Fifteen minutes were required to transet the course, a distance of 1.2 nautical miles. The tide was ebbing during the operation and was 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 from the fathometer print-out. The profile shown in the Figure has been corrected to MLW. This profile is similar to that obtained on the return voyage when its 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.

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 ach correction phase. The result was a meandering and 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.

CONCLUSIONS

Weather conditions at the time the data were gathered allow acceptance of the first hypothesis. No evidence however was accumulated leading to the acceptance of the second hypothesis. It is, 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 flow to a minimum (when the tide shifts there is water movement in the opposite direction). 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.

REFERENCES

National Ocean Survey Chart No. 13309.

STYLE GUIDE

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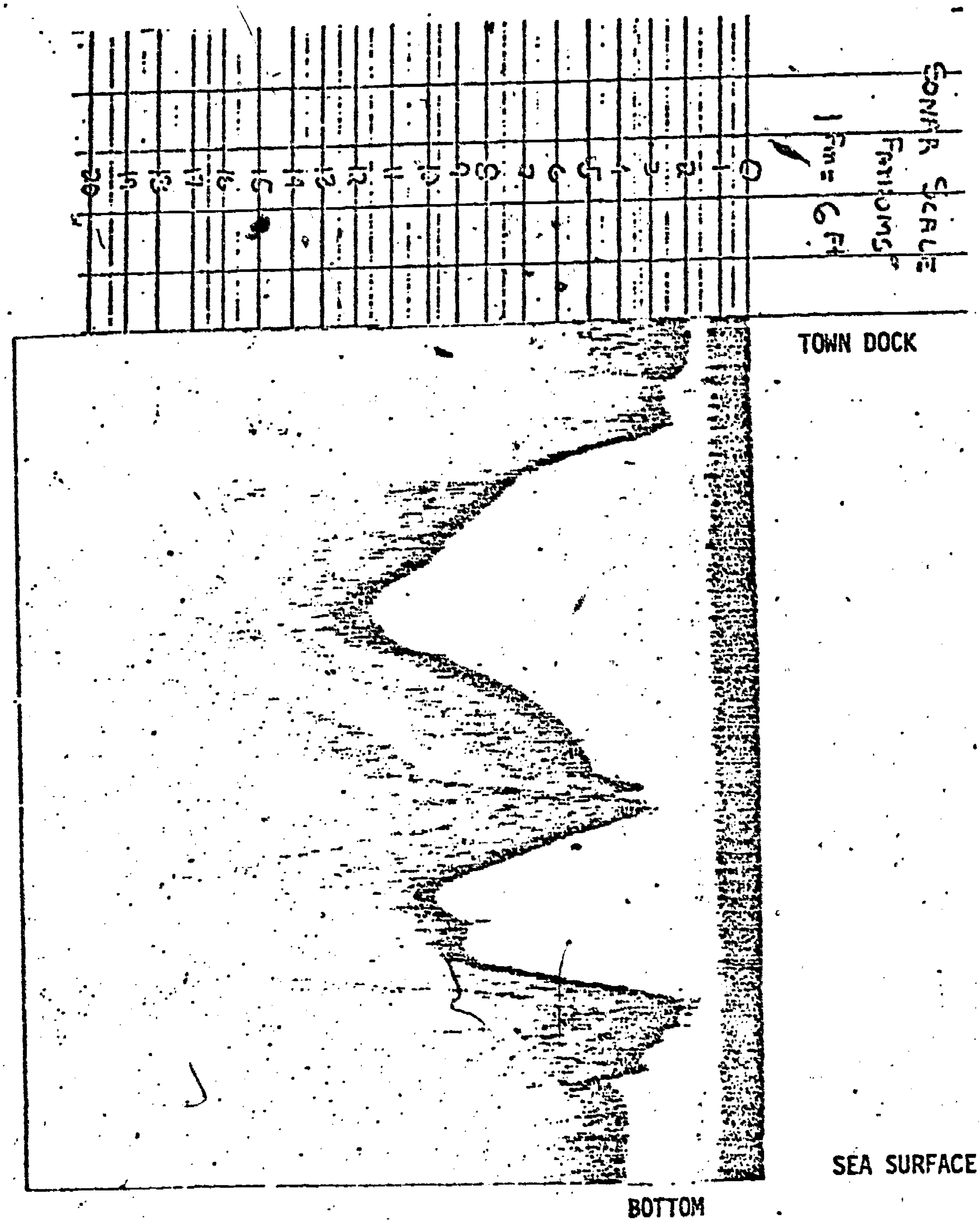

FIGURE 1

BOTTOM PROFILE OF THE BAGADUCE ESTUARY BEGINNING AT THE CASTINE, MAINE TOWN DOCK.