1972

History of Sedimentation In Montsweag Bay

Detmar Schnitker

Recommended Citation

Schnitker, Detmar, "History of Sedimentation In Montsweag Bay" (1972). *Maine Collection*. 185.
https://digitalcommons.usm.maine.edu/me_collection/185

MAINE GEOLOGICAL SURVEY
ROBERT G. DOYLE, STATE GEOLOGIST
WALTER A. ANDERSON, ASSISTANT STATE GEOLOGIST

History of Sedimentation In Montsweag Bay

by

DETMAR SCHNITKER

BULLETIN #25

Department of Forestry
Augusta, Maine
1972

MAINE GEOLOGICAL SURVEY
ROBERT G. DOYLE, STATE GEOLOGIST
WALTER A. ANDERSON, ASSISTANT STATE GEOLOGIST

History of Sedimentation In Montsweag Bay

by

DETMAR SCHNITKER
DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF MAINE
IRA C. DARLING CENTER, WALPOLE, MAINE

BULLETIN #25

Department of Forestry
Augusta, Maine
1972

Contribution No. 43 from the Ira C. Darling Center

Published Under Appropriation 65200

History of Sedimentation in Montsweag Bay

Detmar Schnitker
DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF MAINE
IRA C. DARLING CENTER, WALPOLE, MAINE 04573

CONTENTS

I. ABSTRACT

Montsweag Bay at the central Maine Coast is a deeply excavated bedrock valley that has largely been filled by sediments. The deeper portions of the bedrock valley are filled by a Pleistocene blue clay which is disconformably overlain by thick Holocene sediments. Sediments from piston and Vibra-cores were dated by radiocarbon and pollen analyses. Sedimentation rates for the last 250 years varied between 1.15 and 1.9 cm per year, accelerating towards the Present. These figures compare with actually observed sedimentation rates of 1.9 to 2.8 cm per year. The sediment accumulating in Montsweag Bay can be entirely accounted for by the influx of suspended matter with each tidal cycle through the southern entrance to the Bay. Montsweag Bay is near its terminal stage of becoming a salt marsh.

II. INTRODUCTION

Montsweag Bay is one of the many deep embayments that characterize the central Maine coast and, like them, follows the general geologic and topographic grain of the area. This topographic orientation, generally trending in directions between due north-south to about north 30° east, was brought into its present shape by the Pleistocene ice cover working upon and accentuating the geologic orientation of the bedrock and the pre-existing topography. This ice sheet removed all pre-existing surficial deposits and soils from the bedrock and, upon its melting, left its own glacial deposits in the form of recessional moraines and glacial marine clay, laid down when the sea was in contact with the retreating ice margin. The surficial deposits that now exist in this coastal area are thus the result of processes that have been active here for no more than the past ten to eleven thousand years. This absence of deposits from older, and different, geological circumstances offers a unique opportunity to study a rather uncomplicated geologic situation for which only a limited number of variables have to be accounted.

III. GEOGRAPHIC SETTING

Montsweag Bay (Fig. 1) is part of the Sheepscot River system, to which it is connected through the Back River passage in the north and a more complex passage through Hockomock Bay, Knubble Bay and the Gooserock Passage in the south. The Sasanoa River provides a passage to the Kennebec River. Unlike most of the submerged valleys of this area (i.e. Kennebec, Sheepscot, and Damariscotta Rivers), the floor of Montsweag Bay is flat and very shallow, indicating that this Bay is near its terminal stage of being filled by sediments. A topographic profile drawn across Montsweag Bay and the Sheepscot River (Fig. 2) shows the interruption of the normal variations of elevation that the floor of Montsweag Bay represents, and from this a general impression of the probable degree of sedimentary fill can be gained.

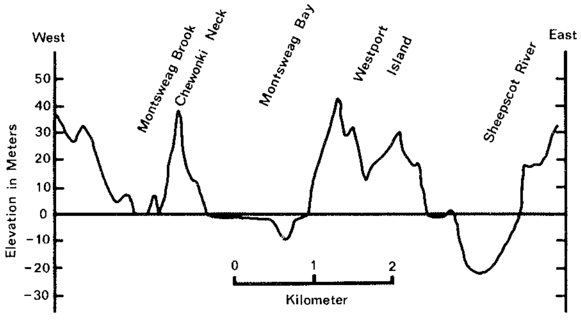

Figure 2.
Topographic profile across Montsweag Bay and Sheepscot River (from U.S.G.S. Chart 314).

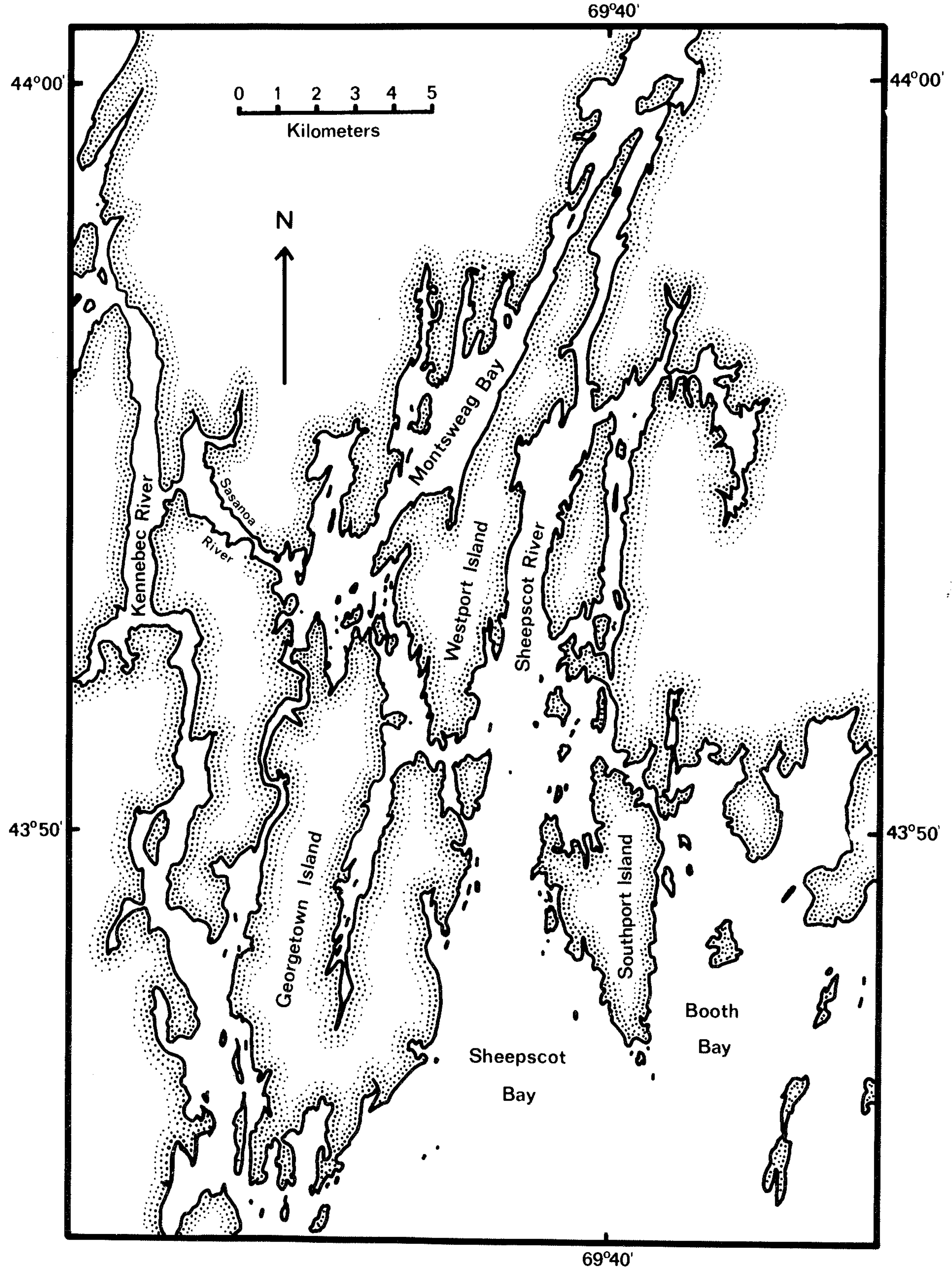

Figure 1.
Montsweag Bay and surrounding river system (from U.S.G.S. Chart 1204).

IV. SEISMIC PROFILING

Using a 800 watt, 3.5 khz sonic profiler, more than 43 km of seismic profile lines were run in Montsweag Bay to measure the thickness of sediment fill and to map the topography of the underlying bedrock. This project, however, was only partially successful. The sediments of the tidal flats and shallow portions of the bay contain large amounts of organic gases which effectively block sound wave propagation through the sediment. Thus, useful records were obtained only from deep water areas, namely the main channel and its branch towards Montsweag Brook (Fig. 3). The very best records are those from the two extremities of Montsweag Bay where tidal currents apparently do not permit the accumulation of gases within the sediments. The seismic profiles thus obtained are not extensive enough and of sufficient quality to achieve the object of the program but the conclusions that can be drawn from them are:

1. The bedrock "bottom" of Montsweag Bay is as deep as projections from the topography of the surrounding area would indicate. Depths of more than 30 meters below sea level occur in several places.
2. Apparently, two types of sediment are present: An upper, acoustically quite transparent sediment, that does not show any indications of internal stratification, and a lower sediment that is a strong reflector and often masks the bedrock below it. This latter sediment does occasionally show reflecting layers, indicating that it is not of uniform composition.
3. The channel that traverses the length of Montsweag Bay is, in most instances, independent from the bedrock configuration and thus apparently free to change its course in accordance with the hydrologic conditions.

V. PLEISTOCENE SEDIMENTS

Sediments probably of Pleistocene age are encountered in the Vibra-core, taken off the dock of the Maine Yankee Atomic Power Company at Bailey Point. At this location, at a water depth of 14 meters, the seismic profile (Fig. 16) indicated a sediment thickness of 19.0 meters. This core (Fig. 4), 10.20 meters in length, recovered sediments that bear a great similarity to the "clays" of the Presumpscot Formation that can be found in much of coastal Maine. This Presumpscot Formation is considered to represent a periglacial deposit, containing fossils of arctic and sub-arctic affinities (Bloom, 1960). Although no identifiable macrofossils were recovered from the core, the microfauna and flora were identical to that contained in a Presumpscot Formation sample from Walpole, Maine. Of particular interest is the abundance and composition of the pollen flora within core samples. Whereas the samples from all other cores and from surface sediments contained on the average about 2000 to 3000 pollen grains per slide, the Pleistocene sediments, using identical sample size and treatment, contained only about 15 to 30 pollen grains per slide. Towards the top of the core the pollen frequency rose to about 50 to 60 grains per slide. The conifer pollen of this core was largely spruce and fir, in contrast to the dominance of pine in all other cores and surface samples. Spruce and fir are the main components of the boreal forest community, whereas the white pine is a present-day resident of this area (northern forest community). The deciduous trees were represented in the core by a few birch and poplar pollen grains, whereas oak and maple were common in the modern samples.

Radiographs of this core required about twice the exposure time for two other cores that were also X-rayed, indicating that the sediment was considerably denser. The sediment showed layering, but it was not sufficiently regular and distinct to be called varved. No evidence of burrowing organisms was found in the lower portion of the core and only two tracks were found near the top (at -1.1 and -0.8 meters), indicating fairly lifeless bottom conditions during the time of deposition.

On the average, the Pleistocene sediment was considerably finer than that of all the other core and surface samples, again resembling the "rock flour" sediments of the Presumpscot Formation (Fig. 10). Four intervals within the core where the median grain size drops to 10μ correlate reasonably well with reflecting horizons of the seismic profiles; the slight discrepancies of correlation probably being due to shortening and compaction of the sediment during coring.

This Pleistocene sediment can be identified on seismic profiles from at least Berry Island to the north, to Long Ledge to the south. Whether the strongly reflecting lower sediment south of Long Ledge corresponds to this Pleistocene sediment cannot be ascertained, it was not encountered again in any of the other cores. It seems reasonable to assume that Pleistocene sediment covers most of the deepest portions of the Montsweag Bay basin.

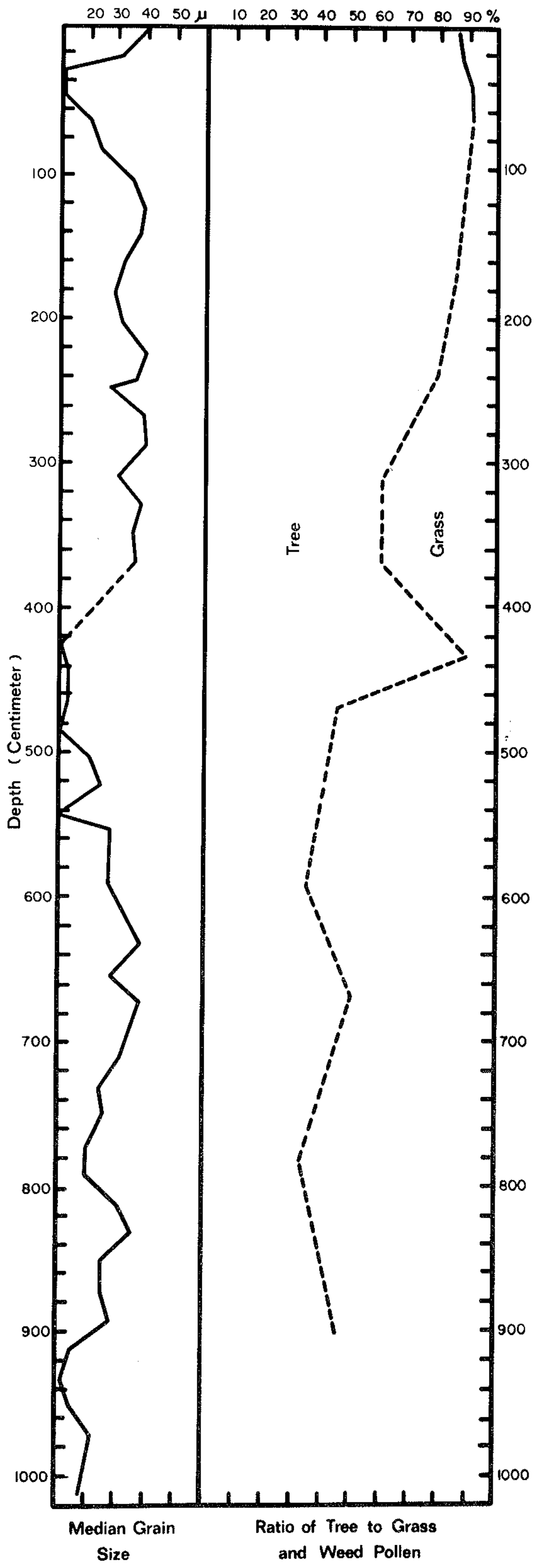

Figure 4.
Grain-size and pollen log of Bailey Point Dock Vibra-core.

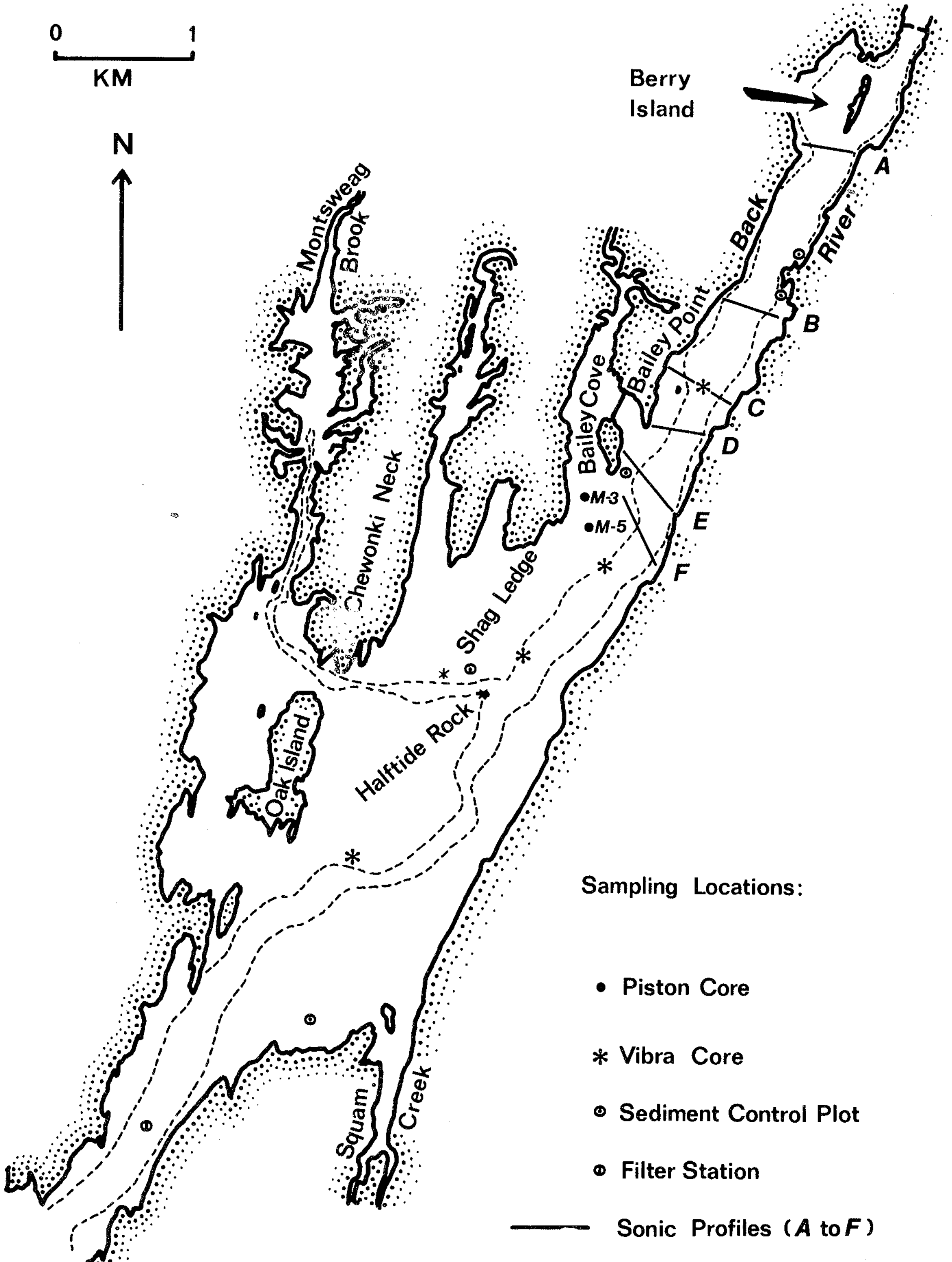

Figure 3.
Montsweag Bay, index to sampling stations and sonic profiles.

VI. HOLOCENE SEDIMENTS

Five additional cores were raised from Montsweag Bay at the locations shown in Figure 3. Two of these cores, M-3 and M-5, are piston cores, the remaining cores were taken with the Vibra-corer. Piston coring offers the advantage of recovering a complete section of the sediments; the cores, however, are mostly short. Vibra-coring, on the other hand, produces long cores, with the disadvantage of a loss of the surficial and watery sediment. It has to be assumed that in all Vibra-cores the top meter and a half are missing. Figures 5 to 9 show the core logs for median grain size and pollen frequencies. Representative cumulative curves for the sediment analyses are shown in Fig. 10.

Throughout all cores, the sediment characteristics vary only within narrow limits. The modal size class varies between coarse and median silt grades. The median grain size fluctuates mostly between 30 and 40μ, indicating that the hydrological conditions under which the sediment accumulated changed very little during the course of deposition.

At the outset of this study it was expected that agricultural activity on the surrounding lands would leave an expression in the sedimentary record. Increased erosion should have concurrently produced a somewhat coarser sediment. Whereas an increase of the sedimentation rate is probable, as will be shown later, no evidence of a coarsening of the sediment can be found. Sediment from increased soil erosion, if it found its way into Montsweag Bay, did not get carried towards the more central parts of the bay, where the cores were taken.

The Vibra-cores from Bailey Cove and Halftide Rock (Figs. 7, 8) show a sharp interval of coarser sediments. Both cores were taken near the edge of the present-day channel, approximately 800 meters apart. These abrupt changes in sedimentary environment were probably caused by a simultaneous event, perhaps a slight lateral shift of the channel towards the west, thus exposing these locations to stronger currents which then inhibited the deposition of the very fine sediment fraction. Should these events really be synchronous, then the sedimentation rate at Bailey Cove was almost exactly twice that of Halftide Rock because the peak of coarse sediment is found at -1.85 meters at Halftide Rock and -3.55 meters at Bailey Cove. This deduction, as will be shown later, is supported by pollen-stratigraphic dating.

Radiographs of these two cores show an irregular bedding of the sediments, with the layering ranging in thickness from less than one to more than 10 mm. The thin beds are usually composed of coarse silt with little clay, the thicker layers are considerably finer grained. The coarser layers represent winnowing residues, produced by intermittent high wave activity (storms). The irregular bedding is frequently disturbed by tracks and trails of burrowing organisms, and the identifiable shell fragments that were found within these cores belong to species that are living in Montsweag Bay today (mostly *Mya arenaria*). No evidence of plant roots was seen, indicating that the bottom of these sites has been covered by at least as much water during the past as there is now (2.5 and 3 meters, respectively, at low tide).

Pollen analysis of the cores M-3 and M-5 and the Vibra-cores from Bailey Cove and Halftide Rock permitted the recognition and dating of two synchronous events which, confirmed by two C-14 dates, led to the determination of absolute sedimentation rates. Following the suggestions of Davis (1967), a search was made for the impression that agricultural activities left upon the record of pollen contained within the sediment. Lumbering and agriculture were introduced to this area by European settlers and is thus historically documented. Likewise, the abandonment of farming within the 1930's, or slightly earlier, is a dated event that can be used in interpreting pollen diagrams. For this particular purpose it was sufficient to classify the pollen into two categories: tree pollen and non-tree pollen. The common tree pollen of this area are: pine, maple, oak, birch, and hemlock; the common non-tree pollen encountered were grasses, ragweed and, rarely, thistle. The clearing of the surrounding land for fields and pastures by the early settlers is revealed within the cores by a reduction of the abundance of tree pollen grains and a corresponding rise in the frequency of grass, cereal and weed pollen.

All four cores contained at least one of these time markers, and core M-5 contained both. In core M-5 (Fig. 6), the relative abundance of tree pollen drops from 65% at the base of the core to less than 50% at the middle (at -1.60 meters) and rises sharply to 70% and more above the -0.80 meter level. Radiocarbon dates were obtained for the -3.25 meter and -0.95 meter levels. These analyses had to be performed on bulk sediment samples because no shell or wood fragments of sufficient size were found at these levels. The radiocarbon dates thus have a wide margin of uncertainty but agree well with the dates derived from the pollen stratigraphy. The date of -250 years (±40 years) for the bottom sample corresponds closely with the historical date for significant settlement and farming in this area in the early 18th century. The date of -50 years (±15 years) at the -0.95 meter level corresponds equally well to the decline of farming in the early 1930's.

Core M-3 exhibits with certainty only the late increase in tree pollen frequency between -0.70 and -0.55 meters (Fig. 5).

The Vibra-cores taken at Bailey Cove and Halftide Rock have only the decrease of the tree pollen frequency represented, the top section, containing the late increase, is probably missing due to the sampling peculiarity of the Vibra-corer.

The pollen of maize (corn) provided an additional time marker. This plant was cultivated in this coastal area by the European settlers only, thus its presence within the core samples dates these as post 1650 to 1700 A.D. Maize pollen was found throughout the length of cores M-3 and M-5 and with certainty down to -1.35 meters in the Bailey Cove Vibra-core and to -1.10 meters in the Halftide Rock Vibra-core. The occurrence of evidence for agriculture thus slightly precedes the decline of tree pollen.

With this information it is possible to calculate absolute rates of sediment accumulation: the lower 2.30 meters of core M-5 were laid down in 200 years = 1.15 cm/year; the upper 0.95 meters were deposited in 50 years = 1.9 cm/year. Part of this apparent increase in sedimentation rate will probably be accounted for by the compaction that the surficial watery sediment still has to undergo. No information is as yet available to properly assess the compaction factor. The sedimentation rate for the top of core M-3 is approximately 1.7 cm/year. No such computations can be made for the Bailey Cove and Halftide Rock Vibra-cores since it is impossible to say how much of their top sediment is missing. However, relative rates can be determined if it is assumed that in both cores approximately the same amount of top sediment is missing. The decrease of the tree pollen frequency takes place at -1.15 meters in the Bailey Cove core and at -0.60 meters in the Halftide Rock core. Also, the incidence of coarse sediment within both cores, mentioned earlier, occurs at depths that show the same 1:2 ratio (-1.85 and -3.55 meters), thus the sediments at Halftide Rock accumulated only about half as fast as those in Bailey Cove.

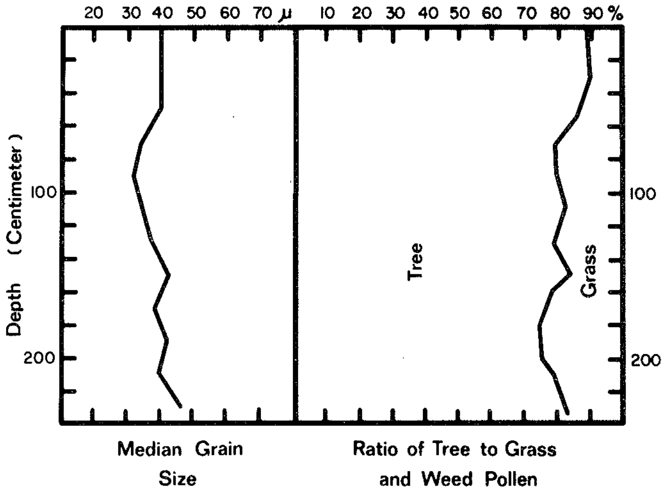

Figure 5.
Grain-size and pollen log of piston core M-3.

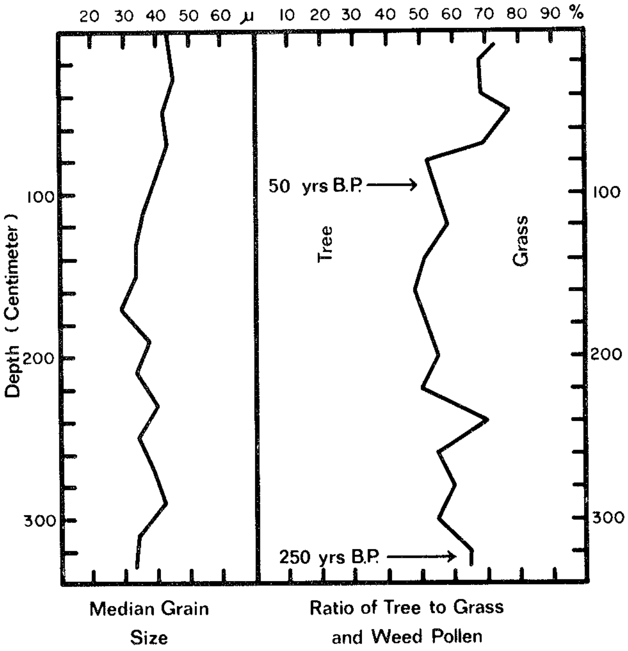

Figure 6.
Grain-size and pollen log of piston core M-5.

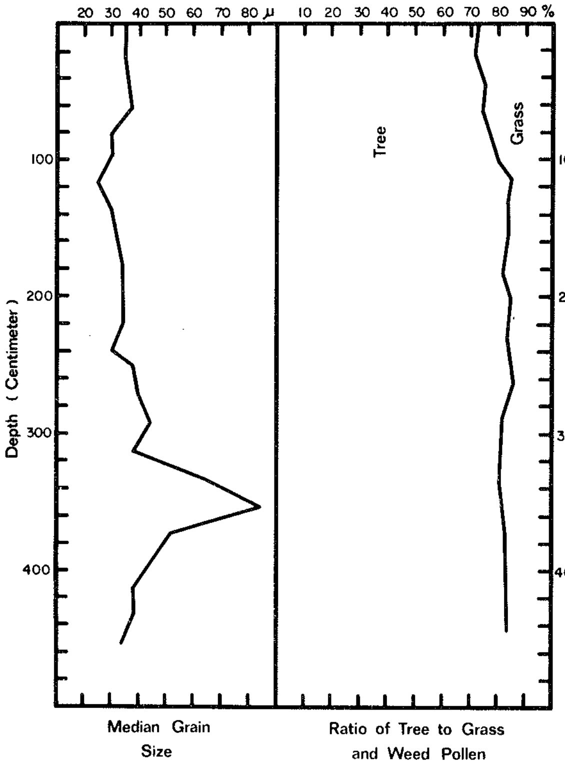

Figure 7.
Grain-size and pollen log of Bailey Cove Vibra-core.

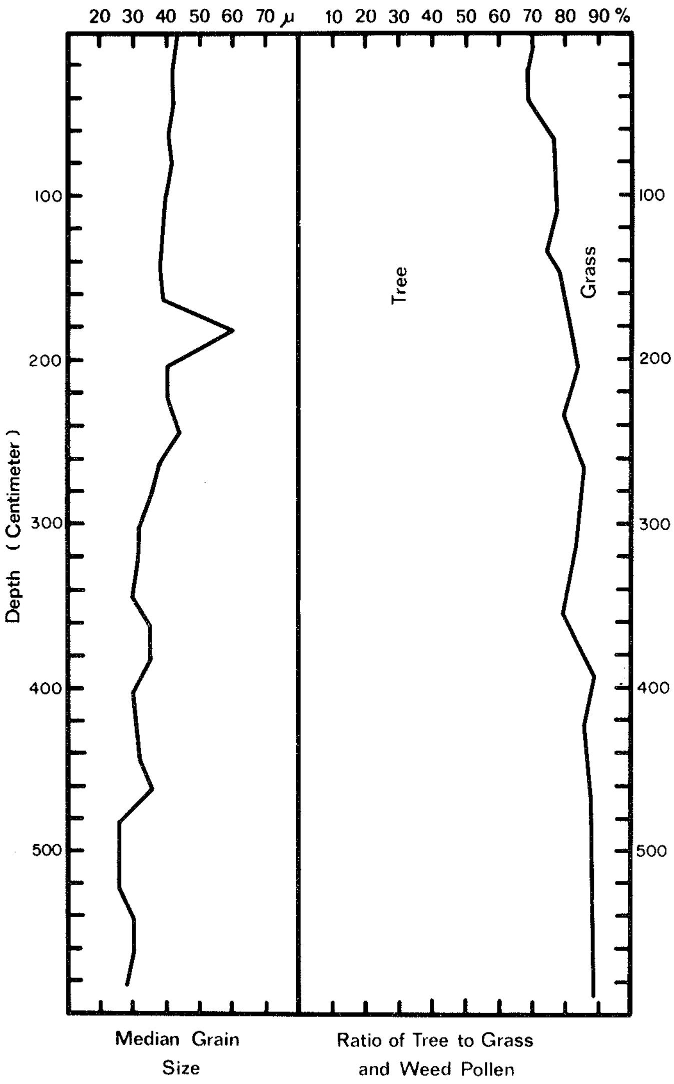

Figure 8.
Grain-size and pollen log of Halftide Rock Vibra-core.

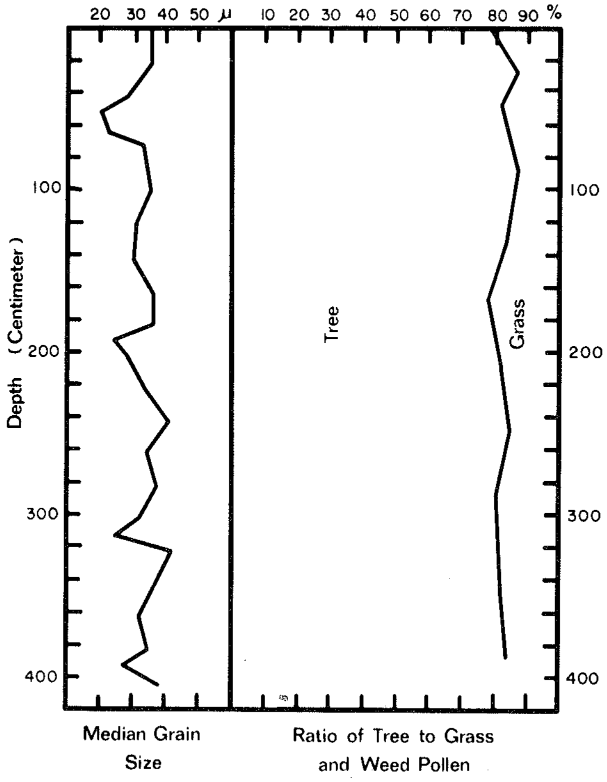

Figure 9.
Grain-size and pollen log of Oak Island Vibra-core.

The fourth Vibra-core, taken east of Oak Island, near the edge of the channel, did not show any clearly interpretable record. The radiographs, sediment and pollen analyses are very similar to those of the last four cores described, the lack of any remarkable event in this fourth core is perhaps best explained by the core site. At this site, where the channel makes a turn to the east, erosion and re-deposition by a shifting channel has left a complicated record that cannot be interpreted without additional cores.

VII. ACTUAL SEDIMENTATION

Radionucleides, produced during the extensive atmospheric nuclear weapons testing during the early and mid 1950's, provide a good mark of reference within a modern sediment sequence. Thus, a core of 75 cm length taken from the high mudflats near Young Point was analyzed for the presence of 137Cs. The results of this analysis, listed below, indicate that 20 cm of sediment were deposited at this site during the past 17 to 20 years, a figure that is only slightly lower than those observed from other cores.

Sample Depth	pCi ^{137}Cs per Core
0 – 5 cm	25.08 ± 32%
5 – 10 cm	25.64 ± 32%
10 – 15 cm	25.08 ± 32%
15 – 20 cm	20.86 ± 36%
20 – 25 cm	ND *
25 – 30 cm	ND
30 – 35 cm	ND
35 – 40 cm	ND
40 – 45 cm	ND
45 – 50 cm	ND
50 – 55 cm	ND
55 – 60 cm	ND
60 – 65 cm	ND
65 – 70 cm	ND
70 – 75 cm	ND

* ND=Not detected, Less than 7 pCi/core.

In March 1970, glass beads of 250μ diameter were distributed over five plots in Montsweag Bay (Fig. 3). Short sediment cores were raised from these plots at irregular intervals until November 1971. In the laboratory the sediment was removed from the top of these cores, millimeter by millimeter, placed under a microscope and the incidence of glass beads recorded. Although animal activity displaced glass beads upwards and especially downwards, a distinct horizon was always recognizable and taken as the original surface. The observed sediment accumulations were recalculated for 12 month averages to make them comparable among each other.

	1970	1970 & 1971
1. N. of Ferry landing	2.4 cm yr. $^{-1}$	1.9 cm yr. $^{-1}$
2. S. of Ferry Landing	2.8 cm yr. $^{-1}$	loss of station
3. E. of Foxbird Island	2.6 cm yr. $^{-1}$	loss of station
4. E. of Shag Ledge	3.2 cm yr. $^{-1}$	2.7 cm yr. $^{-1}$
5. W. of Seal Rock	5.6 cm yr. $^{-1}$	2.8 cm yr. $^{-1}$

The high rates of accumulation that were observed in 1970 were not maintained through 1971. This reduced average of accumulation may be due to one, or both, of the following:

1. The sediment comes to rest at any one place only temporarily and is eroded to be re-deposited at some other location, at least partially, during storms. This explanation is supported by the presence of the irregular bedding observed within the cores, each small bedding plane representing such an episode of erosion and re-deposition.
2. All sediment plots were in tideland areas, and thus susceptible to erosion by ice at low tides during the winter 1970-1971.

VIII. SUSPENDED SEDIMENT

The grain size of the sediment of nearly all samples that were analyzed strongly suggests that the sediment enters Montsweag Bay as suspension load. Ninety-five to 99% of all sediment is finer than 64μ, and thus easily transported in suspension by even moderate currents. Coarse sediments, that are usually transported as bottom load, are scarce or absent.

In order to compare the grain size distribution of the bottom sediments with that of the sediment suspension, glass jars were suspended from anchored floats as sediment traps at various locations within Montsweag Bay. Due to the frequent loss of these floats, the data are too incoherent to be useful as indicators for sedimentation rates. The sediment that was collected in these jars, about one meter above bottom and one meter below low tide level, showed a great similarity to that from bottom and core samples: particles larger than 64μ were absent, the proportion of clay sized particles was about 10% higher than in the core and bottom samples (Fig. 10).

The surface drainage basin of Montsweag Bay is insignificant and can be disregarded as a source of large volumes of sediment. It may be assumed that nearly all sediment enters Montsweag Bay through its northern and southern entrances. Because 80 to 90%

of the tidal flow passes through the southern entrance, 24-hour filter stations were occupied there in April, July, and November of 1971. Surface and bottom water samples were taken at 35 to 45 minute intervals and filtered through pre-weighed Millipore filters (Strickland and Parsons, 1968). The results of these measurements are shown in Figures 11, 12, and 13. It is obvious that every flooding tide carries a higher load of suspended matter than the ebbing tides. Evidently, Montsweag Bay acts as a settling basin, where each tide deposits a portion of its load of suspended matter. Averaged from these observations the flooding tide carries about 8.5 mg per liter and the ebbing tide 6.14 mg per liter of suspended matter. The difference between these two values represents the amount of sediment remaining within Montsweag Bay, about 65 tons per tidal cycle or 1.7 cm of sediment per year if evenly distributed over the entire surface area of the bay. Because even distribution is unlikely to occur, these data agree remarkably well with those observed during 1970-1971 on the glass bead plots, and, if compaction is taken into consideration, with those of the cores as well.

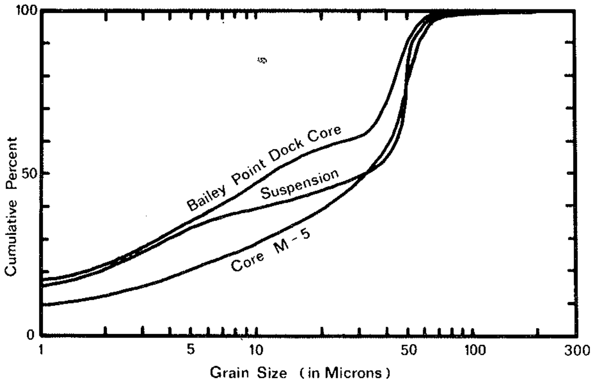

Figure 10.

Cumulative curves of grain-size frequencies for: a) Pleistocene sediment (Bailey Point Dock core); b) Holocene sediment (core M-5); c) Sediment from suspension (sediment trap near Halftide Rock).

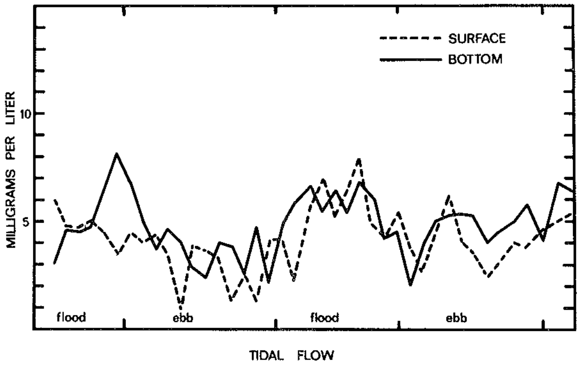

Figure 12.

Concentrations of suspended solids observed during 24 hours in July, 1971.

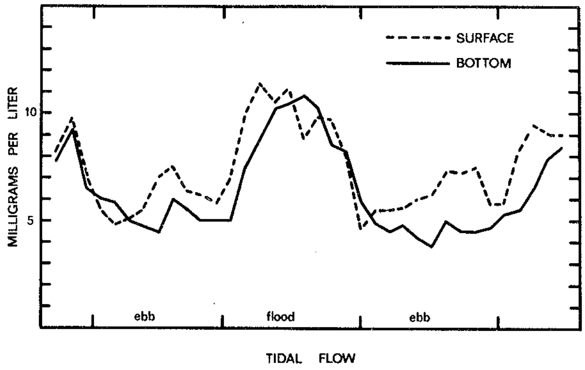

Figure 11.

Concentrations of suspended solids observed during 24 hours in April, 1971.

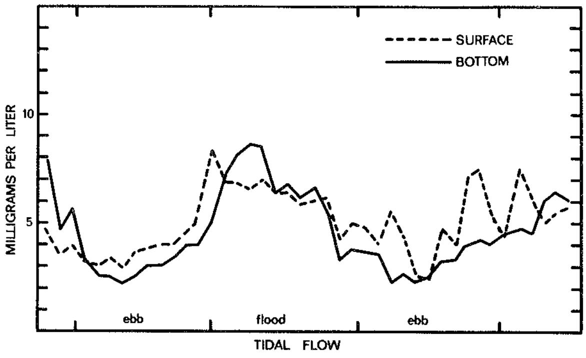

Figure 13.

Concentrations of suspended solids observed during 24 hours in November, 1971.

IX. RECENT CHANGES

A significant change of sediment regime was brought about in the Back River area by the construction of the causeway at Cowseagan Narrows. The Pleistocene sediment, recognized on the seismic profiles and encountered in the Bailey Point Dock core, is overlain by an uncompacted, watery sediment, that contains the typical modern faunal and floral assemblage. This loose sediment is clearly visible on the seismic profiles (Figs. 14 to 19), and ranges in thickness from zero meters near Berry Island to more than 1.5 meters off Bailey Point. Before the construction of the causeway, tidal scour within the Back River was evidently sufficient to prevent the accumulation of sediment on top of the rather stiff and cohesive Pleistocene sediment. With the near elimination of these currents in 1950, the presently found surficial sediments started to accumulate. The residual current near the causeway and Berry Island is still sufficiently strong to reduce the sedimentation rates there, but diminish progressively towards Bailey Point, as shown by a corresponding increase of sedimentation rates in that direction.

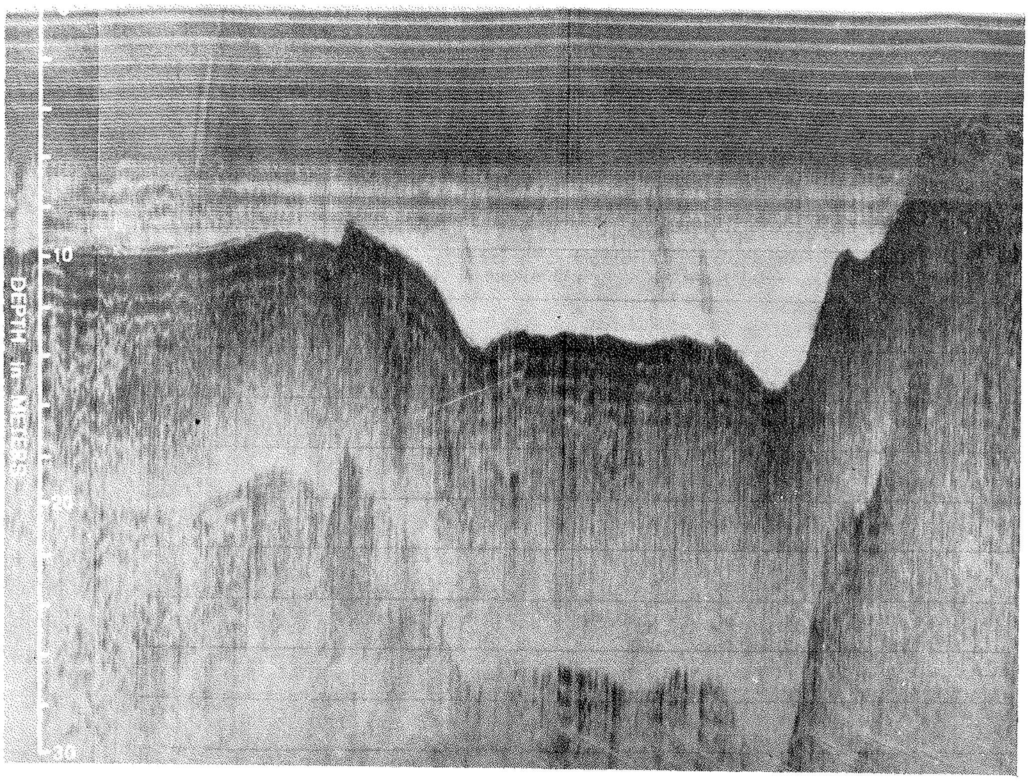

Figure 14.
Sonic subbottom profile across Back River along line A on Figure 3.

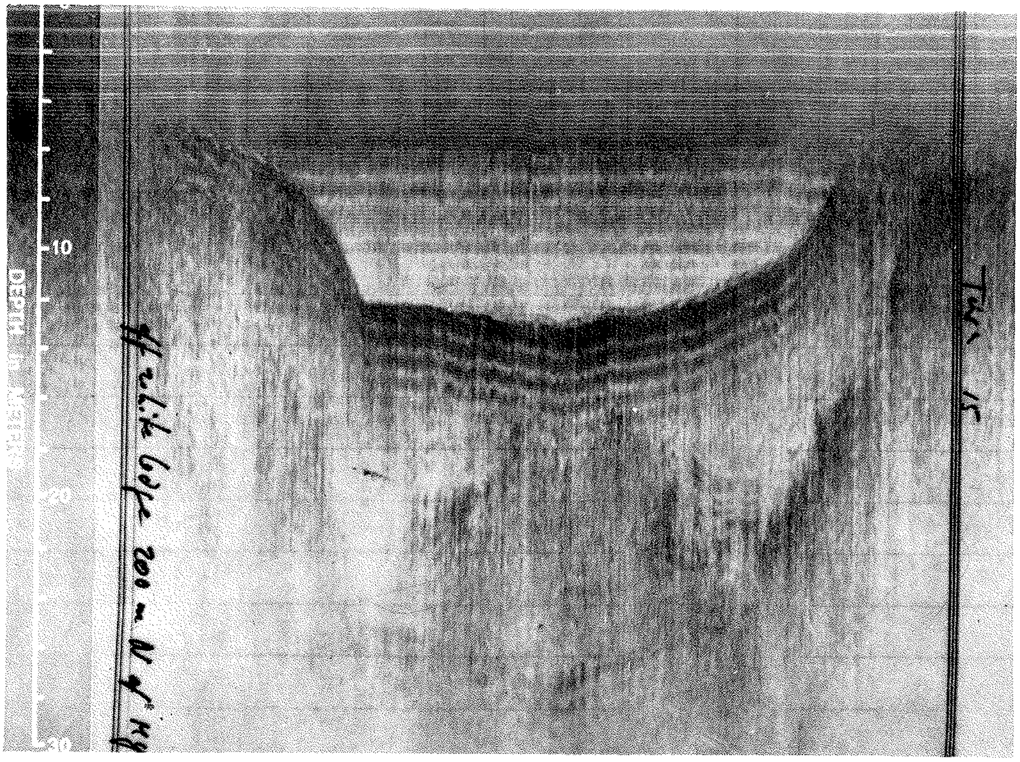

Figure 15.
Sonic subbottom profile across Back River along line B on Figure 3.

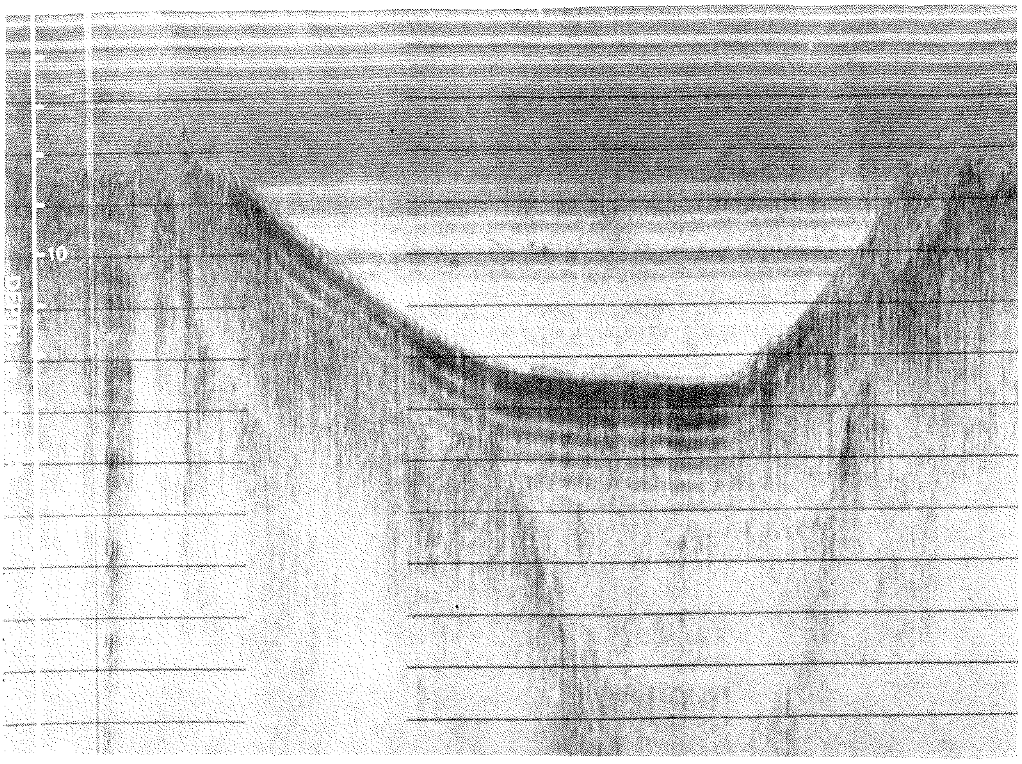

Figure 16.
Sonic subbottom profile across Back River along line C on Figure 3.

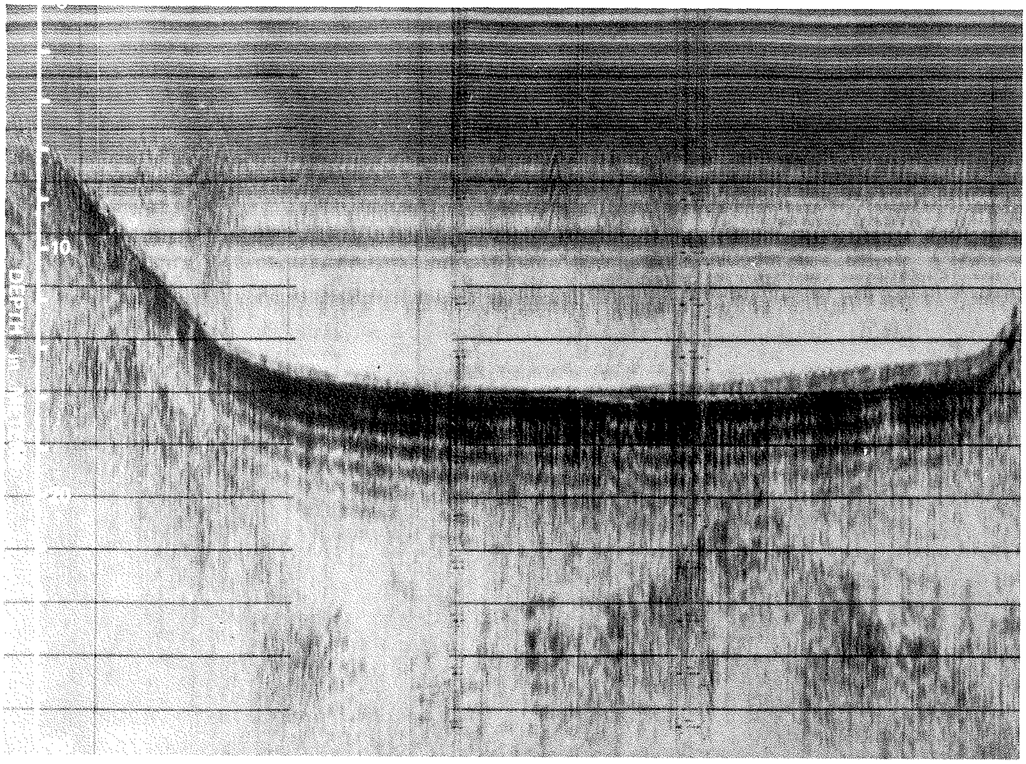

Figure 17.
Sonic subbottom profile across Back River along line D on Figure 3.

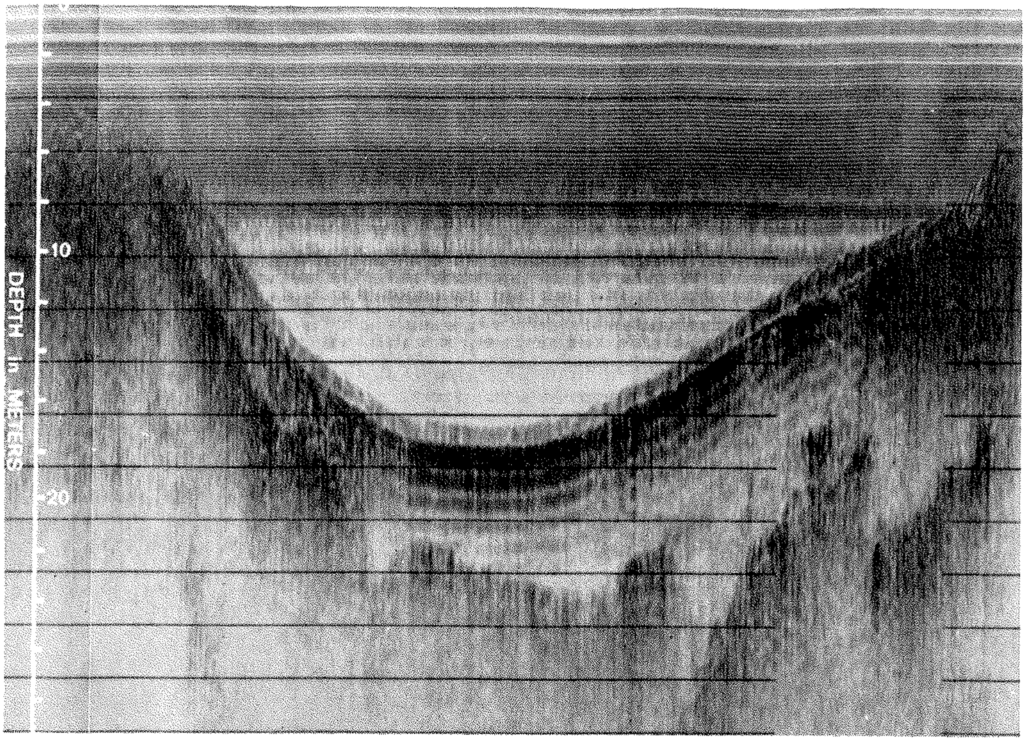

Figure 18.
Sonic subbottom profile across Back River along line E on Figure 3.

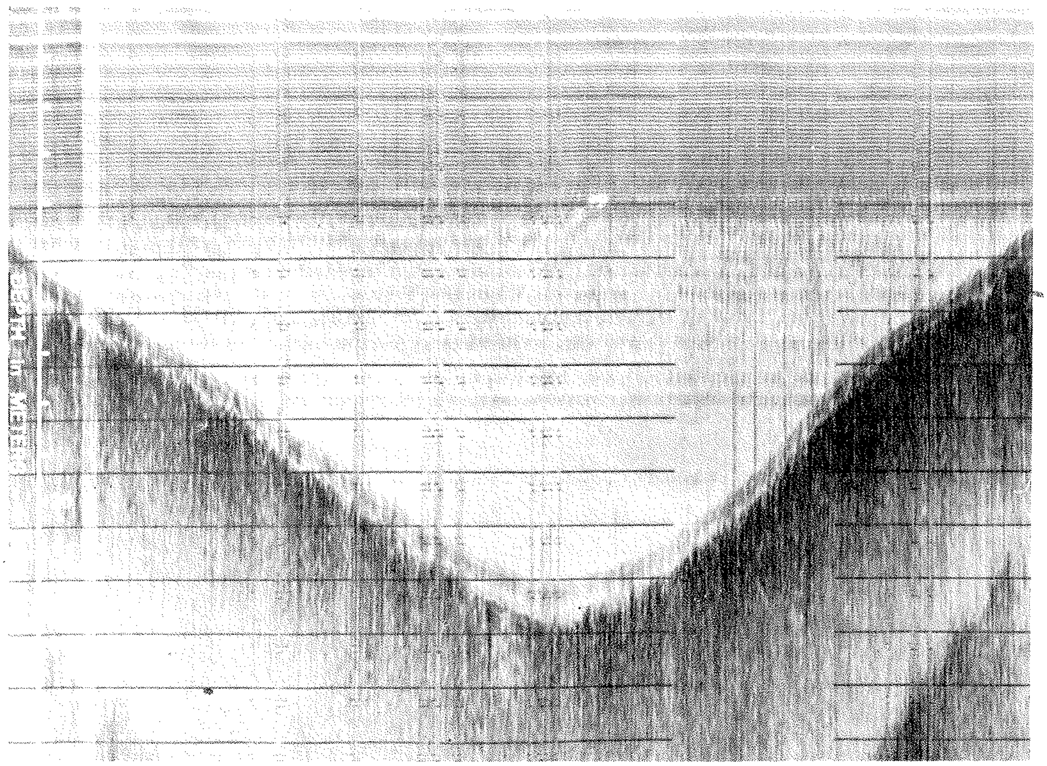

Figure 19.
Sonic subbottom profile across Back River along line F on Figure 3.

X. OUTLOOK

High rates of sediment accumulation are nothing new to Montsweag Bay, but these rates will probably be higher in the future. The gradual filling of the bay with sediment reduces the amount of water that will pass in and out with each tidal cycle and thus reduce the current scour that apparently has kept the neighboring bays and "rivers" open. In addition, much of the bottom of Montsweag Bay has now reached a level where it will be settled by vegetation, which again will enhance the entrapment of suspended sediment. Eventually Montsweag Bay will be transformed into a salt marsh traversed by a number of tidal channels. Because much of the mudflat area is now approximately at low tide level, or slightly below, it will take about 150 years, at the present-day average accumulation of 2 cm/year, before these areas will have built up to high water level. This buildup, of course, will be faster in some areas, slower in others, and will be noticed mostly as an encroachment of salt marsh starting from protected coves, such as west of Oak Island, at Bailey Cove, or at Squam Creek, where this process has already begun.

XI. ACKNOWLEDGEMENTS

This research was supported by grants from the Maine State Geological Survey and the Maine Yankee Atomic Power Company. The Vibra-coring was carried out with a rig provided by Mr. William Miskoe of the University of New Hampshire. To him and Captain P. Jensen I owe sincere thanks for their great help in the field under rather trying circumstances.

XII. REFERENCES

Bloom, A. L. 1960. Late Pleistocene changes of sea level in southwestern Maine. Augusta, Dept. Econ. Devel., Maine Geol. Survey, 143 p.

Davis, R. B. 1967. Pollen studies of near-surface sediments in Maine lakes. *In:* Quarternary Paleoecology, E. J. Cushing and H. E. Wright (eds.), p. 143-173, Yale Univ. Press.

Strickland, J. D. H., and T. R. Parsons. 1968. A practical handbook of seawater analysis: Bull. 167, Fisheries Research Board of Canada, 311 p.