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Title: Preliminary Report on Sea-Level Rise in the Damariscotta Estuary, Central Maine Coast

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Between the towns of Damariscotta and Newcastle, coastal Lincoln County, Maine, the Damariscotta River flows over a series of rock thresholds that impede tidal flow. One of these thresholds, known locally as Johnny Orr, has a depth such that the reversal of tidal currents sets up considerable turbulence and effectively delays the timing of high and low water. This configuration was noted by Richard Goldthwait (1935) who proposed the model on which the current research is based.

In Goldthwait's opinion, the reversing rapids of Johnny Orr represents a stage in the evolution of the estuary. During the earlier period of lower sea levels, the Damariscotta River would have flowed downstream over Johnny Orr. Not until sea level attained nearly its current position could the reverse-flow characteristics occur. A chronology for sea-level rise in the area might be deduced from the history of the Johnny Orr rapids.

Along the banks of the Damariscotta River, prehistoric Indians created huge shell middens dominated by the American oyster (*Crassostrea virginicus*). This species is now disjunct and no longer maintains a large breeding population in the river. Large shell middens upriver from Johnny Orr suggested to Goldthwait that the Indians were gathering oysters after local substrate and water conditions evolved. The latter conditions developed in response to the penetration of salt water above the threshold at Johnny Orr.

In an attempt to date the incursion of salt water, Goldthwait assigned an age to the middens. Lacking radiocarbon or any other isotopic dating techniques, Goldthwait calculated this age based on assumptions about the size of the local Indian populations, the numbers of shells represented in the middens, and how many years it would take for the assumed Indian population to consume enough oysters to account for the volume of middens. Even the sizes of the middens had to be assumed due to extensive alteration and destruction during the nineteenth century.

Some thirty years after Goldthwait's effort, Alan Myers (1965) re-assessed the potential for determining sea-level rise by studying the Damariscotta River above Johnny Orr. Radiocarbon dating had been invented in the intervening years, and Myers referred to dates published by Broecker and others (1956) of about 2,000 B.P. based upon "grab samples" of oyster shells from a midden. These dates, if acceptable, constitute a minimum age for the submergence of Johnny Orr by high tides, as it was only then that the salinity level would support oysters. The current study represents a third attempt to put Goldthwait's original model into operation.

This study has two major components—cultural and bio-geological. The former involves an understanding of the human response to the changing river conditions through a re-interpretation of the oyster shell middens; the latter consists of an analysis of sediment cores taken in the river upstream from Johnny Orr.

The principle behind the sediment core examination was that as sea level rose, an increasing amount of salt water would have entered the river above Johnny Orr, thus affecting the salinity. Increased salinity levels should be reflected in the microfossils present in the sediments. Therefore, if a chronology for changes in salinity could be developed, it would reflect an alteration of the fresh to salt water balance, a feature presumably related largely to sea level rise.

May 19, 1982, was selected as a date when the height and scheduling of tides would allow us to take the University of Maine's Research Vessel Lee under the U.S. Route 1 bridge at Damariscotta-Newcastle, through the rapids and rocks at Johnny Orr, and under the new Route 1 bridge to an area established by Goldthwait and Myers through hand-line sounding to have water depths of 6 m at high tide. The coring crew consisted of Drs. Thomas Kellogg and David Sanger (Institute for Quaternary Studies - University of Maine at Orono) and Michael Dunn, Boat Captain at the UMO Ira C. Darling Oceanographic Laboratory.

Several runs through the area just below the "Indraft" disclosed fathometer readings of up to 10.5 m, considerably deeper than Goldthwait and Myers reported. A series of five sediment cores were taken using a piston corer dropped off the R.V. Lee. The first three cores, taken in deeper water depths, provided sediment deemed suitable for floral (diatom) analysis.

TABLE 1

SEDIMENT CORES FROM THE DAMARISCOTTA RIVER

Core Number	Water Depth (m)	Core Length (m)
1	10.5	1.40
2	9.9	1.23
3	6.0	1.82
4	4.5	0.25
5	4.2	0.25

The top 0-10 cm of each core consists of coarse sand. Below this is a very fine, sticky, gray to dark gray sediment (Munsell 2.5 Y-5/0 to 2.5 Y-4/0) with some black banding. No particle size analysis has been undertaken. Samples from cores 1-3 were selected for diatom analysis by Dr. Davida Kellog of the Institute for Quaternary Studies. Dr. Kellog's report follows:

Samples approximately 0.5 gm in weight were taken at levels near the top, middle, and bottom of three Damariscotta River cores. These samples were processed for diatoms by the method of Schrader (1974). Diatom slides were mounted with Hyrax and were examined under a Leitz Dialux 20 microscope equipped with a 100X oil immersion objective. Each slide was examined in its entirety. All diatoms present were noted in an effort to determine whether changes from typically marine to fresh water assemblages and back, indicative of times of marine regression and transgression, could be detected.

Table 2 lists all species observed in a single slide from each sample, and their abundances and habitat preferences (marine and fresh water). From this table it is clear that diatoms of all species, though usually quite well-preserved, occurred in very low abundance at all levels sampled in each core. In a near-shore estuarine environment such as the one we have sampled in the Damariscotta River, the paucity of diatoms may well be a function of masking by terrigenous sediments. This problem could be dealt with effectively by examining a series of duplicate slides for each sample until statistically valid samples (usually about 300 specimens) are obtained.

The ecological message provided by the diatoms is more complicated than a simple, clear-cut marine/fresh water dichotomy. Although a preponderance of species are marine in the samples from the top of all three cores, some non-marine species are always present, and the proportion of the total diatom flora represented by these non-marine species may exceed that of the marine species in some downcore samples. However, because many of the non-marine species are known to inhabit brackish water or to have wide salinity tolerances, their presence in our samples does not necessarily signal a change in salinity such as we were expecting to encounter at depth in these cores. Many of the same species are present at all depths. It is possible, in view of the likelihood of masking by influx of terrigenous sediments in this area, that our cores have not penetrated to the depth of the first salinity change or that some of the non-marine specimens may have been washed in from fresh water habitats on shore. For this reason, we believe that a suite of longer cores should be taken in the area.

TABLE 2

ANALYSIS OF CORES FOR DIATOMS

Core I

Top (5 cm and 10-11 cm)

Marine Species	No.	Non-Marine Species	No.
Nitzschia cylindrus	1	*Cyclotella stelligera* (marine and fresh water)	2
Cocconeis scultellum var. *parva*	1	*Melosira distans*	1
Rhizosolenia hebetata var. *semispina*	1		
Sponge spicules			

Middle (96 cm)

Marine Species	No.	Non-Marine Species	No.
A few centric fragments		*Cyclotella stelligera*	1
Sponge spicules			

Bottom (136-137 cm)

Marine Species	No.	Non-Marine Species	No.
None		*Cyclotella stelligera*	2
		Melosira distans	2
		Cyclotella comta	1
		Gyrosigma balticum	1

Core II

Top (3 cm)

Marine Species	No.	Non-Marine Species	No.
Cocconeis costata	1	*Tabellaria* (most of the species of this genus occur in fresh water)	1
Sponge spicules		*Cyclotella stelligera*	2

Middle (100 cm)

Marine Species	No.	Non-Marine Species	No.
None		*Cyclotella stelligera*	2
		Tabellaria quadriseptata (dystrophic or oligotrophic waters)	1

Bottom (122 cm)

Marine Species	No.	Non-Marine Species	No.
Nitzschia sp.	1	*Melosira distans*	2
Sponge spicules		*Tabellaria*	1

Core III

Top (7-8 cm)

Marine Species	No.	Non-Marine Species	No.
Melosira sol	1	*Cyclotella stelligera*	1
Navicula directa	1	*Amphora ovalis var. affinis (alkaliphil)*	1
Cocconeis costata	1		
Nitzschia seriata	1		
Radiolarian spines			
Sponge spicules			

Middle (21-22 cm)

Marine Species	No.	Non-Marine Species	No.
Melosira sol	1	*Cyclotella stelligera*	4
Trachyneis aspera	3	*Melosira distans*	3
Sponge spicules		*Gyrosigma macrum (mesohalobe)*	1

Bottom (100 cm)

Marine Species	No.	Non-Marine Species	No.
Centric fragments		*Melosira distans*	6
Sponge spicules		*Cyclotella stelligera*	2
Nitzschia sp.	1	*Cyclotella comta*	1

As Dr. Kellogg's report suggests, it is possible that cores 1-3 are not long enough to reflect the anticipated change from fresh to marine diatoms. The low diatom frequency might suggest a high sedimentation rate. A quick and inexpensive alternative to radiometric dating of the sediments is an examination for pollen reflecting European land clearing activities and subsequent weeds associated with agriculture. R. Scott Anderson and George Litchte of UMO examined a few slides from cores 1-3 in an attempt to ascertain something of the pollen spectra. Unfortunately, pollen counts are very low and, therefore, inconclusive. Dr. Kellogg's speculation that the high sedimentation rate has masked the diatom record appears to be supported by the palynologic analysis.

The cultural historical aspect of the project is a more sophisticated attempt to utilize the Indian occupation to provide a minimum date on the presence of oysters in the river. This research involves locating shell middens that could provide bottom C-14 dates on shells and the context for diagnostic artifacts. Currently, there are remnants of several middens above Johnny Orr, including the famous Whaleback Midden. During the nineteenth century, a number of the middens were extensively mined for road fill, lime, and chicken "scratch". Others were plowed for fields (Castner, 1956).

As some of the middens were demolished, artifacts were collected and taken to various museums in the Northeast. Research by historian Mary Jo Sanger has been directed at ascertaining the history of the midden destruction and the whereabouts of the artifacts collected nearly a century ago. The historical research is almost complete, and those museums holding important Damariscotta collections have been identified. These museums have not yet been visited because only recently has the Harvard Peabody Collection, which is the main Damariscotta collection, been available for study, and even then in part only.

On the basis of those collections already examined by David Sanger, it seems that the middens were being accumulated throughout the Ceramic period (2,500 - 400 B.P.) and possibly into the preceding Late Archaic (pre-2,500 B.P.).

In 1982, time was spent in the field attempting to locate middens, many of which are mere traces. This work was not completed. One midden of considerable interest appears to show a change in species utilization from Crassostrea to Mya arenaria, the soft shell clam. On the basis of associated artifacts, that shift came very late in the prehistoric period. The changeover from oysters to clams may be significant if it represents a change in the local shellfish beds. Clams prefer more saline conditions and are better adapted to colder water temperatures, both of which are characteristics of the modern Damariscotta River.

Prior to the completion of the project, a number of tasks need to be carried out.

1. The situation regarding the sediment cores needs to be clarified. If, as seems reasonable, the sedimentation rate is very high, then the existing cores may not extend far enough back in time to reveal anticipated salinity changes. Larger samples from the three cores will be reduced in an attempt to make up statistically significant sample sizes for both diatom and pollen analysis. Should that still support the high sedimentation rate and a very recent time period, then an attempt should be made to secure longer cores, perhaps through the use of a vibracorer. Alternate locations for cores should be considered.

2. Two of the major museums will be visited in February, 1983 (Peabody at Harvard and Peabody at Salem, Massachusetts).

3. The historical research needs to be better integrated into the archaeological fieldwork. In the early summer of 1983, archaeological field survey and testing will continue. An attempt will be made to date the interface of the clams and oysters at the site mentioned above.

In conclusion, research to date has not yet provided a chronology for sea level change in the Damariscotta River. We are closer to putting some minimum dates on the Indian utilization of the oysters, but the sediment and floral record remains unclear due to problems with sample size. It is anticipated that projected research over the next six months will resolve a number of these questions.

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