CHAPTER 75

OFFSET COASTAL INLETS

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Abstract

Offset coastal inlets are common on the coasts of New England and the northern Gulf of Alaska In both areas, the dominant waves approach the shore at an oblique angle, resulting in a strong net littoral drift The most common type of offset on these coasts is a downdrift offset (i e , the downdrift side of the inlet protrudes further seaward than the updrift side) Wave refraction around the ebb-tidal deltas at the inlets is an important process in the formation of the downdrift offsets, inasmuch as it creates a local reversal in drift direction just downdrift of the inlet, and allows sediment to accumulate there Associated with the offset appears to be a segregation of tidal current flow in the inlets, with the ebb flow being more channelized than the flood

The type of inlet offset at any one location can vary through time Studies of the changes at the Hampton Harbor, New Hampshire, inlet from 1776 to the present show two reversals from updrift to downdrift offsets during that interval

INTRODUCTION

An examination of coastal charts from almost any area in the world will reveal that coastal inlets are rarely symmetrical with respect to the placement of beaches on either side of the inlet They are usually offset, either updrift or downdrift As yet, no satisfactory theory or model has been proposed to explain these offsets [2] Inlets with barrier spits that overlap adjacent downdrift barrier beaches, such as those of Long Island, N Y , seem in accordance with what might be predicted However, many of the

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[2] This problem is under study by Cyril J Galvin, Jr of the Coastal Engineering Research Center, who considers the ratio of net drift to gross drift significant

inlets of the New England and Alaskan coasts are offset in just the opposite direction, that is, the barrier beach downdrift from the inlet protrudes further seaward than the one on the updrift side In fact, our studies indicate that this is by far the most common type of offset inlet on both the Alaskan and the New England coasts

NEW ENGLAND INLETS

Over the period of the last five years, most of the sandy inlets on the New England coast have been studied by members of the Institute of Coastal Research, Department of Geology of the University of Massachusetts With respect to coastal sedimentation, northeasterly storms, which generate waves that approach most of the shoreline obliquely from the northeast, have a dominant influence on the New England coast These waves set up a net littoral drift to the south in most areas At almost every inlet in New England, the barrier beach downdrift of the inlet (i e , on the south side) protrudes further seaward than the one on the updrift side

One of the most important porcesses in the accumulation of sand on the downdrift side of these inlets is wave refraction around ebb-tidal deltas In the case of the Merrimack River Inlet, Massachusetts, the refraction of the dominant northeast waves causes waves to approach from the southeast, resulting in a northerly littoral drift at the south side of the inlet (Figs 1, 2, and 3) This reversal in drift direction on the downdrift side of the inlet serves to promote accumulation of sand to such an extent that the beach builds seaward at that point A wave refraction diagram constructed for the inlet of the Merrimack River illustrates this principle (Fig 1)

ALASKAN INLETS

The depositional portion of the coastline of southeastern Alaska is similar in many respects to the New England coast Important to the theme of this paper is the fact that most of the coastal inlets on this part of the Alaskan coast have downdrift

Fig. 1 Wave refraction diagram at the mouth of the Merrimack inlet, Massachusetts. Note that the refraction of the dominant northeast waves around the ebb-tidal delta has resulted in waves approaching from the southeast and thus in accretion at the south (i.e., downdrift) side of the inlet. Compare diagram with photographs in Figures 2 and 3. Wave fronts are approaching from the northeast with a period of 9 seconds.

Fig. 2 View looking south along the Plum Island beach, Massachusetts, just south of the Merrimack inlet. Coast Guard station in foreground is located on the wave refraction diagram of Figure 1. Note accumulation of sand on the south side of the groins and the oblique approach of the wave crests from the southeast. The groin field is located inside the ebb-tidal delta and is in an area of local reversal of longshore drift which results from wave refraction around the ebb-tidal delta (Fig. 1). In the far background of the photograph, drift resumes its normal southerly trend. Photograph taken June 1968.

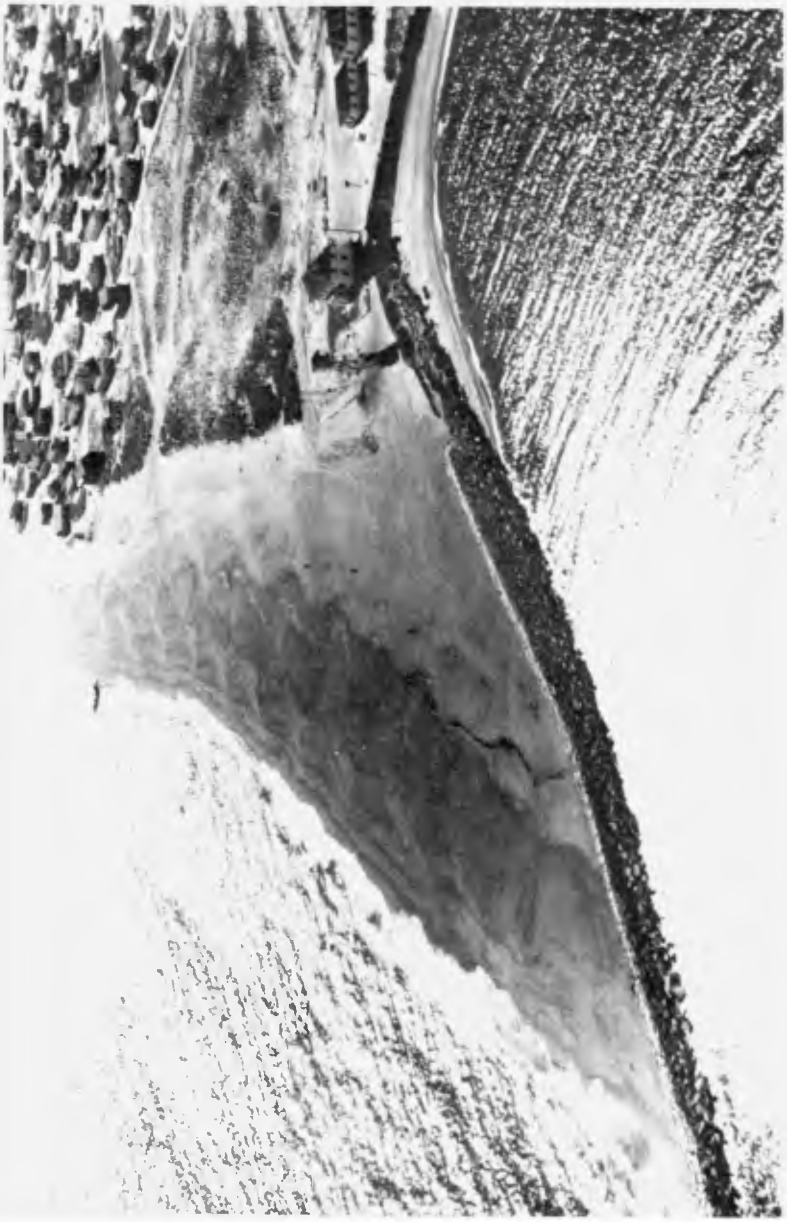

Fig. 3 South jetty of the Merrimack River inlet, Massachusetts, on 16 October 1969. Note the large accumulation and outbuilding of sand behind the jetty, which was restored in the summer and fall of 1968. View looks south. This is further evidence for local reversal in drift direction on the downdrift side of the inlet. Compare with Figures 1 and 2.

offsets Net littoral drift is from east to west, as determined by geomorphologic evidence Figure 4 shows the lineation of coastal sand dunes in response to strong southeast winds These southeast winds are the result of low pressure centers that pass up the Aleutian Island chain and strike the Alaskan coast in the apex of the Gulf of Alaska

The coastal inlets off the Copper River Delta show pronounced downdrift offsets The barrier beaches on the west sides of the inlets have developed large seaward protrusions (Figs 5 and 6) Wave refraction appears to play an important role in the formation of downdrift offsets in this area (Fig 6)

DOWNDRIFT-OFFSET MODEL

From the study of approximately 15 offset coastal inlets, we have derived a simple model that we feel is representative of inlets with downdrift offset The model is given in Figure 7 Waves approaching the shore at an oblique angle produce a strong net littoral drift The supratidal portion of the beach on the downdrift side of the inlet usually protrudes seaward with the beach face of that portion of the barrier beach facing the oncoming waves The barrier beach on the updrift side is usually composed of multiple recurved spits, indicating strong transportation of sediment into the inlet Commonly, the intertidal portion of the inlet is also offset, in that large accumulations of sand on the ebb-tidal delta (usually swash bars) protrude further seaward on the downdrift side than on the updrift side The Barnstable inlet in Massachusetts is an excellent example of this type of offset

Another common feature of these coastal inlets is the segregation of ebb and flood flow Each inlet usually has a main channel that is oriented perpendicular to the shoreline and carries a large portion of the ebb flow The flood flow, on the other hand, tends to be distributed as a sheet with several individual flood channels developed in some cases Usually, the flood channels hug both beaches, flanking the main ebb channel A similar segregation

Fig. 4 Linear coastal dunes near the Bering Glacier, Alaska. Lineation is the result of strong southeast winds generated during southeasterly storms. View is towards the southeast. Sand spit and beach protuberances in background indicate strong littoral drift from east to west.

Fig. 5 Offset coastal inlet, Copper River Delta, Alaska. View is toward the east. Note the large seaward protrusion on the downdrift (west) side of the inlet with the linear beachface (arrow) perpendicular to the southeast, the dominant wave approach direction.

Fig. 6 Offset coastal inlet, Egg Island, Copper River Delta, Alaska. View is toward the east. Note the large protrusion on the downdrift (west) side of the inlet. Wave refraction (illustrated here) is thought to be an important process in slowing down and reversing littoral drift on the downdrift side of the inlet, with the downdrift protrusion building seaward as a series of ridge-and-runnel systems.

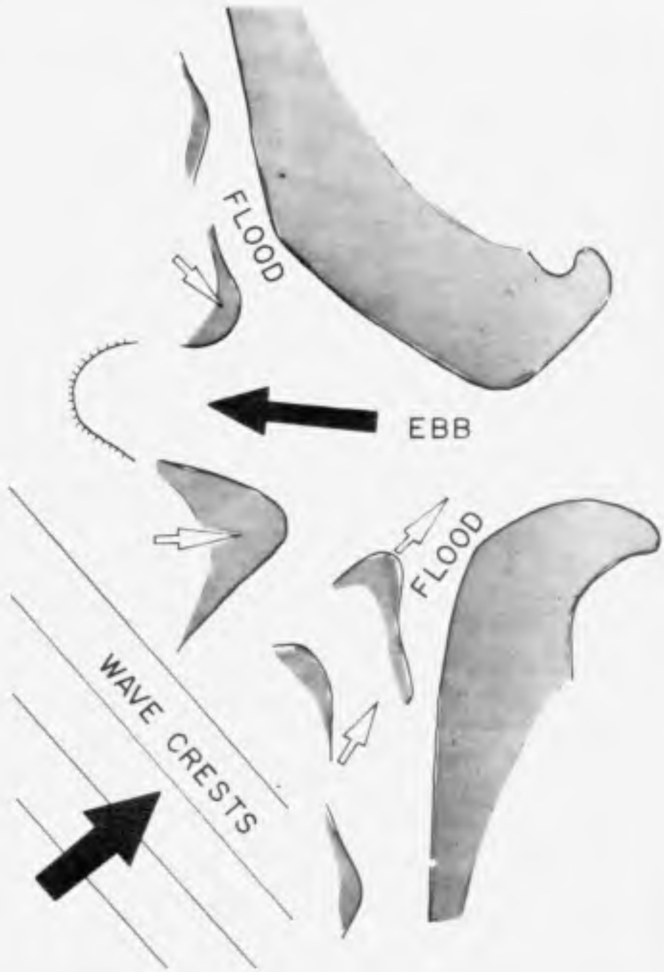

Fig. 7 A simple model for coastal inlets with downdrift offsets on the New England and Alaskan coasts. The downdrift side of the inlet, which is offset seaward, usually has a straight beach face perpendicular to the dominant wave approach direction. The ebb flow is channelized, whereas the flood current tends to develop as sheet flow across the intertidal swash bars and through minor flood channels.

of flow has been observed in model studies by Henry Simmons and his associates at Vicksburg (personal communication, September 1970)

We feel that the reason for this segregation of flow is the occurrence of time-velocity asymmetry of the tidal currents Maximum flood velocities are usually late in the flood-tidal cycle, between mid-tide and high-tide Similarly, the maximum ebb flow is between mid-tide and low-tide, usually quite close to low-tide Thus, the ebb flow tends to be much more channelized than the flood, which flows in as a sheet The exact relationship of this segregation of flow to inlet offset is unknown

A spectacular example of a flood channel located on the downdrift side of an inlet, flanking the main channel, is shown in Figure 8 This figure, a photograph looking downdrift, shows large sand waves in this shallow flood channel which indicate transport toward the inlet An inspection of the bedforms in the channel (on the ground) shows a complete predominance of flood flow in this channel

HISTORIC CHANGES IN INLET OFFSET

Our studies of historical changes on the New England coast indicate that inlet offsets can change through time A study of the inlet at Hampton Harbor, New Hampshire, shows that the offset of the inlet has passed through two cycles since 1776 (Fig 9) In 1776, the northern beach overlapped the southern beach By 1885 this pattern had reversed with the southern beach protruding further seaward than the northern beach This cycle repeated again, with the inlet attaining its present configuration, with a southern protrusion, in 1931 The Merrimack River entrance, the next inlet to the south, shows a similar pattern of migration This long term variation in inlet offset needs to be investigated in much greater detail

Fig. 8 A flood channel on the downdrift side of an offset inlet, Strawberry Reef, Copper River Delta, Alaska (arrows indicate direction of flood current flow). The view is downdrift (southwest) looking out of the inlet. Flood-oriented sand waves in the middle distance indicate transport of sediment into the inlet. The flank of the main ebb channel is at the lower left-hand corner of the photograph. Photograph taken at low tide in July 1970.

HAMPTON INLET, N.H.
SHORELINE CHANGES

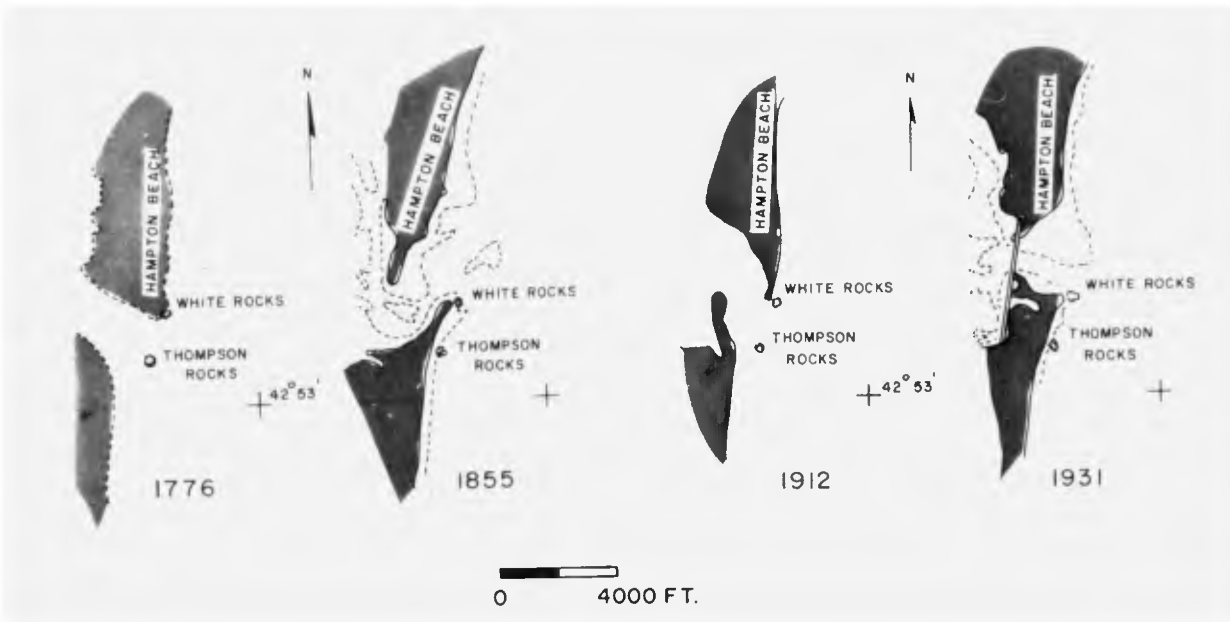

Fig. 9 Inlet changes at Hampton Harbor, New Hampshire, 1776-1931. Note that in 1776 and 1912, the updrift side of the inlet was further offset in a seaward direction, whereas in 1855 and 1931, the downdrift side of the inlet was further offset in a seaward direction.

SUMMARY

Coastal inlets of the shoreline of New England and the northern Gulf of Alaska show some striking similarities Both of these areas are characterized by dominant waves that approach the shoreline obliquely, producing a large net littoral drift Offset coastal inlets are common in both areas, the prevalent type being inlets with downdrift offset We have presented a simple downdrift-offset model that we feel is typical of most of the inlets studied

Associated with the downdrift offsets is a segregation of tidal current flow in the inlets, with the ebb flow being more channelized than the flood How the flow segregation relates to inlet migration is one of the most important questions raised by our study

In this paper we have dwelt on what we consider to be the most common type of offset in the area of study The type of offset can and does vary from inlet to inlet, and, as indicated by our historic studies, can vary even at the same inlet through time

ACKNOWLEDGMENTS

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