CHAPTER 81

DEPARTMENT OF PUBLIC WORKS OF CANADA
DESIGN DIRECTORATE

EXPERIENCE WITH SELF-DREDGING HARBOUR ENTRANCES

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ABSTRACT

About 7 years ago, the Department of Public Works of Canada requested the assistance of the National Research Council to devise a means of reducing sediment deposition in the entrance to a small harbour at Dingwall, Nova Scotia. Siltation of this harbour entrance, which opens to the Atlantic, was so severe that on occasions it was completely blocked by sand at low tides.

The desired objective was to devise a layout of structures which would maintain an entrance depth of 12 feet at low tide. Model studies were carried out and a breakwater configuration was evolved which appeared to have some "self-dredging" characteristics. The recommended structures were built in 1962 and to date have been successful in maintaining minimum depths of 5 feet at low tide which is adequate for the fishing fleet using the harbour. While falling somewhat short of the original objective this performance has been very satisfactory when compared with the conditions which existed before construction.

Similar installations have since been built at two other locations in Nova Scotia Which are on the Gulf of St. Lawrence. Indications so far are that similarly satisfactory results have been obtained.

This paper describes the installations, makes some tentative suggestions concerning the mechanisms involved in their operation and provides data on their performance.

PURPOSE AND SCOPE

Designers of harbour entrances in areas where littoral drift is a problem are constantly searching for solutions which they hope will minimize maintenance dredging problems. The Department of Public Works has, during the past six years, completed three installations of a harbour entrance configuration which was developed for the department by G.E. Jarlan at the National Research Council of Canada and which appears to give promise of a certain measure of success in combatting harbour entrance siltation All three installations have been at small fishing harbours in the Atlantic Province of Nova Scotia. The purpose of this paper is simply to give a very brief description of the design of the entrance and of the results which have been obtained since this concept could perhaps be used to advantage at other locations.

TYPICAL SITE CONDITIONS

The typical site conditions for these installations are

(a) entrance exposed to moderately heavy ocean, or sea, wave climate,

(b) entrance provides access from open sea to inner harbour or lagoon through a sand bar or beach,

(c) depths required at low tide are about 5 to 6 feet to accommodate small fishing vessels,

(d) littoral drift heavy enough to make necessary almost continuous maintenance dredging

DESCRIPTION OF HARBOUR ENTRANCE

The concept of the entrance configuration is illustrated diagrammatically in Fig 1

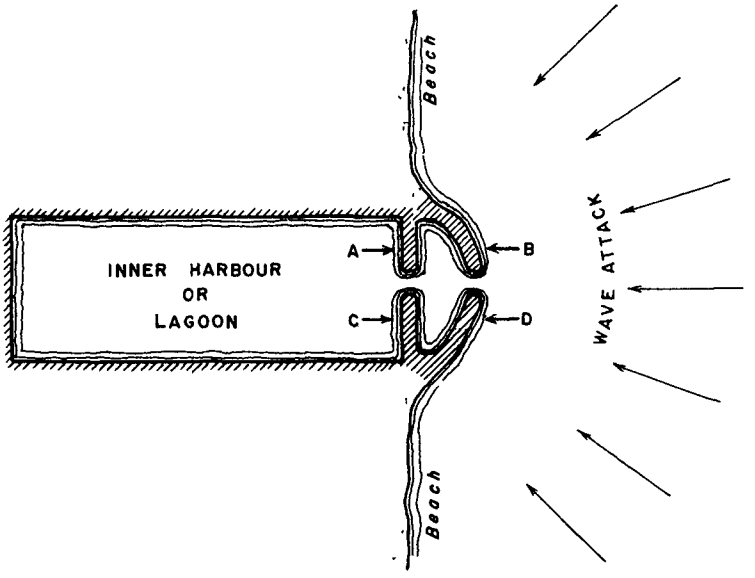


FIG. 1 SPECIAL ENTRANCE CONFIGURATION

Rubble mound breakwater construction has been used for structures A, B, C and D Typical lengths of these structures are

Structures A and C – 240 ft
Structures B and D – 325 ft

The entrance width is approximately 100 feet

The design was developed from model studies about 1960 at the National Research Council of Canada, for the fishing harbour at Dingwall, Nova Scotia, shown in Fig 2 Shoaling of the entrance of this harbour was so severe that it was often possible to walk across the harbour entrance in rubber boots within a few months of completion of dredging to a depth of 13 feet

Prior to the studies which resulted in the design described herein, an attempt had been made to reduce the siltation problem by connecting the harbour with the "North Pond" (See Fig 2) to channel a larger tidal prism through the harbour entrance This, however, failed to solve the problem

The model studies, which did not include tidal effects, showed that the entrance configuration, depicted in Fig. 3, produced a self-flushing action under wave attack Although interesting theoretical explanations of this phenomenon have been proposed (Ref 1), subsequent attempts which were made (Ref 2) to reproduce this self-flushing effect in a laboratory experiment were not very successful The effectiveness and performance of the design can best be judged by consideration of the results of a prototype installation over a period of 6 years

EXPERIENCE TO DATE WITH PROTOTYPE INSTALLATIONS

Harbour entrances based on this design have been installed at Dingwall, Inverness and Pleasant Bay in Nova Scotia Their location is shown in Fig 4. Some of the physical conditions prevailing at these sites are summarized in Table I.

TABLE I – PHYSICAL CONDITIONS

Location	Spring Tidal Range	Area of Lagoon	Area Harbour Entrance at High Spring Tide	Tidal Prism	Annual Dredging Prior to Improvement	Typical Sand Size
	(Ft.)	(Sq. ft.)	(Sq. ft.)	(Cu ft.)	(Cu. yds.)	
Dingwall	4.6	1,700,000	1725	7,820,000	50,000*	Fine sand
Inverness	4.5	1,300,000	1250	5,850,000	5,000	Very fine sand
Pleasant Bay	4.0	243,000	1575	972,000	New location, no data	Shingle beach. Particle size up to 3"

* This was for a dredged depth of approx. 24'.

FIG. 2 AERIAL PHOTOGRAPH OF DINGWALL, N.S.

The installation at Dingwall was completed in 1962, and the entrance between the heads of the breakwaters was dredged to a depth of 12 feet. The design has been successful in maintaining an entrance channel for a minimum depth of 5 feet at low tide which is satisfactory for the fishing fleet using the harbour. No dredging has been required since 1962. Future periodic dredging will be required but this was anticipated.

An indication of developments at the harbour entrance is given in Fig. 5 which compares surveys made in 1959 (before construction), 1963 and 1967. Profiles through the centre line of the harbour entrance for 1961, '62, '63, '64, '65 and '67 are shown in Fig. 6.

It is evident that the action of the structures has enabled an undetermined combination of wave action and tidal currents to bypass the littoral drift on a bar in front of the entrance while maintaining a minimum depth of 5 feet as compared to almost complete blockage before the structures were constructed. The tendency of the bar to advance into the harbour entrance (Fig. 6) is anticipated to be controllable with a very moderate amount of dredging.

FIG. 3 PHOTOGRAPH OF HYDRAULIC MODEL SHOWING GENERAL LAYOUT OF STRUCTURES

The conditions recently prevailing at Inverness which was built in 1965 are shown in Fig. 7. The shoal areas in the channel (min. depth 3 feet) are in all probability derived from "caving-in" of the steep sloped banks of the channel. Dredging to remove these shoals has recently been completed.

Construction of the third prototype installation at Pleasant Bay was completed in 1967 and no performance data is yet available.

THE SELF-FLUSHING ACTION

While tidal currents undoubtedly play a part, it seems that this entrance configuration serves to harness the mass transport aspect of wave motion to produce a periodic seaward directed current through the entrance. The incident waves, entering through the gap between the outer breakwaters, transport a certain mass of water into the harbour. As the bulk of the incident wave energy which enters the harbour is spent on the two inner breakwaters and in the shallow areas to each side of the central channel, a hydraulic head is built up within the breakwater system and the consequent return flow is directed seaward in the form of a periodic flushing current through the gap in the outer break waters. This effect is illustrated diagrammatically in Fig. 8.

The existence of a seiche either in the harbour or within the breakwater system, brought about by the disturbing force of the incident waves impinging on the harbour entrance, has not been proven. If such a seiche does exist it could be a factor contributing to the flushing effect.

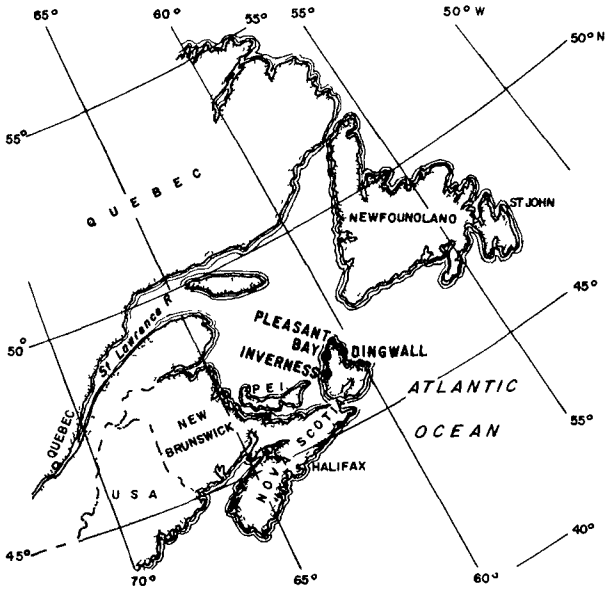


FIG. 4 LOCATION OF PROTOTYPE INSTALLATIONS

NAVIGATION CONSIDERATIONS

This type of entrance has good navigational characteristics because it allows vessels to make a direct entry with no exposure to beam seas. It also is highly effective in reducing wave agitation in the inner harbour

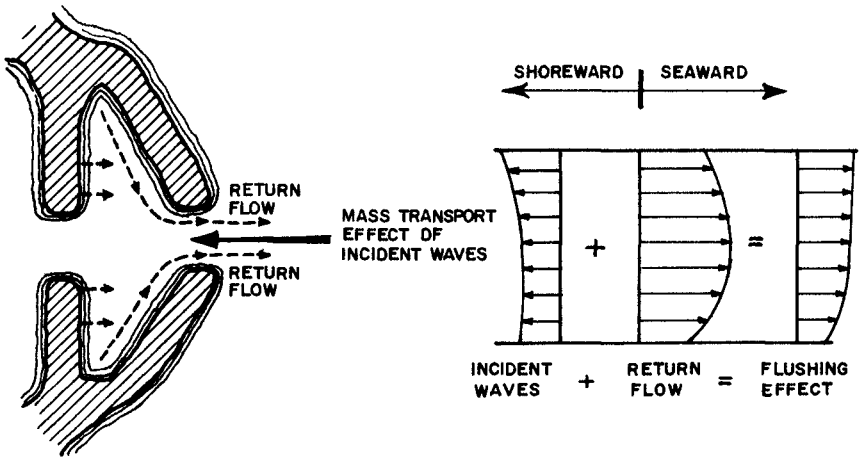


FIG. 8 TENTATIVE ILLUSTRATION OF SELF-FLUSHING ACTION

CONCLUSIONS

While the benefits of these installations could not in any sense be considered spectacular, they have made it feasible to maintain these small fishing harbours in existence without the need for practically continuous dredging in entrance channels exposed to heavy wave action, which presents obvious difficulties The concept may offer a solution in other comparable situations

REFERENCES

1 G E Jarlan, "Remarks on Dingwall Harbour (Nova Scotia)" National Research Council Laboratory Memorandum HY-62. Nov. 1965 (not published)

2 White, I.R P , Investigation of a Self-Dredging Harbour Entrance, Unpublished Thesis, Civil Engineering Dept., Queen's University at Kingston, Canada, April, 1964

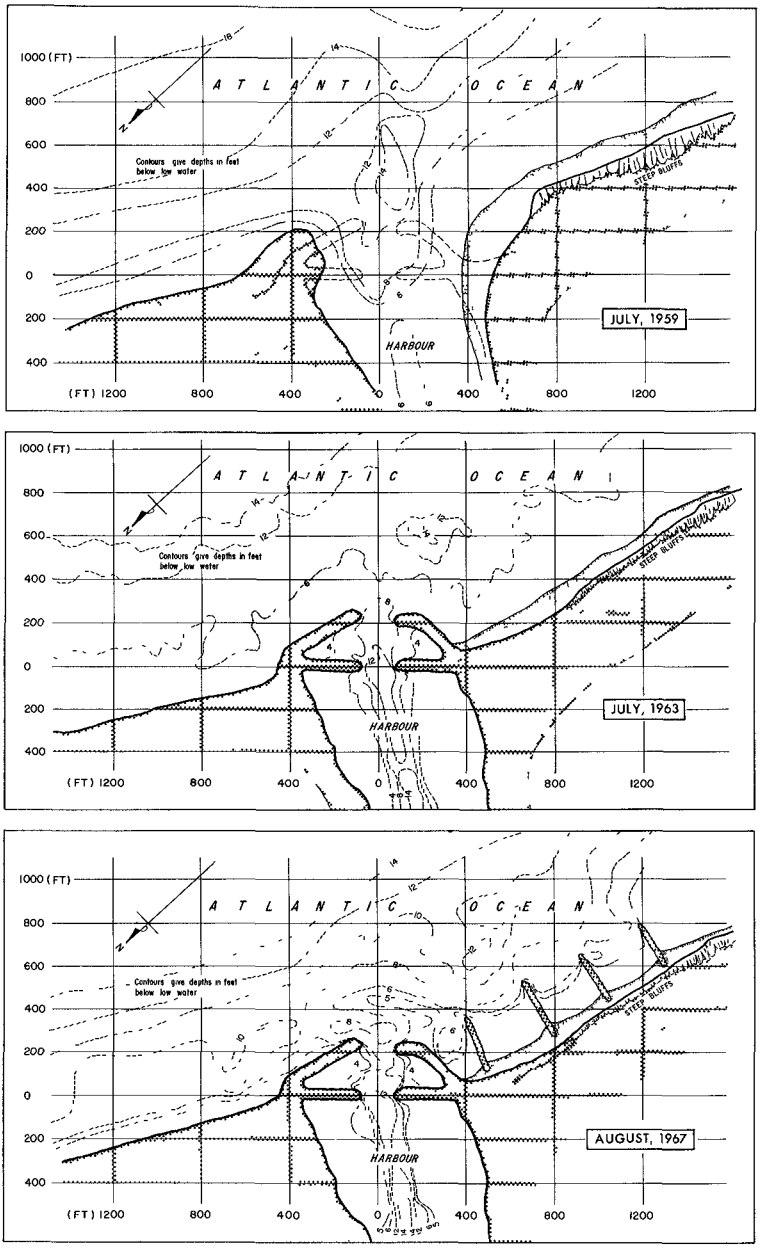


FIG. 5 CONTOUR CHANGES AT HARBOUR ENTRANCE DINGWALL, NOVA SCOTIA 1959–1967

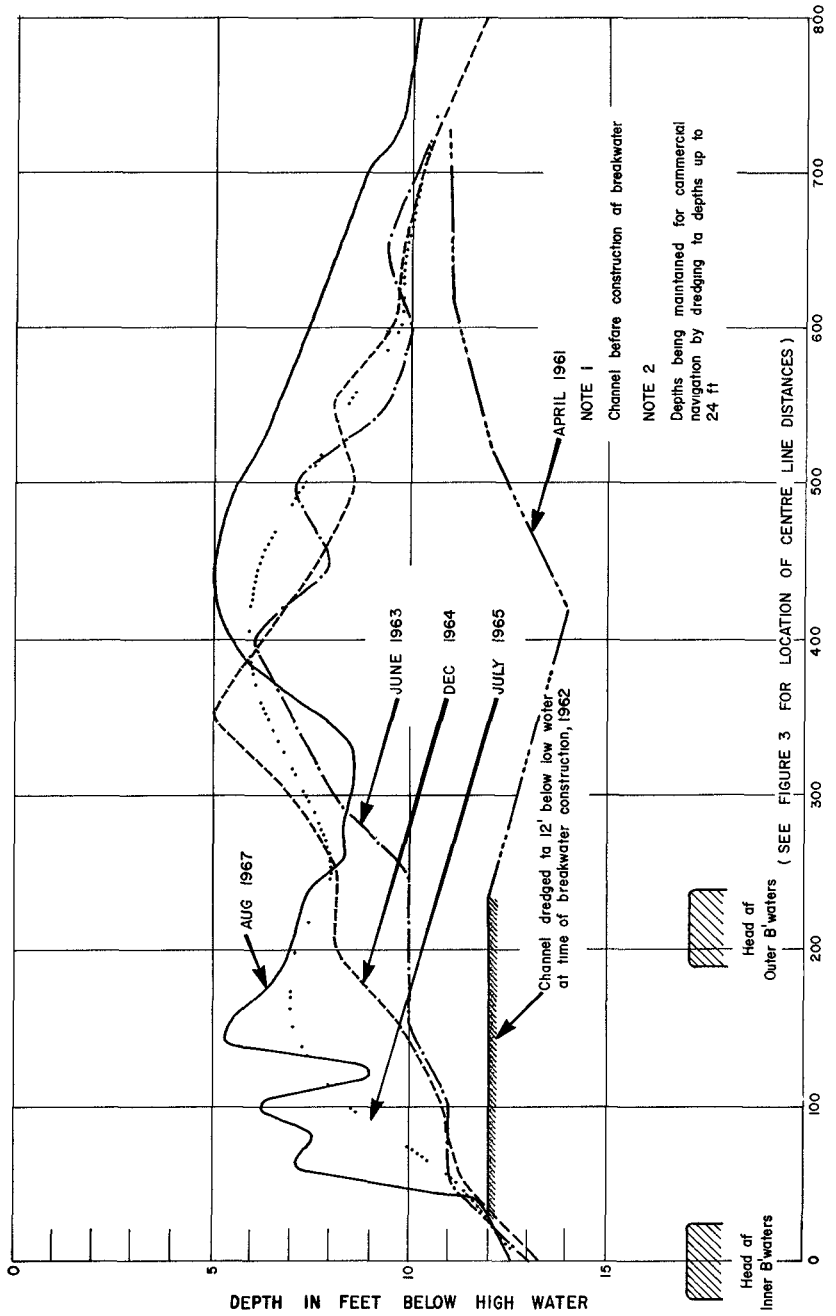
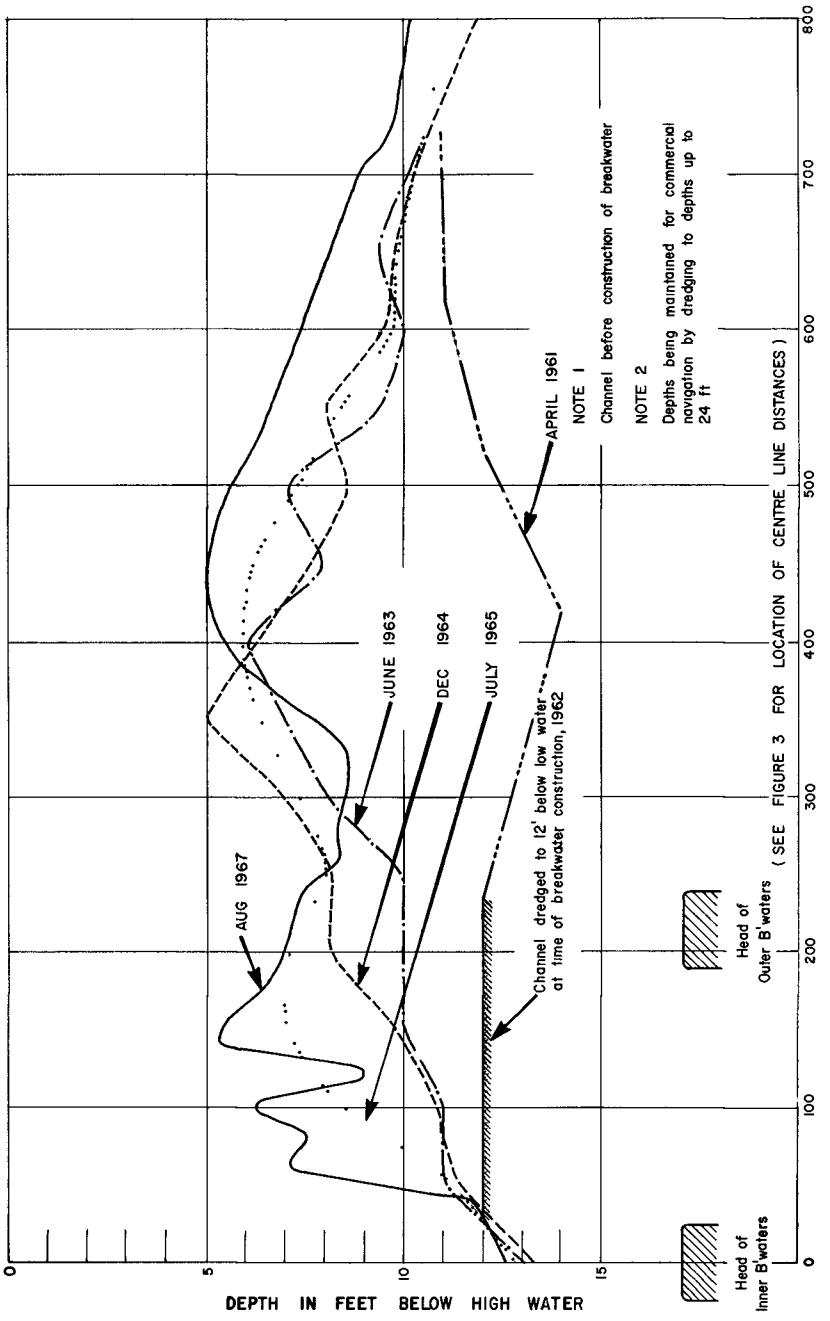


FIG 6 PROFILES ALONG CENTRE LINE OF HARBOUR ENTRANCE



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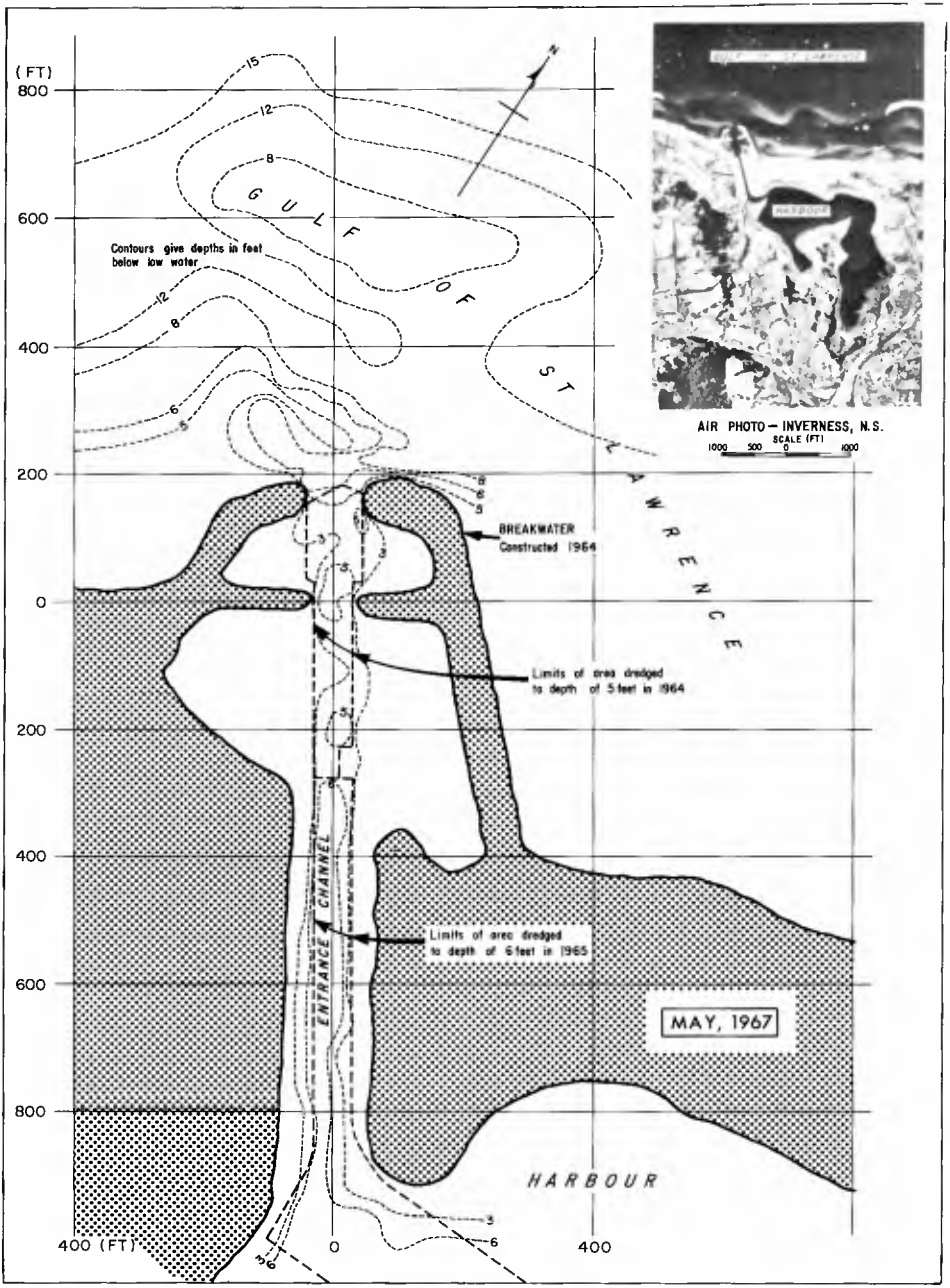

FIG. 7 CONTOUR CHANGES AT HARBOUR ENTRANCE INVERNESS, N. S. 1964 – 1967