CHAPTER 87

PERFORMANCE ASSESSMENT OF SELF-DREDGING HARBOUR ENTRANCES

by

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ABSTRACT

This provides further information and assessment of the three harbour entrance wave traps at Dingwall, Inverness and Pleasant Bay located in Canada. These were constructed to reduce the amount of maintenance dredging required in the entrance channels.

Wave climate data and littoral material analysis are presented.

Observations on the performance of each structure are given and conclusions drawn as to restrictions and constraints on applicability.

PURPOSE

This is a follow-up to the paper presented by Donnelly and MacInnis at the Eleventh Conference on Coastal Engineering in 1968 which should be read as background material for this paper.

Since 1968 data has been produced on wave climate and littoral drift and further experience gained in the effectiveness of the rubble mound four-armed wave traps at Dingwall, Inverness and Pleasant Bay, all located in the Cape Breton area of the province of Nova Scotia, Canada.

WAVE CLIMATE

The deep water wave climate has been estimated for the three locations. However, refraction and diffraction has not been included in the analysis.

The hindcasting routine used to provide the wave data from the hour-by-hour wind data is based on the deep water curves of Sverdrup-Munk-Bretschneider as revised by Bretschneider in 1970 (Look Laboratory Quarterly, June 1970). The wind data was recorded at Cap-aux-Meules in the Magdalen Islands (Gulf of St. Lawrence) and was used for the three sites. This data was obtained during the ice-free period (excluding January, February and March) in 1969, 1970, 1971.

Figs. 1, 2, 3 and 4 show the percentage of time that the significant wave height or significant wave period exceeds the specific values for the given directions or for all directions summed together. For example, at Dingwall, 3% of the time the waves from the S.E. direction exceed 7 feet in height.

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LITTORAL MATERIAL

The grain size distribution of sea bed material taken at the harbour entrances is shown in Fig. 5. This shows the marked differences at the three locations. At Inverness it is mainly a fine sand while at Dingwall the sand ranges from medium to coarse. In the case of Pleasant Bay it runs from coarse sand through fine and coarse gravel. While the curve does not show it, the fact is known that the material runs to cobbles of 6-inch diameter.

SHORELINE AND ORIENTATION

Dingwall is located on a large crescent-shaped bay which extends between two rocky headlands approximately nine miles apart. The bay extends in about 4½ miles. The axis of the bay is oriented approximately N80°E. Inverness is located on a reasonably straight shoreline which runs approximately N.E. - S.W. Pleasant Bay is in a bay or bight approximately four miles wide and 3/4 miles deep. The shore is oriented approximately the same as Inverness.

Fig. 6, 7 and 8 are aerial photos of the three locations showing the entrance structures at the harbours and their orientation and layout.

The sea bottom profile extending from the low water mark to the 18' contour is as shown below:

Dingwall	-	1: 65
Inverness	-	1:100
Pleasant Bay	-	1: 35

STRUCTURE DATA

Some historical information and physical data relating to the three structures are given in the following table.

Location	Date Completed	Design Dimensions of Entrance: Width H.W. Level	Design Dimensions of Entrance: Width Bottom	Design Dimensions of Entrance: Depth at L.W.	Max. Width of Trap Basin (approx)	Equilibrium Depth (approx) ft.
Dingwall						
(a) Entrance Structure	- 1962	129'	80'	12'	600'	5
(b) Groynes	- 1964					
Inverness	1965	119'	90'	5'	300'	2
Pleasant Bay	1967	156'	100'	10'	400'	Variable depending on severity of storms

OBSERVATIONS

(a) Dingwall -
This structure is considered to be reasonably successful with an equilibrium depth at low tide of approximately 5'. Dredging has been carried out to 10' depth every five years in order to straighten and improve the channel. This represents a marked improvement in contrast to conditions which prevailed before the wave trap was built when one could walk across the harbour mouth in the dry at high tide and that only two years after having a dredged channel 26' deep at L.W.

A shoal has developed approximately 250' outside the seaward breakwater which maintains approximately 6' depth at L.W. This, of course, is beyond the control of the flushing action of the wave trap.

This structure had the advantage of being specifically designed from a model study at the National Research Council based on the specific environment prevailing at Dingwall.

(b) Inverness -
This structure is only moderately successful with an equilibrium depth of approximately 2' at L.W. in the wave trap channel and requiring almost annual dredging but of a lesser amount than formerly. Aerial photos show a large amount of material in suspension around the entrance to the wave trap. Indications are that the outer breakwater should be approximately 300' farther seaward in a depth of 12' of water in order to maintain a 5' depth in the wave trap.

A further reason for the limited flushing action appears to be linked to the permeability of the boundaries of the wave trap. As the flushing action is dependent on the development of a hydraulic head within the wave trap, any permeability of the trap walls diminishes this head. This would indicate that grouting of the voids in the trap walls would improve its effectiveness.

(c) Pleasant Bay -
This structure can not be considered to be successful as at times the trap plugs almost completely with beach gravel and sand. The principal reason for this lack of success is because the steep slope of the bottom allows large waves to break near the mouth and carry in the coarse gravel and cobbles which the flushing current is unable to disgorge from the mouth.

CONCLUSIONS

1. It is evident that a slope or gradient of the bottom to seaward from within the trap is essential to permit it to operate successfully. Based on the experience with Dingwall and Inverness, it appears that the ratio of the depth just seaward of the head of the trap to the equilibrium depth in the trap is approximately 2.4 to 1 i.e. to maintain a depth of 5' in the trap channel, the seaward breakwaters should be located to have the head in 2.4 x 5 = 12' depth.

2. As resonance is important in the functioning of the wave trap, it is essential that the trap dimensions be in tune with the predominant

influences in the wave climate. This is evident from the performance of the Dingwall structure, the design of which was developed from an hydraulic model study. The Inverness and Pleasant Bay structures did not have this advantage.

3. The four armed wave trap of rubble mound design is an effective means of maintaining entrances to harbours where 5 to 6 feet depth is required and littoral material in the fine to coarse sand sizes is a problem. It does however require careful attention to wave trap dimensions and should be based on hydraulic model tests.

REFERENCE

1. Donnelly, P. and MacInnis, I.
"Experience with Self-Dredging Harbour Entrances". ASCE Proceedings
11th Conference on Coastal Engineering
p.p. 1283 - 1294, 1968.

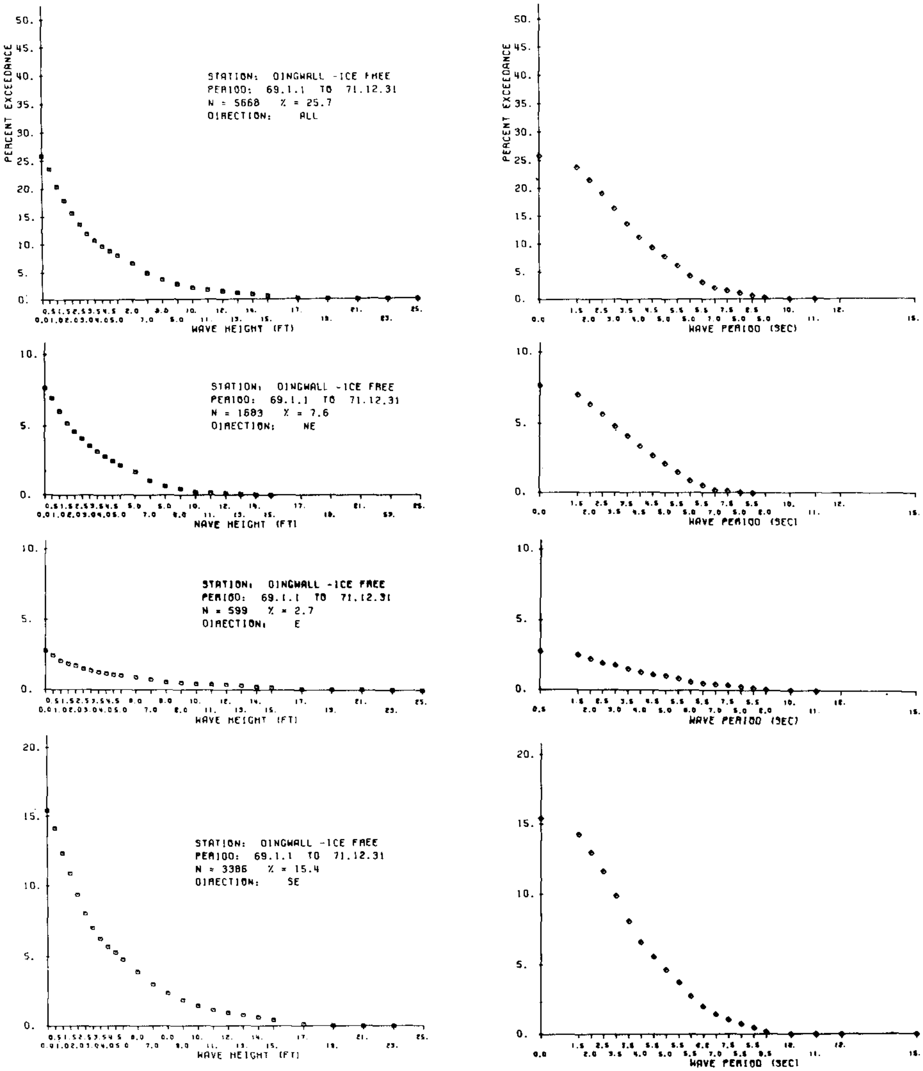


Fig. 1 WAVE CLIMATE DATA FOR DINGWALL

Fig. 2 WAVE CLIMATE DATA FOR INVERNESS

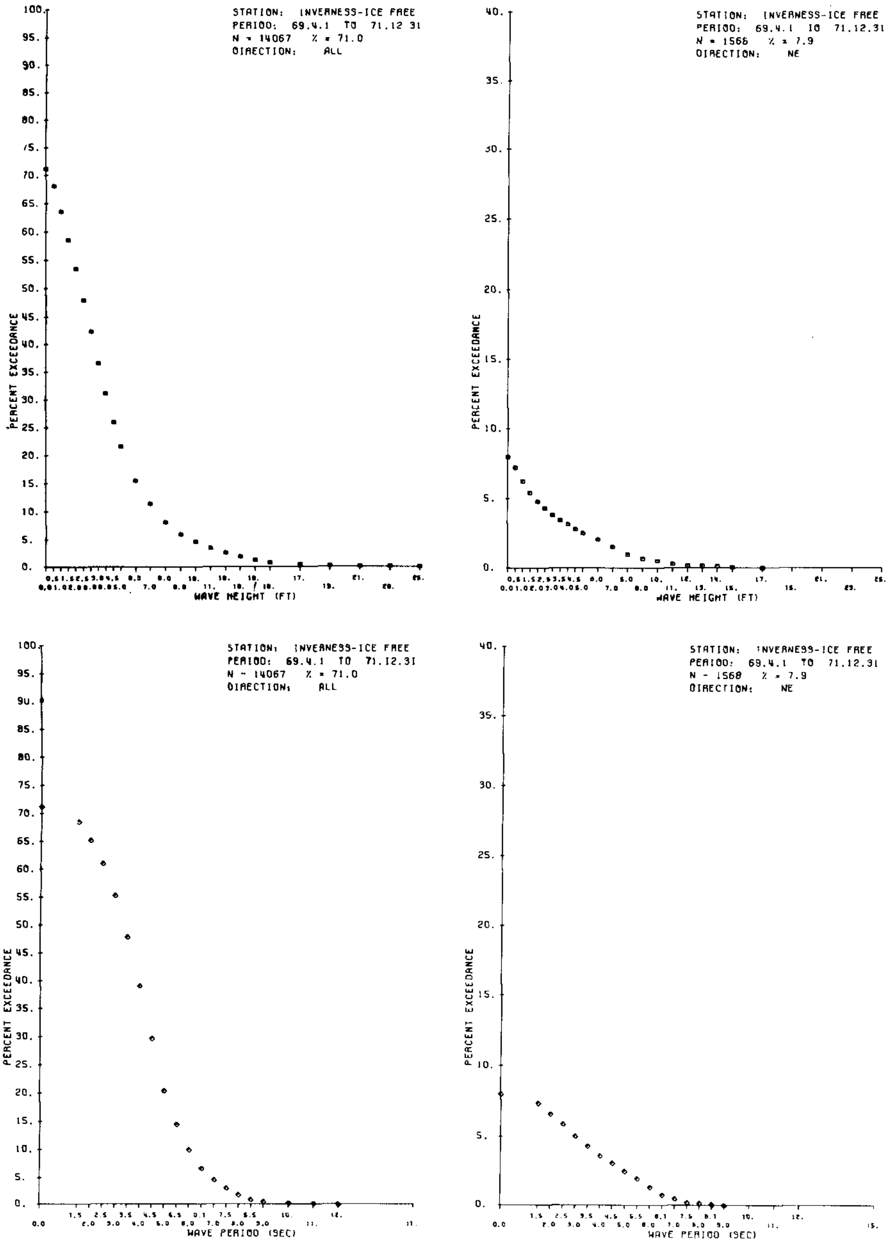


Fig.3 WAVE CLIMATE DATA FOR INVERNESS

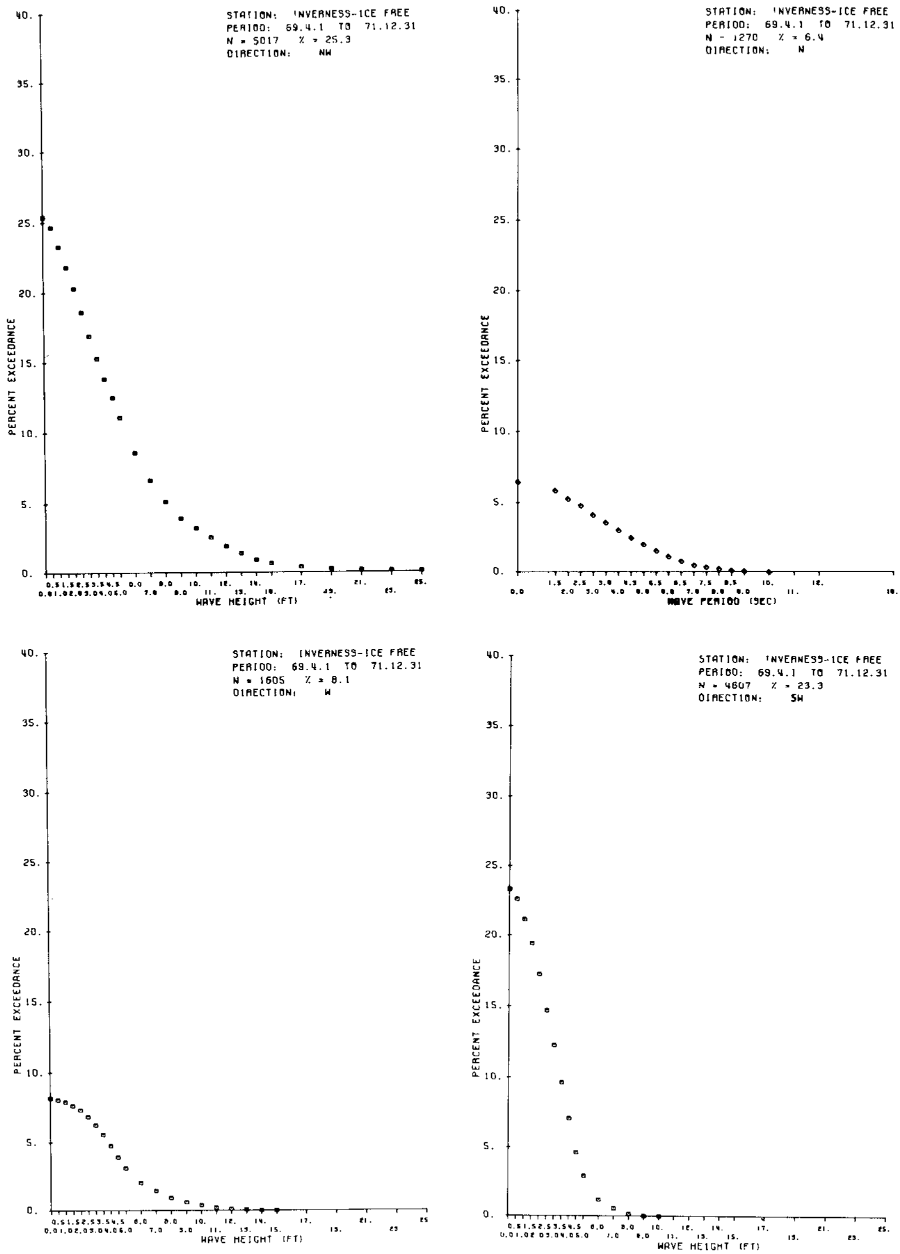
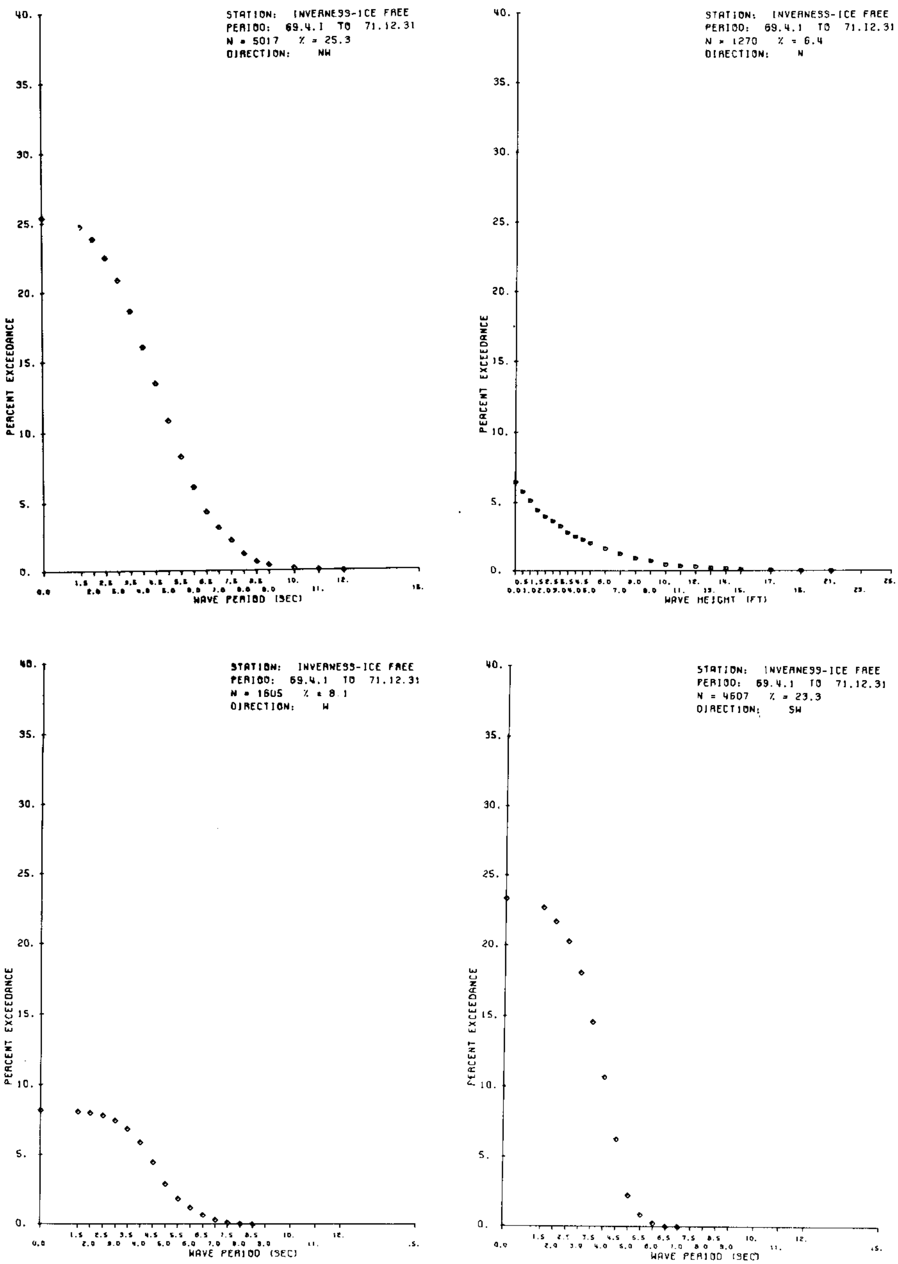


Fig. 4 WAVE CLIMATE DATA FOR INVERNESS



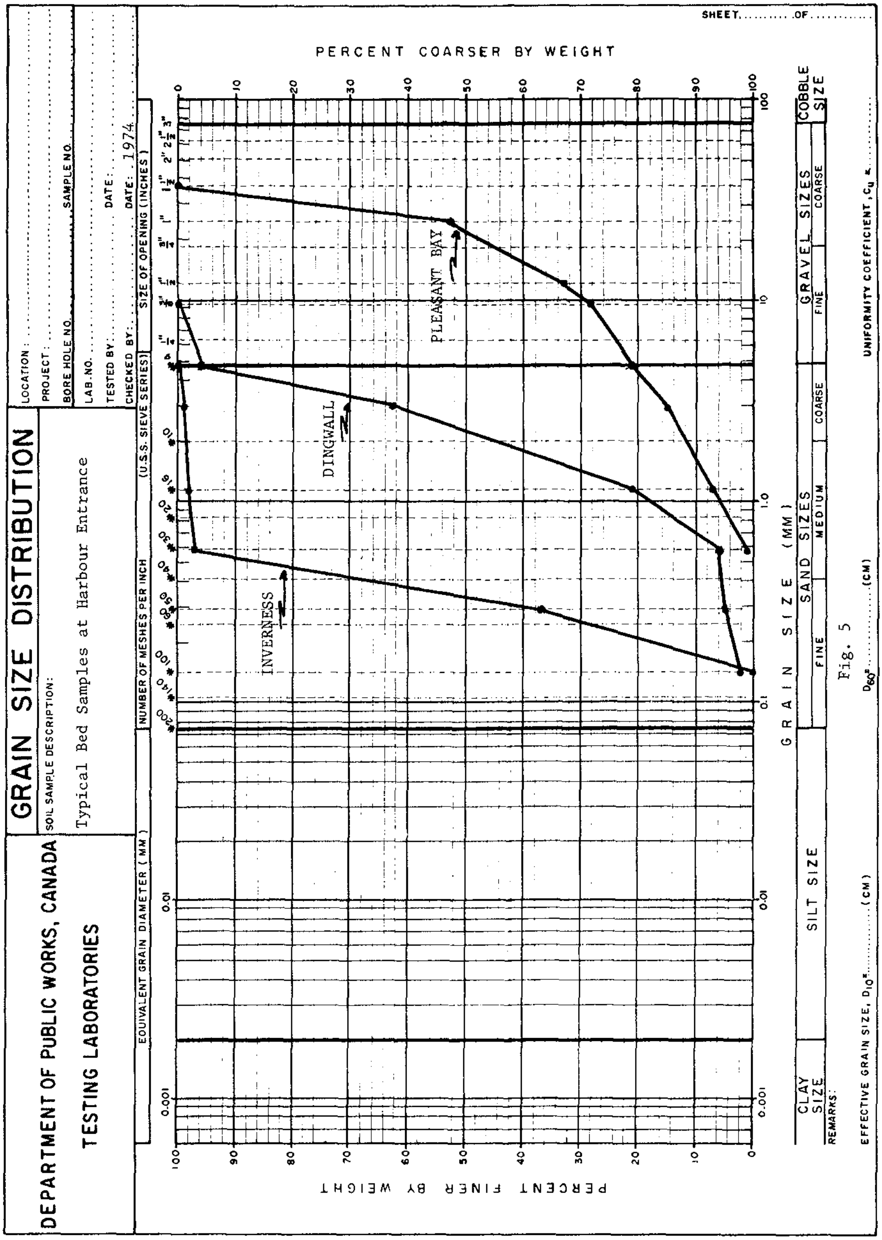

DEPARTMENT OF PUBLIC WORKS, CANADA
TESTING LABORATORIES
GRAIN SIZE DISTRIBUTION
SOIL SAMPLE DESCRIPTION:
Typical Bed Samples at Harbour Entrance
DATE: 1974
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE (MM)
PLEASANT BAY
DINGWALL
INVERNESS
COBBLE SIZE
GRAVEL SIZES
SAND SIZES
SILT SIZE
CLAY SIZE

Fig. 5

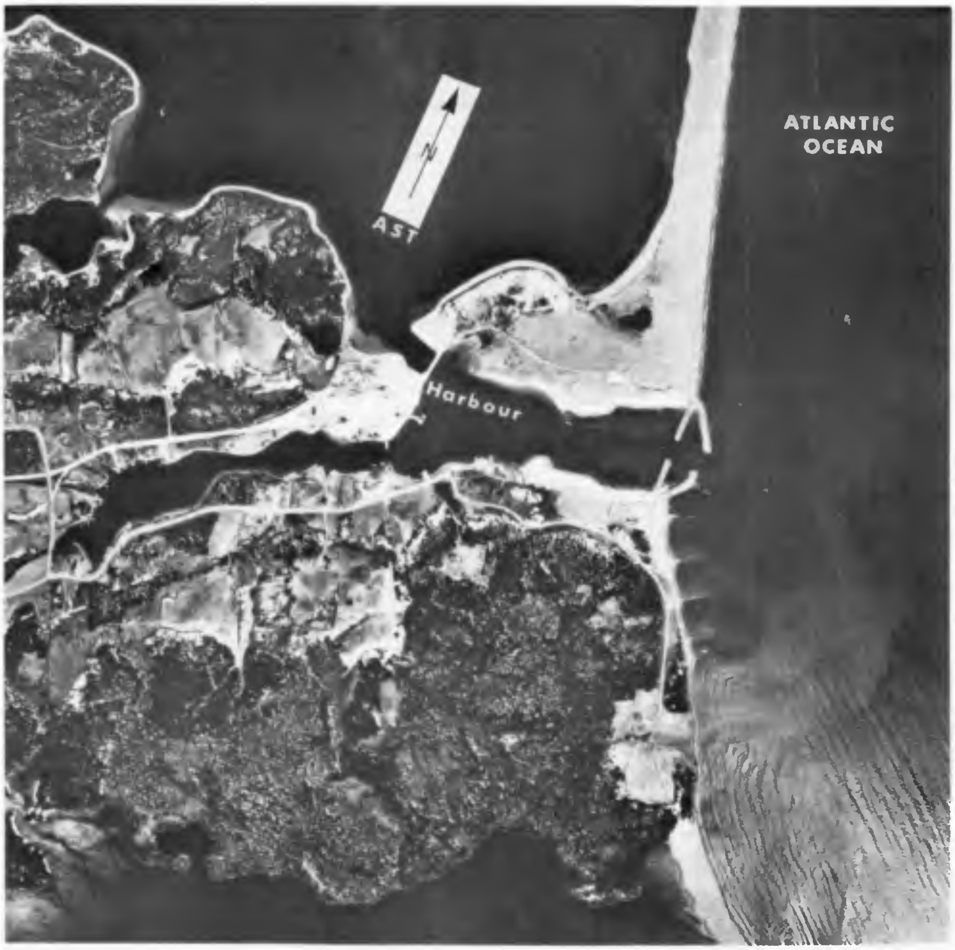


Fig. 6 Aerial Photograph
of
DINGWALL, NOVA SCOTIA

Scale (approx.)

1000 0 1000′ 2000′

Fig. 7 Aerial Photograph
of
INVERNESS, NOVA SCOTIA

Scale (approx.)

1500' 0 1500' 3000'

Fig. 8 Aerial Photograph
of
PLEASANT BAY, NOVA SCOTIA

Scale (approx.)