CHAPTER 80

RIVER MOUTH TRAINING IN NEW SOUTH WALES, AUST.

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ABSTRACT.

A summary is given of the results of training sixteen rivers in an endeavour to increase bar depths for navigation. The bars are of simple crescent formation fed by littoral drift.

Whilst the training works have improved conditions for navigation they have not resulted in any appreciable increase in bar depths.

Despite the complex mechanisms involved in bar formation a consistent simple correlation is found to exist between channel and bar depths. This correlation seems to apply to all rivers and inlets with simple bar systems and extends over a range from a bar depth of two feet to 60 feet. The correlation holds for rivers elsewhere and with varying climates of exposure

RIVER MOUTH TRAINING IN NEW SOUTH WALES, AUSTRALIA.

INTRODUCTION.

1.1 New South Wales has a coastline running roughly north and south from latitude 28°10'S to latitude 37°30'S a distance of about 650 nautical miles. It faces the South Pacific Ocean and Tasman Sea. Numerous rivers and coastal lakes enter the ocean through sand beaches.

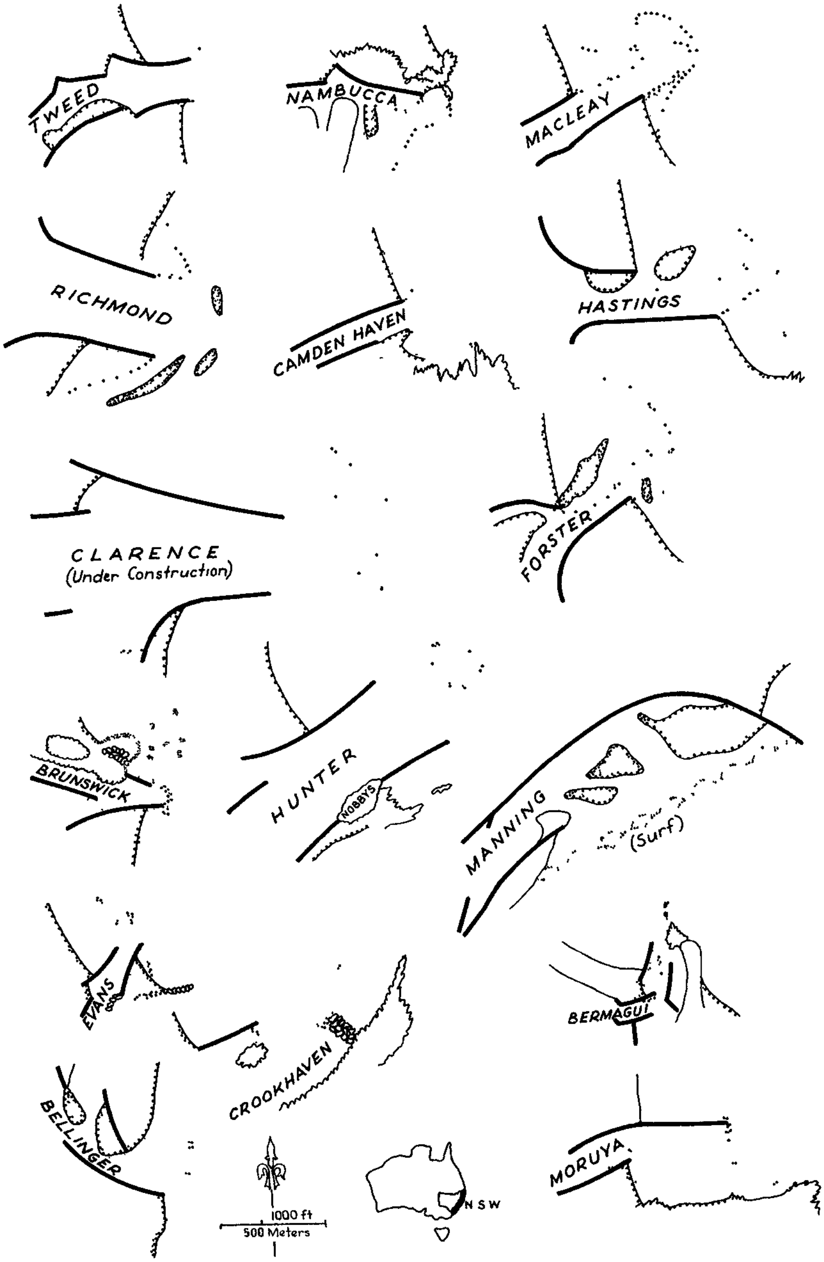
1.2 Sixteen river mouths have been trained to some degree for navigation. These vary in size but all have extremely variable fresh water flow. This variation in the case of the largest, the Clarence River, is from zero to 600,000 cusecs (170,000 cu. meters/sec) and for the greater part of the year the flow is less than 1,000 cusecs (28.3 cu. meter/sec). Tidal flow through the entrance however is about 88,000 cusecs (2,500 cu. meter/sec) at mean spring range (4.4 feet (1.3m) ocean). Other rivers have similar characteristics on a smaller scale and the mouths and lower reaches are in tidal regime. When floods do occure the loss of flow to storage on the flood plain is such that very few floods result in a flow through the mouth much above maximum tidal flow for extreme spring tides.

TRAINING WORKS.

2.1 The rivers became centres of communication early in the history of the State's development as the most convenient and rapid means of transport was by water. Starting with the Hunter River in 1810 training works were constructed to provide safe navigation. The majority of the work was carried out in the period 1880 to 1910 with minor changes and additions to some schemes in the period 1910 to 1930. Commencing in the 1950's a major training scheme was started on the Clarence River and also a programme of development of small river entrances for fishing craft.

2.2 Prior to development all river entrances was unstable and changed with changing weather conditions. In all cases the location of the saddle across the ring bar was variable and often difficult to find or such that a vessel would have to cross a shallower area. The positions of some river mouths also moved up and down the coast over limited distances.

2.3 Training works to improve navigation are conventional and fall into two categories, internal training walls and entrance training jetties. Both types are in all cases of tipped quarry stone or stone and concrete blocks.



TRAINED RIVER ENTRANCES
IN N.S.W.

FIG. 1

2.4 The internal training walls served two functions; the improvement of channel alighments and depths and the fixing of the point of entry into the ocean. The training jetties at the entrance were constructed to serve three functions; to improve the alignment of the entrance, stabilise the bar location and increase depths across the bar.

TRAINING JETTY GEOMETRY.

2.5 The geometry of all trained river entrances is shown in figure 1. Most are approximately at right angles to the general coastline adjacent to them and facing about due east. Of these four have two jetties of approximately equal length and six have two jetties of unequal length. Those having unequal length jetties are again divided into two with projecting jetties on the northern side and four on the southern side. Another three have single jetties only, two of them are on the northern side and one on the southern.

2.6 Four entrances are aligned in a north easterly direction, two have two training jetties and two have one only with a reef in effect acting as a second.

LITTORAL DRIFT.

3.1 With the exception of Newcastle no measurements have been made of littoral drift past any of the entrances. The drift rate at this location is estimated to be about 100,000 cu. yds. per year with between 10,000 and 30,000 cu. yds passing through what would normally be the bar area.

3.2 Prevailing ocean swell is from the south east and coastal features all indicate a littoral drift from south to north.

3.3 There are no known permanent ocean currents past any of the entrances.

3.4 Sand grain sizes are generally in the range 0.2 to 0.3 m.m. median.

3.5 Although no quantitative data are available the indications are that the volume of littoral drift increases from south to north.

RESULTS OF WORKS.

4.1 The results obtained in attempting to stabilise and deepen the river entrances have been satisfactory to a limited degree. With a few exceptions the aim of providing a static entrance has been achieved. Navigable depths on lines of access over the bars have in most cases been improved but in only a few has the depth of water over the bar "saddle" been increased or the bar removed. The improvement gained has generally taken the form of inducing the "saddle" to remain approximately in line with the trained entrance channel. Where a greater bar depth has been obtained it has been accompanied by a deeper entrance channel resulting from narrowing or improved flow characteristics.

SINGLE TRAINING JETTIES.

4.2 Single jetties have proved almost worthless except for two cases which cannot be regarded as typical. At Nambucca and Manning single jetties on the down drift side of the entrance cannot be said to serve any useful purpose. The entrances are unstable and so far as can be seen from old records no better than when untouched. Port Macquarie (Hasting River) at one stage in its development had a single jetty on the up-drift side and under these conditions it also had an unstable entrance. The two successful single jetty entrances will be discussed later in para. 4.10.

TWO TRAINING JETTIES - perpendicular to shore.

a) Equal Projection.

4.3 The effects of two equal length jetties has been to move the bar seaward and improve navigation by causing the bar saddle to align approximately with the channel. Where the depth over the saddle has increased it seems to be related to an increase in channel depth resulting from decreasing the width of the channel. The position of the saddle moves with changes in weather conditions resulting in a decrease in navigable depth and occasional dredging is required.

b) Unequal Projection.

4.4 Where the up-drift jetty projects a large shoal area forms in its lee and the channel is unstable at the outer end fluctuating in direction over an arc which may be as much as 90°. At times more than one channel may form and the ruling bar depth then decreases. A direct approach across the bar and into the channel is only possible for short periods.

4.5 Usually the flood tide tends to concentrate around the end of the shorter jetty. Breaking waves on the shoal area seem to provide a larger volume of sand for inward transport than would be available for an entrance with equal length walls (this has not been checked by measurement).

4.6 Where the down-drift jetty is the longer the channel is stable in location and the bar behaves much as it would with two equal lengths jetties. The depth over the bar seems to be much the same as can be expected for equal length jetties.

4.7 The main disadvantages seem to be the lack of shelter in the outer channel and an apparent increase in sand feed into the entrance channel.

Entrance angled down-drift.

4.8 Four entrances are angled down drift. Three of them have no bars and the fourth a deeper bar than would normally be expected.

4.9 At Newcastle (Hunter River) training works were started prior to 1810 and completed in 1913. Detail surveys of early conditions are not available but it seems that a bar did exist. The bar was removed early in the training process and the entrance has remained bar free. There is however a mound shoal on the line of the northern jetty. Depths over this mound are only a little less than in the channel between the jetties. Although not certain it seems that the original bar was fed mainly by a local inshore reversal of sand drift in the lee of Nobby's Island and reef. There is only a small sand feed past the end of the present jetties, the majority of the littoral drift being apparently deflected by the reef. (ref. 3.) Channel depth between the ends of the jetties was 32ft. below I.S.L.W. but has recently been increased to 36ft. by dredging. The shoal varies between 30 and 32ft.

4.10 Crookhaven and Bermagui are somewhat similarly located but at Crookhaven a headland and at Bermagui a reef takes the place of a training jetty. As in the case of Newcastle the original bars seem to have been fed by a local inshore reversal of littoral drift. Since construction of the training walls no bar has formed at either entrance. Crookhaven has been like this for over 60 years and Bermagui for 10 years. There is however, a rock bar near the outer end of the entrance channel which perhaps could take the place of a sand bar at Crookhaven.

4.11 The other entrance facing away from prevailing wave ac Evans Head. In this case, however, there is no adjacent reef and two are used, the up-drift one projecting slightly. Since completion in 19(bar has existed although at a greater depth than would be expected for existing channel depths. Recently, there were signs that the bar was becoming unstable and tending to become more shallow. This however lasted only for a few months.

Comparison of Results.

4.12 The data in Table I indicates that there is a relationship between bar depth and channel depth. Sufficiently detailed surveys are available in all cases to obtain an accurate cross section and calculate mean channel depth. For ease of comparison therefore, the maximum d the entrance channel has been taken. The location at which this depth i measured is shown in figure 2. In some cases greater depths occur ups caused by geometry and irregular flow patterns, these have been ignor(

4.13 In some cases flow through the entrance channel is not symmetrically distributed and an eccentric cross section occurs. This in a greater maximum channel depth than for symmetrically distributed f Comparison of available detailed cross sections indicates that for unifor distributed flow the following approximations hold.

$$D_{Max} = 1.3\ D_{Mean} = 1.3\ \frac{A}{W} \qquad (1)$$

and for eccentric flow

$$D_{Max} = 1.65\ D_{Mean} \qquad (2)$$

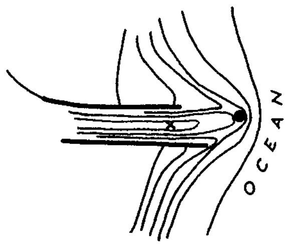
A is cross sectional area of inlet char in sq. ft.

where D is the depth below mean tide l

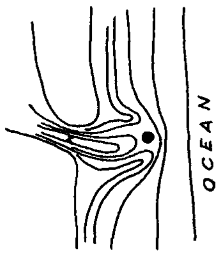
and W is width at mean tide level.

4.14 When an eccentric cross section exists it has been assume it is equivalent to a section with uniformly distributed flow having a depth 0.8 of that existing.

A natural plot of bar depth against maximum channel depth is in figure 3. Although there is an appreciable scatter there appears to be a simple relationship between bar depth and channel depth despite the complex associations involved. The relationship seems to be the same for trained and natural inlets.



TRAINED INLET

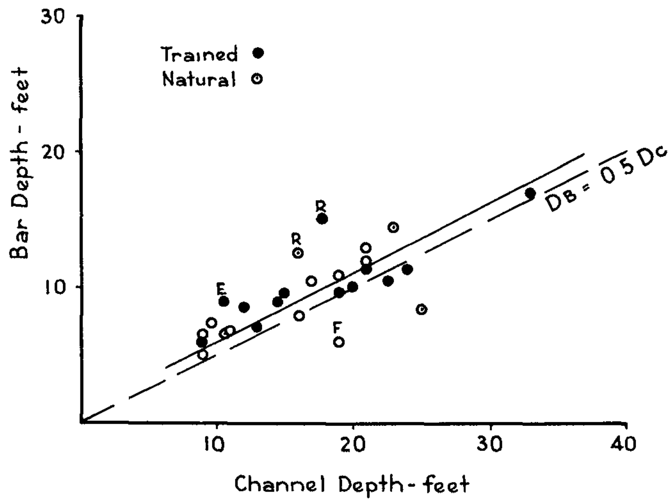


x Measurement point for Dc and W

● Measurement point for DB

UNTRAINED INLET

FIG. 2



PLOT OF BAR DEPTH V CHANNEL DEPTH
(Depths below Mean Tide Level)
N S W Inlets

FIG. 3

4.15 Some comment on the points showing the greatest departure from the general trend is possible. Points labelled (R) are for the Richmond River. The bar here is notoriously unstable and the survey from which the data is taken for the trained condition records a period of good depths. A depth of 11 feet is not uncommon. Possibly the untrained river survey was also taken at a good period as it also was reported to be very unstable. Point (E) represents conditions at Evans River some four years after construction; there have been signs of instability and a tendency to a reduction in depth, although the present depth is as shown. Point (F) is for untrained conditions at Forster. The survey is rather sketchy and these may have been two outlets across the bar.

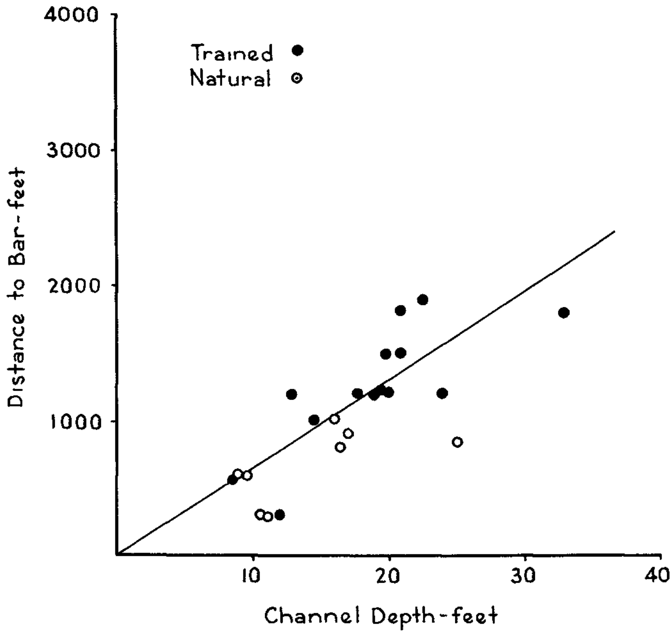
4.16 A second plot of distance from the start of channel expansion to the crest of the bar is in figure 4. Although the scatter is greater there is a visible trend.

4.17 The rather remarkable correspondence between channel and bar depth might be thought to result from similar conditions along a relatively short length of coastline. To check this such data as could be obtained from published charts was collected for other Australian rivers. These were also found to follow the same pattern. A number of river entrances throughout the world and taken from such charts were available were also added. These are listed in Table II, and plotted in figure 5. There will be some error in the assumption made that depth at mean tide level represents regime depth. For depths considered the percentage error would be small.

Conclusions.

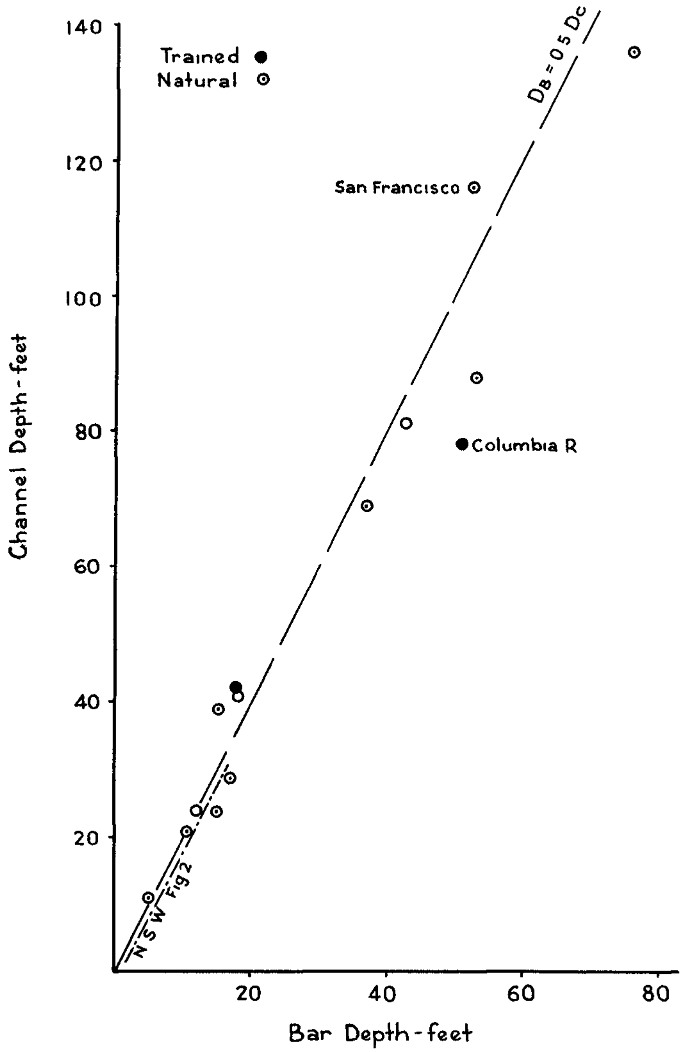
5.1 Despite the complex inter-relationships of wave climate, tidal currents and littoral drift involved there seems to be a simple correlation between channel depth and bar depths for an inlet which is in tidal regime.

5.2 As has been shown by Bruun & Gerritsen (Ref. 1) and O'Brien (Ref. 2) the cross sectional area of an inlet channel is related to tidal flow.



PLOT OF BAR DISTANCE V CHANNEL DEPTH

FIG. 4



PLOT OF BAR DEPTH V CHANNEL DEPTH
PORTS OTHER THAN N.S.W.
FIG. 5

Approximately

$$A = \frac{Qm}{3} \qquad (3)$$

where A = cross sectional area of inlet channel in sq. feet.

Qm = maximum discharge in cusecs for a tide of mean spring range.

from figure 3 or figure 5 the minimum bar depth to be expected would be given by

$$D_C = 1.3\,\frac{A}{W} = 2\,D_B \qquad (4)$$

where D_C = maximum channel depth below the surface when Qm occurs.

D_B = depth over bar saddle at the same time (both in feet)

or

$$D_B = 0.21\,\frac{Qm}{W} \qquad (5)$$

5.3 It also seems that other than in exceptional circumstances it is not possible to remove a bar by training jetties and that the best depth across the bar can only be increased to the same degree as it may be practicable to increase the depth in the channel. This of course applies only to the conditions examined which are that littoral drift depends only on waves and wave induced currents, no appreciable ocean currents are present, and off shore contours are regular and entrance alignment is approximately perpendicular to the coastline.

5.4 There is perhaps an indication that bar depths would be less with training jetties angled down drift. This needs more examination.

5.5 As the effect of jetties is to in effect bodily move the bar formation to another location there is perhaps an inference that littoral drift is only temporarily interupted unless permanent dredging of the bar is involved.

5.6 Detailed examination of littoral drift behaviour in the areas adjacent to the entrances where bars have been removed would probably reveal some interesting information.

TABLE II - INLETS ELSEWHERE THAN N. S. W.

INLET		CHANNEL DEPTH at M. T. L. feet	BAR DEPTH at M. T. L. feet
TASMANIA			
Port Dalrymple	(Natural)	136	76
Macquarie Hbr	(Part - trained)	42	18
George Bay	(Natural)	21.5	10.5
QUEENSLAND			
Urangan	(Natural)	29	17
Morton Bay Boat Chl.	(Natural)	11	5
NEW ZEALAND			
Otago	(Trained)	69	37
Whangerei Hbr.	(Natural)	88	53
Paterson Inlet	(Natural)	81	43
Aotea Hbr.	(Natural)	24	12
Waikato Hbr.	(Natural)	24	15
MISCELLANEOUS			
San Francisco	(Natural)	117	53 dredged (2nd saddle 39)
Columbia River	(Trained)	78	51 some dredging
Cuama (Mozambique)	(Natural)	39	15
Porto de Quelimane	(Natural)	41	18 (2nd saddle 17)

TABLE I - N. S. W. INLETS

RIVER		CHANNEL		BAR		
		Width feet	Max. Depth feet	Dist. from chl. throat feet	Depth at Saddle feet	Original Navigable Depth feet
Tweed	(Trained)	300	14.5	1000	9	
	(Natural)	360	21		13	6
Brunswick	(Tr)	200	12	300	8.5	-
	(Na)	250	9	600	6.5	5
Richmond	(Tr)	1200	17.75	1200	15	
	(Na)		16	1000	12.5	10
Clarence	(Tr)	1200	33	1800	17	
	(Na)	Not available	-	-	-	-
Evans	(Tr)	200	10.5	300	9	
	(Na)	180	9.75	600	7.25	5 to 7
Bellinger	(Tr)	300	9		6.25	
	(Na)					6
Nambucca	(Tr)	300	13	1200	7	
	(Na)					7
Macleay	(Tr)	650	* 24(19.2)	1200	11.25	
	(Na)	1000	21	1500	12	8
Hastings	(Tr)	400	19(15.2)	1200	9.75	
	(Na)		18		7(2 saddles)	7
Camden	(Tr)	400	21	1800	11.5	
Haven	(Na)		17	900	10.5	7.5
Forster	(Tr)	440	22.75	1900	10.5	
	(Na)		19	1200	6	5.5
Manning	(Na)		19	1200	11	
Hunter	(Tr)	1200	39	no bar		15
Sussex Inlet	(Na)	300	9	600	5	
Crookhaven	(Tr)		31		16.75(rock)	
	(Na)		23		14.5	14
Moruya	(Tr)	480	20	1500	10	
	(Na)		25.5	850	8.5	9
Wagonga	(Na)	250	16.5	1000	8	
Bermagui	(Tr)	200	11	no bar	-	
		190	10.75	300	7.5	5 to 7
Merimbula	(Na)	200	11	300	7.75	-

Note: Depths are measured below mean tide level as being approximately the level of maximum ebb discharge.

* Figures in brackets are corrected for eccentricity.