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FISHING INDUSTRY RESEARCH TRUST ACCOUNT

TITLE OF PROPOSAL/PROJECT: RESEARCH INTO STRATEGIES OF APPROACH TO SAND BAR CROSSING FOR FISHING VESSELS

ORGANISATION: VFITC

PERSON(S) RESPONSIBLE:

FUNDS SOUGHT/GRANTED

YEAR	SOUGHT	GRANTED
1982/83		$15,000-

RELATED APPLICATIONS:

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REPORT TO THE FISHING INDUSTRY RESEARCH COMMITTEE REGARDING THE PROJECT "RESEARCH INTO STRATEGIES OF APPROACH TO SAND BAR CROSSING FOR FISHING VESSELS" CONDUCTED BY THE VICTORIAN FISHING INDUSTRY TRAINING COMMITTEE LTD WITH A 1982/83 GRANT FROM THE FISHING INDUSTRY RESEARCH TRUST ACCOUNT

OBJECTIVES

The objectives of the project, as stated in the original application to the Fishing Industry Research Committee for funds, were ".........to research the factors which cause sand bar navigation to be hazardous for small ships, to examine what remedial action skippers who get into trouble on sand bars can take, and to provide information on the basis of such investigations which will enable fishermen, and any others crossing sand bars, to reduce the risk of their crossings."

METHOD

In an endeavour to produce results which would be both interesting and useful for mariners and, in particular, commercial fishing boat skippers, and in order to consider the oceanographic factors associated with sand bars in relation to boat performance and seamanship, the VFITC decided to conduct the project through a case study of the Lakes Entrance ocean sand bar.

To this end a consultant, Mr R Gardiner, was selected to do the case study, the objectives of which were to:-

offer instruction in sand bar crossing and provide the options of techniques used by experienced and knowledgeable boat skippers discuss the interaction between the physical factors of wind, sea, currents, sand, boat stability and boat handling in an ocean sand bar situation using Lakes Entrance as a case study

compile information and a list of knowledgeable people to provide the basis for an audio visual film

The result of Mr Gardiner's research is the "Lakes Entrance Ocean Sand Bar Study". A copy of the study is attached.

Mr Gardiner worked closely with the VFITC in the course of his research, particularly in regard to the matters relating to seamanship.

Efforts were made to ensure that the information generated by Mr Gardiner's work was as correct as possible, and the assistance of persons with expertise in a number of areas was used to check information.

The VFITC received considerable assistance in this regard and this has been acknowledged in Mr Gardiner's report.

Without wishing to place more emphasis on any one individual's assistance than another's it is perhaps worth recording that Professor Jon Hinwood of the Department of Mechanical Engineering at Monash University has advised of the "Lakes Entrance Ocean Sand Bar Study" that "..............it is an excellent report and I believe that it could well serve as a model for instructional reports for use by other States and other government authorities" and "the technical background to the report is clearly presented, and I believe, completely correct".

RESULTS OF THE STUDY

Objective One

"............to research the factors which cause sand bar navigation to be hazardous for small ships ...."

The summary in Chapter 2 contains eight important "principles" which indicate why sand bars can generate hazardous sea conditions and why boat stability can be adversely affected by particular sea conditions.

Chapter 3 and Chapter 4 of the "Lakes Entrance Ocean Sand Bar Study" entitled "Oceanographic Variables at Lakes Entrance" and "Boat Stability and Accidents on the Lakes Entrance Ocean Sand Bar" respectively discuss in detail the natural physical factors and boat stability factors which can make sand bar crossings hazardous.

Objective Two

"..........to examine what remedial action skippers who get into trouble on sand bars can take........."

In all sand bar crossings the boat skipper's most important operational control is the throttle. Boat speed in relation to wave speed is critical and maintaining appropriate boat speed requires constant throttle adjustment.

The advice tendered in Chapter 6 "The Options of Technique for Safe Crossing of the Lakes Entrance Ocean Sand Bar" should assist skippers to recognise boat stability problems and to effect action to maintain control of the boat. However, once a vessel has broached the skipper has lost control and under such circumstances it is not possible to provide useful general advice about remedial action which a skipper might take. Therefore, the "Lakes Entrance Ocean Sand Bar Study" has concentrated on assisting boat skippers to understand what causes a boat to broach and how circumstances which could cause a broach can be recognised in time for remedial action to be taken.

Objective Three

"............to provide information on the basis of such investigations which will enable fishermen and any others crossing sand bars, to reduce the risk of their crossings."

This was the principal objective of the project and the theme about which the "Lakes Entrance Ocean Sand Bar Study" was conducted. Chapter 6 of the study describes the techniques of approach to sand bar crossings for both displacement and planing hulls and this has been written in a way which should be readily understood by interested mariners. The VFITC believes that the techniques described have universal application and accord with techniques practised in waters around the world to negotiate adverse sea conditions similar to those found on sand bars.

The chapters on "Oceanographic Variables at Lakes Entrance" and "Boat Stability and Accidents on the Lakes Entrance Ocean Sand Bar" explain how the wind, sea, currents and sand can interact to create adverse sea conditions and how boat stability is affected by sea conditions.

Parts of the study are based on the knowledge and practices of experienced and highly regarded boat handlers and the strongest and most frequent advice given by such boatmen in the course of enquiries for the study was that each sand bar crossing requires a knowledge of the current conditions and circumstances of the sand bar and each demands continual assessment and the exercise of judgement by the skipper during the crossing.

APPLICATION OF THE FINDINGS TO OTHER PORTS

Following the preparation of Mr Gardiner's initial draft on the report the VFITC engaged Mr C Ballinger to visit the ports of St Helens Tasmania, Port Macquarie New South Wales and Southport Queensland to examine the sand bars which mariners at those ports must negotiate and to discuss with local boat operators the techniques described in the "Lakes Entrance Ocean Sand Bar Study".

The characteristics of the sand bars and the associated water movements vary between sand bar ports to the extent that it was not possible within the scope of this project to provide detailed suggestions which would be valid over time for crossing sand bars at particular ports. The size and location of the sand bar and the depth of water over the sand bar can change at all of the ports referred to with sufficient frequency to quickly invalidate data and advice recorded on a particular date.

Because of physical changes in the sand bars it is imperative that mariners contemplating making a sand bar crossing obtain local and current information about such matters as the line of best water from an authoritative source.

The importance of obtaining current information is illustrated at Lakes Entrance where in certain sea conditions sand movements can significantly alter the extent of the sand bar and the location of the channel across the sand bar and this can occur between the time of a fishing boat's departure for a fishing trip and subsequent return to port.

Discussions with experienced boat operators at St Helens, Port Macquarie and Southport generally confirmed the appropriateness of the advice concerning preliminary knowledge and safety checks and the techniques for inward and outward bound displacement and planing hull vessels contained in Chapter 6 of Mr Gardiner's report.

However, there are practices peculiar to individual ports which emphasise the necessity for local knowledge to be obtained by skippers unfamiliar with a sand bar port they wish to enter. For example, prawn trawler skippers at Southport advised that they leave their boat stabilizer arms out when crossing the Southport sand bar. This practice differs from the practice of otter board and danish seine trawler skippers at Lakes Entrance who retract their boat stabilizer arms.

Although the "Lakes Entrance Ocean Sand Bar Study" relates specifically to Lakes Entrance, boat skippers using other sand bar ports should be able to gain worthwhile information from the study in regard to oceanographic variables, boat stability and crossing techniques which, when adapted to the circumstances and characteristics of their own port, will assist them to reduce the risk of their crossing.

REPORTING

In regard to the requirement under Reports 11 (e) (i) of the conditions of the grant for the project concerning journal publication of the results, discussions have been held with Mr M Bowerman, Editor, "Australian Fisheries" about the preparation of an article for publication in that journal.

Mr Bowerman has suggested that a copy of the "Lakes Entrance Ocean Sand Bar Study" be forwarded direct to him for his reading and that the VFITC liaise with him in the production of an article for publication.

The VFITC and Mr Bowerman are aware that, in accordance with the grant conditions, the VFITC report is to be presented to the Fishing Industry Research Committee before the publication of any material from the report.

Mr Gardiner, as author of the "Lakes Entrance Ocean Sand Bar Study", has ceded copyright to the VFITC to enable the report to be readily reproduced and disseminated for the benefit of fishing industry members.

The VFITC embarked on this project in an endeavour to reduce the risks associated with sand bar crossings for commercial fishermen and accordingly would wish to disseminate the information contained in the "Lakes Entrance Ocean Sand Bar Study" as widely as possible.

...ooo...

In submitting this report the VFITC wishes to express appreciation to the Fishing Industry Research Committee for approving the grant to enable the project to be undertaken.

****

LAKES ENTRANCE OCEAN SAND BAR STUDY

A STUDY OF THE FACTORS TO BE CONSIDERED, AND THE OPTIONS OF TECHNIQUE FOR SAFE CROSSING.

JUNE 1983

VICTORIAN FISHING INDUSTRY TRAINING COMMITTEE LTD.

Prepared by: R. Gardiner

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The study was financed by the Fishing Industry Research Committee

The cover illustration, (Figure 1), shows the *April Hamer* dredging the channel through the ocean sand bar at Lakes Entrance. The photograph was taken by Rob Moss.

1 INTRODUCTION

Lakes Entrance is the largest fishing port in Victoria. It serves as home port to over 100 commercial fishing boats with lengths up to 30 metres (100 ft) and draughts up to 2.5 metres (8 ft). An ocean sand bar extends across the entrance in a horseshoe shape as shown in Figure 1. In adverse weather conditions bar crossing can be hazardous. Since 1969 there have been twelve reported accidents on the bar resulting in ten boat capsizes and four deaths (Cumming, 1981). The shallow draught sidecasting dredger *April Hamer* has maintained a channel of adequate depths (3.5 m to 5 m, 11 ft to 16 ft) across the bar since 1977, but dangerous conditions created by breaking seas can still occur.

In 1980 the Director General of Public Works formed a panel to inquire into the policies being implemented by the Ports and Harbors Division at Lakes Entrance. The Panel consisted of representatives with expertise in coastal engineering, ports and fishing operations. The terms of reference were: "To recommend a coastal management policy for the Port of Lakes Entrance" (P.W.D., 1981). The Panel's main conclusions were:

> No requirement for significant port expansion can be forseen at this stage. This, together with the high cost of civil engineering works effectively rules against the latter on a cost/benefit basis.
>
> The current approach to dredging and coastal management is satisfactory and maintains navigable depths across the bar.
>
> Improved education of masters in bar crossing knowledge and techniques would have significant potential for reducing accidents at Lakes Entrance.

As a result of the Panel's recommendations for improving masters' education and endeavours already shown by the Victorian Fishing Industry Training Committee Ltd, the latter sought a grant from the Fishing Industry Research Committee to research "Strategies of Approach to Sand Bar Crossing for Fishing Vessels". This report *Lakes Entrance Ocean and Bar Study* is part of that research. The objectives of the study were to:

> Offer instruction in ocean sand bar crossing and provide the options of techniques used by experienced and knowledgeable boat skippers.
>
> Discuss the interaction between the physical factors of wind, sea, currents, sand, boat stability and boat handling in an ocean sand bar situation using Lakes Entrance as a case study.
>
> Compile information and a list of knowledgeable people to provide the basis for an audio visual film.

The procedure to satisfy the study objectives was an exhaustive literature survey followed by interviews with professional fishermen, port officers, shipping inspectors, naval architects and coastal engineers.

LAKES ENTRANCE OCEAN SAND BAR STUDY

LIST OF FIGURES

LIST OF TABLES

2 SUMMARY

Ocean sand bars have claimed the lives of many mariners. Some have paid the penalty of inexperience but not all. Expert mariners treat sand bars with extreme caution at every crossing. The sand bar at Lakes Entrance, the largest fishing port in Victoria, extends across the entrance to the port and in adverse weather conditions crossing the bar can be hazardous. Mariners should always keep in mind that it might be far safer to ride out a gale at sea than to cross the bar to enter the port. The bar is most dangerous during the ebb tide.

To understand the technique for safe crossing used by experienced Lakes Entrance boat operators it is necessary to consider the oceanographic and boat stability principles which cause broaching.

The important principles are:

THE LAKES ENTRANCE OCEAN SAND BAR CONCENTRATES WAVE ENERGY BY THE PROCESS OF WAVE REFRACTION WHICH IS CAUSED BY THE DECREASED WATER DEPTH OVER THE BAR, AND THE OUTFLOWING EBB TIDE. THUS, THERE CAN BE DANGEROUS WAVES ON THE BAR WHILE THERE ARE SMALL WAVES IN BASS STRAIT.

THE TRANSVERSE STABILITY OF A FISHING BOAT IS REDUCED BY A WAVE CREST AMIDSHIPS AND IS INCREASED BY A WAVE TROUGH AMIDSHIPS.

WATER PARTICLE VELOCITIES ON THE SURFACE OF A SHALLOW WATER WAVE NEAR TO BREAKING ARE FORWARDS ON THE WAVE CREST AND BACK FACE, AND BACKWARDS IN THE WAVE TROUGH AND FRONT FACE.

GRAVITY AND THE FORWARD MOVING WATER ON THE WAVE CREST ARE TRYING TO PUSH THE BOAT'S STERN DOWN THE WAVE FACE TO THE LEVEL OF THE BOW, WHICH IS BEING PUSHED BACKWARDS BY THE WATER IN THE WAVE TROUGH.

THE FORCE APPLIED BY THE RUDDER IS PROPORTIONAL TO THE SQUARE OF THE VELOCITY OF WATER FLOWING ACROSS IT. IF THE RUDDER IS IN A WAVE CREST AND WATER IN THE WAVE CREST IS FLOWING FORWARDS, THE RESULTING BACKWARDS FLOW OF WATER ACROSS THE RUDDER WILL BE SIGNIFICANTLY REDUCED. THUS THE RUDDER'S EFFICIENCY WILL BE SIGNIFICANTLY REDUCED.

YAWING IS CAUSED BY THE CHANGE IN CURVATURE OF UNDERWATER LINES AS THE BOAT HEELS, AS SHOWN IN FIGURE 26.

HEELING REDUCES RUDDER EFFICIENCY BECAUSE THE TURNING FORCE IS PERPENDICULAR TO THE RUDDER'S SURFACE, AS SHOWN IN FIGURE 27.

A WAVE ON THE BOAT'S QUARTER WILL CAUSE TRIMMING BY THE BOW, AND THUS THE RUDDER MAY BE OPERATING HALF SUBMERGED.

A sudden loss of control and a high rate of turn may result from the application of these principles. The resulting centrifugal forces combined with the high angles of heel can cause considerable damage, or even capsize of the boat.

RECOMMENDED OUTWARD BOUND PRACTICES FOR DISPLACEMENT BOATS

The outward bound technique for displacement boats crossing the Lakes Entrance ocean sand bar, as suggested by experienced and knowledgeable Lakes Entrance boat operators is:

Discuss the line of best water across the bar with experienced Lakes Entrance boat operators.

Steam across to the Flagstaff Jetty; climb over the sand dune to the Flagstaff and observe conditions on the bar.

Estimate the current speed and direction, the wave pattern and the line of best water. The direction of the ebb current may be indicated by the passage of dirty water.

If in doubt about the possibility of crossing safely, go home. Never steam between the piers unless you are prepared to go out the entrance because in some tidal conditions it is impossible to turn the boat around.

Go out at a slow speed except when there is a flood tide. Keep on the leads and visually determine the position of the channel. If the boat is in breaking seas with waves all around, idle ahead with the bow straight into the waves. The safest position for a boat is perfectly still. On no account let the boat start moving backwards. Nudge into the seas. It is good practice to leave the back door of the wheelhouse open so that if a sea breaks the front windows, the water can flow out the back door.

RECOMMENDED INWARD BOUND PRACTICES FOR DISPLACEMENT BOATS

Inward bound operations have resulted in ten of the twelve recorded accidents on the Lakes Entrance ocean sand bar. The inward bound technique for displacement boats, as suggested by experienced and knowledgeable Lakes Entrance boat operators is:

Radio ahead and seek information about the condition of the bar and the line of best water.

Approach the bar and assess the wind, tidal current and sea conditions (an echo sounder can be used to assess wave patterns as referred to in Section 3.3.3). If conditions are too dangerous, stay at sea or go to Port Welshpool.

If a decision to cross the bar is made, lay off some distance outside the bar and assess the tide drift, taking into account that there may be a very strong cross current. The direction of the ebb current can often be determined by the area of dirty water.

Position the boat on the leads and visually determine the alignment of the channel. Judge the position from where to start the run so as to be square on to the waves when the boat passes through the gap between the critical spits (as shown in Figures 33 and 34). Use the Flagstaff and beacons to fix this starting position.

The most dangerous part of the bar is the outer lip.

Judge the wave pattern and start your run just behind a group of big waves. It is often possible to judge which are the big waves by watching along the individual wave crests to where they break on the upcoast beach.

Approach the gap at a slow speed with the stern straight to the waves. Wait until you pick up the first wave, then as the bow comes up to horizontal, open full throttle forward. Don't catch the wave (for the reasons described in Chapter 4). When the wave runs away from the boat, maintain full throttle unless it appears that the next wave will catch the boat. If it appears that this will happen reduce throttle to half or less to lose speed.

Boat speed in relation to wave speed is critical and the appropriate boat speed will require constant throttle adjustment. However, it is essential to keep sufficient power in reserve to be able to increase the water flow across the rudder to maintain steerage if the boat starts to broach when the following wave catches up.

If the following wave is far behind, increase speed, if the wave is close, slow down. Typical bar crossing speeds for displacement boats at Lakes Entrance are about 2 knots in rough conditions and 4 knots in calm conditions.

Align the boat on the leads as quickly as possible after negotiating the outer lip. Have one crew member watch the following waves so that most of the skipper's concentration can be on the leads.

Try to keep on the up wind, up wave or up current side of the channel because if you broach into the side of the channel, you may be washed off or be able to back off.

RECOMMENDED PRACTICES FOR PLANING BOATS

Boats with planing hulls require different techniques to cross ocean sand bars than boats with displacement hulls. The outward bound passage is more dangerous than the inward bound passage for small planing boats because of the increased danger of swamping. The outward bound technique requires constant adjustment of the boat's fore/aft trim by throttle control as each wave is encountered. The inward bound technique is to sit the boat on the back of a large wave and carefully travel across the bar in this position (as described in Section 6.3).

3 OCEANOGRAPHIC VARIABLES AT LAKES ENTRANCE

This chapter explains the oceanographic variables which affect boat stability and alignment when crossing the ocean sand bar at Lakes Entrance. Theory alone is insufficient, but when theoretical knowledge is combined with practice, meaningful experience comes more quickly. It is worth noting that the experienced skippers at Lakes Entrance all have a good understanding of the concepts set out below.

3.1 Geographic Location of Lakes Entrance

The Gippsland Lakes of Eastern Victoria are separated from Bass Strait by a series of coastal sand dunes generally parallel to the adjacent Ninety Mile Beach (Figure 2). Five main river systems with a total catchment of 20,500 km^2 drain directly into the lakes which are 350 km^2 in area.

The natural entrance from Bass Strait to the lakes migrated over several kilometres to as far east as Red Bluff, and on occasions in the past small ships were trapped for months by an ocean sand bar (Fryer 1980).

An artificial entrance about 120 m (400 ft) wide and 6 m (20 ft) deep was cut through the outer sand barrier dune in 1889, providing a permanent navigable entrance.

A channel is currently dredged across the ocean sand bar, but in heavy south or south east weather the bar becomes dangerous and unfit for navigation.

The Port of Gippsland Lakes include:

- All waters of Lakes Wellington, Victoria, King, Reeves, Bunga and all connecting bays, channels, arms and straits.
- The navigable Rivers Latrobe, Avon, Mitchell, Nicholson and Tambo, and creeks flowing into these waters.
- All waters in Bass Strait within three nautical miles off the entrance light to the Port of Gippsland Lakes.

Lakes Entrance is Victoria's largest fishing port and is the commercial centre of the Port of Gippsland Lakes. Over 100 commercial scallop, seine, salmon, trawl and shark fishing boats as well as oil industry supply boats use Lakes Entrance as home port. These boats range in lengths up to 30 m (100 ft) and have draughts up to 2.5 m (8 ft). There is also some use by pleasure craft (P.W.D., 1981).

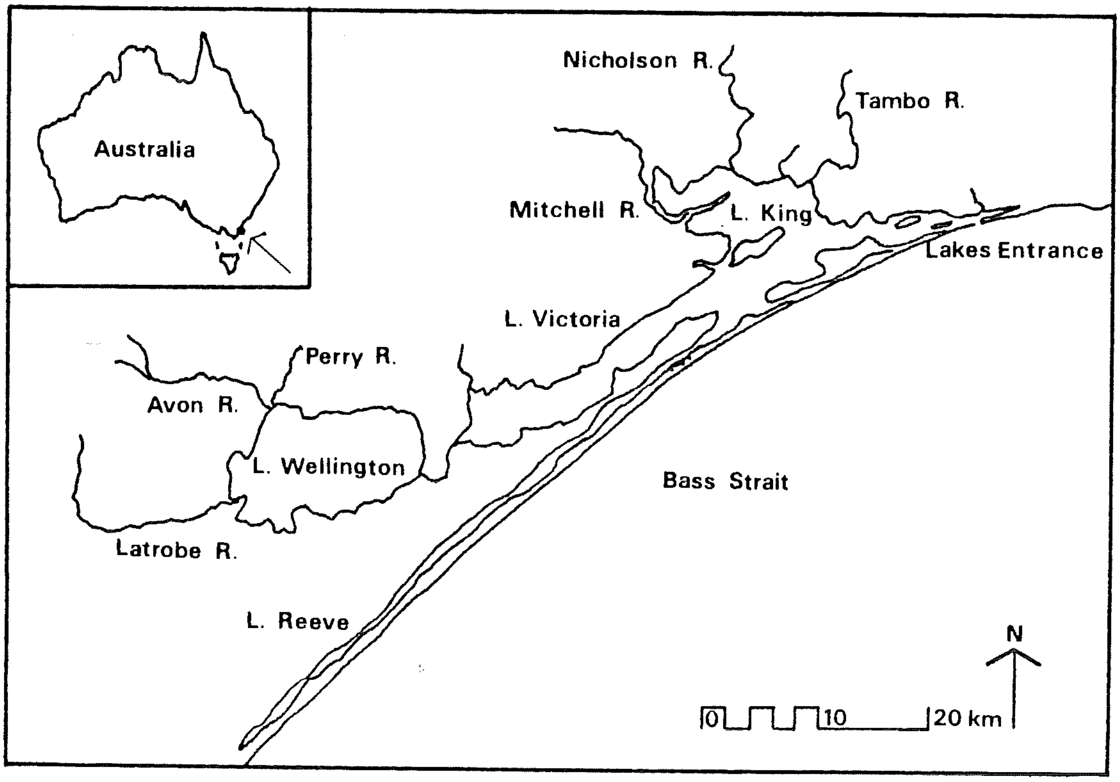


Figure 2. Geographic location of Lakes Entrance

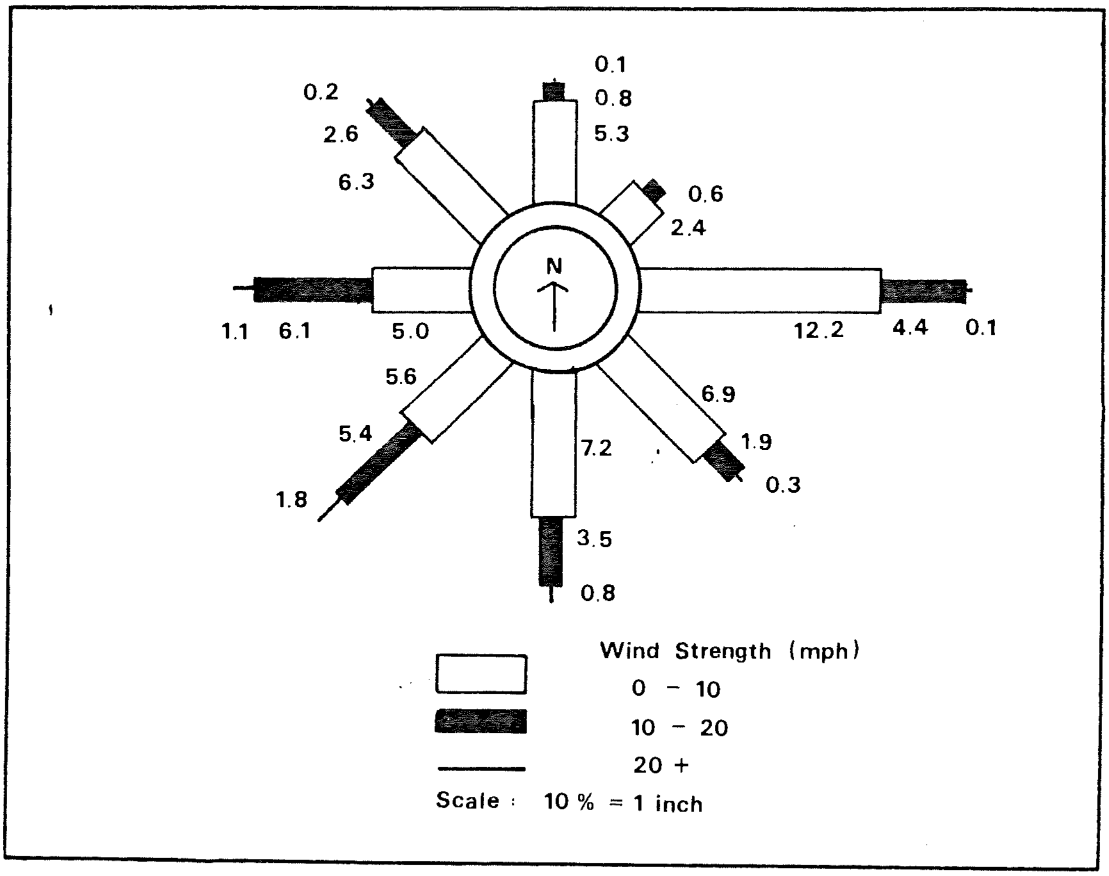


Figure 3. The wind rose for Lakes Entrance (Tan, 1970)

3.2 Wind

Wind creates waves, currents, changes in water level and affects boat drift. Wind speed and strength is measured by a Beaufort Number, miles per hour or metres per second. The direction given is the direction from which the wind is coming. The conversions are shown in Table 1. The wind rose for Lakes Entrance is shown in Figure 3 (Tan, 1970). The wind rose is for the period Spring 1965 to Summer 1968 and represents 2,103 observations of which 14.2% were calm. The length of each portion of each arm represents the percentage of recorded observations for which a particular wind strength was recorded in that direction. The observations were taken at 0900 and 1500 hours by the Public Works Department at Lakes Entrance. The wind energy ratio of the South to West quarter, to the South to East quarter is 3:2 (Tan, 1970).

Table 1 The Beaufort Scale

Beaufort Number	Description	Wind Speed miles/hr	Wind Speed m/sec
0	Calm	0-1	0-0.4
1	Light air	1-3	0.4-1.6
2	Light breeze	4-7	1.6-3.4
3	Gentle breeze	8-12	3.4-5.6
4	Moderate breeze	13-18	5.6-8.3
5	Fresh breeze	19-24	8.3-11.0
6	Strong wind	25-31	11.0-14.1
7	Stiff wind or moderate gale	32-38	14.1-17.2
8	Stormy wind or fresh gale	39-46	17.2-20.8
9	Storm or strong gale	47-54	20.8-24.4
10	Heavy storm or whole gale	55-63	24.4-28.4
11	Hurricane-like storm	64-72	28.4-32.4
12	Hurricane	73-82	32.4-36.7

3.3 Waves

This section discusses wave behaviour. It is necessary to understand wave behaviour in order to understand boat stability, particularly the broaching mechanism in shallow water waves near an ocean sand bar.

3.3.1 Wave Generation

Wind produces two types of wave conditions. These are:

- Seas. Winds from local storms produce steep waves which reach the beach in nearly the same form as they were generated. Their wave length is ten to twenty times their height.
- Swell. Distant storms produce waves which may travel through hundreds or thousands of miles of calm areas before reaching the coast. Under these conditions the short steep waves decay and are eliminated. Only the long, relatively low waves reach the shore. Their wave lengths are thirty to five hundred times their height.

Wind waves are defined by:

- H, Height is the vertical distance from the top of the crest to the bottom of the trough.
- L, Length is the horizontal distance between successive crests.
- T, Period is the time between successive crests passing a given point.
- C, Celerity is the speed at which the wave form propagates.
- d, Depth is the distance from the sea bed to the still water level.

As waves propagate in water, only their form and part of their energy move forward. The water particles remain in the same area. Waves are classified according to the ratio of the depth of water to their wavelength as shown below:

- Deep water wave, d/L greater than $\frac{1}{2}$
- Transitional wave, d/L between $\frac{1}{2}$ and $\frac{1}{25}$
- Shallow water wave, d/L less than $\frac{1}{25}$

The height, length and period of waves are determined by:

- F, Fetch is the distance the wind blows over the sea in generating the waves.
- S, Wind speed.
- t, Time is the length of time the wind blows.
- D, Decay distance is the distance the wave travels after leaving the generating area.

Generally, the longer the fetch, the stronger the wind, and the greater time the wind blows, the larger the resulting wave. The water depth, if shallow enough, will also affect the size of the wave generated. Wind simultaneously generates waves of many heights, lengths and periods.

The theory of wave generation is called hindcasting. Figure 4 shows deep water wave hindcasting curves. At the intersection: Wind Speed read from one axis, and Fetch Length read from the other axis, is the resulting wave period and wave height. The minimum duration curve is the time necessary for the particular wind strength given to produce the resulting wave.

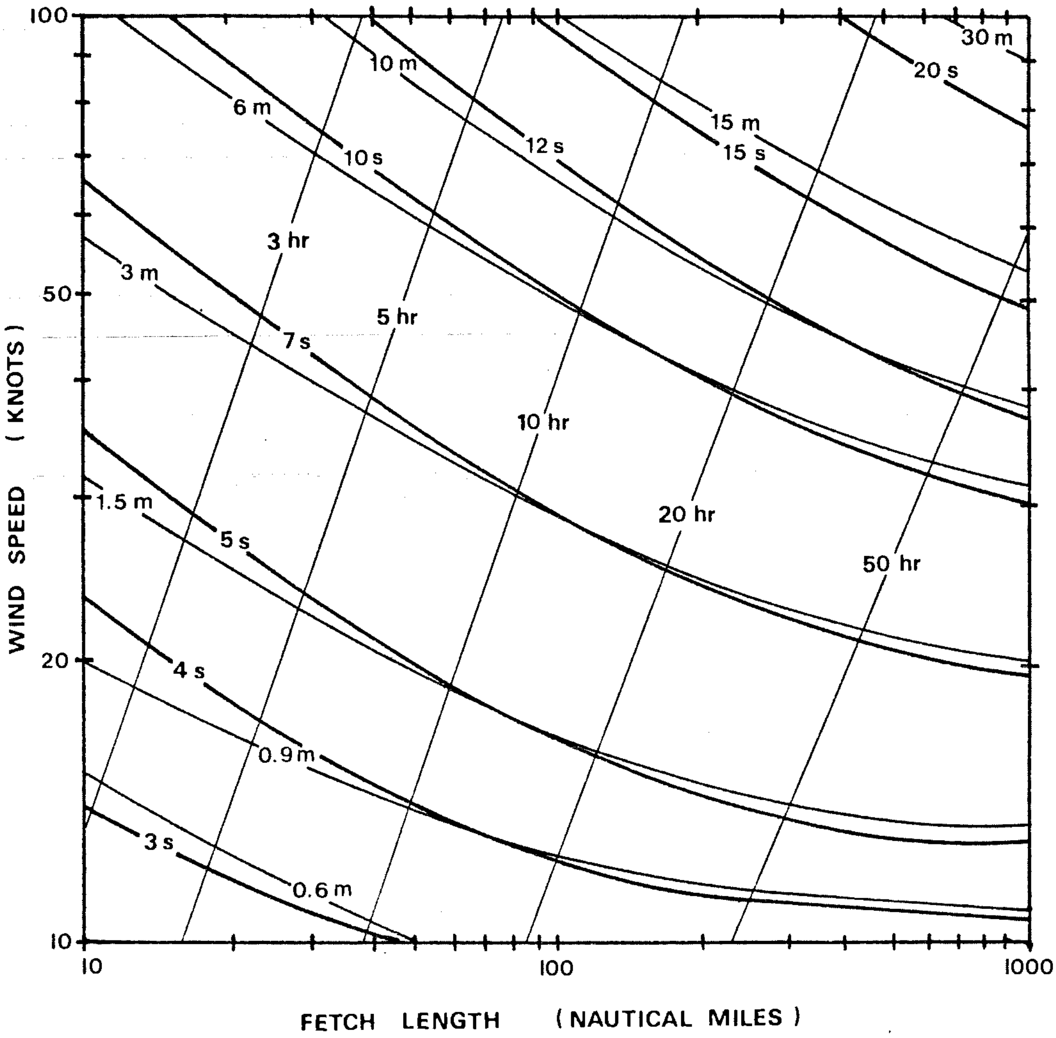


Figure 4. Deep water wave hindcasting curves (C.E.R.C., 1977)

3.3.2 Wave Formulas

The practical use of the following wave formulas is to determine wave characteristics and understand the behaviour of different types of waves in different conditions. These formulas must be worked in metric, and then converted to imperial units using Table 2. The distance travelled by a wave during one wave period is one wave length; thus wave celerity (speed) equals wavelength divided by wave period.

$$C = \frac{L}{T}$$

If you forget which way around this formula goes, you can derive it by balancing the units on each side. Wave celerity is in metres/second and length/time is also metres/second. The following formulas are for deep water waves. The subscript $_o$ denotes deep water waves.

$$C_o = \frac{L_o}{T}$$

$$C_o = 1.561 \times T$$

$$L_o = 1.561 \times T^2$$

The formula for the celerity (speed) of all waves is shown below. It can be approximated for deep and shallow water waves but for transitional waves, it must stay in this complicated form. Tables are needed for the solution. The subscript $_t$ denotes transitional waves.

$$C_t = \sqrt{\frac{gL}{2\pi} \tanh \left(\frac{2\pi d}{L}\right)} \qquad \text{(C.E.R.C., 1977)}$$

The celerity (speed) of a shallow water wave depends only on depth as shown by the following formula. The acceleration due to gravity (g) is 10 m/s . All units must be kept in metric, but that final answer may be converted to knots using Table 2. The subscript $_s$ denotes shallow water wave.

$$C_s = \sqrt{gd} \qquad \text{(C.E.R.C., 1977)}$$

The formulas do not predict wave characteristics exactly, but they are a reasonable approximation.

Table 2 Metric to Imperial unit conversions

Metres (m)	Feet, Inches	Metre/second (m/s)	Knots
0.5	1' 8"	0.5	0.97
1.0	3' 3"	1.0	1.94
1.5	4' 11"	1.5	2.91
2.0	6' 7"	2.0	3.88
2.5	8' 2"	2.5	4.85
3.0	9' 10"	3.0	5.83
3.5	11' 6"	3.5	6.80
4.0	13' 1"	4.0	7.77
4.5	14' 9"	4.5	8.74
5.0	16' 5"	5.0	9.71
5.5	18' 0"	5.5	10.68
6.0	19' 8"	6.0	11.65
6.5	21' 4"	6.5	12.62
7.0	23' 0"	7.0	13.59
10.0	33'	7.5	14.56
20.0	66'	8.0	15.54
30.0	98'	8.5	16.51
40.0	131'	9.0	17.48
50.0	164'	9.5	18.45
60.0	197'	10.0	19.42
70.0	230'	10.5	20.39
80.0	262'	11.0	21.36
90.0	295'	11.5	22.33
100.0	328'	12.0	23.30
110.0	361'	12.5	24.27
120.0	394'	13.0	25.25

3.3.3 Wave Interference and Wave Patterns

A wave train is a group or series of waves with similar characteristics. Waves in the ocean often appear as a confused and constantly changing sea of crests and troughs on the water surface. This is because wave trains of different periods, lengths, heights and directions interfere with each other. The faster, longer period waves overtake and pass through the slower waves. Waves sometimes reinforce or cancel each other by this interaction, or collide and dissipate into turbulence and spray. This is common while waves are under the influence of wind. The direction of wave propagation is the average of the directions of individual waves. The significant wave height is the average height of the highest one-third of waves. As waves move out of the area directly affected by wind, they become more rhythmic with definite crests and troughs. These waves may travel hundreds or thousands of miles from the area in which they were generated. The wave energy is dissipated internally within the wave and by:

- Wave interaction with the air above
- Wave interaction with the sea bed at shallow depths
- Wave turbulence on breaking.

Wave patterns are caused by the constructive and destructive interference of individual wave trains with different characteristics. Different patterns may be common to different areas because the individual wave trains are constrained by local influences. A common observation of this effect is large waves being in groups of 3, 4 or 5. Figure 5 shows wave patterns produced by constructive and destructive interference between two individual wave trains.

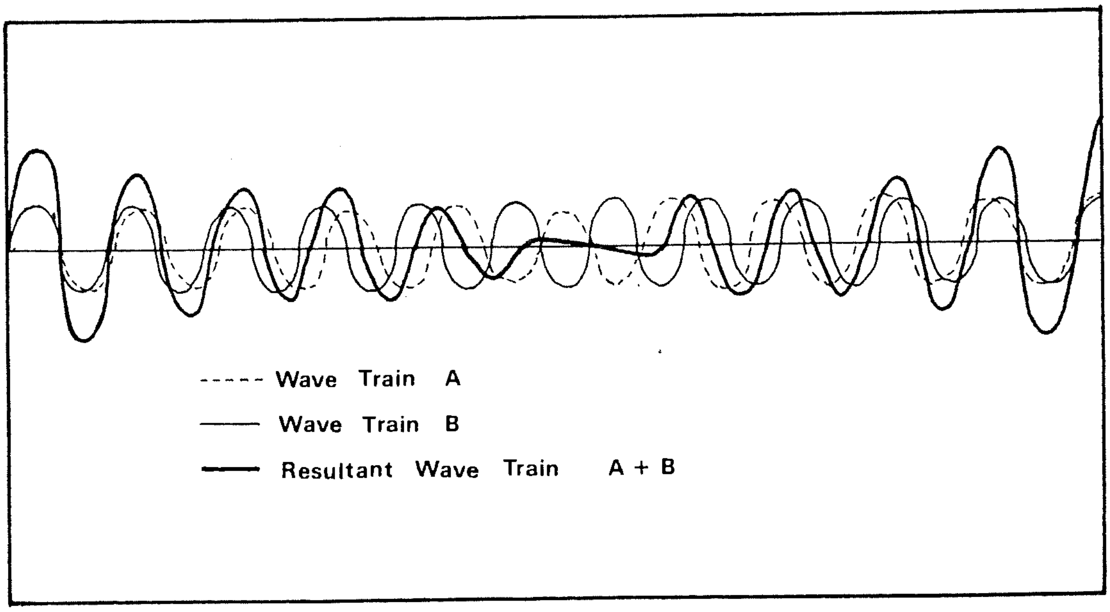


Figure 5. Constructive and destructive interference between two individual wave trains

Echo sounders may be used to assess the wave pattern. Figure 6 shows wave patterns recorded by the echo sounder on the oil rig supply vessel *Makaira* while approaching the bar off Lakes Entrance (Newman, 1983). It can be seen that on that day the large waves were in groups of 2, 4 or 6. The echo sounder paper travelled 10 mm every thirty seconds, thus, the times between the large wave groups can be calculated and are shown on Figure 6. At the time of the echo sounder trace, the *Makaira* was travelling slowly, therefore, the times on the tape will be similar to the actual times. If the *Makaira* had been travelling in the same direction as the waves, the actual time between the sets of big waves would be less than the tape time. If the *Makaira* had been travelling towards the waves, the actual time between wave sets would be more than the tape time.

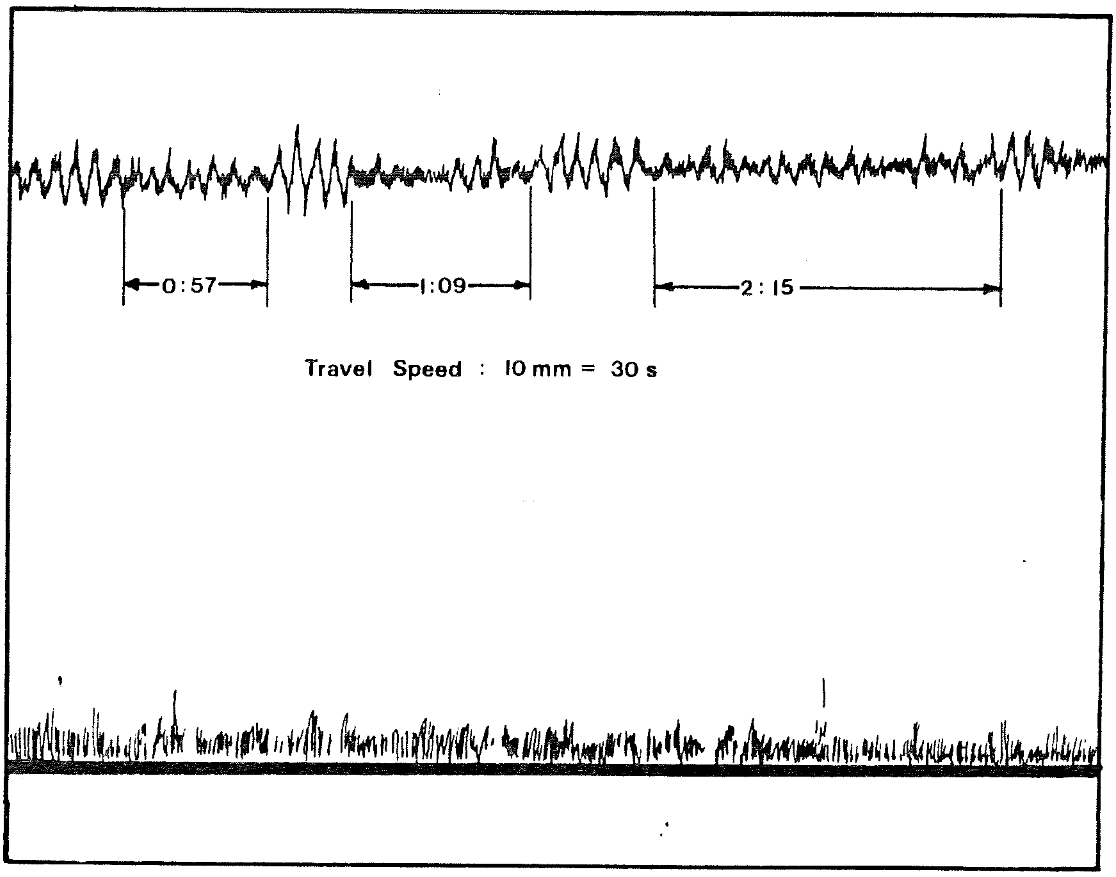


Figure 6. Echo sounder trace showing wave pattern near Lakes Entrance (Newman, 1983)

3.3.4 Wave Energy and Power

The total energy of a wave is the sum of its kinetic energy and its potential energy. The kinetic energy is the energy due to water particle velocities associated with the wave motion. The potential energy is the potential resulting from the wave crest being above the wave trough. The total energy in one wavelength per unit crest width is:

$$E_o = \frac{\rho g H^2 L}{8} \qquad \text{(C.E.R.C., 1977)}$$

ρ is the density of water which is 1,000 kg/m^3. This means that 1 cubic metre of water weighs 1 tonne. In Imperial units this means 36 cubic feet of water weighs 1 ton. For a wave of H = 3 m (10 ft), L = 77 m (253 ft), C_o = 11 m/s (22 knots), g = 10 m/s^2 , ρ = kg/m^3. The resulting wave energy per metre of wave crest is 850 kJ.

For a deep water wave, power is:

$$P = \frac{1}{2}\,\frac{E_o C_o}{L} \qquad \text{(C.E.R.C., 1977)}$$

For the deep water wave as described above, the power is 121 kW per metre of wave crest, or 50 Horsepower per foot of wave crest. This power is dissipated (put into another form) when the wave breaks on the beach.

3.3.5 Wave Refraction

The celerity (speed) of a particular wave train depends on the depth of water in which the wave propagates. As the water depth becomes shallower, the wave slows down. Variation in wave celerity occurs along the crest of a wave moving at an angle to underwater contours because that part of the wave in deeper water is moving faster than that part of the wave in shallower water. This variation causes the wave crest to bend toward alignment with the contours as shown in Figure 7. This bending effect is called refraction and depends on the relationship between water depth and wavelength.

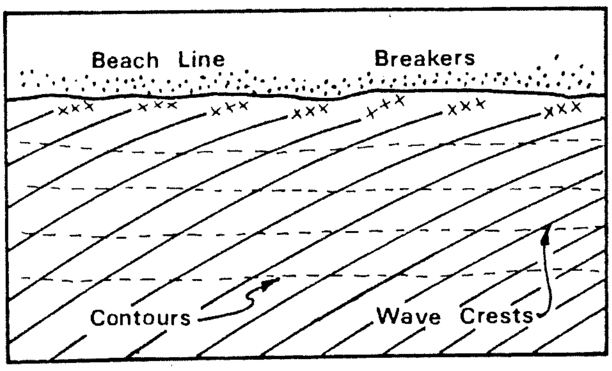


Figure 7. Wave refraction along a straight beach with parallel bottom contours (C.E.R.C., 1977)

Wave celerity is also influenced by currents. If the current is going in the same direction as the wave train, the wave speed becomes the celerity plus the current speed. Thus the wave is stretched, the wavelength increases, and so the wave height decreases. If the current is going in the opposite direction to the wave train, the wave speed decreases. This causes the waves to become closer together with shorter wavelengths. Thus the energy which was previously spread over a longer wavelength must go somewhere, so it goes up and the wave height increases. If there is variation of speed along the wave crest, the wave will bend or refract in the same manner as caused by changes in water depth.

Changes in wave direction result in convergence or divergence of wave energy. Wave rays or orthogonals are lines drawn perpendicular to the wave crests on a wave refraction drawing. If the wave rays or orthogonals converge as in the case of the submarine ridge as shown in Figure 8, the wave energy becomes more concentrated and the wave height taller. Another way of expressing this is that between each wave orthogonal shown, there is an equal amount of energy distributed along the wave crest above the mean water level. If the wave orthogonals become closer together, the water is spread over a smaller lateral distance along the wave crest. Thus, the water is piled higher and the wave becomes taller. If the wave rays diverge as in the case of the underwater canyon shown in Figure 9, the wave energy or wave height decreases. Figure 10 shows wave refraction along an irregular shoreline. This diagram shows clearly the reasons why waves at headlands are larger, and the waves in bays are smaller.

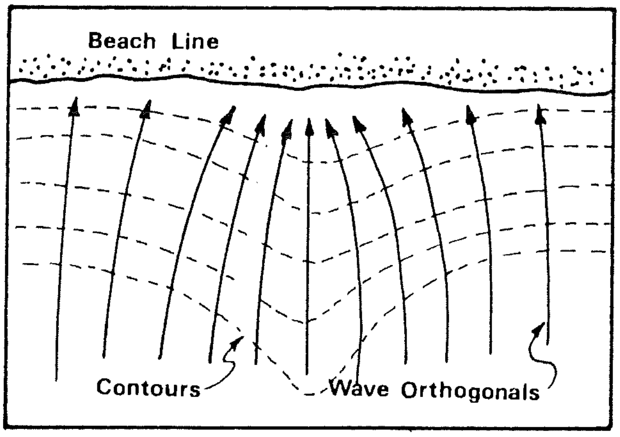


Figure 8. Wave refraction by a submarine ridge (C.E.R.C., 1977)

The Lakes Entrance ocean sand bar acts as a submarine ridge as shown in Figure 8, and thus concentrates wave energy on itself. This produces larger waves in the bar area than at the adjacent beach. The ebb tide also tends to refract waves towards the bar, and thus increases wave energy in this area. The ebb tide also slows down the waves in the bar area, and thus decreases their wavelength and increases their height. Hence the ocean sand bar at Lakes Entrance is dangerous because it concentrates wave energy. Dangerous sea conditions may exist on the ocean bar while seas are relatively calm in Bass Strait.

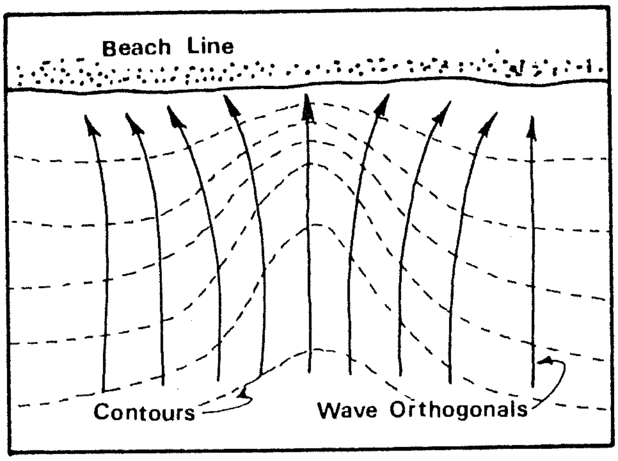


Figure 9. Wave refraction by a submarine canyon (C.E.R.C., 1977)

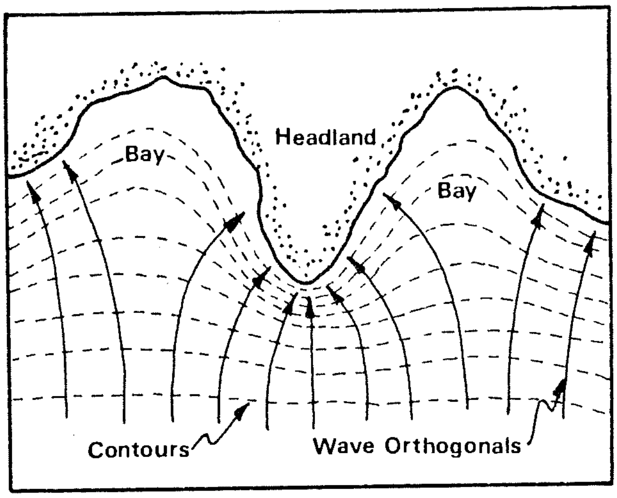


Figure 10. Wave refraction along an irregular coast (C.E.R.C., 1977)

3.3.6 Local Water Particle Velocities in Waves

It is necessary to understand the internal water particle movement and the additional currents produced inside a wave in order to understand the forces on a boat as it moves through the wave.

The water particles move in circular orbits in deep water waves, and elliptical orbits in shallow or transitional water waves as shown in Figure 11. Figure 12 shows the water particle velocities as a wave moves past a fixed position. Figure 13 shows the water surface particle velocities as deduced from Figure 12. The above figures were derived using linear wave theory, which is not a good approximation for shallow water waves. Figure 14 shows approximate surface velocities calculated for a typical large shallow water wave near the Lakes Entrance ocean sand bar. Tables from Dean, 1974 and C.E.R.C., 1977 were used for the above calculations.

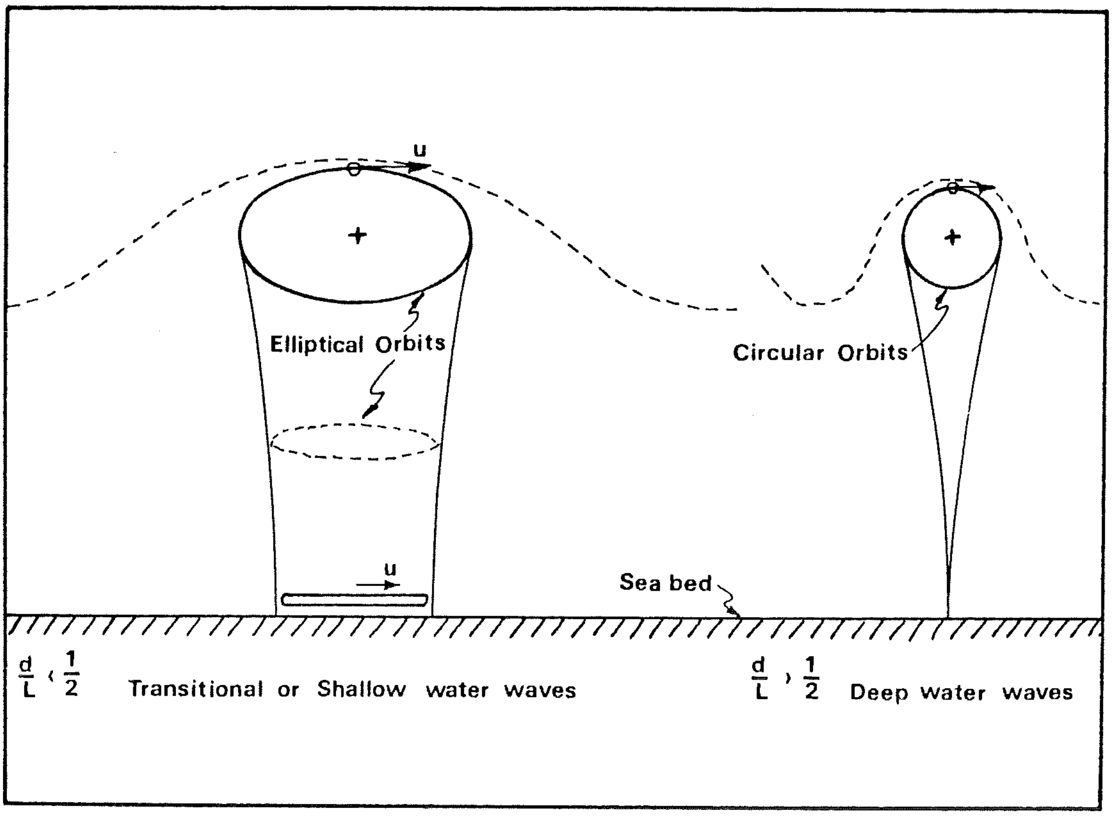


Figure 11. Water particle displacements from the mean position for shallow water and deep water waves (C.E.R.C., 1977)

It is difficult with present theory to calculate the water particle velocities in shallow water waves which are near to breaking. Approximations of speeds will be useful to help understand the reasons why a boat broaches when travelling down the front face of a steep wave.

When a wave is near to breaking, the greatest water particle velocity (at the wave crest) is travelling forward at about 70% of the wave celerity. When a wave breaks, it does so because the water particles at the crest are going faster than the wave celerity (greater than 100%) and simply fall off the front of the wave.

The wave height in Figure 14 is 4 m (13 ft) and the water depth is 5 m (16.4 ft). The wave celerity is 7 m/s (14 knots). The calculated estimate of water particle speed on this wave crest is 3.5 m/s (7 knots) going forward. Estimates of other surface particle speeds are shown in Figure 14. The theory to calculate the water particle speeds on the surface of shallow water waves moving into an ebb current such as at Lakes Entrance is very limited. The ebb current decreases the wave celerity and makes the waves stand up much taller. The ebb current also increases the backwards current in the wave trough and the front face.

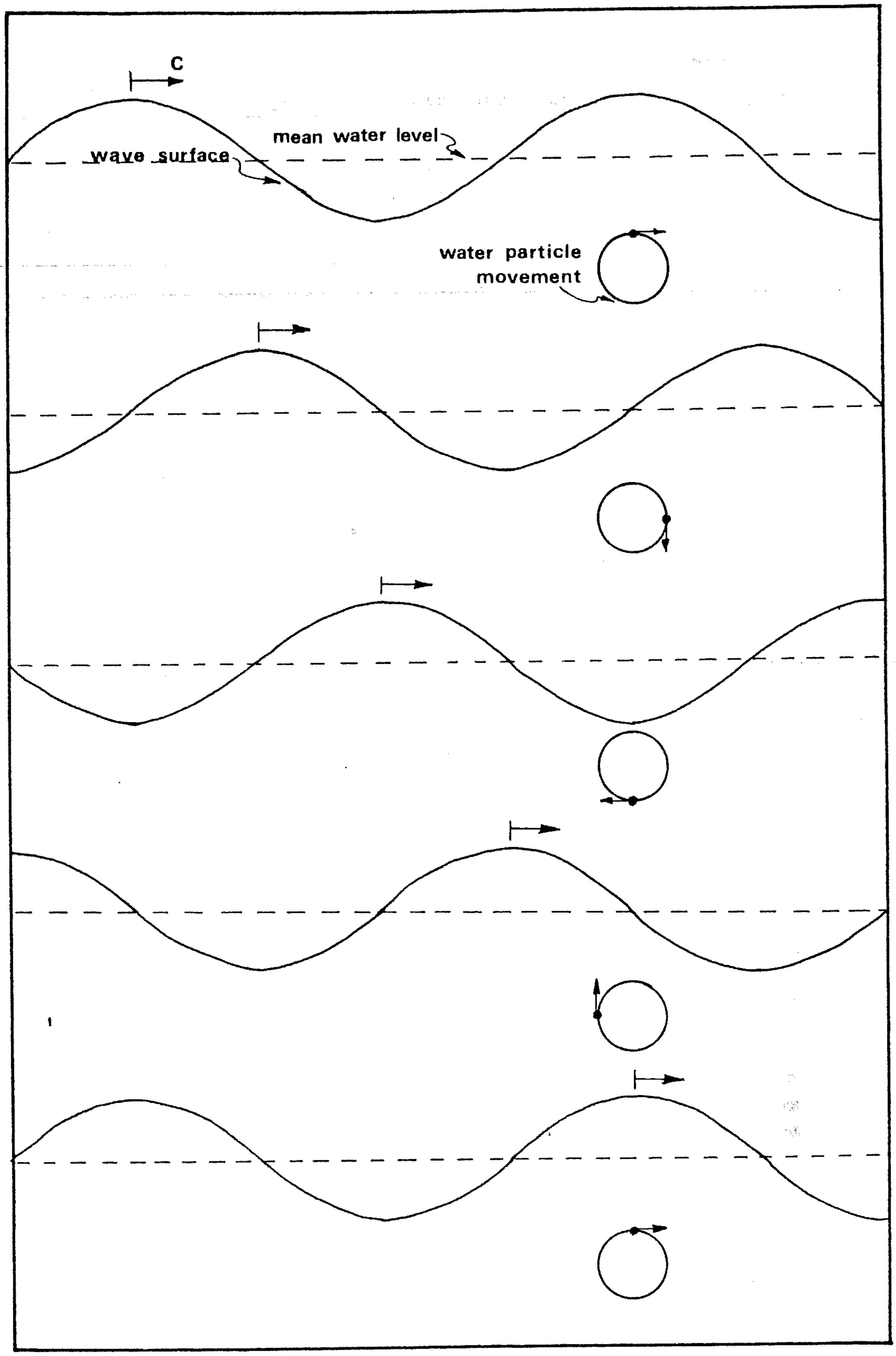


Figure 12. Local water particle velocities

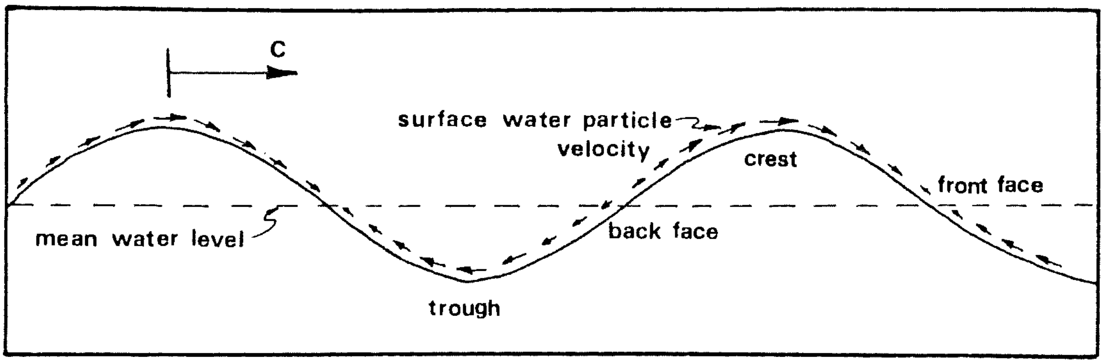


Figure 13. Surface water particle velocities for a deep water wave

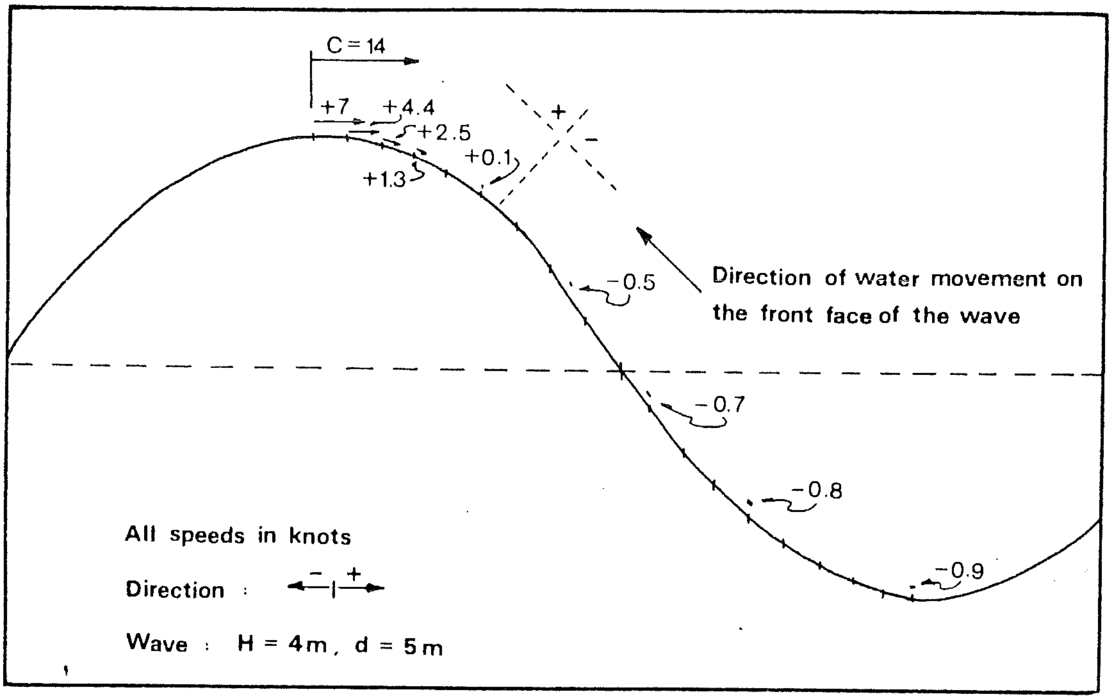


Figure 14. Surface water particle velocities for a shallow water wave. (The above calculated water particle velocities are conservative, actual velocities may be greater)

3.3.7 Breaking Waves

Breaking waves can be classified as:

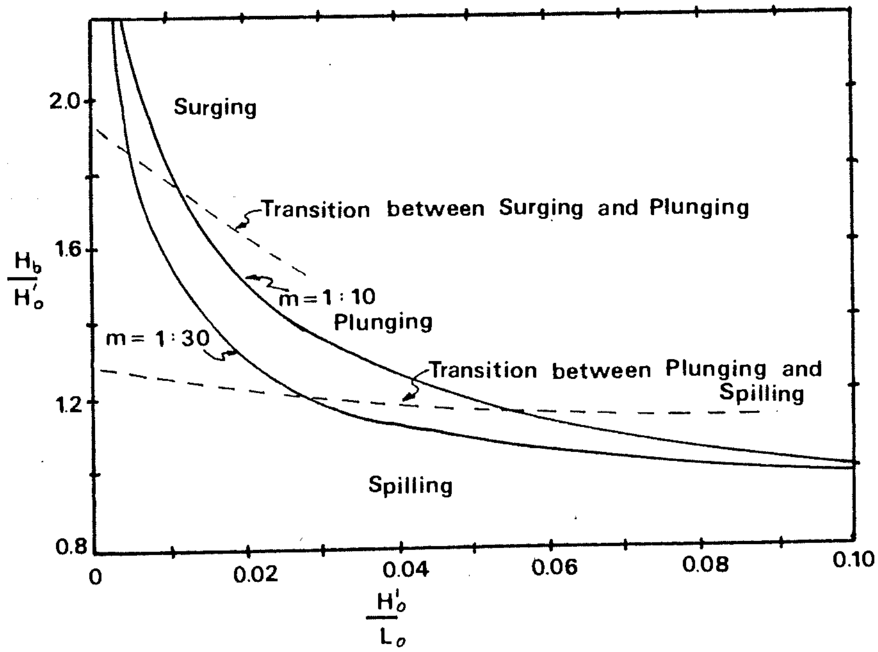
- Spilling. Spilling breakers break gradually and are characterised by white water at the crest.
- Plunging. Plunging breakers curl over at the crest with a plunging forward of the mass of water at the crest.
- Surging. Surging breakers build up as if to form a plunging breaker, but the base of the wave surges up the beach before the crest of the wave can plunge forward.

The water depth, the wave length and the slope of the beach or sea bed determine when a wave will break. The following symbols are used:

- d_b, Depth of water at breaking.
- H_b, Height of wave at breaking.
- H_o, Deep water wave height.
- H_o', Deep water unrefracted wave height.
- m , Slope of sea bed.

Figure 15 shows the breaker height index versus deep water wave steepness for a given beach or sea bed slope. The slope approaching the ocean sand bar at Lakes Entrance is approximately 1:35. The waves which break on this bar are usually plunging waves. This is caused by the ebb current as well as by the sea bed gradient and wave steepness. It is seen that the ratio of breaker wave height to deep water wave height is 1.3 to 1.9 for plunging waves. At Lakes Entrance, the ratio may be higher than this because of the convergence of wave energy due to refraction, as explained in Section 3.3.5. An offshore wind will cause the breaking waves to stand up even taller.

The depth of water in which the waves break can be determined from Figure 16 by putting H_b/gT^2 into the graph for the sea bed slope of 1:35. The result will be the ratio of breaker water depth to breaker wave height.



H_o'	–	Unrefracted Deep Water Wave Height
H_b	–	Breaking Wave Height
L_o	–	Deep Water Wave Length
d_b	–	Breaking Depth
m	–	Beach Gradient
T	–	Wave Period

Figure 15. Wave breaker height index versus deep water wave steepness (C.E.R.C., 1977)

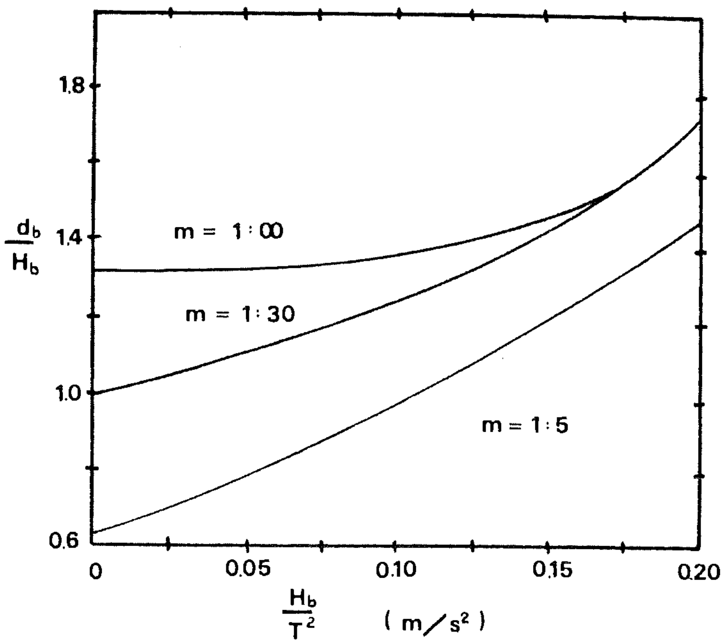


Figure 16. Wave dimensionless depth at breaking versus breaker steepness (C.E.R.C., 1977)

3.3.8 Wave Climate at Lakes Entrance

Lakes Entrance is exposed to local storm waves generated in Bass Strait, and swell waves originating from distant storms in the Southern Ocean or Tasman Sea, as shown in Figure 17. Low pressure systems moving to the south-east of Australia often intensify over the Tasman Sea.

The seas generated by the local storms travel in the direction of the wind that produced them. As the waves approach the shore they "feel" the sea bed and are refracted so that their crests are nearly parallel to the shore when the waves break. The swell waves have longer wave lengths and "feel" the sea bed at greater depths. They refract as they pass the continental shelf and then gradually refract more as Bass Strait slowly shallows. By the time the waves break, they are nearly parallel to the beach. Swell waves account for 85% of wave energy expended on the beach, while locally generated wind waves account for the remaining 15% (Delft, 1975). The direction of a wave is the direction from which it is coming. Waves at Lakes Entrance commonly come from the following directions:

- SW 32%
- S 34%
- SE 26%
- E 8%

The worst sea conditions for crossing the Lakes Entrance ocean sand bar is a SE swell from the Tasman Sea combined with an ebb tide and an offshore wind. SW - S winds can produce quite heavy choppy seas. E winds produce light waves which curl and are dangerous. A SE swell is dangerous because it can cause rapid changes to the bar condition.

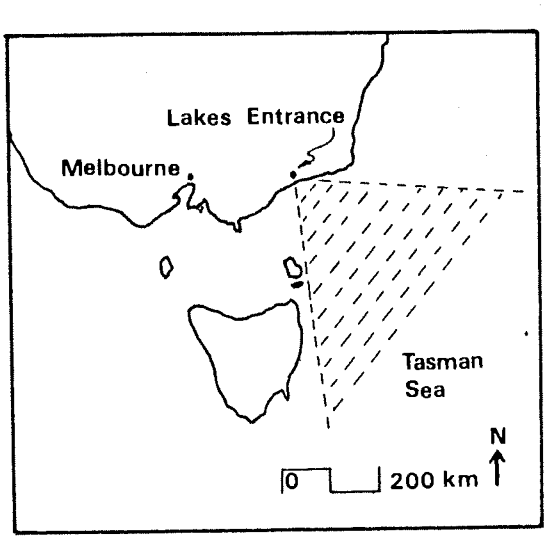


Figure 17. Exposure of Lakes Entrance to S.E. weather

3.4 Currents, Surges and Water Level

Currents are created in oceans, bays, lakes and rivers when water in one area becomes higher than water in another area. The causes of different water levels are:

- astronomical tides
- tsunamis
- river flow
- seiches
- wave set up
- storm surges

3.4.1 Definition of Currents, Surges and Water Level

Astronomical tides are caused by the gravitational attraction between the moon, the sun and the rotating earth, and result in periodic level changes in large bodies of water. Tides follow the moon more closely than they do the sun and since the lunar day is about 50 minutes longer than the solar day, the tides occur about 50 minutes later each day. There are generally two high and two low waters each lunar day. The horizontal movements of water are called tidal currents. The responses of water level changes to the tidal forces are modified in coastal regions because of variations in water depth and lateral boundaries. This causes tides to vary substantially from place to place.

Tsunamis (often mistakenly called tidal waves), are generated by submarine earthquakes, submarine landslides and underwater volcanoes. These waves may travel across oceans at speeds over 100 knots. In the open ocean the wave heights are small but in coastal regions they have been greater than 30 m (100 ft). Lakes Entrance is in a stable area of the world and is not affected by tsunamis.

River flow influences water level and currents. In the case of river flow into a large bay (Port Phillip Bay) river flow has little effect when compared with tide, on the water level in the bay and the current through the heads. In the case of river flow directly into the ocean, river flow has a significant effect on the current direction at the river mouth. Lakes Entrance is a combination of the above two cases. Usually tidal flow is dominant, but when the rivers of south eastern Victoria are in flood, river flow will be significant.

Seiches are long-period standing waves that continue after the forces which started them cease to act. They occur commonly in enclosed or partially enclosed basins or lakes. It is simply the sloshing of water from one end of a lake to the other and back again. Seiching is common in Lake Wellington with a height of 20 mm (1"). The largest seiche observed had a height of 1 m (40") and a period of 1.8 hours (Fryer, 1980).

Wave setup is defined as the superelevation of the water surface due to onshore mass transport of the water by wave action alone. The increase in water level occurs after the waves have broken.

Storm surge is the change in mean water level caused by the actions of storms. Storm surges are caused by moving atmospheric pressure differences and by wind stress accompanying moving storm systems. Winds are responsible for the largest changes in water level. A wind blowing over a body of water exerts a horizontal force on the water surface and induces a surface current in the general direction of the wind. The force of wind on the water is partly due to the inequalities of air pressure on the windward side of waves, and partly due to the shearing stresses at the water surface.

3.4.2 Currents, Surges and Water Level at Lakes Entrance

The normal range of water levels measured by the Lakes Entrance tide board is 0.15 m (6") to 0.85 m (2 ft 9"). Storm surges increase this range to -0.10 m (-4") to 1.10 m (3 ft 7"). South winds cause an increase in water level, and north or east winds cause a decrease in water level. High water and low water at Lakes Entrance is forecast to be 3 hours 25 minutes earlier than Port Phillip Heads (P.W.D., 1971 - 1983).

Lakes Entrance appears to be near the confluence of the tidal wave propagated from the west through Bass Strait, and the tidal wave coming from the Tasman Sea. The Lakes Entrance tides correlate better with Sydney (Fort Denison) than with Point Lonsdale (Fryer, 1981). The tide offshore of Lakes Entrance occurs at about the same time as the tide at Sydney but with about 2/3 its range, which is about twice the tidal range of the Flagstaff Jetty (Delft, 1975).

Current direction is measured as the direction the current is going to. There is disagreement in the references as to the direction of the flood and ebb current parallel to the coast in Bass Strait near Lakes Entrance. This is because of the varying oceanographic influences as described in the paragraph above. Conversations with local fishermen indicate that the current may more often flood SW, and ebb NE at about 1.5 knots. A 15 knot wind will change the direction of this current to that of the wind. Often on the first day the current is from where the previous weather was; on the second day there is minimal current; late in the third day the current is from where the new weather will come. Often low water levels will precede a North or East wind, and high water levels will precede a South or Southwest wind.

Normal flood and ebb currents through the entrance at Lakes Entrance are 0 - 1.5 m/s (0 - 3 knots) but in extreme river floods the ebb current may be as high as 4 m/s (8 knots). The annual river flow is 3,302 million cubic metres. This is 16% of the tidal flow through the Entrance (Delft, 1975). Generally the flood current flows radially into the entrance from Bass Strait. The ebb current tends to "Y" or fork slightly as it comes out of the entrance, as can be seen by the scour in Figure 1.

It is difficult to estimate slack water at the Lakes Entrance ocean sand bar. Local fishermen estimate that if no other variables were acting than tide, then slack water may vary from one to three hours after high or low water outside the entrance. In times of high river flood, the current may ebb continuously for two weeks. River water is fresher and lighter than sea water. Thus the river flow may ebb on the surface through the entrance, while the tide may flood underneath. At low water the current may be ebbing on the surface while the tide is flooding in underneath and the mean water level rising. Storm surges may cause the water level to remain high or low, depending on wind direction, for days. In South or Southwest winds, high water may be reached, but the current will continue flooding on the surface while water may start ebbing underneath. The oceanographic influences at Lakes Entrance are extremely variable.

Breaking seas on the Lakes Entrance bar cause lateral currents when they meet the outgoing ebb current. Local fishermen report that the resulting interface, as shown in Figure 18, can have dramatic effects on boat directional stability.

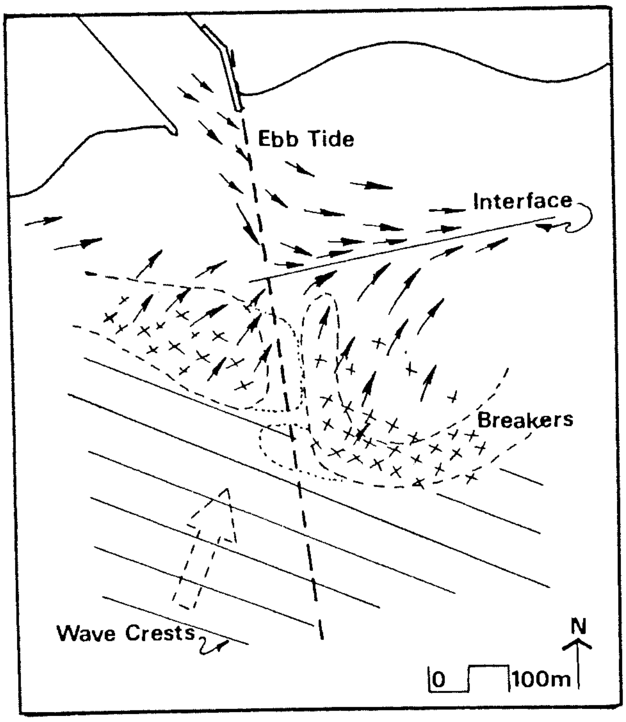


Figure 18. Lateral currents caused when breaking waves meet the ebb current (warning: the ocean sand bar can change alignment daily)

3.5 Sand Movement and the Lakes Entrance Ocean Sand Bar

Most beaches are composed of fine or coarse sand. This material is supplied to the beach zone by rivers, erosion of the coast by waves and currents, and occasionally by onshore movement of material from deeper water. Clay and silt do not remain on ocean beaches because waves create turbulence which keeps them in suspension until they settle to the bottom in quieter, deeper water.

Short steep waves, which are produced by storms near the coast, tend to tear down a beach. Long swell waves, which originate from distant storms, tend to rebuild the beach. Littoral transport is the movement of sediments in the nearshore zone by waves and currents. Transport perpendicular to the coast is called onshore/offshore transport, and transport parallel to the coast is called alongshore transport.

Onshore/offshore transport is determined by wave steepness, sediment size and beach slope. Generally, high, steep storm waves move material offshore to form a bar; the waves then initially break on the bar which protects the beach. This is the beach's self defence mechanism. Long, low swell waves move material onshore. The offshore sand bar which runs along the length of the Ninety Mile Beach is caused by this onshore/offshore movement of sand.

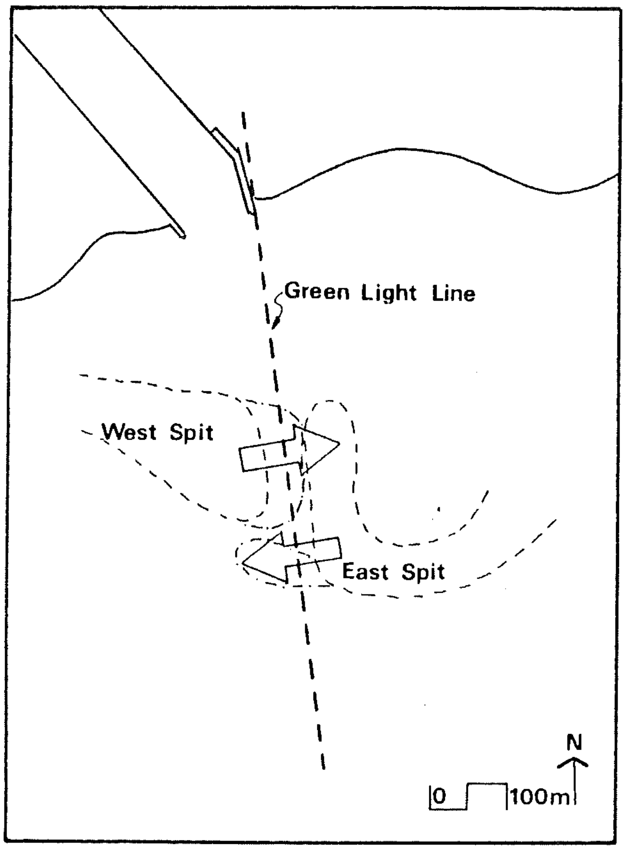


Figure 19. Movement direction of the Lakes Entrance ocean sand bar spits (warning: the ocean sand bar can change alignment daily)

Alongshore transport results from stirring of sediments by breaking waves and the resulting movement of the suspended sediments by the alongshore current created by the waves breaking at an angle to the coast. Due to the variability of wave angle to the coast, the direction of alongshore transport will vary. At Lakes Entrance the historic direction of alongshore transport may have been to the east because the natural entrance ended up at Red Bluff. In the last century it appears that the predominant direction has varied in different decades. As explained in Section 3.4.2 it appears that Lakes Entrance is at a confluence of influences from western Bass Strait and the Tasman Sea. The process of alongshore transport of sediments combined with fluctuations in mean sea level formed the Ninety Mile Beach and the inner marshes and lakes (Fryer, 1971).

The ebb current through the Lakes Entrance channel fans the Ninety Mile Beach offshore sand bar outwards. Sediments from the rivers and lakes deposit on the bar and increase its size dramatically, as shown in Figure 1. Figure 19 shows the alongshore sediment movement of the ocean sand bar spits into the dredged channel between them.

4 BOAT STABILITY AND ACCIDENTS ON THE LAKES ENTRANCE OCEAN SAND BAR

This chapter describes the idiosyncrasies of small ship stability, and discusses the factors which may lead to accidents.

4.1 Boat Stability

The designer of small ships encounters more problems in assuring adequate stability than the designer of large ships. The reasons for this are:

- Environmental conditions are relatively more severe because both operate in the same wind and sea conditions.
- Loading, draft and trim undergo relatively more extreme changes during normal operation.
- Normal operation may involve large disturbing moments and loads such as: heavy nets over the side, towline pull and large heeling moments due to rudder action.
- Greater disparity in geometry, especially freeboard fore and aft (Paulling, 1975).

4.1.1 Transverse Boat Stability

When floating at rest in still water every ship must obey the following conditions:

- The force of buoyancy, assumed to act upwards, must equal the total weight of the ship.
- The centre of buoyancy and the centre of gravity of the ship must be in the same vertical line.

Figure 20 shows a fishing vessel inclined at an angle ϕ to the vertical. The following symbols on the figure are defined as:

- W, Weight of the boat, which acts downward through the centre of mass or gravity, G.
- B, Original centre of buoyancy which moves to B_1 as the boat heels.
- M, Metacentre is the point through which the verticals of B and B_1 intersect.
- WL, Is the original water level, and W_1L_1 is the new water level.
- GZ, Is the righting arm.

Simply explained, the righting arm is the leverage distance from the centre of mass or gravity of the boat, about which the buoyant or righting force is acting. An analogy to righting arm is the length of a spanner handle which is rotating (heeling), a nut.

The righting couple is the weight of the boat W, multiplied by the righting arm length GZ. It is clear from Figure 20 that the righting couple acts only when the metacentre M, is above the centre of mass or gravity G (Baxter,1959).

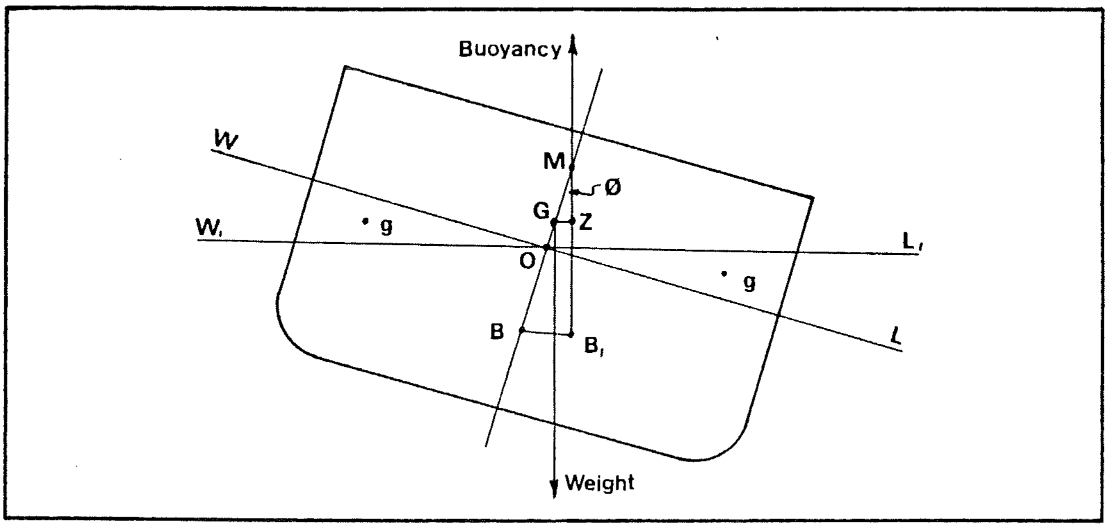


Figure 20. Action of forces in transverse boat stability (Baxter, 1959)

Many types of small ships have great dissimilarities in the geometry of the fore and after sections. Usually the forward sections have high freeboard and narrow waterlines with considerable flare. The typical aft section has low freeboard, wide beam and perhaps shallow local draft. Boats with these types of characteristics are seagoing tugs, small and large fishing boats and oil rig supply boats. The metacentric height, GM, gives a misleading indication of stability of low freeboard boats. It is essential that the righting arm GZ calculations be made in such a way that the vessel is permitted to trim as heel is increased.

When a boat having near fore and aft symmetry heels, the longitudinal centre of buoyancy shifts very little, and thus there is insignificant fore/aft trim. For a boat having a raised forecastle with pronounced flare, combined with a low freeboard aft, this is not the case. This boat will trim when it heels and thus have a reduced righting arm as seen in Figure 21. Figure 21 shows the effect of trim on the local centres of buoyancy for heeled fore and aft sections. The explanation of this Figure is:

- Waterline W_1L_1 corresponds to no trim, and W_2L_2 is the trimmed waterline corresponding to no trimming moment (fore/aft equilibrium).
- If the boat heels about a fixed axis in W_1L_1, the newly immersed area in the forward section will exceed that which emerges, while in the stern, the reverse is true.
- This results in a shift forward of the centre of buoyancy with increasing heel, and a creation of a trimming moment by the stern. If the vessel is allowed to trim, the shaded areas between W_1L_1 and W_2L_2 will emerge forward, and be immersed aft.
- The transverse position of the centroid of the shaded area is such that the local sectional centre of buoyancy tends to move to the left from B_1 to B_2. When this is seen in relation to the forces explained in Figure 20, it can be seen that the result is a reduction of the righting arm GZ (Paulling, 1975).

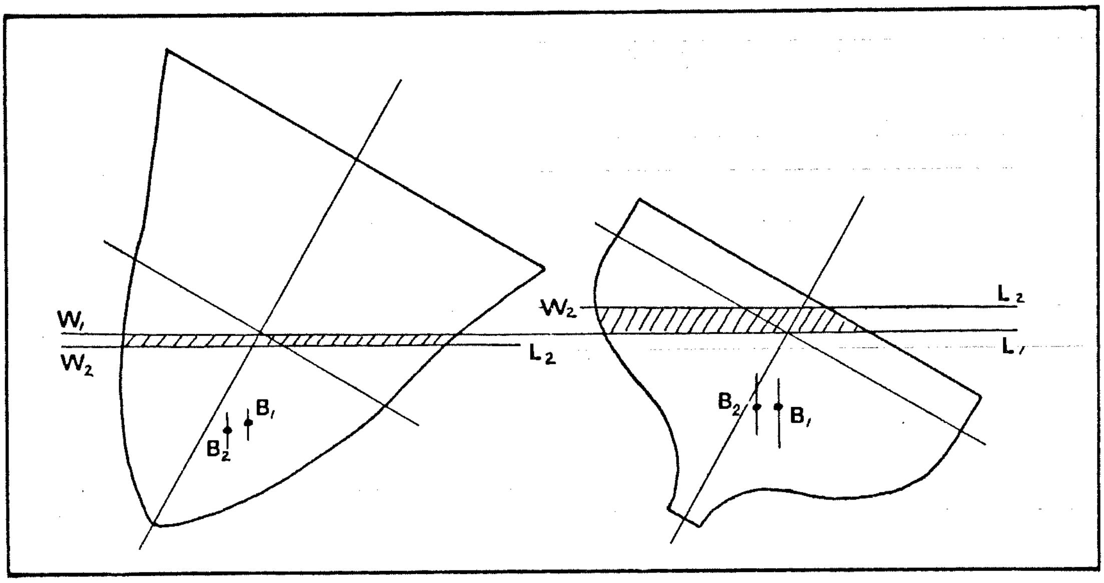


Figure 21. Heeled sections showing effect of trim on local centre of buoyancy (Paulling, 1975)

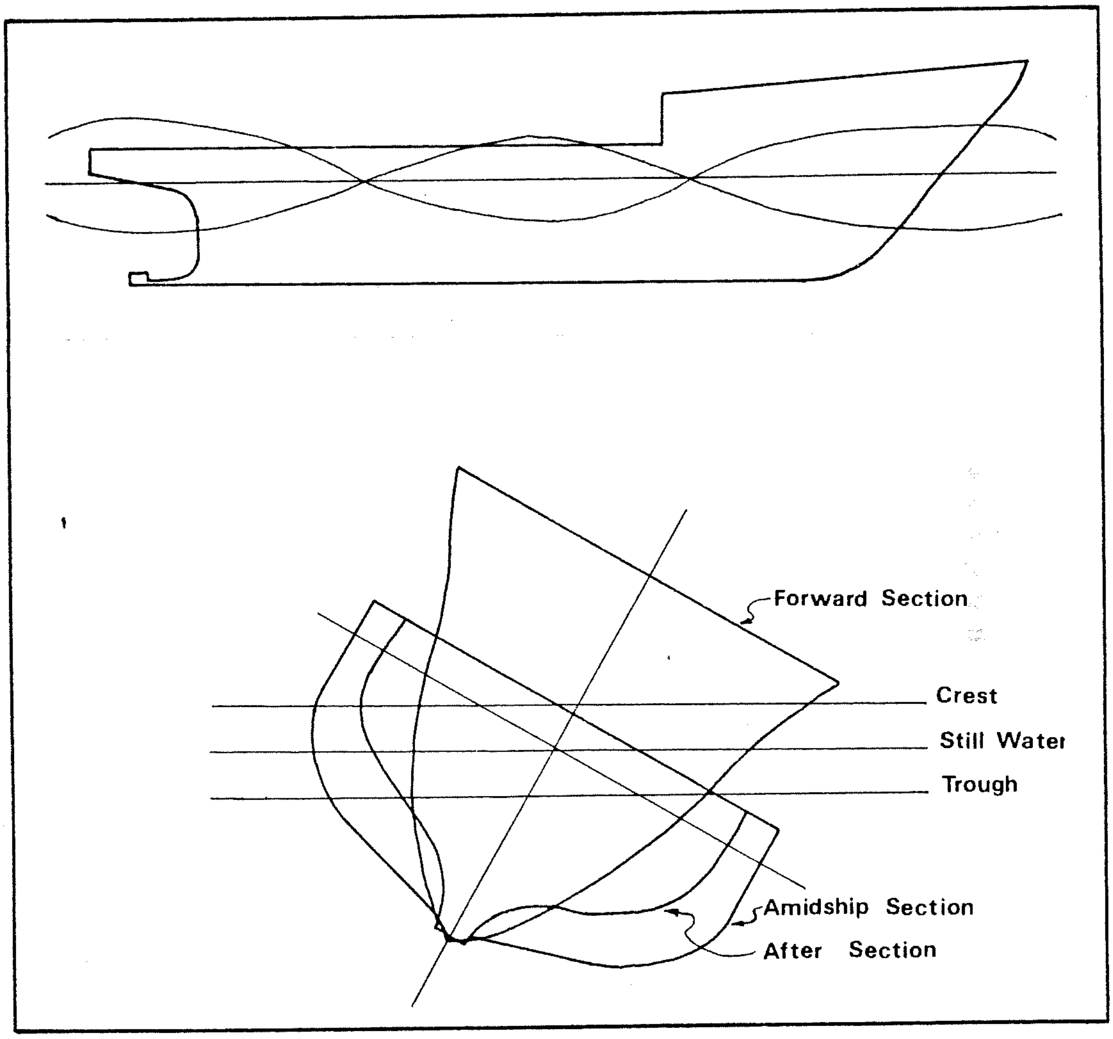


Figure 22. Heeled sections of a boat in following seas (Paulling, 1975)

4.1.2 Geometric Effect of Waves on Boat Stability

The transverse stability of a small ship or fishing boat is dramatically affected by its position on a wave. A fishing boat running before a heavy following sea will sometimes be on a wave crest and sometimes in a wave trough as shown in Figure 22. When the fishing boat is in the wave trough, the flared bow and stern sections are deeply submerged and the vertically sided amidships section is less so, whereas with the crest amidships this situation is reversed. It is clear from Figure 22 that the total righting moment will be greater in the former case than the latter because of the greater contribution from the deeply immersed flared sections. This effect will be most pronounced with vessels having low freeboard amidships and raised superstructure with considerable flare at the ends. Typical righting arm curves in both still water and waves are shown in Figure 23. The wave considered has a length to height ratio of 20. The wave induced reduction in boat stability while at the wave crest is quite apparent, as is the increase in stability in the trough (Paulling, 1975).

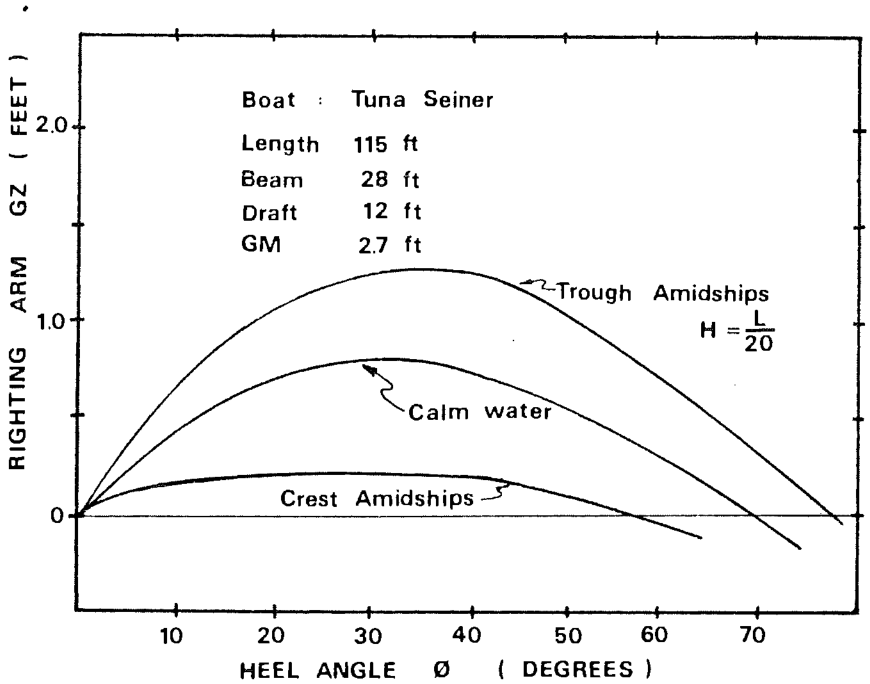


Figure 23. Boat stability in calm water and L/20 waves (Paulling, 1975)

4.1.3 Dynamic Effects of Following Seas on Boat Stability

If the wave crest induced stability reduction is sufficiently severe, the fishing boat may be in danger of capsize. For this to occur, the boat must have reduced stability for about one-half her roll period or longer. This can happen if the boat is travelling at almost the same speed as the wave. The period of time in the wave crest may be sufficient to capsize at slower speeds if the waves are sufficiently steep, and the boat stability initially low.

If the fishing boat is running before regular waves, the righting moment curve will oscillate as successive waves overtake her, between the upper and lower values shown in Figure 23. If this frequency of oscillation is similar to the boat's natural frequency of roll, several regular cycles may cause a large rolling motion to develop. A sequence of events could be as follow:

- A beam wind hits the boat while she is on a wave crest with diminished stability. The boat heels.
- The wave crest moves on and the next wave trough nears the amidships position which results in an increased righting moment. The boat accelerates in roll back towards the upright.
- The next wave crest moves to the amidships position as the boat rolls past the upright position. Her momentum, together with reduced righting moment, causes her to roll too far to the other side.
- Again, the wave crest moves on and the next wave trough with increased righting moment moves amidships as the boat reaches the extreme roll angle.
- This process can be repeated several times if the waves are regular.

4.1.4 Rolling and Capsizing in Beam Seas and Flooding of Internal Spaces

Capsizing in beam seas in open water is usually related to intensive flooding of the deck. Sometimes water is trapped by the bulwarks cumulatively. Thus, the rate of water outflow through the freeing ports is less than the rate of water inflow over the bulwarks in each wave cycle. Several successive waves may cause a capsize.

The rolling period is an indication of a boat's stability. A short stiff uncomfortable roll indicates that the boat is stable. A slow easy roll means that the boat is less stable. If a boat is loaded and its roll becomes very lazy and slow (long period), then the boat's stability may have been reduced to a dangerous level.

Water may flood internal spaces very quickly through an open door. If a door 0.6 m (2 ft) wide has its lower sill submerged 0.6 m (2 ft) under water, it will admit 0.36 tonne (ton) per second. This is 10 tonne (ton) in about 40 seconds (Paulling, 1975).

4.1.5 Case Study of a Capsized Fishing Boat

The following case study is of an Alaskan king crab boat which capsized in the western Gulf of Alaska in relatively good weather in October 1975 (Storch, 1978). The vessel was nearing the end of a fishing trip and the crew were rescued without incident. The characteristics of the vessel were similar to those discussed in Section 4.1. The boat's design dimensions were:

- LOA	23.24 m (76 ft 3 in)
- Beam	6.86 m (22 ft 6 in)
- Depth	3.35 m (11 ft)
- Year Built	1975
- Material	Steel
- Hull Form	Chine
- Deckhouse	Forward
- Compartments	6
- Crab Tanks	2
- Design Fully Loaded Condition	Both crab tanks full, fuel oil tank full, fresh water tank full, 33 crab pots on deck.

The boat's loading condition at the time of capsize was both crab tanks full, fuel oil tank half full, fresh water tank half full and 43 crab pots on deck. In this condition the boat was slightly overloaded and did not have sufficient stability to meet the Inter-governmental Maritime Consultative Organization (I.M.C.O.) criteria, but the boat still should not have capsized in these weather conditions without some other circumstances. Figure 24 shows the boat in its fully loaded design fishing condition, while Figure 25 shows its condition prior to capsize. Both figures graph the righting arm GZ against the angle of heel Ø . The curves on the figures are as follow:

- Curve A was calculated using constant trim. It satisfied the I.M.C.O. stability criteria.
- Curve B was calculated using constant trim moment, but with zero initial trim. This curve does not satisfy the I.M.C.O. criteria.
- Curve C was calculated using constant trim moment, but with the actual initial trim of about 0.46 m (1.5 ft) by the stern. It does not satisfy the I.M.C.O. criteria.
- Curve D is for the boat poised on a wave crest. Most of the righting energy has vanished.
- Curve E was calculated using constant trim moment in the boat's approximate condition prior to capsize.
- Curve F is the boat poised on a wave crest.

At the time of capsizing the boat was operating at low speeds in a quartering sea. The boat may have poised on a wave crest for sufficient time to suffer a reduction in righting energy. This may have resulted in the capsize (Storch, 1978).

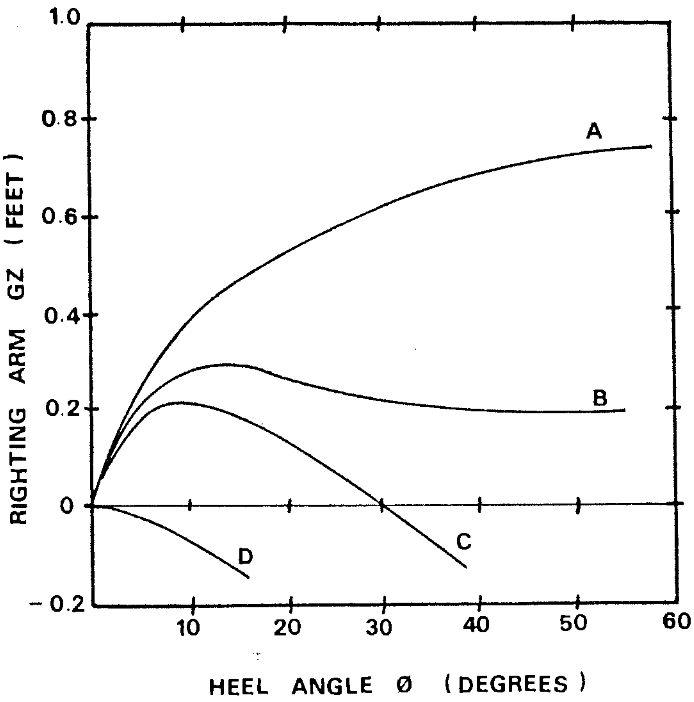


Figure 24. Case study fishing boat in full load design condition (Storch, 1978)

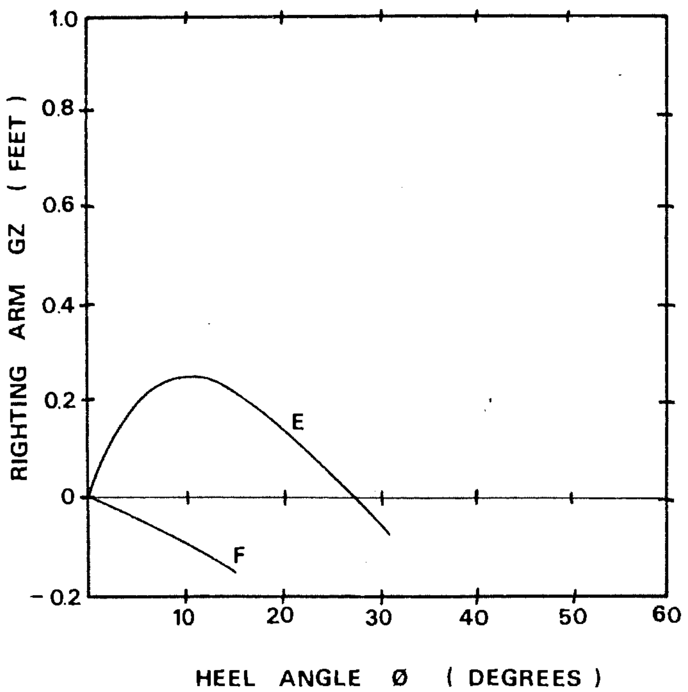


Figure 25. Case study fishing boat in condition prior to capsize (Storch, 1978)

4.1.6 Broaching

This section describes the "true broach" and then explains and discusses all the factors which contributed to that broach.

A boat travelling slower than the waves can be accelerated by the waves to a considerably higher speed. As the boat speed approaches the wave speed external forces may cause the boat to turn a little. If the turning moment applied by the waves is greater than that applied by the rudder, then the boat will yaw or turn more thus increasing the wave induced turning moment and causing further yawing. If the rudder does not catch the boat quickly, the boat will spin around until it is almost beam on to the waves. The loss of control occurs suddenly with a high rate of turn and the centrifugal forces combined with the high heel angles can cause considerable damage or capsize.

Heel induced yawing (turning) is caused by the difference in curvature of the boat's underwater lines when comparing one side of the hull to the other as the boat heels. Figure 26 shows a boat heeling to starboard. The underwater lines of the starboard side have greater curvature than those of the port side. Thus the boat will yaw to port. When a wave crest is positioned at the boat's amidships or quarter, the reduced righting moment will let the boat heel more easily.

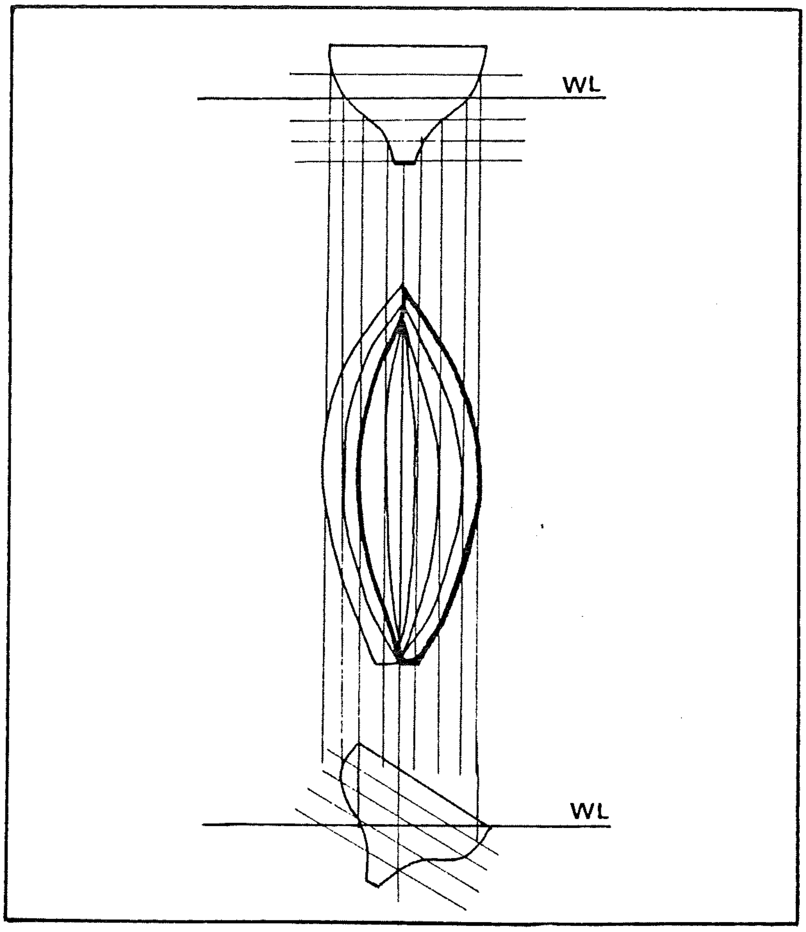


Figure 26. Underwater lines of a heeled fishing boat

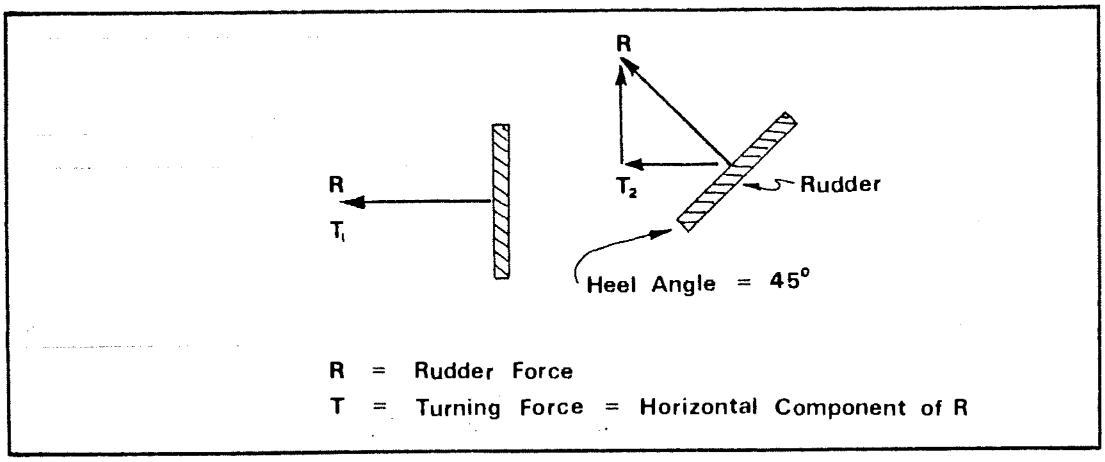


Figure 27. Decrease in rudder efficiency caused by heeling

As a boat heels the rudder's efficiency decreases. This is because the force transmitted by the rudder is perpendicular (directly away) to the rudder's surface. Thus, as shown in Figure 27, the horizontal or turning force of the rudder will decrease as the boat heels. Heeled rudder turning force T_2 is less than original rudder turning force T_1 . When the wave crest is just forward of the stern, the boat will have a trim by the bow and the rudder may be operating half emerged.

Section 3.3.6 describes the water particle velocities in waves. Figure 14 shows the calculated water particle velocities for a 4 m (13 ft) wave at Lakes Entrance. The water particles at the wave crest are moving forward and the water particles on the wave front face and trough are moving backwards. Thus the sharp "V" bow of a boat catches in the backward current of the wave trough and is pushed backwards, while the boat's stern is pushed down the wave by the forward moving water particles in the crest as well as gravity. This causes the boat to turn, then spin, then broach.

The turning force applied by the rudder is proportional to the square of the speed of the water flowing across it. This means that if the speed of water flowing across the rudder doubles (x2), then the turning force of the rudder quadruples (x4). The wave discussed above is travelling forward at 14 knots. The water particles in the wave crest are travelling forward at 7 knots. If the boat is travelling at 9 knots and the stern of the boat is on the wave crest, then the water may be flowing across the rudder at 2 knots. Thus the maximum turning force that the rudder is capable of has decreased to 5% of its original value. In other words, the efficiency of the rudder to stop a broach has decreased to 5%. If the boat has a 45 heel, this is reduced to 3.5%. If the rudder is half emerged, the reduction is to less than 2%. Thus, for the above boat caught on a wave and travelling at 9 knots, the rudder efficiency decreases from 100% to less than 2%, and the subsequent loss of control may result in the boat broaching severely.

Boat speed in relation to wave speed is critical. When crossing an ocean sand bar with large waves, it is necessary to be travelling slowly so as to have power in reserve to increase the water flow across the rudder to maintain steerage if the boat starts to broach when the following wave catches up.

4.2 Accidents on the Lakes Entrance Ocean Sand Bar

The aim of this section is to promote discussion about the causes of accidents on the Lakes Entrance ocean sand bar. Table 3 lists the twelve recorded accidents on the bar. Many more incidents were not recorded. Analysis of the accidents reveal that:

- 9 of the 12 were inbound boats
- 8 of the 9 inbound boats broached and capsized
- 8 of the 12 were scallop boats

Despite an examination of Marine Board of Victoria files it was not possible to draw further general conclusions.

The above three statistics pose three questions which must be individually answered by each boat owner. The questions are:

- Does my boat in a maximum loaded condition have sufficient stability when poised on a wave crest, as discussed in Section 4.1, to be operating from an ocean sand bar port?
- If not, in what sea conditions should I store my catch below deck when crossing the bar?
- In what sea conditions should I not cross the bar?

At the Lakes Entrance ocean sand bar, the critical factors which may lead to an accident are:

- human
  - training
  - experience, judgement and manipulative skills
  - personal state (health, tiredness, emotions)
  - attitude
- equipment
  - stability of boat
  - loading state of boat
  - endurance of boat
  - communications equipment, depth sounders, radar
- environment
  - darkness
  - sea state
  - tide direction
  - wind state
  - likelihood of change in short term

(Cumming, 1981)

It is not acceptable to list human error as the cause of an accident. The cause of error may be:

- work overload, attention distracted
- inappropriate or insufficient information
- inappropriate equipment, poor maintenance
- environmental conditions outside the range of equipment and operator training

(Cumming, 1981)

Table 3. Accidents on the Lakes Entrance ocean sand bar (Cumming, 1981)

Date and Time of Casualty	Name of Vessel Gross Tonnage Year Built	Total Crew	No. Dead	Wind		Sea		Swell	Dimensions and Operation	Construction	Other Details
				Direction	Speed	Direction	Height	S			
18.12.69 15.00 hrs.	Denise Star (VCU) G.R.T. 20.3 1910	2	0	E	15k	130°	M Mod/ Rgh		14.3 x 4.3 x 1.8m Trawler	Timber	Inward. Broached and capsized. Exceptionally large sea reported
02.02.71 07.30	Boomerine	2	0			Short and Steep			10.9 x 3.3 x 1.2m Scallop		Outward. Capsized after scallop dredge lost overboard. Surveyed for Port Phillip Bay limits only.
12.02.71 16.30	Marine Star G.R.T. 60.25 1944		0						19.2 x 5.3 x 2.6m Scallop	Timber	Inward. Grounded on bar. Leak in hull.
17.08.71	Ka-Anna II (WRY) G.R.T. 13 1970	3	0	SE	Light			Break on Bar	11.9 x 3.9 x 1.4m Scallop	Steel	Inward. Large swell on bar - surfed - broached and capsized.
06.06.71 Morning	Hellen (WT6) (Helena)	1	0					S'ly	10.0 x 4.0 x 1.8m Scallop	Timber	Inward. Large swell on bar - surfed - broached and capsized.
19.06.72 18.00	Dennis (WGO) G.R.T. T.62 1966	2	0			SE	Heavy	SE Heavy	11.6 x 3.3 x 1.0m Scallop	Steel	Inward. Broached and capsized.
14.06.73 14.30	Freda	2	0	- Rough Weather -					7.0 x Line/Net		Lorne couta boat - inexperienced crew. Outward. No preliminary inquiry.
14.03.75	San Rocco (LFB 2385)	3	0		Calm	SE'ly - Big Seas on Bar			Trawler	Timber	Outward - vessel immobilised when nets got around propeller - capsized and lost.
08.05.75	Sheila Ray G.R.T. 12.00 1963	3	0	SW Raining and Windy		Mod/Heavy		SW Mod/ Heavy	12.2 x 3.8 x 2.0m Scallop	Timber	Inward - pushed over by roller and beached. Sick man on board - entry necessary
18.03.78 14.00	Shark (WWB) G.R.T. 38 1966	3	3	SE'ly	25k	SE'ly	3m high (average)		18.3 x 4.9 x 3.3m Shark netting	Steel	Inward - surfed - broached and capsized. 3 men trapped in hull. Court of Marine inquiry.
08.02.80 15.00	Boaja (WXS) G.R.T. 44 1970	3	1	WXS	42k	Mod.	with wind wash		15.5 x 5.5 x 2.4m Scallop	Steel	Inward - capsized - stability suspected. 1 man drowned in surf. Vessel salvaged.
24.04.80 19.00	Lefkas (WZJ) G.R.T. 13.7 1973	3	0	SW'ly		SW'ly	Heavy	Heavy	11.4 x 4.6 x 2.0m Scallop	Timber	Inward. Broached and capsized.

5 NAVIGATION OF THE DREDGED CHANNEL ACROSS THE LAKES ENTRANCE OCEAN SAND BAR

This chapter describes the alignment of the dredged channel, the line of best water, and the local port rules for navigation of the Lakes Entrance ocean sand bar. It also describes the dredging signals used by the dredger *April Hamer*.

5.1 Location of the Ocean Sand Bar with Respect to the Leads

The entrance to the Port of Gippsland Lakes (Lakes Entrance) is by way of an artificial channel cut through the beach primary sand dune. The channel is lined by two 445 m (1,460 ft) long close piling piers. From the high water mark the west pier extends 140 m (460 ft) seaward and the east pier 122 m (400 ft). There is a width of 76 m (250 ft) between the pier heads. Stumps of piles which are the remains of destroyed former piers, extend 61 m (200 ft) from the west pier and 21 m (69 ft) from the east pier. The piers are dark in colour making them fairly easy to identify from seaward. Mount Barkly (1.5 km NW) and the Flagstaff at the pilot station on the sand hummocks close east of the piers are marks which help further to identify the piers. The Entrance Light is exhibited from a metal framework tower at the pilot station on the east side of the entrance as shown in Figure 28. There is a fixed Green Light on the east pier head (visible 2 miles) and a Flashing Red Light (2.5 s) on the west pier head (visible 1.5 miles) (Hydrographer of the Navy, 1982).

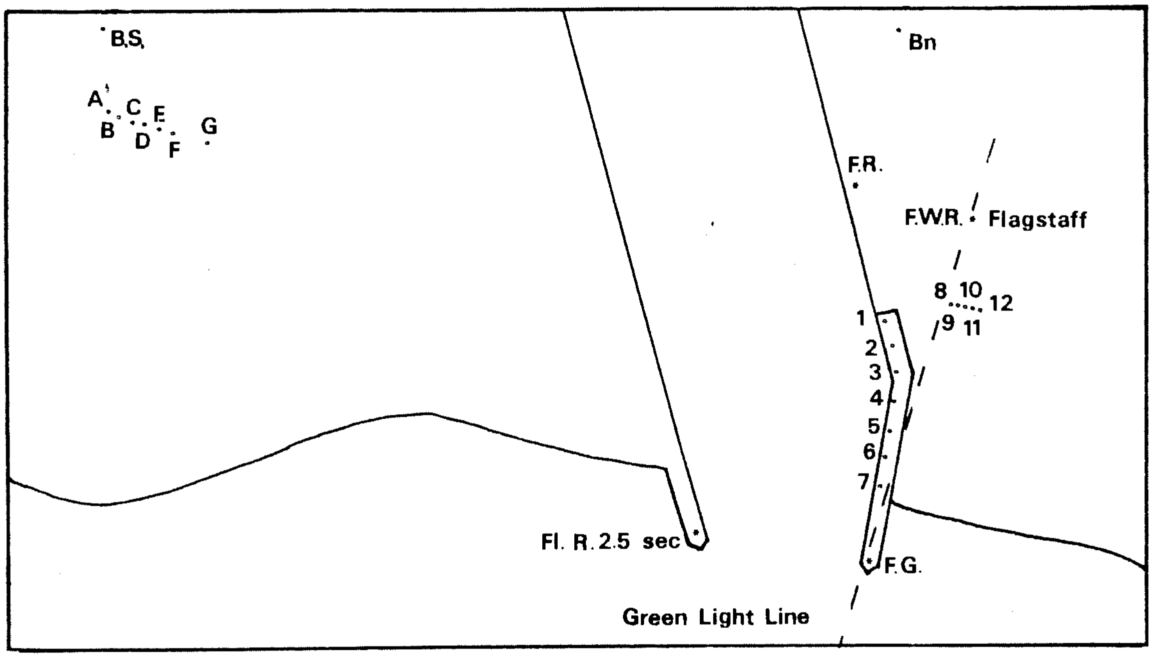


Figure 28. Navigation lights and beacons at Lakes Entrance (P.W.D., 1978-1983)

A sand bar extends across the entrance in a horseshoe shape, as shown in Figure 1. Under normal conditions the bar is about 200 m across on the line of the fairway with its inner edge about 400 m from the pier heads. The bar carries 2 m to 3 m of water at low tide. Since 1977, the shallow draught sidecasting dredger *April Hamer,* as shown in Figure 29, has maintained a channel of approximately 36 m (117 ft) width; and of depths 3.5 m (11 ft) to 5 m (16 ft) across the bar (P.W.D., 1981). The bar moves eastward or westward as a result of seasonal conditions. The sea almost always breaks over the shallow ridge of the bar east of the fairway. The swell usually rolls in across the fairway without breaking, but in heavy S or SE weather the bar becomes dangerous and unfit for navigation (Hydrographer of the Navy, 1982).

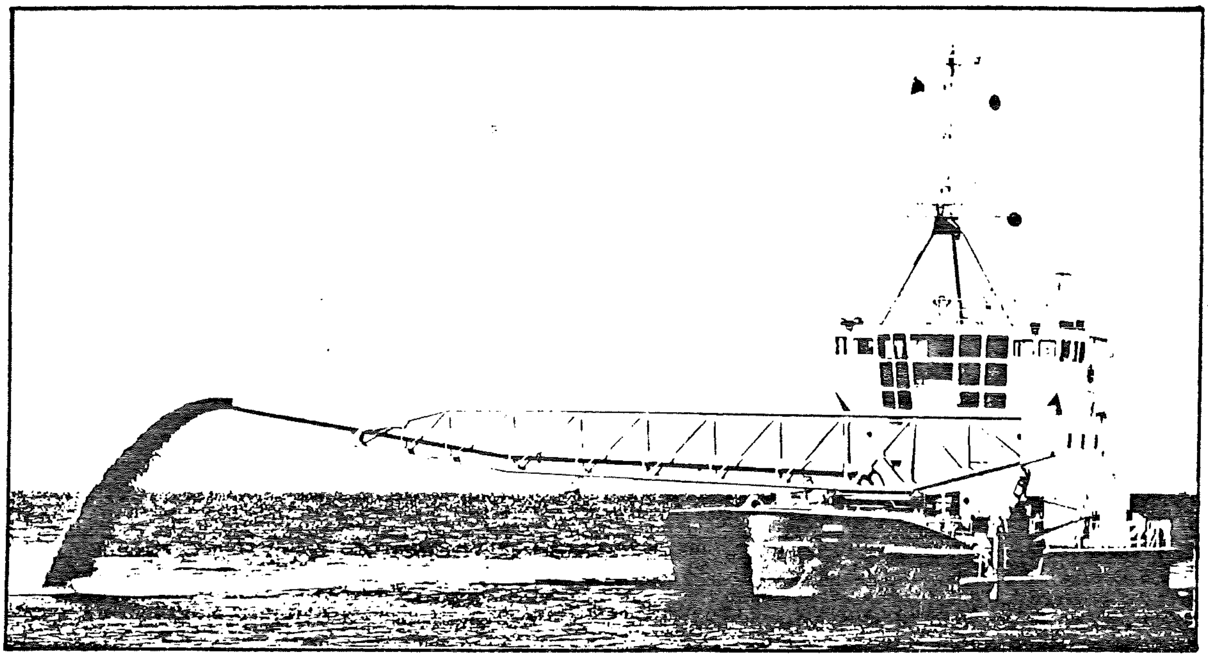


Figure 29. The shallow draught side casting dredger *April Hamer* (Herald, 1977)

The dredged channel across the ocean sand bar is aligned on the green light line as shown in Figure 30. This is an imaginary line between the Entrance Light or Flagstaff at the pilot station, and the Green Light on the east pier head. The centre line of the dredged channel is biased very slightly to the west of this line, since it is from this direction that sand encroachment usually occurs. The alignment of best water across the bar is described by imaginary lines between the Flagstaff and beacons on the east pier head or beach, as shown in Figure 31. It is necessary to discuss the alignment of best water each day with experienced and knowledgeable local boat operators.

A schematic sketch of probable sand spit movement during storms is shown in Figure 19. The outer eastern spit usually moves to the west, and the inner western spit usually moves to the east.

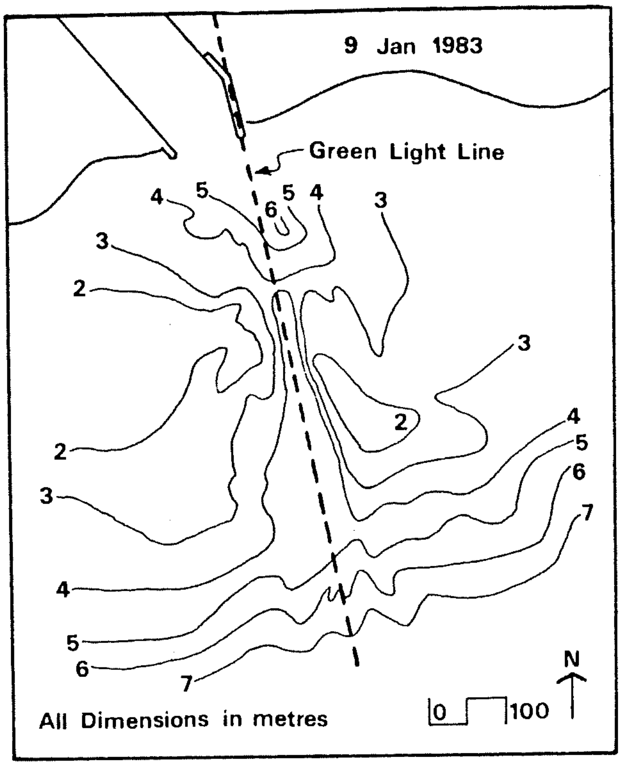


Figure 30. Chart of the dredged channel across the Lakes Entrance ocean sand bar (P.W.D.,1978-1983)

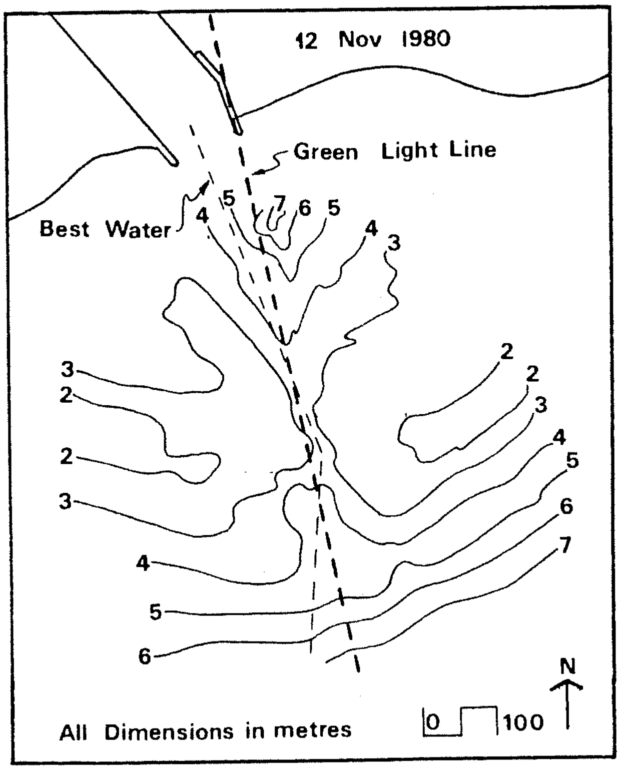


Figure 31. Chart of the Lakes Entrance ocean sand bar showing encroachment into the dredged channel by the western spit (P.W.D., 1978-1983)

5.2 Port Rules

Port Rule (Port of Gippsland Lakes Navigation of Entrance) 1982 (P.W.D., 1982a):

(1) This Rule may be cited as Port Rule (Port of Gippsland Lakes Navigation of Entrance) 1982 and shall be numbered Port Rule 66.

(2) This Rule shall apply only to vessels of less than 40 metres in length overall.

(3) The master of a vessel when departing Cunningham Arm shall keep out of the way of every vessel navigating Reeves Channel.

(4) When two vessels in Reeves Channel are approaching each other on reciprocal or near reciprocal courses at its junction with Cunningham Arm the master of the vessel stemming the tide shall keep out of the way of the vessel proceeding with the tide and nothing in this Rule shall exempt the master of either vessel from complying with the requirements of Rule 39 of the Regulations for Preventing Collisions at Sea (P.W.D., 1983).

(5) The master of a vessel when proceeding to sea and when navigating the waters of the port between the seaward end of the entrance moles and the offshore bar shall keep out of the way of any vessel inward bound into the port.

(6) The master of a vessel navigating the waters of the port between the seaward end of the entrance moles and the seaward (outer) edge of the offshore bar shall maintain a distance of 100 metres astern of any other vessel proceeding in the same direction as his vessel and shall not overtake any vessel proceeding in the same direction as his vessel.

(7) All vessels whether inward or outward bound shall not attempt to pass the dredger "April Hamer" whilst she is dredging between the seaward end of the entrance moles and the outer edge of the seaward bar or engaged in swinging at the landward side of the bar.

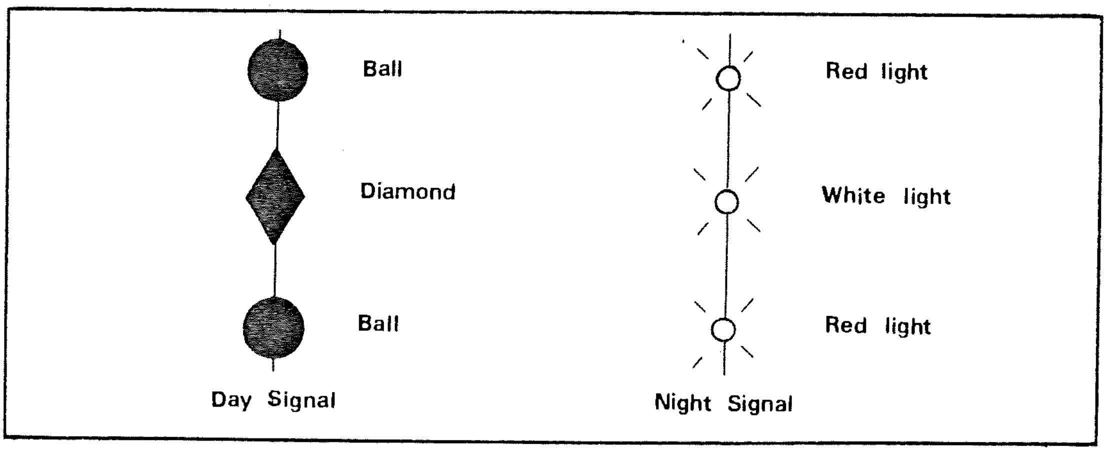


Figure 32. Dredging signal displayed by the dredger *April Hamer*

5.3 Dredger *April Hamer*

The *April Hamer* is a shallow draught, twin screw, trailer suction sidecasting dredger, as shown in Figure 29. Her general dimensions are:

- Length Overall	:	49.5 m	(162 ft)
- Length Load Waterline	:	39.5 m	(130 ft)
- Beam Moulded	:	11.0 m	(36 ft)
- Depth Moulded	:	3.625 m	(12 ft)
- Draught Max.	:	1.75 m	(6 ft)
- Dredging Depth Max.	:	8.23 m	(27 ft)
- Speed (Fully Loaded)	:	9 knots	
- Complement	:	10	

The dredger *April Hamer* can independently steam to any port on the Victorian coast. It is capable of:

- Dredging free running sand or fine compact sand with shell from a minimum of 2 m to a maximum of 8.23 m depth. The twin suction pipes (drag arms) are fitted with swell compensators to prevent excessive vertical movement of draghead in a swell during dredging operation. The dredged material is discharged a distance of 25 m from the ship's side, port or starboard, through the discharge pipe boom.
- Pumping ashore through pipelines when anchored for beach restoration and renourishment programmes.
- Discharge of dredged spoil into hopper barges alongside.

The dredging signals on *April Hamer* are displayed from the masthead, as shown in Figure 32. While in the Lakes Entrance bar area, the dredger crew tunes to SSB channel 2112, and VHF channel 16, and will talk with any boat wishing to navigate the area.

6 THE OPTIONS OF TECHNIQUE FOR SAFE CROSSING OF THE LAKES ENTRANCE OCEAN SAND BAR

This chapter describes the options of technique for displacement and planing hulls for safe crossing of the Lakes Entrance ocean sand bar. It is necessary that the previous chapters have been read. This chapter is not intended to be the final word in ocean sand bar crossing techniques, but is offered to stimulate thought and discussion and to enable the less experienced boat skipper to discuss techniques with experienced and knowledgeable boat operators such as those listed in Chapter 7 Acknowledgments.

6.1 Preliminary Knowledge and Safety Checks

The Lakes Entrance Ports and Harbors Depot provides emergency equipment for boats in trouble. The equipment is stored at the pier on the east side of Bullock Island, and includes:

- Rockets of various sizes which can shoot ropes to a distance of 600 m (2,000 ft).
- Portable 2 inch diameter pumps. There are two at the pier, and another six are available.
- Tow ropes and wires.
- Marine ply for patches.
- Chain, shackles, splitpins etc.

Before attempting to cross the Lakes Entrance ocean sand bar the boat skipper should:

- Satisfy himself that his boat has sufficient stability to cross an ocean sand bar and is seaworthy and capable of taking heavy seas. The boat should have positive steerage (two to three turns lock to lock), and the wheelhouse should have an emergency hatch. Ideally, all compartments should have bilge alarms and the windows should be 10 mm (3/8 in) laminated or armour plate glass held in place by aluminium or steel frames.
- Gain experience in ocean sand bar crossing techniques.
- Obtain local knowledge about the Lakes Entrance ocean sand bar.
- Contact the Officer in Charge at the Lakes Entrance Ports and Harbors Depot (L.E.P.& H.D.) and seek information about the expected sea and weather conditions and the line of best water across the bar.
- Time the trip to Lakes Entrance so as to cross the bar on a flood tide in daylight. Night time crossing should only be attempted by experienced skippers with extensive knowledge of the Lakes Entrance bar.
- Discuss the trip with knowledgeable and experienced local boat operators.

Practices used by experienced and knowledgeable local boat operators are offered for guidance:

- Always have respect for the ocean sand bar.
- Never be in a hurry in a bar port.
- Always notify someone before crossing the bar.
- All crew members must be awake and in the wheelhouse - crewmen on deck may be washed overboard, crewmen below decks may be trapped in the event of a capsize.
- Wear a life jacket if you cannot swim.
- All safety equipment must be in perfect condition and accessible.
- Life jackets should be stored in the wheelhouse within easy reach.
- The liferaft must be attached to the boat with a lanyard, and positioned so that in the event of a capsize it will come free without becoming entangled with the mast or rigging.
- Boats with "wet" wells are not suitable for bar ports. Tanks should be used as an alternative and pumped dry before crossing the bar.
- Never cross the bar with stabilizers down.
- Auto pilots must never be used when crossing the bar.
- Tow ropes must be in good condition.
- Cargo must be secured. If conditions are bad, the fish catch should be stored below deck. A scallop dredge can be tipped back to get it lower.
- The physical, psychological and emotional well being of the skipper is important for clear thinking and quick action. Avoid crossing the bar if you are emotionally upset or affected by alcohol or drugs.

When approaching Lakes Entrance, the boat skipper should radio ahead and determine the line of best water across the bar, and the expected sea conditions on the bar. The radio frequencies at Lakes Entrance are:

- Officer in Charge, L.E.P.& H.D. (Telephone 051 551588)	VHF Channel 16 HF 4645 HF 4535
- Dredger *April Hamer*	VHF Channel 16 HF 2112
- Oil Rigs	VHF Channel 16
- Fishermen's Co-operative (Telephone 051 551688)	HF 4645 HF 4535
- Loch Sport Coast Guard	VHF Channel 16 HF Channels 6 and 7
- Lakes Entrance Coast Guard	VHF Channel 16
- Scallop Boats	HF 2112
- Fishing Boats	HF 2164

- If in doubt about the possibility of crossing safely, go home. Never steam between the piers unless you are prepared to go out the entrance because in some tidal conditions it is impossible to turn the boat around.
- Go out at a slow speed except when there is a flood tide. Keep on the leads and visually determine the position of the channel. If the boat is in breaking seas with waves all around, idle ahead with the bow straight into the waves. The safest position for a boat is perfectly still. On no account let the boat start moving backwards. Nudge into the seas. It is good practice to leave the back door of the wheelhouse open so that if a sea breaks the front windows, the water can flow out the back door.

6.2.2 Inward Bound Displacement Boats

Inward bound operations have resulted in ten of the twelve recorded accidents on the Lakes Entrance ocean sand bar. The inward bound technique for displacement boats, as suggested by experienced and knowledgeable Lakes Entrance boat operators, is:

- Radio ahead and seek information about the condition of the bar and the line of best water.
- Approach the bar and assess the wind, tidal current and sea conditions (an echo sounder can be used to assess wave patterns as referred to in Section 3.3.3). If conditions are too dangerous, stay at sea or go to Port Welshpool.
- If a decision to cross the bar is made, lay off some distance outside the bar and assess the tide drift, taking into account that there may be a very strong cross current. The direction of the ebb current can often be determined by the area of dirty water.
- Position the boat on the leads and visually determine the alignment of the channel. Judge the position from where to start the run so as to be square on to the waves when the boat passes through the gap between the critical spits (as shown in Figures 33 and 34). Use the Flagstaff and beacons to fix this starting position.
- The most dangerous part of the bar is the outer lip.
- Judge the wave pattern and start your run just behind a group of big waves. It is often possible to judge which are the big waves by watching along the individual wave crests to where they break on the upcoast beach.
- Approach the gap at a slow speed with the stern straight to the waves. Wait until you pick up the first wave, then as the bow comes up to horizontal, open full throttle forward. Don't catch the wave (for the reasons described in Chapter 4). When the wave runs away from the boat, maintain full throttle unless it appears that the next wave will catch the boat. If it appears that this will happen reduce throttle to half or less to lose speed.
- Boat speed in relation to wave speed is critical and the appropriate boat speed will require constant throttle adjustment. However, it is essential to keep sufficient power in reserve to be able to increase the water flow across the rudder to maintain steerage if the boat starts to broach when the following wave catches up.

- If the following wave is far behind, increase speed, if the wave is close, slow down. Typical bar crossing speeds for displacement boats at Lakes Entrance are about 2 knots in rough conditions and 4 knots in calm conditions.
- Align the boat on the leads as quickly as possible after negotiating the outer lip. Have one crew member watch the following waves so that most of the skipper's concentration can be on the leads.
- Try to keep on the up wind, up wave or up current side of the channel because if you broach into the side of the channel, you may be washed off or be able to back off.

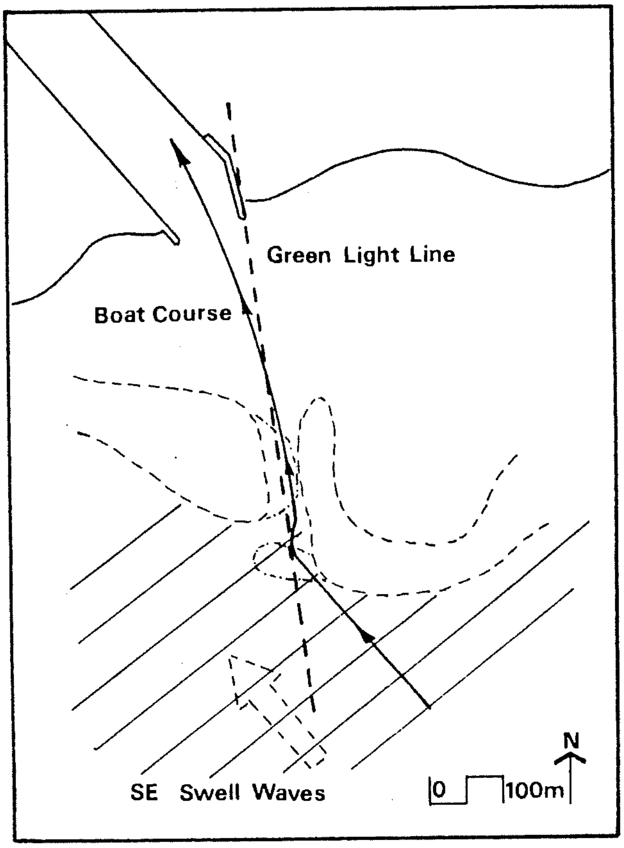


Figure 33. The approach course to the bar for S.E. swell conditions (warning: the ocean sand bar can change alignment daily)

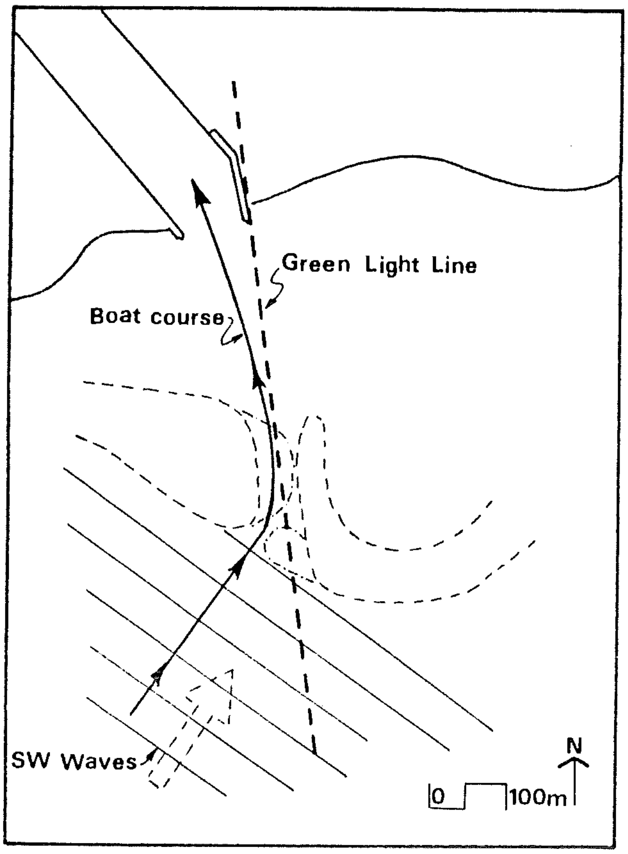


Figure 34. The approach course to the bar for S.W. wave conditions (warning: the ocean sand bar can change alignment daily)

6.3 Techniques for Planing Boats

This section describes small planing boat handling techniques used to cross the Lakes Entrance ocean sand bar. In addition to the preliminary knowledge and safety checks described in Section 6.1 the following also apply to small planing boats.

The motor must be well serviced and running perfectly to negotiate the bar. It must not be misfiring or dropping a cylinder. This can be checked by accelerating to top revs for a short period inside the harbour. Never try to negotiate a bar without reverse gear. Forward and Reverse are important to keep the boat at the correct angle to an approaching breaking wave. If your boat is a half-cabin, check that your exit will not be blocked in an emergency. Life jackets must always be worn.

6.3.1 Outward Bound Planing Boats

The outward bound passage is more dangerous than the inward bound passage for small planing boats because of the increased danger of swamping. The suggested outward bound technique for crossing the Lakes Entrance ocean sand bar is:

- Discuss the line of best water across the bar with local knowledgeable and experienced boat operators and the Officer in Charge of the Lakes Entrance Ports and Harbors Depot.
- If they suggest that the bar is too dangerous for safe crossing, accept their advice.
- If you intend to attempt a crossing motor across to the Flagstaff Jetty, climb over the sand dune to the Flagstaff and observe the conditions on the bar and the channel alignment.
- The bar is most dangerous during the ebb tide, especially in the last two-thirds of the ebb approaching low water at times of full moon.
- It is preferable to go out on the flood tide and return before the tide is ebbing too strongly.
- The skipper must know the limits of his own ability and never be talked into a decision by the crew.
- If in doubt about the possibility of crossing safely, go home.
- Never motor between the piers unless you are prepared to go out the entrance.
- Motor between the pier heads. Wait until there is a calm spot and then go. You are committed to the crossing once you have made a decision to go. Never turn the boat around in front of a curling wave. It is better to meet a wave bow-on rather than beam-on.
- When confronted by a large wave the procedure is to accelerate towards the wave to keep the boat straight. Back off the throttle just before the boat enters the slope of the wave but make sure that the boat stays on the plane.
- Increase the throttle as the boat encounters the wave surge. This will lift the bow and give the power to keep the boat at the correct angle to the wave.
- Back the throttle off slightly as the boat rides over the wave to avoid becoming too airborne and losing control upon re-entry.
- Upon re-entry, accelerate quickly and repeat the procedure if another wave is encountered. During the above procedure the boat must never stop.

6.3.2 Inward Bound Planing Boats

The suggested inward bound technique for small planing boats crossing the Lakes Entrance ocean sand bar is:

- Sit outside the ocean sand bar for 10 or 20 minutes, study the wave pattern and determine the alignment of the channel across the bar. The big waves may be running in groups of two or three.
- When making your run, position the boat on the back of the second or third wave in a group of three. This means that smaller waves are following you and there is less chance that a larger wave will build up behind, and overtake you and the wave that you are on.
- Carefully work the throttle off and on to keep the boat positioned on the back of the wave as shown in Figure 35. Never run over the wave and surf down the front. If you surf down the front, you may broach and be swamped (Hunter, 1978).

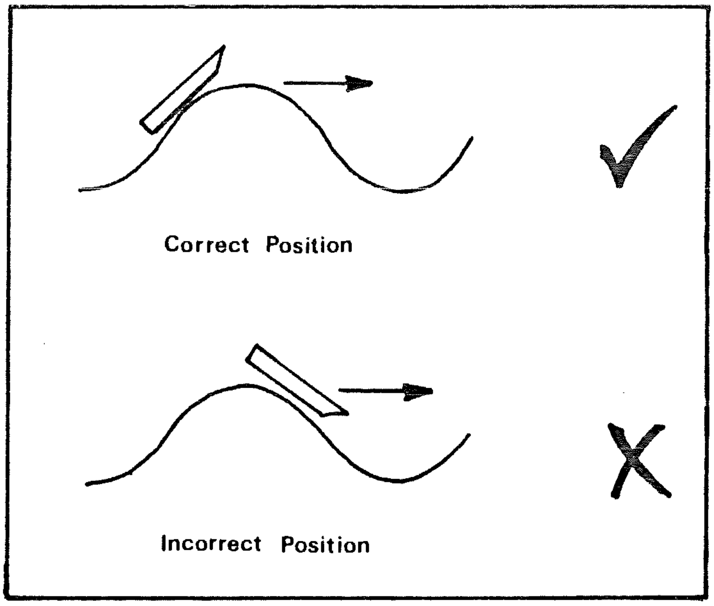


Figure 35. Correct and incorrect inward bound planing boat position on a wave

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SIMPLIFIED

PRESENTATION

OF

STABILITY

FV ... "TAMAR" ...

NOTE: This presentation relates to a prawn trawler of the Success Class, designed and built by Australian Shipbuilding Industries, W.A., who provided the information and drawings from which this book was drawn up.

The information contained is for instruction purposes only.

COMPILED BY ROB LOVELL.

THIS BOOKLET IS NOT TO BE USED FOR OPERATIONAL PURPOSES.

82/50

ERRATA SHEET

Every Displacement Table: Instruction 14) '19E' should read '20E'.

CONTENTS

7. SOUNDING TABLES

7.1 Summary of Tanks and Spaces

Detailed Sounding Tables

8. APPENDICES

Appendix A - Tank Location/Profile Plan

Appendix B - Maximum KG & Trim vs. Displacement & LCG

Appendix C - Blank Displacement Table

Appendix D - Hydrostatic Table

1. INTRODUCTION

The purpose of this book is to assist the Master and all others concerned to load and operate the vessel in such a way as to maintain adequate reserves of stability at all times. The stability of the vessel depends on:

- loading it correctly;
- ensuring that the stability of the vessel is maintained during all operations on board;
- ensuring that the stability is maintained in heavy weather.

Each of these aspects is discussed below.

A stamped, approved copy of this book must be on board at all times. Keep this copy complete and legible. Should it be lost, or become unusable, obtain a replacement copy immediately from the owner (or the Authority).

An excellent introduction to the terms used in stability calculations is contained in the enclosed booklet 'An Introduction to Fishing Vessel Stability', further copies of which are available from:

- National Fishing Industry Training Committee,
  P.O. Box 2851AA,
  MELBOURNE VIC. 3001

2. LOADING

Instructions are given in Section 5 for calculating the vertical centre of gravity corrected for free surface (KGf), and the Longitudinal Centre of Gravity (LCG) of the vessel in any loading condition.

A set of curves has been calculated (Appendix B) showing the trim and limiting KG for this vessel.

Plot the intersection of the LCG and displacement on the curves (Appendix B) and read off the value of the limiting KG. The trim for each condition of loading may also be found from these curves. The criteria for determining the limiting values of trim are:

Limiting trim by the stern = L/15
Limiting trim by the bow = L/45
Minimum freeboard at stern = L/200.

IF THE KGf EXCEEDS THE LIMITING KG EXTRACTED FROM THE CURVES, THE VESSEL'S STABILITY DOES *NOT* MEET THE U.S.L. CODE REQUIREMENTS. THE POSITION OF THE CENTRE OF GRAVITY OF THE VESSEL MUST BE LOWERED BY MOVING WEIGHTS LOWER DOWN IN THE VESSEL OR FILLING TANKS SITUATED LOW DOWN IN THE VESSEL. ALTHOUGH IT WILL NOT SHOW IN THE COMPARISON OF THE VALUE WITH THE CURVES, PRESSING UP SLACK TANKS WILL ALSO HELP BY REDUCING THE FREE SURFACE EFFECT.

2.1 LOADING CONDITIONS

A number of typical loading conditions have been calculated and are shown in Section 6. These conditions may be used as a guide to the stability of the vessel in actual loading conditions. It is recommended, however, that the KG in the actual loading condition be calculated.

A worked example is given in Section 5, to assist in the calculation.

2.2 NOTES ON LOADING CONDITIONS

In Section 6 - Standard Loading Conditions, the vessel's stability has been calculated for nine satisfactory assumed conditions of loading. The vessel is safe for all these conditions. Conditions 4 to 8 all include a stalled winch. The stalling load is located at the point of suspension of the trawl which is assumed to be the point through which the load acts (KG=8.0m,LCG=1.0m aft). Also included in Section 6 are 3 ***Dangerous Conditions.*** These are not recognised loading conditions, but are included to give you an idea of what happens when you snag your gear, or take a wave on deck when the freeing ports are blocked. Comparing Dangerous Condition 1 with Dangerous Condition 2 will give you an idea of the beneficial effect on your vessel's stability of releasing the trawl wire from the trawl block and hauling it over the stern when trying to free a snagged net. The heeling moment is then substantially reduced. The KG of the warp load is then 5.0m, and the LCG 10.0m aft. Dangerous Condition 3 illustrates the effect of a cod end load, blocked freeing ports, and 3 tonnes of water on deck.

3. STABILITY AND ON-BOARD OPERATIONS

3.1 FREE SURFACE EFFECT

Slack tanks have a free surface, the effect of which is to reduce the stability of the vessel. To reduce free surface to a minimum all tanks should be *completely* empty or pressed full, wherever possible, and the number of slack tanks kept to a minimum. The free surface moment (FSM) for each tank is shown on the tank calibration sheet.

Water on deck also has a free surface, the effect of which could be quite large and lead to a significant reduction in stability. It is therefore important to avoid shipping large quantities of water and to allow rapid drainage of water from the deck by keeping freeing ports free of obstruction at all times.

3.2 TANK MANAGEMENT

Below is shown a recommended sequence for the use of liquids in tanks, departure from which may lead to a reduction in stability or an undesirable list or trim. These recommendations should be followed wherever possible. When transferring oil or water by pumping from one tank to another, or ballasting, make every effort to maintain level trim.

Ballasting operations, and transfer of liquid between tanks, should be carried out only in favourable weather conditions.

3.3 RECOMMENDED SEQUENCE OF TANK USAGE

Tank contents should be utilised so as to reduce heel and trimming moments and free surface effects to the greatest possible extent and to maintain the stability of the vessel.

It is recommended that tanks be used in the following order:

Fresh Water	Fuel Oil
Transom Port (6.9)	# 1 FO Stb (10)
Transom Std (6.9)	# 1 FO Port (10)
Fore Peak (4.2)	# 2 FO Stb (13.6)
Total Fresh Water 18	# 2 FO Port (13.6)
	# 3 FO Stb (4.7)
	# 3 FO Port (4.7)
	Total Fuel Oil 56.6

3.4 LIST OR CHANGE IN TRIM

The cause of a gradual or sudden list or change in trim of the vessel should be investigated and rectified promptly.

3.5 PARTICULAR FEATURES OF THIS VESSEL

The sorting tray has a KG of 5.5m, and an LCG of 7.5m aft. The KG and LCG of cargo loaded on the fore and aft decks can be measured from Appendix A at the end of this book, as can the location of the tanks. The loading hatch to the cargo hold is in the centre of the hold. The boxes of prawns should be stowed up to the deckhead, working from both ends of the hold.There is no need then to determine the KG or LCG of the catch.

The values printed on the diagram in 5.3.1 (Fig 1) are then correct.

The transom tanks are not sounded, but are read off the sight glass at the aft Engine Room Bulkhead.

WARNING: The after deck with freeing ports blocked can hold 30 tonnes of water with a KG of 4.5m and LCG of 6.5m. Its free surface moment is 140t.m. Should this happen, an extremely dangerous situation could arise with the vessel having insufficient stability to resist capsizing.

3.5.1 Twin Boom Trawling

A reduction in stability will occur if a trawl is sanded-up or becomes snagged. When attempting to free snagged gear the vessel should be bow-on or stern-on to heavy weather or strong tides (See **Dangerous conditions** - Section 6) The reduction in stability will be minimised if the pull is applied as close to the vessel's centreline and as low as possible.

Attempting to free a snagged net with the block in the normal trawling position will result in a high capsizing moment and may damage the gear.

(Any other features of the vessel with implications for reducing reserves of stability should also be identified and discussed here.)

4. MAINTENANCE OF STABILITY IN HEAVY WEATHER

4.1 WEATHERTIGHT OPENINGS

The vessel's stability has been calculated on the basis that all openings are closed to maintain the weathertight integrity. In heavy weather, all such openings should remain closed and only opened in necessity. In severe conditions all weathertight openings, including doors, hatches and ventilation trunks other than those required for engine aspiration purposes should only be opened with the Master's permission. If opened for access purposes they should be resecured immediately.

4.2 STABILITY IN A SEAWAY

Stability will be reduced when running before a following or quartering sea. In these conditions a vessel may broach. Heavy rolling may cause improperly or loosely-stowed fish, cargo or other items to shift, resulting in a reduction in stability.

4.3 EFFECT OF WIND

High and gusting winds on the beam or quarter will cause the vessel to heel, thus reducing the range of stability and the vessel's ability to resist wave-induced roll.

5. WORKED EXAMPLE

The worked example is calculated for the assumed condition of loading shown in Section 5.2.

5.1 DEFINITIONS

Centre of Gravity

The centre of gravity is the point through which the total weight of the vessel is assumed to act.

KG and KGf

Vertical Centre of Gravity (KG) is the vertical distance of the centre of gravity from the base line. The base line is the line drawn through the lowest part of the keel parallel to the designed water line.

KGf is the Vertical Centre of Gravity corrected for free surface.

KMt

The KMt is the height of the transverse metacentre above the base line. It also happens to be the KGf value at which the vessel develops a capsizing moment and becomes unstable, and will develop an angle of loll. This situation should never be allowed to happen, but if it does, steps must immediately be taken to lower the centre of gravity by removing weights high up, even if it means the jettisoning of deck cargo.

FSM

The Free Surface Moment (FSM) of a partially full fuel oil or water tank is an apparent vertical moment caused by the free surface of the liquid in the tank. The FSM's of all slack tanks are summed and then added to the vertical moment of the vessel. This has the effect of raising the position of the centre of gravity and therefore increases the value of KG to KGf.

LCG

Longitudinal Centre of Gravity (LCG) is the horizontal distance of the centre of gravity from amidships.

LCB

Longitudinal Centre of Buoyancy (LCB) is the horizontal distance of the centre of buoyancy from amidships. The LCB may be likened to the centre of gravity of the under water volume

LCF

Longitudinal Centre of Flotation (LCF) is the horizontal distance of the centre of flotation from amidships. The LCF is the centroid of the waterplane area, and is the point about which the vessel trims.

TPC

Tonnes per Centimetre Immersion (TPC) is the number of tonnes that must be loaded or discharged in order to change the vessel's draft by one centimetre.

MTC

The moment to change the trim of the vessel by one centimetre.

Angles of Flooding

These are angles of heel at which the sill or coamings of openings on or above the freeboard deck and through which progressive down flooding can occur first reach the water level as the vessel heels.

Actual Angle of Flooding

If an opening cannot be closed weathertight at all times when the vessel is under way and progressive down flooding can occur when the sill or coaming of that opening becomes immersed then the heel angle at which this occurs shall be regarded as the actual angle of flooding.

On this vessel, the engineroom air intakes cannot be kept closed and secured at all times when the vessel is under way and progressive down flooding will occur if they become immersed.

Potential Angle of Flooding

If an opening is fitted with a weathertight closing device which can be kept closed and secured at all times when the vessel is under way or at sea, then progressive down flooding can only occur through that opening if the closing device is not closed and secured.

The angle of heel at which the sill or coaming of such an opening becomes immersed shall be regarded as a potential angle of flooding. All openings, through which down flooding can occur if their closing devices are not kept closed and secured, the coamings or lower sills of which immerse at heel angles of 40 degrees or less, must have their closing appliances kept closed and secured at all times when the vessel is under way or at sea.

On this vessel, the engineroom air intakes, which produce the actual flooding angle, and the lowest sill immersion, which produces the potential flooding angle, are situated on the after gantry. Stern trim therefore affects these angles significantly.

NOTE: Where any opening is used for access in the normal working of the vessel, an alternate access should be used in heavy weather. In moderate weather, the opening may be used for access, but the closing appliance must be closed and secured again immediately after use.

Lightship Weight

Lightship weight is the weight (tonnes) of the vessel as delivered from the builder's yard, including all fixed ballast and all fixed equipment such as winches, warps on drums, otter boards and nets but excluding variables such as fuel oil, water, crew and effects, provisions, stores, water in brine tanks and the catch.

In this booklet however, for ease of calculation, the values for the crew and effects, provisions, stores, and water in the brine tanks have been included in the lightship for all the sample conditions. Condition 2, Section 6 shows how this value was calculated.

Deadweight

Deadweight is the total weight (tonnes) of the contents of individual fuel and water tanks, crew and effects, stores, provisions, catch, etc. Each of these items has its own weight, vertical centre of gravity (KG) above the base line and longitudinal centre of gravity (LCG) from amidships, and consequently its own vertical and longitudinal moments.

Displacement

Displacement is the total of the lightship weight and deadweight.

5.2 SAMPLE CONDITION (WORKED EXAMPLE)

5.2.1 Variable Items

Catch	36 tonnes
Cod End	1.5 tonnes
Sorting Tray	1.5 tonnes

5.2.2 Tanks

	Sounding
Fore Peak	0.8m
Transom Port	1.6m
Transom Std	0.0m
# 1 Fuel Oil (P)	0.0m
# 1 Fuel Oil (S)	0.4m
# 2 Fuel Oil (P)	1.4m
# 2 Fuel Oil (S)	0.8m
# 3 Fuel Oil (P)	1.2m
# 3 Fuel Oil (S)	1.1m

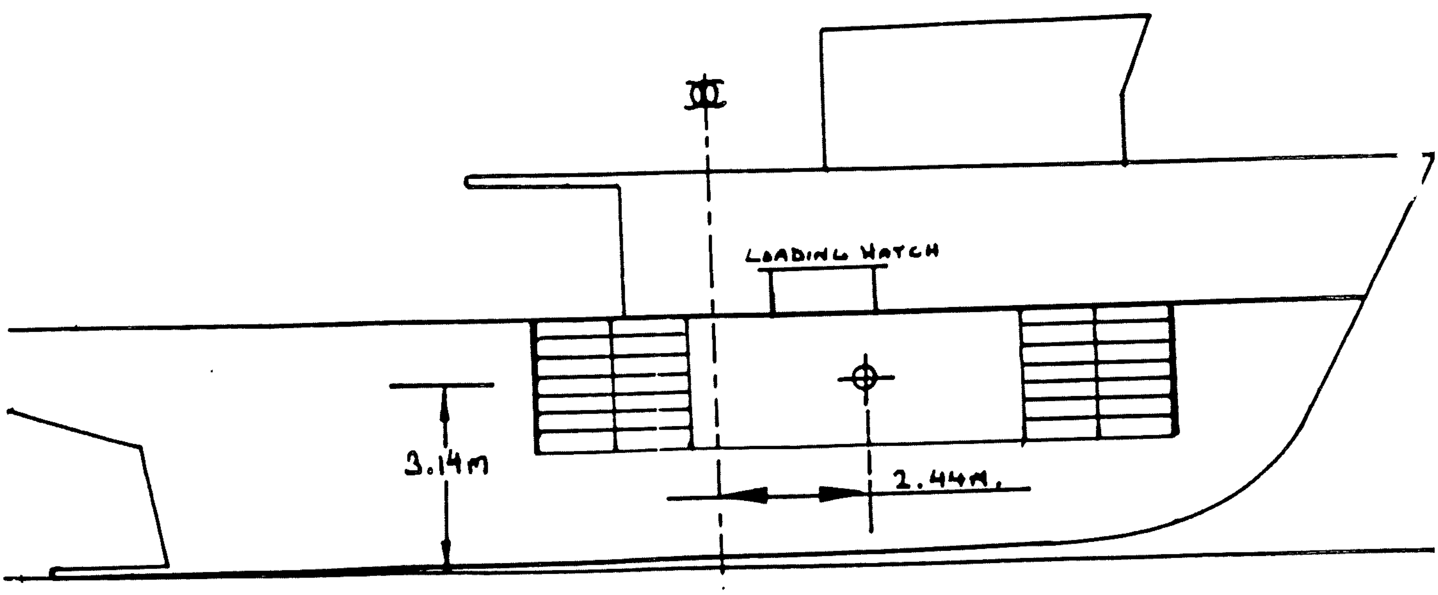
5.3 WEIGHT, KG AND LCG OF ITEMS

5.3.1 Catch

The weight of the catch should be estimated by multiplying the number of boxes by the weight per box. Alternately, estimate the fraction of the hold that is full and multiply it by 48, which is the maximum weight that can be loaded into the hold.

i.e. Three Quarters Full = 0.75 x 48 = 36 tonnes

Figure 1. 1 Loading of Reefer Hold



The hold should be loaded as shown in Figure 1.1, loading at both ends. Otherwise KG's and LCG's must be estimated.

5.3.2 Cod End

The weight of the catch in the cod end is taken to be 1.5 tonnes. The KG and LCG (11.6m & 7.1m Aft) are taken to be at the point of suspension.

5.3.3 Sounding Tables

The sounding tables give Sounding (m), Weight (Capacity x SG of liquid in tank), Vertical Moment (Wt x KG), and Longitudinal Moment (Wt x LCG). Enter the sounding table for the required tank with the sounding of the tank. Extract from the tables the values of weight, Wt x KG and Wt x LCG. Enter these values in the Displacement Table in the appropriate row.

5.4 DISPLACEMENT TABLE

For all stability calculations, use the blank displacement table printed as Appendix C.

Enter in the same table, the values obtained as shown in 5.3.1 to 5.3.3 inclusive.

If any tank is empty, cross out the FSM value for that tank.

5.5 CALCULATION OF DISPLACEMENT, KG AND LCG OF THE VESSEL

Follow the instructions given at the bottom of the table. Each blank cell in the diagram is named according to its row first, then its column. For example, the weight of the catch in the fish hold is written in Cell 12A. Step 1 of the instructions gives the following formula: -

$$16A = 1A + 2A \ldots\ldots 15A$$

This means that the value in Cell 16A (deadweight) is found by adding values in Column A from row 1 to 15.

Step 3 gives the following information: - "10C = 10A x 10B. Now do the same for the rest of Column C".

This means that the Vertical Moment of the Warp/Winch Load is found by multiplying the load by its KG. This is also true for the Fuel and Water Tanks, but since the multiplication has been done for you in the sounding tables, you do not have to do the multiplication for rows 1 - 9.

1) Add up all the values in Column A. This gives the displacement = 206.80

2) Add up all the values in Column C from row 1 to 15, and write the answer in 16C. This is the vertical moment of the Deadweight = 179.29

3) Add up all the values in Column D. This gives the Free Surface moment = 35.8

4) Add the Vertical moments for the Free Surface, Deadweight and Lightship and write the answer in 19C. This is the Vertical Moment corrected for Free Surface = 768.09

$$\text{KGf} = \frac{\text{Vertical Moment}}{\text{Displacement}} \quad \text{(Corrected for Free Surface)}$$

$$= \frac{768.09}{206.8}$$

$$= \underline{3.71\text{m}}$$

5) Add up the values in Column F to get the aft longitudinal moment. Add up the values in column G to get the fwd longitudinal moment. The final longitudinal moment is the difference between the two (18F ~ 18G).

Final Longitudinal Moment = 283.4 (aft) - 89.34(fwd)

= 194.06 (aft)

6) Find the LCG by dividing the final moment (19F) by the displacement (19A).

$$\text{LCG} = \frac{194.06 \quad (19F)}{206.8 \quad (19A)}$$

$$= \underline{0.94\text{m} \quad \text{AFT}}$$

5.6 COMPARISON WITH STABILITY CRITERIA

The values of KGf, LCG and displacement are used by plotting on the curves (Appendix B) in order to determine whether the loading condition satisfies the stability criteria.

5.6.1 Using Appendix B

Draw on the curve a horizontal line corresponding to the vessel's displacement. Draw the vertical line representing the vessel's LCG. On the point of intersection note the Limiting KG. You may also use these curves to obtain the vessel's trim.

The Figure 1.2 below shows how the values of displacement and LCG are plotted on the curves to obtain the limiting KG. The lines of constant trim are also shown on the graph. The trim in this case is about 0.2 metres by the stern. Note that values of trim greater than 0.5m by the head, or 1.5m by the stern are considered to be excessive.

UNDER NO CIRCUMSTANCES SHOULD THE VESSEL BE OPERATED WHEN THE KGf IS GREATER THAN THE LIMITING KG.

In this situation, immediate steps must be taken to lower the centre of gravity. Restow moveable items lower down in the vessel, and press up slack tanks. If this does not achieve the desired effect, it will be necessary to remove some of the weights on deck that are making the vessel unstable.

5.6.2 A Word of Caution

A vessel meeting the criteria may still capsize in very severe weather conditions. It is therefore recommended that the vessel be loaded so that the KG is as low as is practicable. This will give the vessel a reserve of stability to counter any operational factors that may reduce stability. However, it should be borne in mind that an excessively small KG may result in uncomfortable, jerky rolling motion. Such vessels are also prone to synchronous rolling which is also very dangerous.

DISPLACEMENT TABLE - FV TAMAR

Sample Condition - Worked Example

ROW NO.	COLUMN ITEM	A WEIGHT	B KG	C WT x KG	D FSM	E LCG	F AFT (Wt x LCG)	G (Wt x LCG) FWD
1	FORE PEAK FWT	0.3	-----	0.6	1.8	-----	-------	1.5
2	1 FUEL OIL (P)		-----		0.0	-----	-------	
3	1 FUEL OIL (S)	1.2	-----	0.9	7.3	-----	-------	5.3
4	2 FUEL OIL (P)	12.5	-----	17.3	13.6	-----	3.4	-------
5	2 FUEL OIL (S)	5.0	-----	4.9	13.6	-----	1.4	-------
6	3 FUEL OIL (P)	4.7	-----	8.5	2.9	-----	20.5	-------
7	3 FUEL OIL (S)	4.0	-----	6.9	2.9	-----	17.3	-------
8	TRANSOM FWT (P)	0.3	-----	0.8	1.0	-----	2.7	-------
9	TRANSOM FWT (S)		-----		0.0	-----		-------
10	WINCH/WARP LOAD	0.0	8.0	0.0	-----	1.0	0.0	-------
11	COD END LOAD	1.5	11.6	17.4	-----	7.1	10.7	-------
12	FISH HOLD	36.0	3.1	113.0	-----	2.4	-------	87.8
13	SORTING TRAY	1.5	5.5	8.3	-----	7.5	11.3	-------
14					-----			
15								
16	**DEADWEIGHT**	67.0	-----	178.6	43.1	-----	67.2	94.6
17	LIGHTSHIP	146.3	-----	586.3	-----	-----	207.1	-------
18	SUMS OF FWD OR AFT MOMENTS						274.3	94.6
19	**DISPLACEMENT**	**213.3**		808.0			179.6	0.0
20		**KGf**	**3.79**		**LCG**	**0.84**	**AFT**	
21		**LIMITING KG**	**3.97**		**TRIM**	**0.1**	**BY THE STERN**	

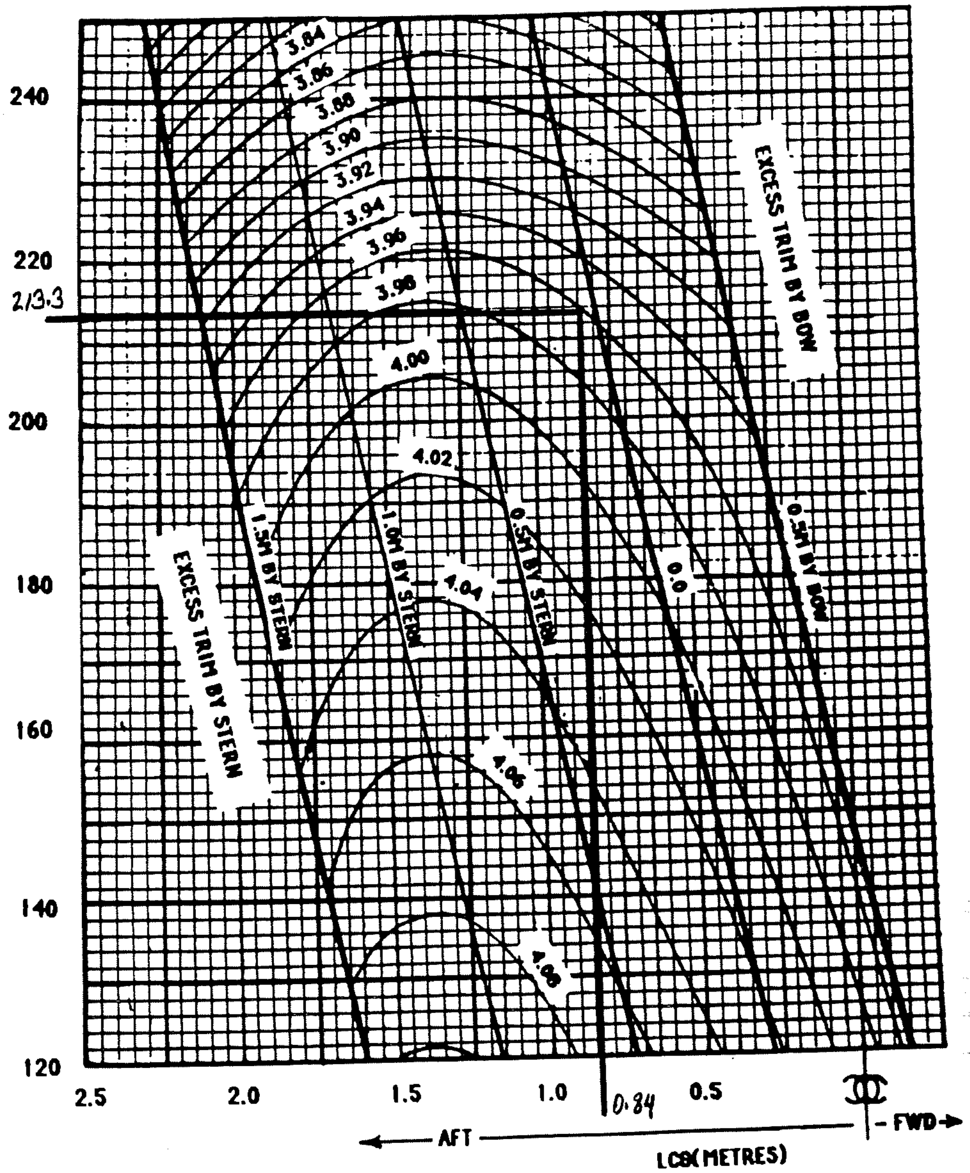
INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows :-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

FIGURE 1.2

MAXIMUM KGf & TRIM vs DISPLACEMENT & LCG



INSTRUCTIONS

1) In the horizontal plane, draw in the line representing the vessel's displacement.
2) In the vertical plane, draw in the line representing the vessel's LCG.
3) Mark the intersection point of these two lines.
4) From the graph read off the value of the Limiting KG.
5) Read off the value of the Trim.
6) **WARNING - IF THE KGf EXCEEDS THE LIMITING VALUE OBTAINED IN 4) ABOVE, THE VESSEL'S STABILITY DOES NOT SATISFY THE USL CODE REQUIREMENTS AND STEPS MUST BE TAKEN TO LOWER THE VESSEL'S CENTRE OF GRAVITY.**

LIMITING KG = 3.96m TRIM = 0.1M BY THE ~~BOW~~/STERN

6. CALCULATED LOADING CONDITIONS

6.1 OPERATING CONDITIONS

The calculated loading conditions that follow are some likely operating conditions that you may encounter. Provided that the vessel is loaded between the extremes, it will have sufficient stability to satisfy the recommended criteria. However, It is recommended that you calculate the stability for each condition of loading.

6.2 DANGEROUS CONDITIONS

Three "Dangerous Conditions" have been calculated. Dangerous Conditions 1 & 2 show the vessel in the same loading condition with a snagged net. In Dangerous Condition 1 an attempt is being made to free the net while the trawl is attached to the trawl block. The vessel has poor stability and this should not be attempted. Dangerous Condition 2 shows the beneficial effect of releasing the trawl block from the boom, and hauling it over the stern when attempting to free the net. In this case the vessel is more stable.

Dangerous Condition 3 is not a recognised Condition of Loading, but is included to give you an idea of the disastrous effect that water on deck can have on your vessel's stability if that water cannot drain away. To avoid this situation, **THE FREEING PORTS MUST NEVER BE BLOCKED, BUT MUST BE KEPT CLEAR AT ALL TIMES.**

DISPLACEMENT TABLE - FV TAMAR

Condition 1 - Lightship

ROW NO.	COLUMN ITEM	A WEIGHT	B KG	C WT x KG	D FSM	E LCG	F AFT (Wt x LCG)	G FWD
1	FORE PEAK FWT		-----			-----	-------	
2	1 FUEL OIL (P)		-----			-----	-------	
3	1 FUEL OIL (S)		-----			-----	-------	
4	2 FUEL OIL (P)		-----			-----		-------
5	2 FUEL OIL (S)		-----			-----		-------
6	3 FUEL OIL (P)		-----			-----		-------
7	3 FUEL OIL (S)		-----			-----		-------
8	TRANSOM FWT (P)		-----			-----		-------
9	TRANSOM FWT (S)		-----			-----		-------
10	WINCH/WARP LOAD		8.00		-----	1		-------
11	FISH HOLD		3.14		-----	2.44	-------	
12	CREW & EFFECTS		6.50		-----	7.7	-------	
13	PROVISIONS		5.10		-----	0.17		-------
14	LUBE OIL		3.50		-----	11		-------
15	BRINE TANK		6.50		-----	0.4	-------	
16	DEADWEIGHT		-----			-----		
17	LIGHTSHIP	140.30	-----	553.00	-----	-----	213.00	-------
18	SUMS OF FWD OR AFT MOMENTS						213.00	0.00
19	DISPLACEMENT	140.30	-----	553.00			213.00	0.00
20		KGf	3.94		LCG	1.52	AFT	
21		LIMITING KG	4.07		TRIM	1.40	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

DISPLACEMENT TABLE - FV TAMAR

Condition 2 - Lightship plus Stores etc.

ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG) FWD	
1	FORE PEAK FWT		-----		0.00	-----	-------	
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)		-----		0.00	-----		-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)		-----		0.00	-----		-------
7	3 FUEL OIL (S)		-----		0.00	-----		-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)		-----		0.00	-----		-------
10	WINCH/WARP LOAD		8.00	0.00	-----	1	0.00	-------
11	FISH HOLD		3.14	0.00	-----	2.44	-------	0.00
12	CREW & EFFECTS	1.5	6.50	9.75	-----	7.7	-------	11.55
13	PROVISIONS	3.00	5.10	15.30	-----	0.17	0.51	-------
14	LUBE OIL	0.50	3.50	1.75	-----	11	5.50	-------
15	BRINE TANK	1.00	6.50	6.50	-----	0.4	-------	0.40
16	DEADWEIGHT	6.00	-----	33.30	0.00	-----	6.01	11.95
17	LIGHTSHIP	140.30	-----	553.00	-----	-----	213.00	-------
18	SUMS OF FWD OR AFT MOMENTS						219.01	11.95
19	DISPLACEMENT	146.30	-----	586.30			207.06	0.00
20		KGf	4.01		LCG	1.42	AFT	
21		LIMITING KG	4.07		TRIM	1.20	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

DISPLACEMENT TABLE - FV TAMAR								
Condition 3 - Departure to Fishing Grounds				- 100% Fuel and Water				
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG)	FWD
1	FORE PEAK FWT	4.20	-----	14.10	1.80	-----	-------	39.00
2	1 FUEL OIL (P)	10.00	-----	14.40	7.30	-----	-------	44.90
3	1 FUEL OIL (S)	10.00	-----	14.40	7.30	-----	-------	44.90
4	2 FUEL OIL (P)	13.60	-----	19.30	13.60	-----	3.70	-------
5	2 FUEL OIL (S)	13.60	-----	19.30	13.60	-----	3.70	-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)	6.90	-----	23.10	1.00	-----	68.90	-------
9	TRANSOM FWT (S)	6.90	-----	23.10	1.00	-----	68.90	-------
10	WINCH/WARP LOAD		8.00	0.00	-----	1	0.00	----- --
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD		3.14	0.00	-----	2.44	-------	0.00
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	74.60	-----	144.70	51.40	-----	186.20	128.80
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						393.26	128.80
19	DISPLACEMENT	220.90	-----	782.40			264.46	0.00
20		KGf	3.54		LCG	1.20	AFT	
21		LIMITING KG	3.96		TRIM	0.40	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

DISPLACEMENT TABLE - FV TAMAR								
Condition 4 - Fishing - First haul					- 90% Fuel and Water with stalled winch			
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG) FWD	
1	FORE PEAK FWT	4.20	-----	14.10	1.80	-----	-------	39.00
2	1 FUEL OIL (P)	10.00	-----	14.40	7.30	-----	-------	44.80
3	1 FUEL OIL (S)	4.34	-----	4.20	7.30	-----	-------	19.50
4	2 FUEL OIL (P)	13.60	-----	19.30	13.60	-----	3.70	-------
5	2 FUEL OIL (S)	13.60	-----	19.30	13.60	-----	3.70	-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)	6.90	-----	23.10	1.00	-----	68.90	-------
9	TRANSOM FWT (S)	6.90	-----	23.10	1.00	-----	68.90	-------
10	WINCH/WARP LOAD	2.50	8.00	20.00	-----	1	2.50	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD	0.00	3.14	0.00	-----	2.44	-------	0.00
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	71.44	-----	154.50	51.40	-----	188.70	103.30
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						395.76	103.30
19	DISPLACEMENT	217.74	-----	792.20			292.46	0.00
20		KGf	3.64		LCG	1.34	AFT	
21	LIMITING KG		3.97		TRIM	0.60	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

DISPLACEMENT TABLE - FV TAMAR

Condition 5- Fishing	- 20% Catch, 80% Fuel and Water with a Stalled Winch							
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG) FWD	
1	FORE PEAK FWT	4.20	-----	14.10	1.80	-----	-------	16.60
2	1 FUEL OIL (P)	10.00	-----	14.40	7.30	-----	-------	44.80
3	1 FUEL OIL (S)	0.00	-----	0.00	0.00	-----	-------	0.00
4	2 FUEL OIL (P)	13.60	-----	19.30	13.60	-----	3.70	-------
5	2 FUEL OIL (S)	13.60	-----	19.30	13.60	-----	3.70	-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)	3.50	-----	10.50	1.00	-----	33.80	-------
9	TRANSOM FWT (S)	6.90	-----	23.10	1.00	-----	68.90	-------
10	WINCH/WARP LOAD	2.50	8.00	20.00	-----	1	2.50	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD	9.60	3.14	30.14	-----	2.44	-------	23.42
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	73.30	-----	167.84	44.10	-----	153.60	84.82
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						360.66	84.82
19	DISPLACEMENT	219.60	-----	798.24			275.84	0.00
20		KGf	3.63		LCG	1.26	AFT	
21		LIMITING KG	3.96		TRIM	0.50	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

DISPLACEMENT TABLE - FV TAMAR								
Condition 6- Fishing	- 50% Catch, 60% Fuel and Water with Stalled Winch							
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG) FWD	
1	FORE PEAK FWT	4.20	-----	14.10	1.80	-----	-------	16.60
2	1 FUEL OIL (P)	0.00	-----	0.00	0.00	-----	-------	0.00
3	1 FUEL OIL (S)	0.00	-----	0.00	0.00	-----	-------	0.00
4	2 FUEL OIL (P)	13.60	-----	19.30	13.60	-----	3.70	-------
5	2 FUEL OIL (S)	0.00	-----	0.00	0.00	-----	0.00	-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)	0.00	-----	0.00	0.00	-----	0.00	-------
9	TRANSOM FWT (S)	3.50	-----	10.50	1.00	-----	33.80	-------
10	WINCH/WARP LOAD	2.50	8.00	20.00	-----	1	2.50	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD	24.00	3.14	75.36	-----	2.44	-------	58.56
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	57.20	-----	156.26	22.20	-----	81.00	75.16
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						288.06	75.16
19	DISPLACEMENT	203.50		764.76			212.90	0.00
20		KGf	3.76		LCG	1.05	AFT	
21		LIMITING KG	4.00		TRIM	0.30	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory.

DISPLACEMENT TABLE - FV TAMAR								
Condition 7 - Fishing	- 80% Catch, 30% Fuel and Water with stalled winch							
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG)	FWD
1	FORE PEAK FWT	4.20	-----	14.10	1.80	-----	-------	39.00
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)	7.20	-----	8.00	13.60	-----	2.00	-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)	6.90	-----	23.10	1.00	-----	68.90	-------
10	WINCH/WARP LOAD	2.50	8.00	20.00	-----	1	2.50	-------
11	COD END LOAD		11.60		-----	7.1	0.00	-------
12	FISH HOLD	38.40	3.14	120.58	-----	2.44	-------	93.70
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	68.60	-----	202.78	22.20	-----	114.40	132.70
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						321.46	132.70
19	DISPLACEMENT	214.90	-----	811.28			188.76	0.00
20		KGf	3.78		LCG	0.89	AFT	
21		LIMITING KG	3.96		TRIM	0.10	BY THE STERN	

INSTRUCTIONS	
THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.	
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the	
sounding tables in columns B and F or G respectively. Then proceed as follows:-	
1) 16A = 1A + 2A .... 15 A	10) 18F = 16F + 17F
2) 19A = 16A + 17A	11) 16G = 1G + 2G 15G
3) 10C = 10A x 10B Now do the same for	12) 18G = 16G
the rest of Column C	13) Obtain the difference between 18F and
4) 16C = 1C + 2C 15C	18G. Write the answer in 19F or 19G
5) 16D = 1D + 2D ... 15D	under the greater of the two values in
6) 19C = 16C + 16D + 17C	18F or 18G. If 18F is the greater value,
7) 20B = 19C / 19A	then the final LCG is aft of midships, other-
8) 10F or 10G = 10A x 10E. If the weight in	wise it is forward.
row 10 is loaded forward of midships, the	14) 19E = (19F or 19G)/19A
value is written in Column G. If the weight is	15) Compare KGf and LCG with limiting
aft of midships, the value is written in Column	values. Determine whether the condition
F. Now do the same for rows 11 to 15.	of loading is satisfactory
9) 16F = 4F + 5F 15F	

DISPLACEMENT TABLE - FV TAMAR

Condition 8 - Departure From Fishing Grounds

- 100% Catch, 20% Fuel and Water with stalled winch.

ROW NO.	COLUMN ITEM	A WEIGHT	B KG	C WT x KG	D FSM	E LCG	F AFT (Wt x LCG)	G FWD
1	FORE PEAK FWT	3.80	-----	12.70	1.80	-----	-------	35.90
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)	1.90	-----	1.30	13.60	-----	0.50	-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)		-----		0.00	-----		-------
10	WINCH/WARP LOAD	2.50	8.00	20.00	-----	1	2.50	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD	48.00	3.14	150.72	-----	2.44	-------	117.12
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	65.60	-----	201.72	21.20	-----	44.00	153.02
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						251.06	153.02
19	DISPLACEMENT	211.90	-----	809.22			98.04	0.00
20		KGf	3.82		LCG	0.46	AFT	
21		LIMITING KG	3.93		TRIM	0.40	BY THE BOW	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the wieght is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory.

DISPLACEMENT TABLE - FV TAMAR

Condition 9 - Arrival in Port | - 100% Catch, 10% Fuel and Water

ROW NO.	COLUMN ITEM	A WEIGHT	B KG	C WT x KG	D FSM	E LCG	F AFT (Wt x	G LCG) FWD
1	FORE PEAK FWT	1.80	-----	5.10	1.80	-----	-------	16.60
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)		-----		0.00	-----		-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	0.60	-----	0.90	2.90	-----	2.50	-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)		-----		0.00	-----		-------
10	WINCH/WARP LOAD		8.00	0.00	-----	1	0.00	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD	48.00	3.14	150.72	-----	2.44	-------	117.12
13	SORTING TRAY	5.5		-----	7.5		-------	
14								
15								
16	DEADWEIGHT	60.60	-----	165.22	15.10	-----	23.00	133.72
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						230.06	133.72
19	DISPLACEMENT	206.90	-----	766.62			96.34	0.00
20		KGf	3.71		LCG	0.47	AFT	
21	LIMITING KG		3.94		TRIM	0.30	BY THE BOW	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.

Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory.

DISPLACEMENT TABLE - FV TAMAR								
Dangerous Condition 1- Fishing		- 20% Fuel and Water, with Snagged Net (attached to trawl bloc						
WARNING!		DO NOT ALLOW THIS TO OCCUR!						
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG)	FWD
1	FORE PEAK FWT	3.80	-----	12.70	1.80	-----	-------	35.90
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)	1.90	-----	1.30	13.60	-----	0.50	-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)		-----		0.00	-----		-------
10	WINCH/WARP LOAD	6.70	8.00	53.60	-----	1	6.70	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD	0.00	0.00	0.00	-----	0	-------	0.00
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	21.80	-----	84.60	21.20	-----	48.20	35.90
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						255.26	35.90
19	DISPLACEMENT	168.10		692.10			219.34	0.00
20		KGf	4.12		LCG	1.30	AFT	
21		LIMITING KG	4.05		TRIM	0.80	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory.

DISPLACEMENT TABLE - FV TAMAR								
Dangerous Condition 2 - Fishing			- 20% Fuel and Water, with Snagged Net (block released)					
WARNING!	DO NOT ALLOW THIS TO OCCUR!							
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG)	FWD
1	FORE PEAK FWT	3.80	-----	12.70	1.80	-----	-------	35.90
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)	1.90	-----	1.30	13.60	-----	0.50	-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)		-----		0.00	-----		-------
10	WINCH/WARP LOAD	6.50	5.00	32.50	-----	10	65.00	-------
11	COD END LOAD		11.60	0.00	-----	7.1	0.00	-------
12	FISH HOLD		0.00	0.00	-----	0	-------	0.00
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15								
16	DEADWEIGHT	21.60	-----	63.50	21.20	-----	106.50	35.90
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						313.56	35.90
19	DISPLACEMENT	167.90		671.00			277.66	0.00
20		KGf	4.00		LCG	1.65	AFT	
21	LIMITING KG		4.04		TRIM	1.25	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory.

DISPLACEMENT TABLE - FV TAMAR								
Dangerous Condition 3 - Fishing								
- 20% Catch, 20% Fuel and Water, with Cod End load, blocked freeing ports, and wave on deck.								
WARNING!		DO NOT ALLOW THIS TO OCCUR!						
ROW	COLUMN	A	B	C	D	E	F	G
NO.	ITEM	WEIGHT	KG	WT x KG	FSM	LCG	AFT (Wt x LCG) FWD	
1	FORE PEAK FWT	3.80	-----	12.70	1.80	-----	-------	35.90
2	1 FUEL OIL (P)		-----		0.00	-----	-------	
3	1 FUEL OIL (S)		-----		0.00	-----	-------	
4	2 FUEL OIL (P)	1.90	-----	1.30	13.60	-----	0.50	-------
5	2 FUEL OIL (S)		-----		0.00	-----		-------
6	3 FUEL OIL (P)	4.70	-----	8.50	2.90	-----	20.50	-------
7	3 FUEL OIL (S)	4.70	-----	8.50	2.90	-----	20.50	-------
8	TRANSOM FWT (P)		-----		0.00	-----		-------
9	TRANSOM FWT (S)		-----		0.00	-----		-------
10	WINCH/WARP LOAD	0.00	8.00	0.00	-----	1	0.00	-------
11	COD END LOAD	1.50	11.60	17.40	-----	7.1	10.65	-------
12	FISH HOLD	9.60	3.14	30.14	-----	2.44	-------	23.42
13	SORTING TRAY		5.5		-----	7.5		-------
14								
15	WATER ON DECK	30.00	4.50	135.00	140.00	6.5	195	-------
16	DEADWEIGHT	56.20	-----	213.54	161.20	-----	247.15	59.32
17	LIGHTSHIP	146.30	-----	586.30	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS						454.21	59.32
19	DISPLACEMENT	202.50		961.04			394.89	0.00
20		KGf	4.75		LCG	1.95	AFT	
21		LIMITING KG	3.96		TRIM	1.40	BY THE STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.
Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, other-wise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory.

7. SOUNDING TABLES

7.1 SUMMARY OF TANKS AND SPACES

Preceding the Sounding Tables is a summary showing the maximum values for each tank or space.

7.2 DETAILED SOUNDING TABLES

These tables show the Soundings (or sight glass readings), Weights, Vertical Moments, and Longitudinal Moments for each tank.

For the transom tanks, the reading is for a sight glass. Thus the weight in the tank increases as the reading decreases.

FV TAMAR
SUMMARY OF TANKS AND SPACES

SPACE	CONTENTS	WEIGHT	KG	LCG	FSM
FORE PEAK	FRESH WATER	4.2	3.39	9.4 F	1.8
TRANSOM (P)	FRESH WATER	6.9	3.34	9.99 A	1.0
TRANSOM (S)	FRESH WATER	6.9	3.34	9.99 A	1.0
	MAXIMUM FW	18.0			
# 1 FUEL OIL (P)	FUEL OIL	10.0	1.44	4.49 F	7.3
# 1 FUEL OIL (S)	FUEL OIL	10.0	1.44	4.49 F	7.3
# 2 FUEL OIL (P)	FUEL OIL	13.6	1.42	0.27 A	13.6
# 2 FUEL OIL (S)	FUEL OIL	13.6	1.42	0.27 A	13.6
# 3 FUEL OIL (P)	FUEL OIL	4.7	1.82	4.4 A	2.9
# 3 FUEL OIL (S)	FUEL OIL	4.7	1.82	4.4 A	2.9
	MAXIMUM FO	56.6			
FISH HOLD	FISH IN BOXES	48.0	3.14	2.44 F	

- FORE PEAK FRESH WATER TANK - FSM = 1.8 t.m. SG = 1.0

SOUNDING (METRES)	WEIGHT IN TANK (TONNES)	VERTICAL MOMENT Wt x KG (t.m.)	LONG'AL MOMENT Wt x LCG (t.m.)
0.2	0.0	0.0	0.2
0.4	0.1	0.1	0.6
0.6	0.2	0.3	1.5
0.8	0.3	0.6	2.5
1.0	0.4	0.9	3.8
1.2	0.6	1.4	5.7
1.4	0.9	2.2	8.2
1.6	1.2	3.1	11.1
1.8	1.6	4.4	14.5
2.0	2.0	5.8	18.7
2.2	2.5	7.7	23.6
2.4	3.1	10.0	29.3
2.6	3.8	12.7	35.9
2.8	4.2	14.1	39.0

- TRANSOM FRESH WATER TANK (PORT OR STB) - FSM = 1.0 t.m. SG = 1.0

SIGHT GLASS READING	WEIGHT IN TANK (TONNES)	VERTICAL MOMENT Wt x KG (t.m.)	LONG'AL MOMENT Wt x LCG (t.m.)
0.2	6.9	23.1	68.9
0.4	5.7	18.5	57.0
0.6	4.6	14.3	45.3
0.8	3.5	10.5	33.8
1.0	2.4	6.9	22.8
1.2	1.5	4.0	13.2
1.4	0.8	2.0	6.9
1.6	0.3	0.8	2.7
1.8	0.1	0.1	0.5

- NO.1 FUEL OIL (PORT OR STB) - FSM = 7.3t.m. SG = 0.85

SOUNDING (METRES)	WEIGHT IN TANK (TONNES)	VERTICAL MOMENT Wt x KG (t.m.)	LONG'AL MOMENT Wt x LCG (t.m.)
0.2	0.5	0.3	2.1
0.4	1.2	0.9	5.3
0.6	2.2	2.0	9.9
0.8	3.6	3.6	15.8
1.0	5.2	5.8	23.0
1.2	7.0	8.9	31.4
1.4	9.1	12.7	40.9
1.6	10.0	14.4	44.8

- NO.2 FUEL OIL (PORT OR STB) - FSM = 13.6t.m. SG = 0.85

SOUNDING (METRES)	WEIGHT IN TANK (TONNES)	VERTICAL MOMENT Wt x KG (t.m.)	LONG'AL MOMENT Wt x LCG (t.m.)
0.1	0.6	0.3	0.2
0.2	0.9	0.5	0.3
0.3	1.4	0.9	0.4
0.4	1.9	1.3	0.5
0.5	2.6	2.0	0.7
0.6	3.3	2.7	0.9
0.7	4.1	3.7	1.2
0.8	5.0	4.9	1.4
0.9	6.1	6.3	1.7
1.0	7.2	8.0	2.0
1.1	8.4	9.9	2.3
1.2	9.8	12.2	2.6
1.3	11.1	14.2	3.0
1.4	12.5	17.3	3.4
1.5	13.6	19.3	3.7

- NO.3 FUEL OIL (PORT OR STB) - FSM = 2.9t.m. SG = 0.85

SOUNDING (METRES)	WEIGHT IN TANK (TONNES)	VERTICAL MOMENT Wt x KG (t.m.)	LONG'AL MOMENT Wt x LCG (t.m.)
0.1	0.0	0.0	0.1
0.2	0.1	0.1	0.3
0.3	0.2	0.2	0.7
0.4	0.4	0.5	1.4
0.5	0.6	0.9	2.5
0.6	1.0	1.4	4.0
0.7	1.5	2.2	6.0
0.8	2.0	3.1	8.3
0.9	2.6	4.3	11.1
1.0	3.3	5.5	14.1
1.1	4.0	6.9	17.3
1.2	4.7	8.5	20.5

8. APPENDICES

The Appendices are provided for your information. It is recommended that you make use of them where necessary.

8.1 APPENDIX A - TANK LOCATION/PROFILE PLAN

From this plan you can see the location of each tank. The graduated horizontal and vertical scales allow you to obtain the KG and LCG for a weight loaded anywhere on the vessel. The points of suspension for the trawl and the cod end load are shown, as is the location of the sorting tray. With a pair of dividers measure the distance that the weight is loaded from midships. Using the horizontal scale you can then obtain its LCG in metres. In a similar manner you can obtain its KG.

8.2 APPENDIX B - MAXIMUM KG & TRIM VS DISPLACEMENT & LCG CURVES

These curves allow you to obtain the vessel's Trim and Limiting KG for any displacement and LCG. Mark off the displacement on the vertical scale and lightly draw a horizontal through this point. In a similar manner draw the vertical line representing the vessels LCG. At the intersection point of these two lines, read off the value of the Limiting KG, and the Trim. Instructions are printed beneath the curves.

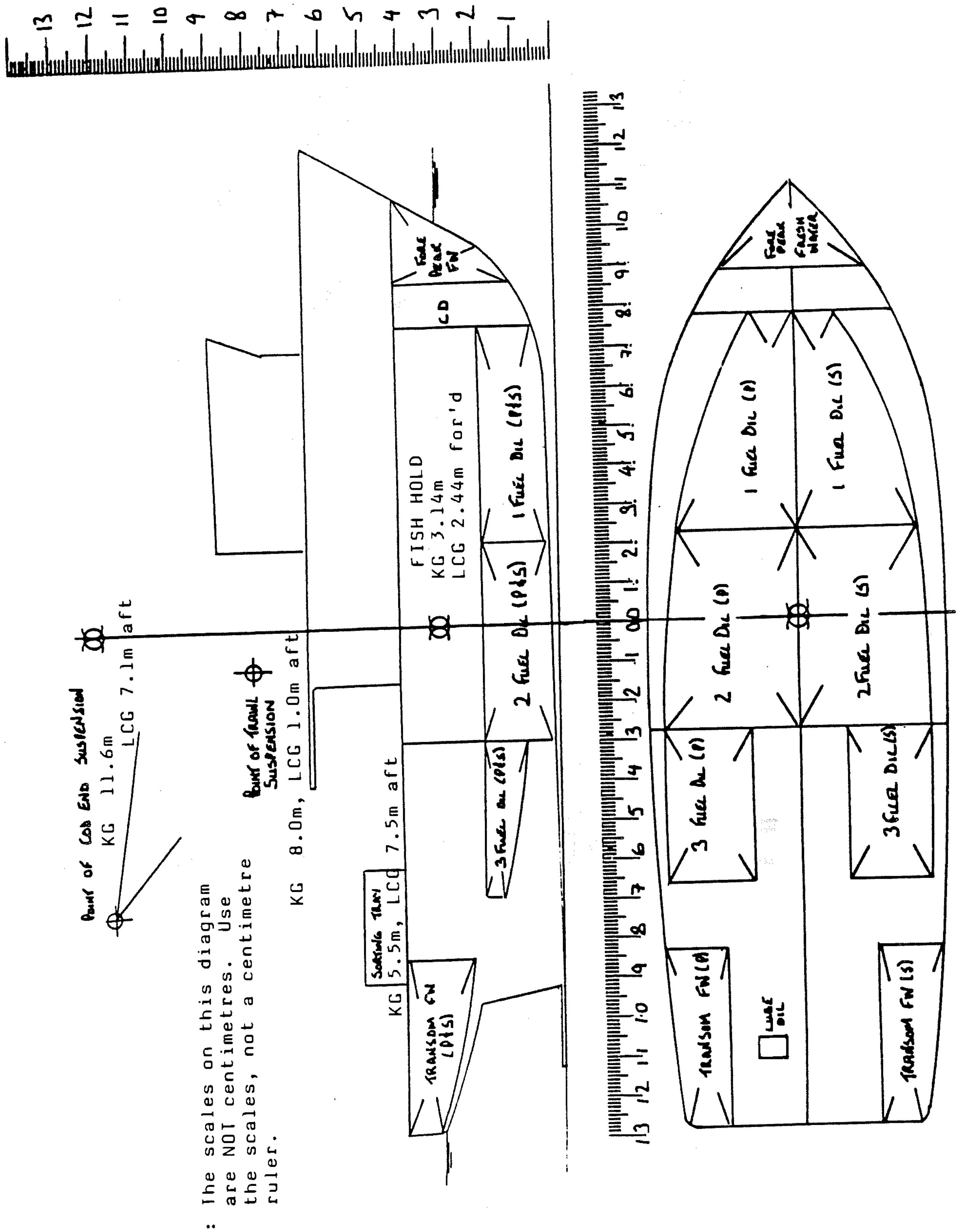
8.3 APPENDIX C - BLANK DISPLACEMENT TABLE

This blank table is provided for you to use when you calculate the vessel's stability. It is suggested that you make photocopies of the table so that you can do your own calculations.

8.4 APPENDIX D - HYDROSTATIC TABLE

This table allows you to obtain the draft at any displacement, the TPC, MTC, LCB, LCF, and the KM. You will not need this information in order to assess the stability of your vessel if you are using the simplified method. However,the information is included so that the vessel's stability can be calculated by traditional methods, if so required.

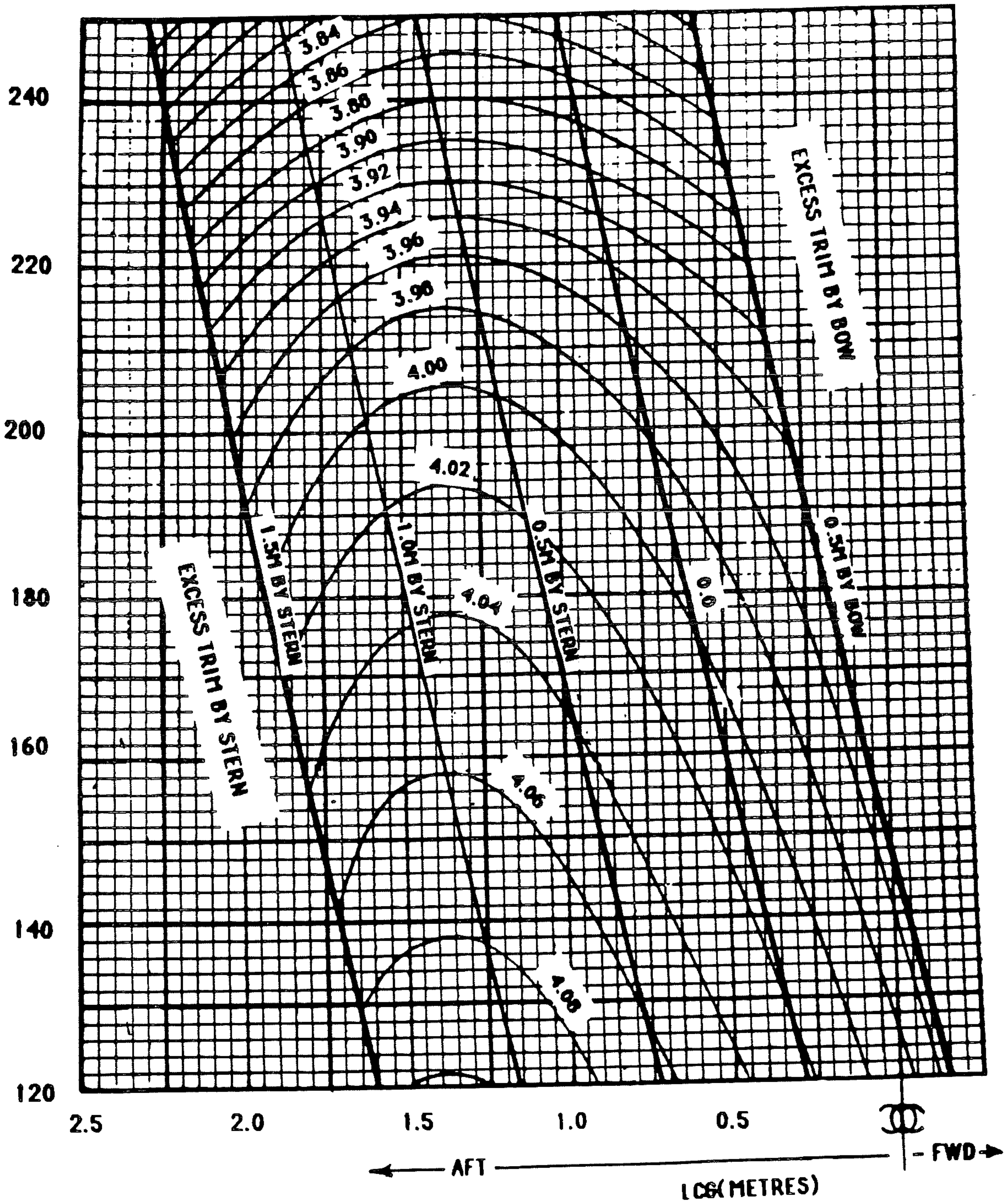
APPENDIX A



NOTE: The scales on this diagram are NOT centimetres. Use the scales, not a centimetre ruler.

APPENDIX B

MAXIMUM KGf & TRIM vs DISPLACEMENT & LCG



INSTRUCTIONS

1) In the horizontal plane, draw in the line representing the vessel's displacement.
2) In the vertical plane, draw in the line representing the vessel's LCG.
3) Mark the intersection point of these two lines.
4) From the graph read off the value of the Limiting KG
5) Read off the value of the Trim.
6) **WARNING - IF THE KGf EXCEEDS THE LIMITING VALUE OBTAINED IN 4) ABOVE, THE VESSEL'S STABILITY DOES NOT SATISFY THE USL CODE REQUIREMENTS AND STEPS MUST BE TAKEN TO LOWER THE VESSEL'S CENTRE OF GRAVITY.**

LIMITING KG = TRIM = BY THE BOW/STERN

APPENDIX C

DISPLACEMENT TABLE - FV TAMAR

DATE ..../......./....... VOYAGE.........................

ROW NO.	COLUMN ITEM	A WEIGHT	B KG	C WT x KG	D FSM	E LCG	F AFT (Wt x LCG)	G FWD
1	FORE PEAK FWT		-----		1.8	-----	-------	
2	1 FUEL OIL (P)		-----		7.3	-----	-------	
3	1 FUEL OIL (S)		-----		7.3	-----	-------	
4	2 FUEL OIL (P)		-----		13.6	-----		-------
5	2 FUEL OIL (S)		-----		13.6	-----		-------
6	3 FUEL OIL (P)		-----		2.9	-----		-------
7	3 FUEL OIL (S)		-----		2.9	-----		-------
8	TRANSOM FWT (P)		-----		1	-----		-------
9	TRANSOM FWT (S)		-----		1	-----		-------
10	WINCH/WARP LOAD		2.5		-----	1		-------
11	COD END LOAD		11.6		-----	7.1		-------
12	FISH HOLD		3.14		-----	2.44	-------	
13	SORTING TRAY		5.5		-----	7.5		-------
14					-----			
15								
16	DEADWEIGHT		-----			-----		
17	LIGHTSHIP	146.3	-----	586.3	-----	-----	207.06	-------
18	SUMS OF FWD OR AFT MOMENTS							
19	DISPLACEMENT		-----					
20		KGf			LCG		AFT/FWD	-------
21		LIMITING KG			TRIM		BY THE BOW/STERN	

INSTRUCTIONS

THE CELLS IN THE DISPLACEMENT TABLE ARE REFERRED TO BY ROW FIRST, THEN COLUMN.

Enter the respective weights in Column A. Enter the Vertical and Longitudinal moments from the sounding tables in columns B and F or G respectively. Then proceed as follows:-

1) 16A = 1A + 2A .... 15 A
2) 19A = 16A + 17A
3) 10C = 10A x 10B Now do the same for the rest of Column C
4) 16C = 1C + 2C 15C
5) 16D = 1D + 2D ... 15D
6) 19C = 16C + 16D + 17C
7) 20B = 19C / 19A
8) 10F or 10G = 10A x 10E. If the weight in row 10 is loaded forward of midships, the value is written in Column G. If the weight is aft of midships, the value is written in Column F. Now do the same for rows 11 to 15.
9) 16F = 4F + 5F 15F
10) 18F = 16F + 17F
11) 16G = 1G + 2G 15G
12) 18G = 16G
13) Obtain the difference between 18F and 18G. Write the answer in 19F or 19G under the greater of the two values in 18F or 18G. If 18F is the greater value, then the final LCG is aft of midships, otherwise it is forward.
14) 19E = (19F or 19G)/19A
15) Compare KGf and LCG with limiting values. Determine whether the condition of loading is satisfactory

APPENDIX D

FV TAMAR

HYDROSTATIC TABLES

Draft	Displac.	T.P.C.	M.C.T.	L.C.B.	L.C.F.	KMl
2.4	128	1.16	1.13	-0.32	-0.98	4.84
2.5	139	1.20	1.24	-0.38	-1.13	4.78
2.6	152	1.24	1.35	-0.45	-1.28	4.72
2.7	169	1.28	1.46	-0.52	-1.44	4.67
2.8	177	1.31	1.58	-0.60	-1.60	4.62
2.9	190	1.35	1.71	-0.67	-1.75	4.58
3.0	204	1.38	1.84	-0.75	-1.90	4.55
3.1	218	1.41	1.93	-0.83	-1.98	4.52
3.2	232	1.44	2.03	-0.91	-2.06	4.49
3.3	247	1.46	2.12	-0.97	-2.14	4.46
3.4	261	1.47	2.15	-1.04	-2.11	4.43
3.5	276	1.48	2.18	-1.09	-2.07	4.40
3.6	291	1.49	2.22	-1.15	-2.04	4.39