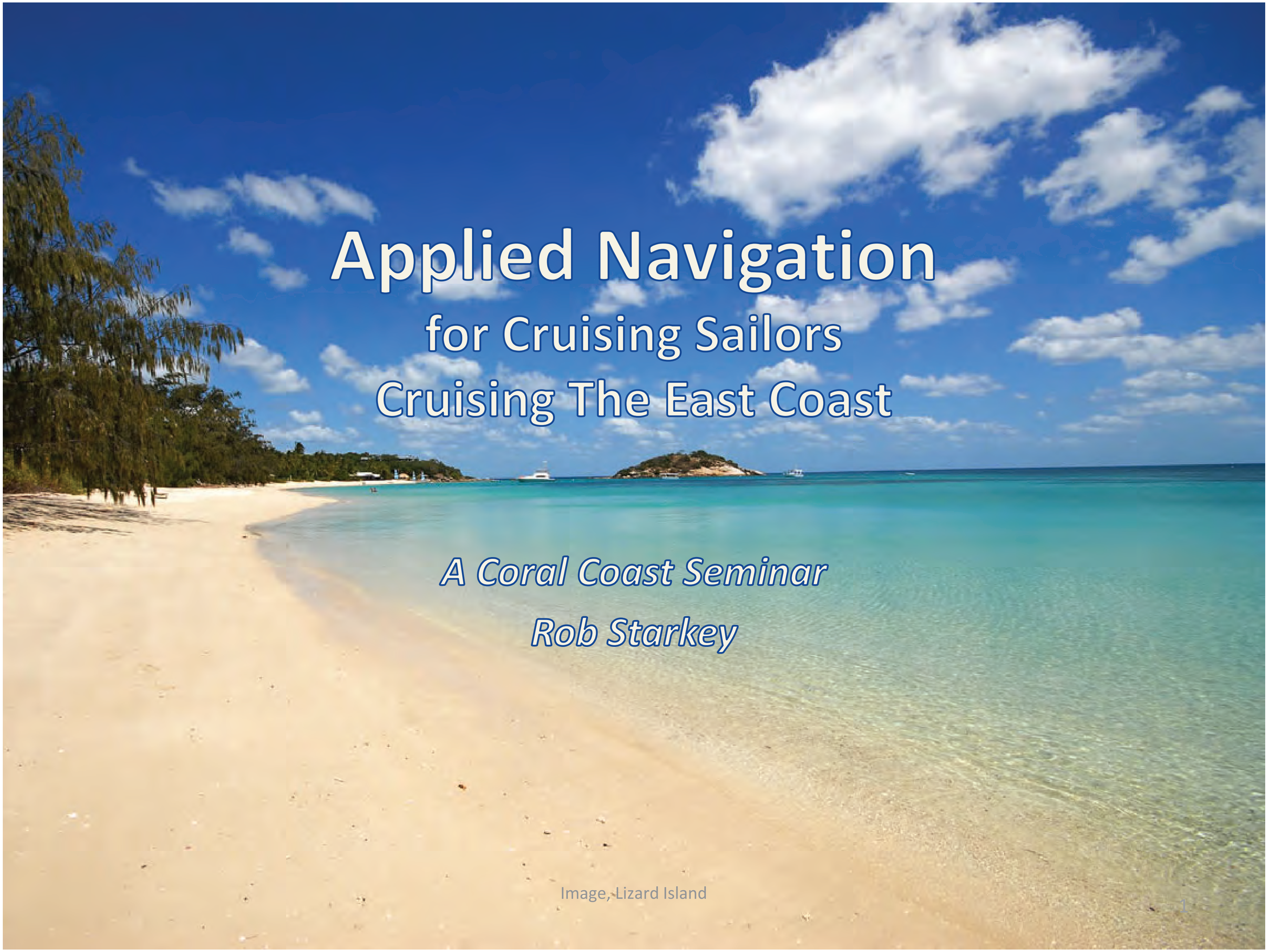


Applied Navigation

for Cruising Sailors
Cruising The East Coast

A Coral Coast Seminar

Rob Starkey

Image, Lizard Island

Context

Applied Navigation

Coastal cruising, Lizard Island to Hobart

Mostly down wind sailing

Long passage days, with minimum average SOG

Mostly motor sailing the rhumb line

- 20% sailing, 60% motor sailing, 20% motoring

No adaptive weather routing

Assumptions

- Charts covering intended cruising area (including ports)
- Charting instruments
- Steering (binnacle) compass
- Hand held compass and emergency steering compass
- Fixed GPS and Chart plotter
- Hand held GPS
- Ship’s Log
- Pilots and other references covering area

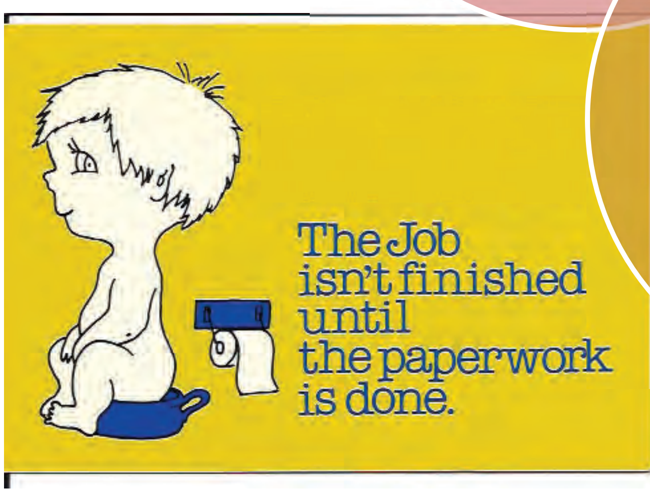
How We Navigate

All of us use electronic navigation

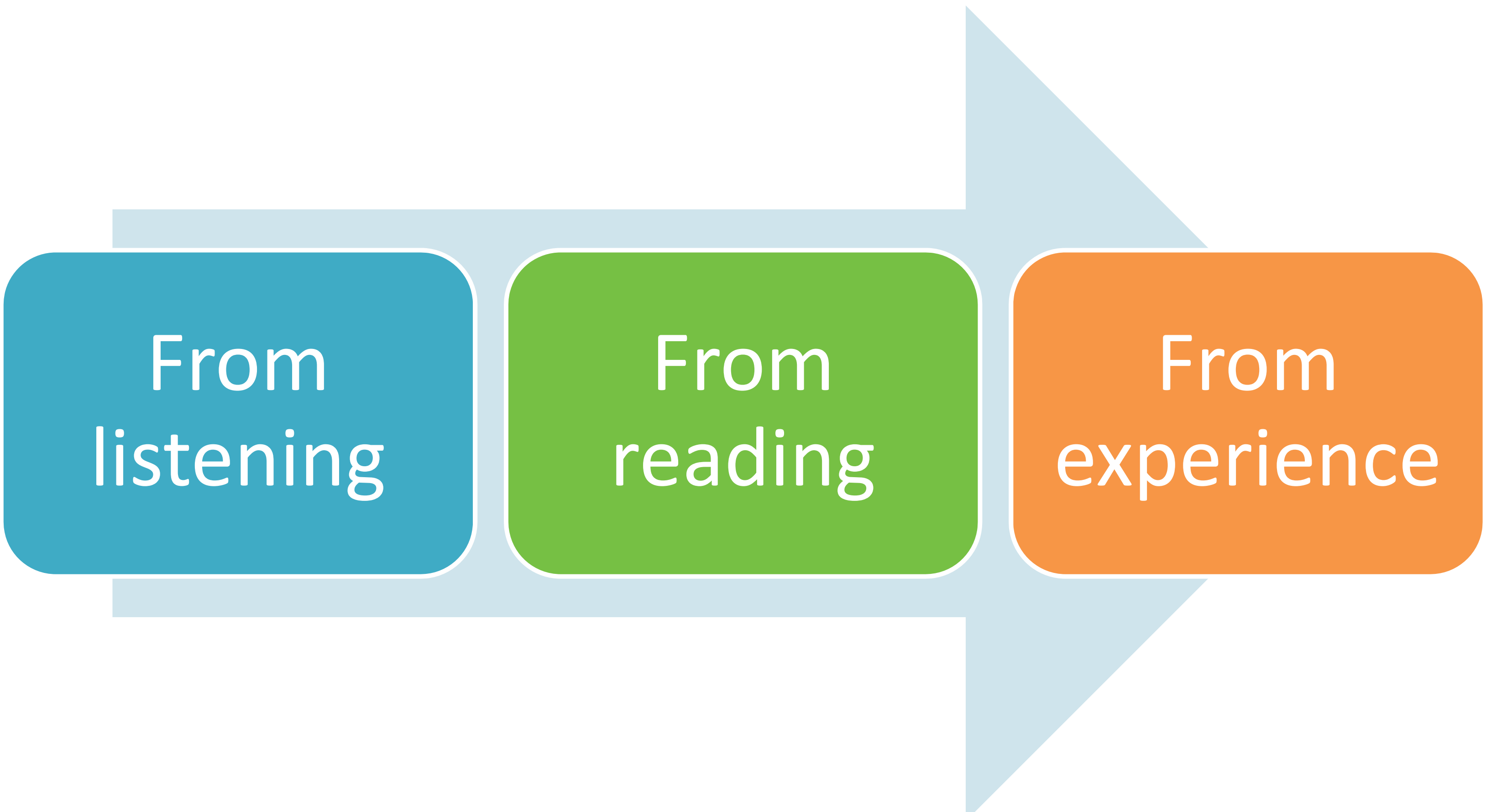
We all carry the regulation paper charts

Some of us use paper charts

Some of us use a Ship's Log



How We Learn



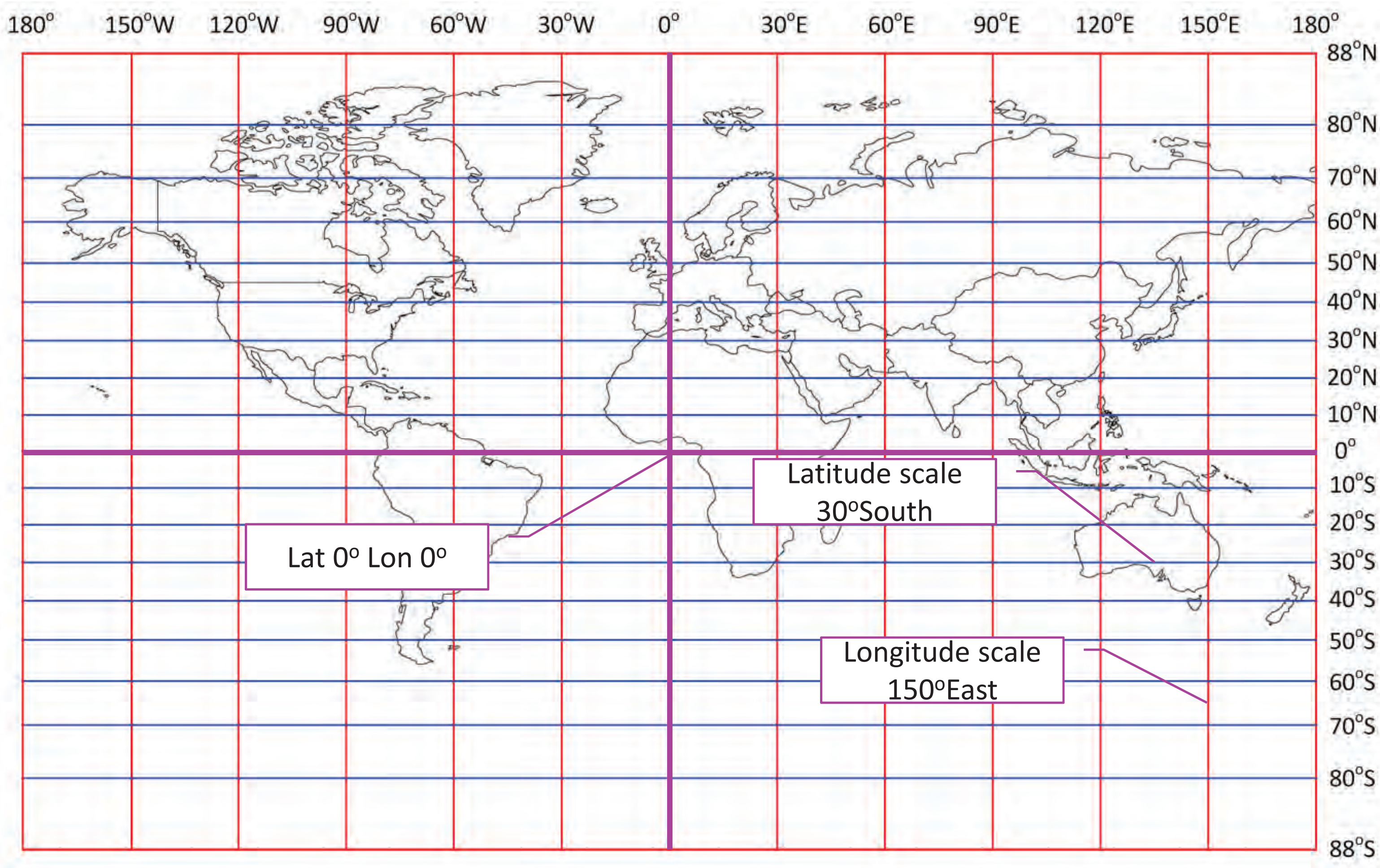
Scope

A Navigation Architecture

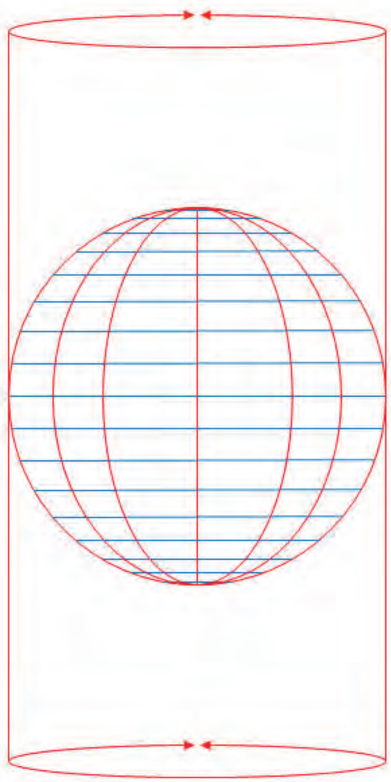
Useful Information
Navigation Methodology
Passage Planning
Instruments, GPS, Plotters, Radar
Conventional Charting
Depth and Tides
Compass Errors and Correction
Distance and Direction
Primary Navigation Inputs
Aids to Navigation
Chart Basics and Maintenance

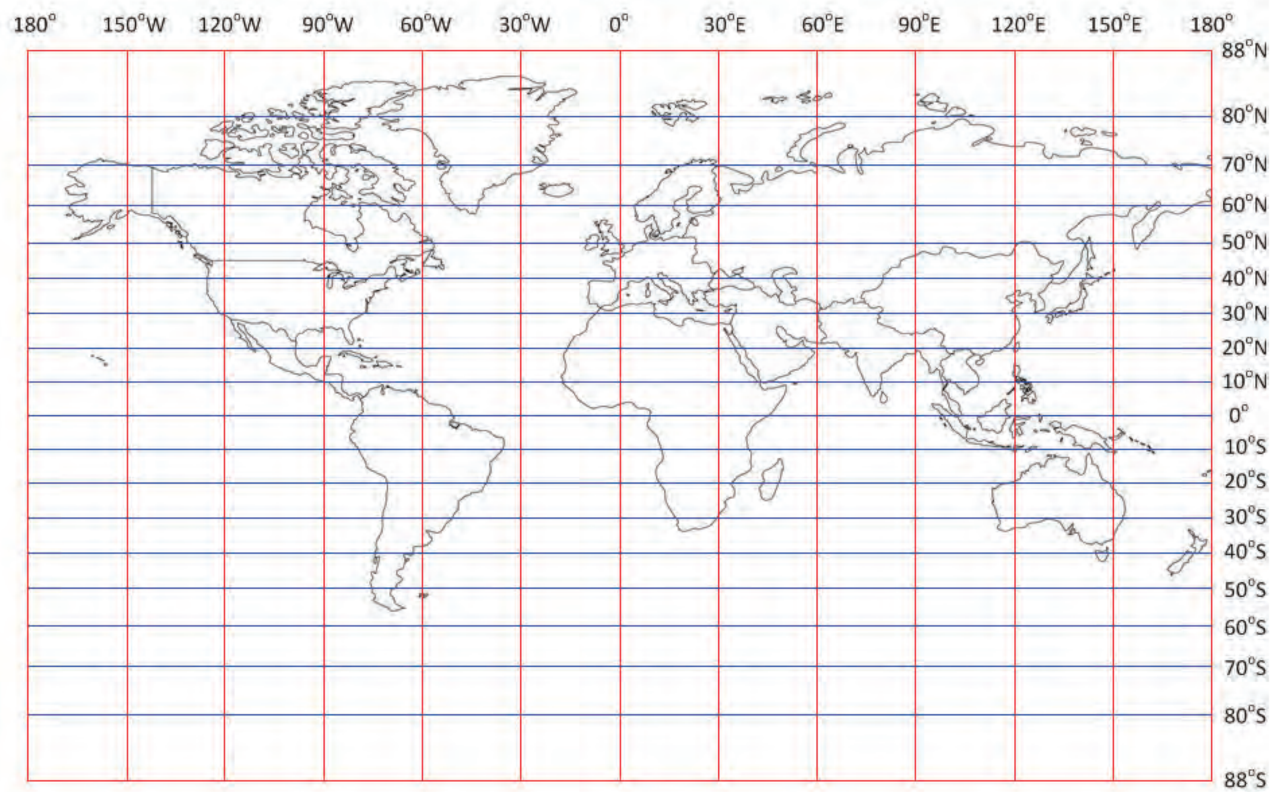
We start here

Mercator Chart



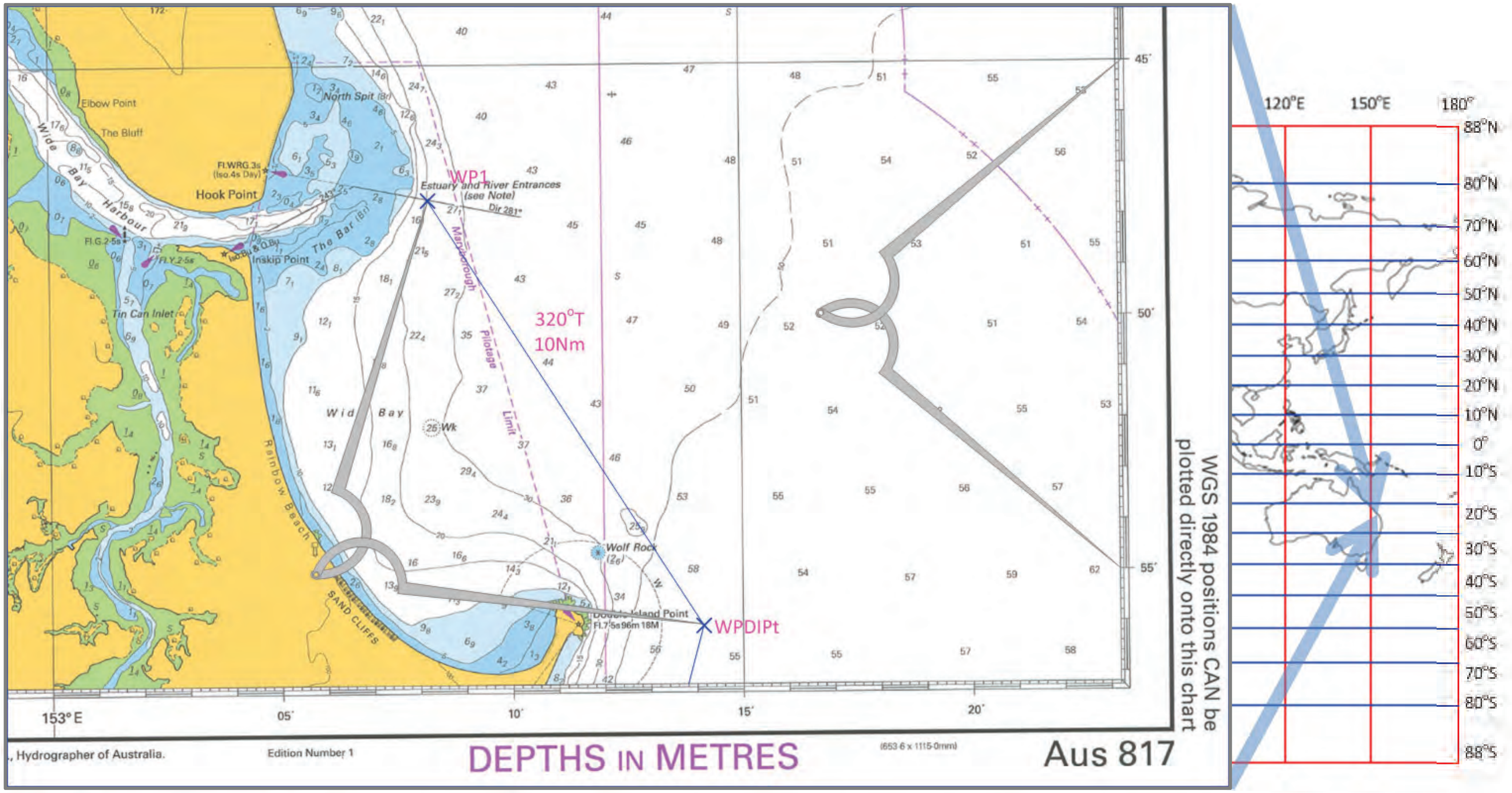
Mercator Projection





Parallel scaling factor = $1/\cos \alpha$, where α= angle of latitude

Why Mercator Projection



Parallel scaling factor = 1/cos α, where α= angle of latitude

Marine Chart

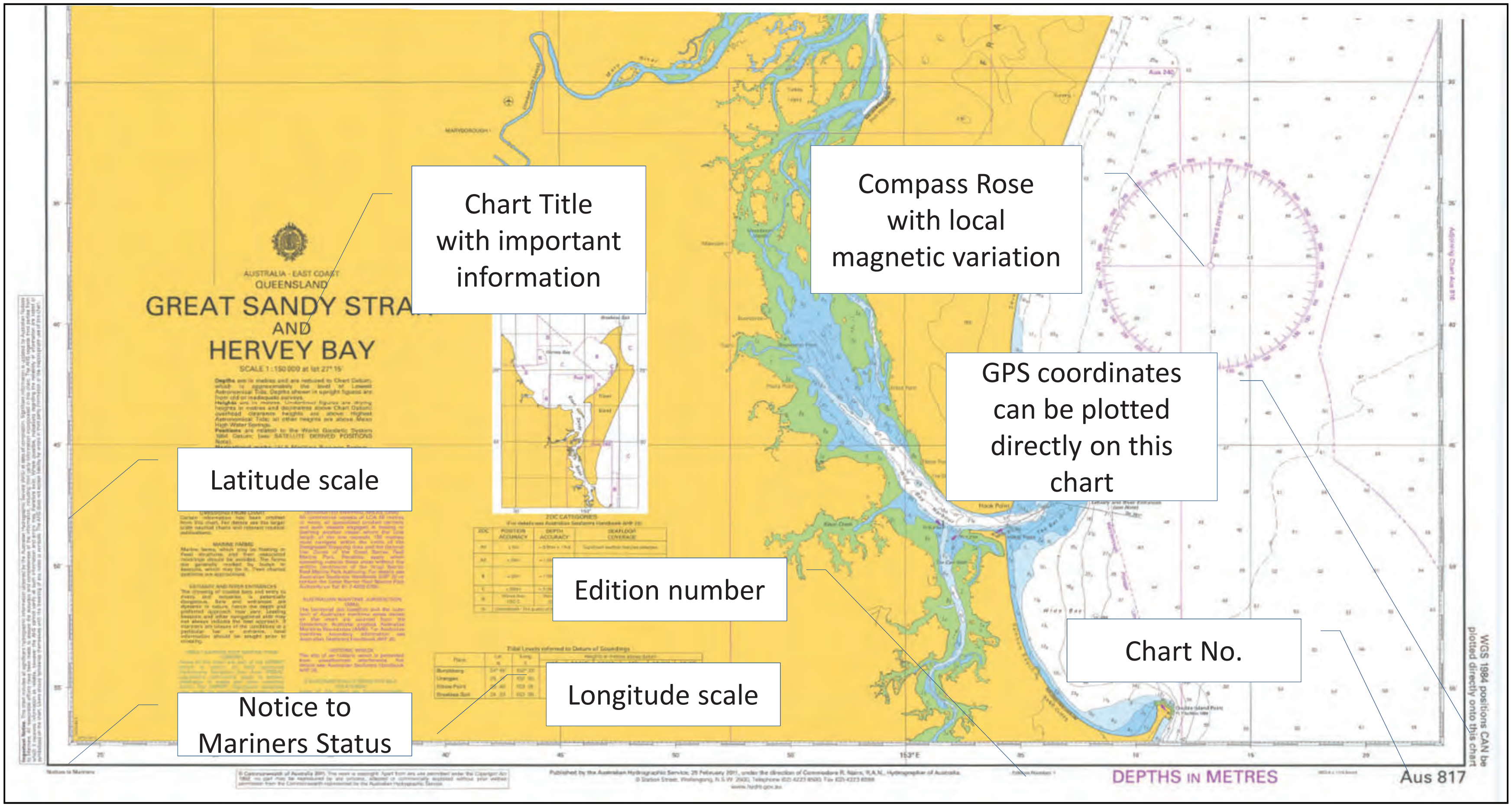
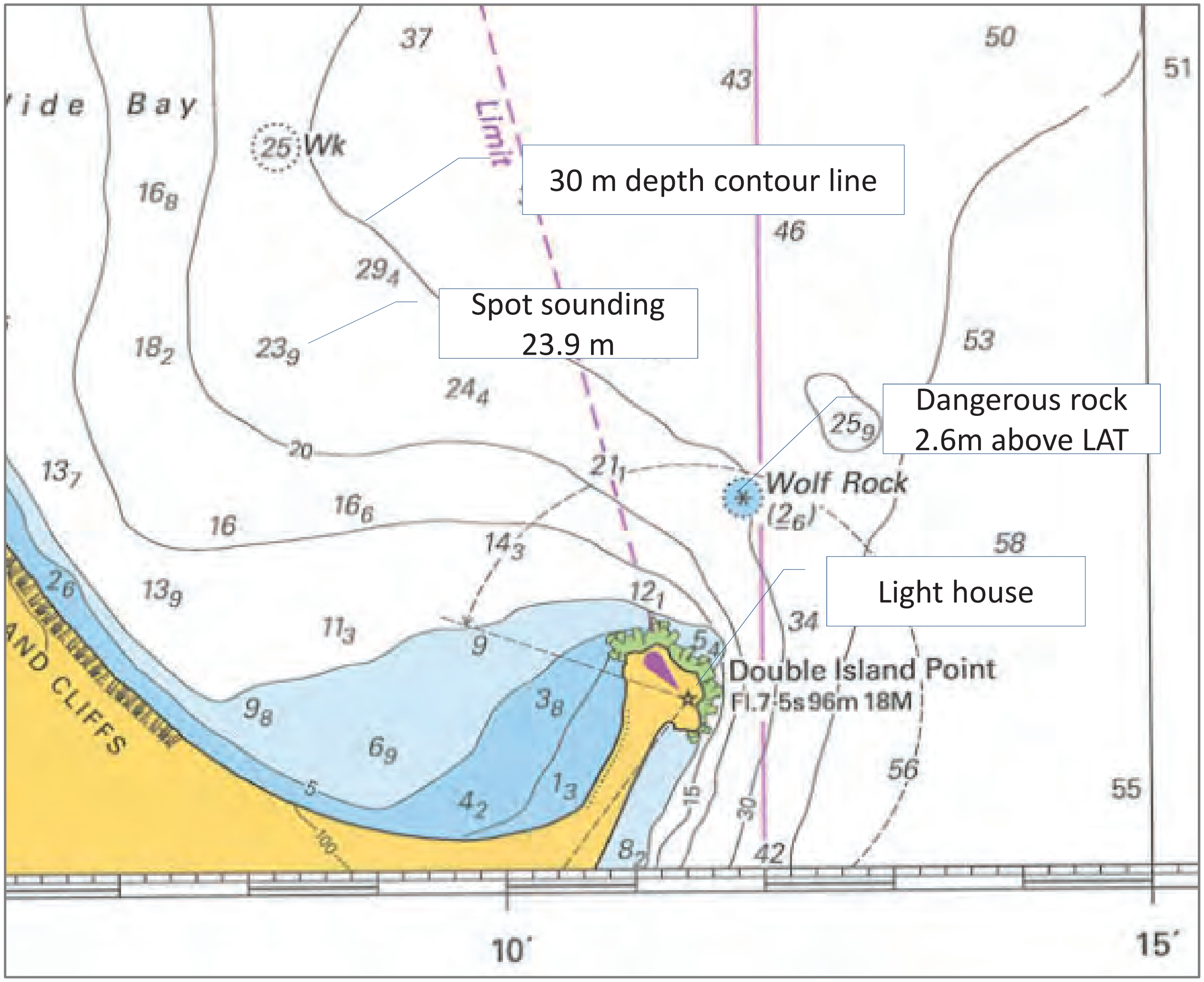
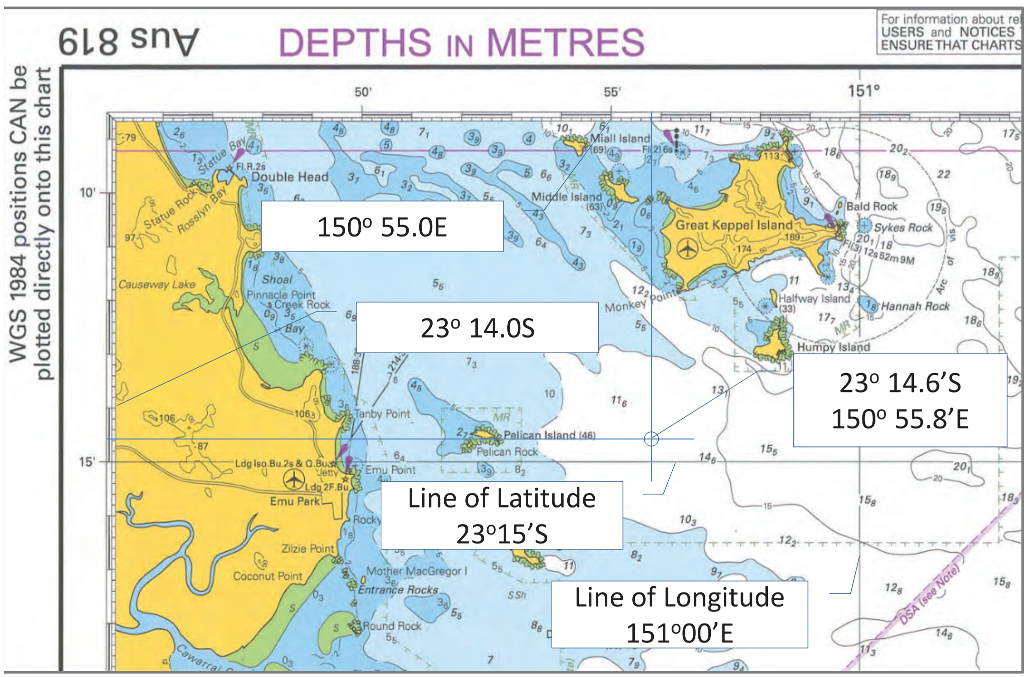


Chart Detail



Position

- Positions defined by horizontal lines (latitude or parallels) and vertical lines (longitude or meridians)
- Latitude measured in degrees, 0° to 90°,North or South of equator
- Longitude measured in degrees 0° to 180°, East or West of Greenwich



- A degree is divided into 60 minutes ('), each minute is divided into decimals
- Example of a position;

Lat 23° 14.6'S

Lon 150° 55.8'E

Chart Maintenance

www.hydro.gov.au

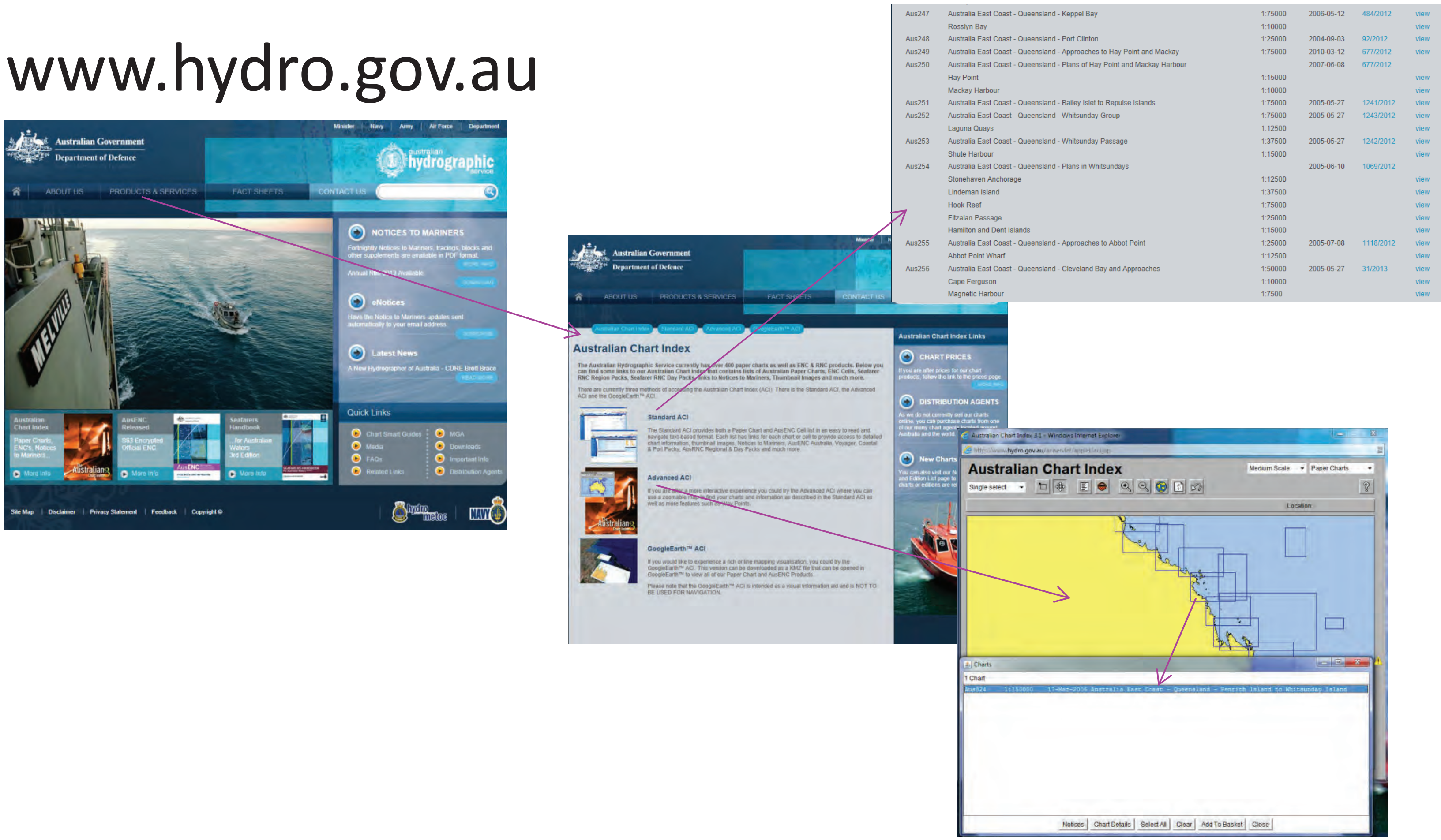
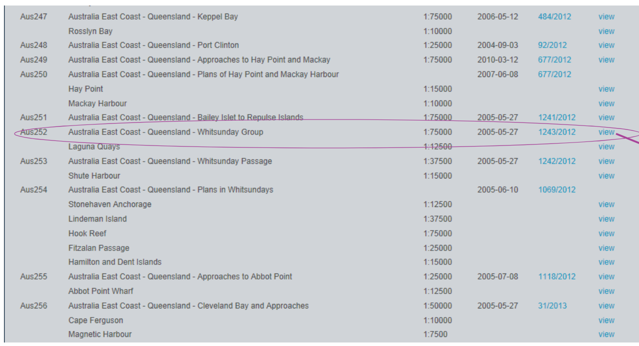


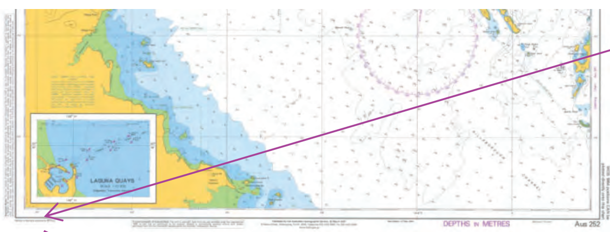
Chart Maintenance

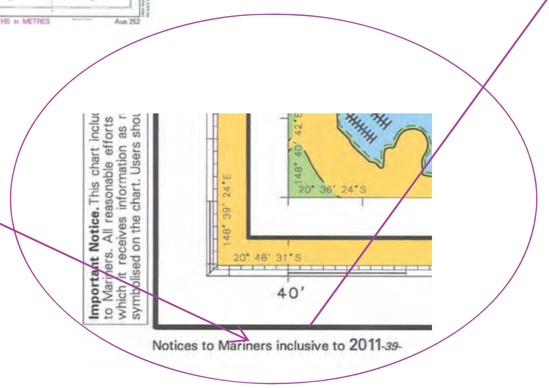
Notice to Mariners Status for AUS 252



Aus247	Australia East Coast - Queensland - Keppel Bay	1:75000	2006-05-12	484/2012	view
	Rosslyn Bay	1:10000			view
Aus248	Australia East Coast - Queensland - Port Clinton	1:25000	2004-09-03	92/2012	view
Aus249	Australia East Coast - Queensland - Approaches to Hay Point and Mackay	1:75000	2010-03-12	677/2012	view
Aus250	Australia East Coast - Queensland - Plans of Hay Point and Mackay Harbour		2007-06-08	677/2012	
	Hay Point	1:15000			view
	Mackay Harbour	1:10000			view
Aus251	Australia East Coast - Queensland - Bailey Islet to Repulse Islands	1:75000	2005-05-27	1241/2012	view
Aus252	Australia East Coast - Queensland - Whitsunday Group	1:75000	2005-05-27	1243/2012	view
	Laguna Quays	1:12500			view
Aus253	Australia East Coast - Queensland - Whitsunday Passage	1:37500	2005-05-27	1242/2012	view
	Shute Harbour	1:15000			view
Aus254	Australia East Coast - Queensland - Plans in Whitsundays		2005-06-10	1069/2012	
	Stonehaven Anchorage	1:12500			view
	Lindeman Island	1:37500			view
	Hook Reef	1:75000			view
	Fitzalan Passage	1:25000			view
	Hamilton and Dent Islands	1:15000			view
Aus255	Australia East Coast - Queensland - Approaches to Abbot Point	1:25000	2005-07-08	1118/2012	view
	Abbot Point Wharf	1:12500			view
Aus256	Australia East Coast - Queensland - Cleveland Bay and Approaches	1:50000	2005-05-27	31/2013	view
	Cape Ferguson	1:10000			view
	Magnetic Harbour	1:7500			view

Outstanding Notices





www.hydro.gov.au

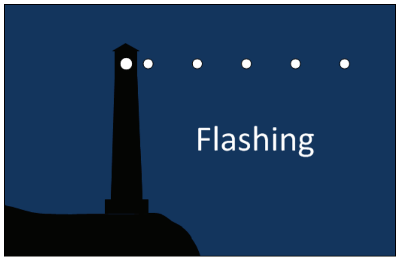
Chart Maintenance

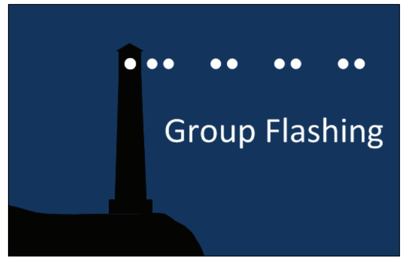
When updating charts, make sure you are applying Notice to Mariners changes to the intended chart version.

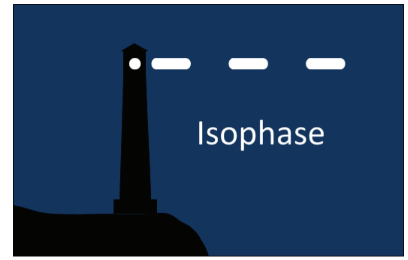
If applying stick-on, make sure chart datums align.

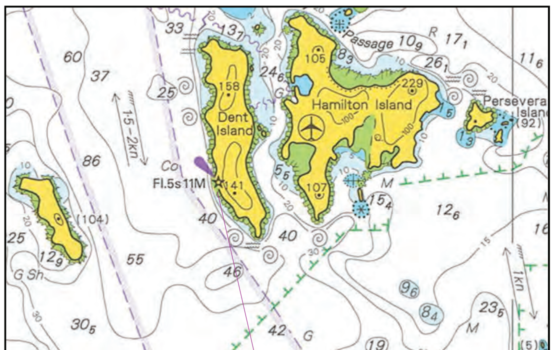
Aids to Navigation

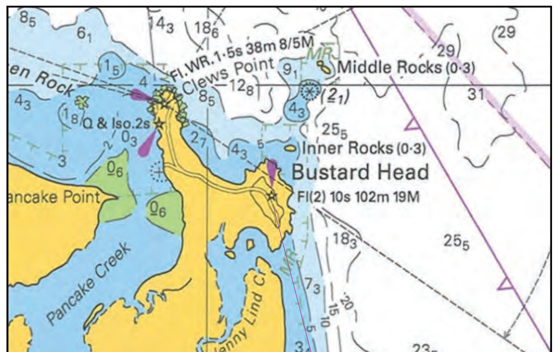
Lights

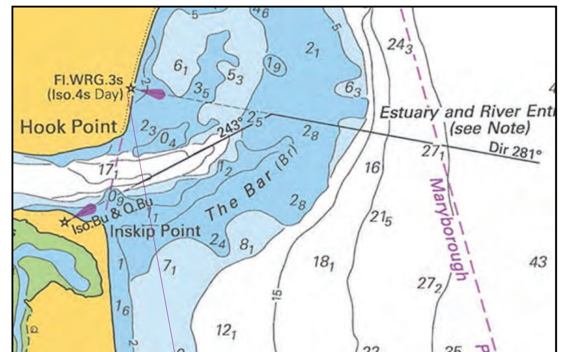












Flashing every 5 seconds, 11 nm vis

Group (2) flashing every 10 seconds, 102m high, 19 nm vis

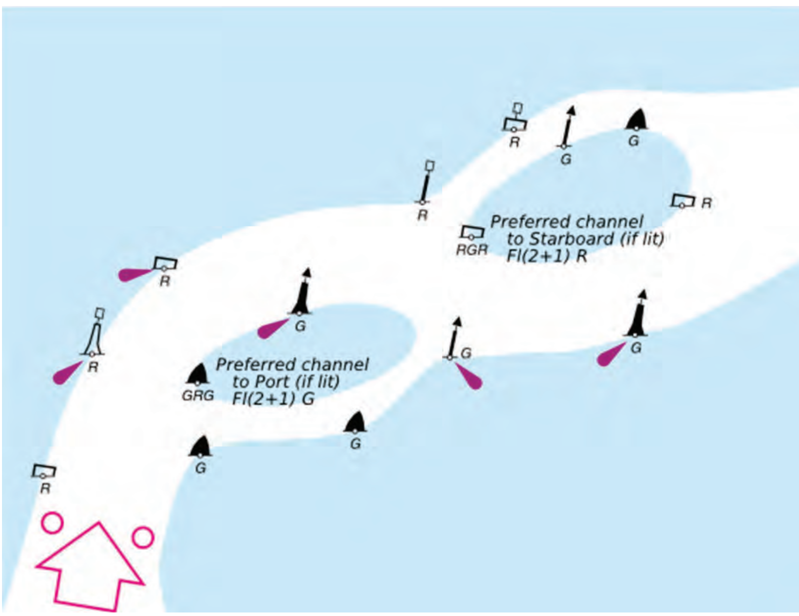
Isophase white every 4 seconds (by day), 7nm vis

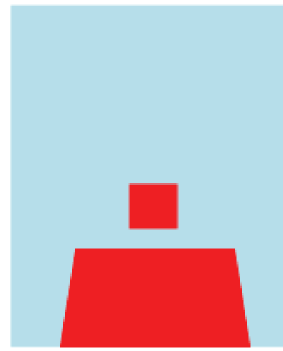
Full list of lights from Hobart to Lizard in Rob's Passage Planner

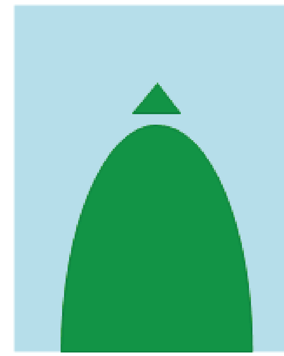
Aids to Navigation

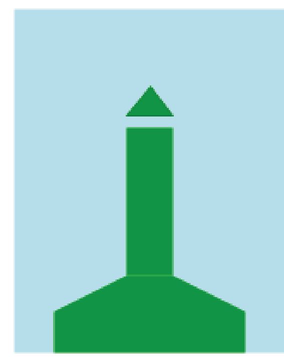
Buoyage

Lateral marks are placed on either side of a channel, as you approach from seaward, red flat top cans to port and green, conical buoys to starboard.







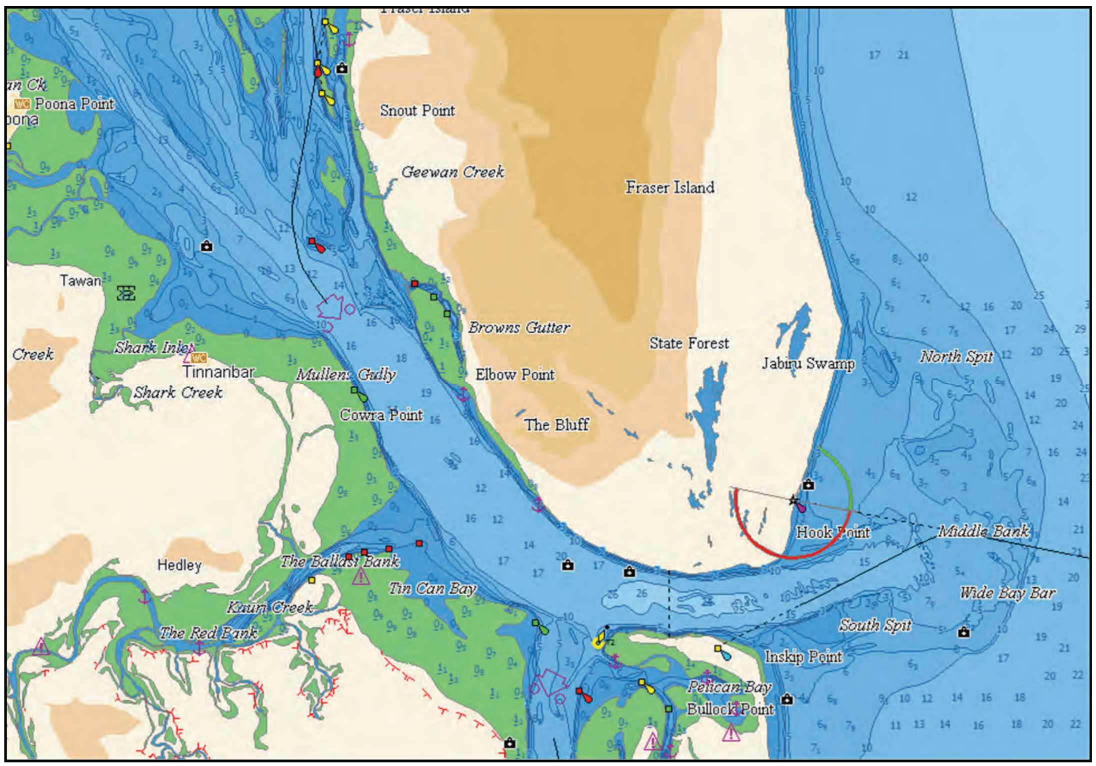


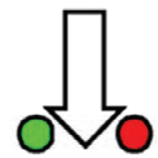
Aids to Navigation

Buoyage

Where the Lateral marks are ambiguous, charts show a direction symbol.

Two examples of this, Great Sandy Straits and Hinchinbrook Channel.





Aids to Navigation

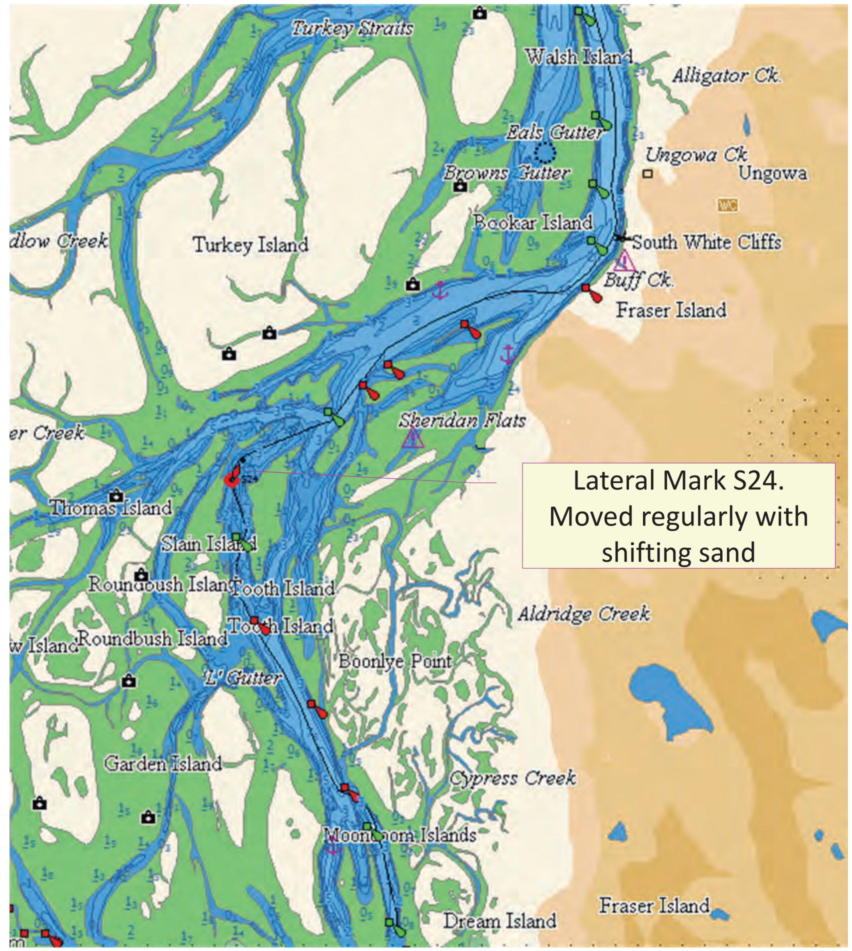
Great Sandy Straits

Lateral marks in the Great Sandy Straits are beacons, fixed into the sea bed and displaying lateral mark colours and markings.

One exception is S24, a movable lateral mark.

This mark is in an area where there is constant change to the sea bed due to North and South tides meeting in this general area.

Always pass S24 on correct side



Aids to Navigation

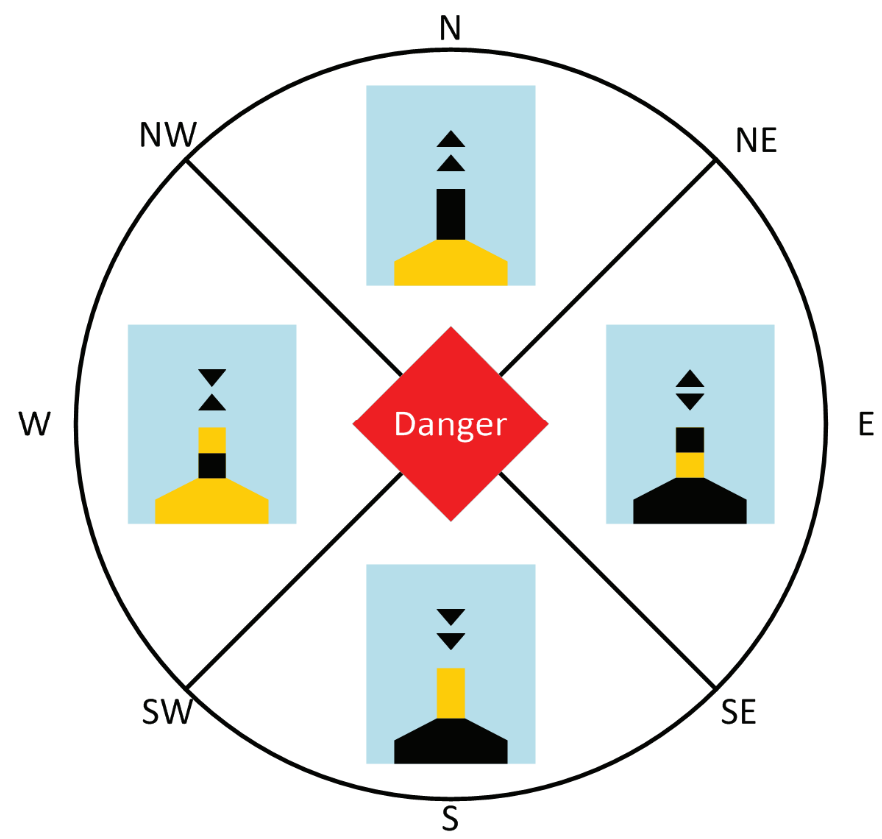
Cardinal Marks

Cardinal marks designate a safe side on which to pass a danger. They feature black and yellow bands topped with black cones or triangles that indicate direction.

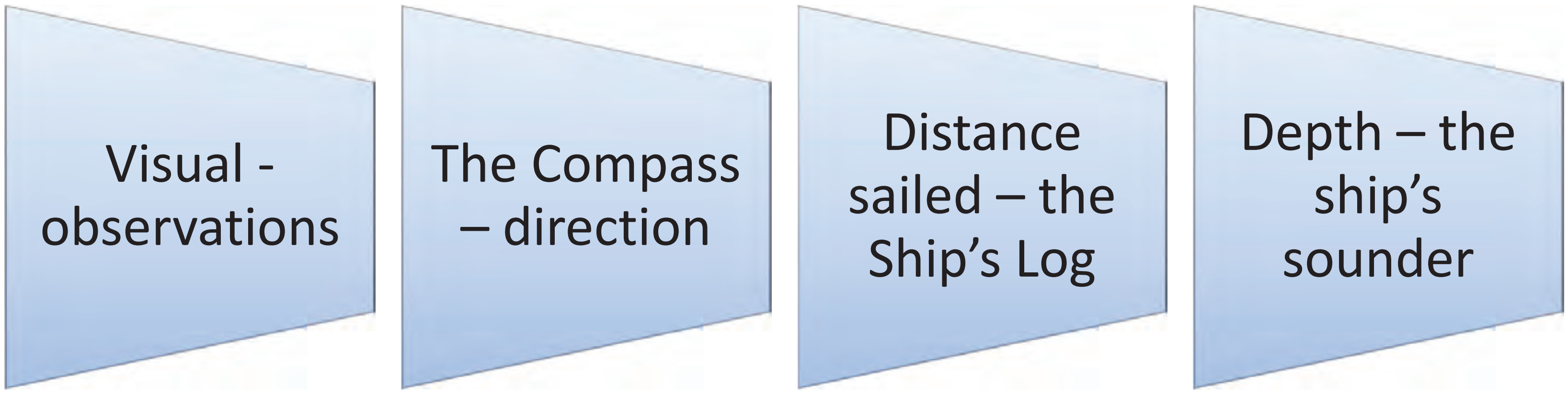
North	2 triangles pointing up
South	2 triangles pointing down
East	2 triangles in diamond shape
West	2 triangles forming sideways W

Light sequences;

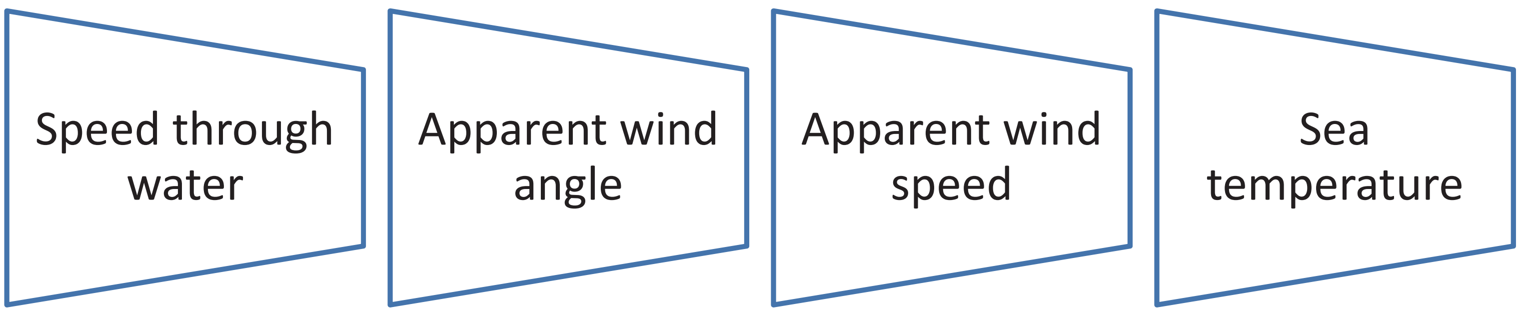
N	Continuous flashes
E	3 flashes in group
S	6 flashes in group followed by 1 long
W	9 flashes in group



Primary Navigation Inputs



Other inputs, read direct from environment and not computed by instruments.



Distance

A sea mile is defined as one minute of **latitude** measured at the Earth's surface.

By International treaty, one nautical mile (nm) equals **1,852 m** and equals one sea mile.

Circumference of the earth is approximately 360º x 60' = 21,600 minutes or sea miles or nautical miles.

Speed is measured in knots. A knot is one nautical mile per hour.

Units of distance;

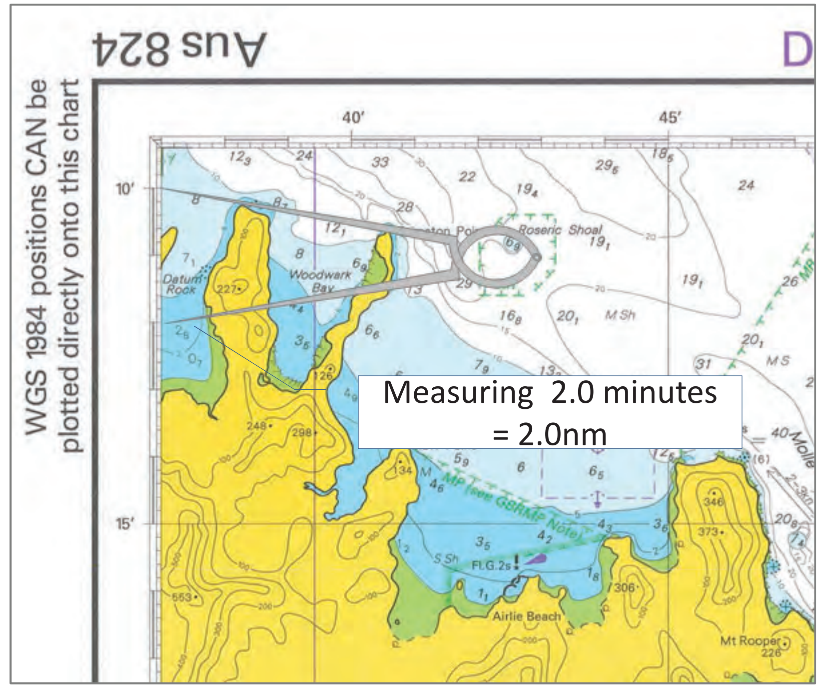
- 1 nautical mile (nm) = 1,852 m *(0.1nm = 185m, 0.01nm = 18.5m)*
- 1 fathom = 6 feet
- 1 cable = 1 tenth of a nautical mile

Measuring Distance On A Chart

One Nautical Mile is defined as one minute of latitude

Latitude scale is on left and right side of chart

Because of scale variation always use scale adjacent to area you are working



Note: As meridians converge at the poles, one minute of longitude varies from about 1,855 m at the equator to 0m at the poles.

Never use Longitude as a measure of distance.

Measuring Distance In Real World

Log distance is derived from the paddle wheel or other instrument measuring speed through the water

This has inherent accuracy issues and does require calibration over a standard mile

Speed should be damped, normal factors range from 0 to 4 seconds.

Direction

Meridians run North South

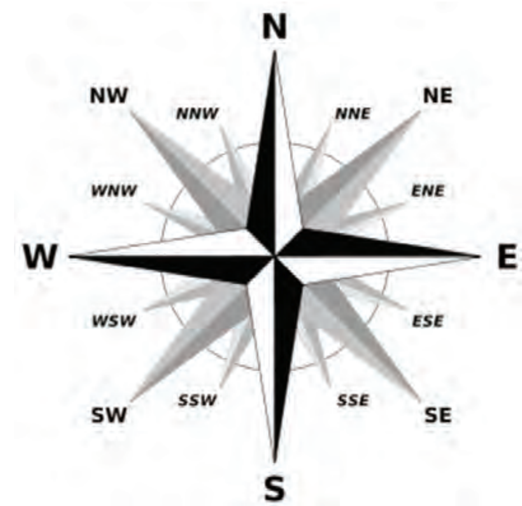
Parallels run West East

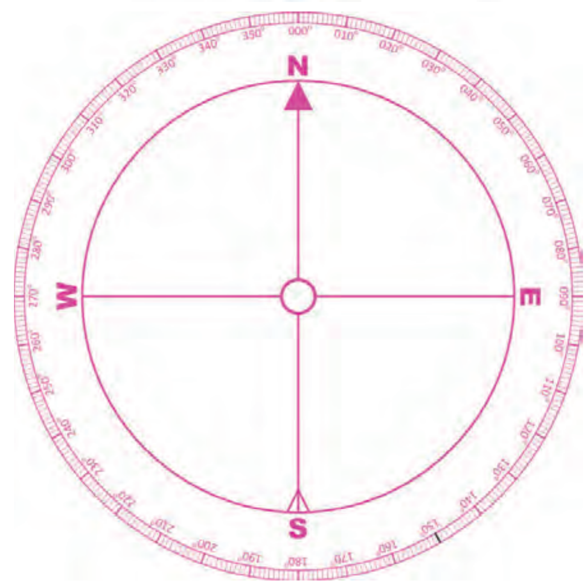
The four points created are called Cardinals; N, S, E, W

Directions between can also be named; NE, NNE, Etc.

For navigation we require the precision of 3 digit notation counting from 000 thru 180 to 360 measured in degrees clockwise from North

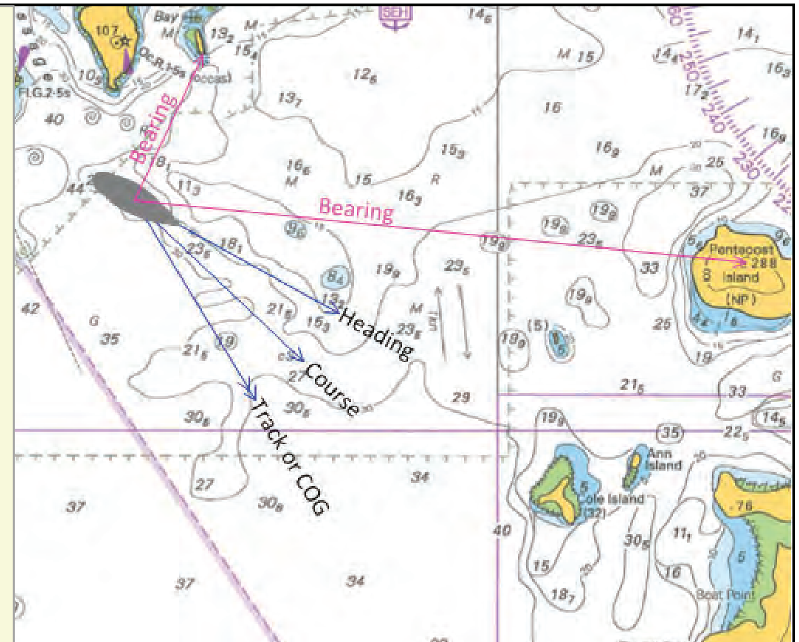
When specifying a direction always use three digits, example “045” for 45^{o} and “225” for the opposite 225^{o}





Different Kinds Of Direction

- **Bearing** – the direction of one object from another. Reading from hand held compass to distant object.
- **Course** – the direction the vessel is being steered. As requested by the Navigator (person or chart plotter).
- **Heading** – the direction the vessel happens to be pointing at any given moment. As indicated by steering compass or fluxgate compass.
- **Track angle** – the direction the vessel is actually moving: it is often abbreviated to Track and can also be called Ground Track, Course Made Good or Course over Ground. As indicated by the GPS.



Measuring Direction In The Real World

All cruising boats should have at least two possibly three compasses.

1) A fixed compass showing the direction the boat is heading, known as the steering compass
2) A hand held compass, for taking bearings (direction from you to other objects)
3) A third type is the Fluxgate Compass, fixed in the boat. This device is the source of the NMEA Heading message used by your Electronic Navigation Aids. Know where it is as easily distorted by Ferrous objects

Compass Errors

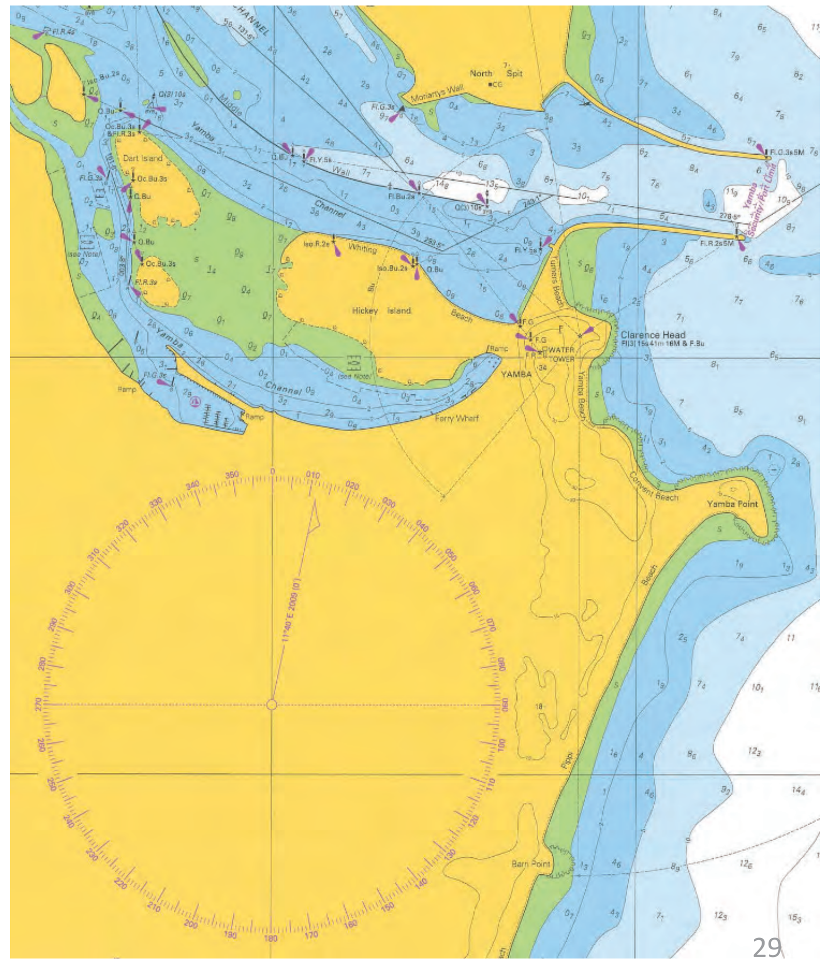
All magnetic compasses exhibit two error types

Variation

Caused by Earth's magnetic field wandering and not aligning with its axis of spin.

As the name implies, magnetic variation varies from location to location.

Variation is printed on our Charts, on small scale charts, covering large areas variation roses will appear a number of times.



Compass Errors

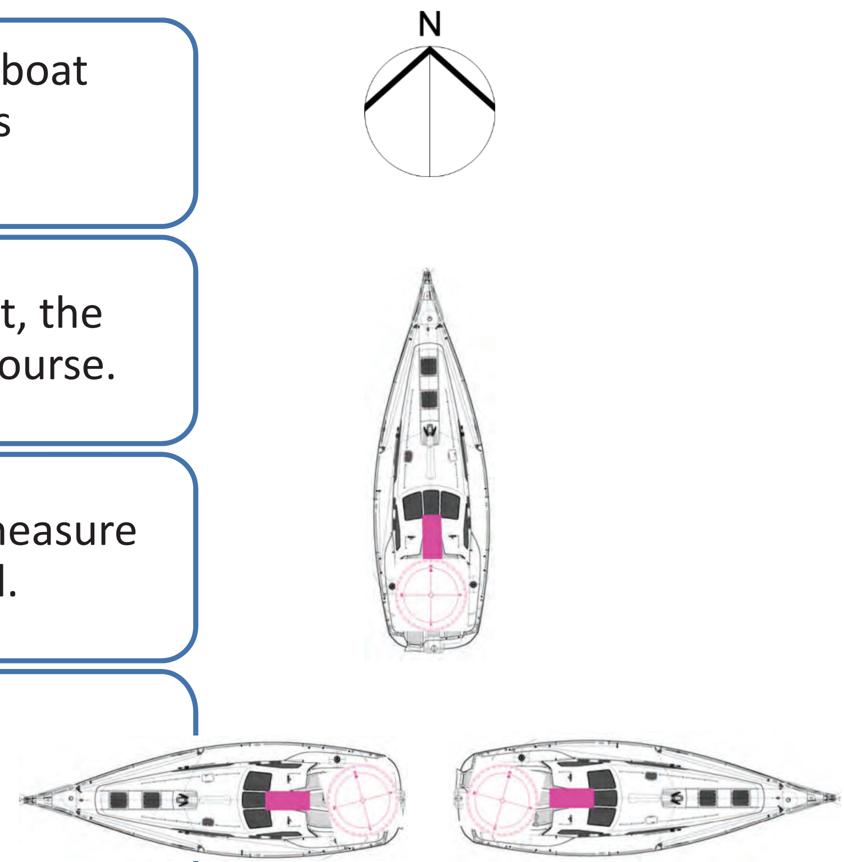
The second error type is, ***Deviation***

Caused by magnetic materials on board the boat making the compass deviate from the earths magnetic field.

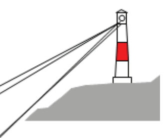
Because it is caused by materials on the boat, the effect will vary markedly as the boat alters course.

Steering compasses should be “swung” to measure and record the deviation on a deviation card.

Generally caused by ferrous engine mass and sometimes by electrical interference

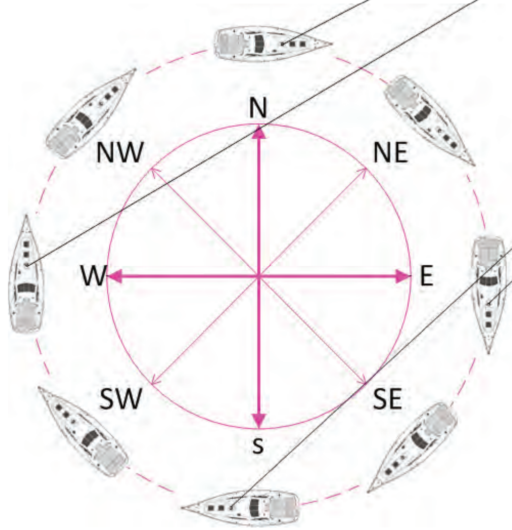


Swinging the Compass



This is a two step process;

1. Find a location on your boat where your hand held compass is free from deviation
2. Measure and document the difference between your steering compass and the hand held (in neutral deviation position)



Step 1:

Identify a remote (about 1.5 to 2.0nm) object, steer you boat in a 30 to 50 m circle, have your crew sight the remote object at each cardinal and ordinal

Continue with different positions on deck until you find a deviation neutral position.

The neutral position will be when each reading is the same.

Swinging the Compass

Step 2:

Once you have a deviation free, compass position, steer the boat on eight headings (000º, 045º, 090º, 135º, 180º, 225º, 270º, 315º).

Compare the headings of the steering compass with those your mate reads out from the hand bearing compass (sighted straight ahead). Any difference is steering compass deviation.

For each of the eight compass headings above, enter the reference compass result into the "Magnetic" column of the deviation sheet.

Once you have the eight compass points entered, extrapolate the remaining points in the deviation sheet.

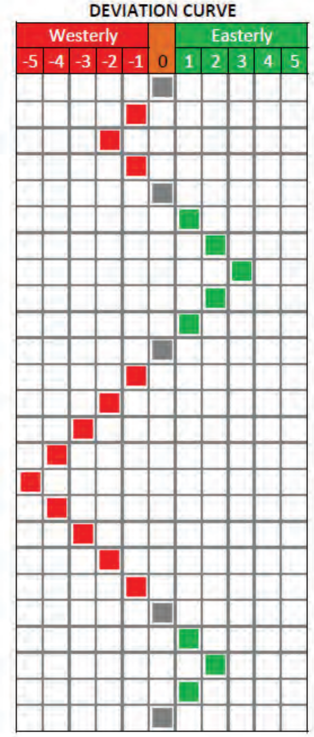
Vessel: MistyBlue

Compass: Steering

DEVIATION TABLE

Cardinal/Ordinal	Compass	Magnetic	Deviation
North	000°	000°	0°
	015°	014°	1° W
	030°	028°	2° W
NE	045°	044°	1° W
	060°		0°
	075°	076°	1° E
East	090°	092°	2° E
	105°	108°	3° E
	120°	122°	2° E
SE	135°	136°	1° E
	150°	150°	0°
	165°	164°	1° W
South	180°	178°	2° W
	195°	192°	3° W
	210°	206°	4° W
SW	225°	220°	5° W
	240°	236°	4° W
	255°	252°	3° W
West	270°	268°	2° W
	285°	284°	1° W
	300°	300°	0°
NW	315°	316°	1° E
	330°	332°	2° E
	345°	346°	1° E
North	360°	000°	0°

DEVIATION CURVE



Observed at: Pittwater

Date: 27th Apr 2013

Correcting Compass Errors

Two types of compass errors means three types of North.

1. **Compass North (C)** is the direction displayed by the compass

   Deviation separates it from:

2. **Magnetic North (M),** the direction the compass would show with a zero deviation error

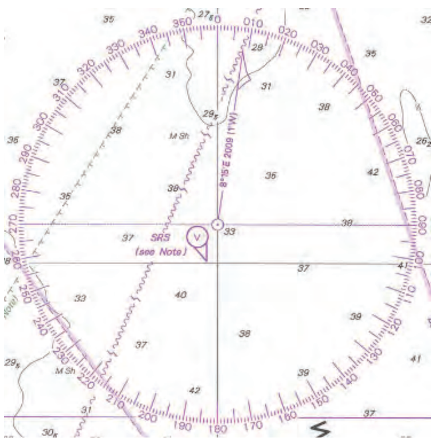
   Variation separates it from:

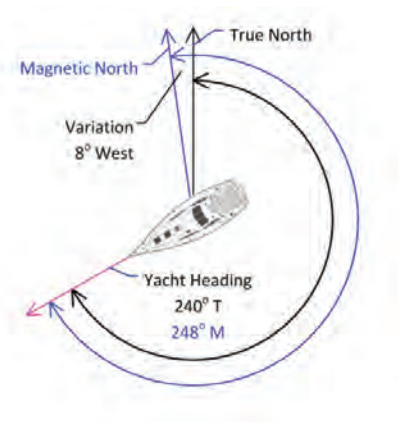
3. **True North (T)**, the direction of a chart meridian towards the North Pole

Variation Correction

If you are navigating using True (T), which is sound, you must adjust your course to steer Magnetic (M) before passing to the helm for use with a magnetic steering compass.

Similarly, any magnetic course bearing from the helm must be converted to True (T) before being plotted on the chart.





The graphic shows clearly that when variation is East, compass is least and when variation is west, compass is best.

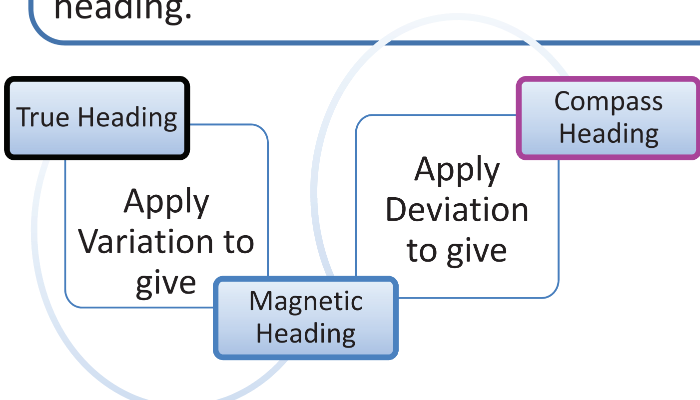
"Variation East, compass least" "Variation West, compass best"

Deviation Correction

If your steering compass has deviation error >= 1^o, a third heading is introduced in addition to True and Magnetic.

A heading taking into account both variation and deviation is called a **compass heading** and designated by **"C"**.

In order to convert from True to a Compass heading, first apply variation to arrive at Magnetic, next apply deviation to the Magnetic value to arrive at Compass heading.



You require a course of 240^o T.

Variation is 8^o East.

Deviation is 4^o East

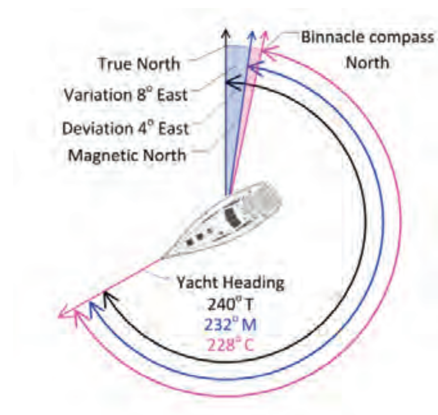
240^o T

- 8^o Variation East Compass least

= 232^{o}M

- 4^o Deviation East Compass least

= 228^o C

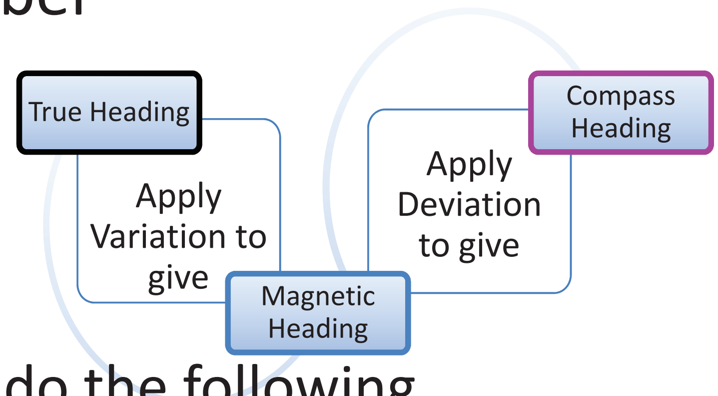


Variation & Deviation Correction

How to remember

“Variation East compass least”

“Variation West compass best”



From True (chart) to Compass (helm), do the following

Variation	Deviation	Formulae (True to Compass)
East	East	C = T - Variation - Deviation
East	West	C = T - Variation + Deviation
West	East	C = T + Variation - Deviation
West	West	C = T + Variation + Deviation

Note: only need to remember one

From Compass (helm) to True (chart) , revers the signs

Variation	Deviation	Formulae (Compass to True)
East	East	T = C + Variation + Deviation
East	West	T = C + Variation - Deviation

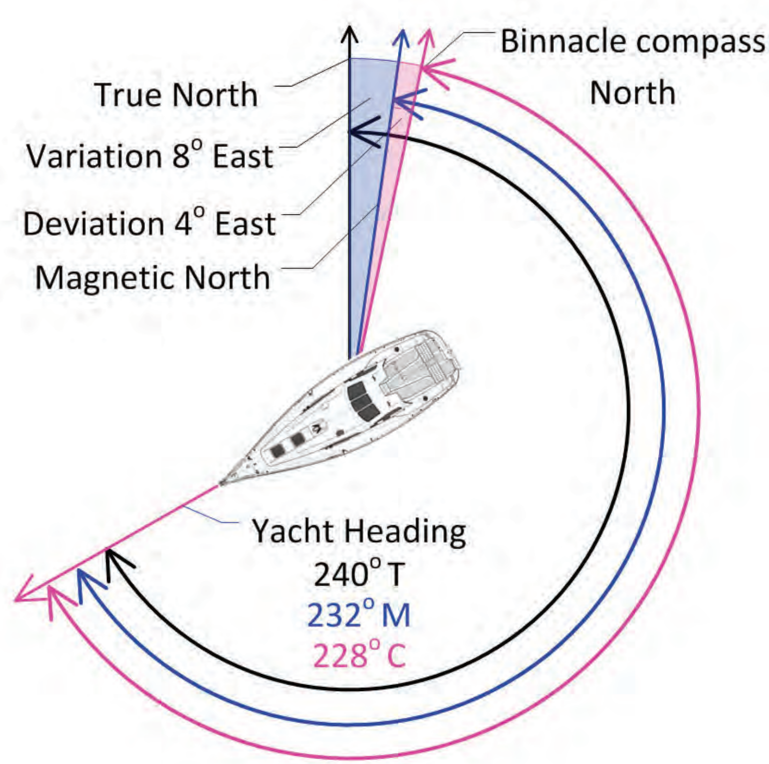
Variation & Deviation Correction

Alternate method to remember

If in doubt about whether to add or subtract, try drawing this sketch and the answer becomes obvious.

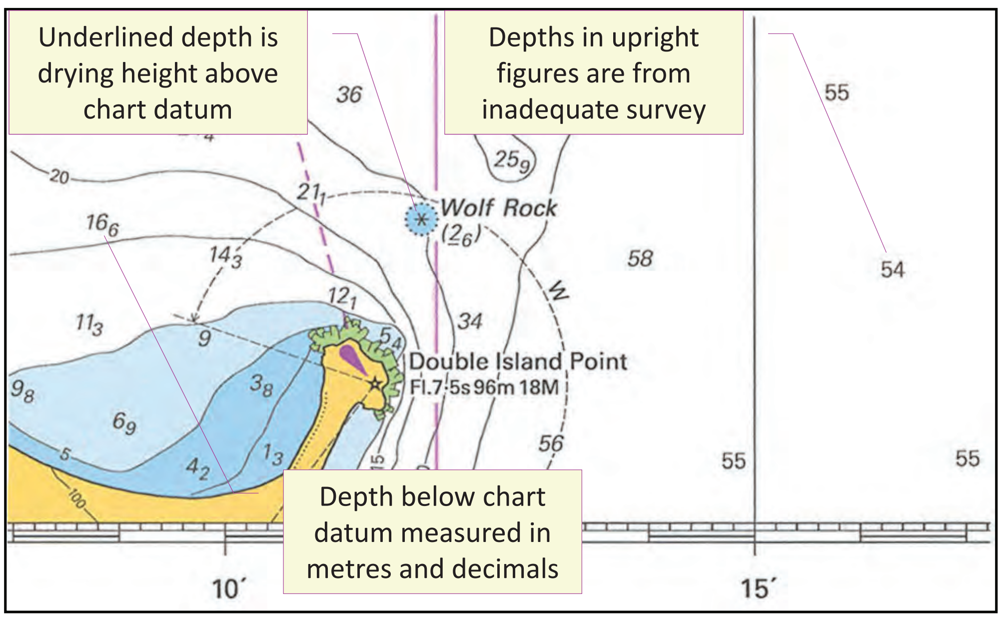
For East variation:

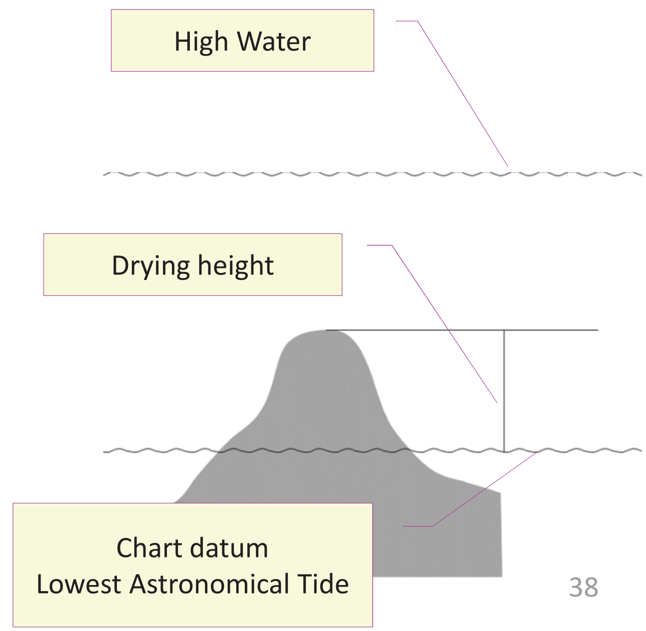
- True to Magnetic, you will subtract as the resulting arc is shorter.
- Magnetic to True you will add as the resulting arc is longer.



Depth

After sight, distance and direction, Depth is the forth navigational dimension.
Modern Australian charts use a Chart Datum based on the Lowest Astronomical Tide (LAT).
Depth of water is found by adding Tide Table depth to chart datum.
Most chart depths are measured in metres.





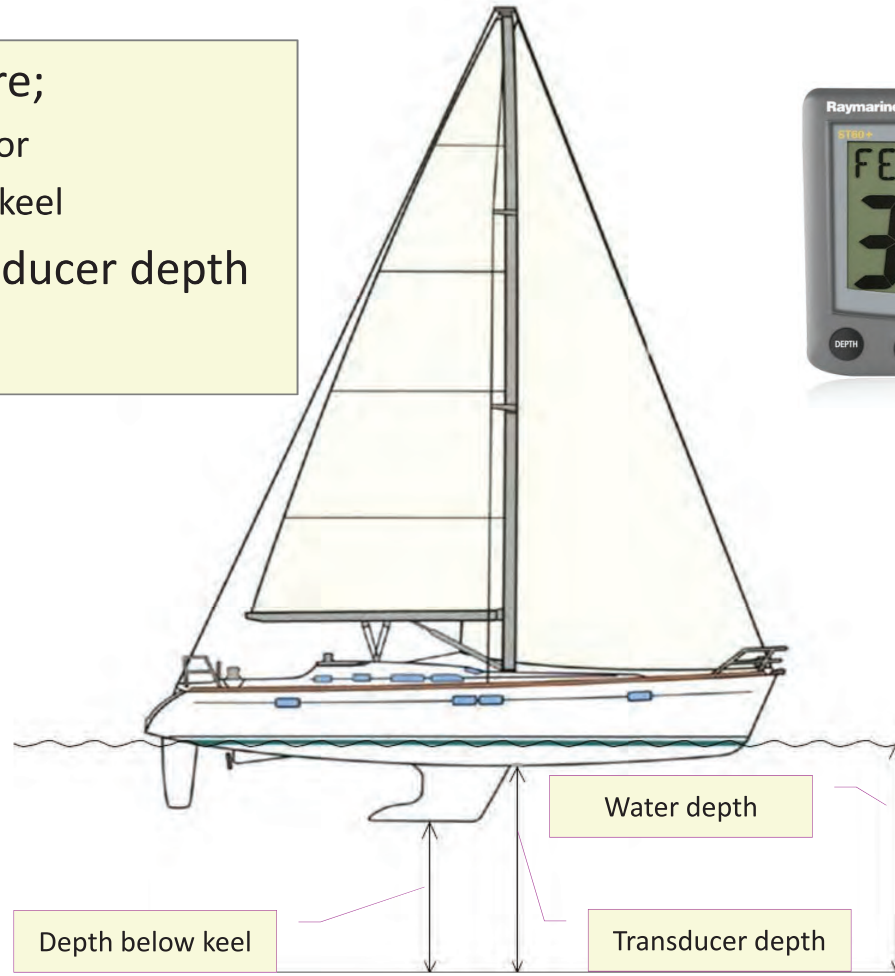
Measuring Depth In The Real World

Normal settings are;

a) Water depth or

b) Depth below keel

Offsets from transducer depth is required, + or -.



Tides

Most of us are conditioned to Sydney tides of 1 to 1.7 metres.

QLD tides are significantly higher, 2m to 7.5m, Mackay HAT = 6.8 m.

Understanding tidal changes is a safety issue as well as a navigation requirement.

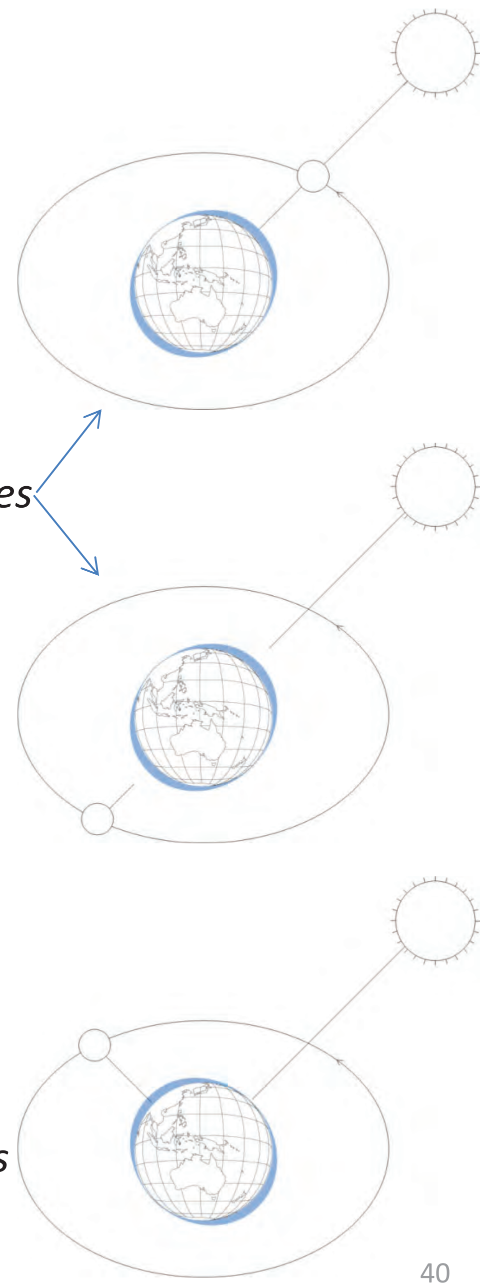
Tides occur because of the gravitational pull of the Sun and Moon. Because of distance and their relative sizes, the Sun's effect is ½ of the Moon's.

Highest and lowest (Spring) tides occur when the Sun and Moon are aligned (Full Moon and New Moon).

Neap Tides (Low High and High Low) occur when the Sun and Moon act against one another.

Spring tides

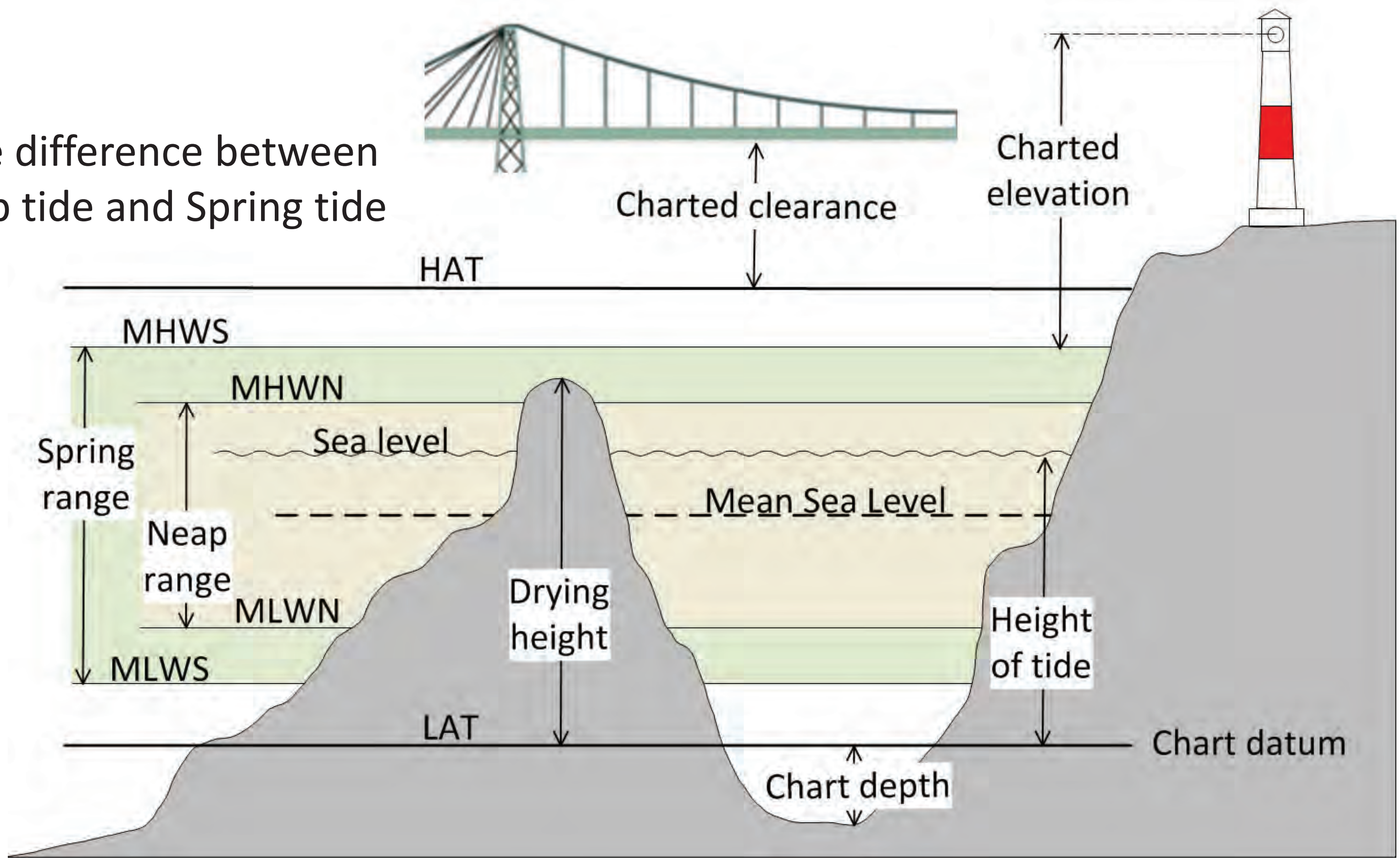
Neap tides



Tidal Definitions

This applies to AUS charts

Note difference between Neap tide and Spring tide



Tide Tables

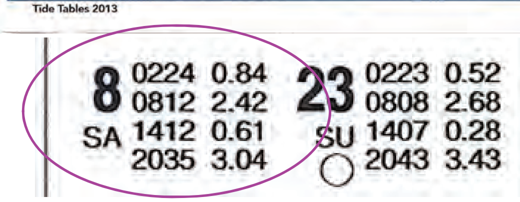
Standard Ports

Times and heights of high and low water for commercial ports (Standard Ports) are documented in the tables (Queensland Tide Tables).

Height of tide specified in Tables is added to Chart Datum to give water depth at specific date and time.

Note: drying heights are subtracted

Time	08:12	14:12
Charted depth	2.50 m	2.50 m
Tide height	+2.42 m	+0.61 m
Water depth	=4.92 m	=3.11 m



Tide Predictions for Secondary Ports

Predictions for Secondary ports calculated from offsets (Ratio and Constant) to Primary ports.

Secondary Ports are listed in the Semidiurnal tide planes” section of the QLD Tide Tables.

To calculate a Secondary Port tide, multiply it’s Primary Port by Secondary Port’s Ratio and add the Secondary Port’s Constant.

Semidiurnal tidal planes — 2013

Height above lowest astronomical tide

Place	Latitude South	Longitude East	Time Difference HW	Time Difference LW	MHWS	MHWN	MLWN	MLWS	AHD	MSL	Ratio	Cons	HAT
Tidal Datum Epoch 1992 -2011			1 H M	2 H M	3 m	4 m	5 m	6 m	7 m	8 m	9	10 m	11 m
Mooloolaba	**26 41**	**153 08**	**Standard Port**		**1.66**	**1.33**	**0.58**	**0.26**	**0.990**	**0.96**	**1.00**	**0.00**	**2.17**
Caloundra Head	26 48	153 09	+0 00	+0 00	1.63	1.34	0.57	0.28	0.99	0.95			2.05
Parrearra (Mooloolah River)	26 43	153 07	+0 23	+0 44	1.67	1.23	0.55	0.20	0.93		0.94	0.00	2.21
Mooloolaba Beach	26 41	153 06	+0 00	+0 00	1.66	1.33	0.58	0.26	0.99	0.97	1.00	0.00	2.17
Maroochydore Beach	26 40	153 06	+0 00	+0 00	1.66	1.33	0.58	0.26	0.99	0.97	1.00	0.00	2.17
Coolum	26 31	153 06	+0 00	+0 00	1.66	1.33	0.58	0.26	0.99	0.97	1.00	0.00	2.17
Maroochy River -													
Picnic Point	26 39	153 05	+1 02	+1 52	0.93	0.65	0.27	0.13	0.46	0.52			1.36
David Low Bridge	26 38	153 03	+1 35	+2 27	0.90	0.66	0.30	0.19	0.44	0.53			1.28
Dunethin Rock	26 35	153 02	+2 09	+3 06	1.03	0.78	0.28	0.15	0.44	0.53			1.41
Junction North Maroochy River	26 34	152 58	+2 18	+3 12	1.15	0.88	0.34	0.22	0.49	0.60			1.57
Noosa Head	**26 23**	**153 06**	**Standard Port**		**1.78**	**1.45**	**0.71**	**0.38**	**1.123**	**1.08**	**1.00**	**0.00**	**2.28**
Noosa River -													
Munna Point	26 24	153 04	+0 42	+1 35	0.78	0.65	0.29	0.17	0.42	0.45	0.40	+0.13	1.10
Tewantin	26 24	153 02	+1 07	+1 49	0.61	0.53	0.28	0.20	0.34	0.38	0.31	+0.09	0.89
Noosa Beaches -													
Noosa Beach	26 23	153 05	+0 00	+0 00	1.78	1.45	0.71	0.38	1.12	1.06	1.00	0.00	2.28
Teewah Sands	26 16	153 04	+0 00	+0 00	1.78	1.45	0.71	0.38	1.12	1.06	1.00	0.00	2.28
Cooloola	26 11	153 04	+0 00	+0 00	1.78	1.45	0.71	0.38	1.12	1.06	1.00	0.00	2.28
Double Island Point	25 55	153 11	+0 00	+0 00	1.78	1.45	0.71	0.38	1.12	1.06	1.00	0.00	2.28
Rainbow Beach	25 54	153 05	+0 00	+0 00	1.78	1.45	0.71	0.38	1.12	1.06	1.00	0.00	2.28
Waddy Point (Fraser Island)	**24 58**	**153 21**	**Standard Port**		**1.75**	**1.44**	**0.81**	**0.50**	**1.007**	**1.129**	**1.00**	**0.00**	**2.37**
Wide Bay Bar (Ocean Side)	25 49	153 03	+0 00	+0 00									
Eurong	25 30	153 07	+0 00	+0 00									
Happy Valley	25 20	153 12	+0 00	+0 00									
Indian Head	25 00	153 22	+0 00	+0 00									
Orchid Beach	24 58	153 19	+0 00	+0 00									
Urangan	**25 18**	**152 55**	**Standard Port**		**3.49**	**2.80**	**1.38**	**0.68**	**2.040**	**2.09**	**1.00**	**0.00**	**4.28**
Kingfisher Bay	25 24	153 06	+0 11	+0 18	3.73	3.00	1.48	0.73		2.26	1.07	0.00	4.58
Bundaberg (Burnett Heads)	**24 46**	**152 23**	**Standard Port**		**2.88**	**2.30**	**1.14**	**0.56**	**1.693**	**1.72**	**1.00**	**0.00**	**3.67**

Bundaberg (Burnett Heads)	**24 46**	**152 23**	**Standard Port**		**2.88**	**2.30**	**1.14**	**0.56**	**1.693**	**1.72**	**1.00**	**0.00**	**3.67**
Great Sandy Strait -													
Tin Can Bay (Snapper Creek)	25 54	153 00	+0 44	-0 16	2.31	1.84	0.91	0.45	1.36	1.36	0.80	0.00	2.94
Elbow Point	25 48	153 01	+0 15	-0 03	2.14	1.71	0.85	0.42		1.28	0.74	0.01	2.73
Snout Point	25 42	152 59	+0 55	+0 29	2.34	1.86	0.92	0.45		1.39	0.81	0.00	2.97
Big Tuan	25 41	152 53	+0 55	+1 05	2.16	1.73	0.86	0.42	1.19	1.37	0.75	0.00	2.75
Boonooroo	25 39	152 54	+0 55	+1 05	2.16	1.73	0.86	0.42	1.19	1.37	0.75	0.00	2.75
Boonlye Point	25 34	152 56	+1 09	+0 57	3.14	2.51	1.24	0.61		1.89	1.09	0.00	4.00
Ungowa Jetty	25 30	152 59	+0 51	+0 49	3.83	3.06	1.52	0.74		2.39	1.33	0.00	4.88

Secondary Port Example

On the 8th June we are planning to navigate Sheridan Flats (Great Sandy Straits). What is Boonlye Point high tide time and height?

Place Tidal Datum Epoch 1992 -2011	Latitude South	Longitude East	Time Difference HW 1 H M	LW 2 H M	MHWS 3 m	MHWN 4 m	MLWN 5 m	MLWS 6 m	AHD 7 m	MSL 8 m	Ratio 9	Cons 10 m	HAT 11 m
Bundaberg (Burnett Heads)	**24 46**	**152 23**	**Standard Port**		**2.88**	**2.30**	**1.14**	**0.56**	**1.693**	**1.72**	**1.00**	**0.00**	**3.67**
Great Sandy Strait -													
Tin Can Bay (Snapper Creek)	25 54	153 00	+0 44	-0 16	2.31	1.84	0.91	0.45	1.36	1.36	0.80	0.00	2.94
Elbow Point	25 48	153 01	+0 15	-0 03	2.14	1.71	0.85	0.42		1.28	0.74	0.01	2.73
Snout Point	25 42	152 59	+0 55	+0 29	2.34	1.86	0.92	0.45		1.39	0.81	0.00	2.97
Big Tuan	25 41	152 53	+0 55	+1 05	2.16	1.73	0.86	0.42	1.19	1.37	0.75	0.00	2.75
Boonooroo	25 39	152 54	+0 55	+1 05	2.16	1.73	0.86	0.42	1.19	1.37	0.75	0.00	2.75
Boonlye Point	25 34	152 56	+1 09	+0 57	3.14	2.51	1.24	0.61		1.89	1.09	0.00	4.00
Ungowa Jetty	25 30	152 59	+0 51	+0 49	3.83	3.06	1.52	0.74		2.39	1.33	0.00	4.88

Bundaberg June 2013

8 SA	0224	0.84	23 SU ○	0223	0.52
	0812	2.42		0808	2.68
	1412	0.61		1407	0.28
	2035	3.04		2043	3.43

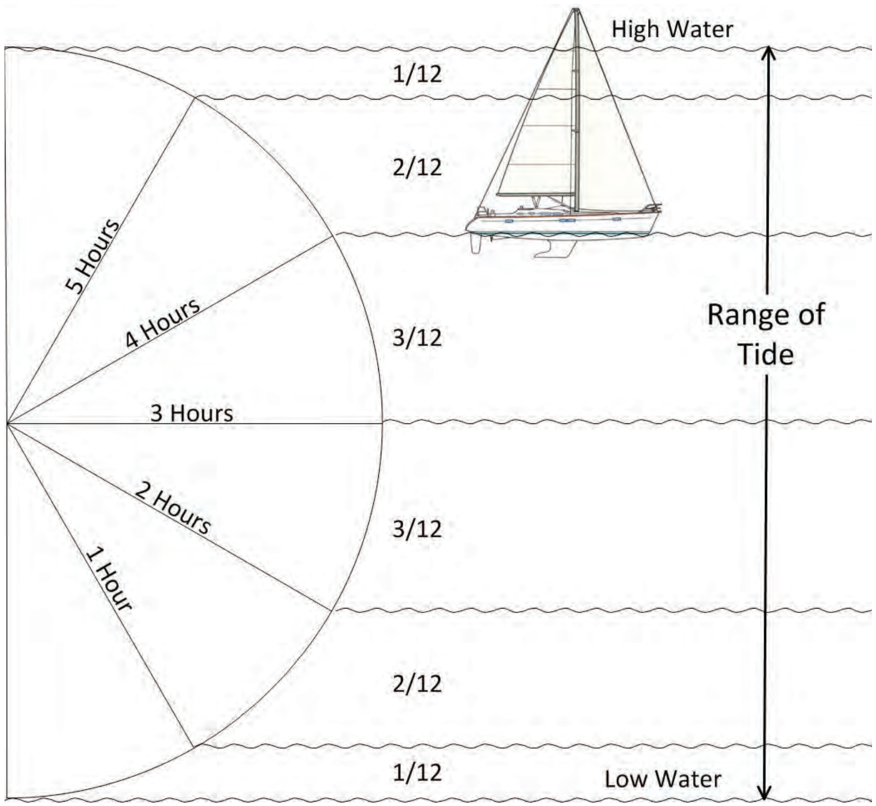
	Tide time	Tide height
Bundaberg	08:12	2.42
Boonlye Point		
Time difference	+01:09	
Ratio		1.09
Constant		0.00
Boonlye (High tide)	09:21	2.64m

=(2.42*1.09)+0.00

Tides Between High and Low

The Rule of Twelfths

What is the Boonlye Point tide at 11:20 on the 8th June?
One method of calculation is to use the rule of twelfths as follows.



	Tide time	Tide height
Boonye high water	09:21	2.64m
Boonlye low water	15:09	0.66m
Range of Tide (H-L)		1.98m
1/12 of range		0.16m
2 hour fall (3/12)		0.49m
Boonlye (2.64 – 0.49)	11:21	2.15m

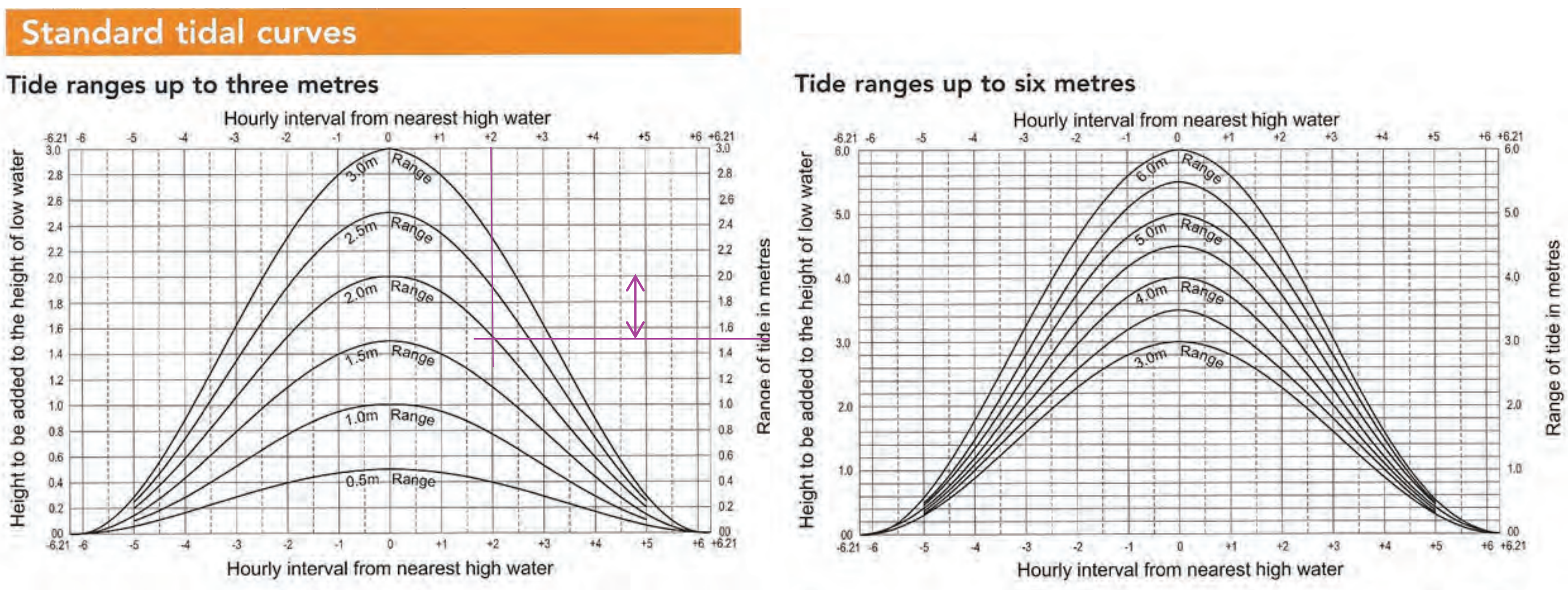
Tides Between High and Low

Standard Tide Curves

What is the Boonlye Point tide at 11:20 on the 8th June?

Another method of calculation is to use the standard curves.

Tide range (High to Low)	= 2.64m – 0.67m	= 1.97m
Tide fall at High + 2 hours	= 2.00m – 1.50m	= 0.50m
Tide height at 11:20	= 2.64m – 0.50m	= 2.14m



Note: Curves show tide range (change) not tide height

An Anchoring Scenario

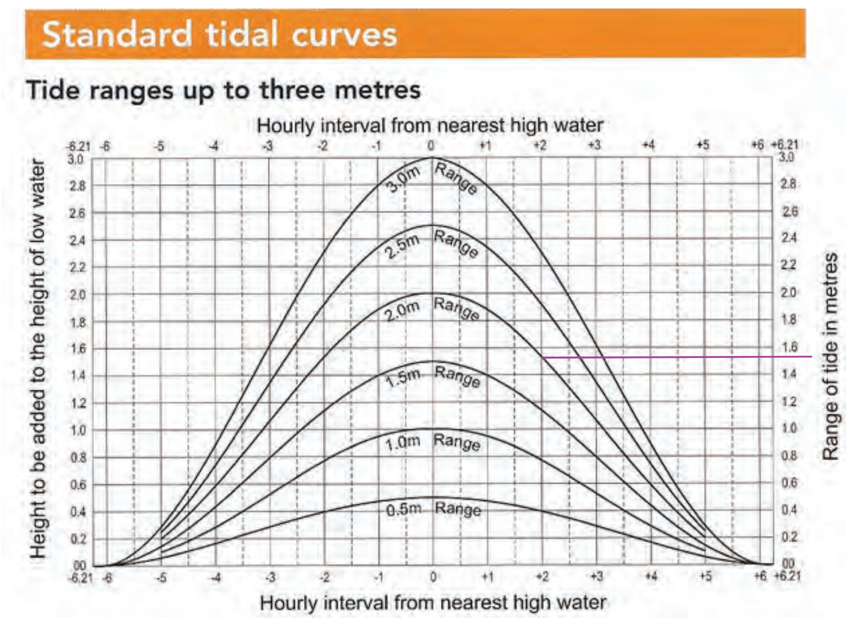
We cross the Wide Bay Bar (WBB) at 0630hrs on 6th June.

The distance from WBB to Garry’s Anchorage, (anchorage) is 18 nm.

Our ETA at Garry’s (SOG = 5 kt) is 1000hrs. Our draft is 2.4m.

What is the minimum depth we require to safely anchor at Garry’s Anchorage on arrival?

From extrapolation between Snout Point and Boonlye Pt, we estimate tides at Garry’s Anchorage;

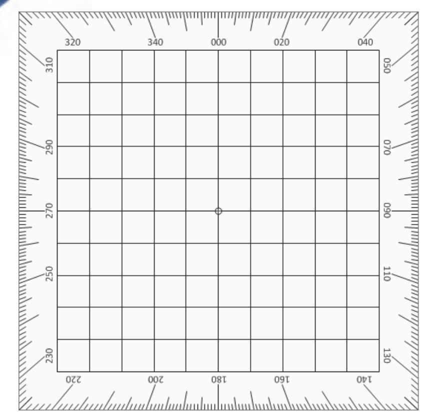


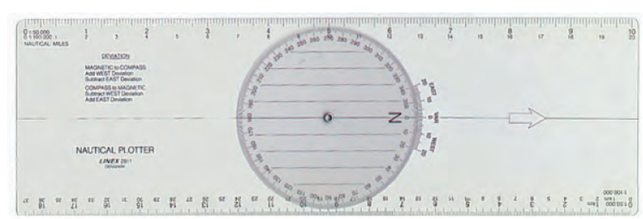
Garry’s Anchorage	0756hrs	2.46m
	1346hrs	0.61m
Tide range (fall)		1.85m
Arrival	1000hrs	
Tide has fallen (2.0m – 1.50m)	2.0hrs	0.5m
Tide yet to fall (1.85m – 0.5m)		1.35m
Safety margin		0.50m
Minimum water under keel (1.40m + 0.50m)		1.90m

Charting Basics

Charting instruments first

- Pencils, soft 2B
- Pencil sharpener
- Eraser, soft
- Dividers and Pencil Compass
- Protractor (square) or Breton Plotter
- Parallel Rule (optional)





Charting Basics

Two tasks you need to be able to perform on the paper chart.

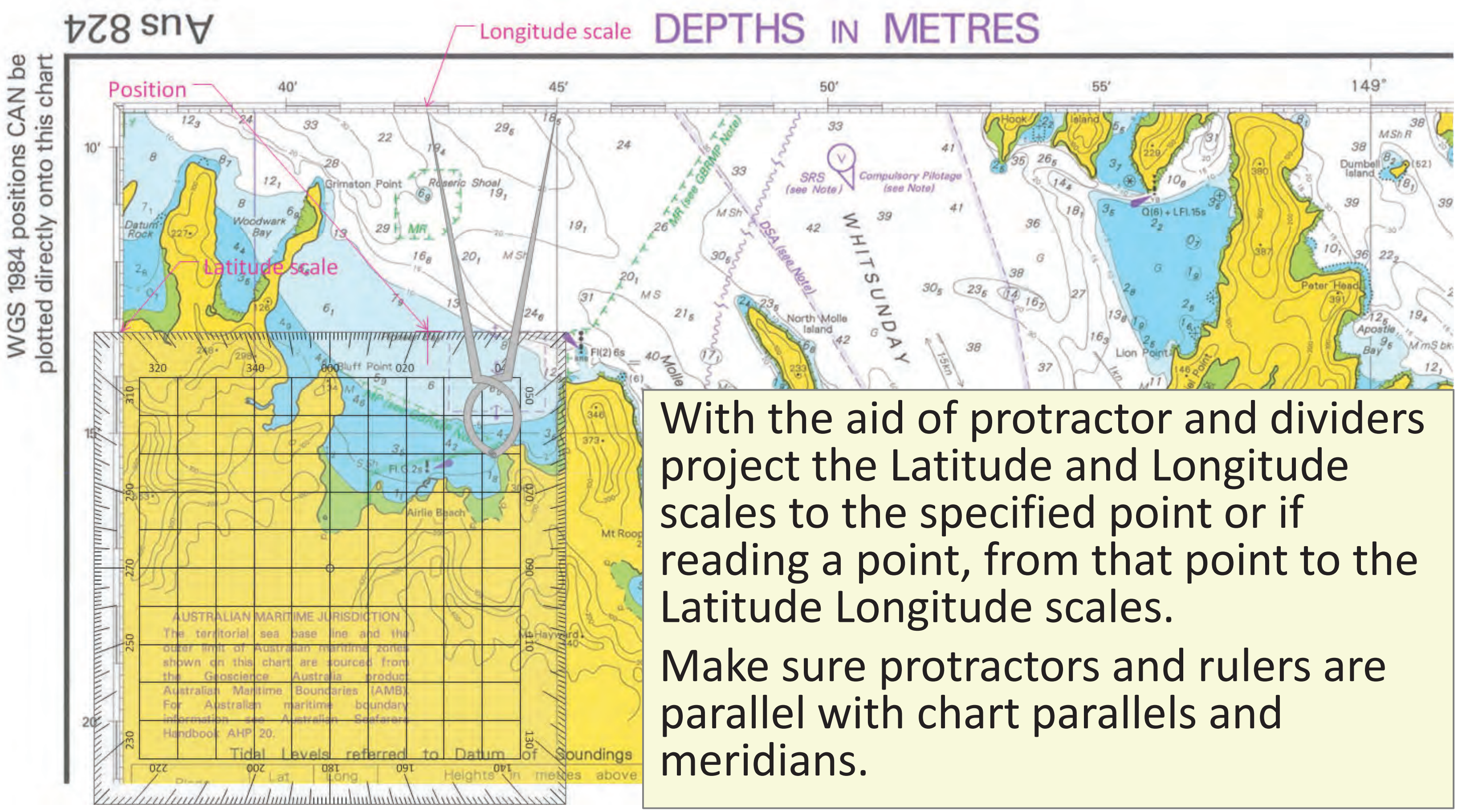
1. **Position**; plot a position from given Latitude Longitude coordinates or read latitude longitude coordinates of an object on the chart.
2. **Line direction and length**; measure direction of a line on the chart in degrees minutes and length in nautical miles (nm). This includes plotting a line on the chart to a specified direction and length

These basic skills enable you to:

a) Plot your Latitude Longitude position on the chart
b) Read a Latitude Longitude position from the chart and transfer to your GPS as waypoint
c) Plot a bearing on the chart from boat to charted object in direction and length
d) Plot your current position as a range and bearing from a charted object

Plotting or Reading a Position

20º13.2’ 148º42.6’

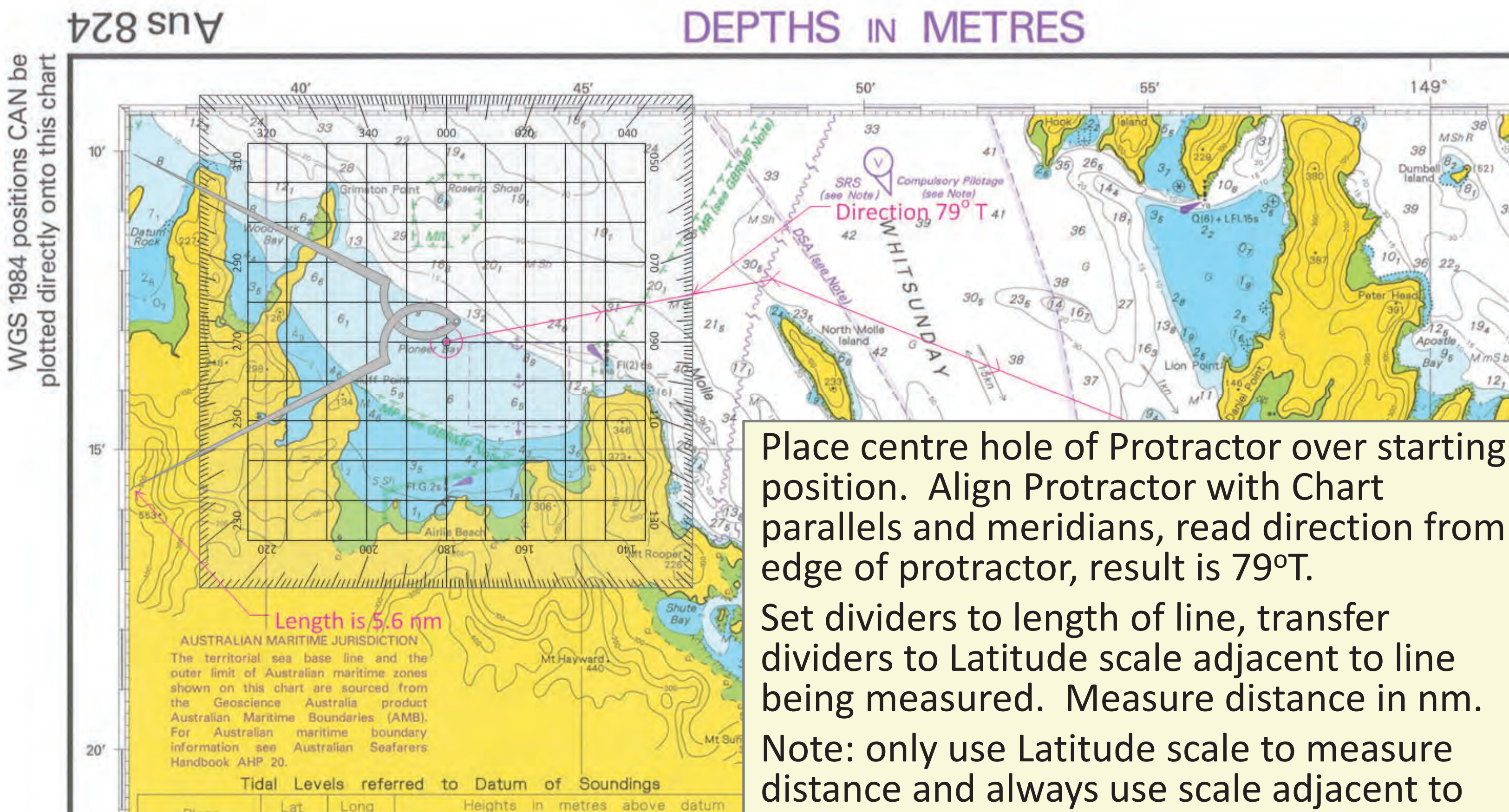


With the aid of protractor and dividers project the Latitude and Longitude scales to the specified point or if reading a point, from that point to the Latitude Longitude scales.

Make sure protractors and rulers are parallel with chart parallels and meridians.

Line Direction and Length

79ºT 5.6nm

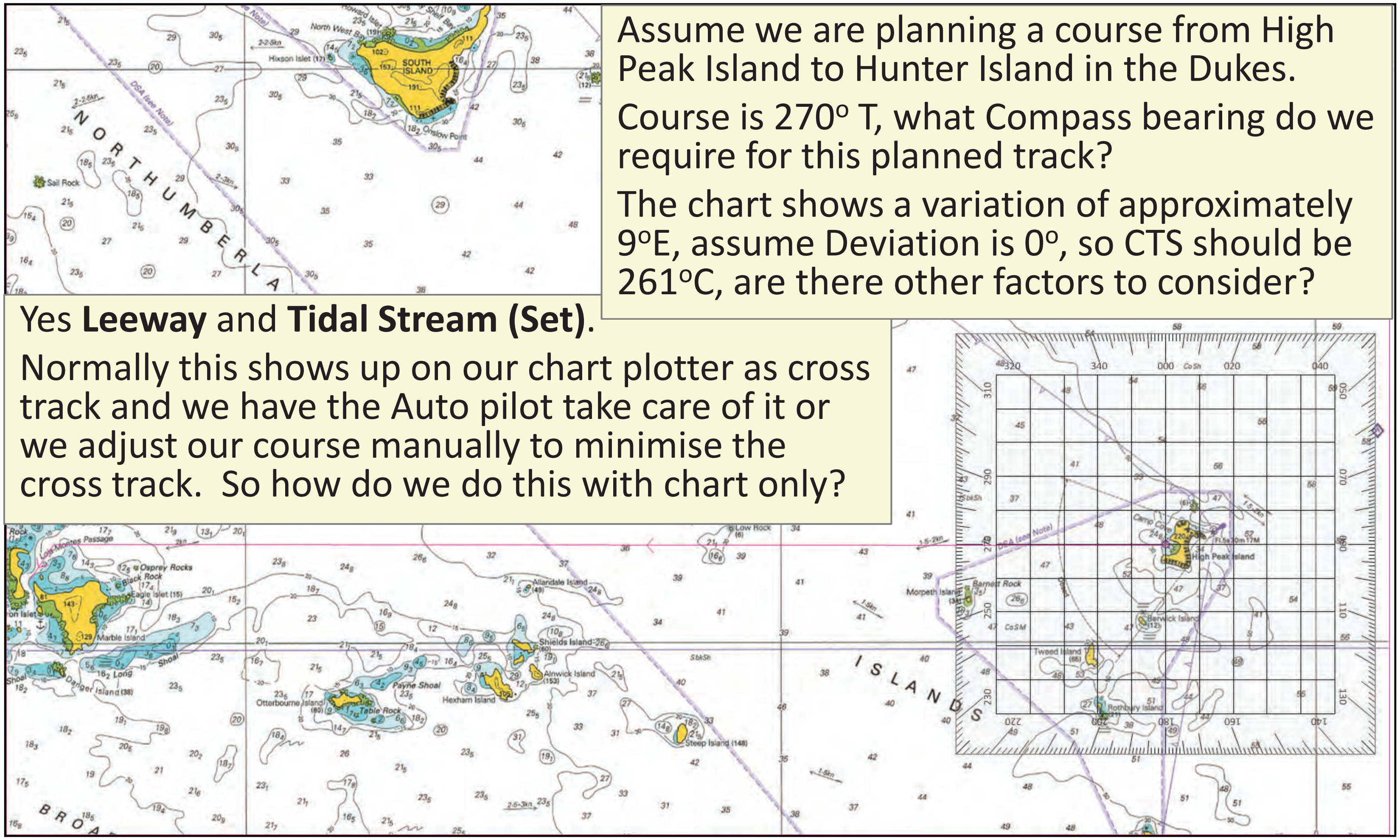


Place centre hole of Protractor over starting position. Align Protractor with Chart parallels and meridians, read direction from edge of protractor, result is 79ºT.

Set dividers to length of line, transfer dividers to Latitude scale adjacent to line being measured. Measure distance in nm.

Note: only use Latitude scale to measure distance and always use scale adjacent to line being measured.

Planning a Course to Steer



Assume we are planning a course from High Peak Island to Hunter Island in the Dukes.

Course is 270° T, what Compass bearing do we require for this planned track?

The chart shows a variation of approximately 9°E, assume Deviation is 0°, so CTS should be 261°C, are there other factors to consider?

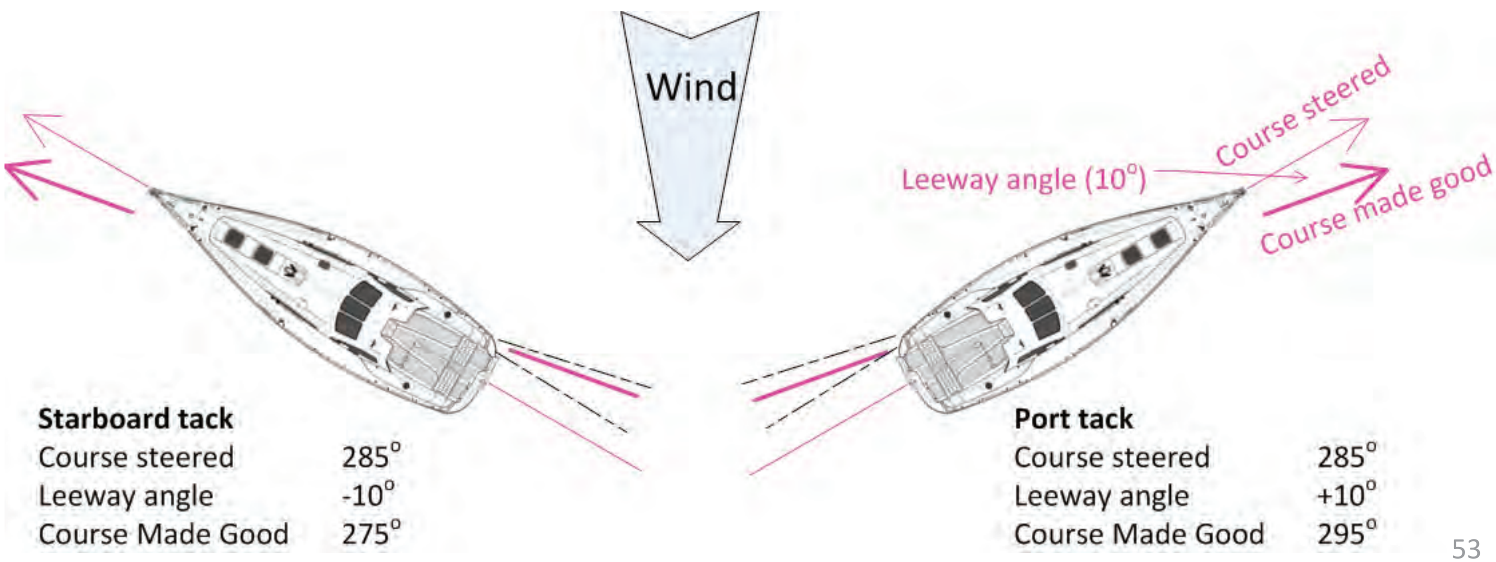
Yes **Leeway** and **Tidal Stream (Set)**.

Normally this shows up on our chart plotter as cross track and we have the Auto pilot take care of it or we adjust our course manually to minimise the cross track. So how do we do this with chart only?

Leeway

When sailing close-hauled the boat will slide sideways, this is called Leeway. It varies by wind angle and by boat type.

- Almost insignificant once the wind is abaft the beam.
- Observe your wake as it streams away from the weather quarter.
- Leeway angle can vary from 7º at 20knots to 10º at 30 knots.
- On a Port tack you will need to add Leeway angle to Course To Steer (CTS) to get Course Made Good (CMG)
- On a Starboard tack you will need to subtract the Leeway angle



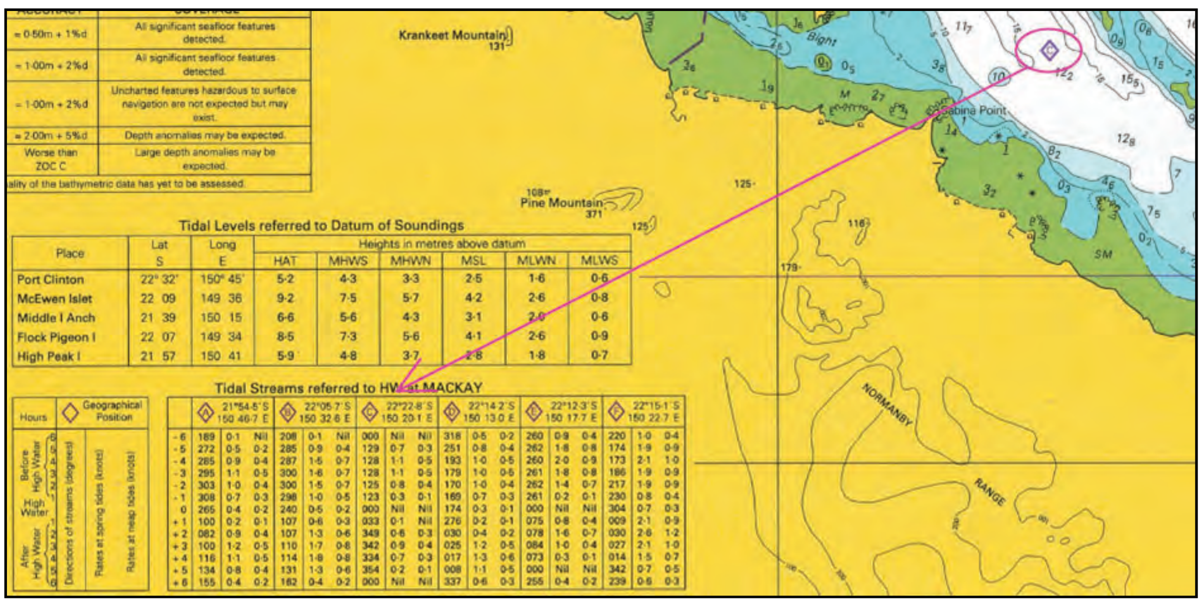
Tidal Stream

Tidal streams can be significant, especially when tides are changing by up to 5m as they do in the Broad Sound area of QLD.

With tides running as much as 3 knots, it's a good strategy to time the passage for tidal streams running in your planned direction.

With a cross tidal stream you will need to adjust your course to steer.

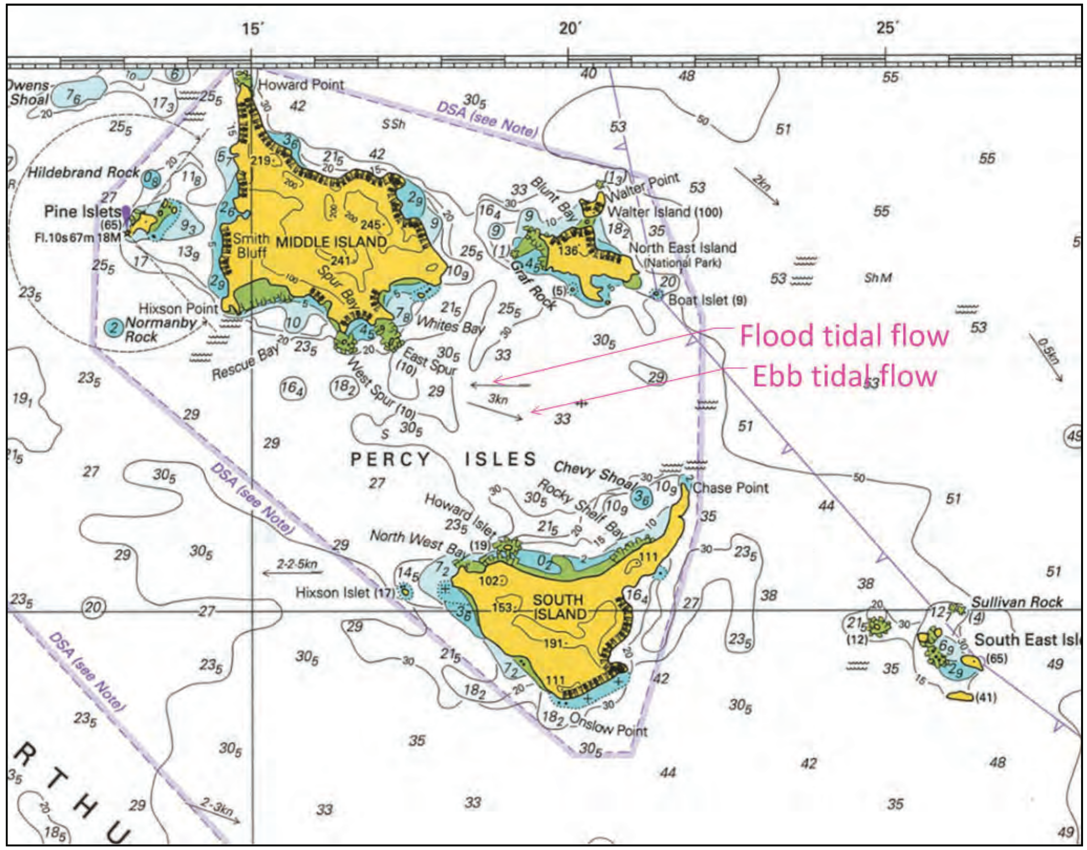
Tidal Streams are related to tides and indicative flows are specified on some charts at locations know as Tidal Diamonds.



Tidal Stream Direction & Speed

Tide direction and strength are shown at significant locations on each chart with arrows and kn.

Feathers = flood.



Course to Steer With Tidal Current

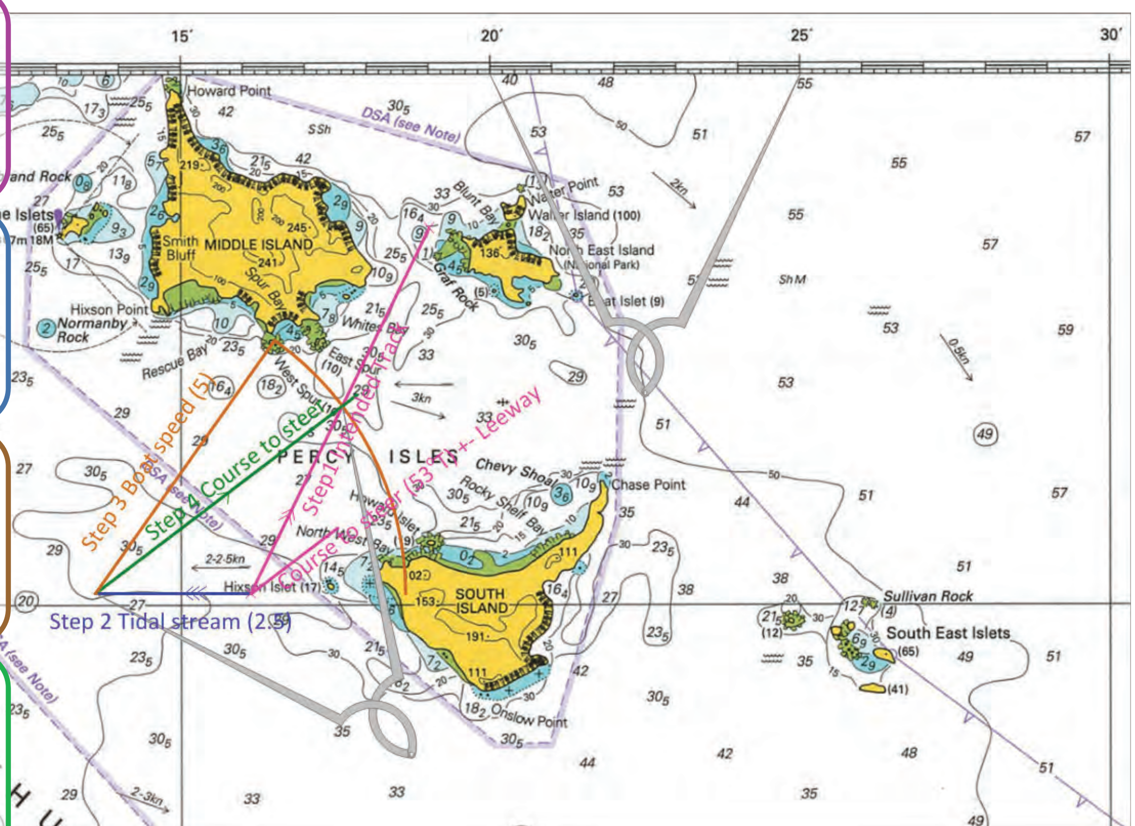
assume flood tide 2.5 knots

Step1, draw the intended track or course to make good.

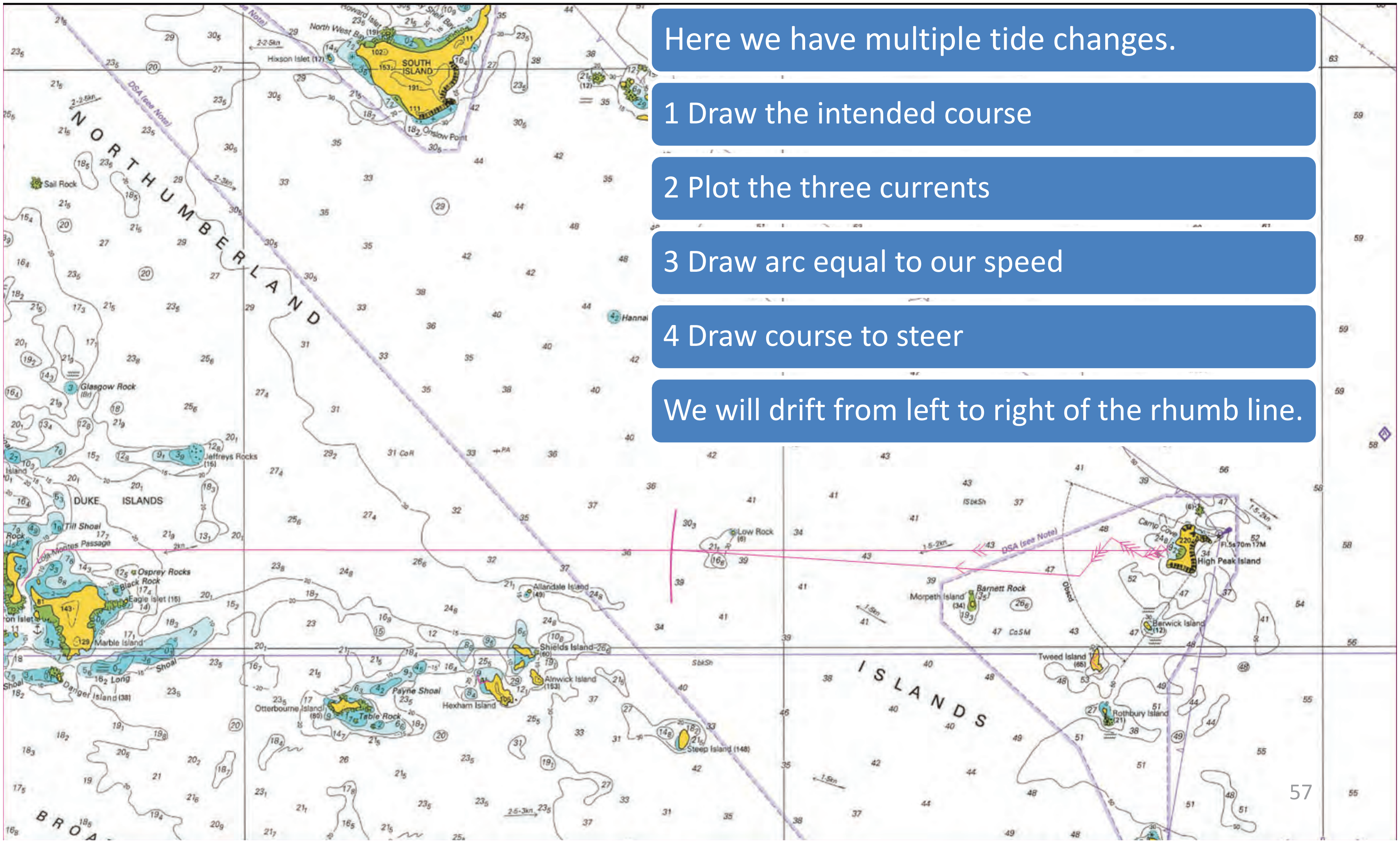
Step2, using any unit, draw the Tide vector (2.5), representing 2.5 knots in direction of flow.

Step 3, set dividers to the planned boat speed same units as tide vector (5knots) and scribe arch to cut track.

Step 4, draw line from end of tide vector to intersection. This is the Couse to steer. Include Leeway.



Course to Steer with Tide Change



Here we have multiple tide changes.

1 Draw the intended course

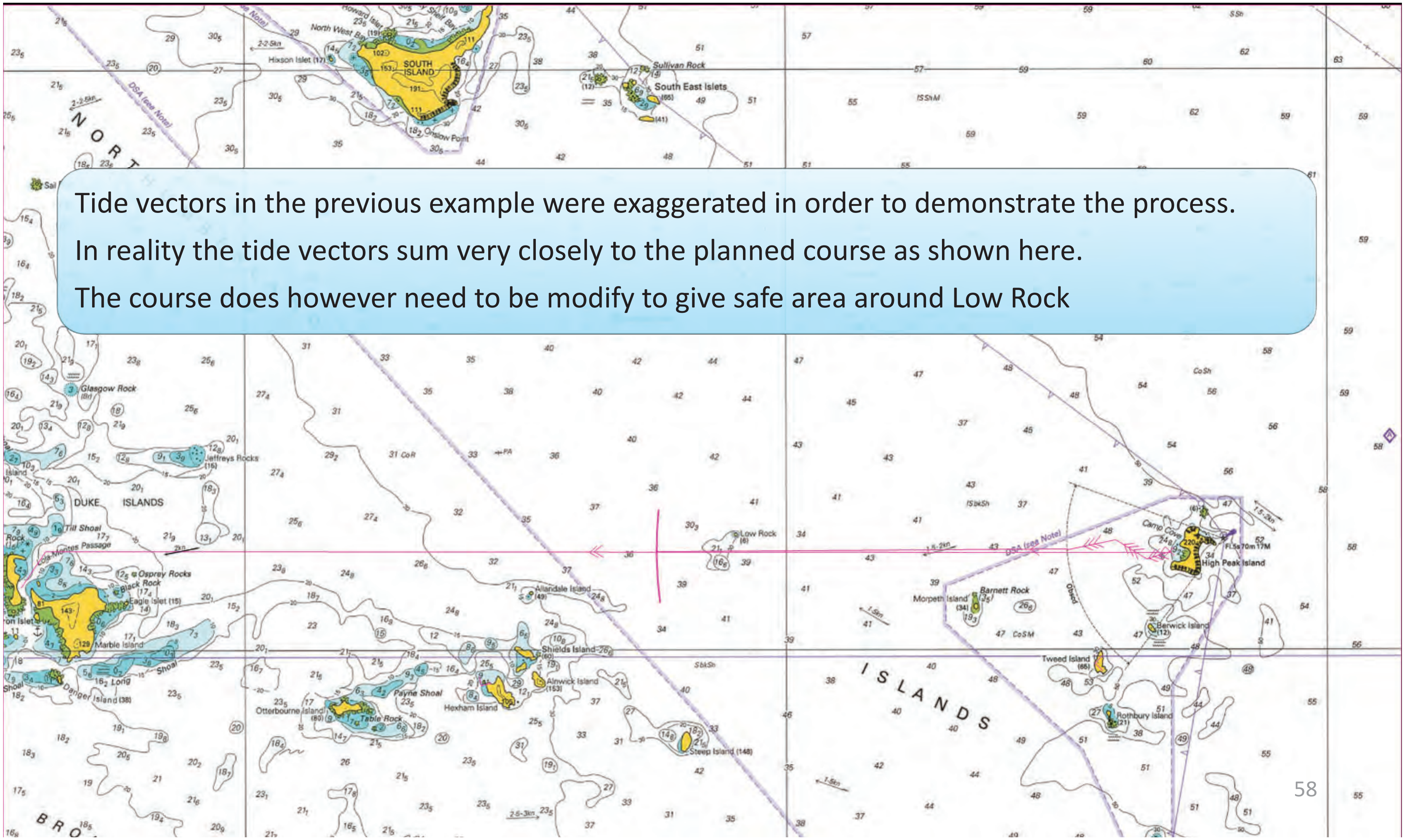
2 Plot the three currents

3 Draw arc equal to our speed

4 Draw course to steer

We will drift from left to right of the rhumb line.

Actual CTS is close to Track

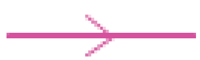


Tide vectors in the previous example were exaggerated in order to demonstrate the process.

In reality the tide vectors sum very closely to the planned course as shown here.

The course does however need to be modify to give safe area around Low Rock

Some Plotting Symbols

T	True heading
M	Magnetic heading (variation corrected)
C	Compass heading (deviated corrected)
	Intended track
	Current vector
	Course to steer
	Line of position vector

Your Position

by Deduction and Observation

We now look at determining position by traditional means, first by deduction and second by observation.

↓

Once core navigation is understood we move onto Electronic Navigation.

↓

Electronic Navigation is an aid to navigation and definitely not infallible.

↓

Can we interpret the data provided?

↓

We will know if our navigational aids fail; if they provide false data, would we know?

↓

Should they fail and also if we are not able to obtain an observation fix, we fall back to deducing (DR) or estimating (EP) our position and this requires regular record keeping, both chart work and Log.