Descriptor

This module aims to provide Observers with the basic understanding of the practical elements of navigation and to explain how a position is determined.

The learning outcomes for this training requirement are:

1. Demonstrate knowledge of navigation and positioning (including latitude/longitude; course and speed);
2. Aware of electronic navigation equipment usage and limitations (GPS; plotters; echo-sounders and sonar); and
3. Familiar with principal functions of electronic fishing aids and the information they provide.

One of the primary objectives of this module aims to provide Observers with the basic understanding of the practical elements of navigation and to explain how a position is determined.

The first question is what is a POSITION ?? and how do we RECORD it ??

In the first picture you can say you are at the Old Town Hall. If you are in Colombo this would be ok. If you were in another country, you would probably say you were at the Old Town Hall in Colombo Sri Lanka. Both are correct and good for a tourist guide.

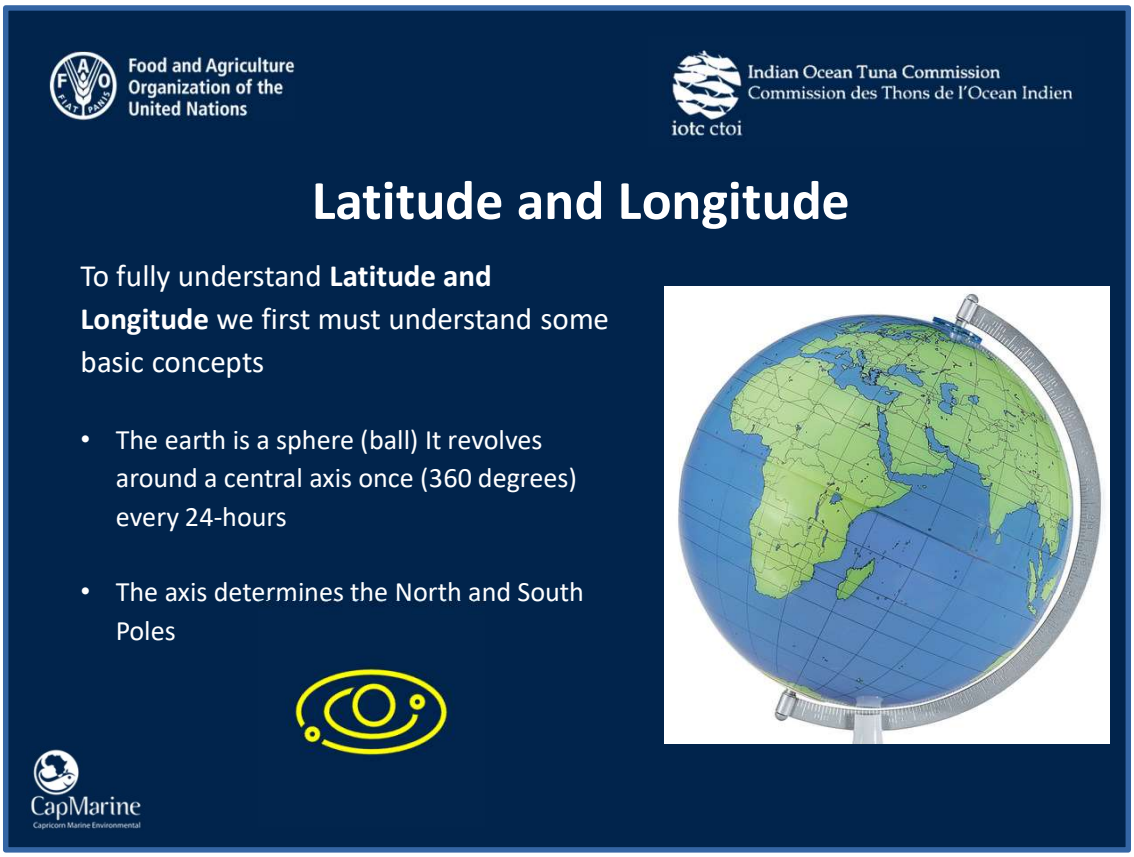
Out at sea this is not going to work, so we must resort to a marine global system.

For observers recording accurate positions are an essential component to support sampling data collected at sea, and importantly, is understanding exactly what you are recording.

Clearly when asked you will know that positions at sea are recorded in coordinates of Latitude and Longitude and these figures are obtained from the GPS on the bridge, but we really need to understand exactly what latitude and longitude is and what the coordinates represent

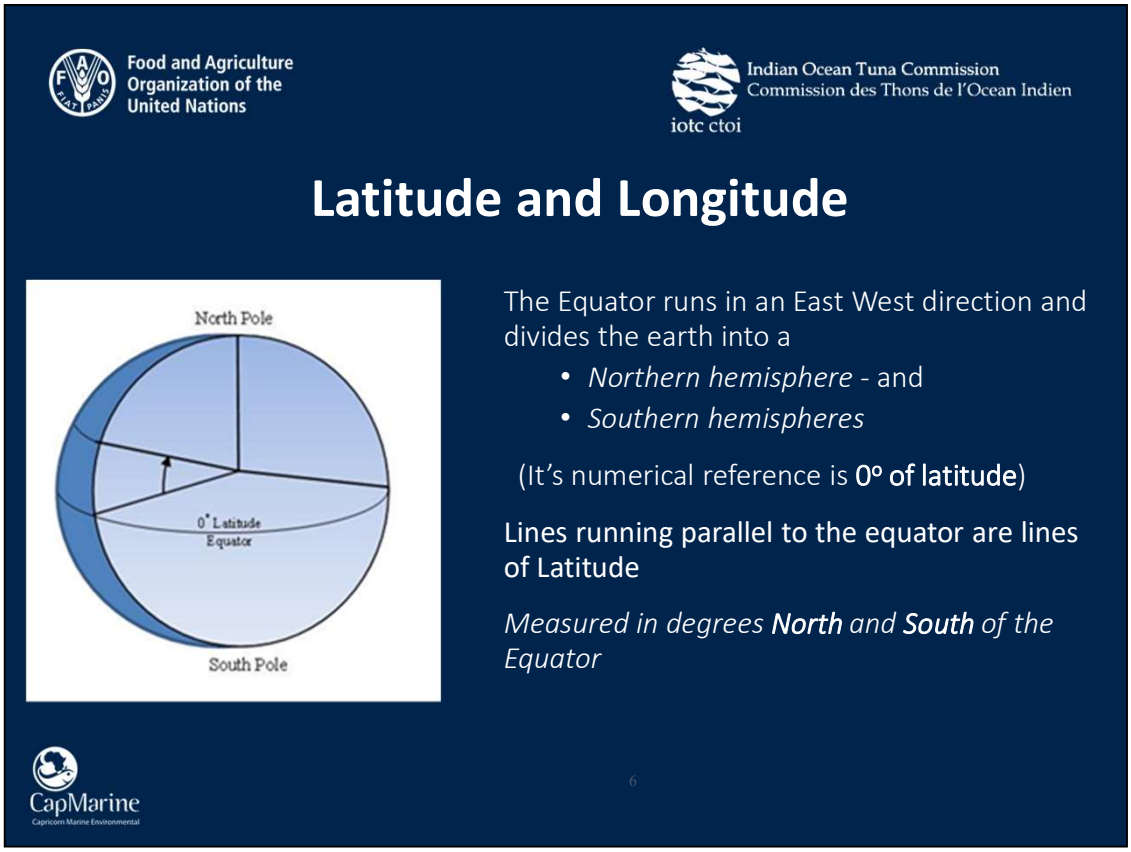
Essentially this requires some basic understanding of the practical elements of navigation that include:

- being able to understand and view the division of the earth's sphere into coordinates of latitude and longitude and why these are measured in degrees;
- basic mathematical theory relating to working with circles and angles and measurements in degrees, minutes and or decimal points of a degree or seconds;
- We need to understand the standard units of measurements for length and speed for both metric and imperial units as the data forms jump around asking these in both nautical and metric units; and
- **finally let's not forget direction and reading a compass.**



To fully understand **Latitude and Longitude** we first must understand some basic concepts:

- The earth is basically **shaped as a sphere** (ball)
- It revolves around **a central axis** **(**360 degrees) every 24-hours. This is on what our regional or "time zones" are based.
- The axis determines the North and South Poles, around which the earth rotates and provides reference to compass direction from the north pole.



Let us first consider Latitude

Imagine a plane that is perpendicular to the earths north-south axis that cuts the earths into a *Northern hemisphere* and *Southern hemispheres*

Where the plane cuts the earths surface it creates a reference line that runs around the earth in an East-West direction and is called the **Equator** (Its numerical reference is **0º of latitude**)

Lines running parallel to the equator are Lines of Latitude and these are measured in degrees **North** and **South** of the Equator with the angle taken from the centre of the earth.

Note: that the north-south axis is 90^{o} to the equator.

I*n summary*:

- the equator is 0^{o} of latitude
- The north pole is 90^{o} north latitude and all reference to latitude north of the equator must have the reference (N);
- The south pole is 90^{o} south latitude and all lines of latitude south of the equator must be references (S); and
- Note; **latitude can never exceed 90^{o}**

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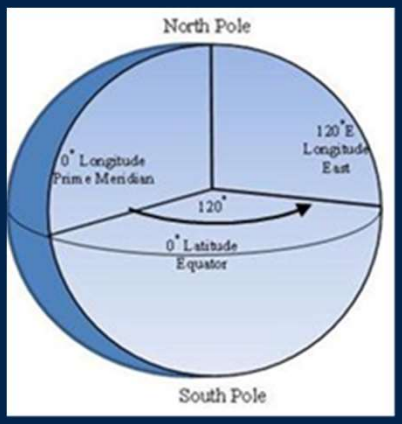
Latitude and Longitude



Longitude are lines drawn from the North to South Pole

All lines of longitude converge and cross at the poles

Longitude is measured **East** or **West** from the **0º Longitude** or *"prime meridian"*

(*Greenwich Meridian)* to a **maximum of 180º** East or West

The prime meridian and 180º line of longitude divide the earth into a East and West hemisphere

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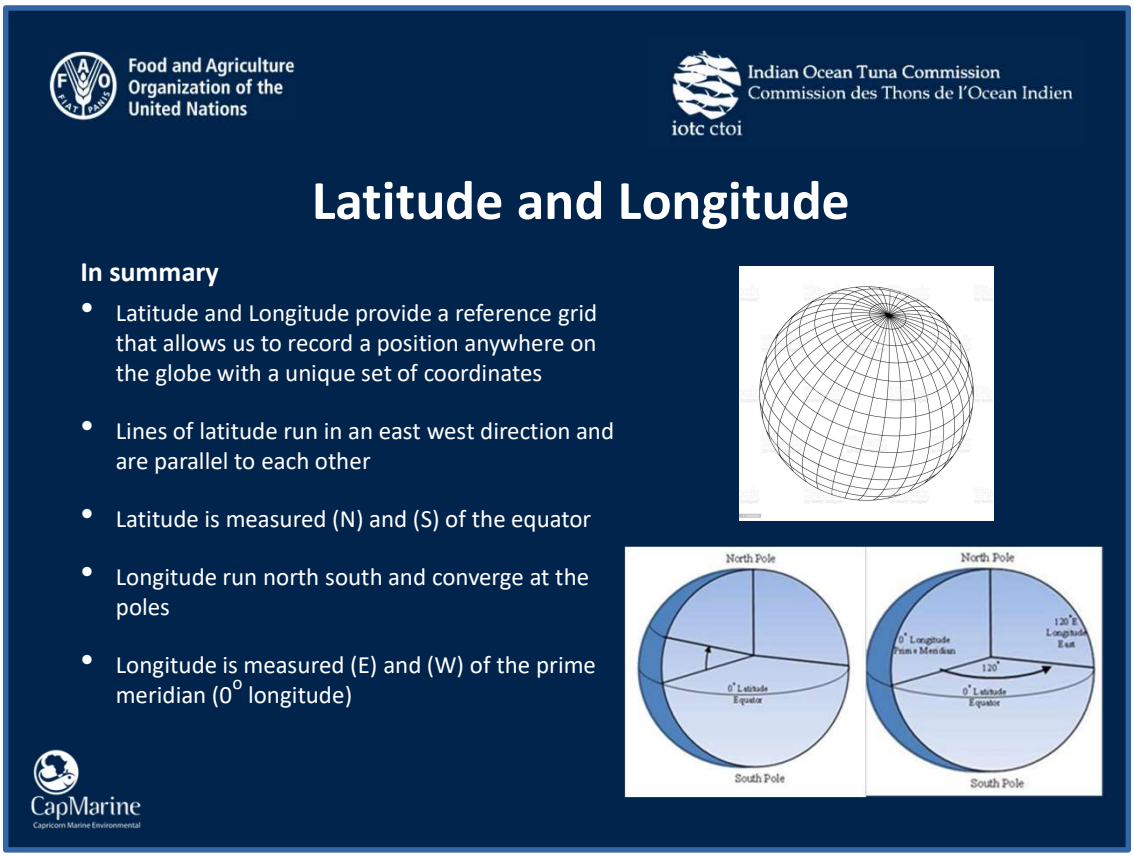
Longitude are lines drawn from the North to South Pole

- All lines of longitude converge and cross at the poles. This is important in that the lines are NOT parallel.
- Longitude is measured **East** or **West** from the **0º Longitude** or *"prime meridian"*
- (*Greenwich Meridian)* to a **maximum of 180º** East or West
- The prime meridian and 180º line of longitude divide the earth into an East and West hemisphere



In summary

Latitude and Longitude provide a reference grid that allows us to record a position anywhere on the globe with a unique set of coordinates of **latitude and longitude**

- Lines of latitude run in an east west direction and are parallel to each other. This affects us if we want to measure distance on a chart.
- Latitude is measured north (N) and south (S) of the equator
- Lines of longitude run north south and converge at the poles. They are also called **"meridians"**
- Longitude is measured east (E)) and west (W) of the prime meridian.
- The Prime Meridian (*unlike the equator in not a natural division*) and has arbitrarily been determined and accepted globally. It is the line of longitude that passes through the town of Greenwich in the UK and is called the **Greenwich Meridian or Prime Meridian**
- Opposite to the prime meridian (0^o longitude we get the 180^o meridian and the two divide the earth into east and west hemispheres.

Time

- Time zones are also measured from lines of longitude as the earth rotates around its axis once ever 24 hours.

  The earth rotates 15 degrees every hour (360 divided by 24)

- Time zones are measured from plus; +12-hours before Greenwich time (i.e. when the sun is perpendicular over the Greenwich meridian "0") to minus; -11 hours when the sun has passed the Greenwich meridian.

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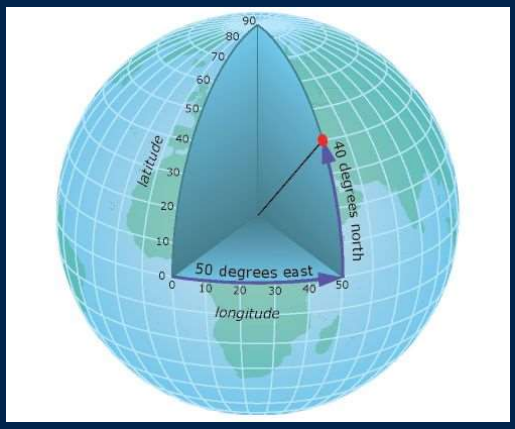
Latitude and Longitude

Positions must be recorded (N) or (S) and (E) or (W) for every position



What are the latitude and longitude coordinates for this position ?

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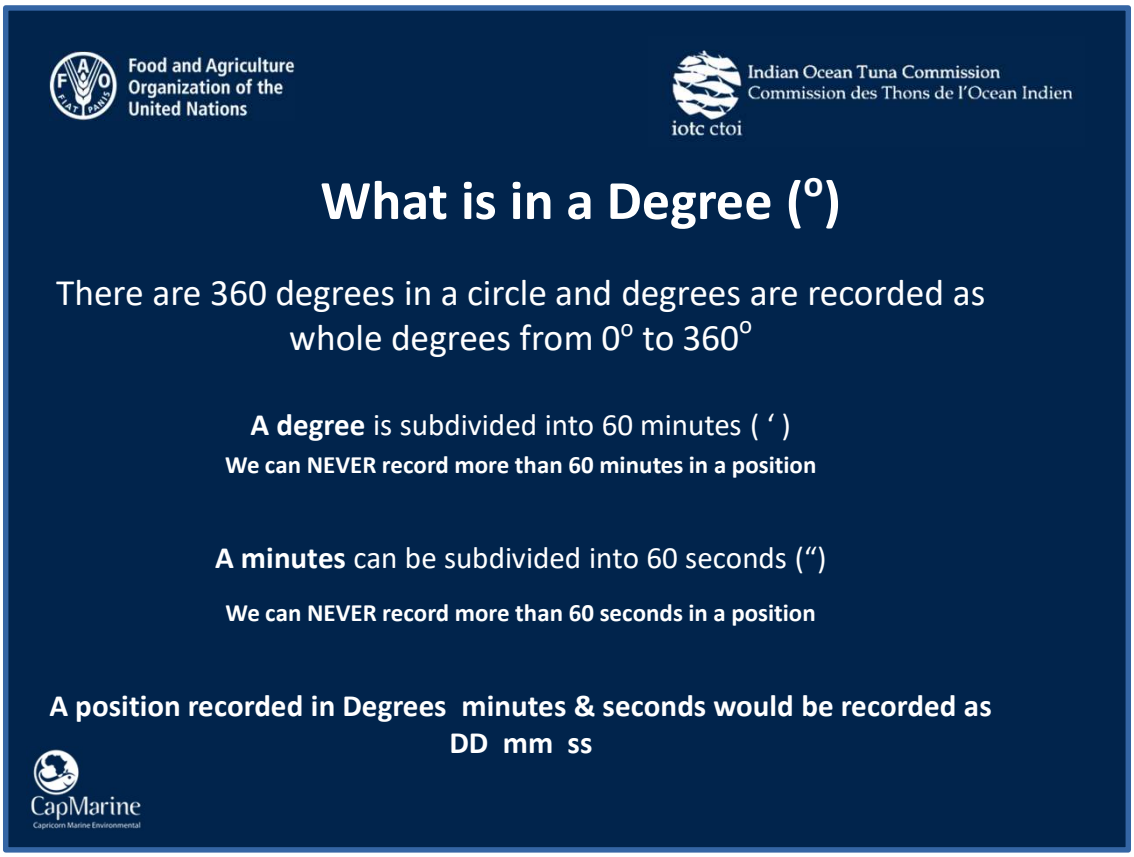
As you should have noted by now: Latitude and Longitude are angular measurements measured in degrees.

It is important to fully understand the units that these are measured in and possible variations in these units when recording positions. These MUST be always remembered:

- Positions are recorded either north (N) or south (S) and east (E) or (W) and this MUST recorded this for every position.



Degrees are recorded as whole **degrees (°)** or sub-units of degrees called **minutes (').**

There are 360° in a circle and 60' minutes in a degree. Therefore, we can NEVER record more than 60' in a position

> *For Example: we can have coordinate of 36° 37' N but can **NEVER** have a coordinate that is 36° 73' N as minutes can never exceed 60.*

Minutes can be further subdivided into seconds **(")** and there are **60" seconds** in a minute. So, like minutes there can never be more than 60" in a coordinate that records seconds in a position.

A position recorded in Degrees minutes & seconds would be recorded as DD mm ss and the minutes and seconds cannot exceed 60

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What is in a Degree (°)
Now for the confusing bit!!

Most position recording instruments are set to record Degrees and minutes and decimals *(tenths) of a minute*

(DD mm.mmm)

Therefore: the decimal minutes can exceed 60

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However, most position recording instruments are set to record Degrees and minutes **and decimals (tenths)** of a minute. (DD mm.mmm)

So, a unit can measure 30° 34.769' in this case the (.768) are tenths of a minute.

For observers this can be an issue if their data forms require a specific format for reporting positions. i.e. the format must be DD mm ss. Many fishing masters don't know the difference are reluctant to reset their instruments.

Also, it is not easy to check what a GPS may be recording especially if it is set to read only 2 decimal places. It is recommended that the observer watch the changing positions to see if the last digits exceed (60) at any time as this will positively indicate the reading is minutes and decimal minutes. *Note you will never record decimal seconds*.

Decimal minutes can be converted to seconds by multiplying the decimal minutes by 60 and always rounding off to two decimal places

From above example, (.769) minutes X 60 = 46 seconds

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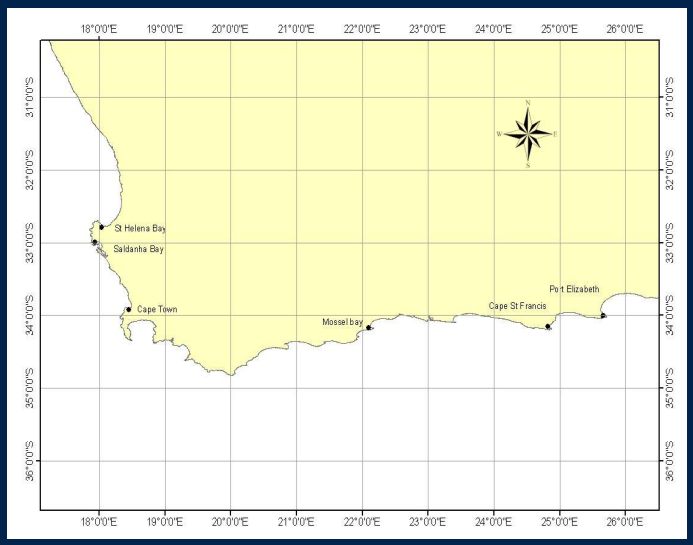
Navigation charts

The top of the chart is orientated to the north

Lines of latitude and longitude are straight lines –

- lines of latitude drawn (east – west)
- lines of longitude drawn (north – south)



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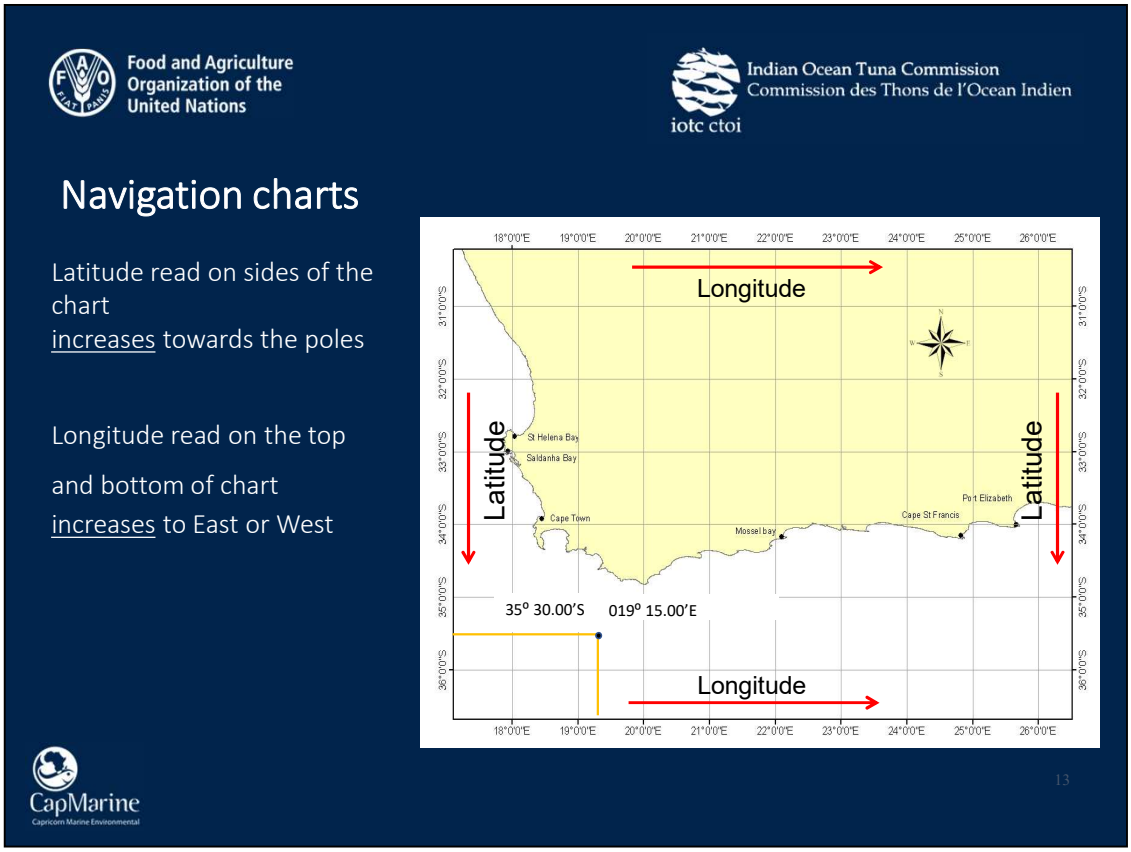
Need to relate latitude and longitude to a navigation charts which are now often reflected on electronic plotters.

Navigational charts are orientated North at the top of the chart and Lines of latitude and longitude shown as 3Com straight lines that are perpendicular to each other with:

- lines of latitude drawn (east – west) horizontally across the chart; and
- lines of longitude drawn (north – south) vertically up and down



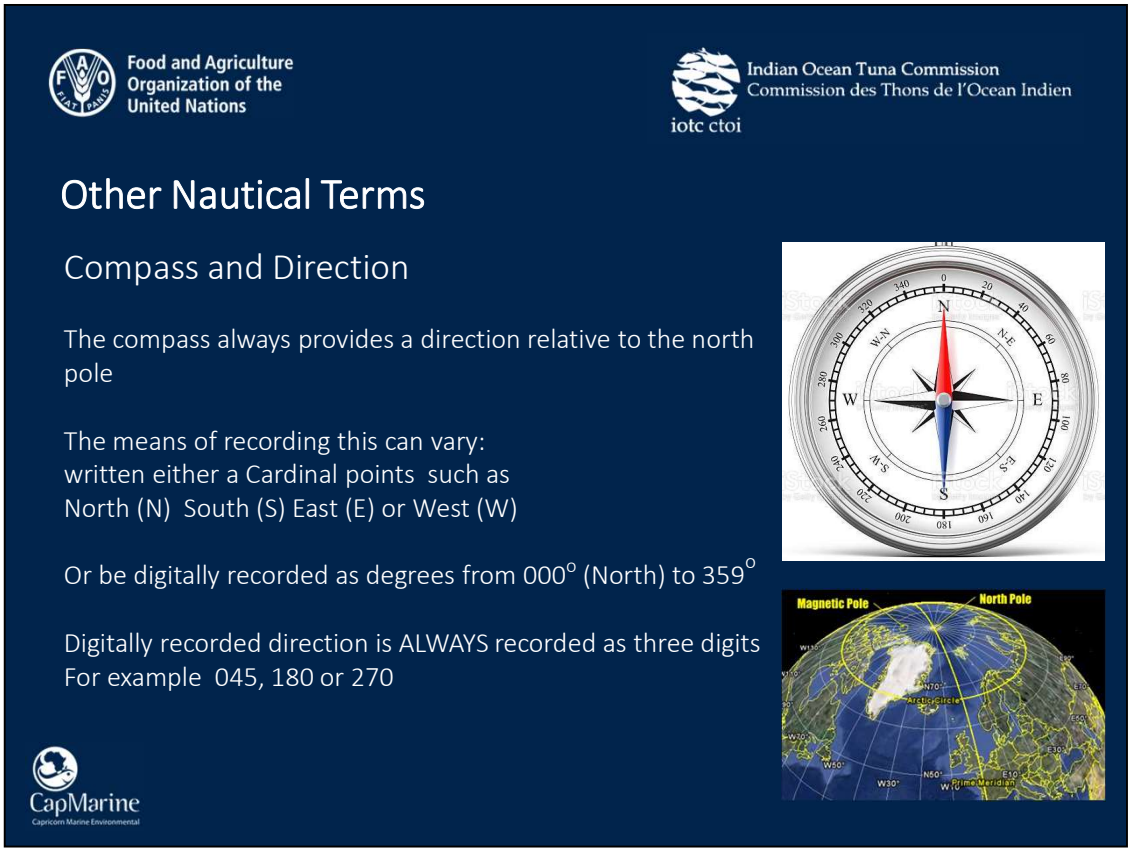
To record a position:

- the coordinates for Latitude can be read on either side of the chart; and
- the coordinates for Longitude can be read on the top or bottom of chart.

The latitude will always increase towards the poles:

- if you are south of the equator the latitude will increase towards the bottom of the chart; and
- if you are in the northern hemisphere the latitude will increase towards the bottom of the chart

Similarly, if you are in the eastern hemisphere (in the Indian ocean) the longitude will increases towards the east (i.e. the right-hand side of the chart)

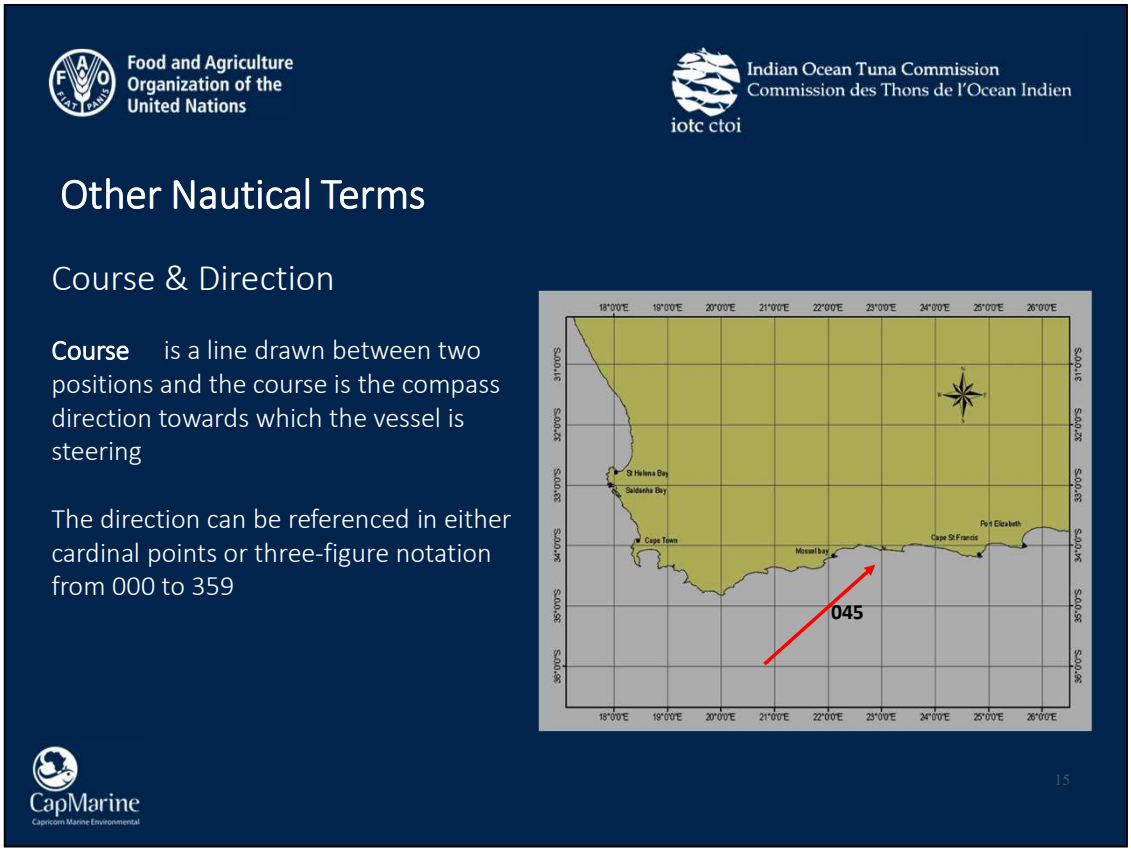


Compass and Direction

The compass always provides a direction relative to the north pole. The means of recording this can vary: Written either a Cardinal points such as North (N) South (S) East (E) or West (W); or Northwest(NW), or East Southeast (ESE), etc.; Or be digitally recorded as degrees from 000° (North) to 359° . Digitally recorded direction is ALWAYS recorded as three digits. For example, 045, 180 or 270.

There are some other factors, such as differences between magnetic compasses and electronic compasses and it is good to remember that a magnetic compass points to magnetic North Pole and is independent of any electrical power, while the electronic compass to the actual North Pole also called True North and is dependant on an external power source. Just for reference:

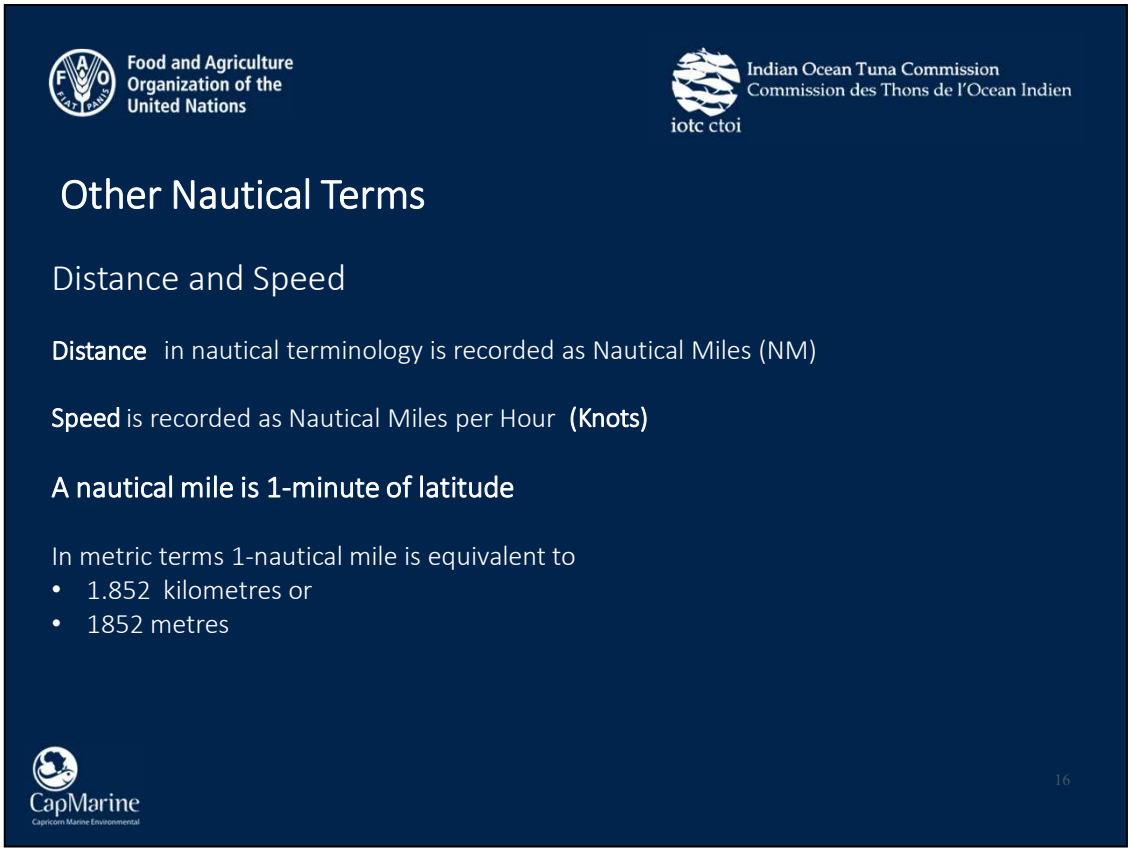
North	(N)	=	000 or 360
East	(E)	=	090
South	(S)	=	180
West	(W)	=	270
North East	(NE)	=	045
North West	(NW	=	315
South-East	(SE)	=	135
South West	(SW)	=	225



Course and Direction

A Course can be plotted onto a chart and is a line drawn between two positions. It is also the compass direction the vessel is steering. The direction can be referenced either in cardinal points i.e. N or E or in three-figure notation from 000 to 359. In normal navigation the course would be written alongside the line drawn on the chart.

Today the **course** is recorded digitally on most of the navigation system together with the speed of the vessel.



Distance and Speed

Distance in nautical terminology is recorded as ***Nautical Miles*** **(nm)**

Speed is recorded as ***Nautical Miles per Hour referred to as (*****Knots)**

A nautical mile, by definition, is "the meridian arc length corresponding to one minute of latitude" Remember we noted that lines of latitude are parallel, and lines of longitude (meridians) converge at the poles.

Therefore, we can **NEVER** measure distance as minutes of longitude.

It is very important for observers to be able to relate between recording distance in nautical miles and speed in Knots.

Navigational equipment will display distance and speed in these units, but often gear parameters are recorded in metric units and it is necessary to convert from nautical units to metric.

It is, therefore, extremely important to remember that a nautical mile is equivalent to 1.852 kilometres or 1852 meters.

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SPEED TIMES DISTANCE

The distance covered by a vessel, its speed or the time that it will take to travel from one position to another, can be calculated from (speed time distance) equations..

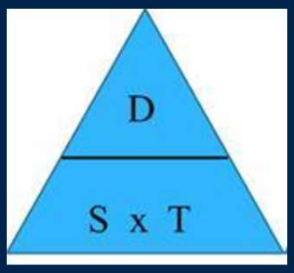
If Speed ***S*** Time ***T*** Distance ***D*** Then

- Speed

  S = D / T nautical miles per hour (knots)
- Time

  T = D / S Time in hours and /or/ minutes (hr:min)
- Distance

  D = S x T Nautical miles (nm)



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Speed and Distance

Considering that a nautical mile is 1-minute of latitude it is possible to measure or calculate distance by recording the difference in the minutes of latitude between two positions. Note this is not an exact measurement and is often estimated as accurately as possible. It does, however, provide some means of verifying positions and raise awareness if there are radical differences between a vessel reported position and an observers estimate, that there may be an error in the figures provided.

To undertake these checks, we use the relationship between distance, speed and time. We call this the distance and speed x time triangle, where Distance in nautical miles is equal to speed (in knots) X time (hours). From the relationship between these three factors if we have any two, we can calculate the third factor.

Speed S = D / T nautical miles per hour (knots)

Time T = D / S Time in hours and /or/ minutes (hr:min)

Distance D = S x T Nautical miles (nm)

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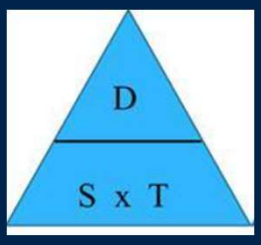
EXAMPLE 1: SPEED TIME AND DISTANCE

It takes you 5 hours to travel 100 NM

What was your speed?

Speed = distance (100) / Time (5)

Speed =20 Knots



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EXAMPLE 2: SPEED TIME AND DISTANCE

If you are entering the EEZ at 02:00 and your vessel is travelling at 10 knots

The limit of your EEZ (exclusive economic zone) is 200 nm from the harbour entrance.

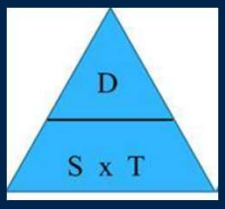
What time will you arrive in Port? (The EEZ is 200 NM)

Time = Distance divided by speed

200 NM / 10

= 20 hours

Start time 02:00 + 20 hours = 22:00



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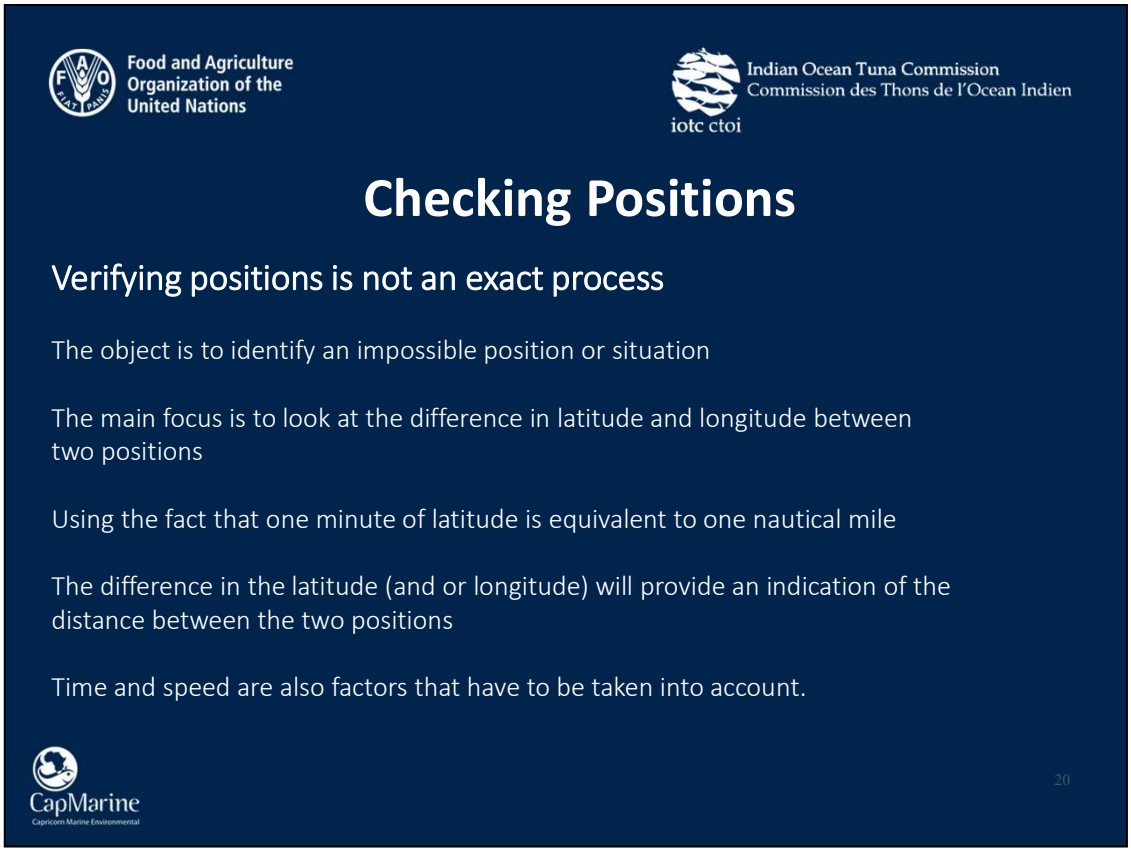


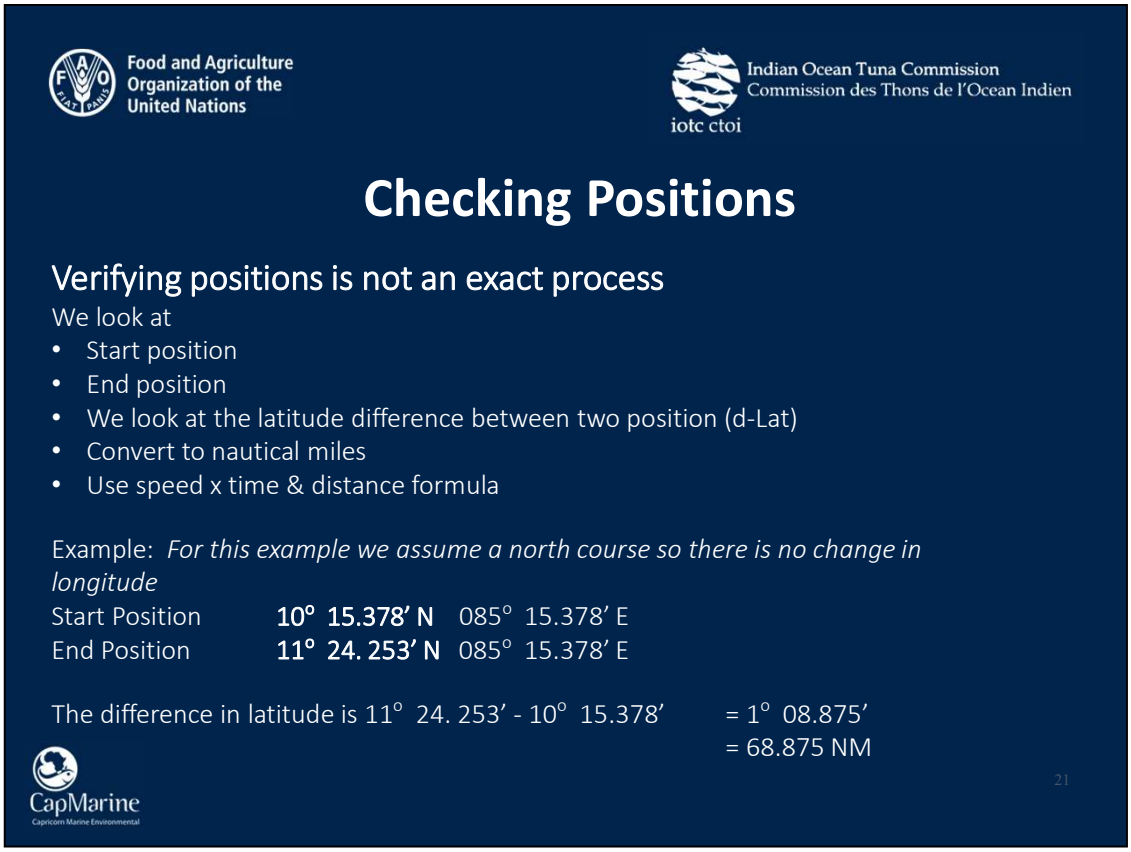
Checking or verifying positions or data from other sources

The object is to identify an impossible position or situation

The focus is to look at the difference in latitude and longitude between two positions, *Using the fact that one minute of latitude is equivalent to one nautical mile.* The difference in the latitude (and or longitude) will provide an indication of the distance between the two positions. Time and speed are also factors that must be taken into account.

A few pointers

- one degree of Latitude is 60 nautical miles
- although we don't measure distance on the longitude scale, when close to the equator the difference is not that large.
- Really need to look at a situation in a dynamic way



Checking or verifying positions or data from other sources

Verifying positions is not an exact process

We first look at the Start position and End position

- We look at the latitude difference between two position (d-Lat)
- Convert to nautical miles
- We can also use speed x time & distance formula for different questions and situations

Example: and f*or simplicity in this example we assume a northerly course so there is no change in longitude*

Start Position **10° 15.378' N** 085° 15.378' E

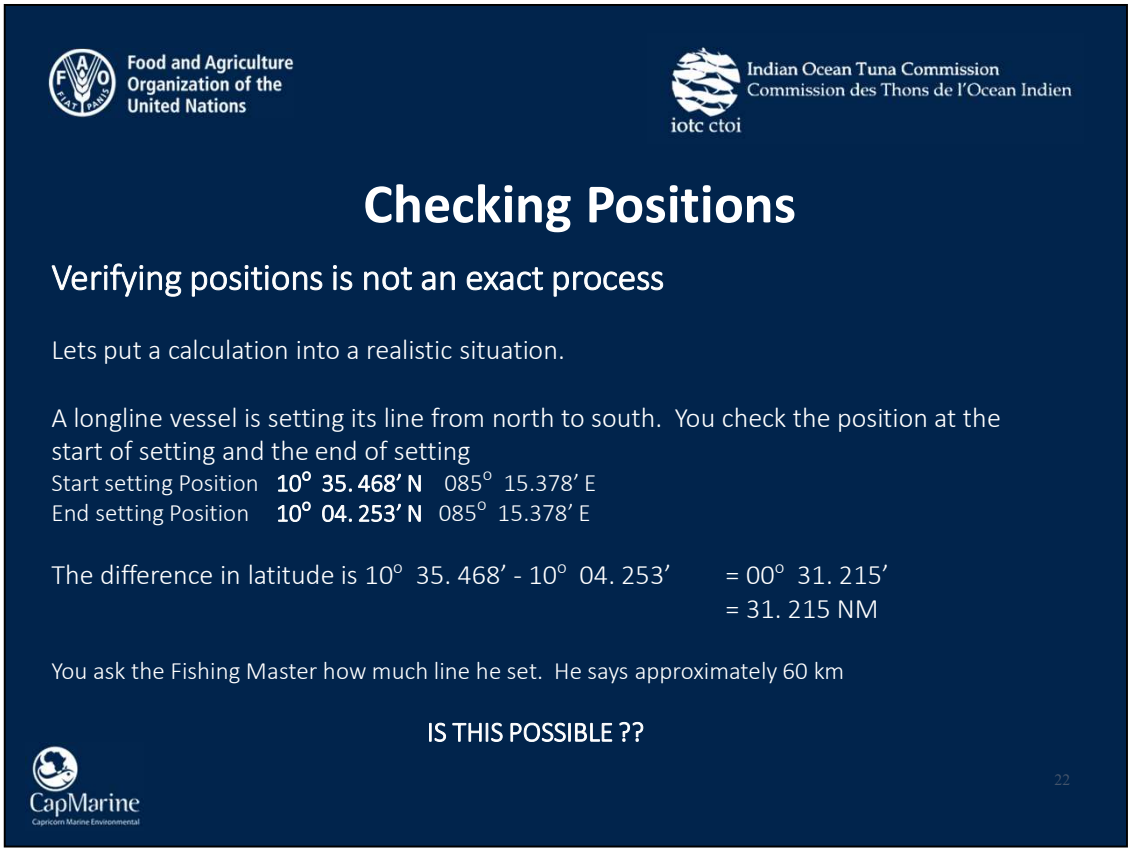
End Position **11° 24. 253' N** 085° 15.378' E

We can see we traveling in a north direction as longitude is the same and latitude is increasing

The difference in latitude is 11° 24. 253' minus 10° 15.378' = 1° 08.875'

= 68.875 NM

There are d-lat / d-long formulas that will calculate an exact length of the hypotenuse if there are differences in both latitude and longitude but for our purposes this level of accuracy is not required.



Checking or verifying positions or data from other sources


WHERE ARE YOU NOW ??
That’s it for now
THANK YOU FOR YOUR PARTICIPATION

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ANY QUESTIONS?

send us a message via Talents LMS

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