The Normal Baseline

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ADMIRALTY
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The normal baseline for measuring the breadth of the territorial sea is the low water line along the coast as marked on large scale charts officially recognised by the coastal state

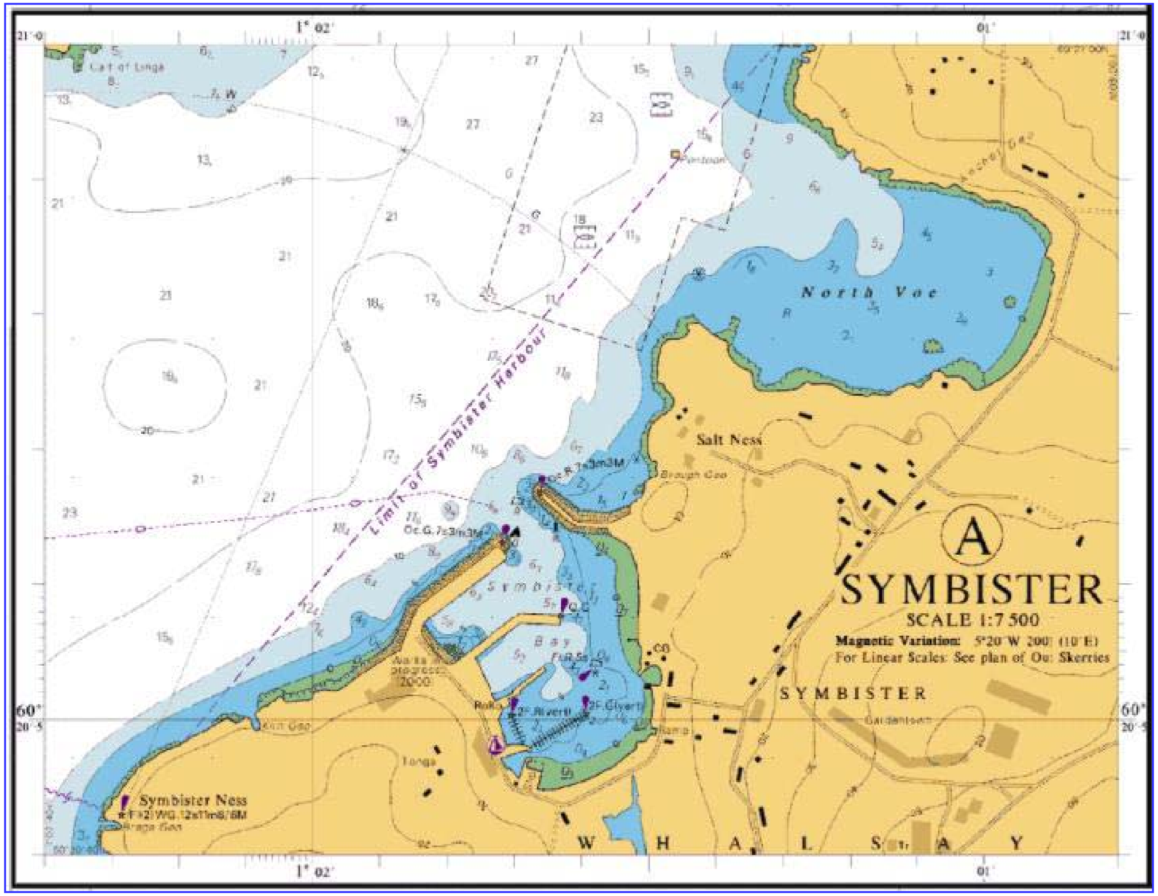
UNCLOS Part II Article 5

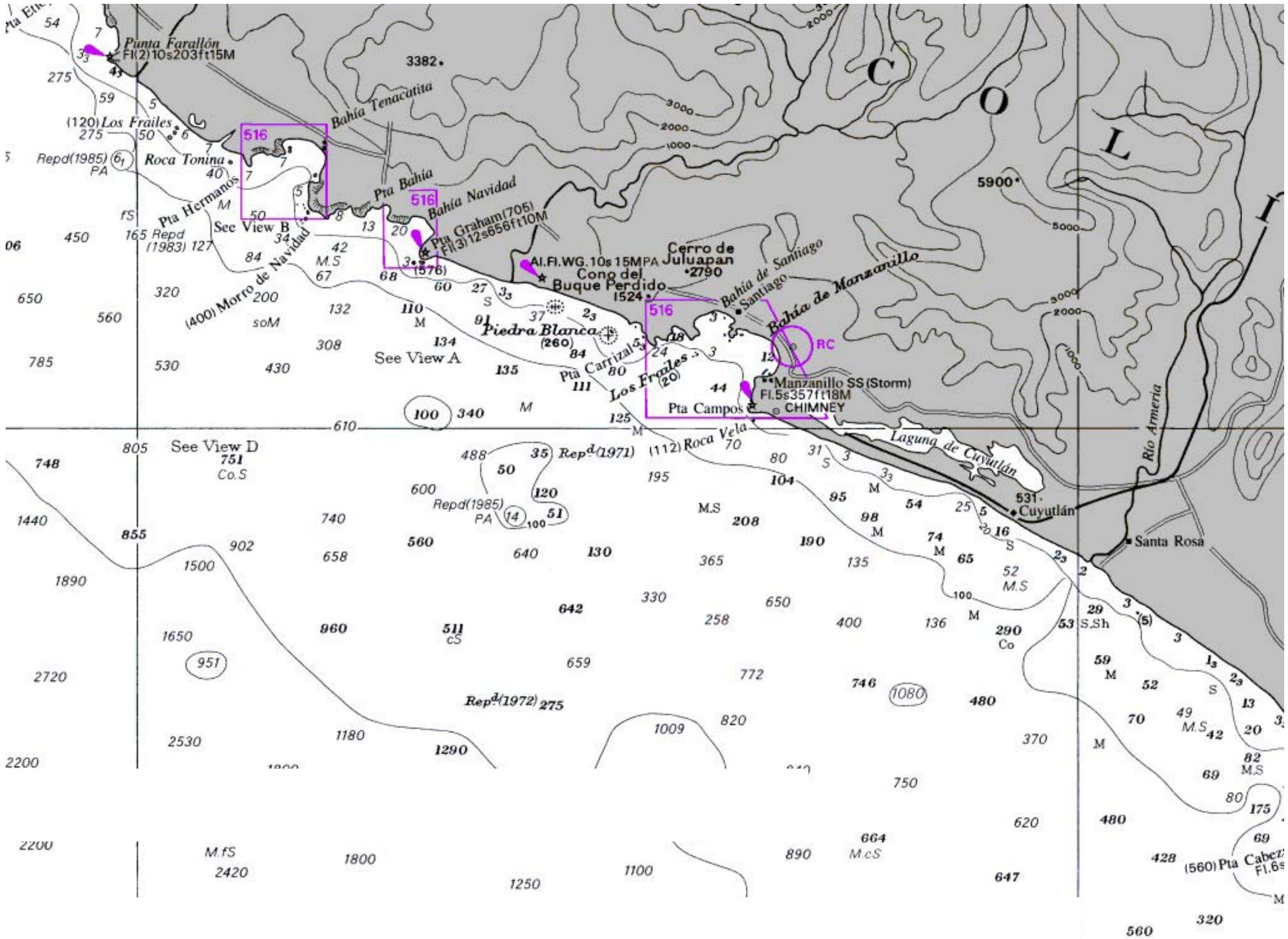
Scope

- Source data of the low water line
- Quality of charting
- Alternative baselines
- Assessing baseline accuracy
- Improving baseline accuracy
- The normal baseline in limits and boundaries

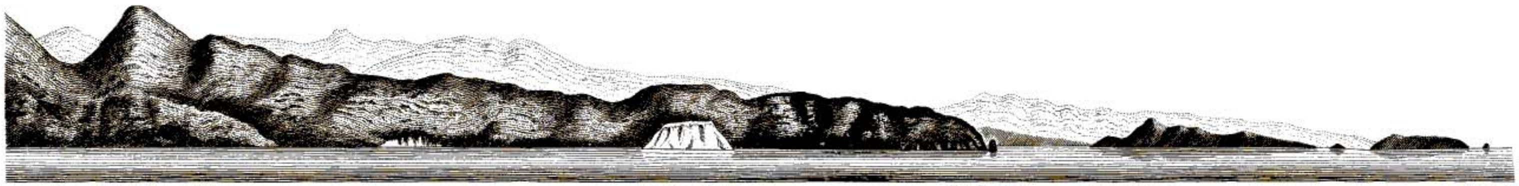
The Low Water Line

- One of the largest and most obvious features on a chart
- Not a very significant feature for the mariner today



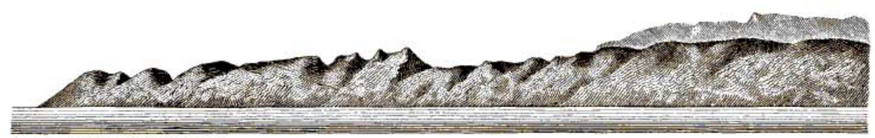


- Historically, the single most important feature on a chart



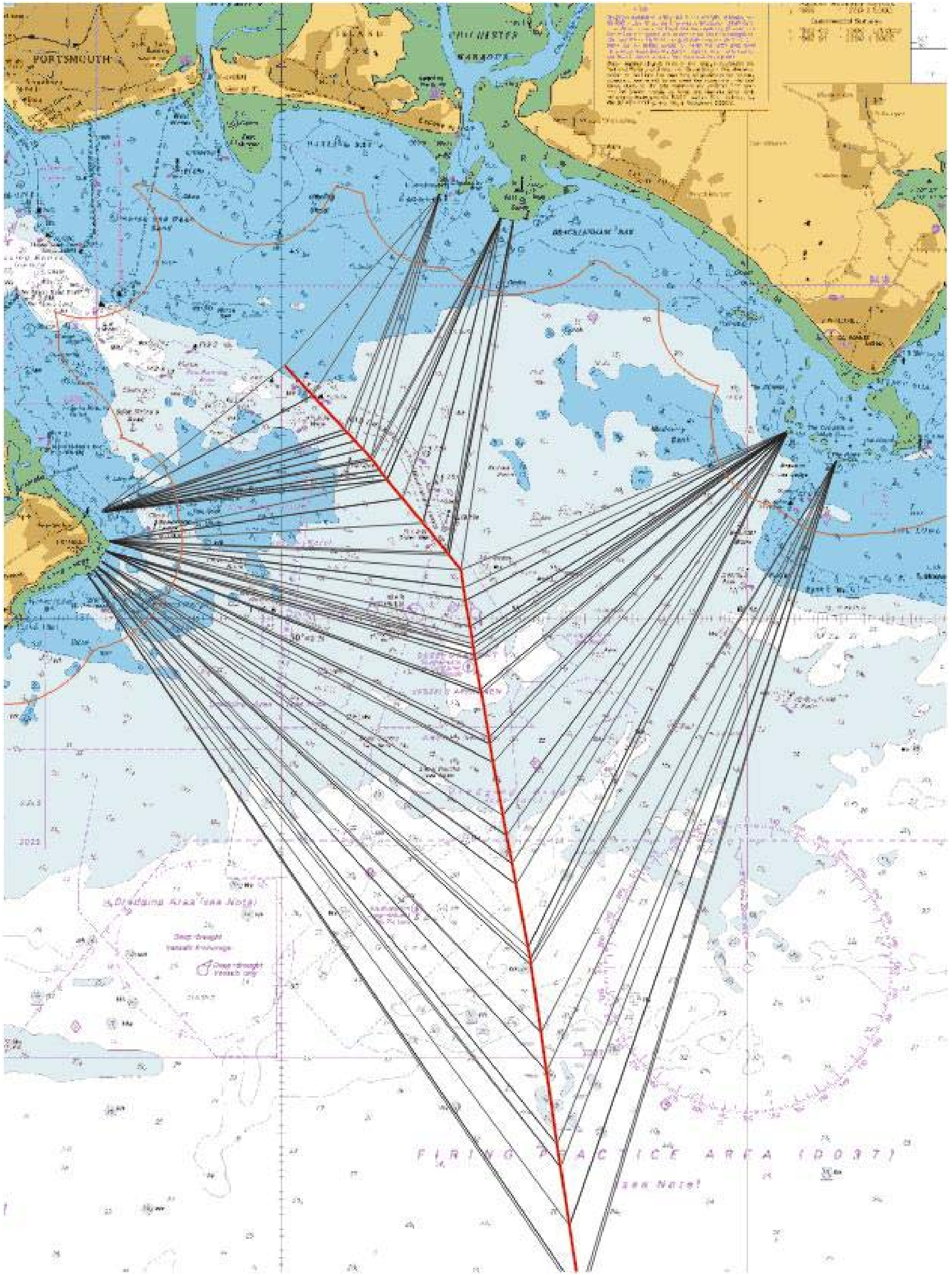
View A (at Lat.19° 05'.5 N., Long.104° 39'W.)

View B (at Lat.19° 12' N., Long.104° 50' W. approx.)



View C (at Lat. 20° 08' N., Long.105° 51' W. approx.)

- **For LOS, the baseline is very significant**
- **for generating maritime zones,**
- **enforcing national jurisdiction**
- **and calculating boundaries**

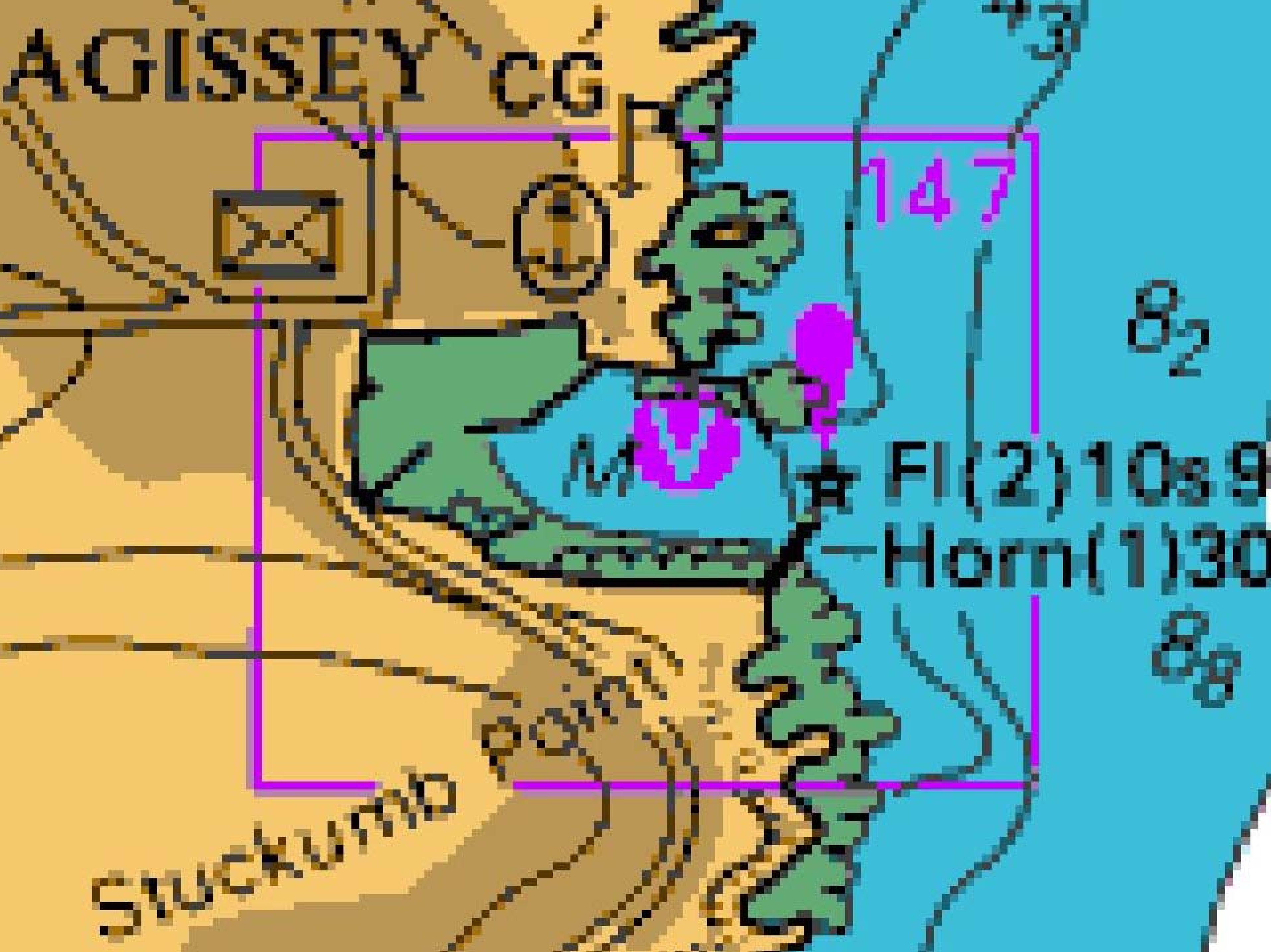


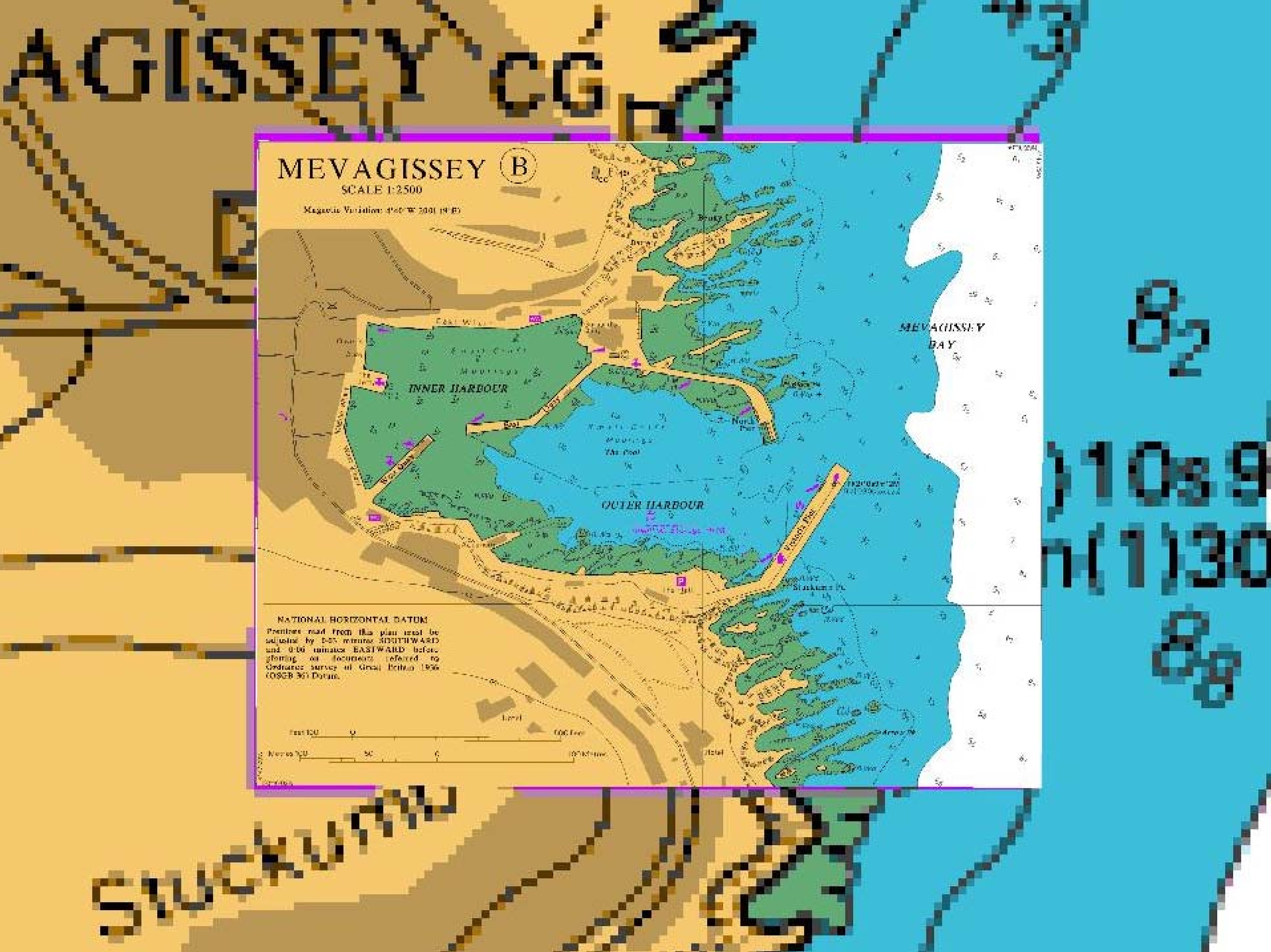
Surveying the Low Water Line

- The GPS effect
- Where does the low water line come from
  - Most data 18-19 century
  - Work for warships in peace
  - Control using horizontal sextant angles
  - Lead Line sounding
  - Shooting rays
  - Sketching
  - Sea sense
  - Local knowledge

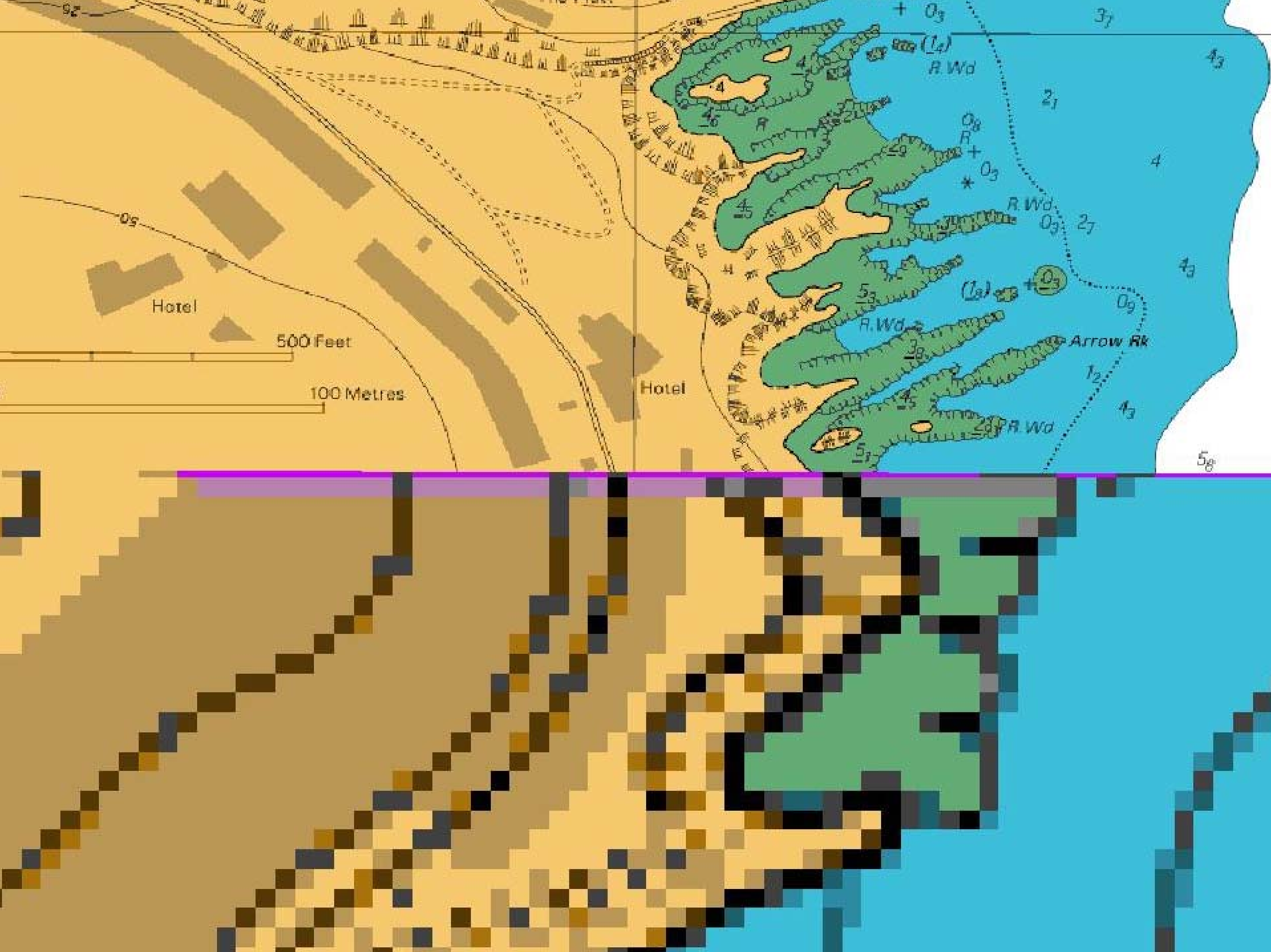
Datums and Control

- Established Land Survey networks
  - Extend network to the coast
  - Secondary marks to control sounding vessels
  - Tertiary marks to work close inshore
- Make your own datum
- GPS exposes the inaccuracies
- Putting them right is not so simple

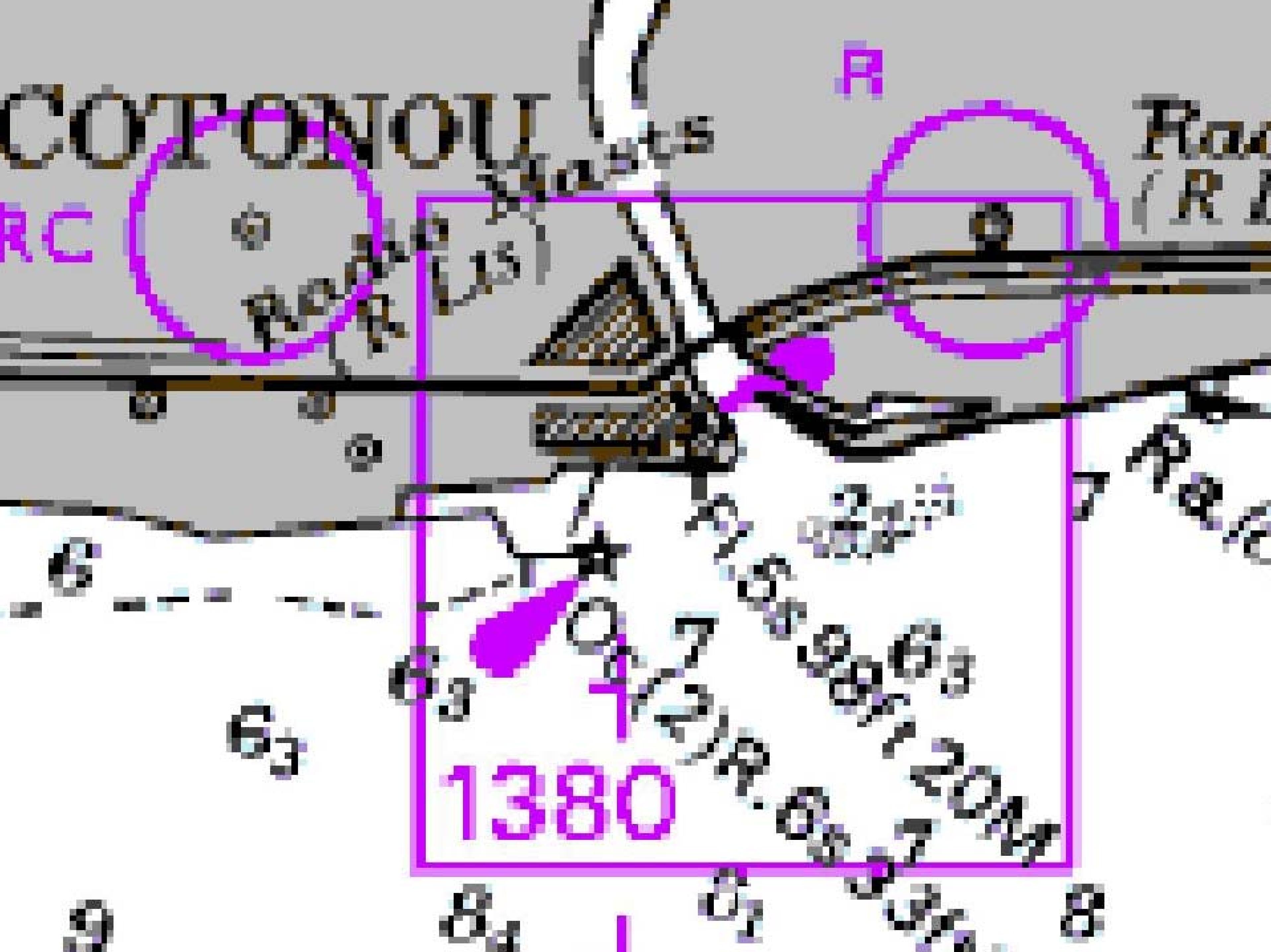

AGISSEY
CG
147
Fl(2)10s9
Horn(1)30
8_2
8_8

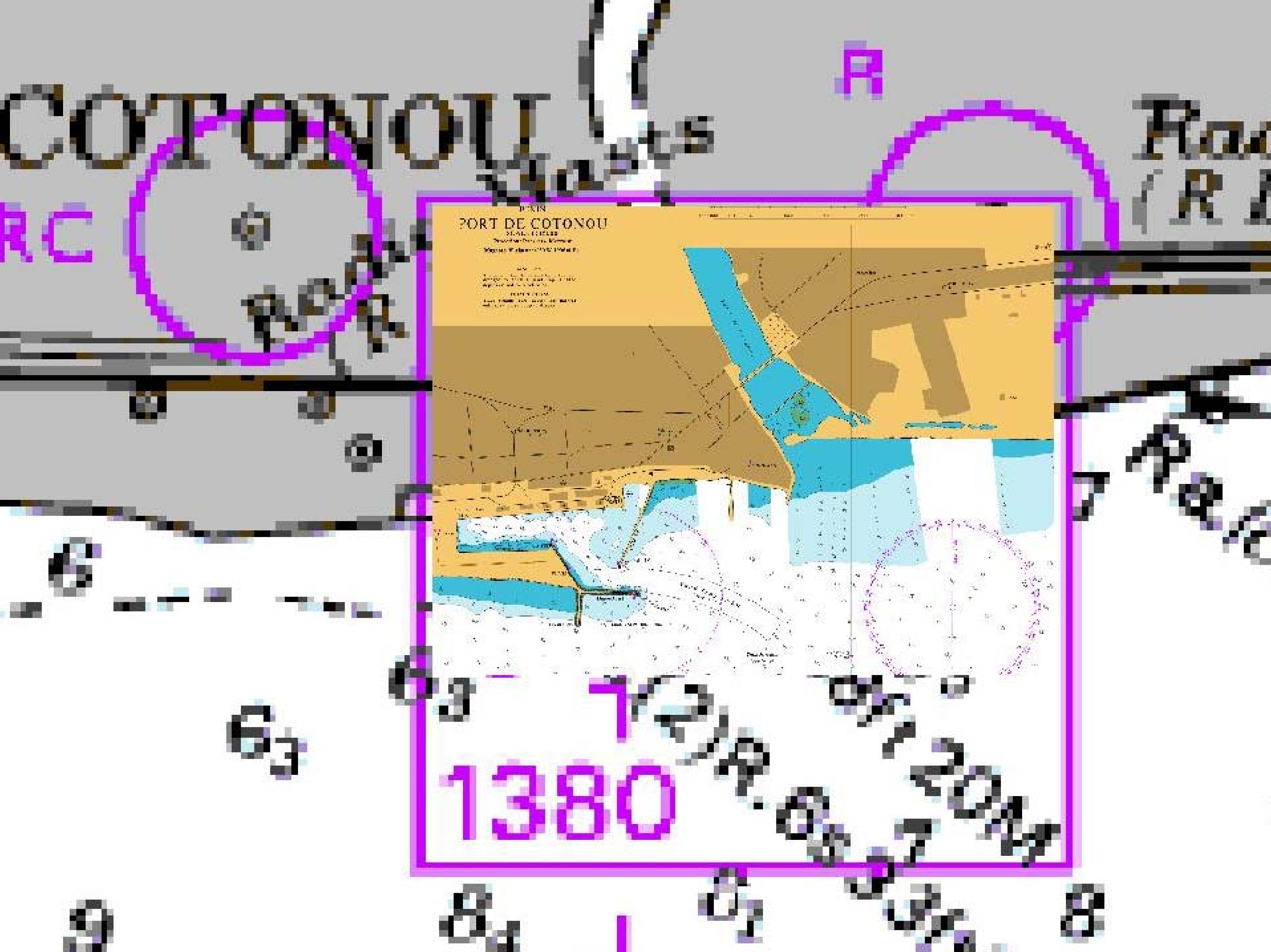


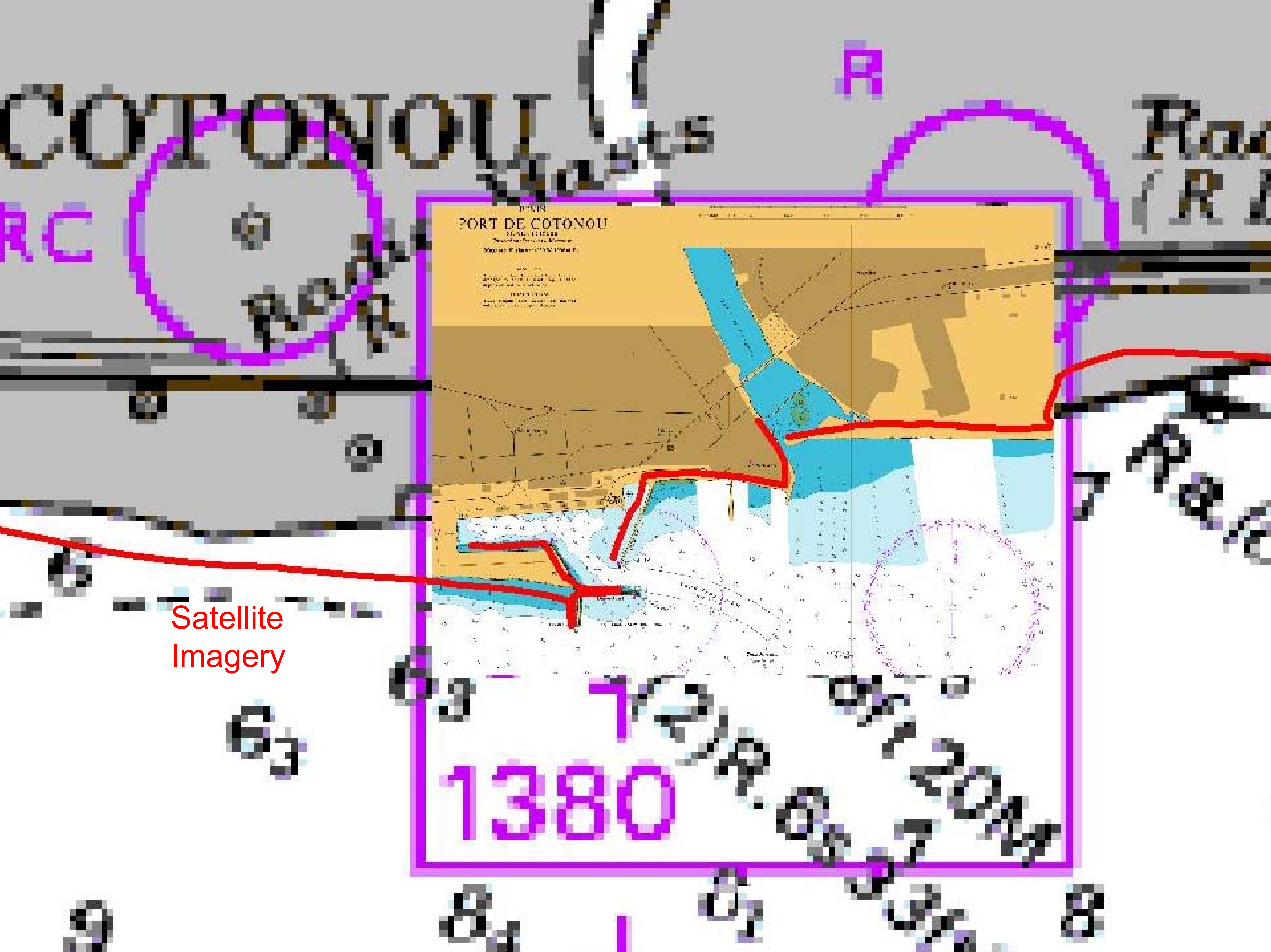
AGISSEY
CG
MEVAGISSEY (B)
SCALE 1:2500
INNER HARBOUR
OUTER HARBOUR
MEVAGISSEY BAY
NATIONAL HORIZONTAL DATUM



Hotel
500 Feet
100 Metres
Hotel
R.Wd
R.Wd
R.Wd
R.Wd
Arrow Rk


COTONOU
RC
R
Masts
1380


COTONOU
RC
R
PORT DE COTONOU
1380
20M



COTONOU
R
PORT DE COTONOU
1380
Satellite Imagery

Accuracy and Errors

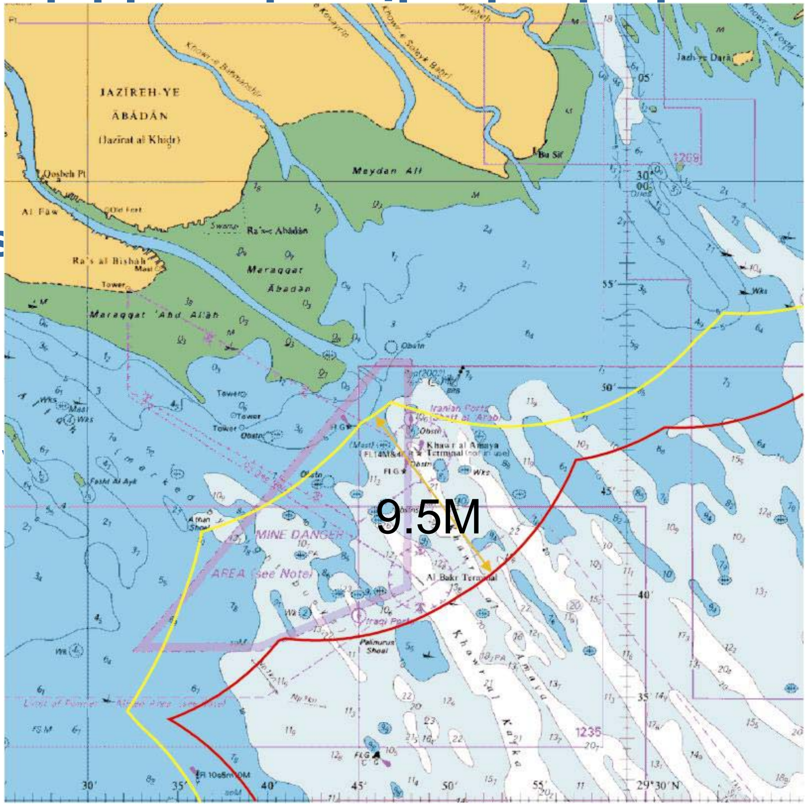
- Visual fixing on 3rd or 4th order control
- Sounding errors
- Tidal errors
- Graphic plotting of results on survey scale
- Symbolising low water line to represent nature of shore line
- The ravages of time
- Visual local fit to a compilation grid [worst case]
- Digitising errors when building the model
- 18/19th century baseline good to 40m at best

The Normal Baseline

- For defining limits and boundaries, we take the charted low water line as precise
- Probably the most inaccurate feature on a modern chart
- The most difficult and expensive to survey accurately
- Why not change to something more easy?

Alternatives

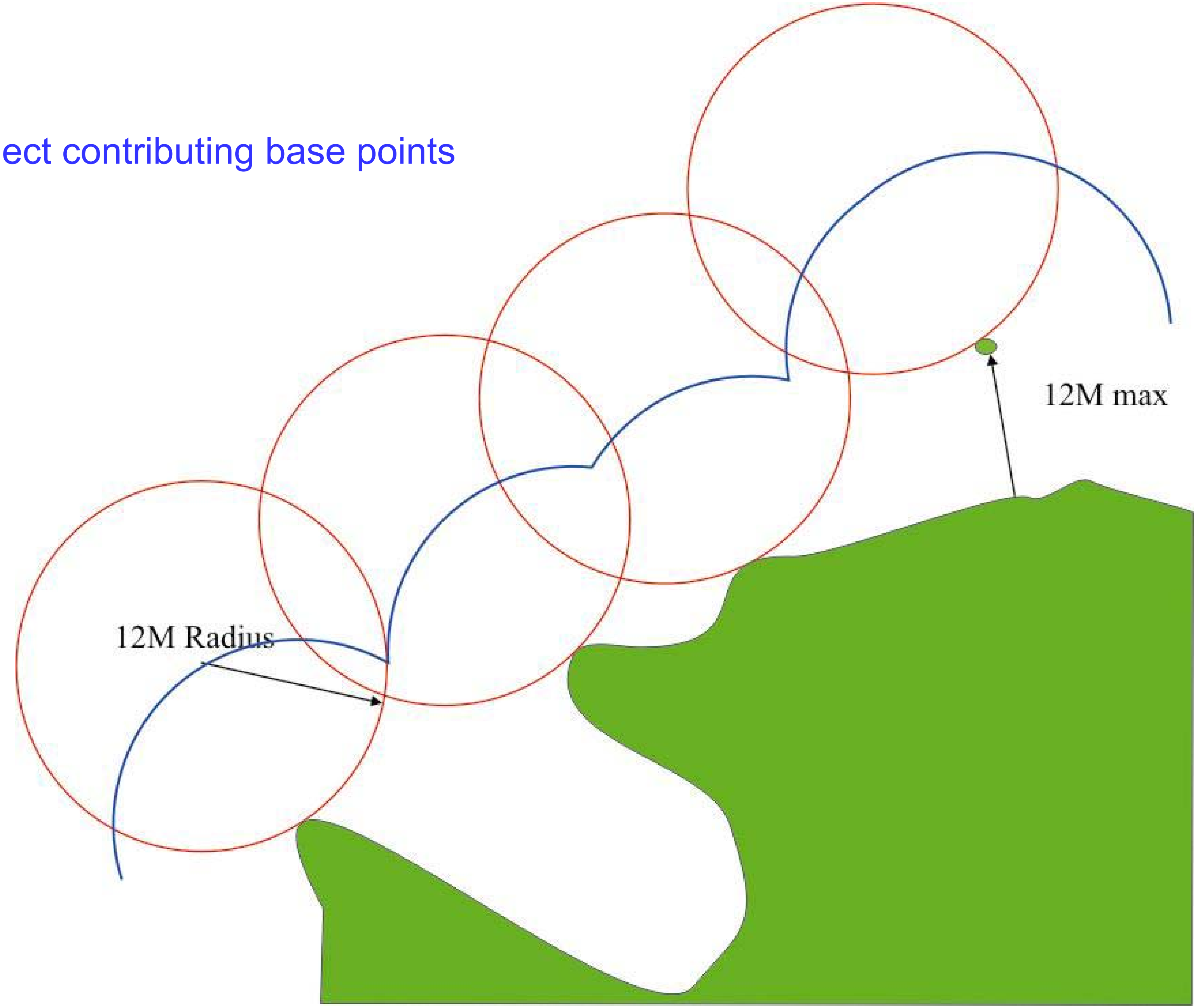
- A feature that is well surveyed,
- Rules out the low water line on
- Alternatives:
  - A series of straight baselines
  - The 10 metre contour
  - The High Water Line
  - Better surveys of the lo



How bad is it?

- Check some areas of relevant coast
- Very little of our coastline is relevant to either limits or boundaries
- Use a crude filter to pick critical headlands

Select contributing base points



Improving the baseline model

- The only option is to gather new survey data. Alternatives for this are:
  - Fix individual base points by GPS
  - Bathymetric Survey to sound the low water line at HW
  - Aerial Photography at LW
  - Satellite imagery
  - LIDAR survey to map the zero isobath

Satellite imagery

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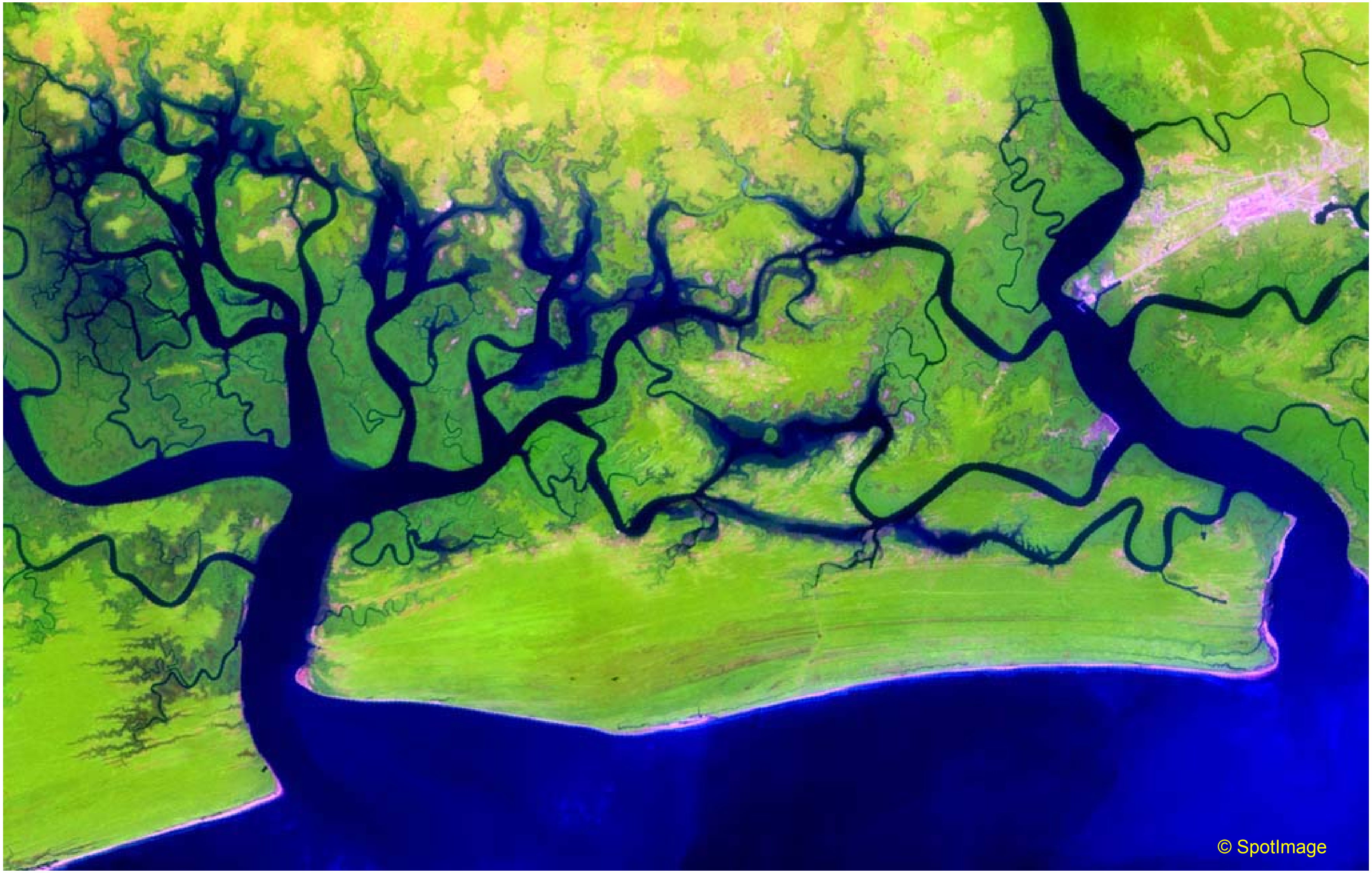
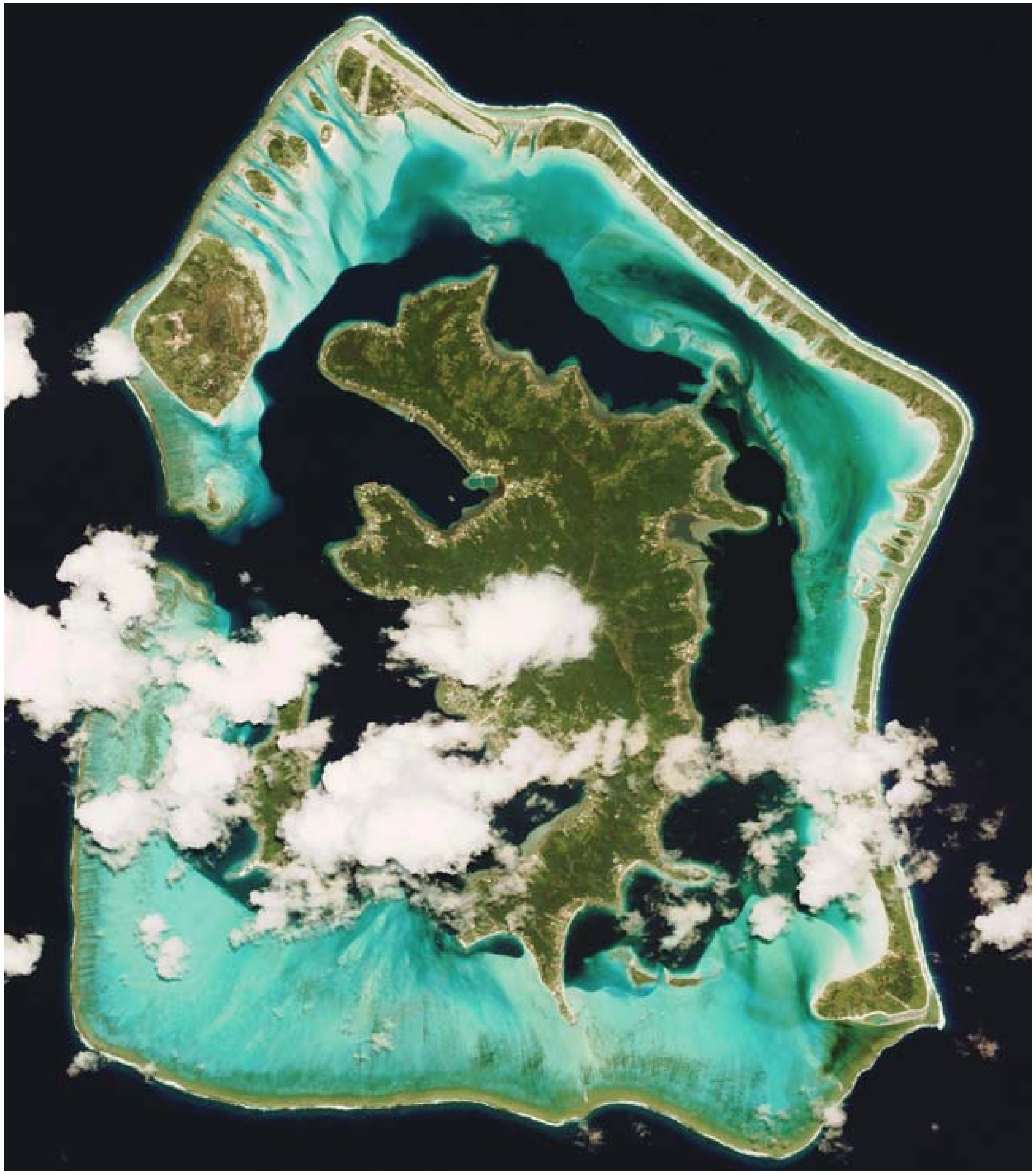
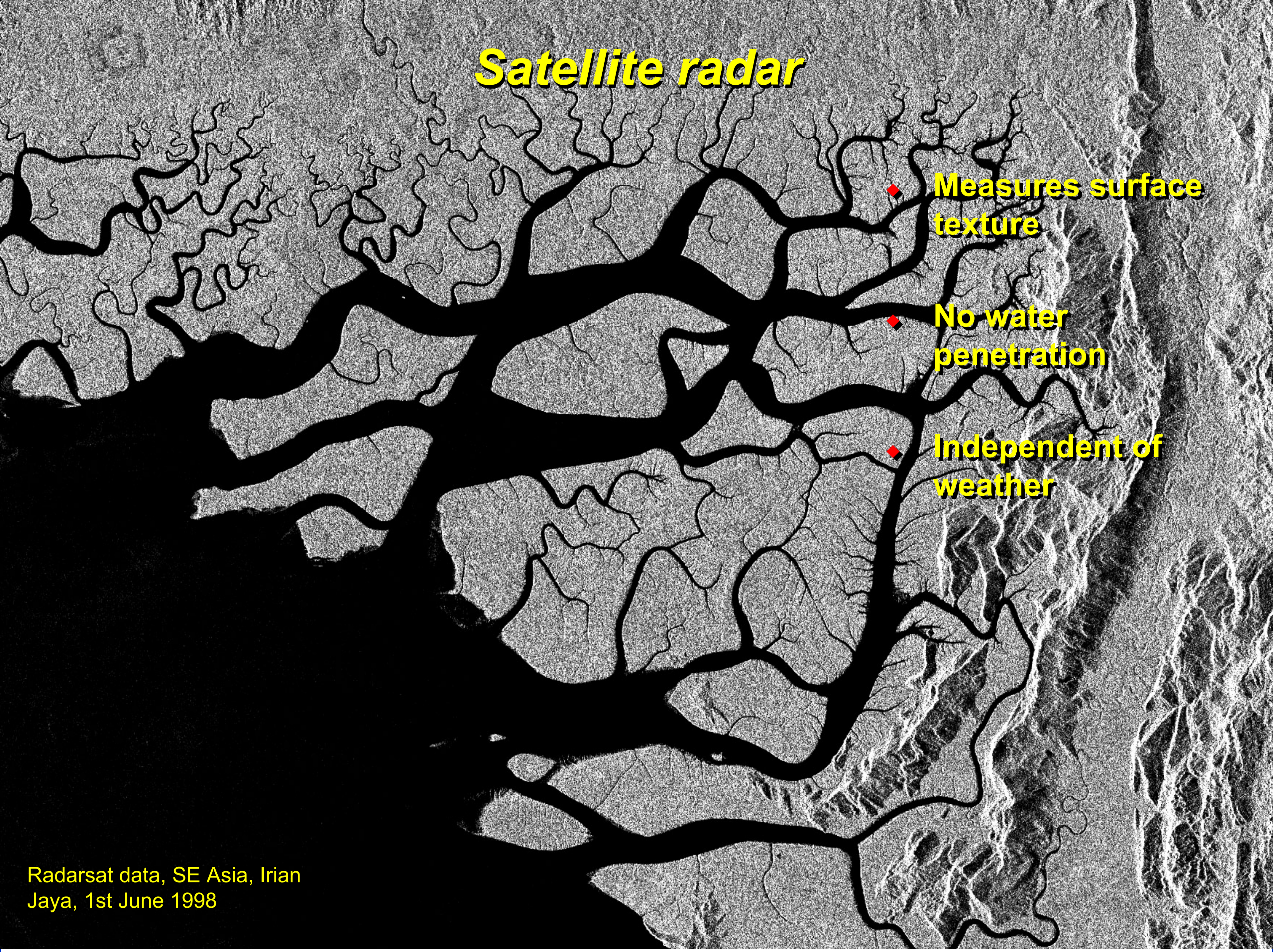
Nigeria: SPOT data (20m)



Southern Spain: Quickbird (60cm)

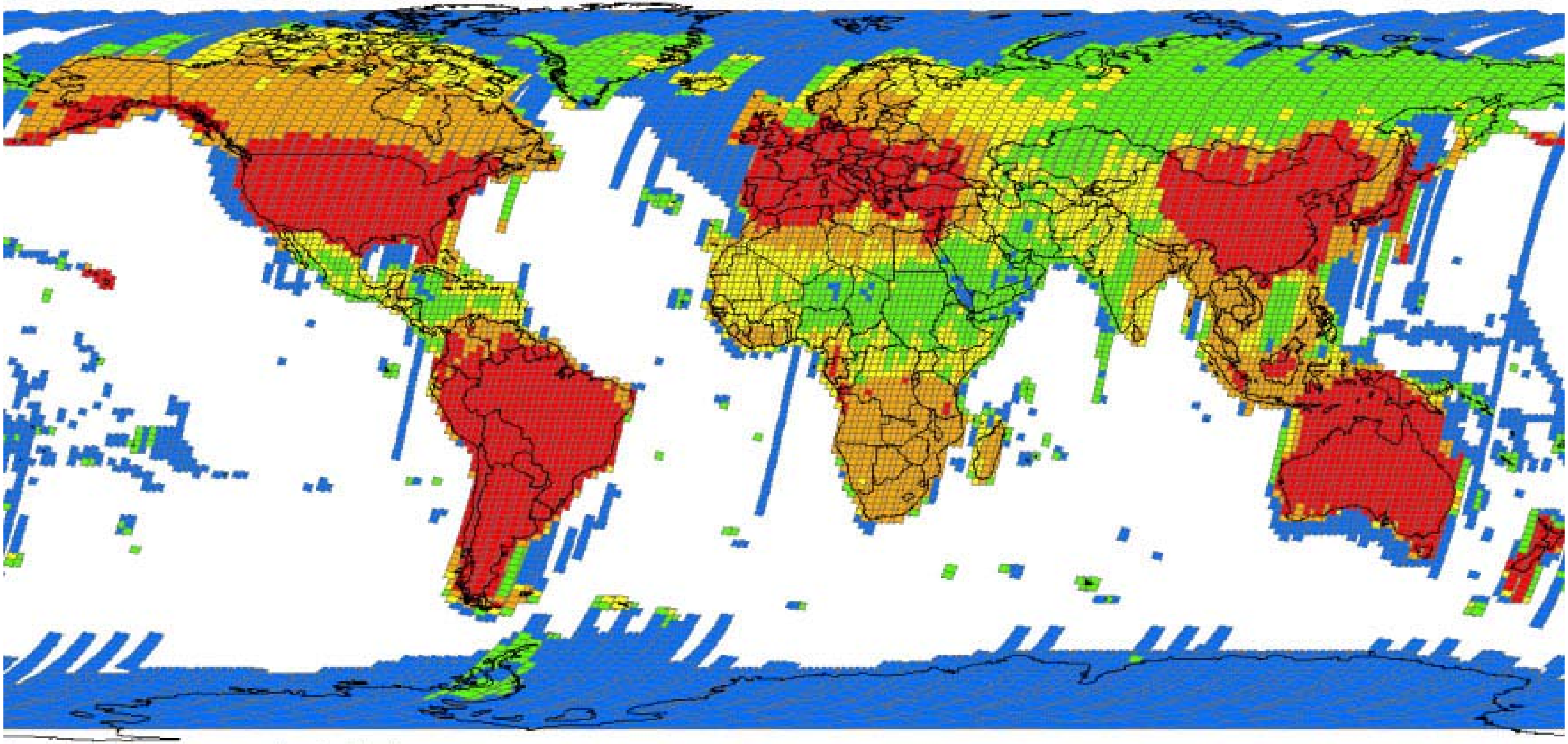
Bora Bora, Tahiti (Quickbird)




Satellite radar
Measures surface texture
No water penetration
Independent of weather
Radarsat data, SE Asia, Irian Jaya, 1st June 1998

Landsat Acquisition Archive

(29 June 1999 – 30 June 2003)



Daytime full scenes acquired globally
29 June 1999 through 30 June 2003

Blue	1 - 14
Green	15 - 32
Yellow	33 - 51
Orange	52 - 71
Red	72 - 91

Spatial Resolution

Commonly used satellites:

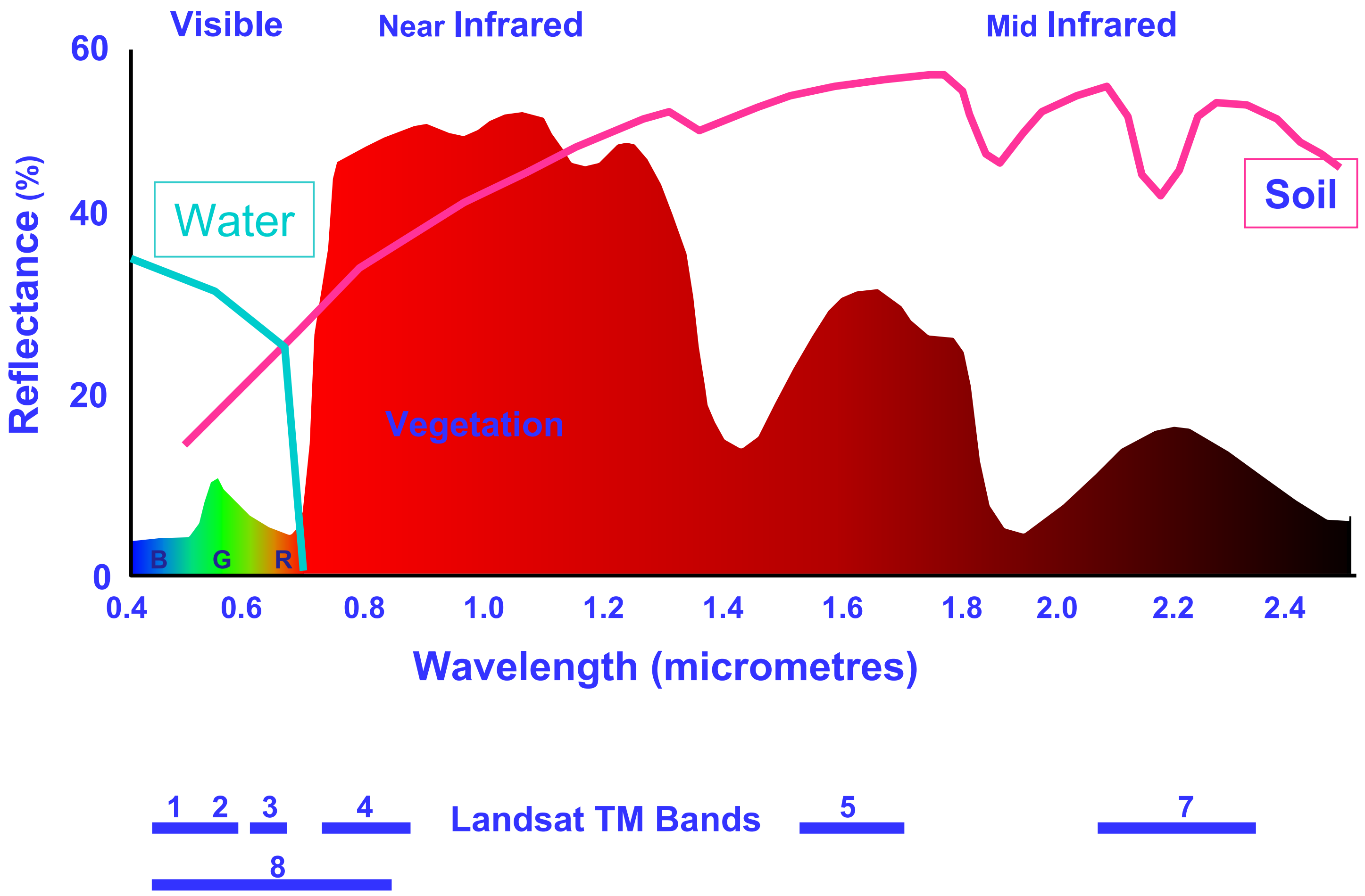
Landsat ETM	15-30-60m
ASTER	15-30-90m
SPOT	10-20m
SPOT V	2.5-10m
IRS	5.8m
EROS	1.8m
Ikonos	1-4m
Quickbird	0.6-2.4m
Aerial photography	25-50cm*

Panchromatic

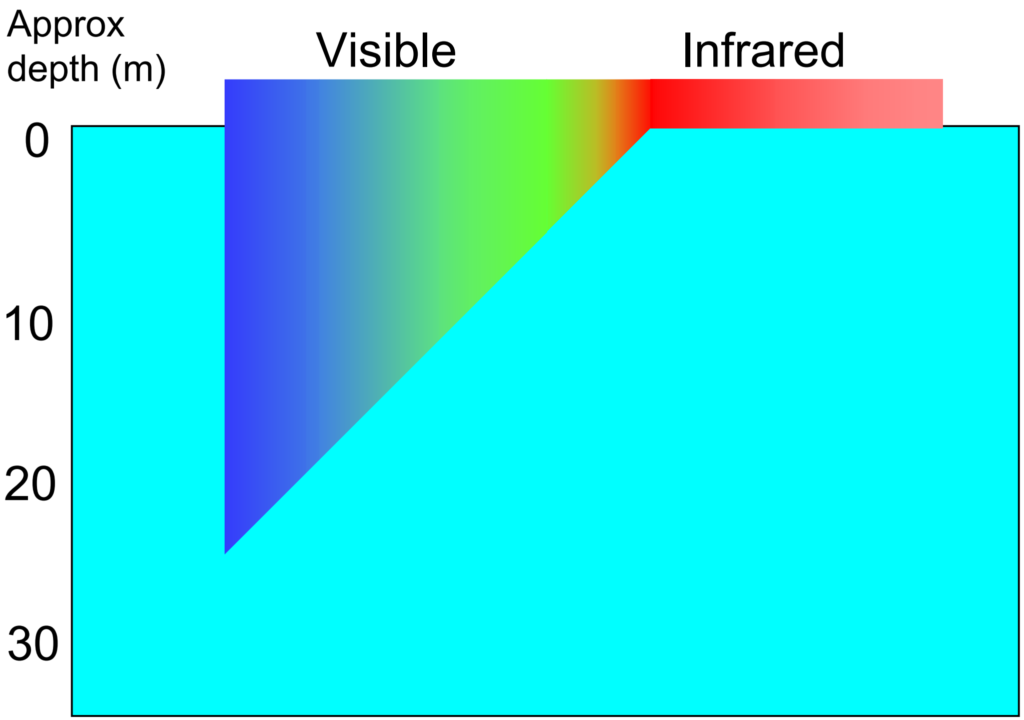
Multispectral

*dependent on altitude - much higher resolutions can be acquired for special purposes

Electromagnetic Spectrum

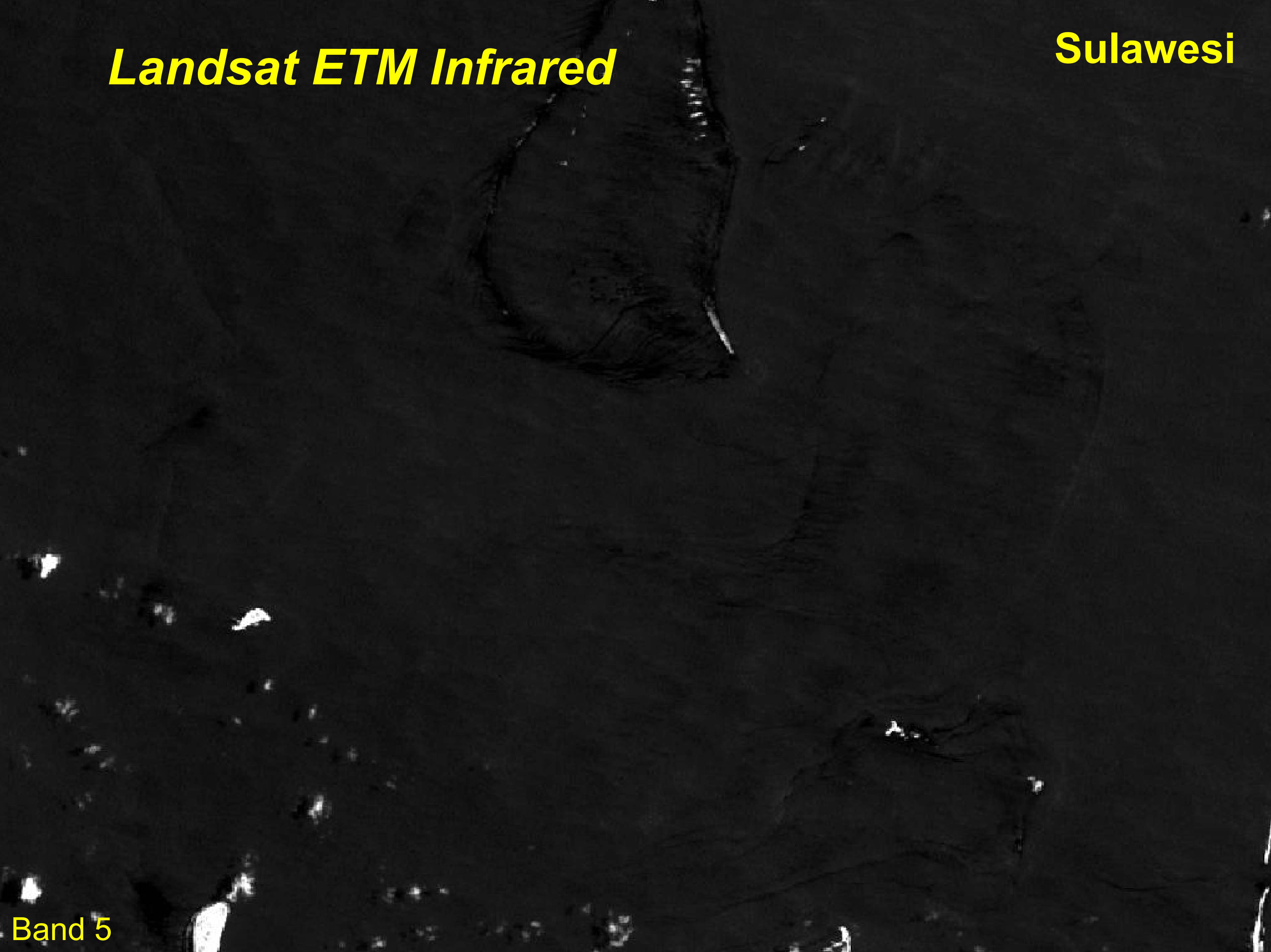


Water Penetration



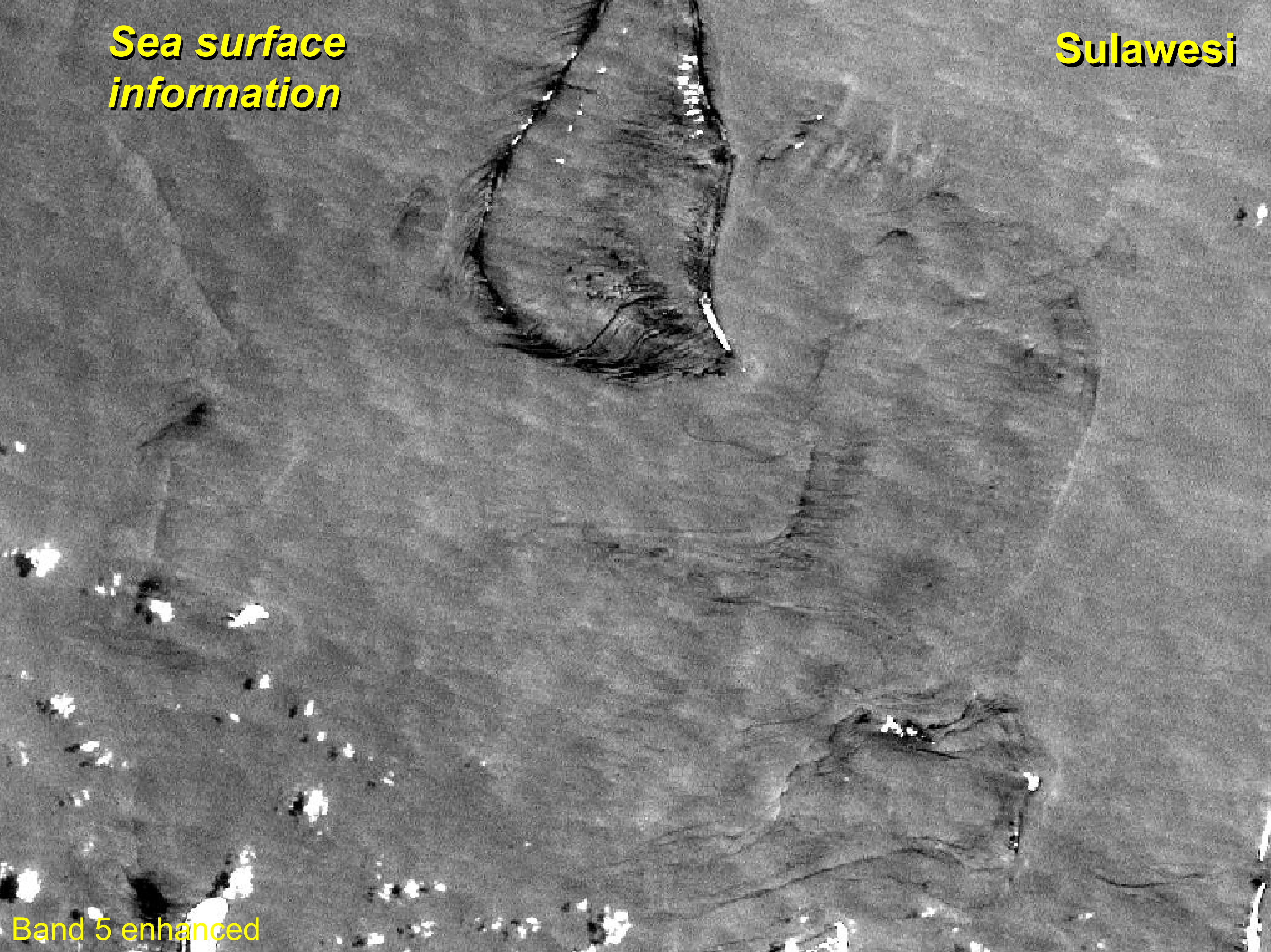
- Blue penetration up to 20m in clear water
- No penetration by infrared
- Quantitative measurement difficult


Landsat ETM
Colour composite
Sulawesi
Bands 123:BGR



Landsat ETM Infrared
Sulawesi
Band 5


Colour composite
Land mask
Sulawesi
clouds
Bands 123:BGR; 5:R



Sea surface
information
Sulawesi
Band 5 enhanced

Costs per sq km

Satellite	Pixel size	Footprint	Cost/scene	Cost/km^2
Landsat ETM	15m	185x170km	$600	2c
SPOT	10m	60x60km	€2600	75c
Radarsat Fine	8m	165x165	$2750	10c
IRS	5m	70x70	$2500	50c
SPOT V	2.5m	60x60	€5400	$1.50
EROS	2m	12.5x12.5	$1500	$10
Ikonos	1m	11x11	$5000	$20-50
Quickbird	0.6m	16x16	$6000	$22-30
Air photos	25-50cm	5-10km	n/a	~$100

Usage of satellite data

Max Scale	Resolution	Satellite	Price/km^2
100,000	15m	Landsat	2c
50,000	5m	SPOT(Landsat)	$2
25,000	2.5m	SPOT5	$2
5-10,000	1m	Ikonos/QB	$25+
<5,000	25cm	Aerial photo	~$100

Satellite data: pros and cons

- ✓ Cheap
- ✓ Up-to-date
- ✓ Near global coverage
- ✓ Relatively accurate reference to WGS84 (without ground control)

- ✗ Not acquired at low water (only exceptionally)
- ✗ Not admissible for definition of normal baseline?

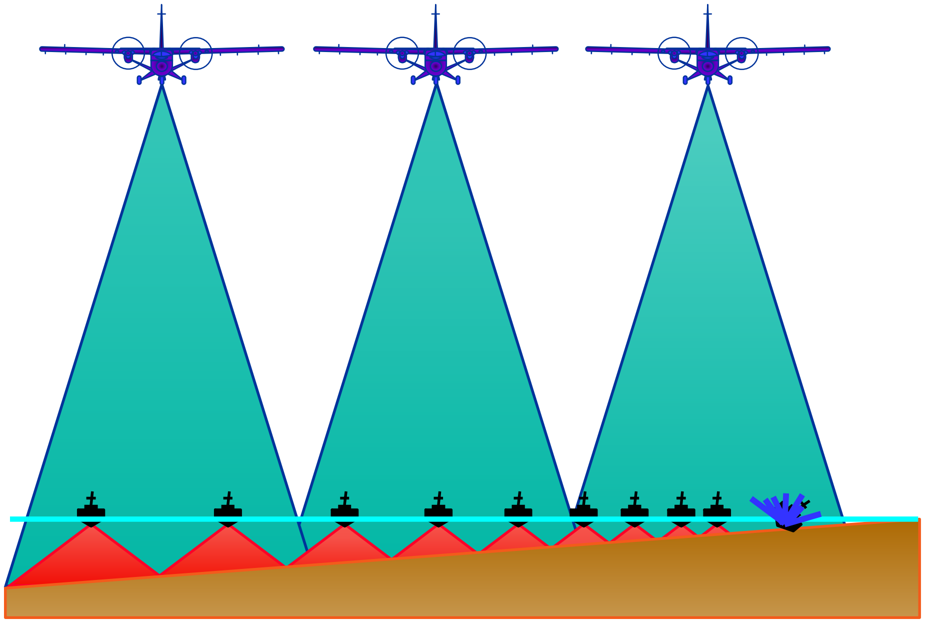
LIDAR

- **Light Detection And Ranging**

Or more generally

- **Airborne Laser Hydrography**

What's the Attraction?



Shallow water boat operations suffer from:

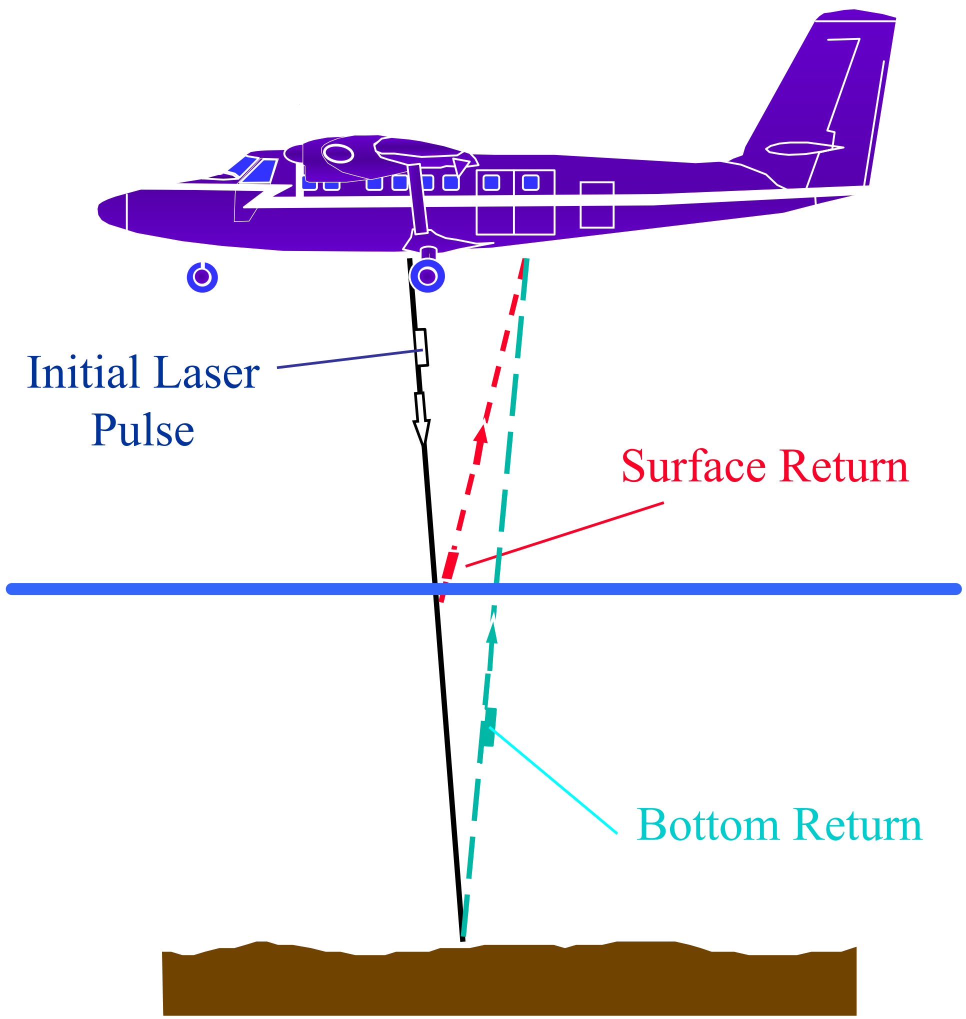
- Slow progress
- Dependence on Mother ship
- Reduced swathe width
- Single beam in shallows
- Weather restrictions

ALL THESE MAKE BOAT OPS EXPENSIVE

The advantages of Airborne Laser Hydrography ALH are:

- Swathe width remains fixed
- Seamless data from shoal depths to low elevations
- Performance improves in shallow water
- Fast progress
- Minimum presence on ground

How does it work?



Initial laser pulse Tx from aircraft.

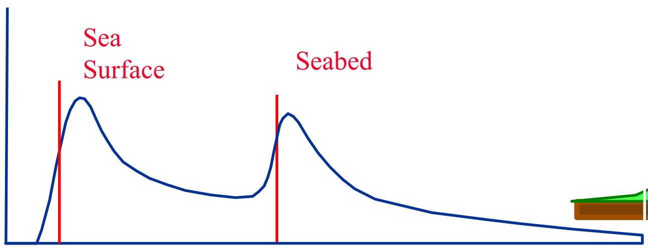
Surface return Rx at aircraft.
Infra-red channel.

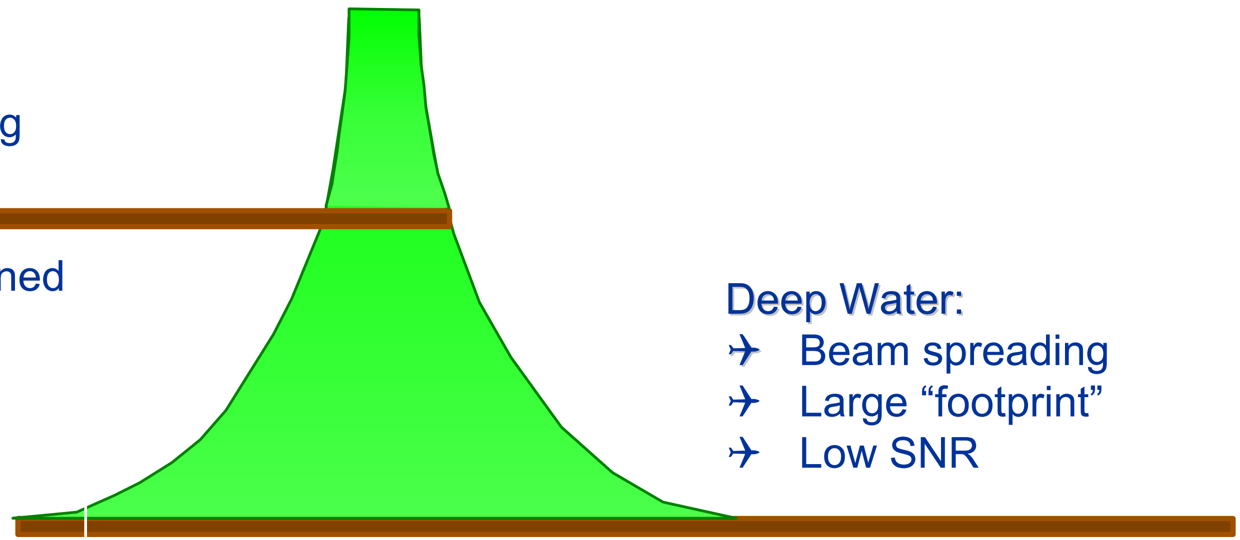
Bottom Return Rx at aircraft.
Blue-green channel.

Time difference equals water depth.

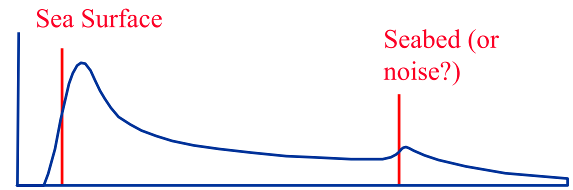
Comparison of characteristics of shallow and deep detection waveforms

Shallow Water:
- Lack of beam spreading
- Small footprint
- Bottom return well-defined





Deep Water:
- Beam spreading
- Large "footprint"
- Low SNR



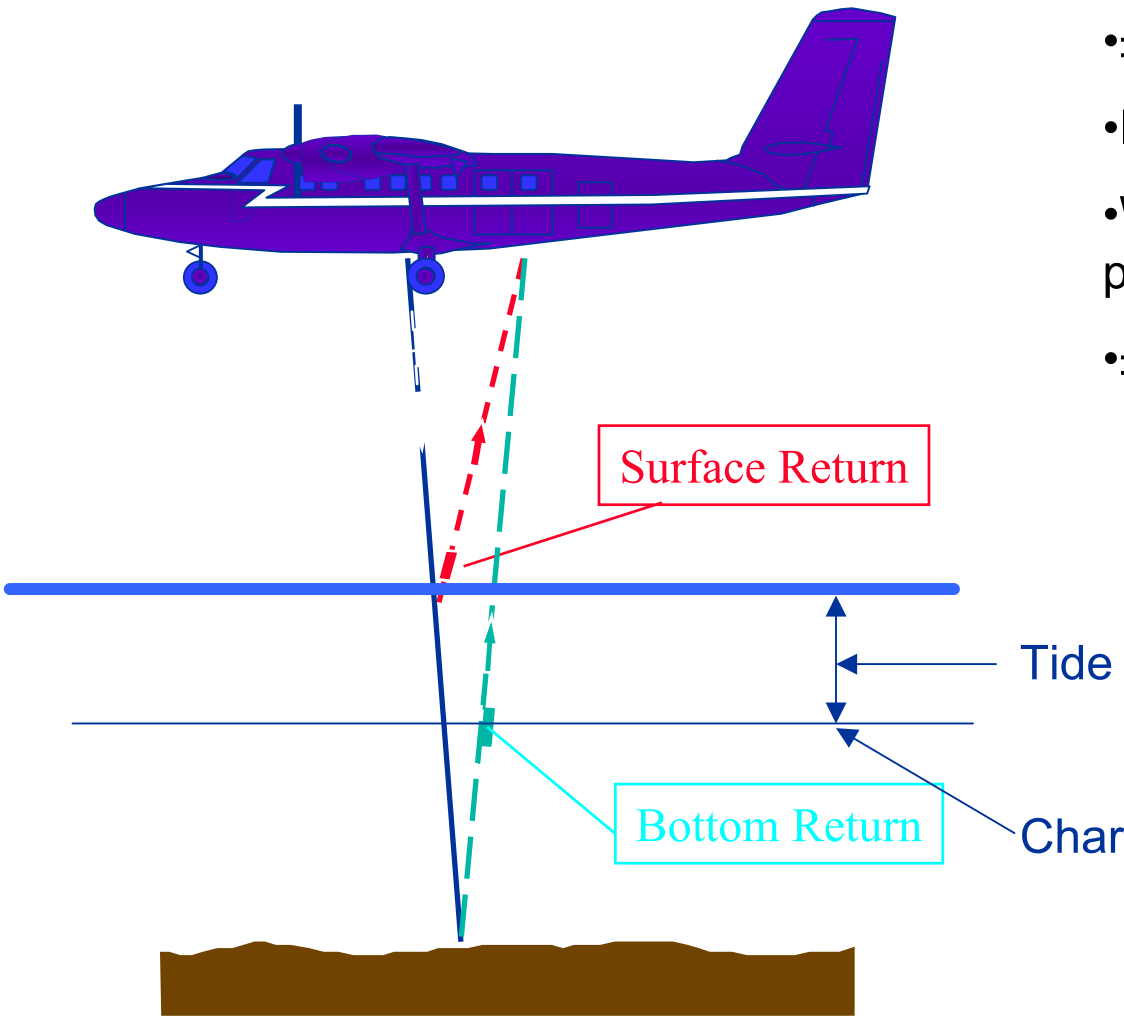
Effective footprint is about ½ depth

Scan width is adjustable

150 kts at 300m alt. gives a 150m swath with 4m spot spacing

Penetration is about 2.5 x secchi depth

Depth Measurement



- ± 1-2 cm
- Reflectivity of bottom
- Weak return in deep or poor conditions
- ± 10-20 cm for elevations

Planning

- Swath width is about 150m
- Look for off-lying low tide elevations
- Monitor progress and change the plan
- Coverage about $25M^2$ per 6 hour mission
- Consult field experts when defining the project
- Mobilisation about $250k [#]
- Cost about $750 per km^2 [#]
- LADS in Australia, SHOALS in USA
- Not enough competition

\# Figures for Shoals [Fugro] working in USA

Working with the baseline

- A vector model of the baseline is required to make use of modern GIS
- The Normal Baseline is the largest component for most states
- Different levels of data capture for different purposes
- A dynamic database
- Source data

Summary

- The normal baseline is not well charted
- Check it
- It may be good enough
- Improving is not easy
- Satellite imagery is cheap but imprecise
- ALH is precise but not cheap
- Build a digital model to make use of GIS

QUESTIONS ?