Undersea Feature Discovery Project Progress Report

UFDP-CHS (Canadian Hydrographic Service)

Undersea Feature Discovery Project Objectives

- UFDP, or the Undersea Feature Discovery Project's goals are:
  1. To create **automated** tools for the **discovery** of all undersea features
  2. To **store** the newly discovered features in reliable database
  3. To provide **feedback**, with Generic Terms Working Group at SCUFN to current IHO undersea feature definitions (B6).



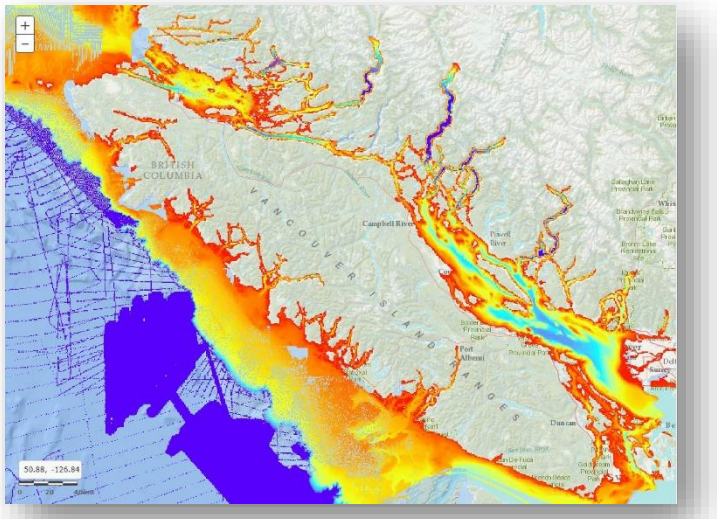
Who are we - The History of UFDP

- CHS (Canadian Hydrographic Service) of Fisheries and Oceans Canada is the leader of a project team called ACUFN (Advisory Committee on Undersea Feature Names).
- ACUFN's goal is to name undersea features and surface maritime features in Canadian water.

Who are we - The History of UFDP

- As technology improves, we now have more bathymetry (seafloor) data with better quality.

CHS Chart NO.391. Vancouver Island

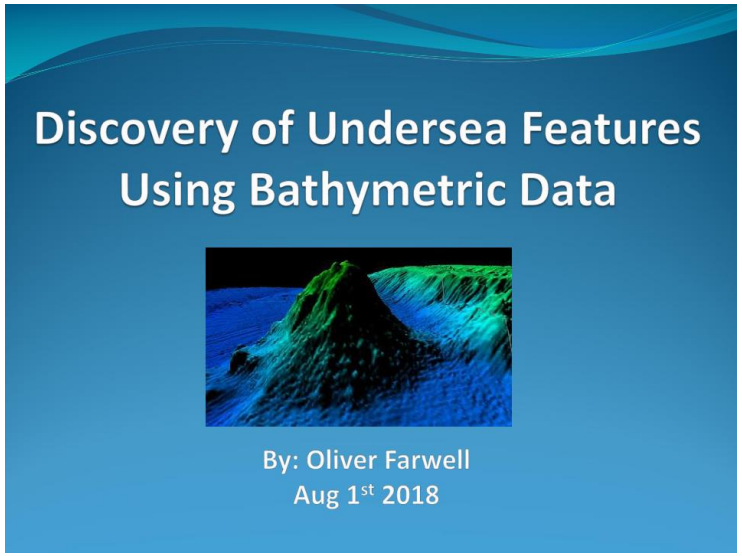


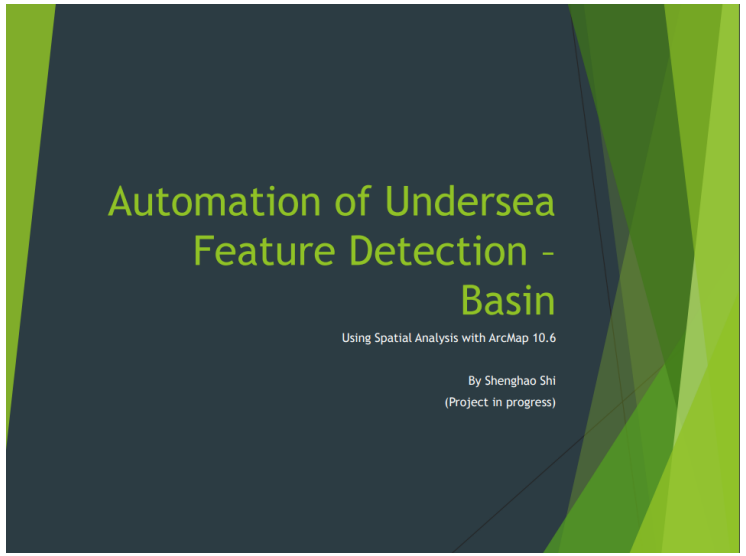
Fisheries and Oceans Canada 500m Bathymetry

- Therefore, ACUFN wants to discover new undersea features.
- The UFDP (Undersea Feature Discovery Project) was born in April 2018.

Who are we - The History of UFDP

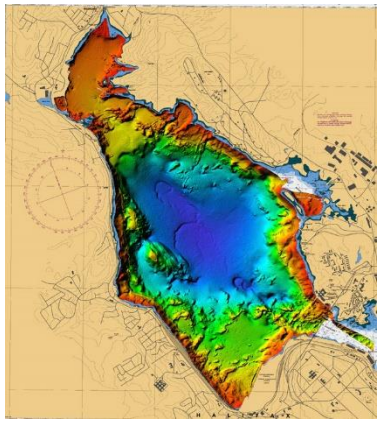
- Canada presented the first two attempts of undersea feature discovery: seamounts and basins.



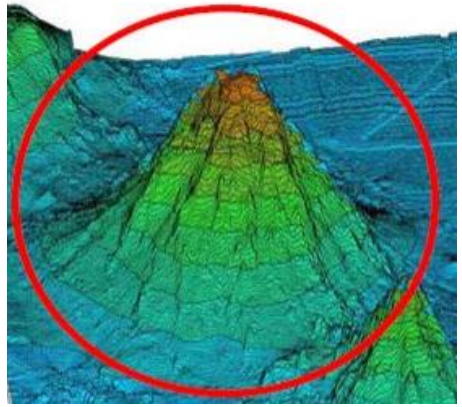


- Great interests were raised internationally on and after SCUFN 31.

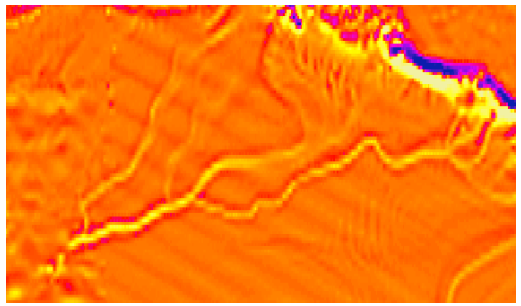
Undersea Features with Completed Discovery Methodologies



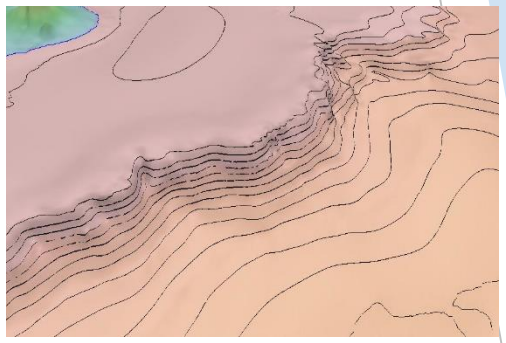
Basin



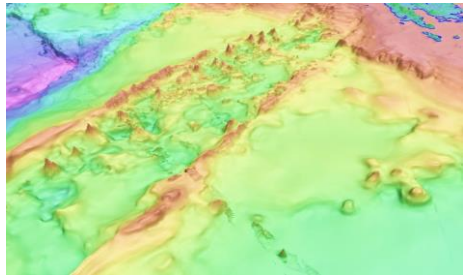
Seamount



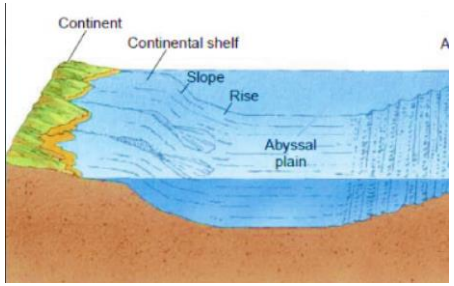
Sea Channel



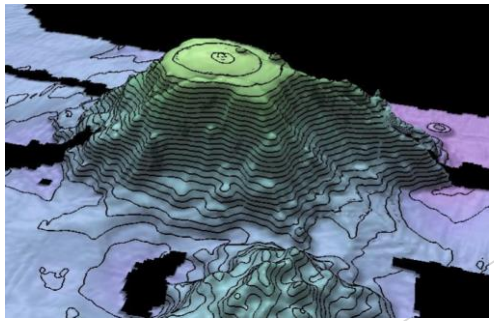
Shelf



Ridge



Abyssal Plain



Guyot

Full List of UFDP Outcomes

- Fully automated Discovery methods:
  - Basins
  - Seamounts
  - Guyot (flat-top seamount, as a sub-category of seamount)
  - Shelf
  - Abyssal Plains
- Completed discovery methods:
  - Ridges
  - Sea Channels
- Discovery methods in progress:
  - Canyon
  - Escarpment

- Python script based tools that help the discovery:
  - Concave Hull
  - Directional Buffer
  - Topographic Position Index
  - TPI-Slope Classification
  - Dual-TPI Slope Classification
  - Filter Elliptical Cones
  - Identify Pelagic Zones
  - Identify Point Nearest Centroid
  - Identify Zonal Maximum Cells
  - Local Topography
  - Nice Raster to Polygons

Issue with Current Undersea Feature Definitions in B-6

SEA CHANNEL

An elongated, meandering depression, usually occurring on a gently sloping plain or FAN.

SEA CHANNEL

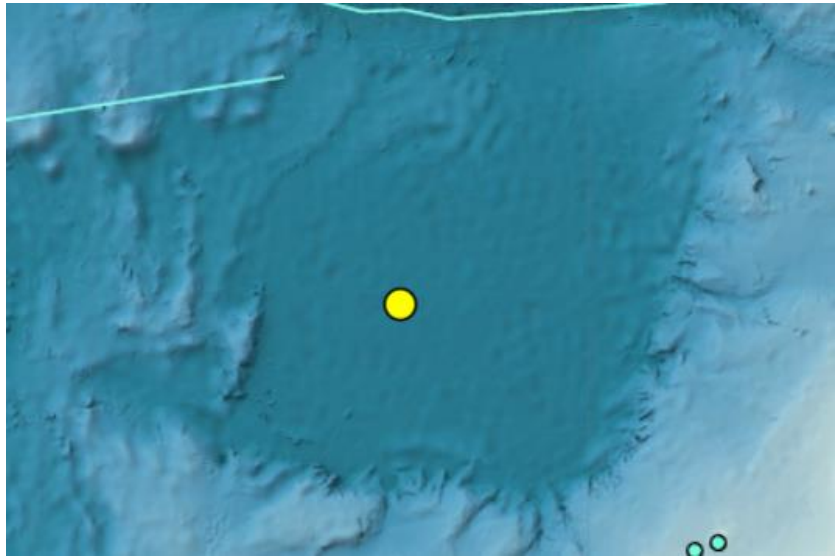
A meandering linear depression with sinuosity typically greater than 1.3, at least no less than 1.15. Feature need to be no shorter than 150 km, usually occurring on a gently sloping plain or FAN where local slope standard deviation is typically less than 0.5 degree, at least no more than 0.65 degree.

Case Study NO.1 Abyssal Plains Detection Method

By: Samir Sellars

IHO Definition

- Abyssal Plains: An extensive, flat or gently sloping region, usually found at depths greater than 4000m



GEBCO identified
Abyssal Plain (Argo)

GEBCO identified
Abyssal Plain (Nares)

Analysis of IHO Definition

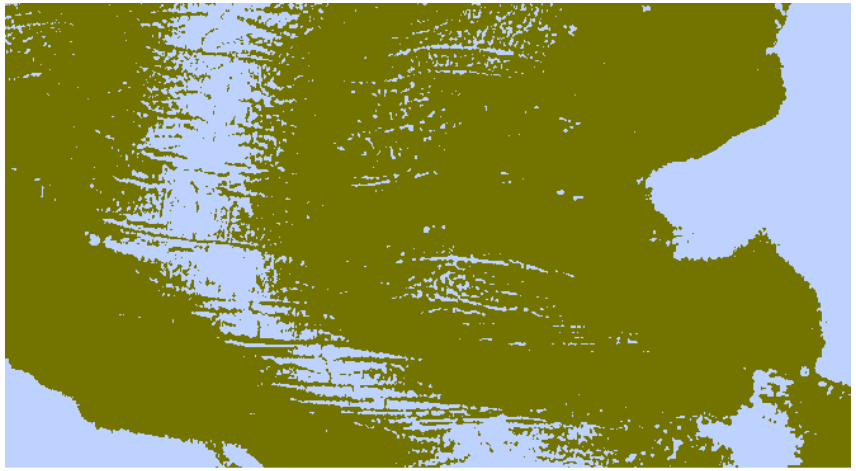
Extensive is non-specific as official plains values range from 850 km^2 to 1,000,000 km^2 and above

IHO Abyssal Plains Definition: An extensive, flat or gently sloping region, usually found at depths greater than 4000m.

What type of difference in elevation is allowed? What would be an average slope?

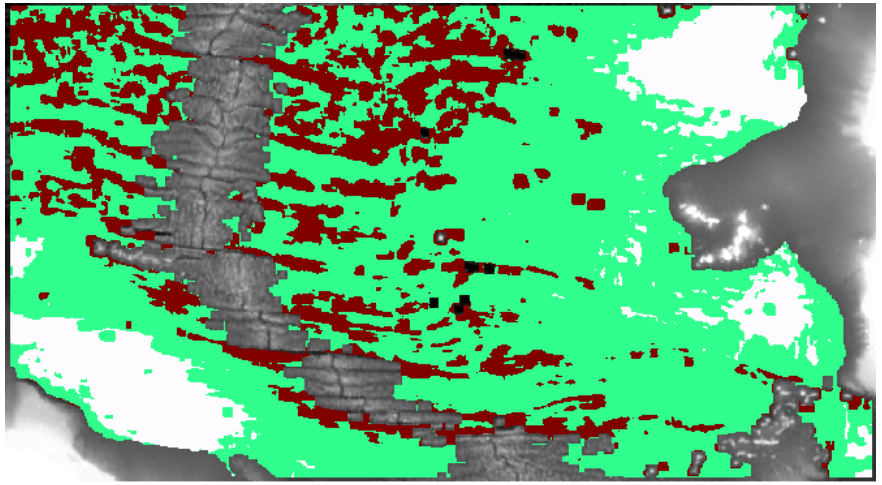
"Usually" allows for subjectivity at beginning depth and the definition does not state a bottom depth

Methodology on Mid-Atlantic Ridge



Identify qualified areas of depth

Green = qualified (-4000 to -6000m)
Blue = unqualified



Data was cleaned and tested for local elevation differences at a scale of 2025 km^2

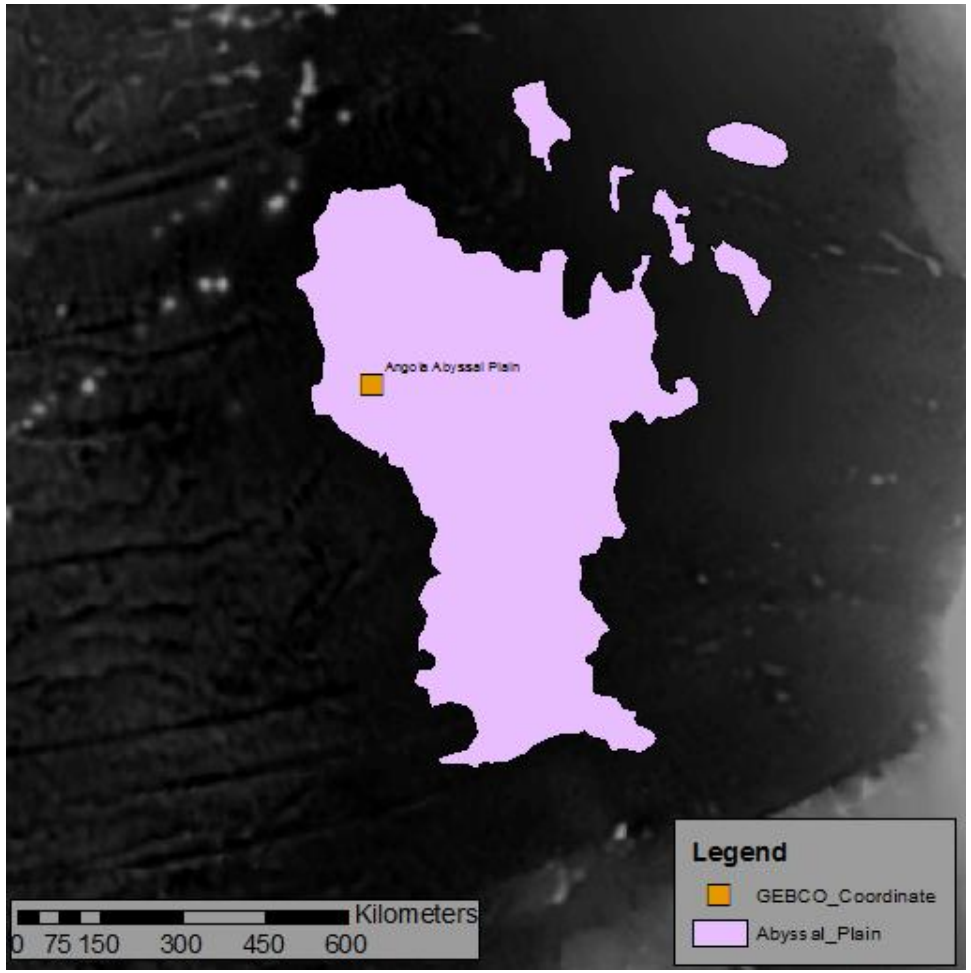
White = relief between 0 – 50m
Green = relief between 50 – 300m
Brown = relief between 300 – 1000m

Methodology on Mid-Atlantic Ridge

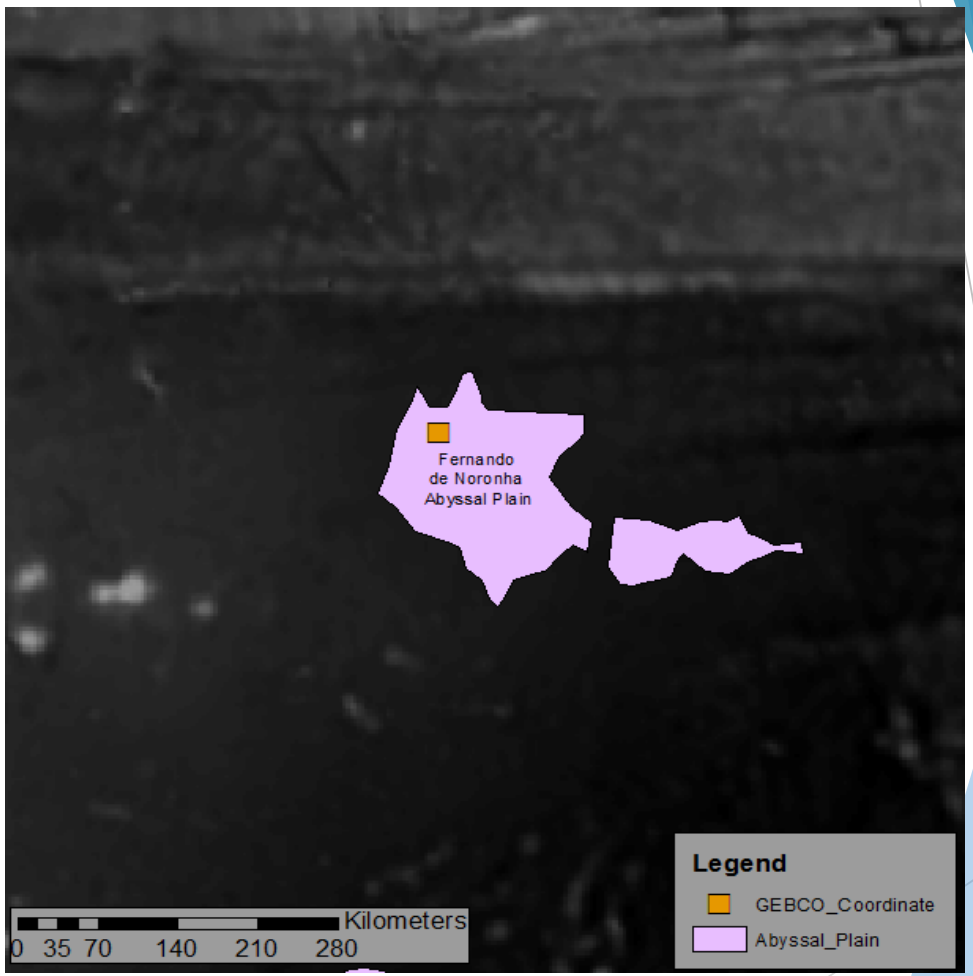
Data was cleaned again and abyssal zone polygons were generated
Abyssal Plain zones under 100km apart were joined

Brown = Abyssal Plain (0 – 50m)
Beige = relief between (50 – 300m)
Red = relief between (300 – 1000m)

More Examples

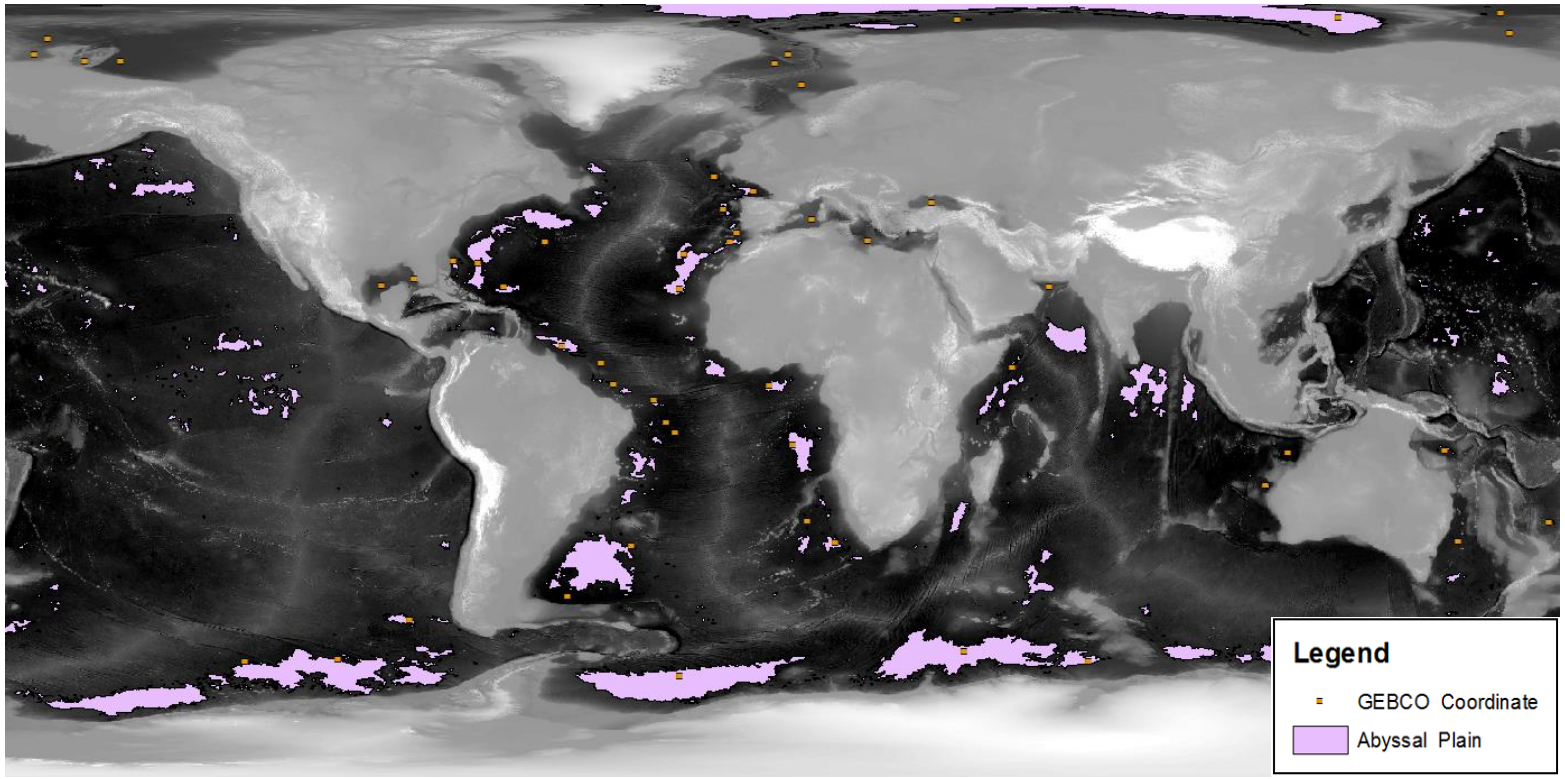


GEBCO identified Abyssal Plain (Angola)



GEBCO identified Abyssal Plain (Fernando de Noronha)

Methodology Tested on World Relief Dataset

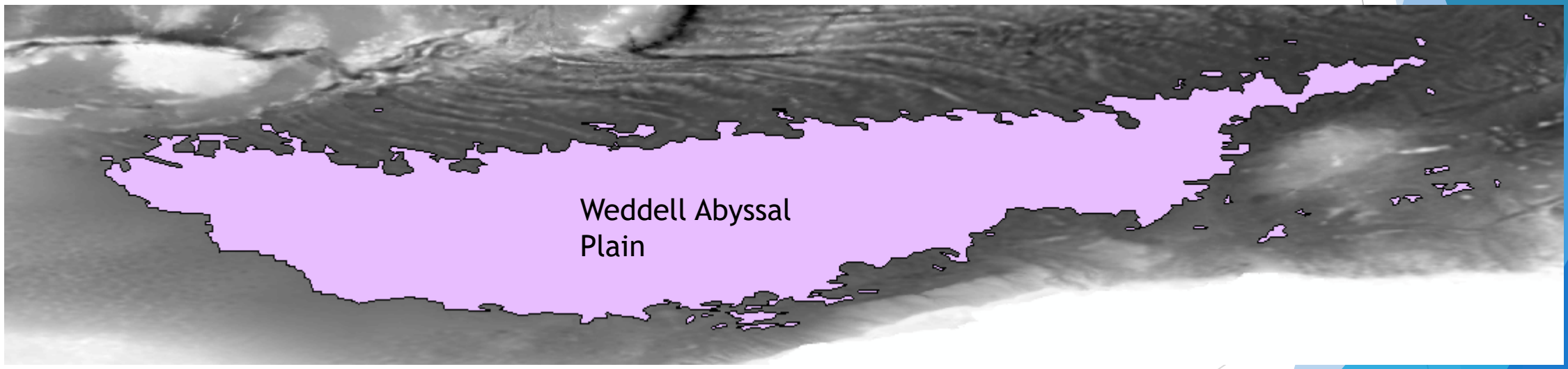


- 249 Separate Plains Identified
- 17 GEBCO abyssal plains points overlap polygons
- 9 GEBCO points overlaid hills or mounts zone
- 12 polygons less than 100 km from GEBCO point
- 14 GEBCO points not on polygons due to lack of depth

Issues and Recommendations

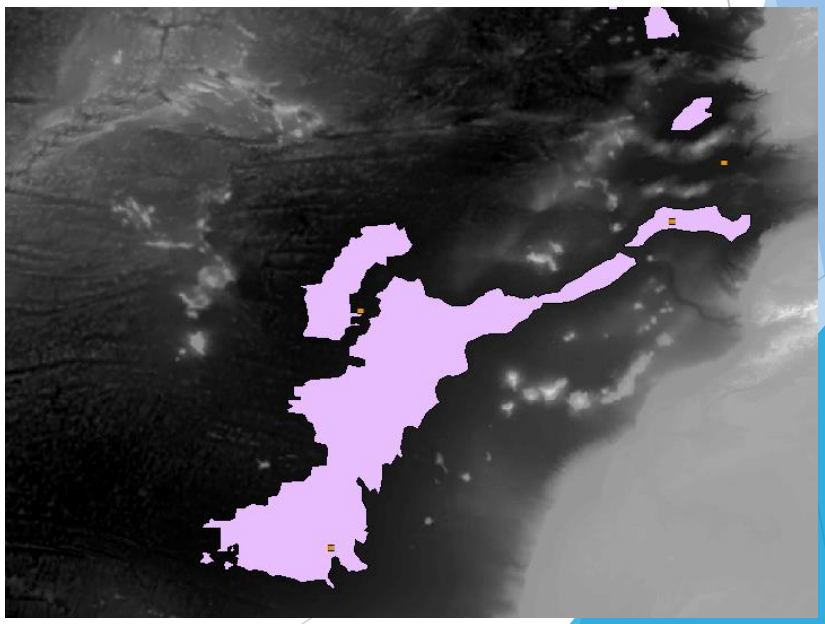
1. Minimum size needs to be agreed upon
2. Levels of relief need to be agreed upon
3. A depth range needs to be agreed upon

A need for defined parameters to eliminate subjectivity



Proposed Example Quantitative Definition

An extensive area larger than 850 km^2, that overlies a flat or gently sloping area with 0 - 50 m of local relief, and is found at a depth between 4000 and 6000 meters



Case Study NO.2 Sea Channel Detection Method

By: Shenghao Shi

B-6 Definition Breakdown

SEA CHANNEL

An elongated, meandering depression, usually occurring on a gently sloping plain or FAN.

B-6 Definition Breakdown

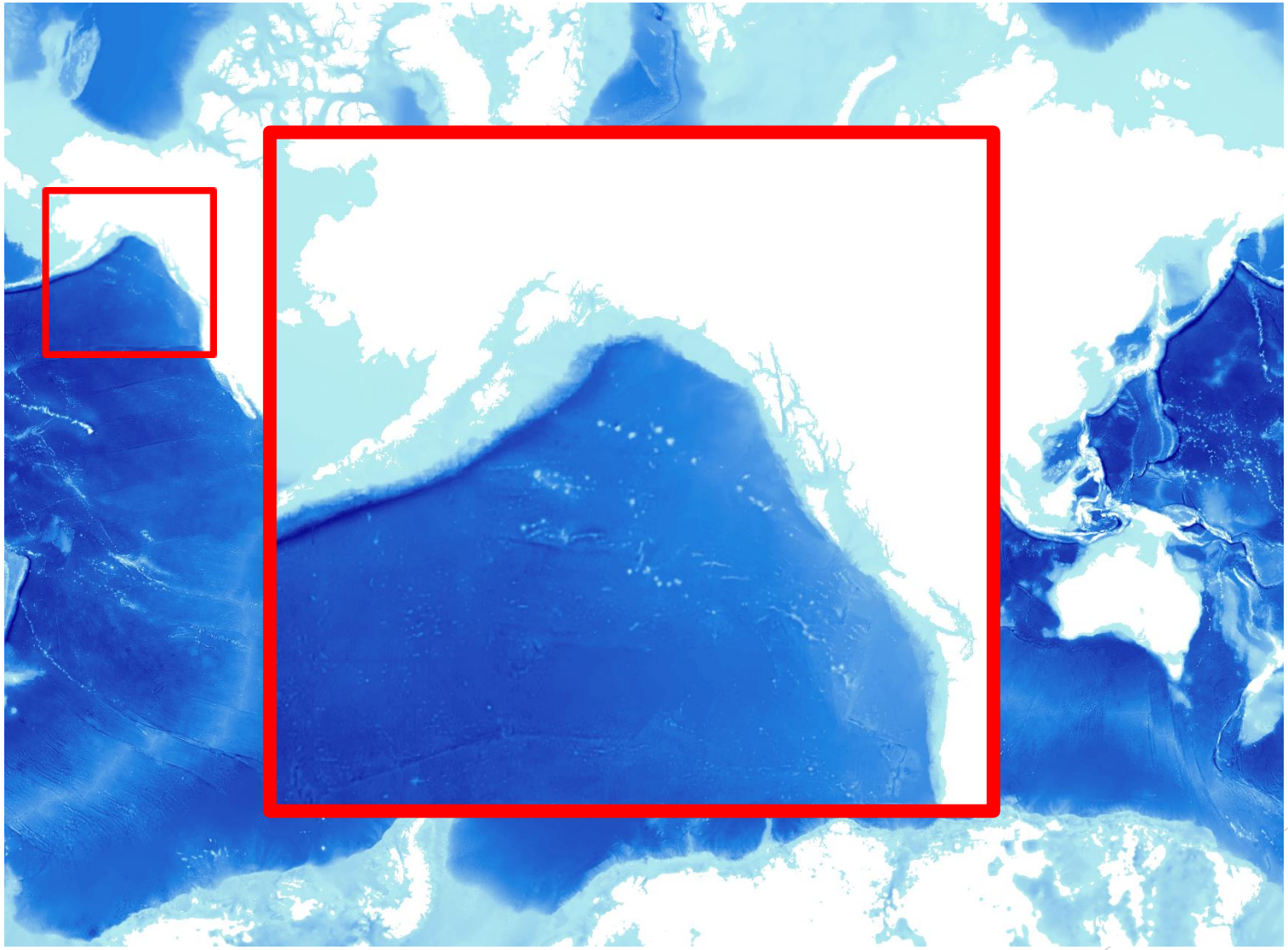
SEA CHANNEL

An elongated, meandering depression, usually occurring on a gently sloping plain or FAN.

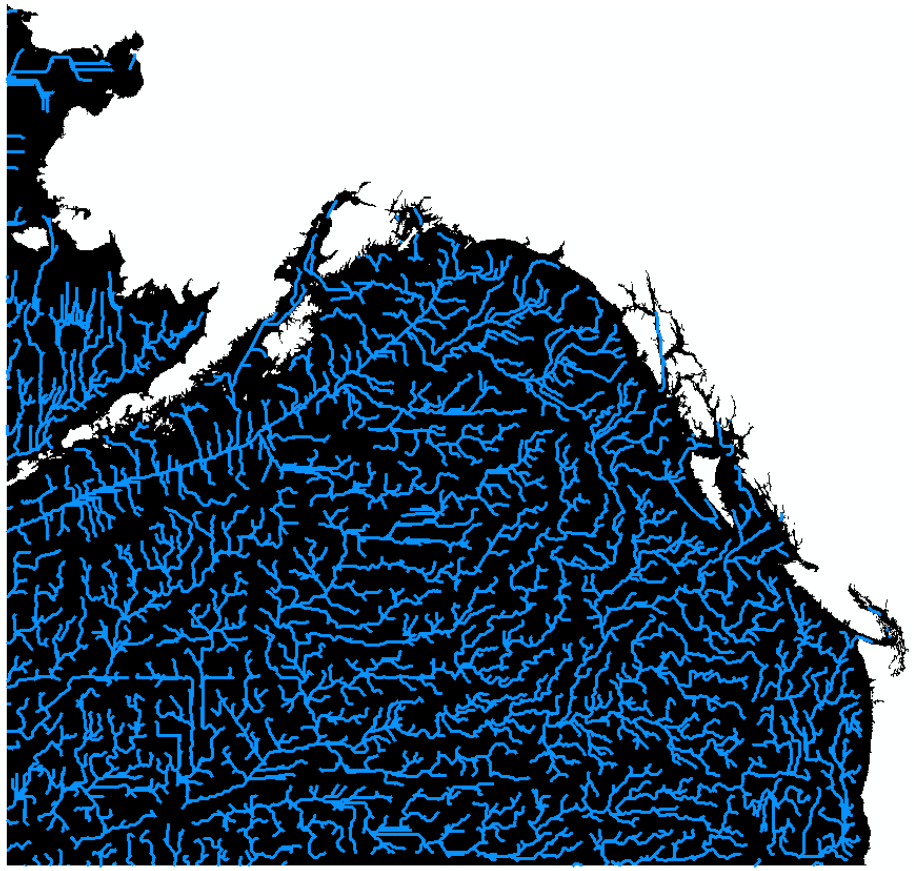
B-6 Definition Breakdown

1. Long
2. Curved/Bended
3. Depression
4. Have a flat surrounding

How were sea channels identified

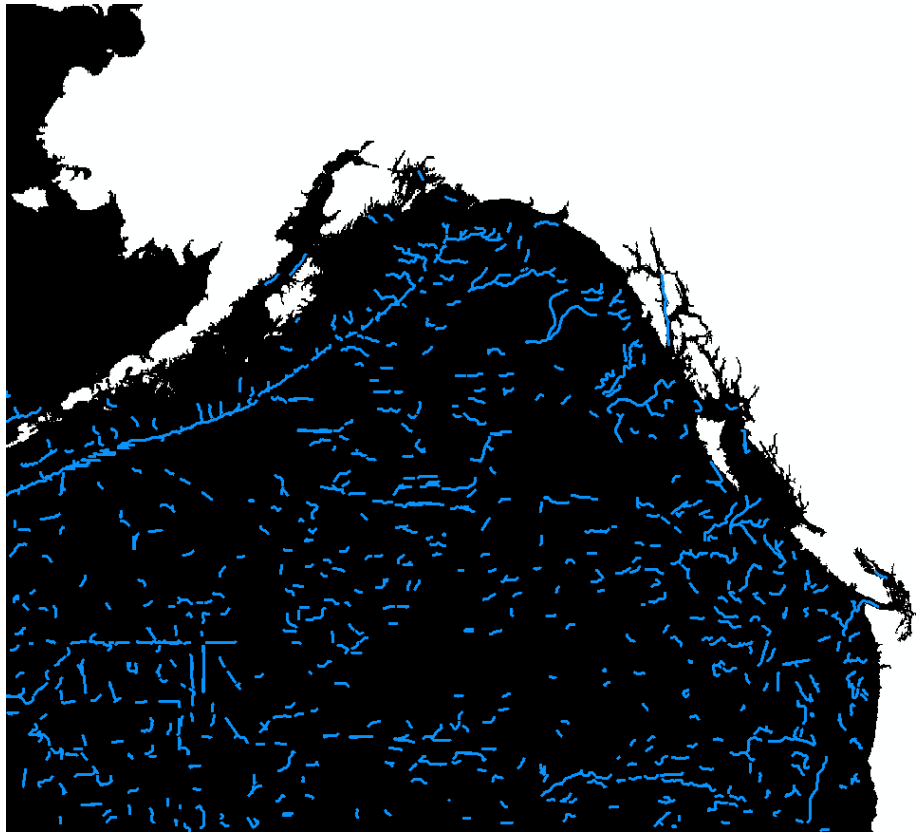


How were sea channels identified



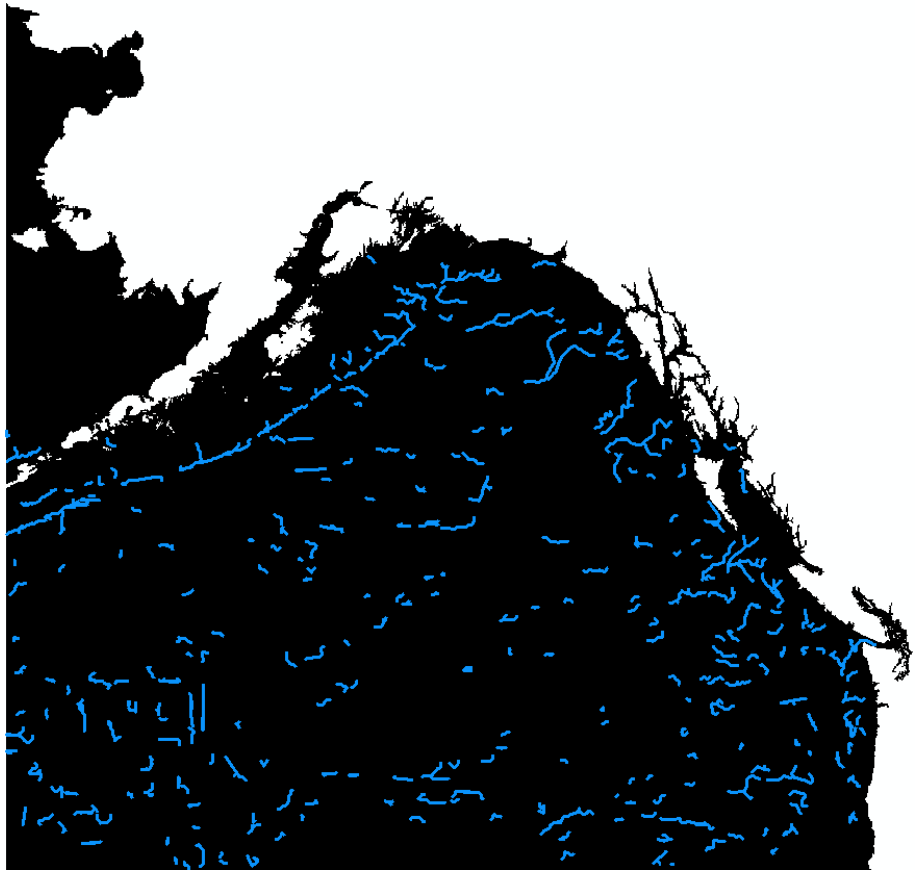
All potential water channels base on floor elevation (DEM)

How were sea channels identified



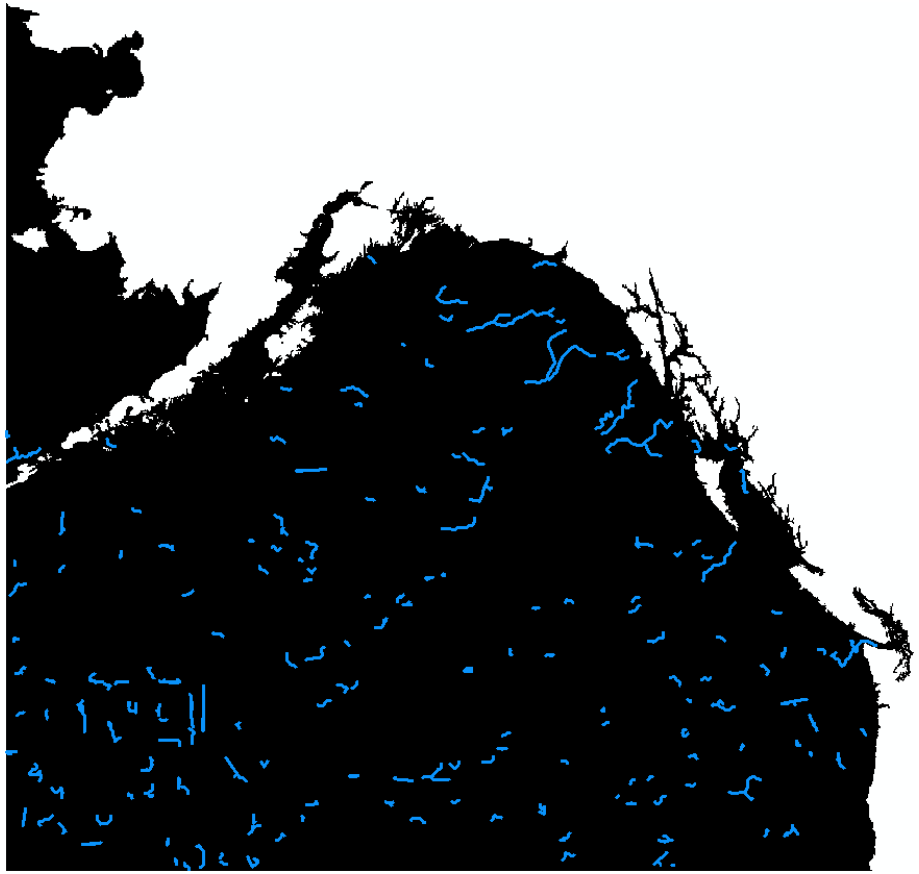
Criteria NO.1 Depression

How were sea channels identified



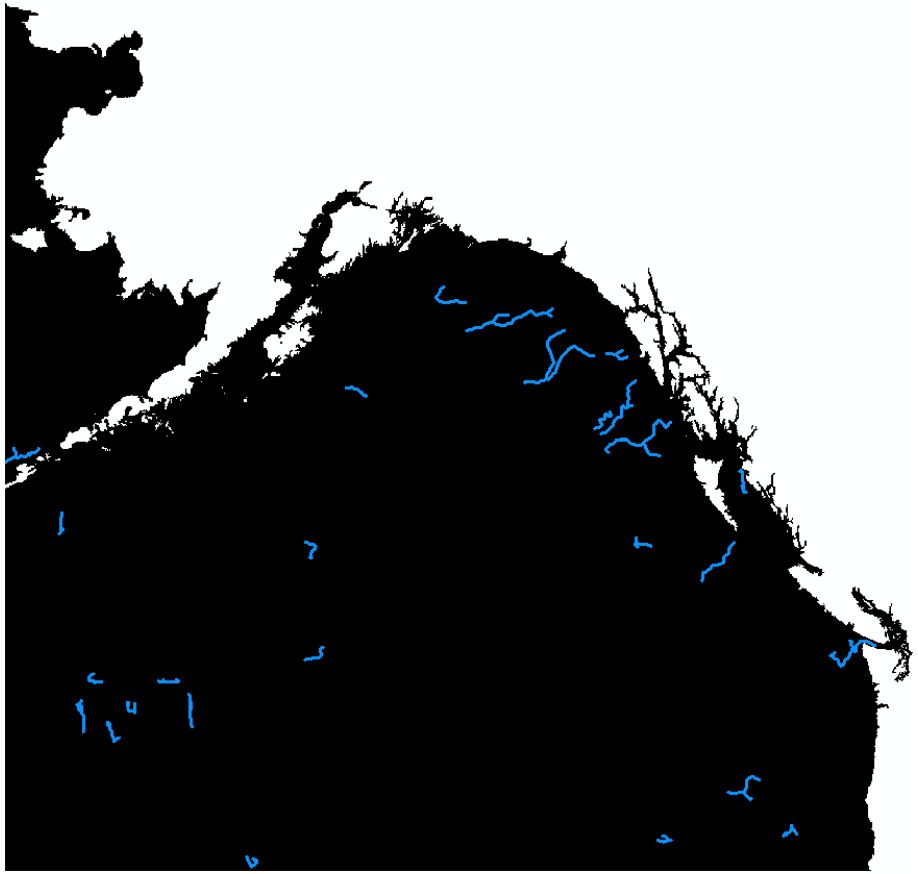
Criteria NO.2 Meandering

How were sea channels identified



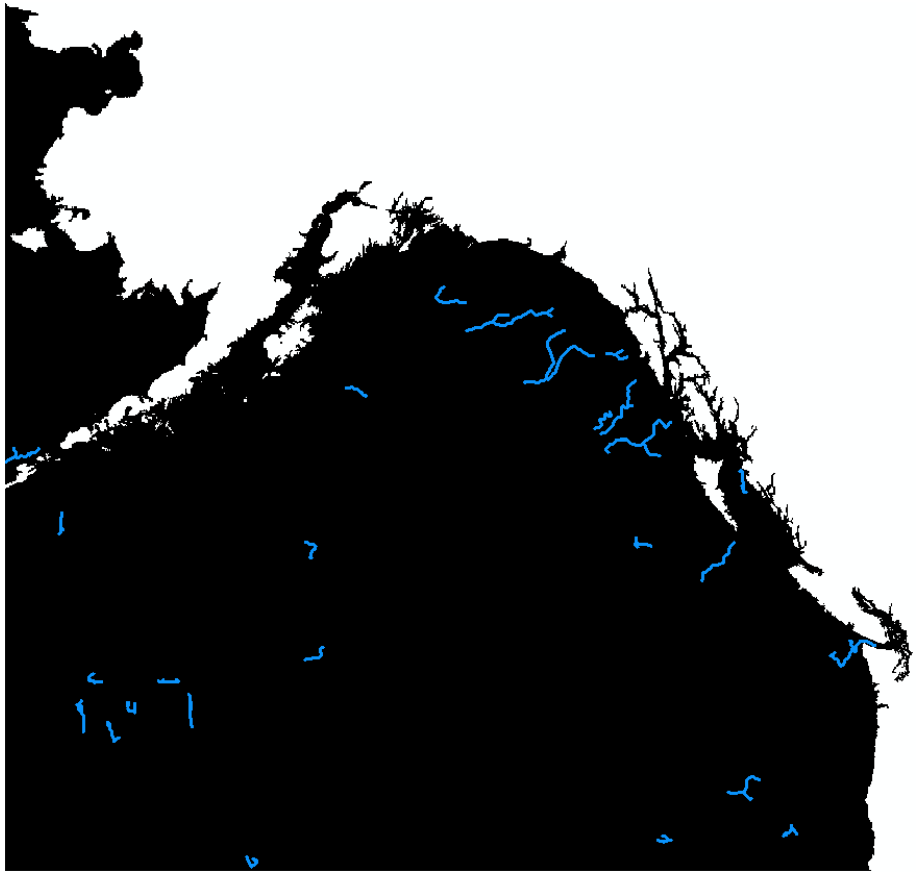
Criteria NO.3 Flat

How were sea channels identified



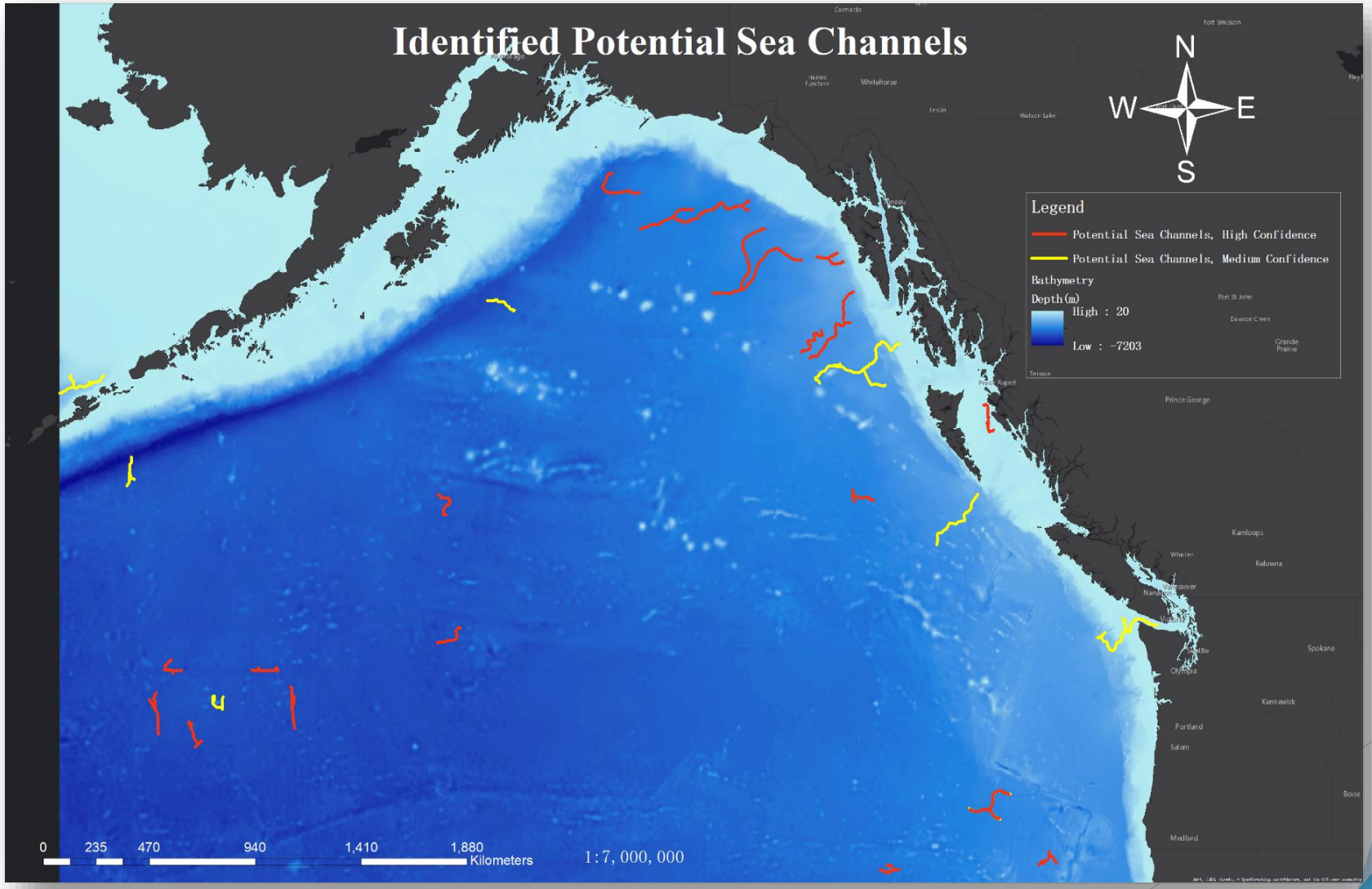
Criteria NO.4 Elongated

How were sea channels identified



Criteria NO.4 Elongated

How were sea channels identified



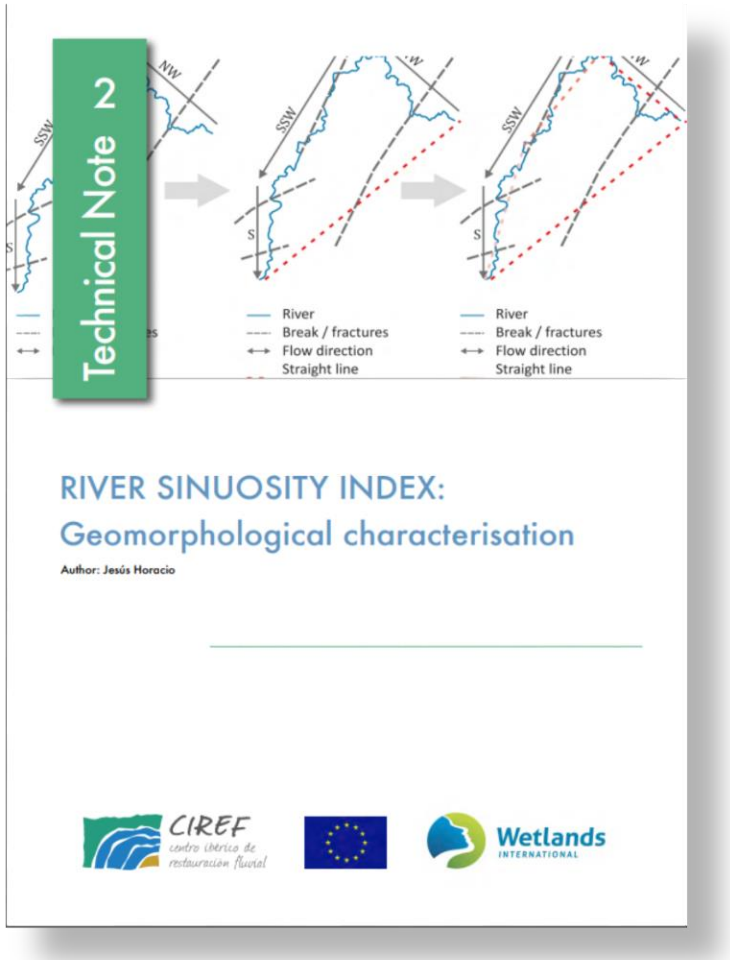
Criteria Analysis

SEA CHANNEL

An elongated, meandering depression, usually occurring on a gently sloping plain or FAN.

1. Elongated
   - How long is elongated?
2. Meandering
   - How curved/bendy is meandering?
3. Depression
   - How depressed it has to be?
4. Gently sloping plain
   1. How flat is gently sloping?

Criteria Analysis NO.1: Meandering

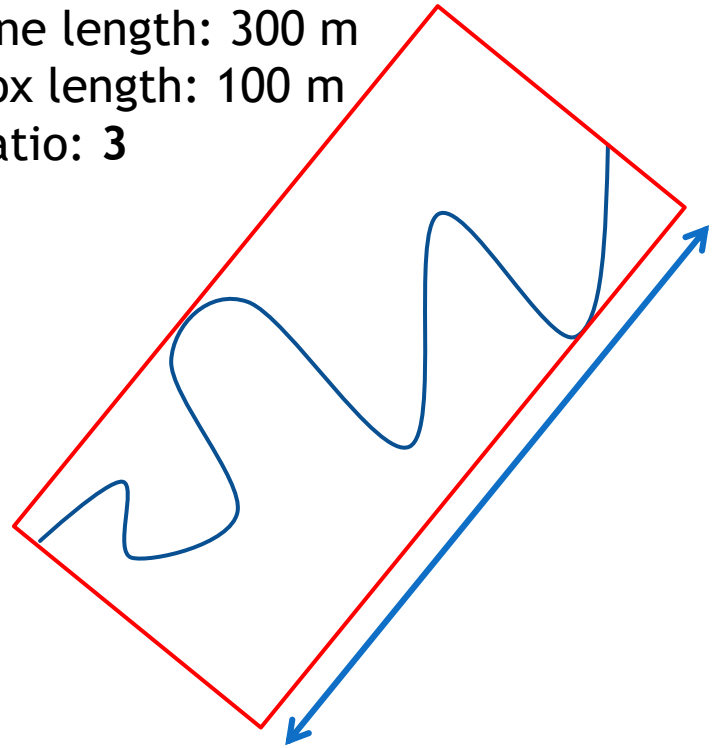


In the article, the author summarized:

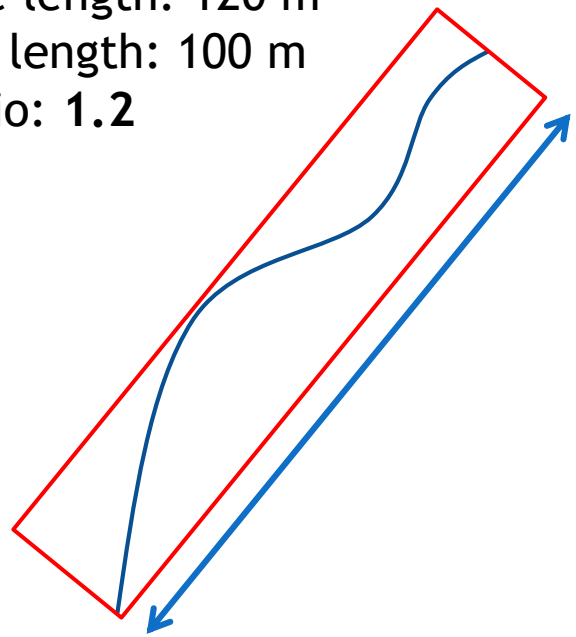
- <1.05 = straight
- 1.05-1.3 = sinuous
- 1.3-1.5 = moderate meandering
- >1.5 = meandering form

Criteria Analysis NO.1: Meandering

Line length: 300 m
Box length: 100 m
Ratio: **3**



Line length: 120 m
Box length: 100 m
Ratio: **1.2**

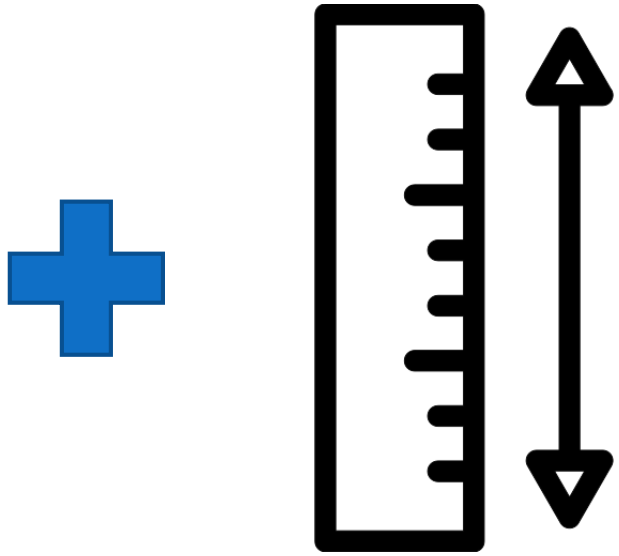


Confidence Level: Very High

Criteria Analysis NO.2: Elongated

	Channel length (km)	Width		Depth (m)	Levees*		Axial slope	Pelagic drape	Heads	Ends	Age (Myr)
		floor (km)	shoulder (km)		high (m)	wide (km)					
NAMOC	3800	1.5–7.5	6–16	100–200	RB 18–87	⩽30	1:1500 to 1:2100	Yes	†Continental slope off Greenland	Sohm Abyssal Plain (5000)	?50
Cascadia	2200	0.65–4.5	4–7	40–320	RB 30+	⩽7.5	1:625 to 1:4000	No‡	Western U.S. margin	Tufts Abyssal Plain (3500)	5
Bounty	1000+	1–2	5–7	150–650	LB 32–84	10–15	1:400 to 1:3300	Yes	Otago continental margin	S.W. Pacific Abyssal Plain (4500+)	50+
Vidal	800+	0.5–1.5	2–4	100–220	No	—	1:1100	Yes	Demerara Abyssal Plain	Barracuda Abyssal Plain (5400)	?
Maury	3500	3–10	5–15	c. 100–300	No	—	1:500 to 1:1000+	?No	Upper Rockall Basin	Iberian Abyssal Plain (5300)	⩾13 (?60)
Surveyor	700	0.5–3	5–8	100–450	RB 40	13	1:500 to 1:1000	?No	†Alaskan Slope	Aleutian Trench (5200)	⩽5
Equatorial Atlantic	1275	2–4	4–8	50–200	LB ⩽25	1–7	1:1040	Yes (⩽60 m)	Brazil continental rise (4300 m)	Fernando de Noronha fracture zone (5450)	15–8
Valencia	200	0.5–4	5–10	200–350	RB ⩽40	1–2	1:150 to 1:600	?No	Ebro fan	Valencia Fan (Balearic Abyssal Plain (2700))	5 (?20)

Summary of physical characteristics of deep-sea channels described in the literature. (Carter, 1981.)



Confidence Level: High

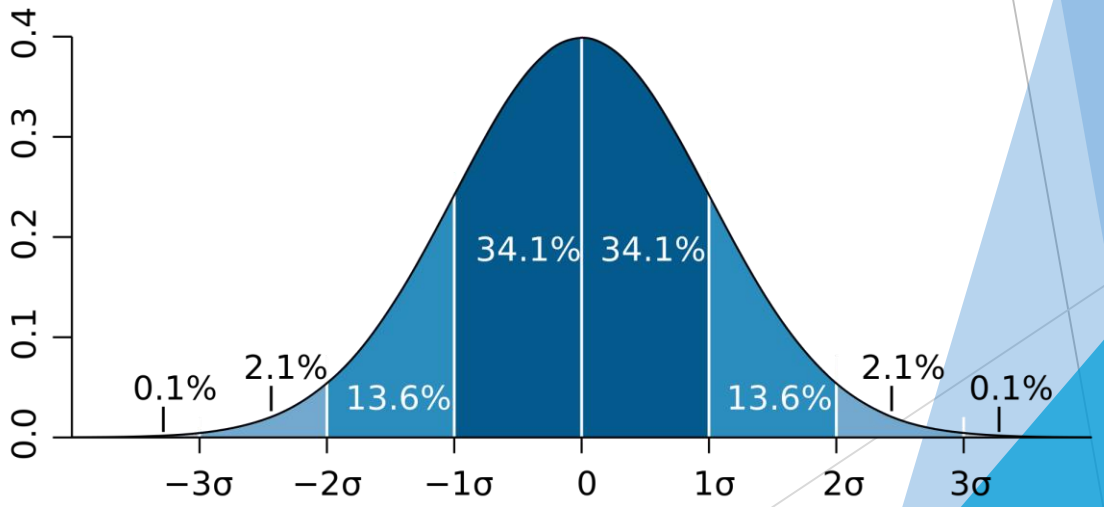
Criteria Analysis NO.3: Gently Sloping

Potential Ways to Define Flatness:

- Slope value
- **Standard deviation of slope**
- Standard deviation of elevation
- Local relief
- Contour line density

Lack of literature and/or data for descriptions of flatness.

Value we used is chosen based on observation and statistics, certain level of **arbitrariness** still exist



Confidence Level: Medium

Improved Definition

SEA CHANNEL

An elongated, meandering depression, usually occurring on a gently sloping plain or FAN.

SEA CHANNEL

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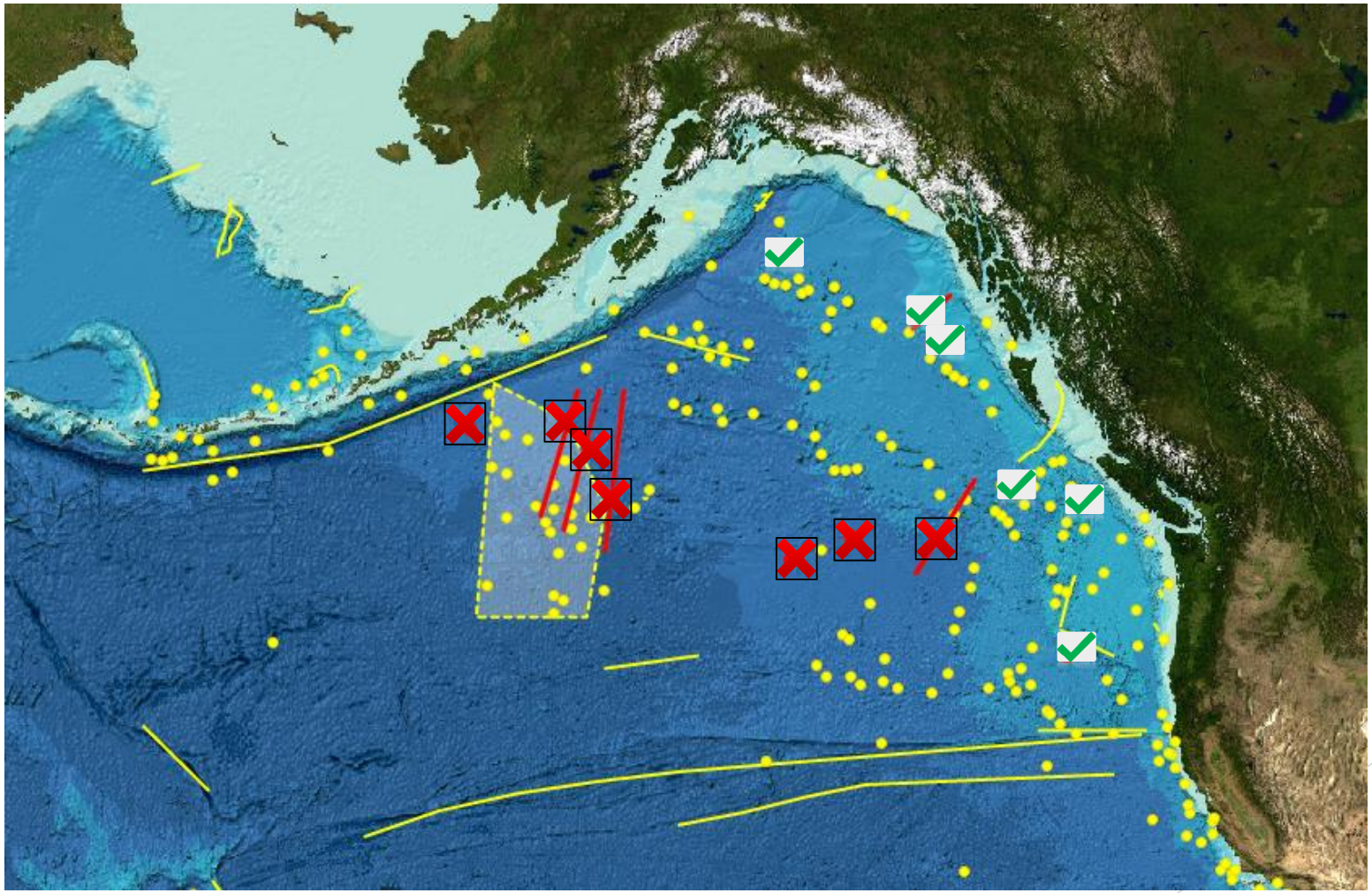
Method Testing Against GEBCO Data

Red Dots = Sea Channels Yellow Dots = Other Undersea Features



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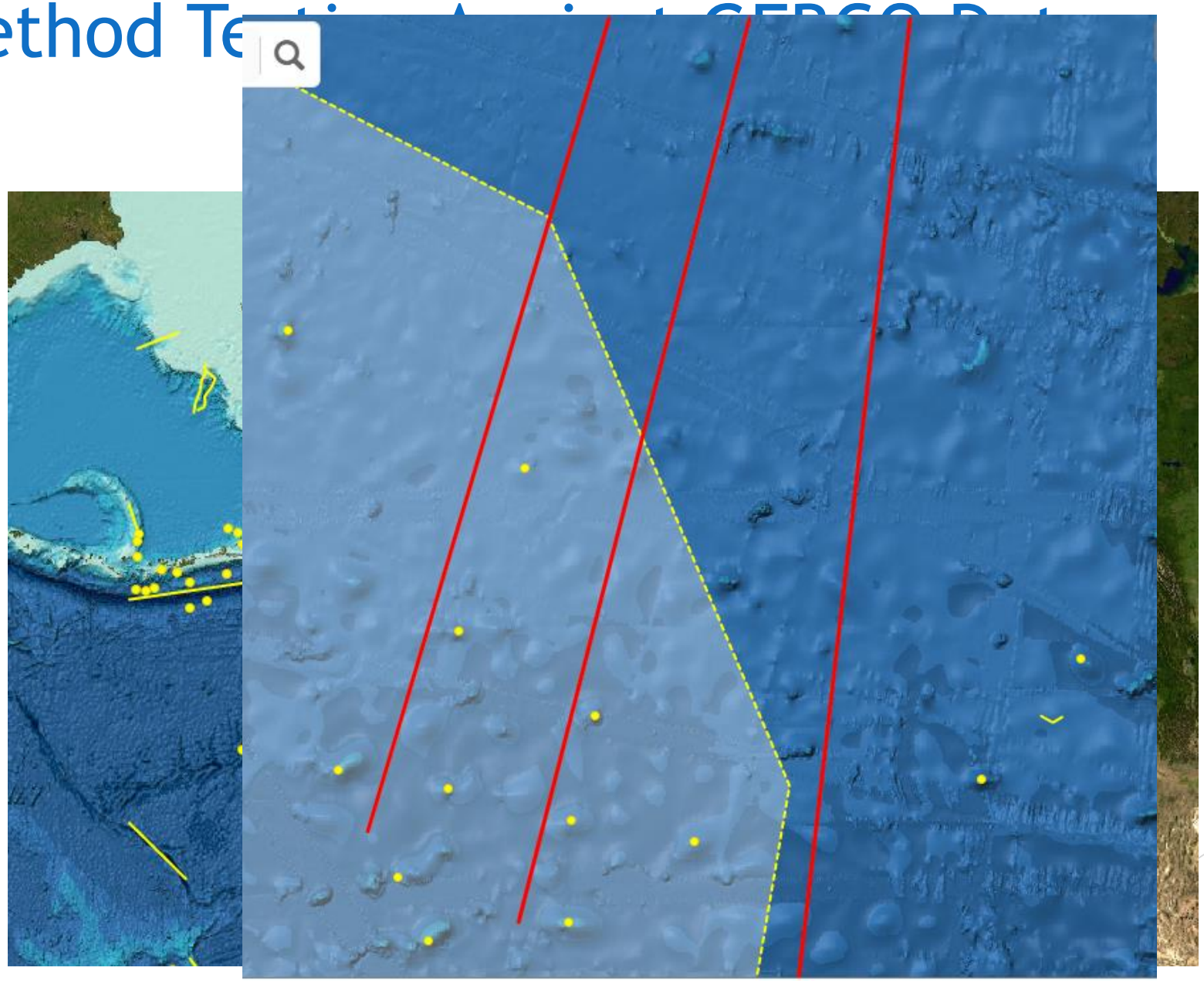
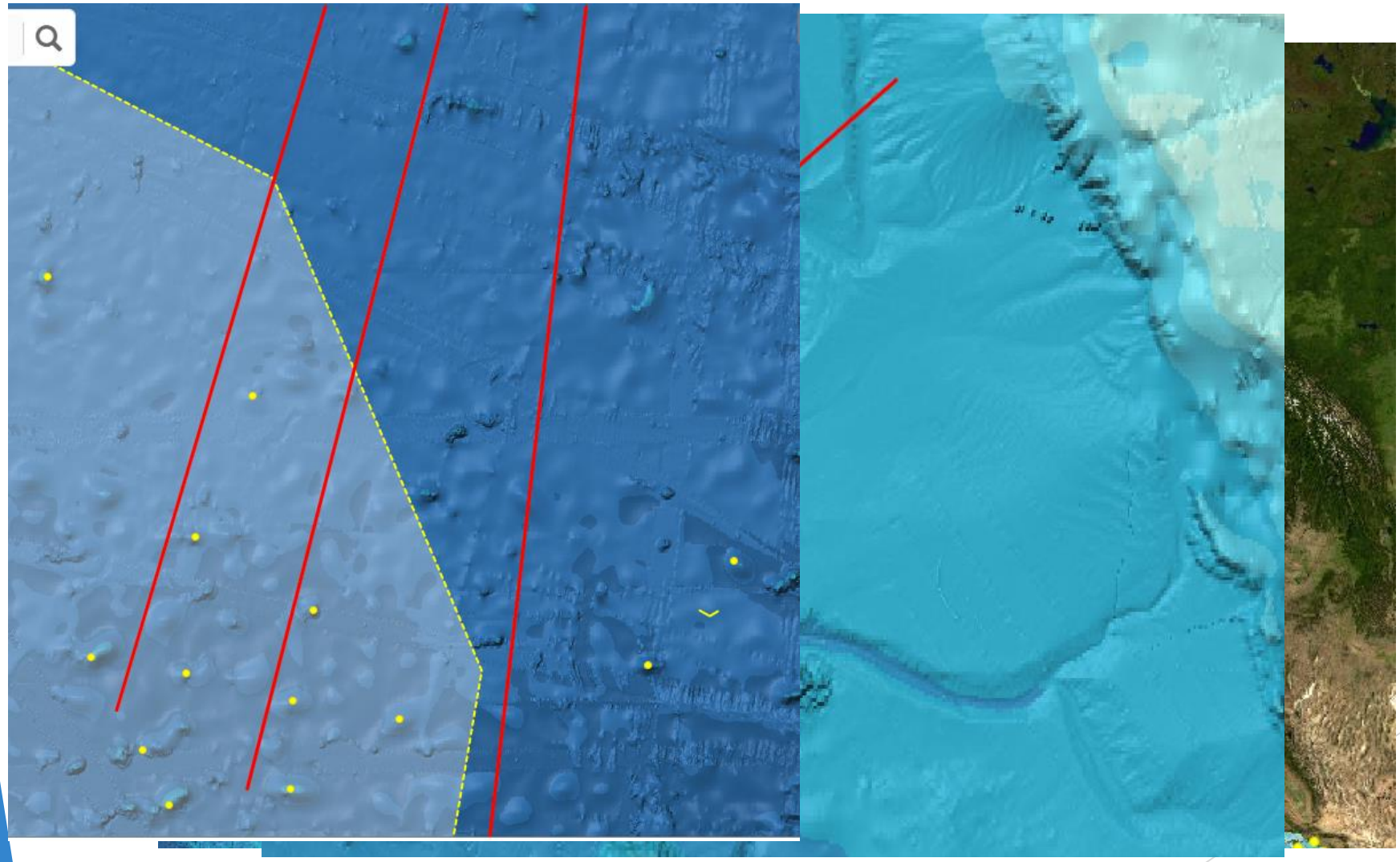


Method Testing Against GEBCO Data



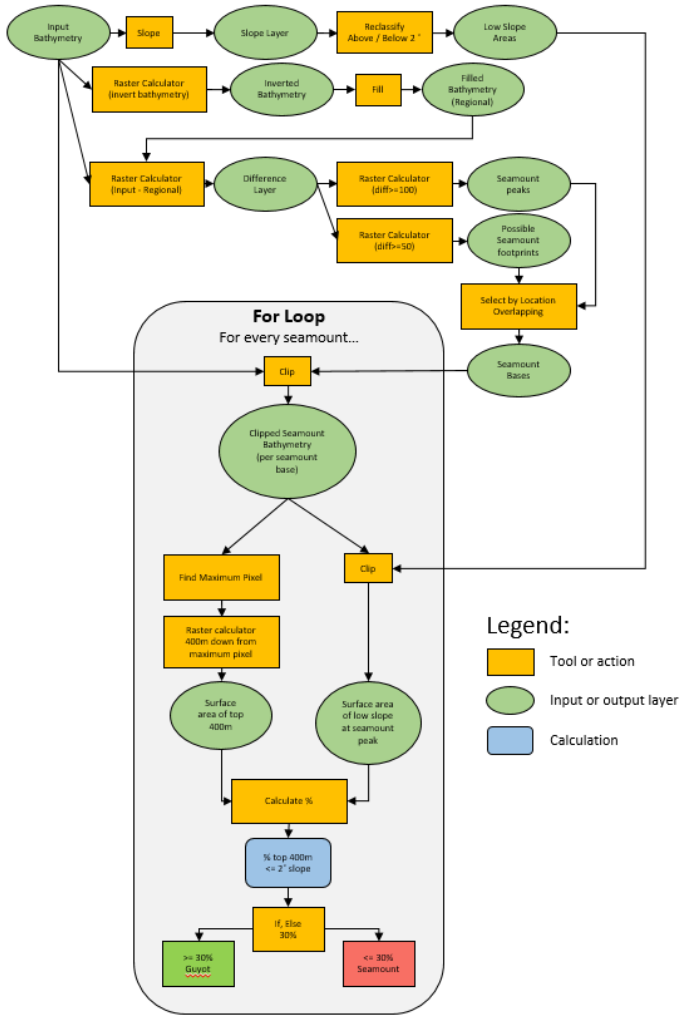
What it means

- Our method is capable of discovering new sea channels base on the B-6 definition.
- Some existing Sea Channels/ Channels could not be identified using bathymetry only.
- The B-6 definition needs an update to function properly as official definition.

Case Study NO.3 Detection Method Automation

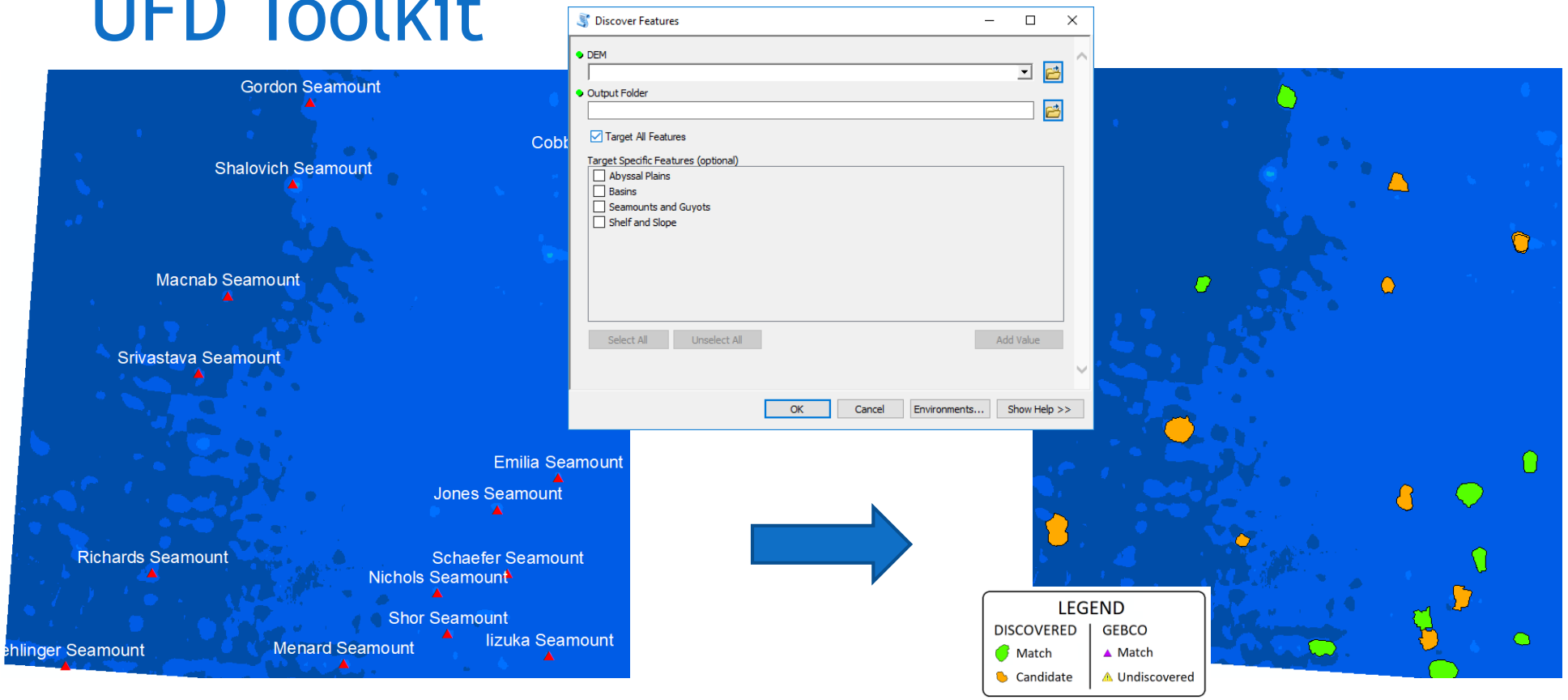
By: Erin Turnbull

Background



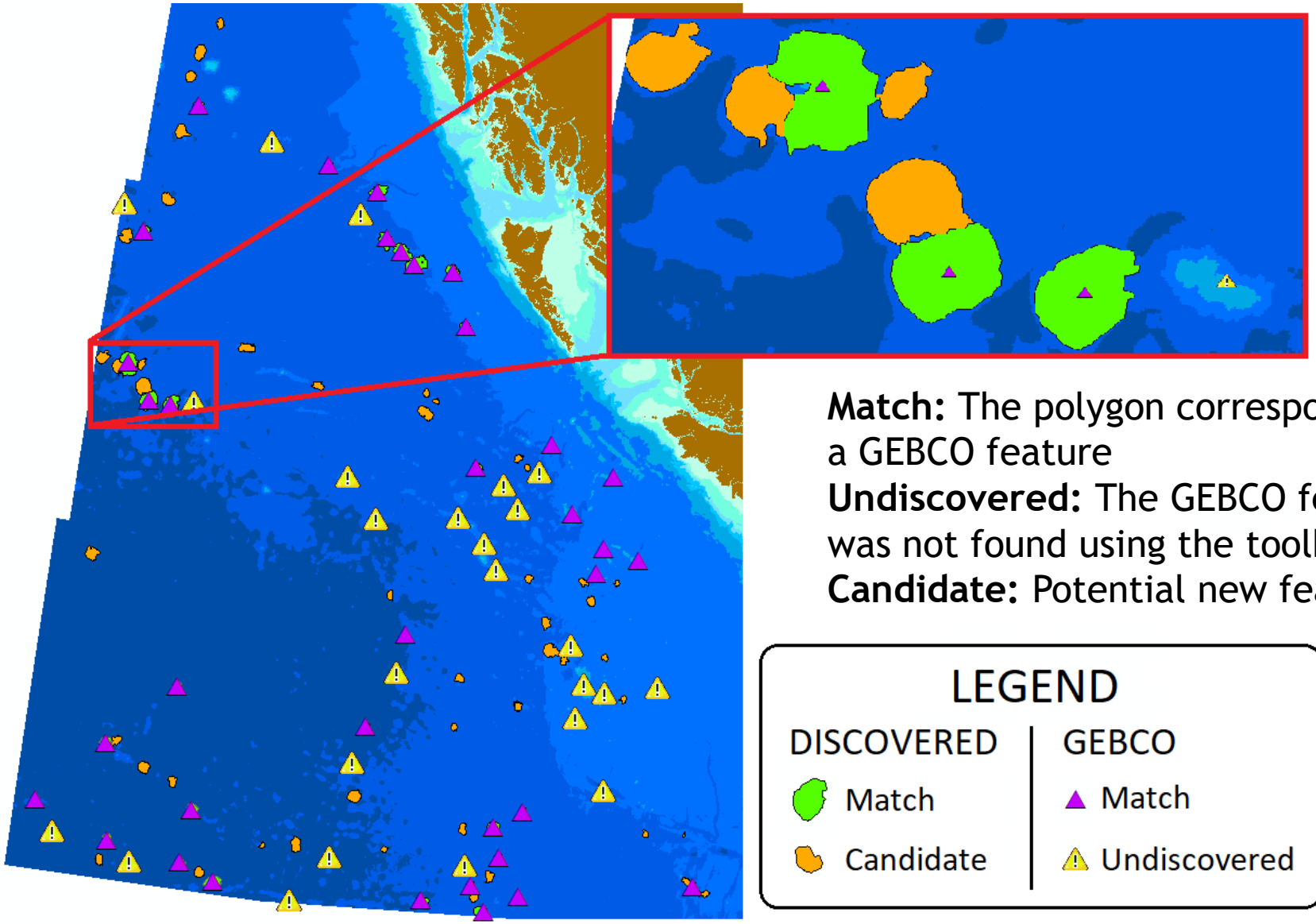
- **Objective:** Determine how suitable our models are by using them to find existing GEBCO features
- Current discovery methods are manual; time-consuming and complicated
- Will need to run repeatedly on large datasets to evaluate suitability
- **Solution:** Automation

UFD Toolkit



- A series of tools for segmenting and classifying undersea features
- Takes 4 minutes to process an area of 400,000 km^2
- Creates polygon shapes for each feature type

Sample Results – Pacific Seamounts



Match: The polygon corresponds with a GEBCO feature
Undiscovered: The GEBCO feature was not found using the toolkit
Candidate: Potential new feature

Validation Results

Generic Type	Total[1]	Matches	Undiscovered	Accuracy	Candidates	Specificity
Abyssal Plain	64	35	29	55%	368	9%
Basin	306	1	305	0%	305	0%
Guyot	180	6	174	3%	118	5%
Seamount	1335	552	783	41%	4537	4%
Shelf	19	12	7	63%	5553	0%

Accuracy: The percentage of GEBCO features found using the toolkit
Specificity: The percentage of discovered features that correspond to existing features

Run on 530 tiles containing at least one GEBCO feature of the given types out of 1440 tiles. Bathymetric data is from GEBCO 2014, projected to the appropriate UTM zone or to Polar Stereographic using the WGS 1984 datum. Features are from the GEBCO Gazetteer.

1: The total number of points is higher than the number of features because the tiles can overlap and some features are precisely on the boundary between tiles.
2: A discovered polygon may occasionally include two GEBCO features, which may affect the number of new features.

Potential Causes

- Choice of projection can alter the results
- Features located near tile edges may not meet criteria
- Parameters may not be well-tuned
- Features may not be good representations of their type
- Feature position may be incorrect
- The data set may not be high enough resolution or may have errors

Going Forward

- Adding new discovery methods (sea channels)
- Refinement of parameters to improve on the accuracy
- Further work on tiling, projections, and distributing features is needed
- Review GEBCO features and select excellent examples as training data
- Tools may be published to allow others to review the methodologies and the results on different datasets
  - Note: Discovery methods are a work in progress and the parameters are subject to change. In addition, this work is meant to facilitate the discovery of features; the results should not be considered a legal or official representation of any feature. Results should be reviewed for accuracy and jurisdiction before being used.

Recommendations

General Suggestions for B6

- Standardize commonly used descriptive terms (equal-dimensional, shallow, deep, elongated, etc.)
  - Example: slope value < 0.5°= *"flat"*
  - 0.5°< slope value < 2°= *"gently sloping"*
  - slope value > 2°= *"steep"*
- Standardize the usage of modal verb (must, should, etc.) and frequency adjectives (sometimes, usually, etc.)
  - Example: chance < 15% = *"seldom"*
  - 15% < Chance < 50% = *"sometimes"*
  - 50% < Chance < 95% = *"usually"*
  - Chance > 95% = *"always"*

Requests

Input Wanted from SCUFN Members

- We are willing to have more in-depth presentation of our work to anyone who is interested.
- The UFDP will highly appreciate support and feedback from SCUFN members, we are expecting expertise, suggestions, and feedbacks include but not limited to the following fields of study:
  - GIS
  - Topography
  - Oceanography
  - Geology
  - Earth science
  - Etc.

Thank you

Contact Info For Further Questions:

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