國立中山大學
National Sun Yat-sen University

THE MCRAE Marine ECOLOGY LAB

3D Analysis and Case Studies

SfM workshop
Guan-Yan Chen
2025 June

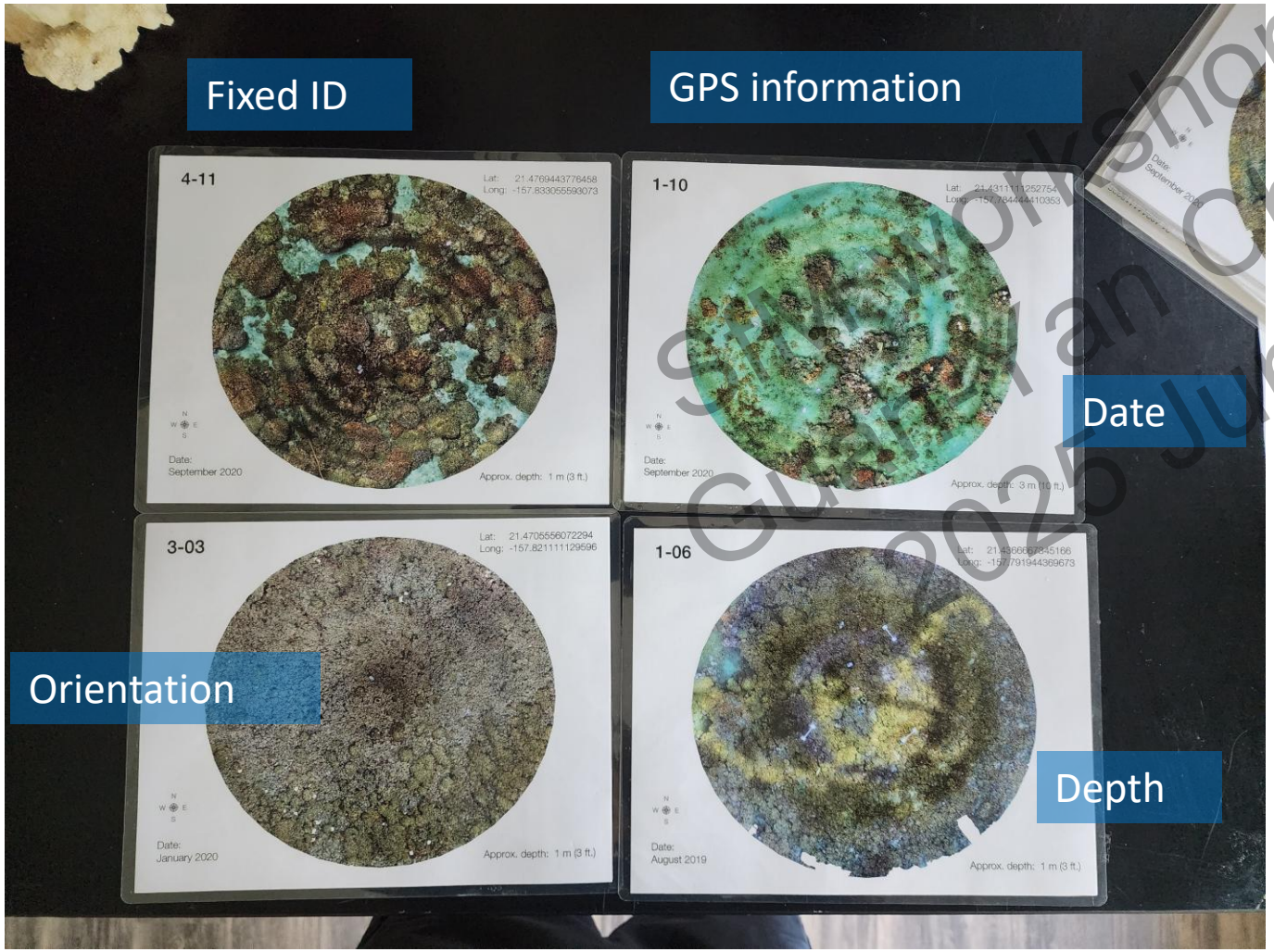
Guan-Yan Chen 陳冠言
Ph.D. candidate, Hawaii Institute of Marine Biology

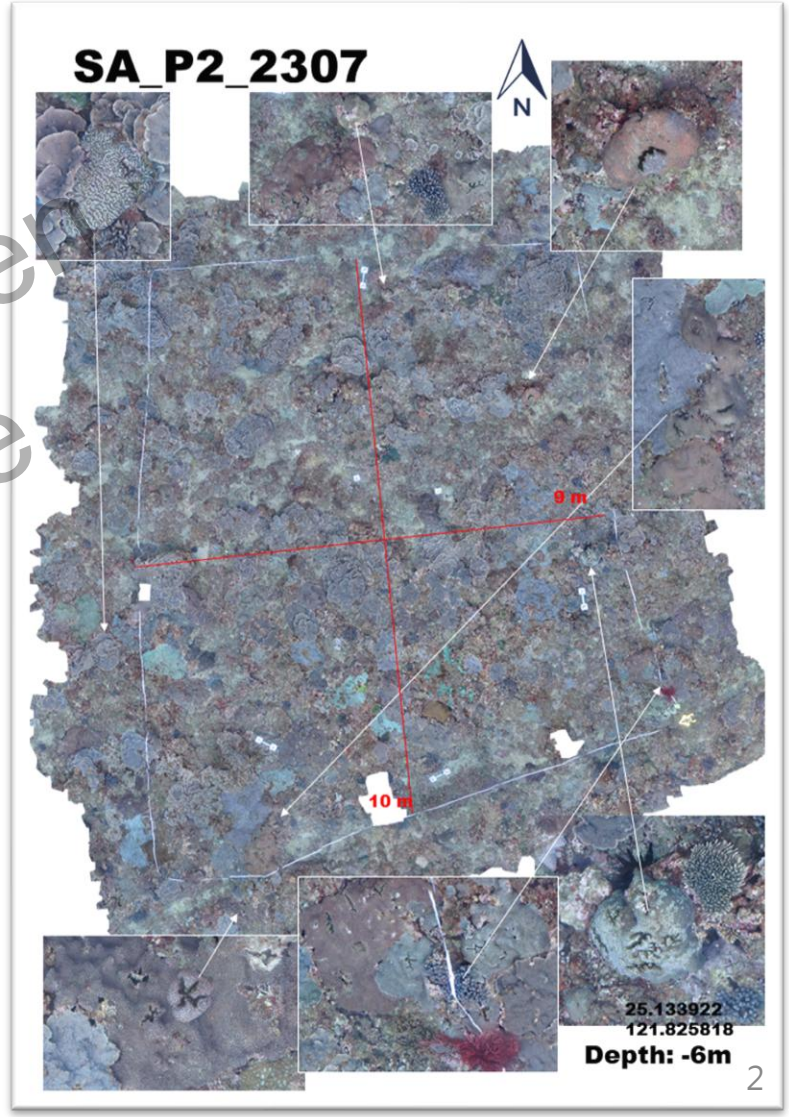
Jun 05 2025
At National Sun-Yet Sen University

Establish a standardized reef area ID for future resource sharing

Data Management and Tracking

Creating maps supports long-term monitoring

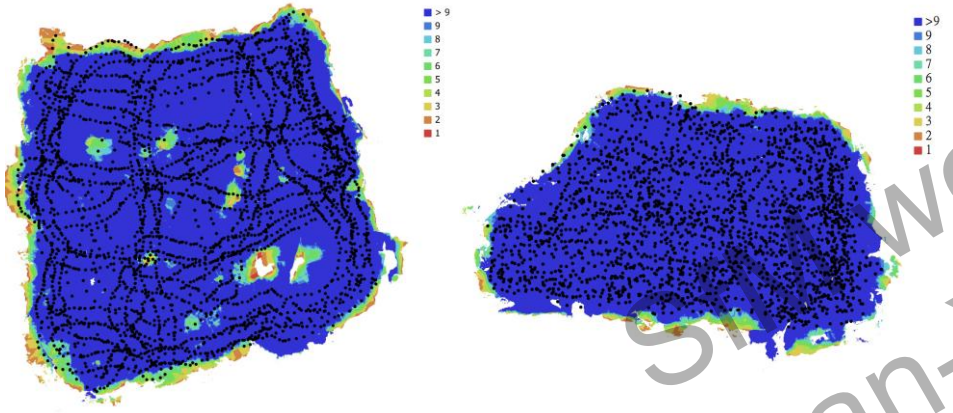




How to Evaluate SfM Output Quality

(The report can be generated after set the reference in Metashape)

1. Ensure photo overlap >9



2. Total scale bar error < 0.002 m

Scale Bars	Distance (m)	Accuracy (m)	Error (m)
target 32_target 37	0.300000	0.001000	0.000849
target 35_target 36	0.299000	0.001000	0.000581
target 45_target 46	0.303000	0.001000	-0.000311
target 52_target 53	0.297000	0.001000	0.001232
Total Error			
Control scale bars			0.000817
Check scale bars			

(NOAA standard)

3. Distance & resolution (suggested value)

Flying altitude: 1.13 m (0.9~1.4 m)

Ground resolution: 0.342 mm/pix (<0.5 mm/pix)

4. Optimize quality with minimal images (cost-efficiency balance)

Try not to take too many photos

Number of images: 7,203 (~3600)

Coverage area: 106 m² (~144 m² for 10X10m plot)

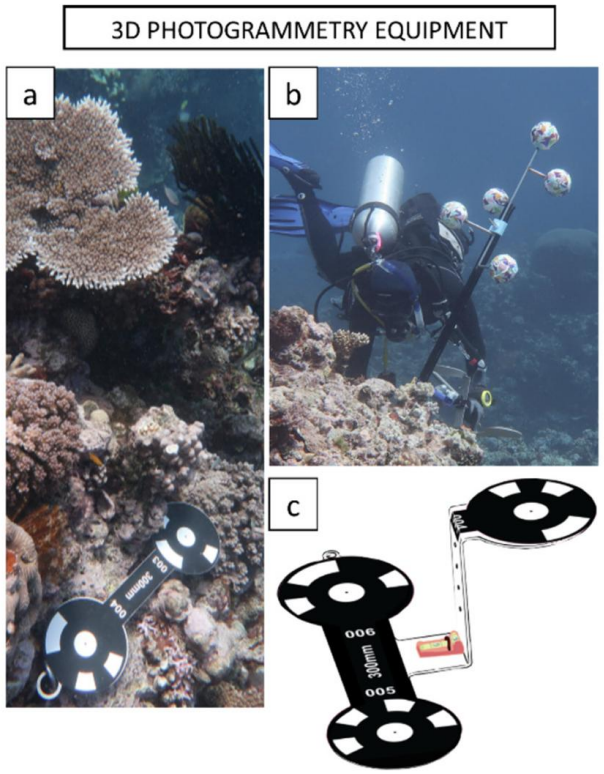
A more serious error analy

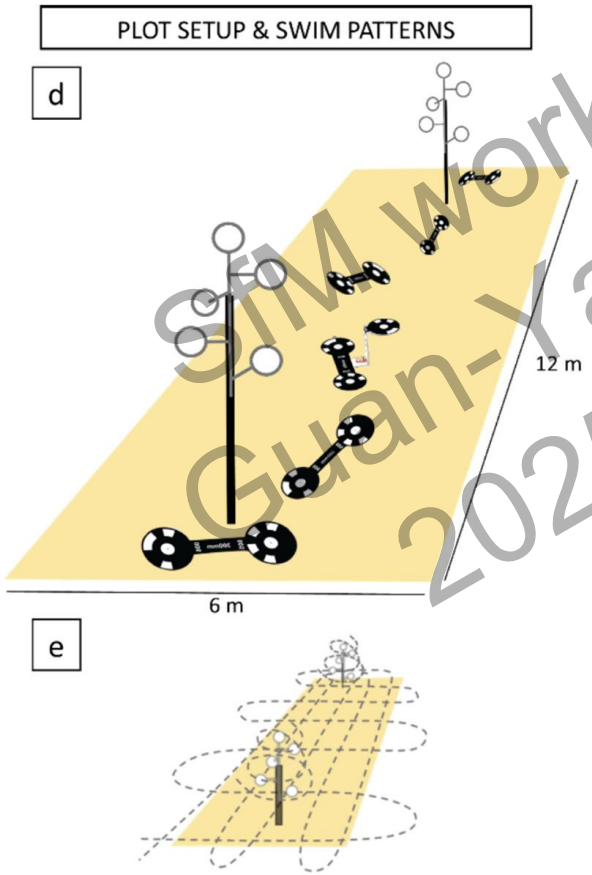
Contents lists available at ScienceDirect
Ecological Informatics
journal homepage: www.elsevier.com/locate/ecolinf

Evaluating error sources to improve precision in the co-registration of underwater 3D models

Marine A.A. Lechene [a,b,*], Will F. Figueira [c], Nicholas J. Murray [a], Eoghan A. Aston [a,b], Sophie E. Gordon [b], Renata Ferrari [b]

[a] College of Science and Engineering, James Cook University, 1 James Cook Dr, Douglas, QLD 4811, Australia
[b] Australian Institute of Marine Science, Townsville, QLD 4810, Australia
[c] School of Life and Environmental Sciences, University of Sydney, Sydney, NSW, 2006, Australia





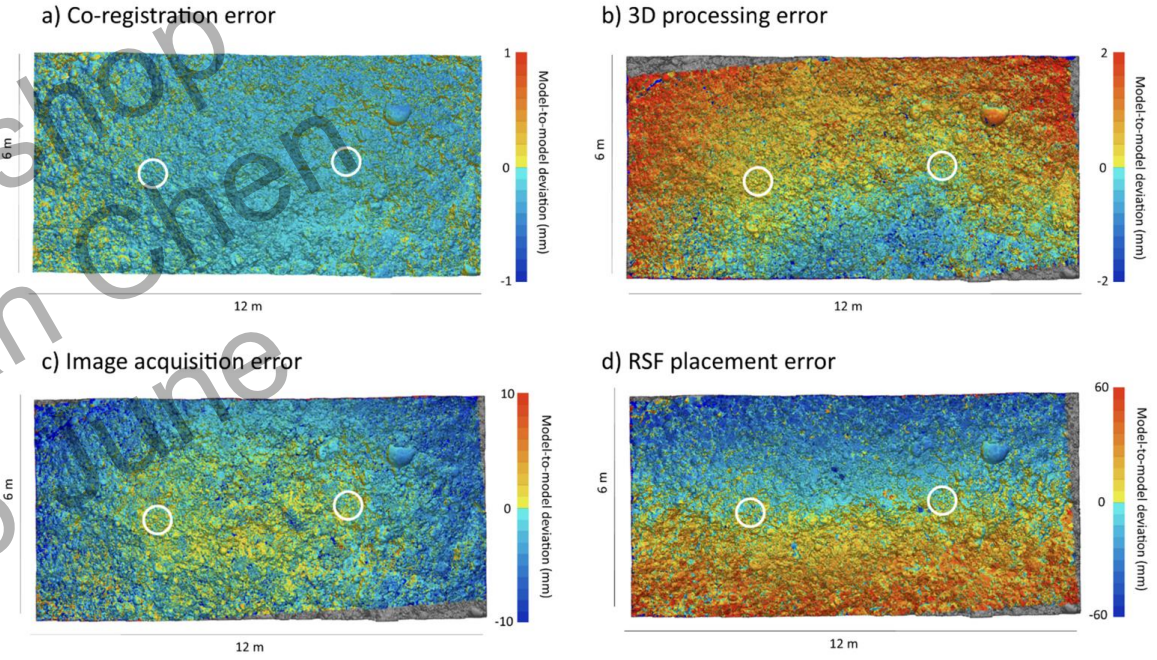


Fig. 6. Example of deviation analysis output using the 3D Compare tool in Geomagic Control X. The heatmaps show the model-to-model deviations (mm) between the reference and test models (note the difference in scale of the heat color ramp). The white circles mark the location of the sphere-trees. Gray areas denote areas of no overlap between models.

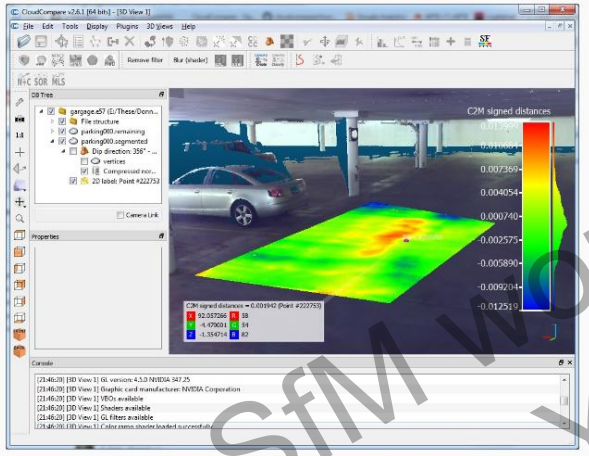
to 2 fps) during image acquisition. Based on our results, if 1.4 mm error is an acceptable threshold, we recommend a minimum image density of 90 images per square meter (~ 6000 images per plot of 72 m^2) which can then be reduced to a third if photo redundancy is high (>2000 images per plot of 72 m^2).

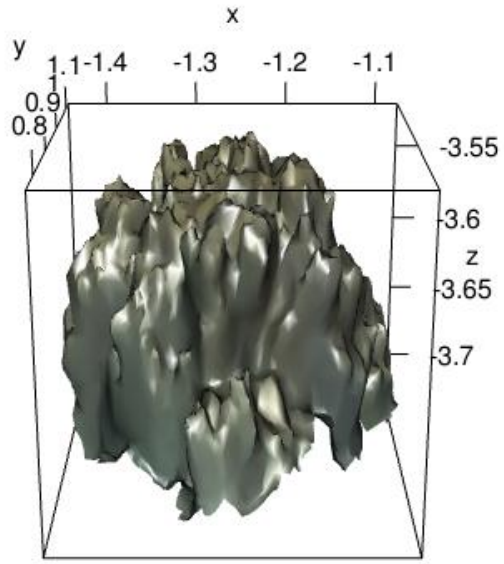
(Lechene et al. 2024)

Colony-scale data analysis

CloudCompare

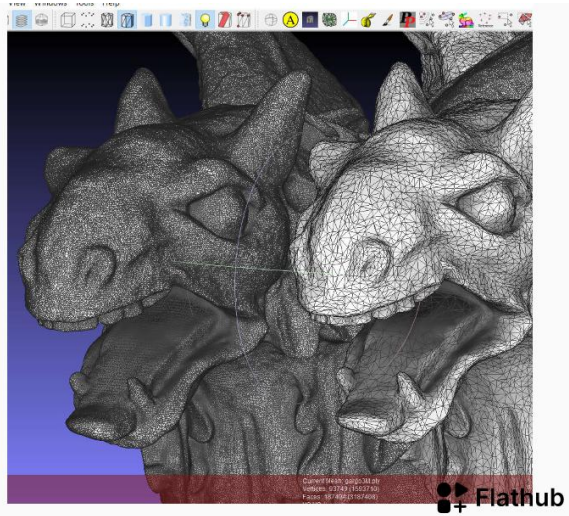
3D point cloud and mesh processing





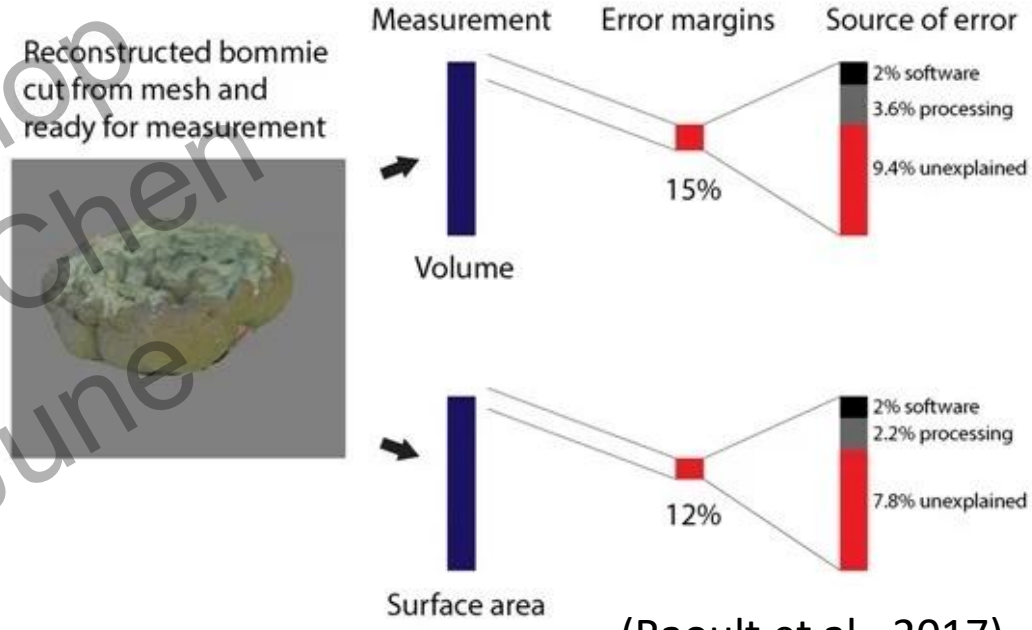
MeshLab

Free and open source processing and editing 3D triangular meshes



Field Coral Volume measurement need improvement

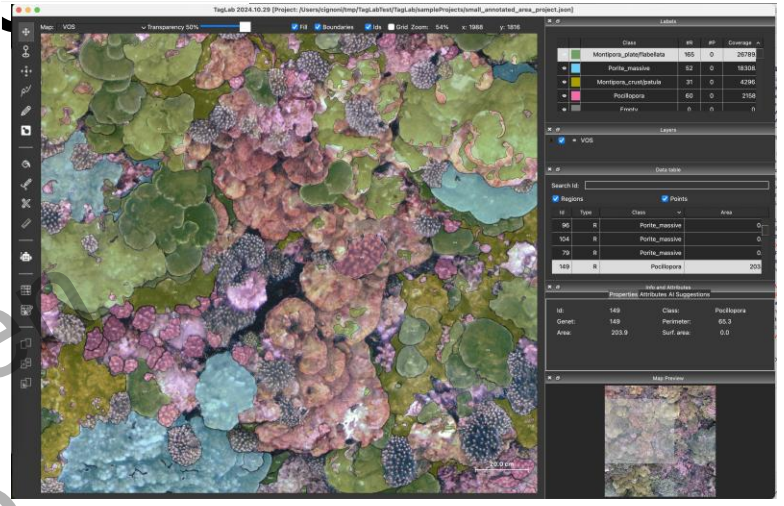
- In situ 3D measurement errors remain high; future enhancements are possible
- Laser scanning or CT scanning offers much higher stability; otherwise, improve equipment quality under ideal conditions



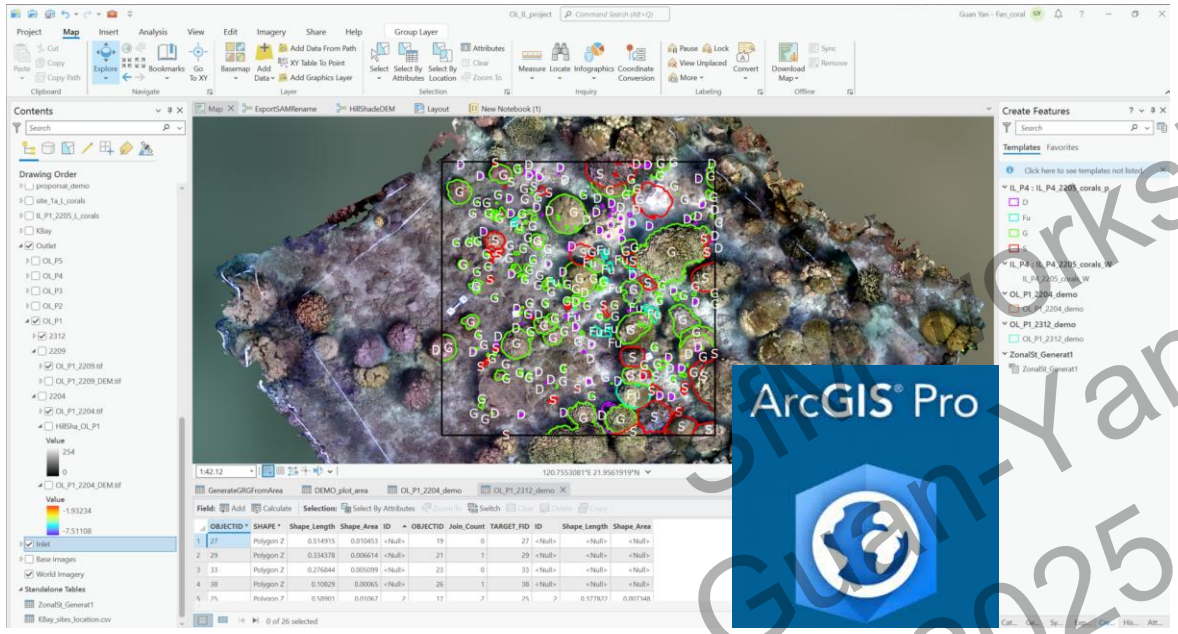
(Raoult et al., 2017)

Habitat-Scale Data Analy

TagLab (Pavoni et al., 2022)



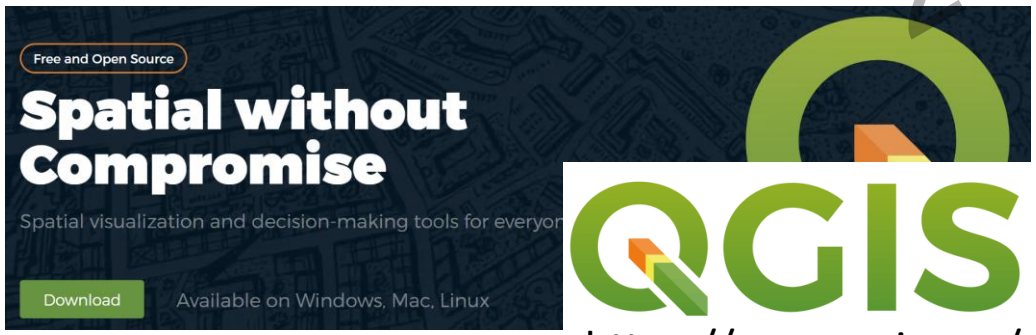
https://github.com/cnr-isti-vclab/TagLab



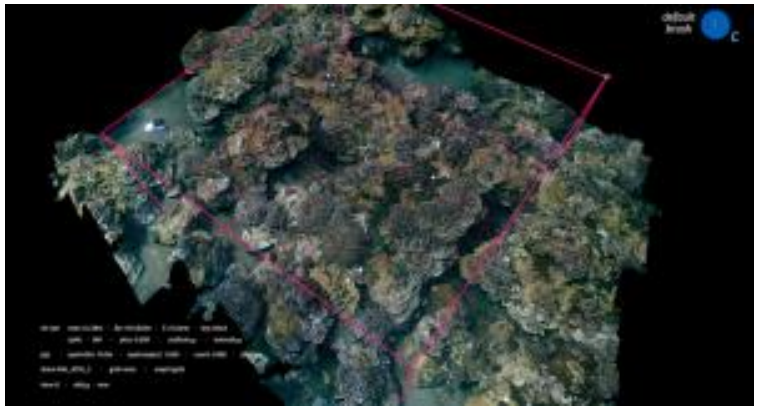
SMW Workshop
Guan-Yan Chen
2025 June

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

(Rubyan et al., 2022)

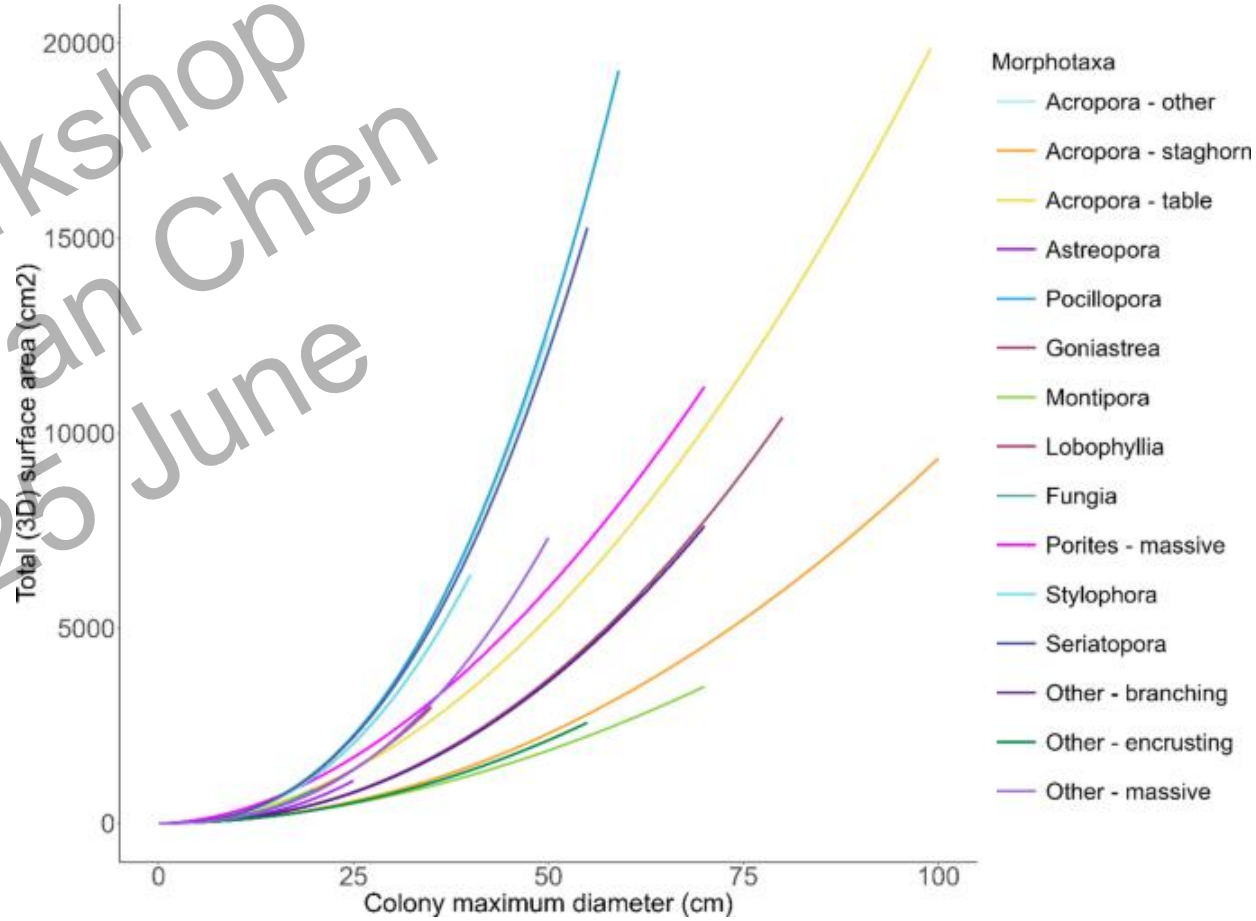


https://www.qgis.org/

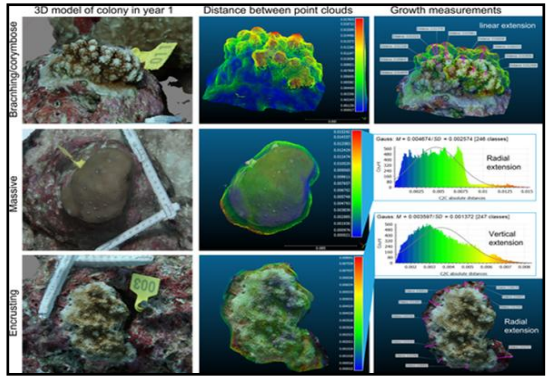


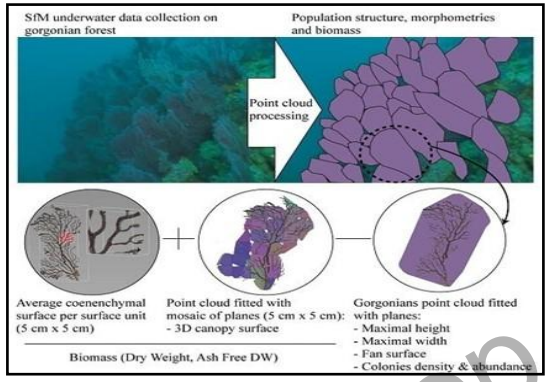
Why Analyze 2D Even After Capturing 3D

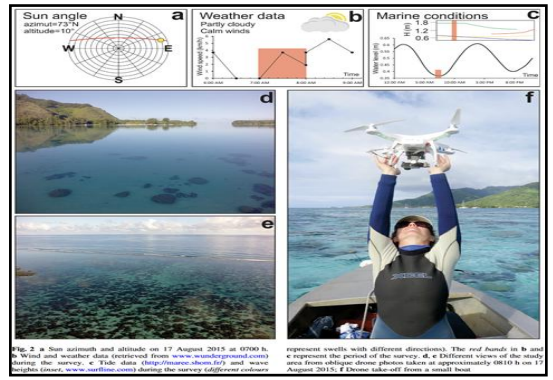
1. The 2D and 3D area for the same morphology correlate highly, serving as a proxy indicator
2. 2D data are essentially orthorectified 2.5D projections of 3D models, presented as 2D images for convenience
3. Increases analysis efficiency and facilitates comparison with historical data



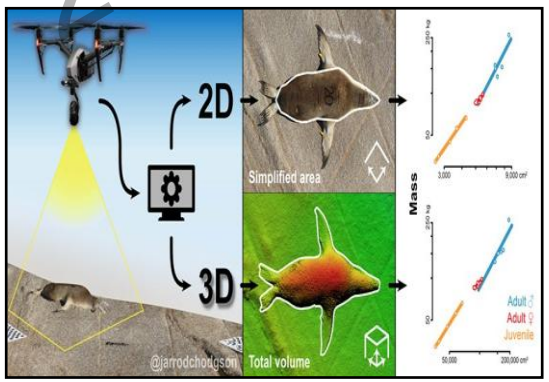
(Chandler et al., 2024)
(House et al., 2018)

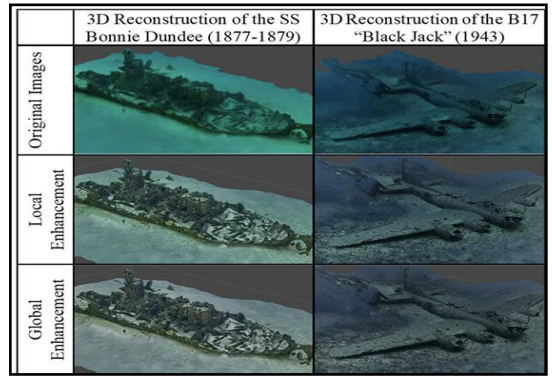




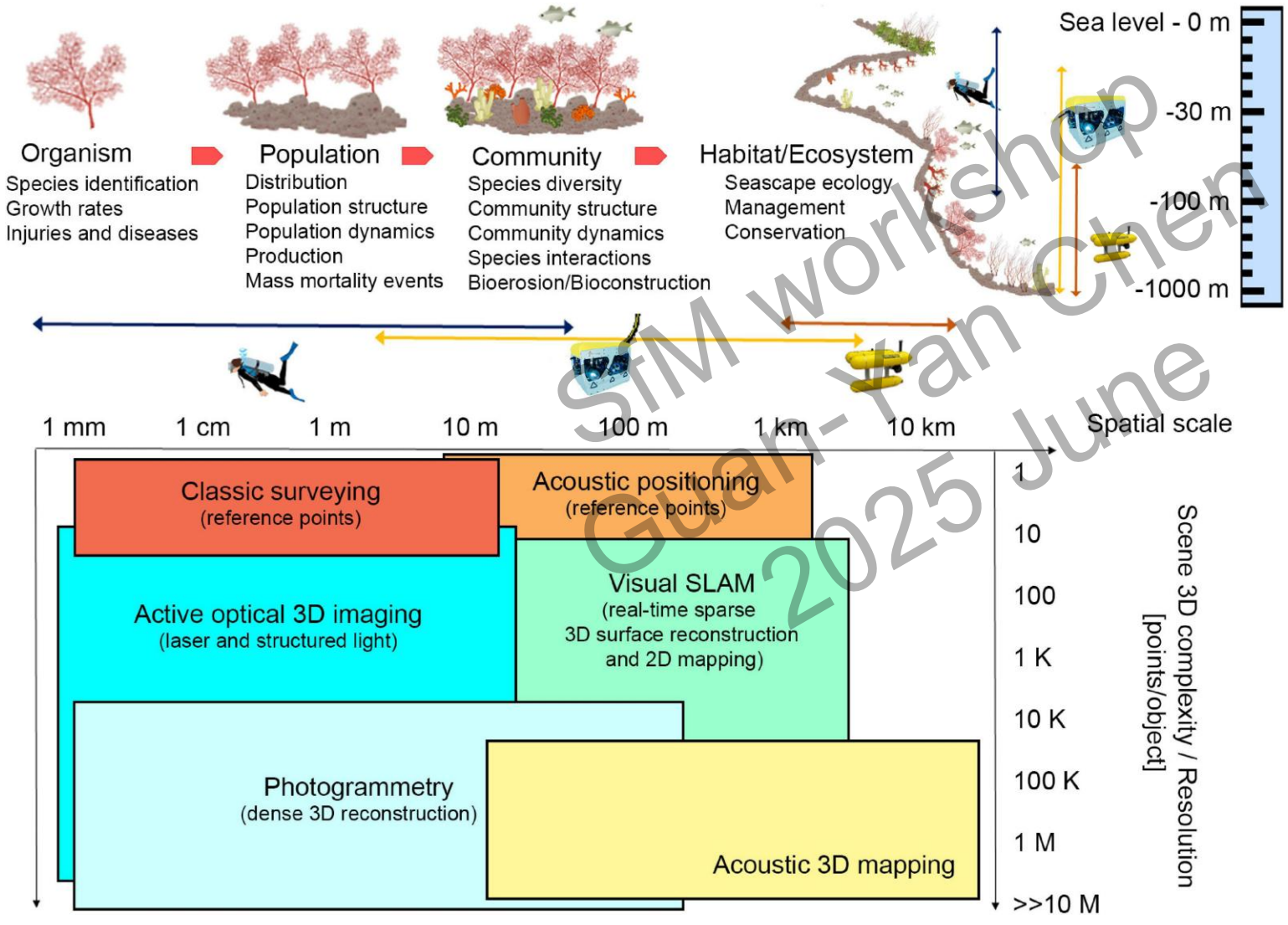


Case Studies of 3D Survey in ocean-science





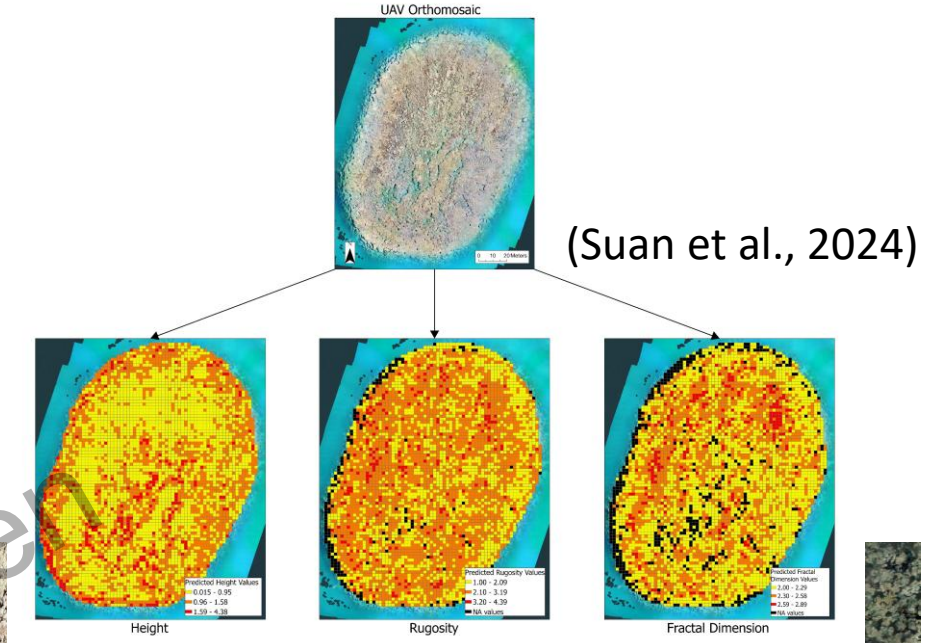
Using SfM in Marine Research



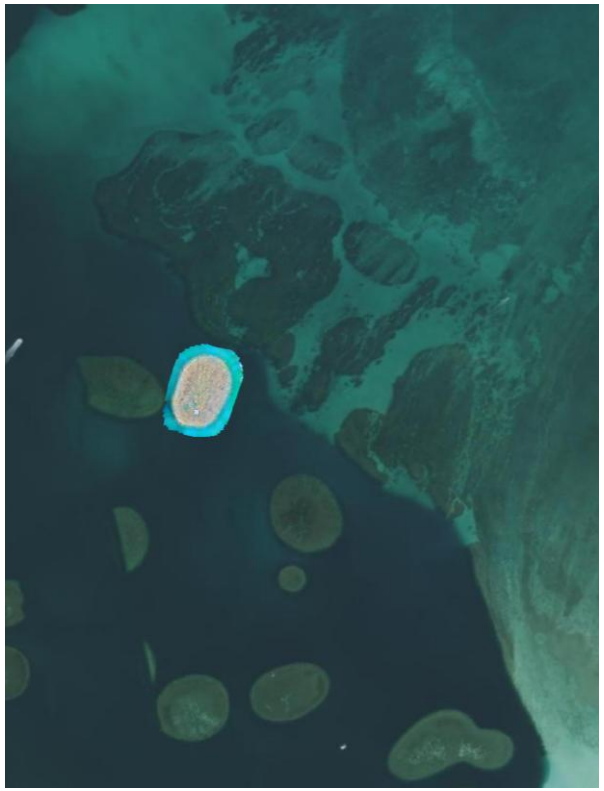
Using appropriate equipment base on spatial scales

(Rossi et al., 2021)

Combine multiple scales SfM data

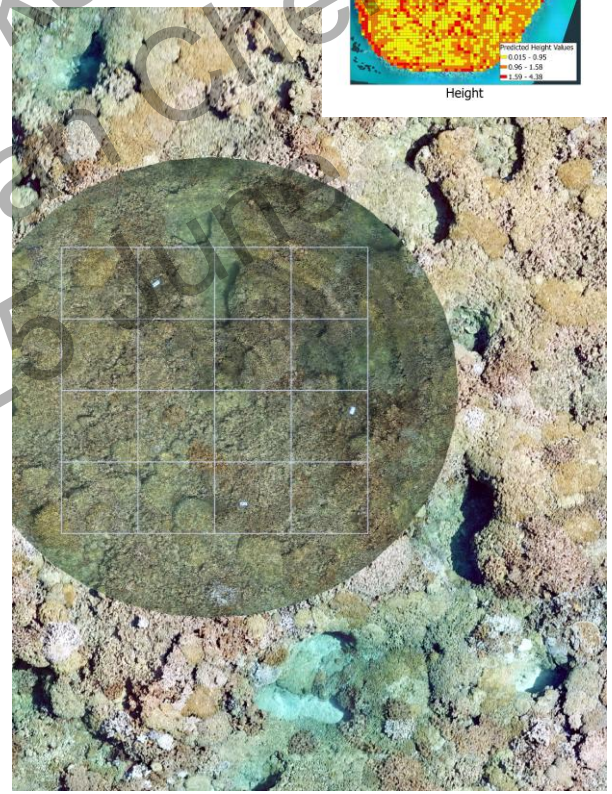


(Suan et al., 2024)

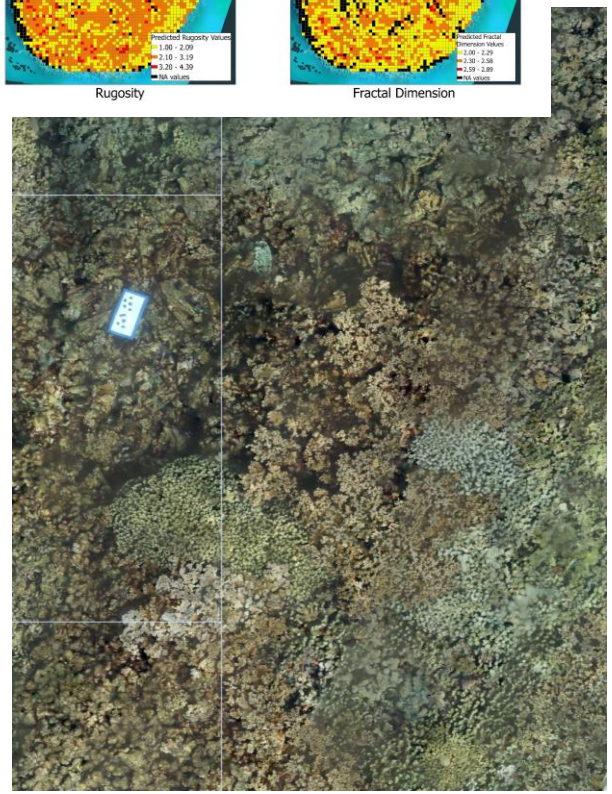


Satellite + drone images

Drone image



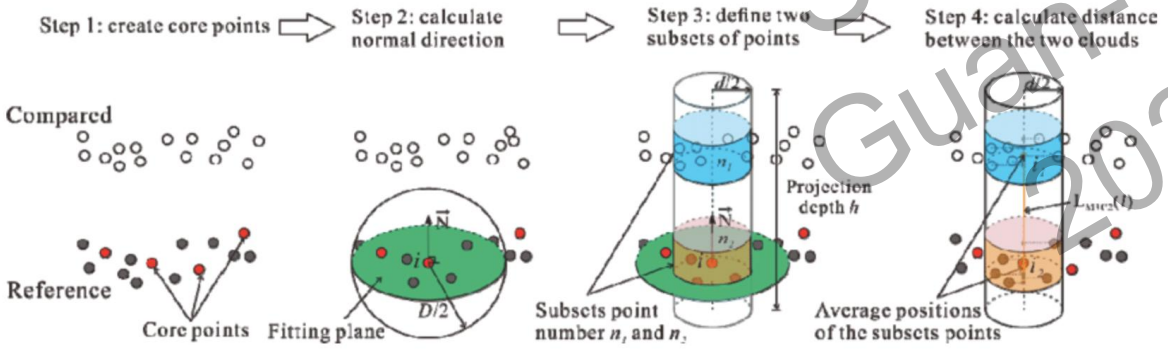
Drone + underwater image



Underwater image

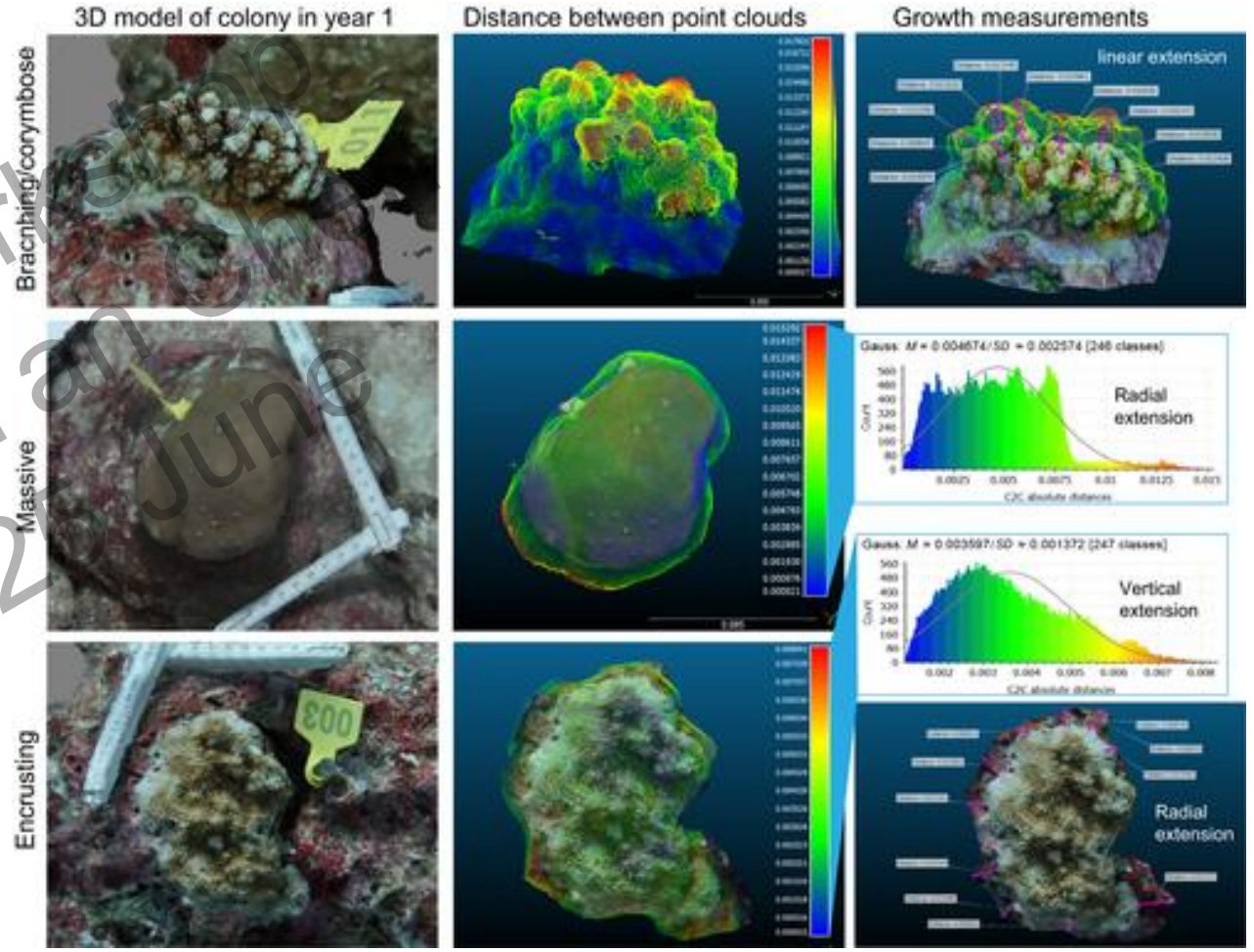
Measure colony growth rate by comparing point clouds

A multiscale model-to-model cloud comparison (M3C2 algorithm)



Cloud-to-cloud distance calculated by the M3C2 algorithm.

Allows quantification of distance changes between two similar clouds



(Lange & Perry, 2020)

3D coral reef growt

Detects annual changes of 10–15 mm with ~1 mm error

(Rossi et al., 2019)

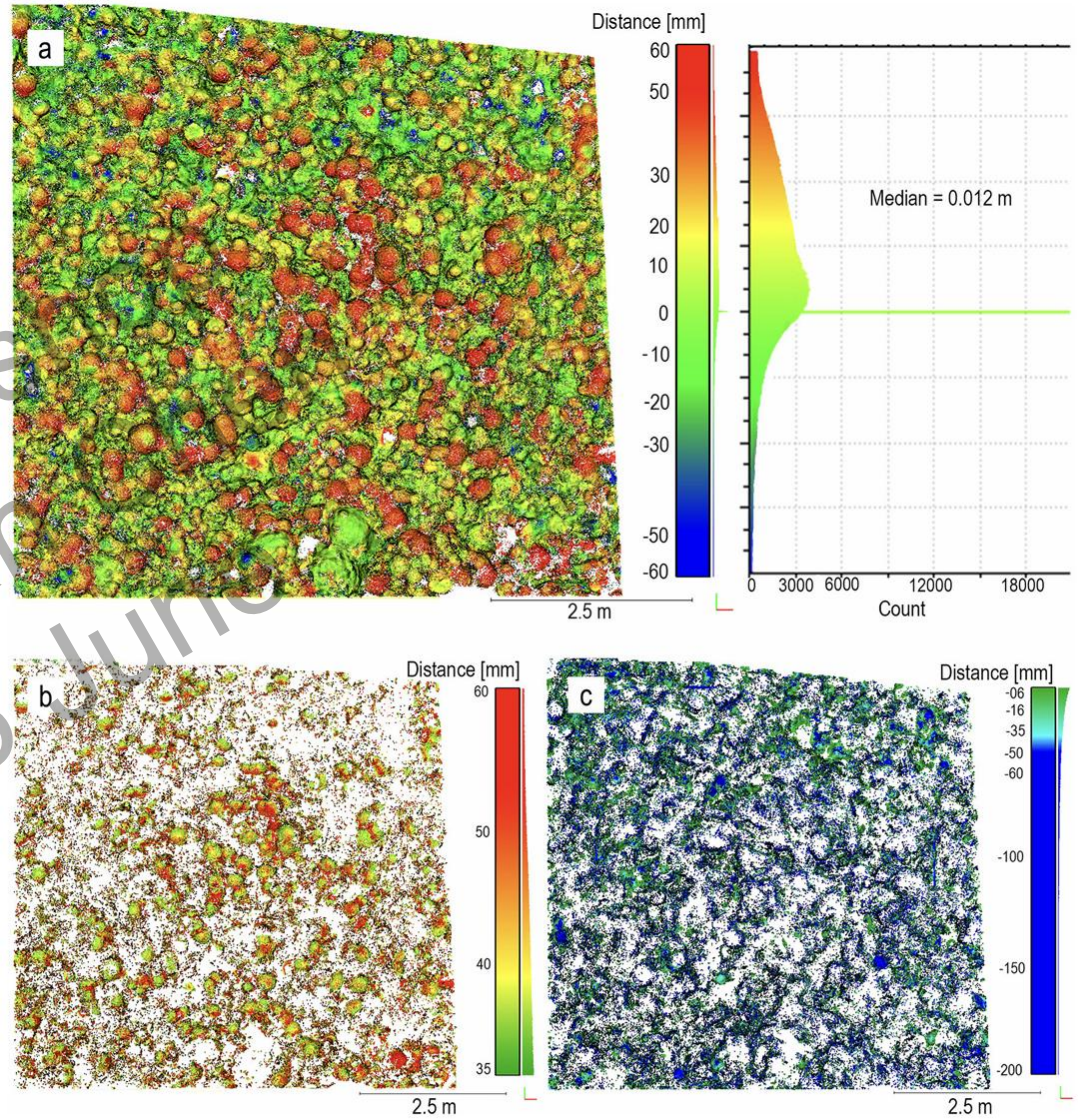
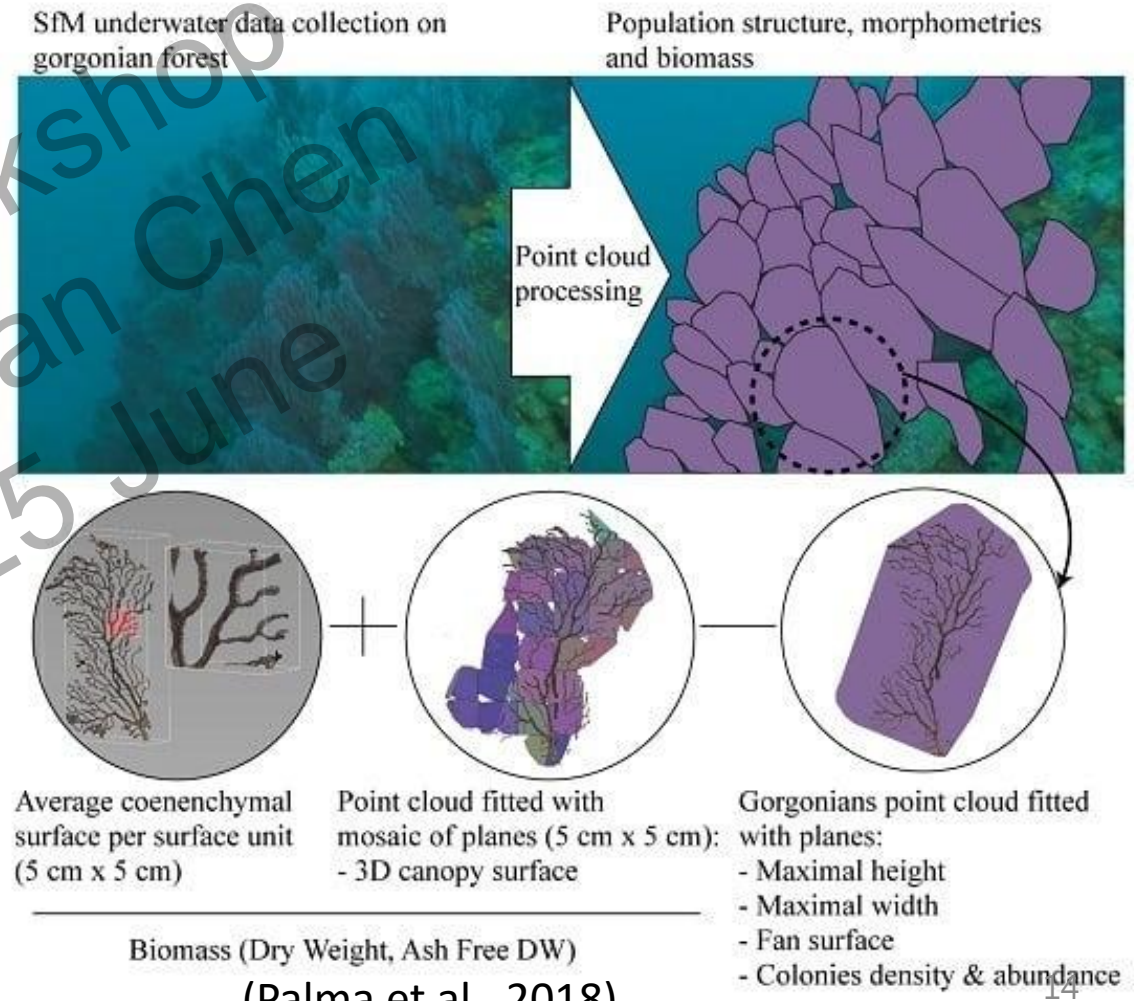


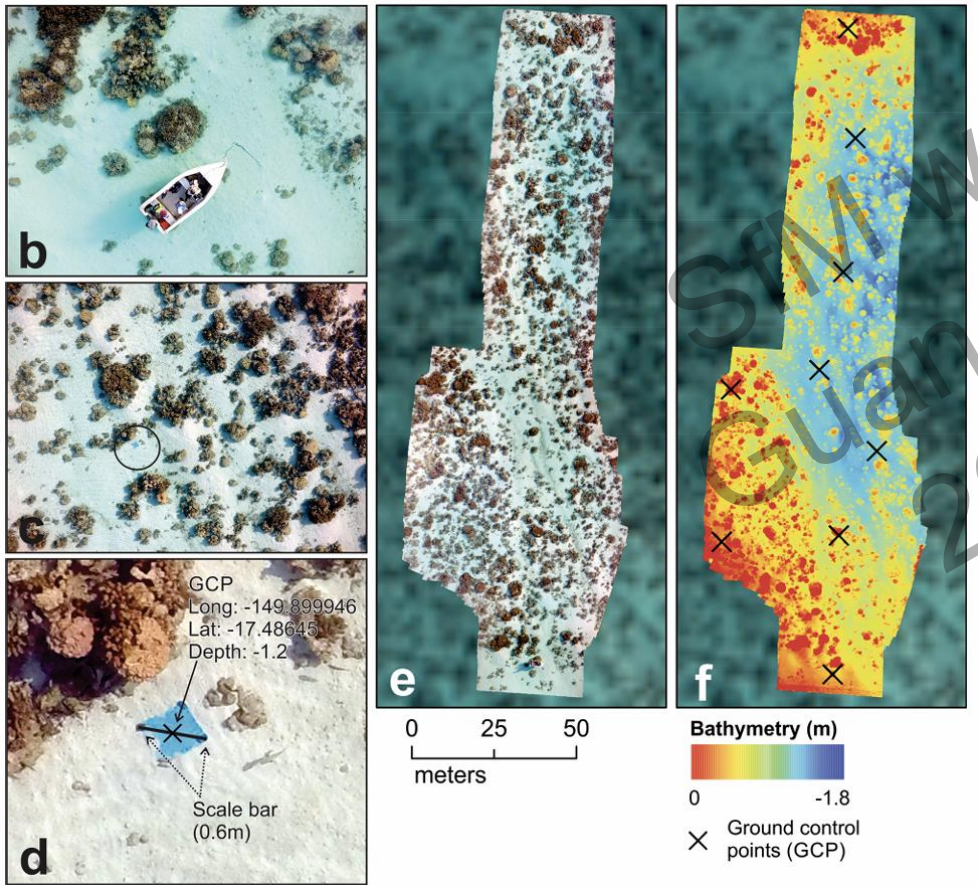
Fig. 4 Comparison and coordinate variations between the 2017 model (reference) and the 2018 model (compared) as projected on the 2017 model. **a** Map of calculated distances (values between ± 60 mm), distribution of values and statistical parameters. **b** Extraction of large positive values (> 35 mm, 85th percentile), yellow color states 30 mm values. **c** Extraction of largest negative values (between − 200 and − 6 mm, the 15th percentile) to better report damaged coral concretions

Gorgonian measurement & point-cloud classification



(Palma et al., 2018)

UAV underwater modelling



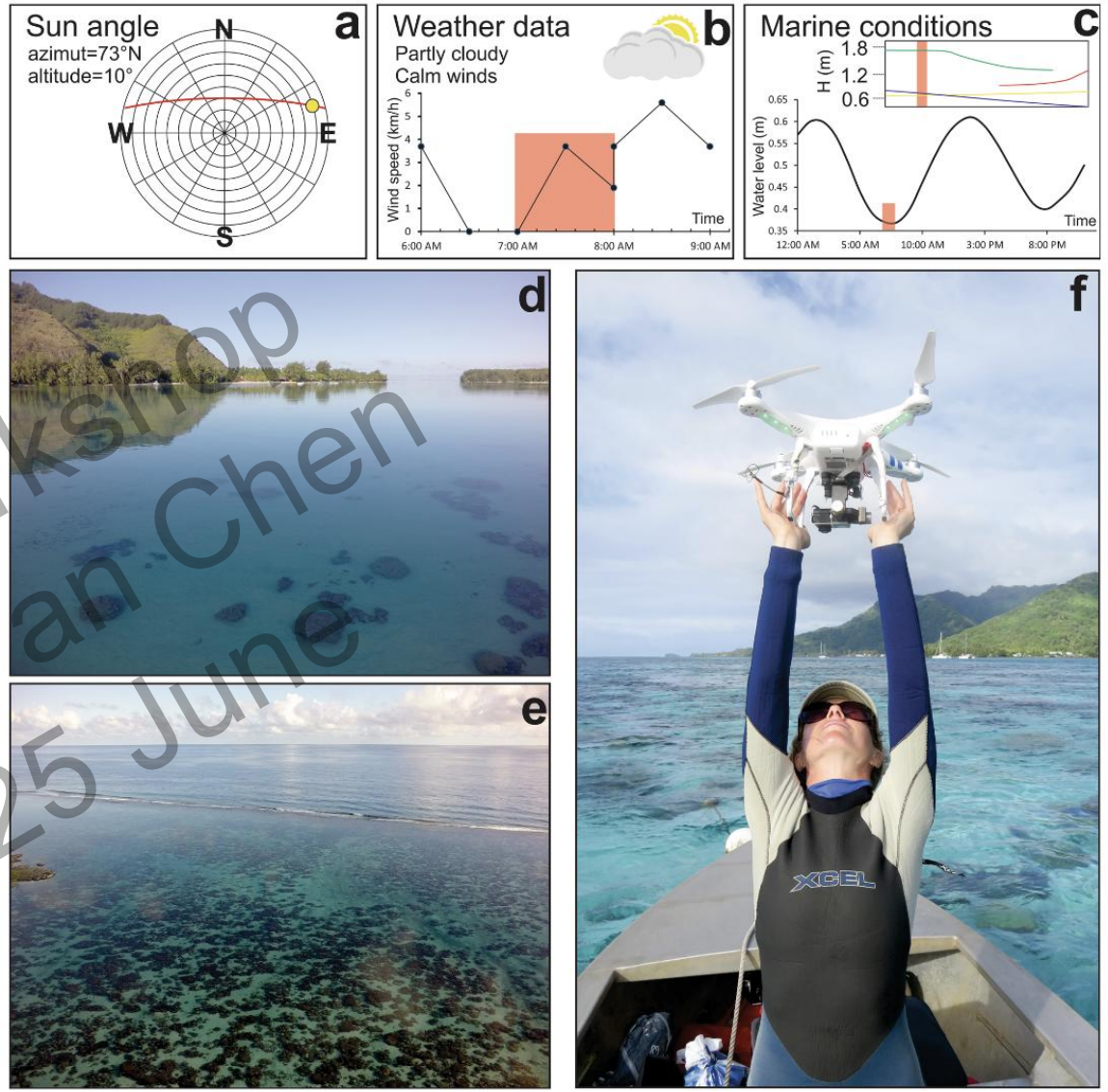
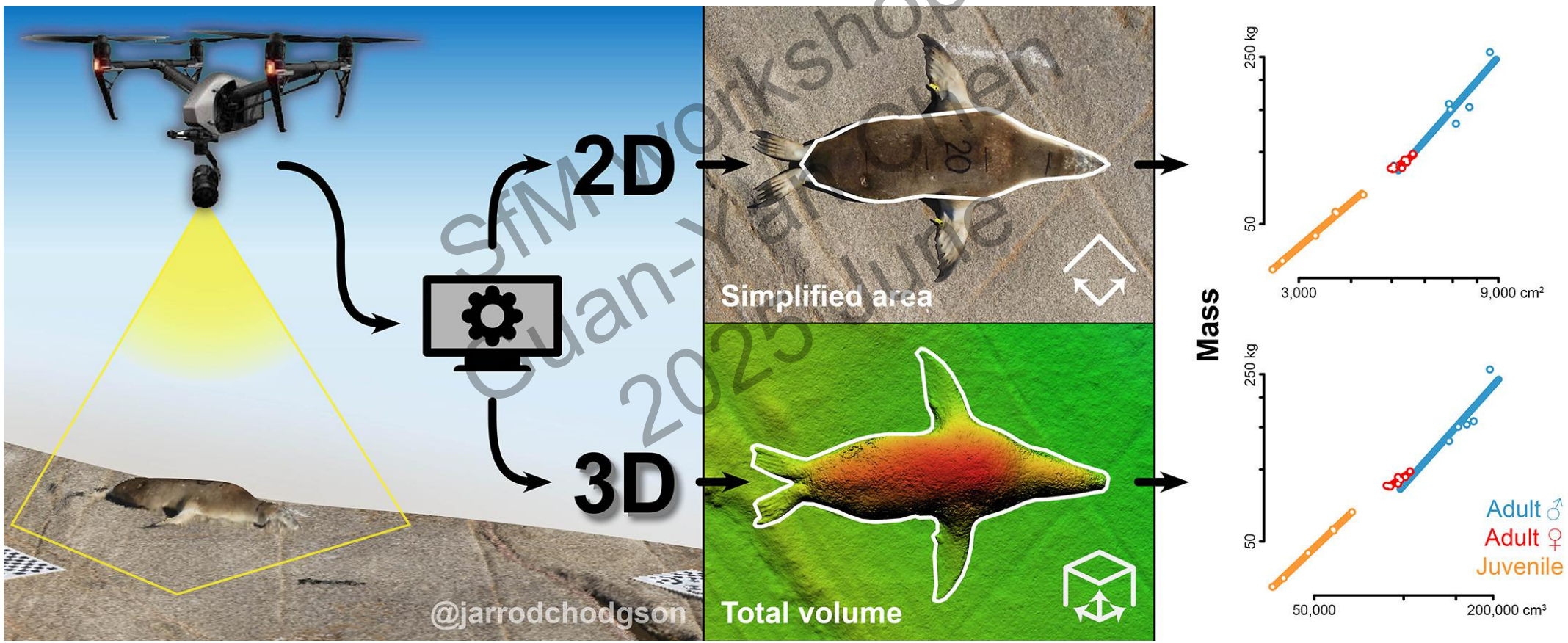


Fig. 2 **a** Sun azimuth and altitude on 17 August 2015 at 0700 h. **b** Wind and weather data (retrieved from www.wunderground.com) during the survey. **c** Tide data (http://maree.shom.fr/) and wave heights (*inset*, www.surfline.com) during the survey (*different colours* represent swells with different directions). The *red bands* in **b** and **c** represent the period of the survey. **d**, **e** Different views of the study area from oblique drone photos taken at approximately 0810 h on 17 August 2015; **f** Drone take-off from a small boat

(Casella et al., 2016)

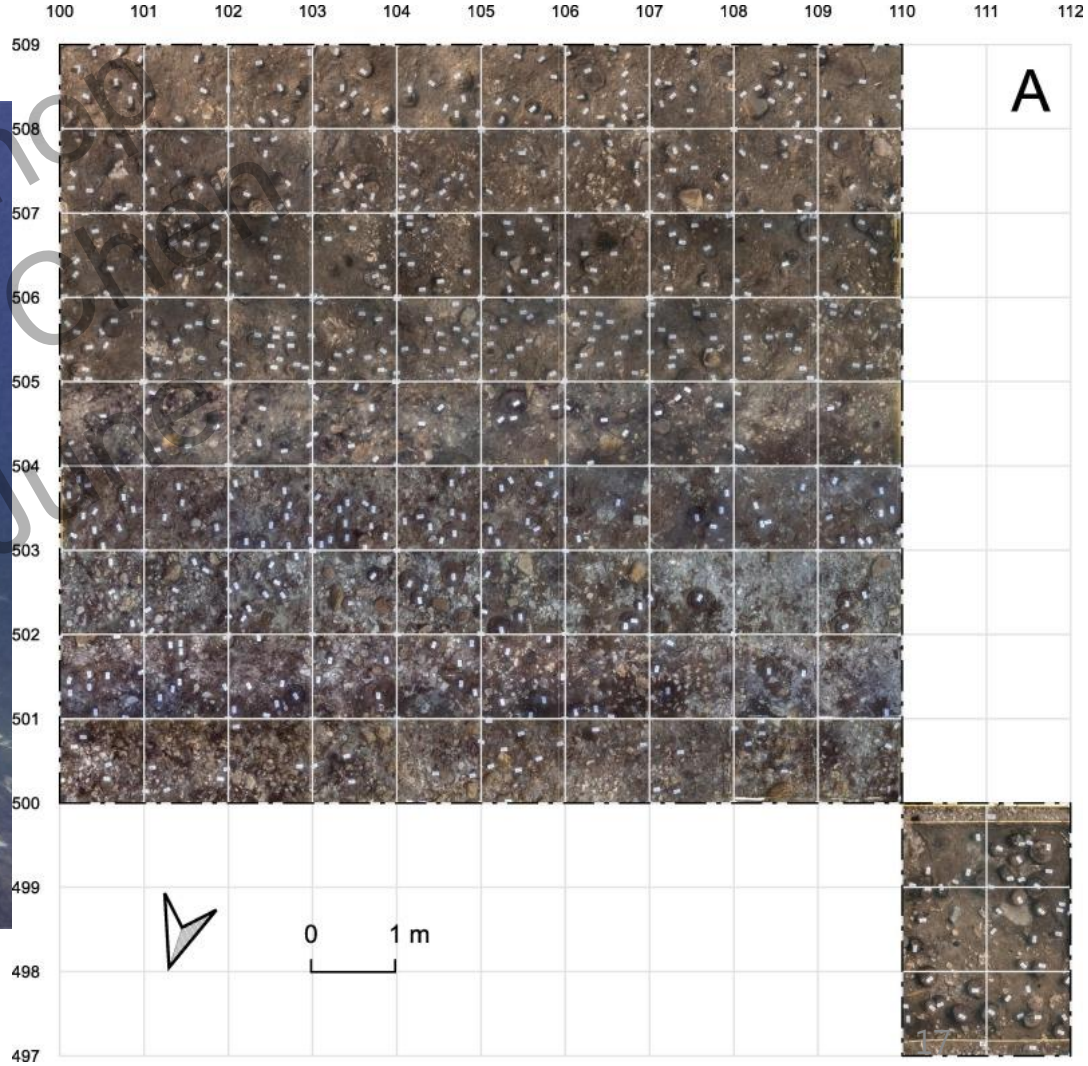
Health assessment of marine mammals



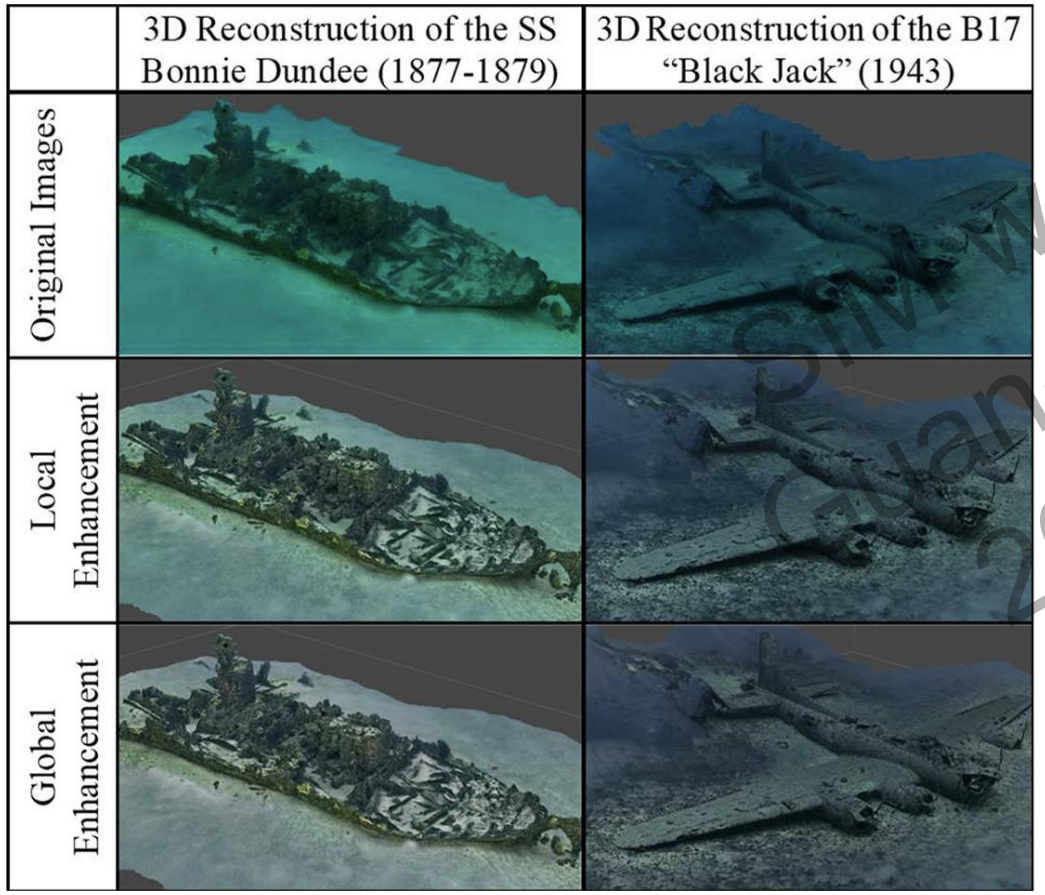
(Hodgsona et al., 2020)

Archaeological-site preservation & AI noise filtering

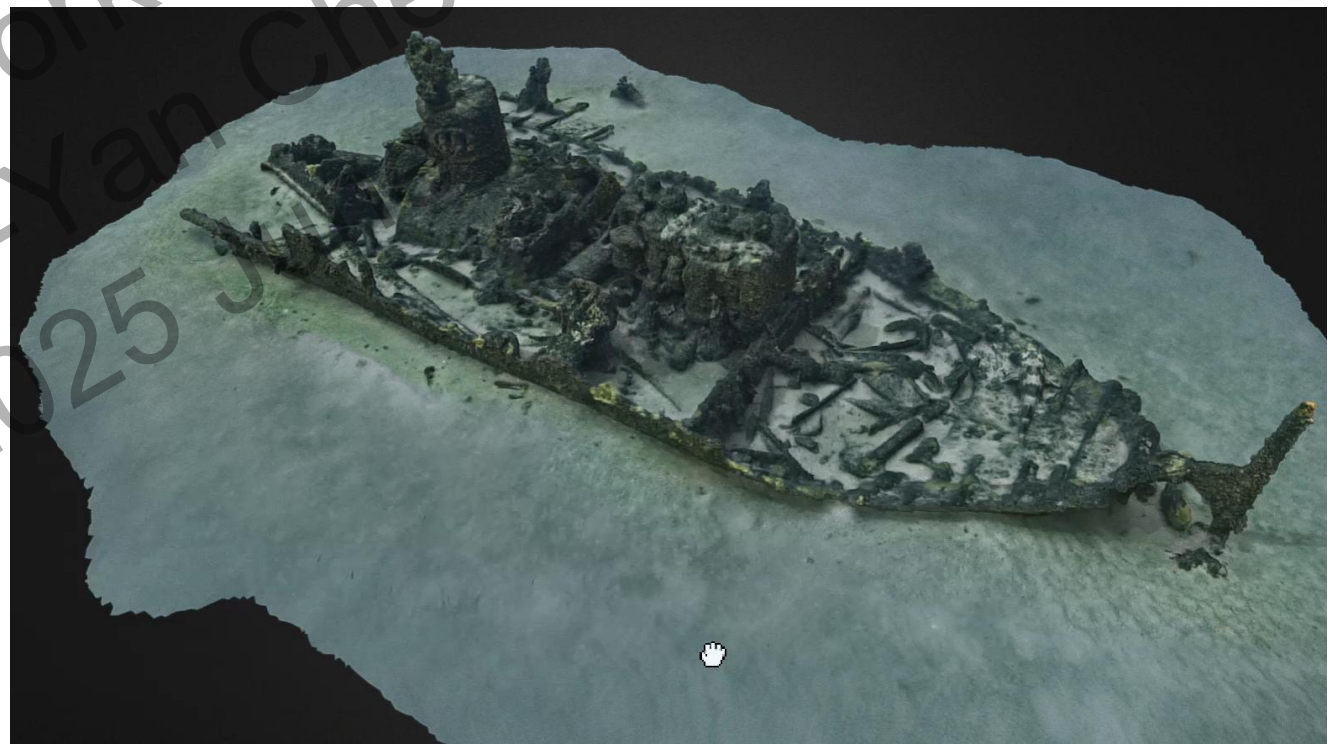
(Reicha et al., 2021)



Shipwreck documentation & online 3D display

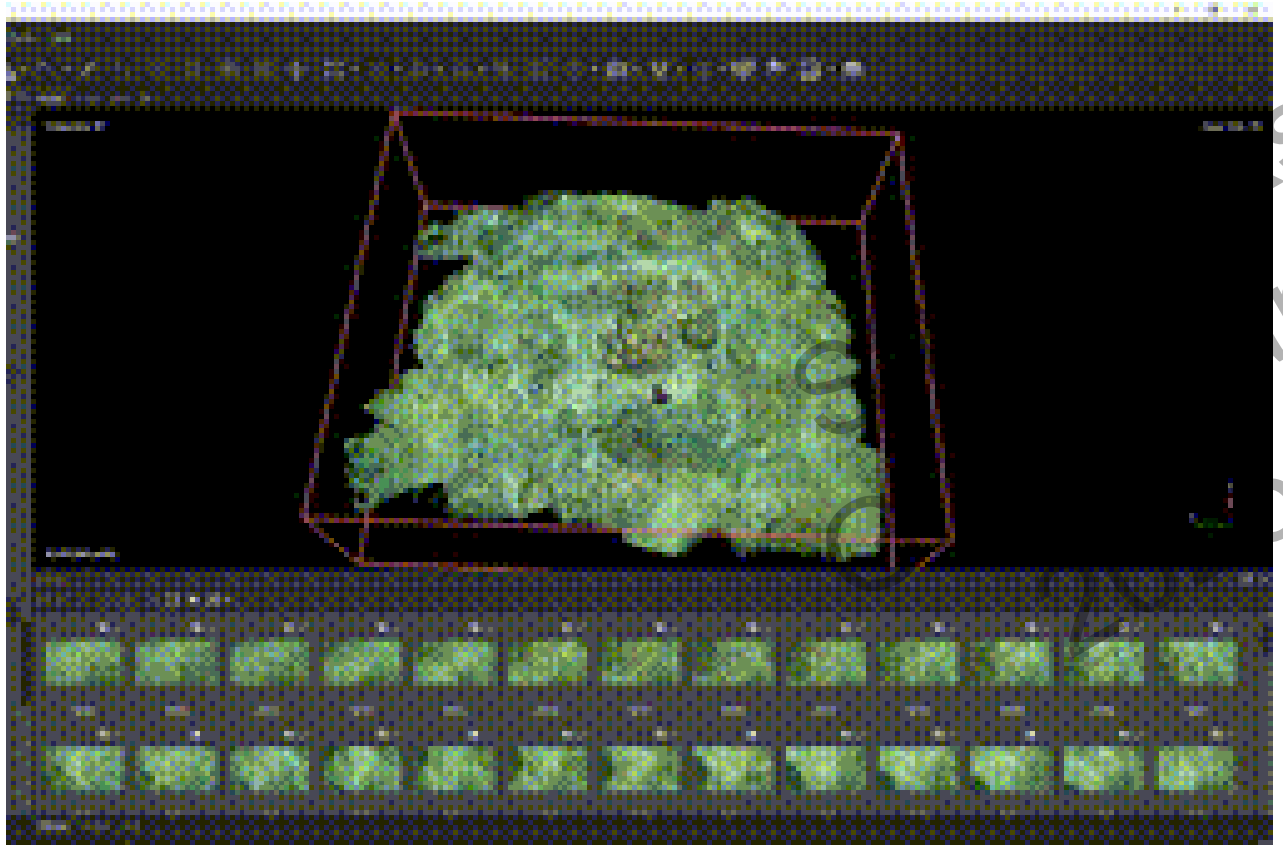


(Adams et al., 2024)



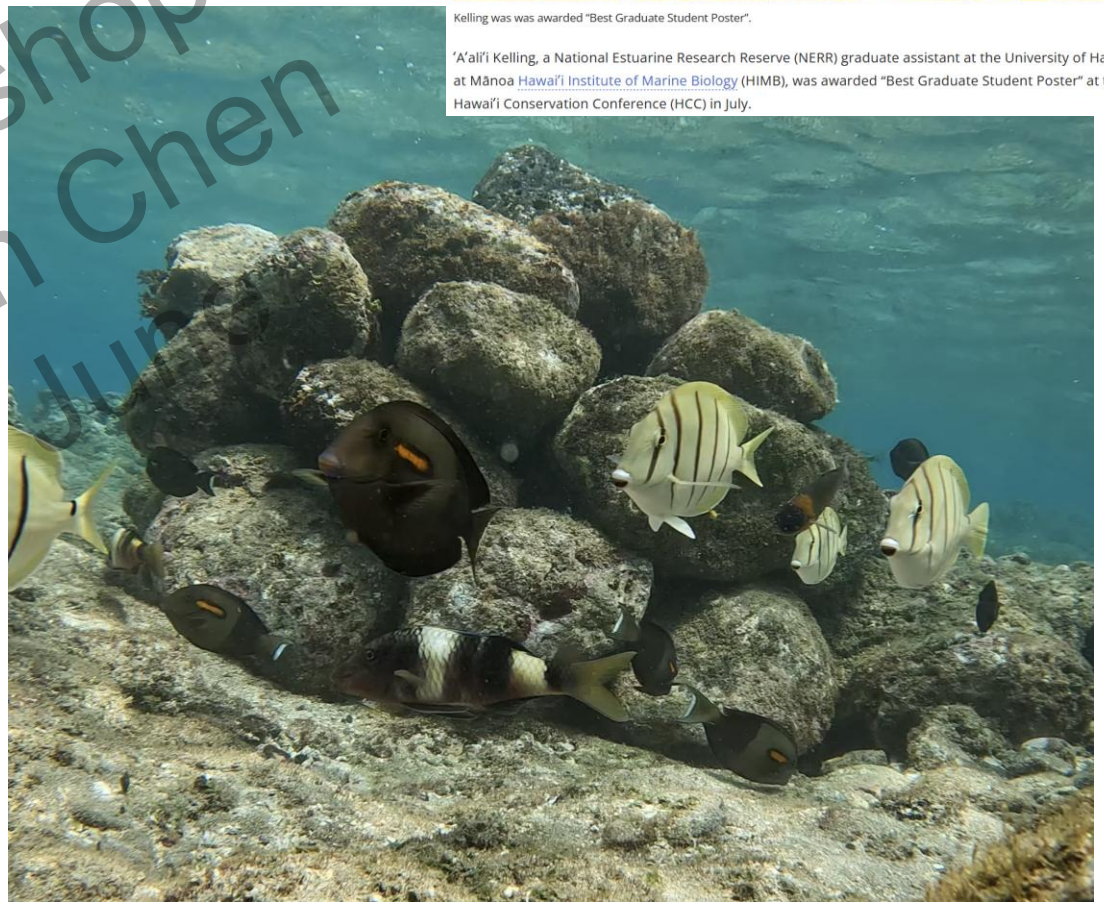
https://skfb.ly/oEWYn

Innovation by merging traditional techniques

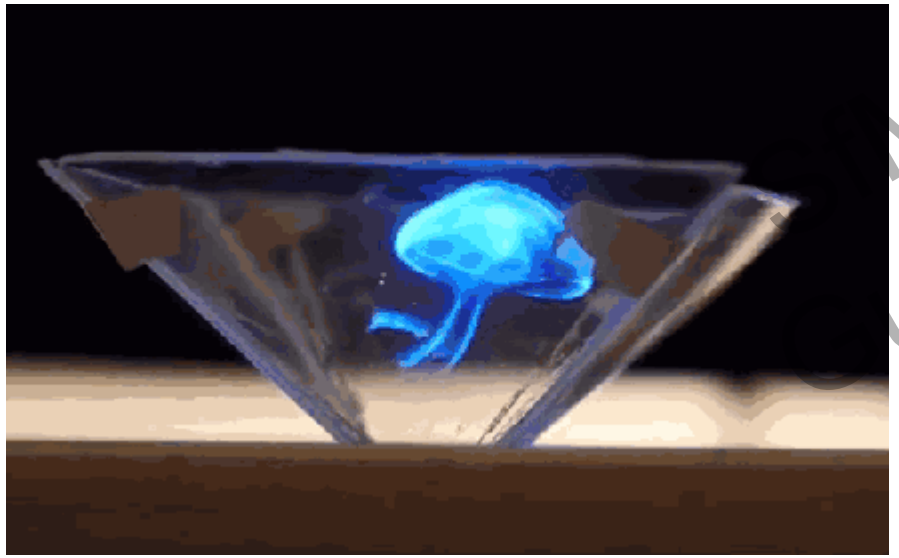


Kelling was was awarded "Best Graduate Student Poster".

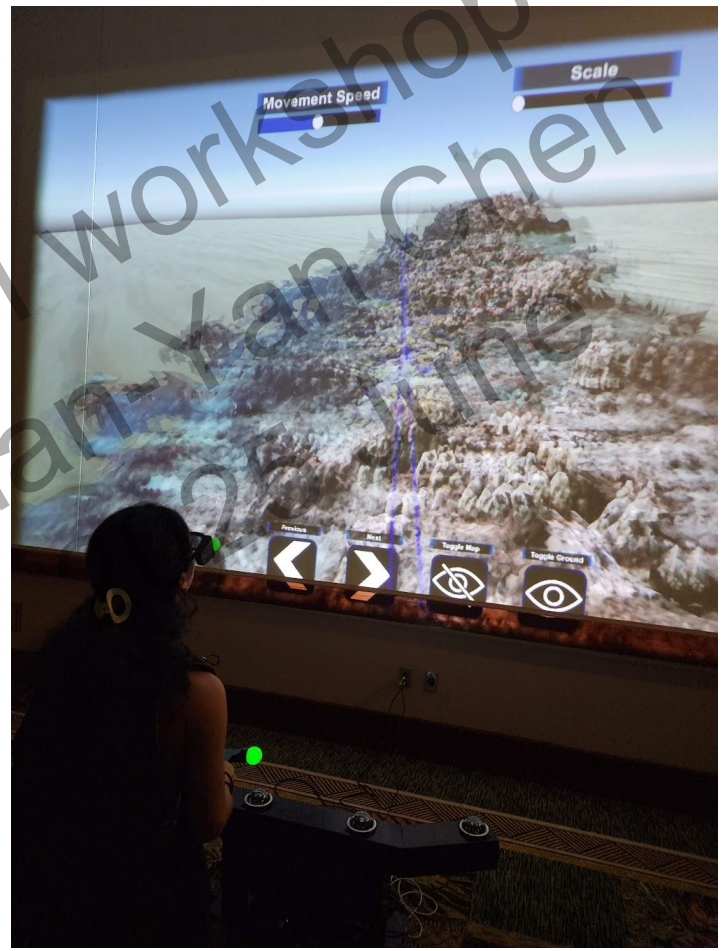
'A'ali'i Kelling, a National Estuarine Research Reserve (NERR) graduate assistant at the University of Hawai'i at Mānoa Hawai'i Institute of Marine Biology (HIMB), was awarded "Best Graduate Student Poster" at the Hawai'i Conservation Conference (HCC) in July.



Diverse ways to show 3D results



3D hologram



VR

AR

App Store Preview

Try this if you are using IPhone

Open the Mac App Store to buy and download apps.

MEGA Lab AR 4+

A Coral Reef in Your Pocket

Alexander Spengler

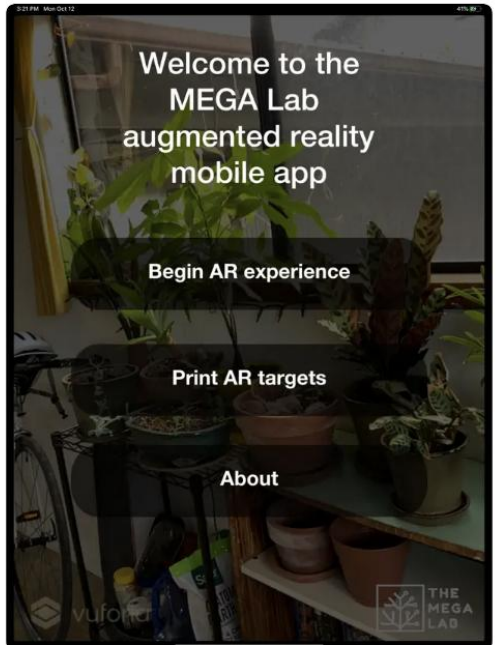
Designed for iPad

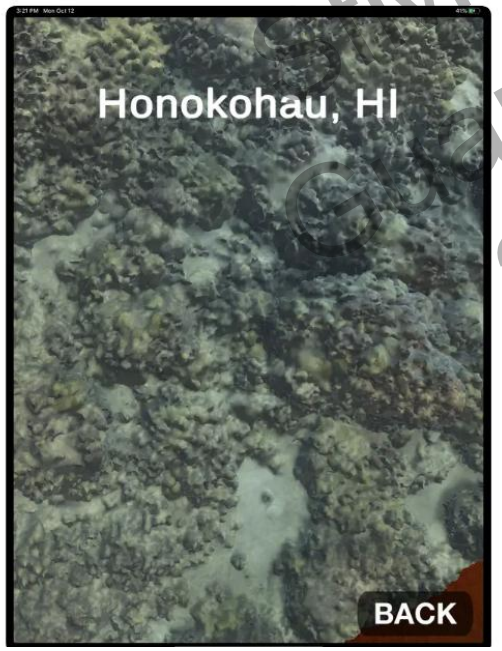
Free

https://apps.apple.com/lc/app/mega-lab-ar/id1526731710

https://isprs-archives.copernicus.org/articles/XLVIII-2-2024/409/2024/

Screenshots iPad iPhone





https://doi.org/10.5194/isprs-archives-XLVIII-2-2024-409-2024

Articles | Volume XLVIII-2-2024

Article Metrics Related articles

11 Jun 2024

MEGA Vision: Integrating Reef Photogrammetry Data into Immersive Mixed Reality Experiences

Alex Spengler, Kailey Pascoe, Cliff Kapono, Haunani Kane, and John Burns

Keywords: coral reefs, photogrammetry, augmented reality, mixed reality, virtual reefs

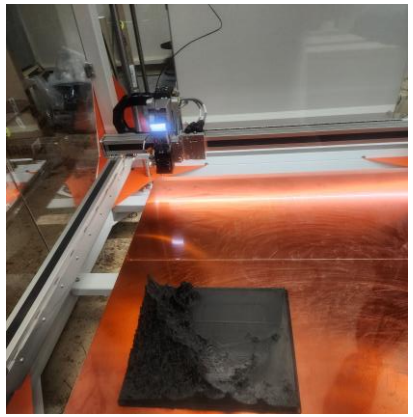
Abstract. Coral reefs and submerged cultural heritage sites are integral to supporting marine biodiversity, preserving human history, providing ecosystem services, and understanding drivers of ecosystem health and function. Despite the importance of these submerged underwater habitats, accessibility to these environments remains limited to specialized professionals. The MEGA Vision mixed reality application integrates photogrammetry-derived data products with augmented reality (AR) technologies to transcend this barrier, offering an immersive and educational platform for the broader public. Using high-resolution imagery from SCUBA expeditions, the app presents users with realistic and spatially accurate 3D reconstructions of coral reefs and submerged archaeological artifacts within an interactive interface developed through Unity and Vuforia. The applications' instructional design includes multimedia elements for enhancing user comprehension of marine and historical sciences. This mixed reality tool exemplifies the convergence of scientific data visualization and public engagement, offering a unique educational tool that demystifies the complexities of marine ecosystems and maritime history, thereby fostering a deeper appreciation and stewardship of underwater environments. By enabling accessible, interactive, and immersive experiences, the application has the potential to revolutionize the way we interact with and contribute to marine sciences, aligning technology with conservation and research efforts to cultivate a more informed and environmentally conscious public.

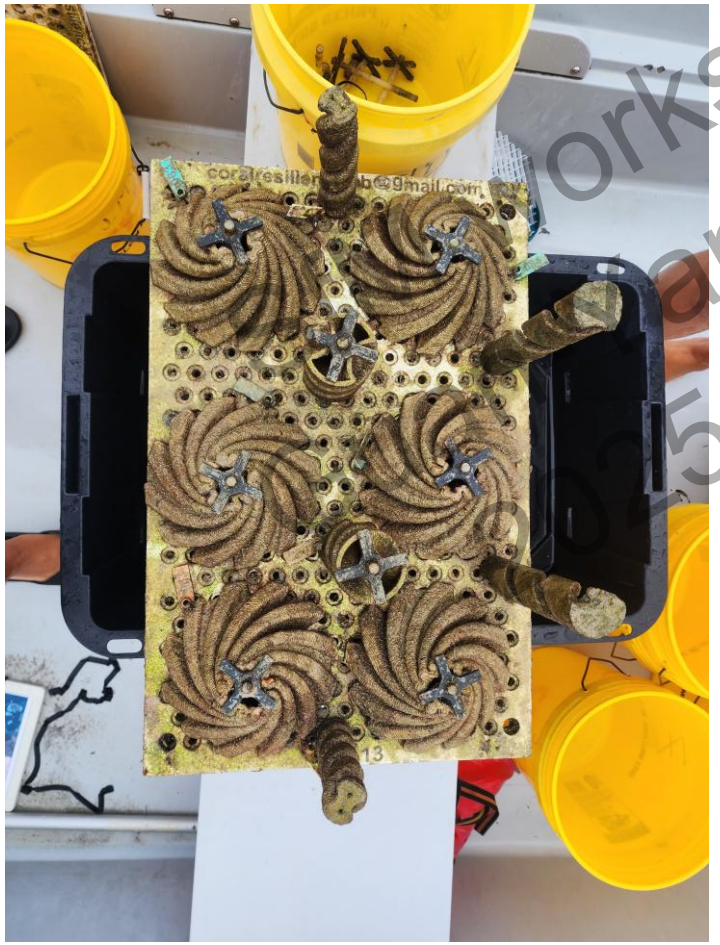
How to cite. Spengler, A., Pascoe, K., Kapono, C., Kane, H., and Burns, J.: MEGA Vision: Integrating Reef Photogrammetry Data into Immersive Mixed Reality Experiences, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-2-2024, 409–414, https://doi.org/10.5194/isprs-archives-XLVIII-2-2024-409-2024, 2024.

(Spengler et al. 2024)

3D works in my lab

Reverse-engineering reef structures + art integration to boost citizen engagement





DARPA

Things old methods couldn’ t do well

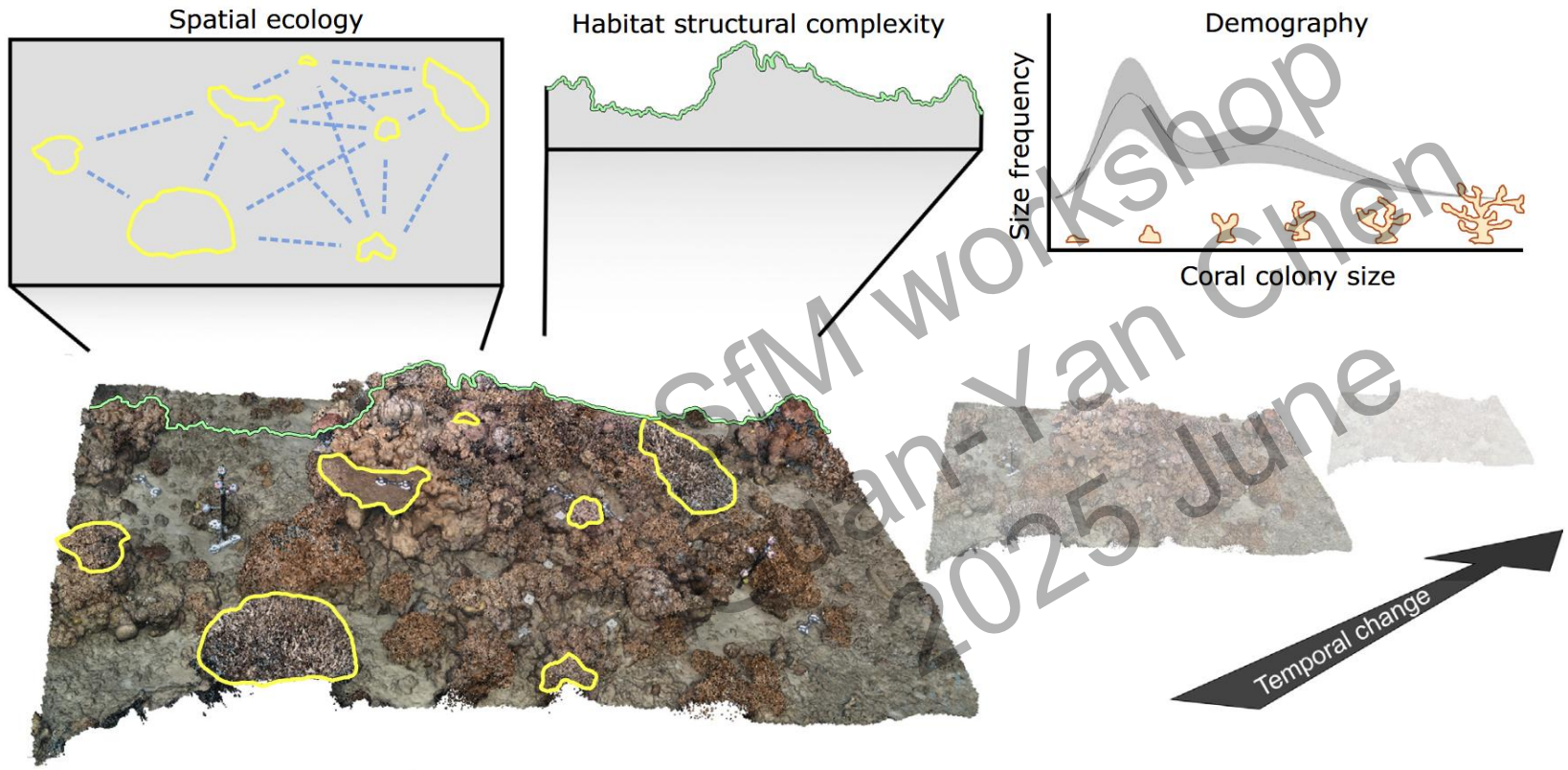


Figure 2. Example 3D model of a reef area through time and some of the key indicators that can be derived to investigate and predict the trajectory of marine ecosystems. 3D models of reef areas facilitate measuring novel metrics that are difficult, expensive, or impossible to quantify otherwise, such as size frequency distribution, demographic rates, spatial context, and 3D structural complexity. 3D models are thus a great tool for innovating metrics and standardizing monitoring in ecosystem restoration.

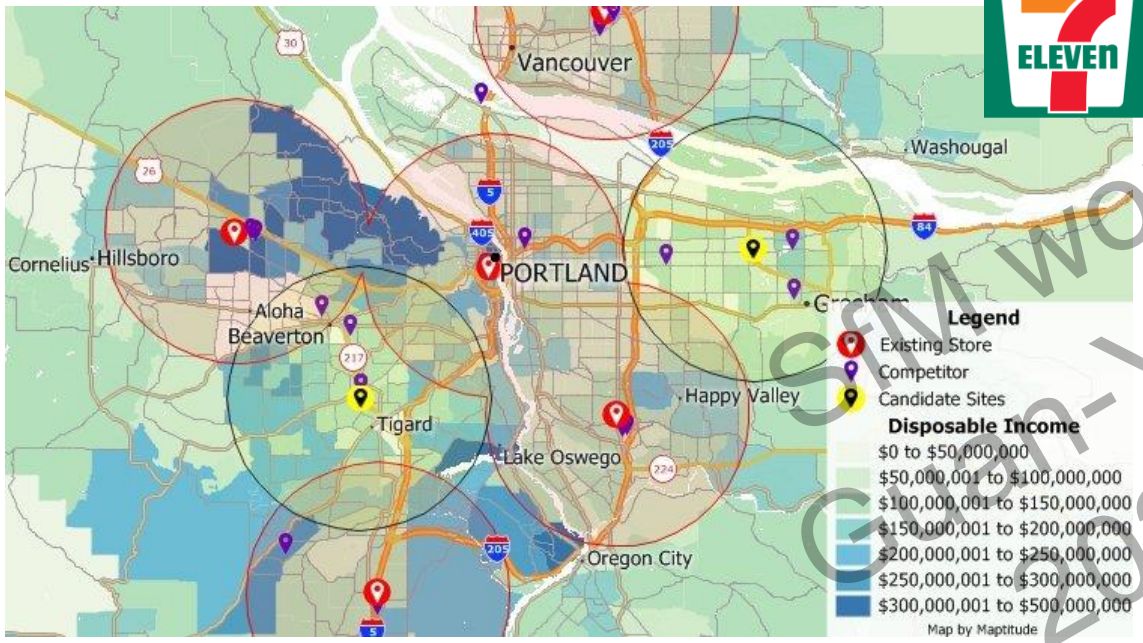
(Ferrari et al., 2021)

- Track historical change
- Analyze population structure
- Quantify structural complexity & morphology
- Uncover effects of spatial determinants

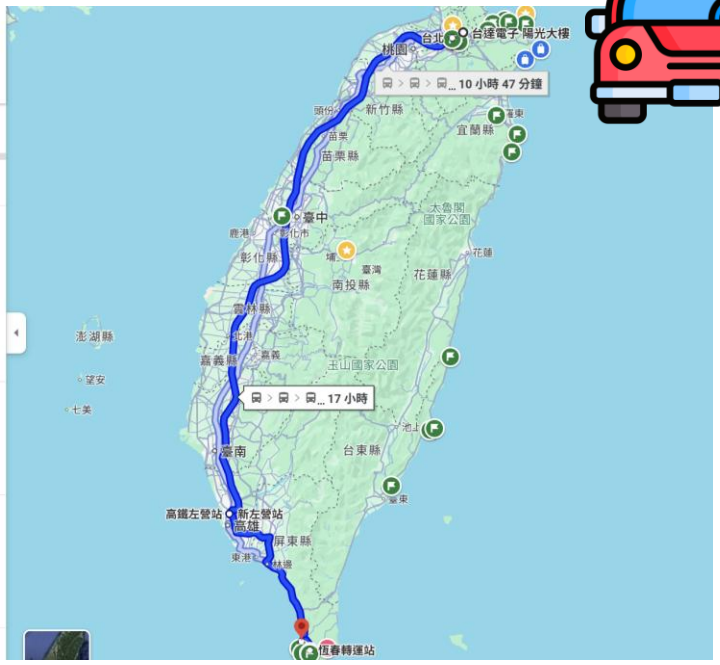
Potential of spatial ecology

treat marine ecosystems
with GIS thinking

Spatial Analysis for Retail Location

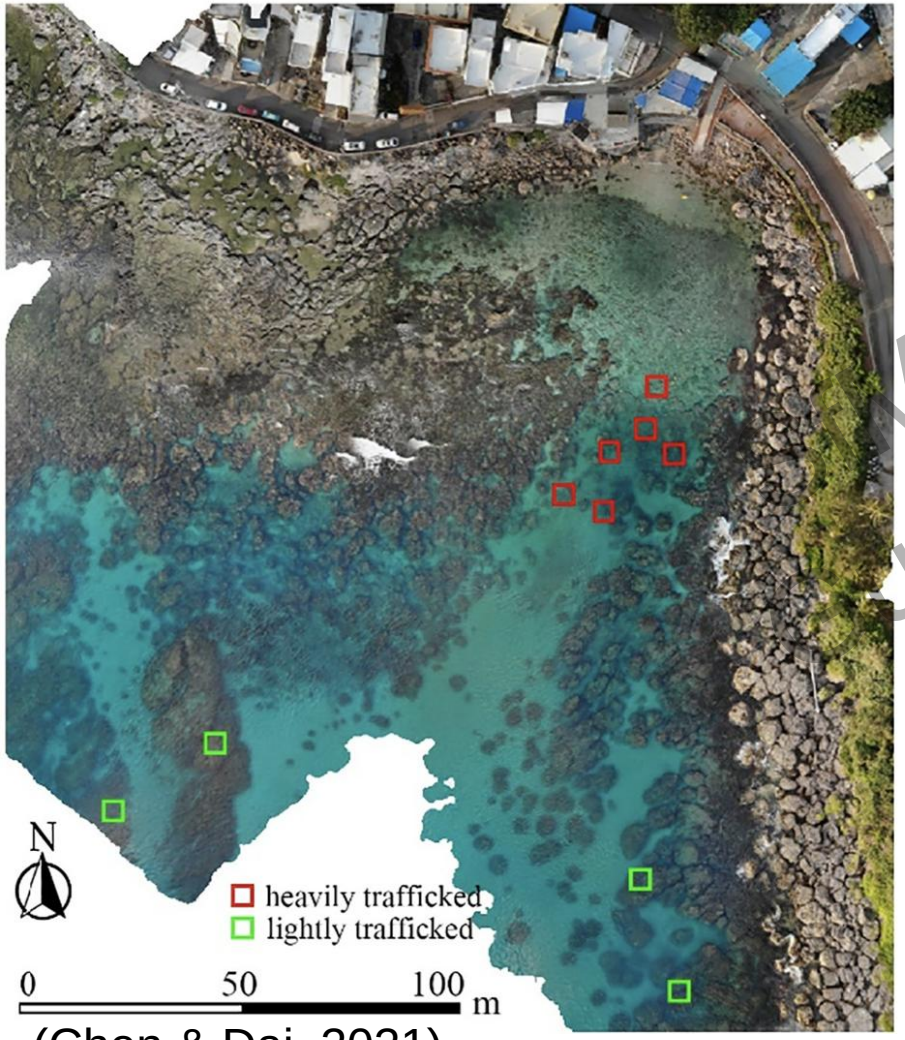


Cost-Efficient Routing



Human impacts on reef 3D structure

(application case from my MSc thesis)



(Chen & Dai, 2021)

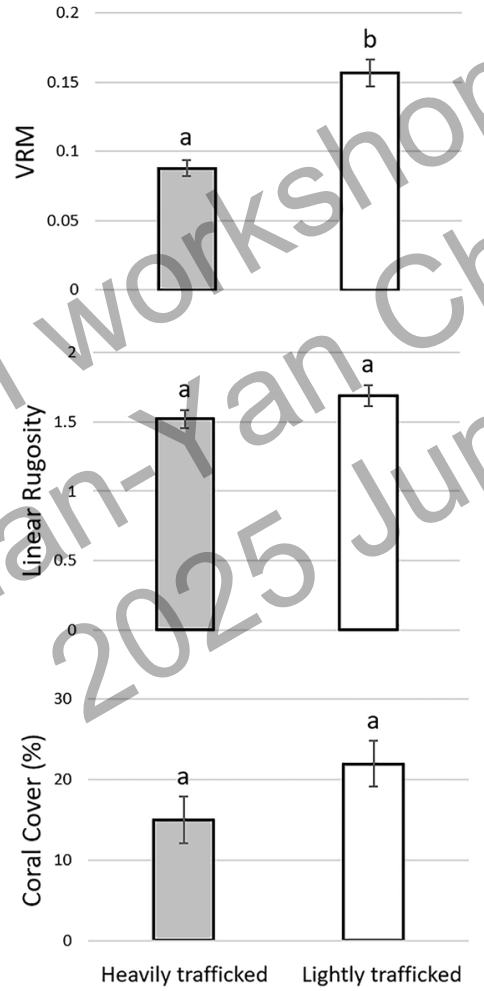
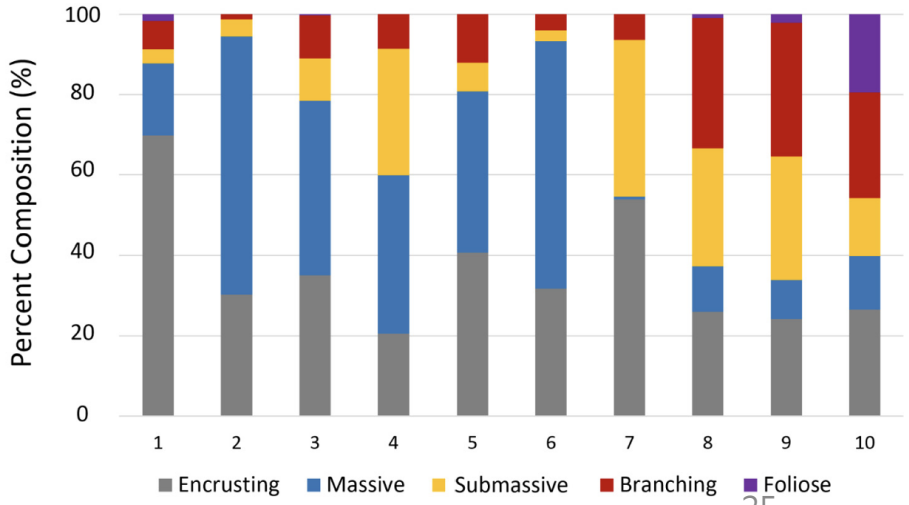


Fig. 3. Mean structural complexity metrics and coral cover (± SE) of heavily trafficked (grey, $N = 6$) and lightly trafficked (white, $N = 4$) sites.



Relative Contributions of Size and Shape to Coral Demography

(application case from my PhD dissertation CH.1)

Guanyan Keelung Chen, Lisa C. McManus, Tung-Yung Fan, and Joshua S. Madin

https://doi.org/10.1086/735482

Abstract

It has been 40 years since T. P. Hughes put forward the idea that the size of modular corals is a better predictor of demographic fates than age. However, colonies of similar size may exhibit different shapes, and shape holds great ecological and evolutionary significance. This study used orthomosaics of coral reefs to track changes in 796 *Pocillopora acuta* colonies in Kenting National Park, Taiwan, over 2 years. We quantified relationships between coral demographic fates and three morphological traits: planar area (size), circularity (shape), and perimeter-to-area ratio, which integrates size and shape. Together, area and circularity consistently explained the most variation for all modular processes except shrinkage, which was explained best by area alone. Including circularity with area significantly improved the capacity to predict survival and fission, with large and circular colonies surviving better and with large and irregular colonies more prone to fission. Circularity also improved predictions of proportional area change, with smaller circular colonies experiencing higher rates of change. Fusion was unrelated to any single morphological trait, presumably because it relies on proximity in space. Perimeter-to-area ratio is the best single trait for survival prediction. Our results highlight that size and shape should both be considered for the demographic modeling of modular organisms.

尺寸與形狀對珊瑚族群動態的相對貢獻

自 Hughes 提出模組化生物珊瑚，其尺寸比年齡更能預測族群動態已過 40 年。然而，相似尺寸的珊瑚群體可能呈現不同形狀，而形狀在生態與演化上具有重要意義。本研究利用墾丁國家公園的珊瑚礁正射影像，追蹤 796 個 *Pocillopora acuta* 群體兩年間的變化，並量化珊瑚族群動態與三種形態特徵之關係：尺寸、圓度（形狀）以及周長/面積比（整合尺寸與形狀）。同時考慮尺寸與圓度對所有模組化過程都有最高解釋力，除了衰減僅由尺寸為最佳解釋。多考慮圓度，顯著提升對存活與分裂的預測能力，大且圓的群體存活率較高，而大且不規則的群體更易分裂。圓度亦能改善對面積變化的預測，小且圓的群體傾向於較高的變化率。融合與任何單一形態特徵無關，可能因其依賴空間上的鄰近性。周長/面積比是預測存活的最佳單一特徵。本研究結果顯示，預測模組化生物的族群動態，應同時考慮尺寸與形狀。

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Ahead of Print

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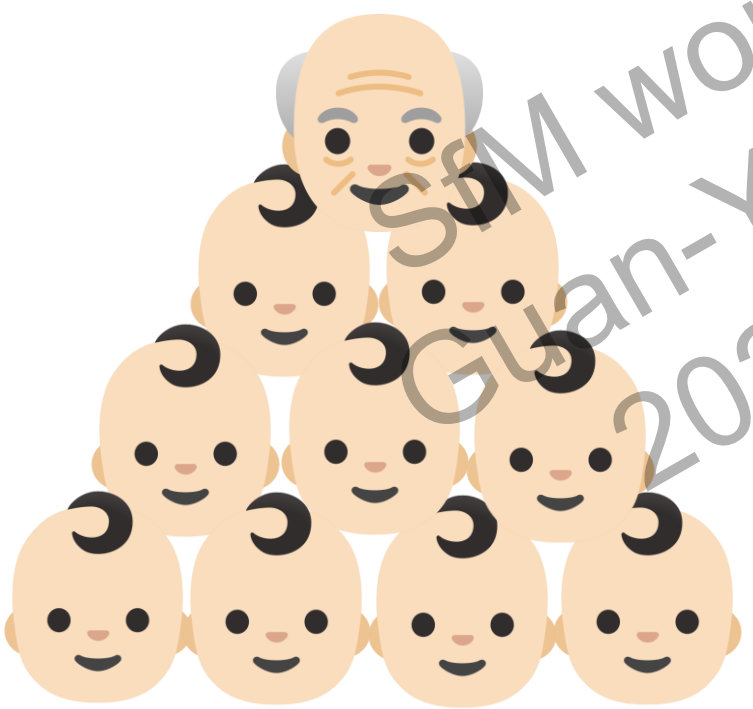
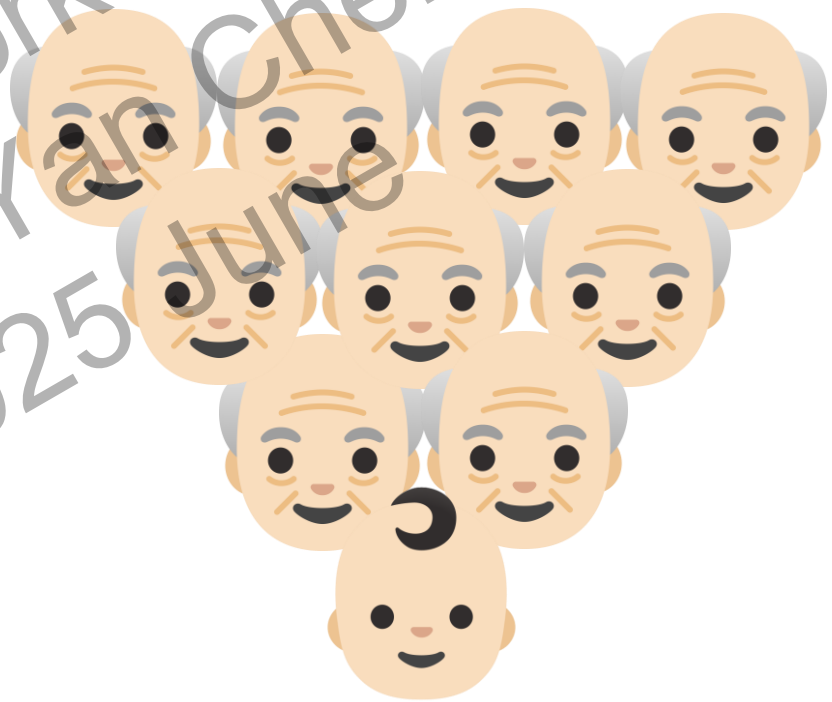
History
Submitted April 30, 2024

The importance of demography

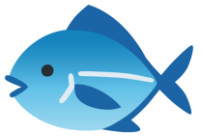
- The **population status** can be understood via the **age structure**
  This analytical logic is suitable for most common animals



Rapid growth



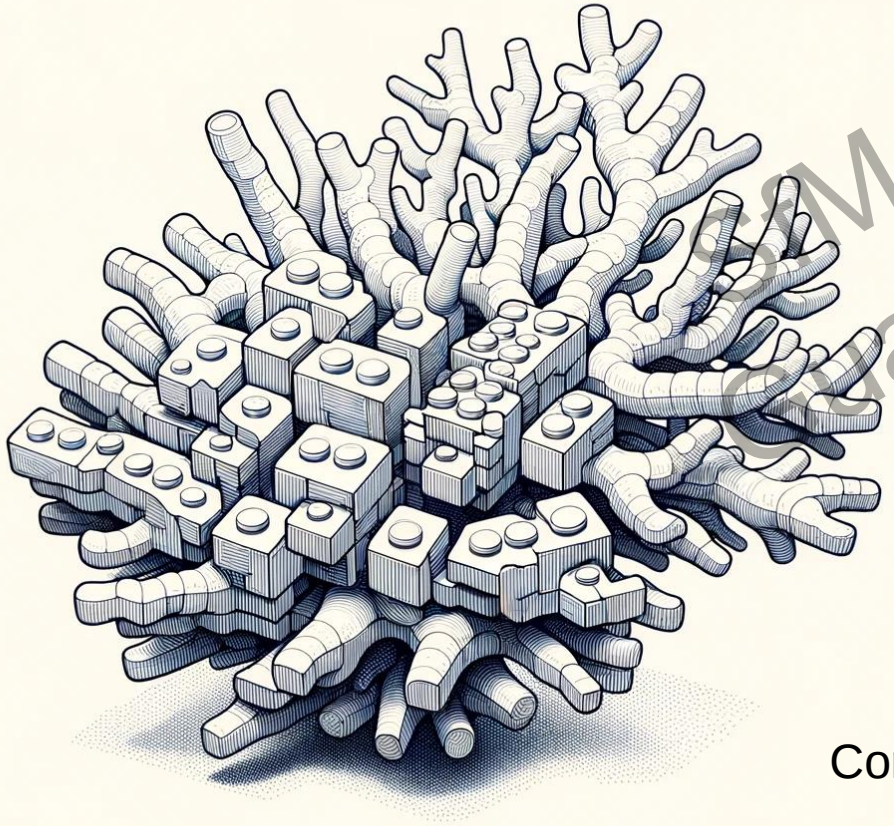
Declining



The uniqueness of modular organism

- Corals can be freely disassembled or assembled

Unsuitable for age-based model analysis

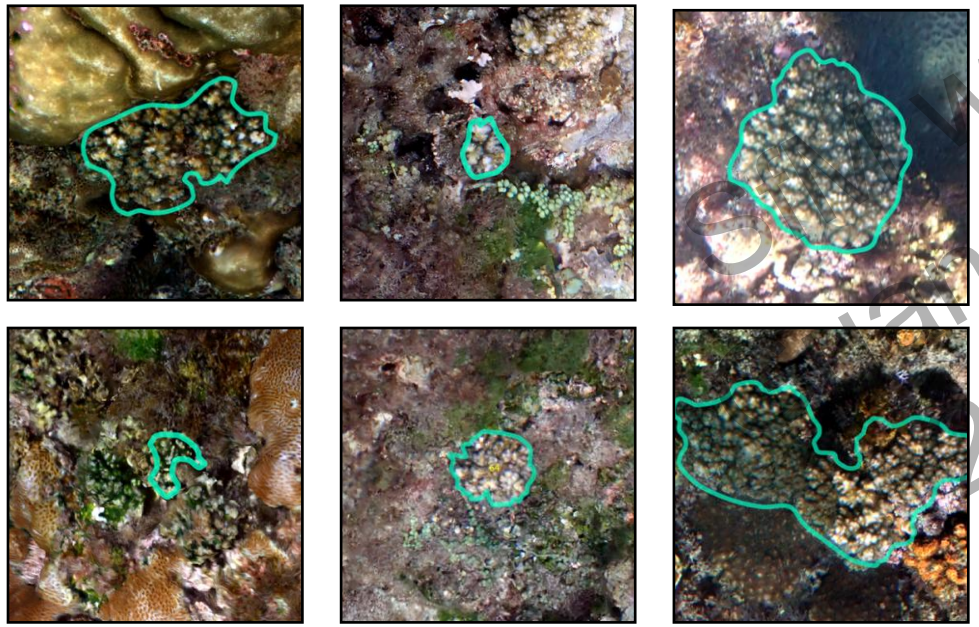


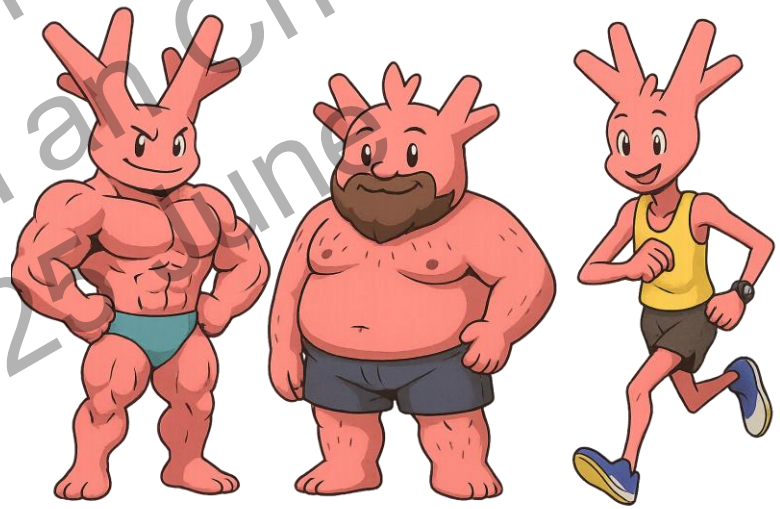
Corals lie about their age, and **size** is a much better predictor !

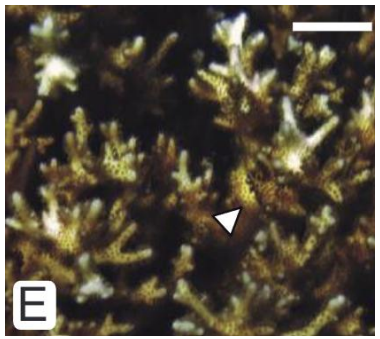
(Hughes & Jackson, 1980)

Morphological diversity of a coral

- **The same size can have different shape,** coral shows high morphological **plasticity intraspecies**
  Shape reflect how a colony interact with environment





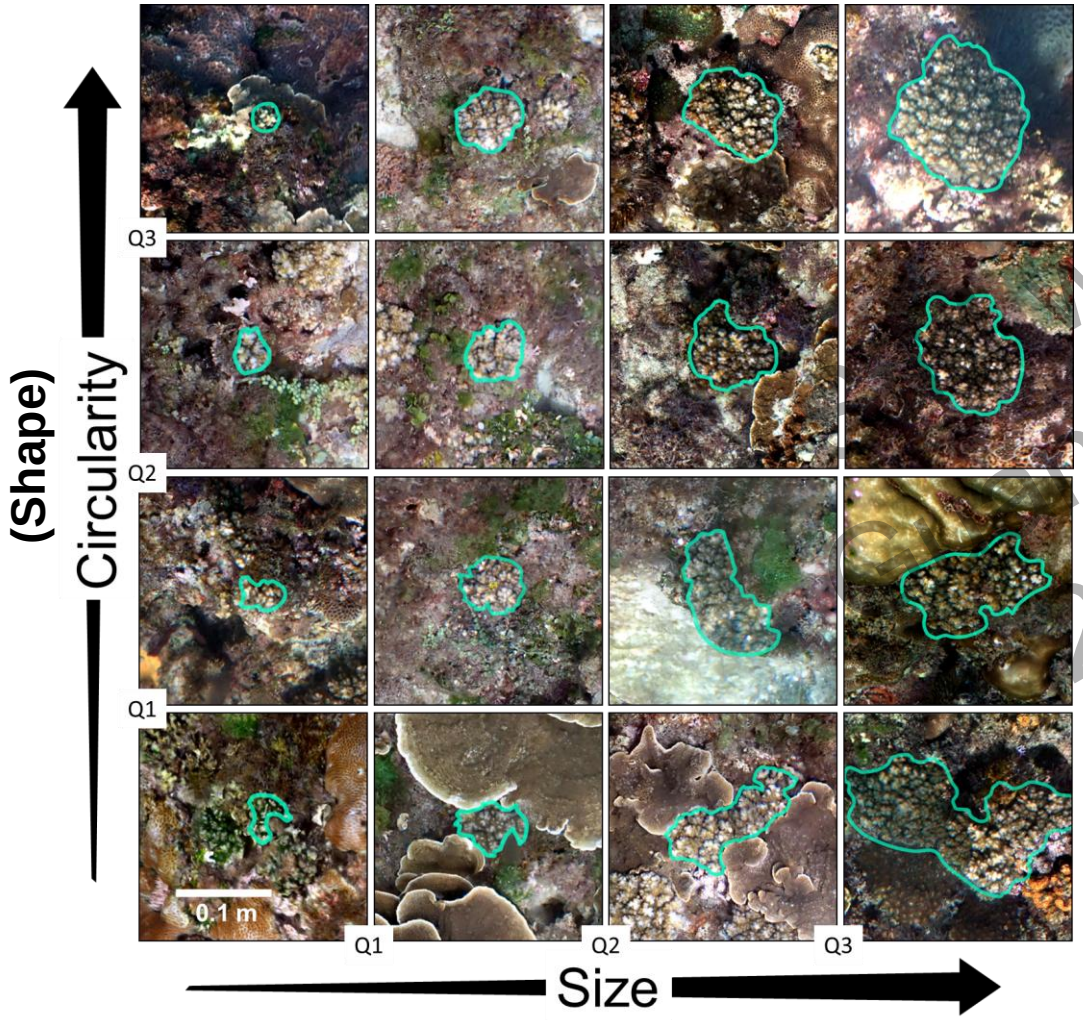


(Paz-García et al., 2015)

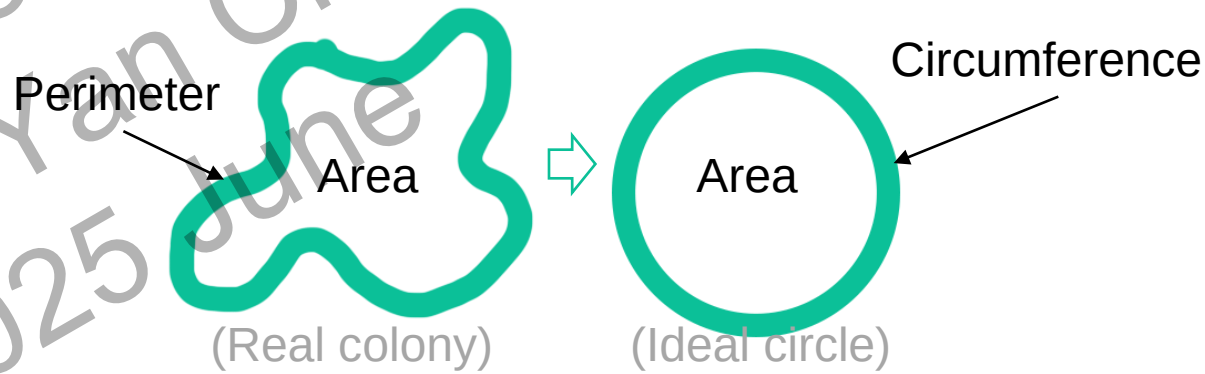
Morphology that adapted to their environment can achieve higher fitness
(Million et al., 2022; Todd, 2008)

(but this effect has seldom been quantified)

Quantifying 2D morphological traits



1. Size = Area
2. P/A ratio = Perimeter / Area
3. Circularity = Circumference / Perimeter

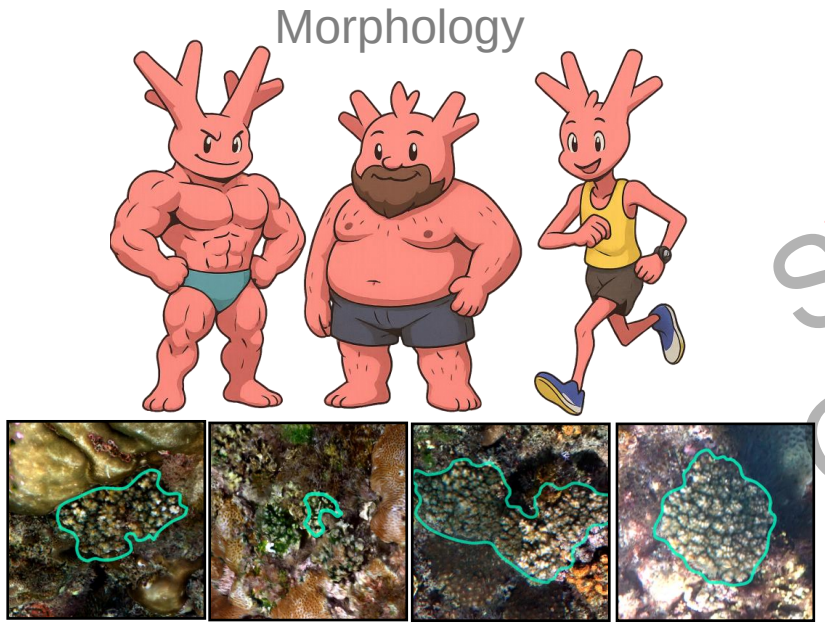


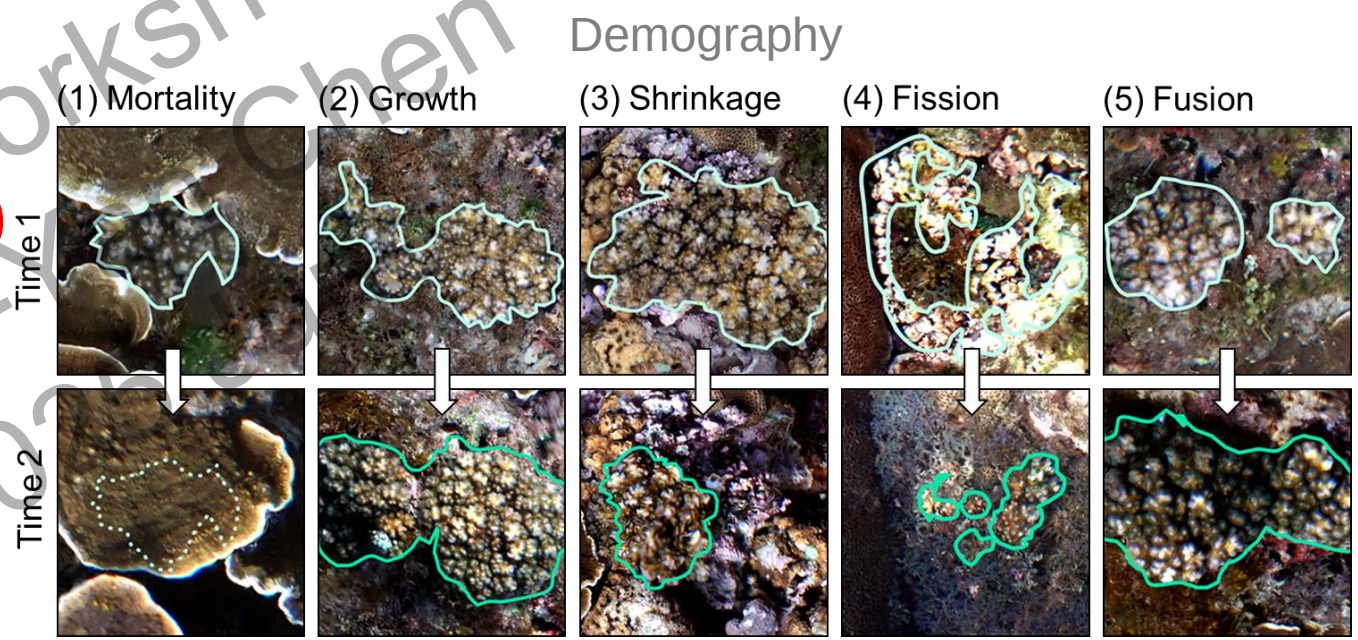
- **Size** and **circularity** are independent ($R^2 = 0.09$)
- **P/A ratio** considers both size and shape

How can we utilize these quantified traits?

Research question

- What are the contributions of shape and size to demography?





1. Size = Area
2. P/A ratio = Perimeter / Area
3. Circularity = Circumference / Perimeter

Fi: reducing the risk of genotype extinction… (Highsmith, 1982)

Fu: accelerate colony growth… (Forsman et al., 2015)

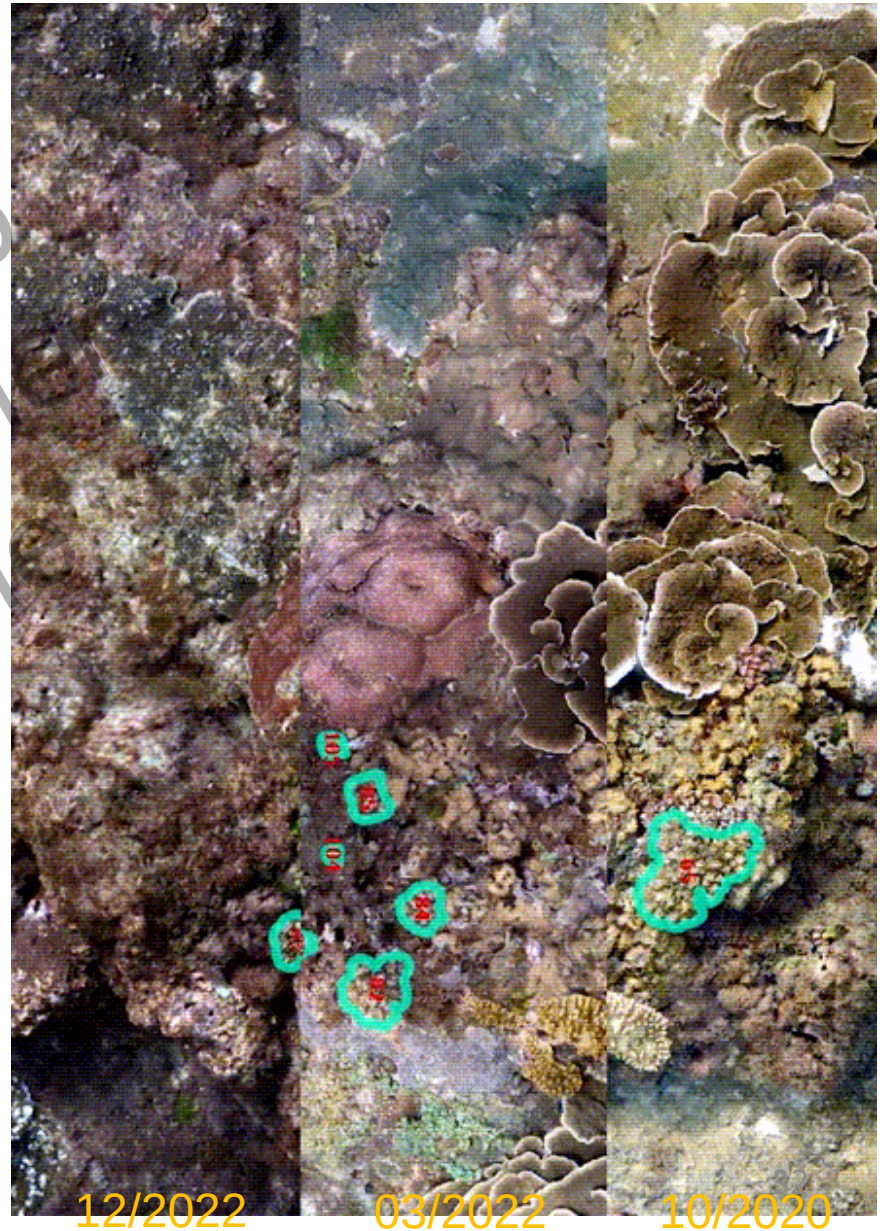
(6) Growth rate = $Area_{t+1}$ / $Area_t$

Data collection

Three surveys were conducted yearly over a **2-year period** (Oct 2020 to Dec 2022)

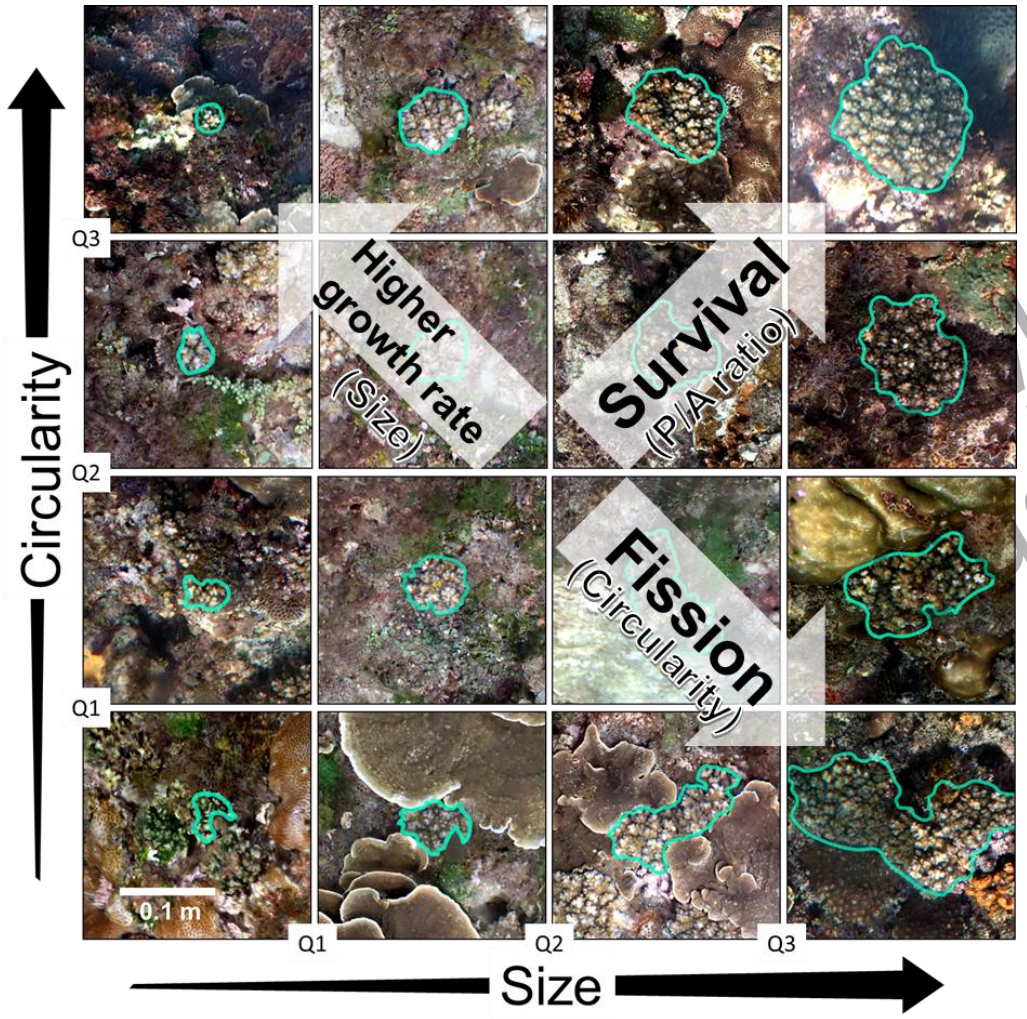
Agisoft Metashape

ArcGIS Pro

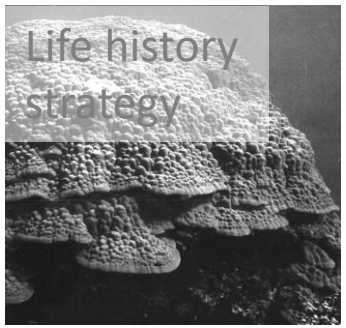


Results

- Both size and shape need to be considered simultaneously.
- Appropriate metrics should be selected based on the interest.



Adverse events



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Relative Contributions of Size and Shape to Coral Demography

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Online enhancements: supplemental PDF.

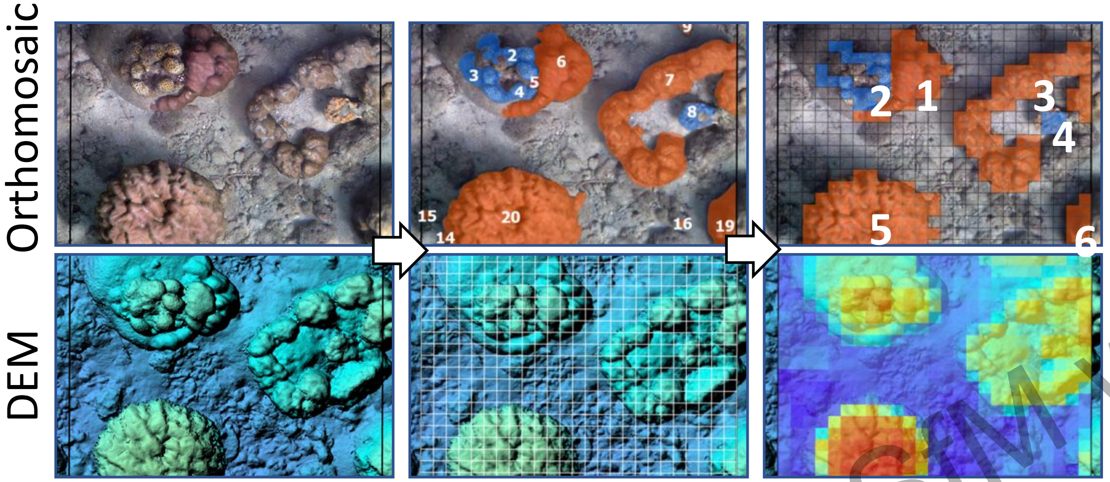
(Chen et al. 2025)

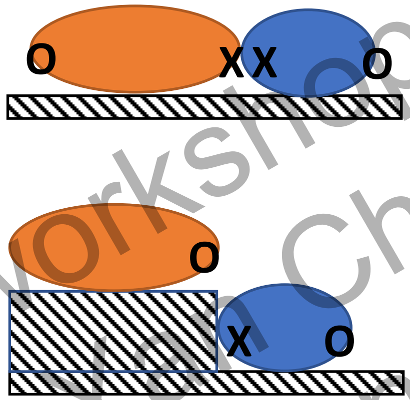
Scan for more details

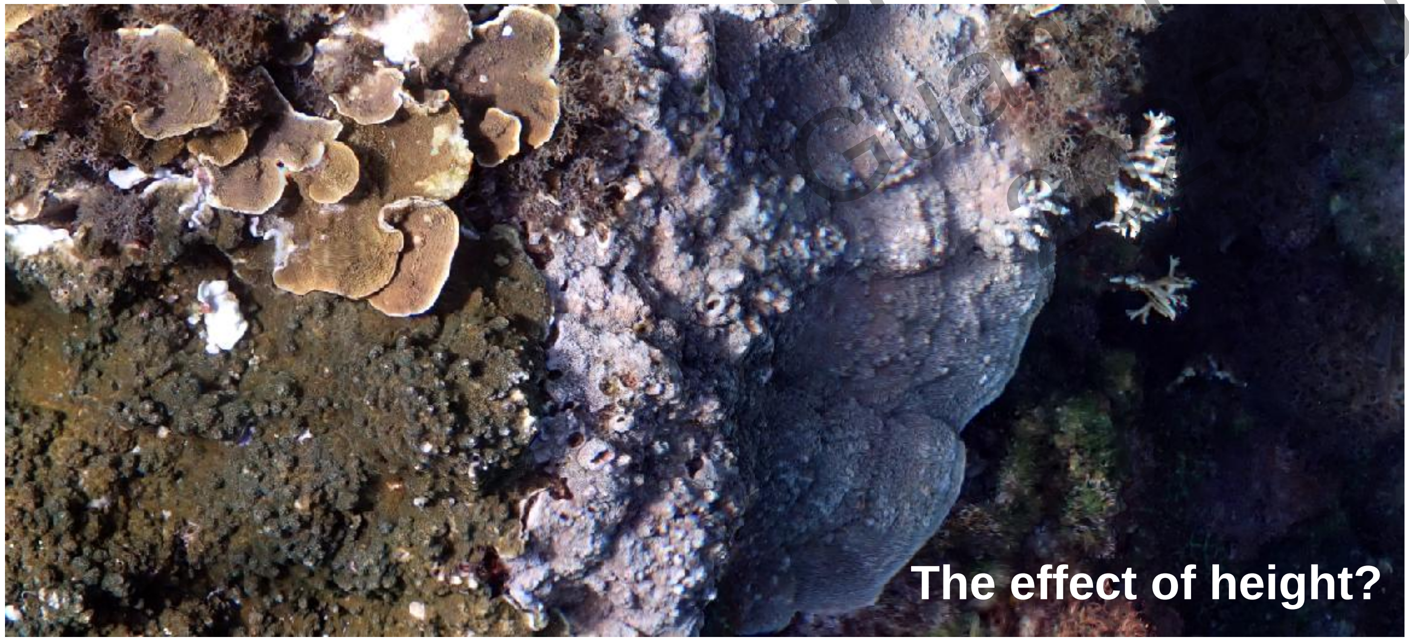
Table 1: Model selection statistics for morphological trait effects on fates

Model	Estimate	df	AIC	R^2
Survival ~ size	1.004***	524	550.3	.04
Survival ~ P/A ratio	−2.547***	524	539.7	.06
Survival ~ circularity	.303*	524	567.4	.01
Survival ~ size + circularity	**1.301*** .549***	**523**	**534.6**	**.07 (+.03)**
Survival ~ size + circularity + size × circularity	1.134* .838 .113	522	536.4	.07
Growth ~ size	−1.368***	402	512.8	.07
Growth ~ P/A ratio	2.175***	402	526.8	.04
Growth ~ circularity	.554***	402	527.8	.04
Growth ~ size + circularity	**−1.164*** .383****	**401**	**506.1**	**.08 (+.01)**
Growth ~ size + circularity + size × circularity	−.775 −.215 −.255	400	507.5	.08
Shrinkage ~ size	**2.204***	**402**	**365.0**	**.12**
Shrinkage ~ P/A ratio	−4.266***	402	370.2	.11
Shrinkage ~ circularity	−.350*	402	408.4	.01
Shrinkage ~ size + circularity	2.182*** −.030	401	367.0	.12 (+.00)
Shrinkage ~ size + circularity + size × circularity	2.190** −.041 −.005	400	369.0	.12
Fission ~ size	2.856***	402	148.3	.13
Fission ~ P/A ratio	−2.459*	402	163.9	.03
Fission ~ circularity	−1.634***	402	141.7	.17
Fission ~ size + circularity	**2.125**** **−1.391*****	**401**	**133.6**	**.23 (+.10)**
Fission ~ size + circularity + size × circularity	1.016 .543 1.474	400	134.1	.24
Fusion ~ size	−.521	402	336.6	.01
Fusion ~ P/A ratio	1.187*	402	336.0	.01
Fusion ~ circularity	−.087	402	339.7	.00
Fusion ~ size + circularity	−.624* −.193	401	337.1	.01 (+.00)
Fusion ~ size + circularity + size × circularity	**−2.807*** 3.236**** **1.392****	**400**	**328.0**	**.05**

My forthcoming research objectives





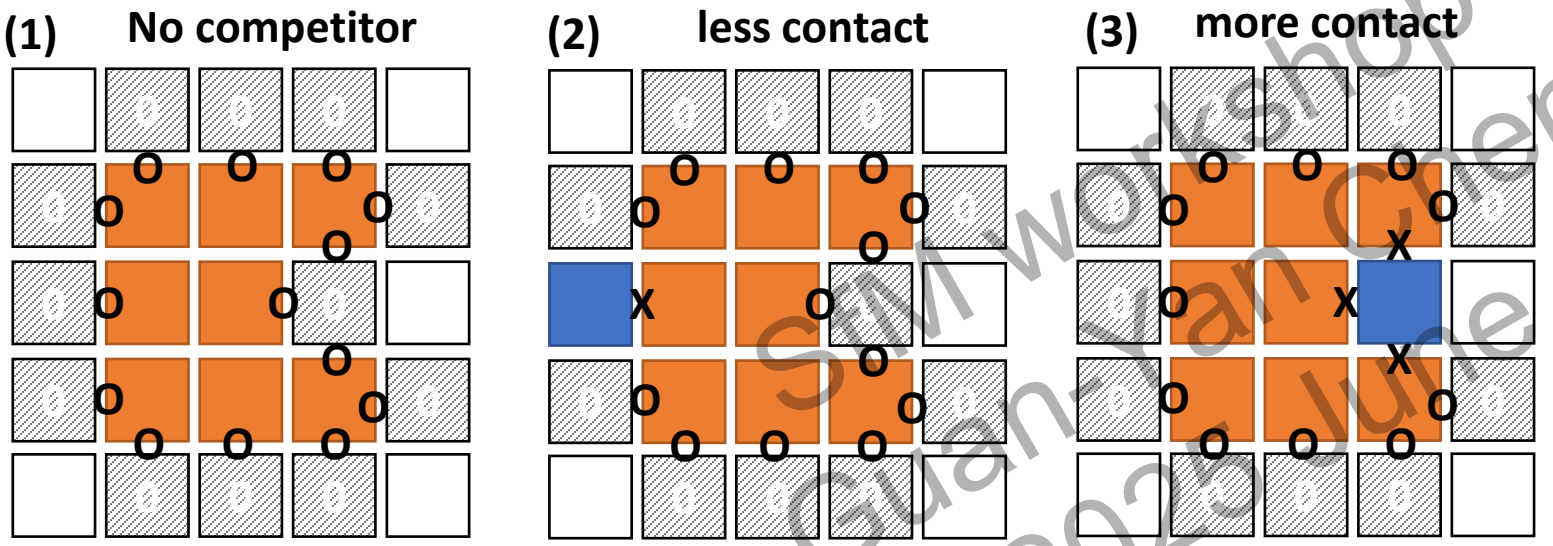


Take Z axis into account

Analysis in the XY plane (2D)

C/P ratio = (Competitor contact length) / (Colony perimeter)

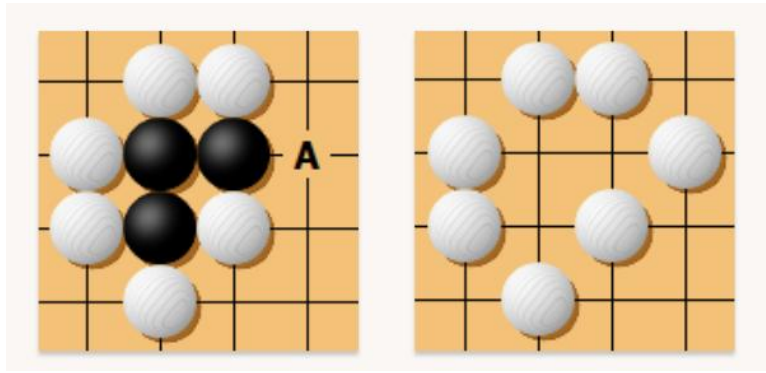
How a colony is constrained by competitors in the horizontal dimension.

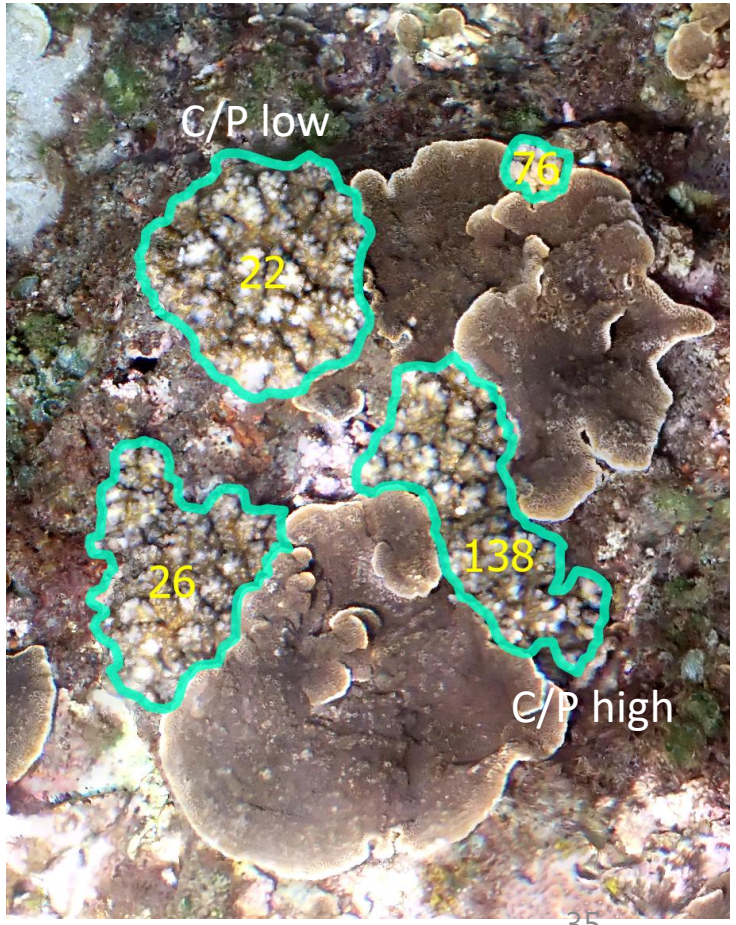


Contact type:
O = no competitor
X = with competitor

(Adjacent) Non-coral
Coral A
Coral B

Scenario	Coral ID	Colony perimeter	Competitor contact length	C/P ratio
(1)	A	14	0	**0**
(2)	A	14	1	**0.07**
(3)	A	14	3	**0.21**





Analysis in the XYZ plane (3D)

F/P ratio = (Free length) / (Colony perimeter)

The percentage of the colony's perimeter that is higher than adjacent cells.

C/P ratio = 0

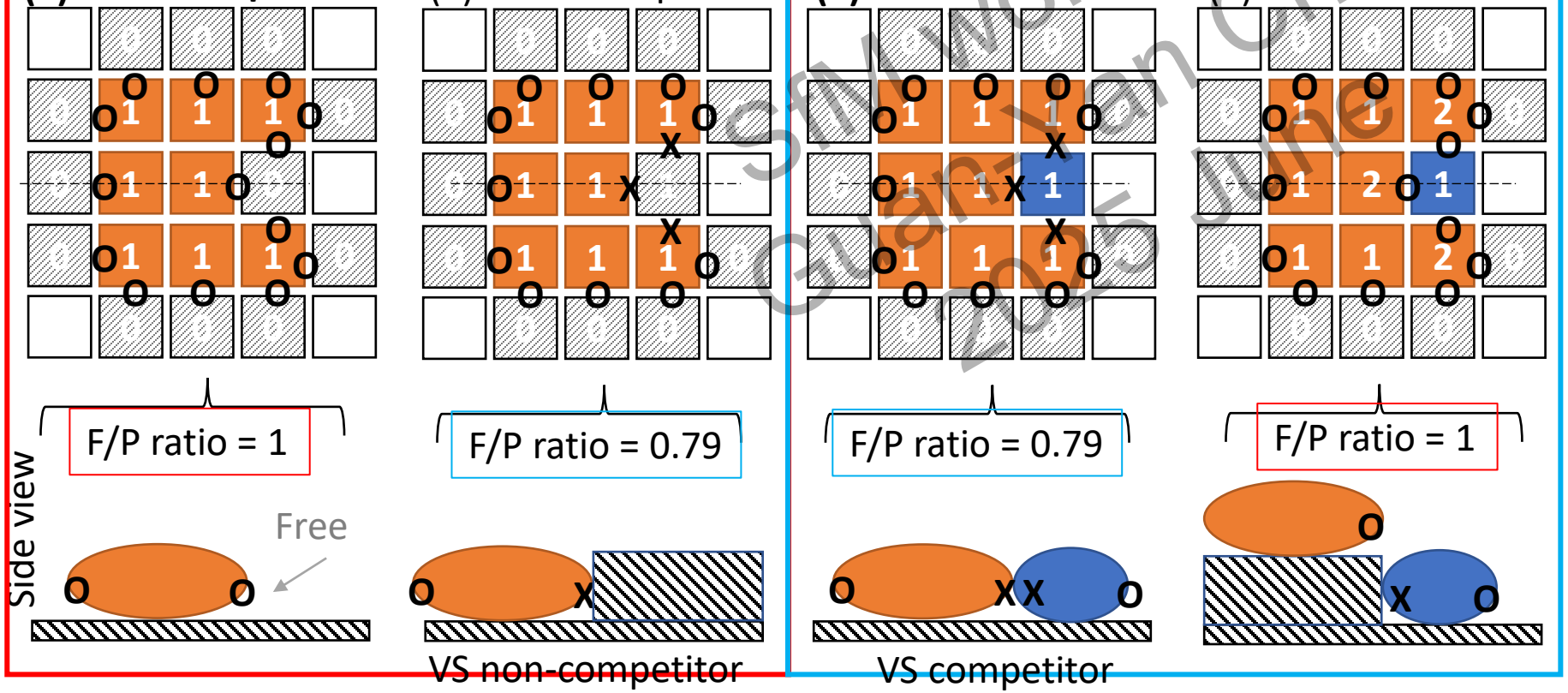
C/P ratio = 0.21

Hight A > Terrain
(1) No competitor

Hight A ≤ Terrain
(2) No competitor

Hight A ≤ Hight B
(3) more contact

Hight A > Hight B
(4) more contact



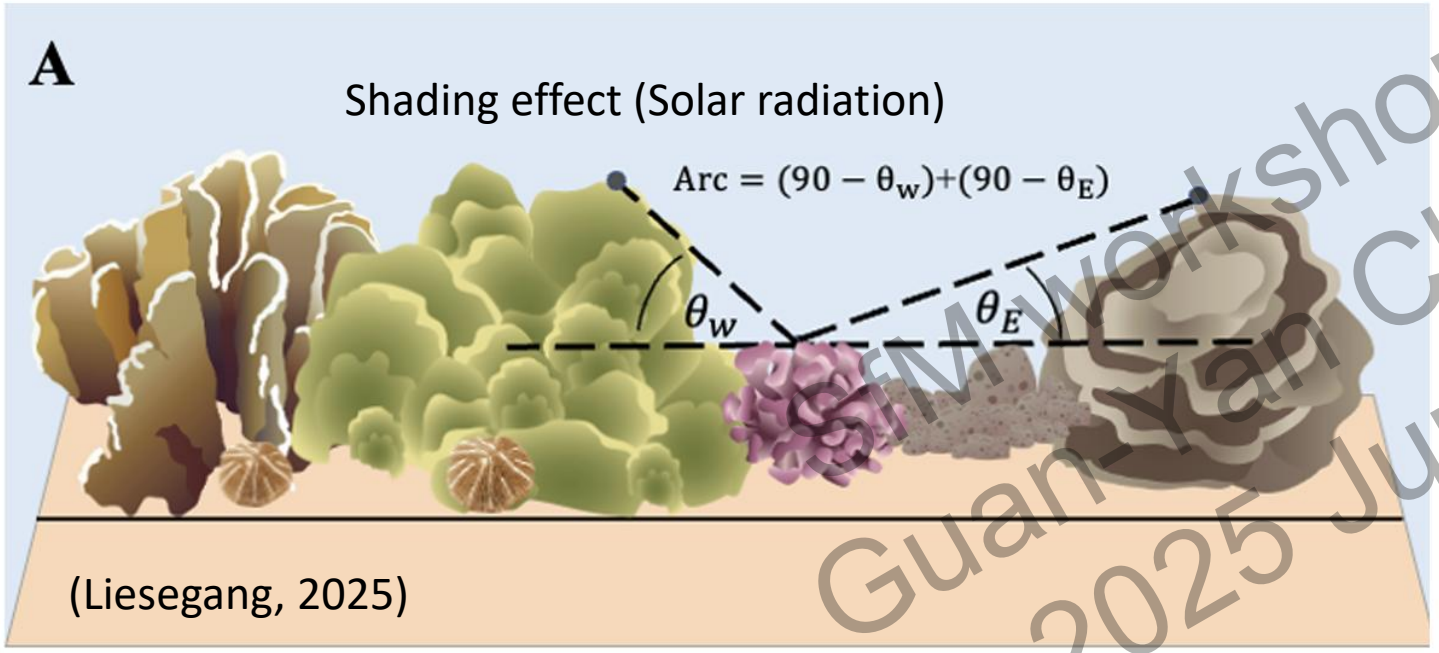
	Mean Height difference	Free length	F/P ratio
(1)	1	14	**1**
(2)	0.92	11	**0.79**
(3)	0.92	11	**0.79**
(4)	1.29	14	**1**

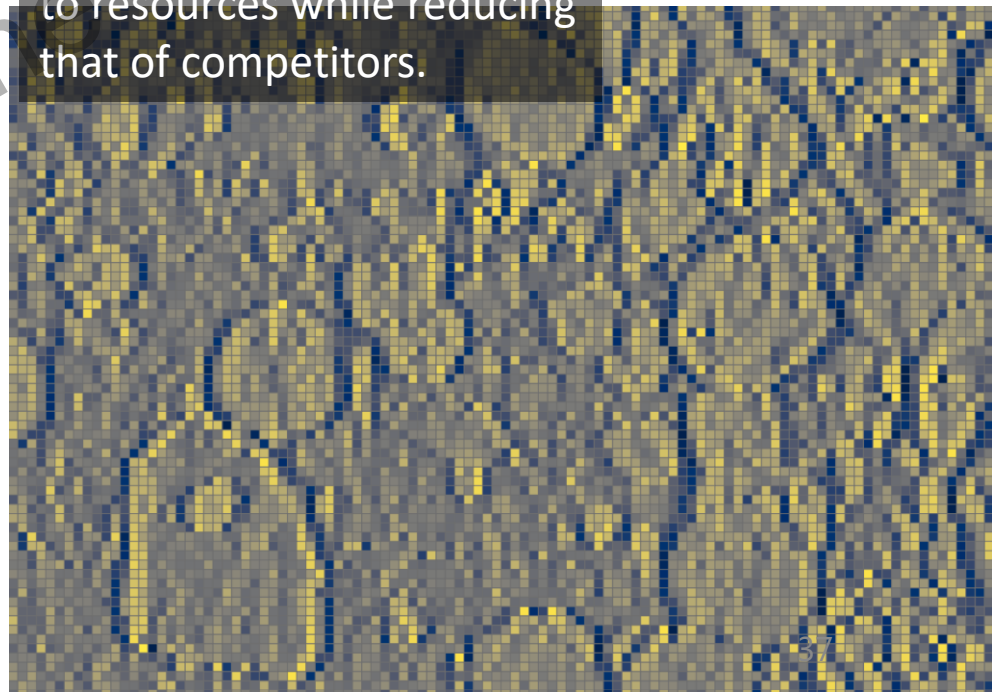
Contact type:
O = Free (higher, ≥ 5cm)
X = Block (no higher, < 5cm)

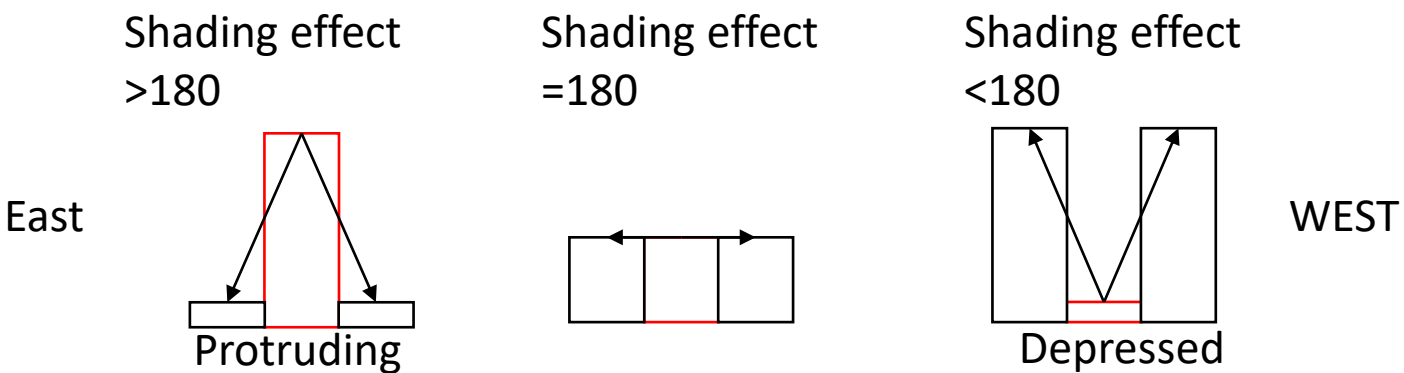
Ch.2: Effects of spatial determinants on coral demography and morphology

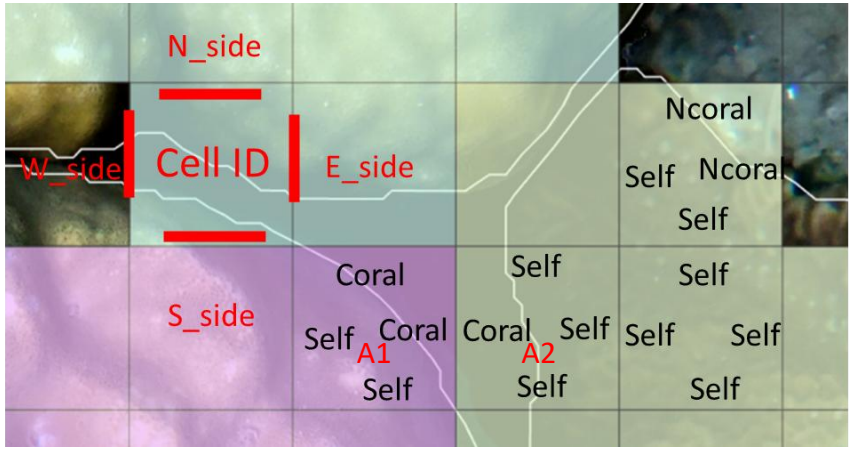
Why greater height may confer an advantage?

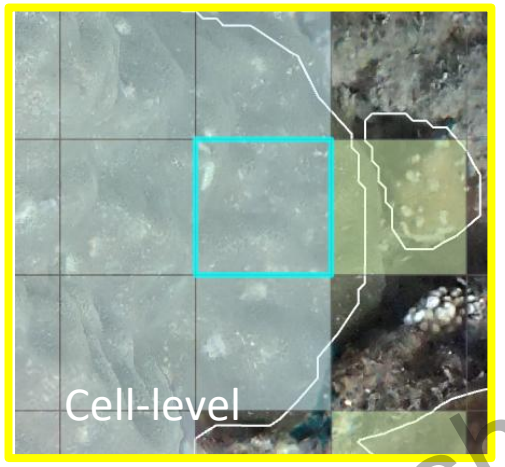
- Height alters the mode of competition (López-Victoria et al. 2006)
- Increased access to light







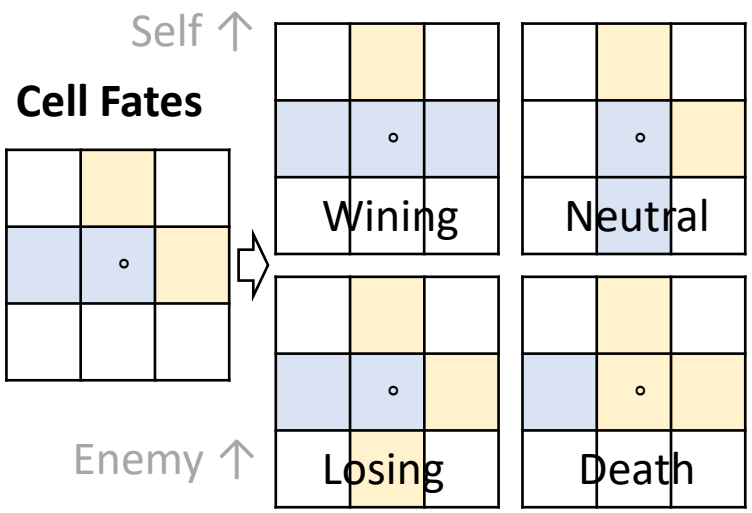




	Colony growth	Colony Shrinkage
Cell win	Real winner 😈	Defender 😢
Cell lose	Expender 😳	Real loser 😭

Zonal statistic

Cell ID	Colony ID	Length	Area	Z_mean	N_side	S_side	W_side	E_side	Shadeing effect	Form	Cell Fates
A1	1	0.2	0.0025	-1.2582	Coral	Self	Self	Coral	159.2834	Massive	
A2	2	0.2	0.0025	-1.4096	Self	Self	Coral	Self	167.7355	Encrust	
A3	2	0.2	0.0025	-1.4005							



Colony-level statistics (GLM)

Growth rate ~ Size + Circularity+ C/P ratio + F/P ratio + Shading + Forms

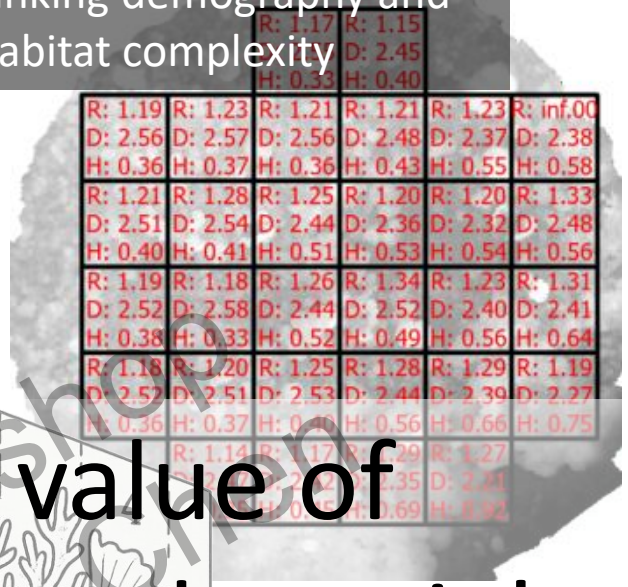
Circ change rate ~ Size + Circularity+ C/P ratio + F/P ratio + Shading + Forms

Cell-level statistics (GLM)

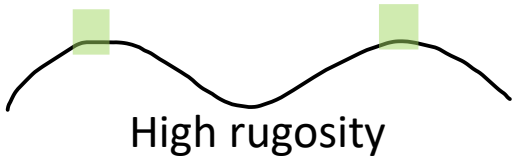
Cell fates ~ ~~Size + Circularity~~+ C/P ratio + F/P ratio + Shading + Forms

More effective restoration strategy

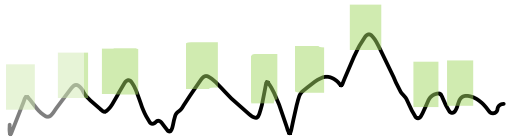
Linking demography and habitat complexity



Potential Shelter?

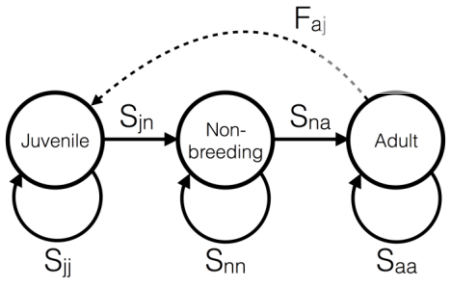


High rugosity

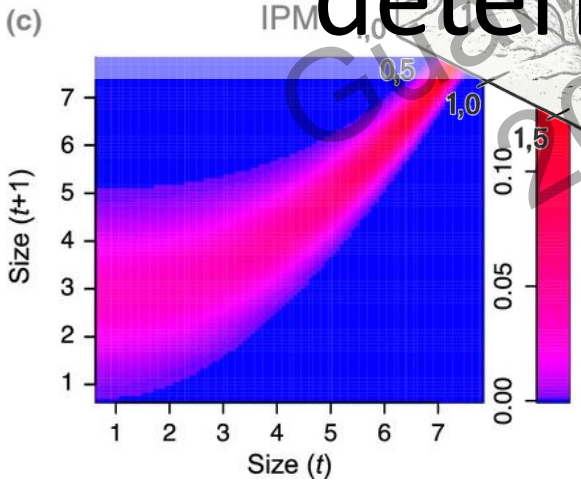


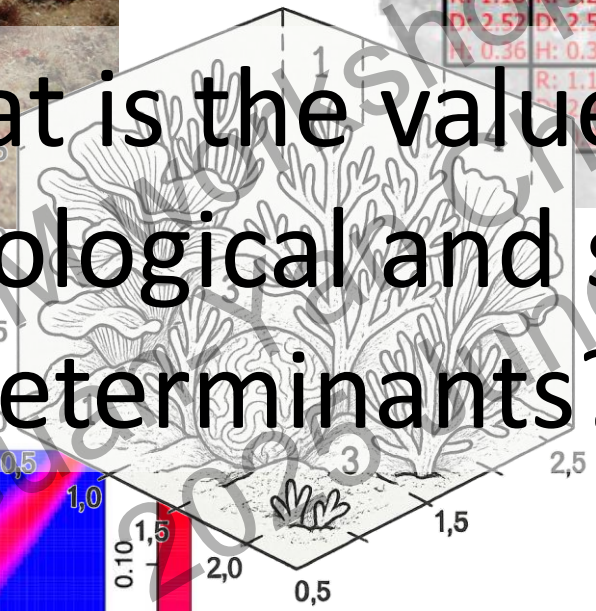
High Fractal dimension

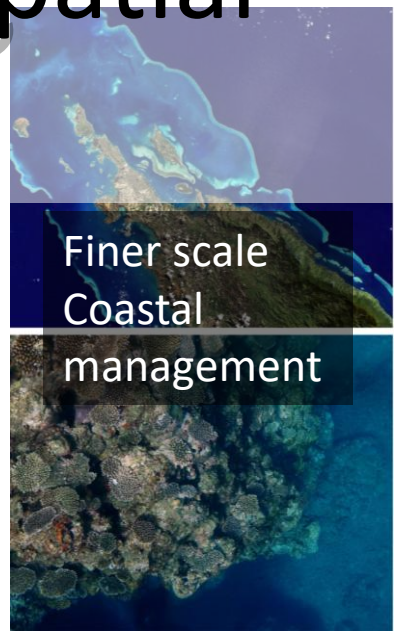
What is the value of morphological and spatial determinants?



$$\mathbf{A} = \begin{bmatrix} S_{jj} & 0 & F_{aj} \\ S_{jn} & S_{nn} & 0 \\ 0 & S_{na} & S_{aa} \end{bmatrix}$$







Finer scale Coastal management

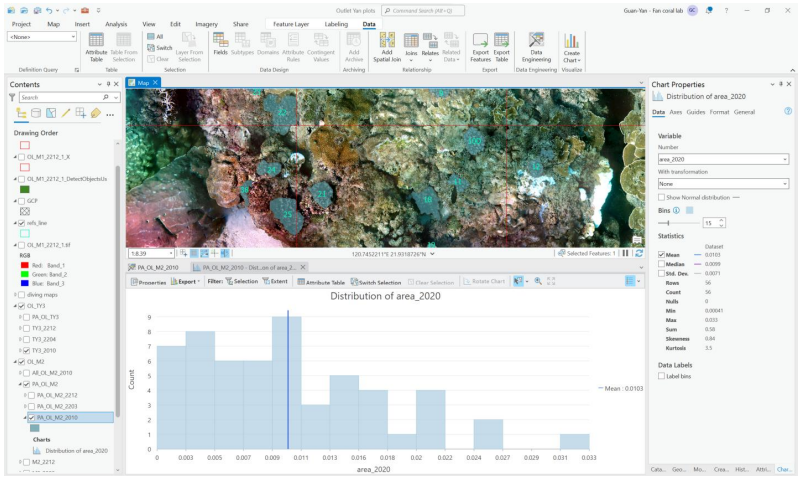
Offer insights beyond size-based metrics

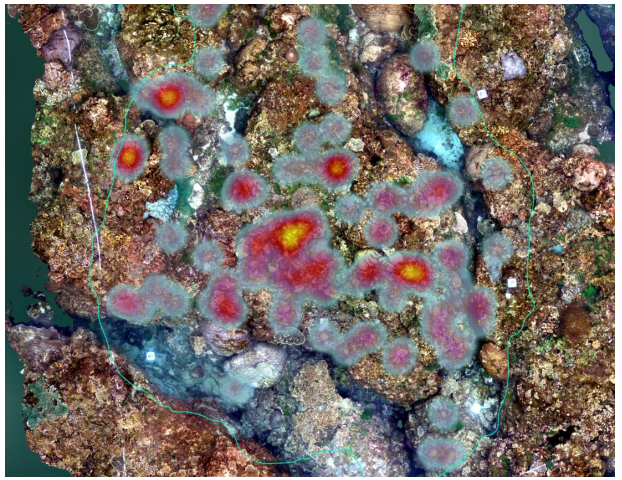
Examine whether these values can be applied globally?

Begin R analysis

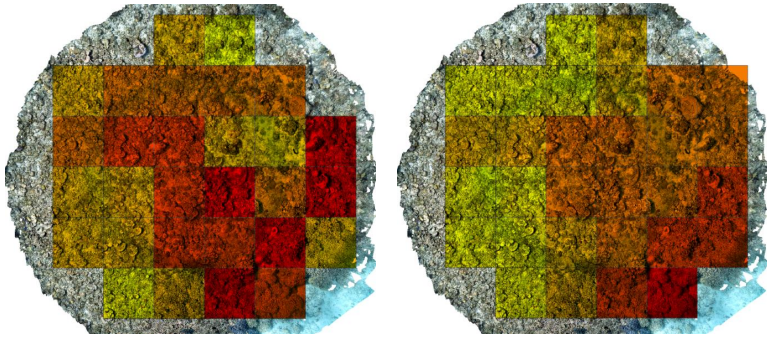
https://github.com/keelungchen/sfm_workshop/blob/main/code/NSYSU_SfM_workshop.md

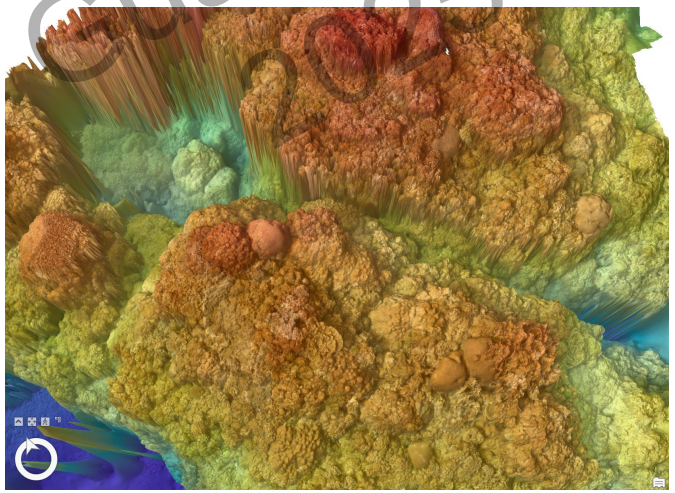
https://github.com/keelungchen/sfm_workshop/blob/main/code/NSYSU_dem_analysis.md

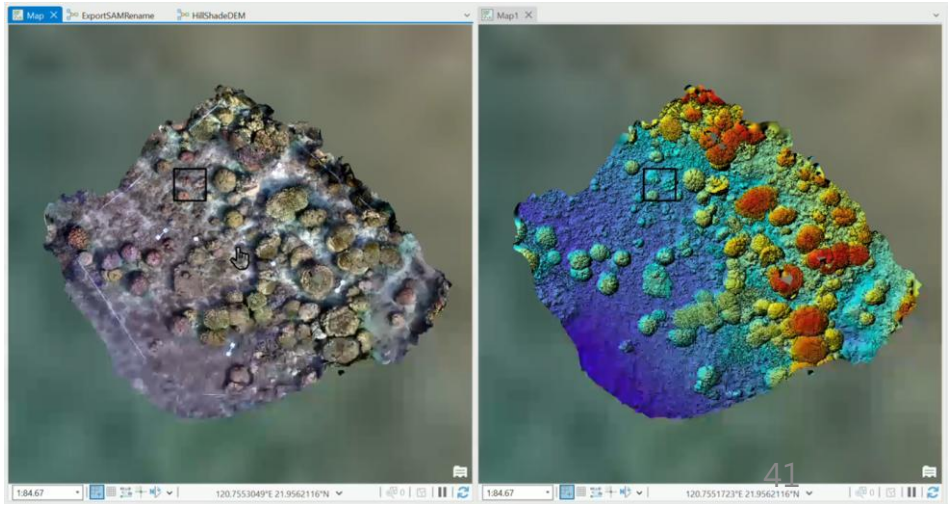




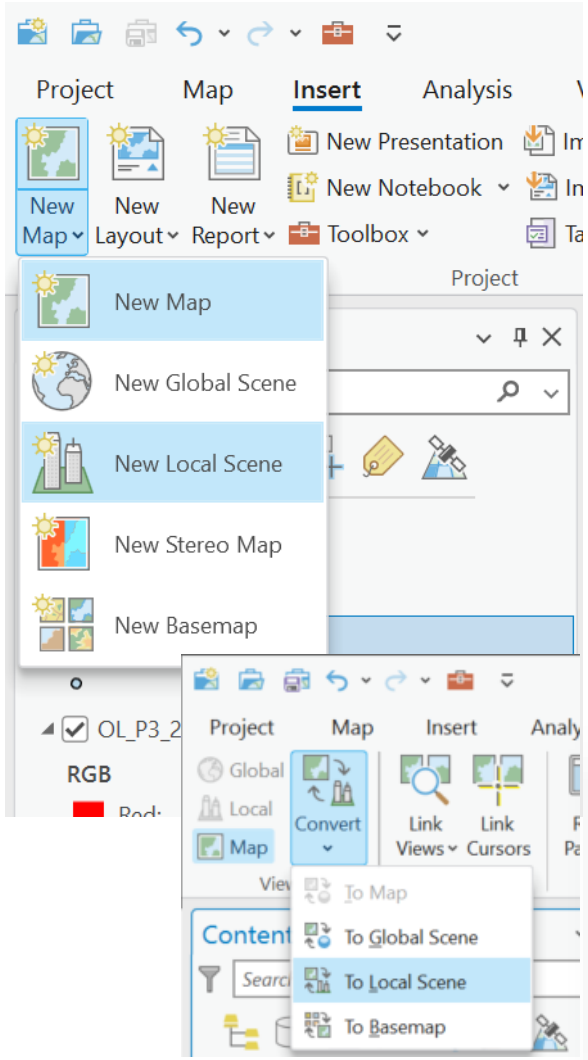
ArcGIS-based analysis & visualization

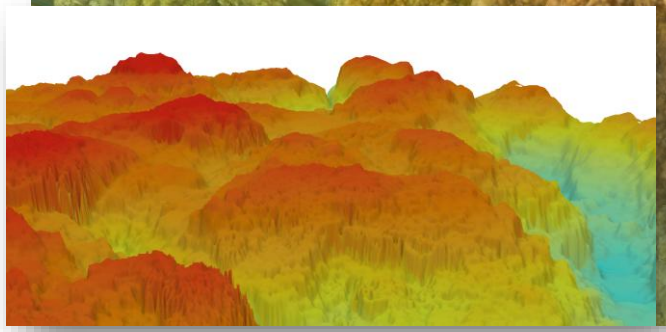






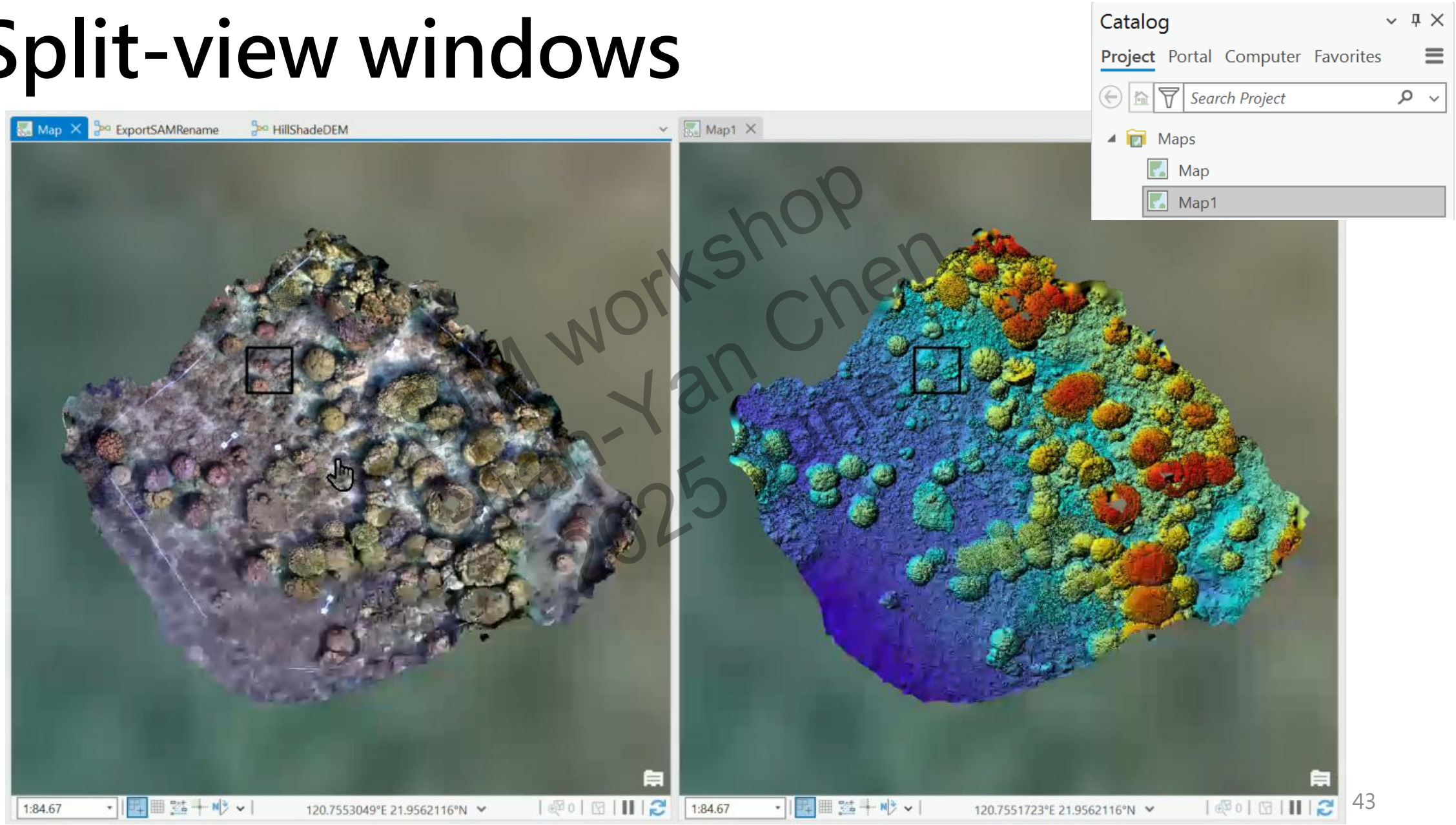
3D scene


Project
Map
Insert
Analysis
New Map
New Layout
New Report
New Presentation
New Notebook
Toolbox
Project
New Map
New Global Scene
New Local Scene
New Stereo Map
New Basemap
OL_P3_2
RGB
Project
Map
Insert
Global
Local
Map
Convert
Link Views
Link Cursors
To Map
To Global Scene
To Local Scene
To Basemap



SIM Workshop
Guan-Yan Chen
2025 June

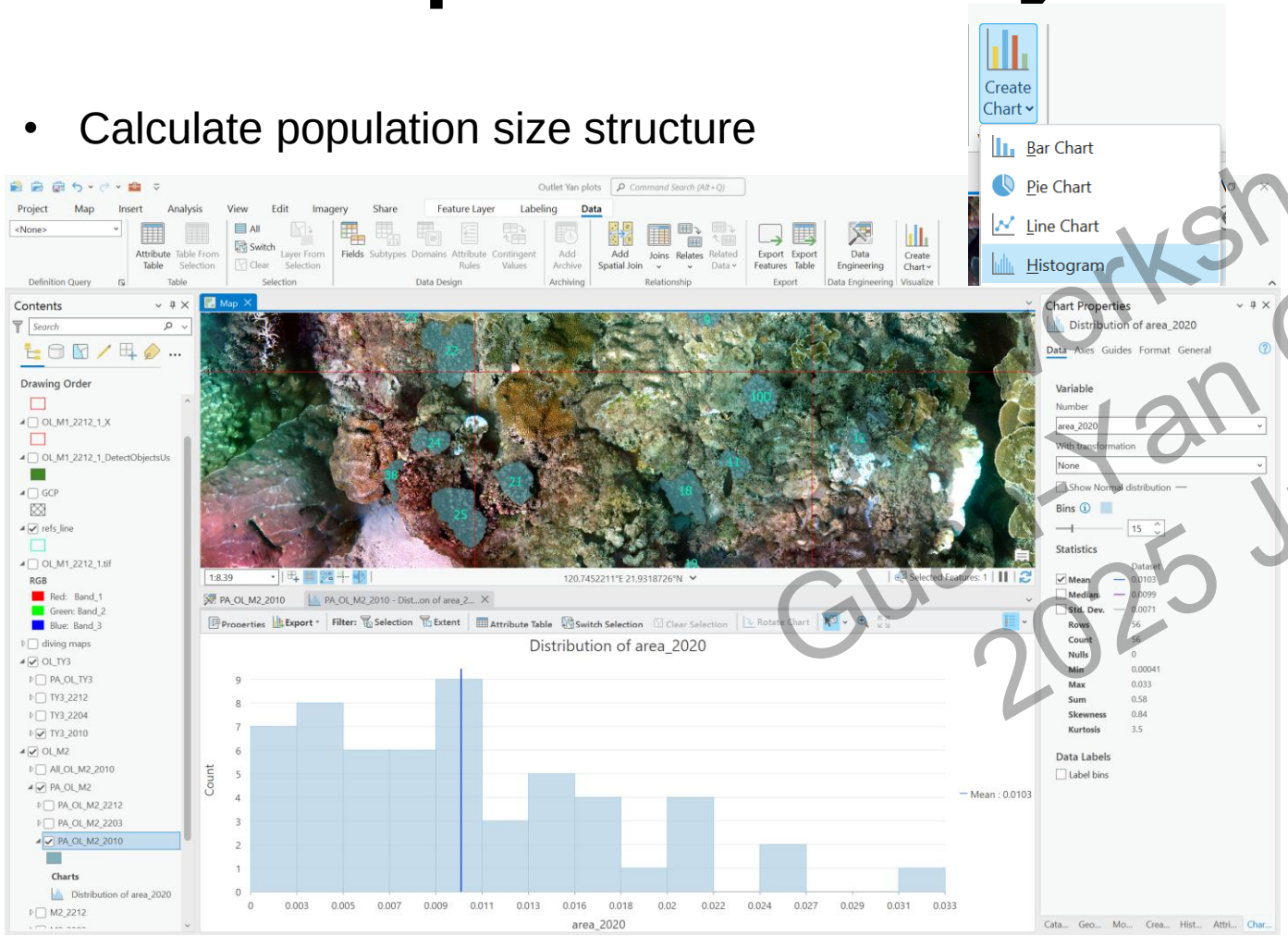
Split-view windows



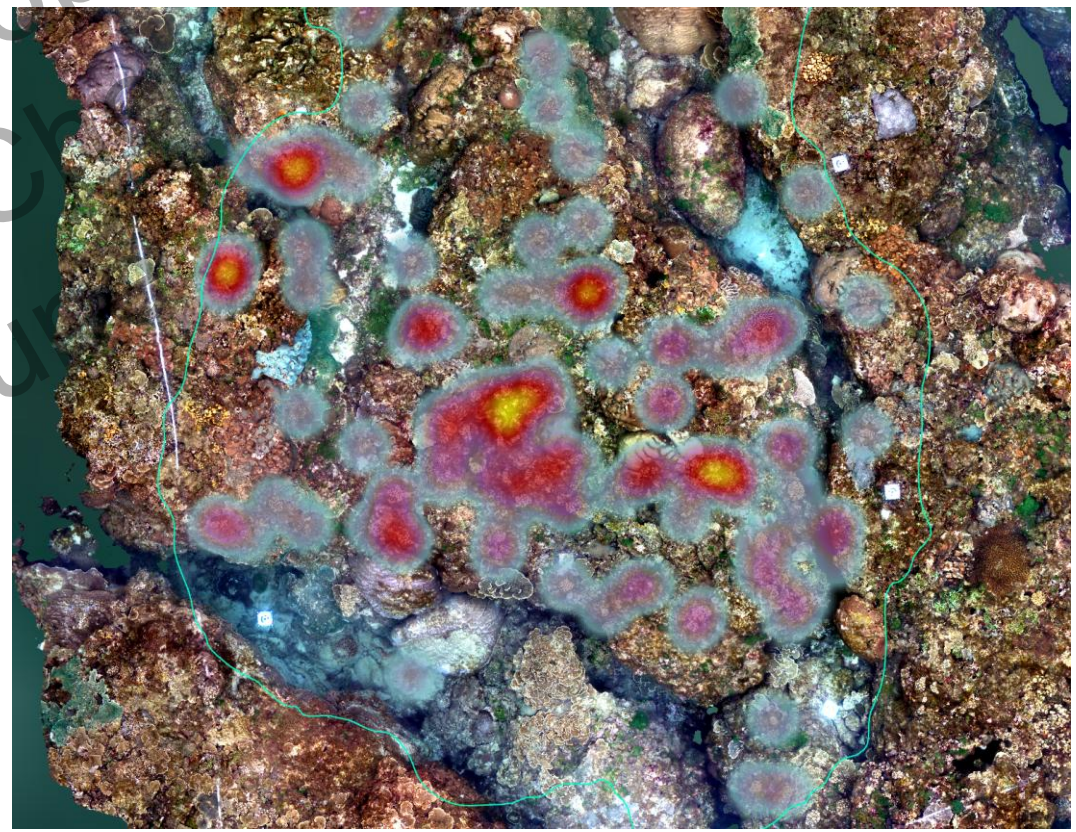
Examples of analysis

One year data

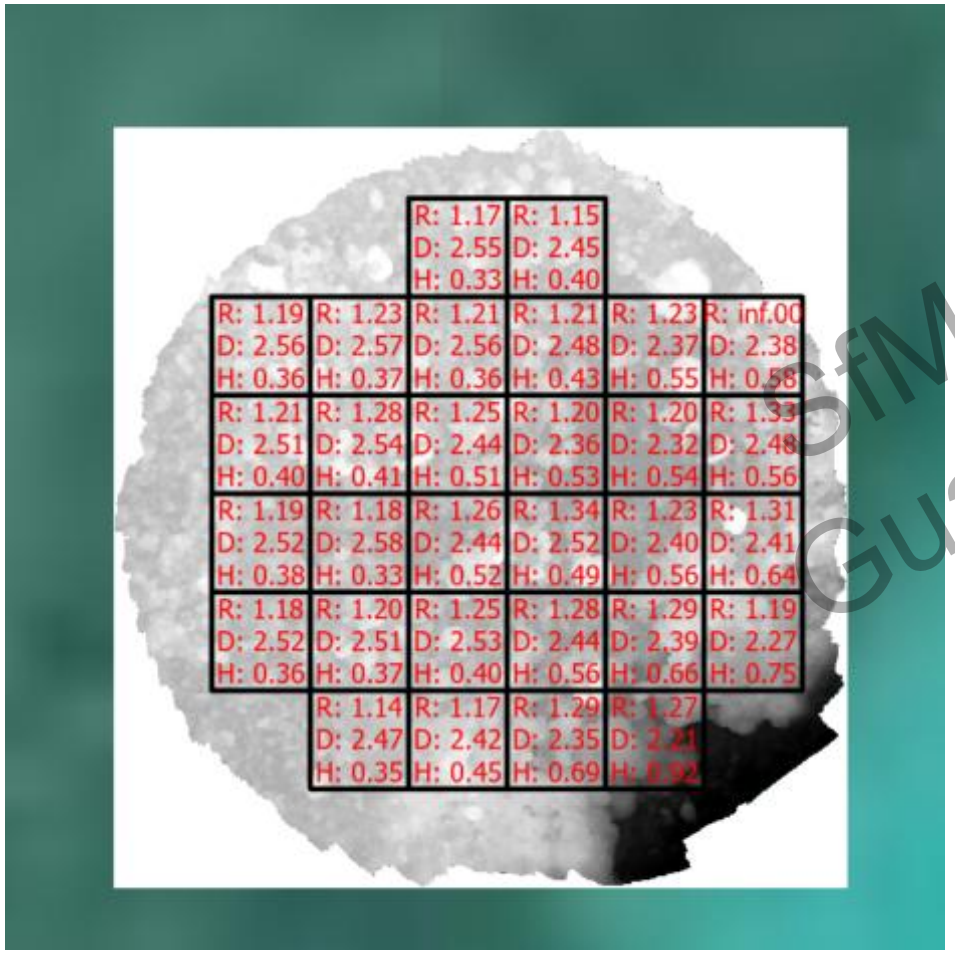
- Calculate population size structure



- Calculate colonies density

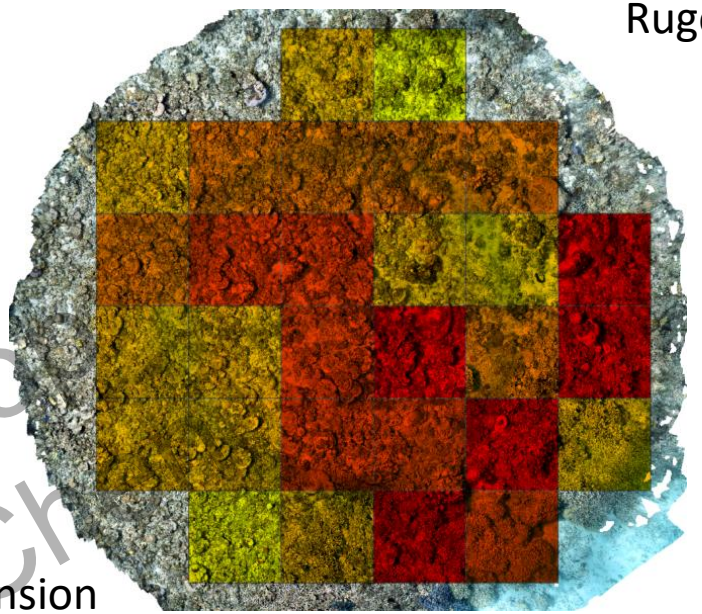


Structural-complexity analysis



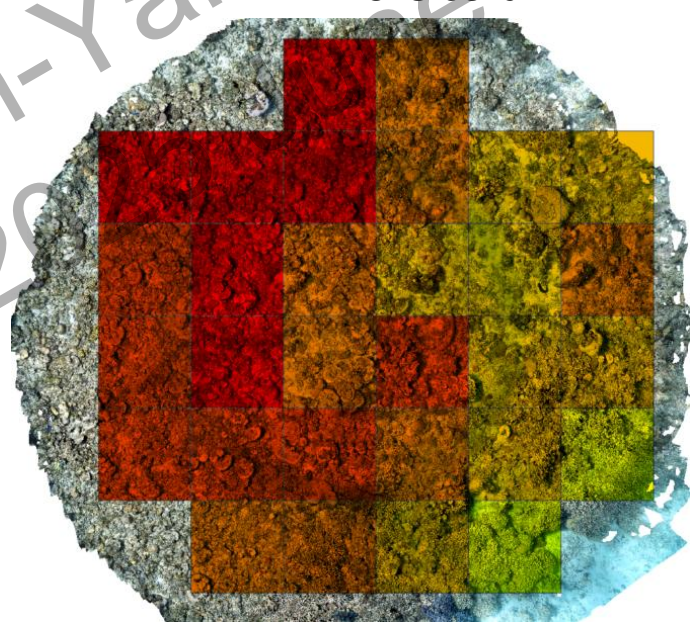
Rugosity

More fish

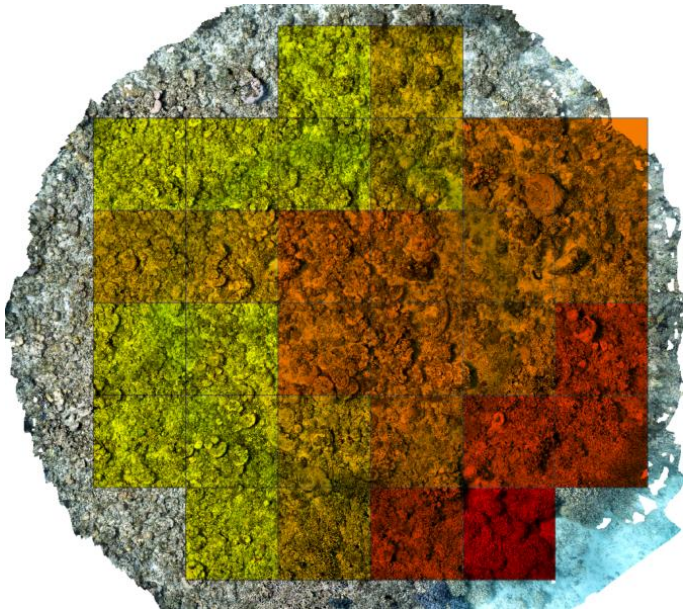


Fractal dimension

More coral



Hight range



More circular colonies(?

Advanced: quantifying inter-colony competition

```
import arcpy
from arcpy import env
from math import sqrt

# 设置工作空间
env.workspace = "C:/Users/keelu/Pictures/GIS data/Outlet Yan plots/Outlet Yan plots/Outlet Yan plots.gdb"

# 输入点要素类
point_fc = "PA_OL_TY3_2212_points"

# 创建线要素类
line_fc = "PA_OL_TY3_2212_line"

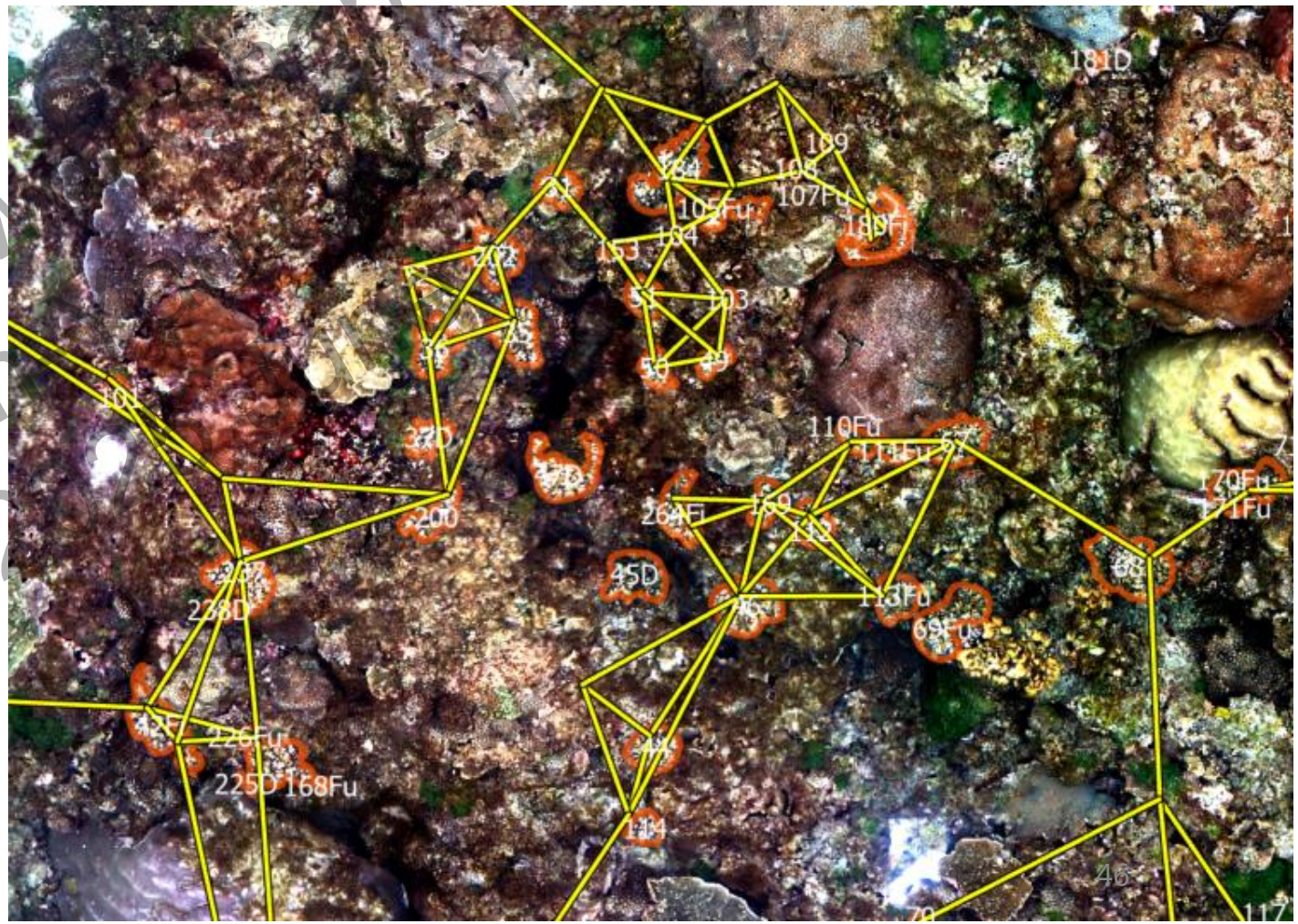
# 将点要素加载到内存中
points = []
with arcpy.da.SearchCursor(point_fc, ["SHAPE@XY"]) as cursor:
    for row in cursor:
        points.append(row[0])

# 计算每个点的三最近邻点并创建线
with arcpy.da.InsertCursor(line_fc, ["SHAPE@"]) as cursor:
    for i, point in enumerate(points):
        distances = []
        for j, other_point in enumerate(points):
            if i != j:
                distance = sqrt((point[0] - other_point[0])**2 + (point[1] - other_point[1])**2)
                distances.append((distance, other_point))

        # 取三最近邻点
        distances.sort(key=lambda x: x[0])
        nearest_points = distances[:3]

        # 创建线
        for distance, nearest_point in nearest_points:
            array = arcpy.Array([arcpy.Point(*point), arcpy.Point(*nearest_point)])
            polyline = arcpy.Polyline(array)
            cursor.insertRow([polyline])

print("连线创建完成。")
```



Advanced: estimating the ecological footprint of transplanted corals

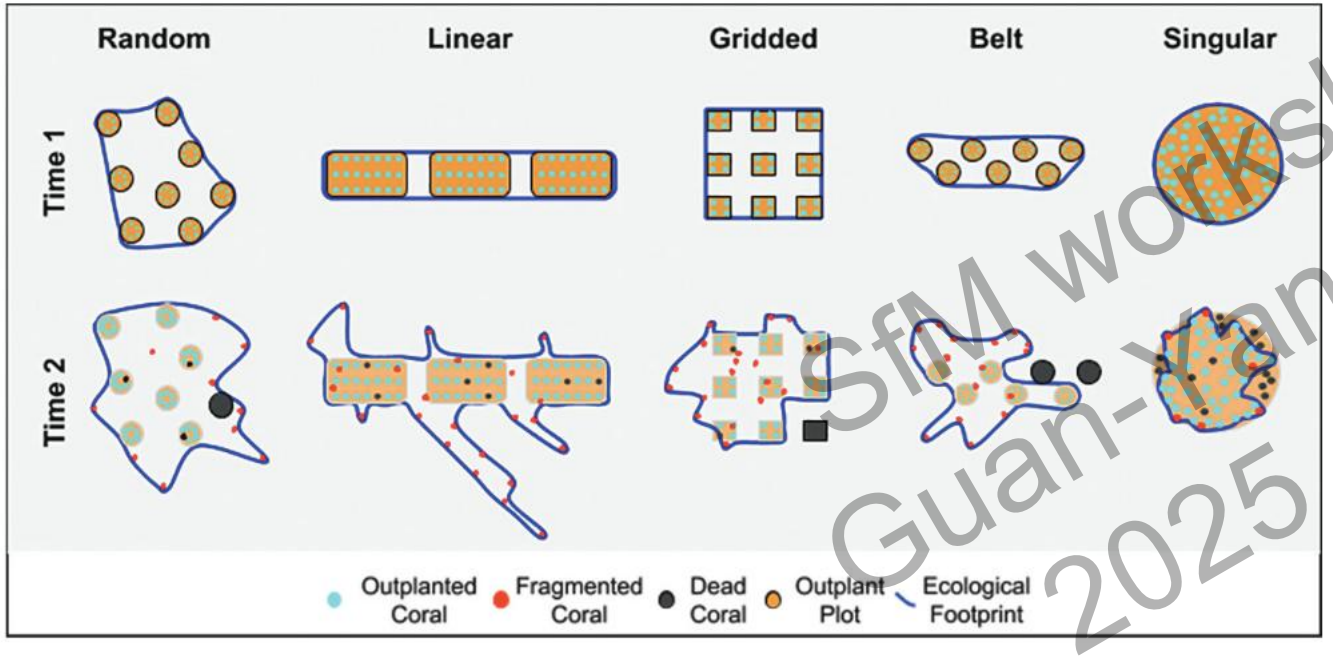


Figure 12. Examples of Outplant Plot (orange area) and Ecological Footprint (blue boundary) on various restoration project designs (random, linear, gridded, belt, and singular). Time 1 is representative of the time of outplanting or shortly thereafter (within a month). Time 2 is representative of a future san orange Outplant Plots are lightened just for reference to Time 1 dia

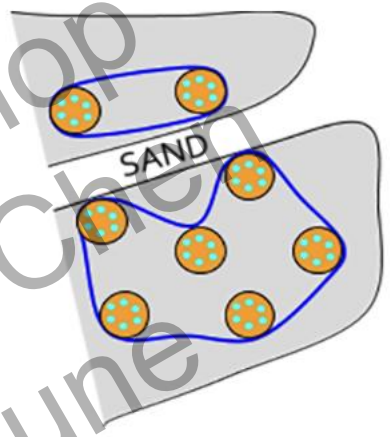
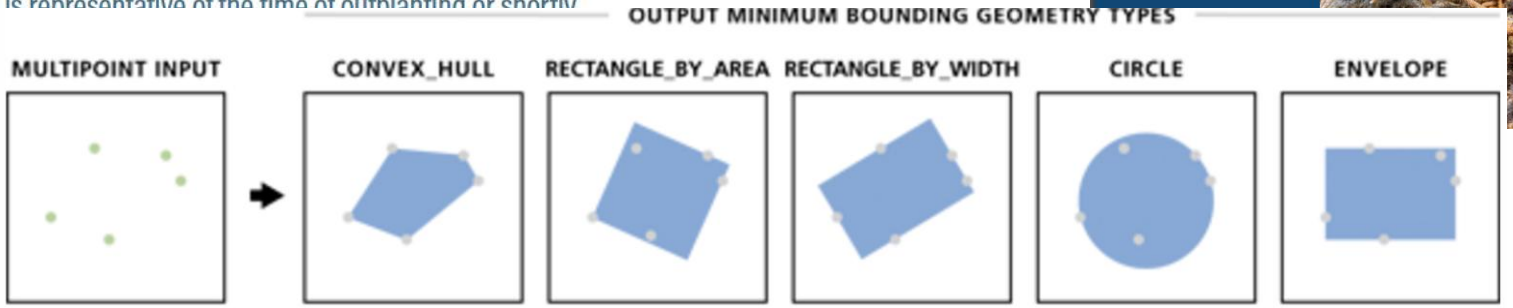
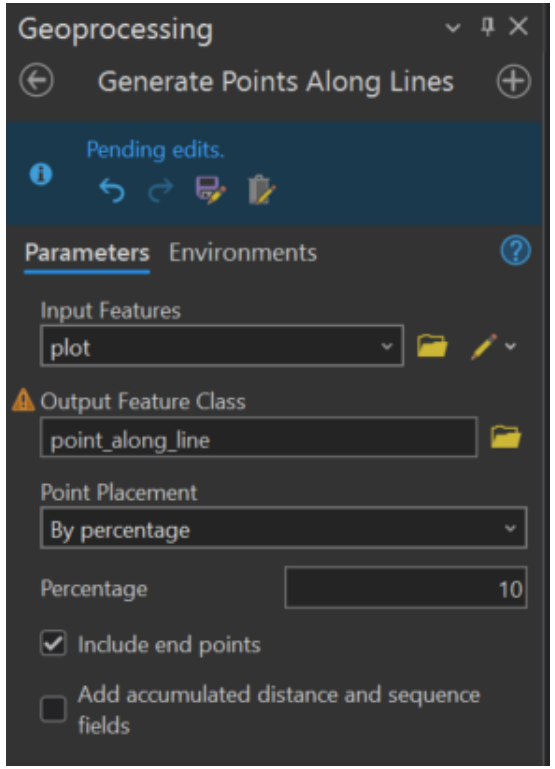
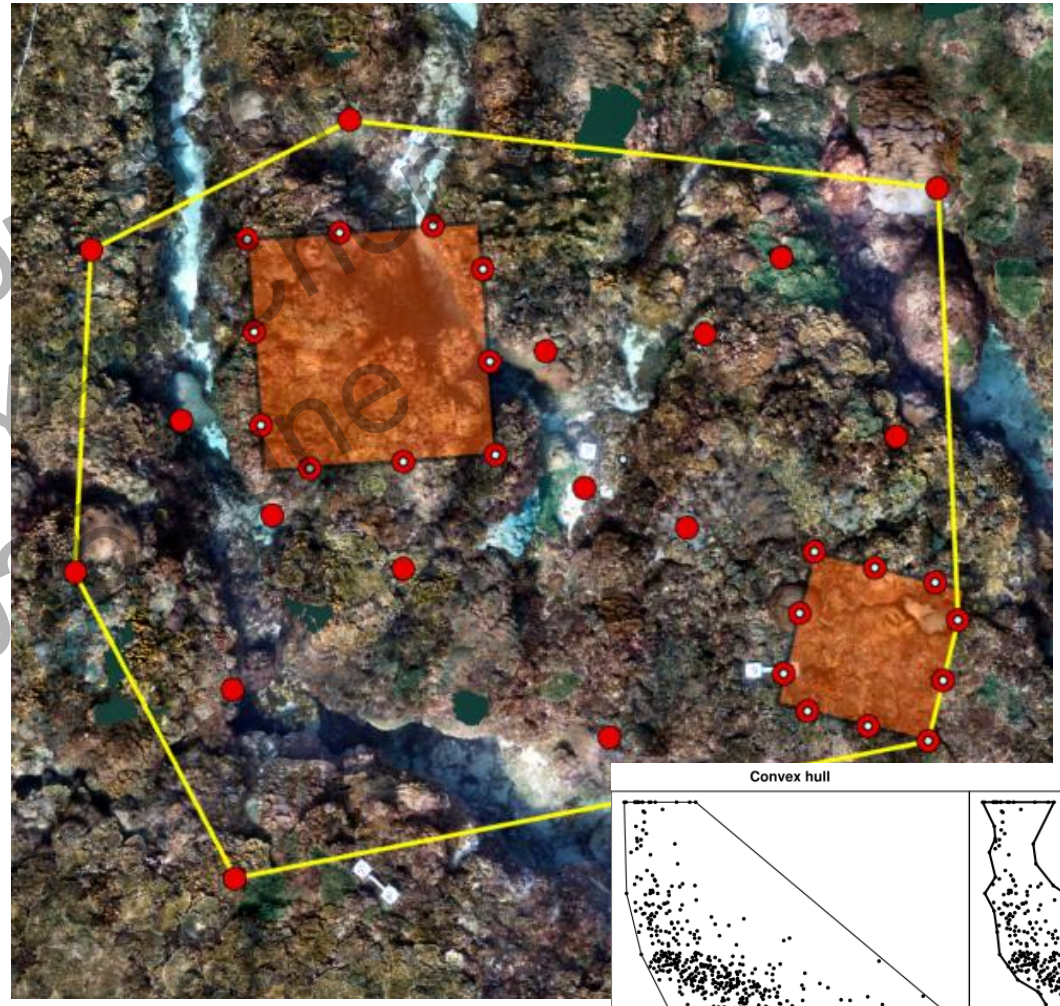


Figure 13. Example of measuring the Ecological Footprint on a spur and groove-like reef

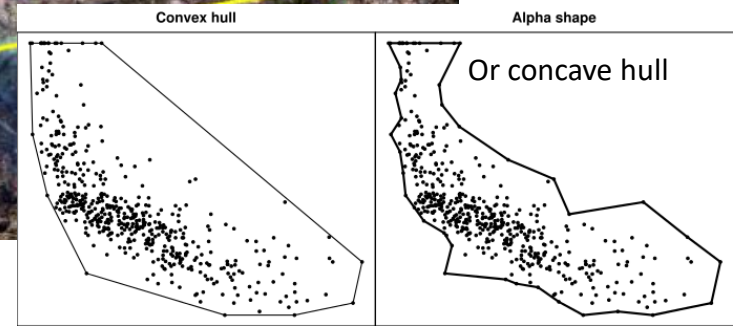


Advanced: estimating the ecological footprint of transplanted corals





手動將點連接也是可以



Fragmented coral

Outplant plot

Ecological footprint

SAM with ArcGIS

Overview Pricing Map Scene Help Sign In

Segment Anything Model (SAM) Overview

Meta's Segment Anything Model (SAM) for segmenting objects in any imagery.

Deep learning package by esri_analytics

Item created: Apr 16, 2023 Item updated: May 4, 2023 Number of downloads: 25,442

Living Atlas

1 Download

SAM.dlpk Deep Learning Package

Description

Segmentation models perform a pixel-wise classification by classifying the pixels into different classes. The classified pixels correspond to different objects or regions in the image. These models have a wide variety of use cases across multiple domains. When used with satellite and aerial imagery, these models can help to identify features such as building footprints, roads, water bodies, crop fields, etc.

Generally, every segmentation model needs to be trained from scratch using a dataset labeled with the objects of interest. This can be an arduous and time-consuming task. Meta's Segment Anything Model (SAM) is aimed at creating a foundational model that can be used to segment (as the name suggests) anything using zero-shot learning and generalize across domains without additional training.

SAM is trained on the Segment Anything 1-Billion mask dataset (SA-1B) which comprises a diverse set of 11 million images and over 1 billion masks. This makes the model highly robust in identifying object boundaries and differentiating between various objects across domains, even though it might have never seen them before. Use this model to extract masks of various objects in any image.

Licensing requirements

ArcGIS Desktop - ArcGIS Image Analyst extension for ArcGIS Pro
ArcGIS Enterprise - ArcGIS Image Server with raster analytics configured
ArcGIS Online - ArcGIS Image for ArcGIS Online

Using the model

Details

Size: 2,464.907 MB
ID: 9b67b441f29f4ce6810979f5f0667ebe

Share

Owner

EA esri_analytics

Tags

Segmentation, Segment anything, segment anything model, dlpk, LivingAtlasDLPK, streetview imagery, aerial imagery, satellite imagery, meta

2 Deep Learning Libraries Installers for ArcGIS

PyTorch, scikit-image, scikit-learn, Keras, cuDNN, plotly, ONNX, DASK, fast.ai, TensorFlow, spaCy

https://www.arcgis.com/home/item.html?id=9b67b441f29f4ce6810979f5f0667ebe

https://github.com/Esri/deep-learning-frameworks/blob/master/README.md?rmedium=links_esri_com_b_d&rsource=https%3A%2F%2Flinks.esri.com%2Fdeep-learning-framework-install

TextSAM (2024 new released)

Text SAM

概述

Deep learning model to detect objects using text prompts.

Deep learning package 擁有者 esri_analytics

建立的項目: 2024年2月2日　更新的項目: 2024年8月1日　下載數量: 81,339

Living Atlas

下載

描述

Text SAM is an open-source sample model that can be prompted using free-form text prompts to extract features of various kinds. This is achieved by using Grounding DINO and Segment Anything Model (SAM). Grounding DINO is an open-set object detector that can find objects given a text prompt. Segment Anything Model can be used to segment any object in a region of interest represented by a bounding box or a point. Both the models are called sequentially within this deep learning package. The bounding boxes representing the detected objects from Grounding DINO are fed into the Segment Anything Model as prompts to generate masks for the objects. Finally, the masks are converted to polygons and returned as GIS features. These features, which are described by the input text prompts, can be any object of interest such as vehicles, swimming pools, ships, airplanes, solar panels, etc.

Licensing requirements

ArcGIS Desktop – ArcGIS Image Analyst and ArcGIS 3D Analyst extensions for ArcGIS Pro
ArcGIS Enterprise – ArcGIS Image Server with raster analytics configured
ArcGIS Online – ArcGIS Image for ArcGIS Online

Using the model

Follow the guide to use the model. Before using this model, ensure that the supported deep learning libraries are installed. For more details, check Deep Learning Libraries Installer for ArcGIS.

Note: Deep learning is computationally intensive, and a powerful GPU is recommended to process large datasets.

詳細資訊

大小: 1,704.814 MB
ID: 8df3bf4167bc4c7b967f677f8b362ec3

分享

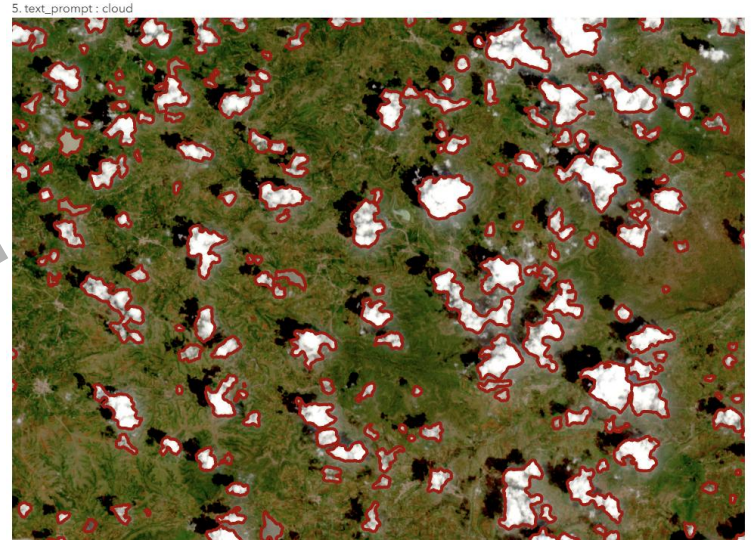
擁有者

esri_analytics

標記

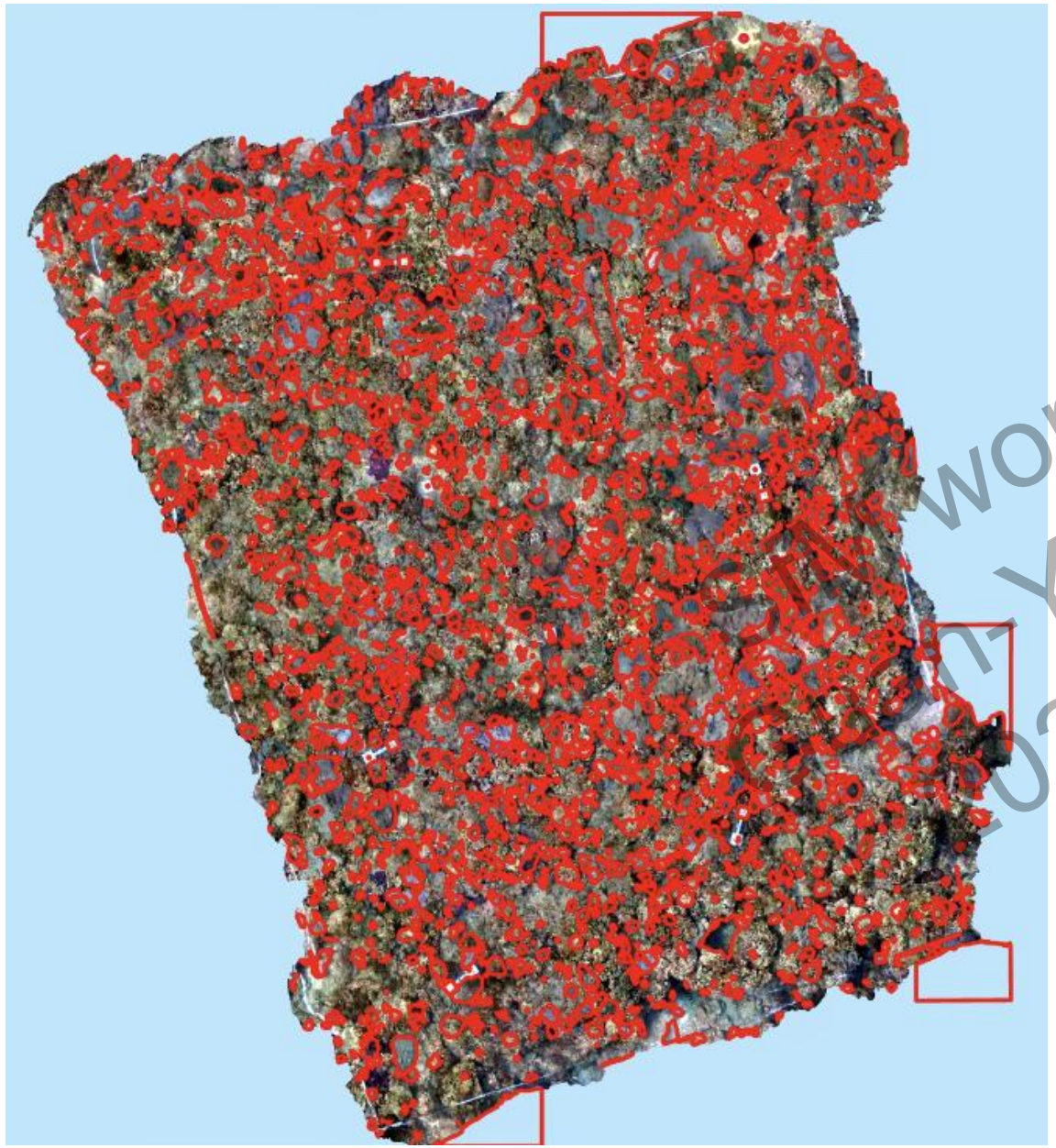
https://www.arcgis.com/home/item.html?id=8df3bf4167bc4c7b967f677f8b362ec3

5. text_prompt : cloud

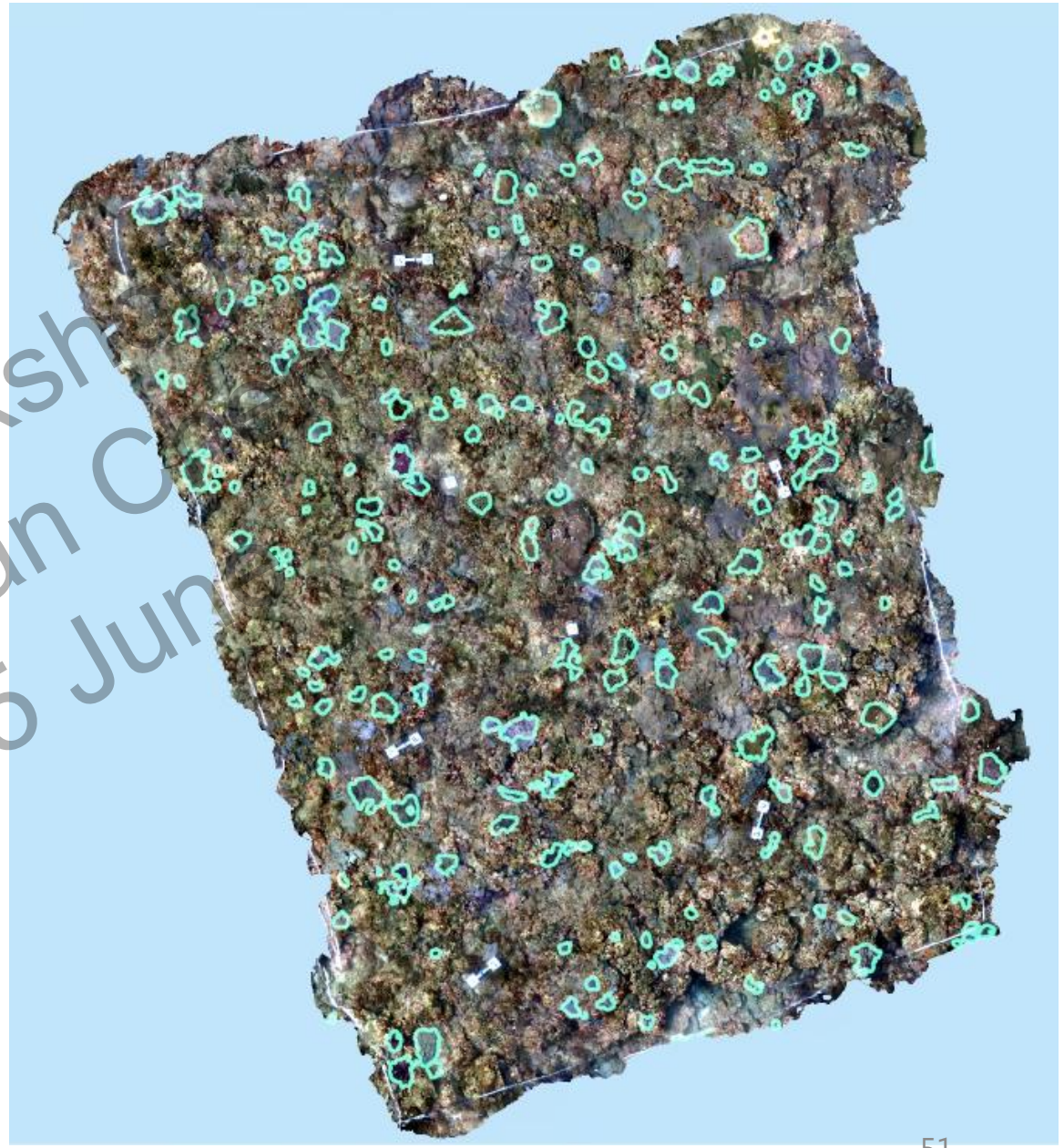


9. text_prompt : window

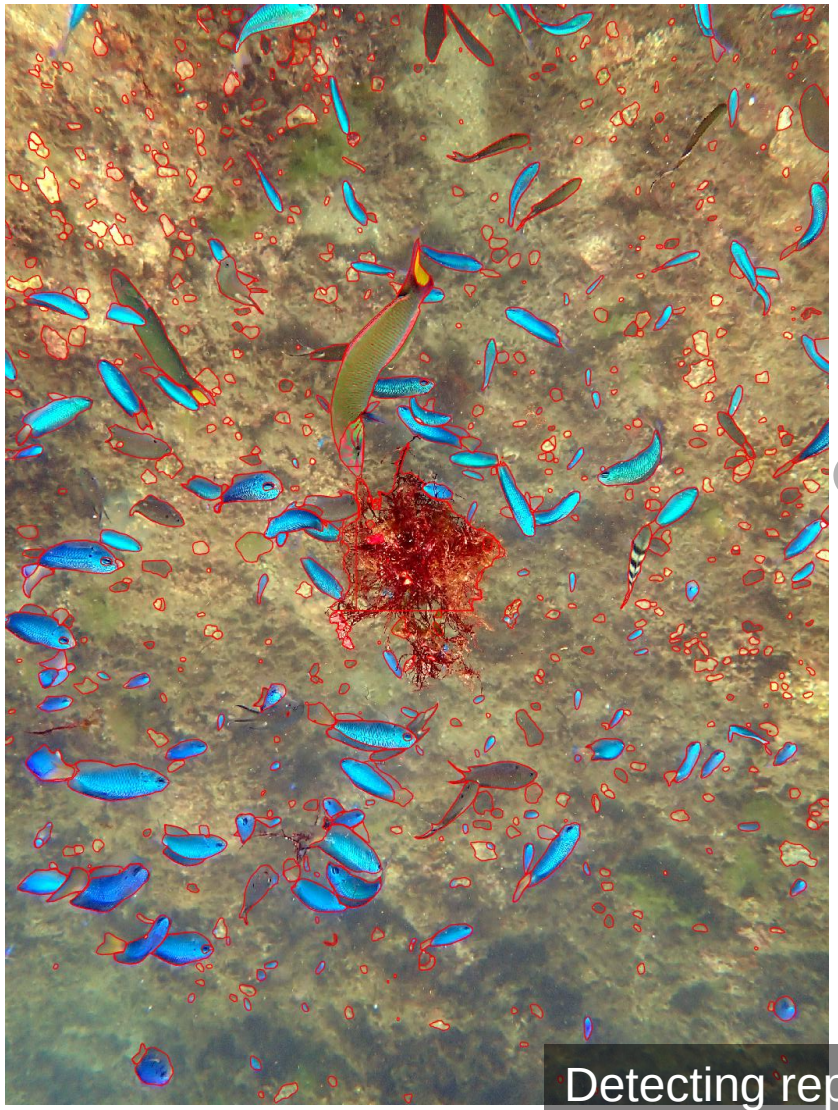
Segment anything model (SAM)

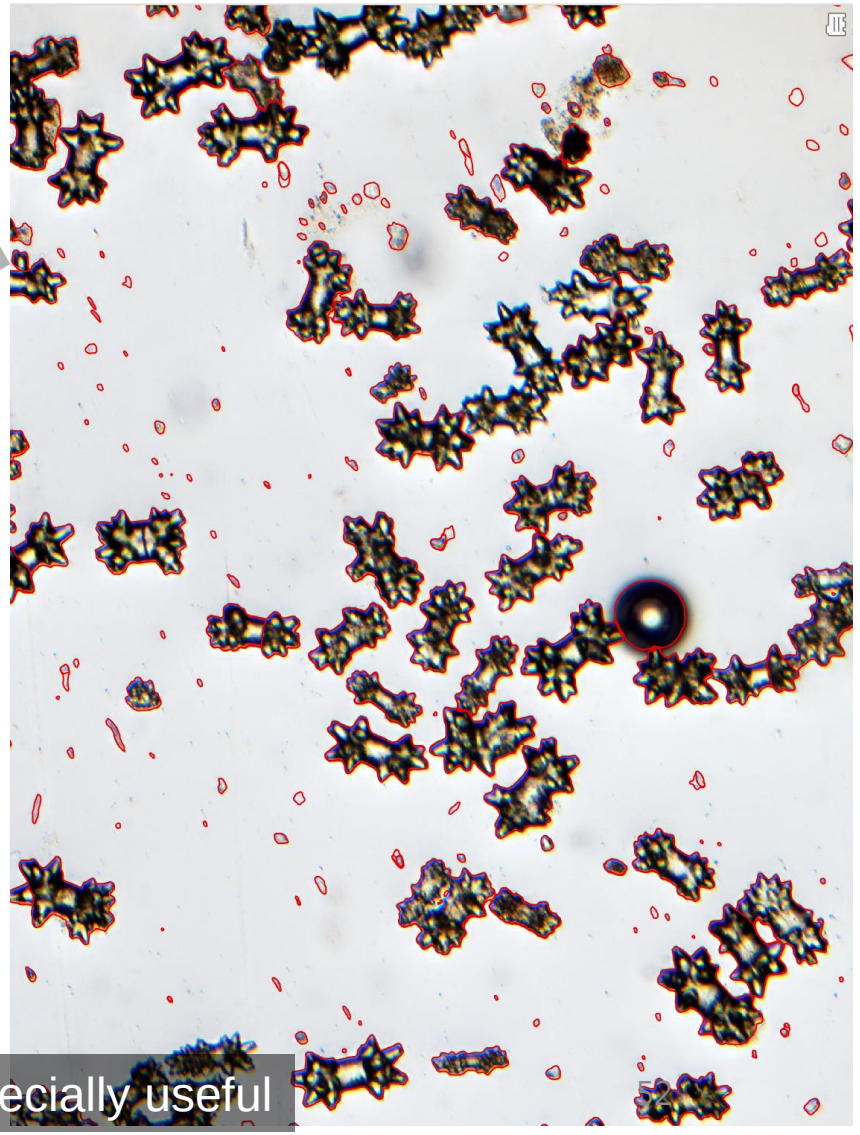


TextSAM, prompt: “coral”



Examples of SAM applications

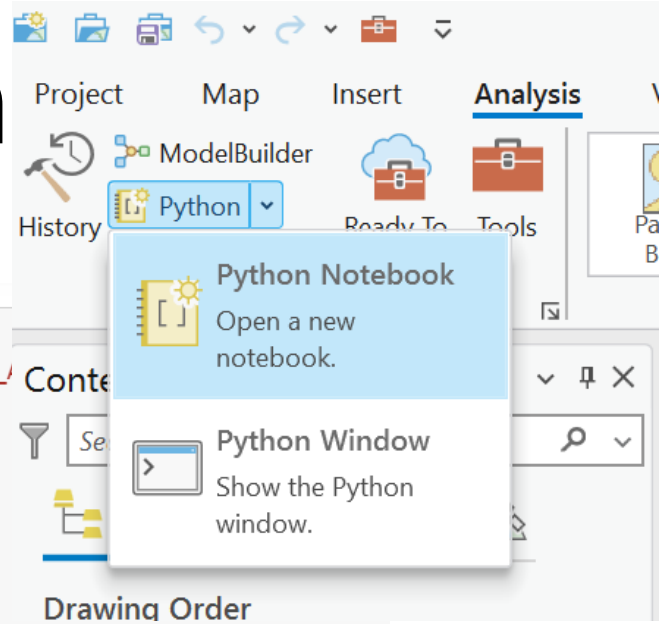




Detecting repeatedly occurring similar objects is especially useful

ID colonies based on size ran

Python can be easily incorporated in ArcGIS



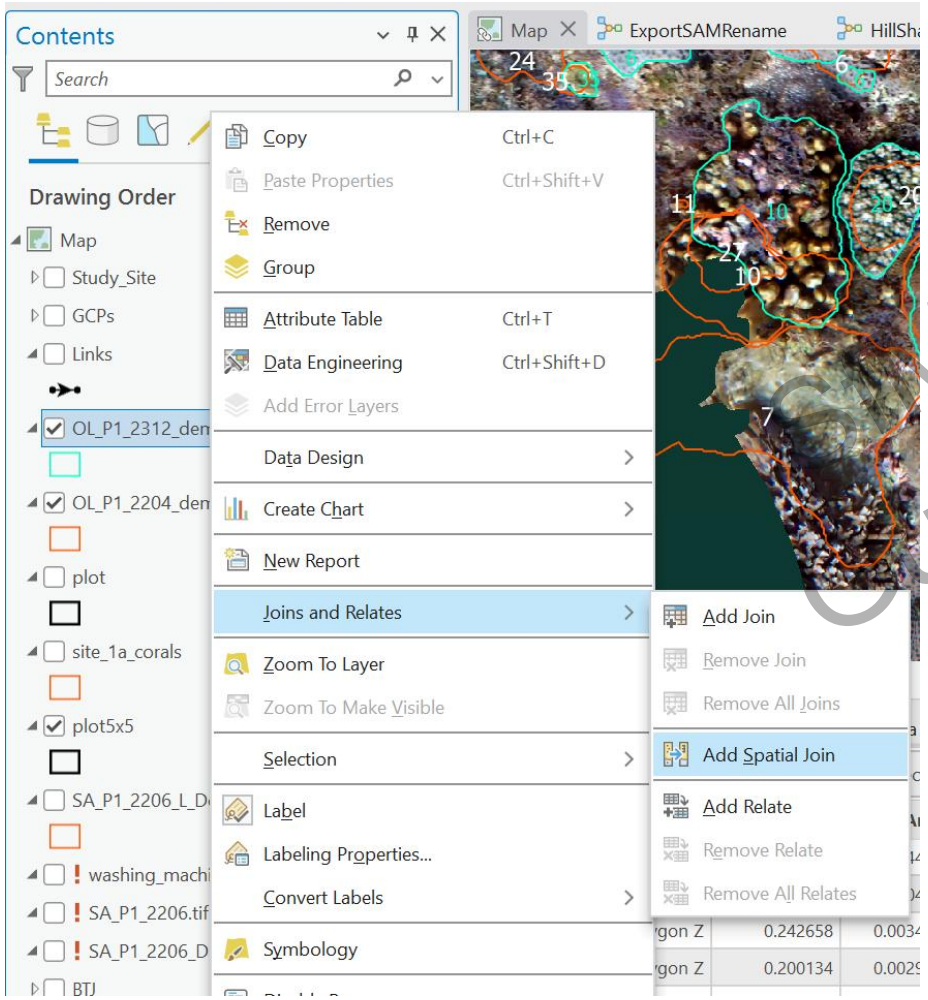

```
In [13]:
1 rank = 1
2 sorted_areas = sorted([row[0] for row in arcpy.da.SearchCursor("IL_P4_2205_corals_p", ["Shape_
3
4 def get_rank(area):
5     global rank
6     rank = sorted_areas.index(area) + 1
7     return rank
8
9 get_rank(!Shape_Area!)
```

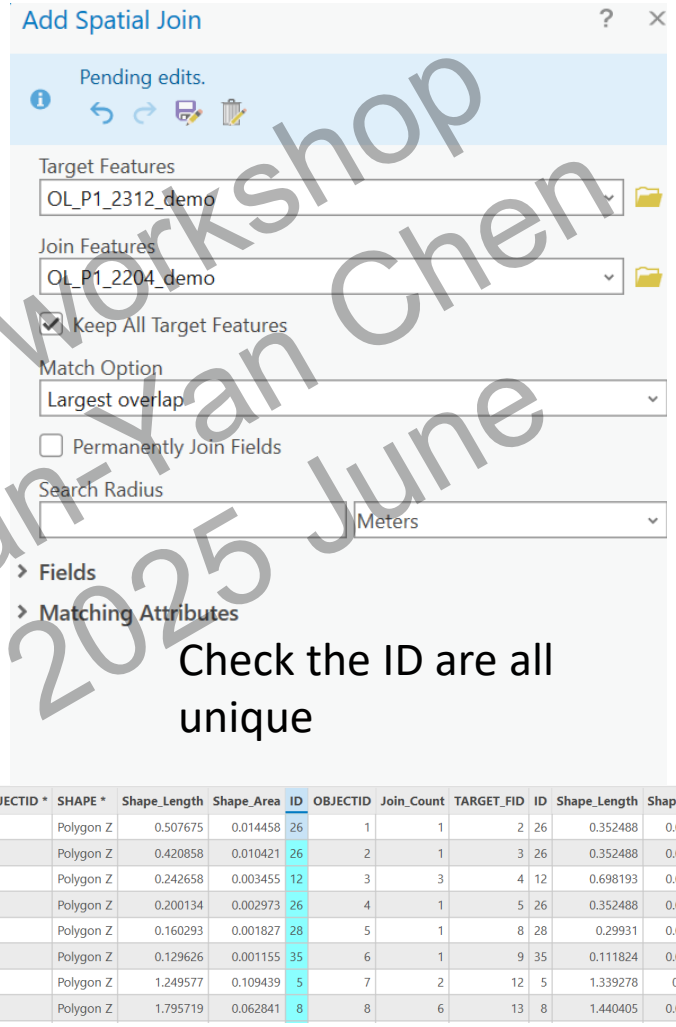

rank = 1
sorted_areas = sorted([row[0] for row in arcpy.da.SearchCursor("**IL_P4_2205_corals_p**", ["Shape_Area"])],
reverse=True)

def get_rank(area):
  global rank
  rank = sorted_areas.index(area) + 1
  return rank

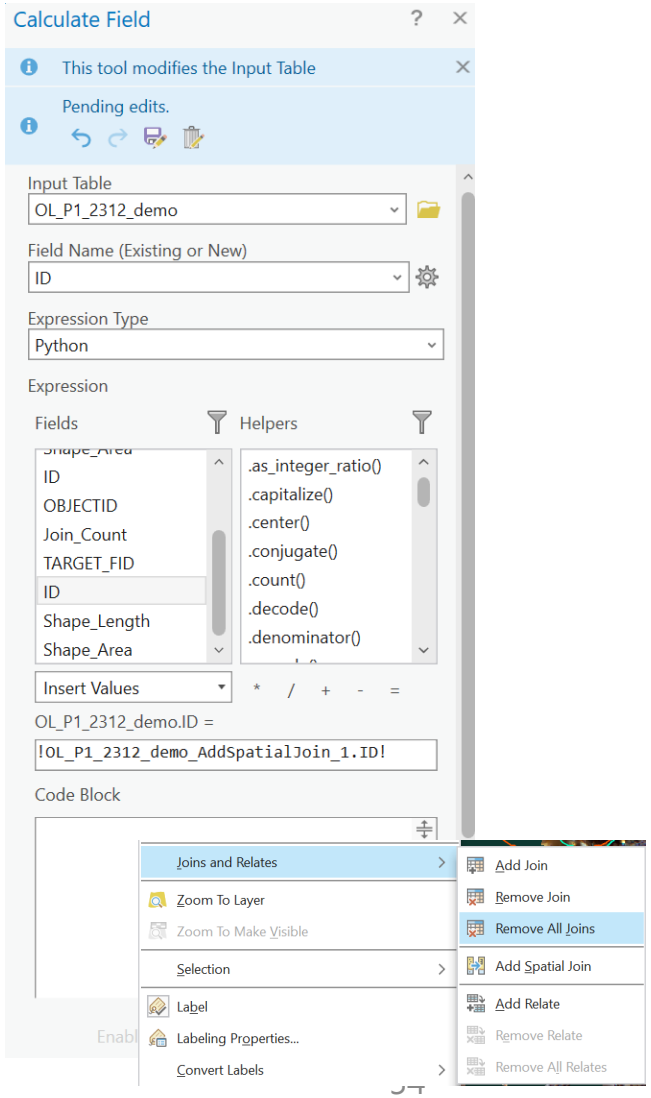
####
get_rank(!Shape_Area!)

Give ID based on spatial overlapping

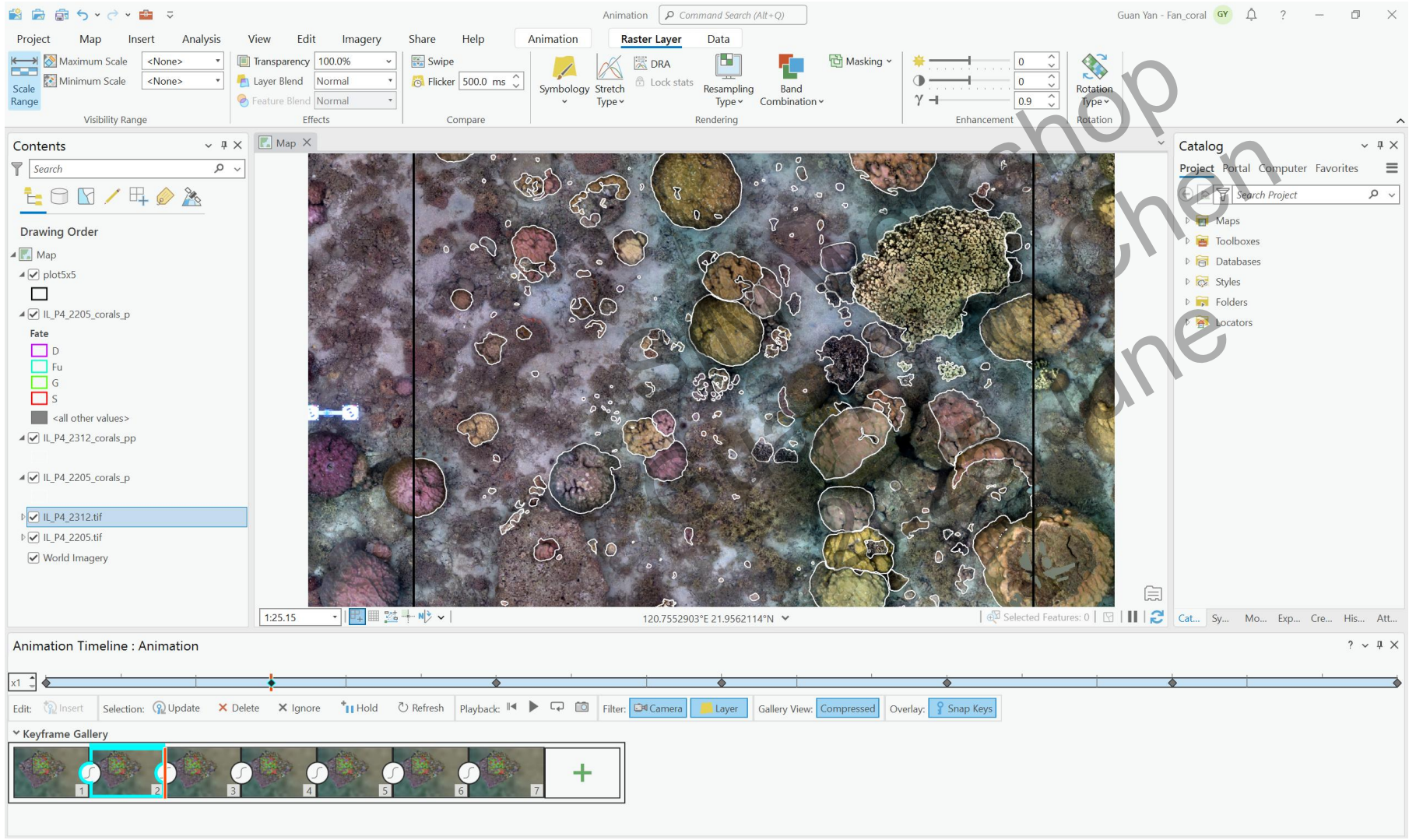


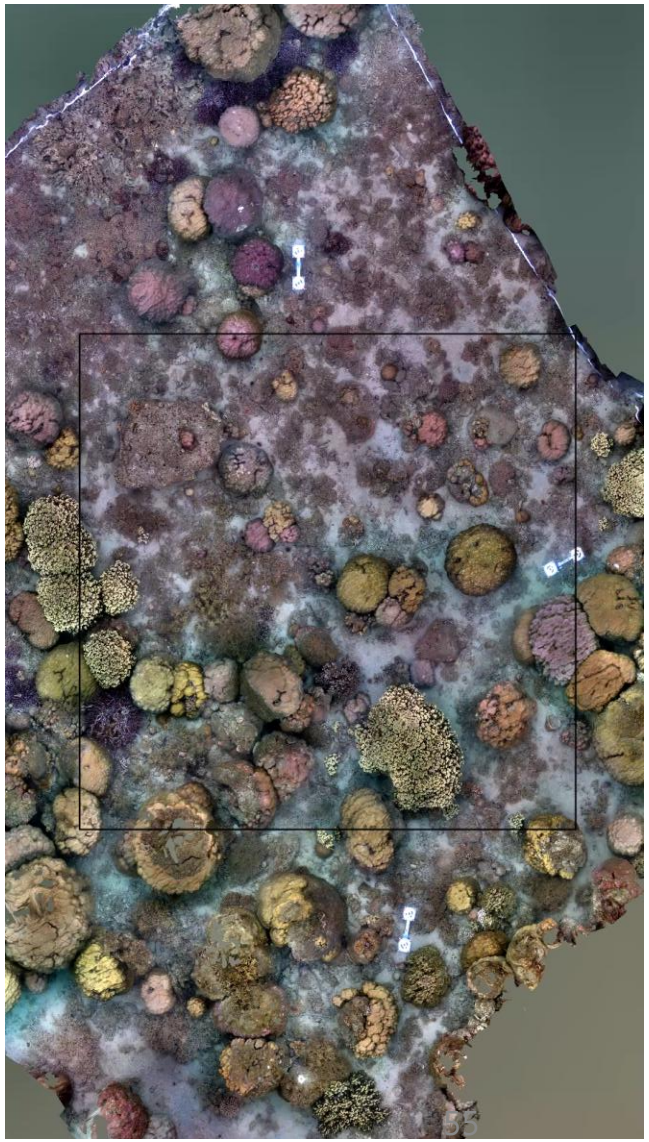


OBJECTID *	SHAPE *	Shape_Length	Shape_Area	ID	OBJECTID	Join_Count	TARGET_FID	ID	Shape_Length	Shape_Area
2	Polygon Z	0.507675	0.014458	26	1	1	2	26	0.352488	0.006676
3	Polygon Z	0.420858	0.010421	26	2	1	3	26	0.352488	0.006676
4	Polygon Z	0.242658	0.003455	12	3	3	4	12	0.698193	0.018561
5	Polygon Z	0.200134	0.002973	26	4	1	5	26	0.352488	0.006676
8	Polygon Z	0.160293	0.001827	28	5	1	8	28	0.29931	0.005445
9	Polygon Z	0.129626	0.001155	35	6	1	9	35	0.111824	0.000897
12	Polygon Z	1.249577	0.109439	5	7	2	12	5	1.339278	0.10593
13	Polygon Z	1.795719	0.062841	8	8	6	13	8	1.440405	0.052743



ArcGIS animation





We can do much more than just corals

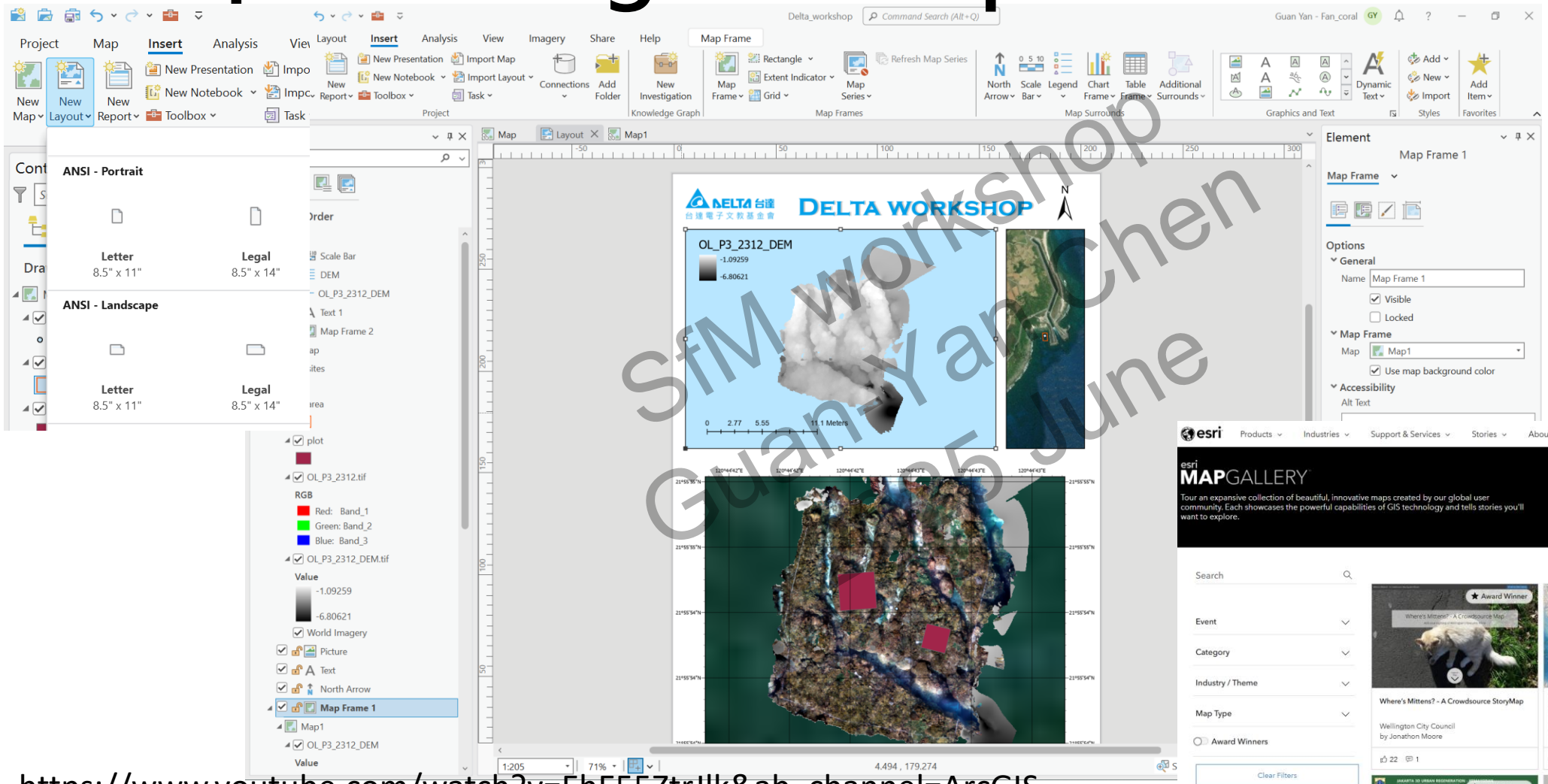
THE MEGA LAB Nā Wana o Laehala

Hoʻolauna Hua Haʻalele Huakaʻi Hoʻina Credit

The drone was preprogrammed, and a flight plan was set using DroneDeploy software. Throughout the flight, the drone was set to 70% - 80% image overlap ensuring the alignment accuracy of sites. Due to imposing legal flying restrictions, the drone was flown at an average of 56 m altitude resulting in ground image resolution ranging from 2.0 cm - 2.5 cm. Several flights were conducted to record both the low and high tide in order to find the average depth. This was done multiple times to compare temporal patterns found within clustering.

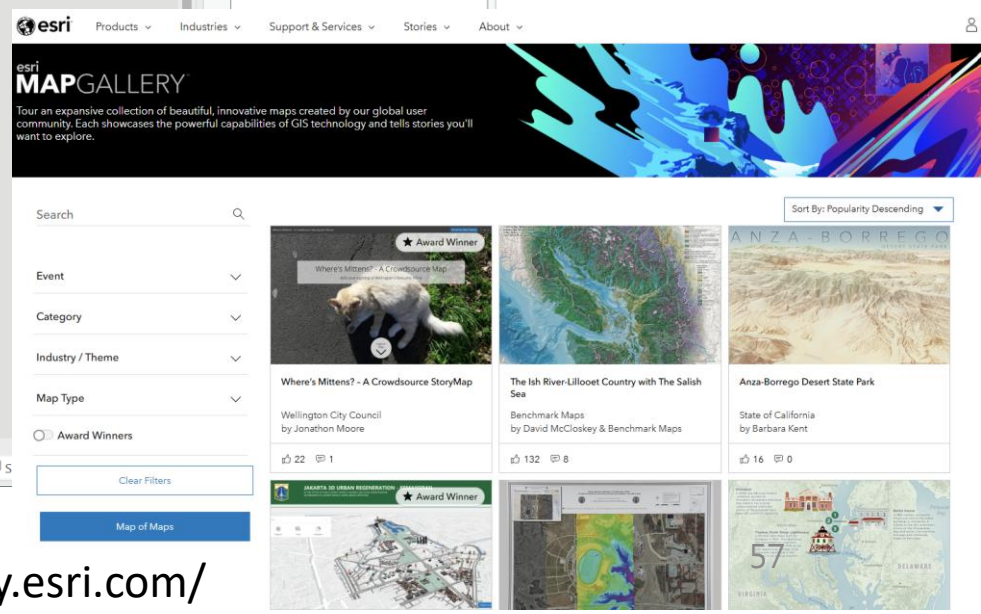
https://storymaps.arcgis.com/stories/52b1f89561d34820bc220b2d0dcd6ad1

Export designed map



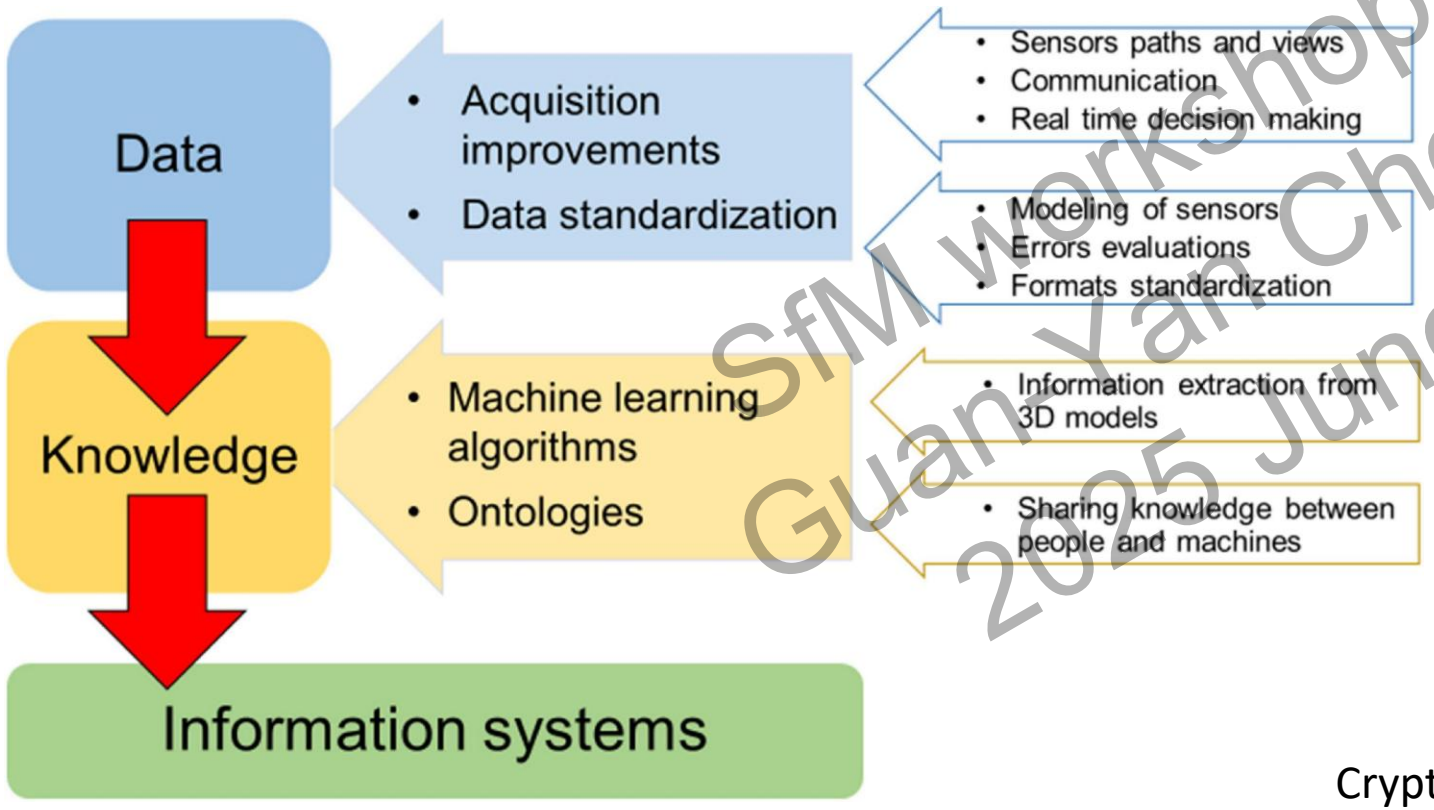
Flattened pdf
Geopdf

https://www.youtube.com/watch?v=EhE55ZtrJlk&ab_channel=ArcGIS



https://mapgallery.esri.com/

Challenges in 3D survey methodology



(Rossi et al., 2021)

Increase survey efficiency

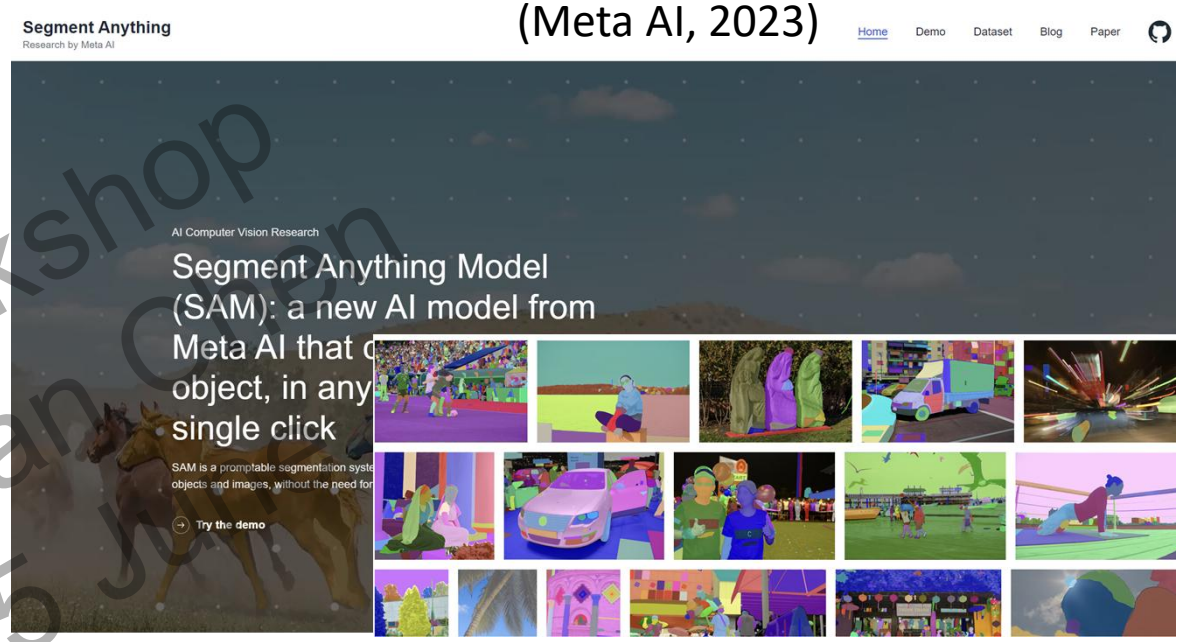
Workflow standardization & error evaluation

Data analysis & sharing

Cryptic species, hard-to-label morphologies, precise geolocation & 3D change detection…

Technological advances confronting the challenges

Large language model save your time
(Meta AI, 2023)



Gather the power of citizen scientists

NASA NeMO-Net (NASA, 2020)

http://nemonet.info/

Description

NeMO-Net is a single player iPad game where players help NASA classify coral reefs by painting 3D and 2D images of coral. Players can rate the classifications of other players and level up in the food chain as they explore and classify coral reefs and other shallow marine environments and creatures from locations all over the world!

Automation of survey equipment

(Vertigo3, 2024) https://vimeo.com/showcase/10597521

CoralSCOP: Segment any COral Image on this Planet

Ziqiang Zheng[1] Haixin Liang[1] Binh-Son Hua[2] Yue Him Wong[3] Put ANG Jr[4] Apple Pui Yi CHUI[4] Sai-Kit Yeung[1]

[1]The Hong Kong University of Science and Technology, [2]Trinity College Dublin, [3]Shenzhen University, [4]The Chinese University of Hong Kong

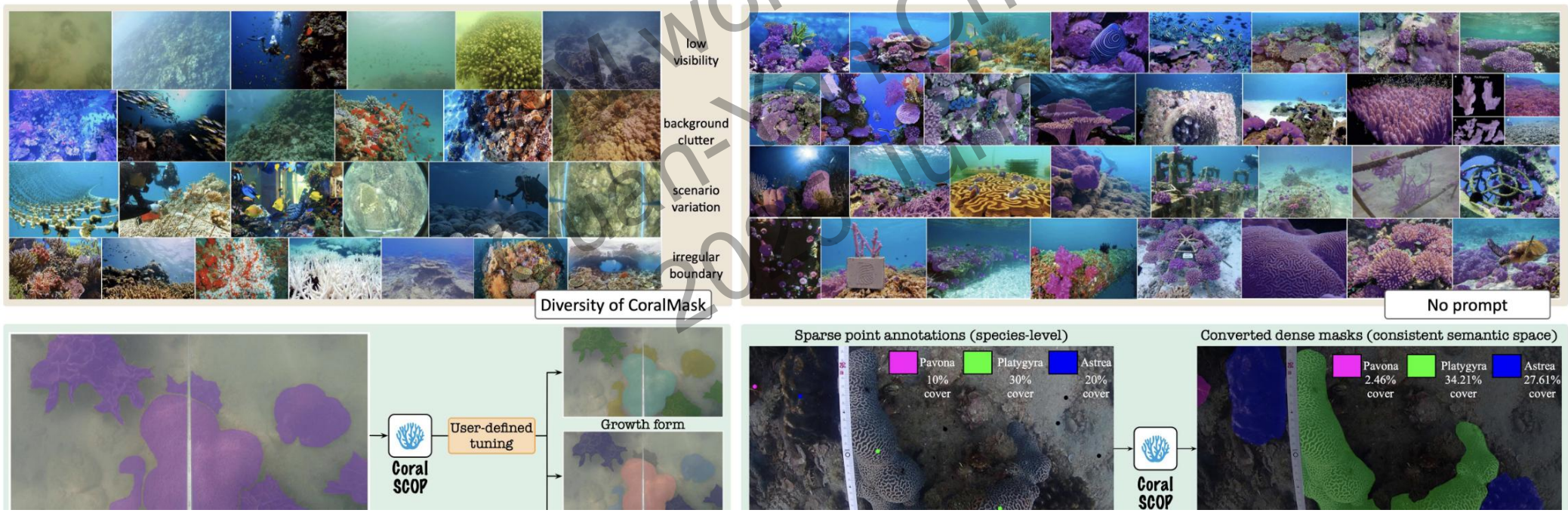
IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2024 **Highlight**✨

PAPER SUPPLEMENTARY CODE DATASET TOOL

📢📢📢 News: We have developed an offline labeling and analysis tool: CoralSCOP-LAT based on CoralSCOP. More details are avaliable at https://arxiv.org/html/2410.20436v1!

📢📢📢 News: Our online website is available now at https://coralscop.ai/!

Enjoy and have fun !



https://coralscop.hkustvgd.com/

BRITISH ECOLOGICAL SOCIETY | Methods in Ecology and Evolution

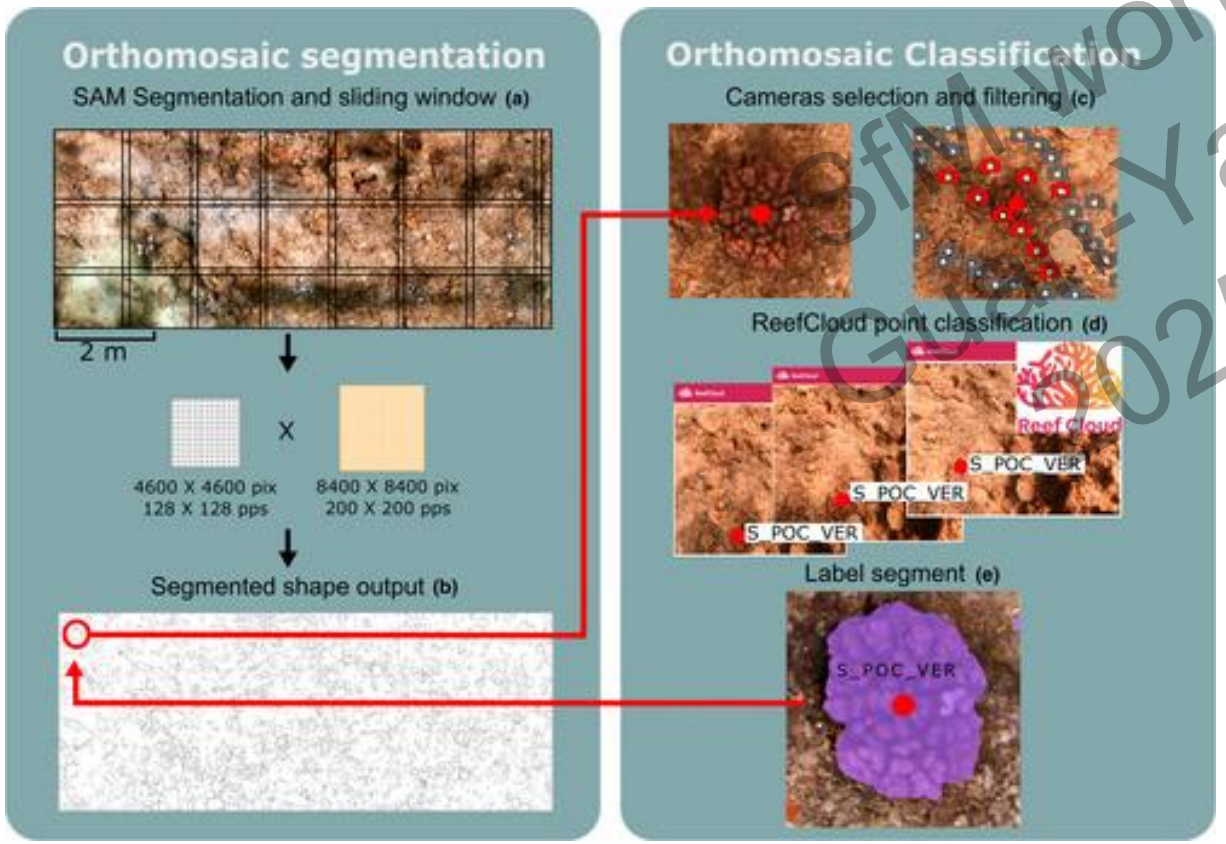
RESEARCH ARTICLE | Open Access

RapidBenthos: Automated segmentation and multi-view classification of coral reef communities from photogrammetric reconstruction

Tiny Remmers, Nader Boutros, Mathew Wyatt, Sophie Gordon, Maren Toor, Chris Roelfsema, Katharina Fabricius, Alana Grech, Marine Lechene, Renata Ferrari

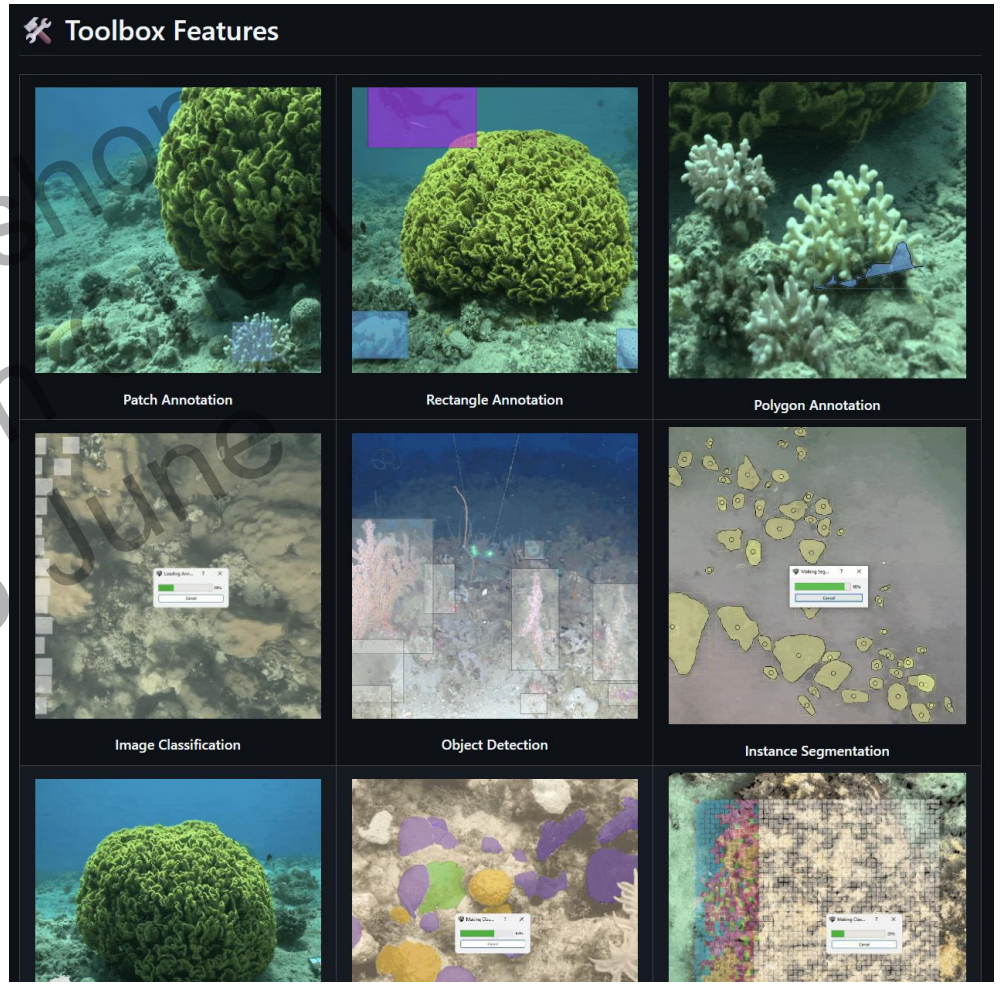
First published: 26 December 2024 | https://doi.org/10.1111/2041-210X.14477 | Citations: 1

Handling Editor: Chloe Robinson



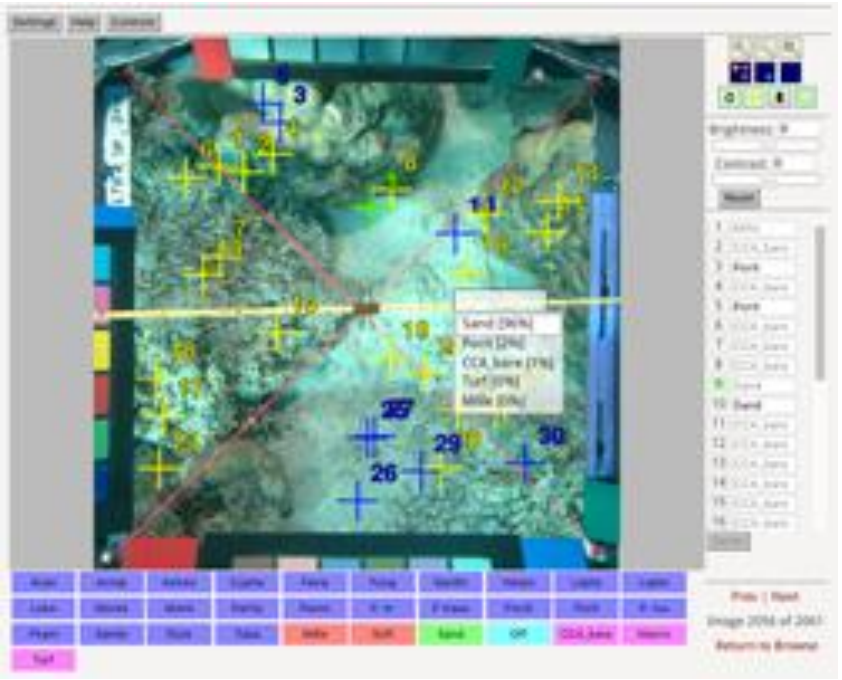
Product Solutions Resources Open

Jordan-Pierce / CoralNet-Toolbox Public



[GitHub - Jordan-Pierce/CoralNet-Toolbox: Tools for annotating and developing ML models for benthic imagery]

My solution: SAM + CoralNet + GIS



Dropbox

Your Dropbox account where the images to be annotated are stored.

1.) You upload the image(s) of interest to a Dropbox account.

2.) You then submit a request to the source for the image(s) to be annotated with the specific sparse labels.

3.) The source downloads the image(s), and provides sparse labels where you requested.

CORALNET BETA

A WEB SOLUTION FOR CORAL REEF ANALYSIS

The CoralNet classifier (i.e. 'source')

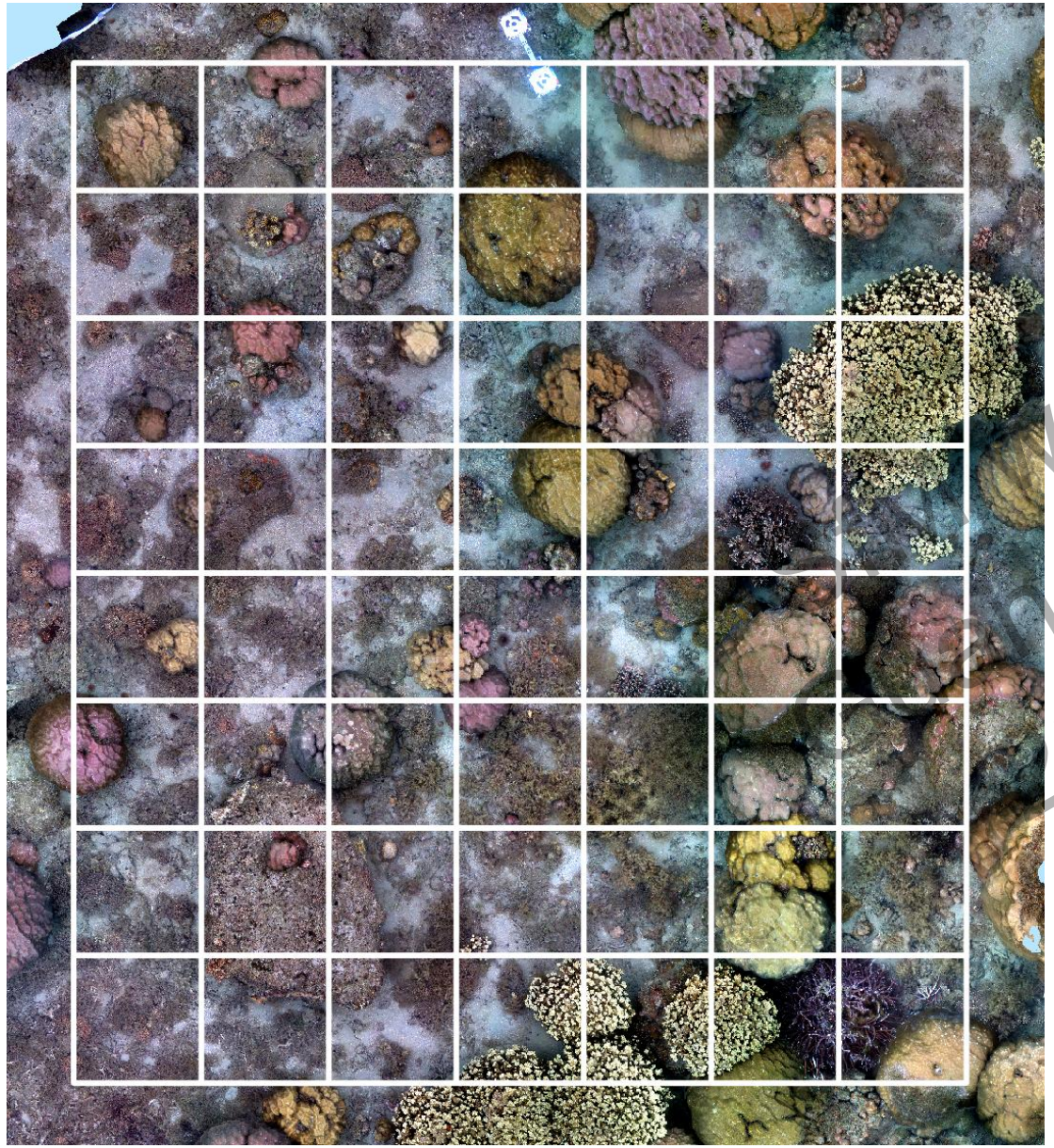
4.) The source sends back the annotations for the given image(s).

(You as anime_irl)

5.) You obtain the annotations and convert them into a .csv file on your local machine.

https://github.com/JordanMakesMaps/CoralNet-API

6*6m plot , 60*60cm grid, 12*12 points
Points at the center of 5cm grid



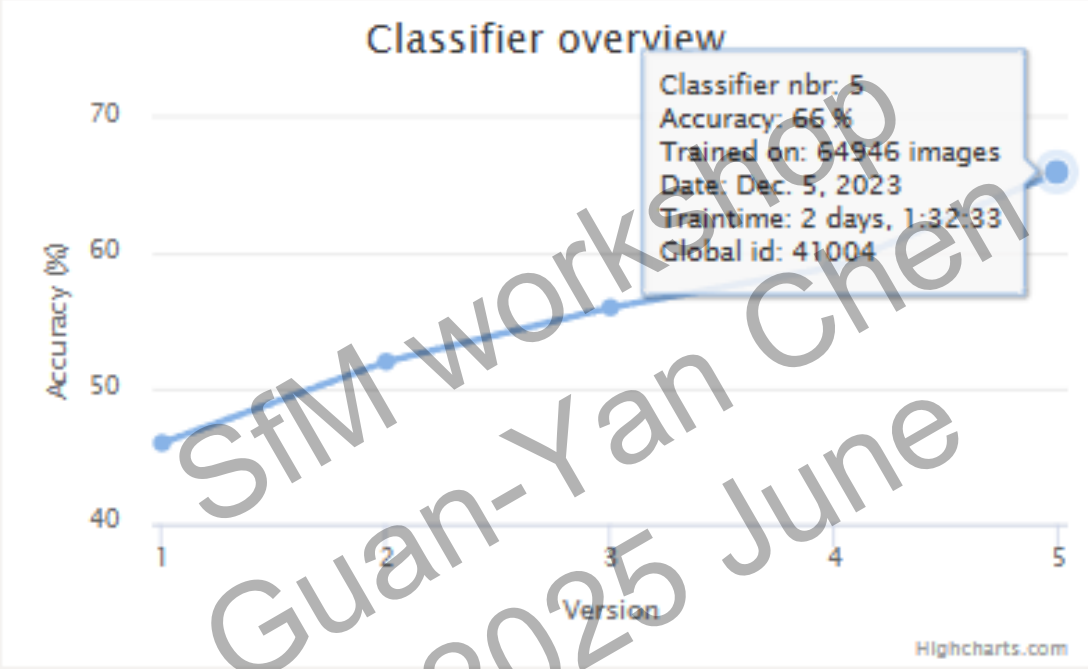
DESCRIPTION

NMMBA CoralLab

AFFILIATION & MEMBERS

NMMBA

ChenGuanYan	**Admin**
Claire	**Admin**
coo987coo987	**Admin**
fuwen	**Admin**
lamkwlouis	**Admin**
Samuel	**Admin**
smerk	**Admin**
tony83111	**Admin**
tting	**Admin**
vickyyuchi	**Admin**
xuanci	**Admin**
Zheng-Qun-Xue	**Admin**
asdf63348	**Edit**
Frank31415926	**Edit**
Jaylin	**Edit**
LEO	**Edit**
raytarn	**Edit**



Last classifier saved: Dec. 5, 2023, 1:56 a.m.

Last classifier trained: Dec. 5, 2023, 1:56 a.m.

Feature extractor: VGG16 (legacy)

Confidence threshold: 100%

To see backend-job status, go here.

IMAGE STATUS

Unclassified: 0

Unconfirmed: 6858

Confirmed: 67036

Total images: 73894

DETAILS

Visibility: Private

Point generation method: Stratified random, 5 rows x 5 columns of cells, 2 points per cell (total of 50 points)

Default image annotation area:
X: 5 - 95% / Y: 5 - 95%

Latitude & Longitude:
22.34178, 120.3725

Created: Oct. 7, 2019

LABELSET

This labelset has 109 labels:

Name	Short Code	Functional Group
CRED-Acanthastrea spp	Acnth	Hard coral
CRED-Acropora spp_branching	Acro(b)	Hard coral
CRED-Acropora spp_tabulate	Acro(t)	Hard coral
CRED-Astreopora spp	Astre	Hard coral
Bleached Acropora	BAcro	Hard coral
Bleached Dipsastraea	BDipsa	Hard coral
Bleached Favites	BFavites	Hard coral
Bleached Hard Coral	BHC	Hard coral
Bleached Lobophyllia sp.	BLobo	Hard coral
Bleached Merulina	BMeru	Hard coral
Bleached Montipora	BMonti	Hard coral
Favidae-Mussidae massive/meandroid Bleached	BPlaty	Hard coral
Bleached Pocillopora	BPoci	Hard coral
Bleached Porites	BPorit	Hard coral
CRED-Branching hard coral	Bra_Hcoral	Hard coral
Bleached Seriatopora	BSeri	Hard coral
Bleached Stylophora pistillata	BStylo	Hard coral
Caulastrea	Caula	Hard coral
CRED-Columnar hard coral	CHcoral	Hard coral
CRED-Coscinaraea spp	Cosci	Hard coral
CRED-Cyphastrea spp	Cypha	Hard coral
CRED-Diploastrea spp	Diploa	Hard coral
Dipsastraea	Dipsa	Hard coral
CRED-Echinophyllia spp	Echinophy	Hard coral
CRED-Echinopora spp	Echinopora	Hard coral
CRED-Encrusting hard coral	EHcoral	Hard coral
CRED-Euphyllia spp	Euphyllia	Hard coral
CRED-Favites spp	Favites	Hard coral
CRED-Foliose hard coral	FHcoral	Hard coral
CRED-Free-living hard coral	Free	Hard coral
CRED-Fungia spp	Fungia	Hard coral
CRED-Galaxea spp	Galaxea	Hard coral
CRED-Goniastrea spp	Goniastrea	Hard coral
CRED-Goniopora/Alveopora spp	Gonio	Hard coral
CRED-Heliopora spp	Helio	Hard coral
CRED-Hydnophora spp	Hydno	Hard coral
CRED-Isopora spp	Iso	Hard coral
CRED-Leptastrea spp	Lepta	Hard coral
CRED-Leptoseris spp	Lepto	Hard coral
CRED-Leptoria spp	Leptoria	Hard coral
Lithophyllon	Litho	Hard coral
CRED-Lobophyllia spp	Loboph_HC	Hard coral
CRED-Merulina spp	Meru	Hard coral
CRED-Massive hard coral	MHcoral	Hard coral
CRED-Millepora spp	Mille	Hard coral
CRED-Montastraea spp	Montas	Hard coral
CRED-Montipora spp_branching	Monti(b)	Hard coral
CRED-Montipora spp_encrusting	Monti(e)	Hard coral
CRED-Montipora spp_foliose	Monti(f)	Hard coral
Mycedium	Myce	Hard coral
Other scleractinians	Other_HC	Hard coral
CRED-Oulophyllia spp	Oulo	Hard coral
Oxypora	Oxyp	Hard coral
CRED-Pachyseris spp	Pachy	Hard coral
CRED-Pavona spp_encrusting	Pavo(e)	Hard coral
CRED-Pavona spp_foliose	Pavo(f)	Hard coral
CRED-Pavona spp_massive	Pavo(m)	Hard coral
CRED-Phymastrea spp	Phymas	Hard coral
Physogyra	Physo	Hard coral
CRED-Platygyra spp	Platy	Hard coral
CRED-Plerogyra spp	Plero	Hard coral
CRED-Pocillopora spp	Poci	Hard coral
CRED-Porites spp_branching	Porites(b)	Hard coral
CRED-Porites spp_massive	Porites(m)	Hard coral
CRED-Psammocora spp	Psammo	Hard coral
Scapophyllia	Scapo	Hard coral
Seriatopora	Seria	Hard coral
CRED-Stylophora spp	Stylo	Hard coral
CRED-Stylophora spp	Stylo	Hard coral
CRED-Symphyllia spp	Sym	Hard coral
Tubastraea coccinea	Tubas	Hard coral
CRED-Turbinaria spp	Turbi	Hard coral
CRED-Anemone	Anemone	Other Invertebrates
Bleached Heliopora	BHelio	Other Invertebrates
CRED-Bivalve	Biva	Other Invertebrates
Millepora bleached	BMille	Other Invertebrates
Briareum	Briare	Other Invertebrates
Soft Bleached	BSC	Other Invertebrates
CRED-Corallimorph	Coralmorph	Other Invertebrates
CRED-Giant clam	Giant clam	Other Invertebrates
Gorgoniidae	Gorgo	Other Invertebrates
CRED-Hydrocoral	Hydrocoral	Other Invertebrates
Junceella	Junc	Other Invertebrates
Lobophytum	Lobophy_SC	Other Invertebrates
Nephthya	Nephthya	Other Invertebrates
CRED-Octocoral	Octocoral	Other Invertebrates
CRED-Unclassified soft coral	Other_SC	Other Invertebrates
Sarcophyton	Sarco	Other Invertebrates
Echinoderms: sea urchin	Sea urchin	Other Invertebrates
Sinularia	Sinu	Other Invertebrates
CRED-Sponge	Sponge	Other Invertebrates
Zoanthids	Zoan	Other Invertebrates
CRED-Fine sediment	Fine	Soft Substrate
CRED-Sand	Sand	Soft Substrate
CRED-CCA growing on hard substrate	CCA_HS	Hard Substrate
CRED-CCA growing on rubble	CCA_rubble	Hard Substrate
CRED-Hard substrate	HS	Hard Substrate
CRED-Turf growing on hard substrate	Turf_HS	Hard Substrate
CRED-Turf growing on rubble	Turf_rubbl	Hard Substrate
CRED-Mobile fauna	M fauna	Other
CRED-Shadow	Shadow	Other
Transect hardware	Transect	Other
CRED-Unclassified/Unknown	Un	Other
CRED-Blue-green macroalga	BG_macro	Algae
CRED-Blue-green macroalga	BG_macro	Algae
CRED-Brown macroalgae	Bro_macro	Algae
EAM: Dead Hard Coral	Dead_HC	Algae
CRED-Green macroalgae	G_macro	Algae
CRED-Encrusting macroalgae	Macro(e)	Algae
CRED-Upright macroalgae	Macro(up)	Algae
CRED-Red macroalgae	R_macro	Algae

```
HTTP 200 OK
Allow: GET, HEAD, OPTIONS
Content-Type: application/vnd.api+json
Vary: Accept
```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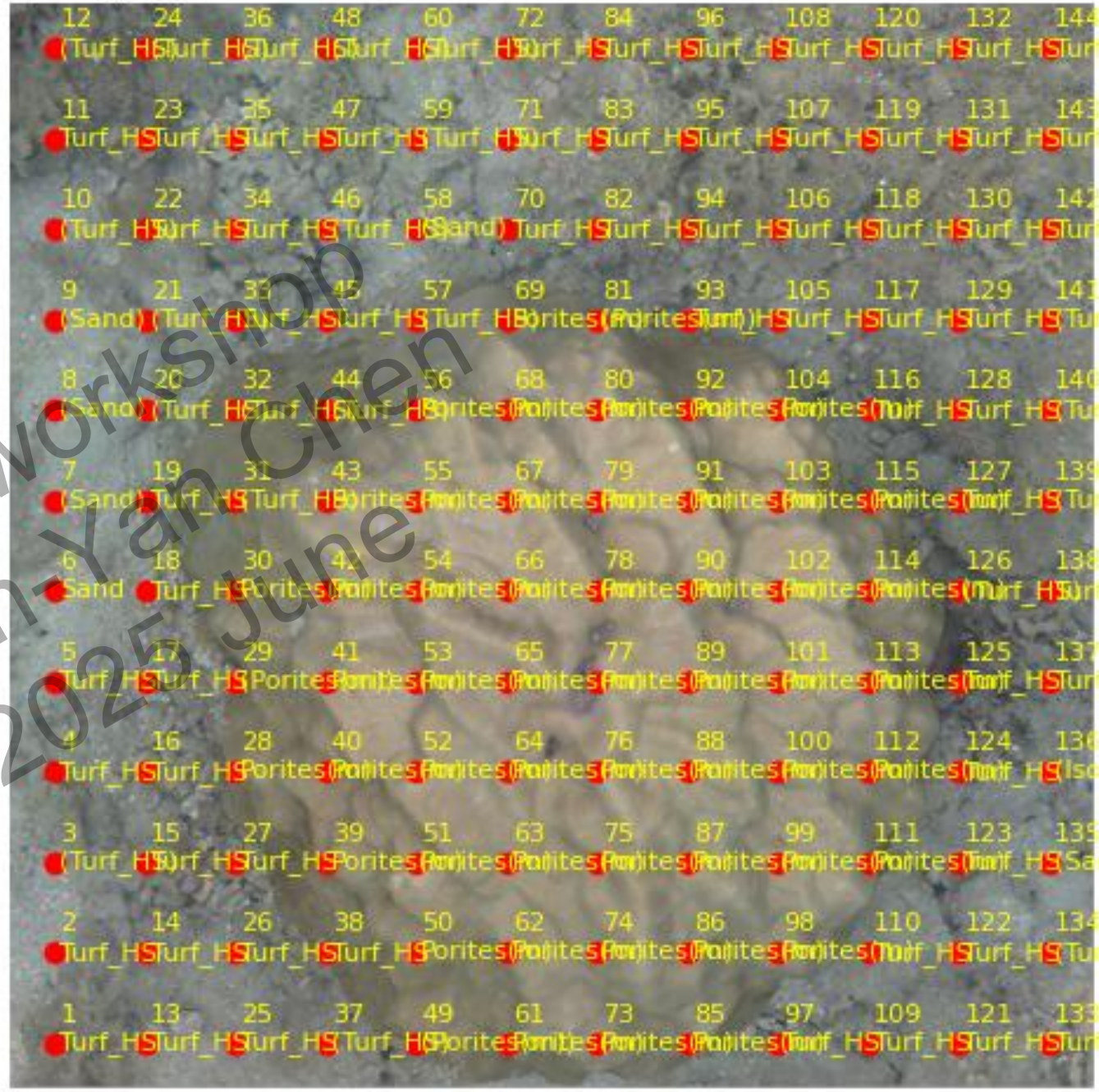
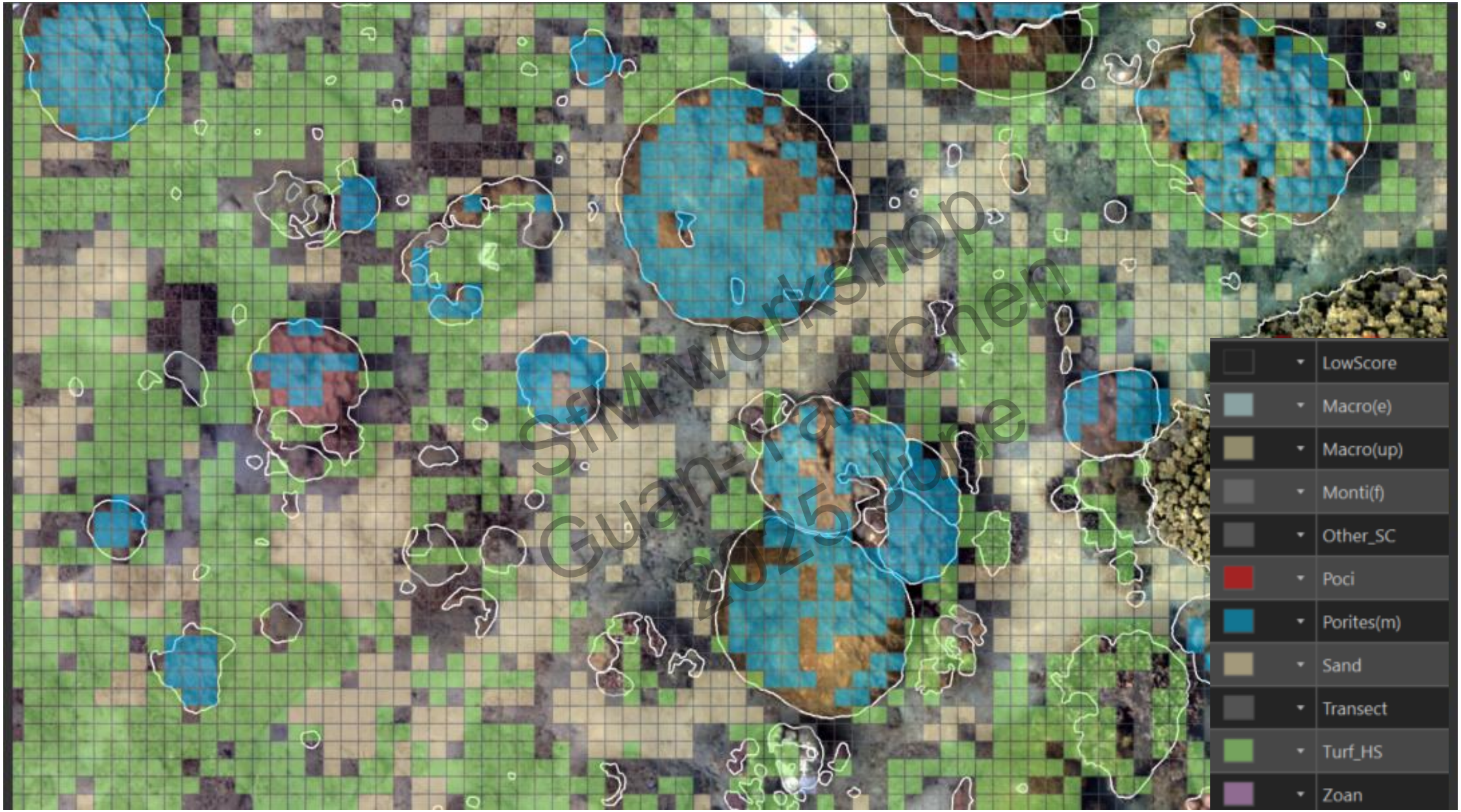
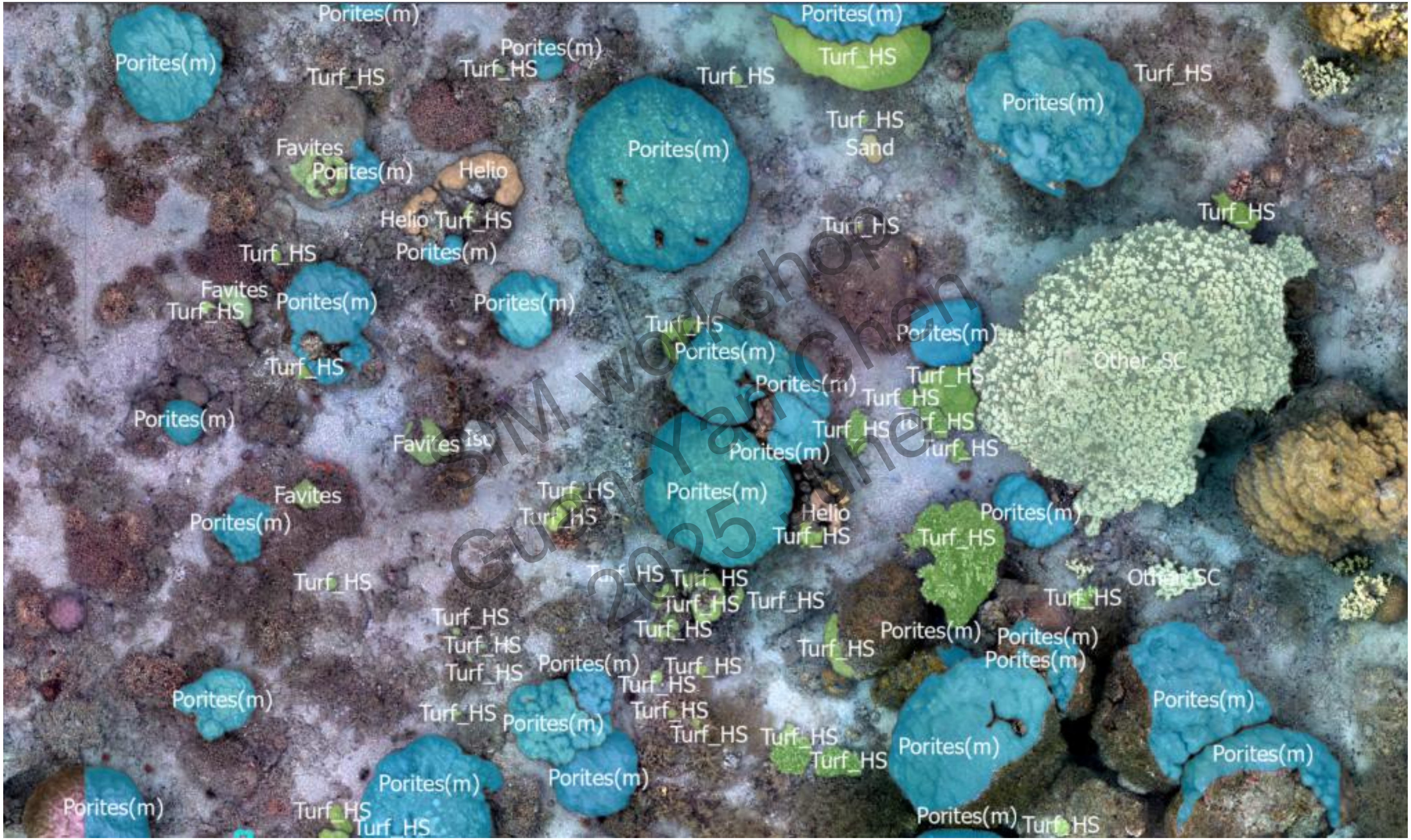
```


Image IL_P4_22050.PNG with Points and CoralNet Classification



解釋用SAM的圈選結果統計多數的 改善預測





Reflecting on challenges & integrating local communities

yahoo! 新聞

CTWANT | 49.9k 人追蹤 ☆ 追蹤

宜蘭豆腐岬珊瑚礁「被插6根營釘」潛水客怒緝凶 真相竟是海保署

周刊王CTWANT |中國時報吳佩蓉

2022年6月8日

日前有潛水客發現宜蘭縣蘇澳鎮豆腐岬的珊瑚礁上插有6根營釘，憤而PO文請大家一起緝凶，網友們怒批真是劣質潛水客；經查海洋保育署是「凶手」，為進行珊瑚監測計畫而釘的。（圖／民眾提供）

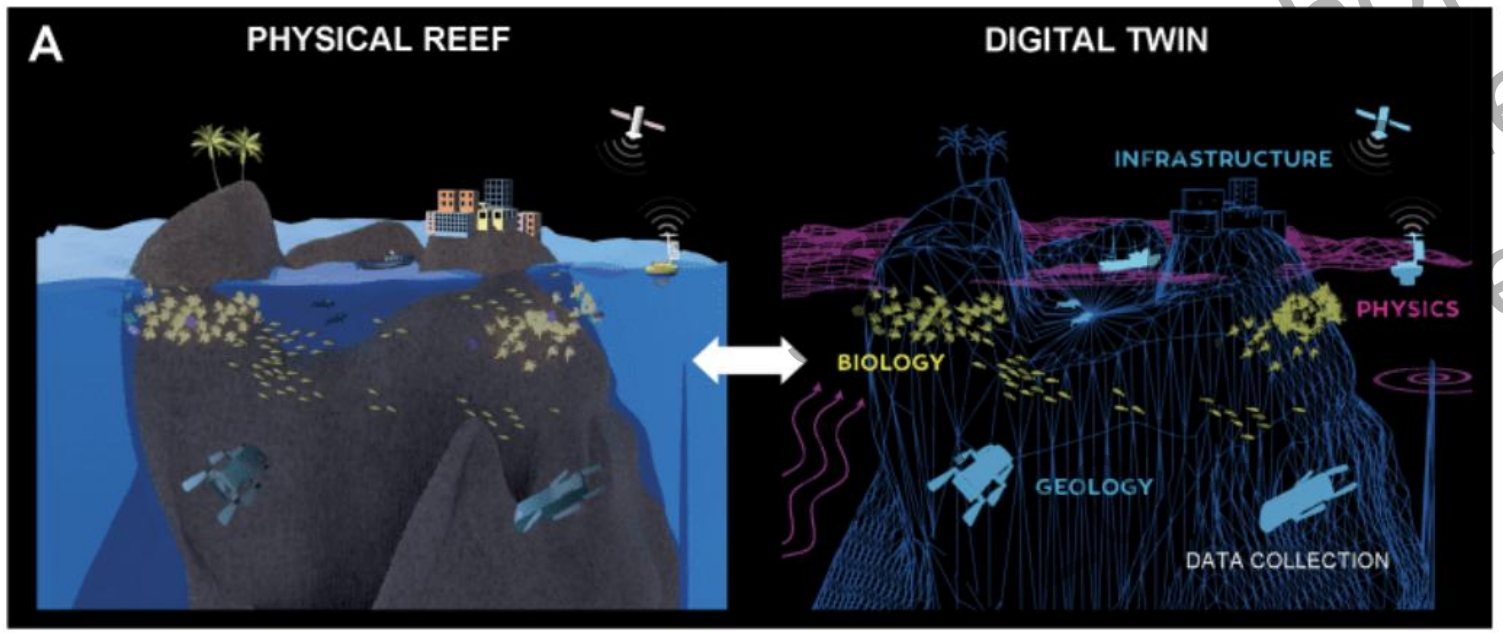
Show locals why surveys are needed and marketing our research better

Future work

Integrate with soundscapes, fish, environmental variables for understand ecological systems better

WOODS HOLE OCEANOGRAPHIC INSTITUTION

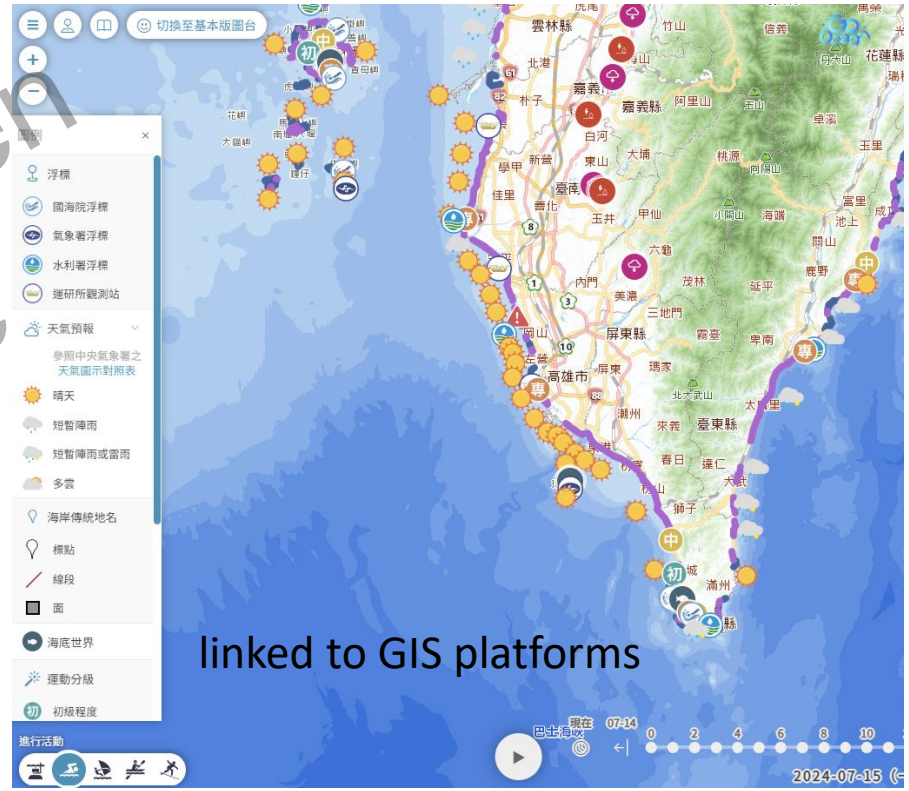
Digital-twin project



The Coral Reef Digital Twin is a virtual representation of a real reef, with all its features, consistently updated with new data from sensors and satellites. The digital twin allows users access to the dynamic, 3-dimensional system from a laptop or cellphone anywhere in the world to get real-time the information needed for sustainable harvesting of reef resources. Image credit: Cohen Lab © Woods Hole Oceanographic Institution

https://www.whoi.edu/press-room/news-release/digital-reefs-awarded-5-million/

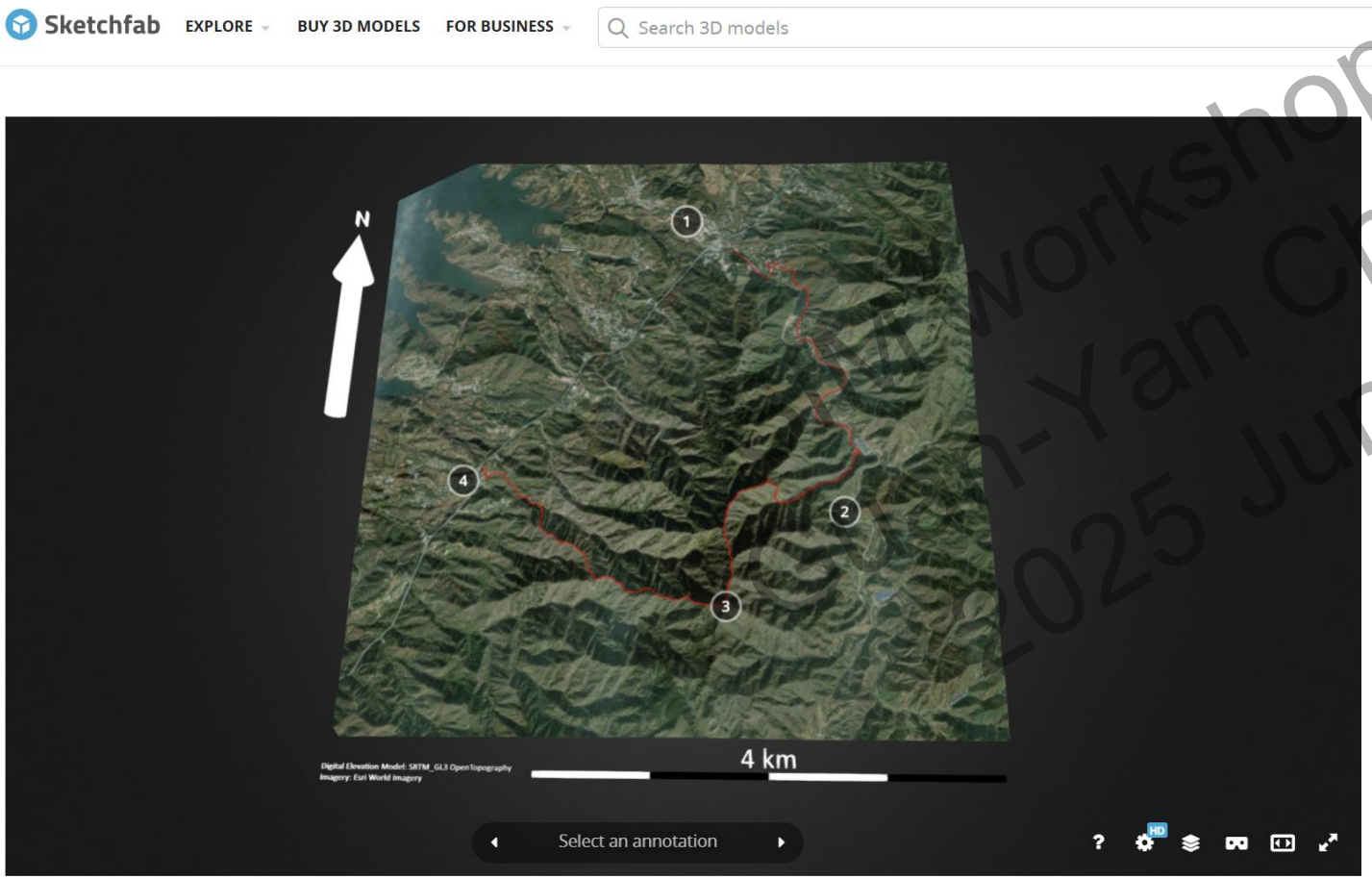
https://goocean.namr.gov.tw/Main/

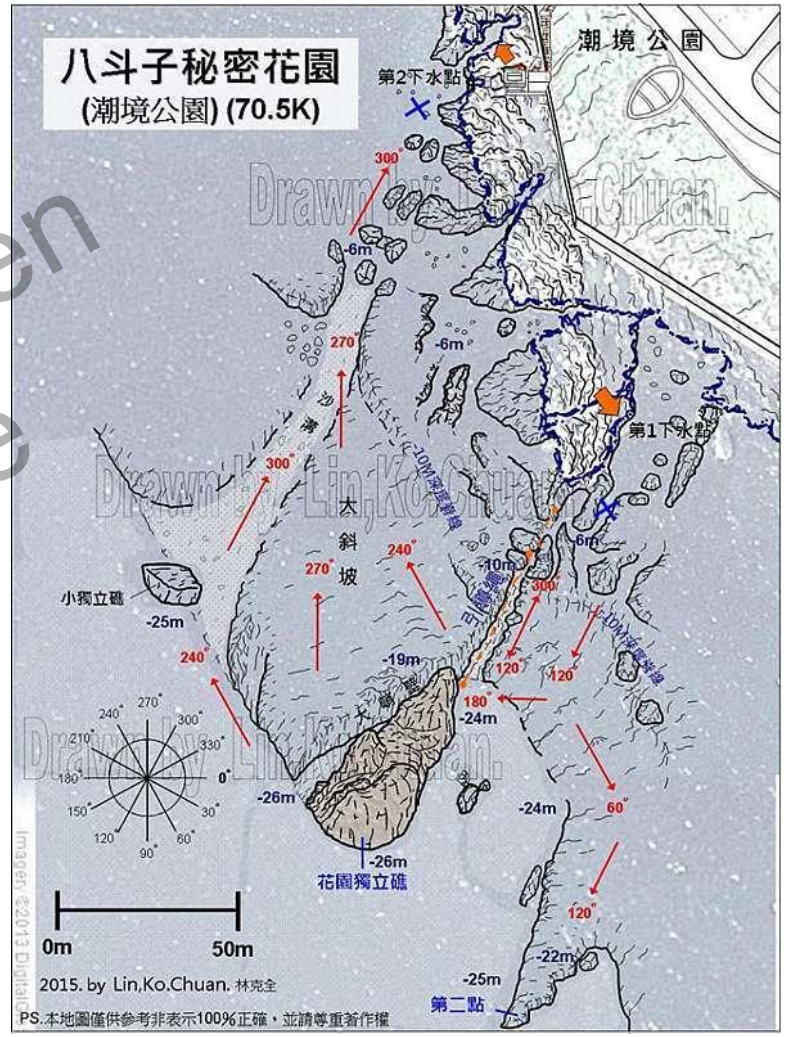


國家海洋研究院
National Academy of Marine Research

How can we utilize underwater 3D reef data? (Ideas please!)

More ideas: underwater 3D dive map

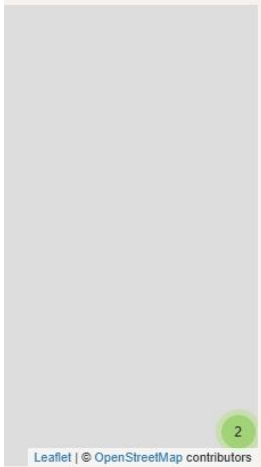


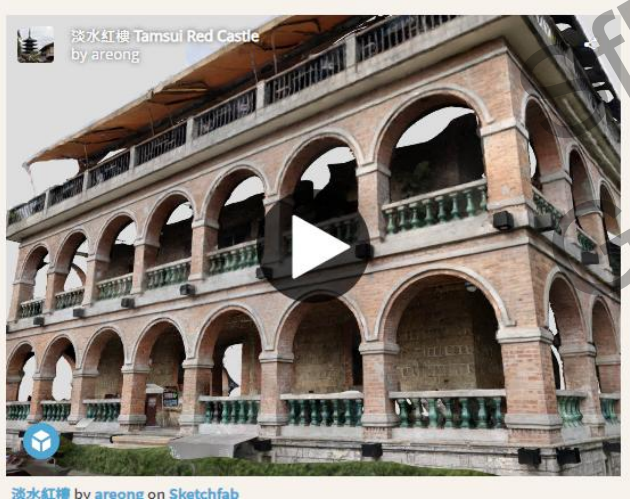


More ideas: conservation of natural landscapes

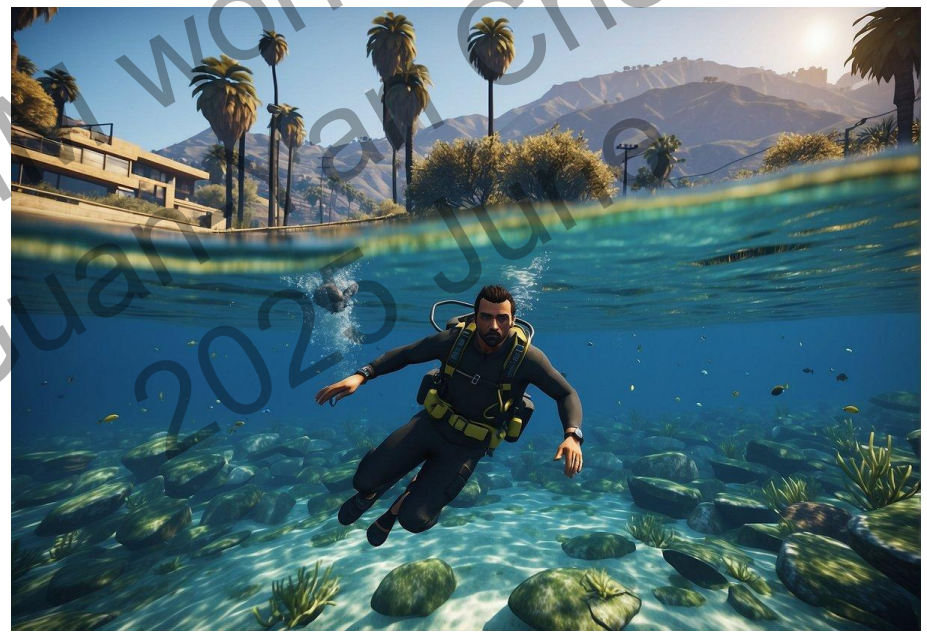
台灣文化資產3D保存計畫

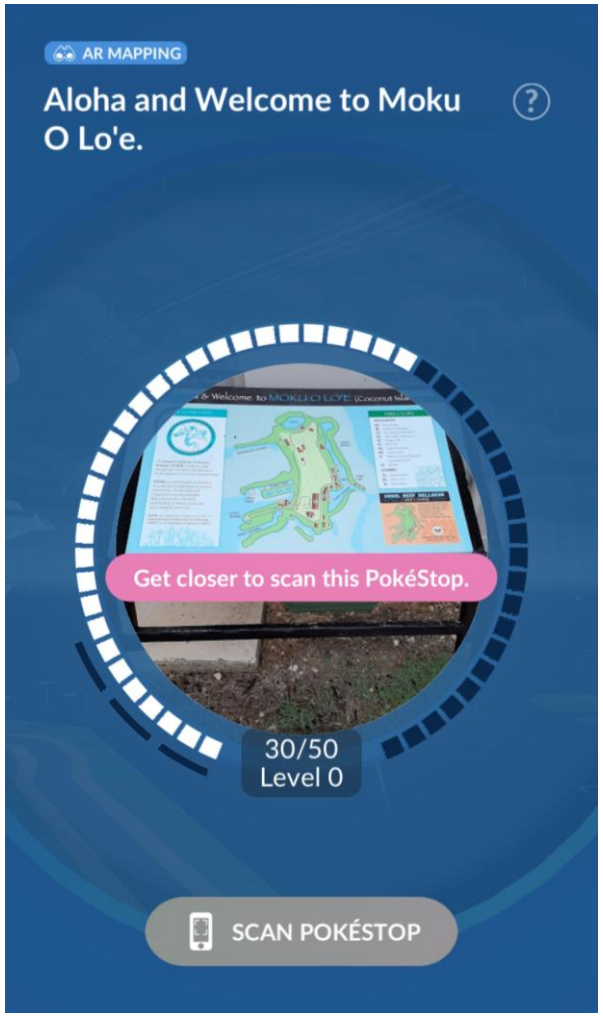
https://areong.github.io/taiwan-culture-3dscan/?utm_source=chatgpt.com





More ideas: gaming & film industries





Q & A

SfM workshop
Guan-Yan Chen
2025 June