

Introduction

1. Why do I want to study Oyster shell ?

The cultured oyster industry in Taiwan generates an annual revenue ranging from NT\$ 40 - 60 billion (Fig. 1). One of the primary threats to oyster cultivation is marine pollution, with substances like TBT being particularly harmful. Consequently, any factors that impact the growth and survival of oysters have the potential to significantly disrupt this lucrative business.

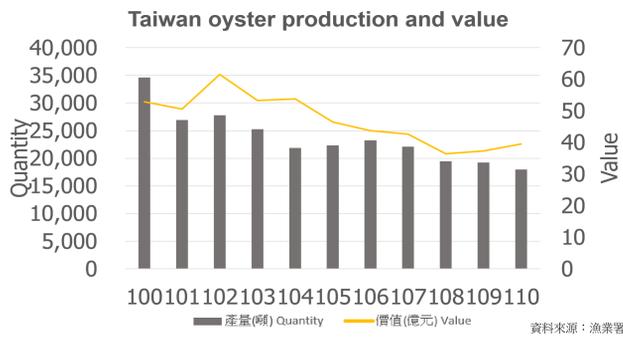


Fig. 1. Taiwan oyster production and value. Year after year, both the quantity and the overall value of the oyster production are steadily declining.

2. Application Of Tributyltin

Tributyltin (TBT) is an organotin compound. It's used to prevent organism growth on boat hulls (Fig. 2). TBT is a significant aquatic pollutant due to its use in marine paint. The global ban on TBT in boats happened in 2008, with Taiwan enforcing it in 2005 (Table 1).

Table 1 Restrictions on TBT in Taiwan

boat size years	> 24m	< 24m
2003	✓	✗
2005	✗	✗



Fig. 2. In the absence of TBT usage, the hull tends to accumulate a multitude of organisms.

3. Oyster deformation as an indicator of marine environmental pollution

TBT pollution leads to chambering, causing shells to become fragile and exhibit abnormal characteristics. It's noteworthy that a higher concentration of TBT correlates with a lower STI value (Table 2). This can be quantified using the Shell Thickness Index (STI).

Table 2 The link between STI and TBT pollution

Sample	STI	TBT
PdSx1	3	2.1
PdSx2	3.7	0.55
SVCx1	6.4	0.15
SVCx2	6.5	0.12

(L. Di 'az a, 2007)

Shell Thickness Index (STI) $STI=L/T$

(L: Length of the left valve; T: Thickness of the left valve)

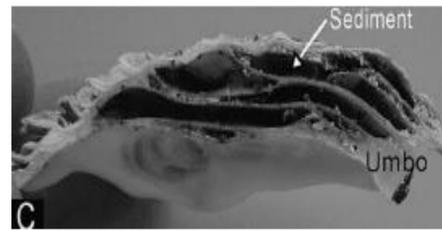


Fig. 3. The STI of *C. gigas* falls between 5 and 10, and it still possesses chambers.

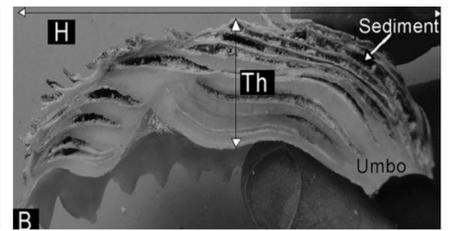


Fig. 4. The STI of *C. gigas* less than 5, it possesses many chambers.

Material

Shell collection site

The sampling point of this experiment is Qigu, Tainan. As the closest land breeding area, it is easily affected by changes in land nutrients (Fig. 5).

In prior publications, Tainan's water quality has consistently received excellent ratings. Notably, among the areas surveyed in Table 3, Anping stands out with the lowest score of 0.8.



Fig. 5. The total samples and Qigu, Tainan.

Table 3 Various estimated target hazard quotients (THQs) for metals and TBT caused by consuming oysters for general population and fisherman in Taiwan

Exposure group	Location	Maximally exposed individuals					Typically exposed individuals				
		TBT	Cu	Zn	Cd	Inorganic As	TBT	Cu	Zn	Cd	Inorganic As
General population	Taiwan area	0.76	2.45	1.12	1.50	1.53	0.10	0.33	0.15	0.20	0.21
Fishermen	Hsiangshan	3.87	20.5	3.87	1.65	2.97	1.47	7.69	1.47	0.61	1.06
	Lukang	2.13	5.68	2.03	1.73	3.24	0.80	2.12	0.76	0.66	1.11
	Taishi	1.00	2.84	1.35	1.76	4.19	0.40	1.06	0.51	0.66	1.47
	Putai	2.07	2.57	0.99	3.29	1.19	0.77	0.96	0.35	1.21	0.40
	Anping	0.80	10.7	6.26	3.60	2.41	0.30	4.05	2.38	1.36	0.91

https://reurl.cc/QZ6y7M

Methodology

1. Micro-CT

1. In past research, the shell-breaking method was mostly used for observation, and we want to try to make a breakthrough. Using a non-destructive method - micro-CT scanning (Fig. 6).



Fig. 6. The Micro-CT in Taichung Science Museum.

2. The Micro-CT principle is to shine X-rays on the sample, and then the sample rotates 360 degrees on the stage to capture images of the object (Fig. 7).

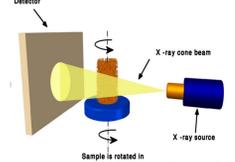
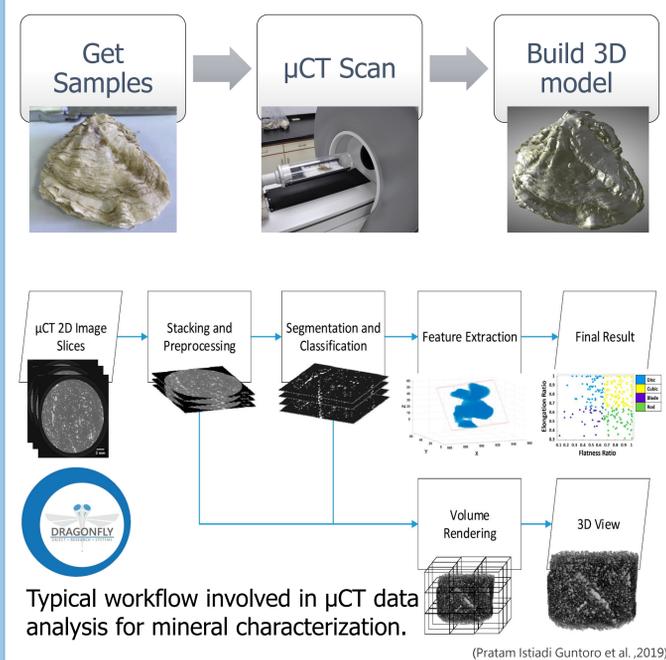


Fig. 7. Principle of the micro-computed tomography system.



2. Dragonfly ORS



Typical workflow involved in μCT data analysis for mineral characterization.

(Pratam Istiadi Guntoro et al., 2019)

Results

In the Chi 2 sample, distinct characteristics of the reconstructed shell have become apparent, including fold ribs (Fig. 8,9). Our initial observations suggest that the Shell Thickness Index (STI) falls within the range of 5 to 10, and the internal voids within the shell primarily consist of wormholes rather than genuine chambers (Fig. 10, 11, 12).



Fig. 8. The oyster sample.

Fig. 9. The oyster's shell.

Sample ID	Length (mm)	Width (mm)	Height (mm) Max-1	Max-2	Max-3	Height (mm) Min-1	Min-2	Min-3	Height (mm) Max average	Height (mm) Min average	standard error (max)	standard error (Min)	STI
chi2	84.77	59.17	10.56	11.25	12.83	2.09	1.92	2.62	11.55	2.21	1.16	0.37	7.34

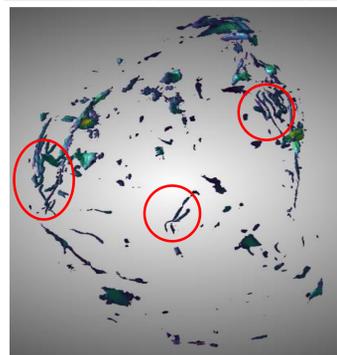


Fig. 10. The oyster's chambers.

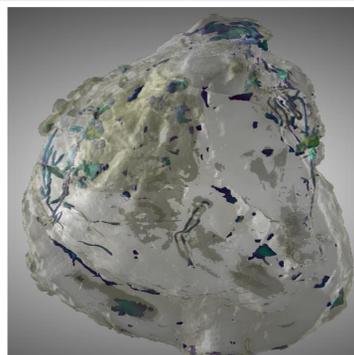


Fig. 11. The oyster's chambers with shell.

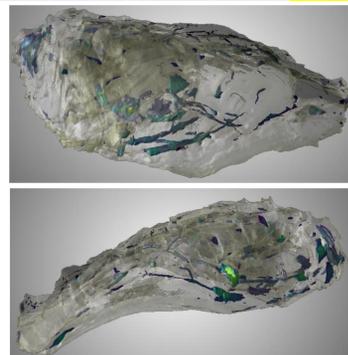


Fig. 12. both sides of the oyster's shelled chambers.

Discussion

In previous articles, I came across information that suggests when oysters are infested with *Polydora* (Fig. 13), their STI values tend to be less than 10.

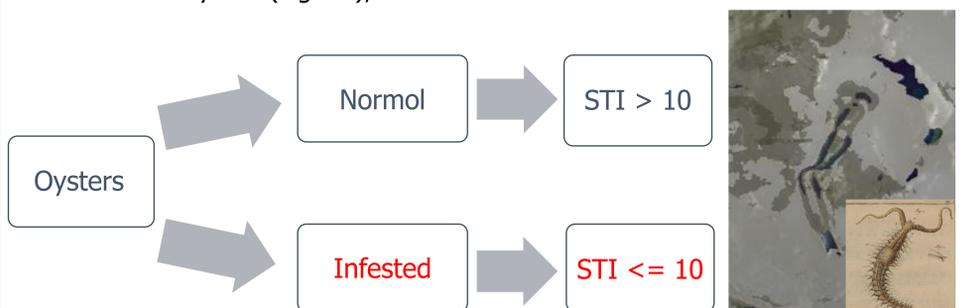


Fig. 13. *Polydora* and wormhole.

(Almeida, M. J., 1998)

Conclusion

1. The STI index is applicable for non destructive 3D micro CT analysis.
2. The chambering of Chi2 are dominantly caused by worm holes instead of TBT pollution.



Reference



Reconstruction



NTNU ES