

2026

MASTER 講堂

啟發思維 拓展視野



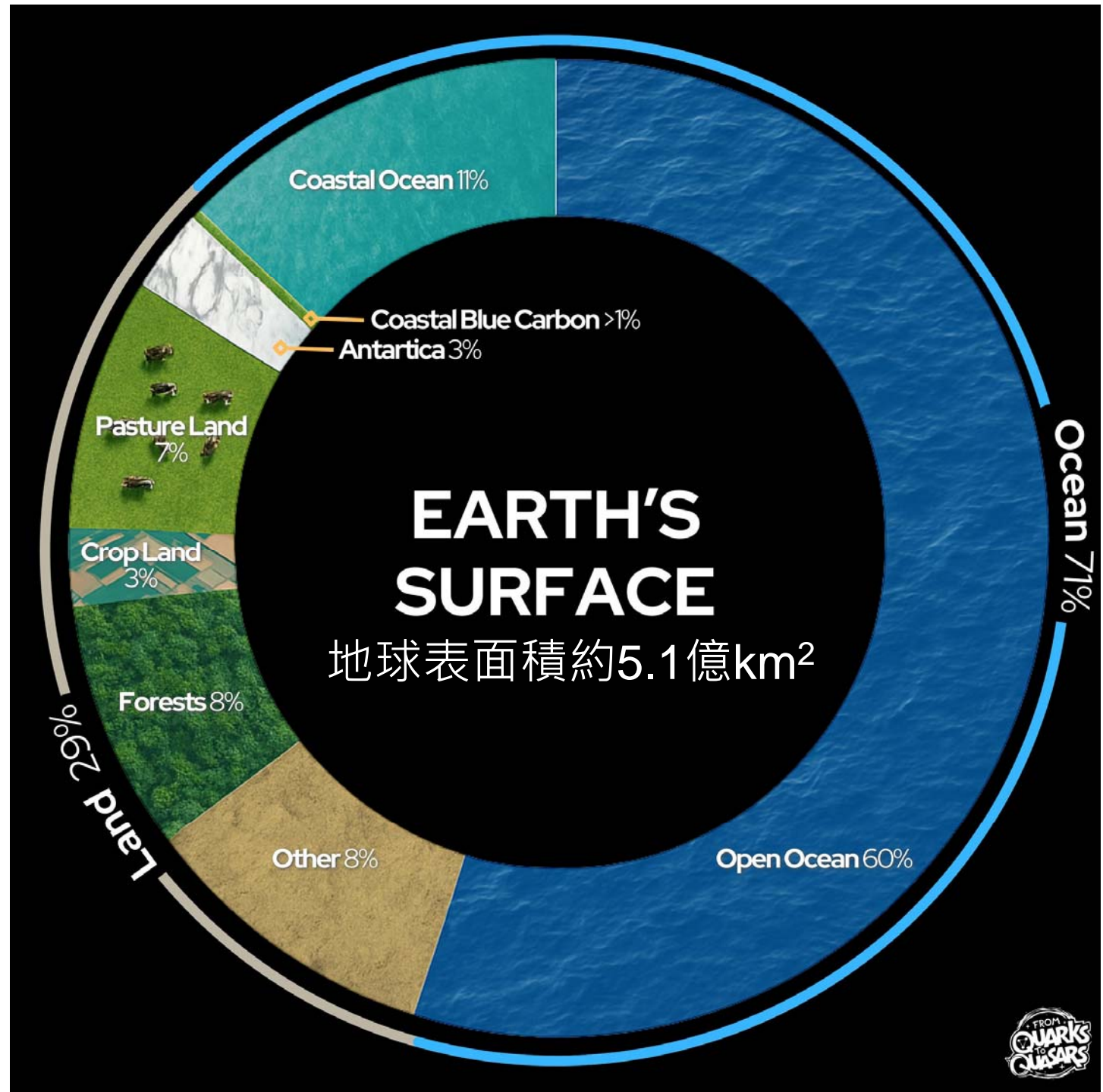
5.20 14:30-16:00

@ 臺大總圖書館 1 樓團體室

海洋連連看—海洋科學到
海洋保育的十萬八千里路

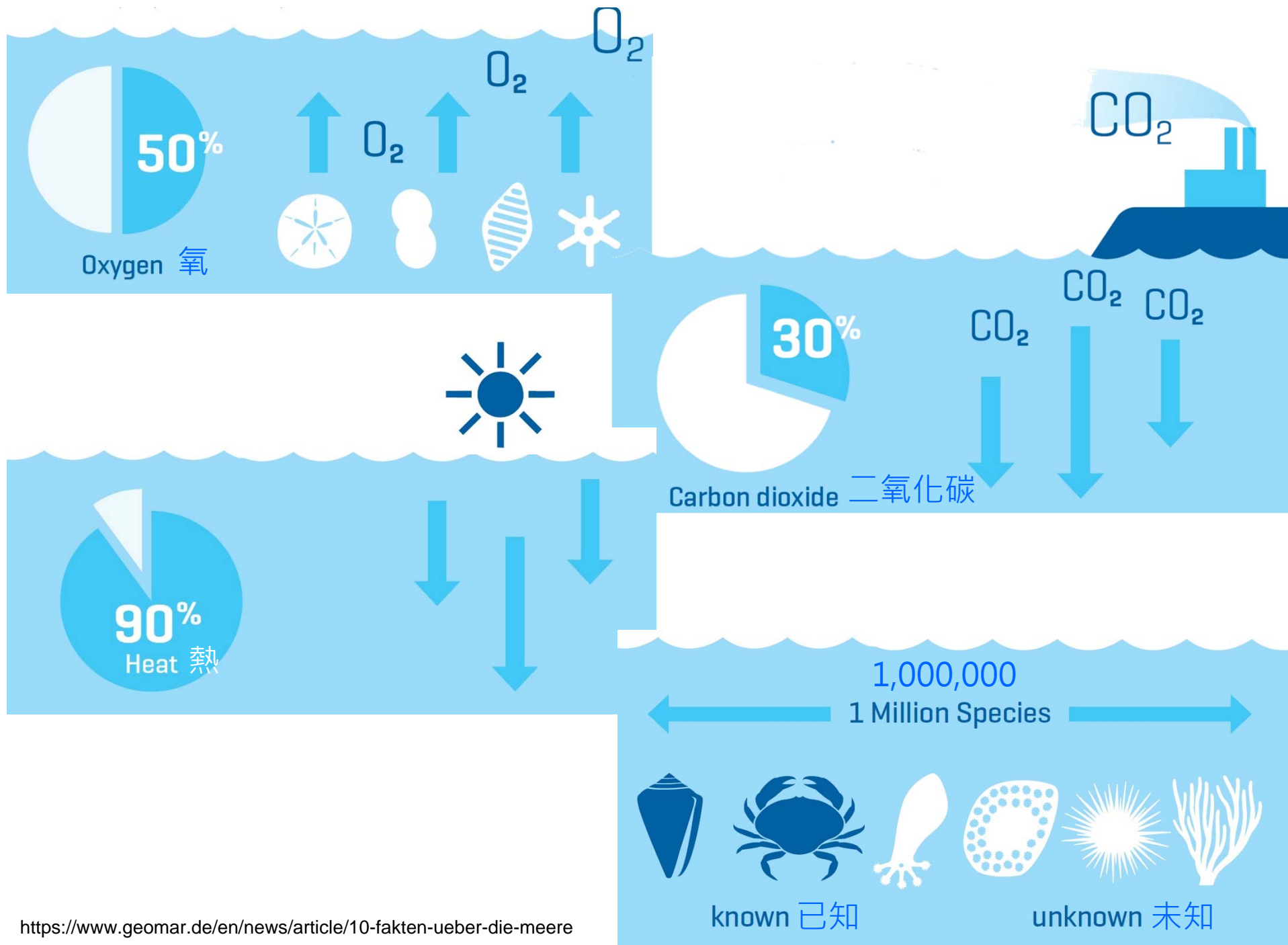
漁業科學研究所

柯佳吟 教授



<https://www.facebook.com/photo/?fbid=1214895700248360&set=a.1049801296757802>





海洋其實離我們很近



「你以為離海洋很遠，其實每天都活在海洋影響裡。」

海洋裡有什麼？

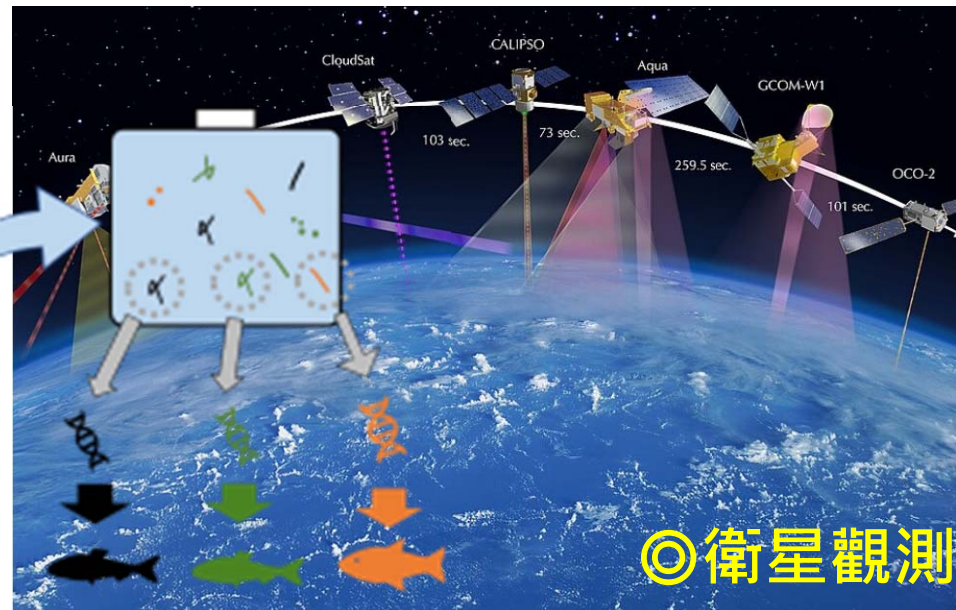




阿拉斯加灣海洋生態系
marine ecosystem in the Gulf of Alaska.

海洋科學家在做什麼？

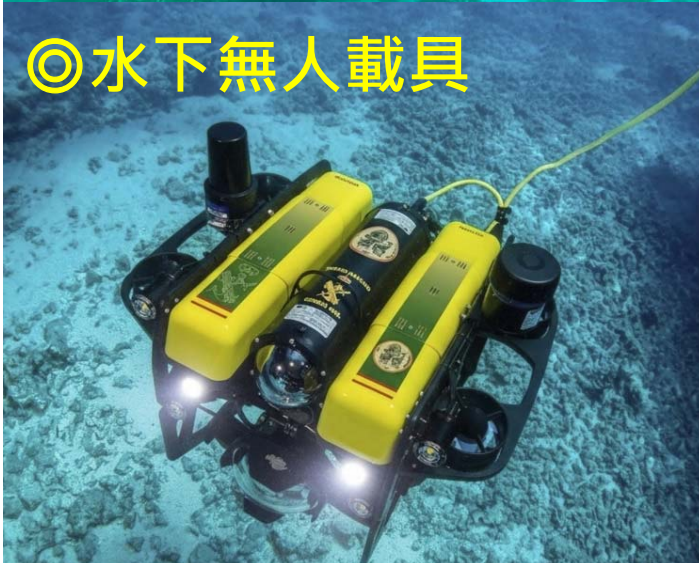
◎潛水調查



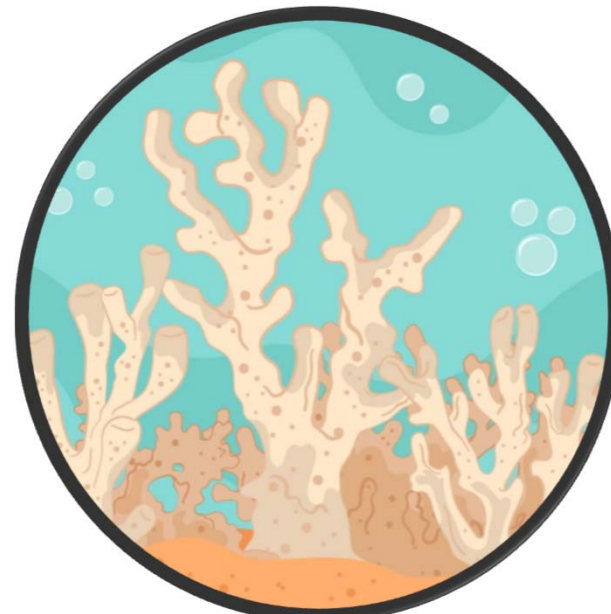
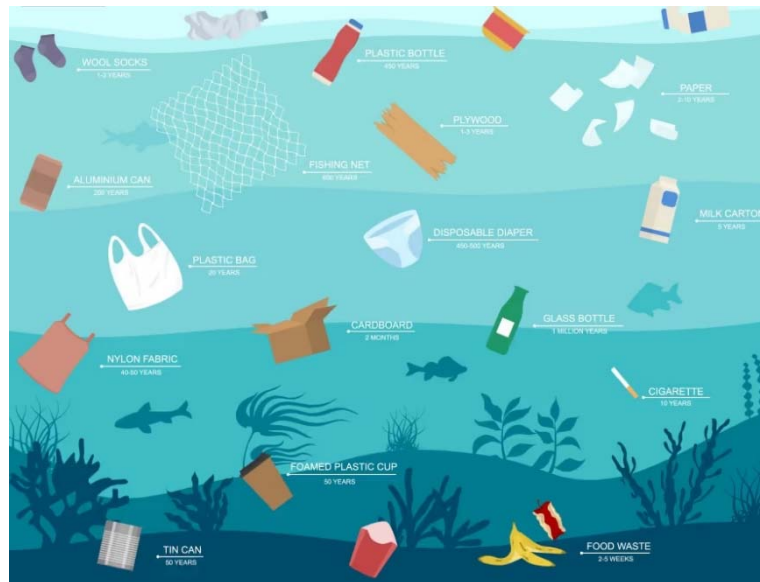
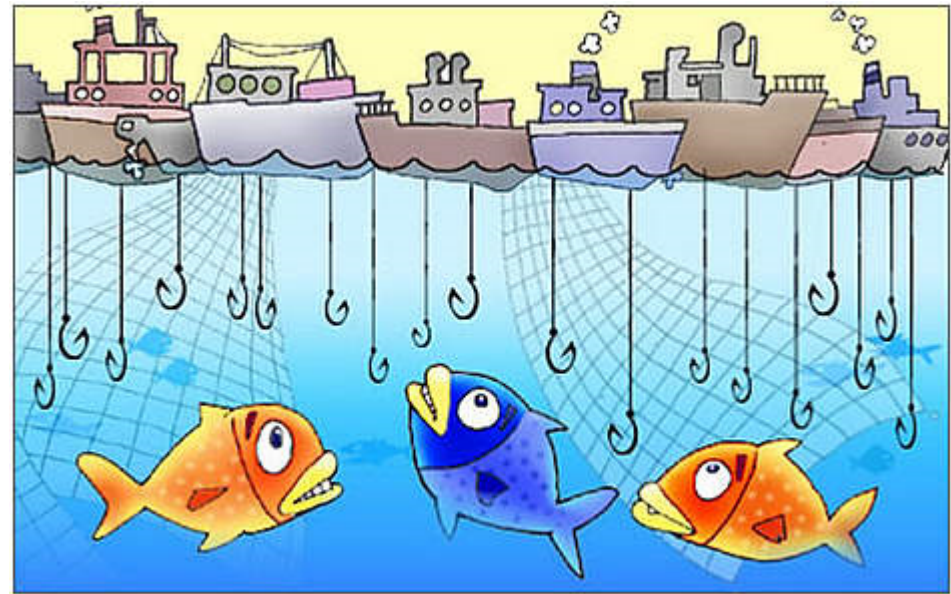
◎海洋調查船



◎水下無人載具



海洋正在發生什麼事？

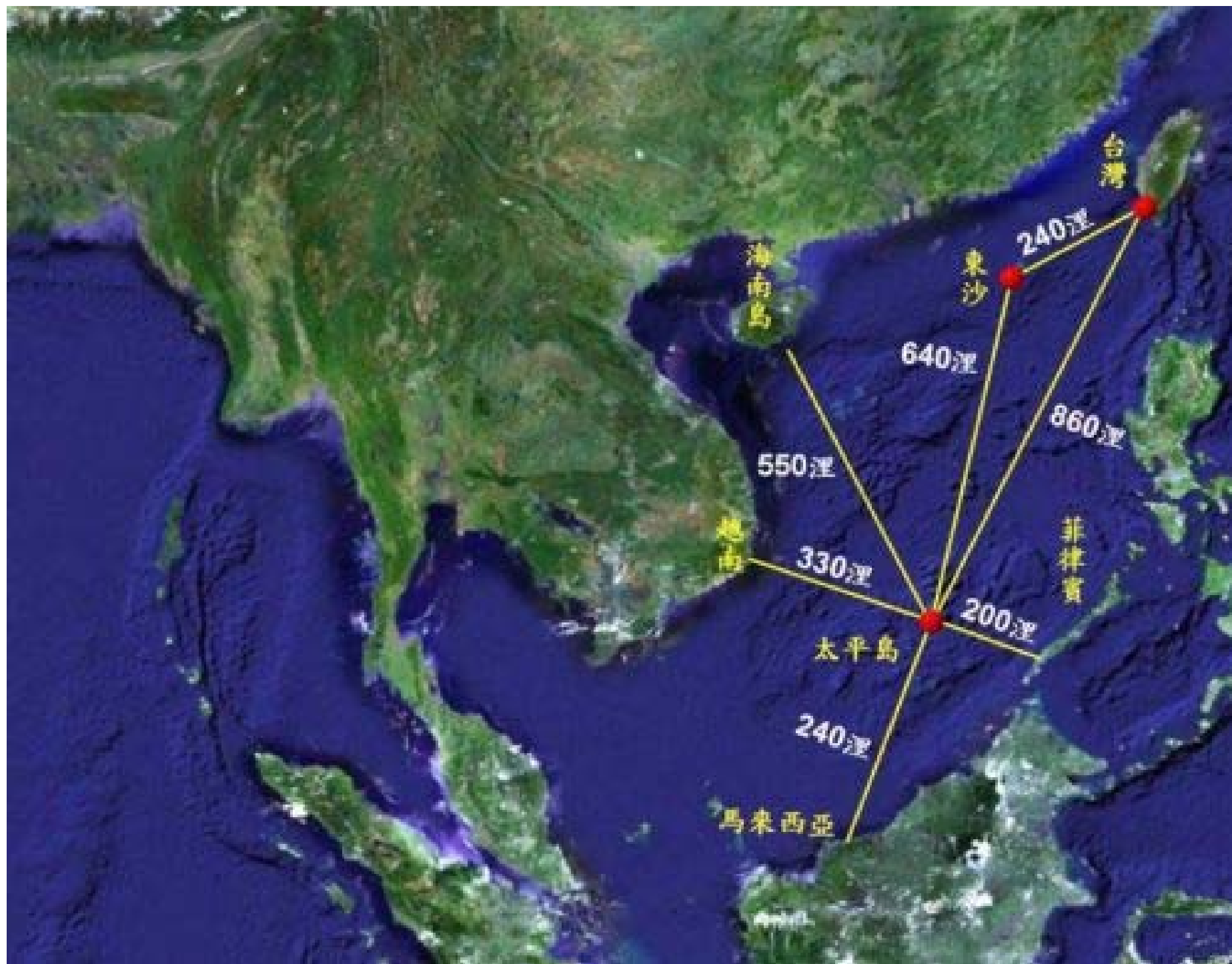


科學如何幫助海洋保育？

科學家有問題!

- 媽媽應該會幫小寶寶找到舒適涼爽的家?!















中華民國
南沙群島

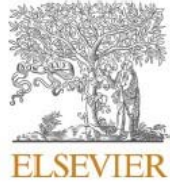
太平島











Natural shading is helpful but not sufficient for mitigating warming in green sea turtle nests in the tropical South China Sea[☆]

Tsung-Han Liu^{a,b}, Ming-Shiou Jeng^c, Chan-Yuan David Lee^a, Chih-Wei Tu^a, Po-Hsiung Lin^d,
Chaolun Allen Chen^c, Chia-Ying Ko^{a,e,*}

^a Institute of Fisheries Science, National Taiwan University, Taipei, Taiwan

^b Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan

^c Biodiversity Research Center, Academia Sinica, Taipei, Taiwan

^d Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan

^e Department of Life Science, Institute of Ecology and Evolutionary Biology, Master's Program in Biodiversity, Museum of Zoology, and Ocean Center, National Taiwan University, Taipei, Taiwan

ARTICLE INFO

Keywords:

Green sea turtle

Chelonia mydas

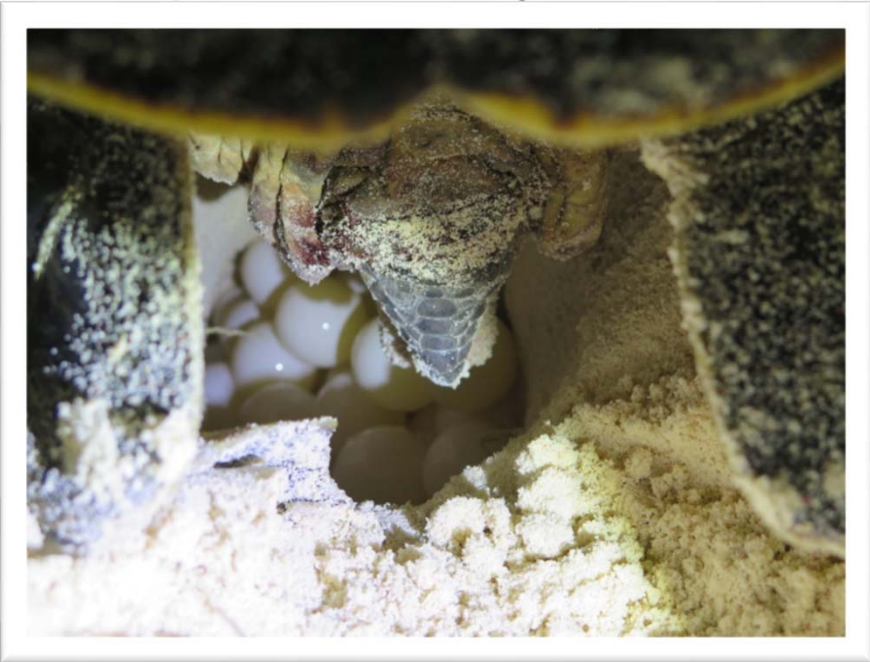
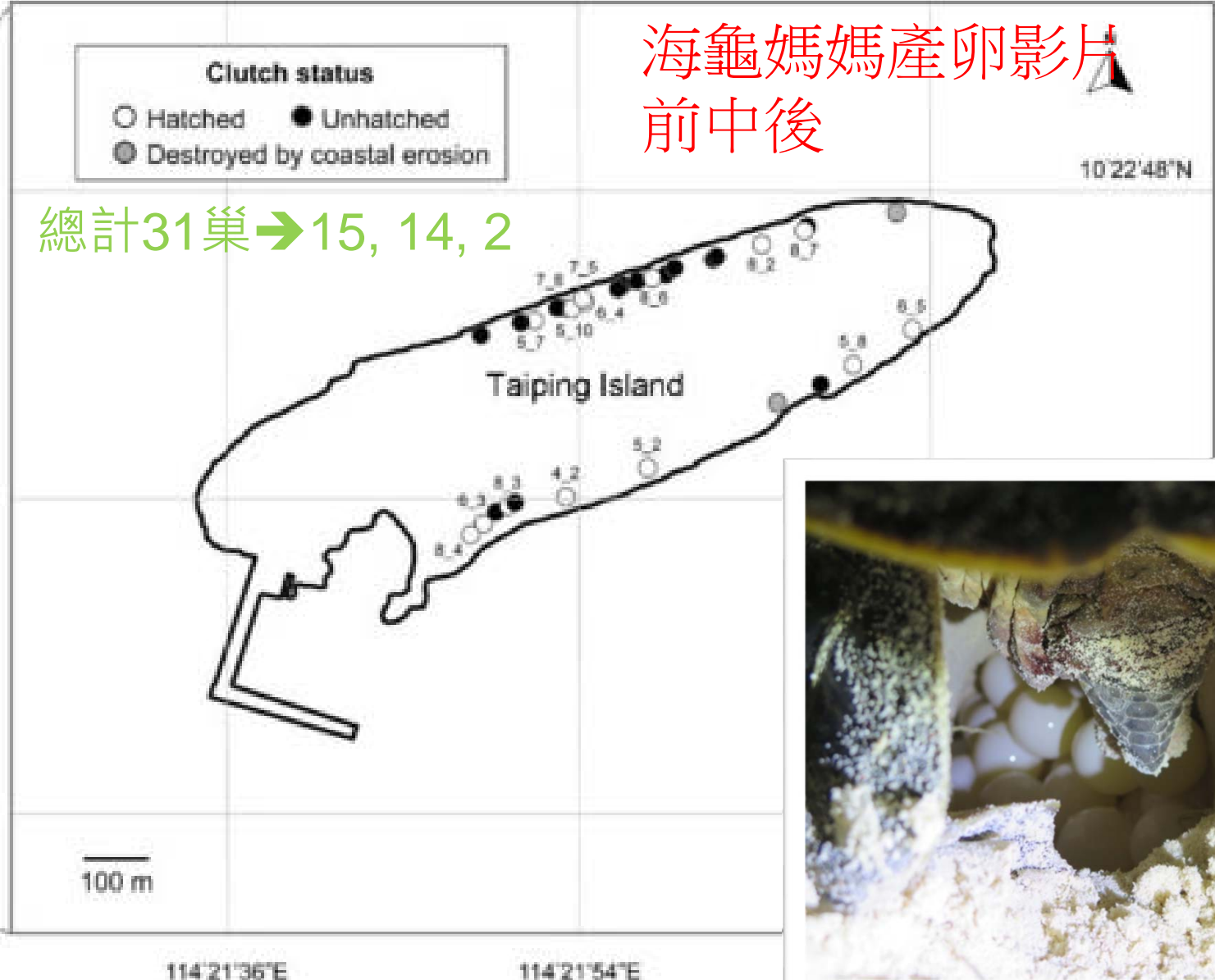
Natural shading

...

ABSTRACT



2021/4-9月, 20:00 & 00:00/每日, 共進行139日, 總計202次全島巡視觀察, 共記錄到1,049筆海龜上岸爬行路徑



實驗分組

低日照、中日照、高日照、



實驗組 vs. 對照組
105 × 105 cm², H 35 cm
~ 40 天





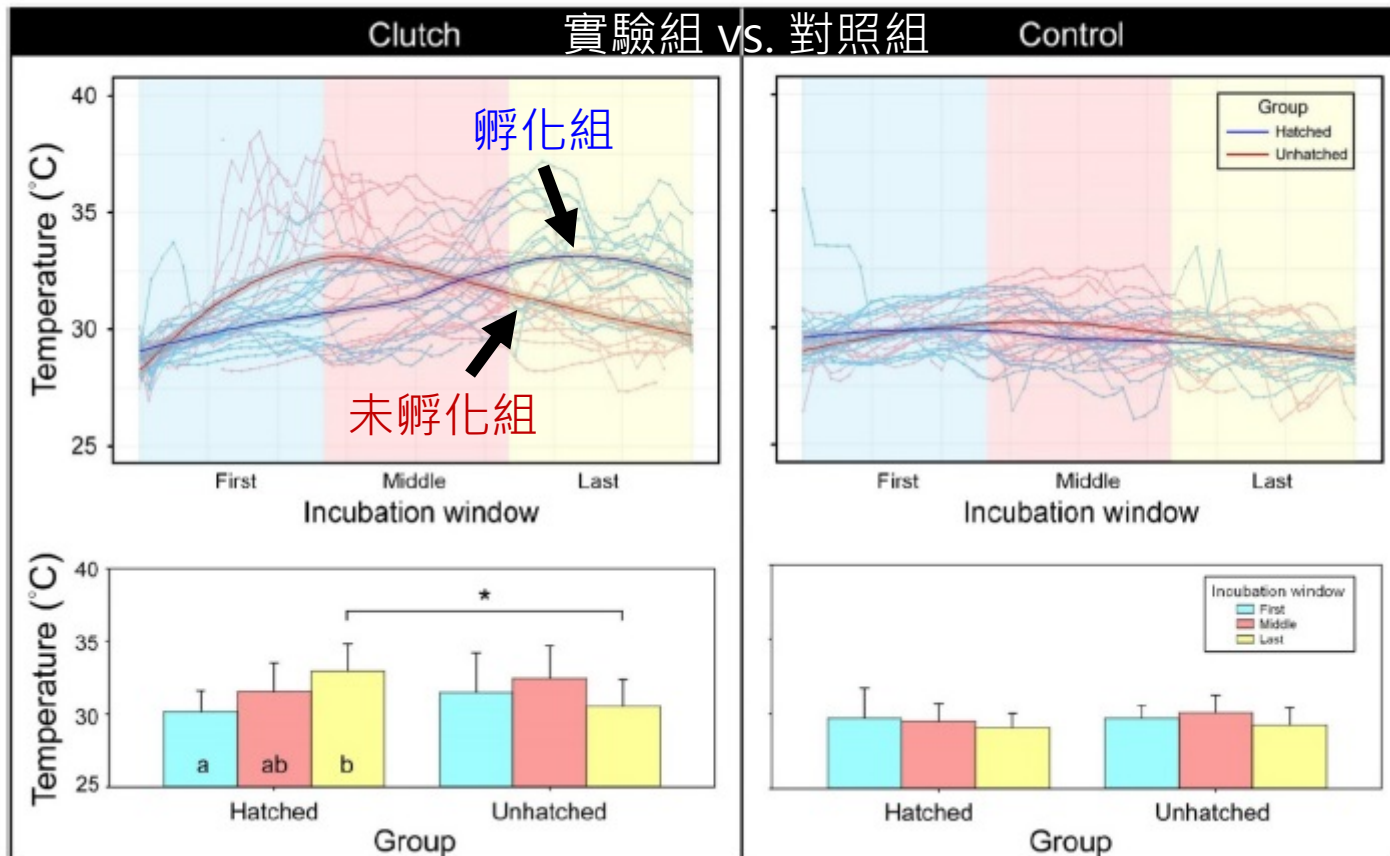
低



中



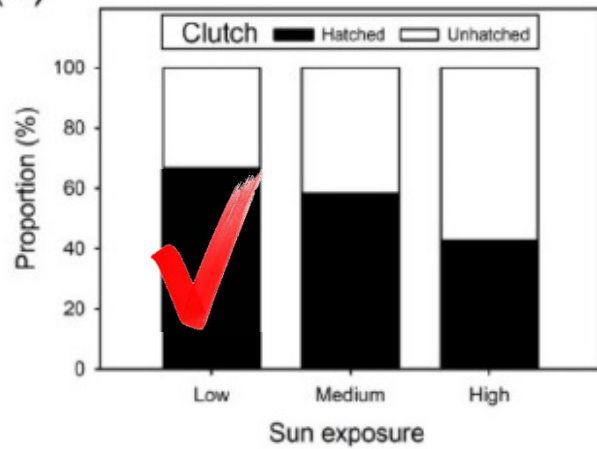
高



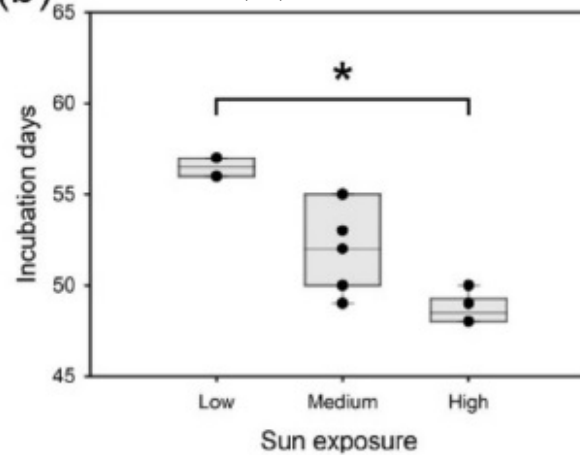
- 孵化組卵窩溫度在整個孵化期內呈現明顯逐漸上升。
- 未孵化組卵窩溫度在孵化初期和中期急劇上升後下降。
- 孵化中期可能是重要時期!



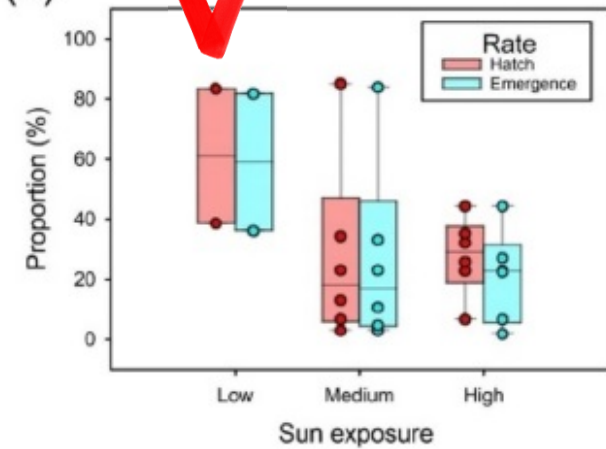
(a) 孵化卵窩比例



(b) 卵窩孵化天數



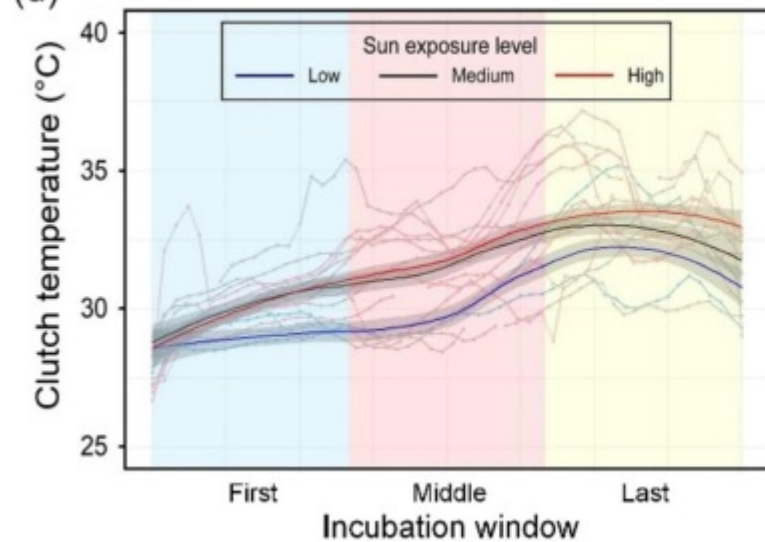
(c) 孵化率與出殼率



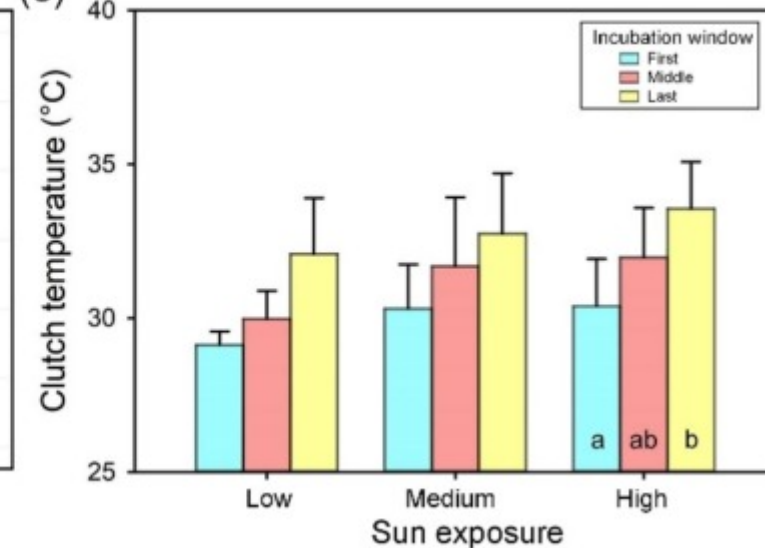
- 低日照下孵化卵窩數比例最高(66.7%)，孵化天數最長(約56-57天)，出殼率也最高



(d) 孵化期卵窩連續溫度變化

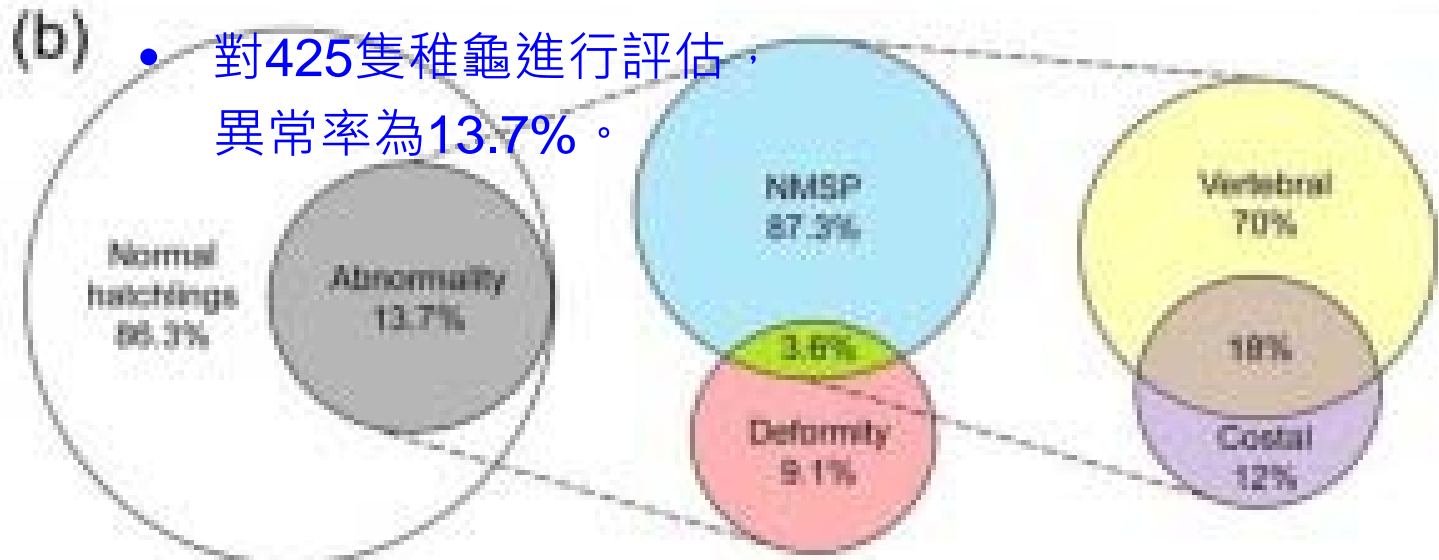


(e) 孵化期卵窩平均溫度變化



- 低、中、高日照平均卵溫度分別為 $30.38 \pm 1.72^\circ\text{C}$ 、 $31.53 \pm 2.1^\circ\text{C}$ 和 $31.94 \pm 2.0^\circ\text{C}$ 。
- 高日照最後一個孵化期，卵窩溫度顯著升高，可能是導致孵化率低的一個關鍵因素。

(a) 正常 鱗甲異常 畸形或同時鱗甲異常和畸形





低



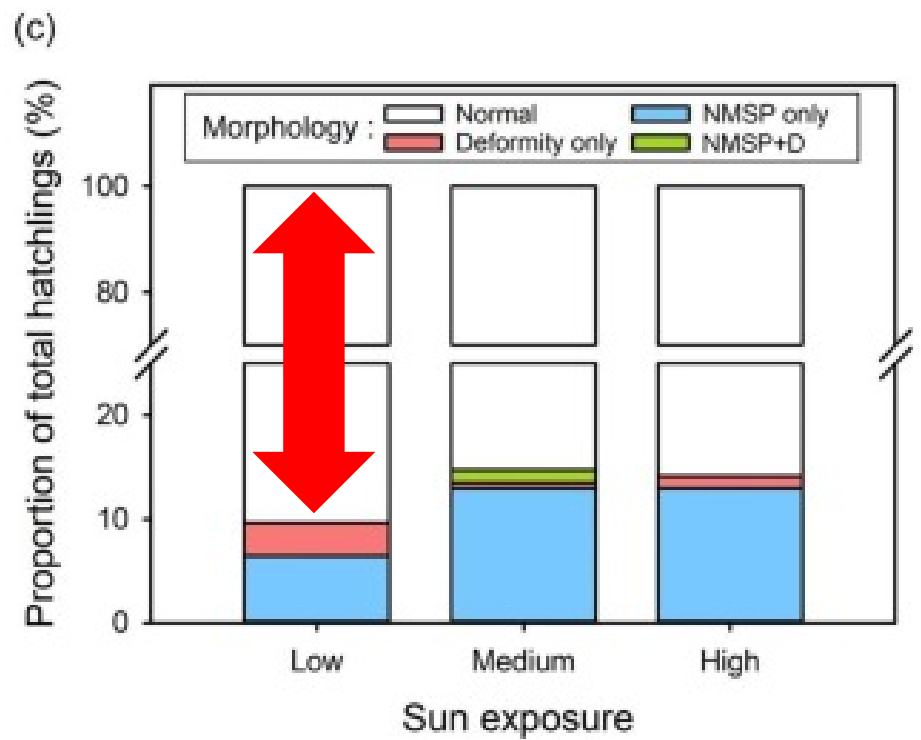
中



高



- 低日照正常稚龜比例最高

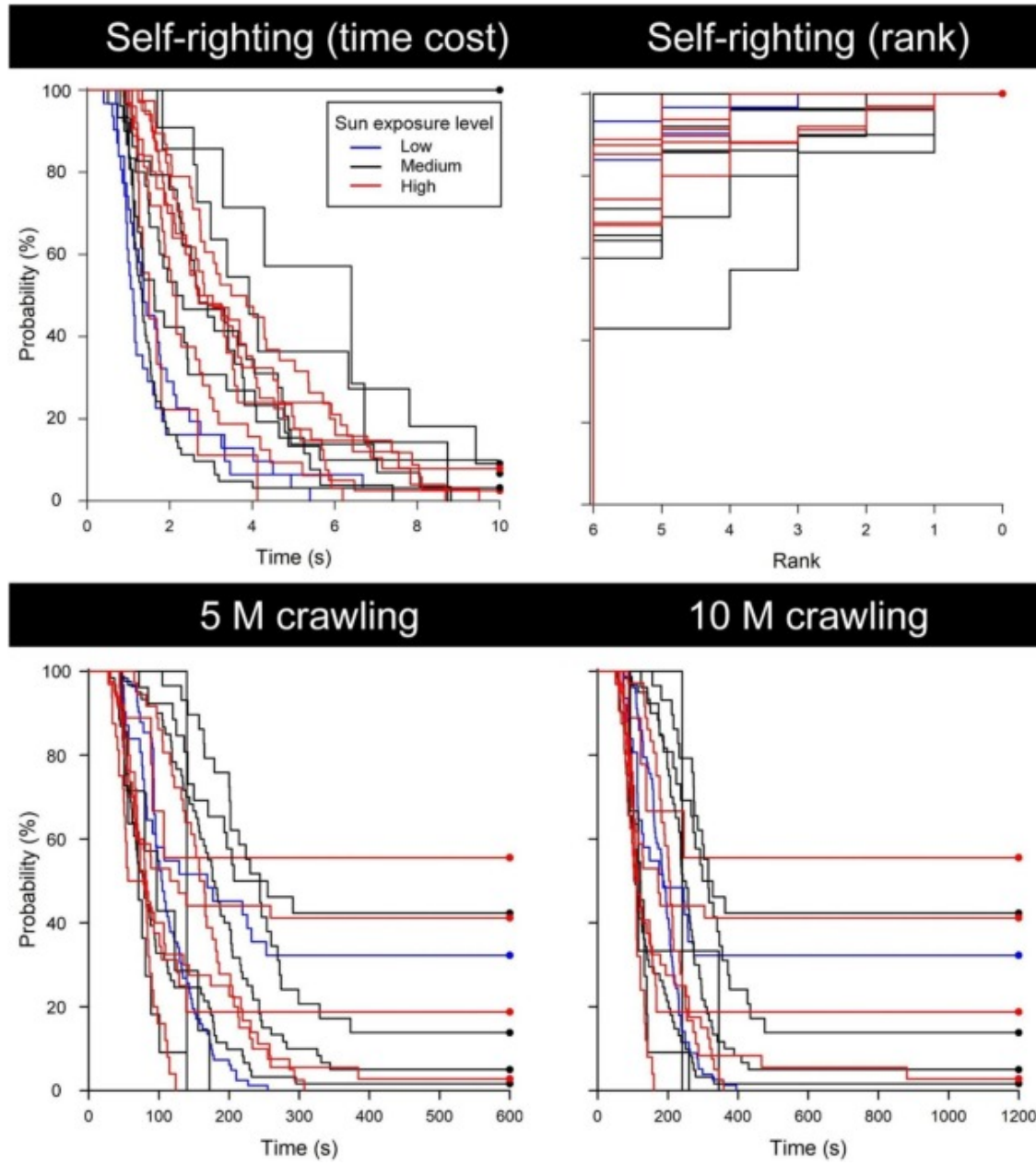


- 翻正能力與爬行速度在三個日照實驗組間則未觀察到差異。

翻正行為影片

爬行速度影片

- 翻正能力與爬行速度在三個日照實驗組間則未觀察到差異。





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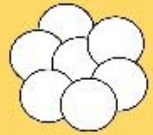
(低日照)

自然遮蔭對於緩解熱帶地區南
沙太平島海龜巢穴的暖化有所
幫助，但還不夠!!!

高日照

低日照

低日照 + 關鍵期降溫



(與高日照相比)

(與高日照相比)

卵窩溫度高 (>31° C)

卵窩溫度較低 (但仍 >30° C)

卵窩溫度較低 (~29° C)

雌性化比例高

雌性化比例高

性別比例相當

低孵化率

高孵化率

高孵化率

高畸形率

低畸形率

低畸形率

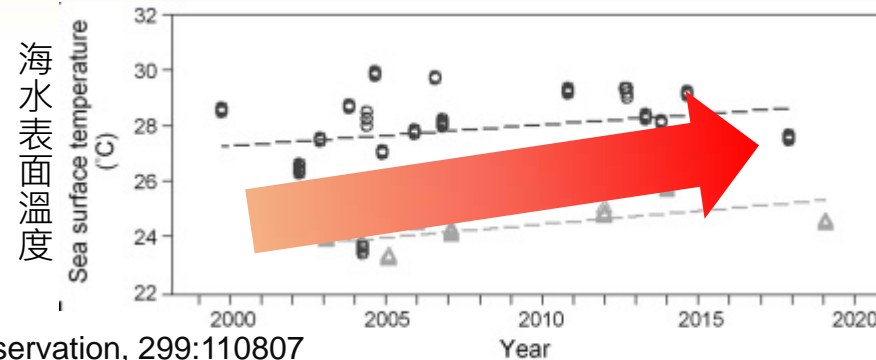


Table 2

The global temperature data of nesting habitats of sea turtles, showing a gradually warming trend from 1998 to 2021.

Year	Species	Location	Latitude	Longitude	Sand temperature (depth of 40–70 cm)	Ave. clutch temp. (°C) - entire period	Avg. clutch temp. (°C) - middle window	Reference
1998–1999	<i>Chelonia mydas</i>	Heron Island	23°26'S	151°55'E	NA	27.2–29.7	27.2–29.1	Booth and Astill, 2001
2000–2002	<i>Caretta caretta</i>	Fethiye beach	36°39'N	29°7'E	NA	29.2 ± 1.4	29.4 ± 1.4	Kaska et al., 2006
2003–2004	<i>Chelonia mydas</i>	Heron Island	23°26'S	151°55'E	26.3 ± 0.1–27.7 ± 0.1	28.0 ± 0.4–28.1 ± 0.2	NA	Booth and Freeman, 2006
2005–2007	<i>Caretta caretta</i>	Mon Repos	24°48'S	152°27'E	28.0 ± 0.1–29.7 ± 0.1	29.6–32.1	NA	Chu et al., 2008
2006–2007	<i>Chelonia mydas</i>	Heron Island	23°26'S	151°55'E	NA	29.9 ± 0.2	NA	Ischer et al., 2009
2007–2008	NA	northern Great Barrier Reef	9°10'S–14°10'S	142°30'E–145°0'E	26.9 ± 0.0–31.1 ± 0.0	NA	NA	Fuentes et al., 2010
2007–2008	<i>Chelonia mydas</i>	Wan-an Island	23°22'N	119°30'E	NA	29.5 ± 1.1–30.6 ± 2.0	31.2 ± 1.3	Chen et al., 2010
2008	<i>Chelonia mydas</i>	Heron Island	23°26'S	151°55'E	NA	28.1–31.1	NA	Booth et al., 2013
2010–2011	<i>Chelonia mydas</i>	Lanyu, Wan-an, and LiuChiu Island	22°2'N–22°22'N	119°30'E–121°32'E	30.4–32.3	30.1–31.3	28.8–33.8	King et al., 2013
2013–2015	<i>Dermochelys coriacea</i>	Pacuare Nature Reserve	10°10'N	83°14'W	NA	28.7 ± 0.5–31.4 ± 0.6	28.0 ± 0.4–31. ± 0.7	Rivas et al., 2019
2014–2019	<i>Chelonia mydas</i>	La Barca and Antonio Beach	21°85'N–21°90'N	84°66'E–84°76'E	NA	30.7 ± 0.3–32.7 ± 1.1	NA	Calderón Peña and Azanza Ricardo, 2021
2015	<i>Caretta caretta</i>	Kochi Beach	33°28'N	133°30'E	NA	27.2–31.0	27.2–33.9	Kobayashi et al., 2017
2015–2017	<i>Caretta caretta</i>	Boca Raton beach	26°20'N	80°4'W	NA	32.4 ± 0.3–33.0 ± 0.4	NA	Lolavar and Wyneken, 2021
2017	<i>Chelonia mydas</i>	Boca Raton beach	26°20'N	80°4'W	NA	27.6–36.0	NA	Bladow and Milton, 2019
2017–2018	<i>Caretta caretta</i>	Mon Repos	24°S	152°E	NA	29.4 ± 0.3–31.9 ± 0.2	NA	Staines et al., 2019
2017–2021	<i>Eretmochelys imbricata</i>	Cousine Island	4°21'S	55°37'E	NA	NA	29.6 ± 1.4	Evans et al., 2022
2018–2019	<i>Chelonia mydas</i>	Ogasawara Island	27°1'N–27°11'N	114°9'E–142°14'E	NA	31.0–32.0	NA	Kobayashi et al., 2020
2019	<i>Chelonia mydas</i>	Chagar Hutang Turtle Sanctuary	5°48'N	103°0'W	NA	29.8 ± 0.2–32.5 ± 0.2	29.6 ± 0.2–32.5 ± 0.2	Reboul et al., 2021
2019	<i>Chelonia mydas</i>	Tambelan archipelago	0°57'N–1°1'N	107°23'E–107°30'E	27.9 ± 0.4–29.8 ± 1.1	NA	NA	Rumaida et al., 2021
2021	<i>Chelonia mydas</i>	Taiping Island	10°22'N	114°22'E	28.1 ± 2.2–30.9 ± 2.6	29.0 ± 0.3–33.1 ± 1.8	29.0 ± 0.2–34.2 ± 0.9	This study

Chelonia mydas: green sea turtle; *Caretta caretta*: loggerhead sea turtle; *Dermochelys coriacea*: leatherback sea turtle; *Eretmochelys imbricata*: hawksbill sea turtle.

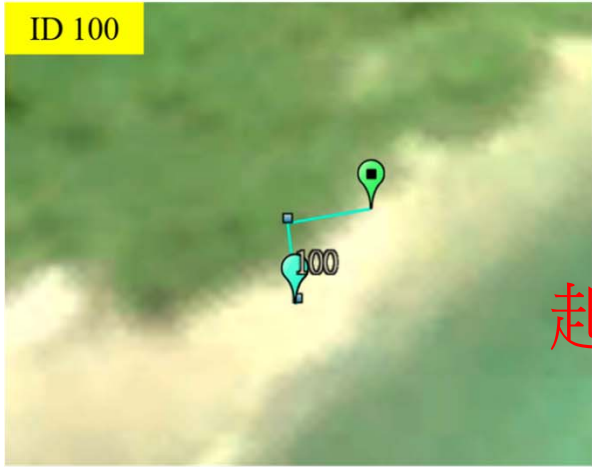


 科學家繼續有問題!

- 媽媽有偏好家的區域?!



ID 100



ID 200



ID 300



起點跟終點?

ID 400



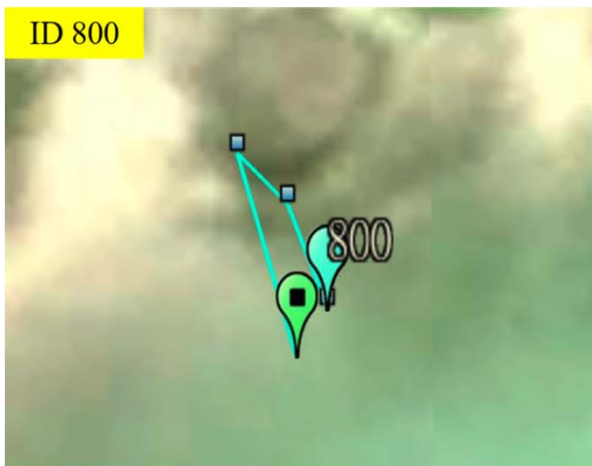
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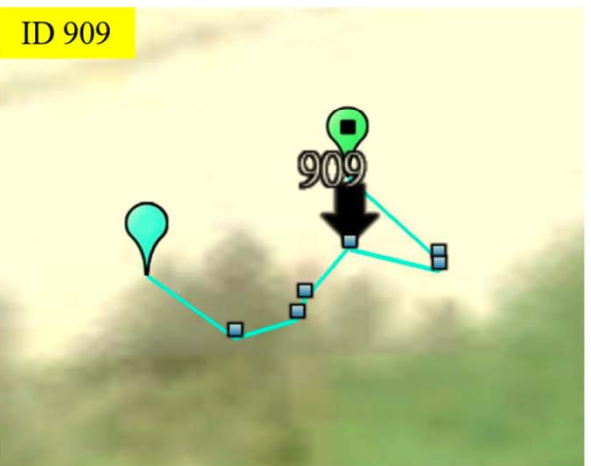
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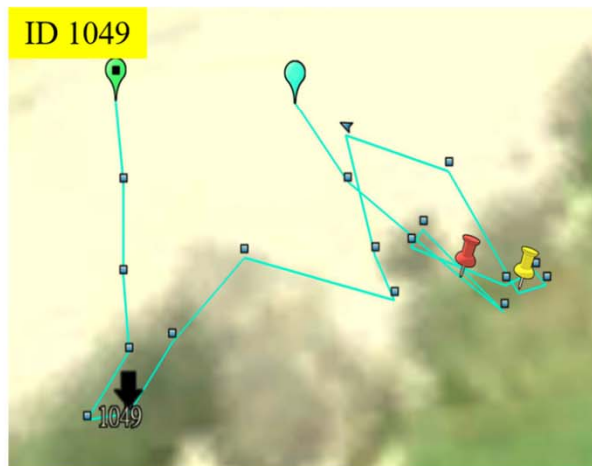
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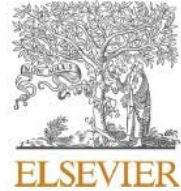


ID 909



ID 1049





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Global Ecology and Conservation

journal homepage: www.elsevier.com/locate/gecco



Original Research Article

Monsoon dynamics shape spatiotemporal patterns in green sea turtle nesting on an island-based habitat

Tsung-Han Liu^{a,b,1}, Ming-Shiou Jeng^{c,1}, Chan-Yuan David Lee^a, Chih-Wei Tu^a,
Po-Hsiung Lin^d, Chaolun Allen Chen^c, Chia-Ying Ko^{a,e,*}

^a Institute of Fisheries Science, National Taiwan University, Taipei, Taiwan

^b Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan

^c Biodiversity Research Center, Academia Sinica, Taipei, Taiwan

^d Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan

^e Department of Life Science, Institute of Ecology and Evolutionary Biology, Master's Program in Biodiversity, Biodiversity Research Center, Ocean Center, and Museum of Zoology, National Taiwan University, Taipei, Taiwan

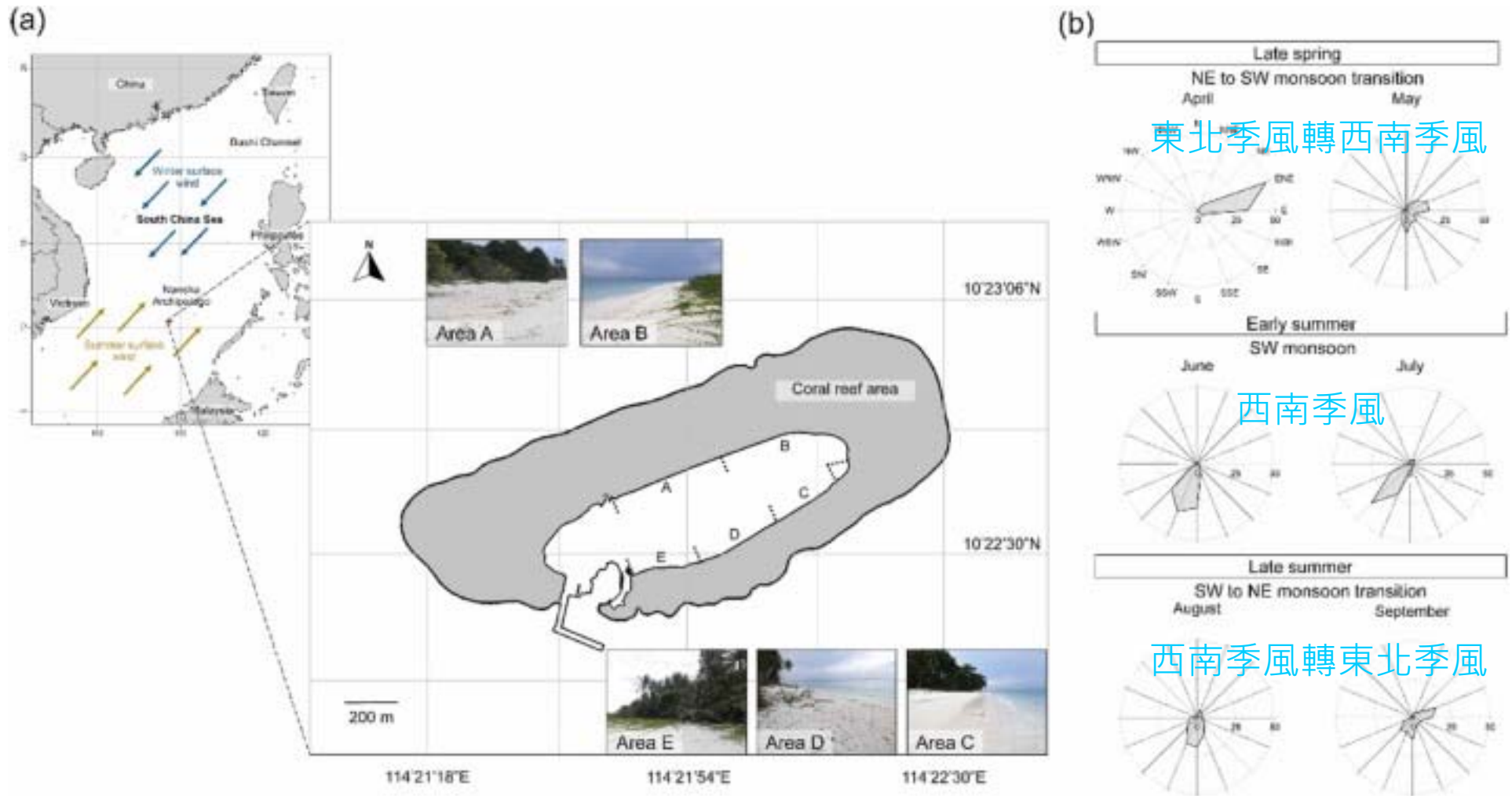
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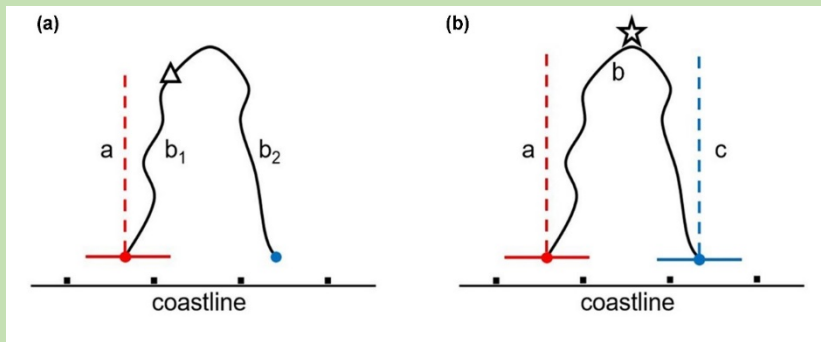
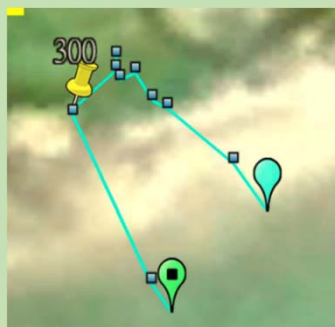
Green sea turtle



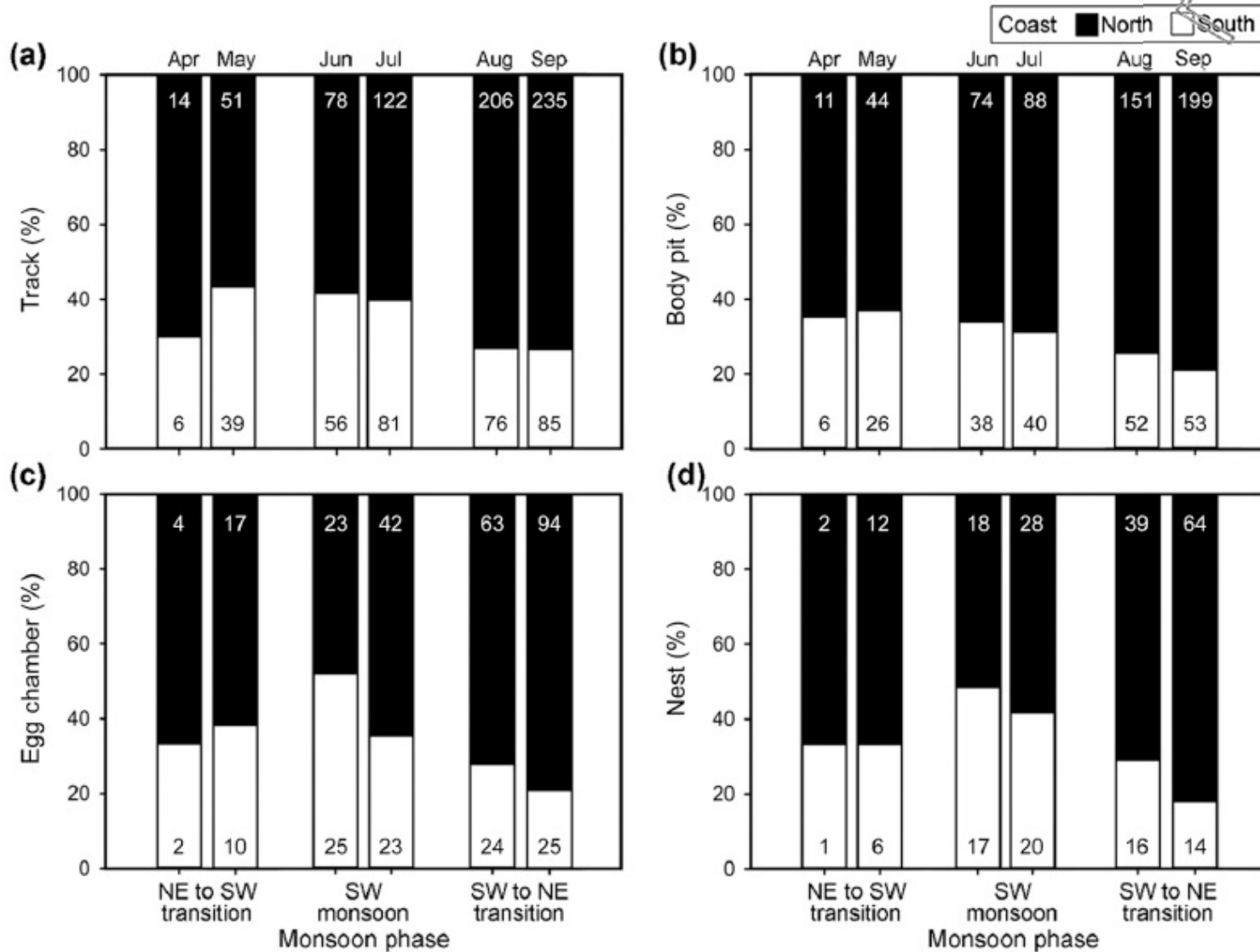
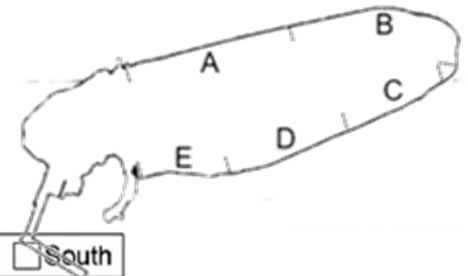
line and
human



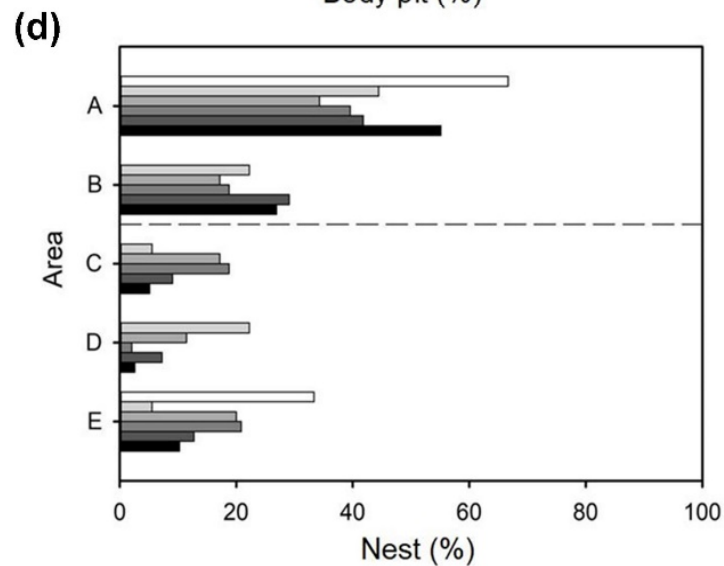
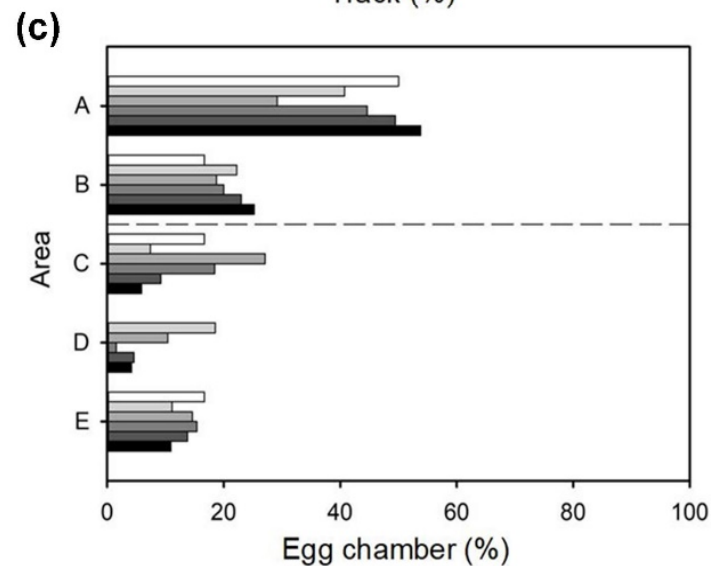
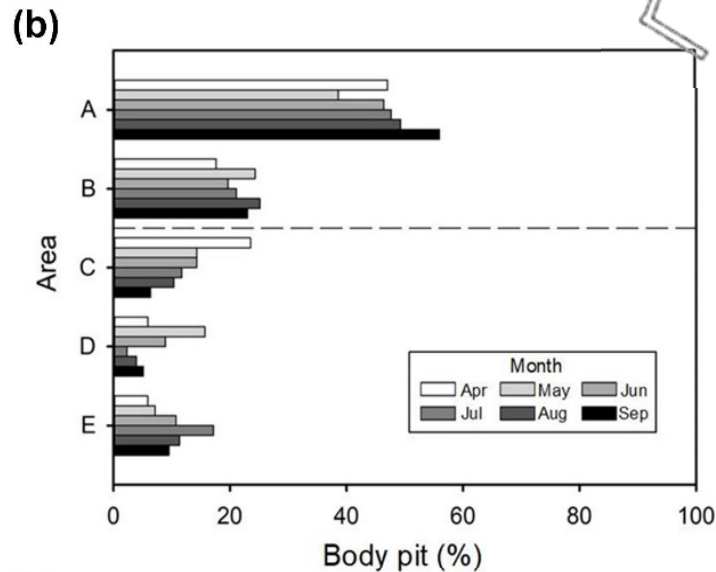
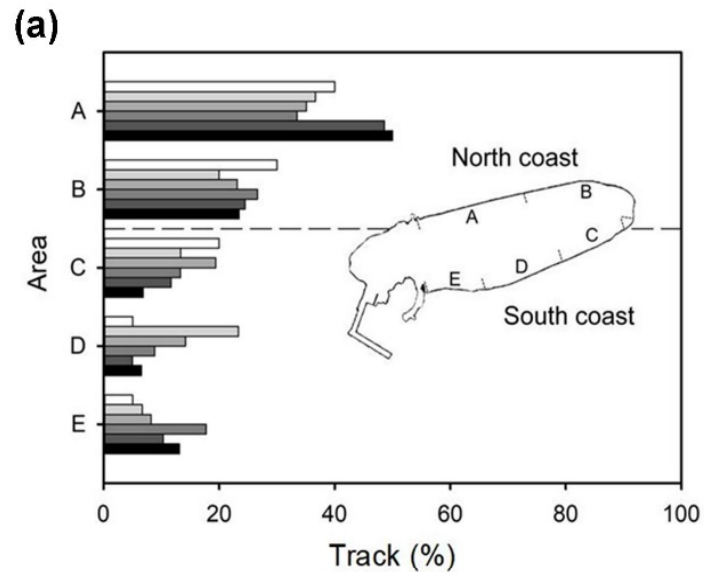
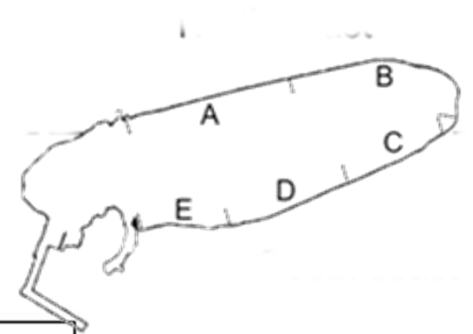
總距離
垂直距離



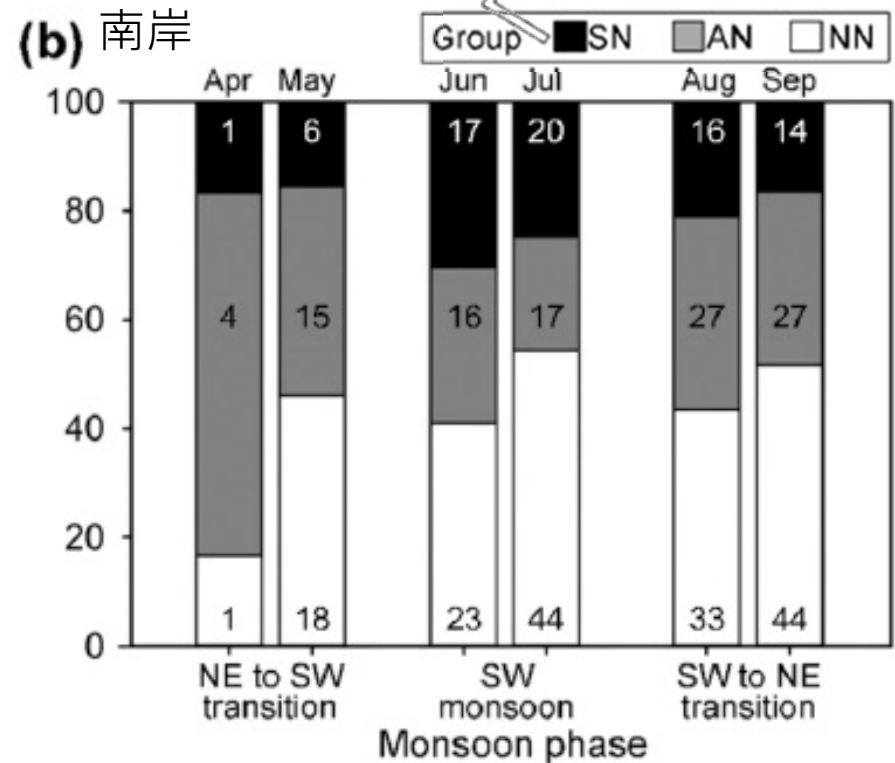
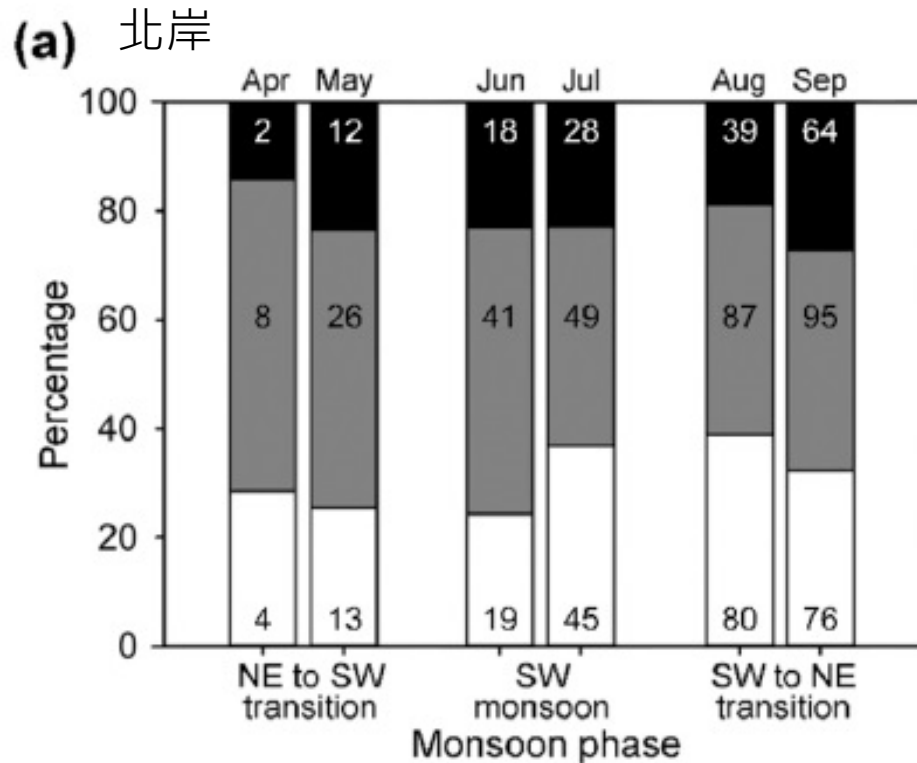
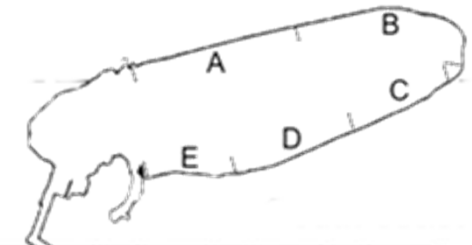
- 北岸有較多的上岸與產卵紀錄，分區以A區有最高紀錄。



- 北岸有較多的上岸與產卵紀錄，分區以A區有最高紀錄。

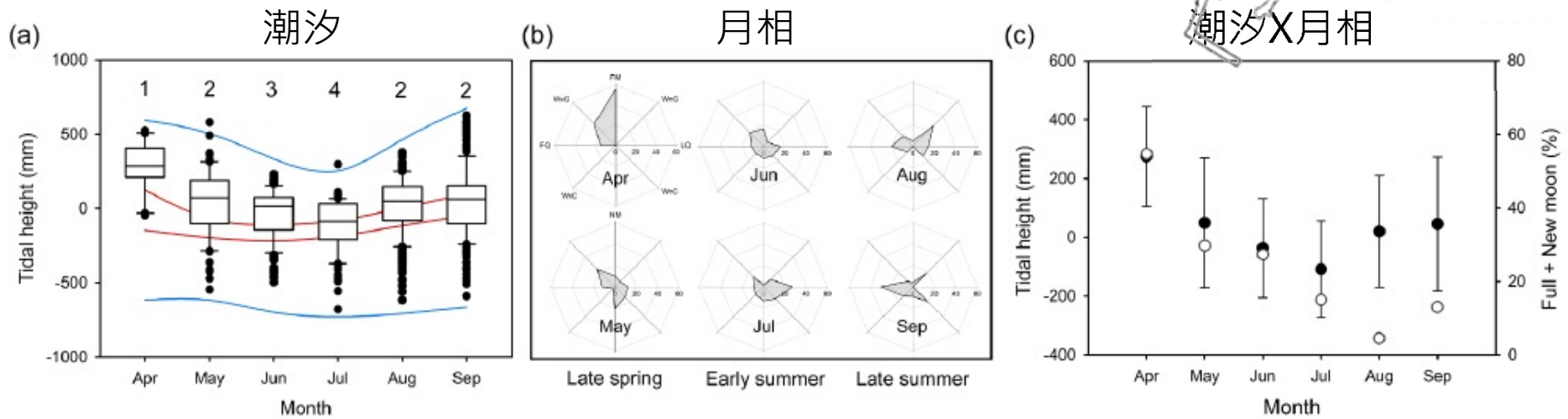
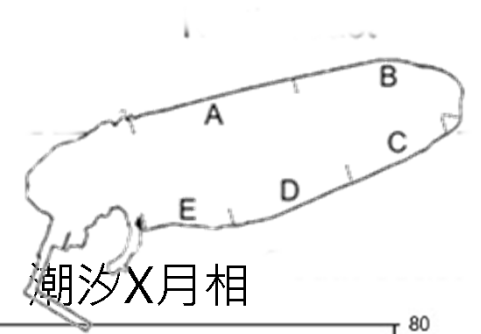


- 季風交替變化，使得綠蠵龜成功產卵機率在南北岸不同。



- ✓ 成功產卵 successful nesting (SN), where the green sea turtle laid eggs successfully
- ✓ 未成功產卵 aborted nesting (AN), a situation in which the green sea turtle excavated a body pit or egg chamber but failed to complete the egg-laying process
- ✓ 未產卵 nonnesting (NN)

- 季風交替變化，綠蠵龜成功產卵需要有不同的天時地利!



Environmental variable		Monsoon phase		
		NE to SW transition (N = 100)	SW monsoon (N = 258)	SW to NE transition (N = 408)
Climatic	Temperature			
	Humidity		-1.81 ($p = 0.091$)	-3.43 ($p < 0.001$)
	Atmospheric pressure			1.97 ($p = 0.002$)
	Wind speed			
	Wind direction (included angle)			
Circadian	Precipitation			
	Lunar phase (illumination)			
	Lunar phase (radians)			
	Daily high tide		-0.85 ($p = 0.074$)	
	Daily low tide			
Topographical	Tidal height			-1.79 ($p = 0.010$)
	Tidal status (0/1)			
	Total distance	5.34 ($p < 0.001$)	3.71 ($p < 0.001$)	1.97 ($p = 0.013$)
Residual deviance	Straightness index			-1.54 ($p = 0.001$)
		195.60	532.82	814.56
AIC		201.60	542.82	828.56



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● 全球海龜保育策略 (以IUCN為例)

1. Ensuring that the conservation of marine turtles is guided by the biological constraints of the animals and the best scientific information available.
2. Conserving and managing natural resources and habitats that are fundamental for marine turtles.
3. Emphasizing management for long-term survival of the species.
4. Recognizing that marine turtles are a shared international resource.
5. Involving local communities in conservation management.
6. Seeking assistance and support from people and organizations interested in conserving marine turtles.
7. Integrating local, regional, national, and international efforts through advisement and advocacy.
8. Helping to build capacity of concerned authorities to conserve marine turtles.
9. Adopting and advocating innovative methods.

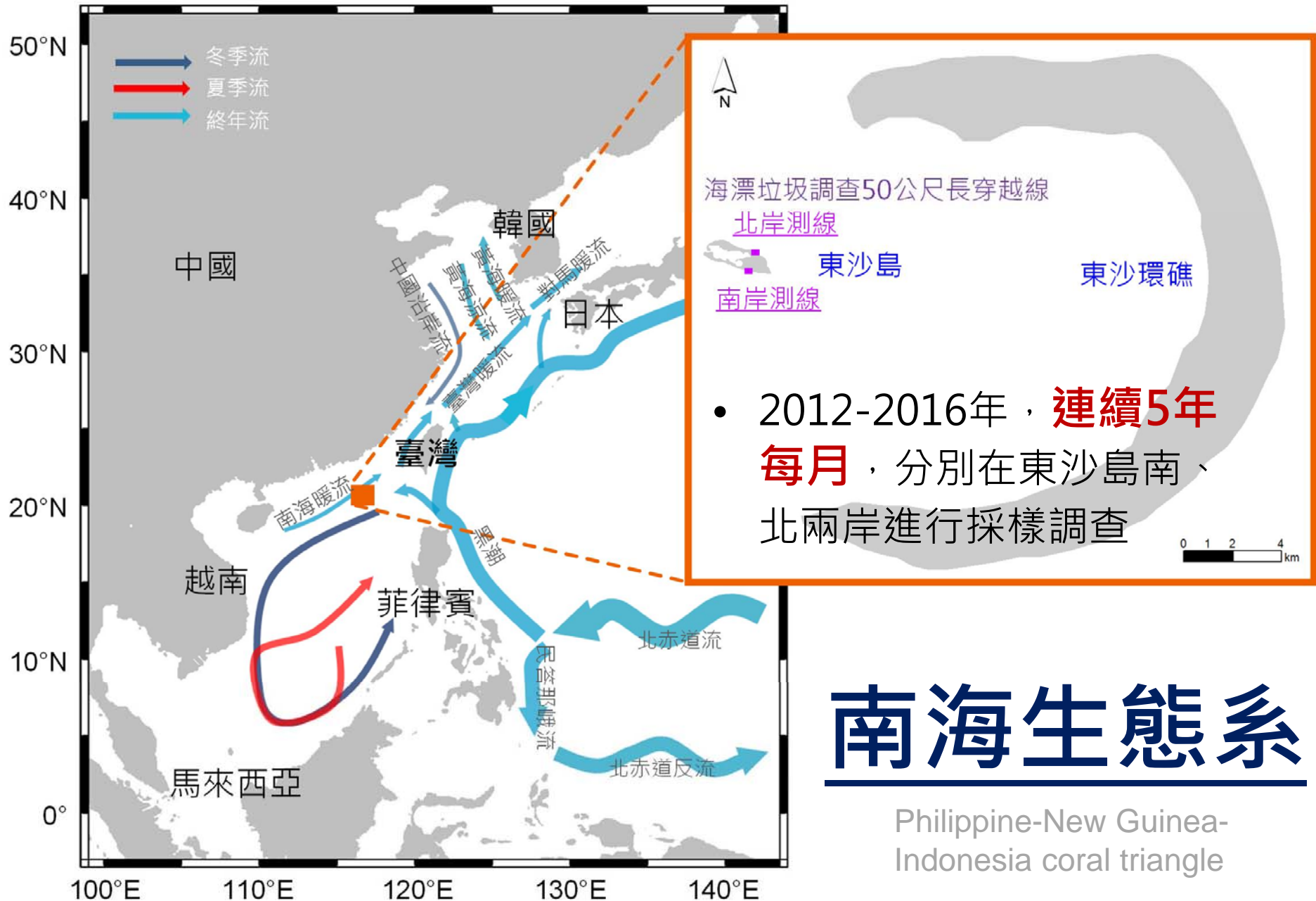
- ✓ 解決海龜生物學中的關鍵知識缺口
- ✓ 確保提供適當且相容的數據，以建立有效的保護管理措施
- ✓ 增進對海龜生態作用的理解
- ✓ 定期監測關鍵族群參數和趨勢

● 臺灣海龜保育策略

科學家有問題!

- 有人願意住在垃圾區跟周圍嗎?
- 我的生物會搬家吧!?





**Monitoring multi-year macro ocean litter dynamics and
backward-tracking simulation of litter origins on
a remote island in the South China sea**

**Chia-Ying Ko, Yi-Chia Hsin, Teng-Lang Yu,
Kuo-Lieh Liu, Fuh-Kwo Shiah and Ming-Shiou Jeng**

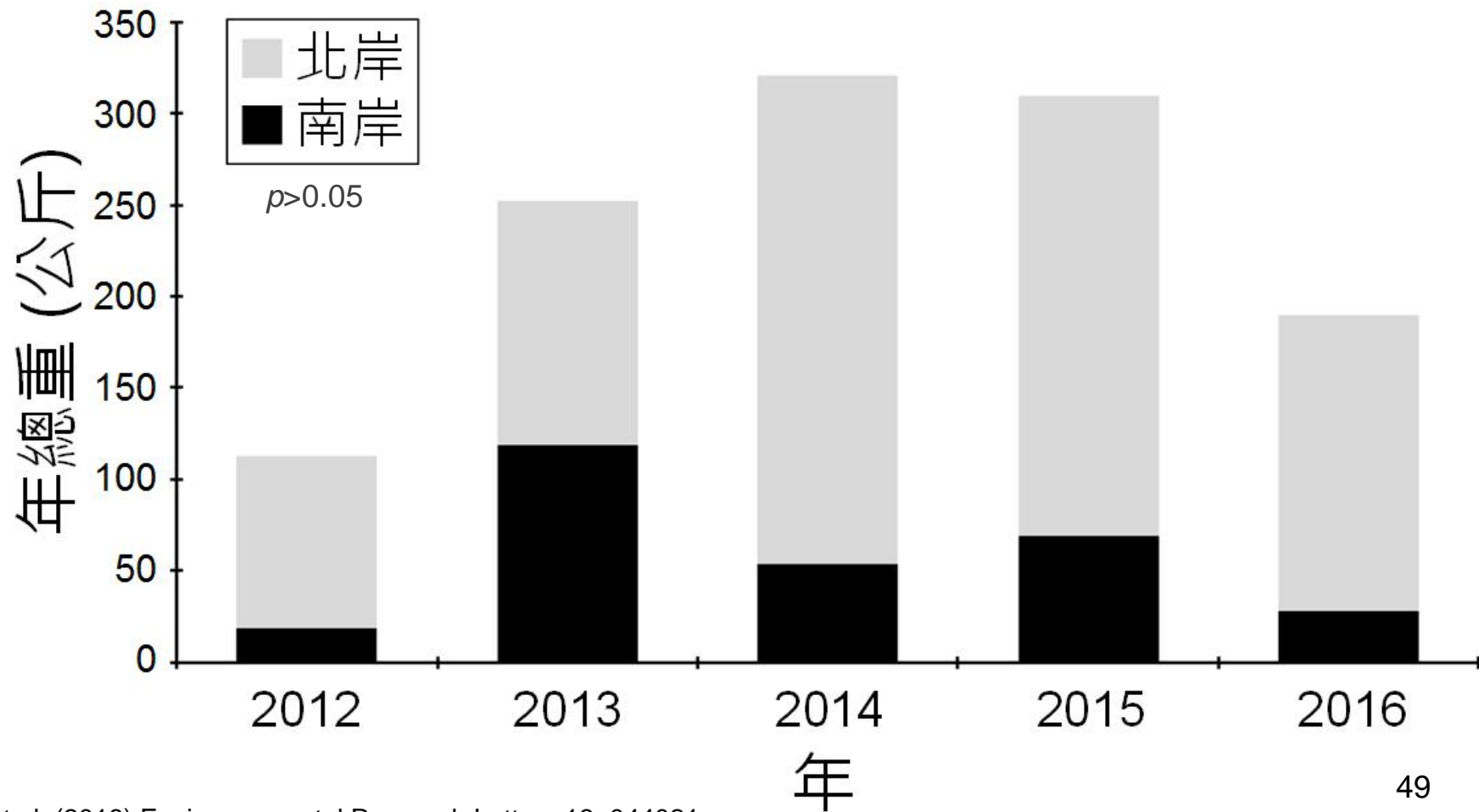
Video abstract



- 單年總重量變化在112.8-320.6公斤間
(南岸：19-118.3公斤、北岸：93.8-266.9公斤)



- 年平均總重量為236.9公斤



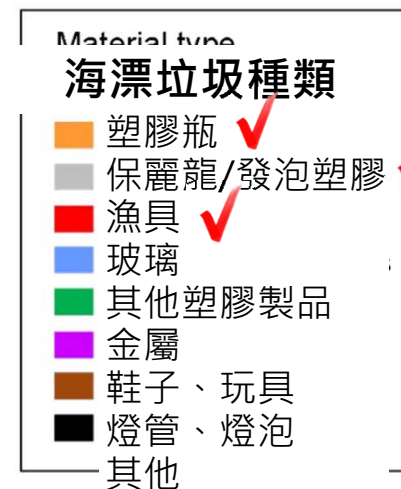
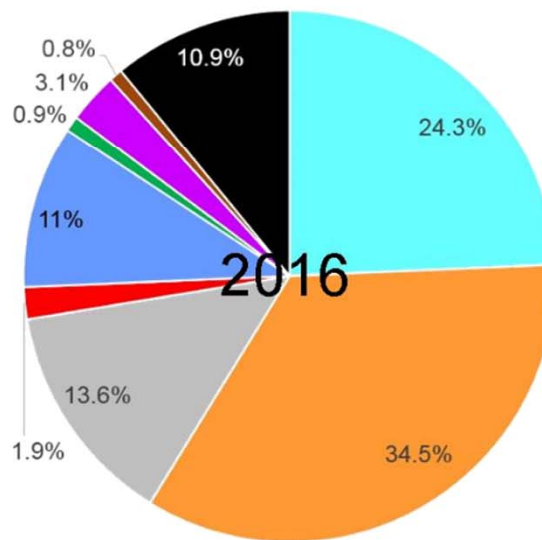
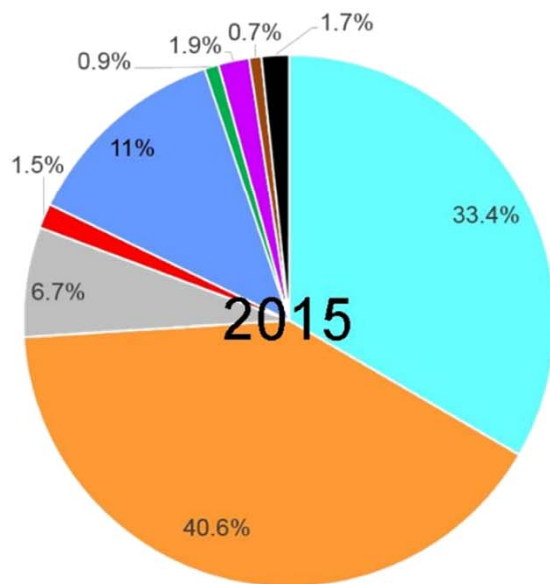
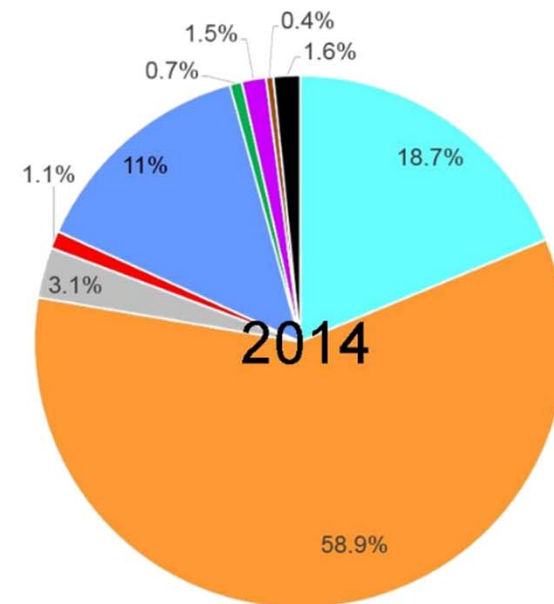
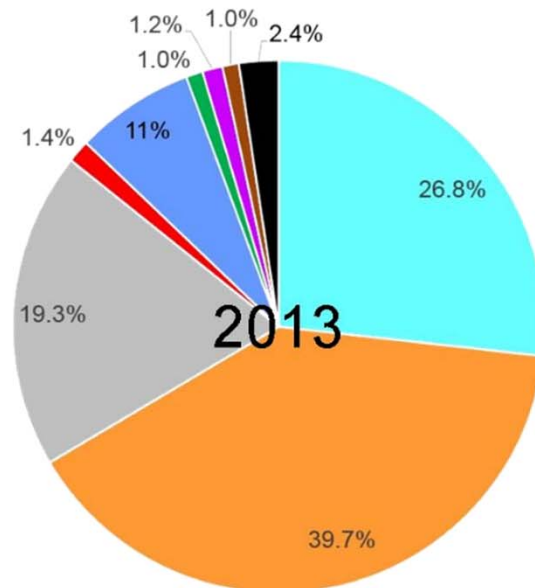
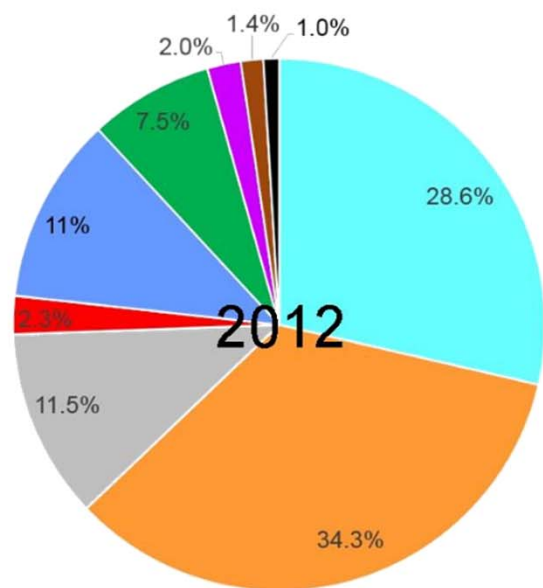
- 多數海漂垃圾屬於未分解型態。



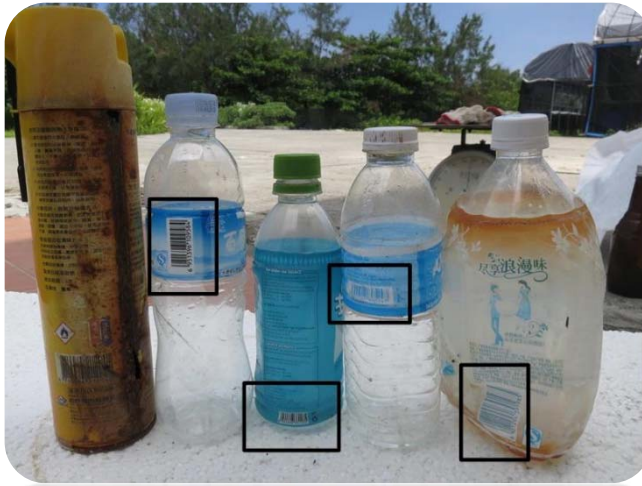


漁具 鞋子
保麗龍 塑膠瓶

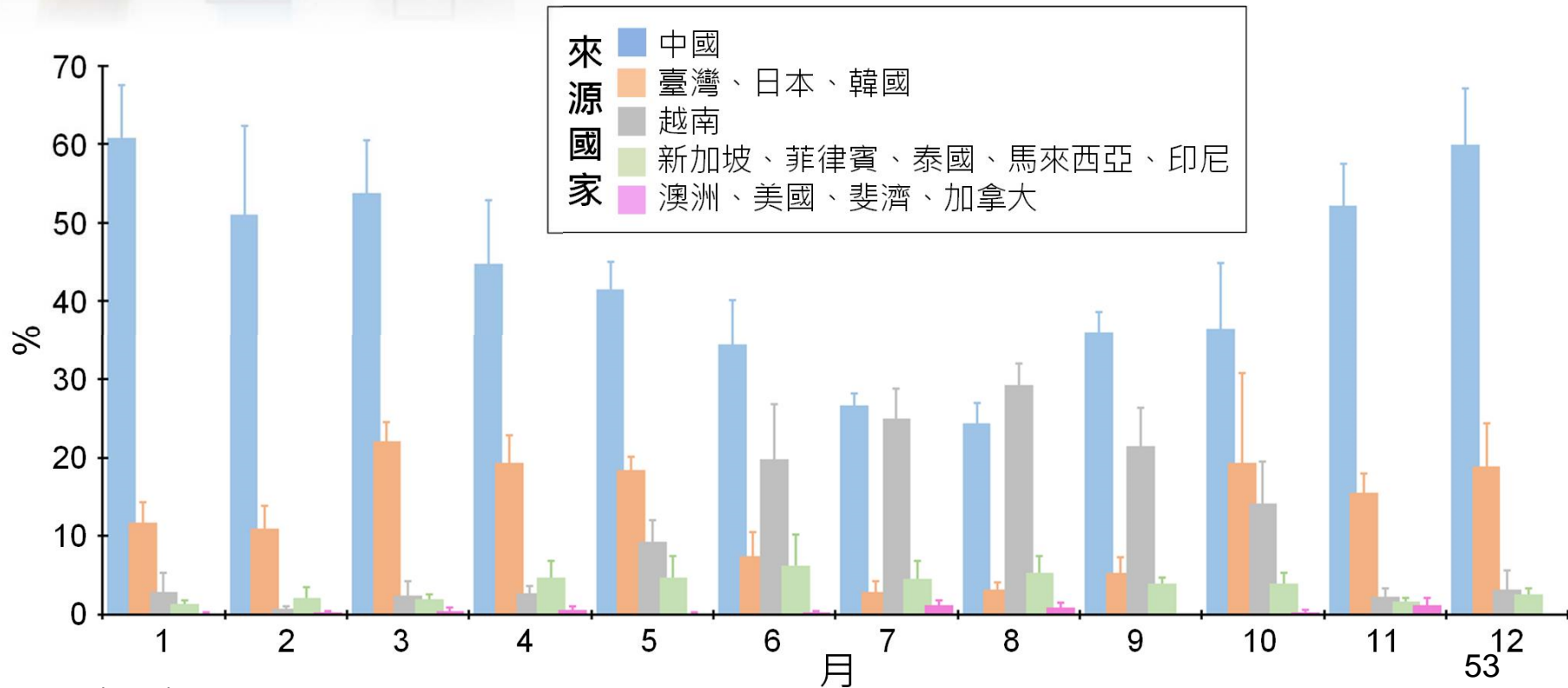




- 保麗龍/發泡塑膠為最大宗，每年約佔41.6%



- 從國際編碼系統(Barcode System)追溯塑膠瓶垃圾來源國，海漂垃圾量最主要來源國為中國、越南，約佔47.5%–63.7%
- 接著為臺灣、日本、韓國等



- 海洋物裡模式模擬：

- >> 以東沙島為中心，反向追蹤垃圾的可能來源
- >> 深度
- >> 海流
- >> 風阻效應(windage)代表垃圾直接受風吹影響的程度，與垃圾之形狀、大小、密度...等因素有關。

☆ 反向追蹤模擬實驗 →

Depth	Windage
0m	0.00
0.5m	N/A
1.0m	N/A
0m	0.01
0m	0.03
0m	0.05
0m	0.10

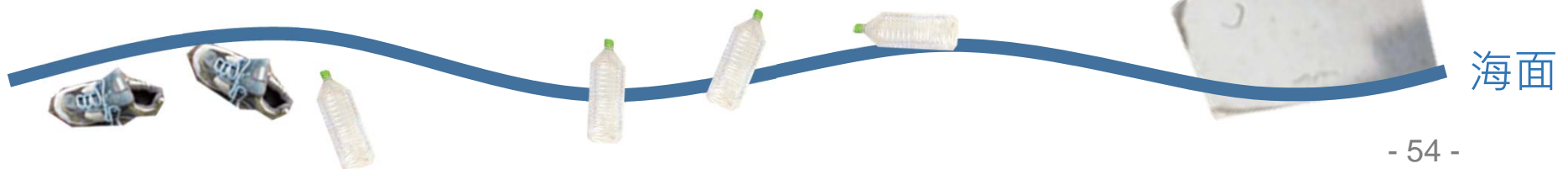
} 無風阻效應實驗

} 風阻效應實驗

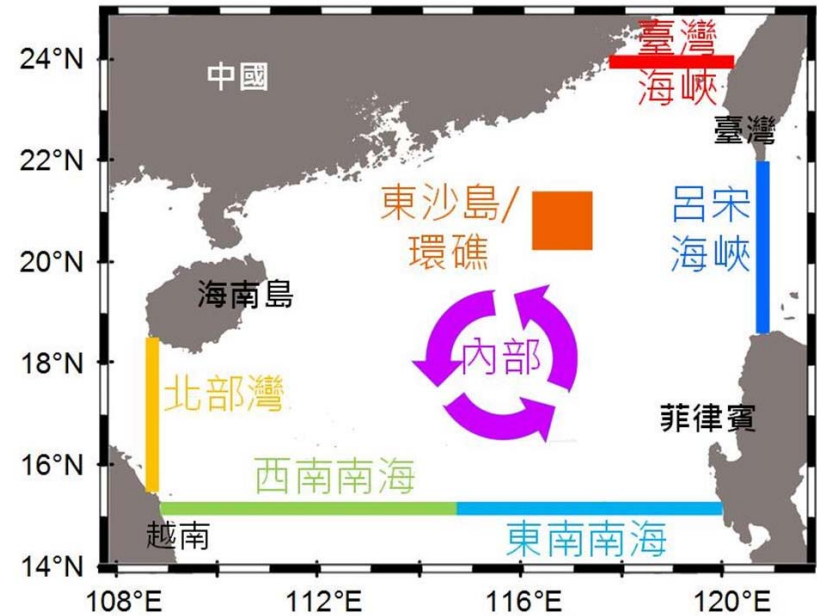
低風阻效應
 $C_w < 1\%$

中風阻效應
 $C_w = 2-3\%$

高風阻效應
 $C_w > 4\%$



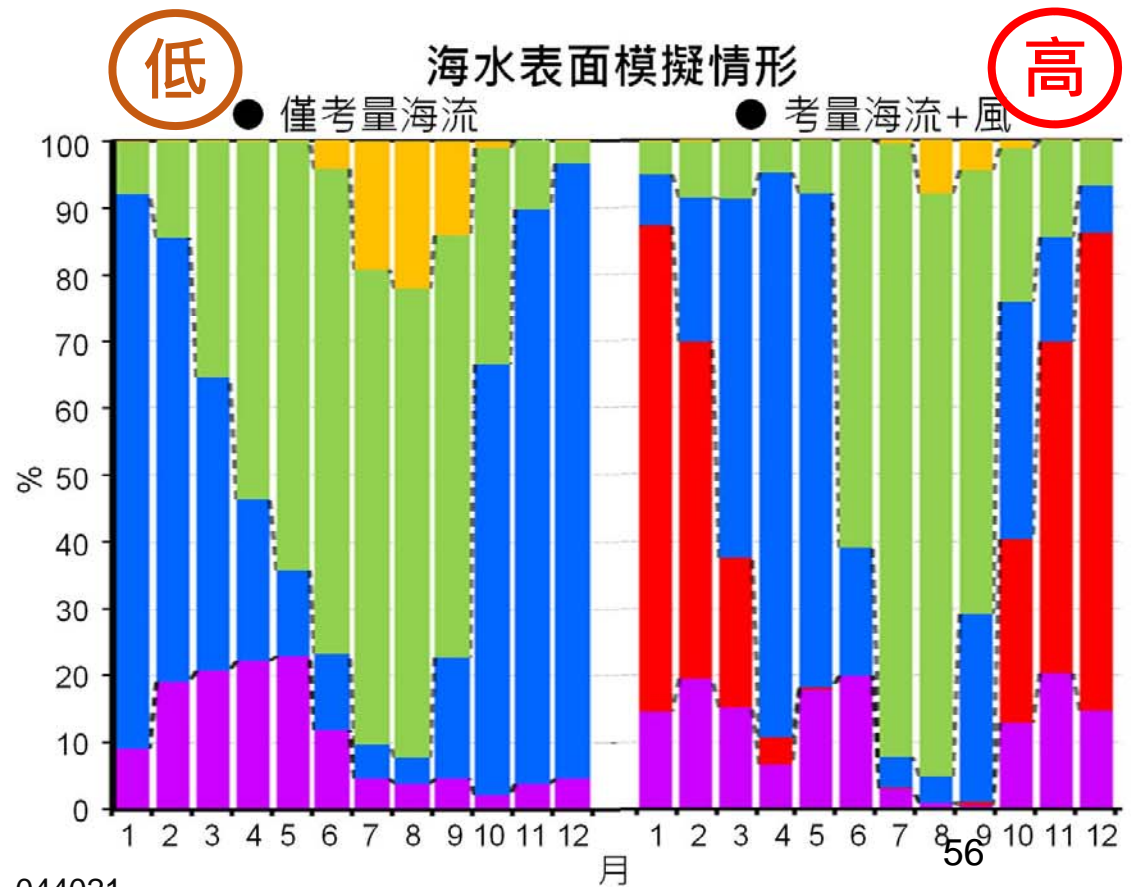
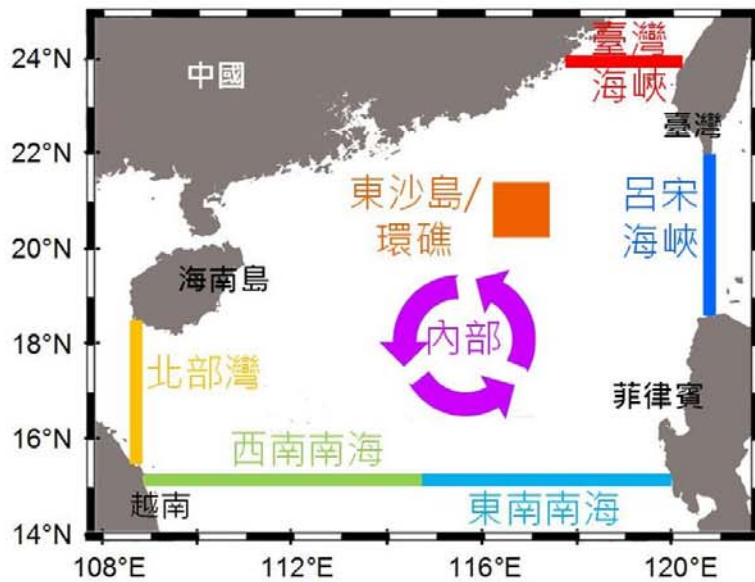
- 不同模擬情形下，海漂垃圾經 8–650 天才會抵達陸地



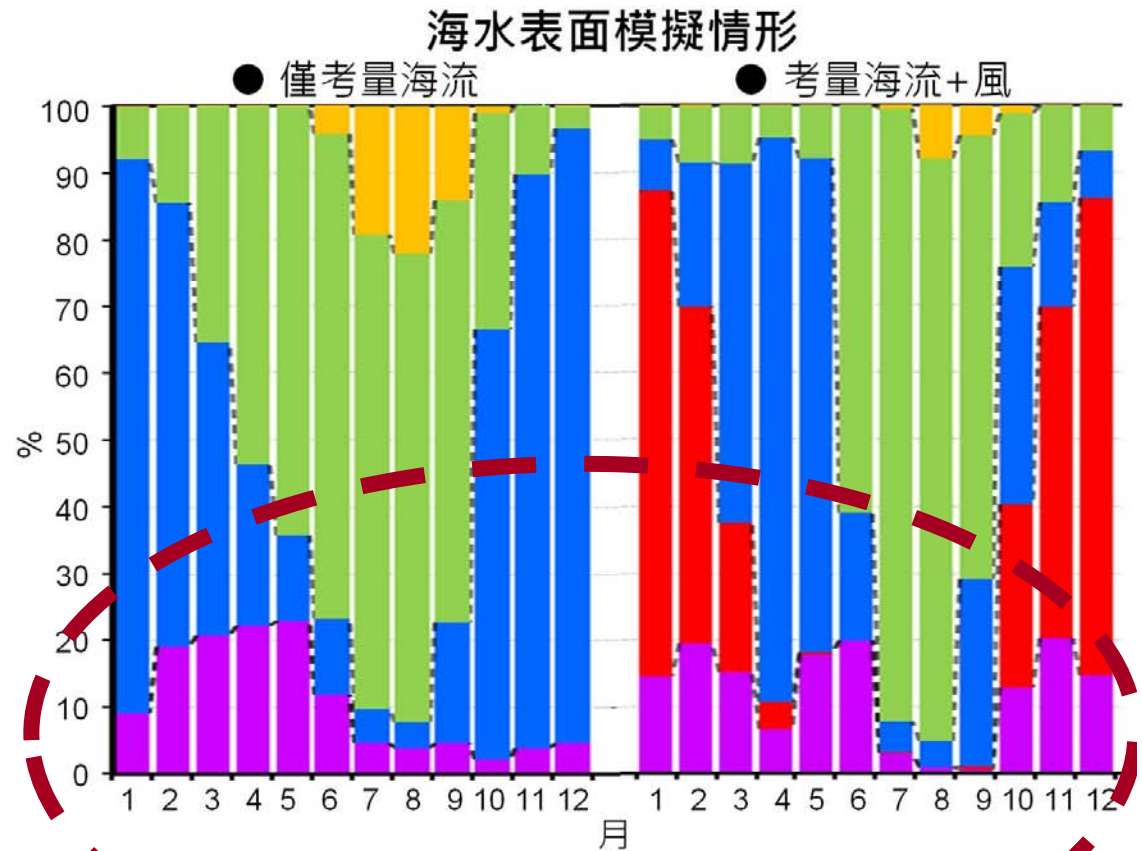
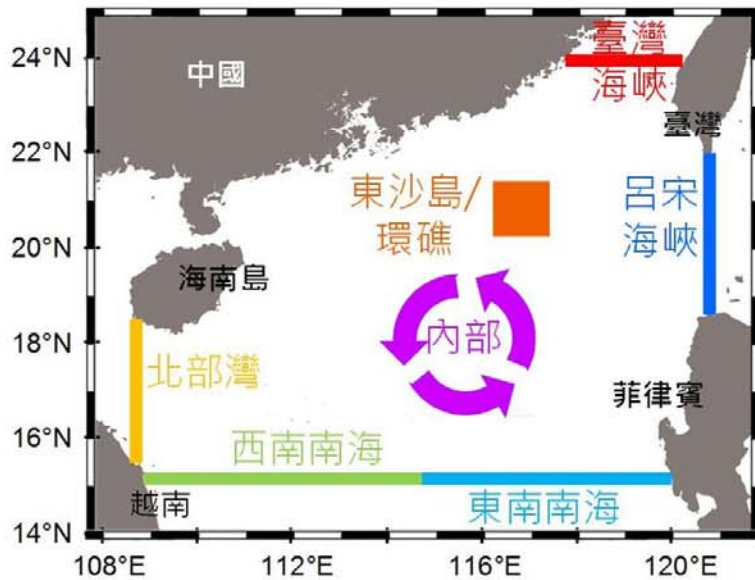
Section	呂宋海峽						
	Surface and windage setting (C_w)					Depth (m)	
Month	0	0.01	0.03	0.05	0.1	0.5	1
January	28	25	63	112	69	27	30
February	31	24	40	62	73	29	42
March	43	22	21	42	45	42	66
April	50	27	20	20	22	48	55
May	55	30	22	21	18	60	72
June	61	44	40	32	27	62	99
July	59	43	40	22	9	57	61
August	81	80	30	18	11	89	91
September	55	34	23	18	12	55	64
October	36	27	28	36	41	36	38
November	25	23	71	86	73	26	29
December	23	28	107	113	87	23	25

Section	北部灣						
	Surface and windage setting (C_w)					Depth (m)	
Month	0	0.01	0.03	0.05	0.1	0.5	1
January	235	217	227	192	198	224	218
February	253	232	245	239	285	255	256
March	297		342	256	289	333	280
April	448		650	468	329	380	305
May	280			632	464	73	294
June	40	34	29	36	22	39	79
July	44	37	37	25	20	44	43
August	57	47	27	24	20	57	57
September	65	48	41	42	43	66	69
October	109	103	79	95	134	109	113
November	128	145	114	186	111	123	127
December	182	178	121	487	382	165	555

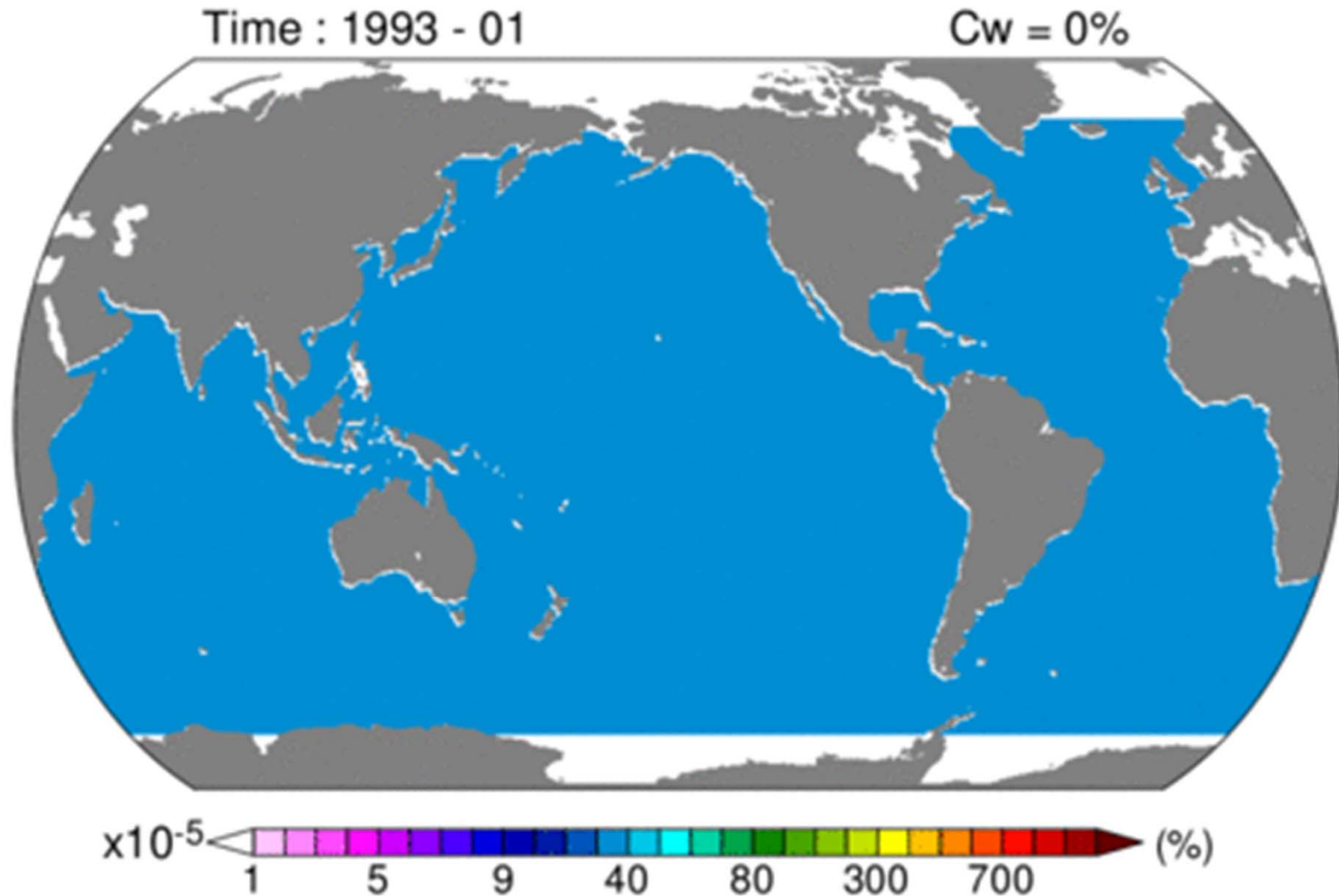
- **低**風阻效應模擬→主要由呂宋海峽(冬)、西南南海(夏)處漂來
- **高**風阻效應模擬→臺灣海峽成為另一主要來源處



- 將有相當比率(每月0.5%-36.2%)的垃圾會持續在海洋中打轉！

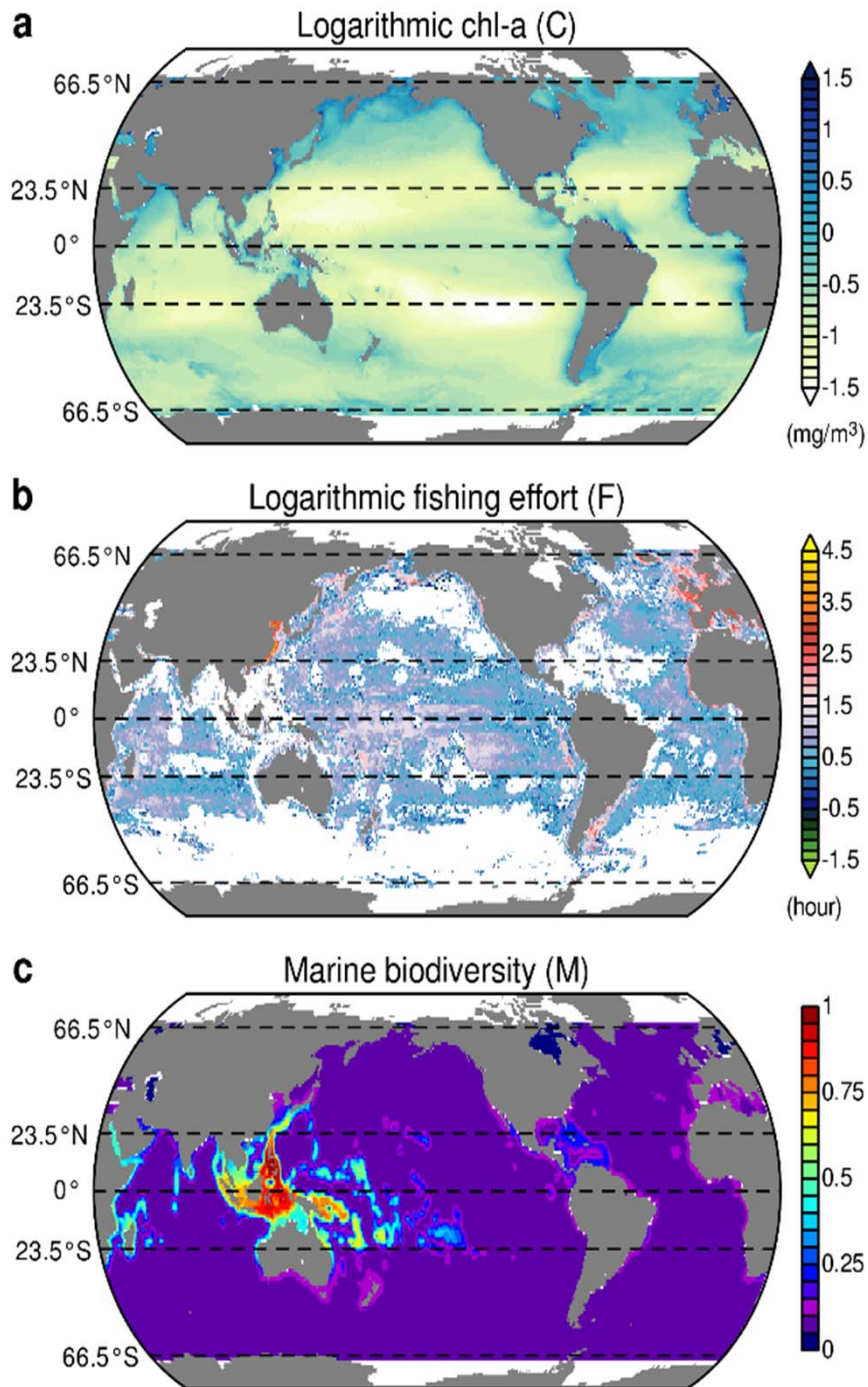


那全球呢?

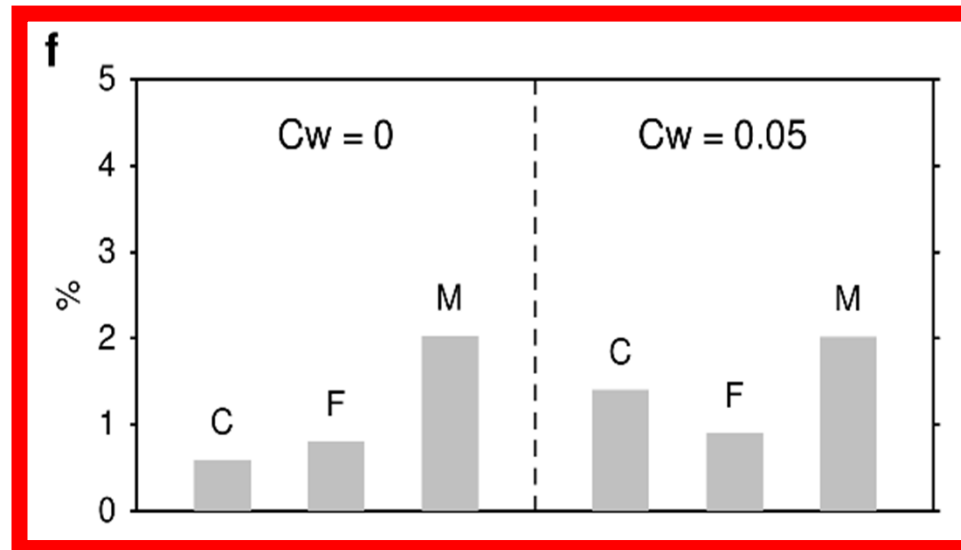


那全球呢？

- (1) 來源分別為沿岸與大洋的海洋垃圾，將會隨著不同的海流與風阻效應，決定其可能的終點。
- (2) 過去被忽視的赤道和極區需要被重新關注
- (3) 超過50%的海洋垃圾仍會持續漂浮在海洋中
- (4) 海洋生物多樣性熱點將遭受最大衝擊



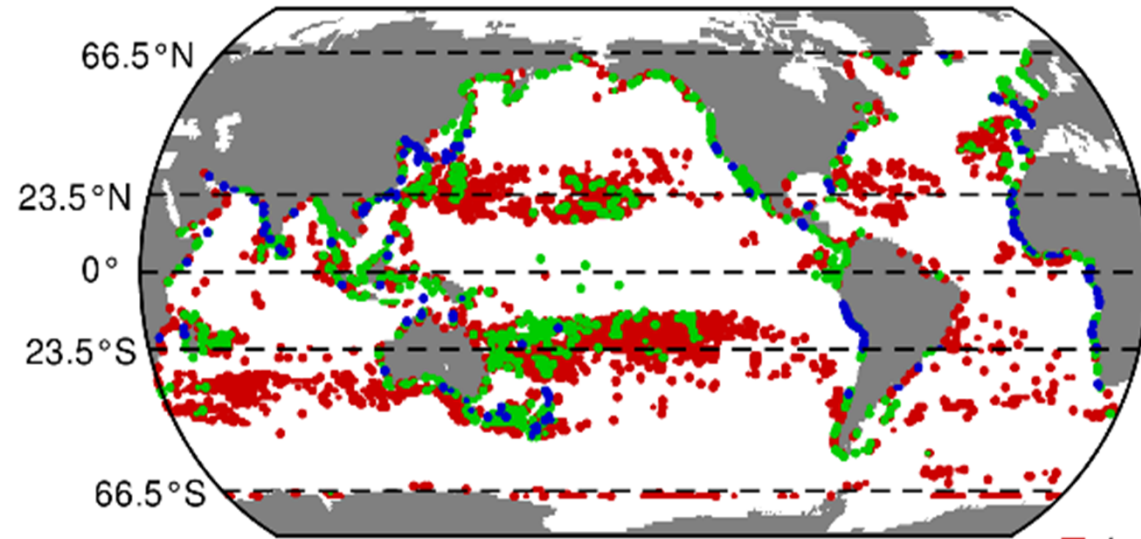
- ✓初級生產力(C)
- ✓漁業活動(F)
- ✓海洋生物多樣性(M)



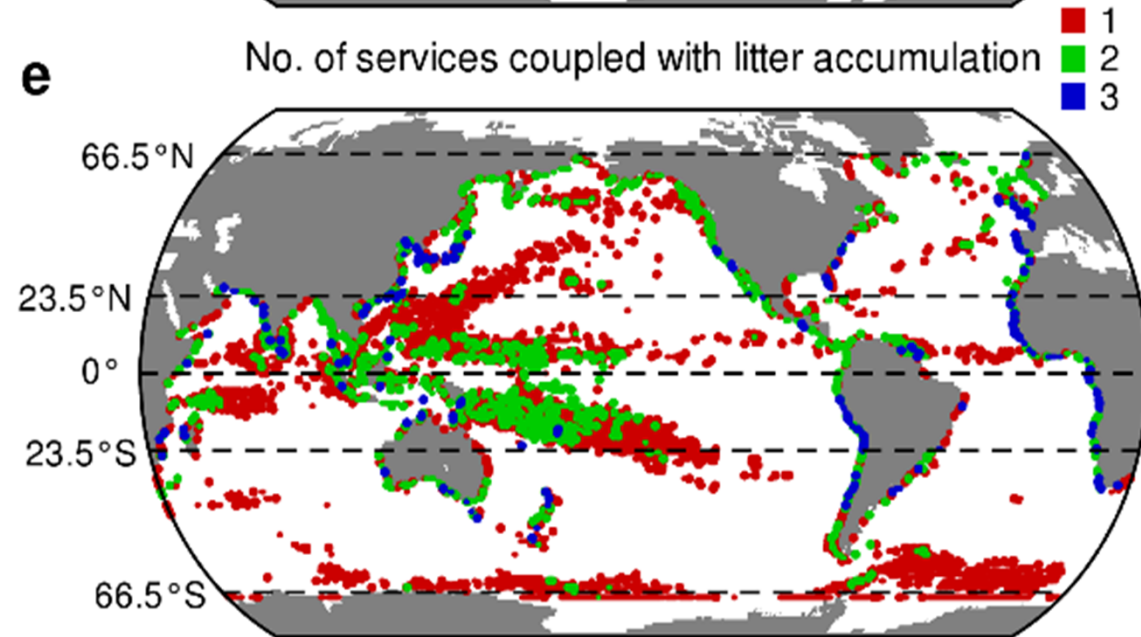
- Marine biodiversity priority areas exhibited 2.03% consistently overlapping with litter accumulation
- 海洋生物多樣性高的區域高度和海廢/海漂垃圾主要累積區域有空間上的重疊 (2.03%)



LOW
windage
低風阻



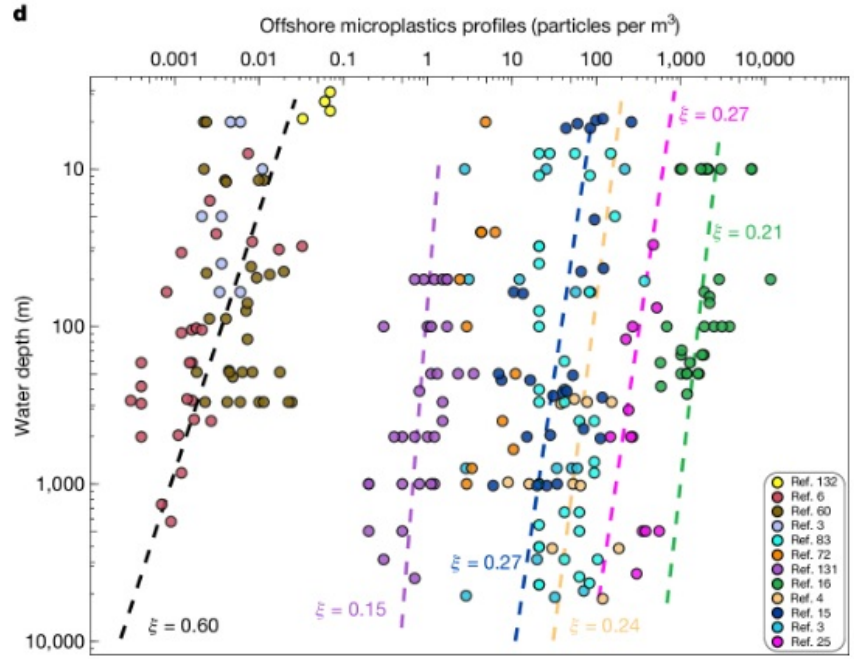
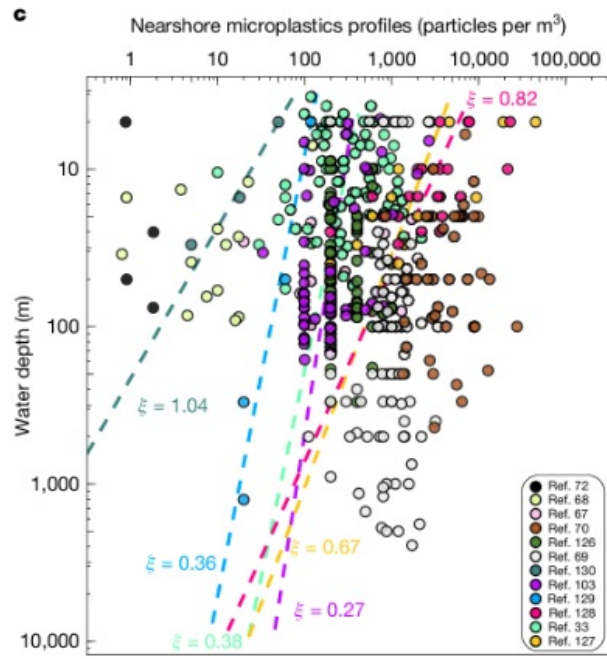
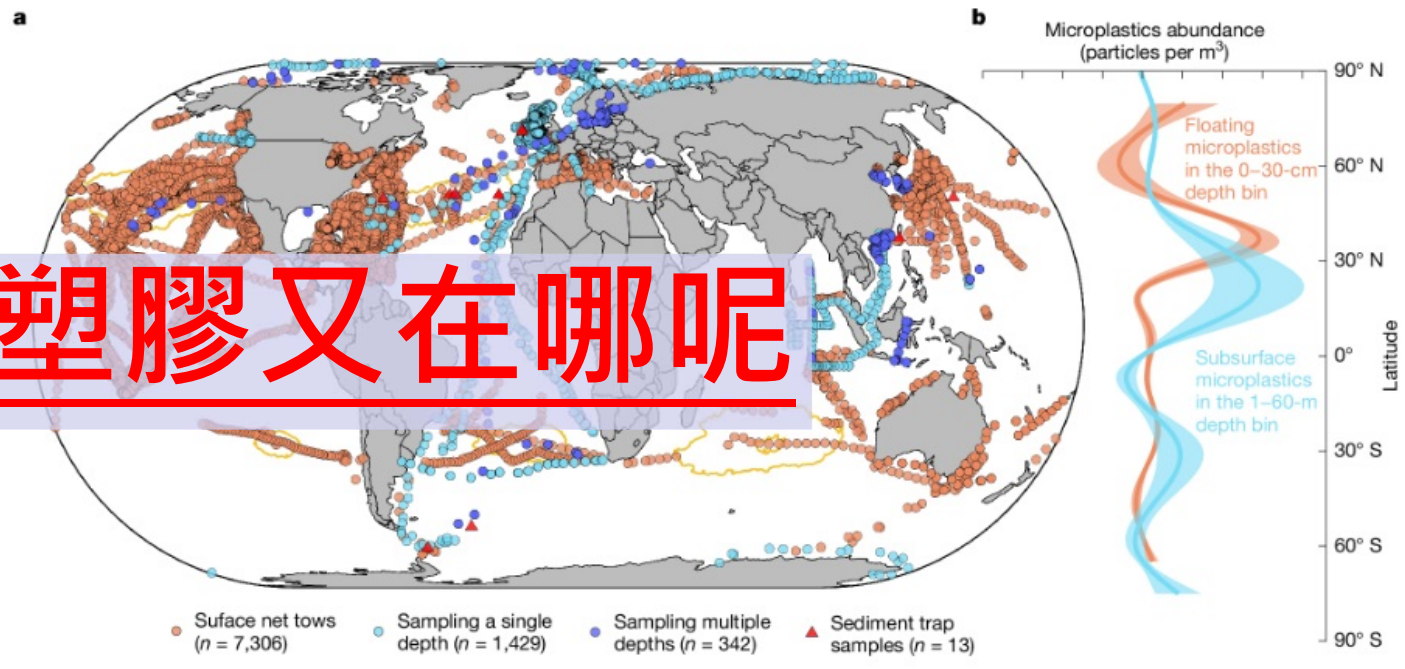
HIGH
windage
高風阻



→ Windage effect on relative litter accumulation had the potential to alter overlaps of ocean services, especially in the coastal areas of all continents and Southeast Asia and the surrounding marginal seas.

尤其在各洲沿岸地區、東南亞與邊緣海區域

那微塑膠又在哪呢







魷魚遊戲

2018/02/01

臺灣重要的遠洋漁業 -- 阿根廷魷魚



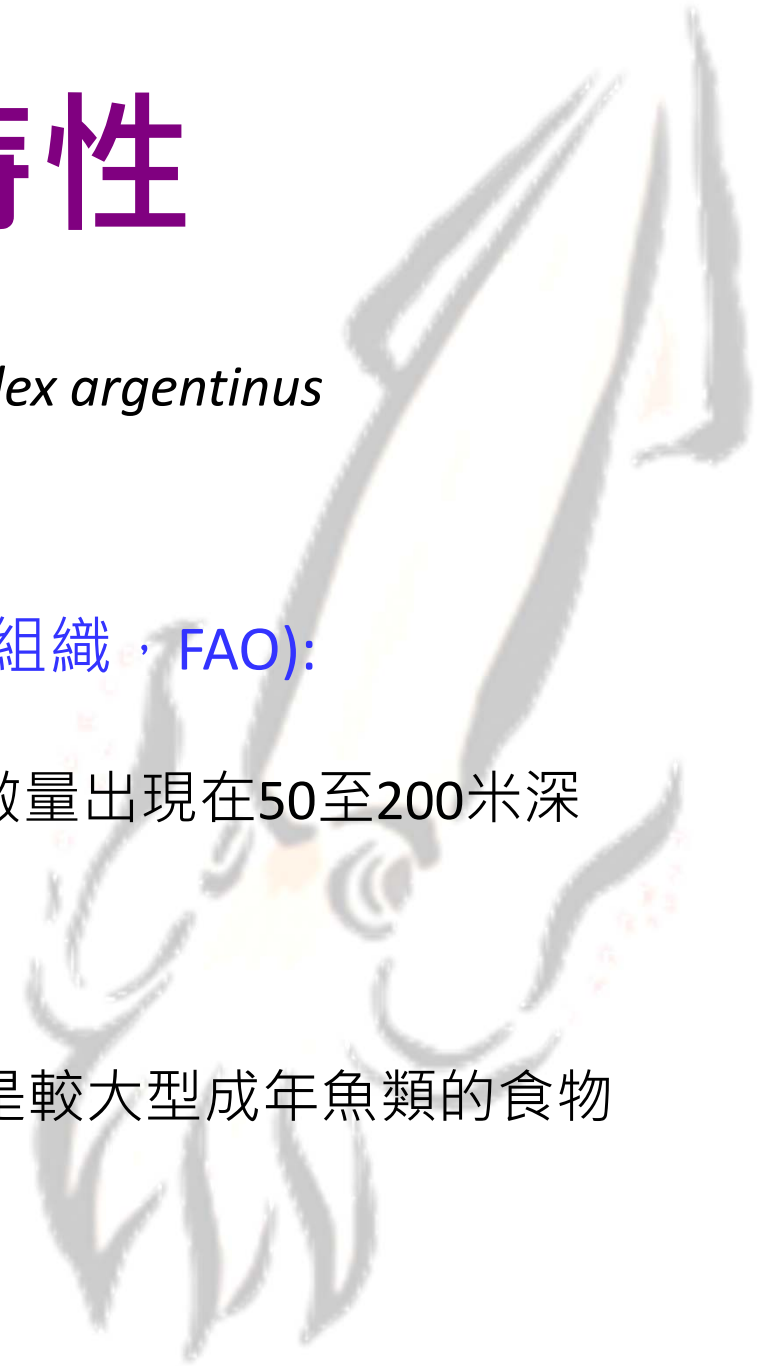


➤ 分布範圍



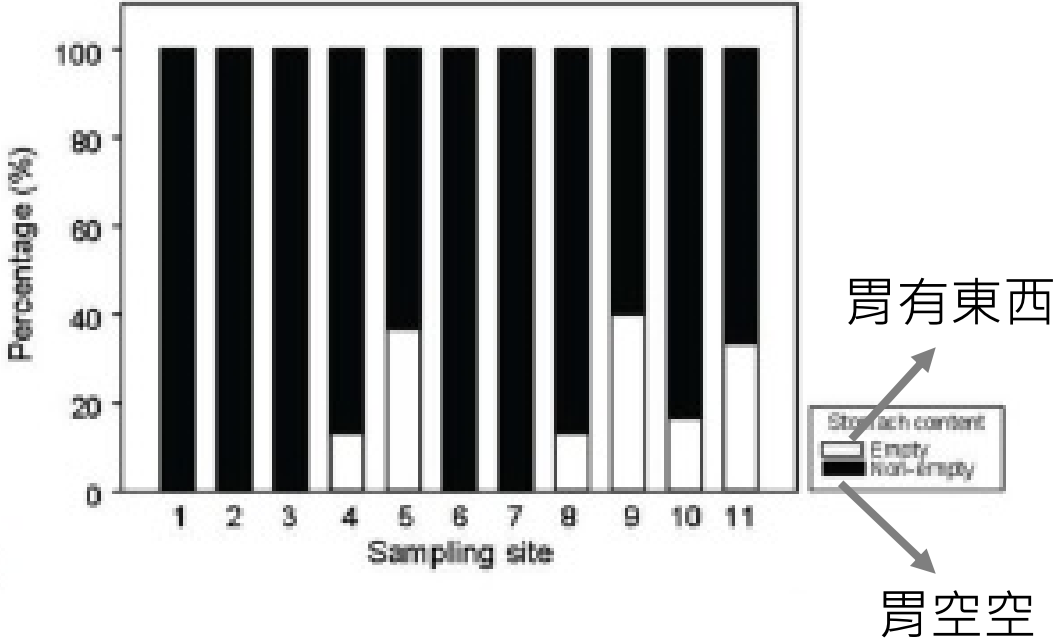
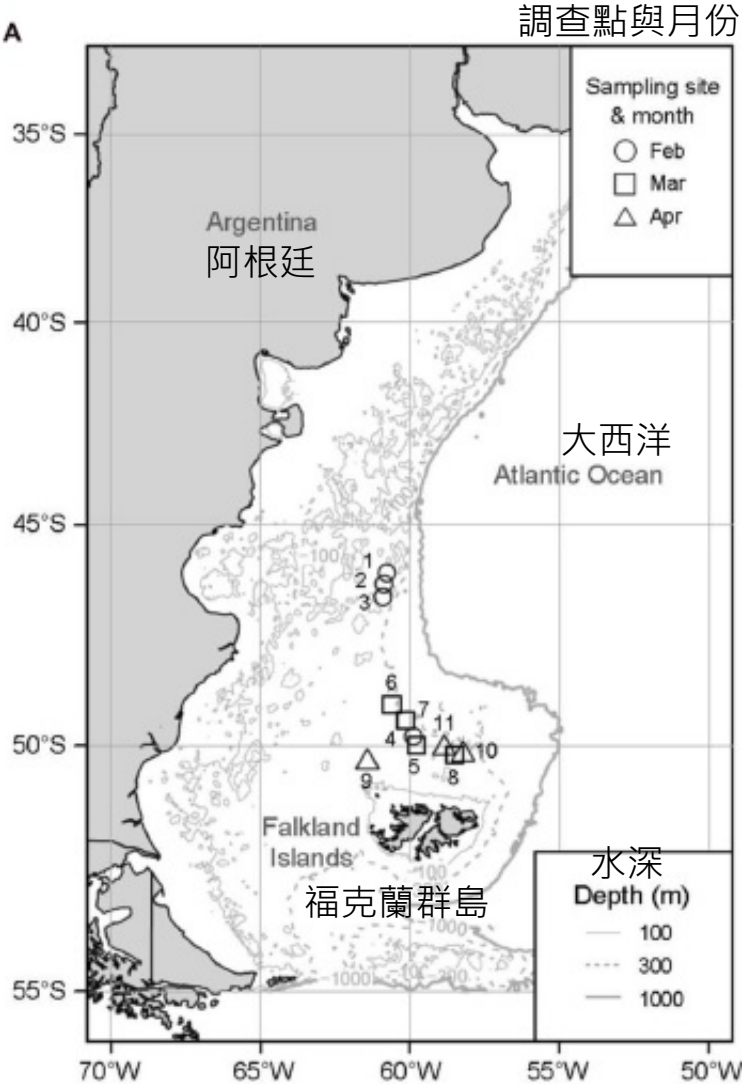
阿根廷魷魚特性

- 阿根廷魷魚 Argentine shortfin squid, *Illex argentinus* (Castellanos, 1960)
- 生物特性 (摘自聯合國糧食及農業組織，FAO):
 - ✓ 生活在淺海至深海(800m)的物種
 - ✓ 南半球的秋至冬季(4-9月)，較多數量出現在50至200米深
 - ✓ 產卵季節為南半球夏季的12-3月
 - ✓ 生長快速，隔年成體約可達40cm
 - ✓ 壽命為1-2年
 - ✓ 以幼魚與浮游蝦蟹為食，同時也是較大型成年魚類的食物



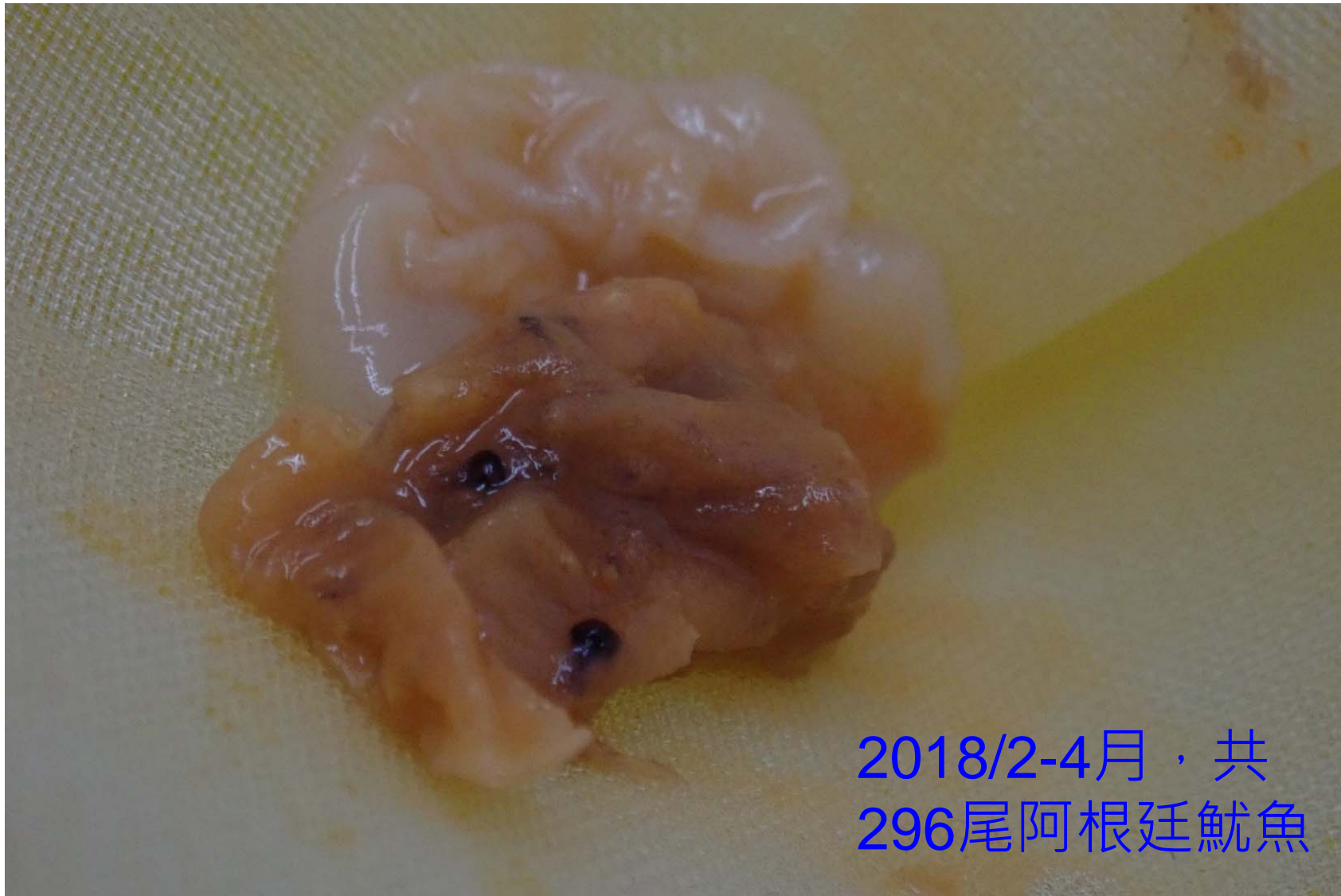


首先，需要先來確定阿根廷魷魚有吃飽!



<https://www.niusnews.com/=P0g2hf31>

胃內含物食性分析

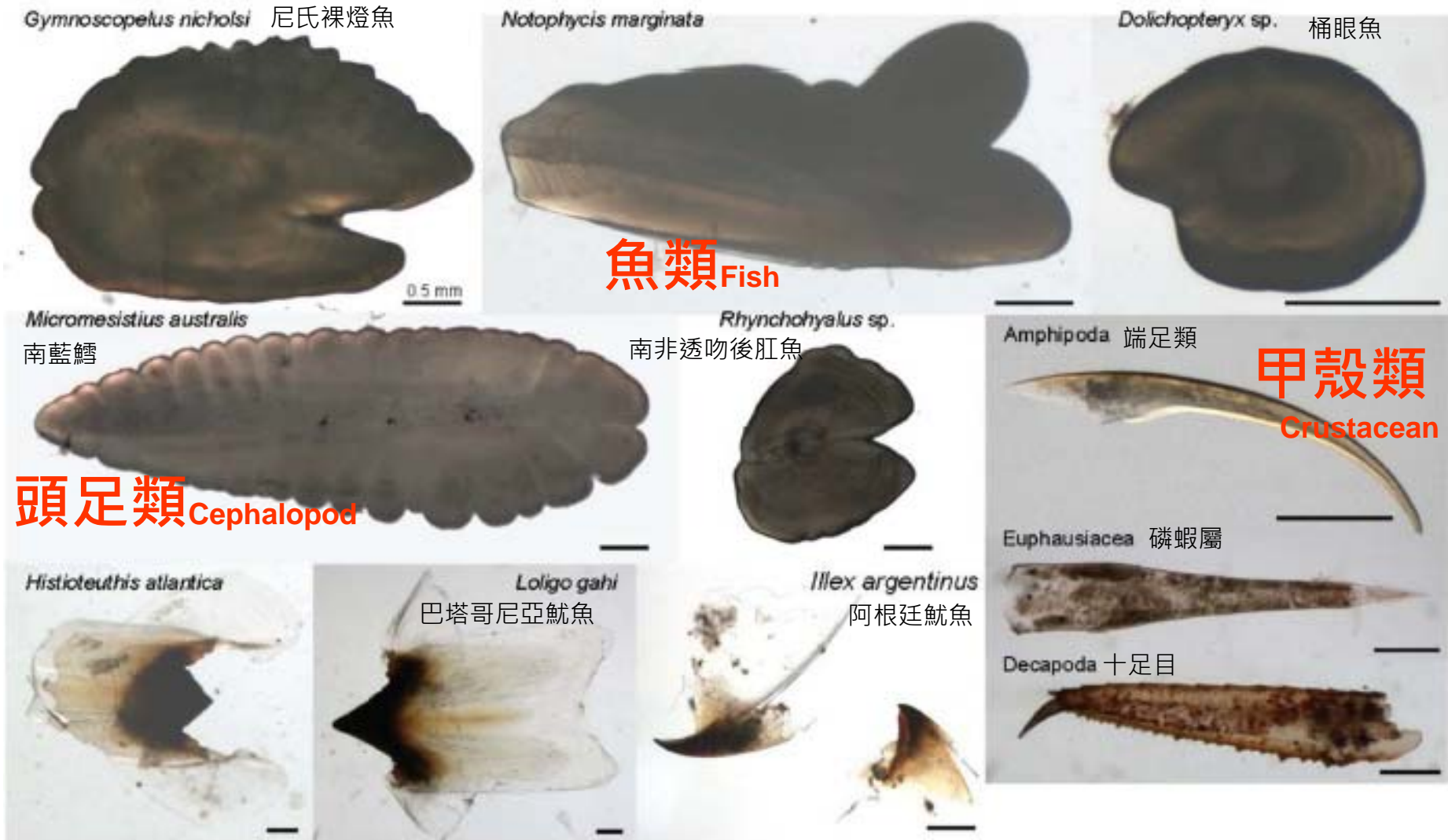


2018/2-4月，共
296尾阿根廷魷魚

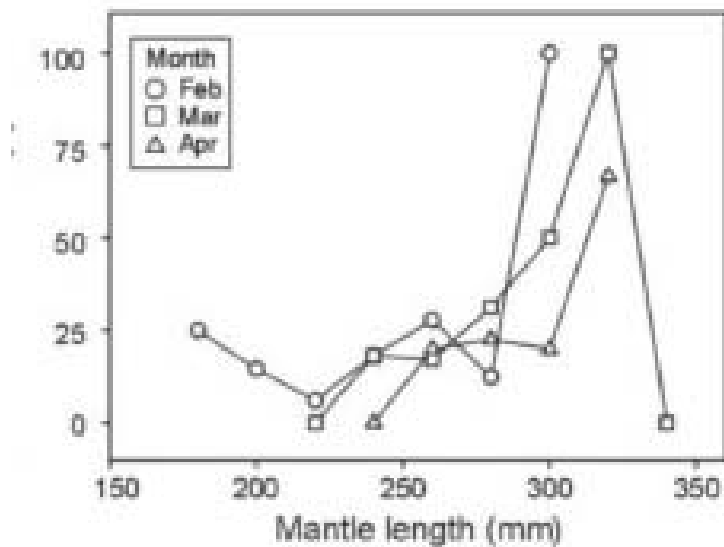
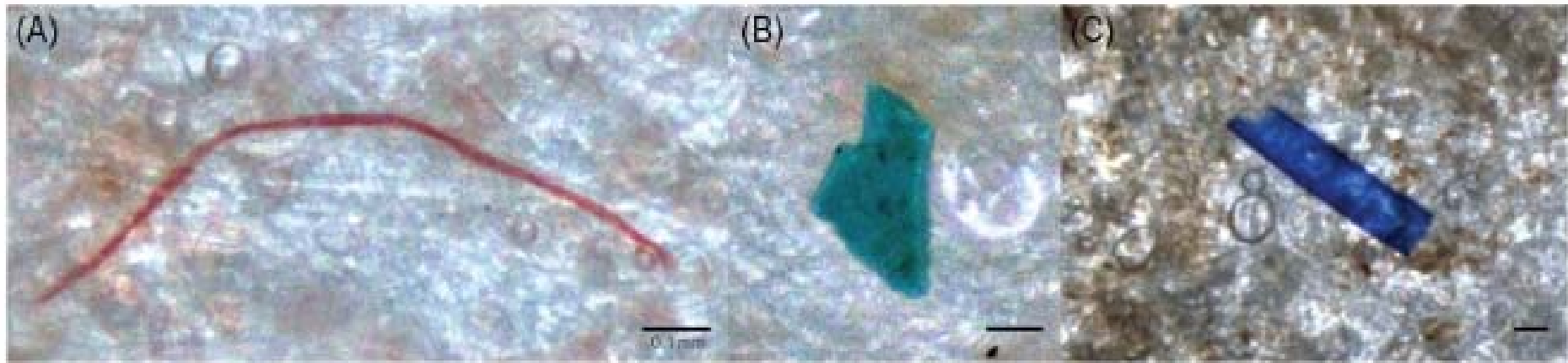


再來，就要看看他們吃了甚麼!

- 耳石
- 喙
- 甲殼碎片



- 海洋生物確實食入了微塑膠，“體型越大”、“有吃魚的”越容易被觀察到。



Dietary composition/Month	Overall
Empty stomach	8/39 (20.51%)
Only fish	3/6 (50%)
Only cephalopod	0/1 (0%)
Only crustacean	38/208 (18.27%)
Fish and cephalopod	0/0
Fish and crustacean	6/28 (21.43%)
Cephalopod and crustacean	2/8 (25%)
All three types of prey	2/6 (33.33%)
Total	59/296 (19.93%)



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CODE: 77072035



<https://www.menti.com/aluciz1zv41v>

海洋保育只靠科學家嗎？

- 減少一次性塑膠
- 選擇永續海鮮
- 淨灘活動
- 公民科學
- 環境教育
- 建議設計保護區
-

海洋保育需要不同的層次?



Levels	Scientific Advice	Management Framework
EBM Ecosystem Based Management	Fisheries, Development, Energy, Eco Tourism, Oil & Gas, Conservation, Marine, Sanctuaries, Aquaculture, Etc	Regional Ocean Plans
EBFM Ecosystem Based Fisheries Management	Climate, Habitat, Predator	Fisheries Ecosystem Plan
EAFM Ecosystem Approach to Fisheries Management	Climate, Habitat, Predator	Fishery Management Plan
SS Single Species	(Single fish icon)	Fishery Management Plan

未來的海洋會變什麼樣子？

A. 沒有行動 (No Action)

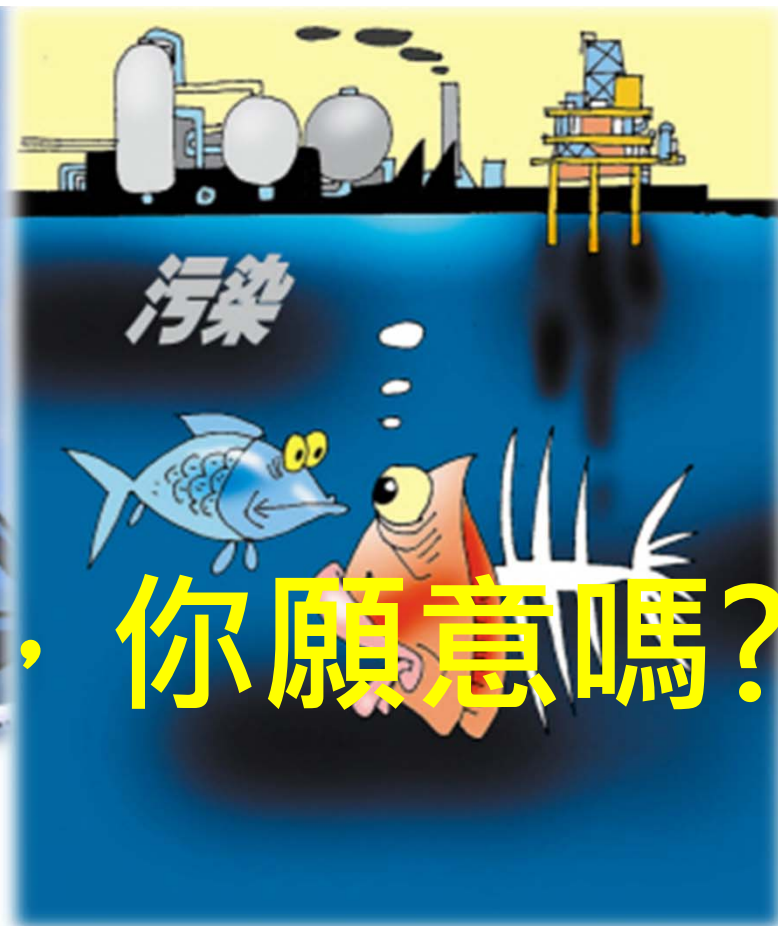
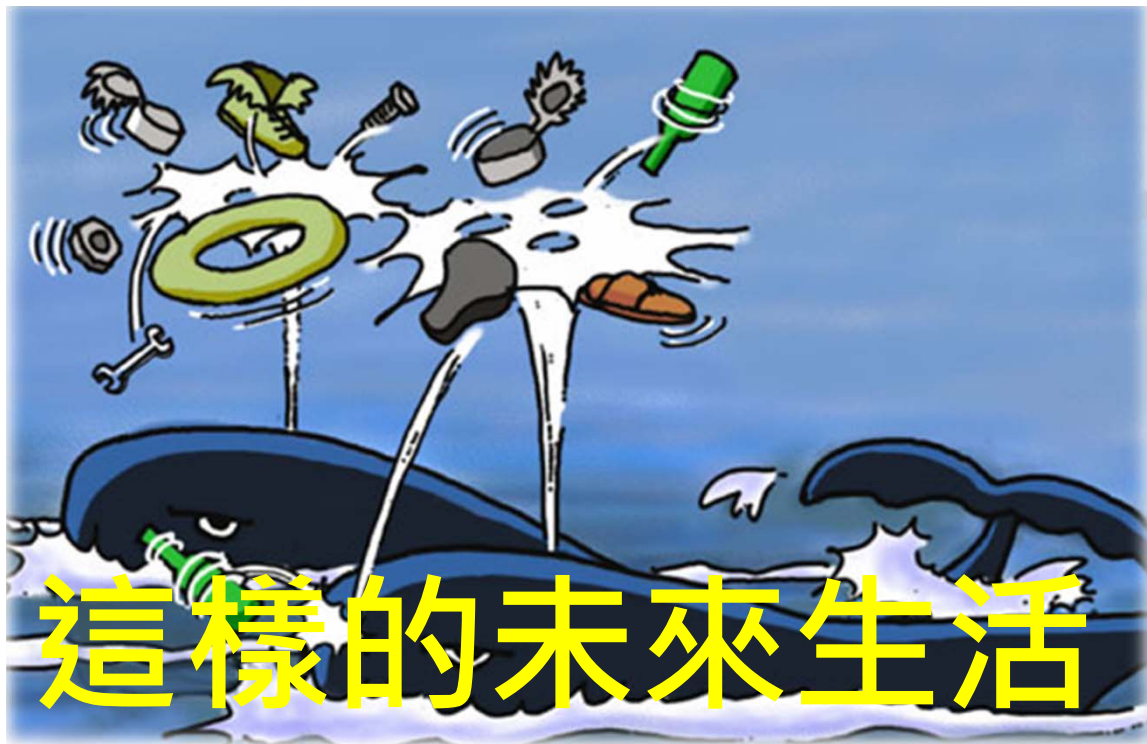


- 更多塑膠
- 生物減少
- 珊瑚消失
-

B. 積極保育 (Active Conservation)



- 生態恢復
- 永續漁業
- 藍碳與氣候改善
-



這樣的未來生活，你願意嗎？

天下无鱼



**「從海洋科學的發現，一路走到
海洋保育的實際行動。」**

**我的行動是科學，嘗試提供科學政具與
數據分析作為政府部門/民眾參考。**

那你呢？





NTU

EER lab



海洋挑戰，"海"能更好!?

從科學到解方

柯佳吟

國立臺灣大學
生物多樣性國際碩士學位學程 主任
漁業科學研究所 教授



謝謝聆聽

cyko235@ntu.edu.tw