

# 2023年海洋科學年會暨國科會海洋學門成果發表會

## 議程表

5月2日(星期二)

B102階梯演講廳

8:30-9:00	簽到 / 報到 / 選舉投票					
9:00-9:10	【開幕式】海洋學理事長致詞/海洋學門召集人致詞					
9:10-9:30	大會演講：永續價值為核心的海洋跨域研究 國家科學及技術委員會_林敏聰副主委					
9:30-9:40	大會致詞：海洋委員會_洪文玲副主委					
9:40-10:00	大會演講：海洋化學自動分析技術之前瞻發展 國立臺灣大學海洋研究所_白書禎特聘教授					
10:00-10:20	大會演講：The Role of Natural Science and Scientists in Ocean Governance and Management Vice-Chair of Future Earth Coast_Dr. Mike Elliott					
10:20-10:45	休息/茶點時間					
10:45-11:00	臺灣海洋聯盟_蔣國平特聘教授_台灣海洋未來十年發展展望					
11:00-12:00	研究船隊與貴儀合併年度績效報告 國家研究船隊總計畫(10分鐘) 新海研1號及貴儀中心(10分鐘) 新海研2號及貴儀中心(10分鐘) 新海研3號及貴儀中心(10分鐘) 勵進研究船(10分鐘) 海洋學門資料庫(10分鐘)					
12:00-13:30	午餐休息(發放餐盒·用餐地點B1餐廳) <b>(12:15-12:45理監事會議)</b>					
	201	203	211	308	208 海報 展 示	212 海 報 競 賽
13:30-13:45	詹森	陳鎮東	林慧玲	夏復國(賴昭成)		
13:45-14:00	張明輝	洪佳章	賀詩琳	何東垣		
14:00-14:15	何宗儒	龔國慶	Raul Tapia	湯森林		
14:15-14:30	陳世楠	洪慶章	Alicia Meng Xiao Hou	樊同雲		
14:30-14:45	陳佳琳	周文臣	林玉詩	楊姍樺		
14:45-15:00	曹俊和	陳宗岳	尤柏森	Crystal McRae		
15:00-15:15	鄭宇昕	溫良碩	張翠玉	李東霖		
15:15-15:45	休息/茶點時間					
15:45-16:00	楊穎堅	雷漢杰	林慶仁	陳仲吉	208 海 報 展 示	212 海 報 競 賽
16:00-16:15	許哲源	謝玉德	張日新	藍國維		
16:15-16:30	方盈智	黃蔚人		陳煦森		
16:30-16:45	曾若玄	施詠嚴	林秀瑾	塗子萱		
16:45-17:00	黃千芬	范嵐楓	町田龍二	鍾明宗		
17:00-17:15	邱永盛	廖文軒	陳宜暄	托星豪		
17:15-17:30	鍾曉緯	Sanjaya Weerakkody	沈康寧	呂曉沛		

大會演講  
船務/業務報告

海洋生物&青年論壇  
海洋物理&青年論壇

海洋地質地物&青年論壇  
海洋化學&青年論壇

紫色字體  
為該場次  
主持人

# 2023年海洋科學年會暨國科會海洋學門成果發表會

## 議程表

5月3日(星期三)

	201	203	211	211	308				
8:15-8:30	簽到 / 報到 / 選舉投票				地質地物/化學組青年論壇評審 主持人為紫色字體	ARATRIKA RAY(青)	生物組青年論壇評審 主持人為紫色字體	208 海報 展示	212 海報 競賽
8:30-8:45		王佳惠	陳品均(青)	1. 李承軒(中央研究院)	RIAH IRAWATI SIHOMBING(青)	8:15-10:00主持人 1. 鍾明宗(臺灣大學) 2. 楊嫻嫻(臺灣大學) 3. 呂曉沛(成功大學)			
8:45-9:00	何真珍(青)	林玉婷	余泓睿(青)	2. 廖文軒(成功大學)	ANITHA MARY DAVIDSON(青)				
9:00-9:15	吳維常(青)	Aafaq Nazir	鄭喬方(青)	3. 張日新(臺灣大學)	Gowri Krishna Girija(青)				
9:15-9:30	林欣怡(青)	Christine H. L. Schönberg	高愷巖(青)	4. 簡嘉德(GEOMAR)	Priyanka Muthu(青)				
9:30-9:45	余岱鈞(青)	陳孟仙	蔣正興	5. 鄧家明(TORI)	Vicente G. Abedneko(青)				
9:45-10:00	蔡維展(青)	鄭力綺	劉祖乾	6. 張詠斌(中山大學)	許家昕(青)				
10:00-10:30	休息/茶點時間							10:30-12:30主持人 4. 李東霖(海洋大學) 5. 塗子萱(中山大學) 6. 沈康寧(國海院)	茶點時間
10:30-10:45	侯丞謙(青)	李明安	洪芷盈(青)	地質地物/化學組青年論壇評審 主持人為紫色字體	蕭博元(青)	208 海報 展示	212 海報 競賽		
10:45-11:00	黃葳柔(青)	廖德裕	Akshat Gopalakrishnan(青)	1. 張日新(臺灣大學)	郭殊君(青)				
11:00-11:15	陳紹強(青)	王慧瑜	鍾佳妤(青)	2. 簡嘉德(GEOMAR)	方澤(青)				
11:15-11:30	陳妍榛(青)	陳瑞谷	陳艾璘(青)	3. 鄧家明(TORI)	田育如(青)				
11:30-11:45	陳銘誼(青)	黃淑強	黃仁愉(青)	4. 李承軒(中央研究院)	馬暉承(青)				
11:45-12:00	郭瀚升(青)	謝泓諺	林恩如(青)	5. 廖文軒(成功大學)	李沐廷(青)				
12:00-12:15	李琦文(青)	林裕嘉	莊淑嫻(青)	6. 張詠斌(中山大學)	蘇又(青)				
12:15-12:30	藍亦汝(青)	蕭仁傑	鄭厚昇(青)		羅翌瑄(青)				
12:30-13:30	午餐休息(發放餐盒·用餐地點B1餐廳) <b>新任理監事選舉開票(開票教室視當場狀況決定)</b>								
14:00-15:30	海報競賽評分時間二樓212教室 【物理組評審】鄭宇昕(海洋大學)/許哲源(臺灣大學)/方盈智(中山大學) 【化學組評審】謝玉德(臺灣大學)/黃蔚人(中山大學)/許介璋(高雄科技大學) 【地質地物組評審】許鶴瀚/張日新(臺灣大學)/林玉詩(中山大學)/尤柏森(TORI) 【生物漁業組評審】時繼宇(海洋大學)、張峰勳(臺灣大學)/托星豪、林裕嘉(中山大學)/曾瓊蓉(TORI)/陳煦森(屏東科技大學)								
15:30-16:00	休息/茶點時間								
16:00-17:30	海報競賽評分時間二樓212教室 【物理組評審】鄭宇昕(海洋大學)/許哲源(臺灣大學)/方盈智(中山大學) 【化學組評審】謝玉德(臺灣大學)/黃蔚人(中山大學)/許介璋(高雄科技大學) 【地質地物組評審】許鶴瀚/張日新(臺灣大學)/林玉詩(中山大學)/尤柏森(TORI) 【生物漁業組評審】時繼宇(海洋大學)、張峰勳(臺灣大學)/托星豪、林裕嘉(中山大學)/曾瓊蓉(TORI)/陳煦森(屏東科技大學)								
18:00-21:00	晚宴								

大會演講	海洋生物&青年論壇	海洋地質地物&青年論壇	紫色字體為該場次主持人
船務/業務報告	海洋物理&青年論壇	海洋化學&青年論壇	

# 2023年海洋科學年會暨國科會海洋學門成果發表會

## 議程表

5月4日(星期四)

	201	203	211	308				
8:15-8:30	簽到 / 報到			粘雅涵(青)	208 海報 展示	212 海報 競賽		
8:30-8:45			李彥輝	邱煒恩(青)			生物組青年論壇評審 主持人為紫色字體	
8:45-9:00	林依依	方天熹	蔡昇芳	陳彥妤(青)			1. 賴昭成 (臺北教育大學) 2. 張順恩(海洋大學) 3. 陳煦森 (屏東科技大學) 4. 鍾明宗(臺灣大學) 5. 楊姍姍(臺灣大學) 6. 呂曉沛(成功大學) 7. 塗子萱(中山大學) 8. 沈康寧(國海院)	
9:00-9:15	曾于恆	陳宏瑜	張峰勳	蔡佳蓉(青)				
9:15-9:30	黃金維	曾筱君	詹雅帆	李良能(青)				
9:30-9:45	李逸環	李宗霖	張順恩	吳孟昕(青)				
9:45-10:00	錢樺	簡國童	蔡安益	蕭仲凱(青)				
10:00-10:15	陳冠宇	林卉婷	楊明哲	石楷(青)				
10:15-10:30	鄭志文	許瑞峯	魏志澐	鐘晟齊(青)				
10:30-10:45	辛宜佳	李承軒	謝學函	林哲越(青)				
10:45-11:00	吳朝榮	謝志強	時繼宇	張瑋珍(青)				
11:00-11:15				吳億鈴(青)				
11:15-11:30								
11:30-12:30	閉幕式及頒獎 地點：B102階梯演講廳							
12:30-13:30	大會撤場							

大會演講	海洋生物&青年論壇	海洋地質地物&青年論壇	紫色字體為該場 次主持人
船務/業務報告	海洋物理&青年論壇	海洋化學&青年論壇	



# 2023年海洋科學年會暨 國科會海洋學門成果發表

2023 Ocean Sciences Conference

May 2-4, 2023

## 議程摘要集

中華民國海洋學會

國科會地球科學研究推動中心

國立臺灣大學海洋研究所

國立臺灣海洋大學海洋科學與資源學院





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## 會議宗旨

海洋科學年會為臺灣海洋科學界每年一度的盛會，2023 年 5 月 2 日至 5 月 4 日將規劃於南山人壽教育訓練中心舉辦。本次年會舉辦方式由海洋學界相關領域老師、研究人員、博士後研究人員、學生及助理於海洋科學年會中報告最新的研究進展與成果，預計約有 300~500 人與會。內容涵括物理海洋、海洋地質和地球物理、海洋化學及生物海洋四大專業以及其相關子議題，以求更廣泛的學術交流。

本次年會內容涵蓋議程分組演講、海報展示及海報競賽；如同以往將舉辦青年論壇，評選出優秀學生報告，頒發獎項以茲鼓勵。會議首日將邀請國家研究船隊新海研 1 號、海研 2 號、海研 3 號、貴儀中心及資料庫進行 15 分鐘成果發表報告。與會者除了可以分享最新的研究成果和進展外，於會議中的交流更有助於學者間相互瞭解與溝通，並提供年輕海洋學子們一個學習分享的平台，也能為推廣海洋科學研究及教育紮下厚實的根基。

## 會議組織

### 一、召集人：

詹森：國立臺灣大學海洋研究所特聘教授/中華民國海洋學會理事長

夏復國：中央研究院環境變遷中心研究員兼副主任

洪慶章：國立中山大學海洋科學系特聘教授

蔡安益：國立臺灣海洋大學海洋環境與生態研究所教授兼所長

陳明德：國立臺灣海洋大學地球科學研究所教授

張明輝：國立臺灣大學海洋研究所教授

### 二、共同主辦單位：

國科會地球科學研究推動中心

國立臺灣大學海洋研究所

國立臺灣海洋大學海洋科學與資源學院

### 三、承辦單位：中華民國海洋學會



## 議程與召集人

	議程	召集人
OC	研究船事務/貴儀中心/資料庫報告 Marine Research Vessels/ Marine Instrument Center/ODB	夏復國
<b>海洋學門基礎領域(含貴儀及資料庫助理/技術員報告)</b>		
OC1	海洋物理 Physical Oceanography	張明輝
OC2	海洋化學 Chemical Oceanography and Marine Chemistry	洪慶章
OC3	海洋地質/地球物理 Marine Geology & Geophysics	陳明德
OC4	海洋生物/漁業 Biological Oceanography and Marine Biology	蔡安益

## 論文編號說明

### ※海報競賽：PCMN

M 代表海報組別；N 代表海報於該組之次序，代號與組別對應如下：

B：海報競賽生物組：如 PCB1 為海報競賽生物組第一號

C：海報競賽化學組：如 PCC1 為海報競賽化學組第一號

G：海報競賽地質/地物組：如 PCG1 為海報競賽地質/地物組第一號

P：海報競賽物理組：如 PCP1 為海報競賽化學組第一號

### ※海報展示：PMN

M 代表海報組別；N 代表海報於該組之次序，代號與組別對應如下：

B：海報展示生物組：如 PB1 為海報競賽生物組第一號

C：海報展示化學組：如 PC1 為海報競賽化學組第一號

G：海報展示地質/地物組：如 PG1 為海報競賽地質/地物組第一號

P：海報展示物理組：如 PP1 為海報競賽組物理組第一號

# 會議議程 紫色字體為該場次主持人

5月2日(星期二)

B102階梯演講廳

8:30-9:00	簽到 / 報到 / 選舉投票				
9:00-9:10	【開幕式】海洋學理事長致詞/海洋學門召集人致詞				
9:10-9:30	大會演講：永續價值為核心的海洋跨域研究 國家科學及技術委員會_林敏聰副主委				
9:30-9:40	大會致詞：海洋委員會_洪文玲副主委				
9:40-10:00	大會演講：海洋化學自動分析技術之前瞻發展 國立臺灣大學海洋研究所_白書禎特聘教授				
10:00-10:20	大會演講：The Role of Natural Science and Scientists in Ocean Governance and Management Vice-Chair of Future Earth Coast_Dr. Mike Elliott				
10:20-10:45	休息/茶點時間				
10:45-11:00	臺灣海洋聯盟_蔣國平特聘教授_台灣海洋未來十年發展展望				
11:00-12:00	研究船隊與貴儀合併年度績效報告 國家研究船隊總計畫(10分鐘) 新海研1號及貴儀中心(10分鐘) 新海研2號及貴儀中心(10分鐘) 新海研3號及貴儀中心(10分鐘) 勵進研究船(10分鐘) 海洋學門資料庫(10分鐘)				
12:00-13:30	午餐休息(發放餐盒，用餐地點B1餐廳) (12:15-12:45理監事會議)				
	201	203	211	308	
13:30-13:45	詹森	陳鎮東	林慧玲	夏復國(賴昭成)	208 海報 展示
13:45-14:00	張明輝	洪佳章	賀詩琳	何東垣	
14:00-14:15	何宗儒	龔國慶	Raul Tapia	湯森林	
14:15-14:30	陳世楨	洪慶章	Alicia Meng Xiao Hou	樊同雲	
14:30-14:45	陳佳琳	周文臣	林玉詩	楊姍樺	
14:45-15:00	曹俊和	陳宗岳	尤柏森	Crystal McRae	
15:00-15:15	鄭宇昕	溫良碩	張翠玉	李東霖	
15:15-15:45	休息/茶點時間				
15:45-16:00	楊穎堅	雷漢杰	林慶仁	陳仲吉	208 海報 展示
16:00-16:15	許哲源	謝玉德	張日新	藍國維	
16:15-16:30	方盈智	黃蔚人		陳煦森	
16:30-16:45	曾若玄	施詠嚴	林秀瑾	塗子萱	
16:45-17:00	黃千芬	范嵐楓	町田龍二	鍾明宗	
17:00-17:15	邱永盛	廖文軒	陳宜暄	托星豪	
17:15-17:30	鍾曉緯	Sanjaya Weerakkody	沈康寧	呂曉沛	

大會演講	海洋生物&青年論壇	海洋地質地物&青年論壇
船務/業務報告	海洋物理&青年論壇	海洋化學&青年論壇





# 會議議程 紫色字體為該場次主持人

5月3日(星期三)						
	201	203	211		308	
8:15-8:30	簽到 / 報到 / 選舉投票			地質地物/化學組青年論壇評審 主持人為紫色字體	ARATRIKA RAY(青)	生物組青年論壇評審 主持人為紫色字體
8:30-8:45	物理組青年論壇評審 主持人為紫色字體	王佳惠	陳品均(青)	1. 李承軒(中央研究院)	RIAH IRAWATI SIHOMBING(青)	
8:45-9:00	何真珍(青)	林玉婷	余泓睿(青)	2. 廖文軒(成功大學)	ANITHA MARY DAVIDSON(青)	
9:00-9:15	吳維常(青)	Aafaq Nazir	鄭喬方(青)	3. 張日新(臺灣大學)	Gowri Krishna Girija(青)	8:15-10:00主持人
9:15-9:30	林欣怡(青)	Christine H. L. Schönberg	高愷燦(青)	4. 莊佩涓(中央大學)	Priyanka Muthu(青)	1. 鍾明宗(臺灣大學)
9:30-9:45	余岱鈞(青)	陳孟仙	蔣正興	5. 鄧家明(TORI)	Vicente G. Abedneko(青)	2. 楊煒燁(臺灣大學)
9:45-10:00	蔡維展(青)	鄭力綺	劉祖乾	6. 張詠斌(中山大學)	許家昕(青)	3. 呂曉沛(成功大學)
10:00-10:30	休息/茶點時間					10:30-12:30主持人
10:30-10:45	侯丞謙(青)	物理組青年論壇評審 主持人為紫色字體	李明安	洪芷盈(青)	地質地物/化學組青年論壇評審 主持人為紫色字體	4. 李東霖(海洋大學)
10:45-11:00	黃威柔(青)		廖德裕	Akshat Gopalakrishnan(青)	蕭博元(青)	5. 塗子萱(中山大學)
11:00-11:15	陳紹強(青)		王慧瑜	鍾佳妤(青)	郭殊君(青)	6. 沈康寧(國海院)
11:15-11:30	陳妍榛(青)	1. 許伯駿(中央大學)	陳瑞谷	陳艾璇(青)	方澤(青)	7. 賴昭成 (臺北教育大學)
11:30-11:45	陳銘誼(青)	2. 陳佳琳(成功大學)	黃淑強	黃仁倫(青)	田育如(青)	8. 張順恩(海洋大學)
11:45-12:00	郭瀚升(青)	3. 鄭宇昕(海洋大學)	謝泓諱	林恩如(青)	馬暉承(青)	9. 托星豪(中山大學)
12:00-12:15	李琦文(青)	4. 方盈智(中山大學)	林裕蕙	莊淑嫻(青)	李沐廷(青)	10. 陳煦森 (屏東科技大學)
12:15-12:30	藍亦汝(青)	5. 許哲源(臺灣大學)	蕭仁傑	鄭厚昇(青)	蘇又(青)	
12:30-13:30	午餐休息(發放餐盒·用餐地點B1餐廳) 新任理監事選舉開票(開票教室視當場狀況決定)					
14:00-15:30	海報競賽評分時間二樓212教室 【物理組評審】鄭宇昕(海洋大學)/許哲源(臺灣大學)/方盈智(中山大學) 【化學組評審】謝玉德(臺灣大學)/黃蔚人(中山大學)/許介璋(高雄科技大學) 【地質地物組評審】許鶴瀚/張日新(臺灣大學)/林玉詩(中山大學)/尤柏森(TORI) 【生物漁業組評審】林芸琪(海洋大學)/張峰勳(臺灣大學)/林裕蕙(中山大學)/曾瓊蓉(TORI)/陳煦森(屏東科技大學)					
15:30-16:00	休息/茶點時間					
16:00-17:30	海報競賽評分時間二樓212教室 【物理組評審】鄭宇昕(海洋大學)/許哲源(臺灣大學)/方盈智(中山大學) 【化學組評審】謝玉德(臺灣大學)/黃蔚人(中山大學)/許介璋(高雄科技大學) 【地質地物組評審】許鶴瀚/張日新(臺灣大學)/林玉詩(中山大學)/尤柏森(TORI) 【生物漁業組評審】林芸琪(海洋大學)/張峰勳(臺灣大學)/林裕蕙(中山大學)/曾瓊蓉(TORI)/陳煦森(屏東科技大學)					
18:00-21:00	晚宴					

大會演講	海洋生物&青年論壇	海洋地質地物&青年論壇
船務/業務報告	海洋物理&青年論壇	海洋化學&青年論壇

# 會議議程 紫色字體為該場次主持人

5月4日(星期四)					
	201	203	211	308	
8:15-8:30	簽到 / 報到			粘雅涵(青)	生物組青年論壇評審 主持人為紫色字體
8:30-8:45			李彥輝	邱婷恩(青)	
8:45-9:00	林依依	方天熹	蔡昇芳	陳彥妤(青)	1. 賴昭成 (臺北教育大學) 2. 張順恩(海洋大學) 3. 陳煦森 (屏東科技大學) 4. 鍾明宗(臺灣大學) 5. 楊姍姍(臺灣大學) 6. 呂曉沛(成功大學) 7. 塗子萱(中山大學) 8. 沈康寧(國海院)
9:00-9:15	曾于恆	陳宏瑜	張峰勳	蔡佳蓉(青)	
9:15-9:30	黃金維	曾筱君	詹雅帆	李良能(青)	
9:30-9:45	李逸環	李宗霖	張順恩	吳孟昕(青)	
9:45-10:00	錢樺	簡國童	蔡安益	蕭仲凱(青)	
10:00-10:15	陳冠宇	林卉婷	楊明哲	石楷(青)	
10:15-10:30	鄭志文	許瑞峯	魏志澐	鐘晟齊(青)	
10:30-10:45	辛宜佳	李承軒	謝學函	林哲越(青)	
10:45-11:00	吳朝榮	謝志強	時繼宇	張瑋珍(青)	
11:00-11:15				吳億鈴(青)	
11:15-11:30					
11:30-12:30	閉幕式及頒獎 地點：B102階梯演講廳				
12:30-13:30	大會撤場				

大會演講	海洋生物&青年論壇	海洋地質地物&青年論壇
船務/業務報告	海洋物理&青年論壇	海洋化學&青年論壇

## 5月2日星期二下午議程



## 海洋物理專題演講



主持人：陳世楠/鄭宇昕  
 南山人壽教育訓練中心201室

時間	演講主題	頁數
13:30-13:45	Stand-alone Seaglider profiling characterizes the anatomy of internal solitary waves in a real-time mode 詹森/國立臺灣大學	P42
13:45-14:00	Internal hydraulic transition and turbulent mixing observed in the Kuroshio over the I-Lan Ridge off northeastern Taiwan 張明輝/國立臺灣大學	P43
14:00-14:15	Variations in current patterns in the northern Taiwan Strait 何宗儒/國立臺灣海洋大學	P44
14:15-14:30	Asymmetries in oceanic mesoscale eddy properties 陳世楠/國立臺灣大學	P45
14:30-14:45	The flow-seamount interactions and the resulting vorticity and divergence obtained by a two-vessel survey 陳佳琳/國立成功大學	P46
14:45-15:00	Eddy-induced Mesoscale and Submesoscale Variability in the North Pacific Subtropical Gyre 曹俊和/國立臺灣海洋大學	P47
15:00-15:15	Propagation Speeds of Shoaling Internal Solitary Waves in the South China Sea 鄭宇昕/國立臺灣海洋大學	P48
15:15-15:45	休息/茶點時間	





## 海洋物理專題演講



主持人：許哲源/方盈智  
南山人壽教育訓練中心201室

時間	演講主題	頁數
15:45-16:00	The impact of typhoons on the upper ocean 楊穎堅/國立臺灣大學	P49
16:00-16:15	Effect of wave direction on momentum flux under a tropical cyclone 許哲源/國立臺灣大學	P50
16:15-16:30	Kuroshio path inferred from satellite-derived sea surface topography between the islands of Luzon and Kyushu in the northwestern Pacific 方盈智/國立中山大學	P51-52
16:30-16:45	A revisit of anti-cyclonic eddies off southwestern Taiwan: in-situ and remote observations 曾若玄/國立中山大學	P53
16:45-17:00	Simulation study of vortex tracking in the strong wake behind Green Island using an ASV fleet 黃千芬/國立臺灣大學	P54
17:00-17:15	Geoacoustic Inversion and Acoustic Propagation Study in the sea area of the Taiwan Bank 邱永盛/國立中山大學	P55
17:15-17:30	Applying Sentinel-3 satellite imagery with ocean current numerical model to estimate the spatio- temporal variation of sea surface Chl-a concentration 鍾曉緯/鉅網資訊股份有限公司	P56



## 海洋化學專題演講



主持人：周文臣/陳宗岳  
南山人壽教育訓練中心203室

時間	演講主題	頁數
13:30-13:45	Nutrient Footprint: From the origin of Kuroshio to the East China Sea 陳鎮東/國立中山大學	P57
13:45-14:00	Vertical transfer efficiency of particulate organic carbon in the northern South China Sea 洪佳章/國立中山大學	P58
14:00-14:15	Long-term observation and research of ocean biological pump in the northwest Pacific 龔國慶/國立臺灣海洋大學	P59
14:15-14:30	Impacts of Typhoons、Eddies And Internal Waves on Biogeochemical Processes in the Northern South China Sea- Study of seasonal particulate organic carbon fluxes in the northern South China Sea 洪慶章/國立中山大學	
14:30-14:45	The relationship between metabolism and carbon sink capacity of the seagrass meadows around Dongsha Island 周文臣/國立臺灣海洋大學	P60
14:45-15:00	Typhoon effect on the southern East China Sea: A case study of typhoon Maria in 2018 陳宗岳/國立臺灣海洋大學	P61
15:00-15:15	Colloidal phosphorous in ocean waters 溫良碩/國立臺灣大學	P62
15:15-15:45	休息/茶點時間	



## 海洋化學專題演講



主持人：謝玉德/黃蔚人  
南山人壽教育訓練中心203室

時間	演講主題	頁數
15:45-16:00	Influences of intruded Kuroshio Intermediate and Deep Waters on the carbonate chemistry along 23.5°N off eastern Taiwan 雷漢杰/國立中山大學	P63
16:00-16:15	Tracing anthropogenic aerosols with barium stable isotopes in the South China Sea 謝玉德/國立台灣大學	P64
16:15-16:30	Biogeochemical variations in the southern Taiwan Strait during summer 2022 黃蔚人/國立中山大學	P65
16:30-16:45	Potential differences between $^{13}\text{C}$ - and $^{14}\text{C}$ -PP in the northern South China Sea 施詠嚴/海軍軍官學校	P66
16:45-17:00	Control of organic carbon and calcium carbonate metabolism on the sink/source status of carbon dioxide in Dongsha seagrass meadows in winter and summer 范嵐楓/國立臺灣海洋大學	P67
17:00-17:15	Distribution of dissolved trace metals in the Atlantic-Arctic transition zone 廖文軒/國立成功大學	P68-69
17:15-17:30	Carbon dioxide removal by seaweed <i>Agardhiella subulata</i> using aquaculture and swine wastewater Sanjaya weerakkody/國立中山大學	P70





## 海洋地質地物專題演講



主持人：賀詩琳/林玉詩  
南山人壽教育訓練中心211室

時間	演講主題	頁數
13:30-13:45	Planktonic Foraminiferal Assemblages from Planktonic Tows and Surface Sediments: the Imprint of Coastal Upwelling in the northern South China Sea 林慧玲/國立中山大學	P71
13:45-14:00	As complicated as it gets: Different upper ocean thermal gradients off Southwest Sumatra derived from biomarker- and foraminifera-based proxies 賀詩琳/國立臺灣大學	P72
14:00-14:15	Foraminifera as a tool for the reconstruction of paleobathymetry and geohazard: A case study Raul Tapia/國立臺灣大學	P73
14:15-14:30	Hemispherically asymmetric trade wind changes in the Indo-Pacific region drive subsurface temperature evolution over the past ~25 kyr Alicia Meng Xiao Hou/國立臺灣大學	P74-75
14:30-14:45	Benthic organic carbon remineralization on a broad shelf receiving small mountainous rivers derived sediment 林玉詩/國立中山大學	P76
14:45-15:00	Behavior of two types of gravity corer and insight on quality of the recovery: A case study of R/V Legend cruises 尤柏森/財團法人國家實驗研究院	P77
15:00-15:15	ocean-bottom water pressure variations caused by ground motion in significant earthquakes 張翠玉/國立臺灣大學	P78
15:15-15:45	休息/茶點時間	



## 海洋地質地物與海洋生物專題演講



主持人：陳宜暄/沈康寧  
南山人壽教育訓練中心211室

時間	演講主題	頁數
15:45-16:00	Design, test and preliminary data analysis of absolute seafloor pressure gauge (APG) 林慶仁/中央研究院	P79
16:00-16:15	Architecture, formation and implication of active structure-controlled intraslope channel system southeast offshore Sendai, Tohoku, Japan 張日新/國立臺灣大學	P80
16:15-16:30	海洋生物組準備	
16:30-16:45	Transcriptome and gene-based datasets revealed the phylogenetic relationships of lancelets (Subphylum Cephalochordata) 林秀瑾/國立中山大學	P81
16:45-17:00	Importance of preserving RNA in zooplankton community-based genetic studies 町田龍二/中央研究院	P82
17:00-17:15	Annual Difference of Environmental DNA composition at Taiping Island, Nansha Islands 陳宜暄/國家海洋研究院	P83
17:15-17:30	Spatio-temporal environmental DNA analyses of fishes around Taiwan 沈康寧/國家海洋研究院	P84



## 海洋生物專題演講



主持人：何東垣/李東霖  
南山人壽教育訓練中心308室

時間	演講主題	頁數
13:30-13:45	Viral shunt in tropical oligotrophic ocean 夏復國(賴昭成)/中央研究院	P85
13:45-14:00	'Iron hypothesis' for coral bleaching: validating the importance of FeSOD expression in endosymbiotic dinoflagellates 何東垣/中央研究院	P86
14:00-14:15	Prevalence, complete genome, and metabolic potentials of a phylogenetically novel cyanobacterial symbiont in the coral-killing sponge, <i>Terpios hoshinota</i> 湯森林/中央研究院	P87-88
14:15-14:30	Status, Conservation and Restoration of Taiwan's Coral Ecosystem under Environment and Climate Change 樊同雲/國立海洋生物博物館	P89
14:30-14:45	Effect of increasing diurnal fluctuations of temperature on microbial composition in reef-building corals 楊姍樺/國立臺灣大學	P90
14:45-15:00	Combining acute heat-stress assays and large-area imaging approaches to identify upper thermal limits of coral colonies across reefs with different temperature histories Crystal McRae/國立海洋生物博物館	P91
15:00-15:15	AI Technology Applied to Coral Reef Ecosystem Analysis 李東霖/國立臺灣海洋大學	P92
15:15-15:45	休息/茶點時間	



## 海洋生物專題演講



主持人：塗子萱/鍾明宗  
南山人壽教育訓練中心308室

時間	演講主題	頁數
15:45-16:00	Effect of tropical cyclone on a continental shelf ecosystem 陳仲吉/國立臺灣師範大學	P93
16:00-16:15	The effect of temperature and heterotrophic feeding on the reproductive performance of the reef coral <i>Pocillopora acuta</i> 藍國維/國立東華大學	P94
16:15-16:30	Influence of climate drive habitat characteristic change on shrimp assemblages in subtropical coastal waters 陳煦森/國立屏東科技大學	P95
16:30-16:45	The diurnal dissolved oxygen variation in seawater is coupled with the DOC excreted by seagrass and microbial activities 塗子萱/國立中山大學	P96
16:45-17:00	Ocean isoscapes and applications to physiological ecology 鍾明宗/國立臺灣大學	P97
17:00-17:15	C:N:P ratios and macromolecular composition in <i>Crocospheera</i> : small- vs. large-cell phenotypes under N-free condition 托星豪/國立中山大學	P98
17:15-17:30	Using a single primer set to reveal various sizes of marine plankton communities along the vertical water column over the diurnal time scale 呂曉沛/國立成功大學	P99



## 5月3日星期三上午議程



海洋物理青年論壇



主持人：鄭宇昕/方盈智  
 南山人壽教育訓練中心201室

時間	演講主題	頁數
08:15-08:30	簽到 / 報到 / 選舉投票	
08:30-08:45	簽到 / 報到 / 選舉投票	
08:45-09:00	Observations of upper ocean temperature and current variation under moderate wind conditions 何真珍/國立臺灣大學	P100
09:00-09:15	Variations of hydrography and biogeochemical properties during summer times in the southeast of Taiwan 吳維常/國立臺灣大學	P101
09:15-09:30	Turbulent mixing of the upper ocean in the southeast sea area of Taiwan during the passage of typhoons and mesoscale eddies 林欣怡/國立臺灣大學	P102
09:30-09:45	Seaglider observations of tropical water mass variability off the eastern coast of Taiwan 余岱鈞/國立臺灣大學	P103
09:45-10:00	The interaction between the river plume and internal tides in the submarine canyon and its influence on sediment transport 蔡維展/國立成功大學	P104
10:00-10:30	休息/茶點時間	





主持人：許伯駿/陳佳琳  
南山人壽教育訓練中心201室

時間	演講主題	頁數
10:30-10:45	The vorticity, convergence, and residual transport of a developed sediment-laden river plume in the meso-tidal condition 侯丞謙/國立成功大學	P105
10:45-11:00	Spatial-temporal variability and long-term trend of oceanic surface mixed layer depths around Taiwan 黃葳柔/國立中山大學	P106
11:00-11:15	Initiating Tropical Pacific Decadal Variability from Off-equatorial Subsurface Temperature Anomalies 陳紹強/國立臺灣大學	P107
11:15-11:30	Estimation of sea ice melt in the Pacific Arctic Region based on T-S observations 陳妍榛/國立中央大學	P108
11:30-11:45	GNSS-R Retrieval Process of Sea Surface Wind Speed 陳銘誼/國立中央大學	
11:45-12:00	Numerical simulation of wind field when a ship enters Taichung Harbor 郭瀚升/國立中山大學	P109
12:00-12:15	Testing the utility of local scaling theory in homogeneous geostrophic turbulence 李琦文/國立臺灣大學	
12:15-12:30	Study on the flow and wave fields in Taoyuan coast based on an unstructured-grid numerical modal 藍亦汝/國立中央大學	P110
12:30-13:30	午休時間 新任理監事選舉開會	



## 海洋生物專題演講



主持人：林玉婷/鄭力綺  
南山人壽教育訓練中心203室

時間	演講主題	頁數
08:15-08:30	簽到 / 報到 / 選舉投票	
08:30-08:45	Fishery biology studies on two small cephalopod species off southwestern Taiwan waters 王佳惠/國立臺灣海洋大學	P111
08:45-09:00	Drivers of coastal benthic communities in a complex environmental setting 林玉婷/國立臺灣大學	P112
09:00-09:15	Stable isotope analysis of otoliths as tracers of hilsa shad ( <i>Tenualosa ilisha</i> ) migration in the Hooghly River Estuary, India Aafaq Nazir/國立臺灣大學	P113-114
09:15-09:30	Bioerosion in the South China Sea Christine H. L. Schönberg/國立中山大學	P115
09:30-09:45	Seasonal variation in fish assemblages and habitat utilization in Chiku Lagoon, Taiwan 陳孟仙/國立中山大學	P116
09:45-10:00	Primely observation in diet composition and migration pattern of <i>Scomberomorus commerson</i> in the waters of Penghu, central Taiwan Strait 鄭力綺/行政院農業委員會水產試驗所沿近海資源研究中心	P117
10:00-10:30	休息/茶點時間	



## 海洋生物專題演講



主持人：王慧瑜/謝泓諺  
南山人壽教育訓練中心203室

時間	演講主題	頁數
10:30-10:45	Habitat Changes and Catch Rate Variability for Greater Amberjack in the Taiwan Strait: The Effects of El Niño-Southern Oscillation Events 李明安/國立臺灣海洋大學	P118-119
10:45-11:00	Dongsha Atoll Research Station Operation Project 廖德裕/國立中山大學	P120
11:00-11:15	Effects of warming on marine fishes depend on life histories 王慧瑜/中央研究院	P121
11:15-11:30	Distribution structure of <i>Sarda orientalis</i> eggs in Yilan Bay under hydrographic conditions 陳瑞谷/農委會水產試驗所	P122
11:30-11:45	Resource dynamics and marine environment: Establishing operational positions for scarce Blackmouth croaker ( <i>Atrubucca nibe</i> ) fishing vessels in southwest Taiwan, standardizing density indicators linked to marine environmental factors, and estimating resource status. 黃淑強/國立中山大學	P123
11:45-12:00	Assemblage of fish larvae in the waters surrounding the Taiwan Bank 謝泓諺/國立東華大學	P124
12:00-12:15	Essential fish habitats in the western Arabian Gulf 林裕嘉/國立中山大學	P125
12:15-12:30	Species specific trophic enrichment factor of stable nitrogen and carbon isotopes in fish otolith organic matter 蕭仁傑/國立臺灣大學	P126
12:30-13:30	午休時間 新任理監事選舉開會	



海洋化學青年論壇

海洋地質地物專題演講



主持人：李承軒/廖文軒  
南山人壽教育訓練中心211室

時間	演講主題	頁數
08:15-08:30	簽到 / 報到 / 選舉投票	
08:30-08:45	Control of organic carbon and carbonate metabolisms on the CO <sub>2</sub> sink/source status in Haikou seagrass meadow in spring and autumn. 陳品均/國立臺灣海洋大學	P127
08:45-09:00	Distribution of marine snow and estimation of particulate organic carbon flux in the ocean around Taiwan 余泓睿/國立臺灣海洋大學	P128
09:00-09:15	Litopenaeus vannamei mariculture might increase the aquatic greenhouse gases concentrations 鄭喬方/國立臺灣海洋大學	P129
09:15-09:30	The Variations of O <sub>2</sub> /Ar-Net Community Production and Air-Sea Carbon Dioxide Flux in the southern East China Sea During Summer 2018. 高愷嶸/國立中山大學	P130
09:30-09:45	Controls of submarine canyons connected to shore during the LGM sea-level rise 蔣正興/國立自然科學博物館	P131
09:45-10:00	Preliminary findings on the sediment dynamics research on the Taiwan Banks 劉祖乾/國立中山大學	P132
10:00-10:30	休息/茶點時間	

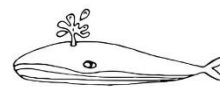




主持人：張日新/莊佩涓/鄧家明  
南山人壽教育訓練中心211室

時間	演講主題	頁數
10:30-10:45	Multiproxy-derived temperature evolution offshore southern Japan over the past 30 kyrs: Implications for Kuroshio Current variability 洪芷盈/國立臺灣大學	P133
10:45-11:00	Multiproxy-derived ocean temperature changes at the edge of the Indo-Pacific Warm Pool since the Last Glacial Maximum : Implications for the recording depth of TEX86 Akshat Gopalakrishnan/國立臺灣大學	P134
11:00-11:15	Sediment trap time series of paleotemperature proxy (UK'37) in the northern South China Sea 鍾佳妤/國立臺灣大學	P135
11:15-11:30	Assessing the thermal gradient approaches used to reconstruct the evolution of the East Asian Monsoon over the past 25 ky in the southern South China Sea: Perspectives from multi-proxy paleotemperature records 陳艾璘/國立臺灣大學	P136
11:30-11:45	Multi-species Mg/Ca-derived upper ocean thermal gradients in the northern South China Sea over the past 24 kyr 黃仁愉/國立臺灣大學	P137
11:45-12:00	Variations in microbial utilization of organic compounds across a tectonic transition in the South China Sea 林恩如/國立中山大學	P138
12:00-12:15	Composition and sources of particulate organic carbon in the northeastern Taiwan Strait 莊淑嫻/國立中山大學	P139
12:15-12:30	Excitation and seasonal variation of seafloor infragravity waves observed at OBS stations 鄭厚昇/國立臺灣大學	P140
12:30-13:30	午休時間 新任理監事選舉開會	





主持人：鍾明宗/楊姍嬋/呂曉沛  
南山人壽教育訓練中心308室

時間	演講主題	頁數
08:15-08:30	Towards a Better Understanding of Moonfish ( <i>Mene maculata</i> ) Distribution in the South Taiwan Waters Using Habitat Suitability Index (HSI) modeling ARATRIKA RAY/國立臺灣海洋大學	P141
08:30-08:45	Using oceanographic environmental factors and fishery data to determine habitat preferences of <i>Eleutheronema rhadinum</i> (east asian fourfinger threadfin) in the coastal waters of Chang-Yuen Rise, Taiwan RIAH IRAWATI SIHOMBING/國立臺灣海洋大學	P142
08:45-09:00	Mesozooplankton mortality events in a shallow water hydrothermal vent- First reports from the volcanic island off northeast Taiwan ANITHA MARY DAVIDSON/國立臺灣海洋大學	P143-144
09:00-09:15	Impact of shallow water hydrothermal vent water on the associated microbiota of <i>Scleractinia Tubastraea aurea</i> ; an in-situ transplantation study. Gowri Krishna Girija/國立臺灣海洋大學	P145-146
09:15-09:30	Bacterial community responses of the hydrothermal vent crab <i>Xenograpsus testudinatus</i> fed on microplastics Priyanka Muthu/國立臺灣海洋大學	P147
09:30-09:45	Impact of ocean acidification on mortality rate and offspring of spiny lobster Vicente G. Abedneko/國立中山大學	P148
09:45-10:00	Temperature-mediated evolution of extraordinarily tiny echinoid <i>Sinaechinocyamus mai</i> based on clumped isotope thermometry of fossilized skeletons 許家昕/國立臺灣大學	P149
10:00-10:30	休息/茶點時間	



主持人：李東霖/塗子萱/沈康寧  
南山人壽教育訓練中心308室

時間	演講主題	頁數
10:30-10:45	Impacts of climate change fluctuations on trophodynamic structure and function around the Taiwan Bank marine ecosystem 蕭博元/國立臺灣海洋大學	P150
10:45-11:00	Composition of zooplankton and content of heavy metals in the Waters Surrounding the Taiwan Bank 郭殊君/國立東華大學	P151
11:00-11:15	Using Finless Porpoise form Matsu as an Indicator of Marine Cd Pollution 方澤/國立中山大學	P152
11:15-11:30	Concentrations of five heavy metals and stable isotopes in the four-stranded cetacean tissues in the water around Taiwan 田育如/國立中山大學	P153
11:30-11:45	A preliminary study on the species diversity and biology of cartilaginous fishes in the coastal waters of kinmen in summer 2021 馬暉承/國立中山大學	P154
11:45-12:00	Trophic ecology of marine fishes revealed by otolith isotope geochemistry 李沐廷/國立臺灣大學	P155
12:00-12:15	A new cryptic species of the pineapple fish genus <i>Monocentris</i> (Family Monocentridae) from the western Pacific Ocean, with redescription of <i>M. japonica</i> (Houttuyn, 1782) 蘇又/國立中山大學	P156
12:15-12:30	Typhoon effects on bacterial diversity and community composition between different water layers in the southern East China Sea 羅翌瑄/國立臺灣大學	P157
12:30-13:30	午休時間 新任理監事選舉開會	



## 海洋物理專題演講



主持人：曾于恆/錢樺  
南山人壽教育訓練中心201室

時間	演講主題	頁數
08:15-08:30	簽到 / 報到 / 選舉投票	
08:30-08:45	簽到 / 報到 / 選舉投票	
08:45-09:00	An Assessment of Poleward Migration's Possible Impact on Typhoon Intensification under Global Warming 林依依/國立臺灣大學	P158
09:00-09:15	Enhancing the ENSO Predictability beyond the Spring Barrier and the Impacts of Extratropical Precursors 曾于恆/國立臺灣大學	P159
09:15-09:30	Gravity and oceanic eddy fields determined from the SWOT altimeter measurements: calibration, validation, and application to oceanic science 黃金維/國立陽明交通大學	P160-161
09:30-09:45	A study on internal waves in the southwestern waters of Taiwan 李逸環/國立中山大學	P162
09:45-10:00	sea ice-wave-sea-air interaction - Fram Strait study based on drifting buoy in 2021 & 2022 錢樺/國立中央大學	P163
10:00-10:15	Bottom Ekman Layer in the Wind Field of Tropical Cyclones: QuikSCAT Observation and the Implication of Coastal Storm Surges 陳冠宇/國立中山大學	P164
10:15-10:30	Improved Understanding of Typhoon-Induced Immediate Chlorophyll-A Response using Advanced Himawari Imager (AHI) Onboard Himawari-8 鄭志文/國立臺灣師範大學	P165
10:30-10:45	Interannual variability of subsurface upwelling system in the northeastern Equatorial Pacific Ocean 辛宜佳/中央研究院	P166
10:45-11:00	Rapid surface warming of the Pacific Asian marginal seas since the late 1990s 吳朝榮/國立臺灣師範大學	P167





## 海洋化學專題演講



主持人：林卉婷/許瑞峯  
南山人壽教育訓練中心203室

時間	演講主題	頁數
08:15-08:30	簽到 / 報到 / 選舉投票	
08:30-08:45	簽到 / 報到 / 選舉投票	
08:45-09:00	Nitrogen species in sediment pore waters of the Danshuei River Estuary, Northern Taiwan 方天熹/國立臺灣海洋大學	P168
09:00-09:15	Contributions of ocean's external nitrogen and phosphorus species from the atmosphere to the southern of the East China Sea 陳宏瑜/國立臺灣海洋大學	P169
09:15-09:30	Seasonal variations of nitrous oxide in a populous urban estuary and its adjacent sea 曾筱君/國立臺灣海洋大學	P170
09:30-09:45	Application of grid-scale model to nearshore anthropogenic pollutant transport 李宗霖/國立中山大學	P171
09:45-10:00	Deciphering terrestrial source strength from coastal water composition 簡國童/國立中山大學	P172
10:00-10:15	Tracking the ocean circulation in the tropical and subtropical Pacific Ocean with anthropogenic 236U - Preliminary results 林卉婷/國立臺灣大學	P173
10:15-10:30	Marine organic particle interactions with pollutants: microplastics and polyfluoroalkyl substances 許瑞峯/國立臺灣海洋大學	P174
10:30-10:45	Occurrence of per- and polyfluoroalkyl substances (PFASs) in sharks from two contrasting habitats: New York Bight and The Bahamas 李承軒/中央研究院	P175
10:45-11:00	Fe isotopic composition of East Asian anthropogenic aerosols: the preliminary study for their contribution to the Northwestern Pacific Ocean 謝志強/國立臺灣大學	P176



## 海洋生物專題演講



主持人：蔡安益/魏志滂  
南山人壽教育訓練中心211室

時間	演講主題	頁數
08:15-08:30	簽到 / 報到 / 選舉投票	
08:30-08:45	Assessment of coral bioerosion rates of different species and sizes of urchins in ambient temperature and heat 李彥輝/國立中山大學	P177
08:45-09:00	Temporal distribution of marine oligotrophic ciliates and Noctiluca scintillans in Jie-Shou Au, Matsu 蔡昇芳/國立臺灣海洋大學	P178
09:00-09:15	Rethinking the measurement of plankton's grazing mortality by dilution experiment 張峰勳/國立臺灣大學	P179
09:15-09:30	Distribution and community structure of unicellular nitrogen-fixing cyanobacteria in East China Sea. 詹雅帆/東吳大學	P180
09:30-09:45	Distinct latitudinal patterns of autotrophic and heterotrophic diazotrophs and their nitrogen fixation in the North Pacific Ocean 張順恩/國立臺灣海洋大學	P181
09:45-10:00	Comparison of viral production and decay rates at the surface and bottom of the euphotic zone in the summertime in the southern East China Sea 蔡安益/國立臺灣海洋大學	P182
10:00-10:15	Population status and conservation plan of endangered horseshoe crab, <i>Tachypleus tridentatus</i> in Penghu 楊明哲/國立中山大學	P183
10:15-10:30	Response of the benthic biomass-size structure to a high-energy submarine canyon 魏志滂/國立臺灣大學	P184
10:30-10:45	The effects of ocean acidification on tiger shrimp and white shrimp 謝學函/國立中山大學	P185
10:45-11:00	The effects of changes in nitrogen and phosphorus nutrient concentrations on the diatom community in the Minjiang River estuarine region 時繼宇/國立臺灣海洋大學	P186







主持人：賴昭成/張順恩/陳煦森  
南山人壽教育訓練中心308室

時間	演講主題	頁數
08:15-08:30	Temporal variation of diatom communities in the Matsu Archipelago 粘雅涵/國立臺灣海洋大學	P187
08:30-08:45	Studies on Noctiluca scintillans population changes in the southwest coast of Taiwan 邱暉恩/國立高雄科技大學	P188
08:45-09:00	Bleaching in the mesophotic coral ecosystems from Xiaoliuqiu Island, Taiwan 陳彥妤/國立臺灣大學	P189
09:00-09:15	Calcification of scleractinian assemblages across a bathymetric and latitudinal gradient in Taiwan 蔡佳蓉/國立臺灣大學	P190
09:15-09:30	Temporal and spatial distribution of gametes in Noctiluca scintillans 李良能/國立臺灣海洋大學	P191
09:30-09:45	Benthic drivers of structural complexity across a transition zone 吳孟昕/國立臺灣大學	P192
09:45-10:00	Impacts of turbulence induced vertical nutrient flux on phytoplankton size structure in the Kuroshio east of Taiwan 蕭仲凱/國立臺灣大學	P193
10:00-10:15	Explore the effect of warming on the <i>Platax teira</i> early life stage by geometric morphology analysis and the shape variability of otolith 石楷/國立東華大學	P194
10:15-10:30	Population genetics study of sea urchin <i>Echinometra</i> in Taiwan. 鐘晟齊/國立中山大學	P195
10:30-10:45	Life-history traits, climate transitions and fishing effects on the spatial synchrony of fish dynamics 林哲越/國立臺灣大學	P196
10:45-11:00	Evaluation of marine recreational carrying capacity: An example of Xiao Liuqiu 張瑋珍/國立中山大學	P197
11:00-11:15	Diversity and Spatiotemporal Distribution of Cephalopods Collected by Modified Beam Trawl in Coastal Waters off Western Taiwan 吳億鈴/國立中山大學	P198

## 海報競賽及海報展示

海報競賽 5月3日 14:00-17:30 南山人壽教育訓練中心 212室

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PCP2	魏以婷	Automated detection of mesoscale eddies and chlorophyll concentration distributions	P201
PCP3	蘇煜鈞	The Branch of Kuroshio Current Eastward into the North Pacific Subtropical Gyre	P202
PCP4	黃偌栩	Future Projection and Variability of Kuroshio under Global Warming	P203
PCP5	Nguyen Thi Kieu Diem 阮喬艷	Ocean thermal responses of typhoon Kompasu (2010) over the East China Sea	P204
PCP6	吳彥祺	Suppressing Wind Stress Variability Leads To Stronger Arctic Warming Via Ocean Heat Transports	P205
PCC1	王嫵婷	Investigate the growth rate of Gracilaria in different environments and their contribution to carbon sequestration.	P206
PCC2	符嫻妤	The impact of strong North-east monsoon on marine biogeochemistry in the northern South China Sea	P207
PCC3	袁菲翎	Spatiotemporal Variations of Partial Pressure of CO <sub>2</sub> in Chiku Lagoon during Summer	P208-209
PCC4	Veran Weerathunga	Carbon dioxide air-sea gas exchange in clam and fish aquaculture ponds in southern Taiwan, a preliminary result	P210
PCC5	沈家瑜	Relationships between primary production and ocean biological pump in the tropical Northwest Pacific in summer	P211
PCC6	劉亭紋	The study of water soluble carbohydrates and stoichiometric variations of nutrients in atmospheric suspended particles over the northern Taiwan	P212

PCC7	陳洪毅	Response of tropical corals to ocean acidification and marine lead pollution in the northern South China Sea	P213
PCC8	黃柏豪	Manifold design and signal treatment of a self-service automated system for seawater analysis	P214
PCC9	林上泓	Observations of Kuroshio Intermediate Water along 23.5°N off eastern Taiwan	P215
PCC10	T.V.K. Lahiruni N. Kumari	Long-term trend of carbonate chemistry off southwestern Taiwan: three decadal time-series study	P216
PCC11	邱志庭	Investigating estuarine barium cycling with laboratory mixing experiments	P217
PCC12	楊博凱	Barium uptake and isotope fractionation in diatoms	P218
PCC13	王俊元	The source of large plume waters in the southern Taiwan Strait during summer 2022: A discussion	P219
PCG1	李佩庭	Temporal variability in the Mg/Ca-derived temperatures of individual foraminifera from SEATS sediment traps in the northern South China Sea	P220
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PCG3	張修璋	Modern Benthic Foraminiferal Assemblages Around the Taiwan Banks in Response to the Upwelling Environment	P222
PCG4	張宸緯	The Preliminary Research of Sediments Trend Analysis of Taiwan Bank	P223
PCG5	歐承侑	Seasonal variation of land-ocean source particles in Qigu Lagoon under tidal action	P224
PCG6	邵昱勳	Application of machine learning algorithms to investigate seafloor gas emission in the northern South China Sea	P225
PCG7	陳維堯	Study of Soft-Sediment Deformation Patterns in the Central Taiwan Strait	P226
PCG8	許庭瑜	Characterization of Geophysical Features in the Huaping Islet Submarine Volcanic Zone	P227

PCG9	王硯葶	Application of precise satellite positioning in bathymetric mapping	P228
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PCB4	劉瀚淮	Effect of hunger on the risk of microplastic ingestion in the false clown anemonefish ( <i>Amphiprion ocellaris</i> )	P233
PCB5	陳品嶧	Comparing biotic and abiotic factors on shaping heterotrophic bacteria metacommunity in the southern East China Sea	P234
PCB6	林彥志	Comparison of bacterial dynamics and primary metabolites of soft corals in situ and artificial cultivation (ex situ)	P235
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PCB17	梁婷滄	Indicators of pelagic forage community shifts related with the abundance of economic tunas in the Indian Ocean	P246
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PCB19	林軒彤	Seasonal variation of free-living nematode community around the Turtle island	P248
PCB20	鄭琬萱	Impacts of resource fluctuation and availability on niche breadth and their consequence on functional performance: a perspective from species to community levels	P249
PCB21	曲昱玲	The toxic effects of ultraviolet filters on <i>Acropora tumida</i>	P250
PCB22	林芷晴	The study of boring organisms diversity in the cultured oysters from Qigu, Tainan.	P251
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## 海報競賽及海報展示

海報展示

南山人壽教育訓練中心 208 室

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PP3	林欣妮	Observations of eddy with CODAR surface current in Nanwan Bay.	P258
PP4	楊濬宇	Multi-satellites observation of chlorophyll concentration and water quality index in Yilan bay	P259
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PP11	Dimas Pradana Putra 蘇德澤	Pre-Trained U-Net Model to improve the Himawari Sea Surface Temperature data gap filling	P266

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# 專題演講與青年論壇摘要

## **Stand-alone Seaglider profiling characterizes the anatomy of internal solitary waves in a real-time mode**

Kai-Chieh Yang, Sen Jan, Yiing Jang Yang, Ming-Huei Chang  
Institute of Oceanography, National Taiwan University

### **Abstract**

Stand-alone real-time Seaglider profiling can characterize the waveform of internal solitary waves (ISWs) in the northern South China Sea, which is of particular importance in evaluating the performance of numerical simulations and forecasting of ISWs. Internal solitary waves (ISWs), which vertically displace isotherms by approximately 100 meters, considerably affect nutrient pumping, turbulent mixing, acoustic propagation, underwater navigation, bedform generation, and engineering structures in the ocean. A complete understanding of their anatomy and dynamics has many applications, such as predicting the timing and position of mode-1 ISWs and evaluating their environmental impacts. To improve our understanding of these waves and validate the two major theories based on the Korteweg-De Vries (KdV) and Dureuil-Jacotin-Long (DJL) equations, the hydrography data collected from stand-alone, real-time profiling of an autonomous underwater vehicle (Seaglider) has proven to be useful in determining the waveform of these trans-basin ISWs in deep water. The solutions to the DJL equation show good agreement with the properties of mode-1 ISWs obtained from the rare in-situ data, whereas the solutions to the KdV equation underestimate these properties.

## Internal hydraulic transition and turbulent mixing observed in the Kuroshio over the I-Lan Ridge off northeastern Taiwan

Ming-Huei Chang<sup>a,b</sup>, Yu-Hsin Cheng<sup>c</sup>, Yu-Yu Yeh<sup>a</sup>, Yiing Jang Yang<sup>a,b</sup> and Sen Jan<sup>a</sup>, Chih-Lun Liu<sup>d</sup>, Takeshi Matsuno<sup>e</sup>, Takahiro Endoh<sup>e</sup>, Eisuke Tsutsumi<sup>f</sup>, Jia-Lin Chen<sup>g</sup>, and Xinyu Guo<sup>h</sup>

<sup>a</sup> *Institute of Oceanography, National Taiwan University, Taipei, Taiwan*

<sup>b</sup> *Ocean Center, National Taiwan University, Taipei, Taiwan*

<sup>c</sup> *Department of Marine Environmental Informatics, National Taiwan Ocean University, Keelung, Taiwan*

<sup>d</sup> *College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA*

<sup>e</sup> *Research Institute for Applied Mechanics, Kyushu University, Fukuoka, Japan*

<sup>f</sup> *Atmosphere and Ocean Research Institute, University of Tokyo, Tokyo, Japan*

<sup>g</sup> *Department of Hydraulic and Ocean Engineering, National Cheng Kung University, Tainan, Taiwan*

<sup>h</sup> *Center for Marine Environmental Studies, Ehime University, Ehime, Japan*

### Abstract

Complex small-scale processes and energetic turbulence are observed at a sill located on the I-Lan Ridge that spans across the strong Kuroshio off Taiwan. The current speed above the sill is strong ( $1.5 \text{ m s}^{-1}$ ) and unsteady ( $\pm 0.5 \text{ m s}^{-1}$ ) due to the Kuroshio modulated by the semidiurnal tide. Above the sill crest, isothermal domes, with vertical scales of  $\sim 20 \text{ m}$  and  $\sim 50 \text{ m}$  during the low and high tides, respectively, are generated by turbulent mixing as a result of shear instability in the bottom boundary layer. Tidally modulated hydraulic character modifies the small-scale processes occurring on the leeward side of the sill. Criticality analysis, performed by solving the Taylor-Goldstein equation, suggests that the observed lee waves and intermediate layer sandwiched by two free shear layers are related to the mode-1 and mode-2 critical control between the sill crest and immediate lee, respectively. Around high tide, lee waves are advected further downstream, and only mode-1 critical control can occur, leading to a warm water depression. The shear instabilities ensuing from the hydraulic transition processes continuously mediate flow kinetic energy to turbulence such that the status of marginal instability where Richardson number converges at approximately 0.25 is reached. The resultant eddy diffusivity  $K_\rho$  is concentrated at  $O(10^{-4})$  to  $O(10^{-3}) \text{ m}^2 \text{ s}^{-1}$  and has a maximum value of  $10 \text{ m}^2 \text{ s}^{-1}$ . The sill on the western flank of the Kuroshio is a hot spot for energetic mixing of Kuroshio waters and South China Sea waters.



## 臺灣海峽北部海流流型的變化

何宗儒、盧靖元

國立臺灣海洋大學海洋環境資訊系

### 摘要

本研究藉由北向通過澎湖水道的漂流浮球案例探討臺灣海峽北側海流型態的變化。歸納漂流浮球軌跡發現臺灣海峽在夏季存在三種不同的海流路徑，促使浮球以順時針方向沿臺灣西岸移動。路徑1的浮球在通過澎湖水道後沿臺灣西側海岸漂至臺灣東北側，路徑2與路徑1前半段漂流軌跡相同，但在通過臺灣西北側時，沒有向東偏轉而是往北移動。路徑3則在通過澎湖水道後受彰雲海脊影響而向外偏轉，與臺灣沿岸保持一定距離並與路徑2一樣往北移動。為釐清不同海流路徑發生的機制，本研究應用區域海洋模型系統(ROMS)來模擬臺灣海峽在不同條件下的流場變化。模式結果顯示在臺灣西側近岸釋放的虛擬浮子比離岸釋放的浮子有更高的機率漂流至臺灣北側沿岸；另一方面過強的西南風反而會使浮子漂流至臺灣北側近岸的機率降低，這說明西南風並不是造成流場在臺灣西北側順時偏轉的主要原因。近一步的模式結果顯示，即使沒有西南風的吹拂，在科氏力的影響下臺灣西北側的流場也會向東偏轉，反而受到漲退潮的往返影響才有明顯的流場變化。

## Asymmetries in oceanic mesoscale eddy properties

Shih-Nan Chen and Chiou-Jiu Chen

*Institute of Oceanography, National Taiwan University, Taipei, Taiwan*

### ABSTRACT

Prior shallow-water (SW) theories and simulations have shown that isolated, mesoscale oceanic vortices (referred to as eddies hereafter) exhibit marked asymmetry in their translation speed. Both anticyclones and cyclones translate westward, but the former/latter are faster/slower than the long Rossby wave phase speed  $c_0$  ( $=\beta L_d^2$ , where  $L_d$  is the baroclinic Rossby radius of deformation). However, such an asymmetry is not apparent in altimeter-based global statistics as synthesized in Chelton et al. (2010). This seemingly contradicting result is investigated here, using a new set of reduced-gravity SW simulations and reanalysis of AVISO's eddy trajectory products. We first examine the robustness of the asymmetry in theories and simulations. Over a range of eddy amplitude and sizes, the simulations show robust asymmetry, with the deviation from  $c_0$  increasing as the eddy amplitude increases. It is shown further that the asymmetry can be understood via an eddy-integrated force balance theory. For an anticyclone, a net equatorward  $\beta$ -induced force requires a westward drift of mass anomaly to provide a balancing poleward Coriolis force. An increase in eddy amplitude strengthens the net  $\beta$ -induced force, thereby enhancing the deviation from  $c_0$  and leading to an increased asymmetry. Guided by the theory, we then re-analyze the global eddy trajectories. It is found that the tracked eddies are dominated by small-amplitude ones which have weak asymmetric speed in nature. When eddies are separated into different amplitude bins, one begins to see indications of asymmetry in global statistics: The bin-averaged translation speed increasingly deviates from  $c_0$  as the amplitude increases, qualitatively consistent with SW theories. Potential influences of eddy-eddy interactions are also explored and discussed.

### **The flow-seamount interactions and the resulting vorticity and divergence obtained by a two-vessel survey**

*Jia-Lin Chen, Ming-Huei Chang, Yiing Jang Yang, Sen Jan (Taiwan)*

*Ren-Chieh Lien, Eric Kunze, Anda Vladoiu, Sebastian Essink, Barry Ma (US)*

Previous studies have reported that currents over topographic features cause strong turbulence toward the downstream. However, the spatial distribution of flow field is commonly expressed by non-simultaneous shipboard measurements. In this study, a detailed view of vorticity and divergence statistics was obtained by a two-vessel survey (NORI and NORIII) in the east coast of Taiwan in May 2022. Synchronous Acoustic Doppler Current Profiler (ADCP) sampling provided the in-situ measurements of the velocity tensor at small scale  $O(10^2\text{m})$  without the usual mix of spatial and temporal aliasing. To illustrate the method and evaluate the performance, the P–S decomposition (Smith 2008) is applied to synthetic data fields composed of both uniform 2D compressional waves (pure P waves, potential flow components, no vorticity) and a field of vortices of alternating sign (pure S waves, solenoidal flow components, no gradient). For comparison, the same method is applying to other ADCP measurements obtained by solely NORIII in July and Sep 2022. The statistics from two-vessel survey shows more positive horizontal divergence and negative relative vorticity. The estimated along transect horizontal divergence (HD) and relative vorticity (RV) are out of phase. The distribution of HD and RV indicates the direction of internal wave propagation with NE/SW crest-lines. Data analysis of two-ship survey clearly indicates that strong negative vorticity is corresponding to the observed upwelling velocity due to internal waves.

## Eddy-induced Mesoscale and Submesoscale Variability in the North Pacific Subtropical Gyre

Chun Hoe Chow<sup>1</sup>, Wee Cheah<sup>2</sup>, Jen-Hua Tai<sup>3</sup>, Shin-Fu Liu<sup>1</sup>, Yi-Chin Lin<sup>1</sup>,  
Yi Ting Wei<sup>1</sup>, Yu-Chun Su<sup>1</sup>

<sup>1</sup>Dept. of Marine Environmental Informatics, National Taiwan Ocean University.

<sup>2</sup>Institute of Ocean and Earth Sciences, Universiti Malaya.

<sup>3</sup>Research Center for Environmental Changes, Academia Sinica.

### Abstract

Several huge phytoplankton blooms were found via satellite ocean-color images in the oligotrophic North Pacific Subtropical Gyre, east of Taiwan, during the summer of some years. We mainly reported the roles of ocean eddies and relative ocean vertical structure in enhancing/inducing the summer phytoplankton blooms in 2003, 2010 and 2018, using the *in-situ* and satellite observations. Different mesoscale and submesoscale dynamic processes of eddies were found contributing to the increase of satellite-observed chlorophyll-a (Chla) concentration near the surface of the bloom regions. The processes were (1) mixed layer deepening near the core of anticyclonic eddies, (2) submesoscale vertical pumping due to eddy-eddy interaction near the edge of eddies, (3) mesoscale vertical pumping near the core of cyclonic eddies, and (4) horizontal advection around the eddy core. Overall from 1998 to 2018, our composite analysis showed that satellite-observed high Chla concentration were found to be enclosed in the core of both cyclonic and anticyclonic eddies. Besides, high-Chla filaments were found between some pairs of eddies where eddy currents were fast. Near the northward-flowing Kuroshio Current, these fast eddy currents could even inject warmer, fresher and higher-Chla waters into the nutrient-poor North Pacific Subtropical Gyre, inducing an eastward Kuroshio branch east of Taiwan in 2010, the year when the largest phytoplankton bloom was ever recorded by ocean-color satellites in the gyre over the period from 1997 to 2022. Moreover, our findings could show a perfect natural environment to stimulate huge phytoplankton growth in the far, nutrient-poor central North Pacific, connecting the issues of oceanography to atmospheric, meteorology, and volcanology.

## Propagation Speeds of Shoaling Internal Solitary Waves in the South China Sea

Yu-Hsin Cheng<sup>1</sup>, Ming-Huei Chang<sup>2</sup>, Yiing Jang Yang<sup>2</sup>, Sen Jan<sup>2</sup>, Steven R. Ramp<sup>3</sup>, and Kristen A. Davis<sup>4</sup>

<sup>1</sup> Department of Marine Environmental Information, National Taiwan Ocean University, Keelung, Taiwan

<sup>2</sup> Institute of Oceanography, National Taiwan University, Taipei, Taiwan

<sup>3</sup> Soliton Ocean Services, LLC, Falmouth, MA, USA

<sup>4</sup> Department of Civil & Environmental Engineering and the Department of Earth System Science, University of California, Irvine, CA, USA

### Abstract

The present study examines the propagation of shoaling internal solitary waves (ISWs) in the South China Sea through the analysis of successive images from the Himawari-8 satellite taken at 10-minute intervals. The transect along the continental slope east of Dongsha Atoll provides valuable insight into the behavior of the waves, revealing a westward decrease in estimated wave speeds from 2.5 to 0.9 m s<sup>-1</sup> over a 60 km distance, as predicted by the Dubreil-Jacotin-Long (DJL) model. The ISWs experienced lateral modulation by a seamount during their propagation towards the atoll, leading to a fluctuation of approximately 0.5 m s<sup>-1</sup> in speed. Interestingly, the study found that 80% of ISWs encountered over the seamount were accompanied by eastward propagating ISWs that appeared as surface signatures, which decelerated rapidly and dissipated over a distance of  $\leq 15$  km. This phenomenon occurred at a distance ( $>30$  km) east of Dongsha Atoll, indicating a possible relationship between eastward ISWs and internal tides.



## The impact of typhoons on the Pupper ocean

楊穎堅、楊芊奕、林欣怡、吳維常、詹森、張明輝、曾于恒、魏慶琳  
國立臺灣大學海洋研究所

自 2016 年起，我們於每年的颱風季節期間至少施放兩組海氣象浮標於臺灣東南外海，觀測海面氣象及上層海洋的變化。在 2016 年至 2021 年期間，兩組海氣象浮標共計進入到 16 個颱風之 1.5 倍的 34 節風速暴風半徑(R34)內，颱風的等級從 TS 到 C5 均有。由於兩個海氣象浮標有時並不會均進入同一颱風暴風圈內，故計有 30 個颱風觀測案例資料。這 30 個案例的大部份資料顯示在颱風經過後，上層海洋因受到激烈的強風吹襲而產生垂直混合、海氣熱通量、Ekman 湧升流等效應作用而變冷，這是所謂的颱風所產生之冷尾跡現象。但有 11 個案例則顯示出颱風過後上層海洋變暖，經分析顯示這些案例之浮標的位置大都約在 34 節風速暴風圈附近海域，相對於上層海洋變冷的案例，是在較遠離颱風中心的位置。此外，此變冷的現象與降溫幅度也與颱風來襲前的混和層厚度有關，混合層較薄、降溫幅度較大，反之亦然。透過數值模式的研究與分析，此較遠離颱風中心之上層海洋變暖現象主要是肇因於颱風吹襲海洋表面所產生的水平流場於輻合區域之下沉海流、以及最大風速暴風圈之外的負風應力旋度所產生之下沉海流。而這颱風所產生的下沉流，最明顯的區域大約是在 34 節風速暴風圈附近海域，下沉流除了會增加上層海洋的熱含量外，也有可能將表層的一些物質輸送到次表層。例如，在 2019 年的海氣象浮標有加掛數個溶氧探針，於米塔颱風期間之溶氧垂直分佈顯示出颱風靠近浮標前所引起的下沉流將溶氧最大值深度下壓至較深的海域。相對於颱風所產生的冷尾跡或是湧升流的研究，關於颱風所引起的下沉流是少之又少，有必要對此現象更進一步的觀測與研究。

此外，我們為了研究颱風與中尺度渦漩所產生的紊流混合現象，2022 年加掛高採樣率之溫壓儀。觀測資料顯示在 2022 年軒嵐諾強烈颱風期間，20 公尺深度的 Richardson Number 之平均值下降至約為 0.25，而 75 公尺深度的資料則無此現象。這代表颱風期間發生紊流混合現象是位在 75 公尺以淺的深度。所以的詳細研究成果，將於研討會中報告。

## Effect of wave direction on momentum flux under a tropical cyclone

許哲源

台大海洋研究所

### Abstract

The relationship between the wind-wave spectrum and downward momentum flux, i.e., surface wind stress  $\tau$  in tropical cyclones was investigated using data from three EM-APEX floats deployed in Super Typhoon Megi (2010). The floats measured  $\tau$  by integrating momentum of ocean current and, in a recent development, directional spectra of surface waves. The wind was captured by aircraft surveys. At wind speeds from 25 to 40 m s<sup>-1</sup>, the  $|\phi|$  increased with the increasing angle between the wind and dominant waves. The  $|\phi|$  was small near the eyewall, where wave energy concentrated in a narrow frequency band. At the location far away from the eyewall, where most spectra were bi-modal in directions with similar frequencies, the stress direction might be similar to the high-frequency waves. The misalignment between the wind and propagating swell might affect the growth and directional spreading of wind waves under tropical cyclones. The resulting wave breaking might then release wave momentum into the ocean as stress clockwise from the wind direction.  $C_{||}$ , the downwind drag coefficient, increased with increasing inverse wave age of dominant waves.  $|C_{\perp}|$ , the magnitude of the crosswind drag coefficient, was significant when low-frequency waves deviated from the wind by more than 90°. The wave directions are used in the inverse wave age for scaling drag coefficients. The new parameterization based on wave dynamics can be useful to improve the prediction of wind stress curl under storms.

## **Kuroshio path inferred from satellite-derived sea surface topography between the islands of Luzon and Kyushu in the northwestern Pacific**

以衛星海表高度資料推演西北太平洋呂宋島與九州島之間的黑潮路徑

Ying-Chih Fang<sup>1</sup>, Wei-Teh Li<sup>1</sup>, and Shao-Hua Chen<sup>2</sup>

<sup>1</sup>Department of Oceanography, College of Marine Sciences, National Sun Yat-sen University, Kaohsiung, Taiwan

<sup>2</sup>Taiwan Ocean Research Institute, National Applied Research Laboratories, Kaohsiung, Taiwan

Variability of Kuroshio paths (KPs) in the northwestern Pacific has been locally investigated in the region between the islands of Kyushu and Luzon. We optimally track KPs by applying an automatic front-detecting method based on maximum geostrophic velocity along a given satellite-derived dynamic height isoline. Our results are robust and consistent with previous studies, showing highly variable KPs east of Luzon and Taiwan. An immediate explanation is the impingement of westward-propagating mesoscale cyclonic and anticyclonic eddies. We observe patterns along the KPs with anticyclones (cyclones) enhancing (weakening) the Kuroshio. The KPs are relatively stable at  $\sim 28^\circ\text{N}$ , in comparison to more variable KPs at the lower latitudes. Most of the variability stems from energy with timescales of  $\sim 30\text{-}160$  d and 1 yr. Temporal variability of surface geostrophic velocities along the KPs is examined in detail, showing substantial deviations from upstream to downstream regions along the KP. There exists surface velocity reduction at  $\sim 26^\circ\text{N}$  and south of  $\sim 23^\circ\text{N}$ . More sustained and identifiable KPs and stronger surface currents at  $\sim 1\text{ m s}^{-1}$  are characteristic of the region from midway along the shelfbreak in the East China Sea to the Tokara Strait. Such regional differences result from the relatively smaller impact of mesoscale eddies that are largely blocked by the

Ryukyu Islands. Our optimally determined KPs are in line with strong surface currents of  $> 0.8 \text{ m s}^{-1}$  observed by the shored-based high-frequency radars (HFR) along the east coast of Taiwan. Interpretation of vortex-like flow patterns in the HFR data is corroborated by the calculated KPs, which provide supportive evidence showing that the measured surface current pattern is related to mesoscale eddies outside the radar footprint. Our work may help interpret and diagnose complicated HFR observations east of Taiwan.

## 台灣西南外海反氣旋渦的回顧:實測與遙測

曾若玄

國立中山大學海洋科學系

### 摘 要

黑潮往北流經呂宋海峽時，常會有部份支流向西入侵南海，並以三種型態之一出現，也就是leak, loop, leap。其中loop是形成順鐘向套流，冬季最常出現。此套流有時會脫離黑潮，在台灣西南外海形成反氣旋渦(Anti-cyclonic eddy, ACE)，會滯留原地或是逐漸向西方移動進入南海。本研究分析1993-2021年冬季的AVISO海面高度、地轉流、風應力、風旋度資料，發現當東北季風偏強、風旋度負值大、還有黑潮入侵的向西流速分量大的情形下，ACE現象最為頻繁而且顯著。當ACE離岸較近時，其逐時表面流場也可以由TOROS高頻雷達(2013-2019)所觀測。

2016年12月到隔年2月期間，發生了一次強度最大而且持久的ACE，ACE先是滯留了將近一個半月，再逐漸向西移動。由AVISO、TOROS以及兩個漂流浮球的觀測都呈現了一致的結果，渦旋的轉速高達1.4 m/s，Rossby number達到1.0。EOF和渦度收支分析結果都表明了渦度方程式中的horizontal advection對於維持此一ACE的強度有重要的地位，而北赤道洋流(NEC)的分叉(bifurcation)位置為15.5°N，遠較平均值(12-13°N)偏北，造成黑潮流量減弱而且入侵呂宋海峽的向西流速增加。

2022年3月20到23日我們搭乘新海研三號探測黑潮套流，分析CTD/LADCP觀測資料結果指出套流核心的上層和下層水團分別為黑潮水與南海水，此時期的衛星水溫、鹽度和葉綠素濃度影像也表明黑潮由呂宋海峽入侵南海。實測資料讓我們對於黑潮入侵和套流、ACE有更深入的了解。



## Simulation study of vortex tracking in the strong wake behind Green Island using an ASV fleet

Tien-En Hou,<sup>1</sup> Chen-Fen Huang,<sup>2</sup> Jenhwa Guo,<sup>1</sup> and Zhe-Wen Zheng<sup>3</sup>

<sup>1</sup> Department of Engineering Science and Ocean Engineering, National Taiwan University

<sup>2</sup> Institute of Oceanography, National Taiwan University

<sup>3</sup> Department of Earth Science, National Taiwan Normal University

### Abstract

The wake behind Green Island (WGI) off east Taiwan, a current-driven strong wake, has a current speed of 1–1.5 m/s. To observe the evolution of WGI events, a fleet of three autonomous surface vehicles (ASVs) is adopted to obtain the synoptic measurements of the current field based on moving vehicle tomography (MVT). The cooperative ASV fleet employs a vortex tracking method in which the fleet formation center follows the estimated position of the vortex center from the MVT-reconstructed current fields. To investigate the tracking performance of the proposed method, a synthetic WGI event is reconstructed by the regional ocean modeling system from November 27 to November 28, 2014, to provide a realistic current field. Further, a kinematic equation of the vortex center derived from the vortex statistics is incorporated into the tracking to mitigate the influence of strong Kuroshio flow on the position estimator. The improved tracking method provides an optimal path for the ASV fleet in the sense that the root-mean-square difference between the formation center and the true vortex center is less than the formation radius. Simulation results demonstrate that the proposed tracking method could provide short-term WGI monitoring.

## 臺灣灘附近海域之海床地音參數研究與聲景調查

邱永盛<sup>1</sup>、楊穎堅<sup>2</sup>、林穎聰<sup>3</sup>

<sup>1</sup>國立中山大學海下科技研究所、<sup>2</sup>國立台灣大學海洋研究所、<sup>3</sup>Woods Hole Oceanographic Institution

### 摘要

臺灣大西南海域自臺灣灘延伸至南海範圍，擁有豐富的漁業資源、石化資源、以及重要的國際航線與戰略地位，然而此海域範圍受特殊水文、地形、與底質多變的環境影響，對聲學系統之運用造成較高的挑戰。過去在長期臺美合作海洋聲學實驗之推動下，對於臺灣西南部海域至南海之水文擾動與海床地形特性已累積有豐富的資料與認識，但在底質地音參數的部份，由於蒐集岩心樣本的成本較高，且不易自岩心樣本獲得地音參數值，在聲學遙測技術尚未廣泛應用之前，對於底質地音參數之大範圍調查是較缺乏的。本研究基於掌握聲學系統運用效能之願景，對臺灣灘附近海域進行海床底質地音參數調查與聲學遙測技術發展，本研究團隊於 2020 至 2022 年間與美國木洞海洋研究院(Woods Hole Oceanographic Institution, WHOI)合作於臺灣西南海域及臺灣灘附近海域進行海洋聲學實驗，於研究中開發出新的聲學遙測技術—臨界斜率地音反算法，亦基於過去已發展之地音參數反算技術，進一步擴展精進為雙階地音反算法，當中結合了運用聲學正向反射係數之反算法，以及運用聲學傳播資料之匹配場法，透過此兩階層之逐步計算，可在大幅降低匹配演算過程計算量之優勢下，獲得精確的海床沉積物參數，本研究中運用上述海床地音參數反算技術進行臺灣灘附近海域之海床地音參數分析。

由於環境噪音本身亦為影響聲學系統運用之關鍵因子，本研究除了對於海床進行主動探測調查外，亦針對此海域之水下聲景進行被動量測與分析，透過使用極低噪水下聲學錄音系統、以及加強錨碇系統抗噪設計，本研究獲得高品質的被動聲學資料，並運用於進行水下聲景分析，分析過程結合機器學習自動化辨識技術進行各種聲訊之自動化辨識，以進行後續聲景特性分析。本研究針對臺灣灘附近海域之風浪噪音、船舶噪音、生物訊號等聲景現象進行討論，藉此了解聲學系統於此海域之噪音干擾條件與運用成效。

關鍵字：臺灣灘、地音參數、聲學反算、水下聲景

## 海洋物理專題演講

# 應用Sentinel-3衛星影像合併海流數值模式推估海水表面葉綠素-*a*濃度時空變化

鍾曉緯

鉅網資訊股份有限公司

劉正千

國立成功大學地球科學系

國立成功大學全球觀測與資料分析中心

### 摘要

海洋環境的基礎生產力，又稱為初級生產力，它決定了整個環境所能負荷的生物量，更是支持前述各種海洋環境生態系內生物多樣性的重要關鍵。就細節來說，海洋中基礎生產力主要是透過初級生產者所進行的光合作用以維持，主要是通過漂移或微弱游動的浮游植物體內葉綠素進行。葉綠素-*a*是一種用於測量的光合作用特異性色素，儘管其與浮游植物碳的關係隨光強度，養分利用率和物種組成而發生顯著變化，但它已成為評估浮游植物豐富度，也可以說是基礎生產力最廣泛測量的指標了。因此，如要進行調查海洋環境的基礎生產力的工作，海水表面的葉綠素濃度就是其中一項不可或缺的因子。本研究透過海流數值模式與資料浮標資料分析海洋水體運動現象，對於葉綠素-*a*濃度時空分布的變化之影響。整合多期Sentinel-3衛星、HYCOM海流數值模式與資料浮標現場觀測資料。先以浮標提供單點之流速資料，分析對應之Sentinel-3衛星像元反算葉綠素-*a*濃度數值，建立流速與葉綠素-*a*濃度變化之迴歸關係。接者，再將建立之迴歸關係式套用至HYCOM海流數值模式，可將點的資料拓展成面的資料。除此之外，整合HYCOM海流數值模式預報資料，可進一步提出海水表面葉綠素-*a*濃度預測資料。總結來說，本研究經過衛星遙測、數值模式與浮標觀測資料等多元資料整合分析，對於海水表面葉綠素-*a*濃度時空變化能有更全面的掌握。未來在海洋環境基礎生產力的調查，甚至海洋碳匯與永續漁業等相關政策規劃上都能有所助益。

## **Nutrient Footprint: From the origin of Kuroshio to the East China Sea**

Chen-Tung Arthur Chen  
Department of Oceanography, National SunYat-sen University,  
Kaohsiung 80424, Taiwan

### **Abstract**

Traditionally, in marine sciences, the term "nutrient" has been applied almost exclusively to nitrogen, phosphorus, and silicon, although minor elements, such as iron, also play an essential role. The primary processes influencing nutrient concentrations in the oceans are the geophysical and biogeochemical processes which control the addition of these elements to seawater and are responsible for their dispersion and removal. The internal movements of nutrients within the oceans are enormous compared with the terrestrial inputs. Take one of the most productive regions of the world's oceans, the East China Sea (ECS), as an example; Numerous studies have reported biological productivity on the ECS shelf and related these activities to nutrients. There are five external sources of nutrients for the ECS, namely the Kuroshio, Taiwan Strait, rivers, submarine groundwater discharge, and the atmosphere. It is generally accepted that the Kuroshio subsurface waters are the primary source of nutrients for the ECS. Yet, exactly which part of the Kuroshio provides nutrients to the ECS and the transformation of the related water masses after the Kuroshio receives input from the South China Sea is unclear. Here we trace the macronutrients from the source of the Kuroshio east of the Philippines to the ECS continental shelf.

### **Vertical transfer efficiency of particulate organic carbon in the northern South China Sea**

J.-J. Hung (洪佳章), L.-S. Tsai, Y.-J. Wang, Z.-Y. Lin, Y.-C. Chung, Y.-H. Lin

#### Abstract

The biological carbon pump (BCP) is the most important biogeochemical process in the surface ocean transferring organic carbon from the upper ocean to the deep interior and allowing atmospheric CO<sub>2</sub> to be removed from the carbon cycle for a long period of time. This study assess the BCP and vertical transfer efficiency of particulate organic carbon (POC) in the northern South China Sea (NSCS). The depth increase of settling fluxes of major components, particularly for lithogenic materials, occurred widely in all stations located on the continental slope and central basin. The results indicate pronounced lateral fluxes derived respectively from Taiwan Island and southeast China, but the lateral fluxes showed a decreasing trend with the increase of topographic depth. The distributions of particles and POC in water columns strongly support larger lateral fluxes occurring in summer than in winter, mainly derived from the seasonal difference of land inputs. The lateral transport accompanied by the year-round surface carbonate production led carbonate and lithogenic materials as dominant ballast agents to enhance deep fluxes of POC, reflected from the proportion of carry coefficients of major components. However, the elevated winter biogenic production resulted in the contrast patterns of export and deep fluxes and transfer efficiency ( $T_{\text{eff}}$ ) of POC between winter and other seasons impacted ultimately by ballast and lateral transport. The  $T_{\text{eff}}$  correlated positively with remineralization depth and negatively with BCP efficiency (Martin's attenuation coefficient "b" value), implying effects of both ballasts and community structures on  $T_{\text{eff}}$ . The lateral and ballast transports play crucial roles on enhancing deep fluxes and transfer efficiency of POC exported from surface to the ocean's interior modulated by oceanic forcing in the NSCS.



## 西北太平洋海洋生物幫浦長期觀測與研究(II)

龔國慶

國立臺灣海洋大學海洋環境與生態研究所

### 摘要

海洋基礎生產力是驅動海洋生物幫浦將大氣二氧化碳傳送至深海的動能，建立經由基礎生產力推算海洋生物碳幫浦的模式，是準確預測未來氣候變遷趨勢和評估國家海洋藍碳儲量的關鍵依據。本計畫在國科會海洋大氣學門重點計畫的支持下，以臺灣東南廣大的熱帶西北太平洋貧營養鹽但卻頻受海氣交互作用(如颱風、中大尺度渦流、黑潮、亞洲沙塵暴)擾動影響的海域為研究場址。根據 2021 和 2022 年夏季兩個航次的現場觀測資料顯示，海洋基礎生產力介於  $105\text{-}340 \text{ mgC m}^{-2} \text{ d}^{-1}$  之間，平均  $198 \pm 86 \text{ mgC m}^{-2} \text{ d}^{-1}$ ，其中體型小於  $20 \mu\text{m}$  的基礎生產力占比達 82%。2021 年海洋基礎生產力與混合層深度有顯著的正相關，顯示藉由海洋垂直擾動將下層較高營養鹽海水傳送至貧瘠有光層的機制可提升基礎生產力，然而 2022 年的結果卻無此關係存在。進一步我們假設海洋生物幫浦的顆粒碳沉降通量主要由微型浮游植物的膠集顆粒，以及分別經由攝食食物鏈和微生物循環圈能量傳遞形成的動浮糞便顆粒等三者的沉降所組成，經由此簡易的食物網模式可以推算出離開有光層的顆粒碳通量平均為  $30.9 \pm 19.7 \text{ mgC m}^{-2} \text{ d}^{-1}$ ，相當於基礎生產力的  $15 \pm 3\%$ 。經與兩筆珍貴的漂浮式沉積物收集器的同步觀測資料顯示，在高基礎生產力時模式的推算結果與沉積物收集器的結果相當，但是在低基礎生產力時模式的推算結果則遠低於沉積物收集器的結果，原因有賴進一步釐清。

## 東沙海草床有機碳代謝作用與碳匯潛力的關係

周文臣

國立臺灣海洋大學 海洋環境與生態研究所

### 摘要

總生產力( gross primary production, GPP)、群落呼吸率( community respiration, CR) 和淨群落生產力 ( net community production, NCP) 是評估海草床有機碳代謝作用三項常見的指標。NCP 為 GPP 與 CR 的差值，當  $NCP > 0$  時，代表 GPP 大於 CR，該群落為自營性應有利於二氧化碳的吸收(碳匯)；反之，當  $NCP < 0$  時，代表群落 CR 大於 GPP，該群落屬異營性應傾向於釋放二氧化碳(碳源)。因此，NCP 被視為評估海草床生態系碳源、匯能力重要的指標。然而，過去關於海草床有機碳代謝作用的研究多集中在歐、美等溫帶海域，東南亞群島不論是海草物種、棲地類型的多樣性、生長密度...等等皆為全球海域的熱點區域，但海草床有機碳代謝作用相關的研究卻極其有限。為彌補此一缺憾，本研究利用 2019 年 6 月 29 日至 9 月 9 日所收集到之高頻溶氧數據 (半小時一筆)，依開放水域質量平衡法計算了東沙島北岸海草床的 GPP, CR 和 NCP。計算結果顯示，研究期間東沙海草床的 GPP 和 CR 較全球平均值高約 2.5 倍 (GPP,  $507 \pm 173$  vs.  $225 \pm 11$   $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$ ; CR,  $497 \pm 171$  vs.  $188 \pm 10$   $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$ )，然而 NCP 卻與全球平均值相似 ( $8 \pm 61$  vs.  $27 \pm 6$   $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$ )，表明具有高 GPP 的海草床不必然具有較高的碳匯潛力。此外，研究期間 NCP 相對恆定，並未出現明顯的時序變化，但海水中的二氧化碳分壓 ( $p\text{CO}_2$ ) 卻呈現逐漸下降的趨勢，且 NCP 與  $p\text{CO}_2$  並無顯著的相關性，表明有機碳代謝作用並非唯一決定東沙海草床碳源/匯狀態的關鍵因子，碳酸鈣的生成與溶解可能亦扮演重要的角色。綜言之，東海海草床有機碳代謝作用的速率與全球平均概況明顯不同，且 NCP 與碳源/匯狀態並無顯著的相關性，此結果表明欲以海草床作為以自然為解方的碳移除工具，仍需進行因地制宜的研究，方能確定其碳匯價值。

## 颱風對東海南部海域的影響：以瑪麗亞颱風 (2018) 為例

陳宗岳

國立臺灣海洋大學海洋環境與生態研究所

### 摘要

颱風的通過對海洋環境，無論是水文或是生態系都會產生極大的影響。但颱風期間的海況不利於現場採樣，因此野外調查數據相對稀缺。本研究在 2018 年 7 月 10 日瑪麗亞颱風通過之前 (2018 年 7 月 6 日至 8 日) 和之後 (2018 年 7 月 14 日至 17 日) 在東海南部進行了現場採樣，以評估颱風通過引起的化學和生物參數的變化。結果顯示，顆粒態及溶解態基礎生產力在颱風前後並無顯著差異，然而 200 公尺葉綠素積分值則呈現顯著增加 (paired *t*-test; *p*-value < 0.05)。除此之外，上層 200 m 的總無機氮 (硝酸鹽+亞硝酸鹽+銨) 在颱風過後也呈現顯著增加 (paired *t*-test; *p*-value < 0.05)。本研究亦首次觀察到細菌的比生長速率 ( $B\mu$ ; bacterial specific growth rate) 在颱風過後提高了  $35.0 \pm 0.35\%$ 。

## 海水中的膠體磷

溫良碩

臺灣大學海洋研究所

### 摘要

大洋海域表層海水中，溶解無機磷常為極度缺乏狀態，因此有機磷便成為浮游生物的替代來源。我們的研究結果證實膠態磷(1kDa~0.45 $\mu$ m, colloidal P) 在海水中，可佔溶解態磷 (<0.45 $\mu$ m, dissolved P) 約~75%以上。溶解磷在水層垂直濃度變化趨勢中，絕大多數有機磷皆為高分子狀態，主要出現於有光層中，低分子態有機磷 (<1kDa) 在海水中的濃度幾乎不太改變。膠體無機磷主要存在於海淡水交換區及近岸海水，大洋海水中幾乎不存在。高濃度的有機磷在海水中的存在與興衰，顯示了浮游藻類與共生微生物的吸收、製造及分解作用，著實控制著海洋生地化循環。本研究更清楚地得知磷在海水中的物種變化，也顯示了膠體在海洋磷循環扮演的重要性及其生物生化反應研究之必要性。

## Influences of Kuroshio Intermediate and Deep Waters on the carbonate chemistry along 23.5°N off eastern Taiwan

Hon-Kit Lui<sup>1</sup>, Shang-Hon Lin<sup>1</sup>, Hsiao-Chun Tseng<sup>2</sup>, You-Lin Wang<sup>3</sup>,  
Chen-Tung Arthur Chen<sup>1</sup>, Gwo-Ching Gong<sup>2</sup>

1. Department of Oceanography, National Sun Yat-sen University
2. Institute of Marine Environment and Ecology, National Taiwan Ocean University
3. Research Center for Environmental Changes, Academia Sinica

### Abstract

It is reported that the outflowing South China Sea (SCS) Intermediate Water (SCSIW) from the Luzon Strait joins the northward-flowing Kuroshio to become the Kuroshio Intermediate Water (KIW). The KIW flows northward, and a branch turns east along the southern Ryukyu Trench. To investigate the distribution of the SCS waters in the West Philippine Sea (WPS), a cruise was conducted along 23.5°N from the east of Taiwan to 125°E in 2022/7/20–23. The potential temperature and salinity distributions show significant KIW signals along the 23.5°N section. Of note is that the KIW signals do not diminish eastward, suggesting that the KIW flows along this section. The pH value of the SCS water is significantly higher than that of the WPS below 700 m depth. In the WPS, a pH minimum occurs at about 900-1000m. A strong intrusion of the SCS water around 1000m depth along the section noticeably increases the pH value, forming two pH minima above and below this depth. Indeed, the intrusion of the SCS water could be observed as deep as 2000m depth. Such a value is consistent with the depth of the deepest sill in the Luzon Strait, indicating that the outflowing deep SCS water flows along with that of the SCSIW and the Kuroshio.



## Tracing anthropogenic aerosols with barium stable isotopes in the South China Sea

Yu-Te Hsieh<sup>1\*</sup>, Kuo-Fang Huang<sup>2</sup>, Chih-Chiang Hsieh<sup>1,3</sup>,  
Chia-Jung Lu<sup>3</sup>, Tung-Yuan Ho<sup>1,3</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taiwan

<sup>2</sup>Institute of Earth Sciences, Academia Sinica, Taiwan

<sup>3</sup>Research Center for Environmental Changes, Academia Sinica, Taiwan

\*Corresponding author. E-mail: [alanhsieh@ntu.edu.tw](mailto:alanhsieh@ntu.edu.tw)

### Abstract

The oceanic barium cycling is tightly linked with terrestrial inputs, upwelling, and carbon export fluxes in the ocean. Riverine input is generally considered as the major supply of Ba to the ocean. However, other sources of Ba have also been identified in different marine environments (e.g., sediments, hydrothermal vents, and atmospheric dust). Although the input of dissolved Ba from atmospheric deposition is often considered to be insignificant due to the low solubility of mineral dust Ba, human activities and urbanisation have rapidly increased the production of anthropogenic aerosols and hence the chemical inputs to the ocean. Ba isotopes have been developed recently as a powerful tracer for tracing Ba inputs to the ocean. In this study, we analyse Ba concentration and isotope compositions in the bulk atmospheric aerosols collected from Dongsha Atoll in the northern South China Sea, a region surrounded by nations with rapid economic growth and industrialization in the Asia-Pacific area. Preliminary data show large variations in the time-series aerosol Ba concentration and isotope composition. In particular, the aerosol Ba concentration increased by an order of magnitude during the Lunar New Year period, which may reflect the influence of anthropogenic aerosols (e.g., barium nitrate used in fireworks). The aerosol Ba isotope compositions varied between seasons and size fractions, which may reflect the changes of atmospheric Ba sources. This study provides the first constraints of Ba isotopes on atmospheric aerosols and highlights the potential of using Ba isotopes to trace anthropogenic inputs to the ocean.

## 2022年夏季台灣海峽南段生物地球化學變化

黃蔚人

國立中山大學海洋科學系

### 摘 要

台灣灘位於台灣海峽南端中央，為一個重要的漁場及海洋生態系統，其地理位置之北邊鄰近東海、西方連接珠江沖淡水、南方面對南海、西方則有黑潮支流及高屏溪沖淡水，此外，台灣灘本身還受到湧升流之影響，在環繞台灣灘之多重環境因子影響下，其中生物地球化學作用之變異目前仍不夠清楚。欲進一步的探討時，很容易受限於其多變複雜的地形與潮汐及其引起的水文變化而影響，湧升流及沖淡水帶來的高營養鹽所衍生出的漁場及生態系，是否又影響該海域的生地化作用，將有賴於跨領域之共同研究。

## 南海北部<sup>13</sup>C-及<sup>14</sup>C-基礎生產力差異探討

施詠巖

海軍軍官學校 應用科學系

### 摘 要

海洋基礎生產力（Primary Productivity, PP）是大氣中二氧化碳轉換至海洋藍碳的進入點，是影響氣候變遷的重要因素之一。準確量測並計算海洋PP並從中了解海洋碳循環，是海洋學家重視的議題。本研究整理2021年9、12月及2022年1月的航次，透過使用<sup>13</sup>C和<sup>14</sup>C作為示蹤劑的現場PP，以探討彼此間的差異。在低緯度海域，不同的季節，以<sup>13</sup>C及<sup>14</sup>C所培養的PP，均能有顯著的正向線性關係，這意味著以<sup>13</sup>C作為示蹤劑所培養得到的PP數據，在低緯度的海域是一種能夠與以<sup>14</sup>C作為示蹤劑培養的PP數據，做一良好轉換替代方法。然而同步觀測到<sup>13</sup>C-PP高於<sup>14</sup>C-PP的議題，則需透過持續的數據累積及搭配其它生地化參數，如浮游藻類同位素同化的問題、藻屬分布的問題等，以進一步釐清<sup>13</sup>C-PP與<sup>14</sup>C-PP之間的差異，讓我們能更加了解南海的PP及其相關的海洋碳循環。

## 東沙海草床冬夏兩季有機碳與碳酸鈣代謝對二氧化碳通量的調控

范嵐楓<sup>1</sup>、康恩誠<sup>1</sup>、周文臣<sup>1,2</sup>

<sup>(1)</sup>國立臺灣海洋大學海洋環境及生態研究所

<sup>(3)</sup>國立臺灣海洋大學海洋中心

### 摘要

本研究利用底棲培養箱(Benthic Chamber) 在東沙島小瀉湖海草床進行冬季(2021年1月)及夏季(9月)的培養實驗,培養期間監測溫度、鹽度、光照、溶氧等參數變化,同時收集水樣品分析酸鹼值(pH)、總鹼度(TA)、和溶解態無機碳(DIC)。此外也採集開放水體和不同深度的孔隙水樣品進行碳化學參數的分析。由開放水體數據顯示小瀉湖海草床的海水碳酸鹽化學特徵表現出明顯的日夜變化:白天 pH 值升高,二氧化碳分壓 ( $p\text{CO}_2$ ) 降低,而夜間狀況則相反。冬夏兩季水體中的  $p\text{CO}_2$  都較大氣  $p\text{CO}_2$  為低,呈現碳匯的特徵。底棲培養結果顯示在冬夏兩季小瀉湖水體中 TA 和 DIC 的濃度皆隨著培養時間而逐漸升高,計算底棲通量結果顯示,冬夏兩季小瀉湖海草床淨生態系統生產力(NEP)及淨生態系統鈣化作用(NEC)皆小於0,屬異營性及碳酸鈣溶解的生態系統,並推測碳酸鈣溶解作用為碳匯形成的主要驅動力。孔隙水的 DIC、TA 及  $\text{Ca}^{+2}$  通量計算結果亦佐證碳酸鈣溶解作用會影響沉積物 DIC 及 TA 的釋放,而冬夏兩季間 DIC 與 TA 釋放量的差異則可能與無氧代謝有關。由系統通量分析來看,小瀉湖沉積物 TA 的釋放可緩和約 40~43% 由 DIC 釋放所造成的碳排放量,再次說明鹼度釋放對增加碳匯的重要性。

## Distribution of dissolved trace metals in the Atlantic-Arctic transition zone

Wen-Hsuan Liao<sup>1,2</sup>, Rob Middag<sup>2,3</sup>, Rebecca Zitoun<sup>2,4</sup>, Patrick Laan<sup>2</sup>

<sup>1</sup> Department of Earth Sciences, National Cheng Kung University, Taiwan

<sup>2</sup> NIOZ Royal Netherlands Institute for Sea Research, Department of Ocean Systems,  
PO Box 59, 1790 AB Den Burg, the Netherlands

<sup>3</sup> Centre for Isotope Research - Oceans, University of Groningen, PO Box 72, 9700 AB  
Groningen, the Netherlands

<sup>4</sup> GEOMAR Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel,  
Germany

### Abstract

The high latitude North Atlantic, specifically the Greenland-Iceland Norwegian-Sea region, is an important thermohaline circulation hub, notably for the formation of North Atlantic Deep Water (NADW). The region exhibits a complex circulation and is subject to various terrestrial inputs and the resuspension of sediments as the forming deep water flows over shallow sills. It is thus critical to study the influence of the diverse inputs and processes on the metal distribution and how they further influence the whole Atlantic Ocean.

Iron (Fe) and manganese (Mn) are often thought to share common sources and sinks in the ocean. However, Fe and Mn also have completely different reactivities and speciation, which can lead to a decoupling of their distributions. The Greenland-Iceland Norwegian-Sea region is an ideal region to study the distributions of both elements to determine the influence of different sources and processes. Moreover, the resulting concentrations represent the preformed concentrations in NADW, which plays a crucial role in trace metal cycles throughout the Atlantic Ocean. Our preliminary results show that the distribution of dissolved Fe and Mn in the region are indeed decoupled. Dissolved Fe exhibits a typical nutrient-type profile, while Mn concentrations, although also depleted at the surface, show a subsurface maximum. The observations suggest biological uptake in surface waters, and imply that there is potential for co-limitation of Fe and Mn, as observed in the Southern Ocean. Near Greenland, elevated Mn and high Fe/N ratios suggest surface input of Fe and Mn from Greenland. At depth, dissolved Fe concentrations near Iceland were relatively high without a concurrent signal for Mn, implying an input of Fe from a deep-water source that does not effectively contribute Mn. Between Greenland and Iceland, the homogeneous Fe and nitrate concentrations imply

that significant physical mixing occurs in this region, while dissolved Mn does not show a similar pattern. Overall, our observations highlight the differential effects of external sources and internal cycling processes on the distribution and concentration of trace metals in a relatively small geographic area.



## Carbon dioxide removal by red macroalgae by *Agardhiella subulata* using aquaculture and swine wastewater in subtropical region.

Sanjaya Weerakkody<sup>1,2</sup>, Chin-Chang Hung<sup>1</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-Sen University, Kaohsiung, ROC.

<sup>2</sup>Department of Fisheries and Aquaculture, University of Ruhuna, Sri Lanka.

### Abstract

Even though macroalgae are key primary producers for capturing CO<sub>2</sub> and removing nutrients, it is critical to develop the most efficient seaweed cultivation on the land, with a suitable nutrient supply. Here we present data for a novel, temperature control macroalgae cultivation system, and measured rates of carbon dioxide removal and nutrient (nitrogen and phosphorus) uptake by different nutrient sources including fish silage, aquaculture wastewater, and pig swine wastewater. In this study, we cultured red seaweed, *Agardhiella subulate* in five 6-ton tanks in a subtropical region, Kaohsiung, Taiwan in 2022. Water temperature, salinity, light intensity, and nitrite were measured daily. The wet weight of seaweed was recorded by-weekly to calculate the average carbon fixation rate. The results showed *A. Subulata* having a carbon capture rate (CCR), higher mean values (4.7 g-C m<sup>-2</sup> d<sup>-1</sup>) in pig swine wastewater followed by fish silage (4.3 g-C m<sup>-2</sup> d<sup>-1</sup>), and lowest values in aquaculture wastewater (3.6 g-C m<sup>-2</sup> d<sup>-1</sup>) with having 33.0 ± 1.4 % of carbon content. This innovative seaweed culture method has demonstrated the potential of an average CO<sub>2</sub> capture rate (55.6 ± 17.3 ton-CO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup>) efficiently in the subtropical regions by using a suitable cooling system used in summer. Furthermore, it shows that pig swine wastewater and fish silage containing high ammonia which can efficiently be used by *A. subulata* mitigate the negative environmental impacts.

**Key words:** Carbon fixation, Aquaculture wastewater, Seaweed, Temperature

## Planktonic Foraminiferal Assemblages from Planktonic Tows and Surface Sediments: the Imprint of Coastal Upwelling in the northern South China Sea

Hui-Ling Lin and Tai-Chun Lin/林慧玲、林黛君

Department of Oceanography

National Sun Yat-Sen University

國立中山大學海洋科學系

### ABSTRACT

Five types of river sediment dispersal systems have been identified in the context of inputs from

major and small mountainous rivers towards the Taiwan Strait (Liu et al., 2018). Foraminiferal shells are considered as “marine end” particles in those dispersal systems in the integrated project FATES. The following are primary findings based on materials collected by the FATES team during comprehensive fieldwork recently. The species compositions of the fresh planktonic foraminifera (shells stained with rose bengal) in the surface sediments were similar along a transect off the Zhujiang River between samples collected in 2018 and 2020. The species compositions in the stained surface sediments, however, were significantly different from the local plankton tows obtained in the same cruise. More specifically, assemblages derived from surface sediment showed a higher abundance of *Neogloboquadrina dutertrei* and *Globigerina bulloides* than tows, whereas the dominant abundance of *Globigerinoides ruber* in sediments was replaced by *Trifarina angulosa* in tows. The higher percentages of upwelling-affiliated species (*N. dutertrei* and *G. bulloides*) in surface sediments might reflect the prevailing hydrographic environment before the sampling cruise conducted in July 2020 since the absolute dominance of *T. angulosa* in plankton tows is a common feature in the subtropical regime. The inconsistency of upwelling imprints shown between surface sediments and plankton tows was also observed near the Taiwan Banks (TB), where high occurrences of *G. bulloides* in plankton tows were not found in sediments. The discrepancy of foraminiferal assemblages between tows and surface sediments implies that the dynamic hydrographic setting around TB is unfavorable for particle sedimentation from water column.

## **As complicated as it gets: Different upper ocean thermal gradients off Southwest Sumatra derived from biomarker- and foraminifera-based proxies**

Sze Ling Ho<sup>1</sup>

<sup>1</sup> Institute of Oceanography, National Taiwan University, Taipei, Taiwan

### **Abstract**

Proxy-derived upper ocean temperature estimates are routinely used to reconstruct past oceanographic and climatic change, as well as being indispensable for the validation of climate models. Although often interpreted interchangeably as annual mean ocean temperature, proxies may record different signals which occasionally lead to contradictory interpretations. Here we use sediment cores from offshore Southwest Sumatra to reconstruct the thermal structure of the upper ocean from the Last Glacial Maximum (LGM, 19-23 ka) to the Late Holocene (0-2 ka). Our multiproxy approach combines published results from organic paleothermometers ( $U^{K'}_{37}$ ,  $TEX_{86}$ ) and Mg/Ca of several species of planktonic foraminifera, as well as new data from a relatively novel proxy, clumped isotopes ( $\Delta_{47}$ ). Measured on the same species of mixed layer- and thermocline-dwelling foraminifera as for Mg/Ca data, our new  $\Delta_{47}$  data show that the surface dwellers recorded a stronger cooling ( $\sim 6^\circ\text{C}$ ) than the thermocline dwellers ( $< 2^\circ\text{C}$ ) during the LGM, resulting in a smaller vertical temperature gradient in the upper ocean relative to the Late Holocene. Despite differences in the absolute value of temperature estimates, the overall glacial-interglacial trend of vertical thermal gradients inferred from  $\Delta_{47}$  data is in agreement with the Mg/Ca-based reconstructions. The trend in these foraminifera-based vertical gradients is, however, the opposite of that derived from biomarker proxies (combination of  $U^{K'}_{37}$  and  $TEX_{86}$ ). Our multiproxy paleotemperature dataset, in combination with a comprehensive review and reanalysis of regional modern-day proxy studies based on plankton net, sediment trap and surface sediment suggest that offshore Southwest Sumatra: 1)  $U^{K'}_{37}$  records annual mean surface temperature signal; 2)  $TEX_{86}$  likely carries the temperature signal from the subsurface ocean but the exact depth origin remains unclear; 3) Mg/Ca records the temperature signal from the habitat depths of foraminifera but thermocline dwellers might be affected by post-depositional dissolution in organic-rich sediments; and 4)  $\Delta_{47}$  provides reasonable temperature estimates of the upper ocean off Sumatra but the LGM SST value is lower than other proxies. We emphasize that interpretation of proxy-derived thermal gradients should be done with caution, accounting for proxies caveats and observations from modern datasets to obtain robust local temperature signals from biomarkers and foraminifera.

**Keywords:** Late Holocene, Last Glacial Maximum, Sumatra, foraminifera, clumped isotopes, Mg/Ca,  $U^{K'}_{37}$ ,  $TEX_{86}$ , multiproxy

## **Foraminifera as a tool for the reconstruction of paleobathymetry and geohazard: A case study from Taiwan**

**Raúl Tapia**

*Institute of Oceanography, National Taiwan University, No. 1, Sec. 4, Roosevelt Road  
10617 Taipei, Taiwan.*

### **Summary**

The abundance of foraminiferal tests in marine sediments is a promising tracer to distinguish between the “normal” sedimentation process and the one due to downslope transport (as in a turbidity current), particularly if the displaced material from a shallow locality differs significantly from the background autochthonous sediments in terms of foraminiferal abundances, such as the ratio of benthic and planktic foraminifera termed %P. However, its applicability in sediments off Taiwan has not been assessed due to lacking a regional reference database. Here we report foraminiferal abundance, %P, grain size, hydrographic and elemental data from 148 sites off six sectors of Taiwan, namely Southern Okinawa Trough, Hopping-Nanao-Hateruma Basins, Taitung-Hualien, Hengchun Ridge, Gaoping, and Changyun Sand Ridge. Based on the hydrographic and sedimentological parameters assessed, seafloor bathymetry is the primary driver of foraminiferal abundance and %P in these regions. Notably, several data points deviate from the regional %P-water depth relationship. Based on sedimentological parameters and previous studies, these outliers may have to do with local sedimentation settings. These processes include earthquake-induced sediment transport via submarine canyon in the Southern Okinawa Trough, typhoon-triggered sediment flushing in Gaoping Canyon, cross-shelf and northward advection of planktic foraminifera on the Gaoping shelf, and carbonate dissolution in deep Hateruma Basin. Off Taiwan, the %P value in sediments increases exponentially with bathymetry ( $R^2 = 0.72$ ) and agrees well with the global calibration obtained by combining data from several ocean basins. Therefore, the regional relationship between %P and water depth could be used to reconstruct paleobathymetry in this area. However, an uncertainty of ~400 m increases with bathymetry, especially at depths greater than 2000 m. Our results also highlight the potential of the %P index as a tracer for downslope transport and lateral advection in the water column. Therefore, the downcore application of %P has the potential to reconstruct past geohazard events while also identifying autochthonous sediment sequences suitable for paleoceanographic reconstruction.

## Hemispherically asymmetric trade wind changes drive Western Pacific subsurface temperature evolution over the past ~25 kyr

\*Alicia Meng Xiao Hou<sup>1</sup>, Sze Ling Ho<sup>1</sup>, Ren Yi Ooi<sup>1</sup>, AiLin Chen<sup>1</sup>, Kuo-Fang Huang<sup>2</sup>, Yuan-Pin Chang<sup>3</sup>, Min-Te Chen<sup>4</sup>, Chuan-Chou Shen<sup>1</sup>, Yu-Heng Tseng<sup>1</sup>, Yi-Chun Kuo<sup>1</sup>

1. National Taiwan University, 2. Academia Sinica, 3. National Sun Yat-Sen University, 4. National Taiwan Ocean University

### Summary

It is crucial to understand the behaviour of the western tropical-subtropical Pacific Ocean (hereafter the WTP) during altered mean climate states given that upper ocean thermal changes in this region are tightly linked to fluctuations in the Asian-Australian monsoon system, El Niño-Southern Oscillation, and global ocean heat content. Here, we examine how surface and subsurface temperatures in the WTP evolved from the last glacial maximum (LGM) to the Holocene in order to decipher the upper ocean thermal response to drastic changes in atmospheric  $p\text{CO}_2$ , global ice volume, and insolation. We performed inter-proxy and proxy-model comparisons using newly generated and a compilation of published surface and subsurface temperature records based on Mg/Ca ratios derived from mixed-layer and subsurface dwelling planktic foraminifera to assess the spatial pattern of upper ocean thermal changes. Our regional temperature reconstruction encompasses diverse regions across the WTP, including the Western Pacific warm pool which is characterized by low seasonal but high interannual variability, as well as the South China Sea and Okinawa Trough, which are both dominated by variability at seasonal frequencies. We demonstrate that surface temperature evolution over the last glacial-interglacial cycle occurred similarly across the entire WTP, with all sites displaying cold surface temperatures during the LGM, followed by a long-term warming towards the Holocene. However, our results reveal spatially diverse directions and magnitudes of subsurface temperatures change during this time interval, notably between sites inside and outside of the warm pool. Data-model comparisons demonstrate a high degree of coherence between proxy- and model-based spatial patterns of glacial-interglacial upper ocean thermal evolution in the WTP, suggesting that our observation of enhanced (muted) subsurface temperature change inside (outside) of the warm pool is a robust signal. We suggest that while radiative forcing associated with a change in atmospheric  $p\text{CO}_2$  was responsible for the uniform glacial-interglacial surface temperature change across the

entire WTP, shifts in wind strength between the LGM and Holocene produced the observed spatial pattern of subsurface temperature change. Our preliminary assessment of CMIP6 model outputs suggest that during the LGM, strengthened (weakened) NE (SE) trade winds enhanced vertical mixing in the Okinawa Trough and SCS and reduced the westward advection of warm water toward the Western Pacific warm pool and suppressed coastal upwelling off the coast of Sumatra. A decrease (increase) in the intensity of the NE (SE) trade winds during the Holocene reduced vertical mixing in the Okinawa Trough and SCS and increased westward warm water transport towards the warm pool and enhanced upwelling off the coast of Sumatra. Since model outputs demonstrate that the largest magnitude of change in wind strength from the LGM to the Holocene occurred within the warm pool, we infer that this may explain the locally amplified glacial-interglacial subsurface temperature change. Thus, our preliminary assessment of upper ocean temperature evolution in the WTP during the last glacial-interglacial cycle reveals that subsurface ocean temperatures in regions inside and outside of the warm pool have may have different sensitivities to major shifts in background climate conditions.



## **Benthic organic carbon remineralization on a broad shelf receiving small mountainous rivers derived sediment**

Yu-Shih Lin

Department of Oceanography, National Sun Yat-sen University

### **Abstract**

Small mountainous rivers (SMRs) on oceanic islands, with their steeply sloped catchments and event-driven transport, are efficient at delivering organic carbon from the terrestrial biosphere ( $OC_{terr}$ ) to the ocean. Our previous study on the Gaoping shelf, a narrow shelf sustained by SMRs, demonstrated high benthic oxygen utilities, potentially due to the degradability of  $OC_{terr}$ . In the present study, we sought to determine whether catchment characteristics or shelf geometry has a greater impact on benthic organic carbon remineralization. The NE Taiwan Strait is a broad shelf supplied by multiple SMRs. The lower benthic oxygen utilities of the coastal mud belt of this area than those of the Gaoping Shelf suggest shelf geometry to be the stronger controlling factor. The offshore mud belt in the NE Taiwan Strait, supported by long-distance cross-shelf transport from both mainland and Taiwanese rivers, showed the lowest benthic remineralization rates. Our result supports the notion that protracted sediment reworking leads to aging of organic carbon and reduced degradability.

# 巨型／台製重力岩心品質管控：以勵進研究船LGD-T46與LGD-T49測試航次為例

尤柏森、陳婷婷

財團法人國家實驗研究院 台灣海洋科技研究中心

### 摘要

透過海洋岩心庫之一站式高解析度非破壞性的分析技術與能量，長期提供勵進研究船各類海洋岩心採樣作業之岩心品質QA/QC管控，並持續作為優化勵進研究船岩心與沉積物採樣技術之參考依據，同時確保海洋岩心本身品質更能符合國內學研界海洋地質相關研究分析所需。相較於過往航次，LGD-T43測試航次岩心的拉張與變形幅度更趨於嚴重，這應是於該航次期間首次更換自製活塞所導致。在巨型活塞岩心分析結果的基礎上，透過挑選勵進研究船LGD-T46與LGD-T49兩航次，於同一參考站位（東經120.2度；北緯22.4度）分別進行 11 公尺巨型重力岩心與 6 公尺台製重力岩心兩沉積物採樣器測試，以瞭解並評估重力岩心之採樣能量。巨型重力岩心採樣管長度自 8 公尺改為 11 公尺，但沉積物長度並無明顯改善，沉積物總長度從 328 公分增加到 390 公分。透過多重感應元岩心記錄器分析，於鄰近岩心之非破壞性分析資料比對下，我們亦發現LGD-T49使用新的布放回收系統，回收作業過程中導致LGD-T49航次之岩心頂部沉積物出現 20-50 公分不等的損失。未來將針對該系統進行調整與修正，以維護樣本之完整性。

## 大地震地震波所引起的海底水壓變化

### ocean-bottom water pressure variations caused by ground motion in significant earthquakes

張翠玉

台灣大學 海洋研究所

#### 摘要

Significant earthquakes generate perceivable ground motions recorded at global seismic networks, which have also shaken the ocean floors and perturbed water mass at deep sea. This study analyzes the bottom pressure data acquired from two sets of the tsunami alarm system deployed in 2018 in east and southwest offshore Taiwan by the Central Weather Bureau (CWB, Taiwan) for regional tsunami hazard monitoring. We statistically evaluated the waveforms of the bottom-pressure time series from 2018 to 2021 (at a sampling rate of every 15 seconds) to investigate the relationship between variations of the ocean bottom pressure with seismic waves. Because the compressibility of the water layer does not play an essential role in low-frequency seafloor oscillations, the seafloor pressure excited by low-frequency seismic waves is proportional to the seafloor acceleration. As the most less response of the bottom pressure is at a frequency higher than the tsunami frequency band (60 mHz, ~17s period), we considered the transition of the water fluctuation in response to the seismic Rayleigh waves. The power spectral analysis showed that the proportionality coefficient of ground motions and water pressure perturbations is equal to the mass of the water column at the installation of the observatory or, approximately, to the product of the water density and the ocean depth. However, the effect of sediment layer resonances may provide uncertainty in pressure /acceleration transition in seafloor water pressures. This study can address the practical issue of whether the threshold value in the PMEL tsunami monitoring system (Deep-Ocean Assessment and Reporting of Tsunami, DART) is appropriate for regional earthquakes capable of generating dangerous trans-Pacific tsunamis.

## 海床絕對壓力計的設計、測試與初步資料分析

Design, test and preliminary data analysis of absolute seafloor pressure gauge (APG)

林慶仁、林豐盛、張坤輝、許雅儒、李昕旻  
中央研究院地球科學研究所

### 摘要

台灣位處於歐亞板塊和菲律賓海板塊的交界處，台灣東部海域不僅地震頻繁而且板塊聚合的速度也比其他的地方快很多，近幾年來中央研究院也在台灣周圍海域進行了一些使用聲波定位方法進行海床大地測量觀測的研究。為配合海床大地測量觀測，海底絕對壓力測量也是另一種測量的方法。

中研院自製的海床絕對壓力計(absolute seafloor pressure gauge, APG)是由Paroscientific Inc.出品的振動石英壓力傳感器，配合RBR-Global Co.出品的OEM資料記錄器 (<http://www.rbr-global.com/products/bpr>) 和EdgeTech海底聲納控制電路板…等元件所組成。目前已經完成15部APG的組裝，有兩種不同的外觀設計，自2021年起已經部佈放於台灣東部海域進行長期觀測，並且已經有回收資料可供分析，2022年也有佈放7部在沖繩海槽，預計2023年8月收回。本文將介紹APG的儀器組裝、出海前的測試及海域資料的初步分析成果。

中文關鍵字: 振動石英壓力傳感器, 絕對壓力計, 大地測量,

英文關鍵字: absolute seafloor pressure gauge (APG),

## 日本東北仙台外海石卷斜坡水道的組構、成因與意涵

張日新<sup>1</sup> 井上卓彥<sup>2</sup> 三澤文慶<sup>2</sup> 荒井晃作<sup>2</sup>

<sup>1</sup>國立臺灣大學海洋研究所

<sup>2</sup>日本地質調查綜合中心

### 摘要

石卷斜坡水道(Ishinomaki slope channel, ISC)位於日本東北、仙台市的外海，為一在活動邊緣上、受構造主控所形成的斜坡水道。利用地球物理資料的綜合分析研究，我們可以了解石卷斜坡水道的組構與成因。根據水深資料與前人研究，我們發現仙台外海水深300公尺處可發現有斜坡水道頭部的特徵，或可向陸延伸至北上川以及周圍的須江斷層和石卷灣斷層。根據重力異常與磁力異常資料，我們皆能發現仙台以東的北上川為一重力異常與磁力異常之低區，再往東的北上山地則更有著向海延伸的高異常值，說明了北上山地有向海延伸的特徵，則斜坡水道可能與北上山地以西的構造低區有關。

根據反射震測資料，我們發現水道下為水道複合體(channel complex)，堆覆於一廣泛存在的不整合面、即水道基底面(basal surface of channel complex)之上。水道複合體有著高振幅反射(High-amplitude reflectors, HARs) 與側向加積體 (Lateral accretion packages, LAPs)的特徵，說明了水道自發育以來持續的向北遷移。水道複合體以北為北上山地的向海延伸，為一基盤高區；而水道以南為斷塊構造，並在海床上有一系列的斷層崖發展，說明此很可能與新構造活動有關，我們希望未來能有進一步的地震學分析。

我們認為石卷斜坡水道的形成係於日本陸上常見大規模的平移斷層構造、即所謂構造線(Tectonic Lines)有關：在中新世時，由於日本海打開、形成了斜貫日本的構造線，在仙台即為所謂的本庄－仙台構造線。本庄－仙台構造線的持續活動，在仙台外海所造成的橫移拉張，形成了坡間盆地以及構造型的斜坡水道，使陸源沈積物得以在斜坡上傳輸與堆積，並在水道末端形成了水道－堆積葉轉型區(Channel-Lobe Transition Zone, CLTZ)。此外，由於近日在日本海溝的研究，發現海溝內的事件沈積物量少於原先的期待。有鑒於斜坡上有坡間盆地的發展，我們認為事件沈積物的堆積可能以坡間盆地為主，而非原先所預想的海溝。

## Transcriptome and gene-based datasets revealed the phylogenetic relationships of lancelets (Subphylum Cephalochordata)

Hsiu-Chin Lin, Ee Von Lim

Department of Marine Biotechnology and Resources, National Sun Yat-sen University,  
Kaohsiung, Taiwan

### Abstract

Lancelets (subphylum Cephalochordata), also known as amphioxi, are a type of chordate. They provide an ideal platform to study the evolution of vertebrates because of the transitional position from invertebrates to vertebrates, the relatively small genome size (~0.5 Gb), and limited gene duplications. It is widely accepted that lancelets occurred more than 500 million years ago and their appearance has not changed much since, thus viewed as a living fossils. Three genera (*Asymmetron*, *Branchiostoma*, and *Epigonichthys*) and approximately 30 species have been identified in shallow tropical and temperate seas of the world. Compared to the significance of lancelets to vertebrate evolution, little attention was paid to the evolutionary relationships of lancelets themselves. Phylogenetic relationships among lancelets are still unresolved due to the low taxon coverage (i.e. maximum 8 out of 30 species included) and limited choice of DNA markers (i.e. mostly mitochondrial DNA). In this study, we generated the first transcriptome dataset of *Epigonichthys* from the Indo-Pacific species *E. maldivensis* using Illumina Sequencing. Out of the transcripts sequenced, a total of 168,445 amino acids from 888 protein-coding genes were retrieved and combined with four other lancelets and four vertebrates for phylogenetic analyses. The topology was well-resolved with strong supporting values. In addition, a five-gene dataset (mitochondrial DNA: 12S, COI, Cytb; nuclear DNA: H3 and 18S) was used to reconstruct the relationships of 9 *Branchiostoma*, 4 *Epigonichthys*, and 4 clades of *Asymmetron*, which has the highest taxon coverage to date. By comparing the topologies of the two datasets, we concluded that (1) only the transcriptome dataset has the power to resolve genus-level relationships, (2) the NW Pacific *B. japonica* is the basal species of *Branchiostoma* and a trans-ocean divergence is observed, (3) the Indo-Pacific widespread species *E. maldivensis* is the basal species of *Epigonichthys*, (4) a potential new *Epigonichthys* species sister to *E. cultellus* was found from the southern South China Sea.



## Importance of preserving RNA in zooplankton community-based genetic studies

Ryuji Machida

Biodiversity Research Centre, Academia Sinica

### Abstract

Community-based genetic studies, such as “metabarcoding”, are getting a popular method to study zooplankton diversity. Majorities of metabarcoding studies preserve the sample in ethanol, extract genomic (gDNA), amplify target genes with PCR, and estimate community diversity indexes from the community samples. However, the methods are expected to be biased because of two reasons: 1) PCR amplification bias and 2) contamination of pseudogenes. In contrast, if we perform metatranscriptome analyses using extracted RNA as templates, we can avoid both of the biases (Metatranscriptome analyses randomly sequence all RNA templates, therefore, PCR amplification is not required. Furthermore, majorities of pseudogene sequences will not be transcribed into RNA. Therefore, pseudogene sequences will not be contaminated into the datasets). Furthermore, we are exploring the potential of estimating growth index from RNA transcripts abundance (Kong et al. 2019). All of the above-mentioned high-quality and -resolution data can only be achieved if you preserve the RNA.

## 南沙太平島周邊海域環境DNA組成之年間差異

陳宜暄<sup>1</sup>、沈康寧<sup>1</sup>、胡誠友<sup>2</sup>、張至維<sup>1,3,4,5</sup>

<sup>1</sup>國家海洋研究院海洋生態及保育研究中心

<sup>2</sup>國家海洋研究院綜合規劃及人力培訓中心

<sup>3</sup>國立中山大學海洋科學系及海洋生態與保育研究所

<sup>4</sup>國立海洋生物博物館及國立東華大學海洋生物研究所

### 摘要

全球氣候變遷下，有限的文獻指出海水暖化引起南沙太平島110年大規模石珊瑚群集衰退，亟需持續掌握生態系復原情形，然而，太平島因地處偏遠，不易進行海洋生態監測及管理。有鑒於此，本研究規劃蒐集南沙太平島周邊海域環境DNA (environmental DNA, eDNA) 資訊，所得資料可作為重大環境變化事件前後之對照基準，探討氣候變遷下不同年間海洋生態的變動，以提供南沙太平島海洋生物多樣性保育及管理之參據。

本研究於110年及111年由海洋委員會海巡署協助南沙太平島周圍海域8測站採集海水，以提取環境DNA資訊進行16S、18S及12S基因片段次世代定序(next generation sequencing, NGS)，分別針對三個生物類群包含(1)海洋菌種、(2)真核生物(eukaryote)及(3)海水魚等進行物種比對，建立生物多樣性指標(diversity index)，並統計分析。

以環境DNA資訊蒐集結果顯示，太平島110年及111年海洋生物組成有年間差異，海洋菌種僅約25%相同(110年373 amplicons，111年200 amplicons)，原以藍菌(Cyanobacteria)為優勢之菌種減少，物種均勻度(species evenness)增加；真核生物種類增加(110年41門590科，111年46門961科)；海水魚類物種數增加(110年34科44屬58種，111年31科50屬81種)，物種組成由沿岸性魚類轉為珊瑚礁及中層魚類，且有101個魚種在過去文獻未曾於南沙發現。

本研究建立南沙太平島環境DNA對照基準，並發展運用於偏遠地區環境DNA海洋生態長期監測之流程。短期建議持續蒐集南沙太平島環境DNA生物資訊，以追蹤珊瑚礁生態系恢復之情形，並可應用本研究環境DNA調查流程輔助偏遠地區生態監測。中長程建議持續擴充臺灣海域海洋生物基因資料庫，以提高環境DNA比對正確性。

## 臺灣海域魚類環境DNA之時空分析

沈康寧<sup>1</sup>、陳宜暄<sup>1</sup>、邱子恩<sup>1</sup>、張至維<sup>1,2,3</sup>

<sup>1</sup>國家海洋研究院海洋生態及保育研究中心

<sup>2</sup>國立中山大學海洋科學系及海洋生態與保育研究所

<sup>3</sup>國立海洋生物博物館及國立東華大學海洋生物研究所

### 摘要

以環境 DNA (environmental DNA, eDNA) 進行海洋生物物種調查是一個較為新興的分子生物學分析方法，其優點在於花費的時間及金錢較少、不需直接對生物進行採集及肉眼看不見或善於躲藏的生物都可以進行調查；缺點則是無法定量及判斷發育階段。此外，可供比對之 eDNA 基因資料庫的完整性及 PCR 過程的選擇性偏差可能會影響到種類的調查結果。本院已建立完成 2020-2021 年臺灣全海域 105 樣點共四季次之 eDNA 資料暨展示平台原型，目前針對臺灣魚類資料庫中 3,290 種魚類進行 12SrRNA 序列之蒐集及分析，發現其中有約 700 多種魚類在國際基因資料庫中並無可比對的序列；另外，現有之通用引子 (universal primer) 可能在數百種魚類做不出 PCR 產物。未來將納入 eDNA 資料暨展示平台並補充至少 500 筆魚類 12S 基因序列資料進入國海院 NODASS (National Ocean Database and Sharing System) 資料庫，供魚類 eDNA 比對使用，另外也對引子組合進行補強，以確保全臺 3,000 多種魚類之 eDNA 皆能順利被 PCR 放大及檢測，增進對物種多樣性及時空分布的了解。

# 海洋生物專題演講

題目: Viral shunt in tropical oligotrophic ocean

## Abstract

Viruses cause massive bacterial mortality and thus modulate bacteria-governed carbon transfer and nutrient recycling at global scale. The viral shunt hypothesis states the crucial role of viral lysis in retaining microbial carbon into food web processes, while its applicability to nature has not been well identified for over two decades. Here, we conducted nine diel surveys in the tropical South China Sea and suggested that the time scale adopted in sampling and system trophic status determine the “visibility” of the viral shunt in the field. Specifically, viral abundance (VA), bacterial biomass (BB), and bacterial specific growth rate (SGR) varied synchronously and presented the significant VA-BB and VA-SGR linkages at an hourly scale, which reveals direct interactions between viruses and their hosts. The differential responses of the viral shunt to temperature, i.e., looser VA-SGR coupling in warm and tighter VA-SGR coupling in cold environments, imply an altered carbon cycling in tropical oceans under climatic warming.

# 「珊瑚白化鐵假說」：驗證共生藻鐵超氧化歧化酶表現的重要性

何東垣

中央研究院環境變遷研究中心

### 摘要

珊瑚礁生態系是地球上生產力暨生物多樣性最高的系統之一，但全球珊瑚受到環境變異影響導致大範圍白化甚至死亡，至今科學界對珊瑚排出共生藻生理及生化成因的了解仍相當有限。我們提出海水中鐵的供應不足可能是珊瑚白化的重要成因：由於珊瑚共生藻在熱及光逆境下在光系統中活性氧物質濃度大量產生，**Water-Water Cycle**中相關含鐵酶需大量表現將活性氧物種等自由基轉化，以保護光合作用蛋白並維持光合作用進行；由於表層海水溶解鐵濃度原本就十分低，一般均在奈莫爾濃度以下，我們假設高溫高光下，由於表層海水分層明顯、物理混合下降、營養物質交換有限，海水及宿主對共生藻的鐵的供應不足，導致活性氧物質濃度大量累積破壞光合作用，也因此導致宿主排出共生藻，造成珊瑚白化。本實驗室過去6來年運用微量金屬緩衝系統，調控海水中微量金屬濃度於皮莫耳等級來養殖珊瑚共生藻，以系統性了解共生藻金屬需求，我們發現不同種屬共生藻在對鐵需求均相當高，在熱逆境下對鐵的需求更大幅提升；近一年實驗亦發現在溫度和光聯合逆境下，高量鐵得以紓解該逆境並維持光合作用效率，初步證據均支持上述珊瑚白化鐵假說。本研究下一步將於實驗室及野外環境控制條件下建構共生藻及其宿主(軸孔珊瑚或小型海葵)化學穩定培養系統，以微量金屬穩定養殖條件在不同溫度及光逆境及鐵濃度供應條件下培養共生藻與模式珊瑚或海葵，共生藻光合作用效率參數、超氧化基及過氧化氫濃度及超氧化歧化酶活性、鐵超氧化歧化酶、過氧化氫酶、光合作用系統代表蛋白表現及濃度變化；我們計畫建立珊瑚礁生態系之海水微量元素採樣技術，並在野外(台灣週邊廢棄小漁港或九孔池)進行鐵添加實驗，驗證提高鐵供應量及鐵超氧化歧化酶的表現是否得以紓解熱及光逆境下對珊瑚白化的衝擊。

## 海洋生物專題演講

珊瑚殺手星野海綿的共生藍綠菌的盛行、基因體和其代謝潛勢

Prevalence, complete genome, and metabolic potentials of a phylogenetically novel cyanobacterial symbiont in the coral-killing sponge, *Terpios hoshinota*

湯森林

中央研究院生物多樣性研究中心

星野黑皮海綿是種可侵略石珊瑚並使其致死的海綿。該物種的爆發常導致許多地方的珊瑚礁遭到嚴重破壞。先前研究顯示海綿需細菌維持其健康。然而，先前並無研究調查不同地理背景下的星野黑皮海綿的微生物組成，先前也沒有研究提供了微生物與星野黑皮海綿之間詳細的相互作用機制。在我們的研究中，我們使用 16S rRNA 基因定序法調查在西太平洋、南海和印度洋的星野黑皮海綿其微生物菌群組成。我們發現來自不同地區的星野黑皮海綿皆有 *Prochloron*、*Endozoicomonas*、*SAR116*、*Ruegeria* 和未知變形菌相關的細菌。其中，*Prochloron* 相關細菌是星野黑皮海綿中最主要和最普遍的藍細菌。這種未培養藍細菌的完整基因組和色素分析與 *Prochloron* 屬的定義不一致，細菌應屬於一新屬與新種，並命名其為“*Paraprochloron terposi*”。我們進一步推測該菌與星野黑皮海綿之間可能的代謝相互作用。除了首度解開共生藍綠菌的基因體外，本研究奠定了了解星野海綿的生態系統、入侵機制和爆發原因重要資訊基礎。

*Terpios hoshinota* is an aggressive, space-competing sponge that kills various stony corals. Outbreaks of this species have led to intense damage to coral reefs in many locations. Previous studies have revealed that bacteria are essential for sponges to maintain its health. Nevertheless, no study has investigated the microbiome of *T. hoshinota* under different biogeographical backgrounds and has provided detailed interplay between microbes and *T. hoshinota*. In our study, the first large-scale 16S rRNA gene survey across three oceans revealed that bacteria related to the taxa *Prochloron*, *Endozoicomonas*, *SAR116*, *Ruegeria*, and unclassified Proteobacteria were prevalent in *T. hoshinota*. Among them, the *Prochloron*-related bacterium was the most dominant and prevalent cyanobacterium in *T. hoshinota*. The complete genome of this uncultivated cyanobacterium and pigment analysis demonstrated that it has phycobiliproteins and lacks chlorophyll b, which is inconsistent with the definition of *Prochloron*. Furthermore, the cyanobacterium was phylogenetically distinct from *Prochloron*, strongly suggesting that it should be a sister taxon to *Prochloron*. Therefore, we proposed this symbiotic cyanobacterium as a novel species under the new genus *Candidatus Paraprochloron terposi*. Comparative genomic analysis revealed that ‘*Paraprochloron*’ and *Prochloron* exhibit distinct genomic features and DNA replication machinery. We also characterized the metabolic potentials of ‘*Paraprochloron terposi*’ in carbon and nitrogen cycling and proposed a model for interactions between it and *T.*



hoshinota. In our study, the finding that one species predominates cyanobacteria in *T. hoshinota* from different geographic locations indicates that this sponge and *Ca. Pp. terposi* LD05 share a tight relationship. Further, our study builds the foundation for *T. hoshinota*'s microbiome and paves a way for understanding the ecosystem, invasion mechanism, and causes of outbreak of this coral-killing sponge. Also, the first *Prochloron*-related complete genome enables us to study this bacterium with molecular approaches in the future and broadens our knowledge of the evolution of symbiotic cyanobacteria.

## 環境與氣候變遷下臺灣珊瑚生態系的狀態、保育和復育

樊同雲、江名祺、鄭庭卉、藍國維、張軒慈、邱郁婷、葉宗旻、Crystal J. McRae  
國立海洋生物博物館

### 摘要

臺灣擁有亞熱帶珊瑚群聚和熱帶珊瑚礁，2021 和 2022 年在北部、東部、澎湖、綠島、蘭嶼、南部和小琉球等地區，共 40 個地點的 2-5 和 5-10 公尺深處，使用橫截線照相監測和珊瑚網分析結果，硬珊瑚覆蓋率分別為 22、36、38、40、33、30 和 11%，全臺灣整體則為 30%；而與 1980 年代相比，珊瑚減少最多的是小琉球(約 50%)，其次是南部(約 20%)，主要由於人為的干擾和污染，如過漁、廢水、沈積物、破壞，以及氣候變遷衝擊，如海洋熱浪引發珊瑚大白化和死亡、颱風等；建議應有效管理海洋保護區和遊客、以及改善水質。目前已在小琉球山豬溝和南部核三廠出水口的消波塊建立耐熱珊瑚苗圃，並進行人工海岸的生態化，也成功培育孵育幼生型銳枝鹿角珊瑚在天然海水的流水式系統和人工海水的再循環養殖系統每月穩定生殖和完全養殖，原地和異地養殖的第二代珊瑚再用作復育，並與政府機關、民間企業和社區合作培育海洋人才和公民科學家。

## 大幅度日間溫度變化與增溫效應對造礁珊瑚微生物族群之影響

謝昀豐<sup>1</sup>、盧致穎<sup>2</sup>、高家敏<sup>3</sup>、劉勃佑<sup>4</sup>、楊松穎<sup>5</sup>、楊姍樺<sup>3</sup>

<sup>1</sup>Max Planck Institute of Molecular Plant Physiology, Germany

<sup>2</sup>中央研究院生物多樣性研究中心

<sup>3</sup>國立臺灣大學漁業科學研究所

<sup>4</sup>國立中山大學學士後醫學系

<sup>5</sup>國立嘉義大學水生生物科學系

### 摘要

珊瑚礁生態系涵養超過四分之一海洋生物，在生態與經濟層面皆扮演重要的角色，但日趨嚴重的海水暖化現象與氣候變遷所導致的極端氣候，都被認為將急速改變珊瑚礁及珊瑚礁生態系的功能。珊瑚與其共伴微生物構成了「共生體」，包含了共生藻，還有以細菌為最大宗族群的其他共伴微生物。這些微生物與珊瑚宿主健康有直接關係。過去研究顯示，共伴微生物的組成會受到多種微觀與巨觀環境因素影響，例如：水溫增高會使珊瑚共生藻離開宿主造成珊瑚白化，進而可能造成珊瑚死亡，也會改變珊瑚共伴菌的組成。過去探討溫度變化對珊瑚生理表現以及共伴菌族群的變動，多根據均溫所設的穩定水溫，或以緩慢增減溫度來進行實驗，但在環境中珊瑚所處的環境單日溫差變化並非穩定，可能出現單日內溫差高達攝氏六度之較大幅度的差距。然而，對於單日大幅度溫差變化對珊瑚與共伴菌族群變動的影響，目前了解有限。鑑於此，本研究使用不同大幅度日溫差伴隨持續增溫的條件，針對兩種台灣常見的造礁珊瑚*Stylophora pistillata*與*Pocillopora acuta*進行為期四周的水缸試驗。實驗過程中，檢測珊瑚宿主過氧化氫酶的活性、共生藻光合作用能力，並以16S rDNA V6-V8區段分析細菌族群的變動。由結果中發現，不同珊瑚物種的宿主、共生藻，與細菌族群，對於日溫差伴隨持續增溫處理下的反應速度不同。根據結果推測，日間溫差震盪或許能夠減緩宿主的熱壓力與縮小菌相受增溫的改變；另外，不同珊瑚物種共生體對於日間溫差震盪與增溫的效應，所採用的適應與生存策略可能有異。本研究最後也根據此兩種珊瑚在日溫差伴隨持續增溫條件下，指出*Acinetobacter*與*Rodobacteraceae*是具有潛力成為指標性的珊瑚共伴菌。本研究的成果，有助於未來了解珊瑚在極端氣候與增溫的壓力下，宿主、共生藻與微生物彼此影響的因果關係。這樣的成果也有助於未來評估應用益生菌在珊瑚復育的可能性，以及可作為監測的潛力指標微生物。

### **Combining acute heat-stress assays and large-area imaging approaches to identify upper thermal limits of coral colonies across reefs with different temperature histories**

Crystal J. McRae<sup>1</sup>, Nathaniel H. Holloway<sup>2</sup>, Hung-Kai Chen<sup>1</sup>, Guan-Yan Chen<sup>1,3</sup>, Zong-Min Ye<sup>1</sup>, Ming-Qi Jiang<sup>1</sup>, Kwok Wai Lam<sup>1</sup>, Yu-Ting Chiou<sup>1</sup>, Tung-Yung Fan<sup>1,4\*</sup>, Stuart A. Sandin<sup>2</sup>

<sup>1</sup> Department of Planning and Research, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan.

<sup>2</sup> Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, La Jolla, California, United States of America.

<sup>3</sup> Hawai'i Institute of Marine Biology, University of Hawai'i, Kaneohe, United States of America.

<sup>4</sup> Department of Marine Biotechnology and Resources, National Sun Yat-sen University, Kaohsiung, Taiwan.

Coral reefs are increasingly being lost or degraded due to high temperature stress associated with climate change. Identification of the upper thermal limits of foundational organisms (i.e., corals) can help inform how reef ecosystems will fare in the future. Here, we take both a lab- (acute heat-stress assay) and a field-based (large-area imaging) approach to compare the thermal response of a common reef-building coral (*Pocillopora acuta*) across reef sites with distinct daily temperature regimes (stable, variable, and warmed/variable) in southern Taiwan. In the lab, we used a modified protocol based on the Coral Bleaching Automated Stress System (CBASS) in which coral fragments were acutely exposed (18 h) to a control temperature (27°C), as well as a spectrum of high temperature treatments (30°C, 33°C, 36°C, 39°C). Dose response curves of photochemical efficiency ( $F_v/F_m$ ) showed that effective dose 50 (ED50; temperature at which 50% of the original  $F_v/F_m$  is measured) ranged from 36.8°C - 37.5°C, with corals from the thermally variable site having lower ED50 than other sites. Assessment of coral colour, host protein, chlorophyll a, and Symbiodiniaceae (density and species) are in progress. In the field, we used large-area imaging to establish monitoring plots at the same source reefs as used in our lab experiment to evaluate how *P. acuta* colonies respond to a summer heat-stress event. Preliminary analyses of coral colour and percent bleaching reveal high similarity across sites, whereby colonies did not show clear evidence of paling or bleaching despite exposure to ~15 degree heating weeks (NOAA Coral Reef Watch). Colony abundance and size differed between reef sites, with the warmed/variable site having the largest, and highest number of colonies. Complementary *ex situ* and *in situ* assessments of upper thermal limits can be used to better inform our understanding of coral thermal tolerance under climate change.

## AI技術應用於珊瑚礁生態系統分析

李東霖

海洋大學電機工程學系

### 摘要

在海洋生態系統中，珊瑚礁生態系統包含了海洋中25%以上的物種，因此監控海洋珊瑚礁生態系統的變化是最能直接反應海洋環境是否劣化的手段。而最著名也是最常用被採用的調查方式則是國際珊瑚體檢基金會使用的「珊瑚礁體檢」。此種調查方式是透過資深潛水員在水下以特地的方式人工紀錄珊瑚覆蓋率、指標魚類及指標無脊椎動物的數量。然而透過此調查方式每100平方公尺所需耗費的人力時間成本至少是五個潛水員一整天，甚至必需面臨水下環境作業各種意外的可能性。所以想要進行長期且高頻率的觀測紀錄有相當大的困難性。

因此我們嘗試建立一套人工智慧識別系統，根據珊瑚礁體檢法自動化分析影像中各種不同珊瑚底質的分佈範圍與比例。同時也能針對指標性魚種進行偵測與計數。目標讓一般潛水員能夠以自由拍照或攝影的方式快速調查並紀錄該珊瑚礁區域的生態狀況，進而提供相關生態學者研究上的參考。

## Effect of tropical cyclone on a continental shelf ecosystem

Chung-Chi Chen

Department of Life Science, National Taiwan Normal University

### Abstract

Over the past few decades, there has been a significant increase in studies exploring the effects of tropical cyclones (such as typhoons or hurricanes) on marine environments. To understand these effects, a variety of methods have been employed, including in situ field observations, traditional observations (e.g., buoys, moorings, argo, gliders), simulation models, satellite data, and combinations of these methods. However, field observations of the biological dynamics of typhoon effects are limited. This study aimed to investigate the effects of Typhoon Maria on the carbon balance of a continental shelf located across the shelf edge of the southern East China Sea off northeastern Taiwan. Shipboard measurements were conducted before (2-4 days) and after (3-6 days) the typhoon swept through the study region. This allowed for an examination and evaluation of the typhoon's potential effects on physical, chemical, and biological responses, particularly on carbon dynamics. Following the typhoon, there was a slight drop in sea surface temperature. The response of variables varied among different sampling stations. However, overall, the concentration of nitrate, Chl *a*, and plankton community respiration over the euphotic depth were higher in the post-typhoon period compared to the pre-typhoon period. The concentration of fugacity of CO<sub>2</sub> over the euphotic zone was similar before and after the typhoon, but its vertical distribution varied. These results suggest that the typhoon caused physical disturbance and increased water column mixing, leading to an increase in nutrients that promoted plankton growth in the shallow water column.

Keywords: Dissolved inorganic nutrients; East China Sea; Fugacity of CO<sub>2</sub> (*f*CO<sub>2</sub>); Heterotrophic bacteria; Organic carbon consumption; Phytoplankton; Typhoon Maria



# 海洋生物專題演講

溫度與餵食對銳枝鹿角珊瑚生殖能力表現的影響

藍國維<sup>1,2</sup>、張軒慈<sup>2</sup>、邱郁婷<sup>2</sup>、商皓惟<sup>2</sup>、Crystal McRae<sup>2</sup>、樊同雲<sup>2</sup>

<sup>1</sup> 國立東華大學海洋生物研究所

<sup>2</sup> 國立海洋生物博物館

海洋暖化與人為影響下，野外珊瑚的消失速度已經超越其恢復能力，導致拯救珊瑚的時間越來越緊迫。當引發珊瑚大白化和死亡的海洋熱浪愈益頻繁和嚴重時，建立可控制環境的室內珊瑚苗圃(Coral nursery) 成為重要的任務。先前我們利用銳枝鹿角珊瑚(*Pocillopora acuta*)在室內養殖配合餵食下，已成功使同一批群體不但持續一年每個月釋放珊瑚幼生，並且完成整個生活史而生產第二代(Lam et al. 2023. Diversity 15: 218.)。此外，發現其生殖似乎同時受到溫度和餵食的影響，進一步實驗評估溫度(高溫:29°C、低溫:26°C)以及有無餵食處理對其生殖表現之影響。第一個生殖週期的初步結果顯示，高溫於有和無餵食組之生殖時間皆早於低溫組，而高溫無餵食組釋放的幼生數顯著高於其他組。因珊瑚之生殖能力會於不同生殖週期中有所改變，因此目前正在延長此實驗時間以獲得更完整的瞭解。這些成果顯示室內養殖系統能夠成為珊瑚苗圃的良好基礎，不僅庇護珊瑚，還能促進珊瑚繁衍後代，並提供活體作為其他研究用途或運用於珊瑚復育上。

## 氣候變遷造成棲地環境改變對亞熱帶海域蝦類群聚的影響

陳煦森<sup>1\*</sup>、陳孟仙<sup>2,3</sup>、陳國書<sup>4</sup>、陳志遠<sup>5</sup>、

<sup>1</sup>屏東科技大學水產養殖系、<sup>2</sup>國立中山大學海洋生態與保育研究所、<sup>3</sup>國立中山大學海洋科學系、<sup>4</sup>國家海洋研究院海洋生態及保育研究中心、<sup>5</sup>國立高雄科技大學海洋環境工程系

### 摘要

在氣候變遷之下，台灣南部經歷了增溫及降雨減少的現象，為了解氣候變遷對亞熱帶海域棲地環境特徵及其蝦類群聚組成的潛在影響，我們比較了早期（2006-2010年）與近期（2016-2019年）利用海研三號於七股海域收集的蝦種及水文資料，期間共計累積26航次的採樣。結果顯示，七股海域的水溫及鹽度在過去15年間均有增加，而底質顆粒亦有變粗的情形，形塑出一個高溫、高鹽、粗底質的棲地環境。海水升溫會促使暖水性蝦種的比例增加，使得蝦種組成轉變為以暖水性蝦種為主的群聚類型。在近期所記錄的蝦種中，我們新紀錄了4種暖水性蝦類，當中暖水性的中華仿對蝦（*Parapenaeopsis sinica*），則取代冷水性的長角仿對蝦（*Parapenaeopsis hardwickii*）成為優勢種。這種暖水性蝦類的比例增加，冷水性蝦種的豐度下降的現象，也反應在近期群聚溫度指數的增加上（早期：119.6；近期：128.3）。蝦種組成的消長除了與海溫的增加有關外，亦受到底質粒徑變粗所影響。粗顆粒的底質提供了能適應粗粒徑的蝦種合適的棲息環境，如中華仿對蝦、彎角鷹爪對蝦。底質變粗的現象可能與曾文溪集水區降雨強度變弱，河川的流量及輸砂量減少有關。在海溫持續升高以及降雨型態改變的雙重衝擊下，未來將改變亞熱帶海域蝦种群聚組成，使得蝦類群聚結構趨向熱帶化，形成以暖水性物種為優勢的群聚類型，並進一步限縮冷水性蝦種於亞熱帶海域的分布範圍。

關鍵字：海水暖化、底質形態、中華仿對蝦、長角仿對蝦、氣候變遷、熱帶化

# The diurnal dissolved oxygen variation in seawater is coupled with the DOC excreted by seagrass and microbial activities

Tzu-Hsuan Tu<sup>1,\*</sup>, En-Ju Lin<sup>1</sup>, Chin-Chang Hung<sup>1</sup>

1. Department of Oceanography, National Sun Yat-sen University

### Abstract

Seagrasses are highly productive primary producers, serving as significant carbon dioxide sequestration for millennia. These ecosystems often produce a surplus of organic matter stored in sediment or exported to adjacent ecosystems as particulate or dissolved forms. Seagrass ecosystems release dissolved organic carbon (DOC) through exudation from seagrass leaves and epiphytes, or sloppy feeding by consumers. Through microbial utilization, DOC is fully involved in the carbon exchange between and is critical in maintaining the high annual productivity of seagrass-dominated communities. However, only some studies have examined *in situ* release of DOC by marine macrophyte communities and subsequent impacts on the ecosystem. Therefore, this study aims to characterize *in situ* changes in primary production and DOC measured over diurnal cycles and microbial control embedded in the water column at Dongsha Island. To address this goal, DOC and dissolved oxygen (DO) fluxes were first quantified in benthic chambers. These results were further integrated with the primary productivity of seagrass communities, overall microbial community composition, and active microbial abundance to address how DO in the water column was regulated by DOC exuded from primary production and microbial communities inhabiting the water column. Generally, the net primary productivity was correlated with temperature, with higher rates in summer. Hourly DO fluxes ranged between -30 to 50 mmol O<sub>2</sub> m<sup>-2</sup>h<sup>-1</sup>. The seagrass meadows on the south coast were highly autotrophic, but the communities at the inner lagoon were net heterotrophic throughout the year. DOC fluxes varied over the diurnal cycle and were contributed by effluxes from sediments. A strong relationship between net DOC and DO changes was found at both sites. The plankton community was a net DOC consumer, indicating benthic-pelagic solid coupling. Finally, data from 16S rRNA amplicon revealed that sequences associated with *Litoricola* were the most dominant group, and their activities exhibited apparent diurnal variation in the water column. Overall, vegetation was the main driving force for maintaining metabolic balance at Dongsha Island.

# 海洋生物專題演講

## 海洋同位素空間圖的建立以及後續應用於生物生理生態的調查

鍾明宗<sup>1</sup>、王佳惠<sup>2</sup>

<sup>1</sup>國立臺灣大學海洋研究所

<sup>2</sup>國立臺灣海洋大學環境生物與漁業科學學系

### 摘要

海洋生物面對日益暖化的海洋，如何調解其生理特徵決定了地理分佈，進而影響人類在漁業資源的使用，調查自然環境中海洋生物的生理特徵及行為面對諸多挑戰，例如無法實際觀測、現有技術的高成本等，因此本計畫使用嶄新的同位素方法，調查十年間台灣周邊海域生物的生理特徵如何在升溫下變化。計畫首先建立台灣周圍海域的同位素空間圖，由於海洋同位素空間圖提供了環境同位素的基礎值，接續便可分析生物碳酸鹽的同位素值、準確校正環境的影響、評估生物因子的調控，並使用生物碳酸鹽的同位素值重建海洋生物的生理特徵。本計畫以頭足類為目標物種，相較於魚類以及其他軟體動物，頭足類的生理生態研究較少，但卻是相當重要的漁業資源，然而資源管理缺乏基礎的生理資訊，因此計畫使用烏賊骨板穩定氧同位素重建個體經歷溫度，以及使用骨板穩定碳同位素作為新陳代謝指標，探討台灣周邊海域四種不同體型大小的優勢物種新陳代謝和溫度的關係，以及體型大小是否影響溫度棲位，進一步了解短生活史的海洋生物\_頭足類是如何在短時間尺度上面對海洋升溫表現出相對應的生理行為。第一年計畫執行台灣周邊海域(包括外海及沿岸)水體以及顆粒性有機質的採樣，並建立同位素空間圖。

## C:N:P ratios and macromolecular composition in *Crocosphaera*:

### small- vs. large-cell phenotypes under N-free condition

托星豪<sup>1,3</sup>、胡瑩玉<sup>1</sup>、Andrew J. Irwin<sup>2</sup>、Zoe V. Finkel<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University

<sup>2</sup>Department of Mathematics and Statistics, Dalhousie University

<sup>3</sup>國立中山大學海洋科學系

### Abstract

*Crocosphaera* is a widespread N<sub>2</sub>-fixing cyanobacterium in the tropical oceans. It has two phenotypes, small-cell and large-cell. The relative abundance of small versus large *Crocosphaera* varies with depth in the field. In this study, we examined the differences on stoichiometry of C, N, P, and macromolecules between the two phenotypes under the combined nitrogen-free condition. The large-cell strain (WH0005) had higher cellular C, N, P quotas than the small-cell strain WH8501. WH0005 also had higher C:N and C:P ratios than WH8501. WH0005 had higher cellular macromolecule contents than WH8501. However, when normalized by cellular volume, WH8501 had relatively higher chlorophyll *a* and DNA than WH0005. Relative cellular C, N, and/or P contributions (in %) from chlorophyll *a*, RNA, DNA were higher in WH8501 than WH0005, whereas C and P contributions from lipid were higher in WH0005 than in WH8501. The difference on C:N:P ratio and macromolecular composition between the strains suggested distinct strategies on elemental utilization between the phenotypes which may reflect on their ecological niches.

# 海洋生物專題演講

## 使用單一引子對揭示跨尺寸海洋浮游生物群聚隨晝夜 之水層垂直分布

呂曉沛

國立成功大學生物科技與產業科學系

### 摘 要

傳統上，海洋浮游生物群聚組成分析主要依據浮游尺寸大小與外觀型態特徵區分為幾個大類群來進行研究。然而，我們已知同等大小相似型態的浮游生物內可能含有高度物種多樣性，並且其營養階層或生態功能可能各自不同。因此，本研究採用分子生物學工具，使用單一引子對(a single primer set)針對全部生物體的核糖體RNA基因，揭示跨尺寸海洋浮游生物物種多樣性，目前測試此引子對能夠有效偵測由小至大的浮游生物類群(包含0.2~20.0 $\mu\text{m}$ 原核細菌與古菌、0.2~20 $\mu\text{m}$ 單細胞微細真核生物、以及20~200 $\mu\text{m}$ 與200~2000 $\mu\text{m}$ 多細胞真核生物)。此引子對結合次世代定序(next-generation sequencing)技術，可廣泛應用於探究西北太平洋海域各類浮游生物的群聚組成與時空分布。目前針對小東海三個測站(St5、St9、和St11)分別進行全日24小時定點蹲站採樣，取得多個時間(每4小時)與多個深度(每25米)之多尺寸浮游生物樣本，我們使用此短期間高密度資料剖析浮游生物的水層垂直分布與日夜移動狀況，並嘗試釐清不同種類的浮游生物如何共同生存與交互作用於海洋生態系統中。



## 和風情況下上層海洋的溫度及洋流變化觀測

何真珍<sup>1</sup>、張明輝<sup>1,2</sup>、許哲源<sup>1</sup>、鄭宇昕<sup>3</sup>

1 國立臺灣大學海洋研究所

2 國立臺灣大學海洋中心

3 國立臺灣海洋大學海洋環境資訊系

### 摘要

在和風( $\leq 8 \text{ m s}^{-1}$ )及晴朗的情況下，上層海洋吸收短波輻射後可形成日暖層(Diurnal Warm Layer, DWL)，在大洋中通常深達大約 5 公尺，日暖層的底部為日暖斜溫層(Diurnal thermocline)，在日暖斜溫層之下至混合層底部則稱作殘餘層(Remnant layer)。為能更好地了解日暖層，本研究分析了 2021 年 5 月在綠島渦流區及 2022 年 4 月在臺灣西南海域佈放的船基海氣通量/交換觀測系統(Ship-based Air-sea Flux & Exchange System, SAFE)資料。SAFE 搭載 1200 kHz 都卜勒流剖儀(Acoustic Doppler Current Profiler, ADCP)及約 50 支溫度計，以 0.5-2 公尺的高解析度測量上層 20 公尺海洋的洋流和溫度。兩次實驗中都觀察到日暖層加深階段在日暖斜溫層上有著顯著的溫度振盪。在小於  $2 \text{ m s}^{-1}$  的微弱風速下，綠島渦流區中的日暖層可達到約 20 公尺，表示該處の日暖層加深主要受到渦流中強烈的內部混合影響，而非由風應力所驅動，且溫度振盪可能是由內波(Internal waves, IW)所引起，但有些波動具有 KH 不穩定(Kelvin-Helmholtz instability)的捲成(roll-up)結構。在臺灣西南海域，日暖斜溫層上的溫度振盪則可能是由風引起的成熟 KH 不穩定，其特徵是捲成和一些破碎的波組合，KH 不穩定導致觀測到的紊流動能耗散率(turbulence kinetic energy dissipation rate)比殘餘層大兩個數量級。上述兩組實驗的溫度震盪都滿足 KH 不穩定的基本定理，即 (1) Miles-Howard 標準、(2)線性穩定分析，以及 KH 不穩定震盪頻率會接近當地浮力頻率(buoyancy frequency)的經驗特徵。本研究探討了日暖層加深的過程，結果顯示內波及 KH 不穩定都扮演著關鍵的角色。

## 臺灣東南海域夏季期間水文及生地化特性變動

吳維常、楊穎堅、魏慶琳  
國立臺灣大學海洋研究所

### 摘要

臺灣東南海域處於西北太平洋內的副熱帶反流區(Subtropical Countercurrent, STCC)，常見因斜壓不穩定(Baroclinic instability)引起的中尺度渦旋，本研究乃探討渦旋對上層海水溶氧濃度和溫度變化的影響。另，西北太平洋亦為颱風生成熱區，本研究亦探討颱風經過時上層海洋的生地化反應以及海氣之間氣體交換變化。本研究以佈放在西北太平洋的兩組海氣象錨碇浮標 NTU1 及 NTU2，於 2018 至 2020 年夏季期間觀測到一個氣旋式中尺度渦旋、一個反氣旋式中尺度渦旋和數個颱風通過。掛載於浮標測站上層海洋的水文、溶氧、螢光和 pH 探針提供了寶貴的時序列觀測資料，有助於更深入了解中尺度渦旋及颱風影響下的物理過程及生地化反應。此外，透過溶氧和總無機碳的質量平衡模式，嘗試推估臺灣東南海域夏季時上層海洋的生物群集淨生產力(Net Community Production, NCP)。

分析結果顯示，在表層處溫度變化受太陽短波輻射主導，但溶氧濃度變化主要受內潮運動影響而非太陽日照。在氣旋式中尺度渦旋通過期間，溶氧濃度和溫度在水深 50 公尺處的潮汐頻帶上分別有高達  $30\mu\text{M}$  和  $5^\circ\text{C}$  的振幅，其變化量隨深度增加而逐漸減小；反氣旋式中尺度渦旋期間，振幅則分別縮小至  $5\mu\text{M}$  和  $1^\circ\text{C}$ 。此現象為中尺度渦旋通過後影響上層海洋溫度結構，使內潮振幅和濃度梯度的垂直結構發生變化所致。在 2019 年米塔颱風暴風半徑通過浮標前後，溶氧濃度在其濃度極大值深度以下分別顯著上升及下降，其分別受颱風通過前外圍的下沉流與通過後產生的垂直混合所致。在 2020 年閃電颱風通過 NTU1 期間，分別約有  $700\text{ mmol m}^{-2}$  的氧氣及  $270\text{ mmol m}^{-2}$  的二氧化碳從大氣被帶入海洋，其中氧氣通量約佔表水層一公尺溶氧總量的 13%，颱風期間二氧化碳通量則約為非颱風時期的五倍。綜整 2020 年 NTU1 浮標觀測資料顯示，在混合層中群集淨生產力平均約為  $45\text{ mmol m}^{-2}\text{ d}^{-1}$ 。

## 颱風與中尺度渦旋經過期間台灣東南海域上層海洋之紊流變化

林欣怡

國立台灣大學海洋研究所

### 摘要

颱風的經過會造成上層海洋溫度下降，形成冷尾跡。引發此現象的主要機制包括紊流混合、Ekman pumping 與海氣間的熱通量交換。為了更好地了解其中的物理過程，並提高數值模型預測的準確性，需要更多對於紊流混合的觀測與研究。然而，在這種極端環境下進行觀測具有相當的挑戰性。此外，渦旋的通過也會對當地背景條件和混合的情況產生影響。我們藉由 2022 年在台灣東南海域布放的海氣象浮標與都卜勒流速剖面儀觀測資料分析水深 20 與 75 公尺處，五級颱風軒嵐諾和中尺度冷渦旋期間的理查遜數 (Richardson number, Ri) 變化。

觀測結果顯示，軒嵐諾颱風經過之前的上層海洋中，Ri 的機率分布峰值約為 3 到 4。當浮標處於 34 節暴風半徑 ( $R_{34}$ ) 內時，水深 20 公尺處，Ri 的機率分布峰值下降至略小於臨界值 0.25，且小於 0.25 的發生機率由 12% 增至 62%，說明颱風引起的流剪切力增強，海洋中的不穩定性增加，從而導致較強烈的紊流混合。而在水深 75 公尺處， $R_{34}$  內的 Ri 機率分布沒有顯著變化，表明颱風引起的紊流混合侷限於此深度之上。此外，當冷渦旋經過時，冷水的湧升使混合層厚度變薄至小於 20 公尺。此時，水深 20 公尺處，Ri 的機率分佈峰值大於 1。隨著冷渦旋離開後，混合層深度重新加深，Ri 逐漸減小，並可觀察到混合層中，Ri 的機率分布峰值約為 0.25，存在邊界不穩定性 (Marginal instability)。說明冷渦旋期間，20 公尺深附近的分層較穩定，抑制了紊流混合。然而，冷渦旋離開後的水深 75 公尺處，Ri 的機率分布峰值由大約 1 左右增加到 3 至 4 附近，透過垂直溫度梯度的變化可以推論，當冷渦旋離開當地，溫躍層的加深使此深度的海水更趨向穩定，減少了紊流混合的發生。

## 使用Seaglider觀測台灣東邊海域熱帶水團的變化

余岱鈞<sup>1</sup>、張明輝<sup>1</sup>、詹森<sup>1</sup>、鄭宇昕<sup>2</sup>

<sup>1</sup>國立臺灣大學海洋研究所

<sup>2</sup>國立臺灣海洋大學海洋環境資訊系

### 摘 要

本研究使用Seaglider於2016年至2022年期間，在台灣東部海域所觀測之數千筆高解析度CTD剖面，研究熱帶水團的變異性。前人研究表示，台灣東部海域熱帶水水團的主要組成成分包含西菲律賓海熱帶水(West Philippines Sea Tropical Water, WPSTW)、北太平洋熱帶水(North Pacific Tropical Water, NPTW)和南海熱帶水(South China Sea Tropical Water, SCSTW)。通常水團研究的分析方法是將觀測到的資料點與水型繪製於溫鹽圖上，並透過肉眼判斷資料點與何種水型相似。若資料量龐大，人工方式將難以快速判讀，因此我們發展了一個水團指標，以量化水團與水型間的相似性。此指標計算在相同密度之下，觀測值與水型之溫度及鹽度差值的均方根(rms)，此方法除了可協助快速且精確地分類觀測值所屬的水型，同時也可以了解水團在空間上的分布。根據 Seaglider 觀測到的水文資料顯示，台灣東邊海域通常呈現出西菲律賓海熱帶水和北太平洋熱帶水混合的特徵，整體上與前者相比更為相似。然而，在2016年底至2017年初，主要成分變成了北太平洋熱帶水，當時北赤道流的分岔點位於最北端，這個事件可能與北赤道流分岔之年際變化有關。呂宋海峽附近量測到的水文性質，則經常具有南海熱帶水的特徵，可能與流場與地形相互作用導致的南海熱帶水與西菲律賓海熱帶水的混合有關。此外，中尺度渦旋與黑潮的相遇可能會導致水團的一些變異。

## The interaction between the river plume and internal tides in the submarine canyon and its influence on sediment transport

蔡維展<sup>1</sup> 陳佳琳<sup>2</sup>

<sup>1</sup>國立成功大學水利及海洋工程學系碩士班

<sup>2</sup>國立成功大學水利及海洋工程學系助理教授

### 摘 要

In this study, the Regional Ocean Modeling System (ROMS, Warner *et al.*, 2008) was used to simulate the flow, temperature, salinity, and sediment in the Gaoping River and Gaoping Submarine Canyon. The simulated horizontal velocities and SSC near the bottom of the canyon demonstrated that the lower layer currents moved up- and down-canyon during the ebb and flood tides, respectively. The model results were similar to the field measurements of direct current and hydrographic data: the along-shelf current flows southeast during floods but changes to the northwest direction during ebbs. The simulated tidal currents in the canyon propagated along the axis, and the direction of tidal current propagation on the shelf was along-shore. (Chiou *et al.*, 2011; Jan *et al.*, 2008; Lee *et al.*, 2008, 2009; Wang *et al.*, 2008). The simulated sediment-laden river plume propagated with an increase in riverine discharge towards the head of the canyon. The cross-canyon currents diverged at the head of the canyon, owing to the along-canyon flows moving upward through the canyon. After the tidal transition, the along-canyon tide moved downward, and the cross-canyon currents flowed toward the canyon. The cross-canyon currents converged toward the head of the canyon where the water depth was deeper. The descending plumes disperse into the canyon toward their right, owing to the combined effect of the Coriolis and flow convergence. Consequently, the typhoon-triggered hyperpycnal river plume flushes sediment-laden river water from the river mouth toward the submarine canyon.

### **The vorticity, convergence, and residual transport of a developed sediment-laden river plume in the meso-tidal condition**

Cheng-Chien Hou, Jia-Lin Chen

In this study, the interactions between the river discharge and tidal flow during Typhoon Kalmaegi were simulated using a three-dimensional regional ocean modeling system (ROMS). The model was calibrated with tidal gauges, acoustic Doppler current profilers (ADCP), suspended sediment concentration (SSC) from sediment samples near the river mouth. Model sensitivity tests were done based on different bottom roughness for the current speed, and drag coefficient for wind (Hsu et al. 2017; Large and Pond 1981). The simulation results are similar to the river plume shown in satellite images: the river plume was dispersed southwestward along the coast during the ebb tides, whereas it predominantly spread northeastward during the flood tides. To illustrate the method and evaluate the performance, the P–S decomposition (Smith 2008) is applied to synthetic data fields composed of both uniform 2D compressional waves (pure P waves, potential flow components) and a field of vortices of alternating sign (pure S waves, solenoidal flow components). The analysis indicates that, during **ebb tides**, the sediment-laden river plume converges at the river mouth in the absent of an anticyclonic bulge. Such a circulation is different from coastal ocean buoyancy-driven circulation where an anticyclonic bulge develops near the source and a coastal current is established along the right hand coast (in the northern hemisphere). The residual circulations were discussed to examine the possibility of southward transport of riverine sediment. The northward transport was significant during typhoon conditions because both Coriolis force and the wind force contribute to the momentum balance equation. However, the sediment flux in the south boundary became southward after the passage of Typhoon Kalmaegi under the meso-tidal condition.



## 台灣周圍海域表層混合層深度的時空變化與長期趨勢

黃葳柔, 方盈智

國立中山大學海洋科學系

### 摘要

混合層通常定義為垂直方向上均勻混合的近表層水層，能影響海氣熱交換與生物初級生產力，能否掌握實驗場域中精確的混合層深度數值對於理解海洋動力過程與模擬預報非常關鍵。本研究利用國科會海洋學門資料庫中的歷史水文資料，嘗試解析台灣周遭海域混合層深度的分布和季節循環，以及混合層深度在長時間尺度下的變化趨勢。我們檢視資料分析的結果，除了觀察到與前人研究結果相符，即台灣周遭海域混合層深度於夏季較淺且冬季較深的季節變動之外，同時也留意到台灣東部(黑潮流區)和西南部海域(小琉球一帶)的混合層深度相較其他分區顯示出更大的季節性差異。此外，本研究亦嘗試使用月平均的統計方式，推敲長時間尺度下的混合層深度變動。結果指出，混合層深度會隨著年份的不同而有所變化。不同年份間的混合層深度，於夏季月份的標準差約40公尺，而冬季月份的標準差可達100公尺，差異相較於夏季更加顯著。本研究的初步分析結果尚未能針對混合層深度變動與現今氣候變遷的相關性提出明確結論；不過西南部海域的長期溫鹽資料卻觀察到與南海表層海水暖化與鹽度增加的共同趨勢。本研究未來工作將結合水團特性並精進有關分析步驟，以深入探討台灣周遭海域混合層深度於全球氣候變遷下的變動以及其對區域海洋學的影響。

## Initiating Tropical Pacific Decadal Variability from Off-equatorial Subsurface Temperature Anomalies

Sieu-Cuong San<sup>1</sup> and Yu-Heng Tseng<sup>1,2</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

<sup>2</sup>Ocean Center, National Taiwan University, Taipei, Taiwan.

### ABSTRACT

Analysis of available observational and reanalysis data has identified the role of off-equatorial subsurface temperature anomalies in the phase reversal of the Tropical Pacific Decadal Variability (TPDV). Specifically, during the mature warm phase of the TPDV, the positive sea surface temperature (SST) anomaly in the central equator induces anomalous cyclonic circulation in the off-equatorial northwestern (southwestern) Pacific and forming the corresponding positive (negative) wind stress curl anomalies in the 2-15°N (2-15°S) latitude band. The resulting positive Ekman pumping induces surface divergence, leading to the formation of isopycnal negative temperature anomaly. This subsurface signal which has the center of action in the northwest then slowly migrates toward the central basin via the North Equatorial Countercurrent (NECC) pathway, outcropping eastward along the equator (the shoaling of the thermocline), and initiating and sustaining a central equatorial cooling around three years later. In addition, the TPDV-forced extratropical atmospheric anomalies during the warm phase induce the state change of the Kuroshio Extension (KE) that subsequently project its atmospheric forcing on the Pacific Meridional Mode (PMM) to further strengthen the subsurface-produced equatorial disturbance 0-12 months before the peak phase. The combined contribution of off-equatorial subsurface signal and PMM eventually turn the system into the cold phase after five years. The center of equatorial negative SST anomaly then forces anomalous atmospheric circulation to form positive subsurface temperature anomaly in the off-equatorial western area and affect KE state. Therefore, a periodic oscillation of around 10 years is achieved via off-equatorial subsurface temperature anomaly and extratropical-tropical ocean-atmosphere interaction.

## Estimation of sea ice melt in the Pacific Arctic Region based on T-S observations

Y-C. Chen<sup>1\*</sup>, V. Mensah<sup>2</sup>, H. CHIEN<sup>1</sup>

<sup>1</sup>Graduate Institute of Hydrological and Oceanic Science, National Central University, Zhongli, Taiwan

<sup>2</sup>Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

1\*: yen410338@g.ncu.edu.tw

### 摘 要

The melting of sea ice is an important process in polar and sub-polar regions as it affects seawater stratification and local climate, contributes to the transport of heat, salt, and nutrients in these regions, and may even remotely influence the global ocean's overturning circulation. In recent decades, the Arctic Ocean's sea ice extent has undergone significant decline, and documenting these changes is thus of crucial importance. Traditionally, estimates of sea ice melting are obtained through satellite observations, but these estimates are subject to significant uncertainty and are limited to the past 20 years. In this study, we used historical ocean temperature and salinity data (T-S end-member method) to estimate sea ice melting in the Pacific Arctic Ocean through T-S analysis. Our methodology is first tested in the Bering Sea, where estimates of satellite-derived sea ice thickness and sea ice production are available.

The proposed method yields a spatial distribution of meltwater thickness comparable to the sea ice thickness obtained from the Merged SMOS-Cryosat2 product. The average sea ice melting value estimated using our method is 0.38 m, also consistent with the averaged sea ice thickness from the SMOS-Cryosat2 product (0.43 m). Besides, there is good agreement between time series of yearly-averaged sea ice melt and sea ice production. Lastly, our results were compared with another meltwater estimation method based on the automatic detection of meltwater layer depth. These two methods produce equivalent results in the Bering Sea, which completes the validation of our T-S-based approach.

Further, we extended the analysis to the Chukchi Sea and Beaufort Sea, whose sea ice cover has been greatly affected by climate change. Preliminary results in these regions also reveal good consistency between the ice melt and ice thickness (SMOS-Cryosat2 product) average values and distribution. The maximum amount of meltwater is located in the center of the Beaufort gyre, consistent with the basin-scale circulation and ice drift in the Beaufort Sea. Results also revealed a large increase in sea ice melt after 2005, which we attribute to the melting of multi-year ice which has affected the Arctic Ocean recently. The average meltwater thickness after 2005 is 0.7 m higher than before 2005, which represents an additional volume of 810 km<sup>3</sup> of sea ice melted into the ocean since that year. This considerable volume is equivalent to the annual sea ice production of the whole Bering Sea.

## 臺中港船隻進港風場數值模擬

郭瀚升 陳冠宇

國立中山大學海洋科學系

### 摘要

風力對於船舶進出港有極為顯著的影響，而隨著船體建造的體積逐漸增加，受風面積增大也使風力造成的影響日趨重要。臺中港在東北季風期間船舶進港時容易受當地風場影響，增加操船的困難性，導致事故在北防波堤及南堤處發生。因此，本研究希望透過風場模擬了解風力對進港船隻的影響。風場模擬採用 CFD 軟體 OpenFOAM，透過 simpleFoam 求解器以有限體積法求解不可壓縮雷諾平均 Navier-Stokes 方程組 (RANS) 配合  $k-\varepsilon$  紊流模型 (Launder et al., 1975) 計算出風場的穩態解。船舶的進港位置參考船舶自動識別系統 (AIS) 資料，選取位於模擬區域內的六個點位，計算船體所受的合力及力矩並利用風力係數進行比較。由模擬結果得知，船體在航線上較接近港口出入口的位置五受到的風力最小。若在沒有北防波堤的遮蔽下，航線上船體受力平均上升 21%，船體在位置五的受力明顯高於平均，顯示該位置北防波堤的遮蔽效果良好。而在最接近入口處的位置六，船體受到的力矩出現最高值，甚至超過沒有北防波堤時的模擬結果。主要受到北防波堤影響，導致下游處風速變化增強，相較於船艙，對左舷艙處造成較大的壓力。

## 以非結構性網格模式探討桃園海岸波流場

藍亦汝

國立中央大學水文與海洋科學研究所

### 摘 要

本研究旨在了解二維非結構性網格數值模式Delft3D FM對於桃園近岸波流場的重現能力，並透過模擬結果分析桃園近岸的波流場特性。桃園潮間帶由沖刷泥沙、礫石及藻礁群組成，此底質成份不僅為該處海岸帶來了生態多樣性，亦形成高粗糙度的底床，從而影響沿岸水體運動、波浪消散及底床剪應力之變化。桃園海岸波流場主要受潮汐、風及波浪此三應力所驅動，為了解波、流及底床剪應力在由藻礁群帶來的粗糙底床上的特性，本研究使用二維非結構性網格數值模式Delft3D FM重建桃園海岸深度平均的波流場。藉由與實測值的比較，可確立Delft3D FM具一定程度能力重現桃園近岸之流速、波浪、波向及底床剪應力。風應力驅動了桃園海岸季節性的波流場變化，本研究以不同風應力邊界條件進行模擬，模擬結果顯示風驅動力對於流場模擬重現度的影響於不同風速、風向有相異的程度。另一方面，底床剪應力的模擬則大幅受波流非線性交互作用影響，在桃園海岸中，波浪的作用大幅貢獻了近岸底床剪應力的變動。

## 臺灣西南海域小型頭足類物種之漁業生物學研究

王佳惠<sup>1</sup>、江俊億<sup>1</sup>、翁語謙<sup>1</sup>、蕭民煌<sup>1</sup>、王珮玲<sup>2</sup>、李明安<sup>1</sup>

1. 國立臺灣海洋大學環境生物與漁業科學學系
2. 國立臺灣大學海洋研究所

### 摘要

貝瑞氏四盤耳烏賊 (*Euprymna berryi*) 及多鈎鈎腕魷 (*Abralia multihamata*) 是臺灣西南海域經濟漁業之常見小型頭足類物種，但它們的成長、生殖與營養區位等漁業生物學資訊仍相當缺乏。本研究自西南海域之底拖網及蝦拖網漁獲中採集該兩物種，測量樣本形態和生殖相關參數，並假定平衡石成長輪以日為單位增生藉以估算其日齡。此外，分析肌肉碳氮穩定同位素 ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ )，估算營養區位 (trophic position) 及其與體型和棲地之關聯。結果顯示，貝瑞氏四盤耳烏賊日齡介於60-112天間，雌性與雄性之平均成長率相近 ( $0.27 \pm 0.04$  mm/day)，外套長與日齡之成長關係式以邏輯迴歸為最佳套適。相對地，多鈎鈎腕魷以多項式迴歸 (polynomial regression) 為成長關係最佳套適，相同日齡(雌性: 44-78天; 雄性: 46-67天)下，雌性平均成長率( $0.74 \pm 0.10$  mm/day)顯著大於雄性( $0.52 \pm 0.07$  mm/day)。兩物種全年皆有個體孵化、無明顯生殖高峰；性成熟雌性之生殖腺重 (含卵巢及附屬腺體) 約佔總重之15-20%。以中型浮游動物作為基準值 (baseline=2,  $\delta^{15}\text{N}$ :  $5.53 \pm 0.96$  ‰;  $\delta^{13}\text{C}$ :  $-21.83 \pm 0.49$  ‰)，估算貝瑞氏四盤耳烏賊之營養區位為 $3.61 \pm 0.47$ ，其攝食寬度反映了底棲環境多樣化的食物來源 (如甲殼類及小型魚類)。本研究提供臺灣西南海域頭足類族群動態的基礎資訊，有助該海域後續漁業管理與生態相關之研究。

關鍵字：平衡石、日成長輪、GSI、碳氮穩定同位素、營養區位



## **Drivers of coastal benthic communities in a complex environmental setting**

Yuting Vicky Lin<sup>1</sup>, Pierre-Alexandre Château<sup>2</sup>, Yoko Nozawa<sup>4</sup>, Rainer Ferdinand  
Wunderlich<sup>3</sup>, Vianney Denis<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei 10617, Taiwan (R.O.C.)

<sup>2</sup>Department of Marine Environment and Engineering, National Sun Yat-Sen University,  
Kaohsiung 80420, Taiwan (R.O.C.)

<sup>3</sup>Department of Bioenvironmental Systems Engineering, National Taiwan University,  
Taipei 10617, Taiwan (R.O.C.)

<sup>4</sup>Biodiversity Research Center, Academia Sinica, Taipei 11502, Taiwan (R.O.C.)

### **Abstract**

Sessile benthos structures coastal benthic communities, which provide shelters, feeding, and reproductive grounds for many associated organisms. However, anthropogenic stressors transform many pristine communities into impoverished states with cascading effects on important ecosystem functioning. Accordingly, identifying the association between environmental drivers and benthic communities could vastly improve our understanding of future changes and better manage marine resources. Here, we documented the benthic composition of 433 transects distributed at 87 locations around Taiwan, selecting 21 environmental (physical-chemical-historical-human) predictors according to their possible influences on the benthos. Using a *k*-means approach, we delineated homogenous communities among transects. We then implemented a series of random forest models to assess the association between environmental predictors and the delineation of all the communities, and between predictors and the occurrence of a particular community. Five communities were identified with distinctive features: hard coral-, digitated octocorals-, clustered octocorals-, turfs-, and crustose coralline algae-dominated communities. Light intensity, unstable substrate, and nitrate were critical for the differentiation of communities and also occurrences of individual communities. In contrast, the distinction and occurrences of communities were poorly associated with temperature anomalies, typhoon disturbances, and management status. Under nutrient enrichment, a ubiquitous and impoverished community dominated by turfs emerges, suggesting a homogenization in benthic assemblages. Severe impacts of human activities appear as the most likely reason to blur regional patterns and the consequence of past climatic disturbances on the communities around the country. Altogether, our results call for taking immediate action to mitigate local stressors to manage reef resources in Taiwan effectively.

## **Stable isotope analysis of otoliths as tracers of hilsa shad (*Tenualosa ilisha*) migration in the Hooghly River Estuary, India**

**Aafaq Nazir**

*Institute of Oceanography, National Taiwan University, Taipei-10617*

### **Summary**

Anadromous fish, such as hilsa shad, are commercially important food fish that primarily inhabit the Hooghly River Estuary. This species shows a complex migratory pattern that present a major challenge for fisheries research. The present study is based on a large collection of isotopic data from otolith specimens of varying sizes, covering populations of different ages. Here, the stable isotopic signature of the otoliths was examined and related to the fish's age and location in the stream length. Otolith  $\delta^{18}\text{O}$  showed significant relationships with fish size (length and weight) and distance from the river mouth, providing a method for distinguishing their habitats. Small hilsa shad showed a preference for freshwater habitats, while larger individuals originated from the Bay area. ANOVA and discriminant function analysis (DFA) were used to categorize fish inhabiting upstream and downstream based on their  $\delta^{18}\text{O}$  values and to define the composition of the end members. A numerical model of two-component mixing was introduced to determine the integrated time interval that was equated with the fish's size to define its specific habitat. Significant variations in otolith  $\delta^{18}\text{O}$  values were found between upstream and downstream of the Hooghly River. The DFA showed that 81% of individuals were assigned to the upstream or downstream of Diamond Harbour, while the remaining 1-2 years old individuals represented a mobile population, likely participating in successful spawning and feeding activities. This method allowed for a better

understanding of the migration tendency of adult individuals, as well as clear identification of their habitats based on isotopic ratios in otolith specimens. This study provides a template for understanding the aquaculture potential and developing scientific management policies for hilsa shad in the West Bengal region of India.

# 海洋生物專題演講

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Abstract for an oral contribution

Christine Hanna Lydia Schönberg<sup>1,2</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan

<sup>2</sup>School of Engineering, The University of Western Australia, Perth, Australia

## Bioerosion in the South China Sea

The South China Sea is an important marine area for many reasons. On one hand, it is a significant source for many fisheries and materials, is traversed by very important shipping routes, and its coasts are very densely inhabited, causing environmental degradation. On the other hand, this marginal sea is close to the Coral Triangle and is highly diverse and an important ecosystem. It contains significant coral reef habitats that are, however, severely impacted by anthropogenic environmental change. The calcium carbonate balance on disturbed reefs shifts from live coral cover and a positive calcification rate to algae and filter feeders and negative calcification, or erosion. Bioerosion is a significant part of a reef's structural regulation, yet in the South China Sea we know near to nothing about bioerosion. Over the last two years, a new project with focus on bioerosion investigated taxonomy, field surveys and experimental work, aiming to investigate different bioeroder taxa. A pilot survey at Dongsha Atoll for internal bioeroders yielded about 20 different species of bioeroding sponges, many of which appear new to science, and more species were found at Liuqiu Island. The collections included *Siphonodictyon mucosum* and various new species of the *Cliona viridis* species complex, known for their ability to invade and sometimes kill live corals. The Dongsha sponge community was further characterized by an unusual abundance of *Cliothosa* spp., a little-known genus that creates large cavities and increases the risk of substrate breakage. We are presently revising this genus, describing the Taiwanese species and redescribing others. Aquarium experiments were conducted on sea urchins, external grazer-bioeroders, quantifying external bioerosion rates under global change conditions for the first time. Further experiments on other bioeroders are ongoing, presently with a focus on responses to heat. Any of the resulting data will help to address the large knowledge gap about bioerosion in the South China Sea and provide information for coral reef management and conservation.

## 七股潟湖魚類群聚的季節變化和棲地利用之研究

陳孟仙

國立中山大學海洋科學系

### 摘要

本研究探討七股潟湖魚類群聚的種類組成、季節變化及主要物種的棲地利用。於 2021 年 9 月至 2022 年 12 月期間，每月以待袋網採集七股潟湖魚類，共獲得 13,301 尾、總重 525 公斤的魚類，有 55 科 102 屬 149 種。前五數量優勢魚種分別為黑邊布氏鰻 *Eubleekeria splendens*、短棘鰻 *Leiognathus equulus*、大鱗鯪 *Planiliza macrolepis*、環球海鯪 *Nematalosa come* 和銀雞魚 *Pomadasys argenteus*，佔 48.48% 的總採集量。對前 30 優勢魚種(占總漁獲量的 94.26%)進行主座標軸典型分析(CAP)，結果顯示七股潟湖的魚類群聚具有顯著的四季分群。各季群的前五優勢魚種都不盡相同，其中黑邊布氏鰻和短棘鰻是夏秋季的優勢種，大鱗鯪和短鑽嘴魚 *Gerres erythrourus* 是冬春季的優勢種，環球海鯪是春夏季的優勢種，線紋鰻鯪 *Plotosus lineatus* 是夏秋季的優勢種。除此之外，春季群的次優勢種還有圈頸鰻 *Nuchequula manusella* 和多鱗沙鯪 *Sillago sihama*；夏季群的優勢種還有大棘鑽嘴魚 *Gerres macracanthus*；秋季群的優勢種還有星雞魚 *Pomadasys kaakan* 和銀雞魚 *Pomadasys argenteus*；而冬季群的優勢種還有鬚鰻鰕虎 *Taenioides cirratus*。七股潟湖依魚種為上述優勢魚種提供產卵、育幼和覓食的棲息地。與 1995-1998 年間的研究相比，本研究中有 65 種相同的魚類，新增 84 種，而有 43 種魚類未被捕獲。七股潟湖 25 年前的魚類群聚以鰻科(Mugilidae)為主，而目前則以鰻科(Leiognathidae)為優勢魚科，有顯著變化。儘管該潟湖仍然是多種熱帶和亞熱帶魚類生活史中不可或缺的棲息地，但整體群聚呈現以小型表層魚類為主的趨勢。

## 康氏馬加鰩食性與行為研究初探

鄭力綺、翁進興、何珈欣

行政院農業委員會水產試驗所沿近海資源研究中心

### 摘要

為了解康氏馬加鰩（以下俗稱土魷魚）食性與洄游路徑分布，本研究自2017年1月至2023年1月於澎湖縣馬公魚市場採集一支釣、延繩釣、刺網漁船捕獲個體，總樣本計1,871尾。該魚種攝食組成以胃內容物之重量百分比、出現率、相對重要性指數分析，四季間消化物比例均高，春、夏季以圓鰩屬為主；秋、冬季則以圓鰩屬、帶魚屬為主要組成。各體長級距間攝食組成亦有顯著差異，<50 cm FL 以鯆科為主，50–70 cm FL以帶魚屬為主，70–120 cm FL 以圓鰩屬為主，>130 cm FL 其餌料生物則以圓鰩屬及眼眶魚為主要組成。透過標識在魚體上之彈脫型衛星標識器顯示，9天紀錄中土魷魚自澎湖花嶼西方往南洄游至巴士海峽附近，再向北移動至福建附近海域，並於該處標識器脫落。另依據2021年6月（150 cm FL）、2023年1月（62-77 cm FL）捕獲之4尾土魷魚樣本其耳石核心至邊緣氧穩定性同位素值（ $\delta^{18}\text{O}$ ）時序列變化，對照日輪分布情形推測，魚體孵化時間約為5月（春季），孵化後38–108天處春、夏兩季， $\delta^{18}\text{O}$  值介於 -2 ~ -4 ‰；日齡 94-197天對應日期約為秋季（9–11月）， $\delta^{18}\text{O}$  值微幅增加，介於-2 ~ -3‰；至12月時耳石  $\delta^{18}\text{O}$  值仍低於-2‰，至1月則有部分個體  $\delta^{18}\text{O}$ 值大幅度增加至-1.67 ~ -1.86‰，棲息水溫明顯大幅度下降。本研究結果可進一步結合周邊海域水文環境資料，對照生殖發育分析結果，進一步探討該魚種產卵及攝餌場時空間變化情形，供漁政管理單位參考。



### **Habitat Changes and Catch Rate Variability for Greater Amberjack in the Taiwan Strait: The Effects of El Niño-Southern Oscillation Events**

Mubarak Mammel<sup>1</sup>, Ming-An Lee<sup>2,3\*</sup>, Muhamad Naimullah<sup>1</sup>, Cheng-Hsin Liao<sup>2</sup>, Yi-Chen Wang<sup>1</sup>, Kuo-Wei Lan<sup>1</sup>, Bambang Semedi<sup>4</sup>

<sup>1</sup>Department of Environmental Biology Fisheries Science, National Taiwan Ocean University, Taiwan

<sup>2</sup>Doctoral degree program in Ocean Resource and Environmental Changes, National Taiwan Ocean University, Taiwan

<sup>3</sup>Center of Excellence for Oceans, National Taiwan Ocean University, Taiwan

<sup>4</sup>Faculty of Fisheries and Marine Science, Brawijaya University, Indonesia

#### **Abstract**

El Niño–Southern Oscillation (ENSO) is a crucial oceanographic phenomenon that leads to interannual fluctuations in the climate and ecosystem productivity of tropical and subtropical areas. These fluctuations affect the suitability of habitats for many commercial fish species. However, detailed information on the effects of this major phenomenon and the resulting environmental changes on the habitat and catch rates of the economically and ecologically crucial species of the greater amberjack (*Seriola dumerili*) in the Taiwan Strait (TS) is lacking. In this study, we employed a weighted habitat suitability index (HSI) modeling method and used remotely sensed marine environmental data as well as data from recorders in Taiwanese fishing vessels (in 2014–2019) to understand the effects of ENSO events on the habitat suitability and catch rates for greater amberjack in the TS. Analysis of variance revealed that environmental factors substantially influenced greater amberjack habitats and catch rates during ENSO events across seasons. The catch rates were high in spring and summer in the southern and northern TS and in autumn and winter in the southern TS. The catch rates were higher in spring, summer, and autumn (>9.0 kg/h) in El Niño years, and in winter, the catch rates were higher in normal years (>12.0 kg/h) and lower in La Niña years. The predicted HSI for the southern and northern TS revealed that greater amberjack populations were predominantly distributed at 20–24°N and 24–28°N, respectively. Opposite habitat suitability was synchronously found in spring and summer during ENSO events, with higher HSI values recorded in spring in El Niño and normal years and higher HSI values recorded in summer in La Niña years. In winter, the HSI values of the southern and northern TS were higher in El Niño and normal years and substantially lower in La Niña years. Habitat suitability was extremely low in autumn. These findings imply that ENSO

events play a key role in regulating environmental conditions and affect the catch rates and habitat suitability for the greater amberjack in the TS.

## 東沙國際海洋研究站維運

廖德裕、黃湘倫、黃康明  
國立中山大學海洋科學系

### 摘要

東沙環礁位於南中國海的北端，地處珊瑚大三角的西側，屬全球海洋生物多樣性最高海域。東沙國際海洋研究站目前營運已逾十年，研究站能提供科研人員宿舍、研究船艇、潛水器具及相關的採樣與研究設備。因應COVID-19防疫政策，目前一週最多能安排13位研究人員同時在島研究。為建立東沙環礁海水基本資料，東沙研究站佈署水下溫度計於東沙的外環礁、內環礁、東沙島等地點，共設置13個測站。另外，預計2023年5月開始，將新建立（1）溶氧（20min一筆）測站於外環礁（北、南）、內環礁（東、西）、東沙島（北、南、小瀉湖內）；（2）鹽度（20min一筆）及（3）葉綠素（20min一筆）測站設置於東沙島北岸、內環礁西邊；（4）營養鹽將以採水方式收集，一年至少四次海水採樣，於外環礁、瀉湖內及東沙島邊各一點位進行採集。東沙研究站收集的水文資料能提供給有研究需求之單位，資料申請方式或登島研究需求者，請詳見中山大學東沙國際研究站網頁 <https://dongsha-mr.nsysu.edu.tw/>。

## Effects of warming on marine fishes depend on life histories

Hui-Yu Wang<sup>1</sup>, Sheng-Feng Shen<sup>1</sup>, and Mikko Heino<sup>2,3,4</sup>

<sup>1</sup>Biodiversity Research Center, Academia Sinica; Taipei, 11529, Taiwan.

<sup>2</sup>Department of Biological Sciences, University of Bergen; Bergen, 5020, Norway.

<sup>3</sup>Institute of Marine Research; Nordnes, Bergen, 5817 Norway.

<sup>4</sup>International Institute for Applied Systems Analysis, Laxenburg, A-2361, Austria.

### Abstract

Warming oceans may exacerbate fluctuations of fish population abundance. However, it is unknown whether such warming effects vary among different fishes. We collected empirical life-history and temperature data of 1210 Indo-Pacific fish populations to assess their population responses to climate warming. Our results show that the effects of warming on growth rates and age-at-maturity depend on life histories. Fishes with slower life histories show an increase in pre-maturity growth and earlier age-at-maturity, which promotes their adult body size and shortens generation times under warming. In contrast, fishes with faster life histories show a decrease in pre-maturity growth and delayed age-at-maturity, resulting in a decrease in adult body size, survival, and fecundity. Consequently, the effects of warming on population growth rates are mixed: positive for fishes with slower life histories, but negative for fishes with faster life histories. Fish conservation would benefit greatly from understanding the heterogeneous responses to warming.

## 宜蘭灣東方齒鯨魚卵分佈水文特性

陳瑞谷<sup>1\*</sup>，黃鼎傑<sup>1</sup>

行政院農業委員會水產試驗所海洋漁業組

\*通訊作者/基隆市和一路 199 號，TEL:(02)2462-2101ext.2418; E-

mail:rgchen@mail.tfrin.gov.tw

### 摘要

東方齒鯨 (*Sarda orientalis*) 俗稱煙仔虎，為大洋性中表層洄游魚種，是臺灣沿近海漁業重要漁獲物種，宜蘭灣海域是東方齒鯨重要的漁獲海域，每年冬春季是其產卵期，此時期肉質肥美，兼因泳速快爆發力十足，亦是娛樂漁業喜愛釣獲的目標魚種。本所自 2020 年開始執行日魚卵生產模式 (Daily Egg Production Method, DEPM)，每年春季在宜蘭灣以仔魚網撈捕魚卵時都會見到東方齒鯨魚卵出現，其魚卵直徑約在 1.2-1.4 mm，具有少見的多油球特徵。在 2022 年 3 月從宜蘭灣 35 個測站中有 17 個站捕獲到東方齒鯨魚卵，共計 92 個，以南澳灣外最多。經 GLM 分析發現，在宜蘭灣出現東方齒鯨魚卵的水文特性為水深 10 m 處 [Chl-a] < 0.5 ug/l，水深 5 m 密度 sigma-theta > 23.1，水深 5 m 鹽度[practical salinity] > 34.3‰，以及水深超過 200 m 的水域，可知東方齒鯨魚卵主要出現在宜蘭灣離岸較遠水深較深的水域，符合其表洋洄游生態習性。

## 台灣西南沿海資料貧乏漁業資源指標之建立－結合海洋環境

### 因子之黑口漁業資源指標建立

張水鏞<sup>1</sup>、袁子倫<sup>2</sup>、盧秉靖<sup>1</sup>、黃淑強<sup>1</sup>

<sup>1</sup> 國立中山大學海洋事務研究所

<sup>2</sup> 私立東海大學應用數學系

### 摘要

漁業對沿海生態常造成重大影響，主因是其未被合適管理；而未能合適管理的重要原因則是缺乏適當的科學證據作為管理的基礎，造成管理者不確定資源受傷程度，也無法說服業者接受如降低努力量之減輕漁業壓力的管理措施。台灣西南沿海黑口（*Atro Bucca nibe*, 黑魷）為當地重要漁業對象，歷經多年捕撈後，漁獲量已明顯下降，但缺乏資源評估所需的漁業資料造成資源狀況無法掌握。

本計畫於前一年度先透過漁船航程紀錄器（VDR）估計高解析度的努力量資料及定義漁場範圍，再結合漁市場船別拍賣資料，而成功在沒有作業日誌情況下建立時序列之單位努力漁獲量（catch per unit of effort, CPUE）資料。本年度則將所建立的資料，以三種模式來進行 CPUE 的標準化，以建立黑口之資源指標

（abundance index）：（1）二階段泛線性模式（delta-GLM），包括考慮及未考慮空間效應；（2）考慮空間效應之兩階段泛加成模式（delta-GAM）；（3）同時考慮時間與空間效應的向量自回歸時空模型（VAST）。考慮到漁獲分布應具有空間自我相關的關係，即距離上越接近的點，會有較高的相關性，因此本計畫將空間因子納入標準化模型做進一步分析。此外，目標魚種因子一直是進行複雜、多魚種漁業之資源動態研究時的重要影響因子，由於拖網漁業漁獲的魚種相當多，因此本計畫使用 k-means 集群分析法來進行分群，也使用主成分分析（PCA）將各航次漁種組成進行之變數進行加權，產生新變數作為替代目標魚種分群變數，進行標準化分析。最後，黑口魚群的分布可能會受到海洋環境的影響，因此本研究在標準化過程也加入海洋環境因子效應，以求能得著具代表性之黑口資源指標。

各模式分析之結果略有不同，但整體趨勢顯示西南沿海黑口資源除了 2015 年聖嬰年有增加之外，整體上都是下降，但至 2021 年似乎有止跌現象。這個結果未來將可應用於資源評估模式中，瞭解黑口之資源狀況，作為加強管理的科學依據。

## 台灣淺灘周邊海域仔稚魚之群聚組成

謝泓諺、邱韋倫、許凌瑄  
國立東華大學海洋生物研究所

### 摘要

本研究利用新海研三號 2021 年 10 月及 2022 年 3 月航次，於台灣淺灘周邊海域調查仔稚魚之群聚組成並探討其時空差異。兩個航次共計採集到 1968 隻仔稚魚，鑑定出 71 科 95 屬 152 種(或外形)，總平均豐度為  $415 \pm 358 \text{ ind./1000m}^3$ 。兩個航次仔稚魚的平均豐度差異不大，於 2021 年 10 月時在湧升區及鄰近湧升區的測站豐度有較高的現象，但這個趨勢在 2022 年 3 月則不明顯。台灣淺灘周邊海域之仔稚魚群聚多樣性高，本研究於 2022 年 3 月出現的物種數較 2021 年 10 月更為豐富，除了於台灣淺灘常見的砂泥底棲性魚類鰕虎科、中深水層性魚類燈籠魚科及洄游性魚類帶魚科之外，兩個航次的優勢魚種明顯不同，群聚組成於季節間的更迭十分明顯，這個現象可由 MDS 結果得到驗證。我們認為，不同季節間洋流的轉換，輸送了不同類群的仔稚魚至台灣淺灘，也造就了台灣淺灘周邊海域仔稚魚的豐富性與多樣性。



## Essential fish habitats in the western Arabian Gulf

Yu-Jia Lin

Institute of Marine Ecology and Conservation, National Sun Yat-sen University

### **Abstract**

Information about habitats occupied by aquatic organisms to complete their critical life history stages, called essential fish habitats, is crucial for their sustainability. In this work we determine essential fish habitats (nursery and spawning grounds) of several fish species inhabiting Saudi territorial waters in the western Arabian Gulf using multiple survey data (2013-2016), geostatistics and indicator species analysis. We built geostatistical maps of the spatial distributions of juveniles and mature fish and examined the strength of association of each species to observed nursery and spawning areas. Fish nursery areas were generally located at nearshore locations while spawning areas were located in offshore waters. The patterns of using nursery and spawning grounds were highly varied among species, supporting a hypothesis of habitat-species heterogeneity: different species use different locations as nursery and spawning grounds. Moreover, we discovered a hotspot of distribution for habitat-forming macroalgae and bryozoans, locating in the northern part of the western Arabian Gulf. These findings suggest the importance of marine surveys as the corner stones for evidence-based spatial planning and ecosystem-based management.

**Keywords:** Arabian Gulf; Essential Fish Habitat; Habitat-forming Organisms, Juveniles; Nursery grounds; Spawning grounds;

## 耳石有機物碳氮同位素紀錄該物種的食階富集係數

蕭仁傑

國立臺灣大學海洋研究所

### 摘要

儘管穩定性碳 ( $\delta^{13}\text{C}$ ) 和氮 ( $\delta^{15}\text{N}$ ) 同位素值被廣泛用於研究攝食生態學和食物網結構，但魚類耳石有機物中的  $\delta^{13}\text{C}$ 、 $\delta^{15}\text{N}$  值卻甚少用於此類研究。本研究評估了肌肉、耳石有機物和餌料之間  $\delta^{13}\text{C}$  和  $\delta^{15}\text{N}$  值之間的關係，上述樣品藉由元素分析儀連接同位素比值質譜儀進行分析。結果顯示  $\delta^{15}\text{N}$  值在肌肉中最高，其次是耳石、餌料和浮游生物，且在大多數樣品中，耳石和餌料之間的  $\delta^{15}\text{N}$  值沒有顯著差異。野生魚類的耳石和肌肉之間的  $\delta^{13}\text{C}$  值相似，兩者都高於它們的餌料同位素值，然而，養殖魚類的肌肉和耳石之間  $\delta^{13}\text{C}$  值雖甚為接近，但仍具有顯著差異，此結果可能反映了養殖魚類經歷食用不同的餌料，或是餌料含有同位素差異極大的成分。這些發現表明，耳石  $\delta^{15}\text{N}$  值可以提供魚類攝食資訊，而  $\delta^{13}\text{C}$  值則可以代表肌肉同位素值，這兩種同位素值可忠實地反映魚類的食階與攝食行為。

## 墾丁海口海草床春秋兩季二氧化碳源匯狀態與有機碳和無機碳代謝之關係

陳品均

國立臺灣海洋大學海洋環境與生態研究所

### 摘要

海草床是重要的沿岸藍碳生態系之一，可以吸收大氣裡的二氧化碳，扮演天然碳匯的角色。過去調查顯示，墾丁海口海草床有台灣本島最大的海草床覆蓋，對緩沖海洋酸化和吸收大氣二氧化碳可能具有重要意義。但目前對於台灣本島海草床的碳匯研究甚少，如果能對於海草床之碳源、匯狀態能有更充分的瞭解，便能更有效幫助達成緩解氣候變化的目標。本研究分別於 2022 年 5（春）和 9 月（秋）使用底棲培養箱，在海口海草床以及裸灘區進行現場培養實驗。培養期間儀器監測項目包括溫度、鹽度、溶氧、pH，另外也採集了海水和沉積物間隙水樣本進行 pH、總鹼度（TA）、和溶解態無機碳(DIC)的分析。春、秋兩季的觀測結果顯示，海草床和裸灘區相比碳化學參數皆表現出更明顯的日夜變化，白天 pH 值升高，DIC 和二氧化碳分壓 ( $p\text{CO}_2$ ) 降低，而夜間狀況則相反。春季觀測期間  $p\text{CO}_2$  平均值為 432  $\mu\text{atm}$ ，呈現碳源狀態，在秋季期間  $p\text{CO}_2$  平均值為 398  $\mu\text{atm}$ ，呈現碳匯狀態。春季底棲培養箱實驗計算結果顯示，春季時海草床和裸灘區的淨族群生產力（net community production）分別為 43.2 和 20.8  $\text{mmolO}_2/\text{m}^2/\text{day}$ ，皆為自營性生態系統，秋季兩者都為 -31.7  $\text{mmolO}_2/\text{m}^2/\text{day}$ ，皆為異營性生態系統；淨鈣化作用速率（net community calcification）春季分別為 -15.2 和 8.0  $\text{mmolC}/\text{m}^2/\text{day}$ ，海草床呈現碳酸鈣淨溶解狀態，裸灘區則呈現碳酸鈣淨生成狀態，秋季分別為 -19.8 和 -21.7  $\text{mmolC}/\text{m}^2/\text{day}$ ，兩者都是呈現碳酸鈣淨溶解狀態。而沉積物間隙水中兩季也都顯示出海草床比裸灘區有更高的鈣離子濃度，綜合兩者結果，推測是海草床存在著有更多的碳酸鈣溶解。綜言之，研究期間在春季海口海草床為自營性生態系統且呈現碳酸鈣淨溶解狀態，但卻呈現碳源狀態，而在秋季的時候海草床為異營性生態系統且呈現碳酸鈣淨溶解狀態，但卻呈現碳匯狀態，上述結果與其源、匯狀態並無良好的對應關係，確切原因仍有待進一步的研究來加以釐清。此外，間隙水  $^{13}\text{C}$  的分析結果顯示沉積物中 DIC 增加主要的來源應為海洋中的浮游植物或是陸源有機質的分解，暗示海口海草床沉積物中有機質主要的來源可能並非海草的碎屑，此發現表明沿岸藍碳生態系統中土壤碳匯計算時，需進一步釐清外源性有機碳的貢獻，否則會顯著高估沿岸藍碳生態系統土壤碳匯的潛力。

## 臺灣周遭海域海洋雪之分佈和顆粒態有機碳通量概算

余泓睿、龔國慶、許瑞峯\*

國立臺灣海洋大學海洋環境與生態研究所

### 摘要

海洋雪(Marine snow)目前學界的定義為由許多物質組成的顆粒態有機碳(POC)，粒徑由釐米至毫米不等，是一種快速沉降顆粒，是構成生物碳幫浦的重要角色。然而我國對於臺灣周遭海域海洋雪之研究甚少，若能夠釐清海洋雪對於區域碳循環的貢獻，便能更準確地估算臺灣海域的碳通量。因此本研究在 2021 年 12 月 (NOR1\_CR0022)及 2022 年 6 月(NOR1\_CR0035)於臺灣周遭海域及西北太平洋海域使用海洋雪捕捉器(Marine snow catcher, MSC)進行採樣，區分沉降顆粒的種類及收集海洋雪豐度、大小與沉降速度等資料，以瞭解臺灣海域之海洋雪基本特性，同時透過比較水化學及膠體濃度等參數，釐清可能影響海洋雪豐度、大小與沉降速度的因子，並藉以海洋雪之濃度估算其 POC 通量。結果顯示，臺灣周遭海域之海洋雪豐度介於  $0.02 \sim 0.14 \text{ agg. L}^{-1}$  之間，西北太平洋則介於  $0.01 \sim 0.21 \text{ agg. L}^{-1}$  之間，並且發現豐度與 Chl-a 積分值呈現顯著正相關，顯示海洋雪形成數量的多寡，會受到植物性浮游生物所影響。而臺灣沿海的海洋雪顆粒大小主要以  $0.5 \sim 1 \text{ mm}$  範圍為主，西北太平洋則以  $0.1 \sim 0.5 \text{ mm}$  為主。至於各測站海洋雪的沉降速度與顆粒大小並沒有顯著相關性，表示沉降速度並不完全受顆粒大小影響，而在沉降速度與蛋白石濃度的統計分析中，顯示兩者有高度的正相關，代表臺灣周遭海域之海洋雪很有可能受到生物礦物的壓載作用。進一步估算 POC 通量，臺灣沿海之 POC 通量範圍為  $103.095 \text{ mg-C.m}^{-2}.\text{d}^{-1}$  至  $485.515 \text{ mg-C.m}^{-2}.\text{d}^{-1}$ ，西北太平洋的 POC 通量估算範圍則為  $113.550 \text{ mg-C.m}^{-2}.\text{d}^{-1}$  至  $180.915 \text{ mg-C.m}^{-2}.\text{d}^{-1}$ 。其中 NOR1\_CR0035 航次則於西北太平洋海域下放 MSC 於 50 與 160 m，並與漂浮式沉積物收集器同步採樣，數據顯示兩者之 POC 通量差異不大，說明使用 MSC 亦可執行海洋有機碳通量之任務。

## ***Litopenaeus vannamei* mariculture might increase the aquatic greenhouse gases concentrations**

Qiao-Fang Cheng<sup>1</sup>, Bo-Kai Liao<sup>2</sup>, and Hsiao-Chun Tseng\*<sup>1</sup>

<sup>1</sup> Institute of Marine Environment and Ecology,  
National Taiwan Ocean University, Keelung 202, Taiwan

<sup>2</sup> Department of Aquaculture,  
National Taiwan Ocean University, Keelung 202, Taiwan

### **Abstract**

After the Industrial Revolution, the atmospheric greenhouse gases concentrations have increased as well as the human population. Demands for aquatic animal protein increases and this has greatly promoted the rapid expansion of global aquaculture industry. Previous studies have pointed out that the aquatic ecosystem is an important source of greenhouse gases. However, scarce researches have focused on the greenhouse gases emissions from the aquaculture. In addition, greenhouse gases emissions may differ between different types of aquaculture ponds, species and pond management practices. Achieving net-zero by 2050 is the global target and consensus, and it facilitates the industrial transformation. In this research, we investigated the concentrations of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O of *Litopenaeus vannamei* mono-mariculture in semi-indoor and indoor concrete ponds. During the culture period to harvest, aquatic environments have been monitored and the concentrations of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O have been analyzed.

Seawater was pumped individually from the aquaculture farm's adjacent sea area to the semi-indoor and indoor ponds as inflow water. The inflow water concentrations of *p*CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in semi-indoor and indoor ponds did not vary much during the entire culture period. In semi-indoor ponds, the average pond water concentrations of *p*CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O during the entire culture period were 2417.1±1854.4 μatm, 3.7±0.1 nM, 22.3±16.8 nM, respectively while they were 2890.9±793.8 μatm, 184.6±252.7 nM, 73.0±54.7 nM in the outflow water. In indoor ponds, the average pond water concentrations of *p*CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O during the entire culture period were 1539.9±1122.1 μatm, 5.7±5.1 nM, 24.2±29.0 nM, respectively while they were 2407.7±2581.8 μatm, 224.7±524.7 nM, 82.4±145.5 nM in the outflow water.

In conclusion, the concentrations of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in the inflow water, pond water and outflow water all exceeded equilibrium, which acted as sources of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O to the atmosphere. Furthermore, ascending trends in CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O concentrations in both the pond and outflow waters were observed with increasing culture days in semi-indoor ponds as well as the indoor ones.

## The Variations of O<sub>2</sub>/Ar-Net Community Production and Air-Sea Carbon Dioxide Flux in the southern East China Sea Summer 2018

Kai-Jung Kao<sup>1</sup>, Wei-Jen Huang<sup>1\*</sup>, Wen-Chen Chou<sup>2,3,4</sup>, Gwo-Ching Gong<sup>2,3</sup>, Hsiao-Chun Tseng<sup>2</sup>, and Veran Weerathunga<sup>1</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan.

<sup>2</sup>Institute of Marine Environment and Ecology, National Taiwan Ocean University, Keelung, Taiwan.

<sup>3</sup>Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung, Taiwan.

<sup>4</sup>Graduate Institute of Marine Biology, National Dong Hwa University, Pingtung, Taiwan.

Correspondence to: Wei-Jen Huang ([wjhuang29@mail.nsysu.edu.tw](mailto:wjhuang29@mail.nsysu.edu.tw))

### Abstract

Continental shelves play a significant role in the global ocean carbon cycle, accounting for 33% of the net community production (NCP) and 15-21% of the net annual carbon dioxide (CO<sub>2</sub>) sink. However, the mechanisms of the NCP and the partial pressure of carbon dioxide (*p*CO<sub>2</sub>) on the continental shelf are still unclear due to the perturbations of the physical processes (ex., upwelling and eddies) and the extreme weather events. Sea surface O<sub>2</sub>/Ar-NCP and *p*CO<sub>2</sub> were measured through the Equilibrator Inlet Mass Spectrometry and the underway *p*CO<sub>2</sub> system in the southern East China Sea (sECS) before (July 6–9, 2018) and after (July 13–17, 2018) Typhoon “Maria.” The mean NCP of the sECS was 43.1 ± 25.8 mmol C m<sup>-2</sup> d<sup>-1</sup> before the typhoon and increased to 69.7 ± 40.9 mmol C m<sup>-2</sup> d<sup>-1</sup> after the typhoon. This NCP result was consistent with our surface *p*CO<sub>2</sub> results, which displayed 325.1 ± 18.3 and 322.9 ± 17.4 μatm on the upwelling regions of shelf break and middle shelf, respectively, before the typhoon. The surface *p*CO<sub>2</sub> dropped to 315.5 ± 15.9 and 305.7 ± 7.2 μatm on the shelf break and middle shelf, respectively, after the typhoon. Our analysis indicates that the temperature effect (40%), net biological activities (-36%), and mixing (-24%) are the controlling factors of *p*CO<sub>2</sub> variations before and after the typhoon. During our study period, the upwelling regions in sECS were autotrophic and acted as strong sinks of atmospheric CO<sub>2</sub> (-4.2 ± 1.2 to -14.1 ± 1.2 mmol m<sup>-2</sup> d<sup>-1</sup>). We suggest that the temperature change, net biological activities, and mixing during the upwelling process characterized the biogeochemical responses over the sECS.

## Controls of submarine canyons connected to shore during the LGM sea-level rise

Cheng-Shing Chiang <sup>1, \*</sup> and Ho-Shing Yu <sup>2</sup>

Only 4% of the world's submarine canyons reach the coastline and remain active today. Among 13 submarine canyons offshore Taiwan, we identified seven (n=7, 54%) that remain connected to shore and active during the present-day highstand. The purpose of this study is to determine the key controls of canyon heads that remain connected to shore with terrestrial sediment input during the Holocene sea-level rise. As a result of high uplift rates, narrow coastal range, steep gradients, and frequent earthquakes, typhoons development in Taiwan mountain belt, Taiwan has the highest-yield river and sediment supply. This has led to the transportation of large volumes of sediment to the surrounding deep seas. Narrow steep shelf and large sediment volumes associated with small mountain rivers are the main controls involved in the development of shore-connected canyons on the active Taiwan margin. Shore-connected canyons are present in greater numbers in the major earthquake zone on the eastern Taiwan margin. Frequent earthquake events are another significant factor in the occurrence of shore-connected canyons in the Taiwan region.



# 海洋地質地物專題演講

## 台灣灘沉積動力架構研究的初步進展

劉祖乾

中山大學海洋科學系

### 摘 要

從物源的角度，基本上台灣海峽的沉積物型態可分為下列幾種對比：大陸源對台灣源，陸源對海源，長江源對珠江源，現代沉積物對殘餘沉積物等等。現代沉積物因和過程及物源有強烈的耦合，所以有高度的多樣性。而台灣灘位於台灣海峽南部，各種「從源到匯」的傳輸途徑均通過此區域。

將現有台灣海峽取得之有限的沉積物樣本中共同測到之環境指標如沉積物粒徑、黏土礦物、及有機質視為示蹤劑，利多變數的分析方法，初步得知台灣灘為現代沉積物傳輸之十字路口，來源多樣化。

同時將台灣海峽取得之的沉積物樣本中共同測到之陸、海源生物指標、粒徑、葉綠素、及海水表層溫度視為示蹤劑，同樣利多變數的分析方法，初步得知台灣灘東側之湧升流為攜帶海源生物指標之有機碳的源區。

台灣灘地處台灣海峽地形、水文、生態之敏感區，中國大陸採砂船、漁船的活動不但牽涉到環境保育(棲地、生態、漁業)的破壞，更可能從事水深、水文探測等妨礙國家安全的活動，因此建議加強在此地之綜合海洋學研究，強化我國對此區域發言權。

## Multiproxy-derived temperature evolution offshore southern Japan over the past 30 kyrs: Implications for Kuroshio Current variability

Zhe Ying Ang<sup>1</sup>, Takuya Sagawa<sup>2</sup>, Ken Ikehara<sup>3</sup>, Minoru Ikehara<sup>4</sup>,  
Jens Hefter<sup>5</sup>, Sze Ling Ho<sup>1</sup>

(1) Institute of Oceanography, National Taiwan University (2) Institute of Science and Engineering, Kanazawa University (3) Institute of Geology and Geoinformation, Geological Survey of Japan, AIST (4) Center for Advanced Marine Core Research, Kochi University (5) Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

The Kuroshio Current is a strong western boundary current of the North Pacific Subtropical Gyre. Offshore southern Japan, the Kuroshio Current exhibits a bimodal feature, i.e., large-meander (LM) and non-large-meander (NLM) paths, which is controlled by changes in the velocity of the Kuroshio Current. Both this feature and the latitudinal displacement of the Kuroshio Extension jet are linked to the variations in the North Pacific Subtropical Gyre circulation. These modern observations have inspired reconstruction approaches, e.g., different types of latitudinal sea surface temperature gradient ( $\Delta$ SST) have been employed to reconstruct glacial-interglacial changes in the strength of the Kuroshio Current and the North Pacific Subtropical Gyre; these include  $\Delta$ SST between offshore and nearshore southern Japan, and  $\Delta$ SST between offshore southern Japan and the Kuroshio-Oyashio transition zone. However, previous studies utilizing the  $\Delta$ SST approach are mostly based only on one proxy i.e., alkenone-based  $U^{K'_{37}}$ . Thus, it remains unknown if the reconstruction is proxy-specific. Furthermore, due to a lack of paleotemperature records, the sites selected for  $\Delta$ SST calculation may not be the best. To further assess the robustness of the reconstructed Kuroshio Current variability, we generate two sets of multiproxy ( $U^{K'_{37}}$  and archaeal GDGT-based  $TEX_{86}^H$ ) SST records spanning the past 30 kyrs using two sediment cores (KPR-1PC and C9035B) retrieved from strategic locations. Both types of  $\Delta$ SST calculated using a combination of our and published  $U^{K'_{37}}$  records yield similar results as previous studies, suggesting a weakening of the Kuroshio Current from the Last Glacial Maximum to the last deglaciation period, followed by an intensification towards the Holocene. These results agree with the reconstructions based on foraminifera. Notably, our  $U^{K'_{37}}$  and  $TEX_{86}^H$  records exhibit similar temporal patterns over the last 30 kyrs. Both proxies agreed well during the Holocene but GDGT-based temperatures were lower during the last glacial, thereby leading to a stronger glacial cooling. GDGT indices commonly used to ensure  $TEX_{86}^H$  data quality indicate that data from the last glacial and deglaciation may have been biased by methanogenic GDGT input. Thus, whilst the temporal patterns in  $TEX_{86}^H$  records are probably reliable judging from its striking resemblance to  $U^{K'_{37}}$  records, the absolute value and magnitude of change should be interpreted with caution. Overall, our multiproxy findings confirm the robustness of the reconstructed Kuroshio Current variability based on  $\Delta$ SST approaches.

**Keywords:** Kuroshio strength, Kuroshio meander,  $U^{K'_{37}}$ ,  $TEX_{86}^H$

## Multiproxy-derived ocean temperature changes at the edge of the Indo-Pacific Warm Pool since the Last Glacial Maximum : Implications for the recording depth of TEX86

Akshat Gopalakrishnan<sup>1</sup>, Liang-Jian Shiau<sup>2,3</sup>, Min-Te Chen<sup>2</sup>, Kuo-Fang Huang<sup>4</sup>, Ai Lin Chen<sup>1</sup>, Masanobu Yamamoto<sup>5</sup> Sze Ling Ho<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

<sup>2</sup>Institute of Applied Geosciences, National Taiwan Ocean University, Keelung, Taiwan.

<sup>3</sup>Exploration and Development Research Institute, CPC Corporation, Miaoli, Taiwan.

<sup>4</sup>Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan.

<sup>5</sup> Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Japan

### Abstract

The Indo-Pacific Warm Pool (IPWP) holds the warmest surface ocean waters on earth and is a major source of heat and moisture to the global climate. Thus, past changes in the upper ocean temperature here are of high interest to the palaeoceanographic community. In this regard, one of the highly debated issue is the diverging temperature reconstructions during the Pliocene based on TEX86 and Mg/Ca of foraminifera. This discrepancy has been attributed to secular changes in seawater Mg/Ca or TEX86 recording a combined surface and subsurface signal. To further shed light on the Mg/Ca-TEX86 discrepancy in the IPWP and depth origin of TEX86 signal, we reconstruct surface and subsurface temperatures at the edge of the IPWP using UK'37, TEX86, and multi-species foraminiferal Mg/Ca. We focus on the past 25kyr, which allows us to rule out the effect of long term variations in seawater composition as a driver of the proxy discrepancy. Our multiproxy surface and subsurface temperatures dataset shows cooler LGM and warmer Holocene. UK'37 and surface-dwelling *G. ruber* temperatures fit well together exhibiting ~2°C warming in the surface ocean since the LGM. *G. ruber* displays peak warming during Early Holocene (EH) followed by cooling towards LH (Late Holocene), whereas UK'37 approaches the saturation limit and thus does not exhibit the same trend. When interpreted as sea surface temperature (SST), commonly applied SST calibrations yield TEX86 temperatures that were considerably higher than modern SST and temperatures derived from UK'37 and *G. ruber* Mg/Ca at our site. Relatively high GDGT 2/3 ratios (7 - 12) throughout the record suggests that the TEX86 likely registers subsurface temperature signal at our site. Indeed, when interpreted as subsurface temperature, TEX86 record indicates a ~1.5°C - 3.3°C warming, similar to Mg/Ca records of thermocline dwelling *P. obliquiloculata* and *N. dutertrei* that show ~2.9°C and ~2.5°C warming since LGM, respectively. Both Mg/Ca of thermocline species and TEX86 exhibit a rise in temperature during EH, followed by a decline during LH. These results imply that TEX86 plausibly reflects temperature at the thermocline close to the habitat depth of *P. obliquiloculata* and *N. dutertrei* at ~ 100m water depth. The subsurface warming trend across the last glacial cycle recorded by foraminifera and GDGTs at our site is consistent with observations at other sites in the IPWP region, indicating a coherent regional climate shift. Our study highlights the potential of utilizing a multiproxy approach in temperature reconstructions to constrain proxy discrepancy and provide a more comprehensive understanding of proxy-derived climate reconstruction.

**Keywords :** IPWP, LGM, Multiproxy, Mg/Ca, Foraminifera, TEX86.

## Sediment trap time series of alkenone-based paleotemperature proxy ( $U^{K'}_{37}$ ) in the northern South China Sea

Chia-Yu Chung<sup>1</sup>, Sze Ling Ho<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

### Abstract

$U^{K'}_{37}$  is a temperature proxy based on alkenones, a type of lipid biomarker, produced by haptophyte algae.  $U^{K'}_{37}$  is widely used to reconstruct past sea surface temperature (SST). The production and sinking process of alkenones in the water column strongly influence the  $U^{K'}_{37}$  value in the underlying sediments. Therefore, the temporal variations in the alkenone flux and the  $U^{K'}_{37}$  value of sinking particulate matter may shed light on the controlling factors of sedimentary  $U^{K'}_{37}$ , which in turn will help improve the interpretation of  $U^{K'}_{37}$ -inferred paleotemperature records. Although many  $U^{K'}_{37}$ -based paleotemperature records have been generated for the South China Sea (SCS), there is still a dearth of modern  $U^{K'}_{37}$  time series here. Due to the high SST in the SCS which may reach  $\sim 30^\circ\text{C}$  in summer, sedimentary  $U^{K'}_{37}$  values here are typically close to the high end of the proxy scale, thus there is also a need to verify the applicability of the commonly applied  $U^{K'}_{37}$  calibrations. In this study, we analyzed sinking particles collected by sediment traps (SEATS) at 2000 m and 3500 m water depths in the northern SCS to assess the temporal variations in alkenone-based  $U^{K'}_{37}$ . The samples were from November 2017–May 2020, with several gaps in the sampling interval. Our preliminary findings indicate  $\sim 3$  months and  $\sim 6$  months of lags at 2000 m and 3500 m, respectively, corresponding to sinking rates of  $\sim 20$  m/d, which are within the range previously reported for the East China Sea (10–33 m/d). Therefore, despite the uncertainty in the determination of time lag due to the discontinuity of our time series, we adjusted the alkenone time series to account for the sinking time. The adjusted time series show that the peak alkenone fluxes occurred in Sep–Nov 2017 (trap-2000 m) and Jun–Sep 2017 (trap-3500 m), while primary production peaked during winter. The correlation between  $U^{K'}_{37}$  and SST is generally low ( $r^2 = 0.2 - 0.3$ ). The Goñi et al. (2001) calibration yields  $U^{K'}_{37}$ -SST values that closely match the SST during summer but are higher than SST during winter. In contrast, the Sonzogni et al. (1997) and Müller et al. (1998) calibrations produce  $U^{K'}_{37}$ -SST values that are lower than SST during summer and higher than SST during winter. Meanwhile, the SCS calibration by Pelejero & Calvo (2003) yields  $U^{K'}_{37}$ -SST values that are considerably higher than SST throughout the entire studied period. Next, we will compare the  $U^{K'}_{37}$  value of surface sediments near the sediment trap site with the flux-weighted  $U^{K'}_{37}$  value calculated from the trap time series to examine whether sedimentary  $U^{K'}_{37}$  here reflects annual or seasonal SST. We will also discuss factors leading to the mismatch between the peak in alkenone flux and primary production, and the absence of temporal variability in the  $U^{K'}_{37}$  time series.

Key Words:  $U^{K'}_{37}$ , Alkenone, Sediment trap, South China Sea

## Assessing the thermal gradient approaches used to reconstruct the evolution of the East Asian Monsoon over the past 25 ky in the southern South China Sea: Perspectives from multi-proxy paleotemperature records

Ai-Lin Chen<sup>1</sup>, Ren Yi Ooi<sup>1</sup>, Raúl Tapia<sup>1</sup>, Kuo-Fang Huang<sup>2</sup>, Li Lo<sup>3</sup>, Min-Te Chen<sup>4</sup>, Stephan Steinke<sup>5</sup>, Sze Ling Ho<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan

<sup>2</sup>Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan

<sup>3</sup>Department of Geosciences, National Taiwan University, Taipei, Taiwan

<sup>4</sup>Institute of Applied Geosciences, National Taiwan Ocean University, Keelung, Taiwan

<sup>5</sup>Department of Geological Oceanography and State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China

### Abstract

The southern South China Sea (sSCS), located at the margin of the warm pool, is influenced by the East Asian Monsoon (EAM). In winter, aided by northeast EAWM, cold surface water is transported from the northern to the southern SCS along the coast, forming a west-east thermal gradient in the surface ocean of the sSCS. This gradient forms a “cold tongue” extending offshore of Vietnam. The modern spatial extent of this west-east gradient increases with the intensity of the EAWM. At the same time, strong monsoonal winds cause vertical mixing in the upper water column, which in turn affects the thermal gradient of the upper water column due to the changes in the depth of the thermocline and the mixed layer. Thus, west-east and vertical thermal gradients have been used to investigate past changes in the EAWM. However, proxy differences have been reported for this region, suggesting that reconstructions may be proxy-specific. Therefore, in this study, we reconstruct the upper ocean temperature at two sites in the sSCS (MD97-2151 and MD01-2390) based on planktic foraminifera Mg/Ca and biomarker-based proxies (algae-based  $U_{37}^{K'}$  and archaea-based TEX<sub>86</sub>). We focus on the temporal evolution of (1) the west-east thermal gradient and (2) the upper water column vertical thermal gradient over the last glacial cycle. Temperature records based on  $U_{37}^{K'}$  and Mg/Ca of surface dweller indicate a comparable decrease in the west-east thermal gradient evolution since the last glacial maximum (LGM), suggesting a general decrease in the intensity of the EAWM since the LGM. However, the fluctuations across the deglaciation derived from these two proxies are anti-correlated. The vertical thermal gradients inferred from biomarker proxies ( $U_{37}^{K'}$  and TEX<sub>86</sub>) and foraminiferal Mg/Ca records of surface- and thermocline-dwelling species all show a decreasing pattern since the LGM, except those based on *Pulleniatina obliquiloculata* at site MD97-2151. The amplitude of vertical thermal gradient change also varies between approaches (biomarker vs. foraminifera) and between sites. In summary, our study shows that the thermal gradient approaches based on both biomarker and foraminifera do yield broad agreement in the reconstructions of glacial-interglacial EAWM evolution but not the amplitude of change or millennial variability. Proxy mismatch may be due to proxy calibration, and/or different seasonality and habitat depth recorded by the proxy carriers.

**Keywords:** South China Sea; East Asian Monsoon ; Seawater temperature

## Multi-species Mg/Ca-derived upper ocean thermal gradients in the northern South China Sea over the past 24 kyr

Ren Yi Ooi<sup>1</sup>, Ai-Lin Chen<sup>1</sup>, Kuo-Fang Huang<sup>2</sup>, Min-Te Chen<sup>3</sup>, Sze Ling Ho<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

<sup>2</sup>Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan.

<sup>3</sup>Institute of Applied Geosciences, National Taiwan Ocean University, Keelung, Taiwan.

### Abstract

The evolution of upper ocean (surface-subsurface) thermal gradient ( $\Delta T$ ) in the South China Sea (SCS) has been used to reconstruct past variability of the East Asian Winter Monsoon (EAWM). The effect of EAWM is particularly strong in the northern SCS (nSCS), but there is a dearth of paired surface-subsurface paleotemperature records here. In this study, we aim to fill in the data gap, while at the same time also assess the spatial representativeness of paleotemperature records in the study area. To achieve our goals, we generate multi-species Mg/Ca temperatures using a sediment core from the nSCS (MD97-2146), which is ~140 km away from site MD05-2904 where Mg/Ca temperatures (Mg/Ca-Ts) were previously published.  $\Delta T$  is calculated as the difference in Mg/Ca-T between surface-dwelling *Trilobatus trilobus* and thermocline-dwelling *Pulleniatina obliquiloculata* and *Neogloboquadrina dutertrei*. According to modern-day studies, *T. trilobus* likely records the annual mean sea surface temperature (SST), while *P. obliquiloculata* and *N. dutertrei* likely record the winter thermocline temperature. The Mg/Ca-SST record of *T. trilobus* shows typical glacial-interglacial swing from colder Last Glacial Maximum (LGM) to warmer Holocene, which is similar to the Mg/Ca record of surface-dwelling *G. ruber* from nearby site MD05-2904. Mg/Ca-subsurface Ts (subTs) of *N. dutertrei* show a cooling trend from 24 kyr to ~10-6 kyr and a warming trend after ~6 kyr. Meanwhile, Mg/Ca-subTs of *P. obliquiloculata* show instead minimal variability with an average temperature of  $21.5 \pm 0.2$  ( $2\sigma$ ) °C throughout the past 24 kyr. This is in contrast to the Mg/Ca-subT record of *P. obliquiloculata* at nearby site MD05-2904, which shows more fluctuations and temperature minima during the LGM and Late Holocene. Due in part to the strong glacial-interglacial change in *T. trilobus* record, the overall pattern in the calculated  $\Delta T$  at our study site is the same for both *P. obliquiloculata* and *N. dutertrei* but with a larger magnitude of change in  $\Delta T_{T.trilobus-N.dutertrei}$ . That is,  $\Delta T$  increases from the LGM to the Holocene. Whilst the general trends in  $\Delta T$  based on both thermocline dwellers and of both sites are in broad agreement, the  $\Delta T_{T.trilobus-P.obliquiloculata}$  record from site MD05-2904 and  $\Delta T_{T.trilobus-N.dutertrei}$  record from our site diverge from each other during several time intervals. In summary, the comparison with MD05-2904 demonstrates that foraminiferal Mg/Ca-based reconstructions of upper ocean temperature in the nSCS are spatially representative. SST records are more comparable between sites than thermocline temperature records derived from *P. obliquiloculata* and *N. dutertrei*. Thus, a better understanding of the ecology of thermocline dwellers will help to constrain the interpretation of thermocline temperature records. Despite the aforementioned differences the foraminiferal Mg/Ca  $\Delta T$  records at both sites indicate an overall increasing trend in the upper ocean thermal gradient, implying that the EAWM intensity has been decreasing over the past 24 kyr.

**Keywords:** Mg/Ca, upper ocean thermal gradient, northern South China Sea, LGM



## Variations in microbial utilization of organic compounds across a tectonic transition in the South China Sea

En-Ju Lin<sup>1</sup>, Tzu-Hsuan Tu<sup>1</sup>, Jhen-Nien Chen<sup>2</sup>, Pei-Ling Wang<sup>3</sup>, Li-Hung Lin<sup>2</sup>

<sup>1</sup> Department of Oceanography, National Sun Yat-sen University

<sup>2</sup> Department of Geoscience, National Taiwan University

<sup>3</sup> Institute of Oceanography, National Taiwan University

### Abstract

Methane hydrates are widely distributed in the South China Sea (SCS) and the tectonic transition in this area may affect the origin of methane in marine sediments. Because the communities in passive (FR) and active (FWCR) margins off southwestern Taiwan were shifted and diversified during burial processes, we hypothesized that microbial differentiation in marine sediments from FR and FWCR would impact organic matter utilization and the origin of methane. We conducted incubations with <sup>13</sup>C-labelled methanol, methylamine, acetate, and glucose with slurries from three depth intervals (5, 50, and 120 mbsf) sampled from both sites to reveal connections between community structures and potential metabolic pathways. We found that methyl-based methanogenesis occurred only in incubations from 5 mbsf in FR, which had an increased proportion of *Methanococoides* spp. In contrast, newly produced methane was not detected in other incubations, and we inferred that fermentation was the primary process consuming methyl compounds due to the accumulation of <sup>13</sup>CO<sub>2</sub>. Methyl compounds were also assimilated and accumulated in microbial biomass at rates ranging from  $7.9 \times 10^{-5}$  to  $2.1 \times 10^{-2}$  mg C/day and  $2.9 \times 10^{-4}$  to  $3.3 \times 10^{-4}$  mg C/day in incubations from FR and FWCR, respectively. In acetate and glucose incubations, heterotrophs were the dominantly enriched groups at both sites and depths. Our results demonstrate that variable microbial communities between tectonic settings affect degradation rates and metabolic pathways of organic matter in marine sediments. In situ methanogenesis is a source of methane in the passive margin, while the active margin may rely on thermogenic methane from the deep reservoir.

Keywords: South China Sea, organic compounds, methane, active/passive margins



## 臺灣海峽東北部顆粒態有機碳的組成與來源

莊淑嫻<sup>1</sup>、李杰<sup>1</sup>、許介璋<sup>1,2</sup>、張詠斌<sup>1</sup>、林慧玲<sup>1</sup>、劉祖乾<sup>1</sup>、林玉詩<sup>1\*</sup>

<sup>1</sup> 國立中山大學海洋科學系

<sup>2</sup> 國立高雄科技大學高瞻科技不分系學士學位學程

### 摘要

臺灣海峽是東亞邊緣海物質運輸的重要通道，前人對其溶解態物質及表層沉積物已有大量研究，但對懸浮顆粒的研究卻相對欠缺。為了追蹤臺灣西北部河流輸出的顆粒態有機碳在海峽中的宿命以及與該區兩段（近岸、離岸）泥質帶的關係，本研究於 NOR3-0104 航次期間（2022 年 6 月 14 至 21 日），在臺灣海峽東北部收集了水文數據、懸浮顆粒以及近表層沉積物樣本。在航次前一週至採樣期間，僅台中梧棲測站於 6 月 8 日達大雨標準、蒲氏風級為 3-4 級，雨量及風速皆小，整體流向朝東北，表水以高溫低鹽的陸棚水為主，底水則為南海水。鹽度數據顯示，沖淡水主體被限制在近岸區域，與近岸泥質帶吻合。

在近岸測站，懸浮顆粒（Suspended Particulate Matter，簡稱 SPM）和顆粒態有機碳（Particulate Organic Carbon，簡稱 POC）濃度皆高，最高值發生在桃園沿岸。河口外的水層從表至底均呈現高葉綠素濃度與較重的 POC 的碳同位素值（ $\delta^{13}\text{C}_{\text{POC}}$ ，約 -23‰ ~ -21‰），顯示浮游植物為 POC 的主要組成，但表層沉積物的總有機碳（Total Organic Carbon，簡稱 TOC）同位素值（ $\delta^{13}\text{C}_{\text{TOC}}$ ）卻為 -25‰，與 POC 成分脫鉤（decoupled）。

在離岸泥質帶測站，懸浮顆粒在表水濃度低，但在密躍層下方至水層底部有高濃度，推測是再懸浮作用的結果。該區 POC 含量與葉綠素均低，次表水（5 公尺） $\delta^{13}\text{C}_{\text{POC}}$  輕達 -25‰，底水  $\delta^{13}\text{C}_{\text{POC}}$  值則較接近沉積物  $\delta^{13}\text{C}_{\text{TOC}}$  數值（-23‰），符合再懸浮特徵。該區 POC 來源尚待進一步有機地化分析釐清。

整體而言，在臺灣海峽東北部除了離岸再懸浮區域以外，懸浮顆粒與表層沉積物有機質組成均有一定程度的脫鉤，暗示夏季 POC 供應不是主因；未來將進一步釐清冬季 POC 供應、選擇性降解與/或水力淘選對沉積物有機質組成造成的影響。

## Excitation and seasonal variation of seafloor infragravity waves observed at OBS stations

利用海底地震儀觀測亞重力波的激發機制與季節變化

Hou-Sheng Cheng<sup>1</sup>, Emmy T. Chang<sup>1</sup>, Yuancheng Gung<sup>2</sup>

<sup>1</sup>Institute of Oceanography, Nation Taiwan University, Taipei, Taiwan

<sup>2</sup>Department of Geosciences, Nation Taiwan University, Taipei, Taiwan

### Abstract

Infragravity waves (IGWs) are low-frequency ocean waves for 30 seconds or longer and can travel great distances without losing energy. They are typically generated by the non-linear interaction of ocean waves and modulated by water depth. IGWs play a role in ocean dynamics and significantly impact coastal hydro-sedimentary dynamics and ice-shelf collapse. In addition, IGWs can enhance the mixing of ocean water and redistribute nutrients and temperature through different water layers. Because IGWs will generate a detectable seafloor signal across the ocean, the seafloor seismometric observations can provide long-term monitoring of IGW energy.

We analyzed the IGWs recorded at the 45 ocean bottom seismometers of the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET). Deploying in the seismogenic area of the historical Tonankai and Nankai earthquakes, DONET consists of 22 seismometric observatories across the Kumano forearc basin (DONET1) and 29 observatories offshore the Kii peninsula (DONET2). The spectral analysis applied to the DONET seismograms shows that the main frequency band of the IGWs recorded at DONET stations is within 0.005 and 0.03 Hz. Furthermore, the strength of IGWs exhibits an annual variation. Through the DONET data, IGWs' energy is relatively vital in winter and low in summer. The peak frequencies of IGWs show a systematical decrease with increasing water depth. Using the dispersion relation, we retrieve the phase velocities of the peak IGWs ranging from 81 to 153 m/sec for the sites within the forearc basin and along the continental slope.

We calculate the incoming direction and phase velocities of IGWs by employing the beamforming algorithm with cross-correlation functions (CCFs). Following Tonegawa et al. (2018), we use bathymetric relief to form wave dispersion and calculate the theoretical group velocity. The ray path is retrieved by solving the eikonal equation to each grid, and then we can locate the excitation of IGWs. With the DONET seismograms, we reproduced the evolution of daily excitation locations from 2017 to 2018. We found that IGW energy constantly transports within the Pacific Ocean with the secular atmospheric condition. For the northern Nankai trough location, the IGWs primarily originate from the western coast of South America. Minor energy of IGWs can also be converted from the coast of the Aleutian islands. Furthermore, tropical cyclones will generate local-to-regional event-type excitations that last for a limited time.

**Towards a Better Understanding of Moonfish (*Mene maculata*)  
Distribution in the South Taiwan Waters Using Habitat Suitability  
Index (HSI) modeling**

Aratrika Ray<sup>1</sup>, Riah Irawati Sihombing<sup>1</sup>, Sandipan Mondal<sup>1,2</sup>, Ming-An Lee<sup>1,2</sup> & Yi-Chen Wang<sup>1,2</sup>

<sup>1</sup>Department of Environmental Biology & Fisheries Sciences, National Taiwan ocean University

<sup>2</sup>Center of Excellence for Ocean Engineering, National Taiwan Ocean University

No. 2, Beining Rd, Zhongzheng District, Keelung City, 202

**Abstract**

The habitat's ability to support life is called habitat suitability (HS). HS modeling is being used more to predict species distribution patterns, where data are scarce, for marine ecosystem management to directly support sustainability development goal 14 (SDG14). The objectives of this study were to compare two HS approaches: arithmetic mean model (AMM) and geometric mean model (GMM) to understand the spatial distribution pattern for *Mene maculata* (moonfish) in terms of catch per unit effort (CPUE) from months of high catch, January to April, 2014 to 2019 in the Southwestern Taiwan (SWT) region and to choose the better HS method for abundance prediction. SWT is a crucial region due to the Kuroshio current, South China Sea current, monsoon, and China coastal current. Moonfish is native to Taiwan and a recently a popular commercial fish species. Satellite-dependent remote sensing data for eight oceanographic variables were analysed using generalized additive model (GAM). Best three parameters (sea surface height SSH, mixed layer depth MLD, and pH) were chosen based on the least Akaike information criterion (AIC), Bayesian information criterion (BIC), and Generalized cross validation (GCV) to model the moonfish habitat. GMM with SSH and MLD had a higher  $R^2=0.91$  than AMM. The multiple HS maps display that SWT is moonfish-friendly. January was the most suitable month with highest prediction between 22°-23.5°N while April was the least. These results have implications for spatial management closures in the SWT area, and future modeling improvements may help use HS maps to manage fishing's impact.

## 海洋生物青年論壇

Using oceanographic environmental factors and fishery data to determine habitat preferences of *Eleutheronema rhadinum* (east asian fourfinger threadfin) in the coastal waters of Chang-Yuen Rise, Taiwan

Riah Irawati Sihombing<sup>1</sup>, Aratrika Ray<sup>1</sup>, Sandipan Mondal<sup>1,2</sup>, Ming-an Lee<sup>1,2</sup>

<sup>1</sup>Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Keelung, Taiwan (R.O.C)

<sup>2</sup>Center of excellence for ocean engineering, national Taiwan ocean university, Keelung, Taiwan (R.O.C)

Corresponding email: [malee@mail.ntou.edu](mailto:malee@mail.ntou.edu)

East asian four-finger threadfin has a high economic value in Taiwan. They are mainly distributed in Japan, China, and Taiwan. Oceanographic conditions are one of a few factors that can influence east asian four-finger threadfin distribution in Taiwan water. This study was conducted on Chang-Yuen Rise, the coast of Taiwan by employing a generative additive model (GAM). The logbook fishery data were collected from 2013 to 2017 and eight oceanographic environmental data were used to understand habitat preferences and distribution of east Asian fourfinger threadfin. The range of each habitat preference performed sea surface salinity (32.8-34.8 psu), eddy kinetic energy ( $0.08 \text{ m}^2/\text{s}^2$ ), northward velocity (-0.1- 0.3 m/s), eastward velocity (-0.1 -0.2 m/s), oxygen (205-217  $\text{mmol}/\text{m}^3$ ), sea surface temperature (20.2-22.3 °C), sea surface chlorophyll ( $0.3\text{-}0.5 \text{ mgm}^{-3}$ ), and sea surface height (0.55-0.62 m). January performed a high distribution in comparison to other months. The high distribution was mainly observed at 24 °N and 120 °E. These findings may add more the understanding of the oceanographic influence on east asian four-finger threadfin for fishery management and to help promote in sustainable development goal (SDG) 14 for sustainable fishery in Taiwan waters.

Keywords: oceanographic environmental factors, *Eleutheronema rhadinum*, GAM, Chang-Yuen Rise

**Mesozooplankton mortality events in a shallow water  
hydrothermal vent- First reports from the volcanic  
island off northeast Taiwan**

**Anitha Mary Davidson<sup>1\*</sup>, Li-Chun Tseng<sup>1</sup>, Yan-Guo Wang<sup>1,2</sup>, Jiang-Shiou Hwang<sup>1,3,4\*</sup>**

<sup>1</sup>Institute of Marine Biology, National Taiwan Ocean University, Keelung 202301, Taiwan,

<sup>2</sup>Third Institute of Oceanography, Ministry of Natural Resources, Xiamen 361005, China

<sup>3</sup>Center of Excellence for Ocean Engineering, National Taiwan Ocean University, Keelung 202301, Taiwan

<sup>4</sup>Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung 202301, Taiwan

**\*Correspondence:** jshwang@mail.ntou.edu.tw

**Abstract**

Several marine and freshwater sources have observed zooplankton carcasses produced by both natural and anthropogenic influences. In some marine habitats, such as hydrothermal vents, the mortality of mesozooplankton is still unclear. Zooplankton mortality has been observed at a number of hydrothermal vents in the deep ocean. The present work represents a pilot study to quantify the mortality of mesozooplankton at a shallow active hydrothermal vent of Kueishan Island, northeast Taiwan. The study considers a number of environmental factors and mesozooplankton samples taken from surface waters at three different locations around the island (hydrothermal vent site, off-vent site, and adjacent coral reef site) during the northeast-southwest monsoon (April) transition period and southwest monsoon prevailing period (June). The key findings demonstrated that mortality was higher at stations affected by hydrothermal vent

effluents during both sampling seasons. The average mortality of total mesozooplankton showed seasonal variations with high mortality in April ( $50.03 \pm 47.5\%$ ) with high fluctuations and lower mortality in June ( $25.59 \pm 21.67\%$ ). Furthermore, a comparison of the mortality of dominant mesozooplankton taxa demonstrated geographic differences during both sampling periods. In April, mortality of mesozooplankton was highest at a hydrothermal vent site (82.18%), followed by the coral reef site (46.93%) and then away from the island offshore (46.60%). In June, hydrothermal vent sites accounted for the highest mortality (55.98%), followed by offshore and coral reef sites (30.46% and 22.71%), respectively. Sampling at different monsoon periods with their distinct changes of environmental variables were used to compare the mortality of various zooplankton taxa. During both sampling periods, acidified seawater from mixed hydrothermal vents (low pH) had a significant impact on copepod mortality. Owing to its accessibility and a shallow epipelagic layer that was directly influenced by HV waters, the current study gave unique insights into the resilience of the pelagic environment around a hydrothermal vent in shallow seas.

**Keyword:** Hydrothermal vents; Mesozooplankton; Natural mortality; Neutral red stain; Vital staining.

**Impact of shallow water hydrothermal vent water on the associated microbiota of Scleractinia *Tubastraea aurea*; an *in-situ* transplantation study.**

K.G.Gowri<sup>1</sup>, Priyanka Muthu<sup>1</sup>, Li-Chun Tseng<sup>1</sup>, Yu-Ling Chen<sup>1</sup>, Ying-Ning Ho<sup>1,2</sup> \*and Jiang-Shiou Hwang<sup>1,2,3</sup> \*

**1. Institute of Marine Biology, College of Life Science, National Taiwan Ocean University, Keelung, Taiwan.**

**2. Centre of Excellence for the Oceans, National Taiwan Ocean University, Keelung, Taiwan.**

**3. Centre of Excellence for Ocean Engineering, National Taiwan**

**\*Correspondence:** jshwang@mail.ntou.edu.tw

**Abstract**

The extreme environment of shallow water hydrothermal vents off Kueishan Island is a natural laboratory to understand the effect of acidification and other global change factors. The azooxanthellate Scleractinia *Tubastraea aurea* is found abundant in this unique extreme environment. In the present study, we tried to analyze the influence of shallow water hydrothermal vent waters off Kueishan island in structuring the bacterial communities associated with the coral. After cross-transplanting the coral from HV to Fulong and Fulong to HV, we analyzed the changes in bacterial community structure. Using 16S rRNA gene primers, we amplified the V1-V9 full-length (~1.5 kbp) 16S rRNA gene, following the SQK-LSK109 protocol (Oxford Nanopore Technologies, Oxford, UK) we performed nanopore



sequencing libraries. No significant difference in alpha diversity indices was observed between coral samples after transplantation. *Sulfurovum* and *Endozoicomonas* were dominant in the coral samples collected from the HV site, while *Rugeria* was abundant in the coral samples from the Fulong site. However, on cross-transplantation, we observed a constant decrease in the abundance of *Sulfurovum* and an increase in *Endozoicomonas* abundance in the corals transplanted to Fulong from the HV site, while we observed an increase in *Sulfurovum* abundance in coral samples moved to the HV site from Fulong. Our current results clearly demonstrate the influence of vent water on the bacterial community composition of *T. aurea*. However, our further analysis will help to fully understand the impact of vent water chemistry and the role of dominant bacterial groups in host resilience.

## Bacterial community responses of the hydrothermal vent crab *Xenograpsus testudinatus* fed on microplastics

Priyanka Muthu<sup>1</sup>, Yun-Cheng Lee<sup>1</sup>, Gowri Krishna<sup>1</sup>, Yu-Ling Chen<sup>1</sup>, Ying-Ning Ho<sup>1,2\*</sup>,  
Jiang-Shiou Hwang<sup>1,2,3\*</sup>

<sup>1</sup> Institute of Marine Biology, National Taiwan Ocean University, Keelung, Taiwan.

<sup>2</sup> Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung, Taiwan.

<sup>3</sup> Center of Excellence for Ocean Engineering, National Taiwan Ocean University, Keelung, Taiwan

### Abstract

Microplastics (MPs) are persistent contaminants found in freshwaters and the oceans from anthropogenic sources worldwide. Microplastics contamination in ecosystems has emerged as a global environmental issue. While increasing research focused on the ecological consequences of plastic pollution, health-related implications of plastic pollution have been somewhat overlooked. In this study we evaluated the effects of polyethylene microplastic contamination on microbial, physical, biochemical characteristics of the hydrothermal vent crab *Xenograpsus testudinatus* over a 7-day food exposure. Different concentrations (0 %, 0.30 %, 0.60 %, 1.0 %) of polyethylene microplastics were used for feed intake experiments. Oxford Nanopore Technology full length sequencing of the 16S rDNA gene was used to explore the changes of the microbial composition in vent crab tissues. At the phylum level, the content of *Firmicutes* significantly decreased in the digestive gland tissue. Furthermore, the predicted function of genes in the microbial community were significantly influenced by MPs. In contrast, were 8 functions in gill and 11 functions in digestive gland tissues identified at low and high intake levels. The dominant function of methylotrophy, dark thiosulfate oxidation, dark oxidation of sulfur compounds, aromatic hydrocarbon degradation and aromatic compound degradation were significantly increased at high intake levels in the digestive gland. These findings indicate that microplastic ingestion causes not only a short-term decrease in energy intake for crustaceans, but also a change in microbial communities and their functions. This study provided a first account on the toxicity of MPs in a hydrothermal vent crab to aid in the assessment of health risks provided by polyethylene MP to marine invertebrates.

**Keywords:** Polyethylene, Oxford Nanopore Technology, Chemoheterotrophs, Functional group, *Xenograpsus testudinatus*.

Vicente G. Abedneko and Chin-Chang Hung

Department of Oceanography, National Sun Yat-sen University

### Abstract

The *Panulirus Homarus* commonly known as the spiny lobster are commonly found in the Indian and Pacific Oceans and are some of the most sought-after seafood in the market. The economic value and demand for spiny lobster will increase as the global population grow. With global warming and rising sea temperatures, ocean acidification (OA) has shown to threaten crustaceans' survival rate and their offspring. Here we conducted controlled pH exposure experiments on 120 young spiny lobsters (20 spiny lobsters (6.0-8.5cm carapace length) per tank, three tanks at pH 7.5 and 8.0 respectively) which were kept in 1000-L tanks continuously supplied with coastal seawater with pH 8.0~8.1. We investigated mortality rate and spawn rate of spiny lobsters exposed to pH 7.5 and pH 8.0 treatments for 1 year. Lobsters reared at pH 7.5 ( $77 \pm 10\%$ ) had a high mortality than those reared at pH 8.0 ( $43 \pm 10\%$ ). Surprisingly, we found that nine spiny lobsters successfully berried eggs from both pH 7.5 (four mother lobsters) and pH 8.0 (five mother lobsters) treatments. We observed that spiny lobsters were able to carry offspring and phyllosoma once hatched they were unable to survive 24 hours at pH 7.5 or 8.0 seawater tanks. However, phyllosoma hatched from pH 8.0 tanks can live up to 10-14 days. The results reveal that ocean acidification may significantly affect survival rate of future spiny lobsters and their offspring.

Key Words: Ocean Acidification, offspring, Spiny Lobster, Phyllosoma, Mortality

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## 化石殼體同位素分析揭示馬氏扣海膽侏儒化演化的謎團

許家昕<sup>1,2,\*</sup>、林日白<sup>1</sup>、朱偉嘉<sup>3</sup>、林千翔<sup>4</sup>、梁茂昌<sup>2,\*</sup>

<sup>1</sup>國立臺灣大學地質科學系

<sup>2</sup>中央研究院地球科學研究所

<sup>3</sup>經濟部中央地質調查所

<sup>4</sup>中央研究院生物多樣性研究中心

### 摘要

馬氏扣海膽(*Sinaechinocyamus mai*)是一種現存於臺灣西部淺海的沙錢海膽，以臺灣大學地質科學系第一任系主任馬廷英教授命名，並且擁有與近親截然不同的體型和生物地理分佈。其中，最引人注目的是成體僅有 1 公分的微小體型，然而其侏儒化演化的觸發機制至今卻尚未明瞭。本研究中從古環境切入，對過去 8 百萬年來保存良好的馬氏扣海膽化石樣本進行傳統的碳氧同位素及非傳統的碳酸鹽叢同位素分析(clumped isotope analyse)，透過假設造殼時殼體與環境處於熱平衡來重建古溫度。研究結果指出，兩種同位素溫度計皆表明馬氏扣海膽有良好的溫度適應能力，相比其近親物種能生存於更高且更廣的溫度範圍。另一方面，馬氏扣海膽的體型也與其生存溫度呈負相關。總結來說，本研究支持在熱氣候事件下，將傾向選擇體型較小的個體，進而導致馬氏扣海膽的冷水種祖先發生侏儒化演化，以適應環境的巨變。

**關鍵字：**侏儒化演化、氣候變遷、冰期間冰期循環、碳酸鹽叢同位素、海膽綱

## 氣候震盪對臺灣淺灘海洋生態系統營養動態結構和功能的影響

蕭博元、藍國璋、廖正信  
國立臺灣海洋大學環境生物與漁業科學系

### 摘要

臺灣淺灘位於臺灣海峽西南海域，由於地形性湧升而成為重要沿近海漁場。臺灣海峽常受氣候變化影響而引發漁業資源波動，然而聖嬰南方震盪（ENSO）如何影響臺灣淺灘生態系則需要進一步釐清。海洋生態系統受多種因素在各個層面上相互作用影響，因而對干擾產生非線性或突發反應（Abrupt responses），透過分析生態系統的營養動力學，可以瞭解種間關係、能量流動以及生物與環境間的之聯繫。本研究使用Ecopath with Ecosim建構了三個質量平衡模型，探討ENSO現象對臺灣淺灘生態系統的影響，分析具代表性之洄游性、底棲性和珊瑚礁物種的生態系結構變化間之關係。研究結果表明，總系統通量（TST）為3391-8619 t km<sup>-2</sup> year<sup>-1</sup>，平均能量轉移效率為18.7%，黃鰹鮪（*Thunnus albacares*）和正鰹（*Katsuwonus pelamis*）為關鍵物種且下行控制對生態系統影響力較大。此外，在ENSO事件期間，總生物量、TST、系統消耗量和呼吸量均有增加，在反聖嬰事件（2017-2018）期間，多樣性、雜食性和連通性指數相對較低，但洄游性物種生物量相對較高，而在聖嬰事件（2015-2016）期間，大多數底棲和珊瑚礁物種的生物量相對較高。在反聖嬰事件中，洄游性物種對生態系統的總影響程度增加，顯示臺灣淺灘生態系統中下行控制作用增強。

## 臺灣淺灘暨週邊海域浮游動物組成與重金屬元素含量研究

郭殊君<sup>1\*</sup>、孟培傑<sup>1,2</sup>、謝泓諺<sup>1</sup>

<sup>1</sup>國立東華大學海洋生物研究所

<sup>2</sup>國立海洋生物博物館

### 摘要

本研究利用新海研三號研究船2022年3月8日至11日的航次，於臺灣淺灘暨週邊海域設置10個測站採集浮游動物及海水樣本，分析浮游動物類群組成和分布情形，同時檢測海水與浮游動物體內Cd、Cu、Cr、Co、Fe、Mn、Ni等七種常見重金屬之濃度。根據目前分析結果，浮游動物共鑑定出27種主要類群，其平均豐度最高的三大類群依序為哲水蚤(Calanoida) 149.96 ind./m<sup>3</sup>、劍水蚤(Cyclopoida) 106.73 ind./m<sup>3</sup>、有孔蟲(Foraminifera) 57.8 ind./m<sup>3</sup>，為最優勢類群。臺灣淺灘暨週邊海域水體中所有測站平均值最高的重金屬為Fe 113.482 µg/L，平均值最低的重金屬為Cd 0.003 µg/L。在浮游動物體內重金屬濃度平均值濃度最高的重金屬為Fe 2681.369 mg/kg，平均值濃度最低的重金屬為Co 1.946 mg/kg。生物濃縮因子BCF範圍為2.7至7.1，數值由高至低依序為：Mn(6.6) > Fe(6.2) > Cr(6.1) > Cd(6.1) > Ni(5.2) > Co(4.6) > Cu(4.1)，表明浮游動物累積中Mn是顯著且累積能力高。待後續了解海水中重金屬濃度及其浮游動物體內的重金屬累積能力與關聯，綜合上述資訊可進一步評估臺灣淺灘暨週邊海域環境與生物的變化。

## 以馬祖露脊鼠海豚(*Neophocaena spp.*) 作為馬祖海域鎘污染的指標

方澤<sup>1\*</sup>、鄭玉婷<sup>2</sup>、姚秋如<sup>3</sup>、周蓮香<sup>4</sup>、陳孟仙<sup>2</sup>

1. 國立中山大學海洋生態與保育研究所
2. 國立中山大學海洋科學系
3. 國立台中科博館
4. 國立台灣大學生態學與演化生物學研究所

### 摘要

本研究檢視了 2004 年到 2015 年間共 22 頭在馬祖擱淺的露脊鼠海豚 (*Neophocaena spp.*)。分析其肝臟、腎臟、肌肉及肺臟組織中鎘的濃度，目的是要了解非必需元素在露脊鼠海豚中的累積。結果顯示腎臟中的鎘濃度最高 ( $6.7001 \pm 13.2522$  mg/kg d.w.)，肝臟其次 ( $1.1495 \pm 1.8868$  mg/kg d.w.)，肺臟與肌肉則是並列最低 ( $0.0607 \pm 0.0504$  mg/kg d.w.;  $0.0307 \pm 0.0359$  mg/kg d.w.)。在亞成體與成體當中，腎臟和肝臟的鎘濃度與體長有顯著正相關，顯示環境中鎘在露脊鼠海豚體內的生物累積。另外，胎兒、新生兒、未斷奶與已斷奶開始自行覓食的幼體中，腎臟的鎘與體長有顯著負相關，同時這些幼體的  $\delta^{15}\text{N}$  與體長也呈現負相關，顯示來自母體(經由胎盤和母乳)的鎘會隨著幼體成長而排出或稀釋。與過去文獻相比，本研究樣本的鎘測值都在安全範圍內，較珠江三角洲和黃海的露脊鼠海豚肝臟與腎臟中的鎘濃度為低。體長與  $\delta^{13}\text{C}$  則沒有明顯的相關性，得知這些個體並不會有棲地明顯的移棲。由露脊鼠海豚腎臟與肝臟鎘的累積趨勢得知，母體與環境都是露脊鼠海豚體內鎘的來源，而雖然馬祖海域有一定程度的鎘污染，但比起其他中國沿岸其污染並不嚴重，也不至於導致露脊鼠海豚的鎘中毒。



## 臺灣周邊海域四種擱淺鯨豚組織中五種重金屬濃度及碳氮同位素之研究

田育如<sup>1\*</sup>、陳孟仙<sup>1,2</sup>、周蓮香<sup>3</sup>、楊瑋誠<sup>4</sup>、姚秋如<sup>5,6</sup>

1. 國立中山大學海洋生態與保育研究所
2. 國立中山大學海洋科學系
3. 國立臺灣大學生態學與演化生物學研究所
4. 國立臺灣大學獸醫專業學院
5. 國立自然科學博物館生物學組
6. 國立中興大學生命科學系

### 摘要

本研究收集 2003 年至 2020 年間臺灣周遭海域擱淺或誤捕之小抹香鯨(*Kogia breviceps*)、印太瓶鼻海豚(*Tursiops aduncus*)、瓶鼻海豚(*Tursiops truncatus*)及糙齒海豚(*Steno bredanensis*)，以火焰式及石墨式原子吸收光譜儀進行其肌肉、肝臟、腎臟與肺臟中鐵、鋅、銅、錳與鎘濃度之分析，藉此探討鯨豚體內重金屬濃度之種別和組織差異，及其濃度與體長的相關性。同時分析肌肉中碳氮同位素，探討鯨豚食性與棲地之差異。四種鯨豚中以小抹香鯨及瓶鼻海豚的重金屬濃度有明顯的組織差異，肝臟中累積濃度為最高(小抹香鯨:鐵為  $1529 \pm 194$ 、鋅為  $69.6 \pm 26.7$ 、銅為  $22.3 \pm 14$ 、錳為  $5.2 \pm 1.7$ 、鎘為  $10.3 \pm 7.3$  mg/kg dry wt.；瓶鼻海豚:鋅為  $223 \pm 152$ 、銅為  $31.6 \pm 23.6$ 、錳為  $11.3 \pm 6.3$ 、鎘為  $2.1 \pm 1.8$  mg/kg dry wt.)，而肌肉最低(小抹香鯨:鐵為  $613 \pm 189$ 、鋅為  $44.1 \pm 7.4$ 、銅為  $2.6 \pm 0.9$ 、錳為  $1.2 \pm 1$ 、鎘為  $0.17 \pm 0.16$  mg/kg dry wt.；瓶鼻海豚:鋅為  $67.5 \pm 30$ 、銅為  $5.3 \pm 2.8$ 、錳為  $1.4 \pm 1.8$ 、鎘為  $0.26 \pm 0.54$  mg/kg dry wt.)。在各組織間鐵濃度皆具有顯著的種別差異，肌肉及腎臟中以小抹香鯨為最高(分別為  $613 \pm 189$ 、 $880 \pm 277$  mg/kg dry wt.)，肝臟則以印太瓶鼻海豚為最高( $3264 \pm 693$  mg/kg dry wt.)，以及肝臟中的鎘濃度也是以小抹香鯨為最高( $10.3 \pm 7.3$  mg/kg dry wt.)。此外，肌肉中的銅濃度及肝臟中的鋅濃度則是小抹香鯨(銅為  $2.6 \pm 0.9$ 、鋅為  $69.6 \pm 26.7$  mg/kg dry wt.)分別顯著低於瓶鼻海豚(銅為  $5.3 \pm 2.8$ 、鋅為  $223 \pm 152$  mg/kg dry wt.)及糙齒海豚(銅為  $4.1 \pm 1$ 、鋅為  $375 \pm 11.4$  mg/kg dry wt.)。小抹香鯨的肝臟及腎臟中的鐵濃度與體長呈正相關，而小抹香鯨肌肉中的鋅濃度、腎臟中的錳濃度以及瓶鼻海豚與糙齒海豚肌肉中的錳濃度與體長則是呈負相關。以穩定同位素之  $\delta^{13}\text{C}$  值及  $\delta^{15}\text{N}$  值推測小抹香鯨棲地離岸最遠且營養階層最低，而印太瓶鼻海豚棲地離岸最近及瓶鼻海豚的營養階層最高。

## 2021 年夏季金門海域軟骨魚類的物種多樣性和生殖生物學初探

馬暉承<sup>1</sup>、陳國書<sup>2</sup>、江國辰<sup>2</sup>、翁進興<sup>3</sup>、葉信明<sup>4</sup>、張至維<sup>1,2,5,6</sup>

<sup>1</sup>國立中山大學海洋生態與保育研究所

<sup>2</sup>國家海洋研究院海洋生態及保育研究中心

<sup>3</sup>行政院農業委員會水產試驗所沿近海資源研究中心

<sup>4</sup>行政院農業委員會水產試驗所

<sup>5</sup>國立中山大學海洋科學系

<sup>6</sup>國立東華大學海洋生物研究所

### 摘要

金門海域擁有豐富的鰩鱓目魚類資源，目前相關的生物學及生活史特徵研究仍十分缺乏；因此本研究進行 1 季次的科學拖網調查採樣，以了解金門海域夏季底棲軟骨魚類的物種多樣性，並對鰩鱓目魚類的生活史特徵進行初步研究。本研究於 2021 年 8 月 14、15 日使用「水試二號」在金門島西南側海域及東南側海域各進行 2 網次網板拖網(OT)及 2 網次法式橫桿拖網(FT)之底棲軟骨魚類調查作業，分別記錄西南側海域 5 科 5 屬 10 種(總數 255 尾)及東側海域 6 科 8 屬 10 種(396 尾)，兩海域合計 8 科 10 屬 15 種。西南側海域豐度最優勢軟骨魚類為寬尾斜齒鯊 *Scoliodon laticaudus*，其次為斑紋琵琶鱓 *Rhinobatos hynnicephalus*，第三為條紋狗鯊 *Chiloscyllium plagiosum*，平均豐度(±SD)在 OT 中依序為每公頃 40.6 (±8.7)、7.6 (±1.3) 及 3.7 (±0.1) 隻，而前三物種中在 FT 中，僅第一網次採獲條紋狗鯊，豐度估值為每公頃 1.5 隻。東側海域豐度最優勢物種是日本單鰭電鱓 *Narke japonica*，其次斑紋琵琶鱓，第三為湯氏黃點鮪 *Platyrrhina tangi*，平均豐度在 OT 依序為每公頃 40.9 (±9.3)、25.2 (±0.6) 及 10.1 (±1.9) 隻，而在 FT 中，僅第一網次中採獲，豐度估值依序為每公頃 24.2、3.0 及 1.5 隻。經解剖觀察日本單鰭電鱓性腺特徵後發現性比(F:M)為 142:83，成熟雌性個體占整體雌性 51%，懷孕後期待產之雌性個體占整體成熟雌性 64%，當中已懷孕的雌魚最小體長僅 13.5 公分；斑紋琵琶鱓與湯氏黃點鮪性別比(F:M)各為 102:31 和 16:38，成熟雌性個體各占整體雌性 63%與 19%，懷孕雌性個體占整體成熟雌性各為 100%與 50%。除上述物種外，亦發現尖嘴魮 *Telatrygon zugei* 少數懷孕個體。本研究首次記錄夏季金門沿海的底棲軟骨魚類多樣性及生殖生物學資訊，並發現本海域為孵育地及攝食場域，後續將規劃其他季節之調查，以更完整了解本海域的軟骨魚類物種多樣性及生活史特徵。

## 耳石同位素用於海洋魚類營養層階生態調查

李沐廷

國立臺灣大學海洋研究所

### 摘要

調查海洋生物在食物網中的營養位階可以了物種和個體之間的食性關係以及生態系統中能量的流動。利用分析組織中的有機物穩定同位素值，即  $\delta^{13}\text{C}$  和  $\delta^{15}\text{N}$  值，為評估生物之間營養位階關係和潛在飲食的常用且有效方法。然而大多數生物體組織的有機物代謝是非常活躍的，因此只記錄到約每周至每月的飲食信息，不太可能完整揭示個體的生活史和飲食轉變。在過去的十年中已經開發出一種先進的技術來測定魚類耳石有機物中所記錄的  $\delta^{13}\text{C}$  和  $\delta^{15}\text{N}$  值，方法可以得知個體整個發育過程中的飲食信息，因為耳石內有機物記錄了生物體終身的同位素信號。本研究的目的為重建石首魚科的營養位階，而石首魚科的耳石尺寸相較於其他物種來的大許多，因此使我們能夠在此物種的多個生命階段中獲得更多飲食信息。透過逐層溶解耳石，並在逐步溶解耳石的過程中三維掃描耳石的型態，以評估每個溶解步驟之間耳石體積和形狀的變化，利用形態學分析探討每次有機物萃取的相對應年齡，萃取出有機物以元素分析儀連結穩定性同位素質譜儀(Elemental Analyzer-Isotope Ratio Mass Spectrometry)進行分析。此實驗重建了 9 種石首魚約 54 隻個體發育過程中的營養位階，以評估種內和種間的變異性。 $\delta^{15}\text{N}$  值結果顯示此 9 種石首魚在子稚魚至成魚過程中營養位階增加皆小於 1，物種內同時期的  $\delta^{15}\text{N}$  值在個體變異相差甚大，然而在物種間的變異卻較小。此方法強調耳石有機物的穩定同位素分析，提供了更多來自個體的信息，而這些信息可以進一步擴展和應用於生物族群研究。

**A new cryptic species of the pineapple fish genus *Monocentris*  
(Family Monocentridae) from the western Pacific Ocean, with  
redescription of *M. japonica* (Houttuyn, 1782)**

Yo Su<sup>1\*</sup> (蘇又), Hsiu-Chin Lin<sup>1</sup> (林秀瑾), Hsuan-Ching Ho<sup>2345</sup> (何宣慶)

<sup>1</sup>Department of Marine Biotechnology and Resources, National Sun Yat-sen University,  
Kaohsiung, Taiwan

<sup>2</sup>National Museum of Marine Biology & Aquarium, Pingtung, Taiwan.

<sup>3</sup>Institute of Marine Biology, National Dong Hwa University, Hualien, Taiwan.

<sup>4</sup>Australian Museum, Sydney, Australia.

<sup>5</sup>Department and Graduate Institution of Aquaculture, National Kaohsiung University of  
Science and Technology, Kaohsiung, Taiwan

**Abstract**

A new pineapple fish is described based on 26 type and 80 non-type specimens collected from Taiwan, Vanuatu, the Solomon Islands, and Queensland, Australia. This new species is sympatric with and similar to *Monocentris japonica* but can be distinguished from the latter in having only 6 or 7 scales on the third scale row below the lateral line; excisura notched and a small pseudo-excisura present on the sagittal otolith; consistently greater head depth, body depth, postorbital length, dorsal-fin–pelvic-fin length, and dorsal-fin–pectoral-fin length in proportion to standard length. A detailed description and designation of neotype are provided for *M. japonica*. DNA barcoding analysis supports the distinction of the new species with an estimated average COI gene divergence of 3.6 % from *M. japonica*.

## **Typhoon effects on bacterial diversity and community composition between different water layers in the southern East China Sea**

Yi-hsuan Lo, Chih-hao Hsieh

Institute of Oceanography, National Taiwan University

### **Abstract**

In the west bound of the northwestern Pacific Ocean, the Southern East China Sea (Southern ESC) is where typhoons frequently pass through, especially under the ongoing climate change. Marine bacterioplankton, as one of the fundamental primary producers and decomposers, stabilize the marine ecosystem via their high diversity and complexity. Nonetheless, few studies look at the relationship between typhoons and the marine bacterioplankton community due to sampling difficulties.

Cruise OR1 Cr1201 and Cr1201-2 in July 2018 were set to capture the effects of super typhoon Maria. Pre- and post-typhoon of bacterioplankton samples were collected in 8 stations with 4 water layers (e.g., Surf, DCM, Mid, Bot) in each station. Meanwhile, CTD was used to collect the physicochemical parameters for environment description. We then employed high-throughput sequencing techniques on the V4-V5 region of 16S rRNA to obtain the diversity and community of bacterioplankton.

Overall, the physicochemical parameters (e.g., temperature, salinity, fluorescence, DIN, etc) appeared not much different before and after the typhoon in the whole southern ESC but more locally in different stations, especially stations with upwelling. However, the variation within different layers still existed and seemed to be the main driving force to separate bacterioplankton communities. We also found that there exhibited a positive correlation between physicochemical dissimilarity and community dissimilarity in the middle and bottom layers, but not in the surface and DCM layers.

# **An Assessment of Poleward Migration's Possible Impact on Typhoon Intensification under Global Warming**

I-I Lin<sup>1\*</sup>, Suzana J. Camargo<sup>2</sup>, Chun-Chi Lien<sup>1</sup>, Chun-An Shi<sup>1</sup>, & James P.

Kossin<sup>3</sup>

<sup>1</sup>Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan

<sup>2</sup>Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA

<sup>3</sup>The Climate Service, Durham, NC, & University of Wisconsin-Madison, USA

Hosting 60% of world's most intense and destructive (Category-5) tropical cyclones (TCs), the western North Pacific Ocean is an important TC basin. Understanding how global warming may influence the intensification of future WNP TCs (aka typhoons) is crucial. Nevertheless, typhoons are also projected to move northwards, i.e., poleward migration, under global warming. This concurrent northward movement adds additional complexity to an already challenging problem. This research investigates the possible impact from poleward migration to future typhoon's intensification over the western North Pacific Ocean. Both moderate, i.e., Representative Concentration Pathway (RCP) 4.5 and strong (RCP 8.5) CO<sub>2</sub> emission scenarios under the Coupled Model Intercomparison Project 5 are investigated.

Reference:

Lin, I-I\*, Suzana J. Camargo, Chun-Chi Lien, Chun-An Shi, James P. Kossin, Poleward Migration as Global Warming's Possible Self-Regulator to Restrain Future Western North Pacific Tropical Cyclone's Intensification, NPJ Climate and Atmospheric Science, 2023.(in press)

## Enhancing the ENSO Predictability beyond the Spring Barrier and the Impacts of Extratropical Precursors

Yu-heng Tseng

Institute of Oceanography, National Taiwan University

### Abstract

El Niño-Southern Oscillation (ENSO) is the dominant interseasonal–interannual variability in the tropical Pacific. However, ENSO predictability has been reduced in the 21<sup>st</sup> century, and the impact of extratropical atmosphere on the tropics has intensified during the past 2 decades, making the ENSO more complicated and harder to predict. Here, by combining tropical preconditions/ocean–atmosphere interaction with extratropical precursors, we provide a novel approach to noticeably increase the ENSO prediction skill beyond the spring predictability barrier. The success of increasing the prediction skill results mainly from the longer lead-time of the extratropical–tropical ocean-to-atmosphere interaction process, especially for the first 2 decades of the 21<sup>st</sup> century. The impacts of Central Pacific (CP) and Eastern Pacific (EP) types of ENSO predictions are also investigated. The forecast of CP indices has overall higher skills than that of EP indices due to the higher persistent forecast skill. At lead time beyond 6-month, the predictability of CP indices can be greatly enhanced by including the extratropical precursor from the North Pacific, confirming the ocean-atmosphere interaction associated with North Pacific Oscillation (NPO)/Victoria Mode (VM) evolution. The predictability of EP indices can be moderately enhanced by including the extratropical precursor from the south, resulting from the charging of the equatorial Pacific. We also find that the predictability of CP indices does not significantly decrease after 2000 while the predictability of EP indices drops dramatically, suggesting the strengthening impacts of NPO/VM on the CP-ENSO in the recent two decades.



使用 SWOT 測高觀測量計算重力和海洋渦旋場：校準、驗證和應用于海洋科學

**Gravity and oceanic eddy fields determined from the SWOT altimeter measurements:  
calibration, validation, and application to oceanic science**

黃金維 劉瀚陽

國立陽明交通大學土木工程系

## Abstract

The SWOT satellite, known as Surface Water and Ocean Topography, was launched on December 16, 2022. It uses radar interferometry to measure surface water heights over a wide swath. The Ka-band Radar Interferometer (KaRIN) onboard the SWOT satellite provides high-precision height measurements on the earth's surface. The mission also carries a conventional altimeter (Poseidon-3C) operating in the Ku and C bands. The wide-swath altimeter can observe up to 120 km (with a 20 km gap near the ground track) and has a spatial resolution of 2 km × 2 km on the sea surface and 500 m on land water bodies. This provides a significant improvement in the resolution of oceanic surface variations by an order of magnitude compared to traditional altimeters. It can detect mid-to-submesoscale oceanic eddies and seafloor features, which were previously indistinguishable using sea surface height measurements from conventional altimeters. The SWOT satellite will observe high-resolution heights of land water bodies, contributing to the study of climate change and global freshwater distribution and storage changes. The first phase of SWOT will be a three-month fast-sampling phase, followed by a three-year science phase for oceanographic and hydrological applications. During the SWOT fast-sampling phase, the satellite will pass through the Western Pacific, South China Sea, and waters surrounding Taiwan, which are known for their complex gravity signals and active ocean eddies. In this study, SWOT sea surface height observations collected during the fast-sampling phase will be used to determine ocean gravity anomalies and eddies as part of the calibration and validation (cal/val) activities of the mission. The NYCU and IONTU teams plan to validate the SWOT sea surface heights by collecting sea surface height data using R/V Ocean Researcher II in June 2022 and computing gravity anomalies using two independent methods. The accuracy and resolution of the ocean gravity field will be evaluated, and the Pyeddytracker (PET) method will be used to verify eddy identification. Shipborne gravity anomalies will be used to assess the results in the entire South China Sea region.

SWOT 衛星，又稱為表面水體和海洋地形衛星，於 2022 年 12 月 16 日發射。該衛星使用雷達干涉測量廣泛區域的水面高度。SWOT 衛星上搭載的 Ka 波段雷達干涉儀 (KaRIN) 提供了地球表面高精度的高度測量。該任務還搭載了一台常規測高儀

(Poseidon-3C)，在 Ku 波段和 C 波段操作。廣域高度計可以觀測到最大 120 公里範圍內（靠近地面軌跡有 20 公里間隙），並在海面上具有 2 公里×2 公里的空間解析度，在陸地水體上具有 500 米的解析度。這相對於傳統高度計將海洋表面變化的解析度提高了一個數量級，可以探測中至亞中尺度的海洋渦旋和海底地形特徵，而這些特徵以前是無法通過傳統高度計的海面高度測量來區分的。SWOT 衛星將觀測陸地水體的高解析度高度，有助於研究氣候變化和全球淡水分佈與儲存變化。SWOT 的第一階段將是為期三個月的快速採樣階段，隨後是為期三年的用於海洋和水文應用的科學階段。在 SWOT 快速採樣階段期間，衛星將穿過西太平洋、南海和臺灣周圍的水域，這些水域以其複雜的重力信號和活躍的海洋渦旋而聞名。本研究將利用 SWOT 衛星在快速採樣階段收集的海表高度觀測資料來確定海洋重力異常和渦旋，作為該任務校準和驗證活動的一部分。NYCU 和 IONTU 團隊計畫在 2022 年 6 月使用 R/V Ocean Researcher II 收集海表高度資料，使用兩種獨立的方法計算重力異常，以驗證 SWOT 海表高度的準確性。將評估海洋重力場的精度和解析度，並使用 Pyeddytracker (PET) 方法驗證渦旋識別。船載重力異常將用於評估整個南海地區的結果。

## 台灣西南海域內波現象探討

李逸環

國立中山大學海洋科學系

### 摘 要

本計畫為 FATES 大型計劃下之子計畫，探討台灣西南海域之水文場，本研究分析聯合觀測中布放於台灣西南海域、台灣灘南邊的錨碇資料，錨碇布放水深約 100 公尺，觀測時間為 2022.Jul.29 22:00~Aug.3 06:00，其他同時之觀測尚有位於台灣灘上的生地化定點觀測，本錨碇串觀測之參數為溫、鹽與流速。根據衛星海面微波觀測結果，本海域為南海內波可能發生之地點，唯水面下之現場觀測資料鮮少，難以證實該海域內波現象之行為。觀測結果指出 100 公尺剖面溫度與流速的時序皆顯示非常明顯的高頻震盪，其震盪週期從數分鐘數小時，流速亦呈現類似之震盪行為，呈現非線性內波之現象，同一水深溫度的振幅約 4~8 度，代表於觀測期間內該處內波現象明顯，更可推測台灣灘的水文變化亦受到非線性內波的影響。

# 海洋物理專題演講

## 海冰-海浪-海氣交互作用－2021年及2022年基於漂流浮標的弗拉姆海峽研究

錢樺<sup>1\*</sup>、陳妍榛<sup>2\*</sup>、傅科憲<sup>3</sup>、王博賢<sup>3</sup>

<sup>1</sup> 國立中央大學水文與海洋科學研究所 教授

<sup>2</sup> 國立中央大學水文與海洋科學研究所 碩士生

<sup>3</sup> 國立海洋研究院海洋科學及資訊研究中心 副研究員

1\*: hchien@ncu.edu.tw

2\*: yen410338@g.ncu.edu.tw

### 摘要

本研究旨在以微型浮標探究海浪-海冰-海氣交互作用對北極地區海洋動力系統、海冰變化和全球環流的影響。海浪會破壞海冰，改變海冰的分佈、形狀和厚度，使反照率、海水分層轉變，影響地球系統的能量平衡。目前的波浪數值模式開發上，需要以實測資料來加以率定及確認，而北冰洋上實測的波浪數據是極端稀少的。因此，進行實地觀測對於探究海浪、海冰、海氣交互作用的相關機制是至關重要的。本研究在2021年和2022年秋季投放共20套微型浮標，進行了一系列基於Lagrangian方法的實際觀測，探測海冰的影響。

觀測過程中，數個浮標曾位於海冰邊緣並經歷了約6米的大浪事件，觀測到海浪入射至海冰時在海冰邊緣的示性波高、海表風速、頻譜特性等波浪參數。本研究將展示在事件中冰緣實測的浮標數據，並收集、分析北冰洋海冰相關的遙測資料，包含美國冰雪資料中心發布的海冰報告、以及由Sentinel衛星之合成孔徑雷達資料、AMSR2之輻射計資料以辨識浮標所在位置的海冰特性，建立海冰邊緣下的波浪頻譜特性。另外，將冰緣的浮標觀測值與ERA5與ARCMFC波浪模式的比較結果顯示，顯著波高的相關係數高 ( $>0.9$ )，均方根誤差 (RMSE) 為0.5米，SI指數約為17%，並且發現在波高極值情況下兩種產品都有低估的趨勢。綜合而言，ARCMFC的表現略優於ERA5。

此外，本研究也分析WSC(West Spitsbergen Current)的表面紊流和水體混合強度，並使用浮標數據估算水平擴散系數和Lyapunov指數(FSLE)，與其他海域的結果進行比較。初步結果顯示，當WSC通過Molloy Deep東側或Yermak Plateau西南區域時會偏折產生分支，沿著 $f/H$ 等值線西向移動，形成大於羅斯比半徑的渦旋。初步分析結果顯示海表有顯著的溫度衰減特性、巨大熱能散失(淨熱通量約 $-200 \text{ W/m}^2$ )及水體輻合現象，且在中尺度流方面，FSLE結果表明，Molloy Deep的擴散強度(Richardson dispersion)大於WSC主軸(Shear dispersion)。我們需要關注WSC分支的平流-渦旋擴散作用過程，增進對於北冰洋的熱收支或海氣-海冰交互作用的理解與掌握。

# Bottom Ekman Layer in the Wind Field of Tropical Cyclones: QuikSCAT Observation and the Implication of Coastal Storm Surges

陳冠宇、張育嘉、劉俊志  
國立中山大學海洋科學系

### 摘 要

An idealized tropical cyclones (TC) has a symmetric wind field. However, friction plays an important role near the sea surface so that the balance between pressure gradient force and Coriolis force has to be modified. The result is a bottom Ekman layer in the atmosphere where wind flows obliquely to the isobar with an inflow angle.

From the completely reprocessed NASA QuikSCAT ocean surface wind vectors, the Joint Typhoon Warning Center and National Hurricane Center best track data in the Northern Hemisphere, the surface wind characteristics of the category-5 TCs with respect to the storm track are identified as: (1) motion-relative wind speeds over  $40 \text{ m s}^{-1}$  with strongest mean winds to the right of the storm track, (2) left to right asymmetry and front to rear symmetry in the mean wind speeds, (3) largest motion-relative inflow angles ( $30^\circ$ - $40^\circ$ ) in the right-rear quadrant, and (4) smallest inflow angles ( $0^\circ$ - $10^\circ$ ) in the left-front quadrant. The combined storm translational velocity ( $\sim 5 \text{ m s}^{-1}$ ) and wind vector shows an increase (decrease) of the motion-relative inflow angle in the rear (front) quadrant, a low (high) speed of outer (inner) core's wind vector in the right-rear quadrants, with associated larger (smaller) inflow angle.

As the second part of this study, the bottom Ekman layer and the inflow angle is used in the wind stress that forces storm surges. Based on the reciprocal Green's function approach developed by the author, the storm surge around Taiwan can be calculated promptly. The result shows atmospheric pressure plays a more important role than the wind stresses. The improvement after considering the inflow angle will be discussed in this study.

## 利用新世代衛星改善颱風引起即時性葉綠素響應之理解

鄭志文<sup>1,2</sup>、林家屹<sup>1</sup>、賀華<sup>1</sup>

<sup>1</sup>國立台灣師範大學 地球科學系

<sup>2</sup>國立台灣師範大學 海洋環境科技研究所

### 摘要

颱風引發之海洋葉綠素a響應將直接或間接影響著當地海洋生態環境與區域氣候平衡，因此更為深入瞭解其相關過程有其必要性。由於颱風當下的惡劣環境以及繞極軌道衛星的觀測限制，過往主要相關研究均使用5-8天合成影像來進行分析，這也導致颱風造成的即時性葉綠素a響應一直無法被適當地釐清。在這項研究中，我們使用Himawari-8衛星搭載之具地球同步軌道特性之先進向日葵成像儀(Advanced Himawari Imager, AHI)重新分析颱風造成的即時性葉綠素a響應。藉由其高頻的觀測，相對傳統透過繞極軌道衛星反演之影像，AHI能提供更為完整之日合成葉綠素a資料，此結果將於研究中獲得證實。同時，透過AHI水色成影像，葉綠素a響應與颱風間更為即時的相互關係得到了進一步的理解。相對前人對於相同議題之理解，AHI/Himawari-8觀測到的即時性葉綠素a響應顯示出更快並且更強烈之反應。在颱風通過之影響下，葉綠素a濃度在通過後的第一天即達到最高值，而非過去研究中常見的3-6天延遲達高峰。並且AHI觀測到的平均葉綠素a變化(計算颱風通過後0-3天期間)約為透過中解析度成像分光輻射計(Moderate-resolution Imaging Spectroradiometer, MODIS)觀測到之2.95倍。

## 西北赤道太平洋次表層湧升之年際變化研究

辛宜佳

中央研究院環境變遷研究中心

### 摘 要

民答那峨圓丘 (Mindanao Dome) 為西北赤道太平洋海域重要的湧升區，本研究利用歷史水文資料、衛星遙測資料以及海洋再分析資料，系統性探討其基本特性、強度及位置之季節變化和年際變化，在年際變化上主要著重於聖嬰尺度變化，特別探討兩類不同聖嬰 (東太平洋聖嬰 vs. 中太平洋聖嬰) 對民答那峨圓丘的影響。世界大多湧升區之湧升流可直接影響至海表面，造成海表溫度降溫及葉綠素濃度增加等現象，但本研究結果顯示，民答那峨圓丘之湧升現象受限於水下50公尺，其對於生地化的影響必須藉其上之大氣風場促成。



## **Rapid surface warming of the Pacific Asian marginal seas since the late 1990s**

Chau-Ron Wu

Dept. of Earth Sciences, National Taiwan Normal University  
Research Center for Environmental Changes, Academia Sinica

### **Abstract**

The East Asian marginal seas gain heat from the warm pool via intrusion of the Kuroshio Current and play an important role in regulating regional climate. Here, we show that the sea surface temperature rise of the East Asian marginal seas, especially in areas where the Kuroshio intrudes, has far exceeded the rate of global ocean warming. We attribute this to warming of the Atlantic since the 1990s, which has affected the Pacific atmosphere via trans-basin effects. Intensified trade winds warmed the Pacific Warm Pool and caused the surface Kuroshio and the regions where it intrudes into marginal seas to warm rapidly in the late 1990s. The impacts of the Atlantic Ocean on the Pacific, Kuroshio, and East Asian marginal seas are greater than those of global warming and have occurred more rapidly.

### Nitrogen species in sediment pore waters of the Danshuei River Estuary, Northern Taiwan.

方天熹，張廷嘉，林瑋鈺

海洋大學海洋環境資訊系

#### Abstract

The Danshuei River Estuary (DRE) in northern Taiwan is a seriously eutrophic estuary. This study examined the dissolved N species (ammonium, nitrite, nitrate and DON), redox potential, dissolved Fe and Mn in sediment pore water (SPW) of the upper, the middle and the lower estuary of the DRE. The TN, TOC and grain size in the core sediment samples were also analyzed. The redox potential of the three SPWs ranged within -139 ~ -369 mV, anoxic environment. The SPW of the upper estuary enriched an extremely high ammonium and DON concentrations, up to 6550  $\mu\text{M}$  and 2050  $\mu\text{M}$ , respectively. Both concentrations in SPW of the middle estuary significantly reduced to less than one third value of the upper estuary. The total dissolved N (TDN) concentrations of the three SPWs were chiefly dominated by ammonium and DON concentration, accounting for 65-99% and 1-34% of TDN pool, respectively. The DON and TN profile in core sediment of the upper estuary indicate that the remineralization of organic N significantly occurred in the core sediment of the upper estuary. The remineralization of DON and TN in core sediment of the upper estuary provide the ammonium source to the deeper layer sediment. While, the ammonium diffusion to the water column of the middle and the lower estuary. The diffusion flux at the upper estuary ranges within  $-4.99 \sim 1.75 \text{ mmole N m}^{-2} \text{ d}^{-1}$ , and ranges within  $0.34 \sim 0.57 \text{ mmole N m}^{-2} \text{ d}^{-1}$  at the middle and the lower estuary.

(Keywords: nitrogen species, sediment pore water, DON, remineralization, the Danshuei River Estuary)

## 海洋來自大氣的外部氮和磷物種對東海南端海域之貢獻

陳宏瑜、陳孟倫

國立臺灣海洋大學海洋環境資訊系

### 摘要

本研究自 Oct-2019 到 Sep-2020 以高量採樣器，在東海南端緊臨中國大陸東南閩江出海口的島嶼馬祖(Mazu)，進行大氣乾沉降採樣。利用六階式粒徑分離器將樣本分為粗顆粒( $PM_{>3}$ )和細顆粒( $PM_{<3}$ )，將 N 和 P 物種區分為水溶(water soluble; WS)與非水溶性(water insoluble; WI)，以探討海域大氣 N 和 P 物種沉降的增加，對於海洋生態系統的影響程度。

研究結果顯示，氣膠的平均質量濃度為  $40.8 \mu\text{g}\cdot\text{m}^{-3}$ ，分析物種的占比依序為：TC (16.9%) >  $\text{SO}_4^{2-}$  (13.0%) > TN (9.8%) >  $\text{Na}^+$  (8.9%) >  $\text{Cl}^-$  (8.7%) >  $\text{Mg}^{2+}$  (1.5%) >  $\text{Ca}^{2+}$  (0.7%) >  $\text{K}^+$  (0.6%) > TP (0.1%)，其中未知物種占 39.7%。TC、TN 與 TP 的平均莫耳濃度分別為 575、284 與  $0.93 \text{ nmol m}^{-3}$ ，TC:TN:TP 的化學計量比為 722:380:1，本地區乾沉降存在明顯的磷缺乏情形。

總懸浮微粒中，WS-TN 與 WI-TN 佔 TN 的比率為 74%與 26%；WS-TP 與 WI-TP 則分別佔 TP 的 47%和 53%。而非水溶性氮、磷的比例皆在東北季風時期(陸源為主)有最高值，於西南季風時期(海源為主)有最低值。在粒徑的分佈上，WS-TN、WI-TN 與 WS-TP 在細顆粒上濃度比例分別為 72、93 與 72%；而 WI-TP 則有相反情況，在細顆粒中的比例只有 37%，遠低於粗顆粒的 63%。相關性分析結果顯示，WS-TN 和 WI-TN 兩者間呈現高度相關( $r = 0.79, p < 0.01$ )，並且和  $\text{nss-K}^+$ 、 $\text{nss-Ca}^{2+}$ 、 $\text{nss-SO}_4^{2-}$  間皆有中度以上的相關性，因此推測水溶性與非水溶性氮物種可能以陸源和燃燒作用有關。WS-TP 與  $\text{nss-SO}_4^{2-}$  有中度相關( $r = 0.42, p < 0.01$ )；WI-TP 則與  $\text{nss-K}^+$  有中度相關( $r = 0.40, p < 0.01$ )，顯示水溶性與非水溶性磷可能分別來自石化燃燒和生質燃燒。

整體而言，大氣 N 和 P 物種濃度主要受到人類活動的影響，與歷史文獻比較結果顯示，非水溶性氮和磷在 TN 和 TP 的佔比，內陸或人類活動地區分別為 39-51%和 95%，明顯高於沿海大氣的 8-26%和 53-63%。通量估計結果顯示，TN 和 TP 的年通量分別為  $48.4$  和  $0.29 \text{ mmol m}^{-2} \text{ yr}^{-1}$ ，呈現明顯季節性變化。TN 和 TP 皆在冬季有最高的平均日通量，分別為  $168.2$  和  $1.08 \mu\text{mol m}^{-2} \text{ d}^{-1}$ ；其中，氮物種中高達 88%的年通量由水溶性氮主導；而磷物種則相反，約 69%由非水溶性磷主導。以上結果顯示，東海南端乾沉降中，氮相較磷有較高的生物可利用率，且可能會造成鄰近生態的營養鹽失衡狀況。

## Seasonal variations of nitrous oxide in a populous urban estuary and its adjacent sea

Hsiao-Chun Tseng<sup>1,2†\*</sup>, Yokie Tai Yuh Han<sup>1†</sup>, Chia-Chia Lin<sup>1</sup>, Gwo-Ching

Gong<sup>1,2</sup>

<sup>1</sup> Institute of Marine Environment and Ecology, National Taiwan Ocean University, Keelung, 20224, Taiwan

<sup>2</sup> Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung 20224, Taiwan.

### Abstract

The first investigations of seasonal N<sub>2</sub>O variations and water-to-air fluxes in the Tamsui River estuary and its adjacent sea were carried out in this study. In the Tamsui River estuary, the concentration of N<sub>2</sub>O decreased with increasing salinity. The seasonal variations of N<sub>2</sub>O concentrations in the estuary were 46.8–148.5 nM in autumn, 15.9–82.5 nM in spring, 11.0–42.0 nM in summer and 13.1–120.6 nM in winter. When salinity regressed to zero, N<sub>2</sub>O concentration was highest in autumn, followed by winter, spring, and summer, which might be influenced by the DO and NO<sub>3</sub><sup>-</sup> concentrations as well as temperature. Because of mountains occlusion, the seasonal variations in wind speed were not large in the Tamsui River estuary. Seasonal variations of N<sub>2</sub>O fluxes in the estuary were 10.9–35.6 μmol m<sup>-2</sup> d<sup>-1</sup> in autumn, 2.8–15.1 μmol m<sup>-2</sup> d<sup>-1</sup> in spring, 2.4–9.5 μmol m<sup>-2</sup> d<sup>-1</sup> in summer and 2.7–26.8 μmol m<sup>-2</sup> d<sup>-1</sup> in winter. In the adjacent sea of Tamsui River estuary, seasonal average N<sub>2</sub>O concentrations in the surface seawater were 10.3±0.2 nM in autumn, 11.6±1.2 nM in spring, 11.4±0.7 nM in summer and 13.8±0.9 nM in winter, with no significantly seasonal changes while wind speed varied greatly seasonally. Seasonal variations of average N<sub>2</sub>O fluxes in Tamsui River estuary's adjacent sea were 40.3±0.7 μmol m<sup>-2</sup> d<sup>-1</sup> in autumn, 19.7±2.1 μmol m<sup>-2</sup> d<sup>-1</sup> in spring, 20.9 ± 1.3 μmol m<sup>-2</sup> d<sup>-1</sup> in summer and 49.0±3.3 μmol m<sup>-2</sup> d<sup>-1</sup> in winter. As a result, seasonal variations in N<sub>2</sub>O fluxes in the estuary were dominated by N<sub>2</sub>O concentrations in the water, whereas in the sea, it was dominated by wind speed. Overall, the Tamsui River estuary and its adjacent sea were net sources of atmospheric N<sub>2</sub>O with annual average fluxes 10.6±6.7 and 32.5±14.5 μmol m<sup>-2</sup> d<sup>-1</sup>, respectively.

## 網格尺度模型在近岸環境人為污染物傳輸的應用

李宗霖

中山大學海洋環境暨工程學系

### 摘要

人為的污染物對人類健康和生態環境有不利影響。沿海水域的污染物的主要來源是河流排放和大氣沉積。當空氣在波浪作用和海風的作用下混入海水中時，會重新聚集成氣泡並漂浮到水面，然後在海水微層中分解。我們過去的研究已經成功地使用多環芳烴（PAHs）作為示蹤劑來描述人類活動污染物在海洋環境中的遷移特徵。在這項研究中，我們使用網格尺度模型（GSM）來比較每小時的PM<sub>2.5</sub>-PAH水準，以合理地評估高雄市PAH變化的長期空間和時間影響及其與哮喘病人的關係。我們發現2013年和2014年構建的網格尺度模型估計的綜合PAHs之間存在明顯的相關性（ $r \sim 0.96, p < 0.01$ ），而且平均絕對誤差顯示出彼此相似的結果，表明之前構建的GSM2013可以應用於不同年份。對高雄市2005年至2018年的PM<sub>2.5</sub>-PAH濃度進行了估算，從得出的資料庫中發現，年均值從2005年的3.18下降到2018年的1.89 ng m<sup>-3</sup>，總體下降了40.6%。在靠近中央公共交通樞紐的城市地區，隨著2007年高速鐵路和2008年大眾快速交通的運行，導致2009年多環芳烴估計大幅下降16%（0.37納克/立方米）。在工業區周邊地區，環境法規，包括空氣污染控制費和上限交易政策，工廠搬遷到新的工業區，以及一個煉油廠的關閉，都有助於降低PAH的濃度。也有證據表明，每年接觸PAHs較多的嚴重哮喘病人可能有較高的任何急性惡化的年度頻率。通過使用GSM建模，本研究展示了一個有用的、可行的城市規劃工具，可以作為未來流行病學和環境管理相關研究的參考。

## Deciphering terrestrial source strength from coastal water composition

Kuo-Tung Jiann and Yu-Nu Huang  
Department of Oceanography, National Sun Yat-sen University, 804 Kaohsiung, Taiwan

### Abstract

Monitoring terrestrial and/or anthropogenic inputs to the seas has been one of the fundamental works in environmental studies. Because chemicals can undergo modification in estuaries before reaching coastal area, studies with high spatial resolution in estuaries are needed in order to better define actual (net) fluxes of chemicals transported to the seas. Although conducting full-scale estuarine sampling is the ideal way to obtain flux results, it will take a great amount of effort and resources, and some segments of specific estuaries have accessibility issues.

Coastal regions are extension of estuaries where water composition are resulted from mixing of estuarine and coastal endmembers. Regional water masses, coastal current, tides, and source strength all contribute to the snapshot water composition observed. However, it is difficult to standardize sampling time with respect to physical forcing at fixed monitoring locations. Therefore, a procedure to standardize chemical composition in coastal waters is needed to assess their variability and imply the results to land-ocean interactions.

In this study, temporally variable oceanic endmembers are identified using HYCOM water characteristics and current information. Oceanic endmember concentrations are paired with coastal water composition and linearly extrapolated to zero salinity, resulting in effective river endmember concentrations (EREC) for each coastal location with a known riverine input. Results are compared with past estuarine studies with better spatial resolution. Differences of EREC between those obtained from coastal and estuarine studies vary with chemical parameters and locations. Chemicals being generally considered having “conservative” behavior have smaller EREC difference, validating at least partially those coastal water composition that allow for the assessment of terrestrial source strength being compared spatially and temporally.

## Tracking the ocean circulation in the tropical and subtropical Pacific Ocean with anthropogenic $^{236}\text{U}$ — Preliminary results

Huei-Ting Lin and Yu-Chen Chou

Institute of Oceanography, National Taiwan University

### Abstract

Changes in ocean circulation greatly impact heat and mass transportation, influencing the marine ecology and human economy. Chemical tracers are powerful tools to enhance our understanding of global ocean circulation, allowing us to validate the acoustic flow meters and temperature-salinity-based density flow models. Here, we used nuclear-test generated anthropogenic nuclide  $^{236}\text{U}$ , discharged at the Pacific Providing Ground (PPG) from 1946 to 1958, to visualize the ocean circulation in the tropical-subtropical Pacific Ocean. This talk will show the  $^{236}\text{U}/^{238}\text{U}$  profiles at Station ALOHA near Hawaii, on the Kuroshio offshore of Hualien and southeast of Taiwan strait offshore of Xiaoliuqiu. Compared with the bomb-generated  $^{14}\text{C}$ -dissolved inorganic carbon (DIC), the two anthropogenic tracers show similar depth distributions but with significant deviation, especially between 250 m and 500 m at Station ALOHA. Since uranium is not as bioactive as carbon, the deviation between  $^{236}\text{U}/^{238}\text{U}$  and  $^{14}\text{C}$ -DIC may result from biogeochemical processes added to physical mixing. Across the Pacific Basin,  $^{236}\text{U}/^{238}\text{U}$  was high on the surface of the seawater in the southwest Taiwan but decreased significantly at a depth of 90 m. In contrast, similarly high  $^{236}\text{U}/^{238}\text{U}$  on the sea surface to a depth of 250 m was observed in the Kuroshio water. We attribute the differences resulting from the high  $^{236}\text{U}/^{238}\text{U}$  in the Pacific seawater and low  $^{236}\text{U}/^{238}\text{U}$  in South China Seawater. Our research is a step further in using anthropogenic chemical tracers to validate ocean circulation models, especially for the Kuroshio current, the South China Sea, and the Pacific North Equatorial Current (NEC). We aim to enrich our understanding of energy and mass transport, which will have future ecological and economic implications.



Marine organic particle interactions with pollutants:  
microplastics and polyfluoroalkyl substances

Ruei-Feng Shiu (許瑞峯)

Institute of Marine Environment and Ecology, National Taiwan Ocean University,  
Keelung, Taiwan

**Abstract**

Organic particles play critical roles in a variety of processes in the ocean, including element cycling, carbon sequestration, food web dynamics, air–sea exchange, and pollutant transport. Due to their amphiphilic nature, hydrophobic pollutants have been found to preferentially associate with marine organic particles, thereby affecting the distribution and ultimate fate of pollutants in the ocean. Our data suggested that microplastics (MPs) can incorporate with marine organic particles forming plastic-gel aggregates that enhance the vertical mobility of MPs including ocean surface to the deeper ocean, or ocean surface to atmosphere environments. Additionally, our study also examined the contamination distribution and partitioning of per- and polyfluoroalkyl substances (PFASs) in the water and suspended particulate matters (SPM) in Tamsui River. The positive correlation between SPM-bound PFASs and transparent exopolymer particles (TEPs) content was observed, providing first evidence that TEPs may accumulate and concentrate more PFASs on the SPM. Collectively, the data offers information about the role of marine organic particles in determining environmental fate of pollutants such as MPs and PFASs.

# 海洋化學專題演講

## Title

Occurrence of per- and polyfluoroalkyl substances (PFASs) in sharks from two contrasting habitats: New York Bight and The Bahamas

## Authors

Cheng-Shiuan Lee<sup>1,2,\*</sup>

<sup>1</sup> Research Center for Environmental Changes, Academia Sinica, Taipei 115, Taiwan

<sup>2</sup> New York State Center for Clean Water Technology, Stony Brook University, Stony Brook, NY 11794, USA

\*+886 2 7875868, [chenglee@gate.sinica.edu.tw](mailto:chenglee@gate.sinica.edu.tw)

## Abstract

Sharks are meso-to-apex predators in marine food webs, serving a diversity of functions throughout marine ecosystems. As a result, sharks are often considered sentinel species for evaluating the overall health of a marine habitat and/or ecosystem. Relatively high levels of organic contaminants, such as per- and polyfluoroalkyl substances (PFASs), have often been found in the tissues of many shark species because of their longevity and slow growth and low reproductive rates. In this study, we provide baseline information on 40 PFAS compounds measured in the shark tissues of five different shark species collected from two distinct marine ecosystems: New York Bight (NYB), North Atlantic Ocean and coastal waters of the Bahamas archipelago. The occurrence of PFASs was found 100% in the collected samples (n=62), with 16 out of 40 PFAS compounds detected. The compound with the highest concentration was PFOA (3.63±4.42 ng/g w.w.), followed by PFBA (2.27±2.12 ng/g w.w.), PFBS (2.14±4.57 ng/g w.w.), PFTrDA (1.96±2.75 ng/g w.w.), PFHxA (1.85±1.59 ng/g w.w.), and PFUnA (1.02±1.48 ng/g w.w.). Among the five shark species, Caribbean reef sharks caught in the Bahamas show the lowest overall PFAS accumulation in their tissues. PFAS concentrations measured in the other four shark species caught in NYB followed the order: common thresher > shortfin mako > sandbar ≈ smooth dogfish. Notably, 7:3FTCA was only detected in the NYB sharks. Ultra-long chain (C≥10) PFAS compounds exhibited a close correlation with stable isotope δ<sup>15</sup>N. Moreover, we found that the ultra-long PFAS concentration was proportional to the total mercury concentration in Caribbean reef sharks. Lastly, the percentage of linear PFOS (L-PFOS/ΣPFOS) was 79±8% in Caribbean reef sharks, while the other sharks from the NYB contained >90% of linear PFOS. Also, the value of %L-PFOS was positively correlated with δ<sup>15</sup>N, indicating preferential accumulation of linear form PFASs in biota. These findings highlight the impact of anthropogenic inputs on PFAS distribution and accumulation in sharks from two important marine ecosystems, and also provide the first baseline information on PFASs in sharks from NW Atlantic and correlate PFASs with other important chemical proxies to refine our knowledge of PFAS accumulation in marine predatory fishes.

## 東亞人為氣膠鐵同位素組成特徵: 對西北太平洋貢獻初探

Fe isotopic composition of East Asian anthropogenic aerosols: the preliminary study for their contribution to the Northwestern Pacific Ocean

謝志強<sup>1,2</sup> and 何東垣<sup>1,2</sup>

<sup>1</sup> 中央研究院環境變遷中心; <sup>2</sup> 台灣大學海洋研究所

### 摘要

東亞位於季風及西風帶，大量岩石性及人為氣膠傳送至西北太平洋，為研究天然和人為氣膠鐵對海洋通量貢獻的理想區域！鐵同位素為估算氣膠鐵對海洋貢獻最可信的參數，然而人為氣膠鐵同位素的端成份值(end member)還存在著爭議！由於人為氣膠主要分布於小型氣膠顆粒，採集不同粒徑大小氣膠對於量化人為氣膠的貢獻極為關鍵！為測定人為氣膠的鐵同位素的端源成份值以推估不同來源氣膠鐵於西北太平洋沉降通量，本研究於彭佳嶼採集五種粒徑的氣膠一年，分析氣膠總鐵及溶解鐵的濃度及同位素組成。研究結果發現人為氣膠的鐵同位素的端成份值為約  $-4.5\text{‰}$ ，推斷來自於化石燃料高溫燃燒後的氣膠，而其主要分布於小於  $1\ \mu\text{m}$  的氣膠上。由於小顆粒氣膠沉降速率相當小，雖然東亞氣膠中人為瞬溶氣膠鐵的濃度可高達  $88\%$ ，但若通量計算，則人為氣膠鐵僅占西北太平洋溶解態氣膠鐵沉降量的  $12\%$ ，主要的溶解態氣膠鐵來源仍為岩石性氣膠。

# 在環境溫度與加熱條件下評估不同的海膽種類及尺寸之珊瑚生物侵蝕速率

李彥輝<sup>1</sup>、熊寶兒<sup>1,2</sup>

<sup>1</sup>國立中山大學海洋科學系、<sup>2</sup>西澳大學工程學院

### 摘要

在全球變遷的背景下，對棲息在珊瑚礁內部的侵蝕生物影響已有評估，但對外部刮食的侵蝕生物影響缺乏可用的資料。此外，過去20年的文獻回顧，台灣沒有關於實驗性水族飼養的生物侵蝕研究。本研究以兩個物種、不同尺寸與兩種不同的溫度量化海膽的生物侵蝕速率，採用梅氏長海膽(*Echinometra mathaei*) 與口鰓海膽(*Stomopneustes variolaris*) 作為人工條件養殖之刮食性侵蝕生物的實驗動物。兩種海膽皆按照體殼直徑尺寸分成3組不同體型進行實驗，海水溫度以25°C為對照組，以29°C模擬熱浪環境條件。提供珊瑚“活石”作為實驗基質在養殖桶中，並分成設置一隻海膽與一快活石的實驗組與無海膽的對照組。實驗進行了18天，每3天將珊瑚活石浮重法在海水中秤重。初步的研究結果顯示，在所有實驗設置下，活石的重量皆隨時間減少，平均重量損失範圍為0.9%至5.8%。海膽平均侵蝕速率的呈現種間差異，在25°C下，較小的海膽物種梅氏長海膽侵蝕較體型較大的物種口鰓海膽多，前者約為22.25 mg/day/ind.、後者約為15.75 mg。兩種海膽的體型大小之間的侵蝕速率也不同，梅氏長海膽在兩種溫度條件下，生物侵蝕會隨體型增大而增加；相較之下，口鰓海膽29°C時生物侵蝕隨體型減小而增加，但在25°C沒有顯著差異。本研究在29°C的熱模擬中，生物侵蝕速率整體上高於25°C，並且兩種海膽有相似的結果，梅氏長海膽平均侵蝕速率約為35.68 mg/day/ind.，後者約為29.77 mg。研究結果出乎意料，因原本假設高溫會對海膽造成壓力，減少進食活動。相反的，海膽的代謝似乎隨著水溫升高而提高。因此我們認為短暫的高溫事件，海膽對珊瑚礁的侵蝕速率將會增加，亦隨著全球暖化而增加。在未來，類似的實驗會以更高的溫度與較長的時間做評估，以更能模擬全球暖化的條件。結合野外的海膽豐富度調查，我們的資料將有助於釐清台灣珊瑚礁的外部生物侵蝕程度，並可用於珊瑚礁的碳酸鹽收支研究、模式建立與管理。

## 海洋生物專題演講

### 海洋寡毛類纖毛蟲與夜光蟲周年分布之關係

蔡昇芳

國立臺灣海洋大學海洋環境與生態研究所

#### 摘要

纖毛蟲(oligotrich ciliates)在海洋食物鏈中扮演著不可或缺的一部分，主要在海洋微生物循環中將能量由微細鞭毛藻往上傳遞至傳統攝食食物鏈的關鍵角色。夜光蟲(*Noctiluca scintillans*)，蟲體直徑介於200-2000  $\mu\text{m}$ 之間，為一非常大、且呈腎形或氣球狀之渦鞭毛藻(蟲)單細胞生物。行異營性生活，攝食小至細菌大到魚卵之潛在餌料，不具餌料選擇性。過去研究顯示，夜光蟲對無殼類纖毛蟲(naked ciliates)攝食率為零，亦即兩物種間並不存在碳傳遞的鏈結。然而，夜光蟲對有殼類纖毛蟲(loricate ciliates)之攝食行為則無相關文獻可考。本研究於2020年採集馬祖南竿介壽澳之海水樣本，觀察了兩類型寡毛類纖毛蟲(有殼類和無殼類纖毛蟲)的數量的變化，發現有殼類纖毛蟲的數量周年均有分布，且在秋季達到了310 cells/L的高值，然而在夜光蟲出現期間則無任何現存量。無殼類纖毛蟲在秋冬期間並未觀察到任何現存量，呈現春天少、夏天多的現象，320 cells/L的高值出現在夏季。由此推測，在夜光蟲大爆發期間，有殼類纖毛蟲容易被夜光蟲的觸手纏住，導致在夜光蟲大爆發期間數量大幅下降。鏡檢亦發現夜光蟲體內有多種有殼類纖毛蟲存在，支持夜光蟲可能會攝食、影響有殼類纖毛蟲的出現與否。

## Rethinking the measurement of plankton's grazing mortality by dilution experiment

Feng-Hsun Chang<sup>1</sup>, Chih-hao Hsieh<sup>1,2,3,4</sup>

<sup>1</sup>*Institute of Oceanography, National Taiwan University, Taiwan;* <sup>2</sup>*Institute of Ecology and Evolutionary Biology, Department of Life Science, National Taiwan University, Taipei, Taiwan;* <sup>3</sup>*Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan;* <sup>4</sup>*National Center for Theoretical Sciences, Taipei, Taiwan*

### Abstract

The dilution experiment is developed to estimate the grazing mortality of plankton in a marine ecosystem. The key assumption of this experimental technique is that the net growth rate of bacterioplankton (intrinsic growth minus grazing mortality) should monotonically decrease with diluted predators. This straightforward assumption has popularized the implementation of dilution experiment in estimating the grazing mortality of bacterioplankton in marine ecosystems. However, conducting dilution experiment is challenging as we found that about 50% of experiments do not yield a decreasing net growth rate of bacterioplankton with increasing virus and heterotrophic nanoflagellates (HNFs). As an attempt to explain these “unexpected” results, we build a theoretical model to mimic the dynamics of bacterioplankton in the dilution experiment. We propose two working hypotheses: (1) The community density of bacterioplankton exhibits a cyclic behavior during the incubation period and improper sampling frequency coincidentally captured the non-decreasing bacterial net growth rate; (2) Certain bacterial taxa are released from grazing due to diluted predators so that total bacterial density increases with diluted predators. These two working hypotheses remain to be tested by further analyses on the dynamics of bacterial community density and the compositional changes of bacterial community. In the future implementation of dilution experiment, we argue that bacterial community density at multiple time point should be collected to verify the estimate of grazing mortality.

Keywords:

Dilution experiment; grazing mortality; productivity; bacterioplankton; phytoplankton

## 東海陸棚海域單細胞固氮藍綠細菌群聚結構之研究

詹雅帆<sup>1</sup>、葉重亨<sup>1</sup>、洪睿焄<sup>1</sup>、林芸琪<sup>2</sup>、蔣國平<sup>2</sup>

1: 東吳大學微生物系

2: 國立臺灣海洋大學海洋環境與生態研究所

### 摘要

在西太平洋海域均屬於氮鹽缺乏的水體，僅有固氮微生物可利用大氣中的氮氣(N<sub>2</sub>)，轉化為生物可以利用的氮，稱作“生物固氮作用”。而這些生物固氮作用對於海洋的基礎生產力是為重要的來源。固氮微生物之生物組成攸關海洋中碳的傳遞、海洋漁業資源多寡，與氣候變遷等重要之議題。因此，本研究目標探討東海海域中固氮微生物之群聚組成。本研究使用海研一號 Cr1232 航次之資料(2019 年 7 月)中的表層與葉綠素極大值層水體樣本，在經過特定過濾方式(0.2 μm~ 3 μm)以及固氮專一性基因 *nifH* 找出固氮微生物，並以大規模定序方式的測序出其種類組成。本研究對於西太平洋海域固氮微生物的研究不僅可貢獻海洋生物資源相關研究的重要參考，且這些固氮微生物對於環境變化的易敏感性，使得固氮微生物的族群消長也可能成為環境變遷的重要指標。



## 海洋生物專題演講

# 北太平洋中自營與異營固氮生物及其固氮作用在緯度上的不同變化趨勢

張順恩

國立臺灣海洋大學海洋生物研究所

### 摘 要

生物固氮作用是支持海洋生產力的重要氮源。固氮藍藻是海洋固氮作用的主要貢獻者。海洋中的非藍藻固氮菌與其固氮潛力近來受到越來越多的關注，但我們仍然不知道它們在海洋中的重要性。在這次報告中，我將展示我們最近對北太平洋固氮生物群落及其固氮活性的調查結果。沿著從亞熱帶環流到赤道的斷面，我們觀察到自營的固氮藍藻和異營的固氮菌(主要為變形菌)之間的更替。通過測量固氮速率，我們推斷異營固氮生物能夠在表層海洋中固氮，而其固氮活性受到它們與自營生物之間的競爭所控制。

### **Comparison of viral production and decay rates at the surface and bottom of the euphotic zone in the summertime in the southern East China Sea**

An-Yi Tsai\*, Patrichka Wei-Yi Chen, Madeline Olivia  
Institute of Marine Environment and Ecology, National Taiwan Ocean  
University, Keelung 202-24, Taiwan

#### Abstract

Viral dynamics are the result of the balance between the rates of viral production and decay. Here, we have carried out independent measurements of viral production and decay rates in different depths of the southern East China Sea in summer (August and October 2021). In this study, the prevalence of viral abundance at the surface waters ( $14.2\sim 27.6 \times 10^5$  viruses  $\text{mL}^{-1}$ ) was significantly higher than bottom of the euphotic zone ( $2.9\sim 12.6 \times 10^5$  viruses  $\text{mL}^{-1}$ ). As for Viruses to Bacteria Ratio (VBR) values, we found a wide variability both at the surface (1.4 to 3.2) and bottom of the euphotic zone (2.1 to 16.2). The results of our study showed that at all stations examined, in the southern East China Sea, the values of gross viral production (GVP) were significantly higher in the sunlit surfaces compared to bottom of the euphotic zone. In particular, our analysis indicates that there is no significant viral decay rates (VD) were observed in some regions at bottom of the euphotic zone. Here we also provide a budget for viral abundance and net viral production in different regions in the southern East China Sea. The GVP or VD is not applicable in our case to explain VBR is high at bottom of the euphotic zone. The mechanisms underlying VBR uncoupling, viral production and viral loss in marine systems are still being investigated.

## 瀕危物種三棘鰲的澎湖族群狀態與多重保育方案

楊明哲

國立中山大學海洋科學系/靜宜大學通識教育中心

### 摘 要

三棘鰲為國際自然保育聯盟（IUCN）紅皮書中的瀕危物種，其血液可製成檢驗疫苗是否有細菌內毒素的鰲試劑，也為海岸生態系的指標物種，但其族群在全亞洲各地都持續衰退中。青螺濕地是澎湖縣唯一的國家級重要濕地，受到濕地保育法管理與保護。在2020~2021年10次調查期間，2020年共發現119隻，2021年共發現331隻，為5-12齡的稚鰲。以捉放標誌法進行族群個體數估算，在考慮蛻殼比例造成估算影響後，估算發現2021年7月為401~403隻，且不同齡期稚鰲其分佈與潮間帶地形有關，熱區集中在低潮區淺水潮池。調查中發現濕地內各樣區都缺乏小於5齡稚鰲，可能和棲地底質粒徑較大、產卵位置較遠、種鰲近年產卵量不足有關。調查中也發現正在產卵的成鰲，針對此區域未來仍應加強保護。針對本研究結果的保育作為（1）應提升青螺濕地稚鰲分布熱區的保護管理為生態復育區；（2）持續進行稚鰲族群監測；（3）澎湖全縣全年禁止捕捉種鰲與稚鰲（已於2022年公告）；（4）與社區持續合作進行海洋環境教育與保育巡守。

## Response of the benthic biomass-size structure to a high-energy submarine canyon

Chueh-Chen Tung<sup>1</sup>, Yen-Ting Chen<sup>1</sup>, Jian-Xiang Liao<sup>1,2</sup>, Chih-Lin Wei<sup>1\*</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan

<sup>2</sup>Taiwan Power Research Institute, Taiwan Power Company, Taipei, Taiwan

### Abstract

Body size regulates all biological processes, including growth, reproduction, metabolism, trophic interactions, etc., and is the master trait across organisms, populations, and communities. Despite a rich literature on the impacts of human and natural disturbances on body size, a clear knowledge gap is the effect of the submarine canyons on the benthic size structures in the deep sea, hindering our understanding of the ecological processes of these dominant ecosystems on the continental margin. Therefore, we conducted repeated sediment sampling to compare meiofauna and macrofauna biomass body-size spectrum, growth, metabolism, and size composition from a high-energy submarine canyon, Gaoping Submarine Canyon (GPSC), and the adjacent continental slope off SW Taiwan. The GPSC is a dynamic ecosystem connected to a high sediment-yield small mountain river subjected to strong internal-tide energy, swift bottom currents, frequent mass wasting events, and high terrestrial sediment inputs. We found that the meiofauna and macrofauna were characterized by relatively larger individuals dominating on the slope to smaller ones dominating in the canyon. As a result, the community biomass, secondary production, and respiration were depressed with distinctive biomass-size composition in the canyon compared to the non-canyon slope. The environmental factors related to internal tide disturbance (i.e., bottom current velocity, duration of sediment erosion, or low light transmission) substantially influence the body size composition of the canyon benthos, while food supplies (i.e., TOC and C/N ratio) and sediment characters (i.e., grain size and porosity) correlated closely with the slope communities. We concluded that the disturbed condition in the GPSC may have wiped out or depressed the local benthic assemblages, and only the smaller, more resilient species could persist. Our results also highlight that the alterations of the canyon benthic community could be a reference to deep-sea ecosystems under anthropogenic disturbances or global climate change.

## 海洋酸化對草蝦及白蝦之影響

謝學函、洪慶章

國立中山大學海洋科學系

### 摘要

人為活動產生大量營養鹽與有機物的廢水，經由河川狹帶至水流較為平緩的河口區域，使水體優養化以及底水的酸化的風險大幅提升，且藉由該機制發生酸化的速率遠高於二氧化碳引發的酸化問題。陸上養殖是全球主要的水產養殖模式之一。養殖期間投入大量的餌料及生物的代謝物，使養殖池水富營養化，並且常伴隨嚴重的酸化。過去研究發現海洋酸化減低海洋鈣化生物的存活率以及影響生理代謝反應，此外，部分研究亦發現養殖在酸化環境中的海鮮，風味以及口感較差。而針對該現象卻未有完整的解釋。草蝦以及白蝦是全球水產養殖的主要兩種物種，養殖期間的酸化是否會對其造成生存、生理以及品質改變為本研究的主要重點。研究期間，我們以二氧化碳控制水體酸鹼值，區分為非酸化組 (pH 8.0) 以及酸化組 (pH 7.5)，並將草蝦與白蝦暴露在這兩種不同水化學條件的環境 28 天，分析蝦在兩種不同環境下的存活率、殼體結構、免疫系統、胺基酸表現是否受到影響，並在實驗第 28 天邀請 40 位委員進行蝦的品質盲測。根據結果顯示，酸化組的草蝦及白蝦存活率分別為 72.5 以及 47.7%，然而分析每日存活率發現草蝦經過 18 天的暴露後死亡率提升，而白蝦隨著暴露時間增加而死亡率趨緩。酸化組草蝦蝦殼厚度顯著高於非酸化組，而白蝦殼體厚度在兩組別間無顯著差異。酸化組的草蝦以及白蝦在總血球數量、吞噬能力以及吞噬指標均顯著低於非酸化組。顯示酸化環境使兩種蝦免疫功能下降。最後在品質盲測方面，酸化草蝦的外觀、口味以及口感獲得的評分顯著低於非酸化組，而白蝦則在兩組間無顯著差異。分析提供不同風味(甜味、苦味及鮮味)的游離胺基酸表現量，酸化草蝦提供鮮味的游離胺基酸表現量顯著低於非酸化組。本研究證實白蝦在適應酸化後，相較於草蝦擁有更佳的酸化耐受性，白蝦品質似乎較不受酸化的影響，因此在狀態較差的養殖水體或是未來持續酸化的海水中，白蝦可能是更好的養殖物種選擇。

關鍵字：酸化、草蝦、白蝦、品質

## 氮磷營養鹽濃度變化對閩江口矽藻族群的影響

### The effects of changes in nitrogen and phosphorus nutrient concentrations on the diatom community in the Minjiang River estuarine region

時繼宇

國立臺灣海洋大學海洋生物科技學士學位學程

#### 摘要

閩江口位於東海南部，人類活動改變了這條河流的營養鹽負載，增加了總氮濃度，在 4 月至 7 月間，甲藻為優勢種類，而在 6 月至 9 月間，矽藻會逐漸成為主要種類，擬菱形藻屬 (*Pseudonitzschia*) 在 8 月至 9 月間會逐漸成為主要的矽藻，而部分此屬的種類具有軟骨酸 (domoic acid) 的製造能力。根據文獻報導，擬菱形藻屬可以更適應高  $\text{NO}_3^-$  濃度，但是由於哪些因素導致該海域不同屬的矽藻演替目前還不明朗，也尚未有研究指出該地區是否存在有毒的擬菱形藻種。

為了了解閩江注入水帶來的營養鹽對馬祖海域矽藻演替的影響，以及是否具有有毒的擬菱形藻種於當地生成，本研究自 2014 年至 2019 年在馬祖周圍海域進行了採樣，分析了不同年份現場、寡營養鹽和富營養鹽處理的多元轉錄組，並在其中發現了與軟骨酸生成相關的基因 *dabA* 的表現，因此證明了馬祖海域具有產毒的擬菱形藻屬存在，並在多元轉錄組中發現在缺氮與缺磷的情況下，會使得 *dabA* 表現量升高。

## 馬祖海域矽藻群聚組成與時間變動

粘雅涵、林芸琪、蔣國平

國立臺灣海洋大學 海洋環境與生態研究所

### Abstract

Diatoms, which are unicellular eukaryotes that perform photosynthesis, and have the ability to convert CO<sub>2</sub> into organic carbon. The diatom genus *Pseudo-nitzschia* may produce domoic acid, which has the potential to impact human health. The Matsu Archipelago is situated in an eutrophic estuary off the Minjiang River, where harmful algal blooms (HABs) frequently occur. The objective of this study is to explore the variations in diatom communities over time, with a focus on *Pseudo-nitzschia* blooms, in the Matsu Archipelago by employing both 18S rRNA V4 amplicon (qualitative method) and microscopic observation (quantitative method), and to understand the mechanisms underlying bloom formation. Sampling was conducted 91 times from August 2021 to June 2022. The maximum diatom abundance was observed in early June 2022, reaching  $4.3 \times 10^5$  cells L<sup>-1</sup>, and the predominant genera were *Chaetoceros* and *Pseudo-nitzschia*. Another diatom bloom was observed at the end of September 2021, with *Pseudo-nitzschia* accounting for 88% of the total diatom abundance. The 18S rRNA amplicon data identified *P. cuspidata* as the dominant species in September, while *P. pungens* was dominant in June. *Pseudo-nitzschia* were more prominent in the 3-20 μm size fraction compared to the 20-200 μm size fraction. Canonical correlation analysis (CCA) demonstrated that the abundance of *Pseudo-nitzschia* in both size fractions correlated strongly with light.



## 臺灣西南沿海夜光蟲(*Noctiluca scintillans*)族群變動研究

邱崢恩

國立高雄科技大學 海洋環境工程系  
指導教授:王樹倫教授、黃榮富 特聘教授

### 摘要

近年在臺灣西南部沿海有過多次的赤潮紀錄，包括雲林、臺南及高雄海域，而養殖漁業為雲林地區的重要經濟來源，一旦赤潮發生將會造成生態衝擊。夜光蟲(*Noctiluca scintillans*)為臺灣周遭海域常見的優勢浮游生物，是甲藻門的單細胞渦鞭毛藻，是造成赤潮的種類之一，雖夜光蟲不含毒性，但當赤潮發生時，會大量消耗水域中溶氧，嚴重時造成水域中魚類、貝類大量死亡，因此本次研究追蹤夜光藻數量及多項水質環境之變化，預期能得出影響夜光蟲族群數量變動的因素，以預測未來赤潮發生時機。本研究以雲林海域 17 個測站為採樣地點(N 23°53'34.36",E 120°12'50.49"至 N 23°44'36.00",E 120°07'53.85")，於 2017 年至 2021 年各四季(共 20 季次)進行採集 16 項水質與夜光蟲數量，並分析夜光蟲變化與水質環境之關係。

初步結果發現，夜光蟲族群在年間及季節間的變化較測站間明顯，2018 年第二季及第三季時，族群數量明顯較其他年度高。使用復迴歸之逐步分析(Multiple regression analysis)，得出影響因子為總油脂量、生化需氧量、溫度、溶氧量、pH 值、鹽度及總磷 ( $R^2$ :0.17-0.37)，其中溶氧量及生化需氧量呈現負相關，其餘因子皆為正相關。分成由各季節的迴歸模型中，較常出現的影響因子為鹽度、溶氧量、磷酸鹽及總油脂量 ( $R^2$ :0.13-0.58)，其中鹽度、磷酸鹽及總油脂量為正相關，溶氧量為負相關；由各年的迴歸模型中，較常出現的因子為溫度、鹽度及透明度 ( $R^2$ :0.11-0.63)，皆為正相關，由此結果推論夜光蟲族群數量與其有關的環境因子，會隨年度及季節而有所改變，鹽度為兩者分析共同的影響因子，當鹽度上升時，夜光蟲數量增加。後續研究將使用其他分析方法，並且加入海域其他生物數據，來進一步探討影響夜光蟲族群變動的因子。

### **Bleaching in the mesophotic coral ecosystems from Xiaoliuqiu Island, Taiwan**

Yan-Yu Chen<sup>1#</sup>, Stéphane De Palmas<sup>1</sup>, Lauriane Ribas-Deulofeu<sup>1</sup>, Yi Wei<sup>1</sup>, Vianney Denis<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan

#Email correspondence: [yanfish32@gmail.com](mailto:yanfish32@gmail.com)

Mesophotic coral ecosystems (MCEs) have been proposed to shelter corals from bleaching, yet, they are not immune to it. However, bleaching remains largely overlooked at those depths due to accessibility and predictability problems. From early August 2022, and for five consecutive weeks, shallow reefs in southern Taiwan were under Bleaching Alert level 2 (the highest level from the NOAA Coral Reef Watch). A recently discovered mesophotic community at -32 m was surveyed around Xiaoliuqiu island using 63 photoquadrats (0.25 m<sup>2</sup>) along three 20 m transects. Photographs were analyzed for benthic composition and bleaching status (fully bleached, partially bleached, or recently dead) using Coral Point Count with Excel extension software. Results showed a benthic community dominated by turf algae (45.0%), followed by hard coral (19.8%) and unstable substrate (18.7%). The coral assemblage was composed of *Acropora tenella*, *Anacropora* spp., with rare occurrences of *Leptoseris papyraceae* and *Psammocora stellata*. Numerous hard coral colonies were found to be bleached (24.9%), partially bleached (10.1%), or recently dead (i.e., colonies colonized by filamentous algae, 11.2%) resulting in almost half the coral assemblage suffering from the heatwave. The investigated community appeared to be unique for the area and composed of coral species preferentially found at mesophotic depths in Taiwan. Despite being protected from high light intensity, coral assemblage suffers from severe bleaching (46.2%) suggesting that some MCEs may suffer the same fate as their shallow counterparts and are in the same need of conservation.

**Keywords:** MCE, the ‘deep reef refugia’ hypothesis, climate change, global warming, deep reef

## Calcification of scleractinian assemblages across a bathymetric and latitudinal gradient in Taiwan

Chia-Jung Tsai<sup>1</sup>, Yuting Vicky Lin<sup>1</sup>, Lauriane Ribas-Deulofeu<sup>1</sup>,  
Meng-Hsin Morris Wu<sup>1</sup>, Vianney Denis<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan

### Abstract

In marine ecosystems, the calcification is a crucial ecological process contributing to complex habitats with a high diversity. In tropical latitudes, scleractinians often represent the main calcifying organisms. However, our understanding of how sub-optimal environmental conditions influence calcification rates is limited. The expansion of coral assemblages from low to high-latitudes at both shallow and mesophotic depths makes Taiwan an ideal location to examine how calcification rates of scleractinians assemblages vary with environments. Using CoralNet carbonate production estimates on photo-quadrats from 65 sites, we evaluated the calcification rates of scleractinian assemblages between shallow (5m-10m) and mesophotic (40m) depths and across eight regions spanning tropical and subtropical latitudes (20.59° N-25.20° N). Our results showed higher calcification rates at shallow depths compared to mesophotic depths. At shallow depths, highest calcification rates were recorded in offshore tropical islands (Dongsha, Lanyu, Ludao). In contrast, lowest rates were found at an offshore tropical island (Xiaoliuqiu), the tropical-subtropical transition (East), and the subtropical region of Taiwan (North). At mesophotic depths, the calcification rates from the offshore island (Ludao) were higher than in both tropical (Kenting) and subtropical (North) regions. Interestingly, at both shallow and mesophotic depths, calcification rates did not vary along latitude. We hypothesize that anthropogenic drivers may be responsible for the pattern observed while contributing locally to the degradation of the coral assemblages. We concluded on the urgency that management strategies take biological processes into account for the sustaining functions of coral reef ecosystems.

## 探討夜光蟲(*Noctiluca scintillans*)配子年間的時空分布

李良能、蔣國平、蔡昇芳

國立臺灣海洋大學 海洋環境與生態研究所

*Noctiluca scintillans*，俗稱夜光蟲，是一種直徑 200 -1000 $\mu\text{m}$  的大型雙鞭毛蟲，被歸類為 HAB（赤潮）的物種。繁殖方式包括有性生殖和無性生殖，無性生殖是以二分裂來繁殖，而有性生殖是以配子生成(Gametogenesis)的形式進行。目前我們對於夜光蟲有性生殖過程及機制已有一定了解，也知道何種環境因素會促進配子生成，然而目前仍未了解有性繁殖對於夜光蟲季節性爆發的影響。為了解決此問題，本研究通過計數野外夜光蟲配子以及成蟲濃度，觀察有性生殖對夜光蟲季節性濃度變動的影響。由於夜光蟲配子體態特徵難以與其他相似雙鞭毛蟲做區別，且大小介於 10 -15 $\mu\text{m}$  與成蟲大小相差許多，本研究使用螢光原位雜合

（FISH）的方法標定開放海域中的配子。在 2021 到 2022 期間，在小東海側線上的海水樣本中(測站分布於從馬祖南竿近海向東南延伸至黑潮影響海域)，馬祖南竿和黑潮周邊測站都觀察到較高的夜光蟲配子濃度，並且終年都有保持一定的最少濃度。此為首次記錄到在黑潮周圍的測站發現夜光蟲配子存在，也是第一次記錄到夜光蟲配子長時間出現在馬祖以及黑潮周邊的海域。目前推論是，黑潮周圍發現的配子來自菲律賓海，是由黑潮往北帶往台灣東北海域，而馬祖南竿的配子則是當地夜光蟲爆發時遺留的，屬於原生族群。我們目前尚不了解夜光蟲配子在長距離移動中的生態意義，以及如何在開放海域沒有成蟲族群的狀態下維持一定的濃度，但夜光蟲配子存在於黑潮周圍的事實，是非常值得深入研究調查。因此對其進一步的研究仍具有重要意義。

## **Benthic drivers of structural complexity across a transition zone**

Meng-Hsin Morris Wu<sup>1,\*</sup>, Chia-Hung Eric Liu<sup>1</sup>, Lauriane Ribas-Deulofeu<sup>1</sup>,  
Yoko Nozawa<sup>2</sup>, Vianney Denis<sup>1</sup>

1 Institute of Oceanography, National Taiwan University, Taipei, Taiwan

2 Biodiversity Research Center, Academia Sinica, Taipei, Taiwan

\*Email: [menghsinmorriswu@gmail.com](mailto:menghsinmorriswu@gmail.com)

### **Abstract**

The loss of resilience of benthic communities is often associated with their flattening, but little is known about variations in structural complexity across natural environmental gradients. Therefore, conclusions on a worldwide resilience loss of coral ecosystems drawn from a few case studies cannot be generalized. Taiwan, located in a tropical-subtropical transition zone, is an ideal location for examining the relationship between the composition of the biotic assemblage and structural complexity. Using Structure-from-Motion photogrammetry, we built Digital Elevation Models (DEM) at 25 plots (5 x 5 m) distributed across five coral regions (Kenting, Lanyu, Ludao, East, and North) spanning a latitudinal gradient from 21.929 ° N to 25.144 ° N. From seven indicators, we selected four sets of metrics (slope, profile curvature, planform curvature, and vector-ruggedness-measure) to measure relevant facets of reef complexity from DEM. Benthic composition was assessed by manually labelling orthomosaic images. We found regional differences in rough-scale profile curvature, but only the rough-scale planform curvature showed a negative correlation with increasing latitudes. Despite significant differences in benthic composition, similar levels of fine-scale complexity were found in the different regions. This suggests that contrasting taxa may provide equally important fine-scale refuges. Overall, our results provide important insights into the role of high-latitude communities under climate change and our understanding of ecological phase shifts in transition zones.

## Impacts of turbulence induced vertical nutrient flux on phytoplankton size structure in the Kuroshio east of Taiwan

Zhong kai Shiao<sup>1</sup>, Chih hao Hsieh<sup>1,2,3</sup>

1 Institute of Oceanography, National Taiwan University, Taipei City

2 Institute of Ecology and Evolutionary Biology, Department of Life Science, National  
Taiwan University, Taipei City

3 Research Center for Environmental Changes, Academia Sinica, Taipei City

### Abstract

Little research has been done in the Kuroshio passing eastern Taiwan investigating the relationship among the three critical factors: turbulent intensity, nutrient flux and phytoplankton size. We examine whether turbulence intensity will increase nutrient flux, which will in turn affect phytoplankton size structure. To study the effect of nutrient flux on phytoplankton growth due to turbulence, we collected water samples and turbulence data from the KTV1 transect between 121.72° and 123° E at 23.75° N of the Kuroshio. Nutrient concentration was determined by flow-injection analyzer, size of phytoplankton is measured with FlowCam. We found that the nutrient concentration increased when under strong turbulence. Due to the increased nutrient flux, the nutrient concentration is raised. It can be inferred from the positive correlation between turbulence intensity and nutrient flux. Nutrient availability makes the growth rates of different size groups of phytoplankton, which leads to the differentiation of size structure.

**Keywords:** Turbulent intensity, Nutrient flux, Phytoplankton size structure

# 以幾何形態分析與耳石形態變化探討暖化對尖翅燕魚初期生活史的影響

石楷<sup>1</sup>、張桂祥<sup>1,2</sup>、謝泓諺<sup>1</sup>

<sup>1</sup>國立東華大學海洋生物研究所

<sup>2</sup>國立中山大學海洋科學與科技全英語博士學位學程

### 摘要

IPCC 2021報告預測全球溫度將在2040年升溫1.5°C。變溫動物的體溫會隨著環境溫度而變化，進而影響魚類發育。由於魚類初期生長階段的生理恆定，代謝速率相較其他生長階段快，對環境壓力的變化更敏感易於觀察其影響。由過去對於燕魚屬稚魚期之覓食行為，不同的體長具不同的覓食方式，但於仔魚期的相關研究則甚少。因此本實驗透過幾何形態分析及矢狀耳石形態變化，探討暖化對尖翅燕魚 (*Platax teira*) 仔稚魚前端身軀的形態及耳石形態指標(shape indices)變化的影響。結果顯示在孵化後第十天，暖化組(30°C)的仔稚魚體長與乾重顯著大於控制組(27°C)。排列檢測(Permutation test)及主成份分析(PCA)結果顯示，兩組之仔稚魚形態具顯著性差異，其洩殖孔、額頭前端，匙骨癒合處及鰓蓋上緣末端具位移現象。此外，耳石的長、寬、周長、面積、圓率、方率、圓度、橢圓度、方波係數及長寬比於兩組間也皆具顯著性差異。整體而言，海水暖化不會造成尖翅燕魚仔稚魚死亡率的上升，但初期生長階段的體形和耳石形態發生異速生長的現象。



## 台灣梅氏長海膽的族群遺傳學研究

<sup>1</sup>鐘晟齊、<sup>2</sup>劉莉蓮、<sup>1,3</sup>林梅芳

<sup>1</sup>國立中山大學海洋生物科技暨資源學系

<sup>2</sup>國立中山大學海洋科學系

<sup>3</sup>國立中山大學海洋生物科技博士學位學程

### 摘要

梅氏長海膽 (*Echinometra mathaei*) 為台灣岩岸潮間帶常見的物種，會挖鑿洞穴，用於自身棲所，這些洞穴也提供其他海洋生物躲藏空間。前人研究，沖繩地區的梅氏長海膽，依據型態與粒線體 DNA 差異，可分為四個不同種：*E. sp. A*、*E. mathaei*、*E. sp. C*、*E. oblonga*，而台灣只有紀錄梅氏長海膽一個種。根據調查，小琉球的肚子坪出現海膽荒礁，其中海膽數量最多的為梅氏長海膽。本研究為了瞭解梅氏長海膽在肚子坪與台灣周遭的族群差異，收集台灣周遭的梅氏長海膽，利用部分粒線體 COI 基因序列進行族群遺傳與親緣關係分析。結果顯示，和沖繩地區的物種組成類似，台灣也有四種長海膽屬的物種。其中，*E. sp. C* 為台灣分佈最為廣泛的物種，而且與其它物種相比具有較低的基因多樣性。另外，基因序列資料，顯示在小琉球肚子坪的海膽為 *E. sp. C*。本研究可以增進瞭解台灣長海膽屬的基因多樣性，進而對海洋保護區的設立與規劃提出貢獻。

## 生活史特徵，氣候變遷與漁撈壓力對魚類族群的空間同步效應之影響

### Life-history traits, climate transitions and fishing effects on the spatial synchrony of fish dynamics

林哲越, 謝志豪  
國立台灣大學海洋研究所

#### 摘要

Spatial synchrony — spatially separated populations simultaneously exhibit similar abundance fluctuations, is a common feature in population dynamics. The pattern of spatial synchrony can vary under the influence of intrinsic and extrinsic processes. Here, we studied how spatial synchrony responds under three underlying mechanisms: life-history traits, climate change, and fishing. We analyzed twenty-nine exploited and unexploited fish species, sea surface temperature (SST), and wind speed from 1951–2007 using data extracted from the California Cooperative Oceanic Fisheries Investigations (CalCOFI). Our results revealed that local scale of spatial synchrony ( $\rho_0$ ) decrease with increasing life-history trait values, meaning that species with traits related to k-strategy tend to have lower synchrony in nearby regions. As expected, climate changes had modified spatial synchrony of fishes and environmental variables. Specifically, four of six species (with complete spatial synchrony pattern), SST, and wind speed show increase in synchrony during the warm climate phase. Furthermore, the increase in synchrony of environmental variables might further lead to the increase in synchrony of fish species. Fishing also had altered species' spatial synchrony pattern, through affecting synchrony in local regions and its scale (the range that population are highly correlated). Exploited species show higher  $\rho_0$  than unexploited species, after accounting for their life-history traits. We also apply an overlapping moving window method to investigate whether higher harvesting intensity enhanced exploited species' synchrony pattern. When harvesting intensity increased,  $\rho_0$  of northern anchovy and Pacific sardine showed an increasing trend. On the contrary, Pacific hake and Pacific mackerel showed a decreasing trend. For the spatial scale, only Pacific hake showed an increasing trend with higher fishing intensity. However, northern anchovy, Pacific sardine, and Pacific mackerel all showed a decreasing trend. Those results indicate that life-history traits, climate change, and fishing can modulate the spatial synchrony of fishes. Our findings highlight the importance of spatial synchrony in fishery management, providing a useful criterion to evaluate species' extinction risk.

## 海洋遊憩承載量之評估：以小琉球之潮間帶為例

張瑋珍<sup>1\*</sup>、張水錯<sup>1</sup>

<sup>1</sup>國立中山大學海洋事務研究所

### 摘 要

近年來，小琉球旅遊人潮急劇上升，雖帶來觀光效益，卻對當地潮間帶生態造成衝擊，並影響遊客體驗或當地觀光經營。為有效限制潮間帶之遊憩使用，並同時為遊客帶來最大生態教育機會，本研究以小琉球自然人文生態景觀區之五個潮間帶作為研究區，進行遊憩承載量之估算。本研究對遊憩承載量之估算以生態有效承載量的評估為主，並考慮到社會承載量及設施承載量之結果進行調整，提出小琉球潮間帶承載量之建議。本研究為國際上首次針對珊瑚礁潮間帶進行遊憩承載量評估之研究，亦為國內首次以國際常用之Cifuentes(1992)方法為基礎進行改良的研究，故其評估方法及成果具有參考價值，但亦有可繼續改善的空間。結果將供管理單位參考，並進一步與利害關係人協調後採取措施。

關鍵字：遊憩承載量、潮間帶、小琉球、生態旅遊

## 臺灣西部沿岸改良式底拖網調查之頭足類多樣性與時空分布

吳億鈴<sup>1</sup>、何瓊紋<sup>2</sup>、陳煦森<sup>3</sup>、陳國書<sup>4</sup>、徐顛雯<sup>5</sup>、陳志遠<sup>6</sup>、陳孟仙<sup>1,7</sup>

<sup>1</sup> 國立中山大學海洋生態與保育研究所

<sup>2</sup> 國立中興大學生命科學系

<sup>3</sup> 國立屏東科技大學水產養殖系

<sup>4</sup> 國家海洋研究院海洋生態與保育研究中心

<sup>5</sup> 台江國家公園解說課

<sup>6</sup> 國立高雄科技大學海洋環境工程系

<sup>7</sup> 國立中山大學海洋科學系

### 摘要

本研究於2007-2021年，以研究船「海研三號」和「新海研三號」的改良桁桿式蝦拖網調查臺灣西部沿岸（苗栗至枋寮）頭足類的物種組成，並以溫鹽深儀（Conductivity-Temperature-Depth measures, CTDs）蒐集水文因子。研究期間共採獲頭足類6科12屬34分類物種（taxa），前六優勢種分別為虎斑烏賊（*Sepia pharaonis*）、唇瓣烏賊（*S. lycidas*）、金烏賊（*S. esculenta*）、貝瑞氏四盤耳烏賊（*Euprymna berryi*）、日本暗耳烏賊（*Inioctopus japonica*）和火槍魷（*Loliolus beka*），佔73.4%。臺灣西部沿海的頭足類群聚組成有顯著的緯度和水深的差異（ $p < 0.05$ ），但無明顯的年間變化。以「七股-茄荳」為界分為南北兩群，以及水深約100 m以深的「澎湖水道」群。北群的優勢種為唇瓣烏賊、日本暗耳烏賊、火槍魷和沙蛸（*Amphioctopus aegina*），南群的優勢種為虎斑烏賊和金烏賊，澎湖水道群則以條紋蛸（*A. marginatus*）和日本暗耳烏賊為優勢。PCA結果顯示，現場採樣時的底層溫鹽呈現明顯的季節變化和顯著的水深不同，但無明顯的南北的差異。顯示頭足類的種類組成分群可能與溫鹽適應、海流和棲地偏好有關。

# 海報競賽摘要

## 冬季黑潮行為研究

張喬瑄

中山大學海洋科學系大學三年級

### 摘 要

本研究利用綠島西方外海的錨碇流剖儀ADCP所測得的流速資料，與衛星量測海表面高度資料做比對，並透過頻帶分析、FFT、調和分析及EOF探討2020.11.19~2021.4.8 五個月間觀測之黑潮變動與中尺度渦漩之間的關係。

## 自動化偵測中尺度渦旋和葉綠素濃度分佈

魏以婷、曹俊和

國立臺灣海洋大學海洋環境資訊系研究所

### 摘要

在西北太平洋副熱帶海域的「海洋沙漠」，其海表面低葉綠素濃度的特徵可從衛星水色影像清楚觀察到。但是，在一些海洋及大氣的誘發條件下，該區葉綠素濃度會明顯升高，呈現海洋渦旋的痕跡。於東經 150 度至 180 度及北緯 15 度至 30 度之間，本研究使用衛星高度計追蹤渦旋，以探討葉綠素濃度在渦旋活躍區中的分佈情形，並根據正反氣旋渦與高低葉綠素濃度的個案分成四類來討論：(1)高葉綠素濃度的氣旋渦中心、(2)低葉綠素濃度的反氣旋渦中心、(3)低葉綠素濃度的氣旋渦中心和(4)高葉綠素濃度的反氣旋渦中心。根據 20 年時間的統計分析結果顯示，在夏季，約有 24.21%的氣旋渦中心有較高的葉綠素濃度，有趣的是，低葉綠素濃度的氣旋渦中心約有 10.60%的案例，前者為傳統已知的想法(氣旋渦中心的湧升流造成表面高葉綠素濃度)，後者則與前者相反，即氣旋渦中心的葉綠素濃度偏低，其發生機率接近前者的一半。在反氣旋渦方面，約有 20.61%的渦中心有較低的葉綠素濃度，而約 13.02%高葉綠素濃度中心的案例，後者發生機率仍有前者的一半。在冬季，約 12.70%的氣旋渦中心有較高的葉綠素濃度，而約 3.85%的氣旋渦中心有較低的葉綠素濃度。在反氣旋渦方面，約有 5.14%的渦中心有較低的葉綠素濃度，但約 16.11%的渦中心有較高的葉綠素濃度，不符合傳統已知想法(反氣旋渦中心的沉降流造成表面葉綠素濃度偏低)的個案比例竟然在冬天比較多。本研究工作證實了，無論是冬天或夏天，在西北太平洋副熱帶海域的反氣旋渦中心可出現葉綠素濃度偏高的情況，而氣旋渦中心的葉綠素濃度則能偏低。除外，本研究工作所發展的程式能自動化地偵測渦旋和葉綠素濃度的分佈情形，未來若能夠更深入地探討其動力機制，將有助於海洋生物地質化學在海洋渦旋的議題探討。



## 於台灣東邊向東進入副熱帶環流的黑潮分支

蘇煜鈞、曹俊和

國立臺灣海洋大學海洋環境資訊系

### 摘要

在北太平洋副熱帶海域，因副熱帶逆流(Subtropical Countercurrent, STCC)與北赤道流交互作用造成海洋的斜壓不穩定，使得該海域常伴隨著許多渦漩。本研究使用衛星高度計和浮標觀測資料，於2013年6月到8月期間的台灣東部觀察到一條異常海流從黑潮主軸向東分支，並持續將高濃度葉綠素輸送至太平洋副熱帶環流區域。在強勁氣旋風和南北溫度梯度的作用下，副熱帶海洋鋒面加強，進一步增強向東的流場。根據研究結果，推斷導致該異常向東海流的機制與氣旋風場無關，而是與北太平洋副熱帶海域之渦漩所產生的地轉流有關。除外，使用了100個虛擬浮標進行模擬和統計，結果顯示，該異常向東流在2013年，流至東經 $132^{\circ}$ 的發生機率大約為28%。

# Future Projection and Variability of Kuroshio under Global Warming

Jo-Hsu Huang, Yu-Heng Tseng, Yi-Chun Kuo  
Institute of Oceanography, National Taiwan University, Taipei, Taiwan

## Abstract

Kuroshio plays a critical role in the ocean ecosystem, weather, and even climate in the Western North Pacific through its significant heat transport and air-sea interaction. The future change and dominant mechanism behind it under global warming remain unclear. Some previous studies suggested a negative midlatitude wind stress curl (WSC) tendency, potentially driven by El Niño or Arctic Oscillation, may accelerate the Kuroshio recirculation. The other studies found that the warmer subtropical mode water (STMW) might be transported to the east of the Kuroshio in the East China Sea (ECS-Kuroshio) along the isopycnals, enhancing the upper-layer velocity under a warmer climate.

Our analysis of the ensemble of 28 CMIP6 low-resolution models in the SSP5-8.5 future scenario projection shows that the kinetic energy (KE) tendency of the Kuroshio along Japanese coast (JP-Kuroshio) is positive while the ECS-Kuroshio is negative. The KE of ECS-Kuroshio increases in the upper 300m and decreases below 300m (i.e., baroclinic change). Compared with the result above, the ensemble of 5 eddy-permitting models shows that the JP-Kuroshio, including the southern recirculation gyre (SRG), enhances more dramatically and the Kuroshio extension moves poleward, while the KE of ECS-Kuroshio decreases in the upper layer. This suggests the consistent baroclinic increase in ECS is not evident in the eddy-permitting models. We also find that the meridional transport change negatively correlates well with the WSC change overall. Particularly, the meridional transport change of the JP-Kuroshio is more sensitive to the WSC in eddy-permitting models. Further ocean model experiments using SSP5-8.5 scenario suggest that warmer SST dominates the Kuroshio change in the upper 300m to the south of 35°N while the impact of WSC determines the change below 300m. Warmer isopycnal temperature transport through the STMW pathway increases the horizontal gradient across the Kuroshio.

# Ocean thermal responses of typhoon Kompasu (2010) over the East China Sea

Thi-Kieu-Diem Nguyen<sup>1</sup> and Po-Chun Hsu<sup>1,2</sup>

<sup>1</sup> Center for Space and Remote Sensing Research, National Central University, Taiwan

<sup>2</sup> Institute of Hydrological and Oceanic Sciences, National Central University, Taiwan

## Abstract

Cyclonic storms, such as typhoons, are among the most devastating natural phenomena, posing significant risks to human life and infrastructure, particularly in coastal regions. Accurate forecasting of these events is essential for mitigating their consequences. In 2010, Typhoon Kompasu intensified to a Category-3 with a 105 knots increase in early September, lingering over the shallow East China Sea for six hours. This event caused significant damage across the Korean Peninsula, including a direct hit on Seoul, not experienced since Typhoon Papiroon in 2000. To scrutinize the interaction between Typhoon Kompasu and the ocean in the shallow East China Sea region, this study utilized satellite observations, reanalysis datasets, and ocean mixing models. The findings indicate that the typhoon induced a substantial cooling effect on sea surface temperature ( $\sim 5^{\circ}\text{C}$ ) to the right of its track, which is attributable to an anomalous ocean thermal structure. Due to the presence of warming sea surface temperature (SST) around  $30^{\circ}\text{C}$ , the dominance of the Yellow Sea cold bottom water, and significant stratification effects may have hindered vertical mixing. The ocean mixing model revealed that shallow water depth could suppress SST cooling during the intensification of both typhoons, as warm SST is maintained in shallow waters due to the absence of deep cold water. Furthermore, the air-sea heat flux provided substantial energy from the ocean to the typhoon, while atmospheric conditions were conducive to the intensification process. The study thoroughly quantified the oceanic thermal responses to Typhoon Kompasu's intensification. The findings offer insights into the intensification of Typhoon Kompasu compared to other cyclonic events that did not undergo intensification in this unique region and highlight the influence of shallow waters on alterations in typhoon intensity. Moreover, the study's results can inform future predictions of oceanic behavior during extreme meteorological occurrences.

## Suppressing Wind Stress Variability Leads To Stronger Arctic Warming Via Ocean Heat Transports

減少風應力變動造成更溫暖的北極氣候

Yen-Chi Wu<sup>1</sup>, Yu-Chiao Liang<sup>1\*</sup>, Sarah Larson<sup>2</sup>, Kay McMonigal<sup>2</sup>, and Yu-Heng Tseng<sup>3</sup>

<sup>1</sup>Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan

<sup>2</sup>Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC, USA

<sup>3</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan

\*Correspondence to: ricky95175@gmail.com, yuchiaoliang@ntu.edu.tw

### Abstract

The Arctic amplification (AA) – the near-surface air temperatures in the Arctic warm 3-4 times more than those in the rest of globe – is the most pronounced feature as a consequence of anthropogenic climate change. While the local radiative feedbacks have been identified as the regional contributors to the amplified Arctic warming, the remote impacts of atmospheric and oceanic heat transports can also play important roles. In this study, we examine the role of oceanic heat transport (OHT) in producing AA with a focus on the contribution of wind stress variability from the atmosphere. We conduct large-ensemble simulations with the mechanically decoupled technique, which relaxes the wind stress to only seasonal climatology values, under the framework of Community Earth System Model version 2 (CESM2). Comparing the results with the fully-coupled atmosphere-ocean-sea ice-land model simulations, we find that suppressing wind stress variability gives rise to enhanced OHT into the Arctic, stronger ocean-to-atmosphere heat fluxes, and resultant warmer near-surface air temperature in the Arctic. Further decomposition of OHT shows that the mean change, rather than the eddy component, dominates. We also analyze the vertical profiles of oceanic temperature, salinity, and mixed layer depth, which are modified by the enhanced OHT. Our results highlight that the Arctic climate system is sensitive to wind stress variability as well as mid-latitude ocean dynamical processes.

## 探討 *Gracilaria* 在不同環境下之成長率及對固碳的貢

### 獻

王嫻婷

國立中山大學海洋科學系

### 摘要

自工業革命至今，人類已經釋放了大約 1.5 兆噸二氧化碳，大氣中的二氧化碳含量比工業化時期前高出 50% 以上，根據研究指出，突破新高的溫室氣體濃度，已經造成了嚴重的熱浪和不斷惡化的洪水、乾旱和風暴，如果溫度上升超過工業化前時代 1.5°C 以上，這些影響將變成災難性的。因此，如何有效控制二氧化碳及其他溫室氣體，已成為全球不可忽視的課題。**碳匯 (carbon sink) 是儲存二氧化碳的天然或人工「倉庫」**，占全球面積 71% 的海洋可以儲存大量的碳，而海洋裡的植物性「藍碳」除了海草、鹽沼地和紅樹林，分布甚廣的藻類也是固碳重要的一環。海藻的減碳方式和植林一樣，利用光合作用將二氧化碳轉換為有機碳及氧氣，但具有生長速率較快及較低的土地面積依存度等優勢，是現今備受關注的固碳明星。龍鬚菜(*Gracilaria*)就是其中之一，台灣及世界各沿岸地區常見的大型藻，是紅藻門江蘘科之下的一個屬，為重要的經濟藻類，除了是鮑魚養殖之優質飼料，又可作為提煉瓊膠的上等原料和人類的保健食品，其產量是水產養殖增長最快的行業之一，佔 2019 年全球海藻原料供應鏈的 10.5%。雖為廣鹽性植物(5-60 psu)，但因為異常氣候與環境的變遷，導致淡水資源將變得不穩定，未來將邁向純海水養殖、淺海養殖以及海上箱網養殖，這也表示藻類的養將會受到限制，如何將海藻產量提高來將固碳最大化，是值得思考的方向。

本研究針對龍鬚菜(*Gracilaria tenuistipitata*)進行實驗培養，觀察分別在不同鹽度-5,10,15,20,25,30 之生長率，找出較適合的生長環境，並且利用最後的總含碳量推算每年大規模之養殖的總固碳量。

## 強烈冬季冷氣團對南海北部低緯度海洋生地化的衝擊

符姍妤

海軍軍官學校應用科學系

### 摘要

隨著全球變遷的速度、頻率及強度持續上升，天氣現象的驟變及人類生活的衝擊，極端天氣事件的產生是現今不可忽視的議題。冬季時，負相位北極振盪（Arctic Oscillation, AO）不同於正相位 AO，代表的是圍繞北極的西風減弱，使極區的冷空氣不但直接影響中高緯度地區，進而南下至低緯度地區。南下的冷空氣與東北季風加乘後，形成一股影響範圍大、時間長及溫度低的強烈冷氣團。此低溫效應在我們 2018、2021 及 2022 年 1 月份的初步研究成果表明，負相位（冷相位）AO 的低溫、強風及高浪，皆是造成低緯度海域海洋浮游植物垂直分布特徵改變及生物量增加的主因。然而這受到負相位 AO 刺激而改變的生地化現象是否能夠增加低緯度海域的碳吸收及碳移除，則需要進一步的研究驗證，因此本研究案的立論假設：

1. 負相位 AO 的低溫效應，改變低緯度海域冬季的生地化參數、浮游植物的垂直結構與組成。
2. 負相位 AO 能夠有效地刺激透光層中浮游植物的生長，增加浮游植物的固碳速率。
3. 負相位 AO 能夠強化透光層中的生物代謝，並進一步提升自透光層輸出至更深海底的碳通量，強化低緯度海洋的碳輸出能力及生物幫浦。

## Spatiotemporal Variations of Partial Pressure of Carbon Dioxide in Chiku Lagoon during Summer

Fei-Ling Yuan<sup>1</sup>, Wei-Ming Chen<sup>2</sup>, Kuei-Chen Huang<sup>1</sup>, Kai-Jung Kao<sup>1</sup>, Veran  
Weerathunga<sup>1</sup>, Wen-Cen Chou<sup>3</sup>, Wei-Jen Huang<sup>1\*</sup>,

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University

<sup>2</sup>Department of Electrical Engineering, National Sun Yat-sen University

<sup>3</sup>Institute of Marine Environment and Ecology, National Taiwan Ocean University

### Abstract

Coastal water environments are integral to the global carbon cycle due to their dynamic carbonate systems, which involve complex biogeochemical and physical processes. However, our understanding of these systems is limited by a lack of spatiotemporal data on the partial pressure of carbon dioxide ( $p\text{CO}_2$ ) variations. In response, we deployed five lab-made autonomous buoy for tidal carbon dioxide (ABTC) in Chiku Lagoon during the summer of 2020 (August 31<sup>st</sup> to September 2<sup>nd</sup>). Surface water temperature, salinity, and  $p\text{CO}_2$  were measured in the upper, middle, and lower regions of the lagoon for 48 consecutive hours with a one-minute sampling interval. Our results indicate that the average  $p\text{CO}_2$  value was  $870 \pm 218 \mu\text{atm}$  in Chiku Lagoon in summer. Additionally, the  $p\text{CO}_2$  variations exhibited a clear spatial gradient, with higher  $p\text{CO}_2$  values observed in the upper region ( $2325 \pm 875 \mu\text{atm}$ ) compared to those in the lower region ( $426 \pm 17 \mu\text{atm}$ ). Furthermore, the upper, middle, and lower lagoons all displayed a significant diel cycle, with lower daytime  $p\text{CO}_2$  values than nighttime values. The lower lagoon near the seawater inlet was an exception, where may mainly display the seawater  $p\text{CO}_2$  signal. Overall, we suggest that Chiku Lagoon acted as a source of atmospheric  $\text{CO}_2$  of  $33.8 \pm 16.3 \text{ mmol m}^{-2} \text{ day}^{-1}$  ( $1.41 \pm 0.68 \text{ mmol m}^{-2} \text{ hour}^{-1}$ ) in summer.



# 1. Carbon dioxide air-water gas exchange in clam and fish aquaculture ponds in southern Taiwan, a preliminary result

Veran Weerathunga<sup>1</sup>, Li-Lian Liu<sup>1</sup>, Fei-Ling Yuan<sup>1</sup>, Sheng Xiang Xu<sup>1</sup>, Kai-Jung Kao<sup>1</sup>, Kuei-Chen Huang<sup>1</sup>, Wei-Ming Chen<sup>1</sup>, Wei-Jen Huang<sup>1\*</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan  
Correspondence to: Wei-Jen Huang ([wjhuang29@mail.nsysu.edu.tw](mailto:wjhuang29@mail.nsysu.edu.tw))

## 2. Abstract

The expansion of inland aquaculture has highlighted the importance of investigating the air-water carbon dioxide (CO<sub>2</sub>) gas exchange in these ponds due to concerns over anthropogenic carbon emissions. However, only few studies have focused on air-water CO<sub>2</sub> gas exchange in clam and fishponds. To address this, we deployed a lab-made autonomous buoy for tidal CO<sub>2</sub> (ABTC) in three clam and three fishponds on the west coast of Taiwan and measured partial pressure CO<sub>2</sub> (*p*CO<sub>2</sub>) at the air-water interface for 24 hours during three culture stages (stocking, middle, and harvesting) from April 2021 to June 2022. CO<sub>2</sub> fluxes were calculated based on the differences between air-water *p*CO<sub>2</sub> and wind speeds. In all ponds, fluxes were stronger during the daytime due to higher wind speeds compared to nighttime. Clam ponds acted as a sink of atmospheric CO<sub>2</sub>

during the stocking stage but became a source during the harvesting stage. Throughout the culture cycle, fishponds consistently acted as a source of atmospheric CO<sub>2</sub>, with the flux becoming stronger over the course of the culture cycle. These findings suggest that culture species and culture stage-based changes in management practices should be considered when estimating air-water CO<sub>2</sub> fluxes in aquaculture ponds. Overall, during one culture cycle, clam ponds acted as a net sink of atmospheric CO<sub>2</sub> ( $1.0 \pm 18.8$  mmol m<sup>-2</sup> d<sup>-1</sup>), while fishponds acted as a net source ( $15.9 \pm 21.3$  mmol m<sup>-2</sup> d<sup>-1</sup>).

## 夏季熱帶西北太平洋海域之基礎生產力與海洋生物幫浦的關係

沈家瑜

海洋環境與生態研究所

### 摘要

自工業革命以來大氣中的二氧化碳濃度便持續在增加，導致全球氣候及生態環境發生異常，尋找儲碳、減碳的方式是現今刻不容緩的議題。已知海洋可透過基礎生產力及生物幫浦，將溶於海中的二氧化碳經由食物網輸送並封存至深海，對調節二氧化碳濃度有重大的貢獻，然而目前對於海洋儲碳能力的估算仍存在著很大誤差，因此有必要瞭解基礎生產力與生物幫浦碳之間的關係以更準確地量化海洋碳匯。本研究以西北太平洋熱帶貧營養海域作為研究場址，於 2021 年 8 月及 2022 年 6 月調查其基礎生產力及生物幫浦碳通量，同時評估利用簡化食物網模式推算生物幫浦碳通量的可行性。根據觀測結果，2021 年夏季航次的基礎生產力平均為  $183 \pm 39 \text{ mgC m}^{-2} \text{ d}^{-1}$  ( $143\text{-}246 \text{ mgC m}^{-2} \text{ d}^{-1}$ )，其中約 80-93% 是由體型小於  $20 \mu\text{m}$  的超微和細微植物性浮游生物所貢獻。而在 2022 年夏季航次的基礎生產力平均為  $211 \pm 120 \text{ mgC m}^{-2} \text{ d}^{-1}$  ( $104\text{-}345 \text{ mgC m}^{-2} \text{ d}^{-1}$ )，部分測站之基礎生產力高於 2021 年航次的結果，推測是由於其中有約 26-36% 是由體型大於  $20 \mu\text{m}$  的微型植物性浮游生物貢獻導致，顯示植物性浮游生物大小對基礎生產力多寡的影響。本研究首次於 2022 年夏季航次以繫繩式漂浮式沉積物收集器取得兩個測站的現場沉降顆粒數據，得出離開有光層的顆粒有機碳通量分別為 78 及  $43 \text{ mgC m}^{-2} \text{ d}^{-1}$ ，同時利用兩站的基礎生產力(分別為 115 及  $240 \text{ mgC m}^{-2} \text{ d}^{-1}$ )及簡化食物網模式估算之碳通量分別為 15 及  $36 \text{ mgC m}^{-2} \text{ d}^{-1}$ ，結果顯示後者實測值與估算值相近，但前者實測值與估算值有明顯差異且呈現低基礎生產力、高碳通量的現象。綜上所述此模式有一定的可用性，然其適用性仍需更多的實測資料進行驗證。

## 台灣北部大氣懸浮微粒中水溶性醣類及營養鹽化學計量變異 之研究

*The study of water-soluble carbohydrates and stoichiometric variations of nutrients in atmospheric suspended particles over the northern Taiwan*

劉亭玟 陳宏瑜

國立臺灣海洋大學 海洋環境資訊系

### 摘要

溶解有機碳(dissolved organic carbon; DOC)是海洋中最活躍的有機碳儲層之一，而碳水化合物已被證實在海洋中占比高達 50%，其中，海源氣溶膠(sea spray aerosol; SSA)被視為海洋碳水化合物進入大氣的主要途徑，因此本研究之採樣點位於東海南部的基隆市海岸邊，於 2010 年 12 月至 2011 年 11 月期間，採集了 60 個大氣懸浮微粒樣本，進行水溶性總碳水化合物(water-soluble total carbohydrates; WS-TCHO)、單醣與多醣(water-soluble monosaccharide and polysaccharides; WS-MCHO and WS-PCHO)及水溶性無機氮和磷物種(water-soluble inorganic nitrogen and phosphorus; WS-IN and WS-IP)之分析，並以氣團軌跡回推資料，探討採集之大氣懸浮來源。

採樣期間大氣總懸浮微粒平均質量濃度為  $0.138 \pm 0.081 \text{ mg} \cdot \text{m}^{-3}$ ，最大值為  $0.429 \text{ mg} \cdot \text{m}^{-3}$ ，銨鹽平均濃度為  $70.7 \pm 37.6 \text{ nmol} \cdot \text{m}^{-3}$ ，硝酸鹽平均濃度為  $94.3 \pm 41.6 \text{ nmol} \cdot \text{m}^{-3}$ ，水溶性無機氮平均濃度為  $165.4 \pm 76.1 \text{ nmol} \cdot \text{m}^{-3}$ ，水溶性無機磷平均濃度為  $0.34 \pm 0.16 \text{ nmol} \cdot \text{m}^{-3}$ ，水溶性總碳水化合物平均濃度為  $6.71 \pm 1.19 \text{ nmol} \cdot \text{m}^{-3}$ ，其中單醣平均濃度為  $3.89 \pm 0.88 \text{ nmol} \cdot \text{m}^{-3}$ ；多醣為  $3.16 \pm 2.72 \text{ nmol} \cdot \text{m}^{-3}$ 。此區域中，WS-IN/WS-IP 的比值為  $492 \pm 66$ ，主要受季節變化影響，而 WS-IN/WS-TCHO 的比值為  $25.5 \pm 12.9$ ；WS-IP/WS-TCHO 的比值為  $0.05 \pm 0.03$ ，兩者具有相似趨勢，且在十月時有最高值，比值分別為 52.4 與 0.1。單醣較多醣的占比高，約占總碳水化合物中的六成，表明生物可直接利用的比例高。

大氣懸浮微粒之來源，在春天、秋天與冬天以大陸性來源為主；而夏天則以區域性與海洋性來源為主。研究結果顯示：總碳水化合物僅在春季有明顯較高，推測與春季時植物光合作用旺盛有所相關。透過相關性分析，水溶性無機氮和水溶性無機磷之間有高度相關性，此結果表示兩者有著相似的大陸性來源；但碳水化合物與這兩者間並無顯著相關性，說明碳水化合物與無機物種的來源不同。

## Response of tropical corals to ocean acidification and marine lead pollution in the northern South China Sea

Hong Yi Chen<sup>1</sup>, Kuo-Fang Huang<sup>2</sup>, Li Lo<sup>1</sup>, Haojia Abby Ren<sup>1</sup>

<sup>1</sup> Department of Geosciences, National Taiwan University, Taipei, Taiwan

<sup>2</sup> Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan

### Abstract

Increasing anthropogenic CO<sub>2</sub> from fossil fuel combustion and land-use practices is reducing surface ocean *pH* (i.e. ocean acidification, OA), leading to the reduction of marine carbonate saturation state ( $\Omega$ ). The associated decline in  $\Omega$  (and seawater carbonate ion concentration, [CO<sub>3</sub><sup>2-</sup>]) could substantially impact calcifying organisms, such as scleractinian corals, and potentially threaten coral calcification and the existence of these unique ecosystems. Marginal seas are particularly susceptible to the influence of natural variability and human activities, and are thus critical areas for studying the response of coral reef ecosystem to environmental changes. Additionally, metal pollutant emitted from industrial activities, such as lead (Pb), has become increasingly severe due to rapid developments of industries and populations in Southeast Asia.

The South China Sea (SCS) is under the influence of the East Asia monsoon system and can serve as an ideal location for investigating interactions between atmosphere, ocean, and anthropogenic influences. Here we present multi-proxy coral records of *Porites sp.* collected from the Dongsha Atoll in the northern SCS on seasonal basis from 1968 to 2010 CE. Coralline  $\delta^{11}\text{B}$  and B/Ca are used as a proxy for calcifying fluid *pH* ( $pH_{cf}$ ) and [CO<sub>3</sub><sup>2-</sup>], respectively, to better constrain aragonite saturation state ( $\Omega_{arag}$ ). The reconstructed  $pH_{cf}$  exhibits a rapid decline over the last 50 years ( $-0.0019 \pm 0.0009$   $pH_{cf}$  year<sup>-1</sup>) and the rising *pCO*<sub>2</sub> can be primarily attributed to the anthropogenic influence. In contrast, the reconstructed  $\Omega_{arag}$  remains relatively constant, suggesting that Dongsha corals are resistant to OA by self-regulation on the carbonate system of the calcifying fluid. The surface ocean *pH* ( $pH_{sw}$ ) exhibits a more secular trend of decreasing *pH* ( $-0.0034 \pm 0.0020$   $pH_{sw}$  year<sup>-1</sup>) since 1968 CE, implying a progressively difficult marine environment for marine calcifiers in the foreseeable future of the SCS.

On the other hand, the coralline Pb/Ca and Pb isotope (<sup>206</sup>Pb/<sup>207</sup>Pb) records are applied to reconstruct the pollution history of Pb and to trace the seasonal variation of Pb sources in the northern SCS. Our results show a gradual increase in skeletal Pb/Ca since 1968 CE, indicating a gradual rise in Pb pollution, particularly after 2000, in coincident with the period of rapid economic development in China and Southeast Asia. The lower <sup>206</sup>Pb/<sup>207</sup>Pb ratios during the winter monsoon period indicate the dominant influence of the isotopic signal from Chinese petrol. Conversely, the slightly higher <sup>206</sup>Pb/<sup>207</sup>Pb ratios suggest a smaller contribution from Chinese-emitted Pb in the summer monsoon period. Compared to the other coral records which are strongly influenced by riverine sediment signals, our record from Dongsha provides a more representative and comprehensive documentation about the historical Pb pollution in the northern SCS.

## 以EXCEL軟體進行自動分析儀訊號的擷取與分析 -以磷酸鹽測定為例

黃柏豪

國立臺灣師範大學地球科學所

### 摘 要

海洋化學探勘經常使用的自動分析儀器，然而各種分析儀都有自己的控制方式、數據處理的軟體。本研究嘗試使用EXCEL軟體，建立一個通用於所有廠牌的信號擷取與處理應用的VBA程式，並根據因為各儀器的輸出方式不一樣，鮑率(baud rate)也不同，首先要建立一個傳輸用的封包，使及時數據按照固定時間一筆的速度，存於指定的EXCEL試算表位置。已擷取的數據可由VBA建立即時或延時的展示圖形、並自動判斷基線及峰值。如果也預先將輸入減量線數據獲取吸光係數，將即時輸入螢幕顯現的原始數據轉換為濃度，不但減少人為抄寫的繁瑣，也降低了可能發生的計算錯誤，使用者測定完畢後只須將EXCEL存檔即可保存到所有測定的完整過程。本研究已將方法應用於序列注入分析儀(SIA)及流動注入分析儀(FIA)等並得到了相當好的成果。此應用程式極為方便，特別是在研究船上使用，可以更有效地完成測定任務。

## Observations of Kuroshio Intermediate Water along 23.5°N off eastern Taiwan

Shang-Hong Lin, Hon-Kit Lui\*, Yu-Shan Huang  
Department of Oceanography, National Sun Yat-sen University

### Abstract

To investigate the spread of South China Sea (SCS) waters in the West Philippine Sea (WPS), three research cruises were conducted along 21.75°N (east to 123°E) and 23.5°N (east to 125°E) off eastern Taiwan in 2018/9/12-14, 2022/3/9-15, and 2022/7/19-24 in the WPS. Our results confirm a previous finding that a mid-depth front exists around 122-123°E at 21.75°N, separating the subsurface and intermediate waters of the SCS and the WPS. Generally, the SCS Intermediate Water (SCSIW) flows out from the Luzon Strait, mixing with the North Pacific Intermediate Water (NPIW) to form the Kuroshio Intermediate Water (KIW). The NPIW has a minimum salinity of 34.2, whereas the SCSIW has a higher minimum salinity of 34.4. Compared with the salinity of the NPIW, relatively high salinities were observed in the intermediate water along the 23.5°N section, likely due to the influence of intruded KIW. The pH value of the SCS water is significantly higher than that of the WPS below 700m depth. In the WPS, a pH minimum occurs at about 900-1000m. The intrusion of SCS water around this depth along 23.5°N section noticeably increased the pH value, forming two pH minima above and below this depth.



## Long-term trend of carbonate chemistry off southwestern Taiwan: three decadal time-series study

T.V.K. Lahiruni N. Kumari<sup>1</sup>, Hon-Kit Lui<sup>1</sup>, Chen-Tung Arthur Chen<sup>1</sup>

<sup>1</sup> Department of Oceanography, National Sun Yat-sen University

### Abstract

The world ocean is acidifying, mainly due to the increasing atmospheric CO<sub>2</sub>. Decadal time-series station data from the open oceans suggest that the surface ocean pH is decreasing at a rate similar to that assuming the air-sea CO<sub>2</sub> equilibrium. However, time-series study in coastal areas is rare. This study used a 30-year data set from 1992 to 2022, consisting of data collected from 58 hydrographic stations in 14 cruises off southwestern Taiwan, to study the rates of temporal changes of seawater carbonate chemistry for the surface water. Only six data with distinguishable low salinity (S) or high apparent oxygen utilization were taken away from our analysis to reduce the influences of riverine inputs (five data) and a regional upwelling event (one data) on determining the rates of temporal changes for the carbonate chemistry. Our time-series data show that the pH at 25°C (pH<sub>25</sub>) or at in-situ temperature (pH<sub>in situ</sub>), normalized dissolved inorganic carbon (nDIC=DIC/S×35), seawater partial pressure of CO<sub>2</sub> (pCO<sub>2</sub>), and the saturation states of calcite (Ω<sub>Ca</sub>) and aragonite (Ω<sub>Ar</sub>) suffered strong seasonal variations. We used multiple linear regression (MLR) with time (t), potential temperature (θ), and S as the independent variables to determine the rates of temporal changes. The θ and S in the MLR were used to eliminate the bias due to uneven distributions of sampling points under strong seasonal variations, precipitation, or evaporation. Our results show that the MLR-determined rates of temporal changes in pH<sub>25</sub> or pH<sub>in situ</sub> are the same of -0.0019±0.0003 pH unit yr<sup>-1</sup>, which is the same as that assuming the air-sea CO<sub>2</sub> equilibrium. The MLR-determined rate of temporal change in nDIC is 1.41±0.16 μmol kg<sup>-1</sup> yr<sup>-1</sup>, matching with the expected 1.22±0.02 μmol kg<sup>-1</sup> yr<sup>-1</sup>. The observed rates of temporal changes in pCO<sub>2</sub>, Ω<sub>Ca</sub> and Ω<sub>Ar</sub> are 1.97±0.25 μatm yr<sup>-1</sup>, -0.017±0.003 yr<sup>-1</sup>, and -0.011±0.002 yr<sup>-1</sup>, respectively. Such values are just slightly higher than their expected rates of 1.63±0.05 μatm yr<sup>-1</sup>, -0.018±0.0004 yr<sup>-1</sup>, and -0.012±0.0002 yr<sup>-1</sup>, respectively, assuming the air-sea CO<sub>2</sub> equilibrium. Our results indicate that the changes in carbonate chemistry in the coastal ocean off southwestern Taiwan are in line with that of the open ocean.

## Investigating estuarine barium cycling with laboratory mixing experiments

### 河口的鋇循環混合實驗研究

Jhih-Ting Chiu<sup>1,2</sup>, Kuo-Fang Huang<sup>3</sup>, Po-Chao Wu<sup>3</sup>, Shih-Nan Chen<sup>1</sup>, Yu-Te Hsieh<sup>1\*</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taiwan

<sup>2</sup>Department of Geosciences, National Taiwan University, Taiwan

<sup>3</sup>Institute of Earth Sciences, Academia Sinica, Taiwan

\*Corresponding author. E-mail: alanhsieh@ntu.edu.tw

### Abstract

Coastal seawater barium has been commonly used as a proxy for tracing riverine inputs to the ocean. However, the non-conservative behaviour of estuarine Ba mixing due to Ba desorption from suspended particulate matter (SPM) can complicate the use of Ba as a riverine tracer. Ba isotopes have been developed as a new tracer to improve our understanding of marine Ba cycling, but the riverine Ba isotope inputs are still poorly constrained. To understand the behavior of Ba and its isotope fractionation during the estuarine mixing, we measured Ba concentrations and isotope compositions in the water samples across a large gradient of salinity in the estuary of Tamsui River in the northern Taiwan. The results show that the maximum Ba desorption covers a wide salinity range from 6 to 15 PSU in the Tamsui estuary. We also conducted an experimental study by mixing seawater with river waters under different SPM conditions in the lab. The preliminary results show that the salinity at where the maximum Ba desorption occurs seems to vary widely, which may correspond to the contents of freshwater SPM. Ba isotopes in these water samples can help us to understand the controls of Ba under different SPM conditions in the estuarine environment.

## Barium uptake and isotope fractionation in diatoms

Po-Kai Yang<sup>1</sup>, Yu-Te Hsieh<sup>1</sup>, Tung-Yuan Ho<sup>2</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taiwan

<sup>2</sup>Research Center for Environmental Changes, Academia Sinica, Taiwan

\*Corresponding author. E-mail: [alanhsieh@ntu.edu.tw](mailto:alanhsieh@ntu.edu.tw)

### Abstract

Oceanic barium serves as a useful biogeochemical proxy indicating marine productivity. Although Ba is not an element required for most marine species during their metabolism, the marine Ba cycle is still heavily involved during biological uptake and barite formation where the C cycle is closely related. Recent developments of Ba stable isotopes show great potential in studying marine productivity. However, the imbalanced inputs and outputs of Ba isotopes remains a challenging question in the marine Ba isotope budget. One major controversy is the large offset of Ba isotope fractionation factor between the barites from experimental studies and from field observations in water columns and marine sediments. The missing information about Ba isotope fractionation through biological uptake of Ba in the upper ocean is important to help in understanding this offset. In this study, we measured Ba uptake rate and Ba isotope compositions on cultivated diatoms, *Chaetoceros muelleri*, to investigate the biological factor that may cause this mismatch in the Ba isotopic fractionation factor between field and laboratory studies. Most importantly, the results of this study provide the first constraint on Ba isotope fractionation during biogenic uptake before barite formation, which can help to evaluate if Ba isotopes in marine barite are a convincing proxy for marine productivity in the past.

## 2022 夏季台灣海峽南段大量沖淡水之來源探討

王俊元、黃蔚人\*、黃貴楨、高愷嶸、Veran Weerathunga、翁家姍  
國立中山大學海洋科學系

### 摘 要

台灣海峽位在南海及東海兩個邊緣海系統以及鄰近數個河流系統之間，受周遭生物地球化學作用一定程度的影響，若能釐清沖淡水來源，便能更清楚該區域之海洋環境結構。在 2022 年夏季勵進航次中於台灣海峽南端之台灣灘海域東側發現大量沖淡水的訊號(鹽度 30.84)，透過實測鹽度剖面發現其寬度約 40 km、深度約 15 m，另外根據葉綠素濃度衛星圖估算其長度約為 5 至 10 km，估計其體積約為 3 至 6 km<sup>3</sup>。然而受限於航次時間，難以完成追蹤該沖淡水訊號之來源。本研究使用 TA、NTA、風向、降雨量、營養鹽之比率以及表面葉綠素濃度衛星圖探討台灣海峽南都周遭可能的淡水來源，包括:珠江、高屏溪以及降雨，並通過周遭環境氣候的探討、個別河流之流量及化學參數等來確認該沖淡水之來源。我們首先通過 NTA 的計算可以排除雨水的可能性。根據沖淡水體積大小，以及上述各生地化參數，我們推測珠江是比較可能的淡水來源。

## Temporal variability in the Mg/Ca-derived temperatures of individual foraminifera from SEATS sediment traps in the northern South China Sea

Pei-Ting Lee<sup>a</sup>, Chuan-Chou Shen<sup>b</sup>, Jeroen Groeneveld<sup>a</sup>, Sze Ling Ho<sup>a</sup>

<sup>a</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan

<sup>b</sup>Department of Geosciences, National Taiwan University, Taipei, Taiwan

### Abstract

Foraminiferal tests in marine sediments are routinely used to reconstruct paleoclimate. Understanding the temporal variations of foraminifera-based proxies and proxy variability within foraminifera population over seasonal and interannual timescales can provide constraints for the interpretation of paleotemperature records. To this end, we generate temperature time series based on the individual foraminifera analysis (IFA) of mixed layer-dwelling species *Trilobatus sacculifer* collected by sediment traps deployed at two water depths (2000 and 3500 m) in the northern South China Sea (nSCS). We analyzed Mg/Ca of the foraminiferal tests, and converted the Mg/Ca values to temperature estimates using a previously published calibration based on bulk (multi-specimen) measurement. This is reasonable because our IFA cleaning protocol yields comparable Mg/Ca values as that used for bulk samples. When averaged by sample (roughly corresponding to 8 days), the *T. sacculifer* IFA-Mg/Ca records based on trap-2000m and trap-3500m generally follow the temporal trend of the satellite sea surface temperature (SST) (GHRSSST-OSTIA). Based on the match in the temporal trends of satellite SST and our weekly averaged IFA-Mg/Ca records, there appears to be 1(2)-week lag for the trap-2000m (trap-3500m) time series. IFA-Mg/Ca data agree well with satellite data during cold seasons, but are ~3°C lower during warm seasons, thereby resulting in an attenuated seasonal cycle. Winter (Dec-Feb) temperatures derived from IFA-Mg/Ca also differ due to ENSO variability, with slightly higher temperatures registered during the La Niña phase when the mixed layer was deeper. The IFA-Mg/Ca temperatures range from 21.72 to 36.00 °C in trap-3500m and 21.04 to 32.75 °C in trap-2000m, on average 3–9°C per sample. In general, the variability (spread in distribution) of the IFA-Mg/Ca values is higher (lower) during warm (cold) seasons. Notably, some IFA-Mg/Ca temperatures exceed the highest satellite SST of the period spanned by the trap time series by up to 4°C reaching value as high as 36°C. This may be in part due to the uncertainty of the calibration or the loss of some chambers of the tests during cleaning as intra-test variability in Mg/Ca temperature can be as high as ~4°C. We will discuss possible environmental factors driving the temporal variability in IFA-Mg/Ca data and implications for paleotemperature reconstruction in the region.

Key words: sediment trap, individual foraminifera analysis, Mg/Ca

# Variations of Shell Size and Species Composition of Planktonic Foraminifera: Observation from Sediment Trap at SEATS, South China Sea

Li-Peng Wu and Hui-Ling Lin

Department of Oceanography, National Sun Yat-sen University

## Abstract

The distribution of modern planktonic foraminifera can be strongly affected by hydrological changes in their habitats. Compared to paleoceanography, time-series studies on modern planktonic foraminiferal population dynamics can reveal a smaller time-scale change. The hydrological condition in the northern South China Sea (NSCS) is strongly affected by the East Asian Monsoon. This study utilized sediment traps to collect sinking particles at the South East Asia Time-series Study (SEATS) station in the NSCS from Nov. 2019 to May 2020. All planktonic foraminiferal tests greater than 150  $\mu\text{m}$  were picked, identified, and classified into 4 size fractions, including “150-250”, “250-355”, “355-425”, and “greater than 425  $\mu\text{m}$ .” In general, *Trilobatus sacculifer*, *Neogloboquadrina dutertrei*, *Globigerinoides ruber*, *Pulleniatina obliquiloculata*, and *Globigerinella siphonifera* were the most abundant species. Results showed that the highest abundance of tests occurred in Dec. 2019, while the minimum value occurred in Nov. 2019. During the collection period, the size fraction of 150-250  $\mu\text{m}$  accounted for the largest proportion. The results showed that only the tests of *G. ruber* were mainly within the 150-250  $\mu\text{m}$  size fraction, while the others were within the 250-355  $\mu\text{m}$  size fraction. Throughout the collection period, *T. sacculifer* and *G. ruber* were the two most abundant species in relative abundance. The peak abundance of the aforementioned species' tests corresponded with high chlorophyll-a concentration, which was probably related to the thickness of the mixed layer.

## Modern Benthic Foraminiferal Assemblages Around the Taiwan Banks in Response to the Upwelling Environment

Hsiu-Wei Chang<sup>1</sup>, Hui-Ling Lin<sup>1</sup>, Tai-Chu Lin<sup>1</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University

### Abstract

Understanding the environmental factors regulating the structure of benthic foraminiferal communities is fundamental to enhance our knowledge of their ecology and to validate their application in paleoceanography. In this study, the influence of hydrological settings on benthic foraminifera around eastern Taiwan Banks were examined. The Taiwan Banks upwelling was formed by the upward transport of the South China Sea water due to the topography and strong tide effect. Surface sediments were collected around Taiwan Banks during three cruises: OR1-1071 (April 22<sup>nd</sup>-24<sup>th</sup>, 2014), NOR1-0029 (April 20<sup>th</sup>-23<sup>rd</sup>, 2022), and LGD-2207 (June 29<sup>th</sup>- August 3<sup>rd</sup>, 2022). Totally seventy-six taxa of all 11,062 individuals of benthic foraminifera were identified, among which *Pararotalia* spp., *Textularia* spp., *Cibicides* spp., *Lobatula* spp. and *Quinqueloculina* spp. were the most abundant taxa. In general, the abundance of benthic foraminifera is higher at the sites near eastern Taiwan Banks, where are also within the range of upwelling region. Canonical correspondence analysis (CCA) was applied to describe the correlations between benthic foraminiferal community and hydrological data from the onboard CTD, including temperature, salinity, oxygen, and fluorescence. The result of CCA showed three benthic foraminiferal assemblages can be linked to hydrological parameter separately. Assemblage 1 dominated by *Pseudorotalia* spp. is associated with higher oxygen content and water depth. Environments with higher salinity and apparent oxygen utilization (AOU) are associated with assemblage 2, which is characterized by the dominance of *Pararotalia* spp. Assemblage 3, dominated by *Cibicides* spp. and *Lobatula* spp. and characterized by warmer temperature and higher fluorescence levels, is located near the eastern Taiwan Banks. The higher foraminiferal abundance with the dominance of *Lobatula* spp. and *Pararotalia* spp. in the surface sediments probably characterizes the upwelling signal in benthic environment around the eastern Taiwan Banks.

Keywords: Taiwan Banks, upwelling, benthic foraminifera assemblage



## 台灣灘沉積物傳輸趨勢分析之初步研究

張宸緯<sup>1</sup>、楊仁凱<sup>1</sup>、Dominique Valdivia<sup>1</sup>、劉祖乾<sup>1</sup>

<sup>1</sup>中山大學海洋科學系

### 摘 要

台灣灘位於台灣海峽南部之地形高區，為中國沿岸流、黑潮支流等海流交會處，同時也是來自台灣源的沉積物、長江源的源沉積物、珠江源的沉積物；以及來自中國東南沿岸河川沉積物在南北輸運間之樞紐，因此造成此區域的沉積物組成複雜。本研究使用「宿命」團隊在台灣灘附近海域採集之表層沉積物樣本，並收集文獻中已發表的粒徑數據，透過粒徑分佈中平均粒徑、淘選度、歪斜度等參數，結合傳輸趨勢分析方法，來初步判斷台灣灘上沉積物的來龍去脈及可能的傳輸模式。

本研究現階段累積的粒徑結果顯示，台灣灘上的平均粒徑較粗且淘選度較好，而台灣灘外圍區域則平均粒徑則較細、淘選度較差。因此，推測是台灣灘區域受到現代水動力作用，使細顆粒沉積物不易停留，以過去末代冰期時的粗砂質殘餘沉積物為主，而台灣灘外圍則因水深較深故水動力對底床作用較弱，因此現代細粒沉積物與殘餘沉積物混雜，而粒徑不一。在歪斜度方面，台灣灘的東北部區域偏向較細的粒徑群組，而西南部區域則偏向較粗的粒徑群組，則可能暗示東北部區域更多受到現代細粒沉積物影響。

接著以沿海岸方向(東北-西南)與垂直海岸方向(西北-東南)假設出七條可能的傳輸方向，並以 McLaren-Bowles 的傳輸趨勢分析方法檢驗。初步的分析結果顯示在台灣灘上，僅存在有沿海岸方向的傳輸趨勢，垂直海岸方向的傳輸則都不成立。沿海岸方向的傳輸趨勢，在近岸區域為東北往西南方向傳輸，而在離岸較遠的台灣灘中部區域則兩方向的傳輸趨勢皆成立(東北往西南以及西南往東北)。

為了能更完整的呈現傳輸趨勢，預計今年度以新海研一號在台灣灘周遭海域進行表層沉積物樣本採樣，為後續分析增加更多的資料點，同時以 Gao-Collins 的傳輸趨勢分析方法建立網格化的二維傳輸趨勢，並結合此區域的黏土礦物分析結果以經驗證交函數(EOF)分析，期望能以綜合且客觀的方式判斷台灣灘區域的沉積物分布、特性以及傳輸模式。

關鍵字：台灣灘、表層沉積物、粒徑分佈、沉積物傳輸趨勢分析

## 潮汐作用下陸海源顆粒於七股瀉湖內之季節變化

歐承侑<sup>1</sup> 李杰<sup>1</sup> 劉祖乾<sup>1</sup>

<sup>1</sup>國立中山大學海洋科學系

### 摘要

七股瀉湖為臺灣西南部漁撈、養殖產業的重地，但於近年卻發現瀉湖整體的海岸線結構有逐年往陸地側退縮，和淺化的趨勢。為釐清在不同季節下，七股瀉湖內顆粒的傳輸和動力狀態，本研究於瀉湖系統中進行了冬夏兩季連續的定點水動力和水文觀測，以及同步採集水體的樣本進行營養鹽分析。根據瀉湖南潮口處的流場圖與壓力計資料顯示，瀉湖系統冬夏兩季的潮汐型態由半日潮主導，且潮差最大約為 1 公尺。夏季期間潮汐水深與鹽度值變化之間具有良好的正相關係 ( $R^2 = 0.74$ )，並且與營養鹽之間呈現負相關 ( $R^2$  至少大於 0.6)，顯示了七股瀉湖系統在夏季受到潮汐漲退作用影響下，水體物質懸浮顆粒的來源應可被分為簡易的陸海雙端源模型。而雙端源系統使七股瀉湖內的懸浮顆粒具有季節性的變化：在夏季退潮時 (瀉湖內呈現淡水源)，懸浮顆粒具有較高的顆粒容積密度；冬季則是於漲潮時 (瀉湖內呈現海水源)，懸浮顆粒才具有較高的顆粒容積密度。除此之外，瀉湖內濁度計資料與顆粒質量濃度 (SSC) 皆顯示冬季的水體濁度較夏季數值高，指出了冬季時期的再懸浮作用可能比夏季時期更加劇烈。未來會使用瀉湖系統內的流場變化 (如流速剪應力) 確認實驗期間的動力狀態。其整合動力結果將會與採集的懸浮顆粒特性比對，並進行顆粒有機碳氮分析 (包含 POC、PN、 $\delta^{13}\text{C}$ 、 $\delta^{15}\text{N}$ )，以解析七股瀉湖系統內於不同季節的顆粒源匯過程。

關鍵詞: 七股瀉湖系統、懸浮顆粒源匯、陸海雙端源、潮汐作用、再懸浮作用

## 應用機器學習演算法調查南海北坡的海床逸氣現象

邵昱勳、張翠玉、黃致展  
國立臺灣大學海洋研究所

### 摘要

海床逸氣是一種常見的地質現象，其排放的氣體主要是以溫室氣體—甲烷為主，這對全球環境有很大的影響。排放的氣體可能來自地層中天然氣水合物的解離，氣體解離後的空間以及移棲的管道都會影響海床的穩定性。現今主要是透過海洋探測船上所搭載的儀器觀測海床逸氣，如藉由聲波測深儀觀察海床氣焰，因此較無法長時間的觀測。

近年來許多研究透過海底地震儀觀測海床逸氣，來達到監測的效果，當解離氣體沿著地層裂隙往上移動到沈積物與海水層的介面時，會因為減壓產生小型的爆裂現象，其能量會沿著地層傳遞到附近的海底地震儀，並產生高頻的短持續時間事件 (Short duration event, SDE) 的波形，波形的振幅在起始的時間點最大，並隨著時間呈指數下降，訊號長度大約 1 到 4 秒，且呈現較為單一的特徵頻率。當訊號振幅較大時，人工檢測相對容易，但如果訊噪比太低，會難以區分訊號與雜訊。而機器學習就是一個解決這問題的方法。

本研究透過機器學習的方式，分析布放在南中國海北坡上海底地震儀的紀錄，並以長短期記憶神經網路作為主要架構，訓練出可以判斷海底地震儀中短持續時間事件的模型。選擇時序資料、包絡線，以及時頻圖做為輸入資料的特徵，並給予模型已標籤的資料，讓模型從訓練資料中透過特徵尋找規律，並依靠此規律在資料中判斷出更多的事件。

最終，本研究透過機器學習辨識且量化短持續時間事件，發現短持續時間事件會隨著潮汐的漲退而表現出周期性，推測海床逸氣的現象與潮汐相關，通常會在漲潮與退潮期間相對活躍。期望藉此研究探討海床逸氣的機制，進一步掌握海床逸氣產生的影響與衝擊。

## Study of Soft-Sediment Deformation Patterns in the Central Taiwan Strait

Wei-Chen Chen<sup>1</sup>、Ho-Han Hsu<sup>1</sup>、Yi-Ping Chen<sup>2</sup>、Ting-Yi Liu<sup>2</sup>、  
Sung-Ping Chang<sup>3</sup>、Yi-Rong Lin<sup>4</sup>、Song-Chuen Chen<sup>4</sup>、Char-Shine  
Liu<sup>2</sup>

(1) Institute of Oceanography, National Taiwan University、

(2) Ocean Center, National Taiwan University、

(3) Department of Earth Sciences, National Cheng Kung University、

(4) Central Geological Survey, MOEA

### Abstract

Offshore wind power has been a significant focus of development in the Taiwan Strait since 2006 due to its considerable potential. However, concerns have been raised regarding pile run and the potential liquefaction processes resulting from high-pressure fluid within sedimentary layers. It is critical to evaluate the potential risk of liquefaction to mitigate this hazard. This study aims to assess the potential risk of geological features that may cause pile run in the Taiwan Strait. To achieve this objective, we utilized sub-bottom profiles, sparker seismic, and multi-channel seismic reflection data to identify fluid migration and soft-sediment deformation features from shallow to deep strata. Additionally, we applied advanced data processing techniques to better image these specific features on all profiles. Based on different acoustic and seismic characteristics observed on the seismic profiles, three types of soft-sediment deformation features have been identified. Type A is characterized by a vertical pipe feature with low amplitude in its interior and high reflection amplitude at the upper boundary, while Type B shows a pillow-like feature with low amplitude in its interior and high amplitude at the upper reflection. Type C presents a depressing feature with high-amplitude reflections at both the upper and lower boundaries. These soft-sediment deformation features can be used to assess the geohazard risk by identifying areas of sedimentary disturbance that may lead to liquefaction, fluidization, and deformation. In the next stage of our research, we will analyze the scale of deformation of these soft-sediment deformation features and explore the relationship between soft sediment deformation and the depositional environment.

## Characterization of Geophysical Features in the Huaping Islet Submarine Volcanic Zone

Ting-Yu Hsu<sup>1</sup>、Ho-Han Hsu<sup>1</sup>、Cheng-Chun Chung<sup>1</sup>、Ching-Yun  
Huang<sup>1</sup>、Arif Mirza<sup>2</sup>、Yi-Rong Lin<sup>3</sup>、Song-Chuen Chen<sup>3</sup>、Char-Shine  
Liu<sup>2</sup>

(1) Institute of Oceanography, National Taiwan University

(2) Ocean Center, National Taiwan University

(3) Central Geological Survey, MOEA

### Abstract

The offshore NE Taiwan region has been significantly impacted by the post-collision collapse and back-arc spreading of the Southern Okinawa Trough, resulting in the development of volcanic and magmatic activities and subsequent hydrothermal systems. These hydrothermal systems have the potential to contain valuable mineral resources, making the area of great interest for exploration. Over the past seven years, 34 geophysical surveys have been conducted in the area, collecting multi-channel reflection seismic data, magnetic data, multi-beam bathymetry, and sub-bottom profile data. Among the 11 identified submarine volcanic or hydrothermal sites, the Huaping Islet Submarine Volcanic Zone (HISVZ) has been a focus of investigation due to its potential mineral resources. However, the detailed distribution and characteristics of HISVZ remain unclear making it difficult to evaluate its potential mineral resources.

This study aims to investigate the geological and geophysical characters and mineral resource potential of HISVZ by examining its volcanic distribution, morphology, features, and mechanisms. To achieve this, multi-beam bathymetry and multi-channel reflection seismic data were utilized to reveal the geophysical characteristics of the area. Advanced data processing flows were developed and applied on collected seismic data to suppress multiple reflections and minimize bubble effect, resulting in improved seismic images of the volcanic features. From seismic facies analysis, several seismic characteristics of the volcanoes have been identified, including high-amplitude reflections in shallow strata below the seafloor, with a blank seismic phase inside or chaotic phase and the signal exhibits a conical feature. Our newly compiled bathymetry data with 25-meter grid spacing provides morphological details of HISVZ in an area of approximately 82 km<sup>2</sup>. Volcanic features have been identified on the MCS profiles at shallow water depths. Additionally, high magnetic anomalies were observed in the magnetic data, indicating possible mineralization.

This study provides new insights into the geological and geophysical characteristics of HISVZ and its potential mineral resources. The results suggest that HISVZ is an active hydrothermal system with a complex volcanic history, making it a promising area for future exploration and assessment of marine mineral resources.

## 精準衛星定位於精密海底測繪之應用

王硯葦<sup>1</sup>、廖音瑄<sup>2</sup>、黃靖芸<sup>2</sup>、劉紹勇<sup>3</sup>、許鶴瀚<sup>2,4</sup>

(1)國立中央大學地球科學學院學士班、(2)國立臺灣大學海洋中心、  
(3)國家實驗研究院台灣海洋科技研究中心、(4)國立臺灣大學海洋研究所

### 摘要

隨著新研究船的啟用，海洋測繪與資料修正技術也隨之精進。透過後處理的精密單點衛星定位技術進行橢球高測量，已可進一步降低高程定位的誤差，達到 0.1 公尺的等級。精密衛星定位已可應用於水深資料處理中的潮位修正，但對於船隻因吃水或姿態變化而引起的動態吃水誤差，現今仍缺乏實際的大洋實測資料進行驗證。因此，本研究使用勵進研究船 LGD2203 航次於東沙海域的多音束水深調查資料、隨船水位計記錄與後處理精密單點定位高程，檢視影響水深量測準確度的因素。比較動態吃水、船隻起伏、航行速度與衛星解算所得之橢球高等結果，以發展提高水深測繪精準度的進階資料處理方式，並作為橢球高測深法應用之實際驗證。

研究結果顯示，實測的橢球高程資料之時序變化是由船隻姿態、動態吃水、潮汐及大地起伏等因素所造成，其中具有高頻之震盪，經過分析後，發現其頻率近似於船隻起伏，然而振幅的變化會受到天氣與海象之影響。此外，吃水量與船速之實測資料呈明顯負相關，靜止與全速航行期間之吃水深度差異近 0.6 公尺。透過迴歸分析，比較出航與返航船速穩定時之推估值，可以發現出航時的實際吃水較推估值多，返航時則較推估值少，其差值可達 0.3 公尺，應證航次期間的船重變化也將對於吃水及水深測量成果造成影響。

本研究顯示精密單點定位高程可實際反映測量因動態吃水變化導致的微小高程變化，對於後續精細資料修正能有所助益，並顯示船速為影響船隻吃水變化的首要因素，而天氣及海象因子亦為影響資料準確度的重要關鍵，因此未來的量化研究方向可以針對大氣資料進行比對。此外，由於缺乏船隻載重的量測數據，載重變化對於吃水量之影響仍有待進一步掌握。

關鍵字：橢球高水深測量、水深資料處理、後處理精密單點定位、動態吃水



## 高精度海床與震測資料探討南觀音凹陷淺層流體移棲特徵

<sup>1</sup>連誌航、<sup>1</sup>許鶴瀚、<sup>2</sup>張頌平、<sup>3</sup>劉家瑄

<sup>1</sup>國立臺灣大學海洋研究所 <sup>2</sup>國立成功大學 <sup>3</sup>國立臺灣大學海洋中心

### 摘要

臺灣海峽近年快速發展離岸風力發電，場址的海床穩定性對於離岸風機架設與海底纜線鋪設等海洋工程是重要的評估項目之一。地層中的流體若往上移棲至海床，將造成海床不穩定而產生工程安全之疑慮。故本研究結合高解析多音束水深資料及火花式放電震測剖面，對南觀音凹陷離岸風電場址的海床形貌與震測相進行分析。進而整合兩種地球物理資料，綜合探討海床凹陷特徵可能的形成原因與發展過程。

藉由本研究的高解析多音束水深資料，可解析公尺到數十公尺尺度的形貌特徵，描述海床上凹陷的空間分布、尺寸與形貌。由水深資料顯示，位於南觀音凹陷西南方有兩處獨立凹陷特徵，其北方則有十處成群的凹陷特徵，與麻坑特徵相似。麻坑的深度約 1.3 至 3 公尺深，長寬約 172 公尺至 900 公尺，形貌呈現一般圓形、細長形或眼形等。

針對火花式放電反射震測資料，消除複反射使資料品質獲得大幅改善，提升對地層分析及流體特徵的辨識效率與可信度。並結合地層中聲學混亂、聲學空白帶、反極性、頂部強反射與管狀通道(氣窗)等震測相特徵，辨識出西南方的麻坑附近，有流體移棲特徵，並且有古麻坑暗示移棲事件有重複發生。透過管狀通道下方的斷層提供較深部流體的移棲通道，並持續補充讓麻坑重複發生。於北方凹陷處，震測資料中未發現流體移棲特徵，但觀察到凹陷下方存在斷層構造，推論可能與斷層活動有關。綜合上述結果，本研究認為，該場址南北方凹陷成因可能不同，而西南方地層有流體向上移棲並在海床形成麻坑，造成海床不穩定。藉此研究，除了對南觀音凹陷的流體移棲的空間分佈和移棲過程有更多了解，並能做為未來離岸風電等海事工程的參考背景資訊。

**關鍵字：**麻坑、流體移棲、多音束水深、火花式放電、離岸風電



## 珊瑚白化：鐵對珊瑚共生藻於高溫高光逆境下的作用

何苡寧<sup>1,2</sup>，曾令偉<sup>1</sup>，何東垣<sup>1,2</sup>

<sup>1</sup>中央研究院 環境變遷研究中心，<sup>2</sup>國立台灣大學 海洋研究所

過量活性氧物質（reactive oxygen species, ROS）被認為是造成珊瑚白化的主因之一。光合作用中，ROS 含量受金屬酶調控，包含超氧化物歧化酶（superoxide dismutase, SOD）。基於先前的實驗結果，我們認為足夠的無機鐵金屬是供應珊瑚共生藻合成 SOD 降低 ROS 的重要關鍵。在各個程度的光及熱緊迫條件下，我們藉由培養不同屬的共生藻，觀察無機鐵（Fe'）濃度培養基質對於生長速率、SOD 活性及光合作用效率表現（ $F_v/F_m$ ）的影響。結果顯示，於持續性熱緊迫（30°C）且無進行溫度馴養的情況下，無論何種無機鐵濃度（10-400 pM），*F. kawagutii* (*F.k.*) 的細胞數均呈現下降的趨勢；有進行溫度馴養時，*F.k.* 於 100 pM Fe' 有稍微生長，而 10 pM Fe' 則不生長。至於間歇性熱緊迫組別（30°C），不論於 100 pM Fe' 或 10 pM Fe'，*F.k.* 皆正常生長且相對於持續性熱緊迫表現出較高的 SOD 活性。至於熱敏性共生藻種 *B. minutum* 及 *S. microadriaticum*，其於短暫 34°C 熱緊迫下， $F_v/F_m$  會明顯下降，但在回復正常溫度（26°C）及正常光照後，給與高鐵條件（1000 pM Fe'）的組別其  $F_v/F_m$  有顯著恢復；同時亦觀察到細胞內金屬鐵的含量與鐵供給有相對應的表現。實驗的結果顯示，對珊瑚共生藻細胞在光及熱逆境的修復中，充足的無機鐵供應扮演十分重要的角色。

## 引起珊瑚骨侵蝕症之纖毛蟲生活史研究

鄭睿嘉

東吳大學微生物學系

### 摘 要

當珊瑚組織上產生疾病時，在珊瑚外觀可以發現組織缺塊、黑化或白化等的症狀，接著會造成珊瑚迅速進入死亡階段。而珊瑚疾病中，有一大部分的感染源是為真核的微生物。本篇研究主要的珊瑚疾病為珊瑚骨骼侵蝕症(Skeletal eroding band)，就是由纖毛蟲種類(*Halofolliculina* spp.)所產生的疾病。藉由正在發生疾病的珊瑚身上，我們以單隻分離技術，將纖毛蟲培養在六孔盤，再利用倒立式顯微鏡及螢光正立式顯微鏡等，進行長時間的觀察以及紀錄。結果指出成體的*Halofolliculina* spp.具有兩種不同的外部型態，一為變形蟲形式，另一種為固著形式，兩種外部型態會做經常的轉換。特別的是，在*Halofolliculina* spp.要進行分裂時，只會在固著形式外型下，在葫蘆形的殼內分裂出新的一代。新分裂出的成體會離開外殼後，在找尋新的地點形成固著的形式。

## 環境微塑膠濃度對眼斑海葵魚(*Amphiprion ocellaris*)的行為表現及攝入微塑膠風險的影響

莊詠筑<sup>1</sup>、陳美琪<sup>2</sup>、陳德豪<sup>1,2,3</sup>

1國立東華大學海洋生物研究所

2國立海洋生物博物館

3國立中山大學海洋生物科技暨資源學系

### 摘要

現今塑膠汙染持續注入於海洋，並廣泛分布於世界海域中，微塑膠普遍地被海洋生物所攝入，包括珊瑚礁魚類，但目前關於探討海洋生物攝入微塑膠的可能因子相關文獻仍相當稀少。本實驗以500-850  $\mu\text{m}$ 的聚乙烯對苯二甲酸酯(PET)微塑膠作為實驗材料，珊瑚礁魚類眼斑海葵魚(*Amphiprion ocellaris*)作為實驗物種，探討環境中微塑膠濃度對眼斑海葵魚行為表現及攝入風險的影響。本研究包括兩個實驗，皆進行微塑膠攝食暴露1小時，接著在48小時的淨化時間後收集魚隻排出的微塑膠，以計數微塑膠的攝入量。第一個實驗目的為評估眼斑海葵魚對微塑膠的行為反應及攝入情形，實驗組別包括純食物組、純微塑膠組、混合組。第二個實驗則探討食物與微塑膠共同存在時，不同微塑膠濃度對眼斑海葵魚行為及攝入風險的影響，實驗組別包括低濃度組、中濃度組、高濃度組(食物與微塑膠比例依序為1:0.1、1:1、1:10)。第一個實驗結果顯示，魚隻主要攝食活動發生在暴露前期(前15分鐘)，所有行為在前期時無組間差異。在暴露後期(後45分鐘)，純微塑膠組的攝食與游泳行為表現下降，並遠離攝食區，混合組則在整個暴露期間持續對攝食區表現攝食探索行為。在排遺的部分，純微塑膠組及混合組中皆有發現微塑膠，但混合組顯著較高。第二個實驗結果顯示，在食物與微塑膠比例接近的中濃度組在攝食區的探索行為持續發生，而在低濃度與高濃度組中，攝食探索行為隨暴露時間下降。排遺結果顯示，隨著暴露濃度增加微塑膠攝入量也會增加，但中濃度組與高濃度組間無顯著差異。總結而言，眼斑海葵魚在只有微塑膠存在時會攝入微塑膠，若有食物同時存在更會增加其攝入微塑膠的機率，且隨微塑膠濃度升高增加其攝入量，但當濃度高達一定程度時，眼斑海葵魚的攝入量會到達一個極限而不會持續增加。

## 飢不擇食？飢餓對眼斑海葵魚微塑膠攝入風險之影響

劉瀚淮<sup>1\*</sup>、陳美琪<sup>2</sup>、陳德豪<sup>1,2,3</sup>

<sup>1</sup>國立中山大學 海洋生物科技暨資源學系

<sup>2</sup>國立海洋生物博物館

<sup>3</sup>國立東華大學 海洋生物研究所

### 摘要

飢餓是影響魚隻攝食行為的一個重要因素，本實驗旨在探討眼斑海葵魚在飢餓情況下是否會因此增加攝入微塑膠的風險及數量，並且當環境中出現不同品質食物區域時，眼斑海葵魚的選擇行為上是否會因為飢餓而出現差異，進而導致涉入較高風險區域當中。實驗採用雙因子設計，分別為飢餓因子及食物因子，飢餓因子分為飢餓(魚隻禁食48小時)及飽食(魚隻禁食4小時)，食物因子分為高品質食物(純飼料)、低品質食物(飼料及微塑膠1:1)及不宜食用物(純微塑膠)。實驗中觀察眼斑海葵魚在同時面對任意2個不同品質食物區時，對於食物的選擇行為及排遺當中所攝入體內之微塑膠數量。飢餓的眼斑海葵魚在面對高度污染的水域(環境中只有純微塑膠攝食區及微塑膠混合飼料攝食區)會有攝食最多的微塑膠風險，同時也觀察到眼斑海葵魚在飢餓的情況時會有移動距離較長的現象，並且相較於正常攝食的眼斑海葵魚會有較高的微塑膠攝入量。環境當中食物組成成份不同可能會影響眼斑海葵魚的微塑膠攝入量，尤其是當眼斑海葵魚飢餓時更加明顯。根據本實驗可以得知，當環境中同時出現微塑膠及食物時，眼斑海葵魚無法準確分辨而會攝入微塑膠，並且當環境中食物資源減少時，會導致眼斑海葵魚因飢餓而增加塑膠攝入風險。

## Comparing biotic and abiotic factors on shaping heterotrophic bacteria metacommunity in the southern East China Sea

Pin-Yi Chen, Feng-Hsun Chang, Chih-hao Hsieh  
Institute of Oceanography, National Taiwan University

### Abstract

Marine heterotrophic bacteria have multiple interactions with phytoplankton. In recent years, researchers have been exploring these interactions in more details to better understand the underlying ecological processes that shape microbial communities. However, most of the interactions are supported by culture experiments, making it challenging to identify the relationships in non-time series samplings and meta-communities' researches. In this study, we hypothesize that chlorophyll-a is contributed by bacterial and eukaryotic phototrophs, separately, including cyanobacteria and Archaeplastida, Ochrophyta and Chrysophyceae (excluded clade C, F). Interactions between heterotrophic bacteria and two type of phototrophs, would occur in high chlorophyll-a zones. Through sequencing 16S and 18S rRNA of 10 cruises in the surface layer of the south East China Sea, alpha diversity of communities, including Chao1, Shannon and Inverse Simpson, are estimated. Firstly, the linear mixed-effect model shows that high chlorophyll-a concentration is significantly related to low alpha diversity indexes (Chao1, Shannon and Inverse Simpson) of eukaryotic phototrophs, but not significantly related to bacterial phototrophs. Besides, for bacterial heterotrophs, only the Chao1 index is significantly correlated to the interaction term including Chao1 index of phototrophic bacteria and chlorophyll-a. Our findings suggest that in high chlorophyll-a zones, eukaryotic phototrophs have low alpha diversity, and bacterial heterotroph in high chlorophyll-a zones prefer interacting with bacterial phototrophs than eukaryotic phototrophs which hints that the effect of size difference may affect the interactions.

## 兩種軟珊瑚在原生環境 (*in situ*) 與異地養殖 (*ex situ*) 的微生物

### 物相及代謝體組成比較

林彥志<sup>1</sup>、王敏真<sup>2</sup>、曾庸哲<sup>2</sup>、楊姍樺<sup>1</sup>

<sup>1</sup> 國立台灣大學漁業科學研究所

<sup>2</sup> 中央研究院臨海研究站

#### 摘要

珊瑚共伴微生物是由珊瑚與許多微生物一起組成，其中的細菌和珊瑚存在許多交互作用，這些交互作用牽涉到珊瑚健康的維持、也可能參與珊瑚的代謝過程、初級代謝物與次級代謝物的合成。初級代謝物是指直接涉及到正常生長、發育與生殖的代謝產物，次級代謝物則是由初級代謝物衍生化的化學物質，這些化學物質在珊瑚個體適應環境壓力下扮演著重要的角色。近年來，氣候變化和人類活動對珊瑚礁生態系造成威脅，為了恢復珊瑚礁生態系和維持珊瑚多樣性，異地珊瑚養殖是其中一種方法。由於軟珊瑚所含的活性物質較石珊瑚更有開發為新藥的潛力，且這些活性物質的形成被認為與共棲菌相關，因此，了解八放珊瑚共棲菌與宿主生理與環境的關係，將能應用在未來量產活性物質資源的開發。然而，目前我們尚未了解在異地養殖下的軟珊瑚是否受到影響，以及其生理代謝狀況是否與原生環境中的珊瑚類似，因此，有必要對異地珊瑚養殖進行更多研究，來確定其是否可以代表原生環境中的珊瑚，並進一步減少採集野生珊瑚的需求。在本研究中，我們調查了龜山島的兩種軟珊瑚 *Lobophytum* sp. 與 *Sinularia* sp. 在異地養殖和龜山島原生環境下微生物和初級代謝物組成之間的差異。我們預期隨著養殖時間的增長，珊瑚菌相組成和初級代謝物組成會逐漸趨於穩定，並且與原生環境中珊瑚的差異趨於相似。利用主成分分析胺基酸組成，在實驗的第一周，兩種軟珊瑚在異地養殖下與原生環境呈現出分群現象，但到了實驗進行的第十週，這兩種軟珊瑚和原生環境的組成逐漸變得相似。然而，珊瑚細菌組成和其他初級代謝物組成仍需進行更深入的後續分析。本研究藉由比較得知人工環境下八放珊瑚生殖生理變化與微生物族群變動所需時間，對八放珊瑚初級代謝物的生成與微生物的關係奠下基石，相信此成果將對於軟珊瑚天然物生合成的研究將有所助益。



## 大幅度日間溫度變化與增溫效應對錦花軟珊瑚

### 生理表現及共伴微生物族群之影響

吳芊儀、張海璿、楊姍樺

國立臺灣大學漁業科學研究所

#### 摘要

珊瑚共伴微生物在維持珊瑚健康上扮演重要角色。菌相組成除了受宿主物種影響外，也會因環境因子所影響。過去珊瑚共伴微生物的研究多聚焦於主要負責造礁的石珊瑚，較忽視軟珊瑚之立體結構也能提供其他生物棲息，與其在珊瑚礁生態系中的角色。近年來全球氣候變遷，海水暖化造成平均海溫上升，導致珊瑚白化事件頻傳，嚴重影響各地珊瑚礁生態系。而氣候變遷不僅使平均海溫上升，單日海溫變化幅度也日益增大，此環境變化是否影響珊瑚仍未被闡明。因此在本研究中我們設計了穩定升溫的水缸實驗並伴隨日間震盪攝氏五度與七度來研究錦花軟珊瑚 (*Litophyton sp.*) 在不同條件下的宿主生理反應、共生藻光合作用能力，及共伴細菌族群的變動。結果顯示在兩個不同溫度震盪的實驗組及穩定升溫的對照組中，珊瑚外觀上皆無明顯白化，且共生藻之光合作用效率穩定；但在共伴細菌族群的結果中發現，隨著溫度的上升，震盪五度和七度的組別中，細菌組成與對照組之間呈現顯著差異，顯示大幅度日間溫差會對珊瑚微生物族群造成影響。透過菌相組成結果，發現有日間溫差的處理下，內生桿菌 *Endozoicomonas* 的相對豐度會隨著震盪幅度的提高而增加。前人研究中得知 *Endozoicomonas* 在石珊瑚中的相對豐度可能會隨環境溫度增高而遞減，與本研究結果有異。因此，*Endozoicomonas* 與軟珊瑚間的關係以及所扮演的角色，是否跟 *Endozoicomonas* 在石珊瑚中相似，值得後續研究加以探討。



# Natal origin of Pacific bluefin tuna (*Thunnus orientalis*) in the California Current Large Marine Ecosystem inferred by otolith oxygen stable isotope analysis

Chia-Cheng Ku<sup>1</sup>, Jen-Chieh Shiao<sup>1</sup>

<sup>1</sup> Institute of Oceanography, National Taiwan University

## Abstract

Pacific bluefin tuna (*Thunnus orientalis*, PBF) is a highly migratory species across the Pacific Ocean and economically important fishery resource. They have complex population dynamics including different spawning grounds, the Western North Pacific Ocean (WNP) and the Sea of Japan (SoJ), and trans-Pacific migration to the California Current Large Marine Ecosystem (CCLME). Natal origin of PBF in the CCLME is required for better understanding population dynamics. To determine the natal origin, fish otolith is a good environmental indicator recording natural tags of the life history. In this study, otolith stable isotope values of  $\delta^{13}\text{C}_{\text{oto}}$  and  $\delta^{18}\text{O}_{\text{oto}}$  were analyzed for 18 subadult PBF caught in the CCLME. Otolith  $\delta^{18}\text{O}_{\text{oto}}$  values suggested that all individuals were hatched from the WNP spawning ground. But no fish from the SoJ were determined probably because of insufficient sample numbers. The greater contribution in the WNP was consistent with previous studies and implied that a higher survival rate of larvae in the WNP compared to the SoJ. It highlights the importance of contribution rates in the WNP to the population. Besides,  $\delta^{13}\text{C}_{\text{oto}}$  values of PBF in the CCLME were higher, which is enriched by the higher  $\delta^{13}\text{C}$  values of the DIC. Furthermore, further studies should increase the sample numbers to entirely understand the contribution of different spawning ground of PBF in the CCLME. The study can help long-term research of PBF's population to future management of this economically and ecologically important species.

## 高溫緊迫對共生性與非共生性海葵的組織學影響研究

羅仔真、劉莉蓮  
國立中山大學海洋科學系

### 摘 要

氣候變遷下，珊瑚或海葵宿主與共生藻間的關係面臨了挑戰，相關的研究也陸續展開，尤其是高溫造成珊瑚或海葵白化的生理反應與調控機制已有許多研究，相較之下，非共生性珊瑚或海葵的研究非常有限，因此，本研究利用組織切片比較共生性及非共生性海葵在高溫（35°C）逆境兩小時後組織的改變及復原情況。高溫處理組中，兩類海葵組織腫脹，並有空泡產生，共生性海葵內胚層破裂且共生藻密度降低，非共生性海葵內胚層同樣有破裂情形，但受損程度較輕微，恢復常溫七天後，兩類海葵組織皆有復原的情況，顯示二者對短期高溫緊迫均具有調適的能力。

## 小琉球芋螺的食性探討

高立容、劉莉蓮

國立中山大學 海洋生物科技暨資源學系、海洋科學系

### 摘 要

芋螺為肉食性的軟體動物，是海洋生態系中常見的高級消費者，也是我們開發醫療藥用的潛力生物類群。全世界的芋螺約有七百種，臺灣有約一百五十種，芋螺依食性分為三大類：食軟體動物類、食蟲類及食魚類，牠們特化的捕食構造包含齒舌和毒腺，對捕食物種具專一性，其中以捕食環節動物門多毛綱物種的食蟲類芋螺最多。小琉球潮間帶的芋螺相較臺灣其他潮間帶物種多樣性更高，本研究探討小琉球芋螺的食性，以瞭解小琉球潮間帶能支持高芋螺物種多樣性的原因。結果顯示花環芋螺、花冠芋螺、斑芋螺和小斑芋螺的碳穩定同位素值相近且齒舌形態相似，推測食物種類可能也類似，此外，小琉球杉福潮間帶同種芋螺之氮穩定同位素值較漁埕尾者高，可能與該地有陸源廢汙水輸入有關。本研究分析十一種芋螺齒舌，結果顯示不同食性的芋螺齒舌構造有所不同，分別是捕食遊走性沙蠶科與磯沙蠶科的”矮寬型食蟲類齒舌”芋螺七種、捕食構築蟲管的蝟龍界科的”細長型食蟲類齒舌”芋螺三種，以及”食魚類齒舌”芋螺一種。整體而言，小琉球以具矮寬型食蟲類齒舌的芋螺最多，環境中也有足以支撐芋螺族群之獵物如遊走性沙蠶與磯沙蠶的存在。

## 圈養白鯨(*Delphinapterus leucas*)之糞便細菌菌相探討

陳怡純<sup>1\*</sup> 陳智耀<sup>2</sup> 郭傑民<sup>1</sup> 李宗賢<sup>1</sup>

<sup>1\*</sup>國立海洋生物博物館

<sup>2</sup>海景世界股份有限公司

### 摘要

哺乳動物的消化道微生物群落有包含細菌、真菌及病毒，這些微生物的存在對於宿主的營養代謝、吸收及消化、以及維持腸道黏膜免疫等功能影響深遠。近年來，研究發現消化道菌相與許多疾病包括糖尿病、肥胖、憂鬱症等，有某些程度的關聯性。

在海洋生物糞便微生物相研究方面，常受限於檢體不易採集，特別是海洋哺乳類消化道的微生物群落資訊皆比其他物種少。有研究指出，糞便菌相可成為整個消化道菌相的可靠指標，因次本研究採集海生館三頭白鯨例行健檢或消化道異常時的糞便樣本，利用次世代定序法進行分析。

研究顯示，在三頭白鯨的糞便樣本中的微生物菌相主要由厚壁菌門(Firmicutes)、變形菌門(Proteobacteria)、梭桿菌門(Fusobacteria)、放線菌門(Actinobacteria)等總計占有90%。值得一提的是，即使白鯨處於相同的環境及飲食，仍然能夠發現其糞便菌相種類存在個體上的差異。因此，本次研究提供了有關圈養白鯨消化道微生物群落多樣性。未來，可以進一步探究白鯨消化道微生物群落的功能及與其健康狀況的相關性，以更多了解動物的生態和生理特徵，提升動物照護上的多方資訊。

## **Study of skeletal organic matrix proteins provides insight into the scleractinian biomineralization evolution**

Wei-Chi Kuo<sup>\*,1</sup>, Mei-Fang Lin<sup>1,2</sup>

Department of Marine Biotechnology and Resources, National Sun Yat-sen University<sup>1</sup>

Doctoral degree Program in Marine Biotechnology, National Sun Yat-sen University<sup>2</sup>

### **Abstract**

Biomineralization is an important feature in Scleractinia to construct the architecture of coral reefs and maintain the ecosystems that breed a lot of marine organisms. A series of proteins called skeletal organic matrix proteins (SOMPs) involves in the process of calcification, which has been affected by environmental changes. Corallimorpharians, the coral-like anemones that do not have calcified skeleton, were found to express SOMPs. However, the origins and roles of SOMPs in corallimorphs are still unclear. The SOMPs in corals and corallimorphs may reveal the evolutionary transition from non-calcified to calcified organisms. Additionally, the study of corallimorphs has provided an opportunity to examine the expression of these calcification-related genes in response to environmental changes.

In this study, using cnidarian comparative genomic and transcriptome approach, orthologous of SOMPs in corals and corallimorphs have been identified. Phylogenetic analysis was applied to infer the relationships among the orthologous groups. The results indicated that some SOM genes have been gained after the divergence of the sea anemone and coral/corallimorph. According to the gene expression data in corals, several SOMPs showed higher expression in the calcicodermis where the calcification occurred than the other cells. These genes have been examined for expression profile in corallimorphs. The result has provided an important insight into the understanding of SOMPs evolution in the non-calcified cnidarians.

# 海報競賽\_PCB13

## 利用碳氮穩定同位素探討臺灣淺灘中國槍魷(*Uroteuthis chinensis*)及貝瑞氏四盤耳烏賊(*Euprymna berryi*)之營養特徵

蕭民煌<sup>1</sup>、江俊億<sup>1</sup>、王珮玲<sup>2</sup>、李明安<sup>1</sup>、王佳惠<sup>1</sup>

(1) 國立臺灣海洋大學環境生物與漁業科學學系

(2) 國立臺灣大學海洋研究所

### 摘要

臺灣淺灘為臺灣西南海域之重要漁場，其中頭足類是常見的經濟性物種，扮演著傳遞浮游生物與中表層掠食者能量的關鍵角色。然而，目前對於該海域的頭足類之營養特徵尚無完整瞭解。本研究以底拖網採集臺灣淺灘之中國槍魷(*Uroteuthis chinensis*)及貝瑞氏四盤耳烏賊(*Euprymna berryi*)樣本，測量外觀形質，並分析兩頭足類物種及其共存之魚蝦類物種之肌肉碳氮穩定同位素( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ )值，用以估算營養區位(trophic position)及攝食寬度(dietary breadth)。中國槍魷樣本之體長範圍在 48~205 mm，肌肉的  $\delta^{15}\text{N}$  值及  $\delta^{13}\text{C}$  值分別為  $11.1\pm 0.6\text{‰}$  及  $-18.2\pm 0.7\text{‰}$ 。貝瑞氏四盤耳烏賊樣本的體長範圍 20~32mm，肌肉的  $\delta^{15}\text{N}$  值及  $\delta^{13}\text{C}$  值分別為  $9.9\pm 0.7\text{‰}$  及  $-18.0\pm 0.5\text{‰}$ 。以臺灣淺灘海域採集之浮游動物碳氮同位素作為基準值，所估算中國槍魷之營養區位為  $3.5\pm 0.44$ ，貝瑞氏四盤耳烏賊為  $3.3\pm 0.32$ ，兩物種之營養區位具中度重疊(67.5%)。根據標準橢圓面積(SEA<sub>C</sub>)估算結果，貝瑞氏四盤耳烏賊的攝食寬度較中國槍魷寬，且介於其他共存魚蝦類物種之間(日本緋鯉 (*Upeneus japonicus*):1.45；半線天竺鯛 (*Ostorhinchus semilineatus*):0.13)。攝食寬度可能與生態習性和棲地有關，中國槍魷具垂直洄游行為使其有機會攝食到中表層營養區位較高的魚類，而貝瑞氏四盤耳烏賊底棲的特性則攝食較多樣化的底棲餌料。本研究結果有助於更加了解西南海域頭足類之生物學及營養特徵，提供未來該海域漁業資源管理所需之參考資訊。

關鍵字：體長體重關係、浮游動物基準值、營養區位、攝食寬度。

## Transcriptomic response of coral to the seasonal changes

Yi-Yuan, Lin<sup>\*1</sup>, Chaolun Allen Chen<sup>3</sup>, Mei-Fang Lin<sup>1,2</sup>

Department of Marine Biotechnology and Resources, National Sun Yat-sen University<sup>1</sup>

Doctoral degree Program in Marine Biotechnology, National Sun Yat-sen University<sup>2</sup>

Biodiversity Research Center, Academia Sinica<sup>3</sup>

### Abstract

Rising sea surface temperature has caused increasing frequency of coral bleaching and mortality, which has a negative impact on the coral-reef ecosystems. To understand the molecular mechanism of corals in response to the high temperatures, the coral *Porites lutea*, which is an important reef-building species worldwide and plays an important role in the marine ecological system, has been studied in this project. Samples were collected from the outlet of the third nuclear power plant (NPPOL) where shallow water average temperature is higher than other coral reef sites in Kenting, and Wanlitong (WLT), where average temperature is relatively stable. In this study, we sampled coral colonies from both locations at 3 to 4 month-intervals to study the seasonal variations as typical of Kenting's tropical monsoon climate in Spring and Summer. The RNA-seq approach was applied. Current data revealed that there is no significant difference in gene expression of the colonies from the two locations. In order to evaluate the corals' molecular regulation to the seasonal changes, more data from the other two seasons Autumn and Winter will be included in further analyses. The results from this study will improve our understanding of corals' plasticity to the seasonal dynamics.



## Characterization of two fishery stocks of swordtip squid

### *Uroteuthis edulis* in the Northwest Pacific

Rui-Yi Hong<sup>1</sup>, Ke-Yang Chang<sup>2</sup>, Chia-Hui Wang<sup>3</sup>, Hsiu-Chin Lin<sup>1</sup>

<sup>1</sup> Department of Marine Biotechnology and Resources, National Sun Yat-sen University, Kaohsiung, Taiwan

<sup>2</sup> Fisheries Research Institute, Council of Agriculture, Taiwan

<sup>3</sup> Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Taiwan

#### Abstract

Cephalopods, including octopuses and squids, are important fishery targets all over the world. In Taiwan, swordtip squid *Uroteuthis edulis* accounts for 65% of the total cephalopod production and is one of the most important species in stick-held dip net fisheries. This species is widely distributed in the West Pacific, from the Japan Sea to northern Australia; and the Indian Ocean. In the NW Pacific, the major fishing ground locates in the East China Sea with an annual landing of  $1.5 \times 10^4$  tons. Nevertheless, the annual catch in Taiwan is continuously dropping since its peak in 1998. Species-specific information on genetic diversity provides important implications for fisheries management. The purpose of this study is to characterize the genetic diversity of *U. edulis* in Taiwan to provide evidence for the future management of squid fishery. We used mitochondrial DNA, Cytochrome C oxidase I and 16S ribosomal RNA, and nuclear DNA, Rhodopsin and Histone, as the genetic markers. The Maximum likelihood trees showed two distinctive clades (A, B) within the species. Geographically, Clades A and B are partially sympatric in the NW Pacific. Clade A is found in colder waters in Japan, China, South Korea, and Taiwan; and Clade B is from the warmer waters in southern China and southern Taiwan. For both clades, no further differentiation was observed in the haplotype networks. Besides, we used daily increments of the lateral dome of the statolith to determine the age and growth of Clade B. In conclusion, two clades of *U. edulis* are identified in the NW Pacific and clade-specific database should be established for efficient management in the future.

Keywords : Swordtip squid, Mitochondrial DNA, Nuclear DNA, statolith, East China Sea.

## 2022 年秋季台灣西部沿海底棲蟹類的多樣性研究

陳宥家<sup>1\*</sup>、陳孟仙<sup>1,2</sup>、陳姿君<sup>2</sup>、陳國書<sup>3</sup>、陳煦森<sup>4</sup>、陳志遠<sup>5</sup>

1. 國立中山大學海洋生態與保育研究所
2. 國立中山大學海洋科學系
3. 國家海洋研究院海洋生態與保育研究中心
4. 國立屏東科技大學水產養殖系
5. 國立高雄科技大學海洋環境工程系

### 摘要

本研究於 2022 年秋季(9 月及 11 月)，以「新海研三號」的桁桿式拖網在台灣西部沿海七個測站(梧棲、台西、七股、茄萣、林園、枋寮和澎湖水道)進行 23 網次採樣，共得 2057 隻蟹類樣品，包含 17 科 31 屬 48 種及未知 5 種。豐度前五優勢種占 85.8%，依序為 *Eodemus subtilis* (31.1%)、假矛形劍泳蟹 *Eodemus pseudohastatoides* (30.3%)、短刺伊氏蟹 *Izanami curtispina*(15.1%)、漢氏單梭蟹 *Monomia haanii*(5.9%)及紅星梭子蟹 *Portunus sanguinolentus*(3.5%)。各測站最優勢蟹種不盡相同，梧棲的最優勢蟹為漢氏單梭蟹(39%)，台西、七股及澎湖水道為假矛形劍泳蟹(77%、31%、49%)，茄萣、林園及枋寮為 *E. subtilis* (69%、92%、86%)。經統計分析呈現顯著的南北分群現象，以梧棲、台西及七股為北群，茄萣、林園及枋寮為南群，澎湖為深水群。北群主要貢獻物種為假矛形劍泳蟹，南群為 *E. subtilis*，深水群則為短刺伊氏蟹。此分群現象可能與先前本海域蝦類研究發現和海床底質、水深及水溫等環境因子之差異有關。

E-mail: [m105110001@g-mail.nsysu.edu.tw](mailto:m105110001@g-mail.nsysu.edu.tw)

## 印度洋經濟性鮪類與餌料生物豐度與結構受海洋環境變動影響之研究

梁婷滄\*<sup>1</sup>、藍國璋<sup>1</sup>、吳研綸<sup>1</sup>、陳律祺<sup>2</sup>

<sup>1</sup>國立臺灣海洋大學環境生物與漁業科學學系

<sup>2</sup>行政院農業委員會水產試驗所

### 摘要

本研究解析鮪類標準化 CPUE 與其餌料生物豐度之間變動特性，探討鮪類與餌料生物之間豐度與海洋環境因子變動之關係。透過小波交叉關聯性分析結果顯示黃鰭鮪與大目鮪在研究年間 1980-2000 年存在 4-10 年正相關循環，根據鮪類空間分布劃分兩個區域，分別是黃鰭鮪與大目鮪共同高釣獲區域 A 區(CPUE> 60%)及黃鰭鮪高釣獲區域 B 區(CPUE> 60%)，分別利用非度量多元尺度法(Non-metric multidimensional scaling)將兩區鮪類標準化 CPUE 與餌料生物豐度年別變動趨勢分群，A 區結果顯示黃鰭鮪與大目鮪標準化 CPUE 與餌料生物中斑點蝦以及甲殼類豐度相關性呈正相關趨勢，與其他餌料生物豐度為負相關趨勢，且兩種主要餌料物種受 SST 以及 PDO 指數所影響，B 區結果顯示黃鰭鮪標準化 CPUE 與餌料生物中軟體動物及櫻蝦科豐度相關性呈現正相關趨勢，兩種主要餌料生物受 DMI 指數、PDO 指數以及 SST 所影響與 A 區大致相同。綜上結果顯示，兩區中鮪類變動情況一致且與餌料生物之間可能存在下行控制的現象，推測可能受到海洋環境因子 SST 以及 PDO 指數所影響。

關鍵字:生物資源結構、下行控制特性、經濟性鮪類

Email : 11131006@mail.ntou.edu.tw

## 利用 IPCC AR6 模式分析氣候變遷對臺灣沿近海

### 尾槍魷屬(*Uroteuthis*)棲地脆弱度之影響

楊雨濛<sup>1\*</sup>、藍國璋<sup>1</sup>、Muhamad Naimullah<sup>1</sup>、蕭博元<sup>1</sup>、張可揚<sup>2</sup>

<sup>1</sup>國立臺灣海洋大學環境生物與漁業科學學系

<sup>2</sup>行政院農業委員會水產試驗所

#### 摘要

尾槍魷屬(*Uroteuthis*)為臺灣沿近海漁業重要經濟性漁獲物種。為探究氣候變遷不同情境下海洋環境變化與人為活動對臺灣沿近海尾槍魷屬棲地脆弱度之影響，收集 2011-2019 年港口查報員查報資料結合漁船航程紀錄器的漁獲資料，加入 IPCC AR6 中 SSP1-1.9、SSP1-2.6 和 SSP5-8.5 模擬，結合棲地適宜度模式預測氣候變遷對臺灣沿近海尾槍魷屬棲地之變動情形，並透過曝露度、敏感度與調適力等三種風險評估指數，計算各空間網格脆弱度指數來評估潛在影響與可能衝擊，建立物種棲地脆弱度。分析結果顯示 IPCC AR6 的模擬預估在未來 2060 年氣候變遷加劇時水溫上升(15.7°C)、溶氧量減少(0.265 mol m<sup>-3</sup>)，而尾槍魷屬的棲息地適宜逐漸向北推移(HSI>0.5)，臺灣西南方海域則逐漸下降(HSI<0.4)。棲地脆弱度分析結果顯示，中國沿岸海域在未來排放情景下的棲地適宜度較高，為高暴露度。而東北部海域則因拖網船及火誘網船隻多，尾槍魷屬豐度高，使海域敏感度與調適力較高。整體而言尾槍魷屬的高脆弱度區域主要分布在澎湖海域與中國沿岸。

關鍵字：尾槍魷屬、氣候變遷、IPCC、棲地適宜性、脆弱度

E-mail：11131004@mail.ntou.edu.tw

## Seasonal variation of free-living nematode community around the Turtle island

Lin, Hsuan-Tung, Yang, Shan-Hua  
Institute of Fisheries Science, National Taiwan University

### Abstract

Free-living marine nematodes are the most abundant metazoans in marine sediment. They play a vital role in the food web and nutrient cycling of the benthic ecosystem. Based on their high sensitivity to environmental changes, they serve as effective bioindicators for environmental assessments. However, most of the studies about nematodes were focused on the parasites that infect animals and plants. The more abundant and diverse free-living species received relatively little attention, especially nematodes from marine environment. The composition of free-living marine nematode in the waters around Taiwan is little known as well. Turtle Island is an active volcanic island, the southeastern tip of the island locates a cluster of hydrothermal vents. By contrast, the western tip has no vent and contains a coral reef ecosystem. Therefore, we collected sediment samples from 6 sampling sites around Turtle Island each season in a year to investigate the spatial and seasonal variations of free-living marine nematode community. The sampling sites included 3 vent sites (Near vent, Far vent and CO<sub>2</sub> vent), 1 coral reef ecosystem (Tail) and 2 middle sites (North, South), which are between vent sites and coral reef. In total, 2770 individuals were isolated and at least 42 species were identified. Overall, the abundance of nematodes significantly increased in spring and summer: Nematodes were the most abundant at Tail, but the abundance rapidly increased at CO<sub>2</sub> vent in spring: besides, at Near vent and Far vent, the abundance was quite low for the whole year. Furthermore, the composition of nematodes was highly influenced by location: North and CO<sub>2</sub> vent had distinct nematode communities; intriguingly, at the other four sites, there was a continuum of changes in nematode composition from coral reef to vents. Based on our finding, we infer that nematode diversity may be influenced by different physical and chemical factors around Turtle Island.

As we know, it is the first study to present a spatio-temporal spectrum of nematode communities between reef and hydrothermal vent ecosystems.

## **Impacts of resource fluctuation and availability on niche breadth and their consequence on functional potential: a perspective from species to community levels**

**Wan-Hsuan Cheng (鄭琬萱)**

**TIGP-ESS, Academia Sinca**

### **Abstract**

To understand the impact of climate change on ecosystem functioning, it is essential to examine how changes in environmental conditions influence species' niche breadth (NB) and functional potential (FP). Theories suggest that species with broad NB are favored in environments with high resource fluctuation and low resource availability due to their increased ability to exploit resources, resulting in a net benefit compared to the metabolic costs. However, since the relationship between NB and FP is dependent on the net benefits which vary with context, it remains unclear how changes in NB affect FP. In this study, I hypothesized that broadening NB confers an increased benefit under environmental change, and that an increase in the benefit of broadening NB will result in a corresponding increase in the slope of the NB-FP relationship (i.e., marginal functional performance (MFP)). To test this hypothesis, I collected 135 prokaryotic community samples from a freshwater system over six years. I estimated NB, FP, and MFP at Amplicon sequence variant (ASV) level by using a sparse regression model to regress 31 ecosystem functions related to carbon utilization against the relative abundance of ASVs. To understand how ASV-level NB, FP, and MFP scaled up to the community level, I used 31 EFs to quantify community-level NB, FP, and MFP. My results supported classical hypotheses that broader NB is favored in environments with high resource fluctuation and/or low resource availability at both the ASV and community levels. I observed that an increase in NB was accompanied by an increase in FP, suggesting weak or no trade-offs among the 31 functions related to carbon utilization. Most importantly, I showed that MFP could increase under environmental change. As a result, both ASV and community-level FP were further enhanced, buffering ecosystem functioning under deteriorating nutrient conditions. My study provides a systematic understanding of how species respond to environmental change and its implications for ecosystem functioning.



## 紫外線過濾劑對隆起軸孔珊瑚 (*Acropora tumida*) 的影響

曲昱玲, 識名信也

國立臺灣海洋大學海洋環境與生態研究所

### 摘要

防曬油是大多數現代人日常生活中不可少的保養品之一，紫外線過濾劑為防曬油中主要保護肌膚避免受到紫外線傷害的成分，其能以多種方式進入海洋，對海洋環境與生態造成影響。本研究的最終目標是評估商用防曬油中紫外線過濾劑對珊瑚的影響，並為未來開發對珊瑚無害的防曬油積累基礎研究資料。為了高效與詳細地評估紫外線過濾劑如何影響珊瑚，本研究使用本實驗室先前建立的「以培養皿培養珊瑚系統」研究紫外線過濾劑對隆起軸孔珊瑚 (*Acropora tumida*) 的影響。首先，實驗 1：測試甲醇、丙酮和二甲基亞砷 (DMSO)，這三種有機溶劑 (濃度：0、0.05、0.1%) 對珊瑚的影響，先前研究中這些有機物常做為溶解紫外線過濾劑的溶劑。接著，實驗 2 和 3：使用實驗 1 中對珊瑚影響最小的有機溶劑溶解 2 個紫外線過濾劑 Benzophenone-3 (BP-3) 與 Avobenzone (Butyl methoxydibenzoylmethane, BMDM)，確認不同濃度 0、1、2、4、6、8 及 10 mg/L 對隆起軸孔珊瑚的影響。實驗為 7 天，將 10 mm x 10 mm x 5 mm 的珊瑚片段黏在培養皿上，使用人工海水養培養，在實驗過程中，於第 3 天更換 1 次培養的海水及餵食豐年蝦 1 次，培養環境為 25°C、LED 燈光強度 20~40  $\mu\text{mol}/\text{m}^2/\text{s}$  及光週期為 12 小時光照和 12 小時黑暗，紀錄珊瑚片段的存活、組織完整性，確認珊瑚白化 (珊瑚顏色變化) 和檢測體內共生藻光化學效率 (Fv/Fm)。在實驗 1 中，結果顯示隆起軸孔珊瑚，在丙酮的存活率為 100%、異常率為 0% 且未造成珊瑚白化，其體內共生藻光化學效率也不受影響，仍維持 0.6 以上 (表示珊瑚健康)，因此選擇丙酮當作溶劑進行不同濃度紫外線過濾劑 (0、1、2、4、6、8 及 10 mg/L) BP-3 與 BMDM 對珊瑚的毒性試驗。實驗 2 結果顯示，隆起軸孔珊瑚片段在 BP-3 濃度 0、1、2 及 4 mg/L 的存活率為 100%，且珊瑚片段未白化和體內的共生藻光化學效率維持 0.6 以上；而濃度 6、8 及 10 mg/L 在 4 天內全數死亡，計算 96 小時的 BP-3 半致死濃度 (Lethal Concentration, LC50) 為 6.938 mg/L，顯示 BP-3 會對珊瑚造成傷害。實驗 3 結果顯示，隆起軸孔珊瑚片段在濃度 0、1、2、4 及 6 mg/L BMDM 的存活率為 100%；濃度 8 及 10 mg/L 在第 4 天開始有珊瑚片段死亡其存活率為 60% 以上，BMDM 所有濃度組在第 96 小時的生存率皆高於 50%，故未計算 LC50，存活之珊瑚片段部分組織有出現異常及白化現象，但體內的共生藻光化學效率仍維持 0.6 以上，顯示 BMDM 會對珊瑚造成傷害。由以上結果比較 BP-3 和 BMDM，BP-3 對隆起軸孔珊瑚有較高的毒性及損害，這與先前研究中所發現的毒性影響結果相似，這 2 個紫外線過濾劑皆會影響珊瑚片段的存活，未來將測試低濃度 (0、1、10  $\mu\text{g}/\text{L}$ ) 及其他紫外線過濾劑對珊瑚的影響，用以累積更多基礎研究資料。



## 台南七股養殖牡蠣鑽孔生物多樣性的探討

林芷晴<sup>1</sup>、劉弼仁<sup>2</sup>、劉莉蓮<sup>1,3</sup>

1. 國立中山大學海洋生態與保育研究所
2. 國立東華大學海洋生物研究所
3. 國立中山大學海洋科學系

### 摘要

牡蠣為臺灣重要的雙殼貝之一，主要的養殖產業分布於西南沿海，其中台南七股瀉湖更是養殖的重要場域。但牡蠣殼內常有鑽孔生物寄生，依體型大小可以分為大型鑽孔生物與鑽孔微生物，前者常見的有：1. 雙殼貝；2. 多毛類，例如：海稚蟲科(Spionidae)、磯沙蠶科(Eunicidae)、索沙蠶科(Lumbrineridae)、絲鰓蟲科(Cirratulidae)和纓鰓蟲科(Sabellidae)，他們能分泌化學物質侵蝕牡蠣殼，或利用身體堅硬部份摩擦牡蠣殼等方法，將牡蠣殼鑽出孔洞；3. 海綿，例如：鑽孔海綿科(Clionidae)，會侵蝕牡蠣殼，在牡蠣殼內形成不規則的空腔。而鑽孔微生物則有藻類及真菌等。被鑽孔的牡蠣殼因有空腔變得脆弱易碎，且牡蠣修補受損的內殼時更會分散生長的能量，進一步影響養殖牡蠣的產業量。臺灣這方面的研究甚少，故本研究於台南七股瀉湖調查鑽孔生物多樣性。結果發現鑽孔多毛類有海稚蟲科、索沙蠶科等物種，海稚蟲科的鑽孔軌跡為 U 型通道及 8 字型之對外開口；鑽孔海綿於牡蠣左殼鑽孔的發生率較右殼高，外殼表面有密集孔洞，殼內有海綿生長形成的網狀通道；鑽孔藻類的發生率樣點間差異高，鑽孔生物的種類及數量與環境因子之相關性持續探討中。

## 海洋污染物「塑化劑」對造礁珊瑚的影響

夏崇瑜，識名信也

國立臺灣海洋大學海洋科學與資源學院 海洋環境與生態研究所

### 摘要

我們的海洋面臨許多問題，其中一個就是海洋塑膠垃圾，而這些海洋塑膠垃圾長時間浸泡在海水會分解出化學物質，進而造成海洋污染，其中一個化學物質為塑化劑，是製作塑膠時的添加物，雙酚 A(Bisphenol A, BPA)與磷酸三(2-氯乙基)酯(Tris(2-chloroethyl) phosphate, TCEP)為兩種廣泛被使用的塑化劑。在先前研究表明，這兩種塑化劑對海洋生物造成毒性傷害、影響生理功能甚至死亡。珊瑚礁生態系為海洋中生物多樣性較高的生態系之一，其中造礁珊瑚為主要形成珊瑚礁的重要角色，但這兩種塑化劑對造礁珊瑚的影響仍未知，本研究透過先前實驗室所建立的培養皿中培養珊瑚系統，測試 BPA 和 TCEP 兩種塑化劑對細枝鹿角珊瑚(*Pocillopora damicornis*)的影響。實驗進行 5 天，將 5 mm x 5 mm 的珊瑚片段黏在培養皿上，以人工海水養培養，過程中於第 3 天更換 1 次培養的海水及餵食豐年蝦，培養溫度為 25°C、LED 燈光強度 20~40  $\mu\text{mol}/\text{m}^2/\text{s}$  並設定光週期為 12 小時光照和 12 小時黑暗，於培養期間觀察與紀錄珊瑚片段的存活率、組織完整性、顏色變化和珊瑚體內共生藻的光化學效率。珊瑚片段分別培養在 9 個不同濃度 (0, 0.5, 1, 5, 10, 50, 100, 250, 500 mg/L) 含有塑化劑的海水中，結果顯示，珊瑚片段在 TCEP 濃度 100 mg/L 以下，皆存活且無異常情形；濃度為 250 mg/L 以上，珊瑚片段的組織出現共肉萎縮或消失等異常情形甚至死亡。珊瑚片段在 BPA 濃度 1 mg/L 以下，皆存活且無異常；濃度為 5 mg/L 以上，皆死亡，由此可知 BPA 相較於 TCEP 對珊瑚造成更嚴重的傷害，我們因此進一步測試不同濃度 0, 1, 2, 3, 4, 5 mg/L 的 BPA 的影響，結果顯示，珊瑚片段在 BPA 濃度 1 mg/L 的存活率為 100%且沒有出現異常；濃度 2 mg/L 的存活率為 33%，濃度 3 mg/L 的存活率為 11%，存活的珊瑚片段有出現組織異常；濃度 4, 5 mg/L 的珊瑚片段皆死亡。本次實驗我們利用培養皿中培養珊瑚系統成功證明了 TCEP 和 BPA 皆會對珊瑚造成傷害，實驗的成果將可以提供一個基礎的研究資料，說明塑化劑對造礁珊瑚的影響，並呼籲大眾減少使用塑膠製品，以保護海洋環境與珊瑚礁生態。

## 中華文蛤與韓國文蛤形態之比較研究

賀子軒 劉莉蓮  
國立中山大學

### 摘要

台灣的文蛤屬物種包含中華文蛤、文蛤、台灣文蛤、韓國文蛤、皺肋文蛤等五種。其中除了皺肋文蛤殼體上有明顯波浪紋路之外，其餘四個物種外型相似度高，且缺乏形質研究的完整論述。本研究結合標本攝影、形質測量與主成分分析，探討中華文蛤與韓國文蛤殼體形態差異，並進行比較、描述與歸納。主成分分析形質結果顯示，殼寬是中華文蛤與韓國文蛤殼體差異貢獻度最高的形質，韓國文蛤殼寬較窄；標本攝影呈現之影像則有韓國文蛤的鉸齒板比中華文蛤更大。

篩選出具有高溫耐受性且成長速度快的珊瑚群體：

## 在氣候變遷下進行珊瑚的復育行動

林子程, 識名信也

國立臺灣海洋大學 海洋科學與資源學院 海洋環境與生態研究所

### 摘要

珊瑚礁生態系是地球上生物多樣性最高的生態系之一，但氣候變遷導致海水溫度日益增高，使得珊瑚產生白化甚至死亡，珊瑚礁生態系正逐漸退化，培養並移植珊瑚成為當今珊瑚復育的方法之一，若能培養出「具有高溫耐受性且成長速度快」的珊瑚群體，並移植至退化中的珊瑚礁，將有助於減緩珊瑚礁生態系的衰退。我們在 2018-2021 年，連續 3 年的夏天，在新北市海洋資源復育園區（簡稱復育園區）的半開放式九孔池中，觀察到池內同時有未白化與發生白化的珊瑚群體，推測在這樣的環境下培養珊瑚，可能可以找到具有高溫耐受性的珊瑚群體。本研究以東北角海域廣泛分布的萼形柱珊瑚(*Stylophora pistillata*)與佛州軸孔珊瑚(*Acropora florida*)為目標物種，選擇 7 個不同地點，採集包含 0-12 公尺不同深度的珊瑚群體，每個物種共採集 100 個群體，將珊瑚培養在復育園區的半開放式九孔池中，進行 3 個月的培養（2022 年 6 至 8 月）。培養的三個月間，池內月均溫為 20.4 至 30.7 °C，並在 7、8 月觀察到兩種珊瑚都有發生白化現象，*S. pistillata* 存活率為 97%，58% 的珊瑚群體未發生白化，39% 的珊瑚群體觀察到部分白化；*A. florida* 存活率為 87%，43% 的珊瑚群體未發生白化，43% 的珊瑚群體為部分白化，亦觀察到 1% 的珊瑚群體有完全白化的現象，*S. pistillata* 與 *A. florida* 未白化的群體其原生長環境多集中在 0-2 公尺的深度；我們也同時找到生長速度快的珊瑚群體。本研究在半開放式九孔池篩選出可能具有高溫耐受性且生長速度快的珊瑚群體，未來將進行溫度試驗（高溫），再次確認這些篩選出來可能具高溫耐受性的群體是否確實能耐高溫，並檢測其體內共生藻的類群（clade），之後成功篩選出的珊瑚群體，未來將大量培養當作珊瑚復育行動的珊瑚群體之一。

# 海報展示摘要

## 台馬之星船載都普勒流速剖面儀的海流資料初步分析

張仁宥 方盈智  
國立中山大學海洋科學系

### 摘要

自 2015 年 8 月起，渡輪台馬之星開始提供往返基隆-馬祖地區的載客服務，穩定離島地區的日常補給需求並促進一定程度的觀光價值。渡輪台馬之星船艙下方裝置了一套船載式都普勒流速剖面儀系統，因此每一次往返基隆-馬祖航程期間同時也在進行走航海流的觀測作業，截至目前該走航海流資料已有近九年的跨度。過去前人研究透過使用奧勒岡州立大學的潮流模式藉以濾除潮流訊號，進而估計台灣海峽流場的體積傳輸量。目前日本已有學者針對渡輪的走航海流觀測提出一套系統性的潮流估算方法並已應用於琉球群島間與九州島的渡輪走航海流資料。其概念係藉由航線周遭的潮位計資料透過反推(inference)而估計出潮汐分量，如此便能改善因採樣頻率不足所導致的訊號混疊(aliasing)。台馬之星的走航海流資料應也可透過調和分析的方式直接估計潮流場，在這基礎上，本研究正在開發適合台馬之星的演算法。濾潮後的長期海流觀測讓我們更有機會了解台灣海峽北端的海流及傳輸量的長期變化。台馬之星的走航海流觀測提供給我們另一個研究台灣海峽海流場的面向。本研究展示目前的渡輪台馬之星的資料收集情況與初步資料處理結果，我們歡迎海洋界先進提供意見與指教。

### The phenomenon of low salinity at the center of anti-cyclonic eddies in the eastern waters of Taiwan

林孟蓁

#### 摘要

在 2022 年 6 月 21 日的觀測資料中發現臺灣東南海域(122.6°E, 21.5°N)出現低鹽海水，伴隨較低濃度的葉綠素-甲 (Chlorophyll-a, Chl-a)與較高的海表面溫度(Sea Surface Temperature, SST)。由於該處是台灣東部渦旋與黑潮相互作用的好發地區，在分析海表面高度異常值 (Sea Level Anomaly, SLA) 後推測可能有一反氣旋渦 (Anticyclonic Eddy, AE) 挾帶低鹽海水流經測站，接著併入台灣東北邊的黑潮主流。本研究利用現場觀測數據及衛星資料，分析此低鹽海水的形成原因及帶來影響。



## 南灣海域 CODAR 表面流場的渦漩觀測

Observations of eddy with CODAR surface current in Nanwan Bay.

林欣妮、陳少華

國家實驗研究院台灣海洋科技研究中心

### 摘要

本研究旨在探討 CODAR 遙測技術在南灣海域的表面流場渦漩觀測的應用，此技術主要應用於近岸海域的流場觀測，並具有測量範圍廣、觀測時間長，且能夠全天候觀測等優點。在本研究中，我們使用了海洋中心於南灣架設之三站 CODAR 雷達所觀測到的高解析度（1X1 公里）逐時表面流場，並對其進行調和分析(Harmonic analysis)以及經驗正交函數分析（Empirical Orthogonal Function, EOF），結果顯示，南灣海域的表面流場受到潮汐的明顯影響，而第二模態（Mode2）則表現出具有渦漩特徵的表面流場。此外，本研究進一步針對經驗正交函數後的特徵值趨勢進行傅立葉分析（Fast Fourier Transform, FFT），能夠在第一與第二模態接觀察到明顯的全日潮及半日潮之頻率，可以推測第二模態的渦漩表現與第一模態的潮汐行為有一定的關係，這些分析表明，南灣海域的表面流場在潮汐週期的影響之下表現出複雜的空間與時間特徵。

## 多衛星觀測宜蘭灣海水葉綠素濃度與水質指數變動

楊濬宇<sup>1</sup>、許伯駿<sup>1,2</sup>

<sup>1</sup>國立中央大學太空及遙測研究中心

<sup>2</sup>國立中央大學水文及海洋科學研究所

### 摘 要

海洋水色是海洋研究中一項重要的數據來源，如何在不同的研究區域根據該地區的海洋物理特徵以及衛星的軌道或時空解析度，選擇適合的資料進行觀測是值得研究的重要議題。宜蘭灣位於台灣的東北角(121.85-122°E, 24.6-25°N)，海灣水的來源有來自蘭陽溪的流入、灣外黑潮水及沿岸水。根據向日葵8/9號衛星的日平均葉綠素濃度資料，宜蘭灣的葉綠素濃度多介於0.2到1 mg/m<sup>3</sup>之間，因此我們選分別代表4種不同的葉綠素濃度狀況的案例，依據高至低排序為具有超過1 mg/m<sup>3</sup>的特殊事件，0.5-0.8 mg/m<sup>3</sup>的較高情況，0.3-0.5 mg/m<sup>3</sup>的普通情況及0-0.3 mg/m<sup>3</sup>的較低情況，資料時間的選取除了考慮葉綠素濃度區間之外，也考慮了向日葵衛星的每小時連續觀測葉綠素濃度資料受雲阻擋導致缺失的情況。基於此葉綠素濃度分類，我們想探討其與水質指數之間的相關性，水質指數的變動使用來自遙測反射率(Remote Sensing Reflectance,  $R_{rs}(\lambda)$ )推導出來的可視化光學波長(Apparent visible wavelength, AVW)，AVW為波段位於波長400至700奈米之間的 $R_{rs}$ 數據進行計算出來的加權平均數，AVW的數值以一個波長值呈現，該波長值即代表該水體對於不同波長的光吸收狀況，假設AVW值落在超過580奈米的位置，代表該水體對於紅光具有較佳的吸收狀況，因而使 $R_{rs}$ 波譜的波峰落在藍光的位置，除了表示波譜的狀況外，對於紅光會有較好的吸收也代表水體可能偏向紅棕色呈現出混濁的水質。我們分別以三個太陽同步衛星，即1公里空間解析度 Moderate Resolution Imaging Spectroradiometer (MODIS)、750公尺空間解析度的 Visible Infrared Imaging Radiometer Suite (VIIRS)和300公尺空間解析度的 Sentinel-3A/B(S3A/B) Ocean and Land Color Instrument (OLCI)以及500公尺空間解析度的 Geostationary Ocean Color Imager (GOCI)衛星資料進行比較與分析。我們首先比較葉綠素濃度在選定時間中在不同衛星觀測的數值變化，再比較AVW的變化以分析出宜蘭灣的葉綠素濃度與水質指數間的相關性，最後再考慮有色可溶性有機物(Colored dissolved organic matter, CDOM)與兩者之間的關聯。

## 利用地球同步向日葵衛星與現場觀測數據評估太陽輻射和海 面風對於近表層海洋溫度分層的影響

許伯駿<sup>1,2</sup>

國立中央大學太空及遙測研究中心<sup>1</sup>

國立中央大學水文及海洋科學研究所<sup>2</sup>

### 摘要

本研究使用地球同步向日葵衛星(Himawari-8/9)觀測的皮層海表溫度(skin sea surface temperature, skin SST)和現場觀測觀測到的容積海表溫度(bulk SST)，包括來自商船、浮球、Argo和浮標的四種儀器類型，構成90,000多個SST數據對用於分析近海面溫度變化，資料時間涵蓋2015年7月至2022年5月。在臺灣附近海域觀測到平均SST偏差(Skin SST – Bulk SST)為 $0.10^{\circ}\text{C}$ ，均方根誤差為 $0.99^{\circ}\text{C}$ 。本研究觀察到海面風速和太陽短波輻射產生的皮層效應導致冷皮層(cool skin layer)和日暖層(Diurnal warm layer, DWL)的出現，90%的SST對偏差在 $-1.55 \sim 1.71^{\circ}\text{C}$ 範圍內。在白天，皮層溫度受到太陽短波輻射加熱，從而使溫度升高並引起DWL，隨著日照的增加，DWL中的SST偏差變得更加明顯。在冬季、強風或低太陽短波輻射期間，DWL可能會消失並轉變成冷皮層。在夜間，近海表溫以受到冷皮層效應為主，但如果風速較弱，白天產生的DWL仍會保留至夜晚。然而，不同觀測位置的水文特徵及其距離海岸的遠近亦會影響到皮層效應的反饋。在近4平方公里的衛星觀測空間網格範圍內，海洋近表面分層是否發生了快速變動，仍有待未來探索。

## 台灣海峽東南部海域的水團變動

<sup>1</sup>郭仲諒、<sup>1</sup>方盈智、<sup>1</sup>陳孟仙、<sup>2</sup>邵煥傑

<sup>1</sup>國立中山大學海洋科學系

<sup>2</sup>新海研3號貴重儀器使用中心

### 摘要

做為連接南海和東海的重要通道，台灣海峽的海洋生地化與物理過程很大程度上受到這兩個邊緣海影響。過去海洋學界利用聲學都卜勒流速剖面儀、自記式剖面浮標、數值模擬與溫鹽水文場深儀等等，對台灣海峽做了大量的基礎調查。這些研究表明台灣海峽的流場和水團變動，同時受到季風、潮流與海底地形的影響。

本研究為本人碩士論文的主軸。我們將利用四個於彰雲隆起以南、澎湖水道以東海域的新海研三號航次，以水文測線與走航海流觀測資料為主，搭配學門歷史水文資料、奧勒岡大學的潮流模式與哥白尼中心環流模式的使用，進而了解台灣海峽東南部海域的水團變化與流場特徵。這些研究成果後續將應用於檢驗婆羅門赤蝦 (*Metapenaeopsis palmensis*)於台灣海峽向北遷移與棲地擴張的生物動力學研究。本海報展示目前的初步分析成果與工作進度，歡迎各位老師與海洋界先進提出建議。

## 南灣區域高頻雷達表面海流觀測驗證

陳少華、程嘉彥、許友貞、黃郁軒  
財團法人國家實驗研究院台灣海洋科技研究中心

### 摘要

本研究區域位於台灣屏東的南灣海域，此區使用三組全向性精簡雷達(貓鼻頭、香蕉灣及南灣)及一組相位陣列海洋雷達觀測資料(位置同全向性精簡雷達之貓鼻頭站)，並為使全向性精簡雷達與相位陣列海洋雷達觀測時間相近，全向性高頻雷達使用單一平均頻譜資料(Cross Spectra Short-time, CSS, 每10分鐘產出一筆代表15分鐘平均的能譜資料)進行短時徑向海流資料(short time radial)計算，再利用整點開始之6筆短時徑向資料平均成每小時徑向海流資料，研究區域內劃分為1公里方格網點，搜索以方格網點中心半徑1.5公里內的徑向資料以最小平方方法計算表面海流。

為了解此區域的雷達觀測的測流品質，使用漂流浮標報位推演之表層海流進行比對分析。為更貼近雷達觀測深度於浮標下加裝4組帆布塑膠支架及浮球組裝的 CODE (Coastal Ocean Dynamics Experiment, Davis 1985、Gerin et al. 2016)拖曳架構；同時為與雷達資料空間及時間尺度接近一致，使用16組浮標進行佈放，若其漂出框定範圍即回收並至上游處重複投放，增加框定區域浮標資料採樣數，最後蒐集與雷達相同時間及空間尺度浮標推演之表面海流資料進行平均。

為使浮標回收作業順利，漂流浮標報位傳輸採用船舶自動辨識系統 (Automatic Identification System, AIS)，此系統使用特高頻頻率 (161.975、162.025MHz)，資料傳輸技術為將每頻段每分鐘切分成2250個時槽，每時槽佔

6.7ms僅可傳輸256bit資料，故報位資料傳遞需經壓縮，資料接收後需解密讀取，但不需額外資料傳輸費用，可於船上AIS設備螢幕即時得知浮標位置，對浮標佈放回收作業有莫大的幫助，在2022年6月及8月兩次浮標佈放實驗，浮標回收率達百分之百。

為比較浮標及雷達觀測表面海流兩者差異，採用相關係數 (Correlation coefficient)及殘差均方根(Root Mean Square Difference)為比對指標，浮標觀測時間區間為2022年8月30日21:00-9月1日09:00(UTC)共36小時資料，實際佈放六次浮標陣，取雷達觀測海流與同時間同點位搜索半徑內的平均浮標推演海流，並考量方格點搜索半徑內的浮標採樣數大於90以上資料進行比對，東西向海流比對殘差均方根35.89cm/s；相關係數為0.76，南北向殘差均方根為8.49cm/s；相關係數則為0.95。

## 台灣海洋科技研究中心海洋雷達觀測系統歷史沿革與現況

程嘉彥、陳少華、黃郁軒、林欣妮

財團法人國家實驗研究院台灣海洋科技研究中心

### 摘 要

海洋表面為許多人類活動所在區域，如航運交通、漁業捕撈及遊憩娛樂等，即時海面訊息的獲取，將有助此類活動進行。為提供台灣周遭海域近即時流場，台灣海洋科技研究中心(下稱海洋中心)發展「臺灣四周海域表層海流即時觀測平臺」，於2008年著手進行高頻雷達測流系統採購及勘點作業，雷達測流系統選擇美國CODAR公司製作的全向型精簡雷達(Compact Antenna)，雷達系統精簡，佔地範圍小，天線系統依頻率不同，有接收及發射共位之單支標準型天線，或接收與發射各一的長距離型天線。於2009-2012期間完成台灣周遭海域11站長距型及4站標準型高頻雷達測流系統。於2015年在馬崗漁港架設長距型測流系統，補足東北角海域觀測缺角，並與和平站共同進行觀測黑潮東北角區域的重任。墾丁南灣區域遊憩活動頻繁，人員落水及失蹤頻傳，為使高頻雷達系統更名為民所用，發揮其即時表面海流觀測能量，於2016年在南灣污水廠架設收發合一之標準型高頻雷達測流系統，提供高解析度及高密度觀測資料，並與鄰近站合成南灣二維海流資料給墾丁管理處作為海上遊憩風險管理參考。為了消除島上近海觀測的盲區，2017年增設枋寮站，以獲取屏東沿海地區至小琉球島間的海流數據，在2018年間，於澎湖白沙建立離島觀測站後寮站，以提升離岸風電海域的常時環境監測資訊。北部部分站點因訊號干擾及維護不易，經評估後停止觀測。於2019年完成夏威夷大學合作完成相位陣列海洋雷達墾丁站架設，墾丁站位於CODAR貓鼻頭站旁，此系統包含4支方形矩陣發射天線，及3X3矩形接收天線，回波訊息經後續資料解析可得徑向流速。



## 臺灣南部附近的海洋熱浪和寒潮事件

林嘉祐<sup>1</sup>、許伯駿<sup>1,2</sup>

國立中央大學太空及遙測研究中心<sup>1</sup>

國立中央大學水文及海洋科學研究所<sup>2</sup>

### 摘要

海洋熱浪(Marine heatwave, MHW)是一種海水溫度突然顯著增溫的現象，而海洋寒潮(Marine cold-spells, MCS)則是一種海水溫度突然顯著降溫的現象，近幾年MHW和MCS的分析方法和相關延伸議題開始受到關注。在本研究中MHW事件以該海域位置在該日的海溫超過以1985-2014共30年為氣候基期的第90百分位值海溫數值且持續五天以上時稱之；MCS的定義則是使用相同氣候基期的第10百分位海溫數值做為閾值，並同樣需要低於該閾值持續五天以上。而為了更好的理解此類事件發生的強度，我們以MHW及MCS的事件發生時該位置點在該日的海溫閾值與氣候基期平均海溫的差值做為分級的標準，即倍率值 $X$ ，若該日海溫與氣候平均差距 $1-2X$ 為中等事件，差距 $2-3X$ 為強事件，差距 $3-4X$ 為嚴重事件， $4X$ 以上則為極端事件。也計算了持續時間，即知道此事件在當地造成多長時間的影響，定義為該年內MHW或MCS事件發生的累積時間。本研究將以臺灣南部四個區域作為分析站點，即小琉球(22.3°N 120.3°E)、墾丁南灣(21.9°N,120.7°E)、蘭嶼(22°N,121.5°E)以及恆春外海(21.8°N,120.8°E)，以分析在1985-2022年間該四區域的MHW及MCS事件發生數目、事件持續時間，並選出發生事件較多的年份、發生較少事件的年份、較高持續時間及較低持續時間的年份進行比較，並繪出臺灣南部(21-22.5°N,119-122°E)的MHW及MCS事件的空間分布，能夠更了解海洋熱浪和海洋寒潮事件在臺灣南部的狀況。



## **Analyses of surface currents around Taiwan derived from the TORI HF-Radar Observations**

Hendrik Grosselindemann<sup>1,2</sup>, Shao-Hua Chen<sup>1</sup>, Xin-Ni Lin<sup>1</sup>, Chia-Yan Cheng<sup>1</sup>, Chau-Chang Wang<sup>1,3</sup>

<sup>1</sup>Taiwan Ocean Research Institute, National Applied Research Laboratories, Kaohsiung, Taiwan

<sup>2</sup>Geomar Helmholtz Center for Ocean Research, Kiel, Germany

<sup>3</sup>Institute of Undersea Technology, National Sun Yat-sen University, Kaohsiung, Taiwan

### **Abstract**

Taiwan is an Island surrounded by ocean currents of different spatial and temporal scales. A network of HF-Radars was set up and is maintained by the Taiwan Ocean Research Institute (TORI) to monitor surface currents of the upper ocean ( $\geq 2\text{m}$ ). Here, five years of hourly data from 2013 to 2018 are analysed in order to characterise the flow field around the island. Spectral analyses reveal the importance of tides in the diurnal and semidiurnal frequency bands. While diurnal tides are stronger on the east of the island, the Taiwan Strait is dominated by semidiurnal tides. The data has then been low-pass filtered to focus on subtidal motions. Three selective cross-strait sections in the Taiwan Strait show a clear seasonal variation between a northward flow in summer and a southward flow in winter along the west coast of Taiwan. This pattern is also corroborated by the first EOF mode explaining 55% of total variance. The mean flow is northward and strongest along the coast of Taiwan. Wind data from the ERA5 Reanalysis field and satellite-derived geostrophic currents are used to investigate their relationship to the radar-derived surface current measurements. A technique of vector cross-correlations was applied and the results show that the wind has a higher impact in the Taiwan Strait, while the region east of Taiwan indicates that the Kuroshio Current predominates the surface current field. Spectral coherence between surface currents and satellite-derived geostrophic currents show a peak at a period of 25 days which might relate to mesoscale eddies. In general, this is an ongoing project and any input and discussion is highly welcome.

# Pre-Trained U-Net Model to Improve the Himawari Sea Surface Temperature Data Gap Filling

Dimas Pradana Putra<sup>1</sup> and Po-Chun Hsu<sup>1,2</sup>

<sup>1</sup> Center for Space and Remote Sensing Research, National Central University, Taiwan

<sup>2</sup> Institute of Hydrological and Oceanic Sciences, National Central University, Taiwan

## Abstract

Satellite-derived sea surface temperature (SST) images are widely used in various applications such as climate monitoring, ocean modeling, and marine ecology. However, the presence of clouds in images often leads to gaps in the satellite data, reducing their temporal and spatial resolution and making it difficult to analyze spatiotemporal patterns. Gap-filling methods are essential to overcome this limitation and provide continuous and consistent SST data. In this paper, we propose a gap-filling method based on U-Net, a state-of-the-art deep neural network model. Our method comprises two main steps. First, we pre-train the U-Net model on a large and diverse dataset of level 4 (L4) SST images. L4 SST images are gap-free products that are generated by blending satellite observations with numerical models and in-situ measurements. Using L4 SST images as surrogate ground truth, we can simulate a large number of SST values with different gap patterns and SST distributions, which can enhance the generalization ability of our U-Net model. The use of L4 SST images is motivated by the limited availability and heterogeneity of ground truth data for training and validating deep learning models. Different regions and seasons may have varying gap patterns, noise levels, and SST distributions, requiring models to be adaptive and robust. L4 SST images provide a consistent and large source of information that can overcome these challenges and improve the quality of gap-filling. Second, we fine-tune our pre-trained U-Net model on a specific target domain using a smaller amount of real SST values with ground truth SST values. This step further improves the accuracy and efficiency of our method. Finally, we compare our method with data interpolating empirical orthogonal functions (DINEOF), a widely used method for satellite image gap filling based on EOF.

## Water Exchange Due to Wind and Waves in a Monsoon Prevailing Tropical Atoll

陳世明

財團法人國家實驗研究院台灣海洋科技研究中心

### 摘 要

Water exchange in coral reef atolls is affected by physical forcings outside the atolls. Characteristics of the consequent water exchange depend on the atoll morphology and the local atmospheric and hydrographic conditions. The pattern of water exchange in the summer, 2021 at the Dongsha atoll under the influences of tides, wind, and waves was investigated by conducting realistic modeling and numerical experiments. Overall, the analysis results suggest that the southwestern wind could enhance the inflow transports at the southern reef flat and could enhance the outflow transports at the northern reef flat/north channel. The northeastern wind induces an inversed pattern. Unlike the wind, the waves always enhance the inflow transports at the reef flat and the locations of enhanced transports depend on the incident directions of the waves. Wind and waves induce shorter hydrodynamic time scales than tides, suggesting more vigorous water exchange during high wind and waves. The directions of wind and waves significantly affect the spatial distributions of the residence time and the age. It implies that the hydrodynamic processes in the Dongsha Atoll would have significant seasonal variability. This study presents different circulation patterns in an atoll system influenced by calm weather and strong wind/waves.

## 颱風引起海洋中尺度渦之動力過程

### On the dynamics of mesoscale eddy induced by typhoon

賀華<sup>1</sup>、林家屹<sup>1</sup>、鄭志文<sup>1,2</sup>

<sup>1</sup>國立台灣師範大學 地球科學系

<sup>2</sup>國立台灣師範大學 海洋環境科技研究所

#### 摘要

過去有大量關於颱風對預先存在中尺度氣旋渦構成影響之文獻，卻鮮少探討當海洋為中性環境時，由於颱風通過所引發具備負水位異常之中尺度氣旋渦 (Cyclonic Ocean Eddy, COE)。透過1993年-2020年之颱風以及對應之水位異常資料，本研究找出在西北太平洋中，歷年來颱風經過後由中性環境構成水位負異常幅度最大的三個範例進行分析，此三例分別為1997年的Rosie、2009年的Nida以及2011年的Ma-on颱風。我們利用區域海洋模擬系統模式 (Regional Ocean Modeling System, ROMS) 對三個例子進行背景環境重建模擬以及設計實驗，實驗結果顯示在颱風Rosie以及Nida通過後，其下方海洋因為受颱風影響由中性水位轉變成COE。在此之中特別針對平移速度遠小於西北太平洋平均第一斜壓波速 (2.9m/s) 的Nida颱風 (1.006m/s) 進行更詳細的COE生成動力分析，研究結果顯示，颱風緩慢移動的情況增加海水動能導致艾克曼抽吸 (Ekman pumping)，對應之湧升現象使等密度線傾斜導致勢能的增加，同時海表高度也因海水湧升造成的斜壓反應而大幅下降開始趨向地轉平衡。另外，透過渦度方程進行收支分析，分析亦顯示除了水平平流以外，湧升以及平流造成的傾斜項也是增加相對渦度促使COE形成的主因之一。

吳欣茹、鄭志文、陳毅睿  
國立臺灣師範大學地球科學系

### 摘要

夏季颱風通過後，多次在台灣東北角龍洞外海引起海表溫下降。2001~2020年 18 個第 5 類颱風中有 3 個颱風路徑十分相似，分別是 2001 年的尤特(Utor)、2008 年的如麗(Nuri)和 2008 年的哈格比(Hagupit)。然而透過龍洞浮標海表溫資料觀察發現這 3 個颱風對龍洞海域造成的降溫幅度卻差異甚大，尤特颱風期間下降最多達 8.8°C，如麗期間降溫為 2.7°C，而哈格比期間海表溫下降幅度僅 1.4°C。前人文獻曾指出，台灣周遭海域颱風引起之海表降溫與颱風行進軌跡間有良好之關係，為了進一步釐清相近軌跡颱風引起近岸海表溫下降之差異，本研究使用區域海洋模擬系統模式(Regional Ocean Modeling System, ROMS)，以重建並分析此三相近軌跡颱風個別引起之上層海洋響應。同時，為了進一步釐清潮汐可能對個別颱風引起降溫過程造成之差異影響，本研究於數值實驗中亦納入了潮汐作用，透過實驗設計以及熱收支守恆方程診斷分析，探討各物理過程對三個颱風期間海表降溫所造成之影響。研究結果顯示，三個颱風降溫過程中下層(20-80m)溫度變化主要是受到垂直平流項影響，而上層(0-20m)溫度變化則主要受到水平和垂直平流項影響所致。其中，造成三個相近軌跡颱風有如此顯著之海表降溫差異，亦與黑潮以及潮汐之即時狀態有關，另外，尤特上層降溫受到垂直混和項之影響相對另外兩個例子亦格外強烈。

## **Spatiotemporal variation of ocean acidification indices and sea surface temperature anomaly in the northwestern coast of the Philippines**

Rose Angeli Tabanao Macagga<sup>1</sup> and Po-Chun Hsu<sup>1,2</sup>

<sup>1</sup> Center for Space and Remote Sensing Research, National Central University, Taiwan

<sup>2</sup> Institute of Hydrological and Oceanic Sciences, National Central University, Taiwan

### **Abstract**

Anthropogenic activities, such as burning fossil fuel and deforestation, result in the continuous emission of greenhouse gases, causing climate change. Among these gases, carbon dioxide (CO<sub>2</sub>) is a major contributor, and its atmospheric concentration has risen by over 40% in the last century. The oceans have become a vital sink for anthropogenic CO<sub>2</sub> through air-sea exchange, leading to the oceans becoming more acidic and the absorption of excess heat generated from the greenhouse effect has led to temperature increases. Ocean acidification is a direct consequence of the oceanic uptake of CO<sub>2</sub>, resulting in a decrease in the pH of surface waters, an increase in the concentration of the inorganic carbon species and surface partial pressure of CO<sub>2</sub> (spCO<sub>2</sub>). Marine heatwave (MHW) events are prolonged periods of anomalously warm seawater temperatures exceeding a particular threshold. Both of these phenomena pose a significant threat to marine processes and ecosystems. The objective of this study is to analyze the spatiotemporal variation of sea surface temperature (SST) and ocean acidification indices in the northwestern coast of the Philippines. We utilized the daily satellite SST dataset from NOAA Coral Reef Watch spanning 1985 to 2022. Additionally, we obtained monthly pH and spCO<sub>2</sub> datasets from 1993 to 2022 from Copernicus Marine Environment Monitoring Service. We conducted empirical orthogonal function analysis on the SST, pH, and spCO<sub>2</sub> datasets to determine the spatial patterns of each parameter and understand how they change over time. Furthermore, we identified the frequency and duration of MHW events from 1985 to 2022. The Philippines is abundant in coral reef regions, with the most extensive coral reef area found in the northwestern Philippines. By understanding the spatiotemporal variation of these parameters, we can gain critical insights into the potential impacts of ocean acidification and MHW events on coral reefs in this region.

### 初步探討東沙海草床之藍碳定量與有機物質降解

王榆茜<sup>1</sup>、黃毓恩<sup>1</sup>、林恩如<sup>1</sup>、塗子萱<sup>1</sup>

<sup>1</sup>國立中山大學海洋科學系

#### 摘 要

海草床具有高度生產力，可提供沿海區域多種重要生態系功能，如透過旺盛的光合作用，海草可將環境中二氧化碳轉變為有機碳儲存於環境中。「藍碳」又稱海洋碳匯，是指海洋或沿海環境如紅樹林、濕地、海草床海底沉積物等棲地中儲存於生物量以及沉積物中的有機碳，其中又以沉積物為海洋中有機碳的主要儲存場域形式。海草床雖只佔全部海洋面積的 0.1%，但海草床沉積物中卻儲存了約  $2 \times 10^{19}$  mg 的有機碳，約佔全球海洋沉積物 10–18% 的有機碳埋藏量，其有機碳來源包含現地海草的合成生產，以及來自於異地由水層中沉降的有機顆粒，是全球碳循環中重要的天然碳庫。東沙環礁周邊海草床面積約 11.85 平方公里，是台灣目前唯一平均覆蓋度高達 90% 以上的連續型海草床。為了探討東沙環礁海草床的碳收支，本研究分析東沙島周邊不同地點海草床沉積物中以及海草植株內的有機碳含量、沉積物內海草分解速率以及海草種類組成、植株覆蓋率等參數。初步結果顯示島周邊海草床平均覆蓋率約為 72%。其中泰來草為島周邊優勢且生產力最高的草種，其冬季生產力為  $2.93 \pm 1.36 \text{ mg DW shoot}^{-1} \text{ d}^{-1}$ 。而島南岸分佈草種則包含泰來草、圓葉水絲草、單脈二藥草、鋸齒葉水絲草，冬季平均生產力為  $2.12 \pm 1.33 \text{ mg DW shoot}^{-1} \text{ d}^{-1}$ ，島內瀉湖分佈草種包含卵葉鹽草及單脈二藥草，後者為優勢草種，其冬季生產力為  $0.41 \pm 0.09 \text{ mg DW shoot}^{-1} \text{ d}^{-1}$ 。此外，島內瀉湖有植株覆蓋區域海草分解速率為  $34 \text{ mg d}^{-1}$ ，無植株覆蓋區域為  $62 \text{ mg d}^{-1}$ ，以此速率及覆蓋面積可推估島內瀉湖每年可儲存約  $1.15 \times 10^5 \text{ mg}$  有機碳。目前結果可幫助我們進一步了解海草床碳收支的情況，未來配合斷落葉片的側向傳輸、粒徑、元素分析結果，可推估大面積的有機碳含量至全環礁的藍碳蘊藏量。



## 2007-2014年夏季西北太平洋海水

### 與長江沖淡水間之總鹼度變化

翁家姍<sup>1</sup>、黃蔚人<sup>1</sup>、周文臣<sup>2</sup>

(1)國立中山大學海洋科學系

(2)國立臺灣海洋大學海洋環境與生態研究所

#### 摘要

來自西北太平洋 (western North Pacific Ocean, wNPO) 的黑潮支流 (Kuroshio branch, KB) 會在夏季時入侵至長江沖淡水 (Changjiang River Plume, CRP) 所覆蓋的東海內陸棚底部，兩者交互影響著東海陸棚的生化反應。而總鹼度 (Total Alkalinity, TA) 在碳酸鹽系統中是守恆且相對重要的參數，了解碳酸鹽系統於海洋的變化有助於因應現今氣候變遷之環境。然而，CRP 與 KB 各別對於東海陸棚之 TA 輸入，至今仍不清楚。本研究結合海洋學門資料庫之夏季東海資料，涵蓋 2007-2014 年，試圖了解夏季時 CRP 與 KB 對於東海陸棚 TA 的影響。結果顯示，東海陸棚西北方主要受到低 TA 之 CRP 輸入，有著較低的 TA ( $2000 \mu\text{mol kg}^{-1}$ )，且因長江流量與風場兩者年際間的差異，影響了其總鹼度之空間分佈。而東海陸棚東南部 (Southeastern East China Sea, SE ECS)，受到 KB 的影響，有著較東海陸棚西北方高的 TA。另還可見鹽度大於 33.5、深度小於 130 公尺 ( $\sigma_{\theta} < 25.4 \text{ kg m}^{-3}$ ) 的範圍內，標準化總鹼度 (Normalized Total Alkalinity, NTA) 為  $2311 \mu\text{mol kg}^{-1}$  且標準差僅為  $\pm 8 \mu\text{mol kg}^{-1}$ ，相較於同樣條件下 ( $S > 33.5$ ,  $\text{depth} < 130 \text{ m}$ ) 位於 wNPO ( $137^{\circ}\text{E} / 10^{\circ}\text{N}$ ) 海水之 NTA ( $\text{NTA} = 2300 \pm 4 \mu\text{mol kg}^{-1}$ ) 還要高，推測兩處 NTA 之差 ( $\cong 10 \mu\text{mol kg}^{-1}$ ) 是由於 wNPO 次表層水 ( $\sigma_{\theta} = 25.25 \text{ kg m}^{-3}$ ,  $\text{NTA} = 2310 \mu\text{mol kg}^{-1}$ ) 抬升至 SE ECS 所致。

為驗證此，在 wNPO ( $137^{\circ}\text{E} / 10^{\circ}\text{N}$ ) 測站使用三種特徵：溫度、TA 與  $\sigma_{\theta}$  以建立預測深度的多元線性回歸模型，並個別將八年 SE ECS 的數據代入。從結果可見，我們推測東海陸棚約 60-80 公尺深的位置來自於 wNPO 約深度 150 公尺海水，使得每年 SE ECS 之 NTA 數值保持  $2310 \pm 8 \mu\text{mol kg}^{-1}$ 。若未來其數值在氣候變遷的條件下有所改變，其隱含之影響因素值得討論。

# 海報展示\_PC4

台灣西南海域碳儲量初估 - 澎湖水道溶解無機碳之空間分布

## Preliminary result of carbon reservoirs in the waters off southwestern Taiwan: Spatial distributions of dissolved inorganic carbon in the Penghu Channel

賴加育、黃貴楨、高愷嶸、黃蔚人\*

國立中山大學海洋科學系

### 摘要

近年來，全球暖化和海平面上升的問題越來越受到關注，世界主要國家也共同訂定 2050 年淨零排碳的目標，旨在增加二氧化碳吸收量，同時減少二氧化碳的排放量。海洋作為地球最大的碳儲存庫，儲存著全球 80% 以上的碳，過去數十年間更是吸收了大約四分之一的人為排放之二氧化碳，在碳儲存的議題中扮演至關重要的角色。台灣周圍的海域面積大於陸地面積，因此台灣鄰近海域中的碳儲量在淨零排碳中扮演的角色也越來越受到重視。為瞭解台灣西南海域海洋棲地之碳儲量，本研究規劃調查台灣西南海域溶解無機碳(Dissolved inorganic carbon, DIC)之空間分布，並計畫建立量測方法學，以增進我們對台灣周圍海域碳通量及碳交換機制的了解。

本研究使用 2019 年南海航次與 2020 年澎湖水道航次資料，以多項式回歸分析法分析垂直水層中鹽度、深度與 DIC 以及 pH 值間之關係。在回歸分析的結果中，得到了澎湖水道之鹽度、深度對 DIC 和對 pH 值之關係式，並進一步將海洋預報模式(Hybrid Coordinate Ocean Model, HYCOM)之鹽度、深度資料代入回歸關係式，估算 DIC 和 pH 值在澎湖水道之空間分布。最後使用 DIC 與水深資料初步估算夏季澎湖水道海域之溶解無機碳碳儲量大約為 709 萬噸。未來將持續採集樣本、蒐集資料，滾動式調整碳儲量計算之方法，完整的估算台灣西南海域之碳儲量。

## 南海北部衛星遙測及現場實測視深度之差異

張芸禎 鄭勝文 孫紹齊  
海軍軍官學校 應用科學系

### 摘 要

海水透明度亦及海水清澈程度，是描述海水光學性質的一個重要參數，我們使用直徑 20 公分且黑白相間的圓形盤用繩子垂直放入海水中，進而觀察圓形盤在海水中可見深度的變化。一般而言，影響視深度最主要的三個參數分別是水深、海洋表層溫度及光衰減係數，因此亦是海洋科學研究重要的一環。在我們初步的研究成果中，遙測與實測的海水透明度，約有-20~50%的誤差。以遙測的方式去獲得海水透明度資料，目前仍無法完全代表海洋的實際狀況。因此需要更多實測資料加以比對確認，才能使遙測的海水透明度資料協助我們進行較無時空尺度限制的海洋科學研究調查。

## 南海北部海域碳匯系數之概況

吳珣涵、謝學函、施詠嚴、洪慶章  
國立中山大學海洋科學系

### 摘要

全球暖化導致地球發燒，極端氣候頻傳，主要的原因是大氣中過高的二氧化碳所導致。因此世界主要先進國家及台灣皆宣告要在 2050 年實施碳中和的目標。目前台灣的二氧化碳排放量每年約 2.9 億噸，要達到碳中和的先決條件，先要清楚目前台灣的自然碳匯量。因此本研究彙整近幾年在南海北部海域-小琉球南部水深約 1000 米之海洋之顆粒性有機碳通量(又稱海洋碳匯係數)資料，這些碳匯係數資料主要是使用漂浮式沉積物收集器，佈放在該水域經過 24 小時回收，顆粒樣品攜回實驗室後再測量有機碳的濃度。資料來源包含春、夏、秋、冬四季與颱風過後安全許可下出海的觀測。結果顯示該海域之碳匯係數從~40 mg-C/m<sup>2</sup>/d 至 ~100 mg-C/m<sup>2</sup>/d 之間，較大的碳匯係數是出現在颱風過後的幾天後，而冬天強勁的東北季風過後，該海域也有類似的高值出現，顯示較大的風浪會將次表層的營養鹽載送至表層而導致微細藻暴增，並促進海洋食物鏈的蓬勃發展，從而增加該海洋棲地的碳匯係數。未來將持續進行樣本之實際量測，並估算四季的碳匯係數及標準偏差，期望未來可以獲得南海北部較完整之碳匯係數與海洋基礎生產力。

## 研析彰化離岸風場海域底質沉積物內鋅含量之時空分布

康兆凱<sup>1\*</sup>、謝炎恭<sup>2</sup>、吳姍萱<sup>1</sup>、楊淞宏<sup>1</sup>、周瑋珊<sup>1</sup>、陳平<sup>1</sup>

1. 國立成功大學水工試驗所

2. 國家海洋研究院海洋生態及保育研究中心

### 摘要

目前離岸風力發電是全球能源轉型重要發展目標，彰化外海域具有台灣最優良的風力能源，並規劃為國內最大的候選場址。近年彰化海域多處風電場域正進行施工與營運階段，然而前人研究報導基樁水下結構物的表面所使用的防蝕工法，將釋出微量鋅離子，為預防風機建置對海洋環境造成影響，需針對風電場海域進行長期監測調查。本研究進行研析彰化海域底質重金屬鋅之含量，綜整國內風場施工過程中彰化海域底質鋅含量時空變化趨勢，並利用富集因子(Enrichment Factor, EF)、地質累積指數(Geo-accumulation Index,  $I_{geo}$ )及潛在生態風險指數(Potential Ecological Risk Index, PERI)等指標，評估離岸風電海域沉積物中重金屬之污染程度及對海域生物的潛在危害與風險。進一步，本團隊於 2022 年 4 月與 9 月分別採集彰化風場海域之底質沉積物，分析結果顯示 2 處測站之鋅含量皆符合國內「底泥品質指標之分類管理及用途限制辦法」之下限值 (140 mg/kg)，亦遠低於美國海洋大氣總署(NOAA)海域沉積物重金屬鋅對生物毒性最低影響範圍值 (Effect Range Low, ERL)(150 mg/kg)，且與歷年數據比較後並無顯著累積上升之趨勢。總合上述成果可知彰化風場海域開發與底質鋅含量之變動，屬於對海域生態環境低影響之程度。

關鍵字: 離岸風電、底質沉積物、鋅含量、富集因子、地質累積指數、潛在生態風險指數

## 澎湖內海營養鹽的時空分布:大型藻養殖條件評估

周雅嵐、盧美臻、辛宜佳、夏復國、何東垣  
中央研究院環境變遷研究中心

### 摘要

大型藻生長快速，加上海洋面積廣闊，大型藻養殖成為淨零碳排的熱門標的生物。由於營養鹽條件為藻類生長的關鍵因子，中研院「環境變遷研究中心生地化核心實驗室」過去三年來積極優化營養鹽測定方法，已具備高效取得高品質海水營養鹽數據的能力。在國家2050淨零碳排政策帶領，中研院「關鍵種子計畫」支持下，本實驗室於2022年7月開始進行澎湖海域主要營養鹽時空變化調查，分析項目包含硝酸鹽、亞硝酸鹽、氨氮、磷酸鹽與矽酸鹽。本研究採集澎湖灣、青灣，與桶盤嶼附近，共27個樣點，每個樣點包含3-4個水層，將進行兩年四季之研究測定。本研究結果將提供澎湖海域之營養鹽環境條件，將成為選取養殖場域的重要依據。

由目前所完成兩季的分析結果可知，就季節變化而言，硝酸鹽、亞硝酸鹽與磷酸鹽在12月的濃度遠較夏季高，營養鹽平均濃度約為夏季10-20倍，個別濃度範圍請參見海報；矽酸鹽的季節差異則較小，氨氮的濃度則是在夏季較高；就空間變化而言，在澎湖灣與青灣所有採樣點中，青灣內靠近馬公市南邊的菜園溼地附近的兩個採樣點的營養鹽濃度均高於其他採樣地點，澎湖灣接近大菓葉區域海鱸養殖區的三個樣點濃度亦稍微偏高，顯見人為活動的影響。本研究初步結果顯示冬季澎湖內海主要營養鹽濃度符合大型藻類最佳養殖環境需求，建議優先進行適合冬春季溫度條件大型藻物種的開發。

除淨零碳排的大型藻生長評估之外，澎湖採收食用之天然大型藻類已有百年歷史，加上無大型工業等污染源，澎湖海域環境亦極為適合食用型大型藻類產業開發。本實驗室已和「澎湖縣水產種苗繁殖場」、「水試所澎湖分所」及當地業者進行初步接觸，將提供澎湖海域及鄰近場域營養鹽條件資訊，在完成兩年每年四季的營養鹽分析調查後，本計畫將提出完整大型藻養殖之潛力場域建議。



**Title: Isotopic evidence for hydrological control of legacy  
nitrogen input into the Atchafalaya River.**

Jian-Jih Chen<sup>1,2\*</sup>, Gen K. Li<sup>3</sup>, Marcus Lin<sup>1</sup>, Ziyue Yu<sup>3</sup>, Justin A. Nghiem<sup>4</sup>, Tianshu Kong<sup>1</sup>, Heather Donnelly<sup>1</sup>, Noah P. Snyder<sup>1</sup>, Hanqin Tian<sup>1</sup>, Michael P. Lamb<sup>4</sup>, Xingchen Tony Wang<sup>1\*</sup>

1. Department of Earth and Environmental Sciences, Boston College, Chestnut Hill, Massachusetts, USA.
2. Department of Marine Environmental Engineering, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan
3. Department of Earth Science, University of California, Santa Barbara, CA, USA.
4. Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, USA.

**Abstract**

The increase in nitrogen (N) input from the Mississippi-Atchafalaya River basin to the northern Gulf of Mexico has led to several negative effects such as eutrophication and hypoxia. In order to reduce the N loading, it is critical to understand the sources of N within these regions. Previous model research suggested that synthetic N fertilizer application is the primary source contributing to N loading. However, some recent studies have reported that excessive N accumulation, also known as "legacy N", resulting from long-term N application may make an important contribution to N input in the northern Gulf of Mexico. In this study, we used the combinations of hydrography, nutrients and dual nitrate isotopes to investigate the origin and cycling of nitrate ( $\text{NO}_3^-$ ) in the Wax Lake Delta. Surveys and field sampling were carried out at Wax Lake Delta on March 24 - 31 (wet season) and August 17-24 (dry season) in 2021. The average values of  $\delta^{15}\text{N}-\text{NO}_3^-$  and  $\delta^{18}\text{O}-\text{NO}_3^-$  were 7.1‰ and 2.3‰, respectively. These values fall within the range of soil  $\delta^{15}\text{N}-\text{NO}_3^-$ , reflecting  $\text{NO}_3^-$  sources are mainly derived from the soil. High  $\text{NO}_3^-$  concentrations and water discharge with low  $\delta^{15}\text{N}-\text{NO}_3^-$  values were found during the wet season, whereas low  $\text{NO}_3^-$  concentrations and water discharge with high  $\delta^{15}\text{N}-\text{NO}_3^-$  values were observed during the dry season. These suggest that more legacy N (low  $\delta^{15}\text{N}-\text{NO}_3^-$ ) was flushed into the river during the wet season. The present work provides direct evidence of the importance of legacy N in the Mississippi-Atchafalaya River basin.



## 海洋大型藻類元素組成特徵

曾令偉, 張睿昇, 何東垣

中央研究院環境變遷研究中心、國立台灣海洋大學海洋中心

### 摘 要

海洋大型藻類為海洋中重要的初級生產者之一，主要分成四類:藍藻門、褐藻門、綠藻門、紅藻門，不僅為各式海洋生物食物及棲地，亦為人類數千年來的重要食物來源，若生長於重金屬污染海域，其藻體易累積重金屬，或者在吸收磷的時候，有可能吸收化性相近的元素(如砷)。在台灣廣泛食用的海洋大型藻類如：海帶、昆布、紫菜等，僅佔海藻極少部分，因此許多藻類具有成為養殖物種的潛力。然而，食用海藻元素組成之文獻卻極為缺乏，且藻體內重金屬含量對於食品安全更是重要，在未來選定適合食用藻種是必要的基本資訊。經過適當前處理程序後，包含海水及徹底的清除及樣品完全的消化後，以高解析感應耦合電漿質譜量測。本研究初步針對 7 種人工養殖之大型藻類進行多種元素測定，包含紅海葡萄藻、卡帕藻、海木耳、麒麟菜、馬尾藻、粗硬毛藻、石蓴，研究各元素組成差異及特徵，不僅可提供元素需求資訊及反應獨特生理機制特徵，做為未來進一步進行實驗基礎，並做為選取未來養殖潛力的物種。

## Using barium to trace underwater mud volcanoes in the Southwest offshore of Taiwan

Ya-Zhen Wu<sup>1</sup>, Huei-Ting Lin<sup>1</sup>, Chih-Lin Wei<sup>1</sup>, Ho-Han Hsu<sup>1</sup>, Kuo-Fang Huang<sup>2</sup>,  
Yu-Te Hsieh<sup>1\*</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taiwan

<sup>2</sup>Institute of Earth Sciences, Academia Sinica, Taiwan

\*Corresponding author. E-mail: [alanhsieh@ntu.edu.tw](mailto:alanhsieh@ntu.edu.tw)

### Abstract

Submarine mud volcanoes and cold seeps are important sources of methane emission, a greenhouse gas, to the ocean. However, it is difficult to precisely trace and quantify their inputs to the ocean. Barium cycling is one of the processes that is significantly disturbed during the sulfate methane transition zone (SMTZ) in the marine sediments where the methane emission is active. Therefore, Ba may serve as a useful tracer to trace the chemical inputs of submarine mud volcanoes and cold seeps to the ocean, and hence the marine carbon cycle. Recent studies of marine Ba stable isotopes have revealed new results of marine Ba cycling, which allow the tracing of different sources of Ba to the ocean. Even though submarine mud volcanoes and cold seeps play important roles in the marine Ba cycle, their Ba isotope compositions and isotope fractionations remain unknown. In this study, we analyzed Ba and sulfate contents in the sediment pore water collected from a marine sediment core from a top of a submarine mud volcano located in the Southwest offshore of Taiwan. We also measured Ba compositions in the seawater samples collected directly above the mud volcano to help to evaluate the impact of submarine mud volcanos on the marine Ba cycle. The data also provide the first constraint on the Ba inputs from cold seeps and mud volcanoes in the Southwest region of Taiwan and may be used as a tracer for reconstructing the activity of methane emission in the past.

**Effects of phytoplankton physiology on global ocean  
biogeochemistry and climate: the role of variable  
stoichiometry**

Chia-Te Chien (簡嘉德), Markus Pahlow, Markus Schartau, Na Li, Andreas Oschlies

GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

The similarity of the average ratios of nitrogen and phosphorus in marine dissolved-inorganic and particulate-organic matter, dN:P and pN:P, respectively, indicates tight links between those pools in the World Ocean. Here we analyse the sensitivity of marine biogeochemistry to variations in phytoplankton N and P subsistence quotas in an optimality-based ecosystem model coupled to the UVic Earth system model. Our results reveal distinct feedbacks between changes in the N and P quotas, N<sub>2</sub> fixation, and denitrification that loosen the coupling between dN:P and pN:P. We demonstrate the importance of particulate N:C and P:C ratios for regulating dN:P on the global scale, with oxygen concentration being an important mediator. Our analysis also reveals a potential interdependence of phytoplankton stoichiometry and global equilibrium climate conditions.

## 西菲律賓海稀土元素之空間分佈與季節變化之特徵

呂佳蓉、廖文軒、王博賢、李治平、Vineet Goswami、楊順中、何東垣  
中央研究院環境變遷研究中心

### 摘 要

本研究旨在經由溶解態與顆粒態的稀土元素(rare earth elements, REE)分析進一步瞭解與探討REE在海洋環境中的分佈與其影響機制。本研究為國際海洋科學研究GEOTRACES的臺灣航次，於2013七月及2014年三月在西菲律賓海進行研究，結果顯示除了Ce以外，溶解態REE濃度在垂直剖面上表現出類營養鹽的分佈曲線。中上層海水(< 600公尺)的REE濃度多呈現一恆定值，而深層海水的REE則隨著深度遞增。深層海水的REE濃度約為表層海水的3-5倍。在中層400-600公尺的海水中可發現到最小的溶解態REE濃度，溫鹽特徵進一步顯示此處的中層水應歸類為北太平洋中層水，因此，此結果表明水平的側向傳輸為中層水主要的REE分佈因子。不同於其他REE元素，溶解態Ce在表層與深層海水均都發現到較高的Ce濃度。在季節方面的表現，夏季表層水的結果顯示高濃度的REE在靠近臺灣外海海域。表層水高濃度的REE可歸因於源自臺灣陸地物質的輸入與來自南海北部海水的入侵，此結果同時也解釋表層海水的REE富集為外部的輸入所致。然而，表層海水的REE富集結果卻只在夏季發生，在春季並未觀察到相同現象。海水中Ce異常(cerium anomaly)現象代表著Ce在海洋環境中與其他REE元素相比，Ce對氧化還原反應的敏感度。在春季上部600公尺的海水中，溶解態Ce異常值隨深度由0.3下降到0.02；反之，顆粒態的Ce異常值則由0.5上升至1.2。相似的垂直剖面分佈亦可在溶解態與顆粒態的Mn中發現，代表在上部600公尺的海水中，Ce和Mn共存著相同的生物氧化作用。

## 南海北部 $^{13}\text{C}$ 及 $^{14}\text{C}$ 基礎生產力之差異

吳婉瑜 李彥杜  
海軍軍官學校應用科學系

### 摘 要

海洋基礎生產力（Primary Productivity，PP）除了是海洋生態系中不可或缺的基礎能量及源頭外，也是影響氣候變遷的重要因素之一。如何能準確量測並計算 PP 並從中了解海洋碳循環，一直是海洋學家重視的議題。大部分的 PP 實驗中會以  $^{14}\text{C}$  做為示蹤劑，培養過程會受到不同程度上的限制，且這些培養實驗，多以甲板培養的方法為主。本研究中透過使用  $^{13}\text{C}$  及  $^{14}\text{C}$  作為示蹤劑、現場和甲板培養及實測和遙測方法，所量測出的 PP 有顯著且正向的線性關係，故於低緯度海域可以使用對環境較無危害的  $^{13}\text{C}$  示蹤劑取代具有放射性的  $^{14}\text{C}$  示蹤劑作為培養方法。

不同的碳移除對我國碳匯的貢獻

林宜靜 劉逸梅 劉恩齊  
海軍軍官學校 應用科學系

## 摘 要

現今因為氣候變遷及工業的發展，二氧化碳排放量愈來愈高，因此了解原有的碳匯，減少碳排並增強或增加新興的碳移除作為，是刻不容緩的議題。本文整理了我國目前已知的碳移除方法或手段，包含森林、綠能、電動車及其它（包含沿近岸海洋藍碳、鈣迴路、大型海藻養殖、碳酸鈣形成等），約佔整體碳匯的 **37.2%**，而大洋藍碳則有 **62.8%** 的貢獻。顯見，要達到碳中和的目標，我們更應積極地抑制碳排，並向大洋尋找增加碳匯的方法

## 臺灣西南部近岸海域沉積物中塑膠微粒之時空變化探討

陳冠元

國立中山大學海洋科學院

### 摘要

海洋塑膠微粒是近年來被熱烈關注的污染議題，主要會造成生物的攝食與累積，最終影響海洋生態環境與食物鏈。本研究收集近17年來由國內海洋研究船所採集的臺灣西南海域近岸表層沉積物樣本，分茄荳、林園、枋寮三個樣站，各有15米和25米處，共計六個樣點，分析其粒徑、有機碳、氮、塑膠微粒含量，以描繪台灣西南近岸海域塑膠微粒的時空分布。

結果顯示，塑膠微粒在此區域大約每100g乾沉積物中含有31.16個塑膠微粒，以碎片佔主要。根據不同塑膠微粒類型與其空間分布差異，推測林園地區的塑膠微粒受高屏溪輸入影響，其較變動的環境可能受事件型降雨影響，但在塑膠微粒的數量和類型上還無法觀測到明顯與單一事件的聯繫。枋寮站環境較為穩定，有最高的塑膠纖維含量，推測可能是來源於更南邊的人為活動聚集地。



## **Eastern Equatorial Pacific oxygen minimum zone dynamics during the Pliocene**

Shraddha Band<sup>1</sup>, Jeroen Groeneveld<sup>1</sup>, Haojia Abby Ren<sup>2</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University, Taipei, Taiwan (R.O.C)

<sup>2</sup>Department of Geosciences, National Taiwan University, Taipei, Taiwan (R.O.C)

The low oxygen concentrations in the Oxygen Minimum Zones (OMZ) in the east Pacific are attributed to two processes, namely, 1) the influx of poorly ventilated waters through circulation of the high latitude northern Pacific subsurface water masses and, 2) the removal of oxygen at subsurface depths through biological degradation of organic matter in the high-productivity upwelling sites. The onset of northern Hemisphere Glaciation (NHG) at 2.75 Ma and associated water column stratification in the North Pacific, potentially restricted the ventilation of subsurface waters that source the Northern and eastern Pacific. In addition, evolution of the cold tongue in the Eastern Equatorial Pacific (EEP) during mid to late Pliocene increased the influx of nutrients to the surface leading to increased organic matter degradation in the subsurface waters. This was further accentuated by the closure of Panamanian gateway during the late Pliocene, leading to accumulation of nutrients along the eastern Pacific upwelling sites. The evolution of cold tongue in the EEP during the mid to late Pliocene led to zonal asymmetry in SST, heat, and nutrient distribution between the West Pacific warm pool (WEP) and the Eastern Equatorial cold tongue. In this study, we aim understand the deoxygenation history of the eastern Pacific focusing on the latter process by reconstructing nutrient characteristic variability in EEP with concomitant evolution of the cold tongue. To strengthen our research objective we aim to reconstruct contemporary Mn/Ca timeseries (IODP site 1338) which responds to the oxygen content in water.

To understand the nutrient utilization in the cold tongue we plan to use the difference in foraminifera-bound- $\delta^{15}\text{N}$  (FB- $\delta^{15}\text{N}$ ) values ( $\Delta\delta^{15}\text{N}$ ) between cores raised from the WEP

(ODP site 1115b, existing record) and EEP (present study) during the Plio-Pleistocene period. To reconstruct the  $\delta^{15}\text{N}$  variability in the EEP, we use FB- $\delta^{15}\text{N}$  record of *T. sacculifer* from IODP site U1338 (2°30.469'N, 117°58.178'W; 4200 m water depth) inside the eastern equatorial cold tongue.

The  $\Delta\delta^{15}\text{N}$  reconstructed using the data from IODP sites 1338 and ODP 1115B will better our understanding of the degree of nutrient pool utilization and its variability during a major step in the closure of the Panamanian gateway, a short glacial period-Marine Isotopic Stage M2 (3 – 2.5 Ma), a stable climate transition of Mid-Piacenzian warm period (3.3 – 3.0 Ma), the onset of Northern Hemisphere Glaciation at 2.75 Ma, and strengthening of Walker circulation at 1.6 Myr BP.

## Stable isotope record of Indian summer monsoon variability in the NW Indo-Gangetic Plain during the past ~80 ka

Mohd Amir<sup>a, b</sup>, Debajyoti Paul<sup>b</sup>, Yuan-Pin Chang<sup>a</sup>

<sup>a</sup> Department of Oceanography, National Sun Yat-sen University, Kaohsiung 804, Taiwan

<sup>b</sup> Department of Earth Sciences, Indian Institute of Technology Kanpur, Kanpur 208016, India

### Summary

The Indian summer monsoon (ISM), which brings >80% of the total annual rainfall to the Indian subcontinent, is a key driver of the Indian climate and is one of the most dynamic climate systems on the earth. It directly affects agricultural production and socio-economic development of the Indian subcontinent, where the livelihood of ~70% of the population depends upon agriculture. Longer continental records of ISM are very rare as well as not robust in terms of either continuity (resolution) or chronology. Here we report, for the first time, continuous and chronologically well-constrained records of stable oxygen ( $\delta^{18}\text{O}$ ) and carbon ( $\delta^{13}\text{C}$ ) isotopes of carbonate nodules, and  $\delta^{13}\text{C}$  of sediment organic matters ( $\delta^{13}\text{C}_{\text{SOM}}$ ) in samples from two (~47 m long) drill-sediment cores, collected from paleo-Yamuna channel in the NW Indo-Gangetic Plain (in north Haryana), to reconstruct ISM precipitation variability and paleovegetation pattern during the past ~80 ka. The  $\delta^{18}\text{O}$  of carbonate nodules ( $-7.80\text{‰}$  to  $-4.04\text{‰}$ , average:  $-6.01\text{‰}$ ), a proxy for ISM intensity, shows a strong negative correlation with the variability in the model-derived ISM precipitation intensity suggesting intense (week) ISM precipitation during late marine isotope stage (MIS) 5, early and late MIS3, and early MIS1 (MIS4, mid MIS3 and MIS2) periods. These changes in the ISM intensity are in-phase with the precession-induced changes in the Northern Hemisphere summer insolation. The  $\delta^{13}\text{C}_{\text{SOM}}$  ( $-22.3\text{‰}$  to  $-27.4\text{‰}$ , average:  $-25.3\text{‰}$ ) indicates a  $\text{C}_3$ -dominated vegetation in the Himalayan catchment with noticeable increase in  $\text{C}_4$  plants during hot early and late MIS3, and early MIS1 periods following the intensifying ISM precipitation. The  $\delta^{13}\text{C}$  of carbonate nodules ( $-3.63\text{‰}$  to  $1.56\text{‰}$ , average:  $-1.55\text{‰}$ ) suggests that this, being also influenced by dissolved inorganic carbon derived from the Himalayan source, could be misleading and therefore requires a careful evaluation.

## **Ocean temperature stratification of the east Pacific during the Pliocene using oxygen isotopes on different species of planktonic foraminifera**

Kuan-Yu Jow, Shraddha Band, Jeroen Groeneveld

Institute of Oceanography, National Taiwan University, Taipei, Taiwan(R.O.C)

### Abstract

Future climate change is a topic that currently receives a lot of interest from the society; increasing emissions of CO<sub>2</sub> related to human activities are not only raising global mean temperature, but also have a large impact on the oceans. Since the geological record, and especially marine sediment cores, offers an opportunity to understand climate system response to a range of forcings and feedbacks, studies of previous time periods that were similar or warmer than today receive a lot of attention. One such interval is the transition from one single glacial period of the late Pliocene (Marine Isotope Stage M2, ~3.25 Ma) to the interglacial MIS KM5c during the mid-Piacenzian warm period (MPWP), which the atmospheric CO<sub>2</sub> was similar to the present.

The East Pacific plays an important role in controlling global climate. Today it is characterized by relatively cold and nutrient-rich water masses that upwell along the coast of South America and at the equator. An important feature on interannual timescales are the variations in El Niño-Southern Oscillation (ENSO). During El Niño, the easterly winds along the equator weaken, allowing warm water from the western Pacific Warm Pool to move eastwards warming the east Pacific. It has been suggested that during the Pliocene this might have been the standard situation, a climate state sometimes referred to as “El Padre”. However, the data from the east Pacific Ocean are still lacking in many places. Thus, in this study we are working on IODP Site U1338 (2°30.469' N, 117°58.178' W; 4200m water depth) from the equatorial Eastern Pacific, using oxygen isotopes on foraminifera including *T. sacculifer*, *N. dutertrei*, *G. crassaformis* and *D. altispira*, to reconstruct how the structure of the water column changed through the late Pliocene. It is planned to supplement the data with analyses of the Mg/Ca ratio on these species of foraminifera to allow separating changes in sea water temperature and salinity.

## Multi-species planktonic foraminifera-inferred upper ocean hydrographic changes of the Okinawa Trough over the past 20 kyr

Ru-Yun Tung<sup>1</sup>, Yuan-Pin Chang<sup>2</sup>, Yu-Shih Lin<sup>2</sup>, Chuan-Chou Shen<sup>3,4</sup>, Yoshimi Kubota<sup>5</sup>,  
Sze Ling Ho<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University

<sup>2</sup>Department of Oceanography, National Sun Yat-sen University

<sup>3</sup>High-Precision Mass Spectrometry and Environment Change Laboratory (HISPEC), Department of Geosciences, National Taiwan University

<sup>4</sup>Research Center for Future Earth, National Taiwan University

<sup>5</sup>Department of Geology and Paleontology, National Museum of Nature and Science, Japan

### Abstract

The Kuroshio Current (KC) is a strong western boundary current that brings an enormous amount of heat from the Equatorial Pacific to the middle latitudes of the western Pacific, thus it exerts a strong influence on the regional climate system here. Studying the long-term variations of the KC will allow us to understand past climate change in the Northwest Pacific. To provide a long-term perspective of the KC variations and its link to the regional climate, here we use Mg/Ca ratios of thermocline-dwelling foraminifera, *Pulleniatina obliquiloculata* and *Neogloboquadrina dutertrei*, to reconstruct past hydrographic changes over the past 18 ka in the northern Okinawa Trough (OT). Interestingly, *P. obliquiloculata*, regarded by some as an indicator of the KC, was not found in samples older than 15 kyr. Its absence during the colder period might indicate a diminishing influence of the warm KC. *P. obliquiloculata* Mg/Ca-derived temperatures show little changes over the past 15 kyr (at ~20°C). The absence during deglaciation and low temperature variability recorded might be due to the relatively narrow temperature tolerance range of this species. *N. dutertrei* Mg/Ca-derived temperatures also show no cooling during the glacial period but instead reach the temperature minimum around 5 kyr during the Holocene. This pattern in the Holocene is in accordance with other reconstructions in the central OT. In contrast to our thermocline temperatures, previously published surface temperatures derived from Mg/Ca of surface-dwelling *G. ruber* and organic proxies indicate 3–10°C of glacial cooling. This difference suggests that the temperature variability at the surface and thermocline is not controlled by a single factor (e.g. Kuroshio Current). A comparison with previously published records of foraminiferal  $\delta^{18}\text{O}$  and Mg/Ca temperature from the region shows similar  $\delta^{18}\text{O}$  values but higher Mg/Ca-derived thermocline temperatures outside of the OT over the 20 kyr; this despite comparable surface conditions (both  $\delta^{18}\text{O}$  values and Mg/Ca-derived temperatures) between the inside and outside of the OT. Differences in thermocline temperatures between the inside and outside of the OT may be due to the varying influence of the North Pacific Subtropical Gyre and/or differences in foraminifera seasonality/habitat depth. In future, we will add thermocline temperature records from a site outside of the OT to increase the latitudinal coverage of our regional compilation.

**Keywords:** Okinawa Trough, Planktonic Foraminifera, Kuroshio Current, Mg/Ca,  $\delta^{18}\text{O}$

## 臺灣東北海域斷層與火成構造之震測特徵

鍾承峻<sup>1</sup>、黃靖芸<sup>1,2</sup>、王明<sup>2</sup>、許鶴瀚<sup>1,2</sup>、劉家瑄<sup>2</sup>、林依蓉<sup>3</sup>、陳松春<sup>3</sup>

<sup>1</sup>國立臺灣大學海洋研究所 <sup>2</sup>國立臺灣大學海洋中心 <sup>3</sup>經濟部中央地質調查所

臺灣東北海域在拉張的地體環境下具有活躍的斷層作用與火成活動，而火成活動所伴隨的相關熱液作用，也使得此區域具有金屬硫化礦物的生成。為了解臺灣東北海域的地質架構與礦床資源潛能，經濟部中央地質調查所自 109 年開始，於基隆陸棚近岸區域及北方三島鄰近海域進行了一系列海洋地質及地球物理相關調查。本研究利用過去新海研 1 號、海研一號及海研二號等歷年航次所收集的多頻道反射震測資料，發展進階處理技術，有效改善海床複反射、氣泡效應及鬼影等各式雜訊影響，優化震測成像品質，以進一步分析臺灣東北海域之地質構造，並呈現外金山、野柳、小野柳及八斗子等四條海域斷層的特徵與分布。此四條斷層皆為東北-西南走向之東南傾正斷層，其中外金山斷層長度約 16.9 公里，於剖面上具有切穿至海床的特徵，並可以對應至海床上分段的外金山線形；野柳斷層切穿至海床的部分長度約 10.23 公里，於海床上可對應至野柳線形，而在東北外海方向則有部分未切穿至海床，長度約 6.89 公里；小野柳斷層是發育自野柳斷層以東的半地盆地內的斷層，並未切穿至海床，長度約 11.36 公里；八斗子斷層為切穿至海床的斷層，長度約 8 公里，但其海床形貌特徵則較不明顯。針對東北外海的火成活動，震測資料顯示北方三島海域於近海床的淺部地層多具有強振幅異常的訊號特徵，且內部為混亂震測相，深部地層則呈反白相，此種訊號組成與海床上的隆起地貌常伴隨出現，可能為海底火山活動所造成。花瓶嶼鄰近海域海床則普遍具有崎嶇不平的地形特徵，震測剖面顯示其下方地層也呈現大範圍的強振幅異常與混亂相之訊號特徵，顯示該區亦可能受火成活動影響。本研究透過新、舊地物資料的整合，並發展進階的資料處理與分析技術，不僅將舊資料的應用價值進一步提升，也透過多重地物資料的綜合解釋，精進臺灣東北海域礦產與地質構造模型，未來不僅對地質風險評估有所幫助，也有益於可能的海底熱液礦產資源之探勘工作。

**關鍵字：** 反射震測、斷層、火成活動、海底火山、熱液礦床、臺灣東北海域

## **A Preliminary Results: Seafloor Manifestations at Mienhua Volcano in Southern Okinawa Trough**

Chieh-Wei Hsu<sup>1,2</sup>, Yu-Shih Lin<sup>1</sup>, Yu-Cheng Chou<sup>3</sup>, Hsin-Hung Chen<sup>3</sup>, Song-Chuen Chen<sup>4</sup>,  
Yunshuen Wang<sup>4</sup>

1. Department of Oceanography, National Sun Yat-sen University
2. Cross College Elite Tech Program, National Kaohsiung University of Science and Technology
3. Institute of Undersea Technology, National Sun Yat-sen University
4. Central Geological Survey, Ministry of Economic Affairs, New Taipei City, Taiwan

### **Abstract**

The Menhua volcano is located in the southern Okinawa Trough, a back-arc basin known for its hydrothermal activity. To examine the geochemical and geological processes in the Menhua volcano, advanced equipment including Fiber-optical Instrumentation Towed System (FITS) and remotely operated vehicle (TORI-ROV) were used to conduct seafloor observations. The observations were analyzed and integrated through scrutinizing, integrating, and analyzing the seafloor images/videos.

The Seafloor Massive Sulfide (SMS) deposits, distributed in the hydrothermal activity influence area, were discovered during this study, providing significant evidence of the volcanic and hydrothermal processes that occur in the Menhua volcano. Additionally, juvenile tubeworms were observed, indicating current hydrothermal vent activity. Growth tubeworms were also observed and found to be buried by mass sulfide deposits, suggesting that hydrothermal fluid might be released from the seafloor periodically. Extensive outcropping of CO<sub>2</sub> hydrate deposits were documented at the seafloor, covering a distance of 110 meters, which is never been reported. Furthermore, the study identifies numerous locations of elemental sulfur deposits that suggest that the sulfur is formed under characterized and distinctive geochemical processes, that is suggested to be associated CO<sub>2</sub> migration.

This study's findings provide a better understanding of the seafloor manifestations and the geological and geochemical processes in the Menhua volcano, which can be used to develop a better comprehension of the volcanic and hydrothermal processes in the southern Okinawa Trough. However, this study's scope is still limited to active hydrothermal sites identified by geophysical data. To gain a more comprehensive understanding of the geological and geochemical processes in the area, future research will need to examine non-active sites.



南沖繩海槽棉花火山熱液煙囪之反差性礦物組合  
**Contrasting Mineral Assemblages of Mienhua Volcano  
Hydrothermal Chimneys in South Okinawa Trough**

徐達偉<sup>1</sup>、蘇志杰<sup>1</sup>、江威德<sup>2</sup>、林玉詩<sup>3</sup>、吳炫賦<sup>1</sup>、許鳳心<sup>1</sup>、陳松春<sup>4</sup>、王詠絢<sup>4</sup>

- 1 臺灣大學海洋研究所
- 2 國立成功大學地球科學系
- 3 國立中山大學海洋科學系
- 4 經濟部中央地質調查所

**摘 要**

南沖繩海槽棉花火山地區為顯著之熱液活動場址，利用水下無人載具於 LGD-2104 航次，在水深約 1380 公尺海底發現兩個活躍熱液煙囪，依據煙囪外型分別命名為魔王煙囪和鬼馬煙囪，此二煙囪相距僅數公尺，卻有迥異之礦物組成。利用採獲的煙囪礦石進行 X 光繞射、電子顯微分析、以及主要和微量元素分析。魔王煙囪礦石以重晶石為主體，含銀礦物種類多，存在於硫銻銀鉛礦、銻銀鉛礦、方鉛礦、膠狀組織黃鐵礦等礦物，多為中晚期熱液成礦產物，成礦溫度相對較低，可能為 <300°C，暗示有較高程度海水涉及熱液循環和沈澱。鬼馬煙囪礦石以磁黃鐵礦、閃鋅礦/閃鐵礦、方鉛礦、方鐵黃銅礦為主要組成礦物，僅在煙囪管壁外側有少量雄黃和輝銻礦，強烈反映早期熱液沈澱產物，成礦溫度為 370–400°C，相較於魔王煙囪，鬼馬煙囪礦石缺乏含銀礦物，銀與金含量亦較低。魔王煙囪和鬼馬煙囪的多樣性礦化現象，可能與近海床發生的相分離作用有關；此外，根據兩煙囪的反差性礦物組成和貴金屬含量，推測棉花火山熱液場址在以中晚期熱液沈澱為主之硫化金屬礦石測站，含銀礦物以及整體礦石含銀量具有較高的潛能。

**Geochemical impacts of hydrothermal activity on sedimentary pore fluids from a shallow-water hydrothermal field offshore northern Taiwan**

台灣北部淺海海床熱液活動徵兆區之沈積物間隙水地球化學特徵

Shein-Fu Wu<sup>1</sup>, Chih-Chieh Su<sup>1</sup>, Feng-Hsin Hsu<sup>1</sup>, Hsiao-Fen Lee<sup>2</sup>, Ta-Wei Hsu<sup>1</sup>, Song-Chuen Chen<sup>3</sup>, Yun-Shuen Wang<sup>3</sup>

<sup>1</sup> Institute of Oceanography, National Taiwan University

<sup>2</sup> National Center for Research on Earthquake Engineering, National Applied Research Laboratories

<sup>3</sup> Central Geological Survey, Ministry of Economic Affairs

Abstract

Geochemical analysis of trace elements (include Fe, Mn, Co, Ni, Cu, Zn, and REE+Y) and was performed on sedimentary pore fluids collected from the Keelung Submarine Volcano (KLSV) and Keelungyu (KLY) regions, a shallow-water hydrothermal field offshore northern Taiwan. For comparison, those analyzes were also conducted on pore fluids from the Mienhua Volcano (MHV) hydrothermal field in the southern Okinawa Trough, where a highly sediment-hosted hydrothermal system and strong hydrothermal activities have been discovered. The KLSV fluids show low-Cl and significant consumption of Mg, as well as a rather low total REE compared to that of the MHV fluids, which is referred to as the vapor-rich phase fluid after phase separation. High Mn/Cl, Ni/Cl, Cu/Cl, and Y/Cl values of low-Cl fluids comparable to those of seawater were observed in KLSV fluids, providing consistent results to emphasize the effect of phase separation on trace element distributions in hydrothermal fluids. In KLY samples, it is revealed that the concentrations of Co, Cu, and Zn are much higher, while the total REE is much lower than those at the other sites. In the MHV field, depth profiles of the trace elements and total REE concentrations in pore fluids, which are characterized with consumed Mg and seawater-like Cl as a liquid phase produced from phase separation, present a distinct enrichment of trace element and total REE concentrations at the bottom water-sediment interface, accompanied by a rapidly downward depletion. The chondrite-normalized REE pattern of MHV pore fluids shows a common pattern of LREE enrichment and a positive Eu anomaly, which differ from patterns in seawater and other sites, implying the impact of hydrothermal activity.

## 岩心採樣管緊急釋放系統設計與測試

黃俊傑、許家維、郭芳旭

國家實驗研究院台灣海洋科技研究中心

### 摘 要

在海洋研究的方法中，重力及活塞岩心樣本是科學家最常分析研究的對象，而隨著國內科學研究船的噸位增加，想要取得更長尺寸的岩心樣本也更加容易，一般來說取得的岩心尺寸愈長相對應的研究時間尺度就愈古老，理論上取得岩心尺寸的長度會受到幾個因素的影響，如重錘的總重量、取樣管的直徑、採樣的方法(重力或活塞)、海床地質組成等等，總體而言，為了取得更長的岩心樣本，岩心取樣系統的重量及體積都會相應的增加。

重力或活塞岩心在海上佈放及回收作業時，一般而言比較會遇到的問題有岩心重錘被佈放繩纏繞、擊發系統未運作、岩心採樣管變形彎曲等，在新型研究船開始採用kevlar等材質做為拉力主繩時，前二項情形已幾乎不容易發生，而岩心採樣管的變形彎曲，當使用的採樣管長度往上增加時，可能因此而勾住在海床而無法抽出或是脫離海床所需的拉力接近拉力絞機的負荷，此時對研究船而言是極為危險的情況，在最壞的情況下就必須剪斷拉力繩，付出極大的成本；因此，海洋中心設計一套可在緊急情況下的岩心管脫離結構，與中心現有釋放儀進行模組化結合，一方面在高危險海域做為作業的安全確保，另一方面在低危海域可以更換為其它觀測儀器，收集近海床數據，目前第一階段則以作業安全的脫離設計與測試為主。

# 海報展示\_PG12

## 勵進研究船岩心系統簡介與海洋岩心實驗室配合作業現況

許家維、黃俊傑、尤柏森、陳婷婷、劉紹勇、許景翔、郭芳旭  
國家實驗研究院台灣海洋科技研究中心

### 摘 要

配合國研院海洋中心 海洋底質沉積物探測技術發展子計畫，勵進研究船之岩心採樣系統將結合岩心採樣資料及採樣時之現場聲納資料進行分析比較，探究船載聲納資料優化岩心採樣品質之可能性。透過與海洋岩心實驗室配合之分析結果，持續修正岩心採樣佈放與回收作業程序，確保精準採樣之岩心品質符合國內學研界海洋地質相關研究分析所需，並逐步朝向發展精準探測技術之目標前進。

## 台灣海洋岩心數位典藏之建置與進展

陳婷婷<sup>1</sup>、尤柏森<sup>1</sup>

<sup>1</sup>財團法人國家實驗研究院 台灣海洋科技研究中心

### 摘 要

為能瞭解並掌握台灣鄰近海域底質特性及其時空演變，我們針對關鍵海域整合岩心分析資料，以建構一『台灣週邊海域海洋岩心數位典藏 (MAR-CODA; MARine COre Digital Archives)』，並透過時間與空間雙向並進的策略，延伸數位資料的深度與廣度。其中非破壞性之岩心量測技術具備快速分析、經濟成本且超高解析度等優點，不僅是國際研究船（美國聯合果敢號、德國太陽號、法國瑪麗安·杜帆妮）以及國際級海洋岩心庫（如ODP-IODP 計畫日本高知岩心庫）必要分析項目外，同時，也是海洋岩心數位典藏規劃重點。有鑑於此，我們特別挑選了涵蓋東海陸棚、台灣海峽、西南海域、東部外海等關鍵海域共計67個站位，進行多重感應源岩心紀錄器（MSCL; Multi-sensor core logger）之非破壞性量測，取得海床表層之物理及聲學重要參數，這包括壓縮波（P波）波速、統體密度、磁感率、孔隙率、粒徑大小、聲阻抗值、電阻抗值、聲衰減率等。在時間分佈上，每站位之箱型岩心沉積物平均長度約48公分，提供近代沉積物紀錄與海洋環境變遷。以1公釐超高解析度之量測，共獲得193,560筆岩心非破壞性資料之時空變化。這一海洋岩心非破壞性數位資料的建置不僅提供了台灣鄰近海域之區域性海洋環境，亦提供岩心比對之重要資料。未來持續強化台灣海洋岩心數位典藏之內容與功能，並朝向台灣海域高解析度之非破壞性地質資料的目標邁進。

## 東沙陸緣高原之構造特徵與地質演化：

### 多頻道反射震測資料初步結果

李品蓁<sup>1</sup>, 張日新<sup>1</sup>

<sup>1</sup>國立台灣大學海洋研究所

#### 摘要

大陸邊緣高原(continental marginal plateau)是指自陸坡向海突出之地勢接近水平（坡度 $<1^{\circ}$ ，大陸斜坡多為 $3\sim 6^{\circ}$ ）的海床特徵，其深度介於大陸棚與下部斜坡之間，為大陸邊緣的一部份。陸緣高原在大西洋、印度洋以及南極海等大洋的大陸邊緣皆有發現，其成因多被解釋為較堅硬而拉張減薄程度較低的岩石圈，或者是張裂早期因橫移壓縮造成的構造抬升。

在東沙環礁附近大陸邊緣，透過 200 公尺以及 1000 公尺等深線進行觀察，我們辨識出向海延伸之東沙陸緣高原。由於缺乏對東沙陸緣高原地下地質之了解以及沉積歷史的掌握，因此目前對於東沙陸緣高原的成因了解非常有限。本研究利用全球水深地形模型、多頻道反射震測資料以及前人發表之震測剖面，統整基盤面(Tg)以及張裂不整合面(T7)之空間分布，描繪東沙陸緣高原層面之空間變化與地下構造，進而探討其構造發展以及演化歷史。

震測資料及構造等時圖之初步結果將東沙陸緣高原分為三個區域，分別為：隆起基盤區、西北凹陷區以及東南斜坡區。隆起基盤於東沙下方以東北-西南向進行延伸，基盤頂部雙程走時約 1 秒，上方缺乏同張裂時期沉積物。隆起基盤依構造差異可再將其區分成南北兩段，北段基盤內可觀察到古背斜構造，南段基盤可見大量向海的方向傾斜之斷塊。基盤西邊邊界為西北-東南走向之東沙斷崖(海床落距約 300 公尺)。東沙斷崖西南側基盤受連續出現的斷層影響，地層落距大，基盤雙程走時最深可達約 4 秒，斷距達 2 秒。西北凹陷區為一沉積盆地，主要為 Tg 到 T7 之沉積地層所填積。東南斜坡區具大量火成作用。

後續工作將透過建立東沙陸緣高原之沉積-構造歷史，了解隆起基盤之形成過程，以及其與張裂早期的橫移壓縮作用是否有關，期望透過與世界上其餘陸緣高原進行比較，能提供與南海張裂機制相關之重要訊息。至於南段基盤之海床正斷層與東沙斷崖是否為活動構造，未來可再進一步討論。



## 臺灣東南海域弧前盆地與陸域海岸山脈南端之構造連接

黃謙煜<sup>1</sup>、張日新<sup>1</sup>

<sup>1</sup>國立臺灣大學海洋研究所

### 摘要

由於歐亞大陸邊緣與呂宋島弧之間的斜向聚合，使得臺灣東南海域成為由隱沒系統向北轉變為碰撞系統的過渡帶，而臺灣東部陸域海岸山脈，被認為是呂宋島弧的向北延伸，與海域弧前盆地有密切的演化關係。本研究針對陸域地層（如利吉層、八里灣層）與構造（如永豐斷層、利吉斷層）向海域的延伸，透過東南海域近岸多頻道反射震測資料，對比陸域海岸山脈南端野外調查結果，探討海陸域地體架構的連接關係，進一步瞭解區域演化歷史。

陸域研究部分，我們將焦點放在海岸山脈最南端受構造活動強烈作用的利吉層，以及其上覆的八里灣層，針對兩者之間的邊界位置，以及不同模型提出的接觸關係可能性，如平移斷層接觸(Chen, 2022)、逆衝斷層接觸(Huang et al., 2018)或沉積接觸(Lai et al., 2021)，嘗試在野外尋找兩地層與構造的向海延伸方向與接觸特徵。根據野外調查，我們在潮來溪沿線觀察到的露頭以雜亂無層理夾外來岩塊的利吉層為主，而潮來溪北邊的郡界溪則出露以濁積岩為主的八里灣層，顯示利吉層與八里灣層之邊界大致位於潮來溪與郡界溪之間，走向約為東西向，此結果與前人(Chen, 2022)所提出的東西向平移斷層（永豐斷層）位置較為接近，然而兩地層接觸關係是否為平移斷層有待確認。

海域研究部分，我們的震測資料範圍涵蓋了東南海域的呂宋島弧、臺東峽谷、花東海脊、南縱海槽等單元。從震測剖面中，沿著陸域地層邊界往東向海延伸的位置，我們在臺東峽谷上游南北兩側觀察到崎嶇的海床，其淺層震測相較為混亂，推測為受構造活動影響而變形，可能與陸域斷層的向海延伸活動有關，從位置分佈判斷，峽谷北側的海床變形大致可視為永豐斷層的向海延伸，而南側海床變形則可視為利吉斷層的向海延伸。除此之外，前人研究視為陸域利吉層前身的花東海脊(Huang et al., 2018; Chi et al., 2014)，其兩翼存在不同的震測相特徵，西翼觀察到向南縱海槽傾斜、往海脊方向減薄之連續訊號，東翼則呈現較為混亂之震測相。

未來將針對海域震測剖面做更詳細的觀察與解釋，結合陸域野外觀察結果，進行海陸域地層與構造的延伸與連接，並嘗試重建區域構造演化歷史。



## AIS船舶自動識別系統在深海儀器的測試與應用

楊金恒：國立臺灣大學地質科學研究所

林慶仁：中央研究院 地球科學研究所

張坤輝：中央研究院 地球科學研究所

陳又嘉：國立臺灣大學地質科學研究所

龔源成：國立臺灣大學地質科學研究所

### 摘 要

目前大部分的海底儀器，都只是搭配無線電信標和閃光燈信標作為儀器浮出水面時的指式，如果海面上的儀器與工作船的距離太遠，在海上儀器收回作業時將會耗費很多時間在搜尋儀器上面。把AIS進行改裝，使其可以附掛在水下儀器上，使儀器浮於水面時發送GPS訊號，透過船載AIS設備以及衛星、沿岸站台接受訊號，以絕對位置的方式進行海面搜索作業，進而提升儀器回收的效率與成功率。

本研究透過觀測船載設備和衛星接收AIS浮標追蹤器訊號的穩定度和解析度，評估AIS系統運用於水下儀器的可行性，並實際將海底儀器與AIS電路結合，檢驗其耐壓、防水能力以及工作穩定度。

## 臺灣海峽離岸風場海域地質構造及海床底質調查

陳憶萍<sup>1</sup>、劉廷毅<sup>1</sup>、林育璿<sup>1</sup>、葉影澄<sup>1</sup>、莊閔涵<sup>1</sup>、  
許鶴瀚<sup>1,2</sup>、蘇志杰<sup>1,2</sup>、張頌平<sup>3</sup>、張日新<sup>1,2</sup>、劉家瑄<sup>1</sup>、林依蓉<sup>4</sup>、陳松春<sup>4</sup>

1國立臺灣大學海洋中心

2國立臺灣大學海洋研究所

3國立成功大學地球科學系

4經濟部中央地質調查所

### 摘要

為兼顧能源安全、環境永續及綠色經濟目標，臺灣大學海洋研究所、臺灣大學海洋中心研究團隊透過執行經濟部中央地質調查所計畫，於臺灣海峽彰濱外海進行離岸風電潛力場址區域之地質調查，同時建置離岸風電海域地質資料庫，協助「離岸風場地質及環境感知系統建置」工作進行，以整掌握離岸風場之地質概況，作為配合政府推動離岸風電重大政策之基礎資料，並協助相關權責及開發單位對風機基礎施工安全及未來運轉階段時的地質風險控管，以期達到我國離岸風電永續發展之目標。

本計畫在臺灣海峽彰濱外海的可能離岸風電場址，利用三個新海研1號航次，在臺灣海峽中線以東、離岸風電第二階段及第三階段場址的調查區域，收集了共1,280公里之多頻道反射震測剖面資料，其中於本計畫範圍內共計1,156公里，同時沿測線收集底質剖面及多音束聲納等地球物理資料，並採集了14站沉積物岩心。

在臺灣彰濱海域發現到多項地質環境因子特徵，如海床沙波、流體移棲、淺部地層發育斷層以及堅硬地層，可能對於現正發展的離岸風力發電以及海底電纜等設施產生重大的影響。透過海床底質與多音束水深資料在海床觀察到許多沙波，沙波劇烈的變化可能對於海床的電纜以及工程設施產生相當大的影響，造成海床的侵蝕或沉積物掩埋工程設施。而透過震測剖面則發現流體移棲的特徵，並於漁探儀水層中發現近海床處有噴氣現象，且在這些聲學空白帶兩側的沉積層，亦顯示地層有受到斷層錯動的影響，這些特徵可能指示流體移棲的活動與斷層構造相伴，流體透過斷層作為管道在地層中向上移棲。此外，在臺灣西部前陸盆地的前凸起及前淵處，辨識了超過10條斷層切過前陸基底不整合面，且大部分斷層並未向上切穿末次冰期不整合面。最後，在水深淺於200公尺的地層中也辨識出許多堅硬地層（如玄武岩層）分布，在架設基樁時，若鑽遇預期外的堅硬地層，更可能導致鑽探設備的損壞，或造成工程延宕並使成本大幅提升。

藉由本計畫的調查與分析結果，除可進一步瞭解中彰雲外海區域構造特徵、沉積特性等地質環境資訊，協助評估未來建置風場區域之地質特性，亦可對不同階段風場區域的選址、開發、設計、施工及營運風險的管控作出貢獻。

### 海洋中心長支距多頻道震測系統之探勘能量發展 Development for Exploration of TORI's LMCS System

洪鄧家明、邱朝聰、余尚學、林聖心、陳鼎仁、黃伊賢、黃奕霖、  
蔡仲霖、曹庭綸、陳虹榜、劉紹勇、郭芳旭

財團法人國家實驗研究院台灣海洋科技研究中心

#### 摘 要

由財團法人國家實驗研究院台灣海洋科技研究中心 (簡稱:海洋中心)所引進臺灣首套工業級長支距多頻道震測 (Long-offset Multi-Channel Seismic, 簡稱: LMCS)系統, 2018年與勵進研究船磨合成功後, 於2019-2022年之間已經完成9個航次, 目前共計蒐集約7,137公里長之震測測線。在此期間LMCS系統配合科學家不同的研究目的, 調整適合之設備與實驗參數 (如:空氣鎗容積、炸測間距與浮纜長度等), 至台灣週遭海域 (如:台灣海峽與台灣西南海域等)進行探測。進而, 搭配勵進研究船遠航的能力, 至太平島、菲律賓海域與南海中部海域等遠洋區域蒐集震測資料。另一方面, 海洋中心LMCS系統之固態浮纜與平行鎗簇, 可提高震測資料品質, 得到更清晰的沉積地層剖面。此外, 能夠利用導航系統伺服器, 彙整震測系統的各項設備資訊, 並計算震測設備與炸點位置, 進行等距炸測, 藉以克服臺灣附近海域多變的海況。海洋中心震測團隊雖然已成功使用勵進研究船搭載LMCS系統蒐集資料, 但未來仍希望持續發展與改善LMCS系統, 以發揮其系統最大性能, 同時能夠配合學研界, 積極投入台灣週遭海域能源與地質災害潛勢等調查研究中, 為國家海洋地球物理探勘研究注入新能量。

## 臺灣海域熱液礦產資源與離岸風電場址地質地物資料庫

### Geology and Geophysics Database of Submarine Hydrothermal mineral resource and Offshore Wind Farm in Taiwan

莊閔涵<sup>(1)</sup>、葉影澄<sup>(1)</sup>、林依蓉<sup>(2)</sup>、陳松春<sup>(2)</sup>  
許鶴瀚<sup>(1)·(3)</sup>、蘇志杰<sup>(3)</sup>、劉家瑄<sup>(1)</sup>、王詠絢<sup>(2)</sup>

(1) 國立臺灣大學海洋中心

(2) 經濟部中央地質調查所

(3) 國立臺灣大學海洋研究所

中央地質調查所自 2016 年開始推動東北海域礦產資源潛能調查工作，並於 2022 年投入臺灣海峽離岸風場海域基礎調查工作，期間協同臺大、中央、成大、中山等工作團隊針對臺灣海域進行資源潛能調查，調查項目涵蓋反射震測、地熱流、地熱模擬、高解析聲納、磁力、地球化學、海床觀測等各式工作。為能將大量資料進行管理與應用，本團隊協助地調所建立資料庫，並進行資料展示與維護作業。至今已在周遭海域執行了 37 個調查航次，收集了 5,362 公里的反射震測剖面、1,498 公里的電火花剖面、8,175 公里的海床底質剖面、49 站地熱流量測、約 4,846 平方公里的多音束水深資料、2,146 公里的底拖聲納剖面、24 站海底地震儀及 7,826 公里的磁力資料；在地球化學與海床觀測工作方面，彙整了 103 站岩心資料，另保存了大量海床觀測影像及水下遙控無人載具調查觀測影片、地溫紀錄與採樣成果，針對樣本分析工作，則包含岩心描述、沉積物粒徑、地化特性、礦物組成、磁學性質及間隙水地化資訊等多種資料。為對資料有效管理，本資料庫針對所收集資料，利用地理資訊系統，將各項資料進行數位展示，依據資料屬性分類、需求導向、工作年度及主題目錄建立資料圖層，再將大數據空間資訊進行視覺化工作，以展示綜合分析成果，並發展相關加值服務。針對多元的地化量化分析資料，也透過 MySQL 關聯式資料庫的建置進行管理，使地化分析成果展示更趨便利。而針對臺灣海峽離岸風場海域資料，也更著重在原始資料的保存，並針對後續地質工程方面的延伸應用，將地物資料的格式加以標準化並增加屬性資料，以利資料的交換同時協助前端資訊平台的建立，未來也希冀能透過資料交換及合作計畫的推動，讓這些珍貴的調查資料能發揮更高的效益與價值

關鍵字：天然氣水合物、熱液礦產資源、離岸風場、海洋資料庫、地理資訊系統

## Practical Interlaboratory Guidelines in XRF-scanning of Long Sediment Records: An Example from IODP Expedition 386

Jun-Ting Lin<sup>1</sup>, Jyh-Jaan Steven Huang<sup>1</sup>, Yu-Hsun Shao<sup>1</sup>, Yen-Hsi Wu<sup>1</sup>, Astuko Amano<sup>2</sup>, Ken Ikehara<sup>2</sup>, Michael Strasser<sup>3</sup>, Jeremy Everest<sup>4</sup>, Lena Maeda<sup>5</sup>, and the IODP Expedition 386 Science Party\*

<sup>1</sup> Institute of Oceanography, National Taiwan University, Taiwan.

<sup>2</sup> Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Japan.

<sup>3</sup> Institute of Geology, University of Innsbruck, Austria.

<sup>4</sup> British Geological Survey, United Kingdom.

<sup>5</sup> JAMSTEC Japan Agency for Marine-Earth Science and Technology, Institute for Marine-Earth Exploration and Engineering (MarE3), Japan.

\*A full list of authors appears at the end of the abstract

### Abstract

Traces left behind by earthquakes in subaqueous environments are essential to submarine paleoseismological investigations seeking to provide long-term earthquake records. During IODP Expedition 386, 29 Giant Piston Cores (GPCs) were collected at 15 sites, totaling 842 meters of cores from 11 individual trench-fill basins of the Japan Trench. Robust event-stratigraphic correlation is thus the key to characterizing event deposits and providing a spatiotemporal framework for the entire Japanese margin. To identify the chemical fingerprints of event deposits, X-ray fluorescence (XRF) core scanning provides a fast, non-destructive, and high-resolution method to obtain semi-quantitative counts of elements in the sediment. However, completing more than 800 meters of sediment cores with only one XRF-scanning machine is time-consuming and laborious. An approach is thus developed by combining two Itrax-XRF core scanners (CS-45 at Innsbruck and CS-49 at AIST, with different generations of XRF detectors) with U-channel samples. By simply normalizing each of the elements with its mean value throughout the core respectively, the resulting elemental counts from different machines can be calibrated and further processed by multivariate statistics, including principal component analysis (PCA) and cluster analysis (CA). The differences in event deposits can therefore be deciphered in a fast, high-resolution, and comprehensive manner in order to provide high-resolution chemostratigraphic correlations along the Japan Trench and guide follow-up studies. Such experience can also be applied in other research where long-term sedimentary records are needed.

Keywords: Non-destructive technique, XRF-scanning, Japan Trench, Earthquake

## Principles and Application of X-Ray Computed Tomography

### System: A Glance at Marine Geological Samples

Yen-Hsi Wu<sup>1</sup>, Yao-Ming Liu<sup>1</sup>, Jun-Ting Lin<sup>1</sup>, Yu-Chun Chang<sup>1</sup>, Gerald Degenhart<sup>2</sup>, Ya-Hsuan Liou<sup>3</sup>, Jyh-Jaan Steven Huang<sup>1</sup>

<sup>1</sup>Institute of Oceanography, National Taiwan University

<sup>2</sup>Medical University of Innsbruck

<sup>3</sup>Department of Geosciences, National Taiwan University

#### Abstract

X-ray Computed Tomography (CT), a computerized combination of multiple X-ray analyses from different angles to produce tomographic images, has been widely used in modern medicine and diagnosis since the 1970s. As a non-destructive and rapid technique, CT is an ideal tool to characterize the internal 3D structures of objects and has attracted various Earth Science disciplines over the last decade. Besides the visual-based observation, quantitative 3D micro-morphometry information can be extracted and linked to grain/pore size, sedimentary structures, and eventually geochemical / mineralogical composition. Here we would like to introduce the newly established Geotek Rotating X-Ray Computed Tomography System (RXCT) at National Taiwan University. The features of this system are (1) high voxel resolution (30 - 350  $\mu\text{m}$ , depending on the sample size), (2) large sample size with source-detector rotation design (1.5 m in length and 15 cm in diameter), and (3) different scanning modes, including 2D radiograph, pseudo-3D laminography, and 3D CT rotating scan. This poster uses a few geological samples to demonstrate and compare different scanning results to provide a preliminary demonstration. The detailed 3D distribution, including sedimentary structures and event layers in the sedimentary core, can be clearly reconstructed to further advance their scientific applications. For now, detailed testing and standard operating procedures are being established with various applications. This is expected to form a new research line to rapidly examine the internal structures without destroying the samples, which may have great potentials in sedimentology, marine geology, paleoseismology, paleontology, mineralogy, petrology, archaeology, and energy-related applications.

Keywords: Non-destructive technique, X-ray computed tomography, 3D reconstruction



## 勵進研究船海床測繪作業的品保措施 Quality Assurance Processes for Seafloor Mapping of RV Legend

劉紹勇、許景翔

財團法人國家實驗研究院台灣海洋科技研究中心

### 摘要

勵進研究船支援精細海床科研調查作業，重要聲納設備如深海多音束音鼓陣列、淺海多音束雙接收音鼓、海床底質剖面音鼓陣列、水下定位系統等，資料品質好壞與精準度必須配搭衛星定位、船姿態、聲速等關鍵參數，然而現場作業(先排除海況條件)特別是多音束測深調查能否掌握這些參數可能存在的偏誤，並能即時改善?本文針對定位精度、船艏向、水深值、offset等重要參數以下列幾種方式進行品保(quality assurance)處理。

1. 先建構精確船體座標(offset)，並增設檢核用參考點。可應用於碼頭、海上、船塢環境下的定位精度檢核作業。
2. 應用資料庫，回溯歷史資料進行分析及比對。可找出不同類別事件的發生頻率，例如衛星定位修正訊號被遮蔽或精度不足的情況。
3. 於船塢環境(dry dock)，進行定位、船艏向精度、聲納測深值、offset 驗證，可確認相關設備符合應有規格及偏差量。
4. 檢核不同船隻相同區域的多音束測深資料，可藉以評估是否存在系統性偏差。
5. 結合其他感測器例如水位計、表水溫鹽儀、透光度及螢光度等現場即時數據，提供動態吃水、聲速變異、海面氣泡干擾等資訊，其可能反映系統未能明顯查知的問題。

相關品保作法將陸續開發及測試，以保持系統高妥善率、穩定呈現應有規格及性能，並監控相關資料精準度，確保勵進研究船海床測繪系統如質如規穩定運作。



## **Sediment transport pathways in northern Taiwan Strait**

Dominique Valdivia<sup>1</sup>、Rick Yang<sup>1</sup>、James T. Liu<sup>1</sup>

(1) Department of Oceanography, National Sun Yat-sen University,  
Kaohsiung, Taiwan (ROC)

### **Abstract**

Long-term sediment transport patterns in northern Taiwan Strait (TS) are primarily related to monsoon-driven coastal current systems such as the south bond Zhejiang-Fujian Coastal Current which delivers Changjiang-sourced distal suspended sediments to the Zhe-Min-Taiwan Strait Mud Belt (ZM-TS MB) in northern TS. Some patterns are related to the dispersal of sediment from rivers in Taiwan. Our aim was to study the coupling between sediment transport in relation to seasonal currents, and source of sediments (from Mainland China and Taiwan). We analyzed sediment pathways based on surface sediment samples using grain size trend analysis models of McLaren and Gao & Collins to reveal transport patterns. Also, we contrasted the grain size data with the surface distribution patterns of Kaolinite, Illite, Smectite, and Chlorite. Our results suggest unlike coarser grained, better sorted and positively skewed relict sediments, modern sediments distributed along the ZM-TS MB are poorly sorted mud, with negative or zero skewness. The high energy sediment transport along hypothetical pathways in central TS started from regions of poorly sorted and negatively skewed to regions of better sorted and positively skewed sediments grain-size distribution patterns. Low energy transport occurs in the northern TS along hypothetical pathways toward regions with better sorting and symmetrical grain-size distributions. Based on Transport Vector method, there is a zone of convergence in north central TS, implying a deposition center. Another convergence center is located closer to the Minjiang River, which coincides with the maximum sedimentation rates reported by Huh et al. (2011). A demarcation line marks the Kaol-rich sediments from Mainland China and Ill-Chl-rich sediments from Taiwan, which also matches with the landward boundary of Mainland-sourced magnetic susceptibility by Horng & Huh (2011).

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### 不同顆粒大小和站間的顆粒性有機物同位素組成比較

陳家婷

台灣大學海洋研究所

#### 摘要

在海洋系統中，浮游植物是初級消費者的主要食物來源，是碳和氮循環中碳和氮進入食物網的第一個步驟。懸浮顆粒有機物 (POM) 的粒徑結構，包括浮游植物群落，大致分為三個大小等級，植物浮游動物依顆粒大小分成：pico ( $< 2 \mu\text{m}$ )、nano (2-20  $\mu\text{m}$ ) 和 micro (20-200  $\mu\text{m}$ )。POM 的大小結構應該是遠洋食物網的一個關鍵屬性。然而，很少有研究調查 POM 的尺寸組成。中國東南海 (ECS) 及其複雜的水文環境為研究 POM 的尺寸組成提供了理想的位置。本研究表徵了 POM 大小類別的穩定同位素組成。

## **Effect of prey density in species distribution modeling: a case study of plankton**

Yun-Yi Lin, Chih-hao Hsieh

Institute of Oceanography, National Taiwan University, Taipei City

### **Abstract**

Biotic interactions (e.g., predation, competition) are considered to be fundamental factors that shape species distribution. However, most studies focusing on species distribution modeling (SDM) often ignore biotic factors in their models or use approximations (e.g., chlorophyll *a*) which can lead to bias.

While the SDM methodology was developed originally from terrestrial organisms, there are growing applications in marine ecology recently. Yet, seldom of these applications focus on plankton community, which is the important base of marine food webs. And due to the selective grazing of zooplankton, they feed on phytoplankton of specific taxonomic groups or sizes, concentration of chlorophyll *a* may not necessarily represent their prey density.

The major goal of this study is to understand the importance of biotic interaction when modeling the distribution of marine organisms. By adding biomass of phytoplankton in specific taxonomic groups and sizes and chlorophyll *a* as a biotic predictor respectively, we try to evaluate and compare their contributions to the model performance of copepod SDM. We expect that the model considering taxon-specific phytoplankton biomass will perform the best, followed by the chlorophyll *a* and null model with no biotic predictor included.

## Planktonic ciliate time distribution relative to *Noctiluca scintillans* in Jieshou Bay during 2020 to 2021

李俊廷

國立臺灣海洋大學 海洋環境與生態研究所

### Abstract

Ciliates are indispensable and basic part of the marine food chain and belong to the exploration cycle at the bottom of the food web. In this study, we observe the changes in the abundance of two different types of ciliates (tintinnid ciliate and naked ciliate) during 2020 to 2021 in Jieshou Bay. In 2020, the abundance of tintinnid ciliates reached high values in late winter and summer, and the abundance of naked ciliates reached a high value only in summer, due to the local regular period of *Noctiluca scintillans* bloom, the impact of high *N. scintillans* abundance in 2020 led to a decline in the abundance of tintinnid ciliates, did not affect abundance of naked ciliates, but nothing like this in 2021. So we assume that a large abundance of *N. scintillans* may affect the number of one of the ciliates, because *N. scintillans* are easy to stick tintinnid ciliates but not easy to stick naked ciliate, so when there are too many *N. scintillans*, the number of tintinnid ciliates will decrease, but we still need more experiments to confirm this.

## Impact of environmental drivers on the microeukaryotic community assembly in Feitsui Reservoir

李鳩彤

國立臺灣大學 漁業科學所

### 摘 要

Freshwater reservoirs support a diverse range of services that humans rely on and these services depend on ecosystem functioning. The response of biological communities to their environment plays a vital role in maintaining ecosystem functioning. Therefore, understanding the assembly of these communities is critical for understanding how ecosystems will respond to environmental changes. Subtropical freshwater reservoirs such as the Feitsui reservoir in Northern Taiwan, are important water sources for human populations but remain understudied. This study uses time series data from 2017 to 2021 to investigate the assembly of microeukaryotic communities in Feitsui Reservoir, focusing on the impact of environmental conditions. The microeukaryotic community composition and structure were characterized using metabarcoding of the 18S rRNA gene on water samples collected bi-weekly over four years. The role of environmental drivers on the community composition and structure was investigated by using constrained ordination analyses which allowed to quantify the impact of environmental conditions on the observed community. For example, water temperature and nutrient concentration were identified as significant drivers shaping the microeukaryotic community of Feitsui Reservoir during the sampling period. A seasonal pattern was identified in the community composition and structure, suggesting that the community undergoes cyclic changes following the seasonality of environmental factors which also follow a seasonal pattern like the water temperature. Understanding the impact of environmental conditions on microbial community assembly can help identify how the ecosystem may be vulnerable to environmental change and can inform us on how climate change could impact ecosystem functioning.

## Temperature Experiments on Internal Bioeroders

Wan Tze Ning Orczy<sup>1</sup>, Christine Hanna Lydia Schönberg<sup>1,2</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University, Kaohsiung,  
Taiwan

<sup>2</sup>School of Engineering, The University of Western Australia, Perth, Australia

### Abstract:

Climate change and extreme weather pose significant environmental challenges to our planet. Coral reef ecosystems are particularly vulnerable to climate change, which affects their biological functions and the human societies that depend on them. Some research suggests that bioeroders, may be more resistant to environmental changes than corals, potentially exacerbating the decline of coral reefs. While previous studies have examined the impact of ocean acidification on internal bioeroders, the effects of temperature on this process are not well understood. To address this issue, we are conducting experiments to investigate the impact of temperature on internal bioeroders. Our study primarily involves heat treatments, with cold treatment as a secondary aspect, and a control group using live rocks collected from Little Liuqiu Island. We are measuring changes in buoyant weight to determine the bioerosion rate of internal bioeroders. The experiments will last for two weeks, and we assume that bioerosion rates will increase in proportion to the temperature until a critical limit is reached. This work is currently underway, and our findings could provide insight into the relationship between temperature and internal bioeroders under different environmental conditions. This knowledge could inform conservation plans and ongoing environmental monitoring efforts.

## **Evaluating time-varying network stability of fish community using empirical dynamic modeling (EDM)**

Romy Ruo-Yu Pan<sup>1</sup>, Chun-Wei Chang<sup>2</sup>, Chih-hao Hsieh<sup>3</sup>

<sup>1</sup>Institute of Marine Affairs and Resource Management, National Taiwan Ocean University, Keelung, Taiwan

<sup>2</sup>Institute of Fisheries Science, Department of Life Science, National Taiwan University, Taipei 10617, Taiwan.

<sup>3</sup>Institute of Oceanography, National Taiwan University, Taipei 10617, Taiwan.

### **Abstract**

Marine communities play a crucial role in sustaining the functions and services in the marine ecosystem, such as biodiversity and food. However, numerous stresses, e.g., climate change and fishing, are threatening marine communities' stability. To better understand the future of marine ecosystems and communities and help improve marine ecosystem management, it is important to evaluate how communities' network stability changed through time and identify the potential drivers. In this study, we apply empirical dynamic modelling (EDM) to evaluate the time-varying community network stability using fish community data collected from three regular surveys, (i) the Northeast Fishery Center (NEFSC) bottom trawl survey, (ii) the International Council for the Exploration of the Sea (ICES) bottom trawl survey, and (iii) the Easter Bering Sea bottom trawl survey. Then, the analysis investigating the environment and fishery effects on fish communities' network and network stability is carried out. This study will help complement the understanding of mechanisms shaping fish community stability and provide insights into ecosystem-based fishery management under climate change.



## Can we collect coral rubble to monitor sponge bioerosion and eutrophication?

Jia-Yi Lim<sup>1</sup>, Fleur van Duyl<sup>2</sup>, Christine Hanna Lydia Schönberg<sup>1,3</sup>

<sup>1</sup>Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan

<sup>2</sup>Royal Netherlands Institute for Sea Research, Texel, Netherlands

<sup>3</sup>School of Engineering, The University of Western Australia, Perth, Australia

### Abstract

A range of environmental changes have been found to increase bioeroder abundances and erosion rates, and we study the relationship of bioeroding sponges with nutrients. As filter feeders, most sponges readily respond to changes in the water quality. Higher sponge bioerosion rates will affect sediment production and quality, as well as render calcium carbonate structures brittle, and will over time reduce the structural complexity of coral reefs. It is especially important to produce baseline data from Taiwan, because there is a lack of bioeroding research. Katherine Holmes (1997) introduced a simple method to assess sponge bioerosion along nutrient gradients or over time by collecting coral rubble and comparing the bioeroding sponge communities in it. According to her results, number of species and extent of sponge borings in the rubble were proportional to nutrient levels. Therefore, this would be a fast and efficient indicator of eutrophication and could be used to monitor bioerosion levels. In a pilot survey, we tested this approach at Liuqiu Island in the southwest of Taiwan. Runoff from the Gaoping River in the Pingtung County south of Kaohsiung seasonally ejects enriched water into the South China Sea close to Liuqiu Island and creates a nutrient gradient in NE to SW direction. Work was ongoing at the time of abstract submission, but preliminary data already showed that the two sites had different bioeroding sponge communities. At the northern site a *Thoosa* species was very dominant, a genus otherwise rarely sampled in the western Pacific. At the southern site, only clionaid species were found. Species counts still had to be established, but the differences in the species compositions already suggested that environmental conditions differed between the chosen sample sites.

## 宜蘭沿海海域浮游動物組成的變動與海水環境之關係

Influence of submarine hydrothermalism on zooplankton distribution and community structure in the coastal zone off northeastern Taiwan

彭紹宏<sup>1</sup> 洪佳章<sup>2</sup> 黃將修<sup>3</sup> 陳鎮東<sup>2</sup> 魏翠萍<sup>4</sup>

1. 國立海洋生物博物館
2. 國立中山大學海洋科學系
3. 海洋大學海洋生物研究所
4. 國立成功大學水科技中心

### 摘要

來自於赤道洋流的黑潮，長年由南至北流經台灣的東部海域，帶來溫暖的海水，並受海底地形的影響，在特定海域產生湧升現象，間接增加營養鹽的輸入，產生豐富的浮游生物並滋養各類海洋生物，成為重要漁場，而宜蘭的近岸海域不僅有黑潮的洋流，還擁有特殊的淺海熱泉，每天不斷的由海底湧出高溫的海水，帶來酸性且富溶解性金屬的水體，這些特殊水環境可能對周遭海域生物帶來影響，尤其無自泳能力的浮游動物，所受衝擊最大，因此本研究針對宜蘭沿岸海域包含海底熱泉區域進行浮游動物組成及水體環境的分析，期了解特殊水文環境與浮游動物之間的關係。

研究結果顯示，近岸海域接近熱泉的海水，具有有高溫、高硫化物濃度、高溶解金屬濃度、低 pH 值、低溶氧的特性。而浮游動物方面，宜蘭沿海，接近熱泉的水域豐度明顯減少，且隨著離熱泉的距離以及環境因子的變動，浮游動物的物種組成大類有明顯變化，部分物種類群如橈足類(copepod)在近熱泉水域相對豐度明顯減少，磷蝦類(Euphausiacea) 及 毛顎類(Chaetognatha)之類群則增加，顯示特殊環境因子的變動可造成鄰近水域浮游動物組成的改變。

## 以漁業資料評估台江沿海中華白海豚主要食餌魚類之季節變化

陳國書<sup>1</sup>、劉商隱<sup>2</sup>、賴建成<sup>3</sup>、陳孟仙<sup>3,4</sup>

<sup>1</sup>國家海洋研究院海洋生態及保育研究中心

<sup>2</sup>國立中山大學海洋生物科技暨資源學系

<sup>3</sup>國立中山大學海洋科學系

<sup>4</sup>國立中山大學海洋生態與保育研究所

### 摘要

本研究主要目的為瞭解台江沿海中華白海豚(*Sousa chinensis*; 以下簡稱白海豚)食餌魚類資源之多樣性及季節性。首先,我們收集文獻資料,總計彙整白海豚的食餌魚類達 42 科。我們再透過分析在 2013–2022 年青山漁港調查的漁獲資料,用以瞭解白海豚主要食餌魚類組成的季節性分布。我們記錄青山漁港的漁獲物中,白海豚食餌魚類有 37 魚科,包括:蛇鰻科 Ophichthidae、海鰻科 Muraenesocidae、糯鰻科 Congridae、鋸腹鰻科 Pristigasteridae、鯷科 Engraulidae、鯉科 Clupeidae、鰻鯰科 Plotosidae、海鯰科 Ariidae、合齒魚科 Synodontidae、鰻科 Mugilidae、鱻科 Hemiramphidae、鶴鱻科 Belonidae、狼鱻科 Moronidae、鮫科 Serranidae、天竺鯛科 Apogonidae、沙鯰科 Sillaginidae、鱈科 Carangidae、鰻科 Leiognathidae、松鯛科 Lobotidae、鑽嘴魚科 Gerreidae、石鱸科 Haemulidae、金線魚科 Nemipteridae、鯛科 Sparidae、馬鮫科 Polynemidae、石首魚科 Sciaenidae、鬚鯛科 Mullidae、雞籠鯧科 Drepaneidae、雀鯛科 Pomacentridae、鰕虎科 Gobiidae、帶魚科 Trichiuridae、長鯧科 Centrolophidae、鯧科 Stromateidae、鰱科 Psettodidae、牙鯧科 Paralichthyidae、鯧科 Bothidae、鯛科 Soleidae 和舌鯛科 Cynoglossidae。另外,我們由 2013–2018 年的港口調查資料中,發現白海豚主要食餌魚科中,鋸腹鰻科、鰻科、沙鯰科、石首魚科和舌鯛科魚類的查報漁獲量呈現減少的趨勢;而鯉科、合齒魚科、鮫科、鱈科、鰻科、石鱸科、鯛科、雞籠鯧科和鯧科等魚類則呈現增加的趨勢,並且查報漁獲量增加的科別中,多數為熱帶魚種,這現象可能與海洋暖化的影響有關。

## Microplastic ingestion in larval fish in the coastal waters of Hengchun, Taiwan

Ming-Yih Leu<sup>1, 2\*</sup>, Sun-Hon Lin<sup>2</sup>, Fung-Chi Ko<sup>1,2</sup>

<sup>1</sup>Department of Biology, National Museum of Marine Biology & Aquarium, Checheng, Pingtung 944401, Taiwan, ROC

<sup>2</sup>Graduate Institute of Marine Biology, National Dong Hwa University, Shoufeng, Hualien 974301, Taiwan, ROC

### Abstract

Microplastics (MPs) have been documented in marine environments worldwide, where they pose a potential risk to biota. Coastal shelf seas are rich in productivity but also experience high levels of MP pollution. In their early life stages, planktonic fish larvae are vulnerable to pollution, environmental stress and predation. To date, the effects of MP ingestion in fish are still unclear. Marine fish eggs and larvae is a crucial part in the recruitment, but environmental interactions between MPs and lower trophic organisms are poorly understood. Here we assess the occurrence of microplastic ingestion in wild fish larvae. Fish larvae were taken across five sites (approximately 1–3 km from shore) in the coastal waters of Hengchun Peninsular, Taiwan from August 2022 to February 2023. We identified 4.8% of fish larvae (n = 146) had ingested microplastics, of which 45.5% were blue, with black (27.3%), clear (18.2%) and red (9.1%) plastics. Ingestion was observed in five species: jarbua terapon (*Terapon jarbua*, n = 4), goatfish (*Upeneus* sp., n = 1), silver-biddy (*Gerres* sp., n = 1) and goby (Gobiidae sp, n = 1). This study provides baseline ecological data illustrating the high probability of microplastic ingestion in marine fish larvae in the Taiwan seawater, which could have an adverse effect on fish health as well as marine biota.

**Keywords:** Microplastic ingestion, Fish larvae, Hengchun Peninsular Taiwan seawaters

## Body size-dependent temperature effects on larval durations for reef fishes

Bo-Rong Chen<sup>1</sup> and Hui-Yu Wang<sup>2</sup>

Institute of Oceanography, National Taiwan University  
Biodiversity Research Center, Academia Sinica

Fish population dynamics are driven by the changes in abundance during the larval stage. Consequently, assessing the effects of temperature on larval duration can help understand how warming affects population size. However, a systematic understanding of temperature effects on larval duration among different fishes is lacking. The effect of temperature on growth rate varies with body size, e.g. the growth rate of small but not large fish accelerates with increasing temperature. Since larval duration tends to reflect growth trends, we expect the effect of temperature on larval duration to be greater for small fish compared to large fish. Reef fishes comprise many families, and their adult body sizes show a bimodal distribution: one mode of small (maximum length < 5 cm) and another of large sizes. Here, we compared temperature-induced changes in larval duration of large and small reef fishes. We combined 1) intertidal reef fish surveys from Taiwan to Japan and 2) literature data for analysis. Both datasets show that, at relatively low temperatures, increasing temperature decreased larval duration for large fishes, but such changes were non-significant for small fishes. On the other hand, at relatively high temperatures, increasing temperature increased larval durations for small fishes, whereas such changes were non-significant for large fishes. These results suggest that the effects of ocean warming on recruitment depend on body size: small fishes may experience lower or more variable recruitment due to longer larval durations under warming, but such effects may be absent or the opposite for large fishes.

## 圓盤狀大型底棲有孔蟲在東沙島的碳酸鈣貢獻

蔡湘妮<sup>1,2\*</sup>，陳建勳<sup>1</sup>，張詠斌<sup>2</sup>

<sup>1</sup>國家實驗研究院台灣海洋科技研究中心

<sup>2</sup>國立中山大學海洋科學系

### 摘要

圓盤狀大型底棲有孔蟲 (Soritids) 是東沙島沿岸的優勢大型底棲有孔蟲，瞭解牠們的族群動態變化，是評估東沙島砂粒底質來源的一個基本資料，在逐漸劣化的珊瑚礁生態環境中，瞭解珊瑚以外的造殼生物碳酸鈣貢獻，亦能作為評估珊瑚礁生態永續的參考。本研究於2019年8月至2020年9月採集東沙島沿岸的表層沉積物樣本，量測Soritids的族群密度、殼體面積及重量，並使用生命表方法估算Soritids的碳酸鈣貢獻。結果顯示東沙島沿岸每平方公尺的Soritids族群密度介於 $0.91.8 \times 10^4$ 至 $1.8 \times 10^4$ 隻；平均密度為 $1.4 \times 10^4$ 隻，樣本中多為無性生殖產生的大球型個體，數量比例超過95%。透過每兩個月的大球型殼體的直徑大小頻度分佈以及族群密度的變化，推測東沙島沿岸Soritids族群生活史約為一年，每年每平方公尺約貢獻150克的碳酸鈣貢獻。

## 以硝酸運輸基因表現評估馬祖優勢矽藻物種 *Skeletonema*

### *dohrnii* 之氮利用情形

陳柏睿

國立台灣海洋大學海洋生物研究所

#### 摘要

矽藻是海洋浮游植物主要的分類群之一，為海洋生態系中重要的初級生產者，其貢獻了約 40% 的海洋初級生產力並固定了超過 20% 的全球二氧化碳，而死亡的藻體將二氧化碳轉移到深海的生物幫浦 (biological pump) 機制也被認為對全球的碳循環有重要貢獻。海洋中矽藻的生長主要受到營養物質限制，其中氮營養是主要的限制因子之一。海洋浮游植物主要可利用的氮營養為無機態的硝酸鹽和銨鹽，其中銨鹽在利用過程中花費的能量較少，故一般來說會優先被浮游植物利用。由於海洋中銨鹽會先被吸收能力較好的小型浮游植物如聚球藻、原真核綠藻吸收，故一般認為屬於大型浮游植物的矽藻在海洋中應主要利用且儲存硝酸鹽為其氮的來源。在海洋環境中由於氮鹽濃度普遍較低，矽藻必需緊密調控主動運輸來獲取氮營養，其中主要負責硝酸鹽吸收的相關基因為 *Nrt2* 基因，該基因由於在不同氮營養條件下表現差異大且靈敏，並較能設計出專一性高的引子，因此被用來做為了解矽藻族群在自然環境中利用氮營養情況的指標。然而矽藻中包括許多不同類群，且同一屬中不同種類對營養鹽的需求及利用也不盡相同，而物種間硝酸鹽營養攝取機制的差異可能造就在不同的氮營養環境下產生不同的優勢物種，因此了解特定矽藻物種對於硝酸鹽攝取的調控，一定程度可以用來解釋該物種的分布模式和消長機制，並能更進一步探討海洋環境的狀態及變化。本研究針對馬祖沿海的優勢藻屬骨藻屬中的 *Skeletonema dohrnii* 來進行，實驗分成實驗室培養實驗和野外實驗兩大部分。實驗室培養實驗以從馬祖水樣中分離出來的藻株為材料，將藻體培養在不同氮鹽的環境下，了解該種對於 *Nrt2* 基因的調控情形，並建立能和野外實驗結果比較的基因表現量基準；另一方面在野外實驗部分，則直接使用馬祖沿海含有藻體的水樣，收取現場樣本，且進行添加銨鹽和缺氮培養實驗，並利用大規模定序分析水中骨藻 *Nrt2* 基因的表現和即時調控情形，作為和實驗室培養對照的基準，進而結合海洋環境營養鹽參數綜合探討此藻種在馬祖地區消長的原因。



**A frozen future for coral reefs: refined techniques for long term cryo-repository using vitrification and laser warming**

Kanokpron Loeslakwiboon<sup>1</sup>, Chiahsin Lin<sup>1,2\*</sup>

<sup>1</sup> Graduate Institute of Marine Biology, National Dong Hwa University, Pingtung, Taiwan

<sup>2</sup> National Museum of Marine Biology and Aquarium, Pingtung, Taiwan

Abstract

Research on the development of innovative cryobanking techniques will aid coral restoration and conservation. To date, there are no published studies on long term cryo-repository of coral larvae. The aim of this study was to apply our customized freezing device and cryojig together with vitrification and laser warming techniques to create the first cryo-repository for coral larvae. In this study, pelagic phase larvae from the corals *Seriatopora caliendrum*, *Pocillopora verrucosa*, and *P. acuta* were used for cryobanking. Two vitrification solutions were formulated with Ficoll and gold nanoparticles. The results showed that over a thousand coral larvae of *Seriatopora caliendrum*, *Pocillopora verrucosa*, and *P. acuta* were successfully stored in the cryo-repository. Our customized innovative technology enabled the long term cryobanking of coral larvae which has never been accomplished before. We believe the methods applied in this study have the potential to be a critical research and conservation tool for wild reef restoration and reef habitat diversity.

Keywords: long term cryostorage, coral larvae, cryopreservation, cryobanking, vitrification

## 台灣西部沿海浮游枝鰓亞目 (Dendrobranchiata) 幼生之時空分布

許詠祺<sup>1</sup>、陳煦森<sup>2</sup>、陳孟仙<sup>3</sup>、林秀瑾<sup>1</sup>

<sup>1</sup>國立中山大學海洋生物科技暨資源學系

<sup>2</sup>國立屏東科技大學水產養殖系

<sup>3</sup>國立中山大學海洋科學系

### 摘要

本研究目的為了解台灣西部近岸海域浮游動物中枝鰓亞目 (Suborder Dendrobranchiata) 幼生之時空組成及分布，枝鰓亞目包含了對蝦總科(Penaeoidea) 及櫻蝦總科(Sergestoidea)，其中具有高經濟價值的蝦類，如草蝦、白蝦、鬚赤蝦(又稱火燒蝦)等。本研究自2021年11月至2022年11月期間，於茄苳、林園、七股、澎湖水道、王功、梧棲等海域，水深15至25公尺處已進行四次動物性浮游生物拖網採樣，並同時收集溫度、溶氧、鹽度等水文資料，以進一步分析樣本中枝鰓亞目幼生之時空分布及與水文環境之關係。初步結果顯示2021年7月瑩蝦科(Luciferidae)佔所有枝鰓亞目約92%，其次對蝦科佔了6%，枝鰓亞目數量有由南至北遞增之趨勢，2021年11月及2022年9月梧棲皆擁有最多數量的枝鰓亞目幼生，未來將會完成兩年期間之數據分析，探討影響枝鰓亞目幼生時空分布變化的可能原因。另外，本研究將針對熱帶性，且為該海域優勢種的婆羅門赤對蝦 (*Metapenaeopsis palmensis*) 進行暖化北移假說之驗證，並探討與黑潮分支水之關聯，此成果將有助於預測氣候變遷對於熱帶海域物種之影響。因幼生鑑種之不確定性，此部分除了利用形態鑑種外，將輔以粒線體DNA中Cytochrome C Oxidase I (COI)為分子條碼(DNA barcoding)確認種類。

## 苗栗離岸風場內牡蠣不同深度之養殖方式評估

藍揚麒、翁進興

行政院農業委員會水產試驗所沿近海資源研究中心

### 摘 要

我國近年來積極推動離岸風場建設，然其設置海域多為我國傳統作業漁場，將排擠當地部份漁法作業。為使我國綠能與漁業發展得以共榮並存發展，水試所遂於苗栗離岸風場內進行牡蠣養殖試驗，並以籠具及傳統式蚵串方式進行不同水層之養殖試驗。初步試驗顯示，傳統式蚵串養殖方式適合近海水表面養殖，而籠具的養殖方式適合水深 5 m 以深之水層養殖。養殖牡蠣之成長速度與海域中之浮游植物量多寡有密切關係。在死亡率方面，近海水表面以籠具養殖之牡蠣夏季期間易受扁蟲捕食而有高的死亡率；傳統式蚵串養殖牡蠣死亡率相當低，無扁蟲危害問題。養殖試驗期間，牡蠣體內金屬含量均低於衛生福利部規範之可食用安全含量。

## 臺灣西南海域烏鯧(*Parastromateus niger*)之生殖生物學及其豐度分布

陳郁凱、吳依淑、翁進興

行政院農業委員會水產試驗所沿近海資源研究中心

### 摘要

烏鯧(*Parastromateus niger*)為臺灣西南海域刺網及拖網漁業重要經濟魚種之一，然而相關基礎調查資料仍闕如，本研究目的即為建立其生殖生物學參數，俾利未來進行管理之用。本研究於2021年10月至2022年10月期間按月至東石漁港及枋寮採樣，共採集雌魚268尾，雄魚124尾，共計392尾樣本，性比為0.68，雌雄比例有顯著差異( $X^2 = 52.9, P < 0.05$ )，體長(fork length, FL)大於320 mm以上之區間以雌性比例顯著高於雄性。雌魚體長範圍介於 117.8-445.0 mm，雄魚介於116.1-385.0 mm，體重(body weight, BW)範圍分別為51.5-2379.7 g以及53.5-1455.2 g。雌雄魚的體長體重關係式經檢定結果顯示有顯著差異 ( $p < 0.05$ )，雌性 $BW = 1.0 \times 10^{-4} FL^{2.73}$  ( $R^2 = 0.99$ )，雄性 $BW = 1.0 \times 10^{-4} FL^{2.69}$  ( $R^2 = 0.99$ )。根據卵巢生殖腺外觀及生殖腺指數月別變動，同時參考卵巢組織切片發育狀態，推估推估臺灣西南海域烏鯧之生殖期介於4至8月，高峰為4至6月。雌魚50%性成熟體長為268.3 mm，雄性則為237.6 mm。單次產卵數範圍為4,140-252,336粒，平均產卵數為78,729粒，卵徑介於0.12 -2.68 mm。枋寮地區於1-3月為烏鯧盛漁期，漁場集中於枋寮峽谷以北100-200m的陸棚斜坡，小於50m的淺水區零星分布。4-9月非漁期，烏鯧魚群消散。10月開始進入漁期，南高雄的高屏峽谷以北150-200m斜坡處有高豐度區，枋寮沿海淺水區開始出現魚群。11月北高雄魚群分布廣，豐度低，南高雄高豐度漁場持續分布於150-200m斜坡處，枋寮峽谷南側50-200處有高豐度。12月南高雄的漁場範圍縮小，豐度下降；枋寮峽谷南側漁場亦逐漸縮小。

## 以寄生橈足類判別台灣海域大棘大眼鯛系群

孫雅鈴<sup>1</sup>、鄭有容<sup>2</sup>、塗子萱<sup>1</sup>

1. 國立中山大學海洋科學系
2. 國立高雄科技大學漁業生產與管理系

### 摘要

大棘大眼鯛(*Priacanthus macracanthus*)為臺灣周邊海域重要的底棲性高經濟價值魚種之一。在全球氣候變遷及長期過度捕撈的情況下，大棘大眼鯛的族群數量呈現逐年遞減的趨勢，2018 年的交易量已不達 200 公噸，遠低於 1985—2001 年間的平均漁獲量（每年 3,000 公噸）。若未能及時給予適當的漁業管理，大棘大眼鯛很可能會因不當的漁業壓力導致其資源枯竭。瞭解漁業系群(stock)等生物學特性將有助於制定正確及有效之漁業管理決策，以達到漁業資源的永續利用。漁業系群的區分除應用基因標誌了解魚群的族群結構以及族群間基因聯通性，用以區分有效漁業系群外，寄生蟲亦被使用作為生物指標，提供判斷魚類種類、洄游路徑以及系群判別的工具之一。因此，本研究欲透過基因標誌以及大棘大眼鯛的寄生性橈足類作為判別工具，解析及區分臺灣周邊海域大棘大眼鯛的族群結構，以及各族群間的基因聯通性。前人研究依據寄生性橈足類感染率及物種組成，將臺灣周遭海域的大棘大眼鯛分為東部以及北部、西南部 2~3 系群。本研究使用的大棘大眼鯛樣本包含北部（大溪、野柳）、東部（富岡）、南部（梓官）等處，共計 45 尾魚體。因 *Caligus absens* 在大棘大眼鯛的感染率高與數量高於其他寄生性橈足類，因此本研究選用其作為指標，分析其粒線體 COI 基因，用以驗證台灣大棘大眼鯛 2~3 系群區分方式的正確性。此外，針對所採集之大棘大眼鯛樣本，採用粒線體 cytochrome b 基因，分析上述漁港所捕撈大棘大眼鯛之族群遺傳結構是否也與藉由寄生性橈足類所界定的系群相吻合。結果顯示在 45 個樣本中，有 32 個單倍型基因，平均單倍型多樣性指數及核苷酸多樣性指數分別為  $h=0.957$ ， $\pi=0.02026$ 。分子變異分析 (AMOVA) 結果顯示，族群間變異成分 8.09%，族群內為 91.91%，顯示族群遺傳變異主要成分來自於群內。遺傳分化指數(Fst)與基因流(Nm)結果顯示，大部分族群存在基因交流，但東部與北部、西南部族群的基因交流相對較少。基於上述結果可將大棘大眼鯛分成東部及北部、西南部兩大系群。為維持族群遺傳多樣性，應將東部及北部西南部兩大系群分別施以不同的保育措施，以確保永續漁業的發展。

## 低溫鍛燒廢棄文蛤殼粉於文蛤養殖過程之應用

王崧雲

國立高雄科技大學水產養殖系

### 摘要

文蛤為國內重要的經濟養殖貝類，近年來由於環境污染，季候變異及養殖管理不當等 原因，以致育成率不佳且產量不穩定，除了影響業者收益，廢棄文蛤殼隨意丟置所衍生的環境衛生與民眾觀感問題，無形間已成為另一隱憂。

本研究以循環經濟-再生加值理念，將經過前處理之廢棄文蛤殼以較低溫度(約 300°C) 模式進行鍛燒處理後，再壓碎成文蛤殼粉，並與市售常見碳酸鈣產品包含牡蠣殼粉、熟石灰、碳酸鈣與鎂鈣肥，透過相關分析試驗，比較低溫鍛燒文蛤殼粉與市售產品之差異及檢測其安全性，另也配合現場確效試驗的進行，實際探討並比較其應用於養殖過程之效益。

經過弧菌檢測結果，低溫鍛燒殼粉並未有菌落生長，顯示未含致病菌。另於毒性檢測結果顯示，施用高劑量的熟石灰會導致大量死亡情況(最低僅有 47%活存率)，其他組別活存率均為 100%。

於養殖效益相關試驗成果顯示，無論於文蛤成長率、殼重或殼厚度，均以牡蠣殼粉與低溫鍛燒文蛤殼粉的組別有較佳之表現，其次為碳酸鈣與石灰的組別，鎂鈣肥的養殖效益最差。另於試驗期間也發現，雖然文蛤粗粉(41.3um)與牡蠣殼粉(40.7um)的粒徑大小差異不大，然而在高劑量使用過程，可能會因為兩者外殼的組成結構不同，以致實際應用於養殖過程時，無法作用完全或釋放，因而導致較難吸收且影響整體養殖效益。

本次試驗設計利用不同土壤改良劑添加於養殖池水，並觀測不同組別間的相關成長差異；透過本次結果發現低溫鍛燒文蛤殼粉及牡蠣殼粉除可有效取代傳統養殖過程，業者經常施用的熟石灰及碳酸鈣產品，另可有效解決文蛤廢棄物的堆積與環境美化問題，並能創造其循環經濟與養殖應用價值，及符合養殖經濟效益，未來將進行土壤改良劑於底質添加及混合後對文蛤成長之相關研究，期能更精確瞭解其於文蛤養殖過程之應用效益。



## 以高通量分子條碼探討小琉球亞潮帶底棲生物群聚組成

劉名允<sup>1</sup>、張景淞<sup>2</sup>、楊樹森<sup>3</sup>

- 1、財團法人國家實驗研究院台灣海洋科技研究中心
- 2、國立陽明交通大學生物資訊及系統生物研究所
- 3、國立清華大學分析與環境科學研究所

### 摘要

底棲生物種類及群聚是食物網重要組成，反應當地生態環境及健康狀態，同時亦可藉以做為環境長期監測、氣候變遷指標。小琉球是台灣唯一的珊瑚礁島嶼，黑潮的支流經過附近海域，氣候溫暖。夏季有冷水團湧升，造成表層水溫下降。小琉球位在高屏溪的泥沙沖刷入海所能到達的範圍之外。利用次世代定序高通量分子條碼(DNA metabarcoding)，探討小琉球亞潮帶底棲生物多樣性及群聚結構。自 2019 - 2021 年於美人洞、衫福漁港、厚石群礁及龍蝦洞水深 10 米處採集底沙，經清洗後收集底棲生物樣品。樣品萃取 DNA 以 PCR 增值 COI 基因片段，以高通量分子條碼((DNA metabarcoding) 定序。定序結果共包含 11 門(Phylum)、23 綱(Class)、43 目(Order) 71 科(Family)。其中數量最多的類群為節肢動物門共有 8 綱(26.61% OTUs)佔大部分，環節動物門 2 綱(24.19% OTUs)，棘皮動物門 6 綱(11.29% OTUs)，軟體動物包含 4 綱 (8.87% OTUs)。

文氏圖(Venn diagram)分析，龍蝦洞有 26 個 OTUs (21.1%)未在其他三個樣站採集到。厚石群礁最少，只有 9 個 OTUs(7.3%)未在其他三個樣站採集到。群聚(Cluster)或非度量多维排列(NMDS)分析顯示 龍蝦洞與其他三個樣站差異最大，位在最外分支。Indicator species 分析結果：美人洞、衫福漁港、厚石群礁及龍蝦洞分別有 2, 3, 1, 5 個 Indicator OTUs。相似度分析(ANOSIM)：龍蝦洞與美人洞、衫福漁港、厚石群礁相似度為 0.1~0.3 之間，遠小於其他三站之間相似度 (0.6 以上)。

分析結果顯示龍蝦洞族群組成與結構與其他三樣站有明顯差異，長期溫度監測顯示龍蝦洞有明顯冷水團湧升現象，是否會影響底棲生物族群組成與結構須進一步探討。



## Effect of different light spectrum and light intensity on growth of scleractinian coral *Pocillopora damicornis* and *Pachyseris speciosa*

Tseng-Hsin Lin<sup>1</sup>, Yu-Min Ju<sup>2,3</sup>

<sup>1</sup>National Dong Hwa University Graduate Institute of Marine Biology

<sup>2</sup>National Museum of Marine Biology and Aquarium

<sup>3</sup>Department of Marine Biotechnology and Resources, National Sun Yat-sen University

### ABSTRACT

Corals in their natural habitat were exposed to sunlight, while blue light has been known to enhance fluorescent protein and has been widely used in aquaculture which have different variation of radiation. In this study, *Pocillopora damicornis* and *Pachyseris speciosa* was cultured in a flow-through aquaculture system using natural seawater, and undergo growth for 16 and 12 weeks under two different spectrum of light (blue light and full spectrum) in three light intensity [high light 400  $\mu\text{mol photons m}^{-2}$ , medium light 200  $\mu\text{mol photons m}^{-2}$  and low light 50  $\mu\text{mol photons m}^{-2}$  for full spectrum, whereas high light 1700  $\text{mW/m}^2$ , medium light 700  $\text{mW/m}^2$  and low light 170  $\text{mW/m}^2$  for blue light] along with feeding *Artimia Cysts* (5000 inds/L, 3 times a week). Measurement of the buoyant weight, volume, zooxanthellae density, chlorophyll a concentration, maximal photochemical yield, and coral health color chart were recorded. During the entire cultivation period, the survival rates of coral was 100% and the water quality were stable. Specific growth rate of coral *P. damicornis* under full spectrum was significantly larger than blue light and light intensity was significantly proportional to growth rate whereas maximum photochemical yield indicated that the corals were normal during the experiment period. In this study, we concluded that full spectrum can effectively increases the growth rate under heterotrophic feeding for *P. damicornis*. Specific growth rate of coral *P. speciosa* under blue light was significantly larger than full spectrum and light intensity has significant difference to growth rate whereas maximum photochemical yield indicated that the corals were normal during the experiment period except high light intensity with full spectrum. In this study, we concluded that blue light can effectively increases the growth rate under heterotrophic feeding for *P. speciosa*.

**Key words:** *Pocillopora damicornis*, *Pachyseris speciosa*, spectrum, light intensity, growth rate

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\*<sup>1</sup>Author 1 : National Dong Hwa University Graduate Institute of Marine Biology

E-mail : sing82930@gmail.com

\*<sup>2</sup>Author 2 : National Museum of Marine Biology and Aquarium. Department of Marine Biotechnology and

Resources, National Sun Yat-sen University

E-mail : yumine@nmmba.gov.tw

## 小琉球地下水滲出對於潮間帶微生物組成影響

王豐寓\*、劉名允、黃婷萱、曾瓊蓉  
國家實驗研究院台灣海洋科技研究中心

### 摘 要

地下水滲出是一個重要的自然現象，會改變潮間帶的微生物群落結構和多樣性，並且對生態系統的穩定性和功能造成影響。地下水通常具有較高濃度的氨氮、硝酸鹽和有機碳等營養物質，刺激微生物的生長和活動。本研究針對小琉球地下水滲出潮間帶的可能地點進行採樣調查並於肚仔坪進行密集採樣，採集潮間帶底質與水樣進行微生物組成與營養鹽分析。結果發現，變形菌為小琉球潮間帶豐富度最高的類群，其次為擬桿菌、放線菌、浮黴菌；在六月份肚仔坪的樣本中，藍綠菌則為第四豐富的種類。在PCA分析發現，受到地下水影響的樣站會群聚在一起；MDS分析則發現，六月份肚仔坪樣本中，*Arcticiflavibacter*、*Nitrospira*與unculture-025 三個屬在地下水的豐度特別高；微生物功能群與環境參數相關分析發現肚仔坪微生物的硝化作用與矽酸鹽、硝酸鹽濃度呈現正相關；以上結果可能是受到地下水滲出帶來高營養鹽的影響。本研究初步發現，地下水高濃度的營養鹽滲出對於小琉球潮間帶微生物組成產生影響；然而，地下水滲出對潮間帶微生物組成的影響是一個複雜的過程，需要進一步的研究和分析。

## Microbial diversity in the water column of south china sea

Feng-Yu Wang, Chiung-Jung Tseng, Min-Yun Liu

Taiwan Ocean Research Institute,  
National Applied Research Laboratories

### Abstract

The microbial communities reflect environmental conditions, such as nutrient status, in the ecosystem. This study investigates the relationship between microbial community diversity in water column and environmental conditions at South China Sea. We collected seawater samples at 12 different depths in South China Sea in July 2018 (LGD-T11). The environmental parameters of each depth were measured, i.e., dissolved oxygen (DO), chlorophyll a (Chl a), particulate organic carbon (POC), nutrient. The V5-V6 hypervariable region of 16SrRNA was amplified and sequenced using an illumina MySeq platform to identify the microbial communities. We obtained 1,302,280 high quality Illumina sequence reads from the sea water samples. 4236 operation taxonomy units (OTUs) were identified by using OUT clustering function merged in CLC-bio, based on the database silva 132. The results show that the most abundant Phylum is Proteobacteria, followed by Cyanobacteria and Actinobacteria in photic zone. On the other hand, Euryarchaeota and Planctomycetes were the second and third abundant phyla in aphotic zone. Three different sample groups were identified by PCA analysis based on the environmental parameters. Cyanobiaceae, Actinomarinaceae, and Flavobacteriaceae are significantly abundant in photic zone. Thioglobacaea, Nitrospinaceae, and Microtrichaceae are more abundant in deep water. Burkholderiaceae is the signature taxa of the group deep2. Our results show that the microbial communities are dynamic in the water column of south China sea. The correlation test suggests the environmental factors may shape the microbial community distribution of the water column in south China sea.

## 澎湖本島南部海域碑礫蛤資源現況

張致銜<sup>\*1</sup>、翁進興<sup>1</sup>、陳郁凱<sup>1</sup>、藍揚麒<sup>1</sup>、邱炤茹<sup>2</sup>、  
行政院農業委員會水產試驗所沿近海資源研究中心<sup>1</sup>、海洋委員會海洋保育署<sup>2</sup>

### 摘 要

碑礫蛤為世界上體型最大的雙殼貝，為評估澎湖南部海域之碑礫蛤分布現況進而推展適當的復育建議，本研究於2022年4月、8月於澎湖南部海域之本島南側沿岸及虎井嶼，以水肺潛水進行碑礫蛤資源現況調查，共計12個測站的穿越線調查。本次調查結果顯示，澎湖南部海域資源狀況仍維持良好的狀況，在鎖港海域之東側SP-06、南側SP-07測站平均密度相對較高為 2.6-2.8 個 /100m<sup>2</sup>，而在香爐嶼海域SP-12測站之平均密度最高為 3.4 個 /100m<sup>2</sup>。各測站以長碑礫蛤(*Tridacna maxima*)及諾亞碑礫(*T. noae*)為主要分布族群數量較多，再次之為鱗碑礫(*T. squamosa*)，此外在鎖港南側SP-07有發現1個罕見之圓碑礫(*T. crocea*)。本研究結果將有助於澎湖海域之碑礫蛤資源保育與復育之推動，並作為未來長期海域生態健康監測之參考依據。

## Ecology of zooplankton at shallow water hydrothermal vents

Subramani Thirunavukkarasu<sup>1</sup> Hans-Uwe Dahms<sup>2</sup>, Johnthini Munir Ahamed<sup>2,3</sup> and Jiang-Shiou Hwang<sup>1,4,5\*</sup>

<sup>1</sup> Institute of Marine Biology, National Taiwan Ocean University, Keelung 20224, Taiwan

<sup>2</sup> Department of Biomedical Science and Environmental Biology, Kaohsiung Medical University, Kaohsiung, Taiwan

<sup>3</sup> Department of Medical Laboratory Science and Biotechnology, Kaohsiung Medical University, Kaohsiung, Taiwan

<sup>4</sup> Center of Excellence for Ocean Engineering, National Taiwan Ocean University, Keelung 20224, Taiwan

<sup>5</sup> Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung 20224, Taiwan

\* To whom correspondence and reprint requests should be addressed: Tel: 886-2-24622192 ext. 5304; Fax: 886-2-24629464; E-mail: Jshwang@mail.ntou.edu.tw

### Abstract

Shallow hydrothermal vents are extreme oceanic environments that are similar to projected climate changes of the earth system ocean. Studies on shallow water hydrothermal vent organisms may fill knowledge gaps of environmental and evolutionary adaptations to this extreme oceanic environment. The abundance and the biomass of the zooplankton populations in the shallow vent can accelerate the significant biological cycle of food web. Moreover, shallow hydrothermal vent systems are unique biodiversity hotspots for many micro-macro zooplankton populations. In which clue to study the many unique species and with valid information on origin of life with evolutionary adaptations in the extreme environments. In contrast, deep vent ecosystem have reduced zooplankton populations with lower abundances. Another, evidence revealed that, the abiotic parameters near to shallow water hydrothermal vents strongly enhances the maximum biomass production in the shallow hydrothermal venting zones. Interestingly, diversity patterns of shallow and coastal water venting zones revealed that the presence of meso-zooplankton assemblage. Maximum abundance of zooplankton population were reported near plume zones of venting areas but ecosystem functioning and zooplankton effects here are still unclear. Therefore, studies are need to explore the dynamic changes of metabolisms and genetic signatures as well.

## 熱帶貧營養鹽海域的病毒分流作用

### 摘要

本研究於 2010 ~ 2017 年的 9 個南海時序測站航次中(SEATS)，進行細菌生產力、細菌生物量與病毒豐度之 24 ~ 36 小時的錨碇實驗。分析結果發現，病毒與細菌之間的交互作用，不僅只有殺死宿主而造成細菌數量減少，宿主死亡後體內的有機物質釋放到水中也能刺激細菌的快速成長，因此我們能觀察到細菌的生物量與生長率非耦合之現象，此結果能印證前人所提出的病毒分流假說 (The viral shunt hypothesis) 能在野外調查所觀察到的證據：病毒裂解細菌能將微生物的碳保留在食物網之中並起到關鍵作用。

## 建構台灣周邊海洋微生物環境DNA分析工具與資料庫

張育榮

國立台灣大學海洋研究所/國科會海洋學門資料庫

### 摘要

探索海洋環境微生物基因科學是近二十年來國際上最熱門的海洋研究項目之一，其中著名的全球海洋採樣研究工作包括了美國的 Socerer II GOS、歐盟的 Tara Oceans、多國參與的 bioGEOTRACES、BIO-GO-SHIP 等。這些計畫所產出的基因資料，成為各國深化精準海洋生態系研究與海洋生技產品研發的基礎資訊。目前國科會海洋學門資料庫正在建構台灣周邊海洋微生物環境 DNA(eDNA)資料庫。目前已經從 NCBI SRA 蒐集台灣研究團隊已發表的海洋環境微生物 16S/18S rRNA 基因定序資料(共 7 份 SRA bio-project 資料，來自 5 篇論文)，建立台灣周邊海洋微生物 eDNA 資料庫與分析工具。包括：1) 自動化 amplicon sequencing 生物資訊分析流程(以 perl 撰寫並以 docker 包裝)，並將多面向的分析資訊 (如: 資料與品質、分類學、生物多樣性等)，整合於友善圖形介面的網頁報表呈現；2) 建立 Amplicon Sequence Variant (ASV) 資料庫；3) 微生物 taxonomy 各階層相對豐度的生物地理分布之互動式比較與統計呈現網頁，可用以統合目前既有 metabarcoding 資料和下階段的 shotgun metagenomic sequencing 資料。逐步建構易用的 eDNA 網站資料庫。



## 海洋學門資料庫—物理海洋資料庫

郭家榆

國科會自然處/臺灣大學海洋研究所 海洋學門資料庫

### 摘要

物理海洋資料庫從1986年籌設資料庫以來，收集、保存和彙整臺灣海洋研究船和其他調查產出的海流及水文資料等，主要是由三艘研究船(新海研1號、2號、3號)配備的鹽溫深儀(Conductivity-Temperature-Depth Profiler，簡稱CTD) 及船載式都卜勒流剖儀(Shipboard Acoustic Doppler Current Profiler，簡稱SADCP) 所收集的物理參數所構成，計算出氣候場上的統計平均，藉助這些水文與海流分布圖可以初步了解臺灣周邊海域海水溫度、鹽度、流速之時空分布特徵。可將物理資料與其他領域資料整合做為環境資料因子，透過時空的統計分析，提供長期且完整、正確之海洋監測與觀測資料，協助政府在制定海洋相關決策時之佐證，並對維護我國海洋權益、規劃海洋資源之永續利用、降低天然災害之損失等等，期能發揮效益。

2022年資料更新狀況如下，CTD資料更新：新海研1號增加19個航次；新海研2號增加20個航次；新海研3號增加40個航次；SADCP資料更新：新海研1號增加27個航次；新海研2號增加27個航次；新海研3號增加58個航次。每月資料由專人交付，透過VPN建立安全通道，並利用SFTP安全檔案傳輸協定上傳或是提供載點下載研究船之物理資料，隨後，經過程式轉檔與校驗處理流程，將數據儲存到資料庫中。資料的點位規劃以各計畫主持人執行科技部計畫所擬訂的，透過現場實驗及觀測，累積海洋基礎而得。

船測的SADCP與CTD資料從資料來源、處理方法及程序及資料品管均已提供至網頁，ODB按照既有的處理程序按部就班進行。隨著橫向資料的整合，各式資料間可互相比對，提高品管準確度。年度ODB配合核心科技計畫資料管制，向各航次領隊提供處理過後的水文資料。其中，有一支溶氧探針的係數有誤，經由領隊回信通知後已處理修正完畢。海流資料方面，新海研1號SADCP儀器使用2套音鼓，分別為75 kHz及150 kHz，其中，150kHz音鼓維修中，計畫期間沒有資料，但是另一組音鼓資料均正常。

## 海洋學門資料庫新版Hidy

呂孟璋  
國立臺灣大學

### 摘要

Hidy 是由海洋學門資料庫（ODB）所開發、維護的資料展示平台，由於近年網頁技術的進步及各大瀏覽器對安全性要求的提升，現行版本所使用的技術逐漸被淘汰；此外，由於不斷增加的功能使得原始碼以及後端資料趨於複雜及混亂。這些因素使現行 Hidy（及其後端系統）不僅維護困難、缺乏彈性，且出現許多安全漏洞，甚至在未來無法使用。因此，我們決定重構新版 Hidy，並在重新設計頁面的同時統整資料來源、整理後端伺服器。在新版的規劃中，外部資料以介接為主，盡量不再下載處理，以減少不必要的資料儲存量；ODB 內部資料（研究船及其他研究者提供）則盡量整合為 API 發布，以增加使用彈性；網頁程式則以更加模組化的方式編輯，使維護便利且更有彈性。除此之外，對各項圖資的來源、處理方法、頻率.....等描述性資料將以更完整的方式呈現。不過由於資料來源、資料儲存、使用率等因素，部分原版的功能暫時不會移植到新版。新版 Hidy 的頁面設計主要讓畫面中地圖的比例增大；地圖以外的部分盡量簡單，避免過多版面及色彩喧賓奪主；圖層選擇以疊合方式更系統化整理越來越多的項目，亦可使程式可以更模組化設計。新版目前仍在內部測試中，預計在年底前發布。

## 國科會海洋學門資料庫 - 海洋熱浪資料庫

葉庭禎

國科會海洋學門資料庫 國立臺灣大學海洋研究所

### 摘 要

全球暖化造成的氣候危機，使得地球持續發燒，陸地上異常高溫的天氣令我們感同身受，同時，海洋也面臨相同狀況。海水與過去平均海洋溫度相比，出現一段時間的異常高溫，稱為海洋熱浪（marine heatwaves, MHWs）。海洋熱浪對於海洋生物、生態系統和人類活動都有著極大的影響。本年度 ODB 使用了 NOAA SST 的資料並依 Jacox et al. (2020) 的方法，對全球 1982 年至今約 40 年間每個月的海洋熱浪進行計算，同時依據 Hobday et al. (2018) 的分級標準，將熱浪分級，建立了一個全球海洋熱浪資料庫。此資料庫內容包含：溫度異常值、熱浪門檻值、熱浪級數與生物地理遷徙最短距離，資料每月更新，預計下半年將海洋熱浪級數資料上線於 ODB 服務平台。ODB 希望透過建立海洋熱浪資料庫，提高使用者對海洋熱浪的認知與意識，也期望可以更進一步幫助學界研究海洋熱浪的時空分布和變化趨勢，同時也可以為預測和應對未來可能發生的海洋熱浪提供重要參考。

## 海洋學門資料庫地質與地球物理GIS資料現況

陳之馨

臺灣大學海洋所/國科會海洋學門資料庫

### 摘 要

為保存國內海洋研究調查成果，行政院科技部自然科學及永續研究發展司海洋學門自 1986 年委由國立臺灣大學海洋研究所服務型研究計畫方式，協助建立與維運「海洋學門資料庫」，海洋學門資料庫的工作除例行資料保存與品管，執行科技部交付的海洋資料、海洋相關資料申請與推廣任務外，近年發展重點著重於各領域資料內容加值及應用查詢的網頁呈現，及資訊技術研發等服務。海洋地質及地球物理資料方面，三艘新研究船航跡、震測測線、海床底質剖面測線、重力資料等航跡定位資料、岩心站位及海床沉積物採樣點站位等多種不同來源資料經過 QA/QC 等資料處理步驟，將資料屬性轉檔處理，已整合入 GIS 系統並建置網頁查詢系統。

## 海洋學門資料庫-生物海洋資料與資訊服務

Ocean Data Bank - Bio-ocean Data and Information Service

黃玉萱<sup>1,2</sup>

1.國科會海洋學門資料庫 2.臺灣大學海洋研究所

國科會海洋學門資料庫 (Ocean Data Bank, 以下簡稱 ODB) 生物海洋資料庫 (Bio-Ocean Database) 彙整台灣周邊海域拖網調查研究、擷取其中生物豐度資料，迄今累計有 475 航次、6700 測站、總共 137,819 筆豐度資料 (以浮游動物與仔稚魚為主)，歡迎各界申請使用 (請至 ODB 官方網站填寫生物資料申請單：<https://www.odb.ntu.edu.tw/odb-services/>)。除了生物海洋資料庫外，ODB 提供生物海洋資訊服務如下：

### 1. BioQuery and OpenAPI (<https://bio.odb.ntu.edu.tw/query/>)

為便於大眾探索、運用生物海洋資料庫，ODB 開發了互動式圖台 BioQuery，使用者能自訂經緯度範圍、生物類群、網目大小、季節...等條件，查詢生物類群地理分布；進一步地，使用者可透過 OpenAPI 將 BioQuery 的查詢結果執行進階統計運算，例如：物種歧異度估算、冗餘分析、生物豐度與環境因子的相關性分析...等等。

### 2. 哲水蚤目物種分類檢索網 CopKey (<https://bio.odb.ntu.edu.tw/>)

ODB 與海洋生物分類學家石長泰教授合作，將石教授的分類著作編撰之《CALANOID COPEPODS OF CHINA SEAS》與《KEY TO THE CALANOID COPEPODS》建置為哲水蚤目物種分類檢索網站，其中收錄上千張石教授提供的手繪或文獻上之分類特徵科學繪圖，物種分布涵蓋臺灣周遭海域，北起渤海向南至黃海、東海和南海等，共計達 30 科、101 屬、576 種，為十分珍貴的科研資源。

### 3. 影像標註伺服器 BIIGLE 2.0 (<https://seaimage.oc.ntu.edu.tw/>)

因應影像分析的研究浪潮，ODB 透過開源程式碼架設影像標註伺服器 Bio-Image Indexing and Graphical Labelling Environment (簡稱 BIIGLE)，BIIGLE 提供直覺的圖形化介面，讓使用者能替影像裡的生物和環境特徵加上標籤 (label) 或註解 (annotation)，便能匯出標註紀錄將影像轉為數值資料。同時，ODB 籌組「海底影像辨識工作小組」使用 BIIGLE 分析台灣西南海域的海底影像，迄今已完成六千多張的影像標註，包含 14015 筆生物紀錄、375 筆海洋廢棄物紀錄。ODB 開發 R 語言套件 biigler (<https://github.com/yhhton/biigler>)，透過 BIIGLE API 實現大量新增標籤或註解，取代在網頁重複地點擊作業、提升工作效率，另也能輔助工作小組的影資料品管。

更多生物海洋資料庫和相關資訊服務介紹請見官方網站 (<https://www.odb.ntu.edu.tw/bio/>)。

## 海洋學門資料庫

林姿吟

臺灣大學海洋所/國科會海洋學門資料庫

### 摘要

國科會海洋學門資料庫 (簡稱 ODB) 的使命是收集、保存和彙整臺灣海洋研究船和其他海洋調查產出的物理、化學、生物、地質、地球物理等跨領域探測數據。其目標是以系統性方式整理、分析及展示海洋研究成果，支援各界海洋相關領域研究需求，並提供資料和增值應用產品供外界申請使用。此外，ODB 也新增研究船 MIDAS 船測資料下載服務，持續維護研究船即時資訊互動系統 (IRIS)，並結合 IOT 資訊與研究船網路與資料儲存架構，提供更便利的海洋探測資訊服務。

除了現有的資料服務外，ODB 也將致力於開發新的資訊整合技術，包括開發新版 Hidy Viewer 的前端介面與後端資料庫，以及開發 ODB 對內整合與對外開放之應用程式介面 (API)，並利用 Web API 加速跨應用、跨領域間資訊服務的整合與使用。ODB 亦會持續參與國內外相關海洋資料單位的討論，分享最新的技術交流，逐漸實現政府開放資料、環境教育推廣、基礎科學教育與海洋研究中長期目標。

## 海洋地質暨海洋地球物理資料庫現況

李筑蕙<sup>12</sup>

(1) 臺灣大學海洋所、(2) 國科會海洋學門資料庫

### 摘要

海洋學門資料庫在水深資料方面的任務是收集與保存海洋研究船於臺灣周邊海域調查的探測結果，自 1989 年累積至今已逾 30 年。新編的數值地形模型資料來源包含過去國內三艘海洋研究船(海研一號、海研二號及海研三號)單音束測深儀所得的探測資料，國科會計畫的多音束測深成果包含新研究船(新海研 1 號、新海研 2 號及新海研 3 號)及國際合作計畫於臺灣周邊海域調查探測成果；更大範圍則以通用大洋水深圖組織(General Bathymetric Chart of the Oceans, GEBCO)出版的全球 15 弧秒網格水深資料組作為輔助資料，彌補整編時資料不足的區域。綜合這些資料，我們依據資料分布密度編製不同解析度的臺灣周圍海域數值地形模型，提供國內學術研究使用或用做工程測量之背景資料。

本年度持續處理多音束水深資料，資料處理部分在淺水域加入潮汐校正，並採用過去 CTD 資料計算的 15 分網格聲速資料以因應新船多音束水深資料的聲速校正需求，在篩除歧異點後製作網格資料，最後統計符合 IHO 測深規範的資料比例。多音束資料處理完成後將投入 ODB 的地形資料組更新或取代原有的單音束資料，新編的地形圖除了加入處理後的多音束資料並加入內政部開放之數值地形模型資料修正離島陸海邊界，經修正後陸地與岸線更為吻合。