研究領域多重角色扮演-以海洋化學為例

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國立東華大學	海洋生物研究所	教授
國立海洋生物博物館		研究員(合聘)

海洋化學多重角色之實例

* 水體及沉積物重金屬物種分析
* 水族館水質監控及管理
* 海域水質對珊瑚礁生態之影響
* 水體藻華成因判讀及預測
* 電廠電解海水模式建置
* 養殖系統最佳臭氧用量之評估
* 有機錫之生物累積機及汙染源追蹤調查
* 油汙事件之水質監測與生態評估
* 海域水質即時連續監測系統之應用

An empirical technique to evaluate the UV irradiation time for highly polluted waters prior to ASV detection

Articles

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An empirical technique to evaluate the UV irradiation time for highly polluted waters prior to ASV detection

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Conducting anodic stripping voltammetry (ASV) to determine non-labile-form metal in a water sample usually requires UV digestion. The time for thoroughly disintegrating metal complexes is lengthy and completion of digestion is not easy to determine. In this study, the degree of dissociation of copper complex, indicated by the ratio of slope changes at ASV titration, was found to be linearly correlated with UV irradiation time ($r^2 = 0.976$). Using slope changes, an equation for estimating the length of UV irradiation time was developed. If the estimated UV digestion time was too long, the same data set could be used to estimate the total concentration of the element using another equation developed from the linear correlation ($r^2 = 0.990$) between the concentration of labile form metal ion and UV irradiation time. The reliability and feasibility of this method were confirmed with standard addition (error < 20%; recovery: 97.5 ± 10.9%).

anodic stripping voltammetry, heavy metals, organic ligands, UV irradiation

Environmental Pollution **80** (1993) 223–230

SPECIES OF COPPER AND ZINC IN SEDIMENTS COLLECTED FROM THE ANTARCTIC OCEAN AND THE TAIWAN ERHJIN CHI COASTAL AREA

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Abstract

The species of copper and zinc, such as bioexchangeable, skeletal, easily reducible (Fe and Mn oxides), moderately reducible (crystalline Mn oxide), organic combined with sulfides, and detritus with minerals, in mud and sand, separated from the surface Antarctic Ocean and the Taiwan Erhjin Chi coastal (including river and estuarine) sediments, have been analyzed by sequential leaching methods. Results show that in the Antarctic Ocean sediments, high concentrations of total copper (128 mg/kg) and zinc (458 mg/kg) were found in the high mud (99·09%) content samples compared with the low concentrations of total copper (83·8 mg/kg) and zinc (288 mg/kg) in low mud (51·69%) content samples. High concentrations of copper, zinc, manganese and iron are possibly due to the characteristics of manganese nodules, in which the species of copper and zinc are mainly contained in the crystalline Mn oxide phase. In the Taiwan Erhjin Chi coastal sediments, the total copper and zinc concentrations in mud and sand vary with season and location. High values were generally observed in the river sediments during the dry season, and low values were in the estuarine and coastal sediments during the heavy rainy season. High percentages of copper (as high as 49·4%) and zinc (as high as 76·7%) in mud and sand were in the bioexchangeable phase including the skeletal phase. This result might be correlated with the problems arising from human impact on copper and zinc as well as sewage pollution in Taiwan. In the organic combined phase, biogenic particulate matter related to higher primary productivity in the Antarctic Ocean is also discussed.

Keywords: copper species, zinc species, Antarctic Ocean sediments, Taiwan Erhjin coastal sediments, oysters.

INTRODUCTION

Some toxic and potentially toxic heavy metals are being released to the marine environment at an increasing rate. When heavy metals enter the coastal water, the majority are absorbed by suspended organic matter and transferred to sediments. The heavy metals in sediments could be released and the amounts of released metals would be larger than those from the decomposition of plankton (Aplin & Cronin, 1985). The processes of both scavenging of copper from sea water and removal of copper from sediments are also correlated with the species and forms in sea water and sediments (Hung *et al.*, 1991).

Copper and zinc are not only essential elements for animal and plant metabolism but are also very toxic to aquatic life. Since August 1973, heavy metals in river, estuarine and nearshore coastal sediments around Taiwan have been monitored (Hung, 1986). The elevation of levels of heavy metals, particularly copper and zinc, in recent sediments indicated that heavy metal pollution of aquatic systems in Taiwan has increased (Hung & Tsai, 1991*a,b*). For instance, extremely high contents of copper (as high as 2130 mg/kg) and zinc (as high as 916 mg/kg) were found during the period of first discoloration of cultural oysters observed in the Erhjin Chi coastal area in January 1986 and mortality appeared 3 months later (Hung, 1988). The species (complexed by inorganic and organic anions, labile and non-labile, polar and non-polar, free ion) and forms (particulate and dissolved) of copper are important in causing the greening and mortality of oysters (Han & Hung, 1989; Hung *et al.*, 1989; Han & Hung, 1990*a,b* Hung & Han, 1990). More recently, studies indicated that correlations among the copper species and forms in both bottom water and sediments, collected along the Erhjin Chi coastal area, were significant (Hung *et al.*, 1991). On the other hand, the Antarctic Ocean is thought to be one of the less polluted areas in the world, although the primary productivity in the Antarctic Ocean is very high (Hung & Tseng, 1978). Therefore, the purpose of this paper is to study the significance of copper and zinc species in surface sediments collected from both the Antarctic Ocean and the Taiwan Erhjin Chi coastal area. In addition, human impact on copper and zinc in the marine environment in Taiwan is evaluated.

國境之南(難) NMMBA

窮鄉僻壤，忙翻之地

屠刀(Meng) VS 微創手術(神級:白、魏、武、曾、溫..)

心路歷程

LTER(長期生態研究)

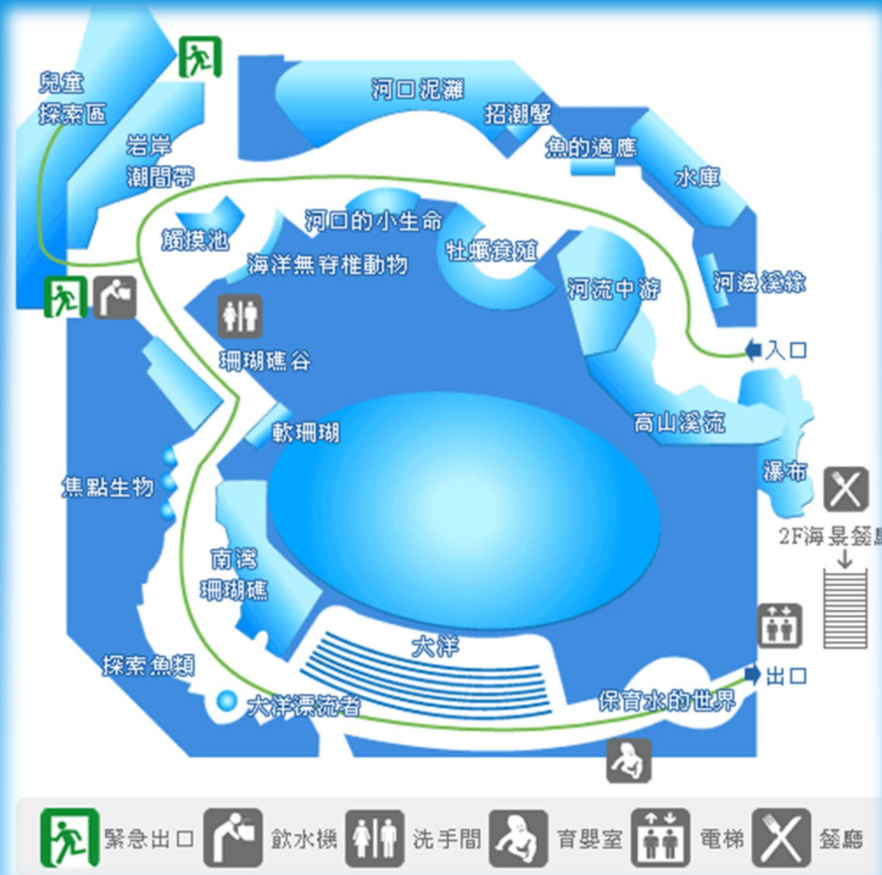
長期飯票?

藥房毒藥XD

國立海洋生物博物館
展場水族缸之水質檢測及管理

樣品來源

本檢驗室檢測之樣品來源為展示場各區展示水缸，由本檢驗室派員至現場進行樣品之採集及現場檢測作業，採樣人員於採樣時並同時填寫現場紀錄。


兒童
探索區
岩岸
潮間帶
河口泥灘
招潮蟹
魚的適應
水庫
觸摸池
河口的小生命
牡蠣養殖
海洋無脊椎動物
河流中游
入口
珊瑚礁谷
高山溪流
軟珊瑚
瀑布
焦點生物
2F海景餐廳
南灣
珊瑚礁
大洋
探索魚類
出口
保育水的世界
大洋漂流者
緊急出口
飲水機
洗手間
育嬰室
電梯
餐廳

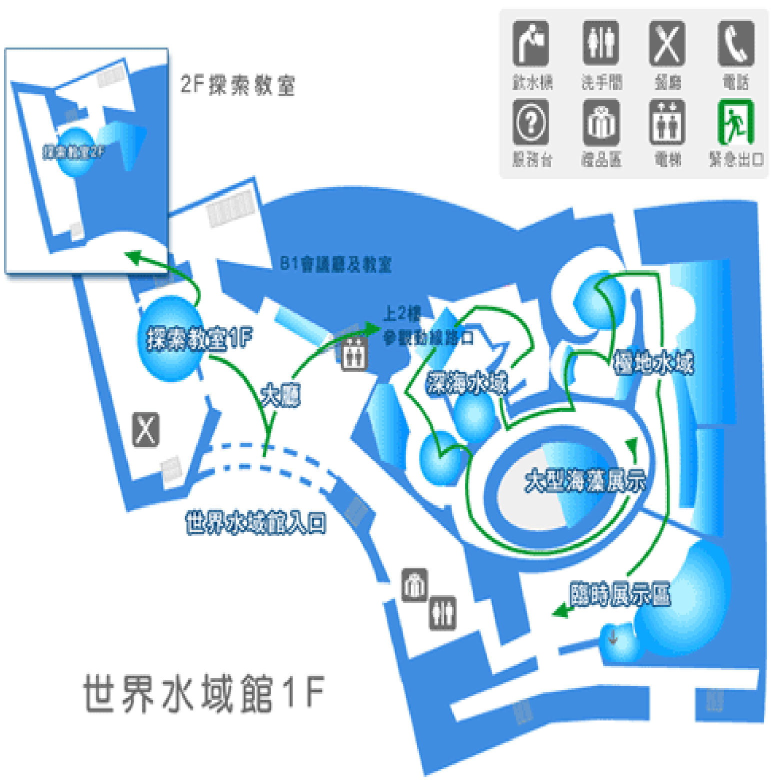
台灣水域館


2F
白鯨看台
海獸池
(白鯨)
2F 特展區
飲水機
洗手間
餐廳
電話
服務台
禮品區
電梯
緊急出口
探索
哺乳類
餐廳
海獸池
(白鯨)
禮品區
花園鰻
珊瑚礁保育
1F
洞穴生物
B1
往2F
白鯨看台
及特展區
出口
入口
1F
沉船探險
B1
海底隧道
水下工作站

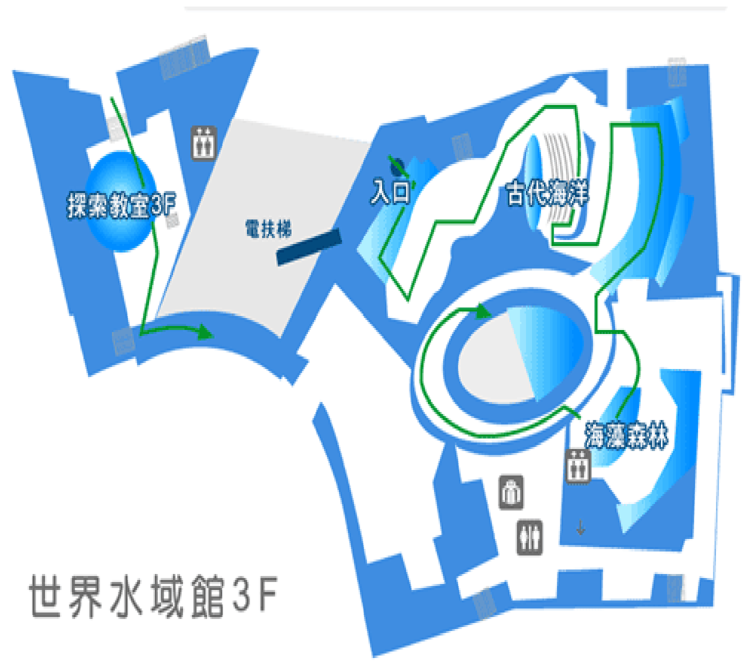
珊瑚王國館

世界水域館

世界水域館1.2F



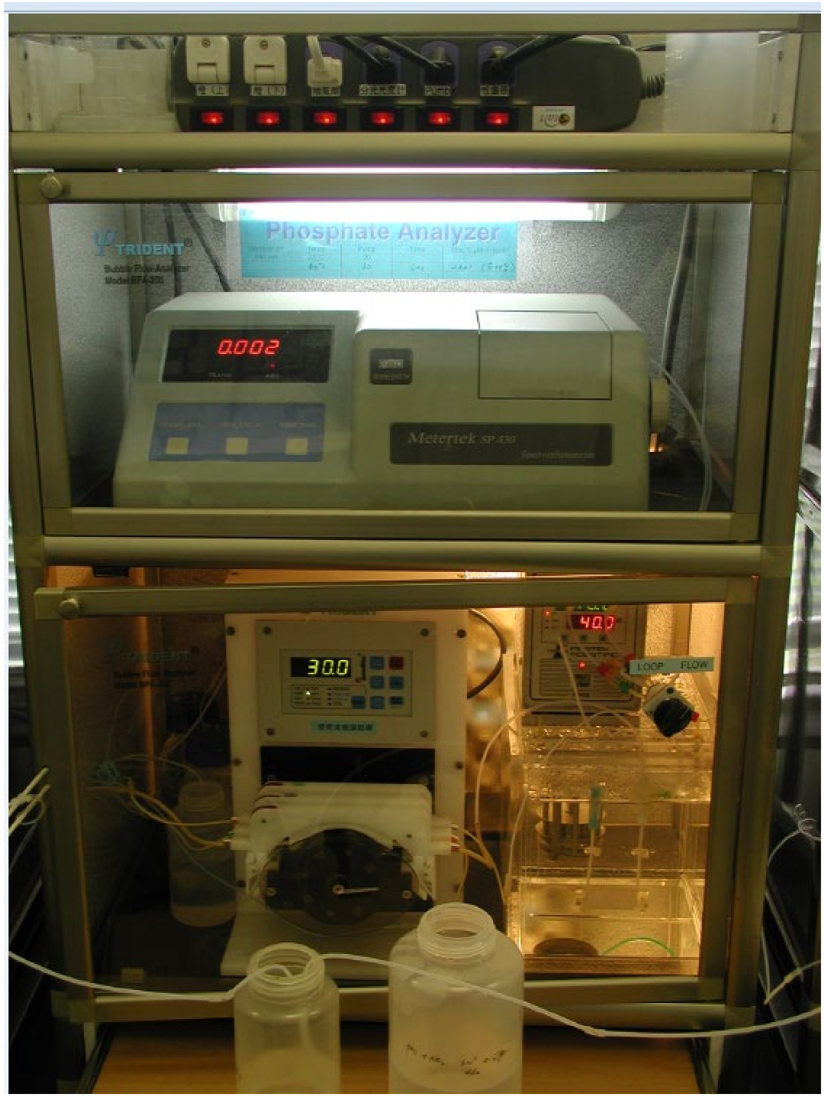
世界水域館3F



YSI 600XL 多參數水質儀

HACH 2100P 攜帶式濁度計

磷酸鹽自動分析儀



分光光度計

國立海洋生物博物館

■台灣水域館 □珊瑚王國館 □水族實驗中心 □水生生物收容中心

水質標準表

項次 / 組別	水溫 ℃	DO %	鹽度 ppt	pH	NH_3N ppm	PO_4-P ppm	NO_2-N ppm	NO_3-N ppm	濁度 ntu	燈光
河邊溪緣	21~29	80~110	0~3	7.5~8.7	<0.1	<1	<0.05	<1	0.5	日光燈(40w*2)*3組
高山溪流◎	15~18	80~110	0~3	7.5~8.7	<0.1	<0.3	<0.05	<1	0.3	鹵素燈(400w)*10組
河流中游	20~26	80~110	0~3	7.5~8.7	<0.1	<0.3	<0.05	<1	0.3	鹵素燈(400w)*13組
魚的適應流水	21~28	80~110	0~3	7.5~8.7	<0.1	<1	<0.05	<1	0.5	鹵素燈(400w)*1組+日光燈(40w*2)*1組
河口生態環境	21~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.6	鹵素燈(400w)*20組
河口幼生	21~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	日光燈(20w*2)*1組
牡蠣架	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*10組+日光燈(40w*2)*13組
軟珊瑚◎	24~27.5	85~110	32~34.8	7.8~8.3	<0.05	<0.01	<0.05	<0.1	0.3	鹵素燈(1000w)*5組
無脊椎動物	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*1組　海葵缸為1000w
觸摸池	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.5	小鹵素燈(15w)*24組
岩岸潮間帶	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*10組
焦點 ABC	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*2組+日光燈(40w*2)*1組
魚類的生存之	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*1組
珊瑚礁谷◎	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*10組
南灣珊瑚礁◎	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(1000w)*7組
大洋池◎	23~28	80~110	30~35	7.7~8.4	<0.1	<0.5	<0.05	<0.5	0.3	鹵素燈(1000w)*10組+日光燈(40w*3)*20組
群游	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*3組
保育水的世界	23~28	80~110	30~35	7.7~8.4	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*7組
水庫◎	20~26	80~110	0~3	7.5~8.7	<0.1	<0.3	<0.05	<1	0.3	鹵素燈(1000w)*2組
大洋的漂流者	23~28	80~110	30-35	7.7~8.4	<0.1	<0.5	<0.05	<0.5	0.5	日光燈(40w*2)*2組外加150w複金屬燈*1藍燈*1

□台灣水域館 ■珊瑚王國館 □水族實驗中心 □水生生物收容中心

水質標準表

項次 組別	水溫	DO	鹽度	pH	NH_3-N	PO_4-P	NO_2-N	NO_3-N	濁度	燈光
	℃	%	ppt		ppm	ppm	ppm	ppm	ntu	
石珊瑚缸	23.5~28	85~110	32~34.8	7.7~8.3	<0.05	<0.01	<0.05	<0.05	0.3	鹵素燈(1000w)*8組 PAR標準350
軟珊瑚缸	23.5~28	85~110	32~34.8	7.7~8.3	<0.05	<0.03	<0.05	<0.1	0.3	鹵素燈(1000w)*7組+藍燈(400w)*2組 PAR標準230
柳珊瑚缸	23.5~28	85~110	32~34.8	7.7~8.3	<0.05	<0.01	<0.05	<0.05	0.3	鹵素燈(1000w)*6組+藍燈(400w)*2組 PAR標準200
碰撞池	23.5~28	85~110	32~34.8	7.7~8.3	<0.05	<0.01	<0.05	<0.05	0.3	鹵素燈(1000w)*59組+藍燈(400w)*8組 PAR標準200
活珊瑚缸	23.2~28	85~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(1000w)*5組+藍燈(400w)*2組 PAR標準230
主珊瑚池	23.2~28	85~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(1000w)*21組+日光燈(40w*3)*29組
糯鰻	23.2~28	80~110	32~35	7.7~8.3	<0.2	<0.3	<0.05	<1.0	0.3	鹵素燈(400w)*2組+日光燈(40w*2)*2組
鰻鯰	23.2~28	80~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*2組+日光燈(40w*2)*2組
鍋爐間	23.2~28	85~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*3組+日光燈(40w*2)*3組
船艙室	23.2~28	85~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*2組+日光燈(40w*2)*2組
船長室	23.2~28	85~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(400w)*2組
花園鰻缸	23.2~28	85~110	32~35	7.7~8.3	<0.1	<0.3	<0.05	<0.5	0.3	鹵素燈(1000w)*4組
海獸池	15~17	80~110	30~34	7.2~8.2	<0.3	<5	<0.05	<1.5	0.3	鹵素燈(1000w)*19組 ORP標準550~650 B0D<3ppm TRO<0.5ppm

國立海洋生物博物館

■世界水域館 □台灣水域館□珊瑚王國館□水族實驗中心

水質標準表

項次 組別	水溫 ℃	DO %	鹽度 ppt	pH	NH_3-N ppm	PO_4-P ppm	NO_2-N ppm	NO_3-N ppm	濁度 ntu	備註	燈光
水母	23-28	80-100	30-35	7.6-8.5	<0.1	<0.3	<0.05	<0.5	<0.4	氣泡	藍燈(40w*2)*6組+小金屬鹵素燈50 [illegible]
鯊魚	22~30	80~100	30~35	7.6-8.5	<0.1	<0.3	<0.05	<0.5	1		鹵素燈(400w)*1組
江魟	25~32	80~100	0~3	6.5~8.5	<0.1	<0.3	<0.05	<1.0	1		藍燈(400w)*1組
鸚鵡螺	15~20	80~100	30~35	7.6-8.5	<0.1	<0.3	<0.05	<0.5	0.3		無
裸臀魚	25~28	80~100	0~3	6.5~8.5	<0.1	<0.3	<0.05	<0.5	0.3		鹵素燈(400w)*1組
異齒鮫	22~26	80~100	30~35	7.6-8.5	<0.1	<0.3	<0.05	<0.5	0.3		鹵素燈(400w)*1組+藍燈(40w*2)*2組
多鰭魚	25~30	80~100	0~3	6.0~8.5	<0.1	<0.3	<0.05	<0.5	0.3		鹵素燈(400w)*1組
象魚	25~32	80~100	0~3	6.0~8.5	<0.1	<0.3	<0.05	<1.0	1		鹵素燈(400w)*2組
紅龍	27~32	80~100	0~3	6.0~7.0	<0.3	<0.1	<0.5	<0.5	0.3		鹵素燈(400w)*1組
火箭魚	22~27	80~100	0~3	7.0~8.5	<0.1	<0.3	<0.05	<0.5	0.3		鹵素燈(400w)*1組
大型藻	12~17	80~110	30~35	7.7~8.5	0.1	<0.3	<0.05	<1.0	0.5	對海水魚而言，NH_3-N > 0.1ppm即有致命風險(且目前平均實測均< 0.05 ppm)	鹵素燈(2000w)*21組 PAR標準50~200 ORP<300
黃鰭鮪	23~28	90~110	32~35	7.7~8.5	<0.1	<0.3	<0.05	<1.0	0.3	鮪魚之需氧量為一般硬骨魚類之3倍；鮪魚為狹鹽性魚類(故忌低鹽性水域)	鹵素燈(1000w)*6組
企鵝	氣溫(-2±1)水溫(5±1)	80~100	30~35	7.2~8.2	<5	<0.1	<1.5	<1.5	0.3	PS：紅龍、企鵝、海鸚鵡、海豹暫時沿用原標準，待獸醫來後再行檢討。	彩色燈(1000w)*23組+白光400w*20組+白光750w*1組 ORP<500
海鸚鵡	氣溫(15±1)水溫(10±1)	80~100	30~35	7.2~8.2	<0.3	<0.1	<1.5	<1.5	0.3		鹵素黃光(1000w)*4組+白光400w*6組
海豹	氣溫(17~23)水溫(17~23)	80~110	30~35	7.2~8.2	<0.3	<0.1	<1.5	<1.5	0.3		鹵素白光(1000w)*6組+黃光(1000w)*6組+白光(400w)*8組

國立海洋生物博物館

■世界水域館 □台灣水域館□珊瑚王國館□水族實驗中心

水質檢測日報表

日　　期：　102 年 9 月 2 日　　星期：一　　天氣：晴

項次 組別	水溫 ℃	DO %	鹽度 ppt	pH	NH_3-N ppm	PO_4-P ppm	NO_2-N ppm	NO_3-N ppm	濁度 ntu
水母	24.0	99.8	31.31	8.19	0.044	0.026	0.009	0.131	0.28
鯊魚	28.3	96.4	28.28	8.22	0.200	0.024	0.005	0.202	8.97
江紅	26.4	98.1	0.10	8.40	0.034	0.016	0.001	0.449	0.28
鸚鵡螺	15.6	97.2	32.31	7.90	0.047	0.351	0.003	1.327	0.26
黑鰭鯊	22.4	97.6	32.16	7.88	0.016	0.045	0.011	1.318	0.27
大型藻	13.7	102.6	31.98	8.00	0.090	0.096	0.005	0.463	0.25
海豹	18.1	101.4	32.57	7.93	0.028	0.388	0.013	1.237	0.24
企鵝	3.0	102.4	31.32	8.03	0.011	0.065	0.006	0.072	0.27
黃鰭鯛	25.2	92.5	32.45	8.01	0.017	0.294	0.025	1.240	0.27
海鸚鵡	9.7	107.7	30.18	7.73	0.113	0.040	0.003	0.023	0.22
湖鱒魚	25.6	97.9	0.12	8.44	0.169	0.046	0.001	0.724	0.24
多鰭魚	25.4	97.8	0.13	8.37	0.020	0.018	0.001	0.483	0.22
象魚	27.3	95.3	0.13	8.18	0.017	0.404	0.006	1.263	0.27
紅龍	28.8	97.1	0.13	8.53	0.016	0.037	0.002	0.610	0.20
大鰭魚	24.6	99.6	0.11	8.52	0.022	0.024	0.001	0.573	0.23

備註:各項檢測異常判定

1. 溫度:低於24℃或高於28℃，海獸池低於15℃或高於17℃。
2. 鹽度:海水低於30或高於35ppt，珊瑚缸低於32或高於34ppt，海獸池低於30或高於34ppt。
3. pH:海水低於7.8或高於8.4，珊瑚缸低於7.9或高於8.2，海獸池低於7.2或高於8.2。
4. DO（%）:低於80% 或高於110%。
5. NH_3-N:高於0.3ppm，珊瑚缸高於0.05ppm。
6. PO_4-P：高於0.5ppm，珊瑚缸高於0.05ppm。
7. NO_2-N：高於0.1ppm，珊瑚缸高於0.01ppm。
8. NO_3-N：高於0.5ppm，珊瑚缸高於0.1ppm。
9. 濁度：高於0.3 ntu。

測試人員：陳韓祥

國立海洋生物博物館

□台灣水域館 ■珊瑚王國館 □水族實驗中心 □水生生物收容中心

水質檢測日報表

日　　期：　102 年 9 月 2 日　　星期：一　　天氣：晴

項次 組別	水溫 ℃	DO %	鹽度 ppt	pH	NH_3-N ppm	PO_4-P ppm	NO_2-N ppm	NO_3-N ppm	濁度 ntu
主珊瑚池◎	25.2	102.2	32.11	8.03	0.016	0.069	0.002	0.437	0.24
[illegible]					0.014	0.345	0.003	1.280	
[illegible]					0.015	0.217	0.005	1.262	
淺珊瑚缸◎	23.7	103.9	32.33	8.20	0.020	0.037	0.004	0.108	0.23
石珊瑚缸◎	24.7	97.2	32.38	7.88	0.018	0.053	0.002	0.440	0.25
軟珊瑚缸◎	24.6	97.4	32.39	7.97	0.100	0.056	0.002	0.452	0.21
柳珊瑚缸◎	24.4	94.9	32.43	7.97	0.022	0.054	0.001	0.420	0.24
碰觸池◎	24.2	97.6	32.14	8.10	0.026	0.022	0.002	0.174	0.22
海獸池◎	16.3	104.3	31.88	7.76	0.116	0.449	0.015	1.322	0.26
船長室					0.018	0.128	0.010	0.677	
船艙室					0.158	0.080	0.003	0.421	
鍋爐間					0.041	0.132	0.007	0.817	
過濾池									
海草缸					0.081	0.067	0.002	0.346	

備註:各項檢測異常判定

1. 溫度:低於24℃或高於28℃，海獸池低於15℃或高於17℃。
2. 鹽度:海水低於30或高於35ppt，珊瑚缸低於32或高於34ppt，海獸池低於30或高於34ppt。
3. pH:海水低於7.8或高於8.4，珊瑚缸低於7.9或高於8.2，海獸池低於7.2或高於8.2。
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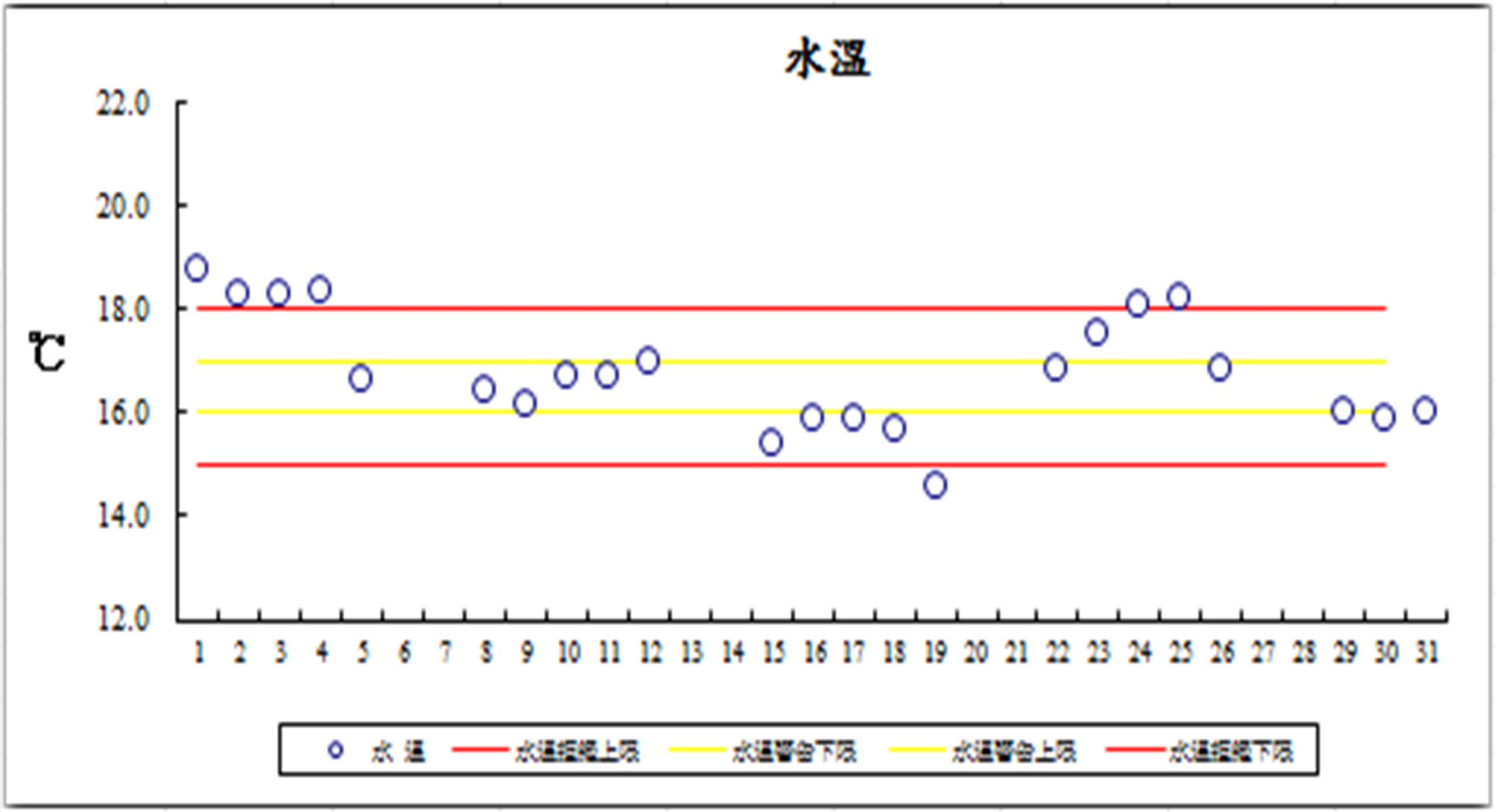
7. NO_2-N：高於0.1ppm，珊瑚缸高於0.01ppm。
8. NO_3-N：高於0.5ppm，珊瑚缸高於0.1ppm。
9. 濁度：高於0.3 ntu。

測試人員：陳韓祥

台灣水域館 2. 高山溪流 101年 1月份 水質測試月報表曲線圖



J Appl Phycol
DOI 10.1007/s10811-011-9775-z

Tew, K.S.*, Jhange, Y.-S., Meng, P.-J. and Leu, M.-Y. 2017. Environmental factors influencing the proliferation of microscopic epiphytic algae on the giant kelp under aquarium conditions. Journal of Applied Phycology. Doi: 10.1007/s10811-017-1148-9. (Online 2017-05-16)
https://link.springer.com/article/10.1007/s10811-017-1148-9

Factors correlating with deterioration of giant kelp *Macrocystis pyrifera* (Laminariales, Heterokontophyta) in an aquarium setting

Kwee Siong Tew · Pei-Jie Meng · Ming-Yih Leu

Received: 24 August 2011 / Revised and accepted: 14 December 2011

Abstract Survival of the giant kelp, *Macrocystis pyrifera* (Linnaeus) C. Agardh, in its natural habitat is governed by abiotic and biotic factors such as temperature, light, nutrients, current velocity, and predators. Factors affecting the survival of the alga in an aquarium setting, however, have not been investigated. The National Museum of Marine Biology and Aquarium (NMMBA), in subtropical Taiwan, is the only aquarium in the world that displays giant kelp that does not have naturally occurring specimens in nearby waters. Giant kelp displayed in aquaria often deteriorates within a 3-month period, yet the cause of this mortality is unknown. We investigated abiotic and biotic parameters affecting survival of giant kelp in aquaria over a 3-month period. The results indicated that temperature, salinity, pH, light, and nutrient concentrations did not affect giant kelp survival. However, the massive proliferation of epiphytic diatoms on kelp blades (from 7×10^2 cells cm^{-2} initially to 3×10^4 cells cm^{-2} after 1 month) was identified as being the most likely candidate affecting survival of giant kelp in an aquarium setting. Potential factors that may stimulate epiphyte proliferation include lack of epiphytic algae control via predation, high nutrient concentrations, a weak current, and a generally stable environment.

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Keywords Diatom · Epiphytic algae · Giant kelp · *Macrocystis pyrifera* · Taiwan

Introduction

The giant kelp, *Macrocystis pyrifera* (Linnaeus) C. Agardh (Laminariales, Heterokontophyta), is the largest benthic organism in the world. This alga is the most widely distributed kelp taxon (Graham et al. 2007) and exists along the temperate coasts of all continents with the exception of Antarctica (Moe and Silva 1977). The kelp forest ecosystem is diverse and productive, hosting a variety of organisms, including marine mammals, fishes, crabs, sea urchins, mollusks, other algae, and epibiota (Mann 1973; Steneck et al. 2002). Ecologically, this aquatic forest is comparable to the terrestrial tropical rainforest.

Giant kelp forests are exposed to varying environmental gradients of abiotic and biotic factors from the surface to the bottom substrate. Studies have indicated that irradiation, temperature, salinity, sedimentation, nutrient concentration, wave action, and amount of epiphytes can significantly affect kelp growth (Dean and Jacobsen 1984; North et al. 1986; Edwards and Hernández-Carmona 2005). In its natural habitat, kelp forests develop on shallow rocky shores with sufficient light penetration (Steneck et al. 2002). As such, the low abundance of kelp in Arctic and sub-Antarctic areas is believed to be a result of light limitation (Henley and Dunton 1997). It has also been shown that temperatures <15°C are optimal for survival of giant kelp and that temperatures >20°C promoted the degradation of this species (Rothäusler et al. 2009). Yet, *Macrocystis* that occur along the southern coasts of California have their highest photosynthetic rates at temperatures

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TRANSPORTATION, HUSBANDARY, AND RELEASE OF A WHALE SHARK (*RHINCODON TYPUS*)

Ming-Yih Leu[1, 2, †], Jan-Jung Li[1], Yu-Min Ju[1], Cher-Ming Hsiao[1], Chih-Wei Chang[1, 2], Pei-Jie Meng[1, 2, †], Kwee Siong Tew[1, 2], and Wei-Hsien Wang[1, 3]

Key words: animal release, aquarium, behavior, husbandry, whale shark.

ABSTRACT

The National Museum of Marine Biology and Aquarium of Taiwan housed a whale shark in a 3.7 million liter indoor oval tank from June 2005 until July 2013, at which point it was released. This study reports the transport of the whale shark into and out of the Museum, its husbandry conditions, feeding regime, growth during captivity, and details on the release of the animal. During the eight years in captivity, the animal grew from 2.3 to 7.8 m in length and from 200 to 3,600 kg in weight when released, with estimated overall growth rates of 0.67 m yr^{-1} and 412 kg yr^{-1} in length and mass, respectively. The animal beached shortly after release, possibly due to having acclimated to life in captivity. Therefore, detailed behavioral knowledge is needed for future releases of animals that have been maintained in captivity for extended periods.

I. INTRODUCTION

The display of large animals has been a focal point of modern aquaria worldwide. The Okinawa Churaumi Aquarium (formerly the Okinawa Expo Aquarium) first exhibited whale sharks (*Rhincodon typus*) to visitors in 1982, and other aquaria followed suit, including the Osaka Aquarium Kayukan, Taiwan's National Museum of Marine Biology and Aquarium (NMMBA), and the Georgia Aquarium (USA), among others. An impressive school of giant manta rays (*Manta birostris*) was displayed in the Okinawa Churaumi Aquarium in November 2002, followed by the Oceanário de Lisboa in Portugal. Great white sharks (*Carcharodon carcharias*) were even put on exhibit in the Monterey Bay Aquarium (USA) in 2004. The largest bony fish, the ocean sunfish (*Mola Mola*), is currently displayed in aquaria such as the Oceanário de Lisboa and the North Sea Oceanarium in Denmark. Transportation of these animals from where they were caught to the aquaria at which they were housed and reared/exhibited often requires careful planning and special equipment and techniques (Uchida, 1982; Correia, 2001; Correia et al., 2008; Correia et al., 2011; Rodrigues et al., 2013) because some of these animals commonly perish during transportation or shortly thereafter (Smith et al., 2004).

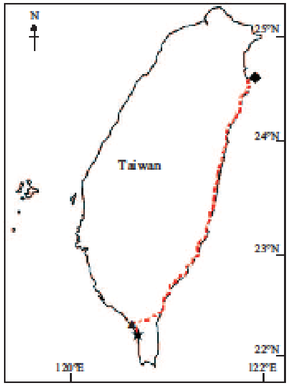

Fig. 1. Transportation of the whale shark from northeastern to southwestern Taiwan by truck (dashed line, representing a 380-km distance). ◆: Set-net location. ★: National Museum of Marine Biology and Aquarium. ▲: Release location.

Paper submitted 02/20/14; revised 11/05/14; accepted 05/11/15. Author for correspondence: Kwee Siong Tew (e-mail: tewks@nmmba.gov.tw).
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† *Both authors contributed equally.*

海域水質對珊瑚礁生態之影響

* 遊客
* 觀光設施
* 廢水
* 遊憩活動

A long-term survey on anthropogenic impacts to the water quality of coral reefs, southern Taiwan

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Environmental Pollution 156 (2008) 67–75

ENVIRONMENTAL POLLUTION

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A long-term survey on anthropogenic impacts to the water quality of coral reefs, southern Taiwan

Pei-Jie Meng [a,b,*], Hung-Jen Lee [c], Jih-Terng Wang [d,**], Chung-Chi Chen [e], Hsing-Juh Lin [f], Kwee Siong Tew [a,b], Wei-Jiun Hsieh [g]

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Suspended solids and ammonium in discharge derived from anthropogenic activities are two main factors causing drop in coral coverage

Abstract

Before 2001, the ecological protection area in the Kenting National Park (KTNP), southern Taiwan, was poorly described. In this study, a set of four-year data (2001–2004) of seawater qualities at 19 sampling sites around the Nanwan Bay in the KTNP was used to explore anthropogenic impacts to ecological environment, especially coral reefs. The parameters of water quality were analyzed immediately after collection. The results showed that higher values of nutrients and suspended solids were attributed to the higher run-off around Nanwan Bay. The fluxes of nutrients and suspended solids were consistently correlated to rainfall. Hence, equations were developed to calculate nutrient fluxes and suspended solids by using only rainfall data. Our results show that suspended solids and ammonia were the dominant factors leading to the drop in coral coverage. In summary, the water quality in the intertidal zone of Nanwan Bay has been degraded and required greater attention.

Keywords: Water quality; Coral reefs; Nutrients; Suspended solids; Kenting National Park; Long-Term Ecological Research (LTER)

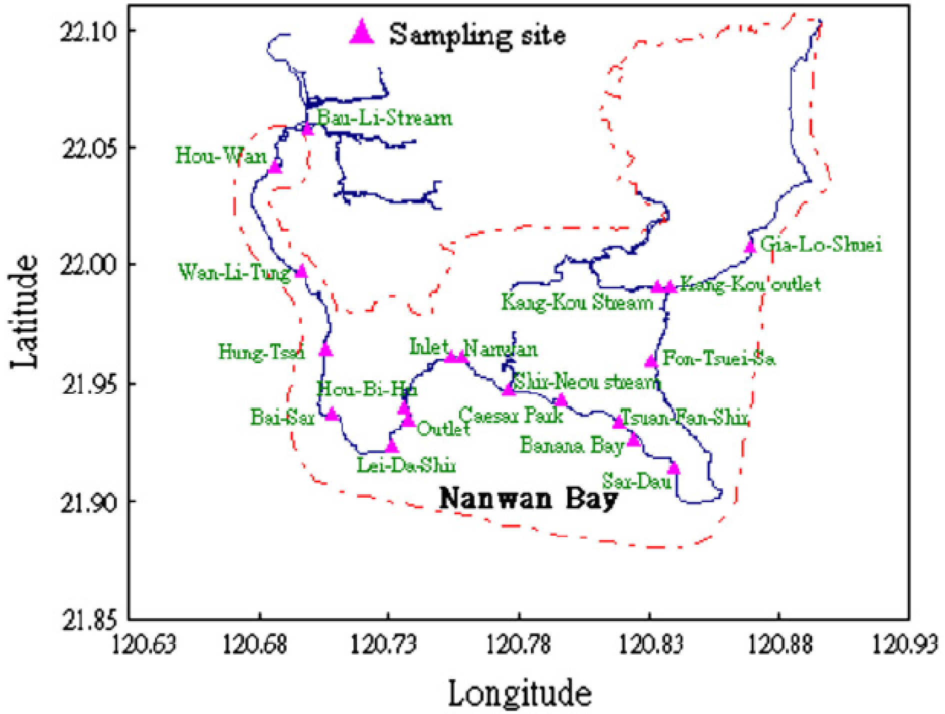

Fig. 1. Locations of water quality sampling sites along the Nanwan Bay. Dotted line indicates the boundary of the Kenting National Park.

Table 2
Correlation coefficients (R) between parameters of water quality and coral coverage rate

Correlation coefficient (R)	Coral coverage	Temp.	Salinity	pH	Dissolved oxygen	BOD_5	Ammonium	Phosphate	Nitrite	Nitrate	Silicate	Chlorophyll-*a*	Suspended solids
Coral coverage	1.0000												
Temp.	0.0731	1.0000											
Salinity	0.3407	0.2350	1.0000										
pH	0.1190	0.3889	0.3397	1.0000									
Dissolved oxygen	0.2312	0.1816	0.4630	0.8163**	1.0000								
BOD_5	0.3988	0.1363	0.9442**	0.1069	0.3015	1.0000							
Ammonium	0.5648*	0.2262	0.6064*	0.0114	0.1589	0.6669**	1.0000						
Phosphate	0.3519	0.2233	0.9893**	0.3114	0.4351	0.9424**	0.6301**	1.0000					
Nitrite	0.3224	0.2482	0.9947**	0.3452	0.4737	0.9408**	0.6159*	0.9902**	1.0000				
Nitrate	0.2170	0.1902	0.9783**	0.3634	0.4500	0.9097**	0.5437*	0.9612**	0.9775**	1.0000			
Silicate	0.3374	0.2394	0.9996**	0.3469	0.4669	0.9401**	0.6055*	0.9914**	0.9952**	0.9785**	1.0000		
Chlorophyll-a	0.2982	0.2444	0.9939**	0.3590	0.4656	0.9306**	0.6103*	0.9922**	0.9945**	0.9717**	0.9956**	1.0000	
Suspended solids	0.5072*	0.0245	0.4735	0.3017	0.1026	0.6283**	0.4117	0.4359	0.4233	0.3586	0.4558	0.4157	1.0000

*: Significant at $p < 0.05$. **: Significant at $p < 0.01$.

The relationship between parameters of water quality and coral coverage rate

- There was significant correlation between salinity and nutrient concentrations in the water. This implies that the sources of nutrients were from streams around Nanwan Bay.

- There was significant correlation between dissolved oxygen and pH in the water. This indicates that the effects of photosynthesis and respiration on pH by organism (such as phyotoplankton and algae) in the water.

- A relatively consistent correlation was found between nutrient and ammonia concentrations in the water and BOD5. On the other hand, there was also significant correlation between nutrient and ammonia concentrations in the water and chlorophyll-*a* contents. As we mentioned before, an increase of domestic wastewaters which carry excessive nutrients will flow into Nanwan Bay without being treated leading to increases in chlorophyll-*a* content and BOD5.

- Effects of water quality (such as sediments, thermal stress and nutrients) on coral reef ecosystem have been widely studied. Our results show that suspended solids and ammonia were the dominant factors leading to the drop in coral coverage.

Impacts of human activities on coral reef ecosystems of southern Taiwan: A long-term study

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Marine Pollution Bulletin

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

Impacts of human activities on coral reef ecosystems of southern Taiwan: A long-term study

Pi-Jen Liu [a,b], Pei-Jie Meng [a,b,*], Li-Lian Liu [c], Jih-Terng Wang [d], Ming-Yih Leu [a,b,*]

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A R T I C L E   I N F O

Keywords:
Anthropogenic impact
Coral reef
Kenting National Park
Long-Term Ecological Research (LTER)
Seawater quality
Taiwan

A B S T R A C T

In July 2001, the National Museum of Marine Biology and Aquarium, co-sponsored by the Kenting National Park Headquarters and Taiwan's National Science Council, launched a Long-Term Ecological Research (LTER) program to monitor anthropogenic impacts on the ecosystems of southern Taiwan, specifically the coral reefs of Kenting National Park (KNP), which are facing an increasing amount of anthropogenic pressure. We found that the seawater of the reef flats along Nanwan Bay, Taiwan's southernmost embayment, was polluted by sewage discharge at certain monitoring stations. Furthermore, the consequently higher nutrient and suspended sediment levels had led to algal blooms and sediment smothering of shallow water corals at some sampling sites. Finally, our results show that, in addition to this influx of anthropogenically-derived sewage, increasing tourist numbers are correlated with decreasing shallow water coral cover, highlighting the urgency of a more proactive management plan for KNP's coral reefs.

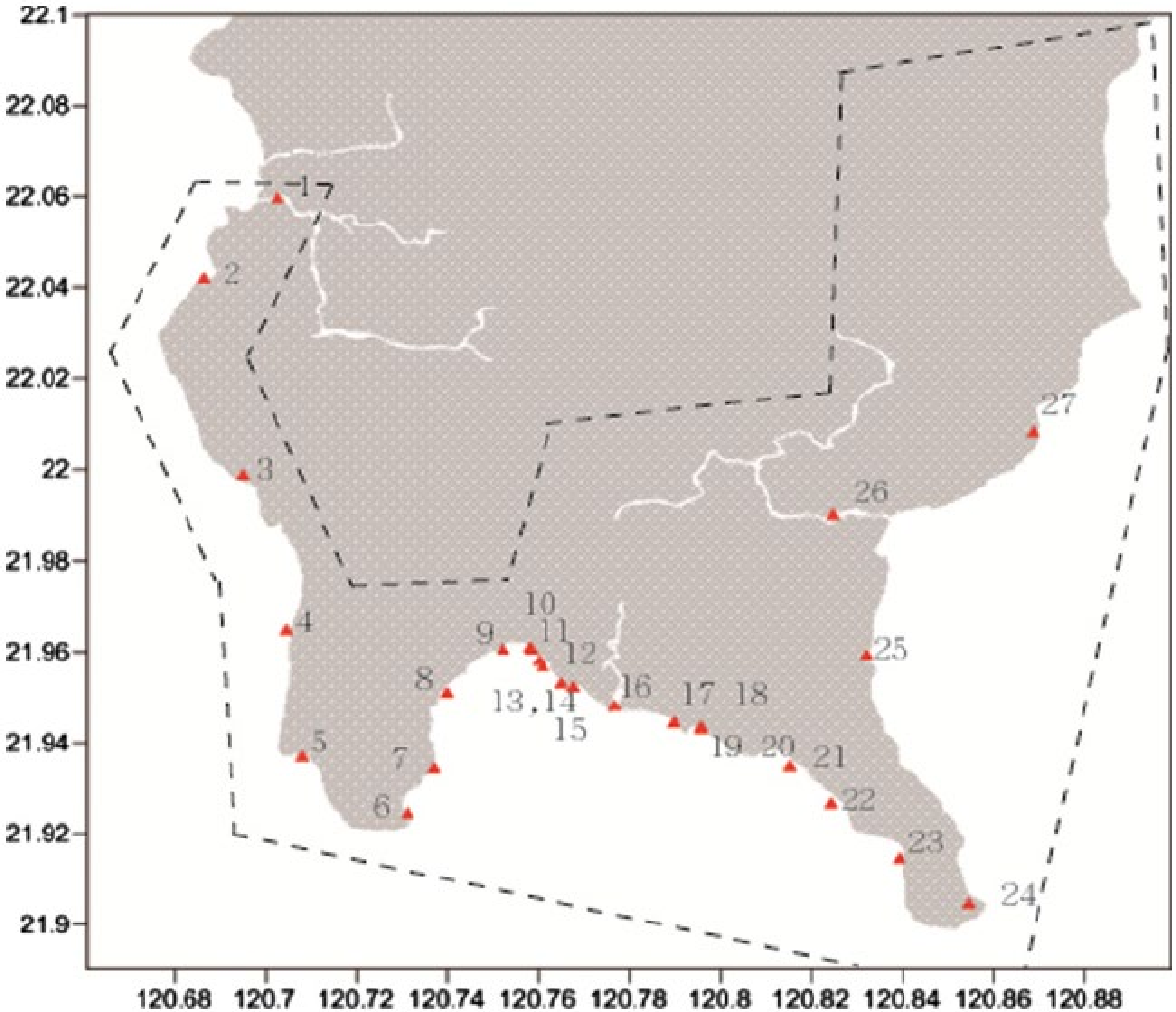


Fig. 1. Locations of sampling sites along the coast of Kenting National Park. The dotted line indicates the boundary of Kenting National Park.

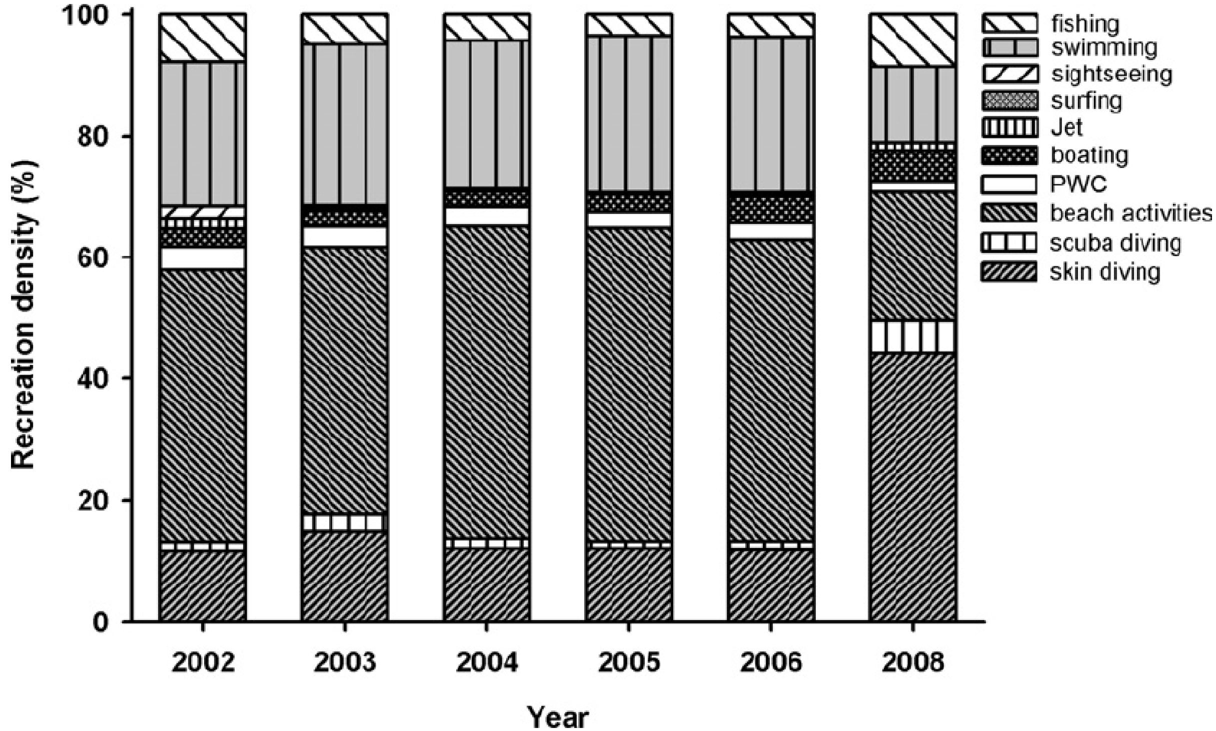


Fig. 2. The recreational densities (expressed as percentages of the average values) observed along the coast of Kenting National Park. PWC, personal watercraft.

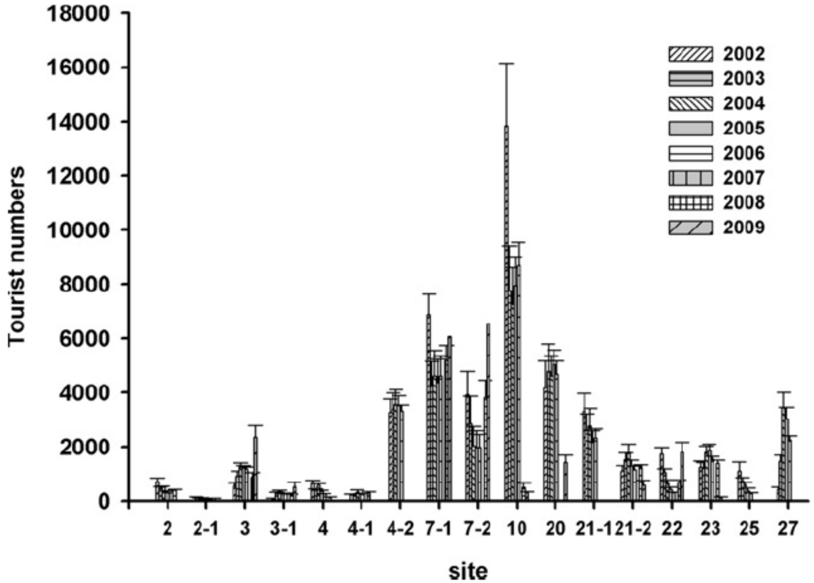


Fig. 3. Average numbers of tourists (expressed as monthly means ± standard error) at the different stations along the coast of Kenting National Park.

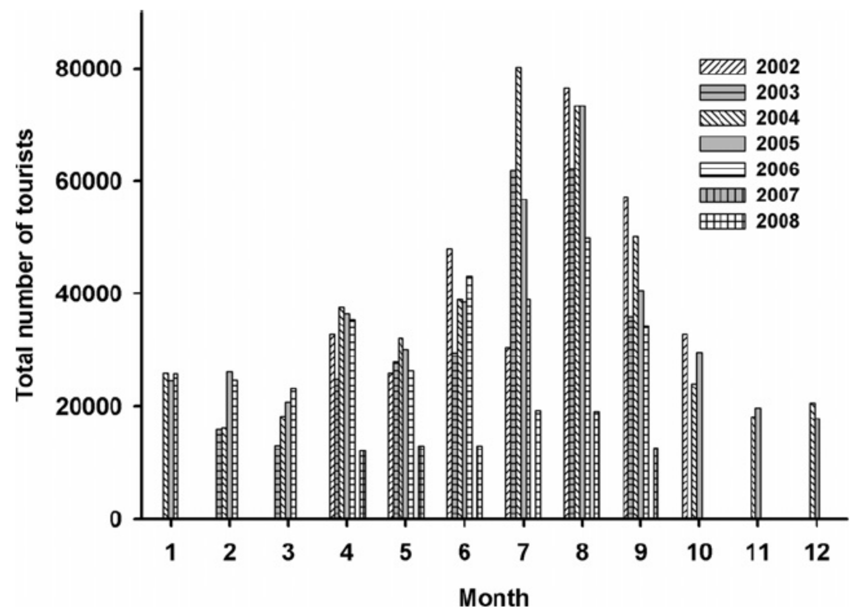


Fig. 4. Total number of tourists observed monthly along the coast of Kenting National Park from 2001 to 2008.

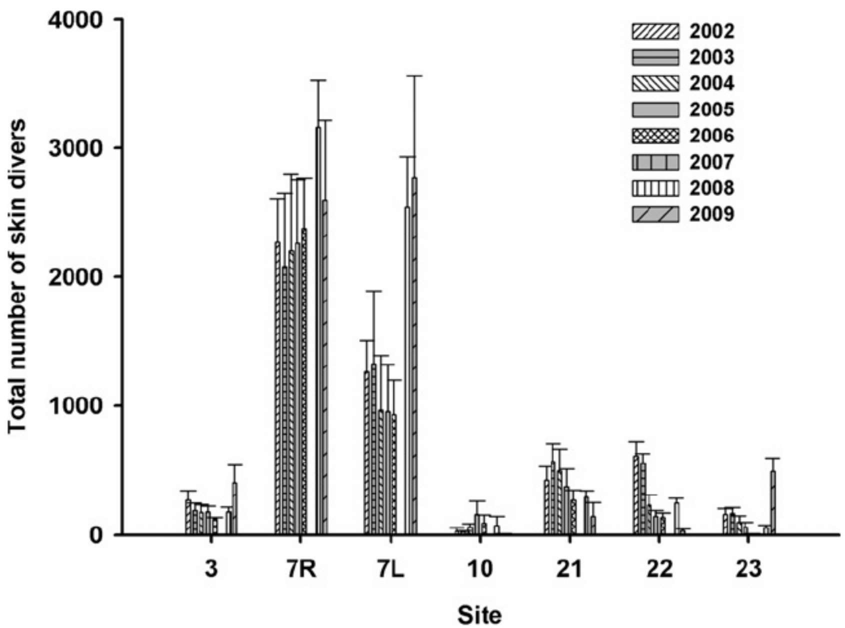


Fig. 5. The average number of skin divers (±standard error) at the different stations of Kenting National Park from 2002 to 2008.

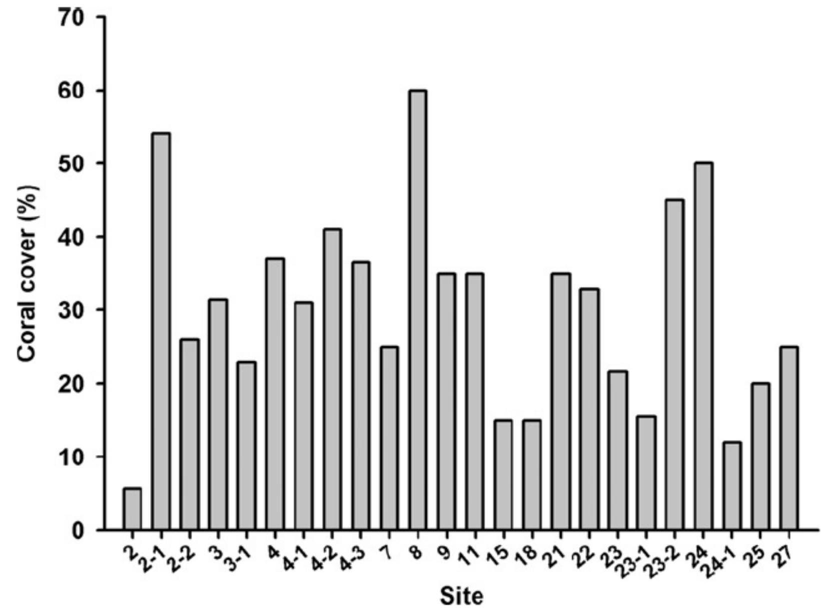


Fig. 6. Coral cover of reef flats at different stations along the coast of Kenting National Park.

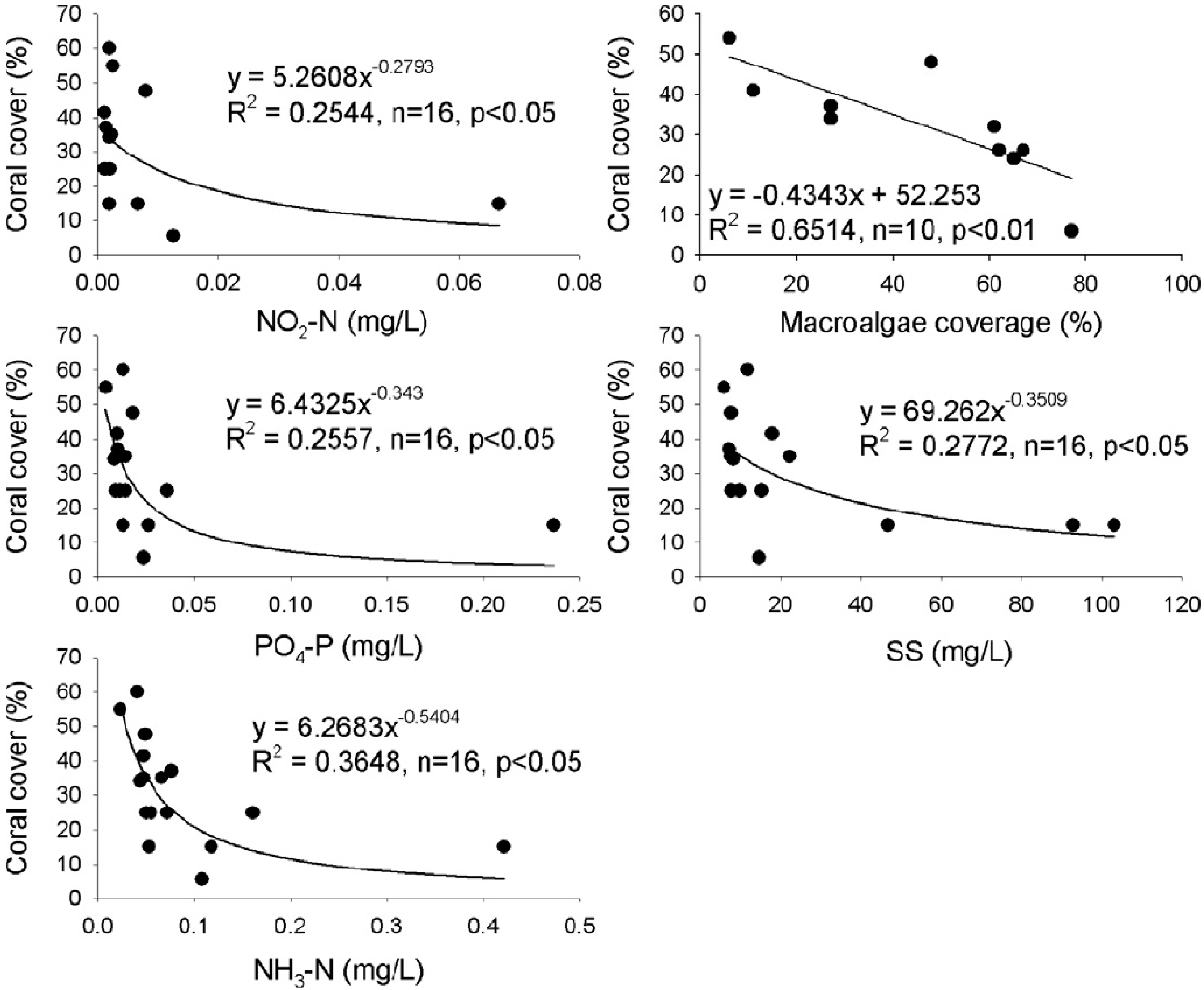
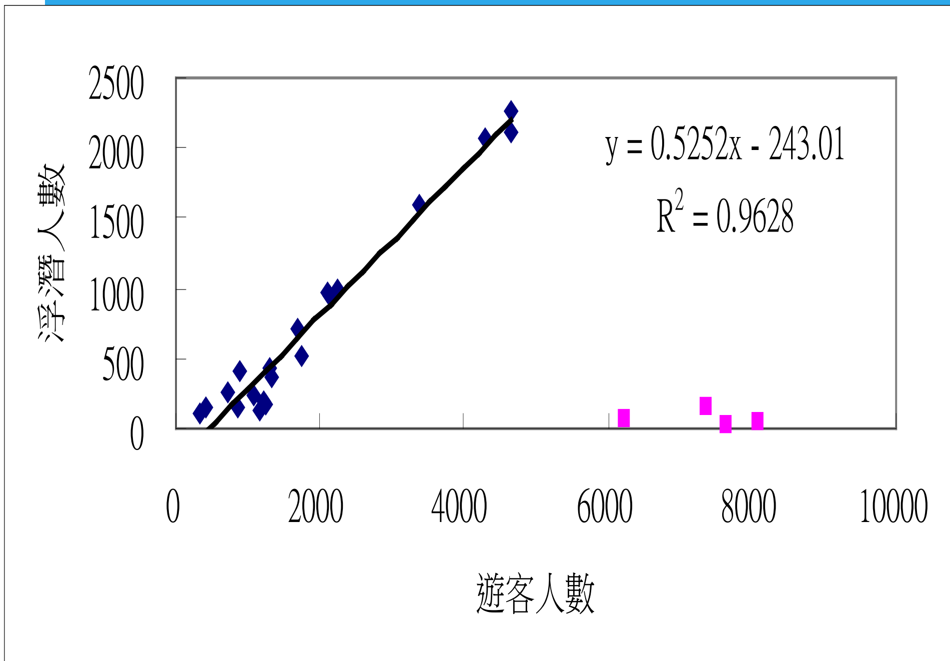
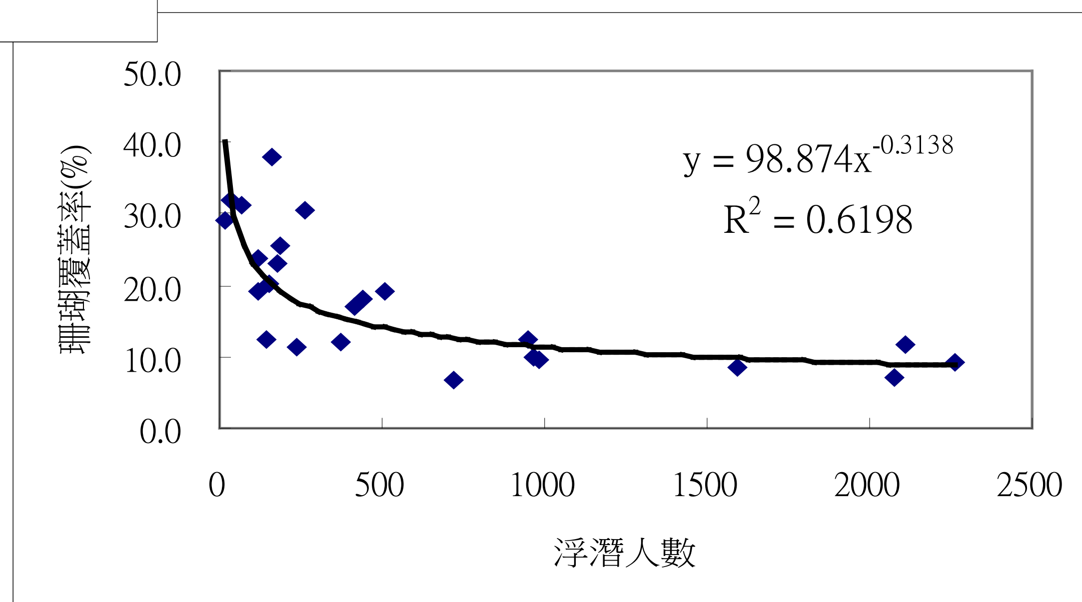


Fig. 7. The correlations between levels of nitrite, phosphate, ammonia, macroalgal cover, and suspended solids and coral cover.

遊憩活動與珊瑚覆蓋率間之相互關係





Journal of *Marine Science and Engineering*

MDPI

Article

The Key Impact on Water Quality on Coral Reefs in Kenting National Park

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† These authors contributed equally to this work.

Abstract: Southern Taiwan's Kenting National Park is a popular retreating place for many domestic and international tourists, with increasing tourist numbers potentially over-burdening the coastal ecosystems. To better understand human impacts, a long-term ecological research program was initiated in 2001 to track water quality at 14 coral reef-abutting sites throughout the park since then. Extracting the data from this 20-year survey, we found that increasing in the nutrient levels during the summer rainy season, together with the drops in salinity led by freshwater inputs (land- & rainfall-derived), was the main impact to coral reef ecosystem of Kenting. Cluster analysis further confirmed the nutrient influx was mainly attributed to the local discharge outlets with dense of villages and hotels at upstream. Therefore, more efforts are needed to input to control tourist number, treat waste water discharge and strengthen land protection facilities.

Keywords: anthropogenic impacts; coral reefs; rainfall; nutrients; seawater quality

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1. Introduction

Kenting National Park (KNP) is located at the southernmost tip of Taiwan, and the plethora of beaches and vibrant coral reefs are a draw for myriad domestic and international tourists. Unfortunately, the pre-Covid tourism boom (3 million in 2001 to 8 million in 2018) has led to increasing coastal development, sewage and other pollutant discharge, and eutrophication [1–3]; high nitrogen and suspended solid (SS) levels have even been linked to coral reef decline in the area [3], with more direct impacts of tourists (e.g., physical damage to coral colonies) having also been documented [4]. The SS, high nutrient loads, and pathogenic bacteria are presumably land-based, entering the ocean via channels or creeks during the May to September rainy season; such runoff can also include fertilizers and pesticides used in local agriculture [4]. Given these threats, KNP initiated a long-term ecological research (LTER) program in 2001, with data collected until 2019. There has been a focus on nearshore environments abutting coral reef ecosystems (N = 19 sites). Herein we sought to use multivariate statistical approaches, namely principal components analysis (PCA) and cluster analysis (CA), to uncover relationships among seawater quality parameters across the LTER study sites, *sensu* [5–11]. The overarching goal was to use this approach to better understand spatio-temporal variation in seawater quality in this ecologically rich bio-region.

Estimating nutrient budgets in a coastal lagoon

Articles

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Estimating nutrient budgets in a coastal lagoon

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To estimate nutrient budgets, water samples were collected at 16 sites in Tapong lagoon from January 2004 through April 2005 and the parameters of water quality were analyzed immediately after collection. These data were used to build a box model for calculating nutrient budgets of the lagoon. We estimated the net amount of nutrient fluxes into (coming from creeks) and out (from tidal inlet) of the lagoon and calculated the total amount of nutrient that deposits into the sediment in a full tidal cycle. During January and April, nutrients (including nitrate, nitrite and ammonia) accumulated in the lagoon, but phosphate, total phosphate and suspended solids were flushed out of the lagoon from the tidal inlet. In addition, a huge amount of suspended solids (13–15 tons per tidal cycle) flew from the lagoon to the adjacent ocean through the inlet-outlet channel.

box model, nutrient budget, coastal lagoon, eutrophication

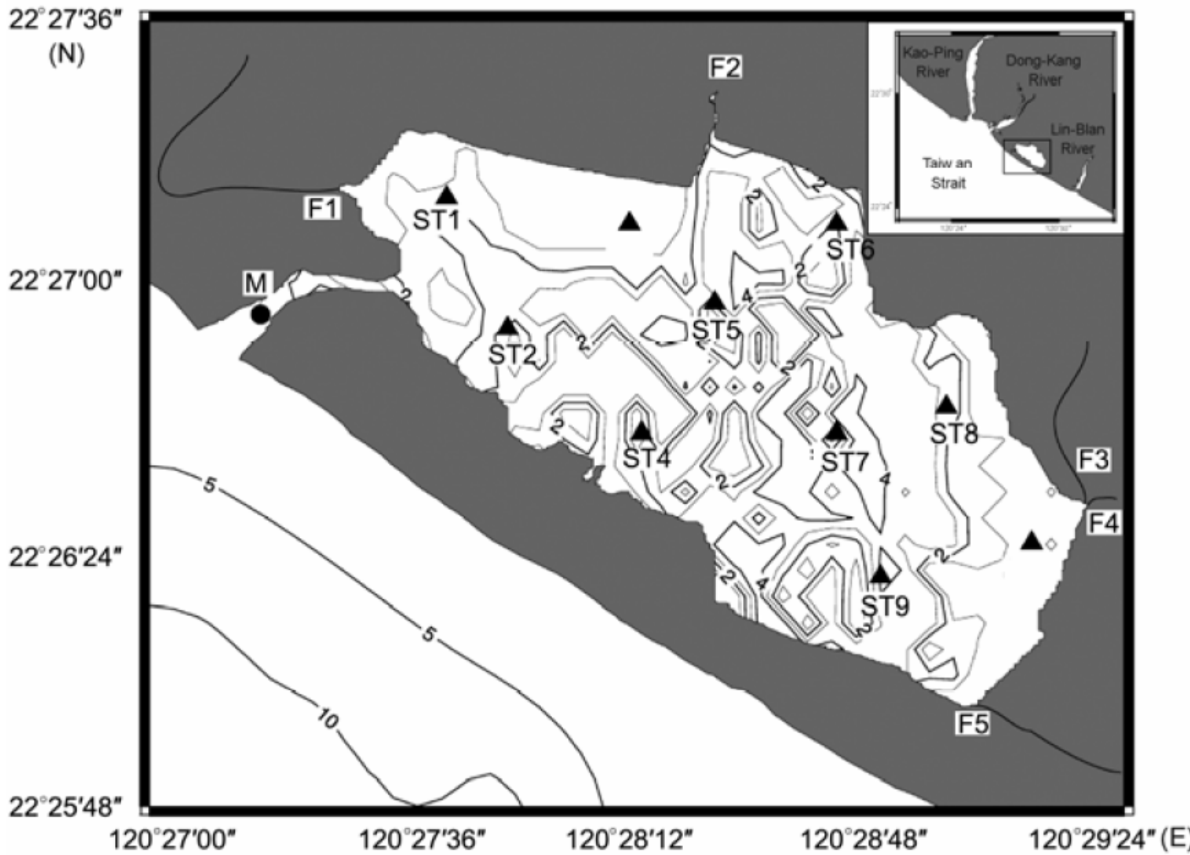

Figure 1 The sampling sites and topography of Tapong Bay and its vicinity, with depth contours in meters. Top right insert is the large-scale setting.

Estimating nutrient budgets with box model

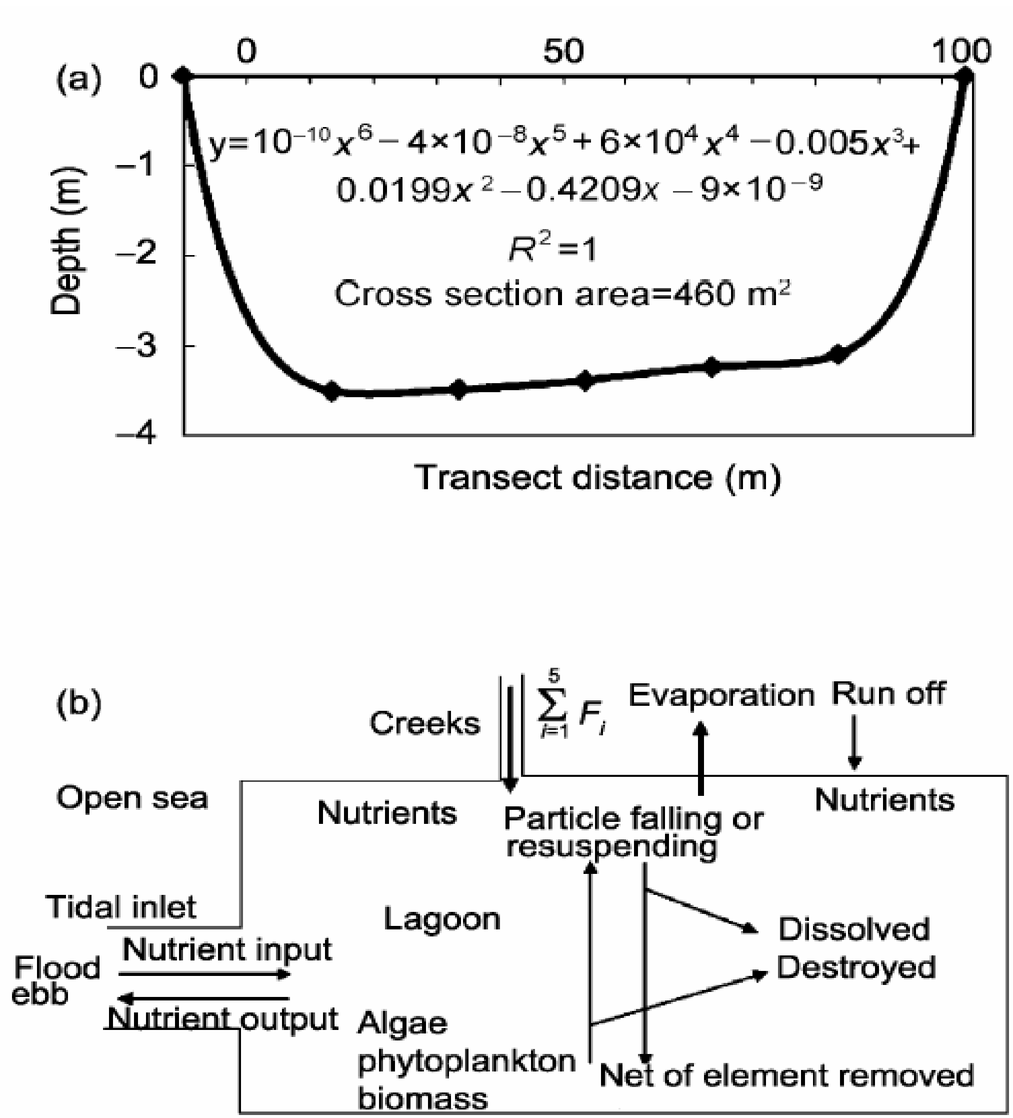

Figure 5 The average cross-section area of tidal inlet at site M (a), and the conceptual flow chart of mass balance for the box-model (b).

Characterising and predicting algal blooms in a subtropical coastal lagoon

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Characterising and predicting algal blooms in a subtropical coastal lagoon

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Abstract. Algal bloom is a major concern worldwide. In this study, we characterised the physical and biochemical parameters during an algal bloom event in a coastal lagoon in an attempt to predict local blooms in the future. Results showed that the highest concentrations of dissolved inorganic phosphorus (DIP), chlorophyll a (chl a) and phytoplankton abundance were found in the inner area, whereas the highest dissolved inorganic nitrogen (DIN) concentration occurred near the inlet-outlet channel. Chl a was correlated with DIP, and there was a significant exponential relationship between chl a and the nitrogen to phosphorus ratio (N/P ratio) across all sampling stations and times. A higher proportion of the variation in chl a was explained by the N/P ratio than either DIP or DIN. We found that a N/P ratio <2.38 will likely trigger an algal bloom (chl a $\geq 10\ \mu g L^{-1}$) in the lagoon. Our results suggest that the N/P ratio could be used as an expedient and reliable measure of the potential eutrophic status of coastal lagoons.

Additional keywords: eutrophication, nutrients, Taiwan.

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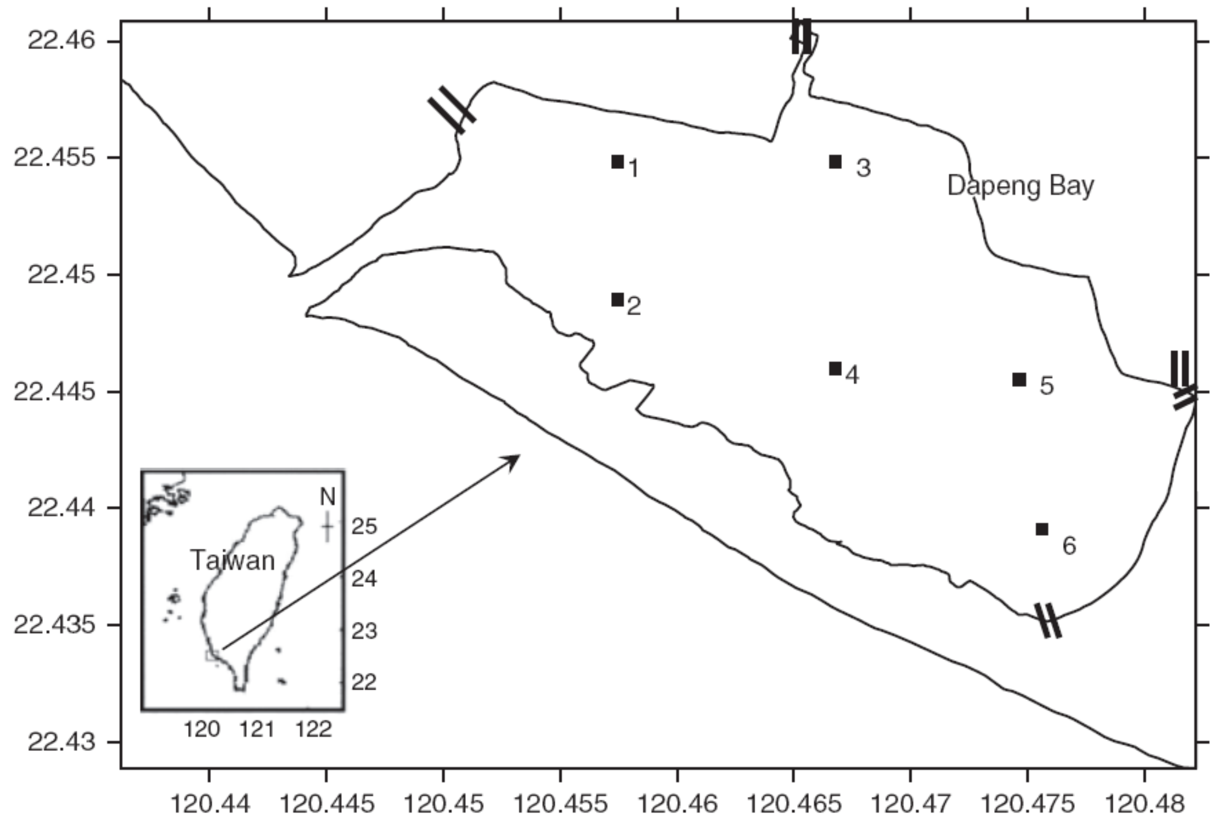

Fig. 1. Location of sampling stations within Dapeng Bay, located in south-western Taiwan. Drainage creeks are indicated by bold '=' signs.

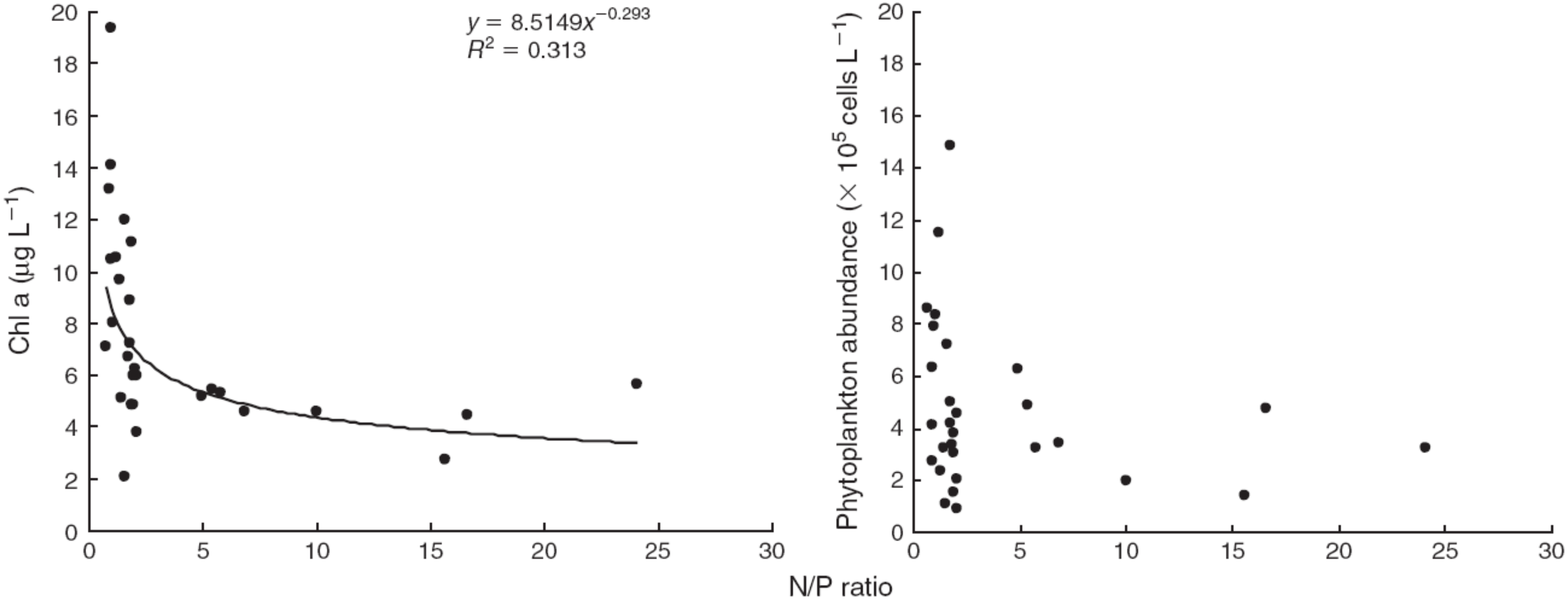

Fig. 7. Relationships between both chl a concentration and phytoplankton abundance and N/P ratio from 6 to 10 September 2005 in Dapeng Bay.

計算式:

∵$Y=aX^{-b}≧10$

∴$\log(aX^{-b})>1$

$\log(a)-b*\log(X)>1$

$\log(a)-1>b*\log(X)$

$(\log(a/10))/b>\log X$

$X<10^{(\log(a/10))/b}$

A Model to Predict Total Chlorine Residue in the Cooling Seawater of a Power Plant Using Iodine Colorimetric Method

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Full Research Paper

A Model to Predict Total Chlorine Residue in the Cooling Seawater of a Power Plant Using Iodine Colorimetric Method

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Abstract: A model experiment monitoring the fate of total residue oxidant (TRO) in water at a constant temperature and salinity indicated that it decayed exponentially with time, and with TRO decaying faster in seawater than in distilled water. The reduction of TRO by temperature (°K) was found to fit a curvilinear relationship in distilled water (r^2 = 0.997) and a linear relationship in seawater (r^2 = 0.996). Based on the decay rate, flow rate, and the length of cooling water flowing through at a given temperature, the TRO level in the cooling water of a power plant could be estimated using the equation developed in this study. This predictive model would provide a benchmark for power plant operators to adjust the addition of chlorine to levels necessary to control bio-fouling of cooling water intake pipelines, but without irritating ambient marine organisms.

Keywords: anti-fouling agent; total residual oxidant; power plant; cooling water.

不同溫度下海水中殘餘氧化劑衰退速算程式

Temp.(℃)	原始加氯量(mg/L)	流速(m/sec)	距離(m)	經過時間(hr)	衰退後含氯量(mg/L)
25(℃)	1	1	500	0.14	0.951
	1	1	1000	0.28	0.905
	1	1	2000	0.56	0.819
	1	1	4000	1.11	0.671
30(℃)	1	1	500	0.14	0.943
	1	1	1000	0.28	0.888
	1	1	2000	0.56	0.789
	1	1	4000	1.11	0.623
40(℃)	1	1	500	0.14	0.923
	1	1	1000	0.28	0.852
	1	1	2000	0.56	0.726
	1	1	4000	1.11	0.527

note:1.當水溫為25(℃)時，衰退後含氯量(mg/L)=原始加氯量(mg/L)*exp(-0.3595*衰退時間(小時))

當水溫為30(oC)時，衰退後含氯量(mg/L)=原始加氯量(mg/L)*exp(-0.4262*衰退時間(小時))

當水溫為40(℃)時，衰退後含氯量(mg/L)=原始加氯量(mg/L)*exp(-0.5757*衰退時間(小時))

2.計算時依不同溫度 之公式，將原始加氯量(mg/L)，流速(m/sec)及距離(m)等參數輸入即可獲得衰退後含氯量(mg/L)

Table 2. Examination of relative error of the model developed in this study. The predicted values of chlorine residue concentration were obtained from the equation $R = [P \times e^{(Q \times t)}]/0.3497$. The real chlorine residue concentration at the end of outlet of discharging pipeline was determined by standard water sampling and iodine colorimetry as described in Experimental.

Power plant	Date	Chlorine residue conc. (mg/L)		Relative error (%)
		Predicted value	Real determination	
Second Nuclear Power Plant	Mar	0.298	0.240	21.4
	May	0.197	0.160	21.0
	Aug	0.086	0.062	32.0
Third Nuclear Power Plant	Mar	0.093	0.088	5.3
	May	0.081	0.070	14.7
	Aug	0.048	0.041	15.6
Pong-Hu Chienshan Power Plant	Mar	0.140	0.133	4.8
	May	0.219	0.235	7.0
	Aug	0.069	0.046	40.2

Optimal Dose of Total Residual Oxidants for Hybrid Tilapia (*Oreochromis mossambicus x O. niloticus*) and Whiteleg Shrimp (*Litopenaeus vannamei*) in Ozone-Treated Sea Water

Optimal Dose of Total Residual Oxidants for Hybrid Tilapia (*Oreochromis mossambicus x O. niloticus*) and Whiteleg Shrimp (*Litopenaeus vannamei*) in Ozone-Treated Sea Water

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Key words: ozone, total residual oxidants (TRO), oxidation-reduction potential (ORP), hybrid tilapia (*Oreochromis mossambicus x O. niloticus*), whiteleg shrimp (*Litopenaeus vannamei*)

Abstract

The purpose of this study was to use total residual oxidants (TRO) as an indicator for determining the optimal ozone dosage needed to control water quality and thereby enhance survival of cultivated aquatic organisms. When the TRO concentration was maintained at 0.16 mg/l for two hours, the total bacteria plate count dropped from 7.7 x 10^3 CFU/ml in the untreated sea water to less than 10 CFU/ml in the ozone-treated sea water. The TRO concentration in the ozone-treated water was well below the 96-h LC_{50} for hybrid tilapia (*Oreochromis mossambicus x O. niloticus*) and whiteleg shrimp (*Litopenaeus vannamei*) determined in this study. Hence, adjustment of the ozone concentration in aquacultural sea water is a viable option that simultaneously kills the majority of harmful bacteria in the water and enhances survival of cultivated aquatic organisms.

Toxicity and bioaccumulation of tributyltin and triphenyltin on oysters and rock shells collected from Taiwan maricuture area

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Toxicity and bioaccumulation of tributyltin and triphenyltin on oysters and rock shells collected from Taiwan maricuture area

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Available online 11 March 2005

Abstract

The present study was undertaken to evaluate the toxicity of tributyltin (TBT) on oysters (*Crassostrea gigas*) and bioaccumulation of TBT and triphenyltin (TPhT) on oysters and rock shells (*Thais clavigera*) from mariculture areas of Taiwan. When treated with concentrations of 0.08, 0.40, 2.00, 10.00 and 50.00 μg TBT/L, the 48-, 72-, 96- and 120-h LC50s of oysters were 44.6, 18.4, 17.9 and 14.3 μg TBT/L, respectively. In the bioaccumulation experiments, oysters and rock shells were exposed to various concentrations of organotins, i.e. A: control, B: 0.40 μg TBT/L, C: 0.40 μg TPhT/L, and D: 0.20 μg TBT/L + 0.20 μg TPhT/L. In general, TPhT was faster accumulated than TBT in both oysters and rock shells and oysters had a higher elimination capability than rock shells. Additionally, greater bioaccumulation and elimination rates had been observed in female oysters than males. To rock shells, the bioaccumulation rate of organotins in imposex females was greater than males and females.

Keywords: Bioaccumulation; Organotin compounds; Rock shells and oysters; Sexual phenomena; Hermaproditic/imposex

Distribution and accumulation of organotin species in seawater, sediments and organisms collected from a Taiwan mariculture area

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Distribution and accumulation of organotin species in seawater, sediments and organisms collected from a Taiwan mariculture area

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Organotin compounds
Tributyltin

ABSTRACT

The present study was undertaken to evaluate the distribution and accumulation of tributyltin (TBT) and triphenyltin (TPhT) in seawater, sediments and selected organisms from a cage mariculture area in southern Taiwan, Hsiao Liouchiou Island. Our results show that ΣOTs were found in concentrations as high as 196 ng/L in seawater collected from the sites in Pai-Sa harbor, and up 1040 ng/g dry wt. in sediments dredged from sites within Da-Fu harbor. Also, ΣOTs concentrations of 859 ng/g dry wt. were observed in the liver of cobia (*Rachycentron canadum*) from mariculture cages. As most published studies have focused on the acute toxicity and bioaccumulation of organotins in mussels, the effects of organotins on cobia and other marine fauna are still poorly understood. This study highlights the significance of ΣBTs accumulation in cobia, as well as in the sediments and seawater surrounding their culture facilities.

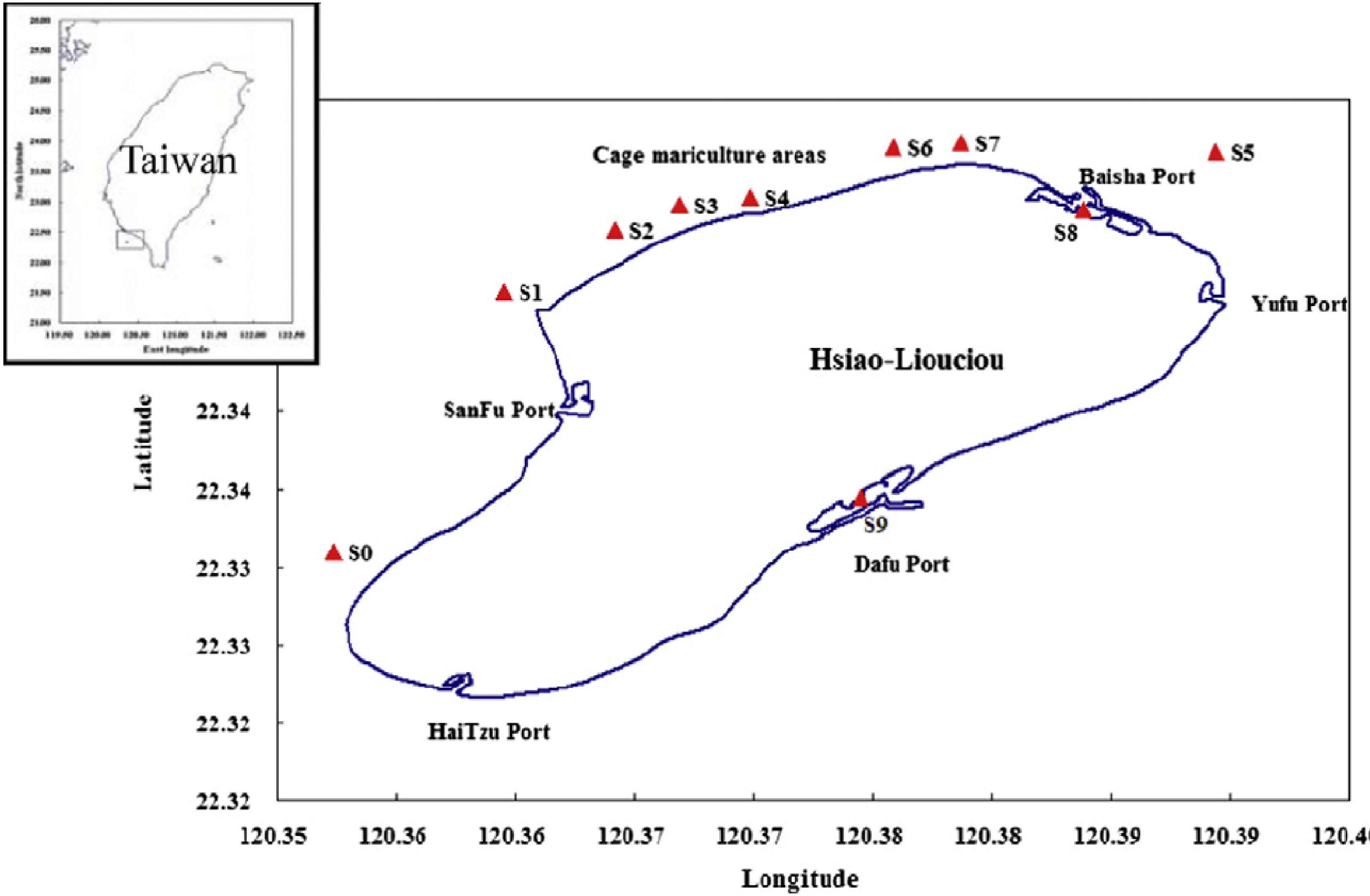

Fig. 1. Locations of sampling sites along the coast of Hsiao Liouciou Island.

Table 1
Concentrations (ng-Sn/g) of organotin species in seawater collected along the coast of Hsiao Liouciou Island.

Station No.	MBT	DBT	TBT	ΣBTs	MPT	DPT	TPT	ΣPhTs	ΣOTs
0	12.9 ± 1.12	28.4 ± 2.53	21.6 ± 2.19	62.9	nd	26.1 ± 2.09	15.3 ± 1.43	41.4	104
1	11.6 ± 0.97	18.5 ± 0.91	22.3 ± 2.21	52.4	nd	20.8 ± 1.49	nd	20.8	73.2
2	12.5 ± 1.64	14.0 ± 1.35	17.7 ± 0.88	44.2	nd	15.7 ± 1.01	nd	15.7	59.9
3	17.0 ± 1.16	12.3 ± 0.49	15.0 ± 0.50	44.3	nd	9.16 ± 0.52	nd	9.16	53.5
4	11.8 ± 1.13	15.7 ± 1.13	28.8 ± 3.67	56.3	nd	7.70 ± 0.39	12.7 ± 0.99	20.4	76.7
5	11.6 ± 0.95	26.6 ± 1.39	6.88 ± 0.52	45.1	nd	7.97 ± 0.68	nd	7.97	53.1
6	4.20 ± 0.20	15.5 ± 1.78	14.5 ± 1.30	34.2	nd	9.58 ± 0.53	nd	9.58	43.8
7	13.4 ± 1.53	21.5 ± 2.15	10.5 ± 1.96	45.4	nd	9.97 ± 0.76	nd	9.97	55.4
8	24.1 ± 1.51	54.2 ± 3.75	112 ± 9.77	190	nd	6.07 ± 0.36	nd	6.07	196
9	19.4 ± 1.20	63.8 ± 3.99	71.4 ± 5.43	155	nd	5.55 ± 0.27	nd	5.55	160

nd: not detected.

Table 2
Concentrations (ng-Sn/g) of organotin species in sediments collected along the coast of Hsiao Liouciou Island.

Station No.	MBT	DBT	TBT	ΣBTs	MPT	DPT	TPT	ΣPhTs	ΣOTs
0	15.9 ± 1.90	4.68 ± 0.67	9.69 ± 0.44	30.3	nd	nd	nd	nd	30.3
1	20.4 ± 1.38	2.83 ± 1.00	5.65 ± 0.23	28.9	nd	nd	nd	nd	28.9
2	25.8 ± 1.88	3.22 ± 0.21	4.34 ± 0.13	33.4	nd	nd	nd	nd	33.4
3	36.3 ± 4.02	2.56 ± 0.12	5.33 ± 0.37	44.2	nd	nd	nd	nd	44.2
4	15.9 ± 0.96	2.44 ± 0.14	3.96 ± 0.84	22.3	nd	nd	nd	nd	22.3
5	30.0 ± 1.01	2.64 ± 0.11	4.22 ± 0.11	36.9	nd	nd	nd	nd	36.9
6	14.6 ± 0.87	2.90 ± 0.12	4.05 ± 0.14	21.6	nd	nd	nd	nd	21.6
7	13.3 ± 1.44	3.10 ± 0.66	4.02 ± 0.73	20.4	nd	nd	nd	nd	20.4
8	177 ± 19.2	151 ± 9.77	567 ± 19.6	895	nd	nd	nd	nd	895
9	56.4 ± 8.90	217 ± 21.1	765 ± 89.2	1038	nd	nd	nd	nd	1038

nd: not detected.

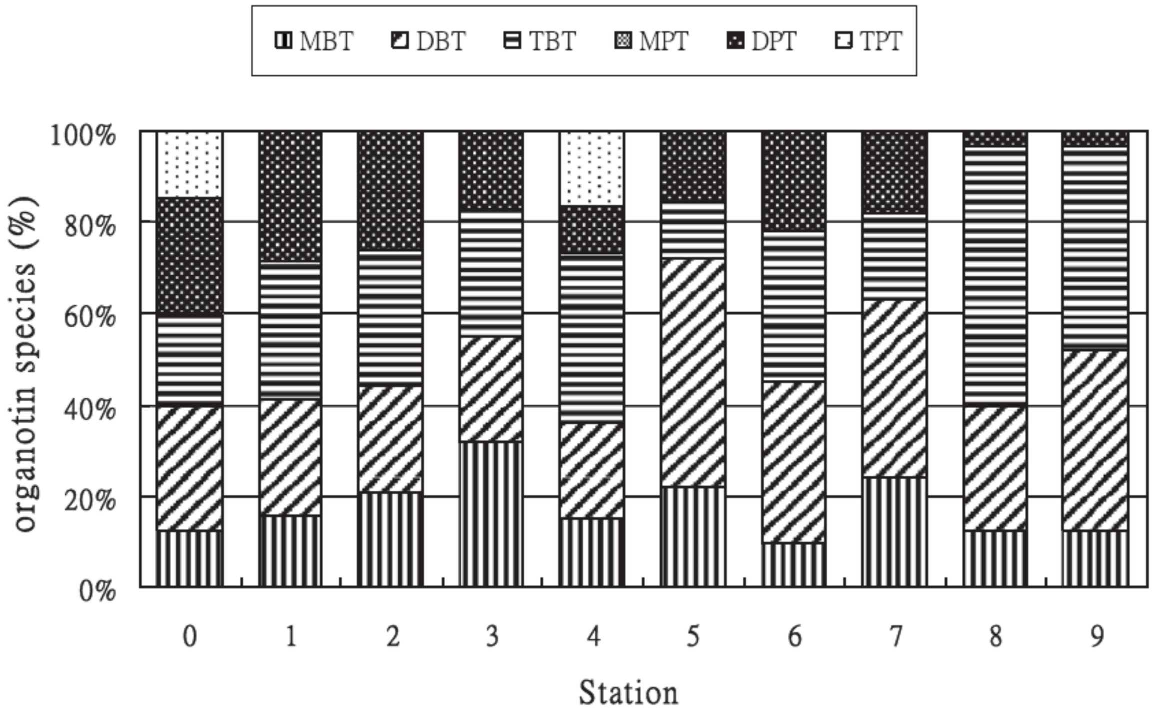

Fig. 2. Percentages of six organotin species (TBT, DBT, MBT, TPhT, DPhT and MPhT) in seawater along the coast of Hsiao Liouciou Island.

Table 3
Concentrations (ng-Sn/g) of organotin species in two barnacle species collected at cage mariculture areas along the coast of Hsiao Liouciou Island.

Species	MBT	DBT	TBT	ΣBTs	MPT	DPT	TPT	ΣPhTs	ΣOTs
Balanus sp.	49.0 ± 6.68	70.4 ± 7.72	238 ± 27.5	357	nd	nd	nd	nd	357
Lepas anserifera	42.5 ± 3.56	63.0 ± 7.80	230 ± 33.0	336	nd	nd	nd	nd	336

nd: not detected.

The impact of two oil spill events on the water quality along coastal area of Kenting National Park, southern Taiwan

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The impact of two oil spill events on the water quality along coastal area of Kenting National Park, southern Taiwan

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A B S T R A C T

In 2009, the container ship Colombo Queen and the oil tanker W-O BUDMO grounded off Jialeshui and Houwan, respectively, in southern Taiwan. Water quality was monitored at each site to evaluate the environmental impact caused by the resulting oil spills. The results show that the PAHs, turbidity, and other nutrients increased shortly after oil spill, however levels of these parameters eventually returned to baseline levels. On the other hand, DO saturation, pH and *chl. a* decreased initially, reached maxima after 10 days, and returned to the baseline levels after 14 days. The *chl. a* concentration, pH and DO saturation fluctuated in a similar pattern at both sites during the oil spills, likely driven by algal blooms. In this study, we documented a full environmental recovery at coastal areas before, during and after the oil spills.

Table 1

The results of QA analyses samples for all chemical parameters (temperature, salinity, pH, dissolved oxygen, nitrite, nitrate, phosphate, ammonium, chlorophyll-*a*, suspended solids and turbidity) investigated. MDL = minimum detection limit.

Chemical parameters	Unit	MDL	Precision (%)	Accuracy (%)
Temperature	°C	–	0.17	–
Salinity	psu	–	0.07	99.9
pH	–	–	0.04	–
Dissolved oxygen	mg/L	–	1.2	–
Nitrite	μM	0.03	0.9	100.9
Nitrate	μM	0.1	5.0	97.2
Phosphate	μM	0.06	4.5	96.9
Ammonium	μM	0.7	3.8	99.4
Silicate	μM	0.2	2.0	102.3
Chlorophyll-a	μg/L	–	8.3	111.8
Suspended solids	mg/L	–	5.8	–
Turbidity	NTU	–	1.6	–

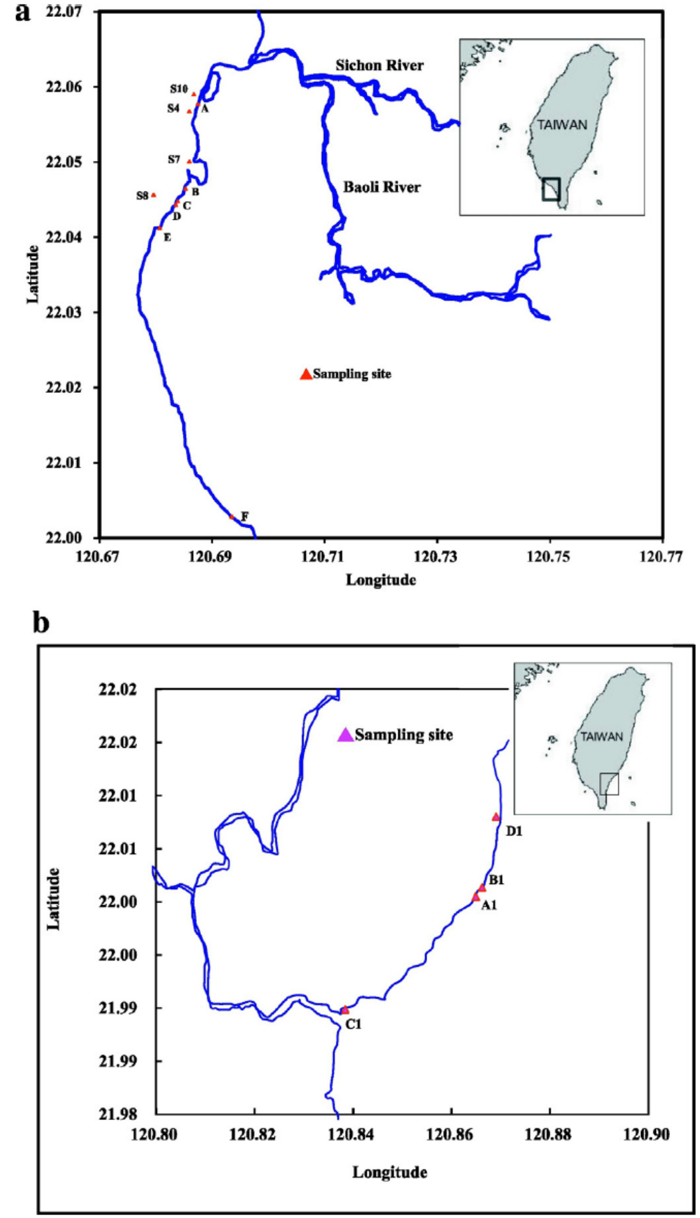


Fig. 1. a. Sampling sites at Houwan. The W-O BUDMO grounded off the coast between sites C and D. Before the oil spill: S4, S7, S8, S10. During and after the oil spill: A, B, C, D, E, and F. b. Sampling sites at Jialeshui. The Colombo Queen grounded off the coast between sites A1 and B1.

Table 2
Seawater quality means (±1 SD) at the different stations sampled along the coast of Houwan after the grounding of the German chemical tanker W-O BUDMO.

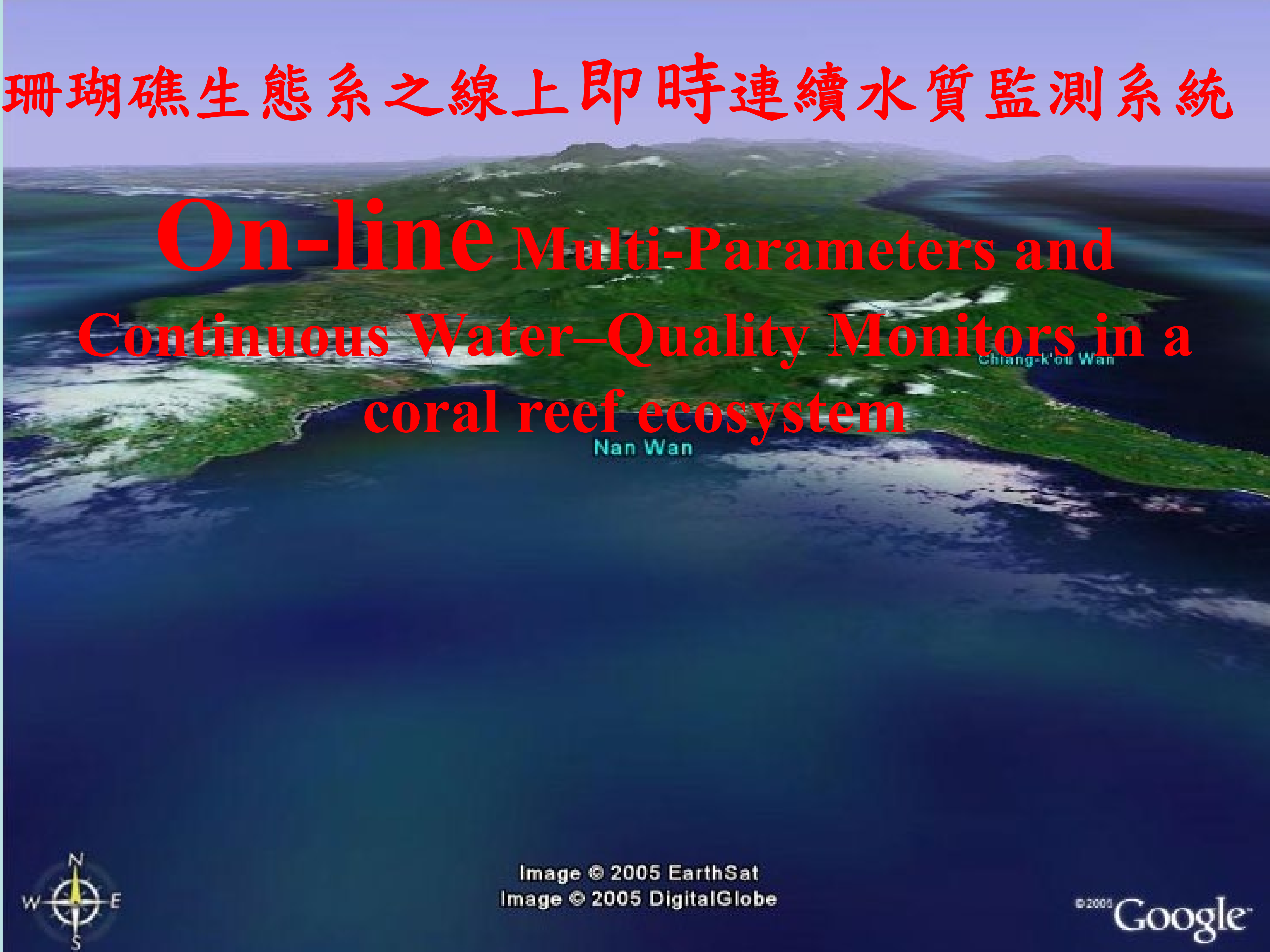
Station no.	Temp. (°C)	Salinity (psu)	pH	Dissolved oxygen (mg/L)	Oxygen saturation (%)	NO_3-N (μM)	NO_2-N (μM)	PO_4-P (μM)	$Si(OH)_4$-Si (μM)	NH_3-N (μM)	Turb. (ntu)	*Chl. a* (μg/L)
A	29.1 ± 1.1	32.16 ± 0.59	8.07 ± 0.12	6.64 ± 0.45	103.5 ± 8.1	1.38 ± 0.59	0.26 ± 0.14	0.33 ± 0.31	6.33 ± 2.68	1.81 ± 0.72	18.7 ± 27.2	1.80 ± 3.36
B	29.2 ± 1.4	31.83 ± 0.67	8.09 ± 0.15	7.18 ± 1.30	112.0 ± 22.5	1.33 ± 0.91	0.80 ± 1.39	0.27 ± 0.26	7.00 ± 3.31	6.05 ± 3.34	18.0 ± 27.4	1.75 ± 2.41
C	29.3 ± 1.5	31.67 ± 0.55	8.04 ± 0.18	6.85 ± 1.22	106.9 ± 21.3	1.09 ± 0.39	0.27 ± 0.07	0.22 ± 0.10	8.99 ± 3.28	21.5 ± 24.3	34.7 ± 65.0	2.00 ± 4.64
D	28.9 ± 1.2	31.04 ± 1.12	7.95 ± 0.20	5.72 ± 1.17	88.2 ± 18.7	2.72 ± 1.79	0.30 ± 0.06	0.27 ± 0.26	14.0 ± 9.10	7.33 ± 5.41	53.5 ± 107	1.39 ± 2.67
E	29.5 ± 0.7	31.75 ± 0.65	8.05 ± 0.13	6.98 ± 0.96	109.2 ± 16.0	2.24 ± 1.24	0.25 ± 0.07	0.25 ± 0.18	7.58 ± 3.42	10.5 ± 23.0	8.58 ± 9.75	1.71 ± 3.37
F	29.7 ± 1.4	31.67 ± 0.76	8.02 ± 0.07	6.43 ± 0.20	100.7 ± 3.8	2.55 ± 1.20	0.28 ± 0.08	0.22 ± 0.12	7.94 ± 3.06	2.51 ± 1.22	9.71 ± 14.7	0.84 ± 0.67

Table 3
Seawater quality means (±1 SD) from Feb. 2009–Jun. 2009 surveyed along the coast of Houwan before the W-O BUDMO oil spills event.

Station no.	Temp. (°C)	Salinity (psu)	pH	Dissolved oxygen (mg/L)	Oxygen saturation (%)	NO_3-N (μM)	NO_2-N (μM)	PO_4-P (μM)	$Si(OH)_4$-Si (μM)	NH_3-N (μM)	Turb. (ntu)	*Chl. a* (μg/L)
S10	26.9 ± 2.0	33.47 ± 1.03	8.22 ± 0.16	6.45 ± 0.42	97.5 ± 9.3	6.49 ± 1.64	0.21 ± 0.17	0.15 ± 0.10	5.35 ± 0.17	1.89 ± 1.71	0.40 ± 0.10	0.48 ± 0.44
S4	26.9 ± 2.0	32.90 ± 1.61	8.30 ± 0.09	6.56 ± 0.48	99.0 ± 10.5	3.68 ± 2.41	0.20 ± 0.17	0.41 ± 0.08	2.28 ± 0.43	1.14 ± 1.80	0.53 ± 0.06	0.72 ± 0.65
S7	26.8 ± 2.2	32.90 ± 1.61	8.26 ± 0.07	6.32 ± 0.45	95.2 ± 10.2	5.78 ± 1.96	0.24 ± 0.07	0.54 ± 0.35	4.30 ± 1.31	0.24 ± 0.04	0.50 ± 0.10	0.12 ± 0.01
S8-S	26.9 ± 2.1	33.07 ± 1.05	8.22 ± 0.02	6.47 ± 0.42	97.8 ± 9.8	6.87 ± 1.18	0.08 ± 0.12	0.30 ± 0.05	4.01 ± 1.77	0.28 ± 0.25	0.30 ± 0.10	0.12 ± 0.01
S8-B	25.8 ± 2.1	33.17 ± 1.05	8.22 ± 0.04	6.43 ± 0.37	95.3 ± 8.7	8.79 ± 3.56	0.10 ± 0.09	0.20 ± 0.06	5.01 ± 3.03	0.54 ± 0.74	0.33 ± 0.06	0.11 ± 0.01

珊瑚礁生態系之線上即時連續水質監測系統

On-line Multi-Parameters and Continuous Water–Quality Monitors in a coral reef ecosystem



A continuous, real-time water quality monitoring system for the coral reef ecosystems of Nanwan Bay, Southern Taiwan

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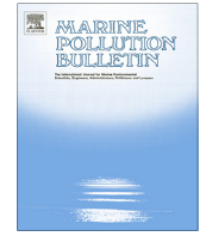

A continuous, real-time water quality monitoring system for the coral reef ecosystems of Nanwan Bay, Southern Taiwan

Kwee Siong Tew [a,b], Ming-Yih Leu [a,b], Jih-Terng Wang [c], Chia-Ming Chang [a], Chung-Chi Chen [d,*], Pei-Jie Meng [a,b,*]

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ABSTRACT

The coral reef ecosystems of Nanwan Bay, Southern Taiwan are undergoing degradation due to anthropogenic impacts, and as such have resulted in a decline in coral cover. As a first step in preventing the continual degradation of these coral reef environments, it is important to understand how changes in water quality affect these ecosystems on a fine-tuned timescale. To this end, a real-time water quality monitoring system was implemented in Nanwan Bay in 2010. We found that natural events, such as cold water intrusion due to upwelling, tended to elicit temporal shifts in coral spawning between 2010 and 2011. In addition, Degree Heating Weeks (DHWs), a commonly utilized predictor of coral bleaching, were 0.92 and 0.59 in summer 2010 and 2011, respectively. Though this quantity of DHW was below the presumed stress-inducing value for these reefs, a rise in DHWs in the future may stress the resident corals.

Table 1
The specifications for precision and accuracy of all measured parameters.

Sensor	Accuracy (%)	Precision (%)
Temperature	99.9	0.8
Salinity	99.9	0.18
pH	99.9	0.43
Dissolved oxygen	100.4	4.55
Turbidity	100.3	6.12

Salinity: IAPSO STANDARD SEAWATER (Batch: P152, 34.993 psu).
pH: Merck Buffer pH4, pH 7, pH 10 and traceable to Standard Reference Material (SRM) from NIST and PTB.
Dissolved Oxygen: Air saturation.
Turbidity: HACH Formazin Turbidity Standard- 4000 NTU.

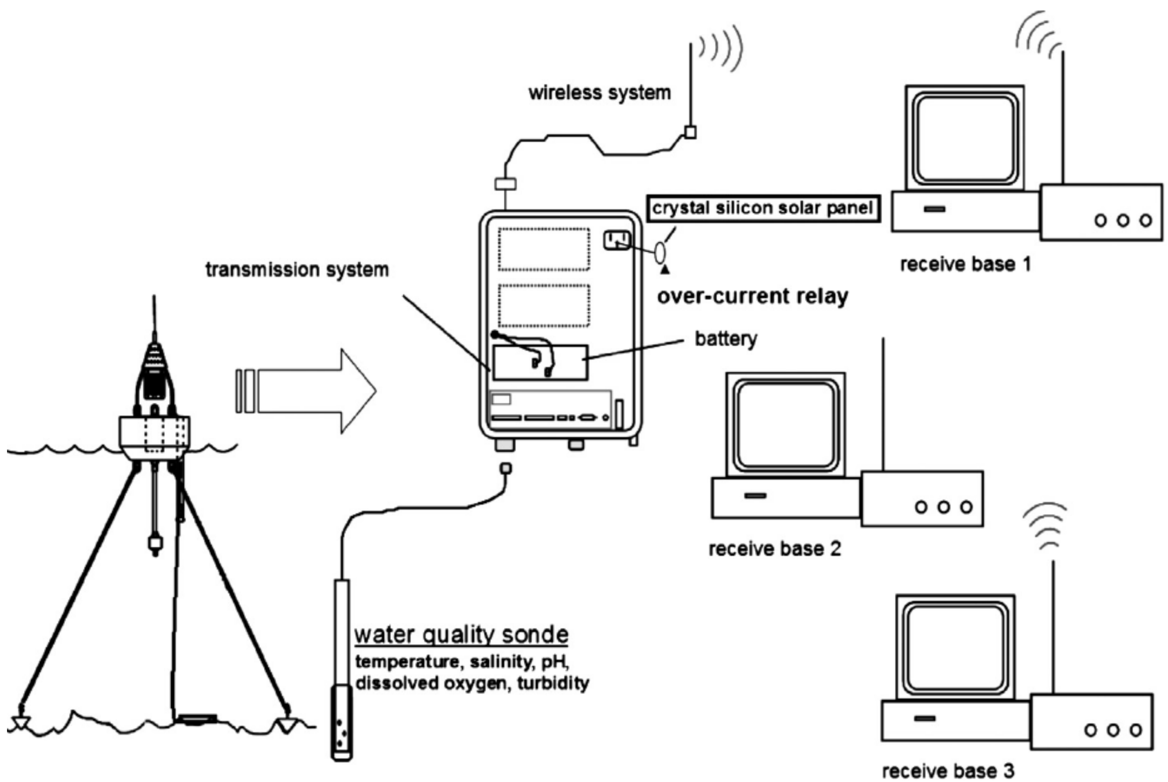

Fig. 1. A schematic of the online, real-time seawater quality monitoring system.

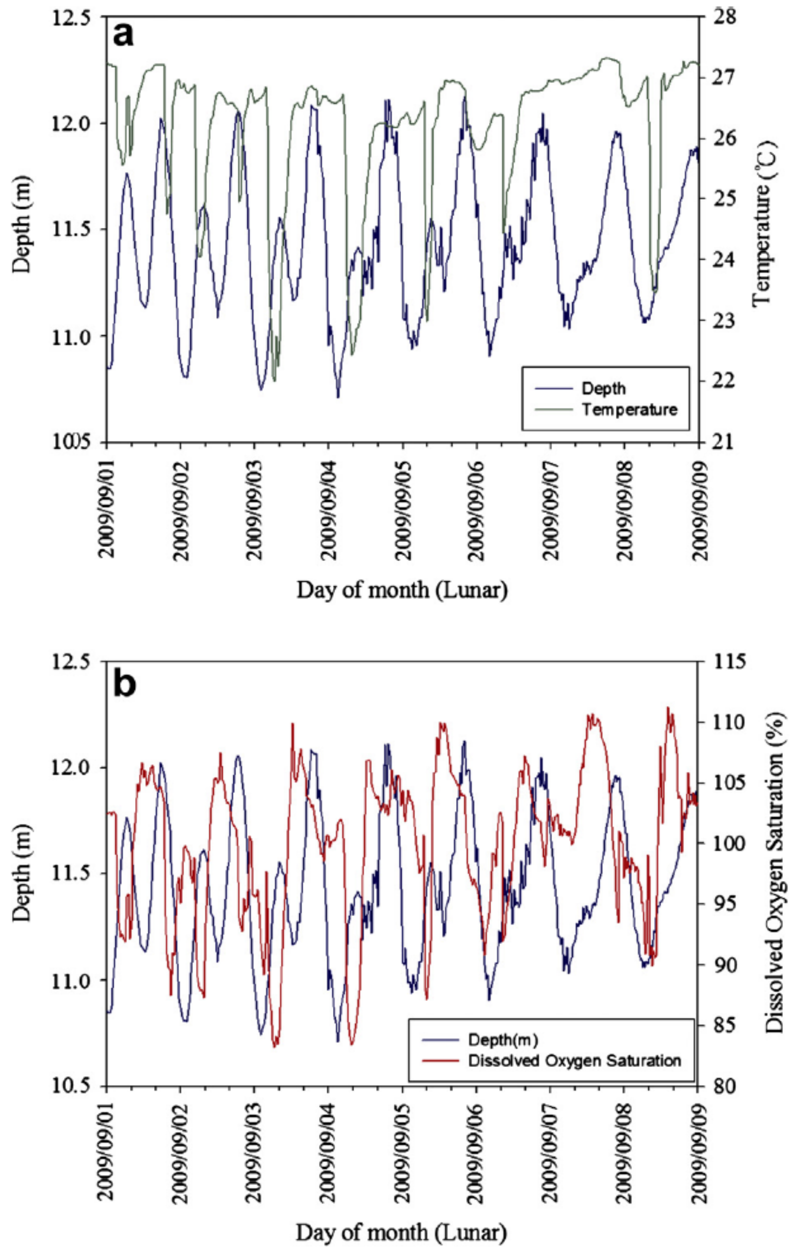

Fig. 4. Temperature and dissolved oxygen concentration changes across a tidal cycle in September 2009 in the coral reef ecosystems of Nanwan Bay, Southern Taiwan.

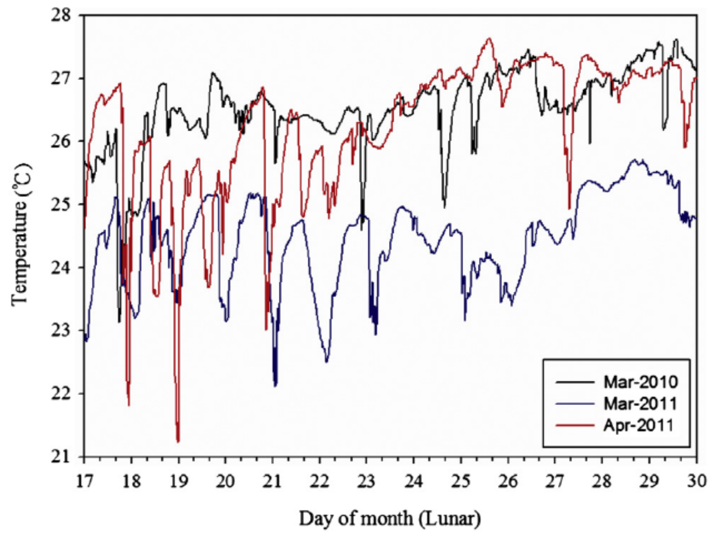

Fig. 5. Days before and after the coral spawning period in 2010 and 2011 in the coral reef ecosystems of Nanwan Bay, Southern Taiwan.

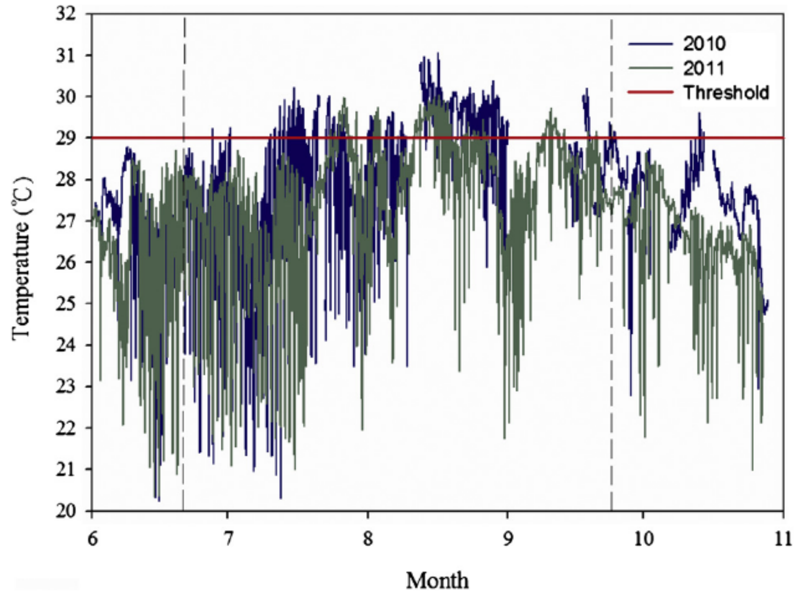

Fig. 6. Temperature logged between June and October in 2010 and 2011. The bleaching threshold temperature has been shown to be at 29 °C. Vertical lines indicate the summer period.

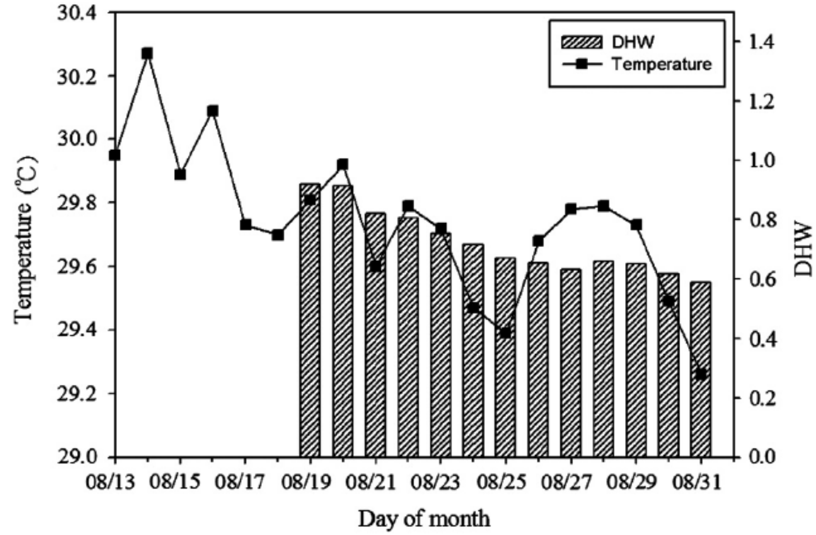

Fig. 7. Degree Heating Weeks (DHWs) ranging from 0.59 and 0.92 within the summer periods of 2010 and 2011, respectively, in the coral reef ecosystems of Nanwan Bay, Southern Taiwan.

Table 2
The stress levels defined are based on current values of the coral bleaching hotspot and Degree Heating Weeks (DHW).

Stress level	Definition	Effect
No stress	HotSpot ≦ 0	No bleaching
Bleaching watch	0 < HotSpot < 1	
Bleaching warning	1 ≦ HotSpot, 0 < DHW < 4	Possible bleaching
Bleaching alert level 1	1 ≦ HotSpot, 4 ≦ DHW < 8	Bleaching likely
Bleaching alert level 2	1 ≦ HotSpot, 8 ≦ DHW	Mortality likely

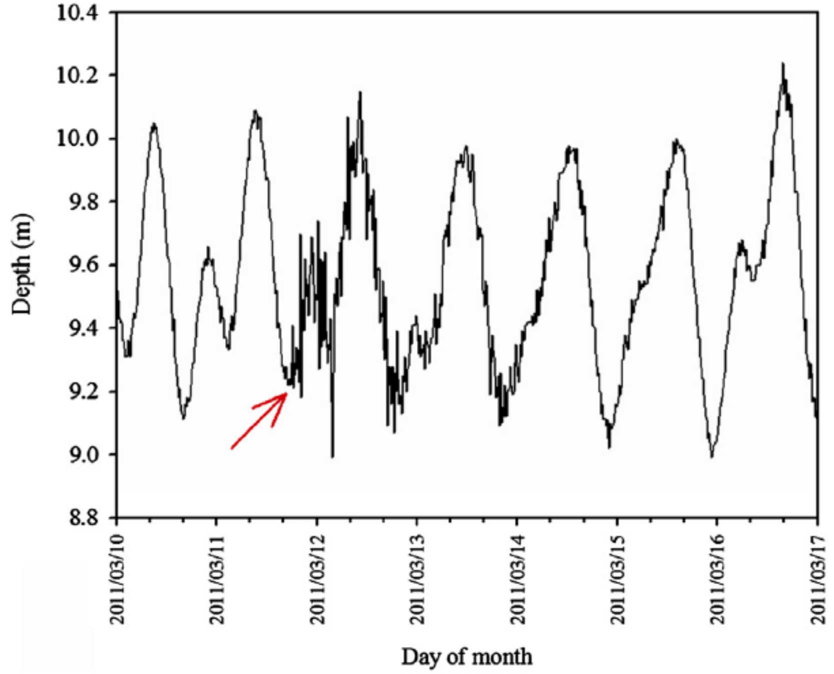

Fig. 9. The abnormal sea-level induced by the Tohoku earthquake and the associated tsunami on March 11, 2011 in the coral reef ecosystems of Nanwan Bay, Southern Taiwan.

交通部觀光局 大鵬灣國家風景區管理處

「大鵬灣域水質環境資料長期即時監測」

卡爾森指數(CTSI) = 〔TSI(SD)+TSI(Chl)+TSI(TP)〕/3

$TSI(SD) = 60 - 14.41 \times \ln SD$

$TSI(Chl\text{-}a) = 9.81 \times \ln Chl\text{-}a + 30.6$

$TSI(TP) = 14.42 \times \ln TP + 4.15$

式中：

SD = 透明度(m)

Chl-a = 葉綠素a濃度(μg/L)

TP = 總磷濃度(μg/L)

CTSI	Chl	P	SD	Trophic Class
< 30—40	0—2.6	0—12	> 8—4	Oligotrophic
40—50	2.6—20	12—24	4—2	Mesotrophic
50—70	20—56	24—96	2—0.5	Eutrophic
70—100+	56—155+	96—384+	0.5— < 0.25	Hypereutrophic

Table 3. Water quality criteria for index score and conversion table of RTSI and CTSI

Trophic Class	Ranks			
	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Dissolved oxygen saturation	DO(%)≤ 114 %	114<DO(%) ≤116 %	116 <DO(%)≤ 129 %	DO(%)> 129 %
pH	pH≤ 8.29	8.29<pH ≤ 8.30	8.30 <pH ≤ 8.41	pH> 8.41
index Scores (Si)	1	3	5	7
RTSI value	RTSI≤ 2	2 < RTSI≤ 4	4 < RTSI ≤ 6	RTSI> 6

	Ranks			
	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
RTSI	≤ 2	>2 ~ ≤4	>4 ~ ≤6	> 6
CTSI	>30 ~ 40	>40 ~ ≤50	>50 ~ ≤70	>70

$RTSI = (S_1+S_2)/2$
S_1: pH index Score
S_2: Dissolved oxygen saturation index Score

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ORIGINAL RESEARCH
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Developing a Real-Time Trophic State Index of a Seawater Lagoon: A Case Study From Dapeng Bay, Southern Taiwan

Chung-Chi Chen[1,2†], Jih-Terng Wang[3†], Chih-Yen Huang[4], Hung-Yen Hsieh[4], Kwee Siong Tew[4,5,6] and Pei-Jie Meng[4,5*]*

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Algal blooms over the past years have caused considerable worldwide impacts on marine ecology, aquaculture, recreational activities, and human health. Therefore, there is an urgent need to develop indices for evaluating the nutritional status of seawater as a means of predicting algal blooms. A long-term water quality monitoring dataset from Dapeng Bay, Southern Taiwan, indicated that seawater dissolved oxygen (DO) concentrations and pH were significantly correlated with algal abundance. Using this dataset, we then developed a real-time trophic state index (RTSI) by (1) referring to the seawater nutrient grading system defined by Carlson's index and (2) incorporating an algorithm based on the relationship between DO, pH, and eutrophication status. The RTSI was superior to contemporary indices in its simplicity, as no complicated nutrient or chlorophyll *a* (Chl *a*) measurements were required, and real-time data were displayed on a personal computer. The index is sensitive to changes in seawater quality that will be of aid to managers.

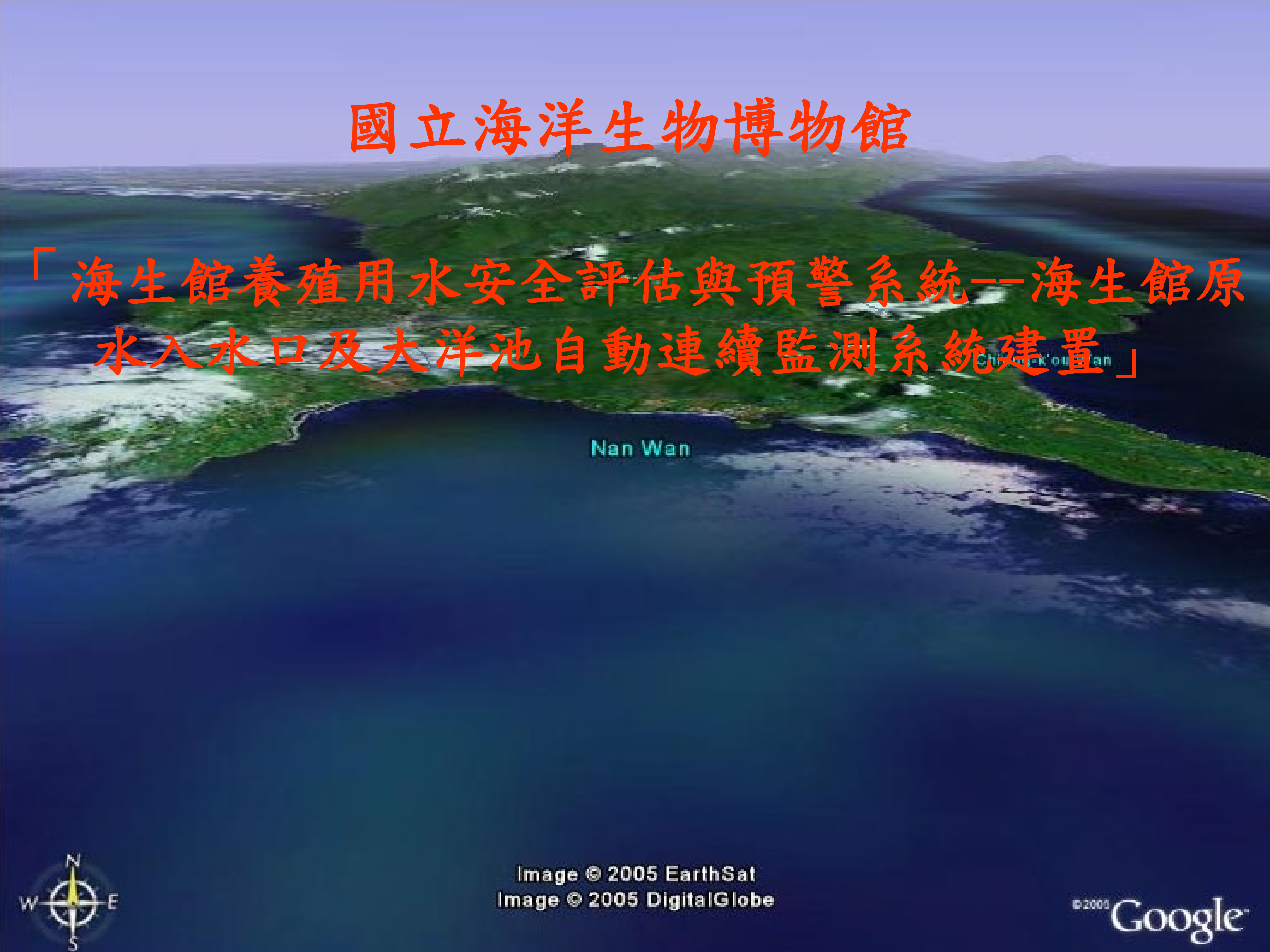
Keywords: algal bloom, nutrients, trophic state index, water quality, Taiwan

INTRODUCTION

Lagoons are semi-enclosed seawater environments that are generally located between landmasses and sandy beaches (Boynton et al., 1996), thereby serving as a transition zone between land and sea (Tew et al., 2008). The calm and oftentimes nutrient-rich waters of a lagoon make for ideal nursery conditions for a wide variety of commercially important fish and invertebrates (Tew et al., 2008, 2010, 2014; Hsieh et al., 2010) and display a rich ecosystem (Araujo et al., 2015). Given the poor water exchange of lagoons, they are highly sensitive to exogenous inputs (Tew et al., 2010), especially nutrients (Pinckney et al., 2001; Hsieh et al., 2010; Tew et al., 2010, 2014). Nutrient influx results in eutrophication, which can stimulate primary production

國立海洋生物博物館

「海生館養殖用水安全評估與預警系統--海生館原水入水口及大洋池自動連續監測系統建置」



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國立海洋生物博物館 水質監測系統

QBox

原水入口	
2019-04-17 16:15	
溫度 (°C)	27.43
比導電度 (mS/cm)	0.05
鹽度 (ppt)	0.02
溶氧飽和度 (%)	106.82
溶氧量 (mg/L)	8.45
酸鹼度 (pH)	8.22
ORP (mV)	308.53
深度 (m)	0.41
濁度 (NTU)	1.03
葉綠素 (µg/L)	0
藍綠藻PE (µg/L)	0.07
系統電壓 (V)	13.59
EXO電壓 (V)	5.8

大洋池	
2019-04-17 16:15	
溫度 (°C)	27.39
比導電度 (mS/cm)	52.61
鹽度 (ppt)	34.6
溶氧飽和度 (%)	94.69
溶氧量 (mg/L)	6.18
酸鹼度 (pH)	7.51
ORP (mV)	228.3
濁度 (NTU)	0.04
葉綠素 (µg/L)	0.23
藍綠藻PE (µg/L)	1.93
系統電壓 (V)	0
EXO電壓 (V)	5.51

系統管理員 admin | 登出

大洋池

搜尋日期 2019-04-14 依 日期時間 排序 Go   輸出 CSV 讀取原始檔

日期時間	溫度 (°C)	比導電度 (mS/cm)	鹽度 (ppt)	溶氧飽和度 (%)	溶氧量 (mg/L)	酸鹼度 (pH)	ORP (mV)	濁度 (NTU)	葉綠素 (μg/L)	藍綠藻PE (μg/L)	系統電壓 (V)	EXO電壓 (V)
2019-04-14 00:00:00	27.1	52.67	34.65	94.44	6.19	7.53	227.21	0.02	0.21	1.78	0	5.39
2019-04-14 00:15:00	27.11	52.67	34.65	95.09	6.23	7.53	227.88	0.02	0.3	1.92	0	5.39
2019-04-14 00:30:00	27.11	52.68	34.66	94.99	6.22	7.52	228.81	0	0.11	1.97	0	5.39
2019-04-14 00:45:00	27.11	52.67	34.65	95.38	6.25	7.52	229.53	0.08	0.18	2.31	0	5.37
2019-04-14 01:00:00	27.11	52.67	34.65	94.98	6.22	7.55	227.24	0.02	0.06	2.28	0.01	5.39
2019-04-14 01:15:00	27.11	52.66	34.65	95.38	6.25	7.54	227.74	0.06	0.25	1.72	0.01	5.37
2019-04-14 01:30:00	27.12	52.67	34.65	95.35	6.24	7.53	228.77	0.03	0.13	2.23	0	5.38
2019-04-14 01:45:00	27.12	52.69	34.67	95.82	6.27	7.54	229.07	0.01	0.11	1.86	0.01	5.39
2019-04-14 02:00:00	27.12	52.68	34.66	95.86	6.28	7.52	230.05	0.05	0.33	2.02	0	5.38
2019-04-14 02:15:00	27.13	52.67	34.65	95.51	6.25	7.51	230.4	0.05	0.24	1.9	0	5.39
2019-04-14 02:30:00	27.13	52.67	34.65	96.06	6.29	7.55	228.81	0.05	0.13	1.98	0	5.38
2019-04-14 02:45:00	27.13	52.66	34.64	96.04	6.29	7.55	229.01	0.03	0.28	1.62	0	5.38
2019-04-14 03:00:00	27.13	52.67	34.65	95.78	6.27	7.53	229.91	0.11	0.15	1.94	0	5.38
2019-04-14 03:15:00	27.14	52.68	34.66	96.22	6.3	7.53	230.75	0.03	0.2	1.66	0	5.38
2019-04-14 03:30:00	27.14	52.67	34.65	95.82	6.27	7.52	231.6	0.08	0.25	1.57	0	5.37
2019-04-14 03:45:00	27.14	52.65	34.63	96.06	6.29	7.56	229.43	0.1	0.24	1.69	0	5.37
2019-04-14 04:00:00	27.14	52.67	34.65	96.32	6.3	7.55	229.64	0.17	0.21	2.27	0	5.37
2019-04-14 04:15:00	27.15	52.61	34.61	96.31	6.3	7.55	230.37	0.05	0.53	2.09	0	5.38
2019-04-14 04:30:00	27.15	52.65	34.64	96.57	6.32	7.54	230.91	0.07	0.03	2.24	0	5.37
2019-04-14 04:45:00	27.16	52.65	34.63	96.56	6.32	7.55	230.26	0.11	0.17	2.23	0.01	5.36
2019-04-14 05:00:00	27.16	52.67	34.65	96.48	6.31	7.53	232.17	0.12	0.17	1.77	0	5.37
2019-04-14 05:15:00	27.16	52.65	34.64	96.4	6.31	7.56	229.68	0.17	0.22	1.75	0	5.37

戶外水體溶氧飽和度日夜變化

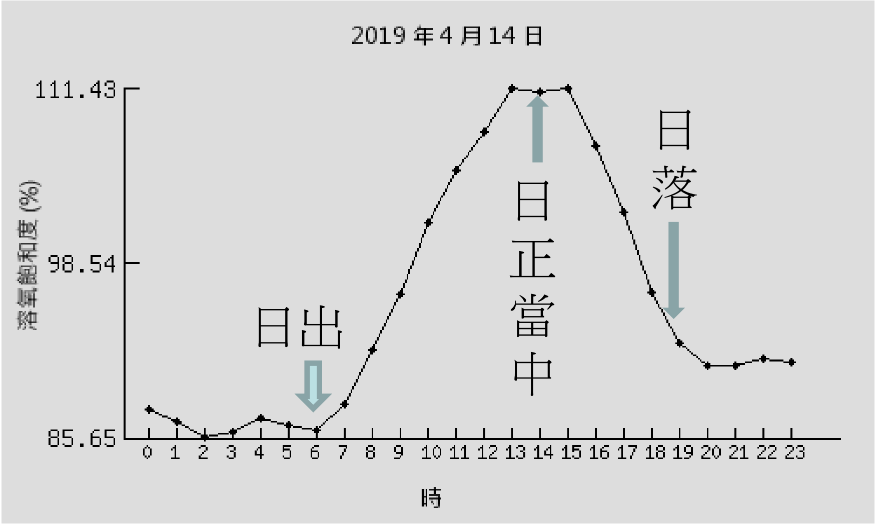
原水入口

首頁 | 資料列表 | 衛星定位 | 統計圖表 | 展示圖片 | 警報通知 | 系統設定 | 系統資訊

日報表 | 月報表 | 年報表 | 趨勢分析圖 | 圖表配置

2019 年 4 月 14 日 溶氧飽和度 (%) Go

時間	監測(平均)值	時間	監測(平均)值
0	87.71	12	108.24
1	86.79	13	111.38
2	85.65	14	111.18
3	85.99	15	111.43
4	87.02	16	107.12
5	86.61	17	102.24
6	86.17	18	96.29
7	88.11	19	92.64
8	92.04	20	90.89
9	96.24	21	90.88
10	101.49	22	91.46
11	105.33	23	91.25
最大值		111.43	
最小值		85.65	
平均值		95.59	



縱軸最低 85.65 最高 111.43 Go

室內缸體溶氧飽和度與生物行為之關係

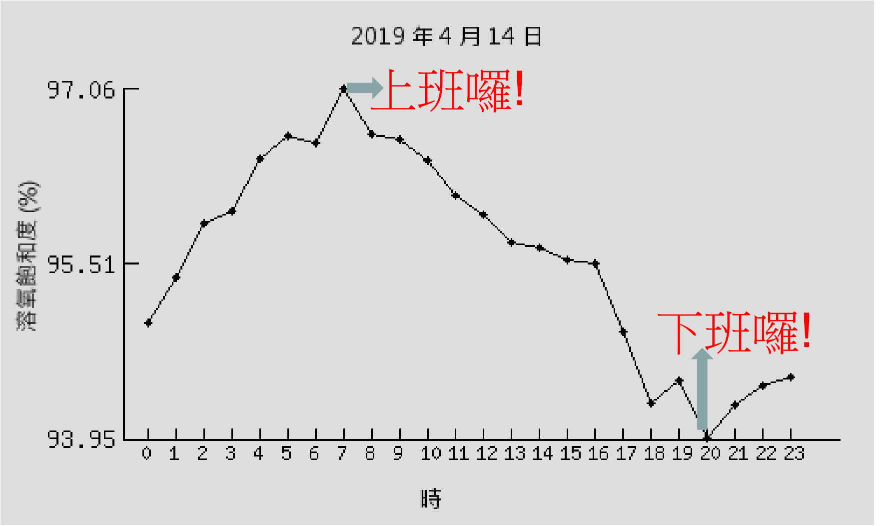
大洋池

首頁 | 資料列表 | 衛星定位 | 統計圖表 | 展示圖片 | 警報通知 | 系統設定 | 系統資訊

日報表 | 月報表 | 年報表 | 趨勢分析圖 | 圖表配置

2019 年 4 月 14 日 溶氧飽和度 (%) Go

時間	監測(平均)值	時間	監測(平均)值
0	94.98	12	95.94
1	95.38	13	95.69
2	95.87	14	95.65
3	95.97	15	95.54
4	96.44	16	95.51
5	96.64	17	94.9
6	96.58	18	94.26
7	97.06	19	94.47
8	96.65	20	93.95
9	96.61	21	94.24
10	96.42	22	94.41
11	96.11	23	94.49
最大值		97.06	
最小值		93.95	
平均值		95.57	



縱軸最低 93.95 最高 97.06 Go

 系統管理員 admin | 登出

Time is up!

現在時間 17:02 休息一下

After a busy day, relax for a while.

謝謝大家

Thank you for your attention

敬請指教！