LIST OF ANNEXES

EXHIBITS

CHINESE GOVERNMENT DOCUMENTS

CHINESE GOVERNMENT DOCUMENTS (TAIWAN AUTHORITIES)

Annex 873	*Communication* from the Ministry of the Interior of the Republic of China (Navy Command Headquarters) to the Ministry of Foreign Affairs of the Republic of China (8 May 1950), reprinted in *Archival Compilation on South China Sea Islands by Ministry of Foreign Affairs*, Vol. 2, Doc. No. III(2):013 (Republic of China Ministry of Foreign Affairs Research & Planning Committee, ed.) (1995)
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Annex 875	Ministry of Foreign Affairs of the Republic of China (Taiwan), "Taiping Island is an island, not a rock, and the ROC possesses full rights associated with an exclusive economic zone and continental shelf in accordance with UNCLOS" (23 Jan. 2016)
Annex 876	Office of the President of the Taiwan Authority of China, "Remarks by President Ma on Taiping Island", (28 Jan. 2016), *available at* http://english.president.gov.tw/Default.aspx?tabid=491&itemid=36616&rmid=2355 (accessed 9 Mar. 2016)
Annex 877	Ministry of Foreign Affairs of the Republic of China (Taiwan), "Taiping Island Survey", YouTube Video (28 Jan. 2016), *available at* https://www.youtube.com/watch?v=Ne8gmN-496o&feature=youtu.be (accessed 8 Mar. 2016)

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Annex 879	Dr. Peter P. Motavalli, *Expert Report on Soil Resources and Potential Self-Sustaining Agricultural Production on Itu Aba* (9 Mar. 2016)

ACADEMIC ARTICLES

Annex 880	Kuan-Hsiung Wang, "The ROC's Maritime Claims and Practices with Special Reference to the South China Sea", *Ocean Development & International Law*, Vol. 41, No. 3 (2010)
Annex 881	Yann-huei Song, "The Application of Article 121(3) of the Law of the Sea Convention to the Five Selected Disputed Islands in the South China Sea", *Chinese (Taiwan) Yearbook of International Law and Affair*, Vol. 27 (2009)

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Annex 884	J. L. Deenik & R.S. Yost, “Chemical properties of atoll soils in the Marshall Islands and constraints to crop production”, *Geoderma*, Vol. 136 (2006)
Annex 885	Lianzhi Xi, “Summary of Land of Guangdong Nansha Islands”, *Soil Quarterly*, Vol. 6, No. 3 (1947)

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Annex 888	Oliver Milman, “Government bans dumping from new dredging projects into the Great Barrier Reef”, *The Guardian* (17 May 2015)

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Marine Industry Standards of the People's Republic of China

HY/T 087—2005

The Guidance for the Assessment of Coastal Marine Ecosystem Health

[…]

1 Scope

These standards stipulate the indicators, methods, and requirements for evaluation of the health of coastal marine ecosystems.

These standards are applicable to the evaluation of the health of ecosystems in domestic and territorial seas of the People's Republic of China, as well as ecosystems in coral reefs, mangroves, seagrass beds, estuaries, and bays under the jurisdiction of the People's Republic of China.

[…]

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[…]

2. Marine Biodiversity and Ecological Conditions

Source: State Oceanic Administration Website Updated on: 04-01-2013

[…]

[…]

2.2.4 Coral reef ecosystem

The coral reef ecosystem has abundant biodiversity and very high productive levels; at the same time, it is an important ecotourism resource. In 2012, the southwest coast of Leizhou Peninsula and Beihai of Guangxi have healthy coral reef ecosystems; the eastern coast of Hainan Island and the Xisha Islands have healthy coral reef ecosystems.

The coverage of hermatypic coral on the eastern coast of Hainan Island and Xisha Islands are at lower levels, with lower supplemental quantity of hard coral; some monitored areas showed damage to coral by predators such as crown-of-thorns starfish and purple drupe.

[…]

2 海洋生物多样性与生态状况

来源：国家海洋局网站　　更新时间：2013-04-01　　打印本页　关闭窗口

2.1 海洋生物多样性

2012年春、夏季，以典型海洋生态系统和关键生态区域为重点，在我国管辖海域994个站位开展了海洋生物多样性状况监测，监测内容包括浮游生物、底栖生物、海草、红树植物、珊瑚等生物的种类组成和数量分布。共鉴定出浮游植物636种，浮游动物704种，大型底栖生物1 087种，海草7种，红树植物10种，造礁珊瑚68种。浮游生物和底栖生物的物种数和生物多样性指数从北至南呈增加趋势，符合其自然分布规律。

渤海区域鉴定出浮游植物182种，主要类群为硅藻和甲藻；鉴定出浮游动物77种，主要类群为桡足类和水母类；鉴定出大型底栖生物343种，主要类群为环节动物、软体动物和节肢动物。2008年以来，渤海湾和莱州湾海域浮游动物多样性指数呈上升趋势，滦河口-北戴河海域底栖生物多样性指数呈下降趋势，黄河口和莱州湾海域底栖生物多样性指数呈上升趋势。

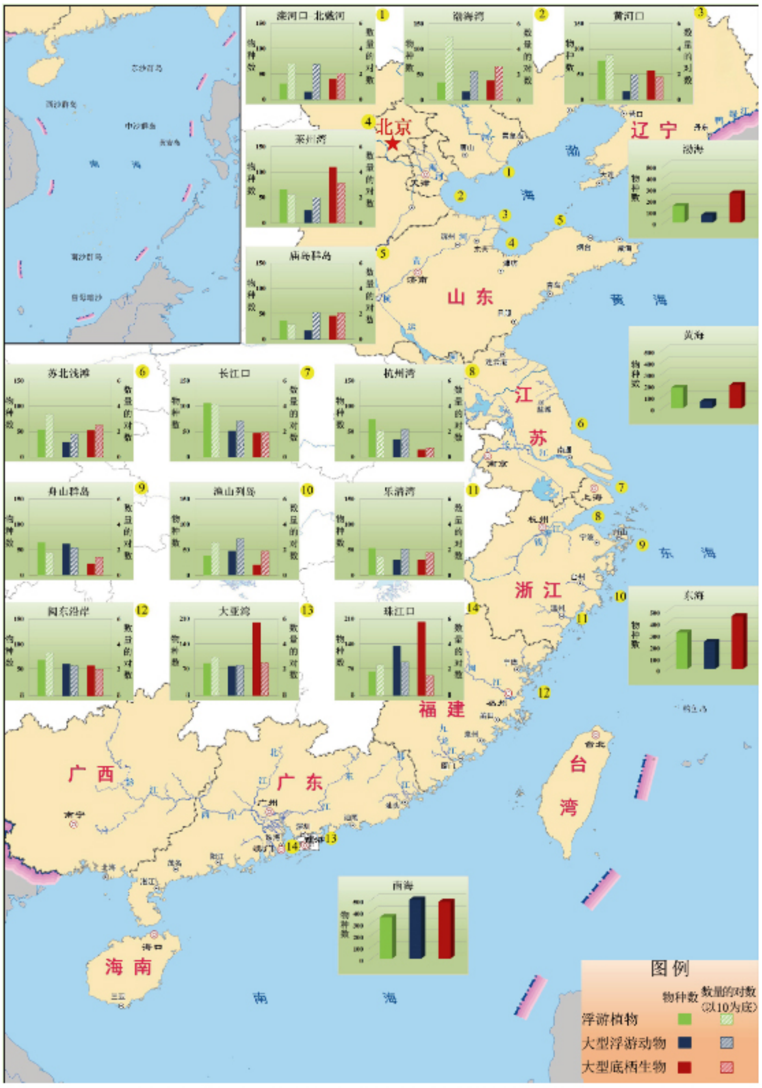
黄海区域鉴定出浮游植物214种，主要类群为硅藻和甲藻；鉴定出浮游动物66种，主要类群为桡足类和水母类；鉴定出大型底栖生物250种，主要类群为环节动物、软体动物和节肢动物。2008年以来，苏北浅滩海域浮游生物和底栖生物多样性指数均呈下降趋势。

东海区域鉴定出浮游植物336种，主要类群为硅藻和甲藻；鉴定出浮游动物237种，主要类群为桡足类和水母类；鉴定出大型底栖生物459种，主要类群为环节动物、软体动物和节肢动物。2008年以来，长江口海域浮游植物多样性指数呈下降趋势，长江口和闽东沿岸海域浮游动物多样性指数呈下降趋势，乐清湾海域浮游动物多样性指数呈上升趋势。

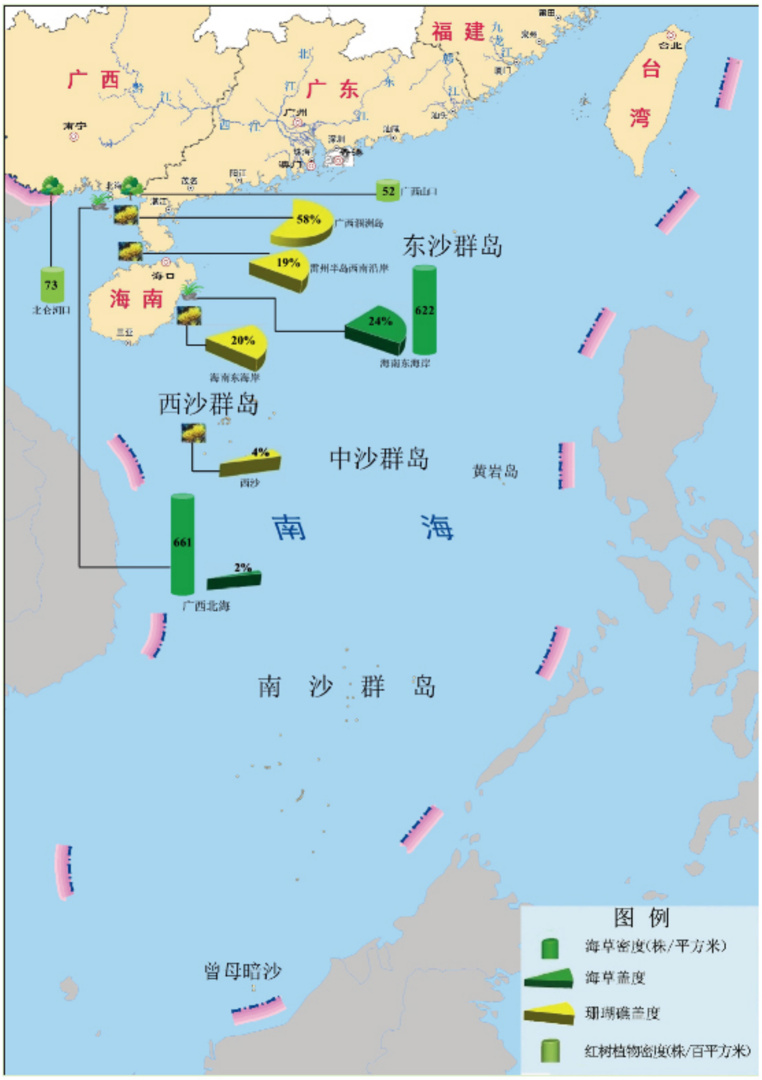
南海区域鉴定出浮游植物438种，主要类群为硅藻和甲藻；鉴定出浮游动物586种，主要类群为桡足类和水母类；鉴定出大型底栖生物587种，主要类群为软体动物、节肢动物和脊索动物；鉴定出海草7种，红树植物10种，造礁珊瑚68种。2008年以来，珠江口和大亚湾海域浮游植物多样性指数均呈上升趋势，浮游动物多样性指数均呈下降趋势，珠江口海域底栖生物多样性指数呈下降趋势，大亚湾海域底栖生物多样性指数呈上升趋势。

夏季重点监测区域浮游生物和大型底栖生物物种数、数量、多样性指数及主要优势种

监测区域	浮游植物					大型浮游动物					大型底栖生物				
	物种数（种）	数量（×10^{4}个细胞/立方米）	多样性指数及趋势		主要优势种	物种数（种）	数量（个/立方米）	多样性指数及趋势		主要优势种	物种数（种）	数量（个/平方米）	多样性指数及趋势		主要优势种
			指数	变化趋势				指数	变化趋势				指数	变化趋势	
滦河口-北戴河	31	656	2.06	↔	洛氏角毛藻 旋链角毛藻	15	573	1.57	↔	强壮箭虫 小拟哲水蚤	40	112	1.58	↘	豆形短眼蟹 长吻沙蚕
黄河口	77	3 526	2.67	↔	中肋骨条藻 旋链角毛藻	17	97	1.28	↔	强壮箭虫 背针胸刺水蚤	58	62.5	2.09	↗	江户明樱蛤 曲强真节虫
长江口	106	14 239	1.25	↘	中肋骨条藻 尖刺菱形藻	51	691	2.04	↘	背针胸刺水蚤 太平洋纺锤水蚤	47	90	1.30	↔	丝异须虫



夏季重点监测区域浮游生物和大型底栖生物物种数和数量



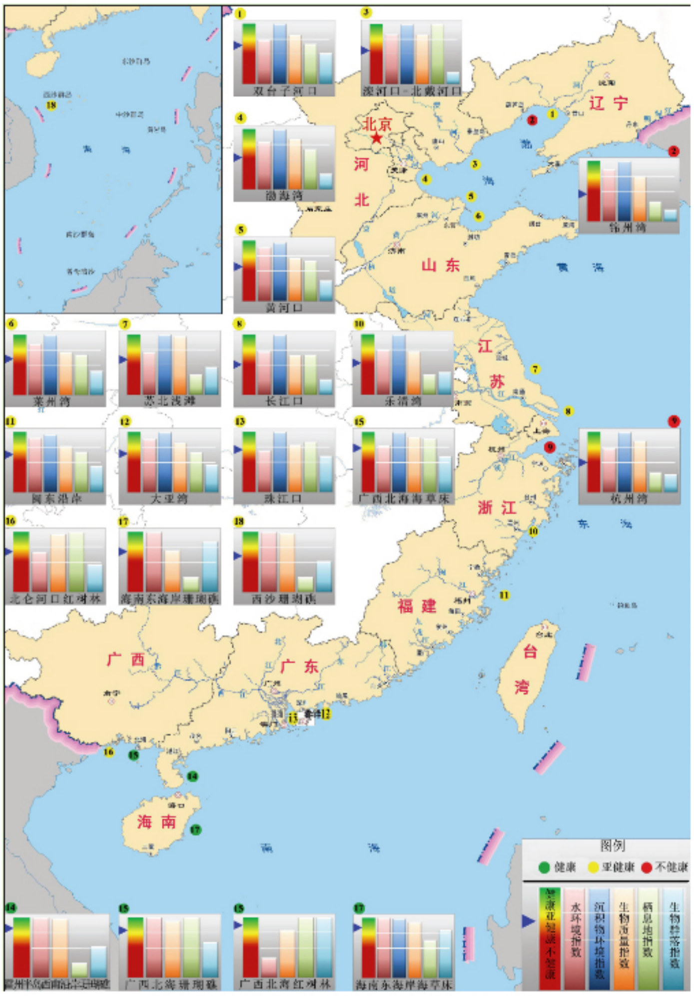
重点监测区域海草、红树植物和珊瑚的生物多样性状况

2.2 重点监测区海洋生态系统健康状况

2012年，对重点监测区的河口、海湾、滩涂湿地、珊瑚礁、红树林和海草床等典型海洋生态系统健康状况进行评价。结果表明，处于健康、亚健康和不健康状态的海洋生态系统分别占19%、71%和10%。

2012年重点监测区海洋生态系统基本情况

生态系统类型	监测区名称	所属经济发展规划区	监测海域面积（平方公里）	健康状况
河口	双台子河口	辽宁沿海经济带	3 000	亚健康
	滦河口—北戴河	河北沿海经济区	900	亚健康
	黄河口	黄河三角洲高效生态经济区	2 600	亚健康
	长江口	长江三角洲经济区	13 668	亚健康
	珠江口	珠江三角洲经济区	3 980	亚健康
海湾	锦州湾	辽宁沿海经济带	650	不健康
	渤海湾	天津滨海新区	3 000	亚健康
	莱州湾	黄河三角洲高效生态经济区	3 770	亚健康
	杭州湾	长江三角洲经济区	5 000	不健康
	乐清湾	浙江海洋经济发展示范区	464	亚健康
	闽东沿岸	海峡西岸经济区	5 063	亚健康
	大亚湾	珠江三角洲经济区	1 200	亚健康
滩涂湿地	苏北浅滩	江苏沿海经济区	15 400	亚健康



2012年重点监测区典型海洋生态系统健康状况

*海洋生态系统的健康状况分为健康、亚健康和不健康三个级别：

健 康：生态系统保持其自然属性。生物多样性及生态系统结构基本稳定，生态系统主要服务功能正常发挥。环境污染、人为破坏、资源的不合理开发等生态压力在生态系统的承载能力范围内。

亚健康：生态系统基本维持其自然属性。生物多样性及生态系统结构发生一定程度变化，但生态系统主要服务功能尚能发挥。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

不健康：生态系统自然属性明显改变。生物多样性及生态系统结构发生较大程度变化，生态系统主要服务功能严重退化或丧失。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

2.2.1 河口生态系统

河口为河流与海洋相互作用的区域，是许多重要海洋经济生物的产卵场、索饵场和栖息地。2012年，监测的典型河口生态系统均呈亚健康状态。

双台子河口、长江口和珠江口海水富营养化严重；滦河口-北戴河大型底栖生物密度偏低，浮游植物丰度偏高；黄河口大型底栖生物密度、生物量偏低，浮游植物丰度偏高；长江口浮游植物丰度异常偏高且大型底栖生物量偏低；各河口区鱼卵仔鱼密度总体较低。

2.2.2 海湾生态系统

海湾是深入陆地形成明显水曲的海域，是人类从事海洋开发活动的重要场所。2012年，监测的海湾生态系统多数呈亚健康状态，锦州湾和杭州湾生态系统呈不健康状态。

受围填海等人为活动的影响，锦州湾栖息地丧失严重；渤海湾浮游植物丰度异常偏高；杭州湾海水富营养化严重，栖息地面积缩减，大型底栖生物密度偏低；各海湾鱼卵仔鱼密度总体较低。

2.2.3 滩涂湿地生态系统

滩涂湿地具有涵养水源、净化水质、护岸减灾和维持区域生态平衡等功能，是应对环境变化的缓冲区。2012年，苏北浅滩滩涂湿地生态系统呈亚健康状态。

苏北浅滩湿地围垦速度较快，滩涂植被现存量较低，栖息地面积大规模缩减，浮游植物丰度偏高，浮游动物密度偏低。

滨海湿地概况

滨海湿地是指低潮时水深浅于6米的水域及其沿岸浸湿地带，包括水深不超过6米的永久性水域、潮间带（或洪泛地带）和沿海低地。我国滨海湿地可分为自然滨海湿地和人工滨海湿地。其中，自然滨海湿地主要包括浅海水域、滩涂、盐沼、红树林、珊瑚礁、海草床、河口水域、泻湖等；人工滨海湿地主要包括养殖池塘、盐田、水库等。

近海海洋综合调查与评价专项调查表明，我国滨海湿地面积为693万公顷（海岸线至负6米等深线），其中自然滨海湿地的面积为669万公顷，人工滨海湿地面积为24万公顷。自然滨海湿地中，浅海水域面积为499万公顷、滩涂面积为46万公顷、滨海沼泽面积为5万公顷、河口水域和河口三

2.2.4 珊瑚礁生态系统

珊瑚礁生态系统具有丰富的生物多样性和极高的生产力水平，同时也是重要生态旅游资源。2012年，雷州半岛西南沿岸和广西北海珊瑚礁生态系统呈健康状态，海南东海岸和西沙珊瑚礁生态系统呈亚健康状态。

海南东海岸和西沙等区域的造礁珊瑚平均盖度处于较低水平，硬珊瑚补充量较低，部分监测区域有长棘海星和核果螺等敌害生物侵害珊瑚的现象。

2.2.5 红树林生态系统

红树林具有稳定和保护海岸的重要作用，为许多海生和陆生生物提供栖息地和食物，是部分海洋鱼类的重要繁育场所。2012年，广西北海红树林生态系统呈健康状态，北仑河口红树林生态系统呈亚健康状态。

监测的红树林生态系统栖息地状况良好，红树林面积保持稳定。广西北海山口红树林监测区域红海榄、白骨壤等红树群落均呈良好生长状态，植株高大，林相整齐。北仑河口红树林监测区域底栖生物密度和生物量偏低。

2.2.6 海草床生态系统

海草床是生产力和生物多样性较高的生态系统，具有净化水体、防浪护岸的功能，是众多经济鱼类和濒危动物的栖息和繁育场所。2012年，海南东海岸海草床生态系统呈健康状态，广西北海海草床生态系统呈亚健康状态。

红树林概况

我国红树林主要分布于广西、广东、海南、福建和浙江南部沿岸。其中以广西红树林资源最为丰富，其红树林面积占我国红树林面积的三分之一，其次是广东、海南、福建和浙江，福建福鼎是我国红树林自然分布的北界，浙江乐清是我国红树林（人工种植）分布最北界。

我国共有真红树物种27种，属典型的东方群系，其中，尖瓣海桑、厦门老鼠簕、海南海桑为我国发现和命名；另有11种半红树物种。我国红树林群落在空间分布上，随着纬度的升高，气候带由中热带、北热带、南亚热带到

2.3 海洋保护区生态状况

2012年，对全国32个国家级海洋保护区开展了监测，其中海洋生物物种类保护区19个；海洋自然遗迹类保护区13个。监测结果表明，海洋保护区环境质量状况良好，主要保护对象或保护目标基本保持稳定。

2.3.1 海洋生物物种类保护区

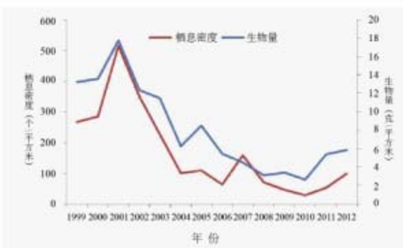
环境质量状况

大部分海洋生物物种类保护区环境质量状况良好。保护区海水中化学需氧量、溶解氧和石油类等监测要素符合第一类海水水质标准的站位比例均在66%以上；沉积物中有机碳、硫化物和石油类等监测要素均符合第一类海洋沉积物质量标准。

保护对象或保护目标状况

文昌鱼、中华白海豚、鸟类、珊瑚、红树植物、水仙花等重点保护的野生生物基本保持稳定。

昌黎黄金海岸国家级自然保护区文昌鱼栖息密度为10~300个/平方米，平均为98个/平方米；生物量变化范围为0.2~18.5克/平方米，平均为5.9克/平方米。2002年以来，文昌鱼的栖息密度和生物量总体呈下降趋势，2011年和2012年略有回升。文昌鱼栖息地退化，砂含量变化及沉积物类型改变，文昌鱼分布区向深水区延伸，主要分布在新开口与大蒲河口外5~15米等深线海域范围内。



1999~2012年8月河北昌黎文昌鱼栖息密度及生物量变化趋势

天津古海岸与湿地国家级自然保护区监测到鸟类52种，主要有黑鹳、东方白鹳、天鹅、风头鹡鹒等。

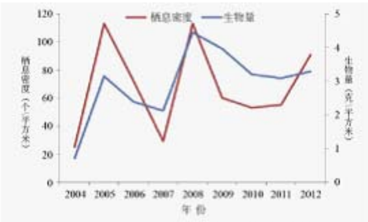
普陀中街山列岛国家级海洋特别保护区鸟类种群数量保持稳定，主要鸟类粉红燕鸥和黑枕燕鸥均出现200只以上的种群。

象山韭山列岛国家级自然保护区监测到黑尾鸥成鸟450只，幼鸟200余只，表明本年度黑尾鸥在韭山列岛成功繁殖。

南鹿列岛国家级自然保护区的野生水仙花10月中旬已大量发芽，平均株高32.6厘米，平均密度为295株/平方米。

乐清市西门岛海洋特别保护区监测到鸟类40种，苍鹭和矶鹬为最常见种类，春季有中勺鹬、翻石鹬，翘嘴鹬、铁嘴沙鸻、灰尾漂鹬、蒙古沙鸻等候鸟出没，秋、冬季有黑尾鸥、红脚鹬、黑腹滨鹬等候鸟出没。保护区红树林主要品种为秋茄，面积13公顷，株高0.2~3.9米，平均密度为2.0万株/公顷。

厦门珍稀海洋生物物种国家级自然保护区文昌鱼栖息密度为4~363 个/平方米，平均为91个/平方米；生物量变化范围为0.01~13.8克/平方米，平均为3.29克/平方米。2010~2012年文昌鱼的栖息密度和生物量总体呈回升趋势。中华白海豚种群数量总体稳定，共发现中华白海豚136次、428头次，其中火烧屿观测点发现64次、234头次。



2004~2012年福建厦门文昌鱼栖息密度及生物量变化趋势

厦门海域中华白海豚

广东徐闻珊瑚礁国家级自然保护区活珊瑚盖度为5~44%，平均为19%；石珊瑚死亡率为0.5~16.7%，平均为8.3%，较上年明显降低。

广西山口红树林国家级自然保护区主要有桐花树、木榄、秋茄、白骨壤、红海榄等品种，株高0.5~5.9米，平均密度为0.5万株/公顷；圈林养殖、人为挖掘和虫害导致区内红树林密度有所下降。

广西北仑河口国家级自然保护区红树林面积1 274公顷，主要有桐花树、木榄、秋茄、白骨壤、海漆、露兜、黄槿、水黄皮、老鼠簕等品种。

海南万宁大洲岛国家级海洋生态自然保护区监测到珊瑚43种，活珊瑚盖度为10~30%，平均为20%。

海南三亚珊瑚礁国家级自然保护区监测到珊瑚47种，活珊瑚盖度为1~60%，平均为24%。

2.3.2 海洋自然遗迹类保护区

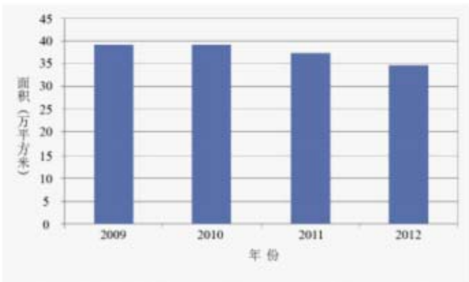
环境质量状况

大部分海洋自然遗迹类保护区环境质量状况良好。保护区海水中化学需氧量、溶解氧和石油类等监测要素符合第一类海水水质标准的站位比例均在74%以上；沉积物中有机碳、硫化物和石油类等监测要素符合第一类海洋沉积物质量标准的站位比例均在95%以上。

保护对象或保护目标状况

陆连岛沙堤、海岸沙丘、牡蛎礁、贝壳堤、海底古森林、岛礁等重点保护的海洋自然遗迹基本保持稳定。

锦州大笔架山国家级海洋特别保护区由于侵蚀作用，陆连岛沙堤变宽、变矮，中段多处断裂，且其西侧出现大量淤泥。通过实施修复工程，2012年沙堤中段多处断裂情况有所恢复。



2009~2012年山东滨州贝壳堤面积变化

刘公岛国家级海洋公园的牙石岛、黑鱼岛、连林岛、大泓岛、小泓岛等海岛自然风貌保存较完整，但由于长期受到海水的侵蚀，部分岛屿的基岩岸线有后退的迹象。

山东烟台芝罘岛群国家级海洋特别保护区的芝罘岛和江苏连云港海州湾国家级海洋公园的竹岛、秦山岛、连岛等海岛自然风貌保护完好。

江苏海门蛎蚜山国家级海洋公园内的鲜活牡蛎有熊本牡蛎、近江牡蛎和密鳞牡蛎等3种。潮间带的优势种为熊本牡蛎，其平均密度和生物量分别为2 199个/平方米和12 361克/平方米；熊本牡蛎的壳高介于10~78毫米，平均为30毫米，其中，壳高20~40毫米的个体在种群内占绝对优势，其栖息密度为1 803个/平方米，约占种群总栖息密度的82%。近江牡蛎和密鳞牡蛎数量较少，仅有零星分布。

象山韭山列岛国家级自然保护区岛礁生态系统保持原状，基本稳定。

浙江渔山列岛国家级海洋公园岛礁保持原状，自然景观保持良好，伏虎礁领海基点保护完好。

深沪湾海底古森林国家级自然保护区监测到埋藏年限为7 000~8 000年的海底古树桩16株，埋藏的树干主茎连同直立主根深度为20~25米，基本保持稳定。

美丽海洋—海洋保护区精华采撷

我国拥有 1.8 万公里的大陆海岸线，海岸线绵长曲折、地质地貌奇异、生物资源独特、文化遗产丰富。海洋保护区的建立使文昌鱼、中华白海豚、儒艮、江豚、白鹳、黑鹳、金丝燕等珍稀濒危物种和贝壳堤、牡蛎礁、海底古森林、陆连岛沙堤、海岸沙丘、柽柳林、红树林、珊瑚礁、海岛等重要海洋生态系统得到有效保护。截止 2012 年，国家海洋局已建立 55 个国家级海洋自然/特别保护区（海洋公园），面积约 83 万公顷。海洋公园是为保护海洋生态与历史文化价值，发挥其生态旅游功能，在特殊海洋生态景观、历史文化遗迹、独特地质地貌景观及其周边海域建立的国家级海洋特别保护区。

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Annex 866

China State Oceanic Administration, *Code of Practice for Marine Monitoring Technology, Part 5: Marine Ecology*, Marine Industry Standards of the People's Republic of China, No. HY/T 147.5-2013 (25 Apr. 2013), *available at* http://www.doc88.com/p-9107173485754.html (accessed 23 Feb. 2016)

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Marine Industry Standards of the People's Republic of China

HY/T 147.5—2013

Code of Practice for Marine Monitoring Technology

Part 5: Marine ecology

Promulgated on April 25, 2013 Implemented on May 1, 2013

Promulgated by: State Oceanic Administration

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Foreword

HY/T 147 *Code of Practice for Marine Monitoring Technology* is divided into seven parts:
- Part 1: Seawater;
- Part 2: Sediment;
- Part 3: Organisms;
- Part 4: Marine atmosphere;
- Part 5: Marine ecology;
- Part 6: Marine hydrology, meteorology, and sea ice
- Part 7: Satellite remote sensing technical methods.

This part is Part 5 of HY/T 147.

This part was drafted according to the rules provided in GB/T 1.1-2009.

This part was proposed by National Marine Environmental Monitoring Center.

This part is attributed to National Technical Committee of Marine Standardization (SAC/TC 283).

This part was drafted by: National Marine Environmental Monitoring Center, South China Sea Environmental Monitoring Center of the State Oceanic Administration, East China Sea Environmental Monitoring Center of the State Oceanic Administration, North Sea Environmental Monitoring Center of the State Oceanic Administration.

The main drafters of this part were: Hang Gengchen, Fan Jingfeng, Ma Yongan, Jiang Wenbo, Zhang Zhendong, Lin Fengao, Li Hongbo, Liang Bin, Xu Daoyan, Shao Kuishuang, Li Dongmei, Liu Yongjian, Liu Shuxi, Yuan Xiutang, Yan Qilun, Liu Guize, Wang Lijun, Liu Changan, Feng Zhiquan, Wang Zhenliang, Liu Na, Yu Zhanguo, Huang Chuguang, Gao Yang, Li Xiuqin, Wei Guiqiu, Yi Bin, Shao Yuzhang, Chen Jiahui, Li Haitao, Xiong Xiaofei, Dong Yanhong, Wu Shiwei, Lu Chuqian, Cheng Xiangsheng, Liu Caicai, Sun Yawei, Qin Yutao, Li Yiyun, Xia Yongjian, Fan Lijing, Ji Huanhong, Huang Hui, Gao Junzhang, Xin Dinghao, Song Chenyao, Cui Wenlin, Qi Yanping, Zhang Qi, Wang Taisen, Wang Xiaoqing, Li Qinliang, Zhao Sheng, Sun Peipei, Zhang Qingbo.

Annex 867

China State Oceanic Administration, "2013 Communique on Marine Environment of China, Part 2: Conditions of Marine Ecology" (25 Mar. 2014), *available at* http://www.coi.gov.cn/gongbao/nrhuanjing/ nr2013/201403/t20140325_30714.html (accessed 9 Mar. 2016)

[…]

2. Conditions of Marine Ecology

Source: State Oceanic Administration Website Updated on: 03-25-2014

[…]

[…]

2.2.4 Coral reef ecosystem

The southwest coast of Leizhou Peninsula and Beihai of Guangxi have healthy coral reef ecosystems; the eastern coast of Hainan Island and Xisha Islands have healthy coral reef ecosystems. The coverage of hermatypic coral has shown overall decline. In the monitored areas on the eastern coast of Hainan Island and Xisha Islands, there is an elevation in supplemental quantity of hard coral. In some monitored areas, coral bleaching has been discovered.

[…]

2 海洋生态状况

来源：国家海洋局网站　　更新时间：2014-03-25　　打印本页　　关闭窗口

2.1 海洋生物多样性

海洋生物多样性监测内容包括浮游生物、底栖生物、海草、红树植物、珊瑚等生物的种类组成和数量分布。在监测区域内共鉴定出浮游植物701种，浮游动物713种，大型底栖生物1 342种，海草7种，红树植物9种，造礁珊瑚104种。浮游生物和底栖生物物种数从北至南呈增加趋势，符合其自然分布规律。

渤海鉴定出浮游植物201种，主要类群为硅藻和甲藻；浮游动物108种，主要类群为桡足类和水母类；大型底栖生物389种，主要类群为环节动物、软体动物和节肢动物。2009年以来，夏季滦河口-北戴河海域浮游植物多样性指数呈上升趋势；莱州湾海域浮游动物多样性指数呈上升趋势；渤海湾和莱州湾海域大型底栖生物多样性指数呈上升趋势，滦河口-北戴河和黄河口海域大型底栖生物多样性指数呈下降趋势。

黄海鉴定出浮游植物263种，主要类群为硅藻和甲藻；浮游动物89种，主要类群为桡足类和水母类；大型底栖生物413种，主要类群为环节动物、软体动物和节肢动物。2009年以来，夏季苏北浅滩海域浮游动物和大型底栖生物多样性指数均呈下降趋势。

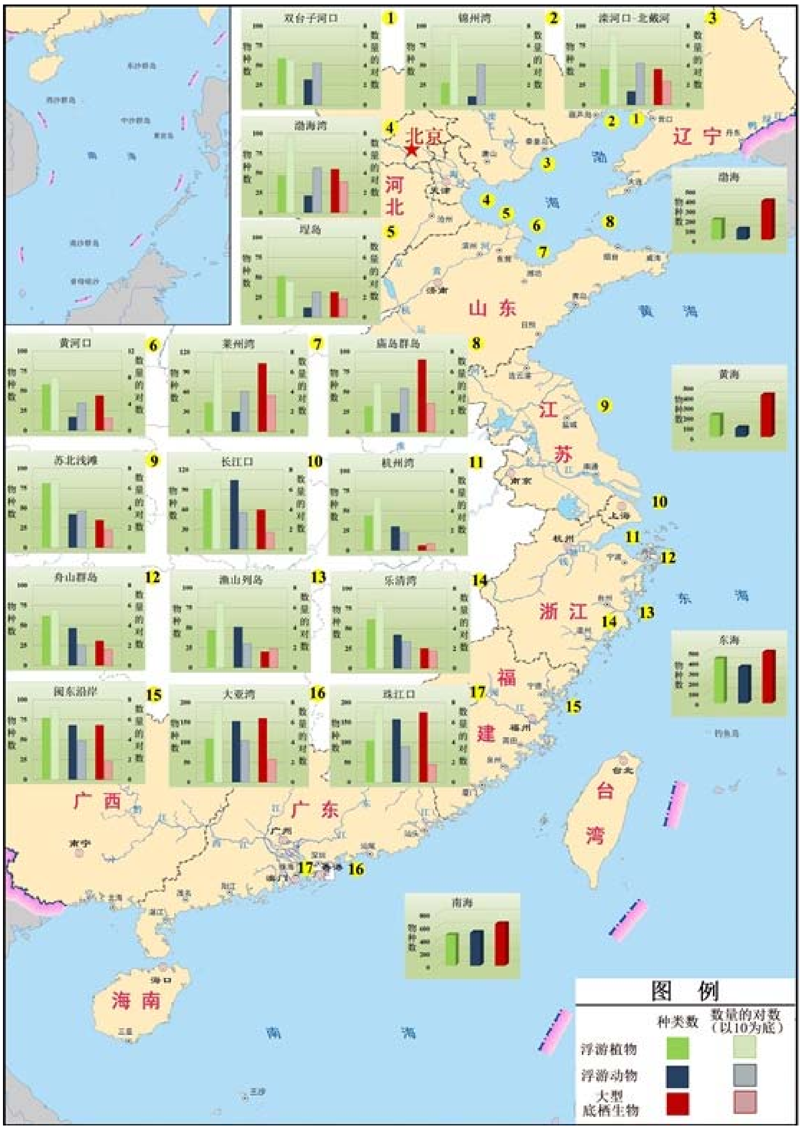
东海鉴定出浮游植物434种，主要类群为硅藻和甲藻；浮游动物351种，主要类群为桡足类和水母类；大型底栖生物512种，主要类群为环节动物、节肢动物和软体动物。2009年以来，夏季长江口和闽东沿岸海域浮游植物多样性指数呈上升趋势；杭州湾和乐清湾海域浮游动物多样性指数呈上升趋势，长江口海域浮游动物多样性指数呈下降趋势；长江口、杭州湾和乐清湾海域大型底栖生物多样性指数均呈下降趋势。

南海鉴定出浮游植物473种，主要类群为硅藻和甲藻；浮游动物546种，主要类群为桡足类和水母类；大型底栖生物645种，主要类群为节肢动物、软体动物和环节动物；海草7种，红树植物9种，造礁珊瑚104种。2009年以来，夏季珠江口海域浮游动物和大型底栖生物多样性指数呈下降趋势，大亚湾海域大型底栖生物多样性指数呈上升趋势。

夏季重点监测区域浮游生物和大型底栖生物物种数、数量、多样性指数及主要优势种

监测区域	浮游植物					浮游动物	大型浮游动物				大型底栖生物				
	物种数（种）	数量（×10⁴个细胞/立方米）	多样性指数及趋势		主要优势种	物种数（种）	数量（个/立方米）	多样性指数及趋势		主要优势种	物种数（种）	数量（个/平方米）	多样性指数及趋势		主要优势种
			指数	变化趋势				指数	变化趋势				指数	变化趋势	
双台子河口	59	4	2.45	—	布氏双尾藻 夜光藻	32	2 424	2.00	—	火腿许水蚤 双刺唇角水蚤	/	/	/	/	/
滦河口-北戴河	45	2 020	2.13	↗	中肋骨条藻 丹麦细柱藻	17	379	1.36	↔	强壮箭虫 小拟哲水蚤	45	243	1.62	↘	日本鼓虾 豆形短眼蟹
黄河口	58	11 307	1.94	↔	假弯角毛藻 中肋骨条藻	17	123	1.46	↔	强壮箭虫 太平洋纺锤水蚤	44	70	1.80	↘	凸壳肌蛤
长江口	91	800	2.18	↗	洛氏角毛藻 尖刺拟菱形藻	104	389	1.97	↘	太平洋纺锤水蚤 背针胸刺水蚤	60	53	1.70	↘	奇异稚齿虫 丝异须虫
珠江口	103	3 300	1.65	↔	中肋骨条藻 柔弱菱形藻	157	71	2.20	↘	肥胖箭虫 中华异水蚤	175	55	1.57	↘	双形拟单指虫
苏北浅滩	81	670	2.58	↔	日本星杆藻 浮动弯角藻	42	55	2.02	↘	真刺唇角水蚤 肥胖箭虫	35	64	1.62	↘	泥螺 加州齿吻沙蚕
锦州湾	28	1 540	2.08	—	中肋骨条藻 丹麦细柱藻	11	2 639	1.11	—	双刺纺锤水蚤 强壮箭虫	/	/	/	/	/
渤海湾	47	5 872	2.00	↔	旋链角毛藻 尖刺菱形藻	21	230	1.73	↔	强壮箭虫 太平洋纺锤水蚤	55	1327	2.49	↗	凸壳肌蛤 棘刺锚参
莱州湾	44	7 913	1.64	↔	拟弯角毛藻 圆柱角毛藻	30	191	2.52	↗	肥胖三角溞 强壮箭虫	103	4161	2.74	↗	凸壳肌蛤
杭州湾	44	29	1.80	↔	琼氏圆筛藻 虹彩圆筛藻	30	66	2.42	↗	虫肢歪水蚤 太平洋纺锤水蚤	6	5	0	↘	豆形胡桃蛤 纵沟纽虫
乐清湾	61	382	2.22	↔	中肋骨条藻 布氏双尾藻	42	310	2.32	↗	刺尾纺锤水蚤 背针胸刺水蚤	25	36	0.83	↘	寡鳃齿吻沙蚕
闽东沿岸	77	1 492	1.32	↗	中肋骨条藻	68	392	2.68	↔	小拟哲水蚤 锥形宽水蚤	68	72	2.50	↔	不倒翁虫 杰氏内卷沙蚕
大亚湾	110	4 576	1.66	↔	柔弱菱形藻 中肋骨条藻	153	229	2.99	↔	鸟喙尖头溞 锥形宽水蚤	160	205	2.00	↗	[illegible] 奇异稚齿虫
担岛	52	4 131	2.47	—	假弯角毛藻 丹麦细柱藻	13	376	0.65	—	背针胸刺水蚤 强壮箭虫	32	68	2.19	—	江户明樱蛤 寡节甘吻沙蚕
庙岛群岛	32	8	2.62	—	夜光藻 三角角藻	23	79	2.39	—	强壮箭虫 五角水母	90	672	3.21	—	日本鳞缘蛇尾 欧文虫
渔山列岛	47	353	2.66		尖刺菱形藻 中肋骨条藻	51	253	2.95		中华哲水蚤 太平洋纺锤水蚤	20	83	2.20		双形拟单指虫 棘刺锚参
舟山群岛	62	40	2.27	—	中肋骨条藻 琼氏圆筛藻	47	114	2.94	—	背针胸刺水蚤 精致真刺水蚤	31	45	1.80	—	不倒翁虫 日本鼓虾

图例说明：变化趋势为五年同期相比，其中↘多样性指数呈下降趋势，↗多样性指数呈上升趋势，↔多样性指数基本稳定。 —缺少近五年的数据进行比较，/无监测数据。



夏季重点监测区域浮游生物和大型底栖生物物种数和数量

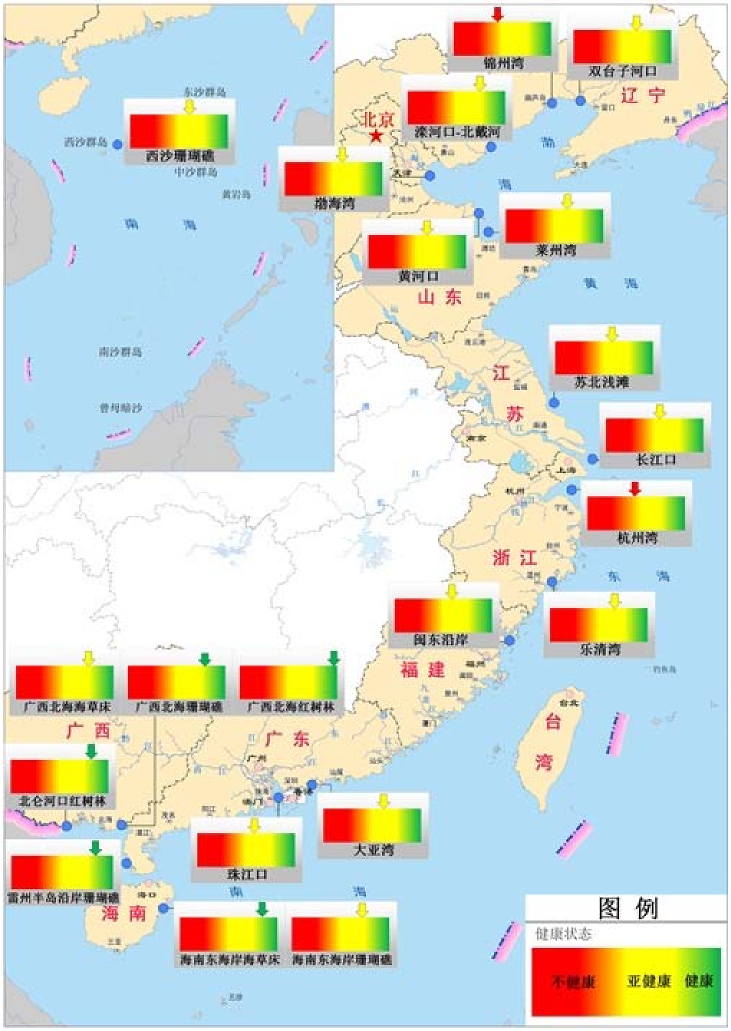
重点监测区域海草、红树和珊瑚的生物多样性状况

2.2 近岸典型海洋生态系统健康状况

实施监测的河口、海湾、滩涂湿地、珊瑚礁、红树林和海草床等海洋生态系统中，处于健康、亚健康和不健康状态的海洋生态系统分别占23%、67%和10%。

2013年近岸典型海洋生态系统基本情况

生态系统类型	生态监控区名称	所属经济发展规划区	生态监控区面积（平方公里）	健康状况
河口	双台子河口	辽宁沿海经济带	3 000	亚健康
	滦河口—北戴河	河北沿海经济区	900	亚健康
	黄河口	黄河三角洲高效生态经济区	2 600	亚健康
	长江口	长江三角洲经济区	13 668	亚健康
	珠江口	珠江三角洲经济区	3 980	亚健康
海湾	锦州湾	辽宁沿海经济带	650	不健康
	渤海湾	天津滨海新区	3 000	亚健康
	莱州湾	黄河三角洲高效生态经济区	3 770	亚健康
	杭州湾	长江三角洲经济区 浙江海洋经济发展示范区	5 000	不健康
	乐清湾	浙江海洋经济发展示范区	464	亚健康
	闽东沿岸	海峡西岸经济区	5 063	亚健康
	大亚湾	珠江三角洲经济区	1 200	亚健康
滩涂湿地	苏北浅滩	江苏沿海经济区	15 400	亚健康
珊瑚礁	雷州半岛西南沿岸	广东海洋经济综合试验区	1 150	健康
	广西北海	广西北部湾经济区	120	健康
	海南东海岸	海南国际旅游岛	3 750	亚健康
	西沙珊瑚礁	海南国际旅游岛	400	亚健康
红树林	广西北海	广西北部湾经济区	120	健康
	北仑河口	广西北部湾经济区	150	健康
海草床	广西北海	广西北部湾经济区	120	亚健康
	海南东海岸	海南国际旅游岛	3 750	健康



2013年近岸典型海洋生态系统健康状况*

海洋生态系统的健康状况分为健康、亚健康和不健康三个级别：

健 康：生态系统保持其自然属性。生物多样性及生态系统结构基本稳定，生态系统主要服务功能正常发挥。环境污染、人为破坏、资源的不合理开发等生态压力在生态系统的承载能力范围内。

亚健康：生态系统基本维持其自然属性。生物多样性及生态系统结构发生一定程度变化，但生态系统主要服务功能尚能发挥。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

不健康：生态系统自然属性明显改变。生物多样性及生态系统结构发生较大程度变化，生态系统主要服务功能严重退化或丧失。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

2.2.1 河口生态系统

监测的典型河口生态系统均呈亚健康状态。多数河口生态系统海水呈富营养化状态，浮游植物密度高于正常范围，鱼卵仔鱼密度较低。双台子河口和珠江口浮游动物密度低于正常范围；长江口大型底栖生物密度高于正常范围，生物量低于正常范围；黄河口大型底栖生物密度低于正常范围。

2.2.2 海湾生态系统

监测的海湾生态系统多数呈亚健康状态，锦州湾和杭州湾生态系统呈不健康状态。生境丧失和人为污染是海湾生态系统面临的主要压力，多数海湾浮游植物密度高于正常范围，鱼卵仔鱼密度较低。锦州湾和杭州湾栖息地面积缩减严重；杭州湾海水富营养化严重；渤海湾浮游动物生物量和大亚湾浮游动物密度低于正常范围；杭州湾大型底栖生物密度和生物量、乐清湾大型底栖生物生物量、闽东沿岸大型底栖生物密度低于正常范围。

2.2.3 滩涂湿地生态系统

苏北浅滩滩涂湿地生态系统呈亚健康状态。苏北浅滩湿地滩涂围垦速度较快，植被现存量较低，现有滩涂植被面积较上年减少近一半。浮游植物密度和浮游动物生物量高于正常范围。

2.2.4 珊瑚礁生态系统

雷州半岛西南沿岸和广西北海珊瑚礁生态系统呈健康状态，海南东海岸和西沙珊瑚礁生态系统呈亚健康状态。珊瑚礁生态系统造礁珊瑚盖度总体有所下

降。海南东海岸和西沙监测区域造礁珊瑚补充量有所升高，部分监测区域发现珊瑚礁白化。

2.2.5 红树林生态系统

广西北海、北仑河口红树林生态系统均呈健康状态。监测区域的红树林生态系统栖息地状况良好，红树林面积保持稳定。北仑河口红树林监测区域底栖生物密度和生物量有所增加。山口红树林监测区域互花米草入侵速度较快，对红树林的生长产生威胁。

2.2.6 海草床生态系统

海南东海岸海草床生态系统呈健康状态，广西北海海草床生态系统呈亚健康状态。监测区域的海草床生态系统健康状况保持稳定。受台风、海岸工程和人类活动影响，海南东海岸海草床生态系统的海草平均密度明显下降。广西北海海草床仍处于退化状态，与上年相比，海草平均盖度显著下降。

国家海洋局组织实施渤海海洋生态红线制度

2012 年，国家海洋局印发《关于建立渤海海洋生态红线制度的若干意见》（以下简称《意见》），要求环渤海三省一市建立生态红线制度，将海洋保护区、重要滨海湿地、重要河口、特殊保护海岛和沙源保护海域、重要砂质岸线、自然景观与文化历史遗迹、重要旅游区和重要渔业海域等区域划定为红线区，并分区分类制定严格的管控措施。

渤海生态红线制度的总体目标有：一是自然岸线保有率不低于 30%；二是海洋生态红线区面积占渤海近岸海域面积的比例不低于三分之一；三是到 2020 年，海洋生态红线区陆源入海直排口污染物排放达标率达到 100%，陆源污染物入海总量减少 10~15%；四是到 2020 年，海洋生态红线区海水水质达标率不低于 80%。同时，《意见》对环渤海三省一市分别提出了具体管控目标。

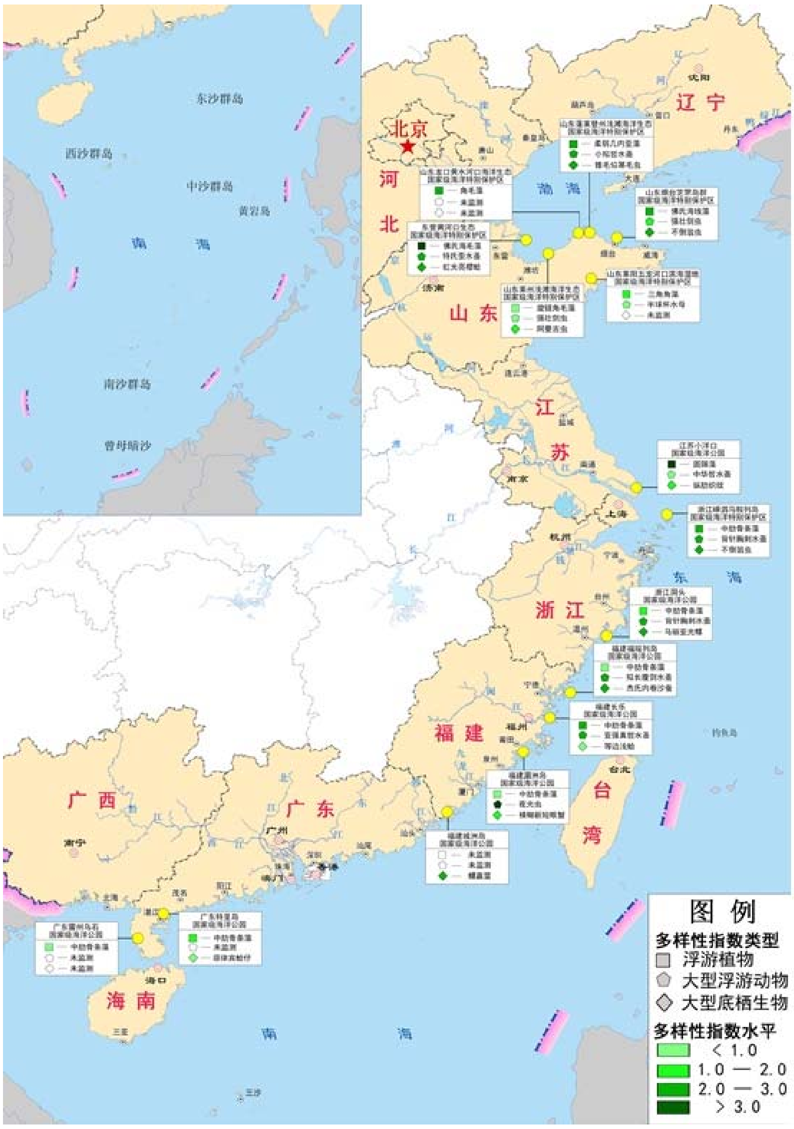
2013 年 12 月，经山东省人民政府批准，山东建立了渤海海洋生态红线制度，将总面积 6 534.42 平方公里的区域划为生态红线区，占山东省渤海管辖海域总面积的 40.05%，并制定了严格的管控措施。辽宁、河北、天津已经完成红线划定方案的编制工作，拟在省（市）政府批准后实施。

2.3 海洋保护区生态状况

48个开展生态状况监测的国家级海洋保护区中，重点保护的海洋生物资源和自然遗迹基本保持稳定，海洋生物多样性总体保持稳定水平。

2013年部分重点保护的海洋生物资源和自然遗迹状况

保护区类型	重点保护资源	保护区名称	变化状况
海洋生物物种类保护区	文昌鱼	昌黎黄金海岸国家级自然保护区	栖息密度和生物量呈下降趋势
		厦门珍稀海洋生物物种国家级自然保护区	栖息密度和生物量基本保持稳定
	中华白海豚	厦门珍稀海洋生物物种国家级自然保护区	种群数量基本稳定
	鸟类	天津古海岸与湿地国家级自然保护区	种类明显增加
		普陀中街山列岛海洋特别保护区	种类和数量基本保持稳定
		象山韭山列岛国家级自然保护区	数量增加
		乐清市西门岛海洋特别保护区	种类数基本保持稳定
	珊瑚	广东徐闻珊瑚礁国家级自然保护区	活珊瑚盖度整体呈上升趋势
		海南万宁大洲岛国家级海洋生态自然保护区	活珊瑚盖度基本保持稳定
		海南三亚珊瑚礁国家级自然保护区	活珊瑚盖度基本保持稳定
	红树	乐清市西门岛海洋特别保护区	平均密度基本保持稳定
		广西山口红树林国家级自然保护区	平均密度基本保持稳定
		广西北仑河口国家级自然保护区	平均密度基本保持稳定
	野生水仙花	南麂列岛国家级自然保护区	面积增加
	柽柳	山东昌邑海洋生态特别保护区	面积基本保持稳定
海洋自然遗迹类保护区	海岸沙丘	昌黎黄金海岸国家级自然保护区	脊线最高点向西北移动
	贝壳堤	天津古海岸与湿地国家级自然保护区	面积基本保持稳定
		滨州贝壳堤岛与湿地国家级自然保护区	面积明显恢复
	海底古森林	深沪湾海底古森林遗迹国家级自然保护区	古树桩数量及完整性基本保存完好
	沙滩	山东烟台牟平沙质海岸国家级海洋特别保护区	面积基本保持稳定
		山东海阳万米海滩海洋资源国家级海洋特别保护区	面积退化情况有所改观
	岛礁	山东威海刘公岛海洋生态国家级海洋特别保护区	面积基本保持稳定
		渔山列岛国家级海洋生态特别保护区	面积基本保持稳定



2013年海洋生态系统类保护区生物多样性水平状况和主要优势种

2.3.1 海洋生物物种类保护区

文昌鱼、中华白海豚、贝类、刺参、珊瑚、鸟类、柽柳、红树、水仙花等重点保护的海洋生物物种资源基本保持稳定。

昌黎黄金海岸国家级自然保护区文昌鱼种群结构正常。平均密度为30个/平方米，平均生物量为2.2克/平方米，呈下降趋势。文昌鱼栖息地退化，砂含量变化及沉积物类型改变是导致其退化的主要因素。

东营河口浅海贝类生态国家级海洋特别保护区监测到贝类8种。平均密度为38个/平方米，平均生物量为0.8克/平方米，主要优势种为光滑河篮蛤。

东营广饶沙蚕类生态国家级海洋特别保护区监测到沙蚕4种。平均分布密度为20个/平方米，平均生物量为0.4克/平方米，主要优势种为寡节甘吻沙蚕。

山东昌邑海洋生态特别保护区柽柳生长稳定，面积为2 929公顷，平均700株/公顷。

山东威海小石岛国家级海洋生态特别保护区刺参平均密度为1.8个/平方米，平均生物量为357克/平方米。

山东文登海洋生态国家级海洋特别保护区内的国家二级保护动物松江鲈鱼体长范围为8.2～23.1厘米，体重范围为25～162克。

普陀中街山列岛海洋特别保护区鸟类种群主要为粉红燕鸥、黑枕燕鸥和褐翅燕鸥，在叶子山周围的岩礁带监测到粉红燕鸥214只。

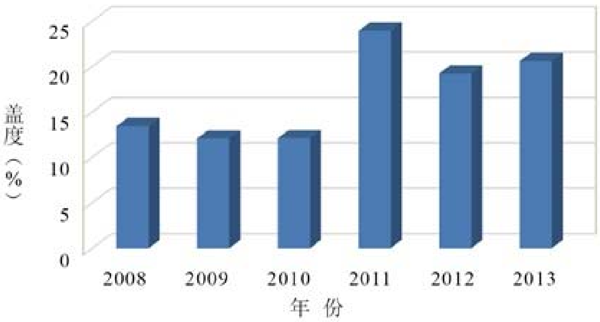
象山韭山列岛国家级自然保护区吸引3 000多只大凤头燕鸥和19只中华凤头燕鸥入区，并成功繁殖600多只大凤头燕鸥幼鸟和多只中华凤头燕鸥幼鸟。

乐清市西门岛海洋特别保护区监测到鸟类39种，主要优势种为小白鹭。保护区红树主要物种为秋茄，平均密度为1.9万株/公顷。

南麂列岛国家级自然保护区的大槠野生水仙花移植增种0.8公顷，平均株高12厘米。海鸟常见种类有白鹭、牛背鹭、池鹭、灰鹭、鸬鹚、鹬等。夏候鸟主要有黑尾鸥、燕鸥等，主要分布在下马鞍、破屿、尖屿。

厦门珍稀海洋生物物种国家级自然保护区文昌鱼及中华白海豚保持稳定。文昌鱼平均分布密度为64个/平方米，平均生物量为3.5克/平方米。共发现中华白海豚151次、542头次，其中火烧屿观测点观测360天，发现中华白海豚65次、212头次。

广东徐闻珊瑚礁国家级自然保护区活珊瑚盖度为10～46%，平均为21%。2008年以来，活珊瑚盖度整体呈上升趋势。



2008～2013年广东徐闻活珊瑚盖度

广西涠洲岛珊瑚礁国家级海洋公园监测到活珊瑚8科15种，盖度为34%。海洋公园内监测到珊瑚死亡时间均在2年以上，2013年未新发现死亡珊瑚。

广西钦州茅尾海国家级海洋公园主要有红海榄、木榄、秋茄、白骨壤、桐花树等红树品种，平均密度为0.4万株/公顷。

海南三亚珊瑚礁国家级自然保护区活珊瑚盖度为5～42%，平均为22%。

2.3.2 海洋自然遗迹类保护区

海岸沙丘、贝壳堤、海底古森林、沙滩、岛礁等重点保护海洋自然遗迹资源基本保持稳定。

昌黎黄金海岸国家级自然保护区的海岸沙丘最大高程为37.1米，鞍部高程为21.3米，分别较上年同期升高了1.6米和0.8米；脊线最高点位置移动变幅较大，向西北移动了12.0米。

滨州贝壳堤岛与湿地国家级自然保护区监测到的均为新生贝壳堤，主要分布于大口河、高坨子岛-棘家堡子岛和汪子岛。2013年通过实施修复工程，使上年因风暴潮及海冰等灾害损毁的贝壳堤明显恢复，现有面积为38.6公顷，较上年增加4.0公顷。

2.3.3 海洋生态系统类保护区

东营黄河口、山东龙口黄水河口、山东莱阳五龙河口、江苏小洋口等河口生态系统类保护区，山东莱州、山东蓬莱登州等浅滩湿地生态系统类保护区，山东烟台芝罘岛群、浙江嵊泗马鞍列岛、福建福瑶列岛、福建湄洲岛、福建城洲岛、广东特呈岛等海岛生态系统类保护区，以及浙江洞头、福建长乐、广东雷州乌石等生态系统类国家级海洋公园生物多样性水平总体保持稳定。

Annex 868

China State Oceanic Administration, *Technical Guidelines for Environmental Impact Assessment of Marine Engineering*, National Standards of the People's Republic of China, No. GB/T 19485 -2014 (1 Apr. 2014)

ICS 07.060;13.020.30
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中华人民共和国国家标准

GB/T 19485—2014
代替 GB/T 19485—2004

海洋工程环境影响评价技术导则

Technical guidelines for environmental impact assessment of marine engineering

2014-04-01 发布　　2014-10-01 实施

中华人民共和国国家质量监督检验检疫总局
中国国家标准化管理委员会　发布

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Table of Contents

Foreword

These standards were drafted according to the rules given by GB/T1.1—2009.

These standards replaced GB/T19485—2004 *Technical Guidelines Regarding Assessment of Environmental Impact of Marine Engineering*. Compared to GB/T19485—2004, the main technical changes in these standards are as follows:

——— Added the definition of hybrid regions (See 3.9), deleted the definitions of sub-sensitive regions in ecological environment and non-sensitive regions in ecological environment (3.6 and 3.7 in the 2004 edition);

——— Adjusted types and scales of marine engineering (See 4.4.1, and 4.3.1 in the 2004 edition);

——— Adjusted basis for determining assessment grades (See 4.5.1, and 4.4.2 in the 2004 edition);

——— Added the definitions and requirements on assessment criteria (See 4.6);

——— Added the definitions and requirements on marine survey and monitoring data (See 4.7);

——— Added requirements on the assessment content and methods for coastal ecological environments, landfill materials for land reclamation engineering, environmental protection facilities, emission of pollutants, emission of low-level radiation wastewater, massive marine engineering and construction projects, site selection and optimization of construction projects, and environmental feasibility of construction projects (See Chapter 4);

——— Adjusted and added Chapter 5, perfected and strengthened requirements on the assessment of clean production, environmental protection strategies and measures (See Chapter 5, 4.12 in the 2004 edition);

——— Adjusted partial content in Chapter 6, Chapter 7, Chapter 8, Chapter 9, and Chapter 10 (See Chapter 6, Chapter 7, Chapter 8, Chapter 9, and Chapter 10; Chapter 5, Chapter 6, Chapter 7, Chapter 8, and Chapter 9 of the 2004 edition);

——— Adjusted partial content in normative appendix A (See Appendix A, Appendix B in the 2004 edition);

——— Adjusted partial content in normative appendix C (See Appendix C, Appendix A in the 2004 edition);

——— Revised normative appendix D "Two-dimensional data simulation of tides, sands, and pollution dissemination" (See Appendix D, Appendix D in the 2004 edition);

——— Added normative appendix E "Three-dimensional data simulation of tides, sands, and seabed accumulation" (See Appendix E);

——— Deleted the original informational Appendix E "Survey of pollution sources into the sea" (Appendix E in the 2004 edition);

——— Deleted the original informational Appendix F "Data simulation methods for marine pollutant transportation and dissemination formulas" (Appendix F in the 2004 edition).

These standards were proposed by State Oceanic Administration.

These standards are attributed to National Technical Committee of Marine Standardization (SAC/TC 283).

These standards were drafted by: National Marine Environmental Monitoring Center; Marine Advisory, State Oceanic Administration.

The main drafters of these standards were: Wang Jianguo, Pan Xinchun, Xu Lina, Xiang Youquan, Zhang Guangyu, Si Hui, Han Jianbo, Hu Songqin, Yang Xin, Yang Xigen, Wang Juying, Han Gengchen, Ma Yongan, Sui Jixue, Liang Yubo.

The issuance of previous versions replaced by these standards:

———GB/T 19485—2004.

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1 Scope

These standards stipulate the work procedures, assessment content, technical methodology, and formulation of reports (forms) for the assessment of environmental impact of marine engineering and construction projects.

These standards are applicable to the assessment of environmental impact of marine engineering and construction projects within the waters, territorial seas, and other sea regions under the jurisdiction of the People's Republic of China; assessment of impact on regional marine environments, retrospective assessment of marine environmental impact, and assessment of environmental impact on construction projects involving the sea may also refer to these standards in execution.

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目　　次

前　　言

本标准按照 GB/T 1.1—2009 给出的规则起草。

本标准代替 GB/T 19485—2004《海洋工程环境影响评价技术导则》。本标准与 GB/T 19485—2004 相比的主要技术变化如下：

——增加了混合区的定义(见 3.9)，删除了生态环境亚敏感区和生态环境非敏感区的定义(2004 年版的 3.6、3.7)；

——调整了海洋工程的类型、规模(见 4.4.1，2004 年版 4.3.1)；

——调整了评价等级判据(见 4.5.1，2004 年版 4.4.2)；

——增加了评价标准的释义和规定(见 4.6)；

——增加了海洋调查和监测资料的释义和规定(见 4.7)；

——增加了海岸生态环境、围填海工程的充填材料、环境保护设施、污染物排放、低放射性废液排放、特大型海洋工程建设项目、建设项目的选址与优化、建设项目的环境可行性等评价内容与方法的规定(见第 4 章)；

——调整、增加了第 5 章，完善和强化了清洁生产、环境保护对策措施等评价内容的规定(见第 5 章，2004 年版 4.12)；

——调整了第 6 章、第 7 章、第 8 章、第 9 章、第 10 章的部分内容(见第 6 章、第 7 章、第 8 章、第 9 章、第 10 章，2004 年版第 5 章、第 6 章、第 7 章、第 8 章、第 9 章)；

——调整了规范性附录 A 的部分内容(见附录 A，2004 年版附录 B)；

——调整了规范性附录 C 的部分内容(见附录 C，2004 年版附录 A)；

——修改了规范性附录 D“平面二维潮流、泥沙、污染物扩散的数值模拟”(见附录 D，2004 年版附录 D)；

——增加了规范性附录 E“三维潮流、泥沙、床面冲淤的数值模拟”(见附录 E)；

——删除了原资料性附录 E“入海污染源调查”(2004 年版附录 E)；

——删除了原资料性附录 F“海洋污染物输运扩散方程的数值模拟方法”(2004 年版附录 F)。

本标准由国家海洋局提出。

本标准由全国海洋标准化技术委员会(SAC/TC 283)归口。

本标准起草单位：国家海洋环境监测中心、国家海洋局海洋咨询中心。

本标准主要起草人：王健国、潘新春、许丽娜、向友权、张光玉、司慧、韩建波、胡松琴、杨欣、杨细根、王菊英、韩庚辰、马永安、隋吉学、梁玉波。

本标准所代替标准的历次版本发布情况：

——GB/T 19485—2004。

引　言

为贯彻《中华人民共和国海洋环境保护法》、《中华人民共和国海域使用管理法》、《中华人民共和国环境影响评价法》和《防治海洋工程建设项目污染损害海洋环境管理条例》等法律法规，防止和控制海洋工程对海洋环境的污染，维护海洋环境、资源的可持续开发利用，维护海洋生态平衡和保障人体健康，维护海洋工程所有者的合法权益，结合海洋环境科学的新进展和实际需求，在总结GB/T 19485—2004 实施以来实践经验的基础上，修订本标准。修订内容主要包括：依据海洋工程定义，规范了海洋工程环境影响评价内容；依据海洋工程类型、建设规模、工程所在海域的生态环境特征，给出了环境影响评价等级的界定方法；规范了海洋工程环境影响评价的工作阶段，规范了海洋工程环境影响报告书和报告表的编制内容、要求和格式；规范了环境影响评价应采用的技术标准、质量指标和技术方法；采用实践中的成熟方法，修改了数值模拟的相关内容等。

海洋工程环境影响评价技术导则

1 范围

本标准规定了海洋工程建设项目环境影响评价的工作程序、评价内容、技术方法和报告书(表)编制的要求。

本标准适用于在中华人民共和国内水、领海以及管辖的其他海域内海洋工程建设项目的环境影响评价工作;区域海洋环境影响评价、回顾性海洋环境影响评价和其他涉海建设项目的环境影响评价可参照执行。

2 规范性引用文件

下列文件对于本文件的应用是必不可少的。凡是注日期的引用文件,仅注日期的版本适用于本文件。凡是不注日期的引用文件,其最新版本(包括所有的修改单)适用于本文件。

GB 3097 海水水质标准

GB 3552—1983 船舶污染物排放标准

GB 4914 海洋石油勘探开发污染物排放浓度限值

GB 8978—1996 污水综合排放标准

GB 11215 核辐射环境质量评价一般规定

GB 11216 核设施流出物和环境放射性监测质量保证计划的一般要求

GB 11217 核设施流出物监测的一般规定

GB 11607 渔业水质标准

GB/T 12763(所有部分) 海洋调查规范

GB 14587 轻水堆核电厂放射性废水排放系统技术规定

GB 17378(所有部分) 海洋监测规范

GB 18218—2000 重大危险源辨识

GB 18421 海洋生物质量

GB 18668 海洋沉积物质量

HJ/T 2.1 环境影响评价技术导则 总纲

HJ/T 2.2 环境影响评价技术导则 大气环境

HJ/T 2.3 环境影响评价技术导则 地面水环境

HJ/T 2.4 环境影响评价技术导则 声环境

HJ/T 19 环境影响评价技术导则 非污染生态影响

HJ/T 169—2004 建设项目环境风险评价技术导则

HY/T 076 陆源入海排污口及邻近海域监测技术规程

HY/T 077 江河入海污染物总量监测技术规程

HY/T 078 海洋生物质量监测技术规程

HY/T 080 滨海湿地生态监测技术规程

HY/T 081 红树林生态监测技术规程

HY/T 082 珊瑚礁生态监测技术规程

HY/T 083　海草床生态监测技术规程
HY/T 084　海湾生态监测技术规程
HY/T 085　河口生态监测技术规程
HY/T 086　陆源入海排污口及其邻近海域生态环境评价指南
HY/T 087　近岸海洋生态健康评价指南
SC/T 9110　建设项目对海洋生物资源影响评价技术规程

3　术语和定义

下列术语和定义适用于本文件。

3.1

海湾　bay;gulf

被陆地环绕且面积不小于以口门宽度为直径的半圆面积的海域。

[GB/T 18190—2000,定义 2.1.19]

注:本标准中的海湾不含辽东湾、渤海湾、莱州湾、杭州湾和北部湾。

3.2

河口　river mouth;estuary

具有常年径流入海河流的终端受潮汐和径流共同作用的水域。

注:改写 GB/T 18190—2000,定义 2.5.1。

3.3

近岸海域　nearshore area

距大陆海岸较近的海域。

注:已公布领海基点的海域指领海外部界限至大陆海岸之间的海域,渤海和北部湾一般指水深 10 m 以浅海域。

3.4

沿岸海域　coastal area

近岸海域之内靠近大陆海岸,水文要素受陆地气象条件和径流影响大的海域。

注:一般指距大陆海岸 10 km 以内的海域。

3.5

海洋生态环境敏感区　marine eco-environment sensitive area

海洋生态服务功能价值较高,且遭受损害后较难恢复其功能的海域。

注:主要包括自然保护区,珍稀濒危海洋生物的天然集中分布区,海湾、河口海域,领海基点及其周边海域,海岛及其周围海域,重要的海洋生态系统和特殊生境(红树林,珊瑚礁等),重要的渔业水域、海洋自然历史遗迹和自然景观等。

3.6

海洋工程　marine engineering

以开发、利用、保护、恢复海洋资源为目的,工程主体位于海岸线向海一侧的新建、改建、扩建工程。

注:海洋工程主要包括:围填海、海上堤坝工程;人工岛、海上和海底物资储藏设施、跨海桥梁、海底隧道工程;海底管道、海底电(光)缆工程;海洋矿产资源勘探开发及其附属工程;海上潮汐电站、波浪电站、温差电站等海洋能源开发利用工程;大型海水养殖场、人工鱼礁工程;盐田、海水淡化等海水综合利用工程;海上娱乐及运动、景观开发工程;其他海洋工程。

3.7

海洋水文动力环境影响　environmental impact on marine hydrodynamics

建设项目(包括新建、扩建、改建工程)对波浪、潮汐、潮流和余流、纳潮和水交换能力、温盐结构等水文动力要素产生的影响。

3.8

海洋地形地貌与冲淤环境影响　environmental impact on marine geomorphology,erosion and siltation

建设项目(包括新建、扩建、改建工程)对海岸、滩涂、海床和底土等自然地理条件的改变及其产生的环境影响。

3.9

混合区　mixing zone

向海洋排放的达标污染物稀释扩散后达到周围海域环境质量标准要求时所占用的海域面积。

注:以排水口为中心,以污染物稀释扩散后达到周围海域环境质量标准的最大距离为半径表示的圆面积。

4　总则

4.1　海洋工程环境影响评价成果

海洋工程建设项目的环境影响评价成果包括环境影响报告书和环境影响报告表。

属于1级、2级、3级评价等级的海洋工程建设项目和特大型海洋工程建设项目,应编制海洋工程环境影响报告书。海洋工程环境影响报告书的编制应符合附录A的要求。

报告书内容应清晰、明确、简洁;其中环境现状可依据海洋调查和监测资料,给出数据汇总表和评价指数汇总表,简要阐明水质、沉积物质量、生物质量等环境现状的综合评价结果;环境影响分析预测内容应简要、突出重点,避免理论性、常识性、解释性的说明内容。

评价等级低于3级的海洋工程建设项目,可编制海洋工程环境影响报告表。海洋工程环境影响报告表的编制应符合附录B的要求。

4.2　海洋工程环境影响评价工作阶段

海洋工程环境影响评价工作一般可分为3个阶段(见图1)。编制环境影响报告表的建设项目可简化评价工作阶段。

a)　第一阶段为准备工作阶段,主要工作内容包括:

——研究有关环境保护与管理的法律、法规和政策,研究与工程环境影响评价有关的其他文件;

——搜集历史资料,开展环境现状踏勘,开展建设项目的初步工程分析;

——确定各单项环境影响评价的评价等级和建设项目的评价等级,明确建设项目环境影响评价内容、评价范围、评价标准;

——筛选出主要环境影响要素、环境敏感目标和环境保护目标;

——明确环境现状的调查内容、调查范围、调查项目(要素或因子)、调查站位布设、调查时段、调查频次、分析检测方法、评价方法、应执行的技术标准等;

——筛选、确定主要环境影响评价要素和评价因子;

——明确下阶段环境影响评价工作的重点内容和环境影响报告书的主体内容等。

b)　第二阶段为正式工作阶段,主要工作内容包括:

——开展详细的工程分析;

——按照已明确的环境评价内容、评价范围和重点评价项目,组织实施环境现状调查和公众参与调查;

——依据环境质量要求,分析所获数据、资料,开展环境现状分析、评价评价;

——开展环境影响预测的分析、评价;

——开展清洁生产、环境风险、总量控制等的分析、评价。

c)　第三阶段为报告书或报告表编制阶段,主要工作内容包括:

——依据环境现状调查和预测分析结果,依照环境质量要求,阐明建设项目选址、规模和布局的环

境可行性分析、评价结论；

——给出环境保护的具体对策措施和建议；

——阐明环境管理和环境监测计划。

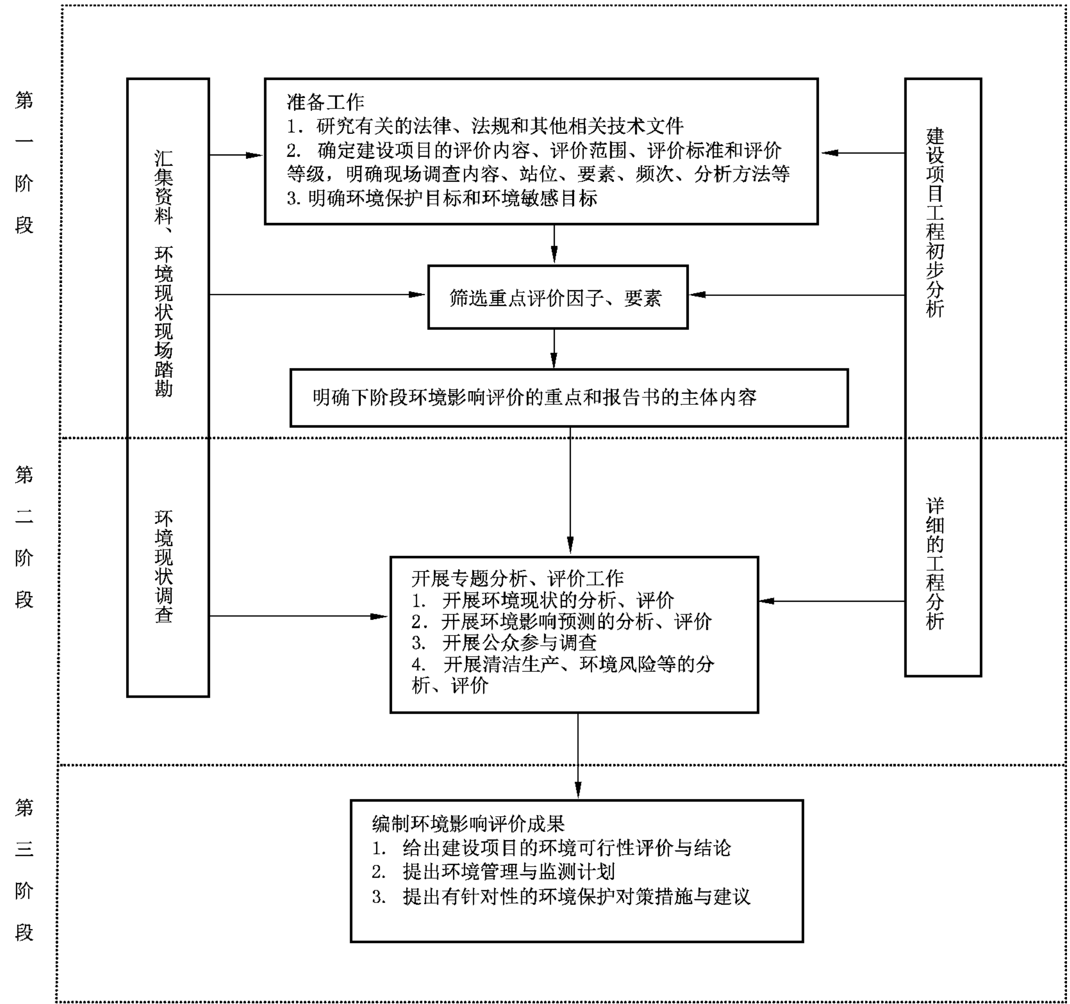

图 1　海洋工程环境影响评价工作阶段框图

4.3　海洋工程环境影响评价工作方案

属于1级评价等级的海洋工程建设项目和特大型海洋工程建设项目，宜编制海洋工程环境影响评价工作方案，其具体内容和格式应符合附录C的要求。

海洋工程环境影响评价工作方案应依据对工程特性和环境特征的初步了解，判定和明确建设项目环境影响评价范围、评价等级、评价标准、主要环境问题、环境敏感目标和主要环境保护对象；初步确定评价内容、评价重点；确定环境现状的调查内容、调查范围、调查项目（要素或因子）、调查站位布设、调查时段、调查频次、分析检测方法、评价方法、应执行的技术标准等评价技术方法和路线；编制用于指导环境影响评价工作的实施方案。

4.4　海洋工程环境影响评价内容与范围

4.4.1　评价内容

海洋工程建设项目的环境影响评价内容，依照建设项目的具体类型及其对海洋环境可能产生的影

响，按表1确定。

表1 海洋工程建设项目各单项环境影响评价内容

建设项目类型和内容	环境影响评价内容						
	海水水质环境	海洋沉积物环境	海洋生态和生物资源环境	海洋地形地貌与冲淤环境	海洋水文动力环境	环境风险	其他评价内容
围填海、海上堤坝工程：城镇建设填海、填海形成工程基础、连片的交通能源项目等填海、填海造地、围垦造地、海湾改造、滩涂改造等工程；人工岛、围海、滩涂围隔、海湾围隔等工程；需围填海的码头等工程，挖入式港池、船坞和码头等；海中筑坝、护岸、围堤（堰）、防波（浪）堤、导流堤（坝）、潜堤（坝）、引堤（坝）、促淤冲淤、各类闸门等工程	★	★	★	★	★	★	☆
海上和海底物资储藏设施、跨海桥梁、海底隧道工程：海上桥梁、海底隧道、海上机场与工厂、海上和海底人工构筑物、海上和海底储藏库等工程；原油、天然气（含LNG、LPG）、成品油等物质的仓储、储运和输送等工程；粉煤灰和废弃物储藏、海洋空间资源利用等工程；海洋工程（水工构筑物）和设施的废弃、拆除等	★	★	★	☆[a]	★	★	☆
海底管道、海底电（光）缆工程：海上和海底电（光）缆等工程；海上和海底输水管道等工程，海洋排污管道等工程，海上和海底石油、天然气等管道输送等工程；有毒有害及危险品物质管道输送等工程；石油、天然气、化学品、有毒有害及危险品管道的废弃、拆除等；海洋电（光）缆废弃、拆除等	★	★	★	☆	☆	★	☆
海洋矿产资源勘探开发及其附属工程：海洋（海底）矿产资源、海洋油（气）开发及其附属工程，天然气水合物开发、海砂开采、矿盐卤水开发等工程，浅（滨）海水库等工程，浅（滨）海地下水库等工程，海床底温泉开发、海底地下水开发等工程	★	★	★	☆[b]	☆[b]	★	☆
海上潮汐电站、波浪电站、温差电站等海洋能源开发利用工程：潮汐发电，波浪发电，温差发电，地热发电，海洋生物质能等海洋能源开发利用、输送设施及网络等工程，风力发电、太阳能发电及其输送设施及网络等工程，海洋空间能源（资源）利用等工程	★	★	★	★	★	★	☆
大型海水养殖场、人工鱼礁工程：大型网箱、深水网箱养殖等工程，大型海水养殖类工程，提水养殖等工程，苔筏养殖等工程，各类人工鱼礁工程，围海养殖、底播养殖等工程	★	★	★	☆	★	☆	☆
盐田、海水淡化等海水综合利用工程：海水脱硫，海水降温（温排水）、增温等工程，盐田、矿盐卤水、盐化工等工程，海水淡化工程，生活和工业海水利用工程，海水热泵、海水直接利用等工程，海水综合利用等工程	★	★	★	☆	★	★	☆

表 1（续）

建设项目类型和内容	环境影响评价内容						
	海水水质环境	海洋沉积物环境	海洋生态和生物资源环境	海洋地形地貌与冲淤环境	海洋水文动力环境	环境风险	其他评价内容
海上娱乐及运动、景观开发工程：滨海浴场、滑泥（泥浴）场、海洋地质景观、海洋动植物景观、游艇基地、水上运动基地、海洋（水下）世界、主题公园、航母世界、红树林公园、珊瑚礁公园等工程	★	★	★	☆	★	★	☆
低放射性废液排海、造纸废水排海、大型温排水等工程	★	★	★	★	★	★	☆[c]
其他海洋工程：工程基础开挖，疏浚、冲（吹）填等工程，海中取土（砂）等工程；水下炸礁（岩），爆破挤淤，海上和海床爆破等工程；污水海洋处置（污水排海）工程等；海上水产品加工等工程	★	★	★	★	☆[d]	★	☆

注 1：★为必选环境影响评价内容；

注 2：☆为依据建设项目具体情况可选环境影响评价内容；

注 3：其他评价内容中包括放射性、电磁辐射、热污染、大气、噪声、固废、景观、人文遗迹等评价内容。

[a] 当工程内容包括填海（人工岛等）、海上和海底物资（废弃物）储藏设施等空间资源利用时，应将地形地貌与冲淤境列为必选评价内容；

[b] 当工程内容为海砂开采、浅（滨）海水库、浅（滨）海地下水库时，应将海洋地形地貌与冲淤环境和海洋水文动力环境列为必选评价内容；

[c] 当工程内容为低放射性废液排放入海工程时，应将放射性、热污染等列为必选评价内容；

[d] 当工程内容包括需要填海的码头、挖入式港池（码头）、疏浚、冲（吹）填、海中取土（沙）等影响水文动力环境时，应将水文动力环境列为必选评价内容。

4.4.2 评价范围

海洋工程建设项目依照评价内容和评价等级，按照第 6 章～第 10 章的具体要求确定各单项评价内容的评价范围。建设项目的总评价范围应覆盖各单项评价范围。

4.5 海洋工程环境影响评价等级

4.5.1 评价等级划分

海洋工程环境影响评价等级，依据建设项目的工程特点、工程规模和所在地区的环境特征划分，按表 2 确定。

工程规模低于表 2 中规模下限（即各单项评价内容均低于 3 级评价等级）的海洋工程建设项目，可编制海洋工程环境影响报告表。

工程规模低于表 2 中规模下限，但位于海洋生态环境敏感区的围海、填海、海湾改造、滩涂改造、盐田、海中筑坝（防波堤、导流堤等）、景观开发、人工鱼礁、排污管道（污水海洋处置）和石油化工等危险物质输送管道工程，应依据工程的特点和所在海域的环境特征，开展专项（题）评价。

表 2　海洋水文动力、海洋水质、海洋沉积物、海洋生态和生物资源影响评价等级判据

海洋工程分类	工程类型和工程内容	工程规模	工程所在海域特征和生态环境类型	单项海洋环境影响评价等级			
				水文动力环境	水质环境	沉积物环境	生态和生物资源环境
围海、填海、海上堤坝类工程	城镇建设填海，工业与基础设施建设填海，区域（规划）开发填海，填海造地，填海围垦，海湾改造填海，滩涂改造填海，人工岛填海等填海工程	$50\times 10^4\ \mathrm{m}^2$ 以上	生态环境敏感区	1	1	1	1
			其他海域	1	2	2	1
		$50\times 10^4\ \mathrm{m}^2$～$30\times 10^4\ \mathrm{m}^2$	生态环境敏感区	1	1	2	1
			其他海域	2	2	2	2
		$30\times 10^4\ \mathrm{m}^2$ 及其以下	生态环境敏感区	1	1	2	1
			其他海域	2	3	3	2
	各类围海工程；滩涂围隔、海湾围隔等围海工程	$100\times 10^4\ \mathrm{m}^2$ 以上	生态环境敏感区	1	1	2	1
			其他海域	1	2	2	1
		$100\times 10^4\ \mathrm{m}^2$～$60\times 10^4\ \mathrm{m}^2$	生态环境敏感区	1	2	2	1
			其他海域	2	2	2	2
		$60\times 10^4\ \mathrm{m}^2$ 及其以下	生态环境敏感区	1	2	2	1
			其他海域	2	3	3	2
	海上堤坝工程；海中筑坝、护岸、围堤（堰）、防波（浪）堤、导流堤（坝）、潜堤（坝）、引堤（坝）等工程；海中堤防建设及维护工程；促淤冲淤工程；海中建闸等工程	长度大于 2 km	生态环境敏感区	1	1	2	1
			其他海域	2	2	2	2
		长度 2 km～1 km	生态环境敏感区	1	2	2	1
			其他海域	2	3	3	3
		长度 1 km～0.5 km	生态环境敏感区	2	2	2	2
			其他海域	3	3	3	3
	需要围填海的集装箱、液体化工、多用途等码头工程；需要围填海的客运码头，煤炭、矿石等散杂货码头；渔码头等工程	年吞吐量大于 100 万标准箱（500 万 t）	生态环境敏感区	1	1	1	1
			其他海域	1	2	2	1
		年吞吐量（100～50）万标准箱（500～100）万 t	生态环境敏感区	1	2	2	1
			其他海域	2	3	3	2
海上和海底物资储藏设施、跨海桥梁、海底隧道类工程	粉煤灰和废弃物储藏工程；海洋空间资源利用等工程；	吞吐（储）量 200 万 t（万 m^3）以上	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		吞吐（储）（200～50）万 t（万 m^3）	生态环境敏感区	1	1	2	1
			其他海域	2	2	2	2
	原油、成品油、天然气（含LNG、LPG）、化学及其他危险品和其他物质的仓储工程，储运、输送工程等；上述工程（水工构筑物）和设施的废弃、拆除等	所有规模	生态环境敏感区	1	1	1	1
			其他海域区	2	1	2	1

表 2（续）

海洋工程分类	工程类型和工程内容	工程规模	工程所在海域特征和生态环境类型	单项海洋环境影响评价等级			
				水文动力环境	水质环境	沉积物环境	生态和生物资源环境
海上和海底物资储藏设施、跨海桥梁、海底隧道类工程	海上和海底物资储藏设施、跨海桥梁工程；海上桥梁、海上机场与工厂、海上和海底物资储藏设施等工程；上述工程（水工构筑物）和设施的废弃、拆除等	所有规模	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	1
	海底隧道工程[a]	所有规模	所有海域	2	3	3	2
海底管道、海底电（光）缆类工程	海上和海底电（光）缆工程；海上和海底输水管道工程；无毒、无害物质输送管道工程；海洋电（光）缆废弃、拆除工程；一般管道废弃、拆除等工程	长度大于 100 km	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	1
		长度 100 km～20 km	生态环境敏感区	2	1	2	1
			其他海域	3	2	3	2
		长度 20 km～5 km	生态环境敏感区	2	2	2	1
			其他海域	3	3	3	2
	海上和海底石油、天然气等输送管道工程；有毒有害及危险品物质输送管道等工程；石油、天然气、化学品、有毒有害及危险品管道的废弃、拆除等工程	管道长度大于 10 km	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		管道长度 10 km～5 km	生态环境敏感区	2	1	2	1
			其他海域	3	2	3	2
		管道长度 5 km～1 km	生态环境敏感区	3	2	2	1
			其他海域	3	3	3	2
	海洋排污管道工程；城市排污管道工程；污水海洋处置等工程	污水排放量大于 30 000 m^3/d	生态环境敏感区	1	1	1	1
			其他海域	2	1	2	1
		污水排放量 30 000 m^3/d～10 000 m^3/d	生态环境敏感区	2	1	1	1
			其他海域	3	2	2	2
		污水排放量 10 000 m^3/d～5 000 m^3/d	生态环境敏感区	2	1	2	1
			其他海域	3	2	3	2
海洋矿产资源勘探开发及其附属工程类	海洋油（气）开发及其附属工程	污水排放量大于 10 000 m^3/d或年产油量大于 100 万 t	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		污水每天排放（10 000～5 000）m^3 或年产油量（100～50）万 t	生态环境敏感区	2	1	2	1
			其他海域	2	2	3	2
		污水排放量（5 000～1 000）m^3/d或年产油量（50～20）万 t	生态环境敏感区	2	2	3	1
			其他海域	3	3	3	2

表 2（续）

海洋工程分类	工程类型和工程内容	工程规模	工程所在海域特征和生态环境类型	单项海洋环境影响评价等级			
				水文动力环境	水质环境	沉积物环境	生态和生物资源环境
海洋矿产资源勘探开发及其附属工程类	海洋(海底)矿产资源开发;天然气水合物勘探开发;海砂勘探开采;矿盐卤水勘探开发;浅(滨)海水库;浅(滨)海地下水库;海床底温泉开发;海底地下水开发等工程	所有规模	生态环境敏感区	1	1	1	1
			其他海域	2	1	2	1
海上潮汐电站、波浪电站、温差电站等海洋能源开发利用类工程	潮汐发电，波浪发电，温差发电，地热发电，海洋生物质能等海洋能源开发利用、输送设施及网络工程;海洋风力发电、太阳能发电及其输送设施及网络工程;海洋空间能源(资源)利用工程;需要填海的火电站等工程	大型(≥100 MW)	生态环境敏感区	1	1	2	1
			其他海域	2	2	2	2
		中型(>20 MW～<100 MW)	生态环境敏感区	1	1	2	1
			其他海域	2	2	3	2
		小型(≤20 MW)	生态环境敏感区	2	2	2	2
			其他海域	3	3	3	3
大型海水养殖场、人工鱼礁类工程	大型网箱、深水网箱养殖;大型海水养殖;高位池(提水)养殖;苔莜养殖等;围海养殖、底播养殖等	用海面积大于 200×10^4 m^2	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		用海面积 200×10^4 m^2～100×10^4 m^2	生态环境敏感区	1	1	2	1
			其他海域	2	2	3	2
		用海面积 100×10^4 m^2～20×10^4 m^2	生态环境敏感区	2	1	2	2
			其他海域	3	3	3	2
	各类人工鱼礁工程	固体物质投放量大于 3 万 m^3	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		固体物质投放量 3×10^4 m^3～1×10^4 m^3	生态环境敏感区	2	1	2	1
			其他海域	3	3	3	2
		固体物质投放量 1×10^4 m^3～0.5×10^4 m^3	生态环境敏感区	2	2	2	2
			其他海域	3	3	3	3
盐田、海水淡化等海水综合利用类工程	海水淡化等海水综合利用工程;海水冲厕等海水直接利用工程;其他生活海水利用工程;海水热泵工程;其他海水综合利用等工程	海水用量大于 10×10^4 m^3/d	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		海水用量 10×10^4 m^3/d～5×10^4 m^3/d	生态环境敏感区	2	1	1	1
			其他海域	3	2	2	2
		海水用量 5×10^4 m^3/d～2×10^4 m^3/d	生态环境敏感区	2	1	2	1
			其他海域	3	2	3	2

表 2（续）

海洋工程分类	工程类型和工程内容	工程规模	工程所在海域特征和生态环境类型	单项海洋环境影响评价等级			
				水文动力环境	水质环境	沉积物环境	生态和生物资源环境
盐田、海水淡化等海水综合利用类工程	利用海水降温、增温等工程；工业海水利用，海水脱硫等工程	海水用量大于 $100\times10^4\ m^3/d$	生态环境敏感区	1	1	1	1
			其他海域	1	2	2	1
		海水用量 $100\times10^4\ m^3/d$～$50\times10^4\ m^3/d$	生态环境敏感区	1	2	2	1
			其他海域	2	2	2	2
		海水用量 $50\times10^4\ m^3/d$～$5\times10^4\ m^3/d$	生态环境敏感区	2	2	2	2
			其他海域	3	3	3	2
	盐田、矿盐卤水、盐化工等工程	用海面积大于 $100\times10^4\ m^2$	生态环境敏感区	1	1	1	1
			其他海域	2	2	2	2
		用海面积 $100\times10^4\ m^2$～$50\times10^4\ m^2$	生态环境敏感区	1	2	2	1
			其他海域	2	2	3	2
		用海面积 $50\times10^4\ m^2$～$20\times10^4\ m^2$	生态环境敏感区	2	2	2	2
			其他海域	3	3	3	2
海上娱乐及运动、景观开发类工程	滨海浴场、滑泥（泥浴）场、海洋地质景观、海洋动植物景观、游艇基地、水上运动基地、海洋（水下）世界、海洋主题公园、航母世界、红树林公园、珊瑚礁公园等工程	污水每天排放 $5\ 000\ m^3$ 以上	生态环境敏感区	1	1	2	1
			其他海域	2	2	2	2
		污水每天排放 $5\ 000\ m^3$～$1\ 000\ m^3$	生态环境敏感区	2	1	2	1
			其他海域	3	3	3	2
		污水每天排放 $1\ 000\ m^3$～$200\ m^3$	生态环境敏感区	3	2	2	2
			其他海域	3	3	3	3
其他海洋工程	水下基础开挖等工程；疏浚、冲（吹）填等工程；海中取土（沙）等工程；挖入式港池、船坞和码头等工程；海上水产品加工工程等	开挖、疏浚、冲（吹）填、倾倒量大于 $300\times10^4\ m^3$	生态环境敏感区	1	1	2	1
			其他海域	2	2	3	2
		开挖、疏浚、冲（吹）填、倾倒量 $300\times10^4\ m^3$～$50\times10^4\ m^3$	生态环境敏感区	2	1	2	1
			其他海域	3	2	3	2
		开挖、疏浚、冲（吹）填、倾倒量 $50\times10^4\ m^3$～$10\times10^4\ m^3$	生态环境敏感区	2	1	3	1
			其他海域	3	2	3	2
	低放射性废液排海、造纸废水排海、大型温排水等工程	所有规模	所有海域	1	1	1	1[b]
	水下炸礁（岩）、基础爆破挤淤、海水中和海床爆破（勘探）等工程	爆破挤淤、炸礁（岩）量大于 $6\times10^4\ m^3$	生态环境敏感区	1	1	2	1
			其他海域	2	2	2	2
		爆破挤淤、炸礁（岩）量 $6\times10^4\ m^3$～$1\times10^4\ m^3$	生态环境敏感区	2	1	2	1
			其他海域	3	2	3	2
		爆破挤淤、炸礁（岩）量 $1.0\times10^4\ m^3$～$0.2\times10^4\ m^3$	生态环境敏感区	2	2	3	1
			其他海域	3	3	3	2

表 2（续）

海洋工程分类	工程类型和工程内容	工程规模	工程所在海域特征和生态环境类型	单项海洋环境影响评价等级			
				水文动力环境	水质环境	沉积物环境	生态和生物资源环境
注：改建、扩建工程的规模宜考虑叠加原工程；并行铺设的海底电(光)缆、海底管道等的长度，宜按总长度计。							
[a] 当海底隧道工程采用明挖(沉管等)方式建设时，应调高相关的单项评价等级。 [b] 低放射性废液排海、造纸废水排海等工程需增加生物遗传多样性分析评价内容。							

4.5.2 评价等级判定

海洋水文动力、海洋水质、海洋沉积物、海洋生态(含生物资源)的各单项环境影响评价等级，依据工程类型、工程规模、工程所在区域的环境特征和海洋生态类型，按表 2 分别判定；建设项目的环境影响评价等级取各单项环境影响评价等级中的最高等级。

同一建设项目由多个工程内容组成时，应按照各个工程内容分别判定各单项的环境影响评价等级，并取所有工程内容各单项环境影响评价等级中的最高级别，作为建设项目的环境影响评价等级。例如，某建设项目由填海、护岸(防波堤)、疏浚、海中取沙(土)、吹填、栈桥等工程内容组成，应按照上述工程内容及其规模，分别判断其海洋水文动力、海洋地形地貌与冲淤、海洋水质、海洋沉积物、海洋生态环境的单项环境影响评价等级，然后取所有评价等级中的最高评价等级，作为建设项目的环境影响评价等级。

海洋地形地貌与冲淤环境评价等级按表 3 判定。

海洋工程的环境风险评价等级应符合 HJ/T 169 的要求。

表 3 海洋地形地貌与冲淤环境影响评价等级判据

评价等级	工程类型和工程内容
1	面积 50×10^4 m^2 以上的围海、填海、海湾改造工程，围海筑坝、防波堤、导流堤(长度等于和大于 2 km)等工程；连片和单项海砂开采工程；其他类型海洋工程中不可逆改变或严重改变海岸线、滩涂、海床自然性状和产生较严重冲刷、淤积的工程项目
2	面积 50×10^4 m^2～30×10^4 m^2 的围海、填海、海湾改造工程，围海筑坝、防波堤、导流堤(长度 2 km～1 km)等工程；其他类型海洋工程中较严重改变岸线、滩涂、海床自然性状和产生冲刷、淤积的工程项目
3	面积 30×10^4 m^2～20×10^4 m^2 的围海、填海、海湾改造工程，围海筑坝、防波堤、导流堤(长度 1 km～0.5 km)等工程；其他类型海洋工程中改变海岸线、滩涂、海床自然性状和产生较轻微冲刷、淤积的工程项目
注：其他类型海洋工程的工程规模可按照表 2 中工程规模的分档确定。	

4.6 评价标准

海洋工程建设项目应按照 GB 3097、GB 18421、GB 18668、GB 4914、GB 11607、GB 3552—1983、GB 8978—1996 等，结合海洋功能区划的环境质量要求，确定评价标准。

采用的评价标准(环境质量标准)应符合海洋功能区的环境功能(质量目标)要求，且不应损害相邻海域的环境功能(质量目标)。

采用国际标准及其他相关标准时，应明确所采用的标准名称、类别和采用的标准值。

采用的评价标准应符合以下要求：

a) 当被评价海域中有不同环境质量标准或标准中的某项(某要素)质量指标不一致时,应以要求严格的环境质量标准为准;
b) 当被评价海域中环境保护目标较多,且有不同环境质量要求时,应以要求最高的保护目标所需的环境质量标准为准;
c) 当被评价海域中依据不同的区划或规划,有不同的环境质量要求时,应当采用符合海洋功能区划和海洋环境保护规划所要求的环境质量标准。

海洋工程建设项目所在海域不具有封闭海域和半封闭海域特征时,采用的评价标准(环境质量标准)应满足评价范围外周边海域的环境质量标准和要求。

4.7 海洋调查和监测资料

4.7.1 海洋调查和监测资料的获取原则

海洋工程的环境现状评价和环境影响预测需使用海洋调查和监测资料。海洋调查和监测资料分为现状资料和历史资料。现状资料指:为满足建设项目环境现状和影响评价要求,通过现场调查、监测后获取的资料。历史资料指:在建设项目开展环境影响评价前已经公开发布或被授权使用的调查、监测资料。

用于海洋工程环境影响评价的海洋调查和监测资料获取原则为:以收集历史资料为主,现场补充调查为辅。充分收集建设项目评价范围内及其周边海域有效的、满足时限性要求的历史资料;当历史资料不能满足海洋工程环境影响评价要求时,通过现场调查获取现状资料予以补充。

4.7.2 海洋调查和监测资料的使用要求

用于海洋工程环境现状评价和环境影响预测的海洋调查和监测现状资料和历史资料(含海洋水文动力、海水水质、海洋沉积物、海洋生态、海洋地形地貌与冲淤等的调查、监测资料),应具备公正性、可靠性和有效性。

提供海洋调查和监测资料的机构或单位,应具有出具社会公证数据的资质,应具有海洋调查、监测的资质、技术能力和设备能力。

使用的历史资料应经过数据分析和质量控制,应按照 GB 17378.2、GB/T 12763.7 中数据分析质量控制的方法和要求、调查资料处理的方法和要求,处理后方可使用。

4.7.3 现状资料和历史资料的公正性、可靠性、有效性

用于海洋工程环境影响评价的所有现状资料,均应提供以计量认证形式出具的分析测试报告(即有 CMA 字样的分析测试报告)或实验室认可形式出具的分析测试报告(即有 CNAS 字样的分析测试报告)。

用于海洋工程环境影响评价的历史资料,均应注明出处,详细列出被引用历史资料的提供机构或单位名称,提供引用文献的公正性、可靠性和有效性的证明材料,提供引用文献的名称、编制单位、编制时间和引用页数等信息;应给出引用历史资料的调查站位、调查内容、调查项目(要素和因子)、调查时间(季节)、调查频次、调查要素和因子的分析检测方法等基本内容。

4.7.4 历史资料的时限性要求

用于海洋工程建设项目环境影响评价的历史资料,应满足下列时限性要求:

a) 海水水质、海洋生态(含生物资源)历史资料应为 3 年以内;
b) 沿岸海域以内的海洋沉积物、海洋地形地貌与冲淤、数值模拟用海洋水文动力历史资料应为 5 年以内;

c) 沿岸海域以外的海洋沉积物、海洋地形地貌与冲淤、数值模拟用海洋水文动力历史资料应为10年以内。

当获取历史资料所依据的环境背景已发生了重大变化，或所采用的分析方法、设备(手段)已被淘汰、替代的，其历史资料不得用于环境现状评价和环境影响预测。

用于环境趋势性变化、年际变化分析的历史资料不受时限性要求的限制。

4.8 环境现状调查

海洋工程环境影响评价的环境现状调查范围应满足反映评价海域环境特征的要求，并应覆盖各单项评价范围。

海洋工程建设项目的环境现状调查站位布设、调查内容(海水水质、海洋沉积物、海洋生物等)、调查项目(要素和因子)、调查时间(季节)、调查频次，应满足环境现状评价的代表性、完整性要求，应满足判定建设项目所处海域环境特征和重点环境问题的要求，应满足建设项目进行环境责任评判的公正性要求，应满足对建设项目实施环境监督管理的要求。

调查站位布设的一般原则是：全面覆盖(范围)，均匀布设，重点代表。

海洋工程建设项目的环境现状调查应注重以下内容：

a) 应明确阐述环境现状的调查范围、调查内容、调查项目(要素或因子)、调查时段(季节)、调查站位布设、调查频次，并应符第6章、第7章、第8章、第9章、第10章的要求。调查站位应给出坐标，调查范围和调查站位应图示。
b) 应阐明调查要素和因子的分析检测方法、执行的技术标准、分析检测仪器设备、分析检出限等，并应符合本标准的要求。

海水水质、海洋沉积物质量的调查监测方法应符合GB 17378、GB/T 12763的要求，海洋生物质量的调查监测方法应符合HY/T 078的要求。

当调查和评价范围位于海洋生态敏感区及其附近海域时，海湾生态、河口生态的调查监测内容和方法应分别符合HY/T 084、HY/T 085的要求；红树林、珊瑚礁、海草床等重要的海洋生态系统和特殊生境的调查监测内容和方法应分别符合HY/T 080、HY/T 081、HY/T 082、HY/T 083的要求。

4.9 环境现状资料

用于环境影响评价的现状资料应满足下列要求：

a) 特大型海洋工程建设项目，须获得海洋水文动力、海水水质、海洋生态(含生物资源)的春、夏、秋、冬四季的现状资料，具体调查站位数量、调查时段等应符合4.8的要求；
b) 1级评价等级的建设项目，须获得海洋水文动力、海水水质、海洋生态(含生物资源)两个季节以上的现状资料，调查内容和具体调查时段等应符合第6章、第7章、第8章、第9章、第10章的要求；
c) 2级评价等级的建设项目，须获得海洋水文动力、海水水质、海洋生态(含生物资源)一个季节以上的现状资料，调查内容和具体调查时段等应符合第6章、第7章、第8章、第9章、第10章的要求；
d) 3级及其低于3级评价等级的建设项目，可收集有效的历史资料。

4.10 特大型海洋工程建设项目

当建设项目的类型和规模符合下列任一指标时，均属于特大型海洋工程：

a) 面积1 000×10^4 m^2 及其以上的填海工程(含城镇建设填海、区域开发填海、石油化工和钢铁项目填海、连片的交通和能源项目填海、填海造地、围垦造地、海湾改造、滩涂改造等)；
b) 面积2 000×10^4 m^2 及其以上的围海工程(含围海、滩涂围隔、海湾围隔、围海养殖等)；

c) 长度 5 km 及其以上的跨海桥梁和长度 10 km 及其以上的海上堤坝工程(含海中筑坝、护岸、围堤(堰)、防波(浪)堤、导流堤(坝)、潜堤(坝)、引堤(坝)等);

d) 用海面积 500×10^4 m^2 及其以上的人工岛、海上机场、海上和海底物资储藏设施等工程;

e) 工程量 5 000×10^4 m^3 及其以上的基础开挖,疏浚,冲(吹)填,海中取土(沙)等工程;

f) 工程量 100×10^4 m^3 及其以上的水下炸礁(岩)、爆破挤淤、海水中和海床爆破(勘探)等工程;

g) 用海面积 500×10^4 m^2 及其以上的海洋(海底)矿产资源开发、连片和单项海砂开发、天然气水合物开发、矿盐卤水开发等工程;

h) 长度 4 km 及其以上的明挖式海底隧道工程(直径或边长大于 50 m 的箱涵、管线、管道)工程;

i) 用海面积 1 000×10^4 m^2 及其以上的盐田、矿盐卤水、盐化工等工程;

j) 库容 10×10^8 m^3 及其以上的浅(滨)海水库,浅(滨)海地下水库等工程;

k) 长度 100 km 及其以上的石油、天然气管道工程,长度 50 km 及其以上的化学品、有毒有害及危险品管道工程;

l) 海水用量 500×10^4 m^3/d 及其以上的海水降温、增温、工业海水利用、海水脱硫等利用工程(包括核电厂、火电厂等);

m) 污水排放(海)量 30×10^4 m^3/d 及其以上的造纸、海洋排污管道、城市排污管道、污水海洋处置等工程。

特大型建设项目应获取评价范围内春、夏、秋、冬四季的海洋水文动力、海水水质、海洋生态和生物资源的现状调查或监测资料。

特大型建设项目应获取两次海洋地形地貌与冲淤、一次沉积物的现状调查或监测资料。

现状调查或监测内容和要素应齐全(应包括生物资源内容)。

特大型建设项目的现状调查或监测范围应大于 1 级评价范围;调查或监测站位的布设数量应符合本标准第 6 章～第 10 章中的要求,在满足 1 级评价要求的基础上适当增加,并满足特大型建设项目环境现状评价和影响预测的需要。

特大型建设项目的环境现状评价和影响预测的范围、深度应在满足 1 级评价要求的基础上适当增加;评价重点内容至少应包括海洋水质环境,海洋沉积物环境,海洋生态环境,海洋地形地貌和冲淤环境,海洋水文动力环境和环境风险等。

4.11 低水平放射性废液排放入海工程

4.11.1 排放要求

确实需要向海域排放低放射性废液的建设项目,应明确低放射性废液中放射性物质的种类、含量和特征,明确排放地点、排放量、排放方式、排放时段、排放频度、稀释方法和稀释率、混合方式和混合范围等排放特征,明确低放射性废液的临时储存方式、防护方法和排放控制方式,明确低放射性废液的检测方法、检测标准和排放监测控制方法;排放的低放射性废液应符合国家放射性污染防治标准。

向海域排放低放射性废液建设项目的放射性废液处理系统的方法和设备要求、处理能力等应符合 GB 14587 的要求。

向海域排放低放射性废液建设项目评价海域的海水、沉积物和海洋生物的核辐射环境质量、环境现状评价、环境预测评价、环境监测和评价结论等,应符合本标准和 GB 11215、GB 11217 的要求。

4.11.2 环境与放射性现状(背景)调查

有低放射性废液排放入海的工程,应获取评价范围内的环境现状调查或监测资料,其中海洋生物要素中应包括生物遗传多样性的调查和评价内容。

有低放射性废液排放入海的工程,应获取低放射性废液排放及其周边海域中海水、沉积物和海洋生

物的放射性现状(背景)调查或监测资料。

4.11.2.1 调查项目和要素

环境现状调查或监测项目中应包含海水、沉积物、海洋生态和生物资源的现状内容,相关的调查要素应符合本标准相应章节的要求。

海洋生物遗传多样性的调查种类应选择当地常见种类,应包括当地常见的、有代表性的藻类、底栖生物和游泳生物。

海洋生物遗传多样性宜采用线粒体 DNA 控制区的常规测序方法进行分析测定,同时宜采用适当方法对样品进行备份并长期保存,以供检测比对。

放射性现状(本底)调查或监测项目中应包含海水、沉积物、海洋生物的天然放射性和人工放射性本底内容,调查要素可包括(参考):

a) 海水水质:总铀、总 β、^{89}Sr、^{90}Sr、^{40}K、^{14}C、^{134}Cs、^{137}Cs、^{54}Mn、^{131}I、^{58}Co、^{60}Co、^{3}H、^{110m}Ag、^{65}Zn、^{106}Rn、^{226}Ra、^{106}Ru 等;

b) 沉积物质量:总铀、总 β、^{90}Sr、^{58}Co、^{60}Co、^{134}Cs、^{137}Cs、^{54}Mn、^{110m}Ag、^{106}Rn、^{226}Ra、^{232}Th、^{40}K、^{106}Ru等;

c) 生物质量:总铀、总 β、^{90}Sr、^{58}Co、^{60}Co、^{54}Mn、^{134}Cs、^{137}Cs、^{110m}Ag、^{226}Ra、^{40}K、^{3}H、^{14}C、^{232}Th、^{65}Zn、^{106}Rn、^{226}Ra、^{106}Ru 等。

4.11.2.2 调查范围和调查站位

环境现状(含海洋生物遗传多样性)和放射性现状(本底)调查或监测的范围,应包括以低放射性废液排放点为中心,半径 30 km～50 km 的海域;调查断面以扇形布置为宜;调查站位的布设应符合全面覆盖、近密远疏、重点代表的原则;调查站位数量应满足调查断面数量(宜不少于 5 条)、每条调查断面中站位设置数量(宜不少于 5 个～6 个站位)、评价范围控制的需要。

4.11.2.3 调查时段和调查频次

放射性现状(本底)和环境现状(含海洋生物遗传多样性)调查或监测资料应在低放射性废液排放工程的可行性研究阶段获得,以满足放射性物质迁移扩散预测分析中叠加放射性本底浓度的需要,以满足排放位置、排放方式等排放工程方案比选和优化的需要,以满足海洋环境影响预测的需要。

环境现状(含海洋生物遗传多样性)调查或监测的频次应符合:海水水质、海洋生态和生物资源的调查频次为 4 次(春、夏、秋、冬四季每季 1 次),沉积物可选择在春、夏、秋三季中调查 1 次。

放射性现状(本底)调查或监测的频次应符合:海水水质、海洋生态的调查频次为 3 次(春、夏、秋三季每季 1 次),沉积物可选择在春、夏、秋三季中调查 1 次。

4.11.3 取排水口方案比选

确实需要向海域排放低水平放射性废水(低放射性废液)的建设项目,应结合温升水排放、污废水排放(余氯和化学废水等)的需求,进行取排水口排放地址、排放方式的方案比选和优化。以温升水、典型放射性元素和污废水在全潮时和潮平均条件下的最大扩散范围为评判指标,以海洋水文动力环境、海洋生态环境、海洋生物、生物资源损害以及工程量、工程造价、工艺难易为评判要素,比较取排水口的排放地点和排放方式,阐明优化结果,并作为建设项目环境可行性的评判指标。

取排水口的选址比选应考虑受纳水体范围内生物、沉积物的放射性长期积累效应和影响。

取排水口不应选址在海湾内和生态敏感区海域,宜选择在有利于水体交换的海湾口外海域和水文动力较强海域。

4.11.4 放射性物质的迁移扩散预测

有低放射性废液排放的工程，应进行详细的放射性物质迁移扩散预测分析；预测方法可采用数值分析方法；预测分析中应叠加放射性核素的本底值；应阐明典型放射性元素在全潮时和潮平均条件下的扩散等值线分布，给出全潮时和潮平均条件下典型放射性核素相对浓度分布图。

4.11.5 跟踪监测

有低放射性废液排放入海的工程，应制定详细的运营期跟踪监测方案，开展低放射性废液长期连续排放对取排水口附近沉积物质量、海洋生物质量的累积效应监测和生物遗传多样性的监测。其监测内容、采样和检测方法、监测结果与记录等，应符合 GB 17378.1～17378.7 的要求。

跟踪监测项目应包括海水、沉积物和海洋生物的典型放射性要素（依据放射性物质迁移扩散预测结果选择），应包括代表性藻类、底栖生物和游泳生物的生物遗传多样性内容。生物遗传多样性的跟踪监测种类、分析方法应与现状调查选择的种类、分析方法相同或相近。

跟踪监测应采用定点监测方法，选择的跟踪监测站位应与现状和本底调查的站位相同或相近；站位应以低放射性废液排放点为中心，选择半径应不小于 50 km 的两条代表性断面中的代表性站位，每条断面的跟踪监测站位应不少于 4 个。

跟踪监测频率：每年应在春、夏、秋三季中选择 2 个季节进行跟踪监测。

低放射性废液排放入海工程运营期跟踪监测的质量保障和质量控制应符合 GB 11216 和 GB 17378 的要求。

4.12 改建、扩建工程

当海洋工程建设项目属于改建、扩建性质时，环境影响报告书和报告表中应增加已建（已运营）建设项目的回顾性环境影响评价篇章，篇章中应对已建（已运营）的工程概况、主要环境问题、原有环评结果与批复（含总量控制）情况、污染物排放状况、污染和非污染（生态）防治控制设施的能力和运行状况、环保设施运行情况、环境事故风险应急设施、采取的环境保护对策措施的有效性、污染防治整改措施、已建项目的环境影响实际结果、环境质量现状等，作出分析评价。

回顾性评价中应充分注重新、老建设项目在污染和非污染（生态）环境影响、污染防控设施的能力、采取的环境保护对策措施、环境风险、污染物排放控制等重要内容之间的相关关系，注重其新、老污染治理和防控能力的分析，注重新、老建设项目环境影响的叠加分析评价，注重环境保护对策措施的实效性、针对性和可操作性分析等内容。

4.13 其他环境影响评价内容

当海洋工程建设项目涉及到放射性、电磁辐射、热污染、大气、噪声、固废、景观、人文遗迹等其他环境影响评价内容时，应按照 HJ/T 2.1、HJ2.2、HJ/T 2.3、HJ/T 2.4 等技术标准的要求进行评价，也可采用现行成熟的评价方法进行评价。

4.14 海岸生态环境

当海洋工程建设项目可能对海岸生态环境（包括近岸自然保护区、近岸和陆地生态系统、海岛生态系统等）产生影响和损害时，报告书和报告表中应增加海岸生态环境的影响分析和评价篇章；其分析评价内容和方法应符合本标准和相关技术标准的要求。

4.15 围填海工程的充填材料

用于围填海工程（含填海造地，围垦造地，围海堤坝填筑，围堤（堰）、防波（浪）堤、导流堤（坝）、潜堤

(坝)、引堤(坝)填筑,工程基础填筑等)的充填材料,应进行填筑材料的理化特性的分析和评价,填筑材料中各类理化物质的含量应符合相关技术标准的要求。禁止容纳危险固体废弃物。

4.16 环境保护设施

报告书和报告表应按照海洋工程的环境保护设施与主体工程同时设计、同时施工、同时投产使用的原则,明确下阶段工作中建设项目应采用的环境保护设施的技术指标、处理工艺和水平、处理能力等具体内容和具体指标的要求,应详细阐述环境保护设施一览表。

4.17 污染物排放

海洋工程建设项目施工期、运营期(含试运行等)排放的污染物种类、排放量、排放地点、排放方式等内容,应符合海洋工程污染物排放的有关管理要求;给出的污染物处理方法、排放浓度控制指标等,应符合国家或者地方规定的排放标准。

在污染物排放总量控制海域,应阐明建设项目污染物排放的总量控制建议值。

在允许污染物排放的海域,达标污染物应优先考虑离岸深水排放方式(不宜采用岸边直接排放方式);应给出污染物(含温升水)扩散混合区及其时空分布范围,其混合区范围和污水排放管道排污口的位置等,应当符合周边海域环境质量和景观等的要求,不应影响所在海域功能区及其相邻海域功能区的环境功能。

区域(连片)和单项海砂开发工程应关注对周边水质环境、生态环境、水动力环境、地形地貌与冲淤环境等环境影响;依据海砂储量、品位和分布特征,关注海砂开采的方式、开采层次和深度,控制日开采强度、年开采总量;应关注开采设备、开采工艺的清洁生产指标。位于区域(连片)开发内的单项海砂开采工程应考虑周边已建、在建和待建工程的叠加环境影响并作为环境可行性的判断依据。区域(连片)和单项海砂开发工程应以海洋生态和环境承载能力为依据,控制和明确污染物的排放强度、排放方式、年排放总量,采取有效、可行的污染防治对策措施,制定合理的跟踪监测方案。

严格限制向海域排放低水平放射性废水(低放射性废液),严格控制含有难降解有机物和重金属的废水排海。

污染物排放的分析、预测应注重下列要求:

a) 明确阐述建设项目施工期、营运期(含试运行等)的污染物排放种类、排放量、排放地点(排污口位置)、排放方式等内容并应图示。
b) 应阐明污染物处理设备(设施)的种类、技术指标、处理能力、工艺水平、过程控制、达标控制等内容;
c) 应阐明污染物排放混合区的具体预测方法,给出扩散混合区范围的确定依据;
d) 应明确污染物处理和排放浓度的控制指标和要求,阐明污染物在取排水口海域的扩散混合区及其时空分布范围和特征;
e) 应明确污染物排放的具体环境保护对策措施。

4.18 环境风险分析

海洋工程建设项目的环境风险分析与评价,应按照 HJ/T 169、GB 18218 和其他有关技术标准的要求,判定建设项目环境风险的危险源和物质危险性,明确环境风险的评价等级、评价内容和源强,按照本标准的要求,开展环境风险的分析与评价。在环境风险分析评价的基础上,阐明有针对性的海洋工程建设期和运营期风险防范对策措施。

具有溢油风险的海洋石油开发和石化、炼化及储藏等工程,应按照 HJ/T 169、GB 18218 和其他有关技术标准的要求,依据工程特征和所处海域的生态环境特征,分析、判定溢油源强并阐明溢油源强的分析计算方法;依据国际、国内的相关统计数据资料,分析、判定工程的环境风险概率,包括船舶碰撞和

直升机坠落等引发的溢油事故风险概率、平台和储油设施火灾爆炸引发的溢油事故风险概率，海底管道泄漏、输油软管破裂、井喷或井涌、立管和软管泄漏等引发的溢油事故风险概率，平台设施、油井等修理、维护过程中引发的溢油事故风险概率等；还应关注海洋石油勘探开发的地质性溢油事故(由人为或未预见的油藏地层中局部压力过高，压裂地层并导致油气窜流到套管以外的地层和海床而造成的溢油事故)的风险概率。

采用回注工艺(或容易引发地质性溢油事故工艺)的工程，应依据工程主体开发(ODP 报告)方案、工程可行性研究报告和相关专题研究报告，阐明钻井溢油风险评估结论和油藏注水溢油风险评估结论。应列表明确工程的安全保护对策措施，应包括回注水压力控制、分层控制、压力和流量动态监测与控制、钻井控制和停注控制等应急处置关键内容。

具有溢油风险的工程，应按照判明的溢油源强，考虑流场及油粒子的扩散特征，结合风场条件，选择代表性风向、风速和典型控制潮时、潮型，考虑周边的生态和环境敏感目标，开展溢油的数值分析预测，应阐明溢油预测分析的边界条件控制和取值方法，明确油品的蒸发、乳化及其在溢油预测中的处理方法；明确溢油到达生态和环境敏感目标的时间和残留油量等数据，明确各种预测条件下溢油特征指标并图示；特征参数预测应符合本导则第 8 章的要求。

应根据海洋工程建设项目编制环境风险应急预案(主要内容包括工程及其相邻海域的环境、资源现状，污染事故的风险分析，应急设施的配备，污染事故的处理方案等)的要求，阐明海洋工程应急预案制定和实施的具体目标、方法、措施和应急设施配置要求等。

具有溢油风险的工程，应制定溢油应急预案，明确应急组织机构图、事故报告程序、应急预案启动程序、应急事故分级响应程序、应急队伍组织和培训及演练等要求；应明确所在海域的区域溢油应急资源现状及分布状况，说明可借助外部应急力量与工程的方位和距离；应阐明应急设备设施到达事故地点的船舶和布设设施设备的配备情况，并分析其机动性、有效性和可行性；依据溢油预测结果，应明确工程应配备的溢油应急设施设备的品种、规格、数量及存放地点等，并分析其机动性、有效性和可行性；从提高各阶段风险应急能力，降低风险概率角度，有针对性的提出风险防范对策措施，明确其具体要求并列表。

4.19 建设项目的政策符合性

海洋工程建设项目应当符合国家产业政策、清洁生产政策、节能减排政策、循环经济政策、集约节约用海等要求。建设项目在评价海域内的环境保护标准(评价标准)应符合相应海洋功能区划和海洋环境保护规划的要求，不应影响海洋功能区的环境质量控制要求或者损害相邻海域的功能。

4.20 建设项目的选址与优化

海洋工程建设项目须进行项目选址(选线)、工程布置方案和环境方案的比选和优化。在拟选地址、工程规模、工程总平面布置、环境保护与污染物处置等方面，以环境影响的方式、范围、程度，对周边海洋生态和海洋功能的影响，环境风险等作为比选要素，进行多方案的方案比选和优化。

区域(连片)和单项海砂开发工程应避免在冲蚀区、地质不稳定区等水动力、地形地貌与冲淤环境敏感区选址。

海洋工程建设项目的选址(选线)、规模、类型等应当符合海洋功能区划、海洋环境保护规划、区域发展规划和相关的产业发展规划。

4.21 建设项目的重新选址

当建设项目存在下述任一状况时，可提出建设项目进行重新选址或重新设计等评价结论和要求：

a) 建设项目的选址(选线)、建设规模、总平面布置、用海方式等不符合现行有效的海洋功能区划、海洋环境保护规划；
b) 建设项目的主体装备、技术设备、工艺水平、能源消耗、减少排放等不符合国家的产业政策、环

境保护政策和清洁生产要求；

c) 建设项目向海域排放的污废水种类、浓度、数量、排放方式和混合区范围等不符合国家或者地方规定的排放标准；

d) 建设项目的建设或运营产生的环境影响，不能满足评价海域和周边海域环境质量保护和控制要求，不能满足保有一定环境容量冗余的要求；

e) 建设项目的建设或运营对周边海洋环境、海洋生态、主要环境保护目标和环境敏感目标将产生重大的不利影响和环境压力；

f) 建设项目的建设或运营对评价海域和周边海域水动力环境、地形地貌环境与冲淤环境将产生重大的不利影响；

g) 建设项目对海洋生态和生物资源将产生重大压力和损害；

h) 建设项目存在重大的且不能承受的环境风险和环境隐患。

重新选址或重新设计后的建设项目应重新开展环境影响评价。

4.22 海洋工程环境影响报告表编制

编制海洋工程环境影响报告表的建设项目，应开展简要的水文动力环境、海洋地形地貌与冲淤环境、水质环境、沉积物环境、海洋生态和生物资源和其他内容的环境现状、环境影响预测的分析与评价。

海洋工程建设项目环境影响报告表的编制内容和格式应符合附录B的要求。

5 海洋工程环境影响报告书的编制

5.1 总论

总论应全面、准确地反映建设项目海洋工程环境影响评价任务的由来和评价目的；报告书编制依据（包括法规依据、技术标准依据和工程技术文件等）；明确评价所采用的技术方法与路线，包括确定评价等级和评价范围、确定环境影响评价内容、筛选出评价重点、确定评价标准（环境质量标准和污染物排放标准）等；明确环境敏感目标与环境保护目标；明确分析预测与评价方法；阐明环境影响要素识别与评价因子筛选原则、方法和结果等。

5.1.1 评价技术方法与路线

5.1.1.1 评价内容和评价重点

依照建设项目的类型、规模和环境特征，明确建设项目各单项环境影响评价内容。

应全面、准确地分析建设项目施工、运营、废弃等各阶段和环境事故状态下的环境问题（包括污染与非污染环境问题），并分析、筛选出主要环境问题及评价重点。

建设项目其他评价内容（包括放射性、电磁辐射、热污染、大气、噪声、固废、自然保护区、景观、人文遗迹等）的确定，应符合建设项目的特征，符合 HJ/T 2.1、HJ2.2、HJ/T 2.3、HJ/T 2.4 等技术标准的要求。

5.1.1.2 评价范围

应按照本标准第6章、第7章、第8章、第9章、第10章的要求，确定建设项目各单项评价内容的评价范围。

建设项目的评价范围应覆盖各单项评价内容的评价范围，评价范围应给出图示，明确评价面积和四至范围（或坐标）。

5.1.1.3 评价等级

建设项目海洋水文动力环境、海洋水质环境、海洋沉积物环境、海洋生态环境和海洋地形地貌与冲淤环境的评价等级应符合本标准的要求；环境风险评价等级应符合 HJ/T 169－2004 的要求。

5.1.1.4 评价标准

海洋工程建设项目评价标准的界定应符合本标准的要求。

5.1.2 环境保护目标和环境敏感目标

应依据建设项目的主要环节问题和环境特征，全面、准确地识别和筛选出环境保护目标和环境敏感目标。

应明确建设项目的环境保护目标及其具体环境质量要求；清晰阐明各环境敏感目标(对象)的方位、距建设项目的距离、环境功能等具体内容和要求并图示。

5.2 工程概况

应详细阐明建设项目的工程概况，注重以下内容：

a) 建设项目的名称、地点，地理位置(应附平面位置图)，建设规模与投资规模(扩建项目应说明原有规模)；
b) 建设项目的总体布置(应附总体布置图，包括附属工程)和建设方案；
c) 建设项目利用海洋完成部分或全部功能的类型和利用方式、范围、面积和控制或利用海水、海床、海岸线和底土的类型和范围，包括占用海域、海岸线的类型、面积和长度，涉及的沿海陆域面积等；
d) 建设项目的典型结构布置图、剖面图，主要工程结构的布置、结构和尺度；典型地质剖面图；
e) 建设项目的基础工程结构、布置，施工组织和工艺、分项工程量、进度计划等；
f) 项目依托的公用设施(包括给排水、供电、供热、通信等)；
g) 生产物流与工艺流程的特点，原(辅)材料、燃料及其储运，原(辅)材料、燃料等的理化性质、毒性、易燃易爆性等，用水量及排水量等；
h) 主体和附属工程的生产工艺及水平、工程施工方案、工程量及作业主要方法、作业时间等。

5.3 工程分析

5.3.1 基础资料和一般要求

海洋工程建设项目的工程分析应以规划报告、工程可行性研究报告(或工程初步设计)、工程专题研究报告等技术文件和资料为基础资料和分析依据。

海洋工程建设项目的工程分析应关注工程建设、运营和废弃过程中，在评价范围内海域和周围海域产生的污染、非污染(包括水文动力、地形地貌与冲淤、生态等)主要环境问题，包括：污染和非污染环节、污染和非污染要素和源强、评价因子的识别、分析评价内容和重点等。

5.3.2 生产工艺和过程分析

应开展详细的生产工艺和过程分析并注重下列内容：

a) 详细分析生产工艺过程、产污环节(应附工艺流程图)和产生的污染、非污染(生态)环境影响环节；
b) 详细分析建设项目的资源、能源、原辅材料、产品等的运输、储运、预处理等环节的环境影响

（包括污染与非污染环境影响）及途径等；

c） 详细分析建设项目基础工程建设过程中的产污环节和产生的污染、非污染（生态）环境问题；

d） 详细分析建设项目的用水、节水方法和途径；水量来源、用途的详细分析及其水量平衡分析并列表；

e） 详细分析建设项目的土石料来源、用途，给出土石料平衡分析并列表；给出反映工程特点的物料来源、用途的详细分析及其平衡分析表；

f） 详细分析并阐明建设项目利用海洋完成部分或全部功能的类型和利用方式、范围，分析并阐明建设项目控制或利用海水、海岸线和海床、底土的类型和范围等。

5.3.3 污染环节与环境影响分析

应详细分析工程的污染环节与环境影响，注重下列内容：

a） 详细分析建设项目施工、生产运行、废弃等各阶段中的产污环节；

b） 详细分析和核算建设期、运营期、废弃期各种污染物的源强、产生量、处理工艺、处理量、排放量、排放去向和排放方式等；

c） 详细分析和核算建设期、运营期和废弃期中各种污染物的污染源强；

d） 列出建设期、运营期和废弃期的污染要素清单；

e） 详细分析各种污染物的治理、回收和利用的流程，分析项目运行与污染物排放间的关系。

污染要素清单内容一般应包括：序号、污染物名称、产污环节、污染物产生量、污染物处理量、污染物处理工艺、污染物排放量、污染物排放源强、污染物排放去向、污染物排放方式和排放地点等内容。

5.3.4 非污染环节与环境影响分析

应详细分析工程的非污染环节和环境影响，注重下列内容：

a） 详细分析建设项目各个阶段产生的非污染环境要素和产生环节；

b） 详细分析和核算建设期、运营期、废弃期各种非污染影响的产生方式、主要影响要素，分析和明确其主要影响类型、影响方式、影响内容、影响范围和可能产生的后果；

c） 详细分析和核算各阶段中各种非污染影响要素的主要控制因子和强度，列出非污染环境影响要素清单。

非污染环境影响要素清单内容一般应包括：序号、非污染要素名称、产生环节、产生方式、主要控制因子和强度、环境影响类型、影响方式、影响内容、影响范围和可能产生的后果等内容。

5.3.5 环境影响要素和评价因子的分析与识别

应明确给出环境影响要素和评价因子的分析与识别的结果，并注重以下内容：

a） 阐明建设项目各阶段环境影响要素和评价因子的识别范围、识别内容和筛选方法；

b） 阐明项目建设、运营、废弃等各阶段的环境影响要素（包括污染要素和非污染要素）和评价因子的筛选结果；

c） 明确项目建设、运营、废弃等各阶段的主要环境影响要素和主要环境影响评价因子；

d） 明确各评价因子的评价内容、评价范围和评价要求等内容。

列出环境影响要素和评价因子分析一览表（示例见表4）。

表 4 环境影响要素和评价因子分析一览表(示例)

评价时段	环境影响要素	评价因子	工程内容及其表征	影响程度与分析评价深度	报告书中分析评价内容所在章节
建设期	海洋生态	底栖生物	填海和构筑物掩埋	+++	7.2.1
		鱼卵仔鱼	航道疏浚、港池开挖产生悬浮物	++	7.3.2
		陆域生态	滩涂植被破坏	+	8.2.2
	海洋水文动力	纳潮量	填海和构筑物影响	+++	6.2.1
	海水水质	悬浮物	航道疏浚、港池开挖产生悬浮物	+++	7.2.4
……	……	……	……	……	……
注 1:+ 表示环境影响要素和评价因子所受到的影响程度为较小或轻微,需要进行简要的分析与影响预测; 注 2:++ 表示环境影响要素和评价因子所受到的影响程度为中等,需要进行常规影响分析与影响预测; 注 3:+++ 环境影响要素和评价因子所受到的影响程度为较大或敏感,需要进行重点的影响分析与影响预测。					

5.3.6 环境影响要素和评价因子分析一览表

编制环境影响要素和评价因子分析一览表应注意以下问题。

评价时段包括:建设(施工)期、运营期、废弃期等。

环境影响要素的内容包括:海洋水文动力、海洋地形地貌与冲淤、海水水质、海洋沉积物、海洋生态、生物资源、自然保护区、环境空气、环境噪声、固体废物、放射性、电磁辐射、热污染、景观、人文遗迹、社会环境等。

应按照建设项目的环境特征选和环境影响要素和评价因子分析与识别结果,择有代表性的评价因子并应符合本标准第 4 章、第 6 章、第 7 章、第 8 章、第 9 章、第 10 章的要求。

工程内容及其表征:指由工程分析得到的环境影响内容及其主要表现形式,一般包括:填海、航道疏浚、港池开挖,清淤、疏浚物倾倒、填海围堰溢流口排放的悬浮物,水下炸礁(爆破),基础爆破挤淤(爆夯),基础开挖,海中取沙土吹填,填海和构筑物造成的水动力、冲淤的时空变化,填海和构筑物对生物、生境的损害,施工产生的废水、固废和生活垃圾,施工船舶增加的航运影响,施工机械噪声,污水排海,底放射性废水排海,余氯排放,温升(温降)水排放,机械卷载,烟尘、粉尘排放,溢油、火灾、爆炸等环境事故等。

影响程度与分析评价深度:指针对某一评价因子及其对应的环境影响内容及其主要表现形式,经工程分析判断出的环境影响程度,以及针对这一评价因子应开展的环境影响评价和预测的内容要求与工作深度,一般用符号标识。

分析评价内容所在章节:列出分析评价内容所在的章节号或页码。

5.4 海域和陆域自然与社会环境现状

5.4.1 陆域自然与社会环境现状

当海洋工程建设项目与临近陆域依托关系紧密时,应阐明和分析建设项目所在陆域的自然和社会环境现状。主要包括:

a) 现有行政区划、人口,城市(或城镇)规模,现有工矿企业和城建区的分布状况,人口密度,交通运输状况及其他社会经济活动等概况;

b） 自然保护区、自然景观及分布；重要的政治和文化设施状况；人群健康状况等；
c） 工程周边现有主要污染源状况，包括主要污染物的产生量、处理量、排放量、排放去向和排放方式等；应标明或图示主要排污口位置；
d） 陆域环境现状，包括大气、生态等环境现状；
e） 项目所在陆域及周边的环境敏感目标现状与分布，环境敏感目标的类型、现状与分布等；给出各环境敏感目标的功能、方位、距建设项目的距离。

5.4.2 海域自然与社会环境现状

应阐明和分析建设项目所在海域及其周围海域的自然和社会环境现状。主要包括：

a） 海洋自然资源（主要包括生物资源、矿产资源、港口资源、景观资源、湿地和滩涂资源、野生生物资源等）现状；
b） 各种海洋资源的开发利用类型和程度，海域的开发利用类型和程度，现有海洋工程和设施的分布状况等；
c） 海岸线、海域的类型；海岸带和海域的地质、地形地貌特征与演变；海域的水文动力情况；区域的气候与气象状况。

项目所在海域及周边海域的环境敏感目标现状与分布，环境敏感目标的类型、现状与分布等；给出各环境敏感目标的功能、方位、距建设项目的距离。

5.5 环境现状评价

5.5.1 一般原则

海洋工程建设项目的环境现状评价应在获取准确、有效的现状资料、充分收集有效的历史资料基础上开展，并应满足下列一般原则：

a） 环境现状的评价范围、评价内容和评价结果，应满足环境现状评价的代表性、完整性要求，应满足判别建设项目所处环境特征、重点环境问题的要求；
b） 环境现状的评价结果应满足全面、客观的基本要求，宜采用表格方式列出各个调查站位、各个采样层次调查（或收集资料）要素的检测值、依据评价标准得出的标准指数值；
c） 应分析污染要素（超标要素）的分布和特征；针对特殊测值和现象应给出至因分析；
d） 应阐明评价范围内和周边海域的环境现状的分析评价结果；应阐明评价范围内和周边海域的环境敏感区、海洋功能区环境现状的分评价结果；
e） 应结合工程所在海域最新的国家、省市和地级市的海洋环境质量公报和其他有公正数据性质的资料，简要阐明建设项目评价范围内和周边海域的水质环境的季节特征、年际和总体变化趋势的分析评价结果。

5.5.2 应关注的问题

海水水质现状的分析与评价中应注重下述要求：

a） 同一站位不同采样层次和不同站位同一采样层次的同一要素，不应采用平均值进行分析和评价；
b） 水质调查要素在平面域的分析评价中，分析数据宜在调查站位控制的评价范围内向内侧插值；
c） 当某一环境要素（因子）超过评价标准时，应继续评价至符合（或劣于）的最大类别标准（例如：某要素超一类水质标准、超二类水质标准、符合三类水质标准）；

海洋生态环境现状的分析评价中应注重下述要求：

——海洋生态要素的现状评价应依据调查特征值，分别给出优势度、物种多样性、均匀度、种类丰度、种类相似性和群落演替等分析评价内容；

——生物量应选择有代表性的调查或监测资料进行分析、评估，不宜采用平均值进行分析。

5.6 环境影响预测与评价

环境影响预测与评价应注重以下内容：

a) 阐明建设项目各单项评价内容（包括海洋水文动力环境、海洋地形地貌与冲淤环境、海水水质环境、海洋沉积物环境、海洋生态和生物资源等）在建设期、运营期等各阶段的环境影响预测与评价的内容、要素、范围、时段及污染要素和非污染要素的特性；

b) 应按照建设项目的特征，选择合理、适用的影响预测与评价方法、数值模式或其他技术手段；

c) 阐明预测模式的预测准确度（可置信区间与实测数据的检验等），给出的预测准确度应满足主管部门监督管理的需要，满足环境保护指标和工程设计等的要求；

d) 应明确阐述建设项目各阶段中污染与非污染预测要素（因子）对环境的影响内容、范围与程度的结论；

e) 应注重水文动力环境（河口、海湾等半封闭海域和环境敏感海域应关注水交换能力）、波浪输沙、地形地貌冲淤、污染物迁移扩散、溢油等的预测分析；注重特征影响因子长期累积效应的预测分析；

f) 应阐明污染物在预测条件下的超标最大分布范围及面积，即超标因素全覆盖状态下的最大外包络线位置与分布；

g) 明确阐述建设项目各阶段中污染与非污染预测要素（因子）可能造成的资源损失量的估算内容和结果；阐明环境损害（价值）的估算内容和结果。

5.6.1 数值预测

当采用数值方法进行预测分析时，应注重下列内容：

a) 预测采用的源强应科学、合理，一般宜采用最大源强；

b) 预测采用的网格尺度（步长）应满足预测精度的要求；

c) 预测主要参数的简化和估值方法等应准确、合理，并应给出依据；

d) 预测模式采用的边界条件、初始条件、计算域、计算参数等计算条件的选取应准确、合理，应与建设项目的特征相一致；

e) 选取的预测范围、预测因子（要素）、预测时段应适用；

f) 应采用合理的检验方法，对预测结果的准确度进行检验；

g) 预测结果的准确度应满足分析评价和管理要求。

5.6.2 类比分析

当采用类比方法进行预测分析时，应注重下列内容：

a) 客观、准确地分析工程与类比对象之间的工程特征相似性（包括建设项目的性质、建设规模、内容组成、产品结构、工艺路线、生产方法、原料燃料来源与成分、用水量和设备类型等）；

b) 客观、准确地分析工程与类比对象之间的污染与非污染特征相似性（包括污染物排放类型、浓度、强度与数量，排放方式与去向，以及污染与非污染方式与途径等）；

c) 客观、准确地分析工程与类比对象之间的环境特征相似性（包括气象条件、水动力条件、地貌状况、生态特点、环境功能、区域污染情况等）。

依据上述分析，以安全原则为判别标准，阐述类比分析结果和验证结果。

5.7 环境风险分析与评价

有环境风险的建设项目，应进行工程环境风险的分析、预测与评价，并注重以下要求：

a) 依照 GB 18218—2000 的要求，进行建设项目环境风险的危险源判定和物质危险性判定；
b) 依照 HJ/T 169—2004 的要求，明确建设项目的环境风险评价等级和评价内容；
c) 阐明建设项目在施工阶段、生产阶段等各阶段可能产生的环境风险的主要因子(含污染与非污染因子)、影响范围及其可能产生的环境影响、损害和潜在环境影响、损害；
d) 详细分析和核算发生环境风险(事故)状况下主要因子的源强、排放量、排放方式和位置等内容。
e) 应阐明建设项目环境风险的危害识别与风险分析(潜在危险性)的内容和方法；应阐明各阶段发生环境事故的风险概率(事故频率)；
f) 应明确发生各类环境风险时，各种污染物(溢油、化学危险品等)的泄漏规模与源强；应预测或分析污染物的迁移扩散路径与范围；
g) 应明确预测污染物的迁移扩散路径与范围采用的方法，阐明预测采用的边界条件、初始条件、计算域、计算参数等计算条件，明确有关参数的估值方法等；
h) 应阐明污染物迁移扩散的路径、扫海面积与时空分布特征，明确对周边环境敏感点和环境敏感目标的影响与作用；
i) 给出的污染物迁移扩散的路径、时空分布特征等应满足分析评价环境风险预案和制定环境风险应急对策措施的要求；
j) 阐明环境风险的分析与评价结论。

5.8 清洁生产

建设项目的清洁生产评价，应满足环境可行性和环境保护对策措施有效性分析的要求，应满足环境监督管理的要求，应给出建设项目清洁生产水平的比较分析结果。

针对建设项目的环境影响(包括污染与非污染环境影响)特点和环境保护要求，应详细分析、评价建设项目各阶段的清洁生产内容，主要包括清洁生产的目的与要求，清洁生产的工艺与流程，清洁生产的控制与管理等，并注重下列要求：

a) 应详细分析建设项目建设、运营等各阶段的生产工艺、方法和设备的清洁生产指标达标状况；
b) 分析建设项目采用的设备、工艺等与国家和行业相关法规和清洁生产要求的符合性；
c) 分析、评价建设项目采用的回收利用废弃物，避免或减少使用有毒有害原料，减少施工和生产过程中的污染因素，采用少废、无废工艺流程及有效的控制措施等内容与清洁生产要求的符合性；
d) 分别从行业、区域等角度，分析、评价建设项目提高资源利用率，优化废物处置的方法和途径等循环经济的符合性；
e) 分析、评价建设项目采用的节能、节水、节约土地等对策措施的实效，并分析与相关清洁生产、节能减排等的符合性；
f) 分析、评价建设项目的污染防治、废物处置设备、对策措施与循环经济理念、相关法规政策和技术标准要求的符合性；
g) 分析、评价建设项目的单位能耗、单位产值、单位附加值、单位占用海域面积、单位占用海岸线尺度、单位耗水、单位占地、单位绿化面积、节能、减排等的具体数据，并应与相关技术指标或要求进行比较分析；
h) 分析、评价建设项目的污水、废气和固废等污染物的处理率、回收率等数据，并应与相关技术指标或要求进行比较分析；

i) 应给出建设项目与同类项目清洁生产的国际、国内比较分析内容，给出清洁生产水平处于国际先进、国内先进、国内一般水平等定量、定性评价结果；
j) 提出建设项目清洁生产方案和对策措施(包括主要设备和工艺等)的改进建议，必要时提出替代方案。

5.9 总量控制

应阐明建设项目建设阶段和运营阶段的污染物排海方式和排海总量，并注重下列要求：

a) 阐明环境质量控制要求和污染物排放总量的预测、分析和控制方法；
b) 阐明应受控污染物排放混合区的时空分布；
c) 阐明应控制的污染物要素和污染物排放削减方式和方法的建议值，给出受控污染物排放总量控制的措施和方法，明确污染物排放总量控制方案和建议值；
d) 阐明污染物排放总量控制对策措施，明确排放方式、地点等的要求与建议；
e) 采用的总量控制措施应能满足排放浓度控制、排放总量控制、混合区范围控制和功能区环境质量控制的要求。

5.10 环境保护对策措施

5.10.1 总体要求

海洋工程建设项目的环境保护对策措施，应具有针对性、有效性和技术经济可行性，应满足环境保护目标的环境质量控制要求，应满足环境质量跟踪监测和环境监督管理的要求。

针对建设项目的环境影响(包括污染与非污染环境影响)特点和环境影响分析评价结果，应详细给出建设项目各阶段的环境保护对策及措施，并符合下列要求：

a) 根据项目污染与非污染的环境特征，提出项目建设阶段、运营阶段等各阶段的污染与非污染环境保护对策、措施；
b) 提出的环境保护对策措施，污染物处置措施，环境保护、恢复、替代或补偿方案等，应具有针对性和有效性；
c) 提出的污染防治对策措施等应满足环境质量控制目标和相关环境保护政策的要求；
d) 提出的环境保护对策、措施，应具备技术可行性、经济合理性，并可作为环境监督管理的依据。

5.10.2 污染防治对策措施

5.10.2.1 建设阶段的对策措施

建设阶段污染物预防、控制和治理对策措施应考虑以下原则和要求：

a) 应明确和给出有效的预防、控制工程产生的悬浮物、污废水、固体废弃物等的对策措施；
b) 应明确和提出施工污废水、施工垃圾、生活污水、生活垃圾等污染物的有效处置措施；
c) 应依据工程所在海域的环境特征，提出最佳的排污方式、地点和时段的对策措施；

应编制建设项目的施工工艺与主要设施设备控制一览表，阐明监管要求。

5.10.2.2 运营阶段环境保护对策措施

运营阶段水质环境、沉积物环境的环境保护对策措施应考虑以下原则和要求：

a) 应针对运营阶段各个产污环节、各类污染物特征，明确和给出有效的污染物处置对策措施；
b) 在实行污染物排放总量控制的区域和海域，应明确和给出污染物排放总量控制的要求、总量控制建议值、污染物总量削减对策措施；
c) 应依据工程所在海域的环境特征，提出最佳的污染物排放方式、排放位置和排放时段的对策

措施；

d) 在满足海域环境质量保护目标要求的前提下，应阐明合理的排污混合区位置和范围，明确提出有针对性的防控对策措施；

e) 应依据环境风险的预测结果，明确和提出有针对性的、可行的环境风险应急预案和防控对策措施；

应编制建设项目的运营期环境保护对策措施一览表，阐明环保控制节点和监管要求。

5.10.3 海洋生态和生物资源保护对策措施

结合工程区域的海洋生态和生物资源特征，根据海洋生态和生物资源现状评价和预测结果，针对海洋生态和生物资源损害的可逆影响、不可逆影响、短期不利影响、长期不利影响、潜在不利影响和复合影响等特征，编制建设项目的生态保护对策措施一览表；针对分析的生物资源损失量和特征，阐明具体修复方案或补偿方案。

5.10.4 环境风险防范对策措施

应结合环境风险分析预测结果，阐明针对建设项目环境风险拟采取的防范对策措施和应急方法，编制环境风险防控对策措施一览表，明确风险应急设施、设备配备的名称、规格、数量等要求。

应阐明建设项目环境风险的应急预案制定和实施的原则、目标、方法和主要内容，包括应急设施和器材、配置地点、机动性、通讯联络、应急组织、应急反应程序等内容。应按照企业自救、属地管理、区域联防的原则，说明本工程风险应急体系与有关各级风险应急体系之间的关系，以及一旦发生环境风险时各级风险应急体系所起作用等内容；应分析拟采取的防范对策措施和应急预案的可行性、有效性。

5.10.5 其他评价内容的环境保护对策措施和建议

海洋工程建设项目涉及到放射性、电磁辐射、热污染、大气、噪声、固废、景观、人文遗迹等内容时，按照 HJ/T 2.1、HJ 2.2、HJ/T 2.3、HJ/T 2.4 等技术标准的要求，提出建设项目在建设阶段、生产阶段的污染与非污染环境保护对策措施和建议。

5.10.6 环境保护设施和对策措施及环保竣工验收一览表

应明确列出工程项目的环境保护设施和对策措施及环保竣工验收一览表，作为建设项目环境保护对策措施的主要内容和环境监督管理的重要依据之一。

这些一览表中应包括环境保护对策措施项目，具体内容（含污染防治的技术指标，技术设备，主要设备的规格、型号、能力，排放量、排放浓度和浓度控制等），规模及数量，预期效果，实施地点及投入使用时间，责任主体及运行机制等必要的内容。一览表的格式和内容可参照表 5 的示例。

5.11 环境保护的技术经济合理性分析

应详细分析、评价建设项目环境保护对策措施的技术经济合理性，包括以下内容：

a) 应阐明、分析建设项目的总投资和经济效益（包括直接、间接经济效益等）；

b) 应阐明、给出建设项目的环境保护设施和环境保护投资（包括环保设施、管理和监测机构的建设及运行费用等），给出生态、海洋生物和生物资源的修复、补偿投资；

c) 估算建设项目的环境直接、间接经济收益；估算建设项目的环境直接、间接经济损失；明确环境保护投资占项目总投资的比例，评价环境保护投资的合理性；

d) 针对围填海工程，应分析、评估围填海成本和围填海经济效益；围填海成本中应考虑直接成本、维护成本、生态资源损失和生态系统服务功能损失等要素，围填海经济效益中应考虑土地地价、土地的经济贡献率等要素；

e) 从经济损益角度分析和评价环保对策措施的可行性、合理性；

f) 给出建设项目环境保护的技术经济的合理性、可行性分析与评价结论。

表 5 建设项目环境保护设施和对策措施一览表(示例)

序号	环境保护对策措施	具体内容	规模及数量	预期效果	实施地点及投入使用时间	责任主体及运行机制
一、污水处理	含油污水处理	隔油池、油水分离器	隔油池 5 m^3,油水分离器 1 台,处理能力 1 t/h	处理后排入污水处理系统,处理回用	综合库机修间附近,与机修间同步建设	××有限公司负责建设、使用和管理
	矿石污水处理	矿石污水处理站	调节池 1 座 4 000 m^3,加药及混凝沉淀设备 1 套,沉淀池 1 座,处理能力 2 00 m^3/h	处理后回用,非正常工况在码头前沿排放入海	堆场附近,与堆场工程同步建设	
	码头面污水收集与处理	污水收集池和配套管道	20 m^3 集水池 1 个,15 m^3 集水池 1 个,污水泵 2 台,DN150 管线 1 000 m	收集码头面初期雨污水,送矿石污水处理站处理	码头及栈桥,与码头工程同步建设	
	生活污水处理	生活污水处理站	格栅井 1 座,SBR 处理设备 1 套,过滤及消毒装置各 1 套,处理能力 40 m^3/d	处理后回用,非正常工况在码头前沿排放入海	生产辅助区,与辅助区同步建设	
	船舶污水处理	船舶压载水接收处理设施	DN400 污水管线 2 500 m,150 m^3 生物灭活缓冲池 1 座,高效压载水生物灭活装置 1 套	收集船舶压载水,送处理设施处理	码头、栈桥及堆场区附近,与码头及堆场工程同步建设	
	……	……	……	……	……	……
二、环境风险防控	事故应急	应急设施及预案	围油栏 1 000 m,纤维式吸油材料 2 t,消油剂 1 t、消油剂喷洒装置等;环境污染事故应急预案	预防、处理船舶事故性污染	码头区,与码头工程同步建设	××有限公司负责建设、使用和管理
	……	……	……	……	……	……
三、海洋生态和生物资源保护	生态补偿	采用增殖放流方法补偿	需补偿的生物损失量 61.71 t	按照相关主管部门的要求,按时完成增殖放流的品种、数量	工程附近海域,施工完成后的 2 年内完成	××有限公司负责组织落实,可委托专业单位完成
	山体生态修复	植树、播撒草籽、土工布和截水沟等	浆砌片石 750 m^3,浆砌块石 2 502 m^3,喷植混生 2.85 hm^2,种树 12 666 株,植草 1.05 hm^2,土工布 7 090 m^2,编织袋 1 550 m^3	防治生态破坏	堆场区、辅助区、山体开挖区等,施工期同步进行	××施工单位负责实施
	……	……	……	……	……	……
四、其他环境保护对策措施	粉尘防治	洒水喷淋设施和管道系统等	喷淋设施 120 套,管网长约 4 000 m,除尘泵房 1 座;水池 2 座,容积共 4 000 m^3	增加矿石含湿量,减少起尘	堆场周边区域,同堆场工程同步建设	××有限公司负责建设、使用和管理
	……	……	……	……	……	……
……	……	……	……	……	……	……

5.12 公众参与

应阐明公众参与的调查目的、调查范围、调查内容、调查方法和调查形式，并应符合下列要求：

a） 公示和抽样调查表格设计的内容应公正、全面、合理；
b） 当采用公示和抽样调查方式时，应在调查表格的工程概况介绍中，向被调查对象公正、客观地告知建设项目的工程概况、主要环境问题、可能的影响范围和影响程度等关键内容；
c） 应明确给出公示的途径方法，明确分析方法；
d） 抽样调查中应详细列出对单位团体及个人的调查范围，调查表格发放、回收方式，调查样本数量及回收率，被调查者中利益相关者的数量、比例等；
e） 抽样调查表中应列出被调查者的通讯地址、通讯方式等相关信息；
f） 公示内容和典型调查表的影印件应列入报告书或附录中；
g） 应阐明和分析被调查对象的分类方法及调查结果的反馈机制，应充分注重不同意见和建议；
h） 应阐明详细的调查分析结果和分析结论。

5.13 海洋工程的环境可行性

5.13.1 总体要求

应设专章分析评价海洋工程建设项目的环境可行性。

应分析、评价工程建设与海洋功能区划和海洋环境保护规划的符合性，与区域和行业规划的符合性，工程建设与国家产业政策、清洁生产政策、节能减排政策、循环经济政策、集约节约用海政策等的符合性，工程选址（选线）合理性，工程平面布置和建设方案的合理性，分析评价工程建设引发的污染、非污染环境影响的可接受性，阐明建设项目的环境可行性分析评价结论。

5.13.2 与海洋功能区划和海洋环境保护规划的符合性

建设项目的选址、类型和规模应符合现行有效的海洋功能区划和海洋环境保护规划的要求。

应给出详细、准确并带有图例的海洋功能区划图、海洋环境保护规划图和相应的海洋功能区登记表等文字说明内容，明确海洋功能和环境质量的要求；阐明建设项目与海洋功能区划和海洋环境保护规划的符合性分析结果。

5.13.3 与区域和行业规划的符合性

建设项目的选址、类型和规模应符合海洋经济发展规划、区域发展规划、城市发展规划、行业发展规划等现行有效的相关规划的内容和要求。

应阐明详细、准确并带有图件、图例的相关规划及相应的文字内容；阐明建设项目与区域和行业规划的符合性的符合性分析结果。

5.13.4 工程建设的政策符合性

应分析、评价建设项目采用的技术措施和环境对策与国家产业政策、清洁生产政策、节能减排政策、循环经济政策、集约节约用海政策、环境保护标准等的符合性，给出具体的分析评价结果。

5.13.5 工程选址与布置的合理性

应通过海洋工程建设项目的选址（选线）、工程平面布置方案和建设方案的比选和优化，分析、评价工程选址与布置的合理性。建设项目的选址（选线）、工程平面布置方案和建设方案的比选和优化，应符合 4.20 的要求。

5.13.6 污染、非污染环境影响的可接受性

应依据环境现状、环境影响预测的结果，分析工程建设产生的污染、非污染环境影响的性质、范围、程度，评估其环境压力和隐患，评价其环境影响的可接受性。

应从建设项目向海域排放的污染物种类、浓度、数量、排放方式、混合区范围，对评价海域和周边海域的海洋环境、海洋生态和生物资源、主要环境保护目标和环境敏感目标的影响性质、范围、程度，对水动力环境、地形地貌与冲淤环境不可逆影响的范围、程度，产生环境风险或环境隐患的概率、影响性质、范围等方面，详细分析其环境影响的可接受性，明确评价结论。

5.14 环境管理与环境监测

5.14.1 环境保护管理计划

应明确环境保护管理计划的主要内容和要求：

a） 阐明建设项目的环境保护管理计划，明确环境管理的内容、任务；
b） 明确环境管理机构设置、管理制度、检测设施及人员配置等要求；
c） 明确环境监理计划和具体内容、任务等要求；
d） 评价建设项目拟采取的环境保护管理计划的可行性和实效性。

5.14.2 环境监测计划

环境监测计划应包括以下主要内容：

a） 应依据环境影响评价与预测结果，提出环境监测计划；监测计划应体现区域环境特点和工程特征；
b） 应明确环境监测站位、监测项目、监测方法、监测频率等主要内容；
c） 应明确监测单位的资质要求和提交有效的计量认证跟踪监测分析测试报告等要求；
d） 评价建设项目拟采取的环境监测计划的可行性和实效性。

可按照 HY/T 076、HY/T 077、HY/T 078、HY/T 080、HY/T 081、HY/T 082、HY/T 083、HY/T 084、HY/T 085 中的监测站位、监测项目等的要求制定环境监测计划。

5.15 环境影响评价结论

海洋工程建设项目的环境影响评价结论应在各单项内容的环境影响评价结论的基础上形成。评价结论应归纳、阐述水文动力、地形地貌与冲淤、水质、沉积物、海洋生态和生物资源以及其他内容的环境影响评价结果，评价结论应简洁、明晰。

评价结论中应阐明建设项目各单项评价内容的环境影响范围和程度的定量或定性结论；应明确建设项目各单项内容的环境影响评价结论，应阐明建设项目在各个阶段能否满足环境质量要求的评价结论，应阐明建设项目的类型、规模和选址是否合理的评价结论，应明确建设项目的环境可行性的评价结论。评价结论应包括以下主要内容：

a） 建设项目的工程分析结论；
b） 建设项目的环境现状分析与评价结论；
c） 建设项目的环境影响预测分析与评价结论；
d） 建设项目的海洋生态与生物资源影响分析、预测与评价结论；
e） 建设项目对主要环境敏感目标和海洋功能区影响的分析、预测与评价结论；
f） 建设项目的环境风险影响分析、预测与评价结论；
g） 建设项目的清洁生产分析评价结论和总量控制建议；

h) 建设项目应采用的具体环境保护对策措施、生态修复与补偿对策措施；
i) 建设项目应采用的环境保护设施的主要内容和具体指标；
j) 建设项目的公众参与分析与评价结论；
k) 建设项目环境保护的技术经济合理性分析结论；
l) 建设项目的区划、规划和政策符合性结论；
m) 建设项目的选址和建设方案合理性结论；
n) 建设项目的环境管理与监测计划；
o) 建设项目的环境可行性的结论。

提出建设项目选址、布置、设计、建设和环境保护策略、环境监测、环境监督管理等方面的其他意见和建议。

5.16 环境影响评价报告书附件

建设项目的海洋环境影响评价报告书附件主要包括：

a) 建设项目前期工作的相关文件、相关资料；
b) 建设项目环境影响评价工作委托书(合同书)；
c) 以计量认证(CMA)分析测试报告或实验室认可(CNAS)分析测试报告形式给出的现场调查、勘测、监测数据资料；
d) 公众参与调查表的代表性影印件；
e) 其他应附附图、附表和参考文献等。

6 海洋水文动力环境影响评价

6.1 通则

6.1.1 评价等级

根据建设项目所在海域的环境特征、工程规模及工程特点，海洋水文动力环境影响评价等级划分为1级、2级和3级。

建设项目的海洋水文动力环境影响评价等级依据表2的等级判据确定。

6.1.2 调查范围

水文动力环境的调查范围，应符合：

a) 调查范围应大于或等于评价范围；调查范围以平面图方式表示，并给出控制点坐标；
b) 1级评价等级的建设项目应进行水文动力环境的现状调查；
c) 2级和3级评价等级的建设项目应以收集近5年项目所在海域的历史资料为主，当所收集的资料不能全面地表明评价海域水文动力环境现状时，应进行必要的现场补充调查。

6.1.3 评价范围

1级、2级和3级评价等级建设项目的水文动力环境评价范围，应符合：

a) 垂向(垂直于工程所在海域中心的潮流主流向)距离：一般分别不小于5 km，3 km和2 km；
b) 纵向(潮流主流向)距离：1级和2级评价项目不小于一个潮周期内水质点可能达到的最大水平距离的两倍，3级评价项目不小于一个潮周期内水质点可能达到的最大水平距离；
c) 评价范围以平面图方式表示，并给出控制点坐标。

6.1.4 评价与预测内容

海洋水文动力环境影响评价包括现状评价和预测评价，并应符合如下规定：

a) 1 级、2 级、3 级评价等级的建设项目，应结合海岸线、海底地形地貌的现状调查和水文动力环境的现状调查，评价海域的水文动力环境现状；

b) 建设项目明显改变海岸线、海底地形地貌等自然地理属性时，应对项目建成后由于海岸线、围填海和构筑物(新形成的地形改变)、海底地形地貌的改变所引起的水文动力的环境变化及其影响，进行预测分析与评价。在预测分析与评价中应分别对建设阶段和营运阶段的水文动力环境影响进行预测分析和评价。

6.2 调查和监测资料的使用

现状资料和历史资料的公正性、可靠性、有效性和时效性等应满足第 4 章的要求。

用于海洋水文动力环境现状评价的数据资料获取原则是：以收集有效的、满足评价范围和评价要求的历史资料为主，以现场补充调查获取的现状资料为辅。

应尽量收集与建设项目有关的历史资料和相应图件，注明其来源和时间；图件应标明等深线、主要岛屿、港口、航道、海岸线和海上建筑物等内容。图件比例尺应尽可能大。

收集的历史资料应包括：水温、盐度、潮流、流向、流速、波浪、潮位、气象要素(气压、气温、降水、湿度、风速、风向、灾害性天气)等。海冰区还应包括海冰要素资料。

历史资料使用时应经过筛选，并符合 GB 17378.2 和 GB/T 12763.7 中海洋调查资料处理的方法和要求。

6.3 环境现状调查

6.3.1 调查内容与方法

海洋水文动力环境的现状调查内容应包括：水温、盐度、潮流(流速、流向)、波浪、潮位、悬浮物、泥沙冲淤、水深、气压、气温、降水、湿度、风速、风向、灾害性天气等项目。

调查方法应按照 GB/T 12763 的要求执行。

6.3.2 调查站位布设

海洋水文动力环境的现状调查站位布设应符合下列要求：

a) 调查断面和站位的布设应符合全面覆盖(范围)，重点代表的站位布设原则；

b) 调查断面和站位的布设应满足数值模拟或物理模型试验的边界控制和验证的要求；

c) 垂直评价海域的主潮流方向布设的断面，1 级评价项目一般应不少于 3 条断面，每条断面应布设 2 个～3 个站位；2 级评价一般应不少于 2 条，每条断面应布设 2 个～3 个站位；3 级评价项目可结合评价需要，适当减少调查断面和站位；

d) 特大型建设项目的断面、站位应在满足 1 级评价要求的基础上适当增加，并应满足水动力环境现状评价与影响预测的需要。

6.3.3 数据分析、处理的质量控制

海洋水文动力环境调查监测资料的数据分析和内部质量控制应符合 GB/T 12763.2 和 GB 17378.2 中的相关要求。

6.4 环境现状评价

海洋水文动力环境现状评价应结合海岸线和海底地形、地貌现状调查结果，详细、全面地阐述海洋

水文、气象要素的现状分布与变化特征，并附以图表说明。主要应包括：

a） 各季节海水温度和盐度的平面分布、断面分布及周日变化；

b） 潮汐潮流特征：潮汐特征及类型，涨、落潮流最大值及方向；余流大小与方向；涨、落潮流历时；涨、落潮流随潮位（涨、落潮）的运动规律及旋转方向；

c） 流场特征与变化，涨、落急和涨、落潮的特征流速；

d） 潮位特征及其变化；典型潮位时的纳潮量及其变化；典型潮位时的水交换量、物理自净能力；

e） 悬沙场的特征；

f） 最大风速、最小风速、平均风速及变化规律，典型日平均风速，主导风向、风速及频率等。

6.5 环境影响预测

6.5.1 预测内容

1 级、2 级评价等级的建设项目的预测重点包括：

a） 预测工程后的潮流和余流的时间、空间分布性质与变化，包括涨、落潮流和余流的最大值及方向，涨、落潮流历时，潮流的运动规律及旋转方向等；

b） 预测工程后流场的特征与变化，含涨、落急和涨、落潮段平均流的特征及其变化；

c） 预测工程后的潮位特征及其变化，悬沙场的特征及其变化；预测波浪输沙、风暴骤淤等特征；

d） 海湾内的建设项目，应预测大、小潮的纳潮量及其变化，海湾水交换量、物理自净能力及其变化。

3 级评价等级的建设项目的预测重点包括：

——预测工程后的潮流时间、空间分布性质与变化；包括涨、落潮流最大值及方向，涨、落潮流历时，涨、落潮流随潮位（涨、落潮）变化的运动规律及旋转方向等；

——海湾内的建设项目，应预测工程后的典型潮位时的纳潮量及其变化，物理自净能力及其变化。

6.5.2 预测方法

可采用以下方法进行海洋水文动力环境的影响预测：

a） 模型实验法，包括数值模拟法和物理模型实验法；其中物理模型实验法适用于复杂海域或对水文动力和泥沙冲淤要求较高的影响预测项目；一般评价项目可采用数值模拟法；

b） 近似估算法，适用于评价等级较低的影响预测项目；

c） 类比法，适用于有成熟实践经验和检验结果，且具备类比条件的预测项目；

d） 采用数值模拟法时，其方法、结果和精度等应符合附录 D 和附录 E 的要求；

e） 数值模拟的具体计算，应根据计算域地形特征、项目布置方案等具体情况，采用成熟、可靠的方法；

f） 海湾内的建设项目，宜选用染色数值实验、粒子追踪或半交换周期等方法，分析、预测和评价物理自净能力变化及其时空分布特征。预测范围应覆盖整个海湾；

g） 低放射性废水排海、温升水和造纸废水排海、典型污染物等迁移扩散的分析预测，宜采用三维水动力模型，对于平均水深小于 10 m 的海域，也可采用二维模型；应连续模拟若干个大、中、小潮；并以连续半月潮作为校核；

h） 预测模式的空间分辨率应不大于 100 m，工程影响区的空间分辨率应不大于 50 m；

i） 预测模式的水陆边界宜采用动边界，以模拟海水的“漫滩”和“露滩”；海湾内如滩涂面积超过海湾总面积的 10%，水陆边界应采用动边界；

j） 开边界的潮位边界条件，宜采用已知潮位或潮汐调和常数形式给出；在采用潮汐调和常数形式给出时，至少取 K_1、O_1、M_2、S_2、M_4 和 MS_4 6 个分潮；

k) 数值模型应经不少于 2 个站位的潮汐、3 个站位的潮流实测资料予以验证。

6.6 环境影响评价

海洋水文动力环境影响评价的内容和结果应符合以下要求：

a) 依据建设项目的工程方案，分析评价各方案导致的评价海域水文环境要素的变化与特征，从环境影响和环境可接受性角度，分析和优选最佳工程方案；
b) 综合分析评价工程前后的流场变化、纳潮量变化、水交换能力及物理自净能力变化的环境可接受性；
c) 根据建设项目引起的流场、潮位场、波浪场、纳潮量、水交换能力等变化情况，结合泥沙冲淤、污染物浓度场等预测结果，分析评价和阐明项目建设对海洋地形地貌与冲淤、海洋水质、海洋生态等可能产生的环境影响范围、影响程度的定量或定性结论；
d) 阐明对环境保护目标、环境敏感目标和周边海域生态环境影响程度的定量或定性结论；
e) 明确建设项目对海洋水文动力环境影响的评价结论；
f) 明确建设项目的水文动力环境影响是否可接受的结论。

应根据海洋水文动力环境影响评价结果，有针对性地提出减缓水文动力环境影响的对策措施。

若评价结果表明建设项目对海洋水文动力环境产生较大影响和环境不可接受时，应明确环境不可行的分析结论，并提出修改建设方案、总体布置方案或重新选址等建议。

7 海洋地形地貌与冲淤环境影响评价

7.1 通则

7.1.1 评价等级

海洋地形地貌与冲淤环境影响评价等级划分为 1 级、2 级和 3 级。依据表 3 的评价等级判据，确定建设项目的海洋地形地貌与冲淤环境影响评价级别。

7.1.2 调查与评价范围

调查与评价范围应包括工程可能的影响范围，一般应不小于水文动力环境影响评价范围，同时应满足建设项目地貌与冲淤环境特征的要求。

调查与评价范围应以平面图方式表示，并明确控制点坐标。

7.2 调查和监测资料的使用

现状资料和历史资料的公正性、可靠性、有效性和时效性等应满足第 4 章的要求。

用于海洋地形地貌与冲淤环境现状评价的数据资料获取原则是：以收集有效的、满足评价范围和评价要求的历史资料为主，以现场补充调查获取的现状资料为辅。

应尽可能地收集建设项目所在评价海域及其周边海域的地形地貌与冲淤环境历史资料，应特别注重各类卫片、历史图件和现状图件的收集与分析。

海洋地形地貌与冲淤的历史资料主要包括：

a) 地形地貌现状：海岸线、海床、滩涂、潮间带和海岸带地形地貌特征及其变化资料，各种海岸类型（包括河口海岸、砂砾质海岸、淤泥质海岸、珊瑚礁海岸、红树林海岸等）地形地貌的特征及分布范围资料，地面沉降和海岸线、海床、滩涂、海岸等蚀淤资料；
b) 海洋地质现状：地质类型、沉积类型与构造，硫化物、有机质、附着生物等资料；
c) 图件：水深地形图、海岸线图、地质地貌图、遥感图像（卫片、航片）等。

7.3 环境现状调查

7.3.1 调查内容

现状调查的内容包括查清工程评价海域及其周边海域的地形地貌与冲淤环境的分布特征,包括海洋地形地貌、海岸线、海床、滩涂、海岸等的现状,蚀淤现状、蚀淤速率、蚀淤变化特征等,海底沉积环境和腐蚀环境等现状。

7.3.2 调查方法

海洋地形地貌与冲淤环境的现状调查方法应按照 GB/T 12763 中海洋地质地球物理调查的要求执行;腐蚀环境调查方法应按照 GB 17378 的要求执行。

7.3.3 调查断面布设

根据随机均匀、重点代表的站位布设原则,布设的岸滩冲淤调查断面和站位应基本均匀分布并覆盖于整个评价海域及其周边海域。调查断面方向大体上应与海岸垂直,在建设项目主要影响范围和对环境产生主要影响的区域应设调查主断面,在其两侧设辅助断面;1 级评价项目应不少于 3 条调查断面;2 级评价应不少于 2 条断面。特大型建设项目的调查断面应在满足 1 级评价要求的基础上适当增加,并应满足地形地貌与冲淤环境现状评价与影响预测的需要。

7.3.4 调查时段

海洋地形地貌与冲淤环境各要素的调查一般不受年度丰、枯水期的限制,可与海水水质、海洋沉积物、海洋生态和生物资源等评价内容的调查时段一并考虑。

7.3.5 数据分析、处理的质量控制

数据分析和实验室的内部质量控制应符合 GB 17378.2 中的有关规定和实验室质量控制的相关要求。

7.4 环境现状评价

海洋地形地貌与冲淤环境现状分析与评价应包括以下内容:

a) 重点分析与评价建设项目所在海域及其周边海域的海岸、滩涂、海床等地形地貌的现状,冲刷与淤积现状、蚀淤速率、蚀淤变化特征等;
b) 铺设海底管线、海底电缆、海洋石油开发等建设项目应增加海洋腐蚀环境的分析与评价内容。

7.5 环境影响预测

7.5.1 预测内容

预测项目和内容主要包括:

a) 预测建设项目建设期和建成后(含正常工况和非正常工况)和环境风险条件下,对海岸、滩涂、海床等地形地貌、冲刷与淤积的可能影响,并分析评价其产生的影响范围和程度;
b) 1 级评价项目应重点对评价海域及其周边海域的形态变化(包括海岸、滩涂、海床等地形地貌),冲刷与淤积变化,泥沙运移与变化趋势等的范围和影响程度进行预测分析和评价,主要应包括工程后的冲刷与淤积变化、蚀淤速率变化、蚀淤特征变化等内容;
c) 列出冲刷与淤积、泥沙运移与变化趋势等的增加值与稳定值的时空分布图表。

7.5.2 预测方法

预测方法可按下列内容选择：

a) 预测方法可采用模拟实验法(包括数值模拟和模型实验)、图形对比法和近似估算法等方法；

b) 近似估算法适用于3级评价项目。

7.5.3 数值模拟

应采用本标准附录D和附录E的数值模拟方法进行预测。

数值模拟的具体计算，应根据计算域地形特征、项目布置方案等具体情况，采用成熟、可靠的方法。

数值模拟获得的预测结果，应采用调查或最近监测的实测数据予以验证，其验证方法和精度(准确度)应符合附录D的要求。

7.6 环境影响评价

建设项目海洋地形地貌与冲淤环境影响评价结果应符合以下要求：

a) 依据建设项目的工程方案，分析评价各方案导致的评价海域及其周边海域地形地貌与冲淤环境要素的变化与特征，从环境影响和环境可接受性角度，分析和优选最佳工程方案；

b) 根据建设项目引起的海岸线、滩涂、海床等工程后的冲刷与淤积变化、蚀淤速率变化、蚀淤特征的时空变化、泥沙运移与变化等预测结果，结合海洋水文动力、污染物浓度场等预测结果，评价该工程对海域地形地貌和冲刷或淤积的影响；

c) 综合分析评价工程前后的冲刷与淤积变化、蚀淤速率变化、蚀淤特征的时空变化、泥沙运移与变化的环境可接受性；

d) 阐明建设项目对海洋地形地貌与冲淤环境影响的评价结论，阐明建设项目是否满足预期的地形地貌与冲淤环境要求的结论，阐明地形地貌与冲淤的环境影响是否可行的结论。

应根据海洋地形地貌与冲淤环境影响评价结果，提出有针对性的地形地貌与冲淤环境的保护对策措施。

若评价结果表明建设项目对海岸、滩涂、海床等的地形地貌和冲淤产生较大影响，影响海洋工程的功能且环境不能接受时，应阐明环境不可行的分析结论，并提出修改建设方案、总体布置方案或重新选址等建议。

8 海洋水质环境影响评价

8.1 通则

8.1.1 评价等级

海洋水质环境影响评价依据建设项目所在海域的环境特征、工程规模及工程特点，划分为1级、2级和3级三个等级。建设项目的水质环境影响评价分级原则和判据见表2。

8.1.2 调查与评价范围

海洋水质环境现状的调查与评价范围，应能覆盖建设项目的环境影响所及区域，并能充分满足水质环境影响评价与预测的要求。

调查与评价范围应以平面图方式表示，并明确控制点坐标。

8.2 调查监测资料的获取和使用

用于海洋水质环境现状评价的数据资料获取原则是：以收集有效的、满足评价范围和评价要求的、

有效的历史资料为主，以现场补充调查获取的现状资料为辅。

现状资料和历史资料的公正性、可靠性、有效性和时效性等应满足本标准第四章的要求。

使用现状和历史资料时须经过筛选，应按 GB 17378.2 中数据处理与分析质量控制和 GB/T 12763 中海洋调查资料处理的方法和要求，处理后方可使用。

8.3 环境现状调查

8.3.1 调查断面和站位布设

1 级水质环境评价项目一般应设 5 个～8 个调查断面，2 级水质环境评价项目一般应设 3 个～5 个调查断面，3 级水质环境评价项目一般应设 2 个～3 个调查断面；每个调查断面应设置 4 个～6 个测站；调查断面方向大体上应与主潮流方向或海岸垂直，在主要污染源或排污口附近应设调查断面。特大型建设项目的调查断面、站位应按照 1 级评价要求的上限数量布设，并应满足水质环境现状评价与影响预测的需要。

特大型和 1 级、2 级水质环境评价项目的调查站位布设应满足建立环境影响预测数学模型的需要；除设置调查断面和站位外，评价海域内主要污染源或排污口附近应设站位，以建立污染源输入与水质之间的响应关系。水质调查监测站位应均匀分布且覆盖整个评价海域。

建设项目在不同海域布设的海洋水质环境最少调查站位数量应满足表 6 的要求。

当工程性质敏感、特殊，或者调查评价海域处于自然保护区附近、珍稀濒危海洋生物的天然集中分布区、重要的海洋生态系统和特殊生境（红树林、珊瑚礁等）时，水质调查站位应多于最少调查站位数量。

表 6 最少调查站位数量表

评价等级	最少调查站位数量 个		
	河口、海湾和沿岸海域	近岸海域	其他海域
1	20	15	10
2	12	10	8
3	8	8	6

8.3.2 调查时间和频次

应根据当地的水文动力特征并考虑环境特征，依照表 7 确定河口、海湾、沿岸海域、近岸海域和其他海域的水质环境现状的调查时间和频次。

当河口和海湾海域的丰水期水质劣于枯水期时，应尽量进行丰水期调查或收集丰水期有关调查监测资料。

表 7 各类海域在不同评价等级时水质调查时间

海域类型	海洋水质环境影响评价等级		
	1 级	2 级	3 级
河口、海湾和沿岸海域	应进行丰水期、平水期和枯水期（夏季、春或秋季和冬季）的调查；若时间不允许，至少应进行春季和秋季的调查。	应进行丰水期和枯水期（夏季和冬季）的调查；若时间不允许，至少应进行一个水期（或季节）的调查。	至少应进行 1 次调查。
近岸海域	应进行春季、夏季和秋季的调查；若时间不允许，至少应进行一个季节调查。	应进行春季和秋季的调查，若时间不允许，至少应进行一个季节的调查。	至少应进行 1 次调查。

表 7（续）

海域类型	海洋水质环境影响评价等级		
	1级	2级	3级
其他海域	应进行春季和秋季的调查；若时间不允许，至少应进行1次调查。	至少应进行1次调查(春季或秋季)。	至少应进行1次调查。
注：河口及海湾海域，沿岸海域和近岸海域在丰水期、平水期和枯水期(或春夏秋冬四季)中均应选择大潮期或小潮期中的一个潮期开展调查(无特殊要求时，可不考虑一个潮期内高潮期、低潮期的差别)；选择原则为：依据调查监测海域的环境特征，以影响范围较大或影响程度较重为目标，定性判别和选择大潮期或小潮期作为调查潮期。			

8.3.3 调查参数选择

水质调查参数应根据建设项目所处海域的环境特征，环境影响评价等级，环境影响要素识别和评价因子筛选结果，按表8选择，使用时可根据具体要求适当增减。表8中建设项目类型中的具体工程内容，应按照表1、表2中的相应内容确定。

表 8 水质调查参数表

序号	建设项目类型	水质调查参数
1	海上娱乐及运动、景观开发类工程 盐田、海水淡化等海水综合利用类工程	酸碱度、水温、盐度、悬浮物、生化需氧量、化学需氧量、溶解氧、硝酸盐氮、亚硝酸盐氮、氨氮、活性磷酸盐、表面活性剂、石油类、重金属、大肠菌群、粪大肠菌群、病原体等
2	人工岛、海上和海底物资储藏设施、跨海桥梁、海底隧道类工程	酸碱度、水温、盐度、悬浮物、生化需氧量、化学需氧量、溶解氧、硝酸盐氮、亚硝酸盐氮、氨氮、活性磷酸盐、表面活性剂、石油类、重金属等
3	围海、填海、海上堤坝类工程	酸碱度、盐度、悬浮物、化学需氧量、溶解氧、氰化物、硫化物、氟化物、挥发性酚、有机氯农药(六六六、滴滴涕)、石油类、重金属、多环芳烃、多氯联苯等
4	海上潮汐电站、波浪电站、温差电站等海洋能源开发利用类工程 低放射性废液排放等工程	酸碱度、水温、盐度、悬浮物、化学需氧量、氰化物、硫化物、氟化物、挥发性酚、有机氯农药(六六六、滴滴涕)、石油类、重金属、多环芳烃、多氯联苯、放射性核素等
5	大型海水养殖场、人工鱼礁类工程	酸碱度、水温、盐度、悬浮物、生化需氧量、化学需氧量、硫化物、挥发性酚、溶解氧、硝酸盐氮、亚硝酸盐氮、氨氮、活性磷酸盐、大肠杆菌等
6	海洋矿产资源勘探开发及其附属工程类海底管道、海底电光缆类工程 基础开挖，疏浚，冲(吹)填，倾倒，海中取土(沙)，水下炸礁(岩)，爆破挤淤，需填海的码头，挖入式港池、船坞和码头，污水海洋处置(污水排海)，海上水产品加工等其他海洋工程	酸碱度、盐度、悬浮物、化学需氧量、溶解氧、硝酸盐氮、亚硝酸盐氮、氨氮、活性磷酸盐、氰化物、硫化物、氟化物、挥发性酚、有机氯农药(六六六、滴滴涕)、石油类、重金属、多环芳烃、多氯联苯等

8.3.4 样品的采集、保存和分析方法

海洋水质环境的现状调查和监测的样品采集、贮存与运输，应按照 GB 17378.3 和 GB/T 12763.4 中海水化学要素的调查、观测的有关要求执行。样品的分析方法应符合 GB 17378.4 中的要求。

8.3.5 数据分析、处理的质量控制

水质样品分析和数据处理应符合 GB 17378.2 中的要求。

数据分析和实验室的内部质量控制应符合 GB 17378.2 中的有关规定和实验室质量控制的相关要求。

8.4 环境现状评价

8.4.1 评价内容

水质环境现状评价应给出调查站位的平面分布图，给出调查要素的实测值和标准指数值，综合阐述海水环境的现状与特征，主要应包括：

a) 简要评价调查海域海水环境质量的基本特征；针对特殊测值和现象给出致因分析；
b) 结合工程所在海域的其他有公正数据性质的资料，简要阐明建设项目评价范围内和周边海域水质环境的季节特征、年际和总体变化趋势的分析评价结果；
c) 阐明评价范围内和周边海域的环境现状的综合评价结果。

8.4.2 评价标准

评价标准应采用 GB 3097 中的相应指标。有些内容(要素)国内尚无相应标准(指标)的，可参考国际和国外的相关标准(指标)进行评价，同时应符合 4.6 的要求。

8.4.3 评价方法

应采用单项水质参数评价方法，即标准指数法。当有特殊需要时，可采用多项水质参数评价方法，或按照 HJ/T 2.3 的要求执行。

8.5 环境影响预测

8.5.1 资料与数据

水质环境影响预测所需的资料与数据包括：污染源调查数据，水质调查监测数据，海洋生物调查数据，工程分析资料，海域自然环境现状调查资料，海洋功能区划资料和其他相关参考资料。

8.5.2 预测方法

预测方法可按下列内容选择：

a) 模型实验法，包括数值模拟法和物理模型实验法。其中物理模型实验法适用于复杂海域或对预测有特殊要求的建设项目。一般建设项目可采用数值模拟法；
b) 经验公式法(近似估算法)，适用于 2 级、3 级评价项目；
c) 类比法，适用于有成熟的实践经验和检验结果，且具备类比条件的预测项目。

8.5.3 预测项目和内容

预测项目和内容主要包括：

a) 在建设期、运营期(含正常工况和非正常工况)和环境风险事故条件下，分别定量预测分析各主

要污染因子在评价海域的浓度变化(平面分层)及其空间分布;

b) 给出各主要污染因子预测浓度增加值与现状值的浓度叠加分布图(表);

c) 针对污染物(含悬浮物)扩散,应合理选择有代表性的边界控制点,分别计算各控制点在不同潮时状况下的预测浓度增加值,叠加各控制点在各个潮时状况下和现状值的浓度分布,按照各控制点最外沿的连线,明确污染物(含悬浮物)扩散的各标准浓度值的最大外包络线、最大外包络面积及其平面分布;

d) 污染物排海混合区的范围,应阐明全潮时和潮平均条件下达标浓度值的最大外包络线、最大外包络面积及其空间分布,取达标浓度值的最大外包络线距排污口中心点的最大距离为混合区控制半径,明确混合区的最大面积及空间位置;

e) 分析预测海域物理自净能力和环境容量的变化与分布特征;

f) 针对溢油扩散,应分析计算至溢油消散或最终登岸(不再漂移)时段,明确相应于不同时刻的溢油路径、扩散面积、扫海面积、登岸地点和油膜厚度等特征参数。

预测分析中应考虑由建设项目引起的海岸形态、海底地形地貌的改变,对污染因子在评价海域浓度分布状况的影响。

8.5.4 数值模拟

采用数值模拟法时,应符合附录D和附录E的要求。

数值模拟的具体计算,应根据计算域地形特征、项目布置方案等具体情况,采用成熟、可靠的方法。

数值模拟方法获得的预测结果,应采用调查或最近监测的实测数据予以验证,其验证方法和精度(准确度)应符合附录D的要求。

8.6 环境影响评价

建设项目海洋水质环境影响评价的内容和结果应符合以下要求:

a) 依据建设项目的工程方案,分析评价各方案导致的评价海域及其周边海域水质环境要素的变化与特征、物理自净能力和环境容量的变化与特征,从水质环境影响和可接受性角度,分析和优选最佳工程方案;

b) 根据建设项目引起的水质环境要素、物理自净能力和环境容量的变化与特征等预测结果,说明影响范围、位置和面积,同时说明主要影响因子和超标要素;结合海洋水文动力、地形地貌与冲淤、海洋生态和生物资源等预测结果,评价工程建设对水质环境的影响;

c) 阐明评价海域水质环境影响特征的定量或定性结论;

d) 明确建设项目是否能满足预期的水质环境质量要求的评价依据和评价结论。

若评价结果表明建设项目对所在评价海域的海水水质、自净能力和环境容量产生较大影响,不能满足评价范围内和周边海域的环境质量要求,或其影响将导致环境难以承受时,应提出修改建设方案、总体布置方案或重新选址等结论和建议。

8.7 环境保护对策措施

应根据海洋水质环境影响评价结果,提出有针对性的水质环境的保护对策措施,主要应包括:

a) 应针对工程的污废水排放入海,提出污废水处理设施处理技术(方法)水平、处理量、达标率、管道离岸深水排海方式等方面的具体要求;

b) 应提出有效处置工程产生的悬浮物、施工污废水、施工垃圾、生活污水、生活垃圾等污染物的具体对策措施;

c) 应依据工程所在海域的环境特征,提出最佳的污染物排放方式、取排水口位置、排放方式和排放时段的对策措施;

d) 在实行污染物排放总量控制的区域和海域，应明确和提出污染物排放总量控制的要求、总量控制建议值、污染物总量削减对策措施；
e) 在满足海域环境质量保护目标要求的前提下，应给出合理的排污混合区位置和尺度，明确和给出有效的对策措施；
f) 应依据环境风险的预测结果，明确和提出有针对性的、可行的环境风险应急预案和防控对策措施；
g) 应从环境监督管理角度提出必要的环保对策措施和建议。

9 海洋沉积物环境影响评价

9.1 通则

9.1.1 评价等级

海洋沉积物环境影响评价依据建设项目所在海域的环境特征、工程规模及工程特点，划分为 1 级、2 级和 3 级。其分级原则和判据详见表 2。

9.1.2 调查与评价范围

依据建设项目的评价等级确定环境现状调查与评价范围时，应将建设项目可能影响海洋沉积物的区域包括在内，即调查与评价范围应能覆盖受影响区域，并能充分满足环境影响评价和预测的需求；一般情况下应与海洋水质、海洋生态和生物资源的现状调查与评价范围保持一致。

当建设项目所在区域有生态环境敏感区和自然保护区时，调查评价范围应适当扩大，将生态环境敏感区和自然保护区涵盖其中，以满足评价和预测环境敏感区和自然保护区所受影响的需要。

调查与评价范围应以平面图方式表示，并给出控制点坐标。

9.2 调查和监测资料的使用

用于海洋沉积物环境现状评价的数据资料获取原则是：以收集有效的、满足评价范围和评价要求的、有效的历史资料为主，以现场补充调查获取的现状资料为辅。

现状资料和历史资料的公正性、可靠性、有效性和时效性等应满足第 4 章的要求。

使用现状和历史资料时须经过筛选，应按 GB 17378.2 中数据处理与分析质量控制和 GB/T 12763 中海洋调查资料处理的方法和要求，处理后方可使用。

9.3 环境现状调查

9.3.1 调查断面与站位布设

1 级和 2 级评价项目的沉积物环境调查断面设置可与海洋水质调查相同，调查站位宜取水质调查站位量的 50%左右，站位应均匀分布且覆盖（控制）整个评价海域，评价海域内的主要排污口应设调查站位。特大型建设项目的调查断面、站位应在满足 1 级评价要求的基础上适当增加，并应满足沉积物环境现状评价与影响预测的需要。

3 级评价项目的沉积物环境调查站位布设应覆盖污染物排放后的达标范围；一般可设 2 个～4 个断面，每个断面设置 2 个～3 个测站。断面方向大体上应与主潮流方向或海岸垂直，在主要污染源或排污口附近应设主断面。

9.3.2 调查时间

沉积物调查时间应与海洋水质和海洋生态和生物资源调查同步进行，一般进行1次现状调查。

9.3.3 调查参数

沉积物调查参数包括常规沉积物参数和特征沉积物参数。

常规沉积物参数主要包括(参见GB 17378.5中所列各测定项目)：总汞、铜、铅、镉、锌、铬、砷、硒、石油类、六六六、滴滴涕、多氯联苯、狄氏剂、硫化物、有机碳、含水率、氧化还原电位等。可依据海域功能类别，评价等级及评价要求，建设项目的环境特征和环境影响要素识别和评价因子筛选结果进行适当增减。

特征沉积物参数应根据建设项目排放污染物的特点，评价海域和周边海域的海域功能要求及环境影响评价的需要选定，主要包括：沉积物温度、密度、氯度、酸度、碱度、含氧量、硫化氢、电阻率等项目；沉积物中的大肠菌群、病原体、粪大肠菌群等项目。

若港口和航道工程、疏浚工程、围(填)海工程等有疏浚物处置的建设项目处于生态环境敏感区时，应进行疏浚物的生物毒性检验试验。

9.3.4 样品的采集、保存和分析方法

沉积物现状调查时样品的采集、保存与运输应符合GB 17378.3中的要求；样品的分析方法应符合GB 17378.5中的要求。

9.3.5 数据分析、处理的质量控制

沉积物样品分析和数据处理应符合GB 17378.2中的要求。

数据分析和实验室的内部质量控制应符合GB 17378.2中的有关规定和实验室质量控制的相关要求。

9.4 环境现状评价

9.4.1 评价参数

环境现状的评价参数应包括全部调查参数。

9.4.2 评价标准

环境现状的评价标准应采用GB 18668中的质量标准，同时应满足评价海域和周边海域的海洋功能区划中所对应的沉积物环境质量的要求。

9.4.3 评价方法

沉积物质量现状评价应采用标准指数法。

根据沉积物参数实测值，分析评价调查海域的沉积物环境现状及其分布，阐述该区域沉积物环境质量现存的主要问题。

9.5 环境影响预测

采用的沉积物环境影响预测方法应满足环境影响评价的要求。1级评价项目应尽量采用定量或半定量预测方法，2级和3级评价项目可采用半定量或定性预测方法。

9.5.1 预测因子(参数)

应根据建设项目的工程分析结果,结合沉积物环境影响评价等级,在常规沉积物参数和特征沉积物参数中筛选预测因子(参数);甄选的预测因子应具有代表性,数目不宜过多,应能反映建设项目对沉积物环境的影响状况。

9.5.2 预测时段

一般建设项目,应对建设阶段和运营阶段的沉积物环境质量影响进行预测。海洋固体矿产资源开发等建设项目,应进行建设阶段、运营阶段和废弃阶段的沉积物环境质量影响预测。

9.5.3 预测内容与范围

沉积物环境质量影响预测的范围和内容应包括:

a) 预测分析各预测因子的影响范围与程度,应着重预测和分析对环境敏感目标和主要环境保护目标的影响;
b) 有污染物排放入海的建设项目(例如污水排海工程等),应重点预测和分析污染物长期连续排放对排污口、扩散区和周围海域沉积物质量的影响范围和影响程度;
c) 1 级和 2 级评价项目应给出沉积物预测因子的分布和趋势性描述,明确影响范围与程度。3 级评价项目应定性地阐述影响范围与程度。

9.6 环境影响评价

建设项目海洋沉积物环境影响评价的内容和结果应符合以下要求:

a) 依据建设项目的工程方案,分析评价各方案导致的评价海域及其周边海域沉积物环境要素的变化与特征、污染物长期连续排放对沉积物质量的影响特征,从沉积物环境影响和可接受性角度,分析和优选最佳工程方案;
b) 阐述建设项目导致的评价海域和周边海域沉积物环境要素的变化与特征;
c) 应根据各评价因子的平面分布特征说明其影响范围、位置、面积和程度,同时说明主要影响因子和超标要素;结合海洋水文动力、地形地貌与冲淤、海洋生态和生物资源等预测结果,评价该工程对沉积物的环境影响;
d) 阐明评价海域沉积物环境影响特征的定量或定性结论;
e) 阐明建设项目是否能满足预期的沉积物环境质量要求的评价依据和评价结论。

若评价结果表明建设项目对所在评价海域和周边海域的沉积物环境质量产生较大影响,或不能满足环境质量要求和海洋功能要求时,应提出修改建设方案、总体布置方案或重新选址等建议。

9.7 环境保护对策措施

应根据海洋沉积物环境质量和影响预测的评价结果,有针对性地提出沉积物环境的保护对策措施,主要应包括:

a) 从改变排污方式上提出最佳的排污方式和时段的对策措施;
b) 在满足环境质量和海域功能要求前提下,提出科学、合理界定排污混合区的对策措施;
c) 提出在填海(吹填造陆)和港池、航道疏浚等过程中悬浮物扩散的防治对策措施;
d) 从管理角度提出必要的环境保护对策措施,管理方案和跟踪监测方案。

10 海洋生态环境影响评价

10.1 通则

10.1.1 评价等级

海洋生态环境(包括海洋生物资源)影响评价依据建设项目所在海域的环境特征、工程规模及特点,划分为1级、2级和3级。评价等级的分级原则和判据详见表2。

10.1.2 调查评价范围

海洋生态和生物资源的调查评价范围,主要依据被评价海域及周边海域的生态完整性确定;调查与评价范围应覆盖可能受到影响的海域。

1级、2级和3级评价项目,以主要评价因子受影响方向的扩展距离确定调查和评价范围,扩展距离一般不能小于8 km～30 km,5 km～8 km和3 km～5 km。

海洋生物资源的调查评价范围应能够反映建设项目所在海域的资源特征并具有代表性,宜覆盖海洋生态环境的调查评价范围,同时应符合相关技术标准的要求。

调查与评价范围应以平面图方式表示,并给出控制点坐标。

10.2 调查和监测资料的使用

用于海洋生态和生物资源影响评价的数据资料获取原则是:以收集有效的、满足评价范围和评价要求的、有效的历史资料为主,以现场补充调查获取的现状资料为辅。

现状资料和历史资料的公正性、可靠性、有效性和时效性等应满足本标准第四章的要求。

应充分收集评价海域及其邻近海域已有的海洋生态和生物资源的历史资料,包括海域生物种类和数量、外来物种种类数量、渔业捕捞种类及产量、海水增养殖种类与面积、自然保护区类别与范围、珍稀濒危海洋生物种类与数量等。还应收集叶绿素a、初级生产力、浮游植物、浮游动物、潮间带生物、底栖生物、游泳生物、鱼卵仔鱼等的种类组成和数量分布历史资料。

使用现状和历史资料时须经过筛选,应按GB 17378.2中数据处理与分析质量控制和GB/T 12763中海洋调查资料处理的方法和要求,处理后方可使用。

10.3 环境现状调查

10.3.1 调查和监测方法

海洋生态环境的现状调查和监测方法,应符合GB 17378、GB/T 12763、HY/T 078、HY/T 080、HY/T 081、HY/T 082、HY/T 083、HY/T 084、HY/T 085的要求。

海洋生物资源的现状调查方法(包括调查方法、调查断面和站位、调查内容)应符合相关的国家和行业技术标准的要求。

10.3.2 调查断面和站位

根据全面覆盖、均匀布设、生态环境敏感区重点照顾的调查断面和站位布设原则,布设的调查断面和站位,应均匀分布和覆盖整个调查评价海域和区域;调查断面方向大体上应与海岸垂直,在影响主方向应设主断面。各级评价项目调查断面、调查站位的布设可与水质调查相同,可从水质调查站位中选择控制性调查站位,数量一般不少于水质调查站位的60%。特大型建设项目的调查断面、站位应按照1级评价要求的上限数量布设,并应满足生态环境现状评价与影响预测的需要。

当调查与评价海域位于自然保护区,珍稀濒危海洋生物的天然集中分布区,海湾、河口,海岛及其周

围海域，红树林，珊瑚礁，重要的渔业水域，海洋自然历史遗迹和自然景观等生态敏感区及其附近海域时，调查站位应多于最少调查站位数量。

根据全面覆盖、典型代表的潮间带调查断面布设原则，特大型海洋工程建设项目的潮间带调查断面应不少于6条，1级评价等级的建设项目应不少于3条，2级和3级评价等级的建设项目应不少于2条。调查断面中调查站位布设和调查内容，应符合GB/T 12763、HY/T 078、HY/T 080、HY/T 084、HY/T 085等的要求。

10.3.3 调查内容

1级评价项目和特大型建设项目的生物现状调查内容应根据建设项目所在区域的环境特征和环境影响评价的要求，选择下列的全部或部分项目：海域细菌(包括粪大肠杆菌、异养细菌、弧菌等)、叶绿素a、初级生产力、浮游植物、浮游动物、潮间带生物、底栖生物(含污损生物)、游泳动物、鱼卵仔鱼等种类与数量，重要经济生物体内重金属及石油烃的含量，激素、贝毒、农药含量等。有放射性核素评价要求的项目应对调查海域重要海洋生物进行遗传变异背景的调查。

2级评价项目的生物现状调查内容应根据建设项目所在区域的环境特征和环境影响评价的要求，选择下列的全部或部分项目：叶绿素a、浮游植物、浮游动物、潮间带生物、底栖生物(含污损生物)、游泳动物等种类与数量，重要经济生物体内重金属及石油烃的含量、农药含量等。

3级评价项目应收集建设项目所在海域近三年内的海洋生态和生物资源历史资料，历史资料不足时应进行补充调查。调查内容至少应包括叶绿素a、浮游植物、浮游动物、潮间带生物、底栖生物、游泳动物种类和数量，重要经济生物体内重金属及石油烃的含量等。

生物(渔业)资源的调查内容应根据建设项目所在区域的环境特征和环境影响评价的要求，调查、收集评价海域的浮游植物、浮游动物、潮间带生物、底栖生物、游泳生物、鱼卵和仔鱼等的种类组成和数量分布等，调查、收集渔业捕捞种类组成、数量分布、生态类群、主要种类组成及生物学特征、主要经济幼鱼比例、渔获量、资源密度及现存资源量，海水养殖的面积、种类、分布、数量、产量、产值等生物资源内容。

当调查与评价海域位于自然保护区，珍稀濒危海洋生物的天然集中分布区，海湾、河口，海岛及其周围海域，红树林，珊瑚礁，重要的渔业水域，海洋自然历史遗迹和自然景观等生态敏感区及其附近海域时，应针对生态敏感目标的空间分布，选择有代表性的、可反映其生态特征的调查内容(要素)，获取较完整的调查数据。

10.3.4 调查时间与频次

海洋生态和生物资源的调查时间应根据所在海域的位置，合理选择代表季节特征的月份。

1级和2级评价项目一般应在春、秋两季分别进行调查；有特殊物种及特殊要求时可适当调整调查频次和时间。

调查时间可与水质调查同步；同时应尽量收集调查海域的主要调查对象的历史资料给予补充。

10.3.5 样品的采集、保存和分析方法

海洋生物调查样品的采集、保存与运输应符合GB 17378.3中的要求；样品的分析方法应符合GB 17378.6中的要求。

10.3.6 数据分析、处理的质量控制

海洋生物样品分析和数据处理应符合GB 17378.2中的要求。

数据分析和实验室的内部质量控制应符合GB 17378.2中的有关规定和实验室质量控制的相关要求。

10.4 主要评价和预测因子的筛选、确定

应依据对建设项目现状和潜在海洋生态和生物资源问题的分析，以及对建设项目性质和海域海洋生态和生物资源基本特征的分析，用列表法等方法对主要海洋生态和生物资源评价因子进行筛选、确定。海洋生态评价因子也可按照 GB/T 12763 的相关内容和要求选择。

以海洋生态和生物资源的环境现状评价为基础，通过评价要素的重要性分析，确定主要生态预测因子，以此进行预测分析。生物资源的主要预测要素应根据工程的特点、评价海域及其周边海域的生物资源特征，合理选择可以进行量化评估的要素，开展预测分析。

通常可以采用生态机理或类比法，在现状评价的基础上，确认主要生态预测因子，也可以借助数学方法进行因子的重要性分析。

10.5 海洋生态环境敏感区的分析评价

当评价范围位于海洋生态敏感区及其附近海域时，应按照建设项目的现状资料和预测结果，有针对性地阐述如下分析评价内容：

a) 应阐明生物群落结构和演替的现状评价及其工程后的预测分析和评价，主要内容包括：物种多样性分析评价(含优势度指数、物种多样性指数)，均匀度、丰富度分析评价，种类、群落相似性分析评价，生物群落演替分析评价，海水、沉积物、生物质量分析评价，有机污染和富营养化分析评价；分析评价的内容和方法应符合 HY/T 078、HY/T 080、HY/T 081、HY/T 082、HY/T 083、HY/T 084、HY/T 085 的要求；

b) 应阐明海洋生态健康状况的现状评价及其工程后的预测分析和评价，分析评价水质环境、沉积物环境、生物生态环境、栖息地环境和生物指标，给出海洋生态健康评价结果；分析、评价内容和评价方法应符合 HY/T 086、HY/T 087 的要求。

10.6 环境现状评价

10.6.1 评价内容

海洋生态和生物资源环境现状评价内容应包括：

a) 分析和评价叶绿素、初级生产力、浮游动植物、底栖生物、潮间带生物的种类组成和群落的时空分布；

b) 分析和评价海域的生物生境现状、珍稀濒危动植物现状、生态敏感区现状、海洋经济生物现状等；

c) 分析和评价生物量、密度、物种多样性(含优势度指数、物种多样性指数)、均匀度、丰富度、种类和群落相似性、生物群落演替、有机污染和富营养化等参数；

d) 分析、评估评价海域的海洋生态系统服务功能(含供给、调节、文化和支持服务功能)现状和经济价值；

e) 从生态系统完整性的角度评价生态环境现状，注意区域生态环境的功能与稳定性；

f) 结合评价海域和周边海域近年来的生物(渔业)资源密度分布和变化趋势，依据现状资料和历史资料，客观、合理地评估各类生物(渔业)资源的种类、密度、主要经济种类、资源量等及其分布特征；

g) 分析、评价建设项目所在区域生物(渔业)资源的现状、特征、生产能力、主要经济种类、资源变化趋势和其他重大生态问题；

h) 用可持续发展的观点评价海洋生物(渔业)资源的现状、发展趋势和承受干扰的能力。

海洋生态和生物资源现状评价应分析、评估原有海洋自然生态系统或次生生态系统的生产能力状

况并用调查、分析数据予以佐证。

10.6.2 评价方法

海洋生物质量的评价应符合 HY/T 078 的要求。滨海湿地的生态环境评价应符合 HY/T 080 的要求。海湾、河口生态环境的评价应符合 HY/T 084、HY/T 085 的要求。陆源入海排污口及其邻近海域的生态环境评价应符合 HY/T 086 的要求。河口与海湾、珊瑚礁、红树林、海草床等近岸海洋生态健康的评价应符合 HY/T 087 的要求。

海洋生态系统服务功能价值可采用替代成本法、影子工程法、防护费用法、市场价格法等方法。

其他内容的分析评价可按照 HJ/T 19 的要求，采用定性与定量相结合的方法，例如图形叠置法、生态机理分析法、类比法、列表清单法、质量指标法、景观生态学法、系统分析法、生产力评价法、数学评价方法等。

10.7 环境影响预测

10.7.1 预测内容

海洋生态的影响预测内容包括：

a） 分析评价海洋生物、生境及其生产能力是否因工程的建设和运营受到了损害或潜在损害，是否可引起其他重大生态问题；

b） 重点分析海岸线变化、栖息地被占用、海床（滩涂）冲刷与淤积、污染物排放等对海洋生态（含底栖生物、游泳生物、浮游生物、生物量、珍稀濒危动植物、生态群落与结构等）产生的影响；

c） 分析建设项目建设阶段对海洋生态的影响，主要包括施工活动使海洋生境变化的定量程度，以及由于此种变化导致评价因子的变化而使生物生态受到的影响范围和影响程度；

d） 分析建设项目运营阶段对海洋生态的影响，主要包括生产运行改变了的生态环境区域空间格局和水体利用的影响状况，以及由此而影响海洋生态的范围和程度。

海洋生态和生物资源影响预测内容包括：

——分析评价生物（渔业）资源的特征、生产能力是否因工程的建设和运营受到了损害或潜在损害，是否可引起其他重大资源问题；

——重点分析海岸线变化、栖息地（洄游路线）被占用、海床（滩涂）冲刷与淤积、污染物排放等对生物资源（含鱼卵和仔稚鱼、水产养殖等）产生的影响；

——分析建设项目建设阶段对生物资源的影响，主要包括施工活动使生物资源遭受的损失量和生物资源受到的影响范围和影响程度；

——分析建设项目运营阶段对生物资源的影响，主要包括生产运行改变了的生境空间格局对生物资源的影响范围和程度。

海洋生态和生物资源影响预测应关注如下重点：

——建设项目所产生的各种干扰，对评价区域内的海洋生态和生物（渔业）资源是否带来某些新的变化；

——是否使某些生态问题严重化；

——是否使海洋生态和生物（渔业）资源发生了时间与空间的变更；

——是否使某些原来存在的生态问题向有利的方向发展等。

3 级评价项目要对关键评价因子（如珍稀濒危物种、海洋经济生物等）进行预测；2 级评价项目要对所有重要评价因子进行单项预测；1 级评价项目除了进行单项预测外，还要对区域性全方位的影响进行预测；有低放射性废液排放的建设项目，除了开展 1 级评价项目的预测外，还应进行海洋生态遗传变异趋势的预测。

应预测、分析建设项目施工阶段对海洋生态和生物资源造成影响的性质、范围、程度、时段；应预测、分析建设项目运营阶段各主要因子对海洋生态和生物资源造成影响的性质、范围、程度、时段。生产阶段的预测时段应不少于5年。

应预测、分析建设项目所造成的水文动力条件变化而导致岸线、海底地形变化等对海洋生态和生物资源的影响。

10.7.2 预测方法

海洋生态主要影响因子的预测可采用数值模拟方法；也可采用类比分析、生态机理分析、景观生态学等方法进行定量、定性的预测分析和评估。

生物资源的定量评估方法应符合下述要求：

a) 生物资源的影响预测可采用定量评估方法，给出的定量评估结果应客观、合理；
b) 应依据评价海域和周边海域近年来的生物资源密度分布和变化趋势，依据现状资料和历史资料，客观、合理地选用生物资源密度数据；
c) 应依据评价海域和周边海域近年来的鱼卵、仔稚鱼和幼体与成体的分布和变化趋势，依据实验研究成果，合理地选择鱼卵成活率、仔稚鱼成活率、幼体折算为成体换算比率、经济生物平均成体最小成熟规格等计算参数；
d) 应依据污染物的种类、特征，合理确定污染物扩散范围内不同污染物浓度的增量区，合理选择不同污染物浓度增量区内生物资源的损失率等关键参数。

10.8 环境影响评价

10.8.1 环境影响分类

海洋生态和生物资源的环境影响划分为有利影响和不利影响，短期影响和长期影响，一次性影响和累积影响，明显影响和潜在影响，局部影响和区域影响，可逆影响和不可逆影响等类型。

10.8.2 替代方案的比选

替代方案是指海洋工程在建设规模、选址和总体布置方面的可替代(比选)的方案，包括项目的保护对策措施的多方案比较。

替代方案原则上应达到海洋生态和生物资源保护的最佳效果；在方案比选中应评价各方案的优点和缺点。

对海洋生态和生物(渔业)资源有明显影响的1级评价项目须进行替代方案比选，并应对关键的海洋生态问题和生物资源问题及其保护对策措施进行多方案比较，择优选择。

10.8.3 环境影响评价结果

建设项目海洋生态和生物(渔业)资源的影响评价内容和结果应符合下列要求：

a) 应根据海洋生态和生物资源现状评价和分析预测结果，结合海域的生态特征，按照生态环境和资源的可承载能力，分析海洋工程选址和布置的合理性，对建设项目的选址和布置方案开展多方案的比选和优化，保障海洋生态和生物资源的可持续利用；
b) 依据建设项目的工程方案，分析评价各方案导致的评价海域及其周边海域海洋生物、生态环境、生物物种多样性、生态群落等指示要素的变化与特征，分析评价生态功能、生态稳定性的变化与特征，分析评价生物资源的变化与特征；从生物生态、生物资源的影响程度和可接受性角度，分析和优选最佳工程方案；
c) 阐明生物生境现状、珍稀濒危动植物现状、生态敏感区现状、海洋生物现状评价结果；

d） 阐明建设项目导致的评价海域海洋生态和生物资源主要要素的变化与特征评价结果；
e） 根据各评价因子的定量或定性结果说明主要影响因子的影响范围、位置和面积；
f） 明确建设项目是否满足预期的海洋生态、生物生境质量要求的评价结论；
g） 明确建设项目导致的对海洋生态、生境的影响和干扰是否可以承受的评价结论；阐明评价海域的海洋生态是否存在不可承受的损害或潜在损害的明确结果；
h） 明确建设项目所在海域生物资源的现状、特征、资源量变化趋势和其他重大问题的评价结论；阐明生物资源损失的量化评价结果；阐明生物资源的抗干扰承受能力的分析结论；
i） 阐明建设项目导致的生态生境破坏、珍稀濒危动植物损害、海洋经济生物重要产卵场受损、生物多样性减少、外来生物入侵危害等重大海洋生态问题的评价结论；
j） 从海洋资源可持续发展角度，明确项目建设是否会产生重大的海洋生态和生物资源损害，阐明评价海域的生态功能、生态稳定性和生物资源干扰承受能力等的变化是否可接受的评价结论。

若评价结果表明建设项目对所在评价海域及其周边海域的海洋生态和生物资源产生较大影响，环境不可承受或不能满足环境质量要求时，应提出修改建设方案的规模、总体布置或重新选址等建议。

10.9 海洋生态保护与损害补偿

10.9.1 海洋生态损害评估

1 级评价等级和位于海洋生态敏感区及特大型的建设项目，应设专章评估建设项目造成的海洋生态损害，主要评估内容包括：海洋生境损害，海洋环境功能损害，海洋生物物种、种群、群落损害，海洋生态系统服务功能(供给服务、调节服务、文化服务和支持服务功能等)损害等。

海洋生态损害评估专章的主要内容应包括：涉海工程建设对海洋生态损害的预测与评估；海洋生态损害价值估算；海洋生态修复、恢复、补救方案或海洋生态损害补偿方案；海洋生态损害跟踪监测与后评估方案等。

海洋生态损害价值估算的主要内容包括：海洋生境丧失的损失，海洋环境功能损害的损失，海洋生物物种、种群、群落损害的损失，海洋生态系统服务功能减弱的损失等。

10.9.2 海洋生物与资源损害补偿

对海洋生物资源造成损害的建设项目，应遵照国家和行业有关损害评估、补偿的相关法规和技术标准，估算海洋生物和渔业资源的损失量，明确海洋生物和渔业资源修复或补偿方法。

按照预测或明确的悬浮物和各类污染物的影响面积，依据 SC/T 9110 等相关技术标准，考虑生物的成幼体比例等因素，按照各个季节的鱼卵仔鱼、底栖生物、游泳生物等的代表性数据，列表分析、计算生物生态和渔业资源损失量；列表中应明确计算公式、计算参数的取值依据，明确各个种类生物资源损失量的具体分析方法。

海洋生物和渔业资源补偿方案中应明确一次性补偿或分期补偿等补偿方式。

10.9.3 海洋生态保护对策措施

对海洋生态有不利影响的建设项目，应依据影响的范围和程度，明确海洋生态的保护、恢复或补偿具体对策措施；其对策措施应进行有效性评估论证，经方案比较后择优选择。应依据建设项目生产的海洋生态损害特征，制定有针对性的海洋生态跟踪监测方案。

海洋生态的保护、恢复、替代或补偿对策措施应考虑以下原则：

a） 当珍稀濒危物种和敏感生态因子受到影响时，应提出可靠的海洋生态保护对策措施；

b） 涉及生态敏感海域和需要保护的海洋生物物种时，应制定具体的海洋生态保护、恢复对策措施或替代方案；

c） 针对再生周期较短的生态和资源损失，当其恢复的基本条件没有发生逆转时，应制定临时补偿对策措施；

d） 针对不可逆性质的生态损害，应制定生态保护、恢复对策措施或一次性、分期补偿对策措施。

附 录 A
（规范性附录）
海洋工程建设项目环境影响报告书格式与内容

A.1 文本格式

A.1.1 文本规格

海洋工程建设项目环境影响报告书文本外形尺寸为A4(210 mm×297 mm)。

A.1.2 封面格式

海洋工程建设项目环境影响报告书封面格式如下：

第一行书写项目名称：××××工程(居中，不超过30个汉字)；

第二行书写：环境影响报告书(居中)；

第三行落款书写：编制单位全称(居中)；

第四行书写：地名(居中)；

第五行书写：××××年××月(居中)。

以上内容字体字号应适宜，各行间距应适中，保持封面美观。

报告书(送审稿)应有环境影响评价单位的公章。

A.1.3 封里1内容

封里1为环境影响评价证书1/3比例彩印件，同时应写明证书持有单位的全称、通讯地址、邮政编码、联系电话、传真电话、电子信箱等。

A.1.4 封里2内容

封里2中应写明：环境影响评价委托单位全称，环境影响评价承担单位全称，环境影响评价证书等级与编号，环境影响评价单位负责人姓名、职务、职称，项目负责人姓名、职务、职称，审核人姓名、职务、职称，主要参加人员的姓名、职务、职称和证书编号等。

A.1.5 封里3内容

封里3应写明环境影响评价协作单位及主要参加人员情况，包括协作单位全称，环境影响评价证书等级与编号，参加的环境影响评价工作内容，负责人姓名、职务、职称，主要参加人员的姓名、职务、职称和证书编号等。

A.1.6 封里4内容

封里4为技术签署页，应给出环境影响报告书主要编写(制)人员姓名、专业、负责编制的责任章节并签名，明确校核、审核、审定和批准等人员的姓名、职务、职称、岗位证书编号等内容并签名；明确评价协作单位应所承担的专题内容和主要参加人员情况并签名。应给出项目负责人登记证资质彩印件。

A.2 报告书章节内容

海洋工程建设项目环境影响报告书应包括表A.1中的全部或部分章节内容。如有需要，其中的有

关章节内容可另行编制成册。依据建设项目特点和环境影响评价内容，可对下列章节适当增设或删减。

表 A.1 海洋工程建设项目环境影响报告书章节

1 总论
 1.1 评价任务由来与评价目的
 1.2 报告书编制依据
 1.3 评价技术方法与技术路线
 1.4 环境保护目标和环境敏感目标
2 工程概况
 2.1 建设项目名称、性质、规模及地理位置
 2.2 工程的建设内容、平面布置、结构和尺度
 2.3 工程的辅助和配套设施，依托的公用设施
 2.4 生产物流与工艺流程、原(辅)材料及其储运、用水量及排水量等
 2.5 工程施工方案、施工方法、工程量及计划进度
 2.6 工程占用(利用)海岸线、滩涂和海域状况
3 工程分析
 3.1 生产工艺与过程分析
 3.2 工程各阶段污染环节与环境影响分析
 3.3 工程各阶段非污染环节与环境影响分析
 3.4 环境影响要素和评价因子的分析与识别
 3.5 主要环境敏感目标和环境保护对象的分析与识别
 3.6 环境现状评价和环境影响预测方法
4 区域自然和社会环境现状
 4.1 区域自然环境现状
 4.2 区域社会环境现状
 4.3 环境质量现状概况
 4.4 周边海域环境敏感目标的现状与分布
5 环境现状调查与评价
 5.1 水文动力环境现状调查与评价
 5.2 地形地貌与冲淤环境现状调查与评价
 5.3 海水水质现状调查与评价
 5.4 海洋沉积物环境质量现状调查与评价
 5.5 海洋生态环境(包括生物资源)现状调查与评价
 5.6 其他环境要素现状调查与评价(包括大气、放射性、噪声等要素和陆域环境)
 5.7 环境敏感目标、重点保护对象和海洋功能区环境现状调查与评价
6 环境影响预测与评价
 6.1 水文动力环境影响预测与评价
 6.2 地形地貌与冲淤环境影响预测与评价
 6.3 海水水质环境影响预测与评价
 6.4 海洋沉积物环境影响预测与评价
 6.5 海洋生态环境(包括生物资源)影响预测与评价
 6.6 主要环境敏感区和海洋功能区环境影响预测与评价
 6.7 其他内容的环境影响预测与评价(包括大气、放射性、噪声等要素和陆域环境)
7 环境风险分析与评价
 7.1 环境风险危害识别与事故频率估算
 7.2 环境风险影响预测方法和主要预测主要因素

表 A.1（续）

7.3 污染物迁移扩散路径、范围和扩散浓度、时空分布 7.4 事故后果分析(后果估算与风险估算) 7.5 环境风险防范对策措施和应急方法 **8 清洁生产** 8.1 建设项目清洁生产内容与符合性分析 8.2 建设项目清洁生产评价 **9 总量控制** 9.1 主要受控污染物的排放浓度、排放方式与排放量 9.2 污染物的排放削减方法 9.3 污染物排放总量控制方案与建议 **10 环境保护对策措施** 10.1 建设项目各阶段的污染环境保护对策措施 10.2 建设项目各阶段的非污染环境保护对策措施 10.3 建设项目各阶段的海洋生态保护对策措施 10.4 建设项目的环境保护设施和对策措施一览表 **11 环境保护的技术经济合理性** 11.1 环境保护设施和对策措施的费用估算 11.2 环境保护的经济损益分析 11.3 环境保护的技术经济合理性 **12 公众参与** 12.1 公众参与的调查方法与过程 12.2 公众参与的调查范围、内容和结果 12.3 公众参与结果分析 12.4 调查结果的处理与反馈情况 12.5 公众参与分析结论(包括对建设项目的态度、意见和建议等) **13 海洋工程的环境可行性** 13.1 海洋功能区划和海洋环境保护规划的符合性 13.2 区域和行业规划的符合性 13.3 建设项目的政策符合性 13.4 工程选址与布置的合理性 13.5 环境影响可接受性分析 **14 环境管理与环境监测** 14.1 环境保护管理计划 14.2 环境监测计划 **15 环境影响评价结论及建议** 15.1 工程分析结论 15.2 环境现状分析与评价结论 15.3 环境影响预测分析与评价结论 15.4 环境风险分析与评价结论 15.5 清洁生产和总量控制结论 15.6 环境保护对策措施的合理性、可行性结论 15.7 公众参与分析与评价结论 15.8 区划规划和政策符合性结论 15.9 建设项目环境可行性结论

表 A.1(续)

15.10 其他意见和建议
16 环境影响评价报告书附件
环境影响评价报告书附件应包括：
• 建设项目前期工作的相关文件、相关资料
• 建设项目环境影响评价工作委托书(合同书)
• 以计量认证(CMA)分析测试报告或实验室认可(CNAS)分析测试报告形式给出的现场调查、勘测、监测数据资料
• 公众参与调查表影印件
• 其他应附附图、附表和参考文献等

附　录　B
（规范性附录）
海洋工程建设项目环境影响报告表格式与内容

B.1　文本格式

B.1.1　文本规格

海洋工程建设项目环境影响报告表文本外形尺寸为 A4(210 mm×297 mm)。

B.1.2　封面格式

海洋工程建设项目环境影响报告表封面格式如下：
第一行书写项目名称：××××工程(居中，不超过 30 个汉字)；
第二行书写：环境影响报告表(居中)；
第三行落款书写：环境影响报告表编制单全称(居中，加盖公章)；
第四行书写：××××年××月(居中)；
第五行书写：地名(居中)。
以上内容字体字号应适宜，各行间距应适中，保持封面美观。

B.1.3　封里 1 内容

封里 1 为环境影响评价证书 1/3 比例彩印件，同时应写明证书持有单位的全称、通讯地址、邮政编码、联系电话、传真电话、电子信箱等。

B.1.4　封里 2 内容

封里 2 中应写明：环境影响评价委托单位全称，环境影响评价承担单位全称(加盖公章)，环境影响评价证书等级与编号，环境影响评价单位负责人姓名、职务、职称，项目负责人姓名、职务、职称，校核、审核、审定和批准人的姓名、职务、职称等。

B.1.5　参加评价人员基本情况

应给出项目负责人登记证资质彩印件；参加评价工作所有人员的基本情况应按照表 B.1 内容填写。

表 B.1　评价人员基本情况

姓名	从事专业	技术职称	上岗证书号	本评价职责	签名
……	……	……	……	……	……

B.2 报告表表格与内容

B.2.1 建设项目基本情况

应按照表 B.2 的格式与要求填写建设项目的基本情况表，可根据建设项目的特点填写空格内容。

表 B.2 建设项目基本情况表

建设项目名称		建设单位	
法人代表(签字)		建设地点	
通讯地址		联系人	
邮政编码		联系电话	
电子信箱		传真	
项目设立部门		文号	
项目性质	新建 改扩建 技术改造	工程总投资	万元
其中环保投资	万元	所占比例	%
报告表编制单位		环评经费	万元
建设规模(按工程性质可增减下列内容)			
总工程量	m^3	陆域挖方量	m^3
海域挖方量	m^3	海域填方量	m^3
海域使用面积	m^2	水下疏浚量	m^3
滩涂使用面积	m^2	占用岸线长度	m
年污水排海量	m^3	年用水量	m^3
年废弃物倾倒量	m^3	建设总面积	m^2
……	……	……	……

B.2.2 工程概况与分析

应按照表 B.3 的格式填写工程概况与分析表。

工程概况与分析的主要内容应包括：建设项目所在地理位置(应附平面图)，建设方案(附平面布置图)，生产物流特点与流程，生产工艺及水平，原(辅)材料、燃料及其储运，用水量及排水量等概况；建设项目利用海洋完成部分或全部功能的类型和利用方式、范围和面积，建设项目控制或利用海水、海床、海岸线和底土的类型和范围，包括占用海域面积，涉及的沿海陆域面积，占用海岸线和滩涂等概况。

建设项目的典型结构布置，主要工程结构的布置、结构和尺度。工程项目依托的公用设施(包括给排水、供电、供热、通信等)。主体工程、附属工程、基础工程的施工方案、工程量及作业主要方法、作业时间等。

表 B.3 工程概况与分析表

(可附图、表格和填加页) ……

B.2.3　污染与非污染要素分析

应按照表 B.4 的格式填写建设项目的污染与非污染要素分析表，给出环境影响要素和评价因子的分析与识别结果。

污染与非污染要素分析的主要内容应包括：建设项目施工、生产运行、废弃等各阶段中的产污环节。分析各种污染物的产生量、处理工艺、处理量、排放量、排放去向和排放方式等；分析各种污染物的治理、回收和利用措施以及工程运行与污染物排放间的关系；分析和核算建设和生产运行阶段中（含非正常工况下）各种污染物的污染源强排放量、排放去向和排放方式，并列出污染要素清单。

分析非污染影响环节和要素的主要类型、影响方式、影响内容、影响范围和可能产生的结果。分析和核算各阶段中各种非污染影响要素的主要控制因子和强度，列出非污染影响要素清单。

表 B.4　污染与非污染要素分析表

（可附图、表格和填加页） ……

B.2.4　环境现状分析

应按照表 B.5 的格式填写建设项目所在环境现状分析表。建设项目所在区域环境现状分析的内容应包括自然环境状况和社会环境状况。

自然环境现状应包括：

分析和评价建设项目所在区域的海岸岸滩、海岸线与海域地质、地形、地貌现状，所在区域的环境现状（包括水文动力环境、地形地貌与冲淤环境、水质环境、沉积物环境和海洋生态和生物资源等），自然保护区环境现状，其他要素（包括大气、放射性、噪声等）的环境污染、环境损害现状，海洋工程现状，污染源及其分布现状等。

社会环境现状应包括：

分析和概述建设项目所在区域现有工矿企业和生活居住区的分布状况和人口密度，海域使用现状，交通运输情况及其他社会经济活动现状，风景游览区、名胜古迹以及重要的政治文化设施现状，人群健康状况等。

表 B.5　环境现状分析表

自然环境现状（可附图、表格和填加页）： ……
社会环境现状（可附图、表格和填加页）： ……

B.2.5　环境敏感区（点）和环境保护目标分析

应按照表 B.6 的格式填写建设项目的环境敏感区（点）和环境保护目标分析表。主要内容应包括：

列出建设项目所在区域海洋环境敏感区、环境保护目标和沿岸陆域环境保护目标清单，列出环境敏感区、保护目标的性质和规模，分布的位置、面积和距建设项目的距离等（图示）；分析上述保护目标面临的环境威胁和压力，明确各保护目标的保护标准和保护级别。

主要海洋环境保护目标应包含海洋自然保护区、海水增养殖区、海洋生物产卵场和索饵场、海水利用区、河口、风景旅游区、红树林、珊瑚礁和其他环境敏感目标等。主要沿岸陆域环境保护目标包含居民

区、学校、文物区、风景区、水源区和生态敏感点等。

表 B.6 环境敏感区(点)和环境保护目标分析表

(可附图、表格和填加页) ……

B.2.6 环境影响预测分析与评价

应按照表 B.7 的格式填写建设项目环境影响预测分析与评价表。

建设项目海洋环境影响预测分析与评价的主要内容应包括:建设项目对海洋水文动力环境的影响分析与评价;对岸滩稳定、海岸线变化、海底稳定及冲刷和淤积的影响分析与评价;分析和评价建设项目建设期、运营期、废弃期和事故状态下的污染与非污染要素(因子)对海水、沉积物和海洋海洋生态和生物资源的的影响内容、影响范围、影响程度和影响结果;分析、评价采取的环境保护对策措施的针对性、可行性。应给出建设项目的环境影响分析与评价结论,包括对建设项目各阶段的环境影响、事故阶段环境影响、区域与社会环境影响等的综合分析和评价结论。

必要时应进行专项环境影响分析与评价,专项环境影响分析与评价内容可另行编制专题报告书。

表 B.7 环境影响预测分析与评价表

(可附图、表格和填加页) ……

B.2.7 环境保护对策措施

应按照表 B.8 的格式填写环境保护对策措施,提出工程各阶段的环境保护对策措施,海洋生态和生物资源修复与补偿等具体的、有针对性的对策措施,主要内容应包括:回收利用废弃物,避免或减少使用有毒有害原料,减少施工和生产过程中的污染因素,采用少废、无废工艺流程及有效的控制措施和管理等;具体节能、节水对策措施;建设项目各阶段污染物处理对策措施;生态保护的对策措施;环境风险防控对策措施,环境保护对策措施的合理性、可操作性、技术经济可行性等的分析评价等。

表 B.8 环境保护对策措施与环境影响评价结论表

环境保护对策措施(可附图、表格和填加页) ……
环境影响评价结论(可附图、表格和填加页) ……

B.2.8 环境影响评价结论

应按照表 B.8 的格式填写环境影响评价结论,评价结论中应阐明建设项目的环境影响范围和程度的定量或定性结论;应明确环境现状与环境质量预测的影响分析与评价结论,阐明建设项目在各个阶段能否满足环境质量要求的评价结论,应明确建设项目的类型、规模和选址是否可行的评价结论。

B.2.9 附件

建设项目环境影响评价报告表附件应包括：

a） 建设项目的立项文件；

b） 建设项目环境影响评价工作委托书(合同书)；

c） 其他应附的附图、附表和参考文献等。

附 录 C
（规范性附录）
海洋工程建设项目环境影响评价工作方案格式与内容

C.1 文本格式

C.1.1 文本规格

海洋工程建设项目环境影响评价工作方案文本外形尺寸为 A4(210 mm×297 mm)。

C.1.2 封面格式

海洋工程建设项目环境影响评价工作方案封面格式如下：

第一行书写项目名称：××××工程(居中，不超过 30 个汉字)；

第二行书写：环境影响评价工作方案(居中)；

第三行落款书写：编制单位全称(居中)；

第四行书写：地名(居中)；

第五行书写：××××年××月(居中)。

以上内容字体字号应适宜，各行间距应适中，保持封面美观。

C.1.3 封里 1 内容

封里 1 为环境影响评价证书 1/3 比例彩印件，同时应写明证书持有单位的全称、通讯地址、邮政编码、联系电话、传真电话、电子信箱等内容。

C.1.4 封里 2 内容

应写明环境影响评价委托单位全称，环境影响评价承担单位全称，环境影响评价证书等级与编号，环境影响评价单位负责人、项目负责人和主要编写(制)人员的姓名、职务、职称和证书编号等内容。

C.1.5 封里 3 内容

封里 3 为技术签署页，应明确环境影响评价工作方案主要编写(制)人员的姓名、专业、负责编制的责任章节并签名，明确校核、审核、审定和批准等人员的姓名、职务、职称、岗位证书编号等内容并签名；明确评价协作单位应所承担的专题内容和主要参加人员情况并签名。

C.2 海洋工程环境影响评价工作方案内容

C.2.1 总则

应阐明评价任务的由来和评价目的，评价工作方案的编制依据，评价引用的技术标准与环境质量要求，评价范围、评价内容(含各单项评价内容)与评价重点，评价工作等级(含各单项评价内容的等级)，环境敏感目标与环境保护目标等。

C.2.2 工程概况

应阐明建设项目名称，建设规模与投资规模(改、扩建项目应说明原有规模)，建设项目所在地理位

置(应附平面图),建设方案与总体布置(附总体布置图);阐明建设项目利用海洋完成部分或全部功能的类型、利用方式、利用范围和面积,阐明建设项目控制或利用海水、海床、海岸线和底土的类型和范围,包括占用海域面积,涉及的沿海陆域面积,占用海岸线和滩涂等概况,生产物流特点与流程,生产工艺及水平,原(辅)材料、燃料及其储运,用水量及排水量等概况;工程施工方案与施工方法,工程量及作业时间等概况。

C.2.3 工程分析实施方案

建设项目工程分析实施方案应明确建设项目施工、生产等各阶段工程分析的目的、内容、方法和要求,工程分析内容一般应包括:

a) 生产工艺过程分析。应详细分析生产工艺过程(附工艺流程图),分析建设项目资源、能源、废物等的运输、储运、预处理等环节的环境影响及来源,分析项目的建设和运行给当地和周围海域带来的环境问题,分析并阐明建设项目利用海洋完成部分或全部功能的类型和利用方式、范围和面积,分析并阐明建设项目控制或利用海水、海床、海岸线和底土的类型和范围等。
b) 污染环节和环境影响分析。应详细分析建设项目施工、生产运行、维护检修和事故等各阶段中的产污环节和各种污染物的产生量、排放量、排放去向和排放方式等,分析各种废物的治理、回收和利用措施以及工程运行与污染物排放间的关系,核算各阶段的污染源强并列出污染要素清单。
c) 非污染环节和环境影响分析。应详细分析建设项目施工、生产运行、维护检修和事故等各阶段中产生的非污染环境要素,确定其主要影响方式、内容、范围和可能产生的结果,分析其主要控制因素,核算并列出非污染要素清单。

有特殊需求的建设项目的工程分析内容应根据具体情况适当增加或调整。

C.2.4 环境影响要素识别和评价因子筛选实施方案

应明确建设项目环境影响要素识别和评价因子筛选实施方案。应对建设项目施工、生产和环境事故等各阶段的环境影响要素(包括污染要素和非污染要素)和评价因子筛选提出详细的识别与分析要求,阐明各阶段环境影响评价因子的筛选原则和方法,明确建设项目各阶段环境影响要素的识别范围、分析内容和评价因子等,筛选出主要环境影响要素、环境敏感区、环境敏感目标和主要环境保护对象,确定主要环境影响评价因子,阐明环境影响评价的范围、内容和方法等具体要求。

C.2.5 区域自然和社会环境现状

应初步了解并阐明建设项目所在区域及周围海域的自然环境概况与特征,制定区域自然环境和社会环境现状调查实施方案,主要内容包括:

阐明区域环境质量概况,主要包括海洋水文动力环境概况,海洋地形地貌与冲淤概况,海域水质概况,海域沉积物质量概况和海洋生态、生物资源概况等。

应阐明建设项目所在海域和区域的社会环境与社会经济活动现状,主要包括城市(或城镇)规模,行政区划及人口,现有工矿企业和生活居住区的分布状况,人口密度,交通运输状况及其他社会经济活动等内容。

应阐明建设项目周围海域海洋功能区划和海洋环境保护规划的主要内容、环境管理要求,阐明海洋经济开发利用的内容、类型和程度,海域开发使用现状,现有海洋工程和设施的分布状况等。

应阐明海洋自然资源(主要包括生物资源、油气资源、矿产资源、景观资源、湿地和滩涂资源、野生生物资源等)现状和开发利用现状。

C.2.6 环境现状调查与评价实施方案

应制定环境现状调查与评价实施方案。根据已分析确定的各单项评价的内容、范围和等级,结合环

境特点和现状评价及影响预测的需要，尽量详细地制定包括调查范围、调查项目、调查方法、调查时间、调查站位布设、调查频次、分析监测方法等内容的现状调查实施方案，并明确调查所应执行的技术标准。

依据已界定的各单项评价内容的环境影响评价等级，明确用于评价和分析预测的资料收集的目的、内容、范围等要求。

应明确环境现状的评价范围、评价内容、评价标准、评价方法并提出评价结果的具体要求。

应明确环境敏感区(例如生物资源区、海水养殖区或珍稀濒危物种分布区等)的调查与评价内容，对已界定的环境敏感区、敏感目标、重点环境保护对象(如生物资源等)和周边海洋功能区提出调查内容、范围和方法的具体要求，并界定其评价方法、评价标准、评价内容和评价范围。

C.2.7 环境影响预测与评价实施方案

应制定环境影响预测与评价实施方案，并明确以下内容：

a) 各单项评价内容的预测的目的和要素，预测的范围、时段，参与预测的污染要素和非污染要素的特性、源强，采用的主要预测方法和模式，边界条件、初始条件、计算域、计算参数等计算条件的选取及简化，有关参数的估值方法等，同时应明确预测精度要求及其检验要求；
b) 应对建设项目施工阶段、生产阶段、废弃阶段等各阶段的影响要素、影响内容、影响范围、影响程度和影响结果等，提出具体预测要求。预测的准确度指标应满足主管部门管理和指导环境保护设计等要求；
c) 应明确环境影响预测的评价内容、评价方法和评价标准，提出评价的具体要求。

C.2.8 环境风险分析与评价实施方案

有环境风险的建设项目，应制定环境风险分析与评价实施方案，明确以下内容：

a) 提出环境风险分析内容和方法的要求，包括对建设项目各阶段环境事故发生概率的分析要求，对自身和非自身环境事故叠加的风险概率的分析要求，对发生各类环境事故时各种污染物排放规模与源强的分析要求，对污染物迁移扩散路径与范围的预测要求，对可能造成的各类环境影响和潜在影响的分析要求等；
b) 依照 GB 18218 的要求，明确建设项目环境风险的危险源判定和物质危险性判定；
c) 依照 HJ/T 169—2004 的要求，明确建设项目的环境风险评价等级和评价内容；
d) 明确环境事故影响预测的方法，包括预测范围、主要预测因素、污染物扩散浓度、面积等时空要素，应明确不确定性分析内容和方法；
e) 明确环境事故处置分析要求，包括对应急设施和器材、配置地点、机动性能、通讯联络、应急组织、应急反应程序、各阶段拟采取的防范措施的可行性、有效性等的分析内容。

C.2.9 清洁生产与污染物排放总量控制实施方案

应给出建设项目的清洁生产分析实施方案，明确清洁生产的分析与评价要求。主要包括对清洁生产工艺的分析要求，对工程建设施工、生产等各阶段的节能、减排和清洁生产措施及效果的分析要求，对建设项目各阶段清洁生产水平的分析要求等。

制定污染物排放总量分析与控制实施方案。主要包括依据环境质量控制要求，给出纳污混合区的位置、面积，提出污染物排放总量控制建议，确定污染物排放削减方式和方法的建议值，提出污染物排放总量控制实施计划等内容。

C.2.10 环境保护对策措施分析与评价实施方案

应制定环境保护对策措施分析与评价实施方案，明确污染防治对策措施的分析与评价要求。主要包括对回收利用废弃物，避免或减少使用有毒有害原料，减少施工和生产过程中的污染因素，采用少废、

无废工艺流程及有效的控制措施和管理等的要求；对用水和节水方法、途径和具体节水措施的分析要求；对建设项目各阶段污染物处理措施的分析要求；对生态保护对策措施的分析要求；对环境风险防控措施的要求，对环境保护对策措施的合理性、可操作性、技术经济可行性等的分析评价要求。

C.2.11 公众参与实施方案

应制定公众参与实施方案。包括公众参与的方法、形式，详细列出对单位、团体及个人的调查方法、调查内容(例如调查表格格式及发放、回收方式等)，明确调查范围和样本数量，明确被调查对象的分类方法及反馈机制，明确对调查结果的分析方法及分析结论的要求。

应明确公示和抽样调查表格设计的内容，公示和抽样调查表格的内容应明确、公正、全面、合理；

应明确公示和抽样调查表格中工程概况的内容，在工程概况中应向被调查对象公正、客观地告知建设项目的主要环境问题、可能的影响范围和影响程度、拟采取的主要保护对策措施等关键内容。

C.2.12 环境管理与环境监测

应制定环境管理与环境监测实施方案。包括对建设项目环境管理的内容、任务，环境管理机构设置，环境保护管理制度、设备、人员配备等提出要求；依据环境评价与预测结果，制定环境监测计划，明确环境监测的项目、方法、频率及监测实施机构等要求；明确建设项目环境保护设施和对策措施验收的具体分析评价要求。

C.2.13 环境影响可行性评价实施方案

应制定环境影响可行性评价实施方案。明确建设项目环境影响可行性的评价方法，提出建设项目各阶段各单项评价内容的环境现状的分析与评价要求，环境影响预测的分析与评价要求，非污染损害影响的分析与评价要求，环境事故影响的分析与评价要求，清洁生产措施和污染防治对策的分析与评价要求，给出建设项目选址合理性和环境可行性的分析评价要求等。

C.2.14 评价成果与文件

应详细列出环境影响评价应提交的评价成果和评价文件清单，详细列出建设项目海洋工程环境影响报告书的篇、章、节内容。

C.2.15 评价工作的组织与计划进度

应明确建设项目环境影响评价工作的组织、任务分工、协作单位和计划进度，给出环境影响评价工作的组织和计划进度框图。

C.2.16 评价工作经费预算

应按照评价工作内容和范围所界定的工作量，依据有关取费标准，做出评价工作经费预算。

C.2.17 环境影响评价工作方案附件

建设项目的海洋环境影响评价工作方案附件应满足附录 A 的要求。

C.3 评价工作方案章节内容

海洋工程建设项目环境影响评价工作方案应包括表 C.1 中所列的全部或部分章节内容。如有需要，其中的有关章节内容可另行编制成册。依据建设项目的特点和环境影响评价具体要求，可对下列章节内容适当增设或删减。

表 C.1　海洋工程建设项目环境影响评价工作方案章节

1　总则
1.1　评价任务由来与评价目的
1.2　工作方案编制依据
1.3　环境影响评价技术方法与路线
1.4　评价内容与评价重点(含各单项评价内容)
1.5　环境影响要素识别和评价因子筛选
1.6　环境敏感区与环境保护目标
2　工程概况
2.1　项目名称、建设与投资规模及地理位置
2.2　建设方案和总体布置概述
2.3　占用(利用)海岸线、滩涂和海域状况
2.4　生产物流与工艺流程、原(辅)材料及其储运、用水量及排水量等
2.5　施工方案、施工方法、工程量及作业时间
3　工程分析实施方案
3.1　生产工艺与过程分析方法
3.2　工程各阶段污染环节和环境影响分析方法
3.3　工程各阶段非污染环节和环境影响分析方法
4　环境影响要素识别和评价因子筛选实施方案
4.1　污染环境影响要素和评价因子分析与筛选方法
4.2　非污染环境影响要素和评价因子分析与筛选方法
4.3　环境敏感目标和重点环境保护对象分析与筛选
4.4　工程各阶段环境影响评价内容和分析、预测方法
5　工程区域自然和社会环境现状
5.1　工程区域自然环境现状
5.2　工程区域社会环境现状
5.3　工程海域自然环境现状
5.4　工程海域海洋资源及开发利用现状
6　环境质量现状调查与评价实施方案
6.1　环境现状调查
6.1.1　环境质量现状调查范围与站位布设
6.1.2　调查内容、调查项目(要素)、调查与分析方法
6.1.3　调查时间与调查频率
6.2　环境质量现状评价(包括评价方法、评价标准及要求)
6.2.1　水文动力环境现状评价方法
6.2.2　地形地貌与冲淤环境现状评价方法
6.2.3　海水环境质量现状评价方法
6.2.4　沉积物环境质量现状评价方法
6.2.5　海洋生物环境质量和海洋生态、生物资源现状评价方法
6.2.6　其他环境要素环境质量现状评价(包括大气、放射性、噪声等)
6.3　环境敏感区调查与评价
6.3.1　环境敏感区调查范围与站位布设
6.3.2　调查项目与方法、调查时间与频率
6.3.3　环境敏感区现状评价方法

表 C.1(续)

7 环境影响预测与评价实施方案
7.1 水文动力环境影响预测与评价方法
7.2 地形地貌与冲淤环境影响预测与评价方法
7.3 水质环境影响预测与评价方法
7.4 沉积物环境影响预测与评价方法
7.5 海洋生态和生物资源影响预测与评价方法
7.6 其他环境要素环境影响预测与评价(包括大气、固废、噪声等)方法
8 环境风险分析与评价实施方案
8.1 环境风险源项分析方法(危害识别与事故频率估算)
8.2 环境风险后果分析方法(后果估算与风险估算)
8.3 环境风险影响预测评价方法
8.4 环境风险防范对策措施和处置的分析要求
9 清洁生产与污染物排放总量控制实施方案
9.1 建设项目各阶段清洁生产内容分析方法
9.2 建设项目各阶段清洁生产评价方法
9.3 项目各阶段污染物排放源强及达标分析方法
9.4 区域环境容量分析方法
9.5 受控污染物筛选与纳污混合区分析方法
9.6 污染物排放总量控制方案
10 环境保护对策措施分析与评价实施方案
10.1 建设项目各阶段的环境保护对策措施分析与评价方法
10.2 建设项目各阶段的生态保护对策措施分析与评价方法
10.3 建设项目各阶段的环境风险防范措施分析与评价方法
10.4 环境保护对策措施的费用估算分析与评价方法
10.5 环境和生态保护对策措施的技术、经济可行性分析方法
11 公众参与实施方案
11.1 调查方法和形式
11.2 调查范围与调查表设计
11.3 调查结果的汇总与分析方法
12 环境可行性评价实施方案
12.1 与海洋功能区划和海洋环境保护规划的符合性分析评价方法
12.2 与区域和行业规划的符合性分析评价方法
12.3 建设项目的政策符合性分析评价方法
12.4 工程选址与布置的合理性分析评价方法
12.5 污染、非污染环境影响的可接受性分析评价方法
13 环境管理与环境监测实施方案
13.1 环境管理方案制订方法
13.2 环境监测计划编制方法
13.3 环境管理和环境监测计划的可行性评估
14 评价成果与文件
14.1 评价成果清单(含附件、图表等)
14.2 报告书(报告表)的主要内容(至章节)
15 评价工作的组织、分工与计划进度
15.1 评价工作的组织与分工

表 C.1（续）

15.2　评价工作进度计划 **16　评价工作经费预算** **17　附件** 环境影响评价工作方案附件应包括： a）　建设项目前期工作的相关文件、相关资料 b）　建设项目环境影响评价工作委托书(合同书) c）　其他应附的附图、附表和参考文献等

附 录 D
（规范性附录）
平面二维潮流、泥沙、污染物扩散的数值模拟

D.1 适用范围

本附录规定了平面二维潮流、泥沙、污染物扩散及溢油、冷热源扩散的数值模拟原则、方法、内容及要求。

属于宽浅型水域且潮混合较强烈、各要素垂向分布较均匀的近岸海域或河口、海湾，可采用二维数值模型近似描述海水的三维运动；其余情况则宜采用三维数值模型。

D.2 模型计算域的确定及网格剖分

D.2.1 模型计算域确定

模型计算域的确定应符合：

a） 计算域应能反映工程海区整体流场特性和特征，应保证计算域开边界处的水文要素不受域内工程方案的影响；
b） 开边界宜选在流场比较均匀的断面。

D.2.2 网格剖分

网格剖分应符合：

a） 网格大小应有足够的空间分辨率，并应考虑海洋水质、地形地貌与冲淤、海洋生态和生物资源、海洋沉积物环境等评价内容的预测需求；
b） 网格结点水深应能反映水下地形特征和工程前后水深变化；
c） 应有利于概化和反映岸线边界、岛屿边界和工程方案的固边界。

D.3 平面二维潮流、泥沙、污染物扩散的数值模拟

D.3.1 基本资料

用于平面二维潮流泥沙数值模拟的基本资料应符合如下要求：

a） 实测资料应满足模型的边界条件和模型潮位验证的需要，包括：开边界端点的潮位数据，计算域内至少 2 个站的潮位数据，计算域内 2 个～6 个测点的潮流和余流周日连续观测数据，测点的多少依评价等级的高低确定；
b） 潮流的调和分析应按 GB/T 12763.8 中海洋调查资料处理所列方法和步骤进行；
c） 岸界和水深应从实测水深图或最新出版的海图上读取，同时应注意海图水深与平均海平面之间的转换。读取岸界数据时应注意当地虾池、盐田和围海造地等的实际范围以及建设项目引起岸线改变和地形改变的详细情况。

D.3.2 基本方程

D.3.2.1 潮流运动方程

潮流运动可按下列方程控制，见式(D.1)～式(D.3)：

连续方程：

$$\frac{\partial \zeta}{\partial t}+\frac{\partial}{\partial x}[(h+\zeta)u]+\frac{\partial}{\partial y}[(h+\zeta)v]=0 \qquad \cdots\cdots\cdots\cdots\cdots\cdots(\mathrm{D}.1)$$

x 向动量方程：

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}-fv=$$

$$-g\frac{\partial \zeta}{\partial x}+\frac{\partial}{\partial x}(N_x\frac{\partial u}{\partial x})+\frac{\partial}{\partial y}(N_y\frac{\partial u}{\partial y})-f_b\frac{\sqrt{u^2+v^2}}{h+\zeta}u \qquad \cdots\cdots\cdots\cdots\cdots\cdots(\mathrm{D}.2)$$

y 向动量方程：

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+fu=$$

$$-g\frac{\partial \zeta}{\partial y}+\frac{\partial}{\partial x}(N_x\frac{\partial v}{\partial x})+\frac{\partial}{\partial y}(N_y\frac{\partial v}{\partial y})-f_b\frac{\sqrt{u^2+v^2}}{h+\zeta}v \qquad \cdots\cdots\cdots\cdots\cdots\cdots(\mathrm{D}.3)$$

式(D.1)～式(D.3)中：

ζ ——相对某一基面的水位(m)；

h ——相对某一基面的水深(m)；

N_x——x 向水流紊动粘性系数(m^2/s)；

N_y——y 向水流紊动粘性系数(m^2/s)；

f ——科氏系数；

f_b ——底部摩阻系数。

D.3.2.2 悬沙输移扩散方程

悬沙输移扩散可按下列方程控制，见式(D.4)：

$$\frac{\partial s}{\partial t}+u\frac{\partial s}{\partial x}+v\frac{\partial s}{\partial y}=\frac{\partial}{\partial x}(D_x\frac{\partial s}{\partial x})+\frac{\partial}{\partial y}(D_y\frac{\partial s}{\partial y})+\frac{F_s}{h+\zeta} \qquad \cdots\cdots\cdots\cdots\cdots\cdots(\mathrm{D}.4)$$

式中：

D_x ——x 向悬沙紊动扩散系数(m^2/s)；

D_y ——y 向悬沙紊动扩散系数(m^2/s)；

F_s ——源汇函数[$kg/(m^2 \cdot s)$]。

D.3.2.3 床面冲淤变化方程

床面冲淤变化可按下列方程控制，见式(D.5)：

$$\gamma_0\frac{\partial \Delta h}{\partial t}+\frac{\partial q_x}{\partial x}+\frac{\partial q_y}{\partial y}=-F_s \qquad \cdots\cdots\cdots\cdots\cdots\cdots(\mathrm{D}.5)$$

式中：

Δh ——冲淤厚度(m)；

q_x ——x 向底沙单宽输沙率[$kg/(m^2 \cdot s)$]；

q_y ——y 向底沙单宽输沙率[$kg/(m^2 \cdot s)$]；

γ_0 ——底沙干容重(kg/m^3)。

D.3.2.4 污染物扩散方程

污染物扩散的基本方程,见式(D.6):

$$\frac{\partial(HC)}{\partial t}+\frac{\partial(uHC)}{\partial x}+\frac{\partial(vHC)}{\partial y}=\frac{\partial}{\partial x}\left(D_xH\frac{\partial C}{\partial x}\right)+\frac{\partial}{\partial y}\left(D_yH\frac{\partial C}{\partial y}\right)+Q \quad \cdots\cdots\cdots (D.6)$$

式中:

H ——水深(m);

C ——某种污染物浓度(mg/L);

D_x,D_y ——分别为 x 向及 y 向紊动扩散系数(m^2/s);

Q ——污染物源(汇)项[$g/(m^2 \cdot s)$];

对于热(冷)源排放:$Q=-\frac{k_TC}{\rho C_P}+qT_0$;

式中:

C ——水体温升(降)(℃);

k_T ——水面综合热交换系数[$J/(s \cdot m^2 \cdot ℃)$];

ρ ——水的密度(kg/m^3);

C_P ——水的比热[$J/(kg \cdot ℃)$];

q ——为温(冷)排水的源强(m^3/s);

T_0 ——为温(冷)源的排放温升(降)(℃)。

D.3.3 计算模式

应根据计算域地形特征、项目布置方案等具体情况,采用有限差分法、有限单元法、边界元法等适宜的方法计算。

D.3.4 初始条件和边界条件

D.3.4.1 初始条件

初始条件按式(D.7)~式(D.11)确定:

$$\zeta(x,y,t)\big|_{t=0}=\zeta_0(x,y) \quad \cdots\cdots\cdots (D.7)$$

$$u(x,y,t)\big|_{t=0}=u_0(x,y) \quad \cdots\cdots\cdots (D.8)$$

$$v(x,y,t)\big|_{t=0}=v_0(x,y) \quad \cdots\cdots\cdots (D.9)$$

$$s(x,y,t)\big|_{t=0}=s_0(x,y) \quad \cdots\cdots\cdots (D.10)$$

$$C(x,y,t)\big|_{t=0}=C_0(x,y) \quad \cdots\cdots\cdots (D.11)$$

式中:

ζ_0、u_0、v_0、s_0、C_0——分别为 ζ、u、v、s、C 初始时刻的已知值。

D.3.4.2 边界条件

当计算域内存在大面积潮间浅滩时,宜采用动边界技术处理露滩问题。

D.3.4.2.1 固边界

固边界应按下列方法确定。

法向流速为零:

$$\vec{V} \cdot \vec{n} = 0 \quad \cdots\cdots\cdots\cdots(D.12)$$

法向泥沙通量为零：

$$\frac{\partial s}{\partial \vec{n}} = 0 \quad \cdots\cdots\cdots\cdots(D.13)$$

式中：

$\vec{n}$——固边界法方向。

D.3.4.2.2 水边界

水边界应按下列方法确定。

潮流用已知潮位或流速控制：

$$\zeta(x,y,t)|_{\Gamma} = \zeta^{*}(x,y,t) \quad \cdots\cdots\cdots\cdots(D.14)$$

或

$$\vec{V}(x,y,t)|_{\Gamma} = \vec{V}^{*}(x,y,t) \quad \cdots\cdots\cdots\cdots(D.15)$$

悬沙按入流和出流情况分别控制。

入流时：

$$s(x,y,t)|_{\Gamma} = s^{*}(x,y,t) \quad \cdots\cdots\cdots\cdots(D.16)$$

出流时：

$$\frac{\partial s}{\partial t} + u_n \frac{\partial s}{\partial \vec{n}} = 0 \quad \cdots\cdots\cdots\cdots(D.17)$$

式中：

Γ ——水边界；

ζ^{*} ——已知潮位(m)；

$\vec{V}^{*}$ ——已知流速(m/s)；

s^{*} ——已知含沙量(kg/m^3)；

u_n ——法向流速(m/s)。

D.3.5 基本参数

水流紊动粘性系数 N_x 和 N_y 宜由试验确定，或通过验证计算确定，其值可取 50 m^2/s～500m^2/s；悬沙紊动扩散系数 D_x 和 D_y 可取与相应的水流紊动粘性系数 N_x、N_y 相同数值；泥沙静水沉降速度宜通过试验或经验公式确定。

D.4 溢油粒子模型

D.4.1 模型计算域的确定及网格剖分

溢油粒子模型计算域的确定、网格剖分和基本资料应符合 D.1、D.2 的相关要求。

D.4.2 漂移

粒子方法将运动过程分为两个主要部分，即平流过程和扩散过程。宜采用确定性方法模拟溢油的输移过程。单个粒子在 Δt 时段内由平流过程引起的位移可表达为式(D.18)：

$$\overline{\Delta S_i} = (\overline{U}_i + \overline{U}_{wi})\Delta t \quad \cdots\cdots\cdots\cdots(D.18)$$

式中：

$\overline{S}_i$ ——代表第 i 粒子的位置；

$\overline{U}_i$ ——代表质点初始位置处的平流速度；

$\overline{U}_{wi}$ ——表示风应力直接作用在油膜上的风导输移。

D.4.3 水平扩散过程

宜采用随机走步方法来模拟湍流扩散过程。随机扩散过程可以用式(D.19)描述。

$$\overline{\Delta \alpha_i} = R \cdot k_\alpha \Delta t \qquad \text{(D.19)}$$

式中：

$\overline{\Delta \alpha_i}$——$\alpha$ 方向上的湍流扩散距离(α 代表 x、y 坐标)；

R ——[−1,1]之间的均匀分布随机数；

k_α ——α 方向上的湍流扩散系数；

Δt ——时间步长。

因此，单个粒子在 Δt 时段内的位移可表示为：

$$\overline{\Delta\gamma_i} = (\overline{U}_i + \overline{U}_{wi})\,\Delta t + \overline{\Delta\alpha_i} \qquad \text{(D.20)}$$

D.4.4 边界条件处理

油粒子团在运动过程中，可能到达陆地(岛屿)的边界；这时，认为这些粒子粘附在陆地(岛屿)上，不再参与后续计算。

D.5 验证计算及精度控制

D.5.1 验证计算

验证计算应通过参数的调整，满足模拟计算结果与实测结果基本相符的要求，同时应满足验证计算精度的要求。

验证计算内容应主要包括：1)潮位过程线验证；2)流速、流向过程线验证；3)流路验证。

D.5.2 精度控制

验证计算精度应符合：

a) 潮位最高最低潮位值允许 偏差为±10 cm；

b) 流速过程线的形态基本一致，涨落潮段平均流速允许偏差为±10%；

c) 流向，往复流时测点主流流向允许偏差为±10°，平均流向允许偏差为±10°；旋转流时测点流向允许偏差为±15°；

d) 流量，断面潮量允许偏差为±10%；

e) 特大型和1级评价等级的建设项目应进行床面冲淤验证，其平均冲淤厚度偏差应小于±30%，并应满足冲淤部位与趋势相似的要求；

f) 如需进行含沙量验证，则要求含沙量变化趋势一致，潮段平均含量允许偏差为±30%。

D.6 计算成果

通过项目建设前后的模拟计算，应给出各方案的潮位、潮差、流速、流向、含沙量、床面冲淤变化及溢油路径、扩散特征等模拟结果，并附以相应的图表。

附 录 E
（规范性附录）
三维潮流、泥沙、床面冲淤的数值模拟

E.1 适用范围

本附录规定了三维潮流、悬沙输移扩散、床面冲淤变化数值模拟的原则、方法、内容及要求。

潮混合不充分、各要素垂向分布不均匀的海域，海域水文条件较复杂或模拟分辨率要求较高等状况时，应采用三维潮流泥沙数值模拟方法。

E.2 模型计算域的确定及网格剖分

模型计算域的确定及网格剖分应符合 D.2 的要求。

垂向分层可根据试验要求、水深及工程性质确定。

E.3 三维潮流泥沙数值模拟方法

E.3.1 基本资料

用于三维潮流泥沙数值模拟的基本资料除应满足 D.3 的要求外，还应包括不同水层的流速、流向和含沙量资料。

E.3.2 基本方程

E.3.2.1 潮流运动方程

潮流运动可按下列方程控制，见式(E.1)～式(E.4)：

连续方程：

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \qquad \cdots\cdots\cdots\cdots (\text{E}.1)$$

x 向动量方程：

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}=$$
$$-\frac{1}{\rho}\frac{\partial P}{\partial x}+\frac{\partial}{\partial x}(N_x\frac{\partial u}{\partial x})+\frac{\partial}{\partial y}(N_y\frac{\partial u}{\partial y})+\frac{\partial}{\partial z}(N_z\frac{\partial v}{\partial z})+fv \qquad \cdots\cdots\cdots\cdots (\text{E}.2)$$

y 向动量方程：

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}=$$
$$-\frac{1}{\rho}\frac{\partial P}{\partial y}+\frac{\partial}{\partial x}(N_x\frac{\partial v}{\partial x})+\frac{\partial}{\partial y}(N_y\frac{\partial v}{\partial y})+\frac{\partial}{\partial z}(N_z\frac{\partial v}{\partial z})-fu \qquad \cdots\cdots\cdots\cdots (\text{E}.3)$$

z 向动量方程：

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}=$$
$$-\frac{1}{\rho}\frac{\partial P}{\partial z}+\frac{\partial}{\partial x}(N_x\frac{\partial w}{\partial x})+\frac{\partial}{\partial y}(N_y\frac{\partial w}{\partial y})+\frac{\partial}{\partial z}(N_z\frac{\partial w}{\partial z})-g \qquad \cdots\cdots\cdots\cdots (\text{E}.4)$$

式中：

t ——时间(s)；

g ——重力加速度(m/s^2)；

ρ ——海水密度(kg/m^3)；

x、y、z ——原点置于某一基面，z 轴垂直向上的右手直角坐标系坐标；

u、v、w ——空间流速矢量 $\vec{v}$ 沿 x、y、z 轴的速度分量(m/s)；

P ——水压力(kg/m^2)；

N_x、N_y、N_z ——分别为潮流沿 x、y、z 向的紊动粘性系数(m^2/s)。

E.3.2.2 悬沙输移扩散方程

悬沙输移扩散可按下列方程控制，见式(E.5)：

$$\frac{\partial S}{\partial t}+u\frac{\partial s}{\partial x}+v\frac{\partial s}{\partial y}+w_f\frac{\partial s}{\partial z}=\frac{\partial}{\partial x}(D_x\frac{\partial s}{\partial x})+\frac{\partial}{\partial y}(D_y\frac{\partial s}{\partial y})+\frac{\partial}{\partial z}(D_z\frac{\partial s}{\partial z}) \quad \cdots\cdots\cdots\cdots\cdots\cdots(E.5)$$

式中：

S ——水体含沙量(kg/m^3)；

D_x、D_y、D_z ——分别为泥沙沿 x、y、z 向紊动扩散系数(m^2/s)；

w_f ——z 向有效流速(m/s)，$w_f=w-\omega$(ω 为泥沙沉降速度)。

E.3.2.3 床面冲淤变化方程

床面冲淤变化可按下列方程控制，见式(E.6)：

$$\gamma_0\frac{\partial \Delta h}{\partial t}+\frac{\partial q_x}{\partial x}+\frac{\partial q_y}{\partial y}-\omega_{fb}s_b=D_{zb}\frac{\partial s_b}{\partial z} \quad \cdots\cdots\cdots\cdots\cdots\cdots(E.6)$$

式中：

Δh ——床面冲淤厚度(m)；

γ_0 ——底沙干容重(kg/m^3)；

q_x ——沿 x 向的底沙单宽输沙率[$kg/(m^2\cdot s)$]；

q_y ——沿 y 向的底沙单宽输沙率[$kg/(m^2\cdot s)$]；

s_b ——临底处水体含沙量(kg/m^3)；

ω_{fb} ——临底处泥沙有效沉速(m/s)；

D_{zb} ——临底处泥沙垂向紊动扩散系数(m^2/s)。

E.3.3 计算模式

应依据计算域地形特征、项目建设方案等，可采用垂向坐标变换法、流速分解法、分层二维法、过程分裂法、边值模型法、破开算子法、谱方法、解析法等计算模式计算。

E.3.4 初始条件和边界条件

E.3.4.1 初始条件

初始条件可按式(E.7)～式(E.10)确定：

$$\zeta(x,y,t)\big|_{t=0}=\zeta_0(x,y) \quad \cdots\cdots\cdots\cdots\cdots\cdots(E.7)$$

$$u(x,y,z,t)\big|_{t=0}=u_0(x,y,z) \quad \cdots\cdots\cdots\cdots\cdots\cdots(E.8)$$

$$v(x,y,z,t)|_{t=0}=v_0(x,y,z) \quad \cdots\cdots (E.9)$$

$$w(x,y,z,t)|_{t=0}=w_0(x,y,z) \quad \cdots\cdots (E.10)$$

式中：

ζ_0、u_0、v_0、w_0、s_0——分别为 ζ、u、v、w、s 初始时刻的已知值。

E.3.4.2 边界条件

当计算域内存在大面积潮间浅滩时，宜采用动边界技术处理露滩问题。

E.3.4.2.1 固边界条件

固边界的边界条件可按下列方法确定：

a) 法向流速为零，见式(E.11)：

$$\vec{V}\cdot\vec{n}=0 \quad \cdots\cdots (E.11)$$

b) 法向泥沙通量为零，见式(E.12)：

$$\frac{\partial s}{\partial \vec{n}}=0 \quad \cdots\cdots (E.12)$$

E.3.4.2.2 水边界条件

水边界的边界条件可按下列方法确定：

a) 用实测潮位或分层流速(分量)过程控制：

$$\zeta(x,y,t)|_{\Gamma}=\zeta^*(x,y,t) \quad \cdots\cdots (E.13)$$

或

$$u(x,y,z,t)|_{\Gamma}=u^*(x,y,z,t) \quad v(x,y,z,t)|_{\Gamma}=v^*(x,y,z,t) \quad \cdots\cdots (E.14)$$

b) 分层含沙量按入流、出流两种情况控制：

1) 入流时：

$$s(x,y,t)|_{\Gamma}=s^*(x,y,z,t) \quad \cdots\cdots (E.15)$$

2) 出流时：

$$\frac{\partial s}{\partial t}+u_n\frac{\partial s}{\partial \vec{n}}=0 \quad \cdots\cdots (E.16)$$

式中：

Γ ——水边界；

ζ ——相对于某一基面(一般指坐标系原点所在基面)的潮位；

ζ^* ——ζ 的已知值；

u^*、v^*——u、v 的已知值；

s^* ——s 的已知值；

u_n ——边界法向流速。

E.3.4.2.3 水面边界条件

水面边界条件可按式(E.17)～式(E.20)确定：

$$\frac{\partial u}{\partial z}=0 \quad \cdots\cdots (E.17)$$

$$\frac{\partial v}{\partial z}=0 \quad \cdots\cdots (E.18)$$

$$w=\frac{\partial \zeta}{\partial t}+u\frac{\partial \zeta}{\partial x}+v\frac{\partial \zeta}{\partial y} \quad \cdots\cdots (E.19)$$

$$w_f + D_z \frac{\partial s}{\partial z} = 0 \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.20)}$$

E.3.4.2.4 床面边界条件

床面边界条件可按式(E.21)～式(E.24)确定：

$$\frac{\partial u}{\partial z} = \frac{\tau_x}{\rho N_Z} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.21)}$$

$$\frac{\partial v}{\partial z} = \frac{\tau_y}{\rho N_Z} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.22)}$$

$$w = -u \frac{\partial h}{\partial x} - v \frac{\partial h}{\partial y} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.23)}$$

$$-D_z \frac{\partial s}{\partial z} - \omega_{fb} s_b = \begin{cases} M(\dfrac{\tau}{\tau_e} - 1), \tau \geqslant \tau_e \\ 0, \tau_d < \tau < \tau_e \\ \omega_{fb} s_b (\dfrac{\tau}{\tau_e} - 1), \tau \leqslant \tau_d \end{cases} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.24)}$$

式中：

τ ——底部切应力(N/m^2)；

τ_x、τ_y——分别为底部切应力矢量 $\vec{\tau}$ 沿 x 、y 向的分量(N/m^2)；

τ_e ——临界冲刷切应力(N/m^2)；

τ_d ——临界淤积切应力(N/m^2)；

M ——冲刷系数[$kg/(m^2 \cdot s)$]；

h ——相对于某一基面(一般指坐标系原点所在基面)的水深(m)。

E.3.5 基本参数

N_x 、N_y 、D_x 、D_y 宜采用试验或经验公式确定，可取 50 m^3/s～500 m^3/s。

N_z 、D_z 宜采用试验或经验公式确定，D_z 可取 N_z 的值。

τ、τ_x、τ_y 可按式(E.25)～式(E.27)确定：

$$\tau = \rho f_b (\bar{u}^2 + \bar{v}^2) \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.25)}$$

$$\tau_x = \rho f_b \sqrt{\bar{u}^2 + \bar{v}^2}\, \bar{u} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.26)}$$

$$\tau_y = \rho f_b \sqrt{\bar{u}^2 + \bar{v}^2}\, \bar{v} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\text{(E.27)}$$

式中：

$\bar{u}$、$\bar{v}$ ——分别为 u 、v 的垂线平均值；

f_b ——底摩擦系数，$f_b = g/c^2$，$c = \frac{1}{n}(h+\zeta)^{\frac{1}{6}}$ 。

τ_d、τ_e、M 与底质密实度、底质粒径等因素有关，可由试验确定，当缺乏试验资料时也可经验证计算确定。

E.4 验证计算及精度控制

E.4.1 验证计算

三维潮流泥沙数值模拟的验证计算应包括下列内容：

a） 潮位过程线；

b） 分层流速、流向、含沙量过程线；
c） 垂线平均流速、流向、含沙量过程线；
d） 底床冲淤变化。

E.4.2 精度控制

潮位、分层流速、流向、垂线平均流速、流向等的验证计算精度应满足 D.5 的要求。

E.5 计算成果

通过项目建设前后的模拟计算，应给出各方案的潮位、潮差、流速、流向、含沙量及床面冲淤变化等模拟结果，分析和给出项目实施前后的流速、流向、含沙量垂向变化、悬浮沙迁移扩散、床面冲淤变化的分布特征，并附以相应图表。

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GB/T 19485—2014

中 华 人 民 共 和 国
国 家 标 准
海洋工程环境影响评价技术导则
GB/T 19485—2014
*
中国标准出版社出版发行
北京市朝阳区和平里西街甲2号(100029)
北京市西城区三里河北街16号(100045)
网址:www.gb168.cn
服务热线:400-168-0010
010-68522006
2014年8月第一版
*
书号:155066·1-49719

GB/T 19485-2014

Annex 869

China State Oceanic Administration, South China Sea Branch, "Communique on the Oceanic Conditions of the South China Seas Region in 2013" (14 Aug. 2014), *available at* http://www.scsb.gov.cn/Html/2/13/article-1121.html (accessed 9 Mar. 2016)

[…]

Communique on the Oceanic Conditions of the South China Seas Region in 2013

Issue date: [08-14-2014 3:48 PM] [Font: Large | Medium | Small] [Print this page] [Return to previous page]

In accordance with requirements of *Marine Environment Protection Law of the People's Republic of China* and related duties of marine environment protection imposed by the state, the South China Sea Branch of the State Oceanic Administration has hereby formulated and promulgated the *Communique on the Oceanic Conditions of the South China Seas Region in 2013*.

[…]

[…]

Sea regions beyond the near shores

The condition of the seawater environment in the northern sea region of South China Sea is good, of the first or second grade of seawater quality.

The condition of the seawater environment in the central and southern sea region of South China Sea is maintained at a good level, with elements including pH, inorganic nitrogen, active phosphate, petroleum, dissolved oxygen, and heavy metals all meeting the criteria for the first grade of seawater quality.

Main bays

[…]

[…]

The quality of sediments in the sea regions near the shores of Hainan Island is good. The mercury, lead, arsenic, copper, zinc, chromium, sulfates, organic carbon, petroleum, hexachlorocyclohexane, dichlorodiphenyltrichloroethane, and polychlorinated biphenyl content at all testing sites meet the quality standards for grade 1 marine sediment. At individual testing sites, the cadmium content exceeded the quality standards for grade 1 marine sediment, and reached the quality standards for grade 2 marine sediment.

Sea region beyond the near shore

The quality of sea region sediment in the northern sea region of South China Sea is good. The mercury, cadmium, arsenic, copper, zinc, chromium, sulfates, organic carbon, petroleum, hexachlorocyclohexane, dichlorodiphenyltrichloroethane, and polychlorinated biphenyl content at all testing sites meet the quality standards for grade 1 marine sediment. At individual testing sites, the lead content exceeded the quality standards for grade 1 marine sediment, and reached the quality standards for grade 2 marine sediment.

The quality of sea region sediment in the Xisha Islands is good, with all monitored elements meeting the standards for grade 1marine sediment.

[…]

[…]

2.2.3 Coral reef ecosystem

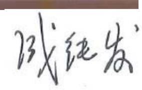
In 2013, the southwest coast of Leizhou Peninsula and Weizhou Island of Beihai, Guangxi has healthy coral reef ecosystems; the eastern coast of Hainan Island and the northern region of Xisha Islands have healthy coral reef ecosystems. The coverage of hermatypic coral decreased compared to five years ago everywhere, with greater decrease on the eastern coast of Hainan Island. The northern region of Xisha Islands has greater influence of human activity, with more abundant types of hermatypic coral reefs, but the coverage is lower. In the last two years, the supplemental quantity of hard coral increased in Weizhou Island of Beihai, Guangxi; the eastern coast of Hainan Island; and the northern region of Xisha Islands.

[…]

2013年南海区海洋环境状况公报

发布时间：[2014-08-14 15:48] [字体：大 中 小] [打印此页] [返回上一页]

依据《中华人民共和国海洋环境保护法》规定和国家赋予的相关海洋环境保护职责，国家海洋局南海分局组织编制了《2013 年南海区海洋环境状况公报》，现予发布。

国家海洋局南海分局局长：

2014年4月广州

概述

2013年，在国家海洋局领导下，国家海洋局南海分局认真贯彻落实党的十八大作出的"建设海洋强国"战略部署，组织广东省、广西壮族自治区、海南省和深圳市海洋行政主管部门，全力开展海洋生态文明建设，积极拓展南海区海洋环境监测和海洋生态保护工作，取得了较好的成效。

2013年，通过开展海水、沉积物和海洋大气监测，掌握了南海区海洋环境状况和变化趋势，为海洋污染防治和海洋环境保护提供基础依据。通过进行生物多样性和典型生态系统监测，进一步了解南海区生物群落结构和生态系统健康状况，为生态环境修复提供科学数据；通过实施海洋倾倒区、海洋油气开发区、涉海工程和陆源排污等监测，掌握海洋开发、陆源和河流携带污染物入海的状况，为海洋监管提供数据支持；通过海水浴场、滨海旅游度假区和海水增养殖区监测，不断促进公益服务水平和效能；通过强化赤潮、海洋环境突发事件、海洋放射性、海水入侵、土壤盐渍化和重点岸段海岸侵蚀监测，监控主要海洋环境风险和海洋环境突发事件对海洋环境的影响，提升海洋环境突发事件应急应对能力；通过推进海洋保护区建设和生态文明示范区建设，逐步修复受损生态，保护海洋生态环境。

2013年南海区海水环境和沉积物环境状况总体良好。绝大多数的珊瑚礁生态系统、红树林生态系统和海草床生态系统呈健康状态。海水浴场和滨海旅游度假区的娱乐用海功能能够正常发挥。海水增养殖区环境状况基本满足养殖活动要求。海水入侵、土壤盐渍化和海岸侵蚀程度没有明显变化。南海区的国家级海洋保护区主要保护对象基本稳定，海洋环境质量状况总体良好。三沙市海域环境状况优良。海洋倾倒活动和海洋油气开发活动未对周边海域环境敏感目标及其它海上活动造成明显影响。涉海工程周边海域环境状况基本满足海域功能区海洋环境保护要求。

近岸局部海域水体污染、生态受损、陆源入海污染物超标排放等环境问题依然突出。近岸海域劣于第四类海水水质标准的海域面积较2012年有所增加。部分河口、海湾等经济活动比较频繁的海域生态系统仍处于亚健康状态。陆源入海排污口达标排放率仍然较低，重点陆源入海排污口邻近海域环境状况较2012 年未见明显改善。

1　海洋环境状况

1.1 海水

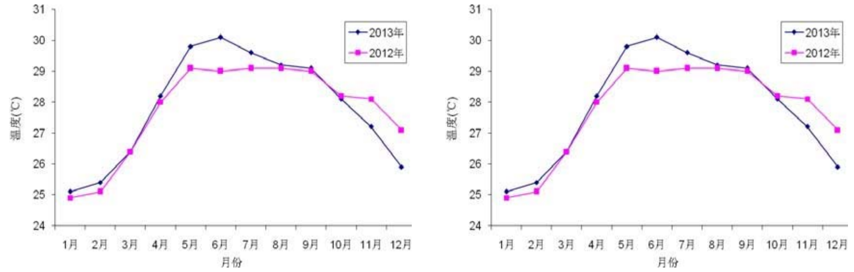
2013年南海区完成了841 个站位的海水环境监测，监测内容包括水温、盐度和海流等水文要素，pH、无机氮、活性磷酸盐、石油类、化学需氧量、溶解氧和重金属等水质要素。

1.1.1 海洋水文状况

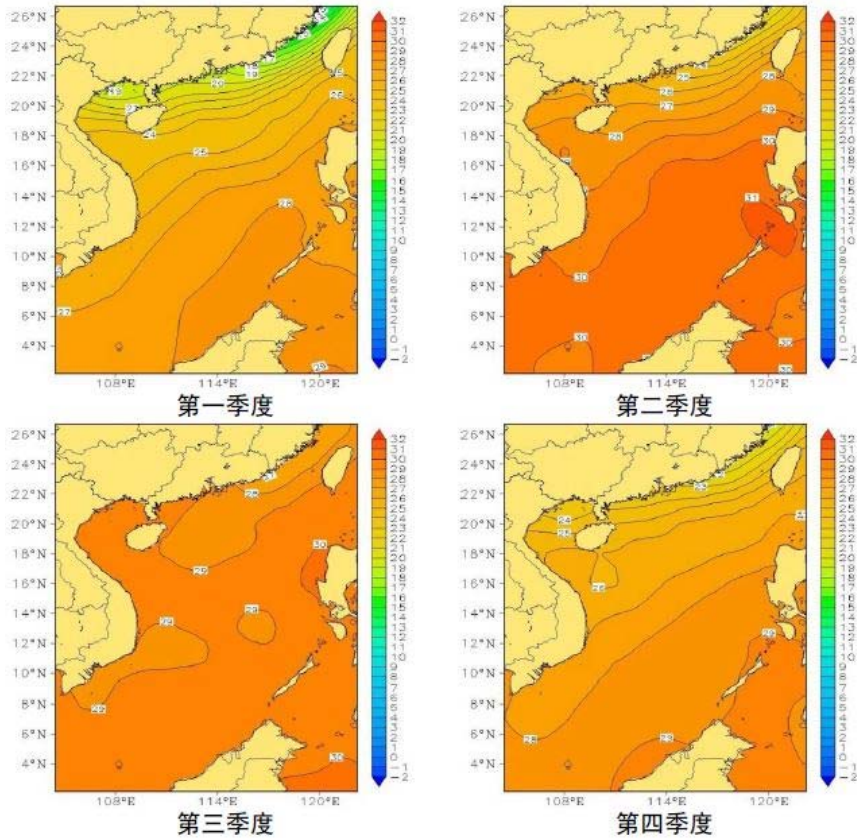
海洋表层水温　南海区各月表层水温实测数据分析结果显示，月均海洋表层水温最低出现在1 月，为25.1℃；最高出现在6 月，为30.1℃。

第一季度			第二季度			第三季度			第四季度		
1 月	2 月	3 月	4 月	5 月	6 月	7 月	8 月	9 月	10 月	11 月	12 月
25.1	25.4	26.4	28.2	29.8	30.1	29.6	29.2	29.1	28.1	27.2	25.9
25.6			29.4			29.3			27.2		

2013年南海区各月和各季度海洋表层平均水温（℃）



2012年和2013年南海区各月和各季度表层平均水温变化趋势图



2013年南海区各季度表层平均水温分布图

海水表层盐度　南海区夏季海水表层盐度在36.2 以下，低盐区域主要分布在河口和近岸。夏季低盐区低盐程度和范围较春季、秋季大，珠江口等河口海域的低盐状况尤为明显。

2013年南海区北部夏季海水表层盐度分布示意图

海流

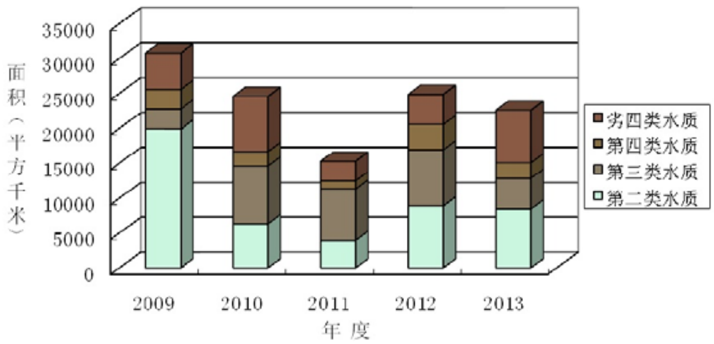
南海区环流状况　南海上层环流具有明显的季节性特征。冬季，整个南海为气旋式环流；夏季，南海北部仍为气旋式环流，南海中南部转变为反气旋式环流。

南海区近岸海域海流状况　2013年重点选择了珠江口的内伶仃、粤东的遮浪和粤西的台山海域开展海流观测。监测结果表明，内伶仃海域潮流为半日潮，呈现往复流特征，主流向为西北-东南向，流速大；余流较弱，流向为东南向。遮浪海域潮流为半日潮，呈现旋转流特征，流速较小；余流较弱，流向为西南向。台山海域潮流为半日潮，呈现旋转流特征，流速较小；余流较弱，流向为东南向。

1.1.2 海水环境状况

2013年南海区海水监测结果显示，海水环境状况总体良好，近岸局部海域污染依然严重，主要污染物为无机氮和活性磷酸盐。

南海区夏季未达到第一类海水水质标准的海域面积为22560平方千米，其中第二类、第三类和第四类海水水质标准的海域面积分别为8450平方千米、4380平方千米和2200平方千米，劣于第四类海水水质标准的海域面积约7530平方千米。劣于第四类海水水质的污染物主要为无机氮和活性磷酸盐。



2009年**~2013**年夏季南海区水质污染面积柱状图

近岸海域

汕头饶平至湛江徐闻以东近岸海域主要污染物为无机氮和活性磷酸盐。劣于第四类海水水质标准的站位主要分布在珠江口海域，其次为汕头近岸、红海湾、江门近岸和湛江港等局部海域。

北部湾近岸海域主要污染物为无机氮和活性磷酸盐。劣于第四类海水水质标准的站位主要分布在廉州湾、钦州湾和北仑河口等局部海域。

海南岛近岸海域环境状况良好，未出现劣于第三类海水水质标准的站位。

近岸以外海域

南海北部海域海水环境状况良好，属于第一类或第二类海水水质。

南海中南部海域海水环境状况保持良好，海水中pH、无机氮、活性磷酸盐、石油类、溶解氧和重金属等要素均符合第一类海水水质标准。

主要海湾

广东海湾环境状况总体一般。汕头湾和湛江港劣于第四类海水水质标准的范围较大，海门湾、红海湾和大亚湾局部海域劣于第四类海水水质标准，主要超标物为无机氮和活性磷酸盐；其余海湾海水质量状况总体较好。

广西海湾海水环境状况总体较好。钦州湾劣于第四类海水水质标准的范围较大，廉州湾和防城港局部海域劣于第四类海水水质标准，主要超标污染物为无机氮和活性磷酸盐；其余海湾海水质量状况良好。

海南海湾的海水环境状况均为良好，各海湾均属于第一类或第二类海水水质。

国家财政支出项目——海洋环境综合整治修复

为了保护海洋生态环境，修复海岸和海岛，遏制滨海湿地恶化，广东省先后启动了台山市下川岛综合整治修复项目、广东省惠州市赤沙湾海域海岸带综合整治修复项目、珠海横琴综合整治修复项目等。以横琴项目为例，通过项目的实施，能有效保护海岛和周边海域的资源环境，特别是滨海湿地生态环境，提高海岛抗击自然灾害的能力，保护海岛居民的生命财产安全，促进社会经济与自然环境的和谐发展。项目主要内容包括修复芒洲破旧海堤，提高海岛减灾防灾能力，加固芒洲破旧水闸，控制芒洲湿地水量，同时通过芒洲湿地土地平整与绿化，美化芒洲湿地环境。

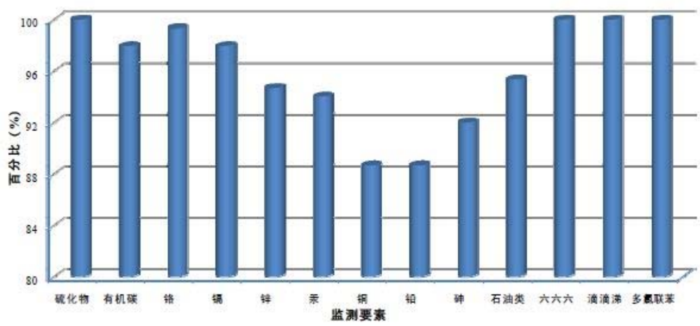
1.1.3 海水富营养化状况

近十年的监测结果显示，由于近岸局部海域海水中无机氮和活性磷酸盐超标严重，导致水体富营养化。2013年南海区呈现富营养化状态的海域面积为11390平方千米，其中轻度、中度和重度富营养化海域面积分别为4640平方千米、3560平方千米和3190平方千米。重度富营养化海域主要分布在珠江口海域，其次是汕头近岸、红海湾、江门近岸、湛江港和钦州湾等局部海域。

2013年南海区夏季海水富营养化状况示意图

1.2 海洋沉积物

2013年，南海区共开展了150 个站位的海洋沉积物监测，监测站位主要集中在南海北部，监测要素包括汞、镉、铅、砷、铜、锌、铬、硫化物、有机碳、石油类、六六六、滴滴涕、多氯联苯共13 项。监测结果显示，南海近岸海域沉积物质量状况总体良好，所有监测站位六六六、滴滴涕、多氯联苯含量均符合第一类海洋沉积物质量标准，硫化物、有机碳、石油类符合第一类海洋沉积物质量标准的站位比例在94%以上，重金属符合第一类海洋沉积物质量标准的站位比例在86%以上。超第一类标准的站位主要集中在珠江口海域，主要污染物为铅和铜等。南海近岸以外海域沉积物质量状况依然保持良好。



2013年南海区海洋沉积物监测要素符合第一类海洋沉积物质量标准的站位比例图

近岸海域

汕头饶平至湛江徐闻以东近岸海域沉积物质量状况总体良好。所有站位硫化物、六六六、滴滴涕、多氯联苯含量均符合第一类海洋沉积物质量标准，铬、镉、有机碳、石油类、锌、汞、砷符合第一类海洋沉积物质量标准的站位比例均在83%以上。超第一类标准的污染物主要为铅和铜，站位超标率分别为20.8%和23.6%，超标站位主要集中在珠江口海域。

北部湾海域沉积物质量状况良好。所有站位的汞、镉、砷、铜、锌、铬、硫化物、有机碳、六六六、滴滴涕、多氯联苯含量均符合第一类海洋沉积物质量标准。超第一类标准的污染物主要为铅和石油类，站位超标率分别为5.0%和20.0%，超标站位主要集中在钦州湾附近海域。

海南岛近岸海域沉积物质量状况良好。所有站位的汞、铅、砷、铜、锌、铬、硫化物、有机碳、石油类、六六六、滴滴涕、多氯联苯含量均符合第一类海洋沉积物质量标准。个别站位的镉含量超过第一类海洋沉积物质量标准，属于第二类海洋沉积物质量。

近岸以外海域

南海北部海域沉积物质量状况良好。所有监测站位的汞、镉、砷、铜、锌、铬、硫化物、有机碳、石油类、六六

六、滴滴涕、多氯联苯的含量均符合第一类海洋沉积物质量标准。个别站位的铅含量超过第一类海洋沉积物质量标准，属于第二类海洋沉积物质量。

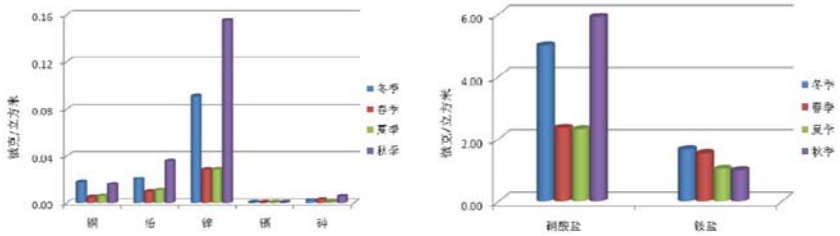
西沙群岛海域沉积物质量状况良好，所有监测要素含量均符合第一类海洋沉积物质量标准。

1.3 珠江口海洋大气污染物沉降状况

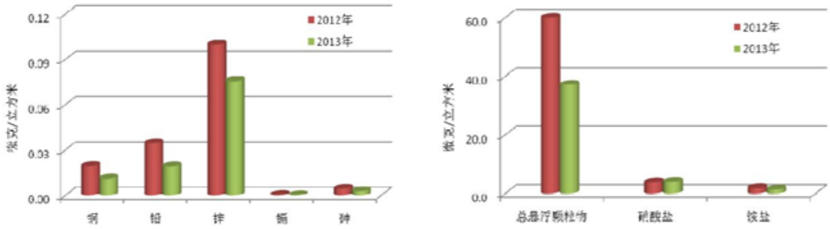
2013年，在珠江口大万山开展了海洋大气污染物的干沉降和湿沉降监测。

1.3.1 海洋大气污染物干沉降

2013年，珠江口海域气溶胶中铜、铅、锌、镉、砷以及总悬浮颗粒物和铵盐的年平均含量与2012 年相比均有不同程度的降低。总悬浮颗粒物年平均含量为37.0微克/立方米，硝酸盐为3.89微克/立方米，铅为0.0193微克/立方米，镉为0.00034微克/立方米。气溶胶中铜、铅、锌、硝酸盐的平均含量表现为秋、冬季高于春、夏季，污染物平均含量季节性差异显著。



2013年珠江口海域气溶胶中主要污染物含量示意图

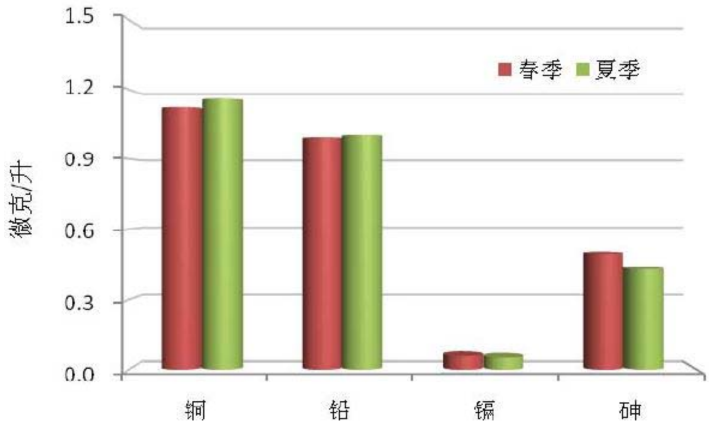


2012年**-2013**年珠江口海域气溶胶中主要污染物含量示意图

1.3.2 海洋大气污染物湿沉降

2013年，珠江口海域湿沉降中铜、铅、锌、硝酸盐、铵盐的年平均浓度较2012年均有不同程度的降低镉和砷年平均浓度与2012年基本持平。

全年降水pH值的变化范围为4.92-7.18，均值为5.33；与2012年相比，降水pH值有所升高。



2013年珠江口海域湿沉降中主要污染物浓度示意图

2 海洋生物多样性与生态系统健康状况

2.1 海洋生物多样性

2013年春、夏和秋季，在南海典型海洋生态系统和重点生态区开展了海洋生物多样性状况监测，监测内容包括浮游生物、底栖生物、珊瑚、红树植物、海草等生物的种类组成和数量分布等。南海区共鉴定出浮游植物473种，浮游动物546种，底栖生物645种，造礁石珊瑚104种，红树植物9种，海草7种。

珠江口海域鉴定出浮游植物183种，浮游动物150种，底栖生物308种；大亚湾海域鉴定出浮游植物171种，浮游动物201种，底栖生物315种。

广东雷州半岛珊瑚礁监测区鉴定出造礁石珊瑚21种，广西北海珊瑚礁监测区鉴定出15种，海南东海岸珊瑚礁监测区鉴定出52种，西沙群岛珊瑚礁监测区鉴定出57种；广西北仑河口红树林鉴定出红树植物8种，山口红树林鉴定出5种；广西北海海草床鉴定出海草3种，海南东海岸海草床鉴定出5种。

近岸趋势性监测海域共鉴定出浮游植物243种，浮游动物119种，底栖生物94种。近岸以外海域，南海北部鉴定出浮游植物154种，浮游动物356种，底栖生物180种。

海域	季节	浮游植物				浮游动物				底栖生物			
		种数(种)	数量(个细胞/立方米)	多样性指数	主要优势种	种数(种)	数量*(个/立方米)	多样性指数*	主要优势种*	种数(种)	数量(个/平方米)	多样性指数	主要优势种
大亚湾	春季	52	2.46×10^5	2.67	夜光藻 叉角藻	108	262	1.80	鸟喙尖头溞 肥胖三角溞	153	197	2.20	奇异稚齿虫 光滑倍棘蛇尾
	夏季	110	4.58×10^7	1.66	柔弱菱形藻 中肋骨条藻	大型浮游动物				160	205	2.00	短吻铲荚螠 奇异稚齿虫
						92	229	2.99	鸟喙尖头溞 锥形宽水蚤				
						中、小型浮游动物							
						127	15233	3.44	强额拟哲水蚤 简长腹剑水蚤				
	秋季	100	1.32×10^7	2.70	菱形海线藻 伏氏海毛藻	75	71	3.19	肥胖箭虫 红纺锤水蚤	125	72	1.74	短吻铲荚螠 颗粒六足蟹
	平均	—	$\mathbf{1.97\times10^7}$	**2.34**	—	—	**187**	**2.33**	—	—	**158**	**1.98**	—
珠江口	春季	111	7.48×10^6	2.26	柔弱菱形藻 中肋骨条藻	78	264	1.64	火腿伪镖水蚤 中华异水蚤	134	135	1.38	刺缨虫 双形拟单指虫
	夏季	103	3.30×10^7	1.65	中肋骨条藻 柔弱菱形藻	大型浮游动物				175	55	1.57	双形拟单指虫
						95	71	2.29	肥胖箭虫 中华异水蚤				
						中、小型浮游动物							
						119	3823	2.85	中华异水蚤 强额拟哲水蚤				
	秋季	82	2.40×10^5	1.92	中肋骨条藻 丹麦细柱藻	81	96	2.70	刺尾纺锤水蚤 亚强次真哲水蚤	171	36	1.62	光滑河蓝蛤
	平均	—	$\mathbf{1.36\times10^7}$	**1.94**	—	—	**144**	**2.19**	—	—	**75**	**1.52**	—

注：* 除注明外，均指大型浮游动物。

2013年珠江口和大亚湾海域浮游生物和底栖生物种数、数量、多样性指数及主要优势种

海区		生物类群	种数(种)	数量*	多样性指数	主要类群
近岸趋势性监测海域		浮游植物	289	3.90×10^7	2.60	硅藻、甲藻
		浮游动物	134	3.25×10^3	2.73	桡足类、枝角类
		底栖生物	85	185	2.00	软体动物、环节动物
近岸以外海域	南海北部	浮游植物	154	0.90×10^6	3.24	硅藻、甲藻
		浮游动物	356	143	4.91	毛颚类、桡足类
		底栖生物	180	26	1.20	节肢动物、脊索动物
	南海中南部	浮游植物	71	1.53×10^3	3.77	硅藻
		浮游动物	306	75	6.15	桡足类

注：*浮游植物数量单位为个细胞/立方米，浮游动物数量单位为个/立方米，底栖生物数量单位为个/平方米。

2013年近岸趋势性监测海域与近岸以外海域浮游生物、底栖生物种数、数量、多样性指数及主要类群

2.2 海洋生态系统健康状况

2013年，对南海区河口、海湾、珊瑚礁、红树林和海草床5种类型共10个海洋生态系统健康状况的评价结果显示，南海区典型海洋生态系统处于健康或亚健康状态。

2.2.1 河口生态系统

2013年，珠江口生态系统呈亚健康状态。海水中无机氮含量偏高，沉积物质量良好，浮游动物和鱼卵、仔稚鱼密度偏低。近五年，珠江口浮游植物多样性指数年际变化幅度较大；浮游动物的数量和多样性指数略呈下降趋势；底栖生物的种类数维持稳定，但栖息密度和多样性指数略呈下降趋势。

生态系统类型	监测海域名称	所属经济发展规划区	监测海域面积（平方千米）	健康状况
河口	珠江口	珠江三角洲经济区	3 980	亚健康
海湾	大亚湾	珠江三角洲经济区	1 200	亚健康
珊瑚礁	雷州半岛西南沿岸	广东海洋经济综合试验区	1 150	健　康
	广西北海	广西北部湾经济区	120	健　康
	海南东海岸	海南国际旅游岛	3 750	亚健康
	西沙珊瑚礁**	海南国际旅游岛	400	亚健康
红树林	广西北海	广西北部湾经济区	120	健　康
	北仑河口	广西北部湾经济区	150	健　康
海草床	广西北海	广西北部湾经济区	120	亚健康
	海南东海岸	海南国际旅游岛	3 750	健　康

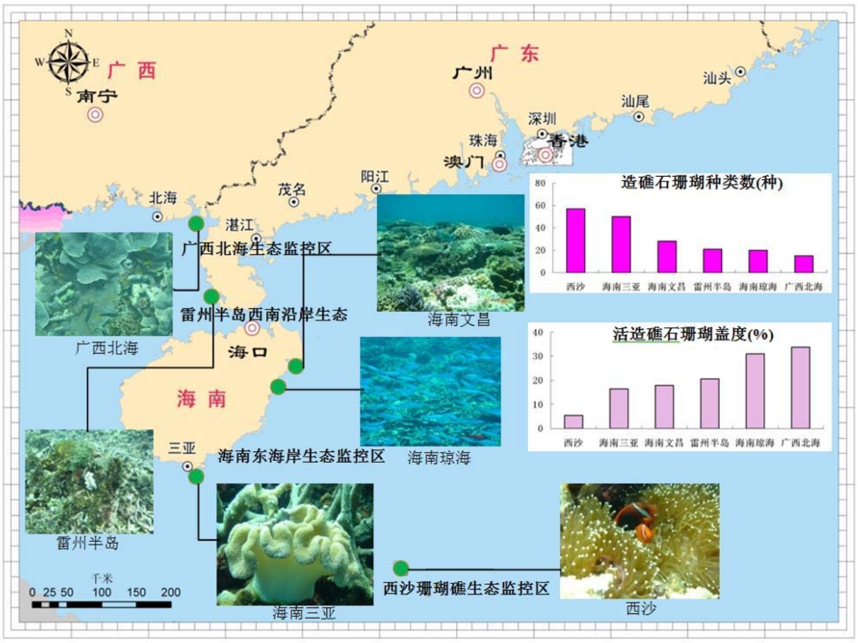
2013年重点生态区海洋生态系统基本情况

2.2.2 海湾生态系统

2013年，大亚湾生态系统呈亚健康状态。海水中个别站位石油类含量偏高，沉积物质量状况保持良好，浮游植物数量偏高，浮游动物数量和生物量均偏低，鱼卵、仔稚鱼密度偏低。近五年，浮游植物数量上升，多样性指数变化幅度较大；浮游动物数量年际变化较明显，多样性指数略有下降；底栖生物数量年际间波动较大，生物量略有上升。

2.2.3 珊瑚礁生态系统

2013年，雷州半岛西南沿岸和广西北海涠洲岛珊瑚礁生态系统呈健康状态；海南东海岸和西沙群岛北区珊瑚礁生态系统呈亚健康状态。各地活造礁石珊瑚盖度较五年前均有所减少，其中海南东海岸下降幅度较大。西沙群岛北区是人类活动影响较大的区域，活造礁石珊瑚种类较丰富，但盖度较低。近两年，广西北海涠洲岛、海南东海岸和西沙群岛北区硬珊瑚补充量有所增加。



2013年重点生态区造礁石珊瑚种类和盖度示意图

南海沿岸珊瑚礁资源概况

珊瑚礁生态系统是多样性最为复杂、生产力又极高的海洋生态系统，被称为“海洋中的热带雨林”。珊瑚礁构筑的礁石立体结构，为其它生物提供了极好的栖息环境，吸引了大量生物前来觅食和繁殖。生态学家常把它看作是海洋生态系统进化所能达到的上限，它对于海洋环境和海洋生态系统的优化都具有重要的意义。同时珊瑚礁和其它生物绚丽的色彩，具有极高的观赏价值。

珊瑚礁主要分布区域、种类和盖度

省份	主要分布区域	种类数	盖度（%）
广东	大亚湾	21	27.5
	万山群岛	25	18.2
	茂名放鸡岛	13	9.7
	雷州半岛西南沿岸	21	20.6
广西	广西涠洲岛	15	33.8
海南	海南岛东海岸	52	15.8
	西沙群岛	57	5.4

西沙珊瑚礁

2.2.4 红树林生态系统

2013年，广西山口和北仑河口红树林生态系统呈健康状态。红树林湿地和植被面积保持稳定。山口红树林红树植物平均密度为9933株/公顷，北仑河口红树植物平均密度为13028株/公顷。山口红树林群落类型保持稳定，维持原有生境完整性。北仑河口红树林鸟类种类丰富，底栖生物栖息密度和生物量较高。

南海沿岸红树林资源概况

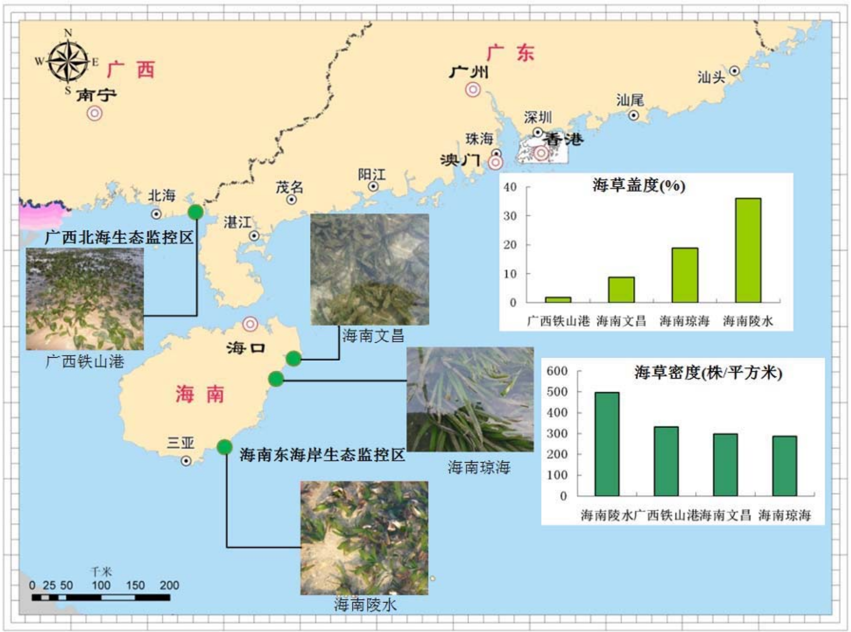
中国大陆现有红树林22 000余公顷，其中90%左右分布在南海的广东、广西和海南三省区。红树林复杂的根系为海洋动物提供了理想的栖息环境和丰富的食物来源；红树林区是候鸟的越冬场和迁徙中转站，也是各种海鸟的觅食栖息、生产繁殖的场所；红树林具有防风消浪、促淤保滩、固岸护堤、净化海水和空气的功能；红树林的工业、药用价值也很高。

红树林面积、种类数、主要分布区域和主要种类

省份	面积（公顷）	种类数	主要分布区域	主要种类
广东	9084	19	湛江、深圳福田、珠海淇澳岛	秋茄、白骨壤、桐花树
广西	6272	18	山口、北仑河口、茅尾海	白骨壤、桐花树
海南	3930	35	东寨港、清澜港	秋茄、白骨壤、桐花树

2.2.5 海草床生态系统

2013年，广西北海海草床生态系统呈亚健康状态，海南东海岸海草床生态系统呈健康状态。广西北海海草平均密度为330株/平方米，北暮监测区海草密度较2012年下降了72%，山寮监测区首次发现喜盐草。与五年前相比，广西北海海草盖度显著下降，部分区域下降50%以上。海南东海岸海草平均密度381株/平方米，底栖动物生物量较五年前有所增加，海草密度较五年前下降，但盖度近两年维持稳定。



2013年重点监测区海草密度和盖度示意图

南海沿岸海草床资源概况

海草是生活在浅海的一类高等植物，具有根、茎、叶的分化，能开花和结果。海草床是由水体、底质、生活其中的海草和其它生物群落构成的一个典型的海洋湿地生态系统，具有较高生物量和生产力。海草床重要的生态功能体现在固着底质、稳定潮滩、生物固碳（约占整个海洋生态系统每年固碳量的15%）、净化水体、为一些珍稀食草动物提供食物等，其中最重要的是为众多生物（贝、鱼、虾、蟹、水鸟等）提供多样化的栖息地。

海草床主要分布区域、面积和主要种类

省份	主要分布区域	面积（公顷）	主要海草种类
广东	雷州流沙湾	900	喜盐草、二药藻
	饶平柘林湾	40	喜盐草
	湛江东海岛	9	贝克喜盐草
	珠海唐家湾	8	贝克喜盐草
	江门上川岛	7	矮大叶藻
	考洲洋	7	喜盐草
广西	北海	861	喜盐草、二药藻、矮大叶藻、贝克喜盐草
	防城港珍珠湾	64	矮大叶藻、贝克喜盐草
海南	文昌沿岸	>1000	海菖蒲、泰来藻
	琼海龙湾	350	海菖蒲、泰来藻
	陵水黎安湾	207	海菖蒲、泰来藻
	陵水新村湾	304	海菖蒲、泰来藻、针叶藻、二药藻

2013年广西北海沙背的海草床

幼鱼栖息在海草上

3　海洋环境监管监测

3.1 海洋倾倒区

2013年南海区在用倾倒区18个，其中国务院批准的海洋倾倒区8个，临时性海洋倾倒区10个。全年总倾倒量2958万立方米，倾倒物全部为涉海工程建设或港口航道维护产生的疏浚物。

2013年，南海区倾倒区海水、沉积物和海洋生物等要素跟踪监测结果显示，各倾倒区使用过程中倾倒区及其周边海域海洋环境质量未发生明显变化，满足海洋功能区环境保护要求。各倾倒区海水中悬浮物增量、石油类、铜、铅、镉、锌、铬、汞和砷等含量基本符合第一类海水水质标准。海洋沉积物中各污染物的含量基本符合第一类海洋沉积物质量标准。倾倒区范围内底栖生物种类数、栖息密度和生物量等略有下降。倾倒区海域水深测量结果显示，在用倾倒区水深变化未超出倾倒区选划时预测的范围。

倾倒活动未对所在海域环境质量和邻近海域用海项目造成明显影响，倾倒区功能发挥基本正常。

珠江口海洋倾废全覆盖监视监管

——强化倾废监管之一

珠江口海域是南海区疏浚倾废活动最为密集的区域之一，为了强化倾废活动监管，2013 年南海分局开展了珠江口海域海洋倾废全覆盖监视监管，共出动执法艇 36 航次，海上值守 208 天，派出执法人员 832 人次，监视泥驳船、抓斗船 800 多艘次，登检船舶 120 艘次，发现违规倾废行为 6 起。

通过加强监管，有效地规范了珠江口海域海洋倾废作业秩序，有力地打击和震慑了违规作业行为，提高了海洋环境保护意识，保护了珠江口及周边海域海洋环境。

深挖潜力，充分发挥海洋倾废记录仪的监管作用

——强化倾废监管之二

2013 年，南海分局通过深挖海洋倾废记录仪潜能、完善监管制度、升级改造管理系统等多项措施，提升了海洋倾废记录仪管理系统的运行效率，完善了行政审批部门、执法监察部门与技术支持部门之间的联动机制，强化对海洋倾倒活动的监控监管能力。2013 年，共对 30 余项海洋倾倒活动实施了动态、实时、有效监控，查处违法违规倾倒行为多起，有力地制止了违法违规倾倒现象的出现。

海洋倾废记录仪是一种集定位、吃水测量和数据传输系统为一体的监控设备，通过系统终端，实时掌握海洋倾倒船舶的位置和吃水信息，以有效监控船舶装载废弃物的倾倒位置和装载情况。

技术人员安装调试海洋倾废航行记录仪图

3.2 海洋油气开发区

2013年，南海区海上油气开发区生产水排海量为14101万立方米，钻井液排海量为6.4万立方米，钻屑排海量为2.6万立方米。

2009年**~2013**年南海油气开发区生产水、钻井液和钻屑排放状况图

2013年，对珠江口油气田、文昌油田、崖城气田、乐东气田、东方气田、涠洲油田等11个油气开发区开展了海水、沉积物和海洋生物监测。监测结果显示，各油气区附近海域海水中石油类等要素符合第一类海水水质标准；沉积物要素符合第一类海洋沉积物质量标准；海洋生物群落未受影响。

南海区各油气开发区附近海域海洋环境质量基本符合海洋功能区的环境保护要求，未发现油气开发活动对毗邻海域海洋功能产生明显影响，没有发生重大溢油事件。

3.3 涉海工程

3.3.1 跨海大桥工程

2013年，对港珠澳大桥施工海域的监测结果显示，港珠澳大桥施工海域海水中石油类含量符合第二类海水水质标准，施工区附近海域悬浮物增量未超出工程环评报告书预测的浓度和影响范围。海洋沉积物各监测要素含量与该海域的背景值基本持平，符合第二类海洋沉积物质量标准。未发现施工对毗邻海域海洋功能产生明显影响。

3.3.2 核电站附近海域放射性状况

2013年，对运营的大亚湾核电站附近海域开展了海水、沉积物和海洋生物放射性监测，同时对在建的台山核电站、阳江核电站、防城港核电站和昌江核电站附近海域开展了海洋环境放射性本底调查。

大亚湾核电站附近海域海水中氚、锶-90和铯-137等人工放射性核素比活度均在本底范围之内，符合国家海水水质标准；沉积物和海洋生物体中铀-238、钍-232、镭-226、钾-40、铯-137、总β放射性水平与运营前相比基本一致。

在建的台山核电站、阳江核电站、防城港核电站和昌江核电站附近海域的海水、海洋沉积物和海洋生物体中放射性核素含量水平在我国南海海洋环境放射性本底范围之内。

3.4 入海排污口及其邻近海域环境状况

2013年，对南海区120个陆源入海排污口开展了监督性监测，并对其中排污量大的15个入海排污口邻近海域的环境质量进行了监测。广东、广西和海南沿岸监测的入海排污口数量分别为81个、20个和19个，各占总数的67.5%、16.7%和15.8%。监测的120个排污口中，工业类排污口占32.5％，市政类排污口占55.8%，排污河占10.0%，其他占1.7%。

2013年南海三省（区）部分入海排污口图

3.4.1 入海排污口排污状况

2013年3月、5月、8月和10月对入海排污口排污状况的监测结果显示总达标排放率为61.4%。其中，40个入海排污口全年4次监测均达标，占监测排污口总数的33.1%，较2012年降低了14.2%；26个排污口3次达标；19个排污口2次达标；12个排污口1次达标；仍有23个排污口全年4次监测均不达标，占监测排污口总数的19.2%，较2012年增加了2.6%。

2013年南海区入海排污口达标排放情况统计图

入海排污口排放的主要污染物为总磷、化学需氧量（CODCr）、悬浮物和氨氮，各要素达标排放率依次为59.6%、89.4%、92.3%和95.0%。与2012年相比，总磷达标排放率略有下降，化学需氧量（CODCr）、悬浮物和氨氮达标排放率有所上升。

不同类型入海排污口的达标排放率从高到低依次为：排污河75.0%、工业类排污口69.5%、市政类排污口54.1%。

排污河 12条排污河全年48次监测达标排放率为75.0%。主要超标污染物为总磷、氨氮和化学需氧量（CODCr）。

工业类排污口 40个工业类排污口全年154次监测达标排放率为69.5%。主要超标污染物为总磷、化学需氧量（CODCr）和悬浮物。

市政类排污口 67个市政类排污口全年259次监测达标排放率为54.1%。主要超标污染物为总磷、化学需氧量（CODCr）、悬浮物和氨氮。

3.4.2 入海排污口邻近海域环境状况

2013年，对15个重点入海排污口邻近海域进行了监测。其中，5月对入海排污口邻近海域实施水质监测，8月对入海排污口邻近海域实施水质、沉积物、生物质量和底栖生物监测。

水质状况 15个排污口中，5月和8月各有11个和13个排污口邻近海域水质不能满足所在海域海洋功能区水质要求，分别占监测总数的73.3%和86.7%。主要污染物为无机氮和活性磷酸盐，其次为生化需氧量（BOD5）、化学需氧量（CODMn）和石油类等。与2012年相比，有1个排污口邻近海域水质略有好转，2个排污口邻近海域水质有所下降，其它排污口基本没有变化。

沉积物状况 南海区10个监测的入海排污口中，有5个排污口邻近海域沉积物状况不能满足所在海洋功能区沉积物质量要求，占监测总数的50.0%。主要污染要素为石油类，其次为铜等重金属和硫化物，工业排污口和排污河超标比例较高。与2012年相比，有1个排污口邻近海域沉积物质量状况有所改善，3个排污口邻近海域沉积物质量状况下降。

3.5 主要河流污染物入海状况

2013年，南海区监测的9条主要河流污染物入海量分别为：化学需氧量（CODCr）115.9万吨、氨氮（以氮计）2.9万吨，硝酸盐氮（以氮计）35.0万吨，亚硝酸盐氮（以氮计）2.9万吨，总磷（以磷计）3.0万吨，石油类1.3万吨，重金属3869吨（其中铜721吨、铅253吨、锌2853吨、镉34吨、汞8吨），砷485吨。

2013年南海主要河流污染物入海量（吨）

3.6 海洋垃圾

2013年，在南海近岸海域开展了海洋垃圾监测，监测内容包括海面漂浮垃圾、海滩垃圾、海底垃圾的种类、数量和来源等。

海面漂浮垃圾 湛江市观海长廊海域、北海市侨港海域、钦州市三娘湾月亮湾和三亚市三亚湾4个海域的海面漂浮垃圾监测结果显示，海面漂浮垃圾主要以塑料瓶、塑料袋、聚苯乙烯泡沫和木片（块）等为主。中小块漂浮垃圾的平均数量密度为913个/平方千米，平均质量密度约为1千克/平方千米；其中塑料类垃圾数量最多，占48.8%，其次为木制品类和聚苯乙烯泡沫类垃圾，分别占16.3%和14.0%。大块和特大块漂浮垃圾的平均数量密度为19个/平方千米，其中塑料类垃圾约占70.4%。垃圾来源统计结果显示，92.9%的海面漂浮垃圾来自陆地活动。

海滩垃圾 深圳市大鹏湾下沙海滩、北海市侨港海域海滩、钦州市三娘湾月亮湾海滩、防城港市大坪坡海滩、三亚市亚龙湾沙滩5个海岸沙滩的垃圾监测结果显示，海滩垃圾的平均数量密度为3368个/平方千米，以聚苯乙烯泡沫类最多，占46.7%，其次为塑料类、木制品等垃圾，分别占18.7%和13.1%；海滩垃圾的平均质量密度为306千克/平方千米，以水泥块等其他人造垃圾的质量密度最大，约为288千克/平方千米。来源统计结果显示，海滩垃圾中91.3%来自陆地活动。

2013年南海区监测海域海洋垃圾数量分布图

海底垃圾 北海市侨港海域、钦州市三娘湾月亮湾和三亚市三亚湾3个海域的海底垃圾监测结果显示，海底垃圾的平均数量密度为827个/平方千米；平均质量密度约为27千克/平方千米，主要为塑料类垃圾，约占79.3%。来源统计结果显示，92.4%海底垃圾来自陆地活动。

4 海洋环境灾害及突发海洋污染事件

4.1 海洋赤潮

2013年南海区通过航空遥感监测、船舶巡航监测、沿岸人员巡视等方式在南海海域开展赤潮灾害应急监视监测工作。

2013年南海区共监测到赤潮6次，赤潮累计面积约167平方千米，出现有毒赤潮种类为双胞旋沟藻、夜光藻、米氏凯伦藻和球形棕囊藻，出现频率和面积最大的赤潮生物为中肋骨条藻。2013年两次较大面积的赤潮均发生在广东湛江港附近海域。2001年以来，2013年赤潮发生的面积较小，次数较少。

2001～2013年南海区赤潮统计图

2013年南海区发生的赤潮统计

4.2 海洋溢油

2013年8月14日10时左右，受台风“尤特”影响,香港一艘满载5.7万吨镍矿的“夏长号”货船在珠海万山群岛附近海域沉没，现场监测结果显示，沉船附近海域有油膜漂浮海面，沉船东北部约400米处海水中石油类最高含量超第三类海水标准。

4.3 海水入侵及土壤盐渍化

2013年，海水入侵和土壤盐渍化监测结果显示，南海沿岸监测区海水入侵和土壤盐渍化范围较小。

海水入侵状况 南海沿岸监测区海水入侵范围为0.1千米~1.4千米。绝大部分监测站点氯度（Cl-）小于1000毫克/升，属轻度入侵或无入侵。与2012年相比，广东茂名龙山、湛江湖光以及海南三亚海棠湾监测断面的海水入侵范围略有扩大，其余断面无明显变化。

土壤盐渍化状况 南海沿岸监测区土壤盐渍化范围一般在0.3千米~4.0千米。广东湛江和海南三亚监测区土壤含盐量相对较高，部分为重盐渍化土或盐土，其余监测区盐渍化程度较轻。与2012年相比，广西北海土壤盐渍化范围有所下降；广东湛江、阳江以及海南三亚海棠湾监测区的盐渍化范围有所扩大。

2013年南海沿岸海水入侵和土壤盐渍化范围及变化趋势

4.4 重点岸段海岸侵蚀

2013年，南海区重点岸段海岸侵蚀监测结果显示，广东省雷州市赤坎村岸段和海南省海口市长流镇镇海村岸段仍处于侵蚀状态。

赤坎岸段 属砂、石混合土质海岸。监测结果显示，侵蚀岸段长约400米，位于赤坎渔村的西南侧，侵蚀陡崖高约4米～7米。与2012年相比，赤坎岸段海岸平均后退了约2米，侵蚀速率略有降低。

2009年～2013年南海区重点岸段海岸侵蚀状况及变化趋势

镇海岸段 属砂质海岸。监测结果显示，侵蚀区西侧的镇海渔港弧形防波堤，受海浪冲刷影响，堤坝部分岸段出现崩塌，岩基也遭到破坏。

5 公益服务

5.1 海水浴场环境状况

2013年4月24日至10月31日对南海区10个重点海水浴场开展每日监测。监测要素主要包括与休闲活动相关的水文气象、水质、海面状况等。监测结果以预报信息的形式通过南海海洋预报网等媒体每日发布，部分浴场还在当地政府网站或浴场游人集中区域发布，为公众滨海休闲活动提供了重要的参考信息。

2013年南海区重点监测海水浴场状况

各浴场监测结果显示南海区海水浴场的环境状况良好。浴场休闲功能主要受天气和风浪等自然因素影响。

水质 海水浴场水质等级为良以上的天数占所有监测天数的99%。其中，阳江闸坡海水浴场每天监测结果均为优。

健康指数 广东南澳青澳湾等9个海水浴场的年度平均健康指数为优，浴场环境对人体健康潜在危害低。海口假日海滩海水浴场健康指数为良，主要由部分监测时段粪大肠菌群含量较高引起。

游泳适宜度 游泳适宜度是综合海水浴场水文气象、水质、海滩环境、游泳健康指数做出的评价。10个海水浴场适宜和较适宜游泳的天数比例在62%～87%。

2013年南海区海水浴场综合环境状况

5.2 滨海旅游度假区环境状况

2013年，3月24日至10月31日对深圳大小梅沙、湛江东海岛、北海银滩、三亚亚龙湾4个重点滨海旅游度假区开展每日监测。监测要素包括与休闲活动相关的水文气象、沙滩环境、水质、景观等。监测结果每日通过南海海洋预报网等相关媒体发布。

对各滨海旅游度假区环境状况、休闲活动条件状况进行年度统计评价。结果显示，滨海旅游度假区环境状况优良，各项指数均在良好以上，适宜开展休闲（观光）活动；影响各项休闲观光活动的主要因素是天气不佳。

2013年南海区重点监测滨海旅游度假区状况

水质状况 南海区重点监测的4个滨海旅游度假区水质指数均在4.3-4.8之间，平均指数4.5，水质极佳。

海面状况 度假区全年海面状况平均指数4.4，海面状况优良。其中13%监测天数由于受天气不佳的影响，海面状况为差。

休闲观光条件状况 南海区各度假区休闲观光平均指数为4.2，很适合开展休闲观光活动。适宜开展各类休闲观光活动的天数均达到82%以上。

2013年重点滨海旅游度假区环境状况指数

三亚亚龙湾滨海旅游度假区

5.3 海水增养殖区环境状况

2013年对南海区14个海水增养殖区水质、沉积物、生物质量进行监测。监测结果显示，各海水增养殖区的环境质量均能满足养殖功能要求，综合环境质量等级为优良或较好。

2013年海水增养殖区综合环境质量等级示意图

水质状况 实施监测的海水增养殖区水质状况总体较好。各增养殖区海水中化学需氧量、汞、镉、铅、砷、铬和锌浓度均符合功能区要求的第二类海水水质标准。部分养殖区中粪大肠菌群、pH、溶解氧、无机氮、活性磷酸盐和石油类浓度超第二类海水水质标准。各个增养殖区中，水质状况较好的是广西涠洲岛海水增养殖区，各监测要素均符合第二类海水水质标准。

沉积物质量状况 实施监测的海水增养殖区沉积物质量总体良好。各增养殖区沉积物中汞和有机碳含量均符合功能区要求的第一类海洋沉积物质量标准。部分增养殖区中铜和石油类含量超第一类海洋沉积物质量标准。各个增养殖区中，广东柘林湾海水网箱养殖区、广西防城港珍珠湾珍珠养殖区、海南临高后水湾海水增养殖区沉积物中各监测要素含量均符合第一类海洋沉积物质量标准。

生物质量状况 实施监测的大部分增养殖区的生物质量状况较好。各增养殖区生物体中汞、砷、六六六含量均符合功能区要求的第一类海洋生物质量标准。部分养殖区石油烃、粪大肠菌群、铅和镉含量超第一类海洋生物质量标准。增养殖区麻痹性贝毒和腹泻性贝毒符合增养殖区海洋生物质量要求的站位比例在90%以上。各个增养殖区中，广西北海廉州湾对虾养殖区生物体中各要素均符合第一类海洋生物质量标准。

综合环境质量等级 2013年综合评价结果显示，在监测的14个增养殖区中，64.3%的增养殖区综合环境质量为"优良"，35.7%为"较好"。比较2010至2013年增养殖区综合环境质量等级状况，广东茂名水东湾网箱养殖区、海南海口东寨港海水增养殖区、海南陵水新村海水增养殖区综合环境质量等级逐年升高，其余增养殖区综合环境质量等级基本持平。

南海增养殖区综合环境质量等级状况

2013年南海区对5个国家级海洋自然保护区和5个国家级海洋公园开展了监测，监测内容包括水文、水质、沉积物、浮游生物、底栖生物和保护对象状况等。

6.1 海洋保护区建设与管理

国家级海洋自然保护区监测结果显示，海水质量状况总体良好，沉积物中各监测要素含量符合第一类海洋沉积物质量标准，主要保护对象和生物群落基本保持稳定。

6.1.1 国家级海洋自然保护区

广东徐闻珊瑚礁国家级自然保护区2013年鉴定出造礁石珊瑚21种、软珊瑚1种，主要优势种为澄黄滨珊瑚、交替扁脑珊瑚和角孔珊瑚。平均活珊瑚覆盖率为20.6%，与2012年相比略有增加。建区后徐闻加强了珊瑚礁管护工作，珊瑚礁生态系统逐渐恢复。

广西北仑河口红树林国家级自然保护区2013年红树林群落结构和类型基本保持不变，整体长势良好。鉴定出红树植物8种，主要优势种为桐花树、秋茄和木榄；底栖生物44种，平均栖息密度和生物量分别为319个/平方米和577克/平方米；鸟类74种，主要优势种为白头鹎、黑卷尾和大山雀。5月至8月，竹山发生了小面积的广州小斑螟虫害，危害的主要树种为白骨壤和桐花树。2013年红树林育苗力度加大，保护区有林面积突破1300公顷。

红树林群落监测

广西山口红树林生态国家级自然保护区 2013年红树林群落结构和类型基本保持不变，林相良好。鉴定出红树植物5种，分别为桐花树、红海榄、木榄、秋茄和白骨壤；底栖动物42种，平均栖息密度和生物量分别为187个/平方米和226克/平方米。部分红树林4-8月发生了广州小斑螟和三点广翅蜡蝉虫害，保护区工作人员及时采取措施进行灭杀，有效遏制了虫害。互花米草进一步加速扩展，对红树林的生态健康有一定影响。建区后保护区坚持"养护为主，适度开发，持续发展"的保护方针，通过加大保护力度、强化滩涂治理、推进人工造林等多种措施，使有林面积从1990年的730公顷，发展到目前的824公顷。

海南三亚珊瑚礁国家级自然保护区 2013年鉴定出造礁石珊瑚48种，主要优势种为多孔鹿角珊瑚、伞房鹿角珊瑚和标准蜂巢珊瑚，平均活珊瑚覆盖度为22.0%，硬珊瑚补充量为0.61个/平方米；珊瑚礁鱼类24种，平均密度为0.55尾/平方米。建区后，保护区禁止采挖珊瑚礁以及限制捕捞，使人类活动对珊瑚礁生态系统的负面影响程度持续减少，珊瑚礁生态状况早期大幅下降的趋势得到明显抑制。但三亚珊瑚礁现阶段仍受海洋工程建设及不断增加的污水、废弃物排放等威胁。

海南万宁大洲岛海洋生态国家级自然保护区 2013年鉴定出造礁石珊瑚43种，主要优势种为疣状杯形珊瑚、多孔鹿角珊瑚和伞房鹿角珊瑚等，平均活珊瑚覆盖度为20.7%，硬珊瑚补充量平均值为0.83个/平方米；珊瑚礁鱼类10种，平均密度为0.25尾/平方米。金丝燕种群数量在30-40只之间,栖息地为南罗燕子洞、暗岩燕子洞和大架燕子洞等3处。岛上有野生维管植物618种，植被覆盖率达95%以上，主要优势种为小花龙血树。建区后保护区开展了巡视执法、宣传教育、生态监测等各项管理活动，滥采燕窝、炸鱼、电鱼、毒鱼和毁林等严重破坏生态资源的行为得到有效遏制。

2013年南海区海洋自然**/**特别保护区分布及相关情况示意图

6.1.2 国家级海洋公园

广东海陵岛国家级海洋公园 海陵岛海岸线曲长，生境类型多种多样，生态景观丰富，是中华白海豚、黄唇鱼、文昌鱼、太平洋丽龟、绿海龟和玳瑁等国家一级和二级重点保护动物的活动与栖息海域。2013年监测海域海水和沉积物质量状况良好。

广东特呈岛国家级海洋公园 特呈岛为北热带气候区典型的海岛与海洋生态系统，有海岛陆地次生季雨林、海草床、人工鱼礁和滨海湿地等生态系统；有中华白海豚、布氏鲸鱼、十三棱海龟等国家一级和二级重点保护动物; 受保护鸟类资源丰富。2013年监测海域海水和沉积物质量状况良好；鉴定出浮游植物45种，浮游动物28种。

广东雷州乌石国家级海洋公园 公园内珊瑚礁和人工鱼礁重点保护区为423.1公顷；候鸟栖息地生态修复区和红树林生态修复区为80.2公顷。2013年监测海域海水和沉积物质量状况良好；鉴定出浮游植物50种，优势种为中肋骨条藻。

广西钦州茅尾海国家级海洋公园 公园内现有红树林1025.3公顷、沼草61.8公顷、近江牡蛎天然母贝生长地和近江牡蛎采苗区等重要海域3279.4公顷。2013年监测海域海水和沉积物质量状况良好；红树植物平均密度为每公顷4000株，主要优势种为桐花树。

广西涠洲岛珊瑚礁国家级海洋公园 公园划分为公山珊瑚礁生态保护区、坑仔珊瑚礁资源适度利用区、竹蔗寮珊瑚礁资源适度利用区三个功能区。2013年监测海域海水和沉积物质量状况良好。竹蔗寮近岸海域鉴定出造礁石珊瑚13种，平均活珊瑚覆盖度为23.5%；橙黄滨珊瑚为绝对优势种，分布面积占45.6%。牛角坑近岸海域鉴定出造礁石珊瑚15种，平均活珊瑚覆盖度为44.2%，主要优势种为十字牡丹珊瑚和膨胀蔷薇珊瑚。

珊瑚礁水下监测

6.2 美丽富饶的三沙

三沙地处南中国海，主要包括西沙群岛、中沙群岛、南沙群岛的岛礁及其海域。三沙岛礁数量众多，海域面积广阔，并拥有丰富的渔业资源以及巨大的石油和天然气储量，其广阔水域又是海洋生物多样性极高的区域，在我国海洋生态系统中具有重要作用和独特的功能。

2013年监测结果显示，三沙海域海水透明度高，水质良好；海水中重金属、石油类等均处于低含量水平，基本属未受污染海域。4月浮游植物和浮游动物的监测结果表明，该海域浮游植物和浮游动物的多样性指数都较高。

华光礁航拍图　　　　　　　　　　七连屿航拍图

三沙海域珊瑚礁生态系统是全球范围内生物多样性最高的生态系统之一，具有极高的生态和旅游观赏价值。文献资料显示，三沙海域拥有造礁石珊瑚200种以上，占世界珊瑚种类的20%以上。

三沙海域渔业资源丰富，拥有鱼类500多种，其中包括金枪鱼、大黄鱼、鲐鱼、红鱼等经济价值极高的优质鱼类。三沙海域具有红珊瑚、库氏砗磲和鹦鹉螺等国家一级保护动物。此外，还包括海龟、玳瑁、白乳参、乌乳参、梅花参、虎斑贝、唐冠螺、眼球贝、蜘珠螺、鲨鱼等国家珍稀海洋生物。

Annex 870

China State Oceanic Administration, "2014 Communique on Marine Environment of China, Part 2: Conditions of Marine Ecology" (16 Mar. 2015), *available at* http://www.coi.gov.cn/gongbao/nrhuanjing/nr2014/201503/t20150316_32224.html (accessed 9 Mar. 2016)

[…]

2. Conditions of Marine Ecology

Source: State Oceanic Administration Website   Updated on: 03-16-2015| Print this page | Close window

[…]

[…]

2.2.4 Coral reef ecosystem

The eastern coast of Hainan Island has a healthy coral reef ecosystem; the southwest coast of Leizhou Peninsula, Beihai of Guangxi, and the Xisha Islands have healthy coral reef ecosystems. The coverage of hermatypic coral continues the trend of overall decline, with decline in coverage of hermatypic coral being more significant on the southwest coast of Leizhou Peninsula and Weizhou Island of Beihai, Guangxi; coverage of hermatypic coral is low in the Xisha Islands.

[…]

2 海洋生态状况

来源：国家海洋局网站　　更新时间：2015-03-16

2.1 海洋生物多样性

海洋生物多样性监测内容包括浮游生物、底栖生物、海草、红树植物、珊瑚等生物的种类组成和数量分布。在监测区域内共鉴定出浮游植物687种，浮游动物673种，大型底栖生物1 479种，海草6种，红树植物9种，造礁珊瑚77种。

渤海鉴定出浮游植物212种，主要类群为硅藻和甲藻；浮游动物85种，主要类群为桡足类和水母类；大型底栖生物390种，主要类群为环节动物、软体动物和节肢动物。

黄海鉴定出浮游植物230种，主要类群为硅藻和甲藻；浮游动物107种，主要类群为桡足类和水母类；大型底栖生物374种，主要类群为环节动物、软体动物和节肢动物。

东海鉴定出浮游植物298种，主要类群为硅藻和甲藻；浮游动物341种，主要类群为桡足类和水母类；大型底栖生物623种，主要类群为环节动物、节肢动物和软体动物。

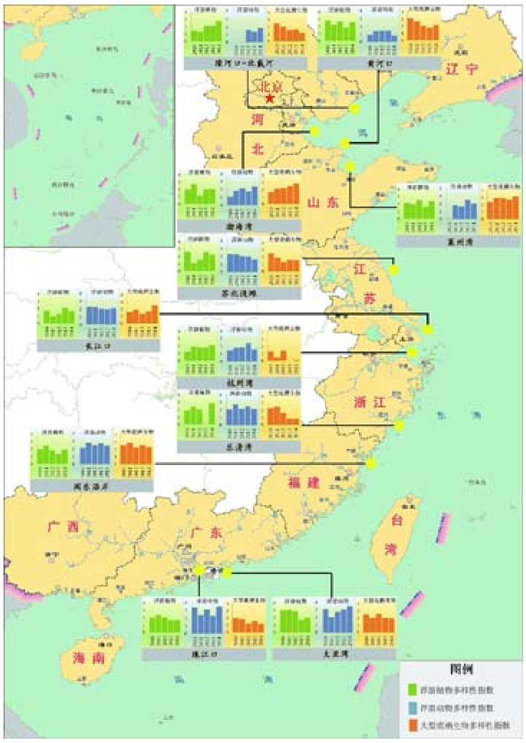
南海鉴定出浮游植物487种，主要类群为硅藻和甲藻；浮游动物551种，主要类群为桡足类和水母类；大型底栖生物901种，主要类群为环节动物、节肢动物和脊索动物；海草6种，红树植物9种，造礁珊瑚77种。

夏季重点监测区域浮游生物和大型底栖生物物种数、密度、多样性指数及主要优势种

监测区域	浮游植物				浮游动物				大型底栖生物			
					物种数（种）	大型浮游动物						
	物种数（种）	密度（×10^{4}个细胞/立方米）	多样性指数	主要优势种		密度（个/立方米）	多样性指数	主要优势种	物种数（种）	密度（个/平方米）	多样性指数	主要优势种
双台子河口	45	25	2.60	中肋骨条藻 浮动弯角藻	36	145	1.76	强壮箭虫 火腿许水蚤	/	/	/	/
滦河口-北戴河	67	1 479	2.79	丹麦细柱藻 旋链角毛藻	22	242	1.84	异体住囊虫 球型侧腕水母	42	211	1.16	豆形短眼蟹
黄河口	60	5 014	2.60	拟扭链角毛藻 佛氏海线藻	16	267	0.84	强壮箭虫 背针胸刺水蚤	63	173	2.21	凸壳肌蛤 日本长尾虫
长江口	94	175	1.74	中肋骨条藻 梭角藻	91	811	2.14	背针胸刺水蚤 太平洋纺	83	147	2.48	钩虾 丝异须虫

								锤水蚤				
珠江口	75	319	1.67	尖刺伪菱形藻 丹麦细柱藻	151	160	3.48	刺尾纺锤水蚤 鸟喙尖头溞	167	32	1.20	无
苏北浅滩	63	516	2.24	中肋骨条藻 浮动弯角藻	43	41	1.60	真刺唇角水蚤 中华假磷虾	40	55	1.56	文蛤 四角蛤蜊
锦州湾	30	40	3.02	三角角藻 窄隙角毛藻	11	7 672	1.06	小拟哲水蚤 双毛纺锤水蚤	/	/	/	/
渤海湾	53	7 044	2.06	中肋骨条藻 旋链角毛藻	30	144	2.38	异体住囊虫 强壮箭虫	61	648	2.85	凸壳肌蛤
莱州湾	42	350	2.47	佛氏海线藻 旋链角毛藻	21	119	2.02	小拟哲水蚤 强壮箭虫	113	2 708	3.18	凸壳肌蛤 丝异须虫
杭州湾	64	86	2.11	中肋骨条藻 琼氏圆筛藻	44	126	1.60	太平洋纺锤水蚤 虫肢歪水蚤	7	3	0.14	无
乐清湾	70	24	2.89	中肋骨条藻 琼氏圆筛藻	47	78	2.13	刺尾纺锤水蚤 百陶箭虫	34	128	0.85	寡鳃齿吻沙蚕
闽东沿岸	89	874	1.90	中肋骨条藻 柔弱拟菱形藻	88	189	2.38	软拟海樽 中华假磷虾	79	122	2.35	双鳃内卷齿蚕 不倒翁虫
大亚湾	68	78	2.00	叉角藻 中心圆筛藻	145	363	3.48	鸟喙尖头溞 亚强真哲水蚤	179	125	1.93	短吻铲荚螠 多丝独毛虫

图例说明：　/无监测数据或数据不完整。



2010～2014年夏季重点监测区域浮游生物和大型底栖生物多样性指数

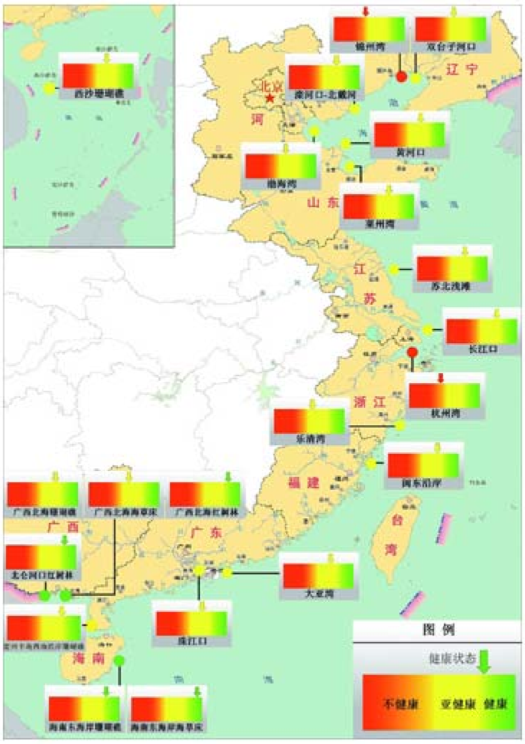
重点监测区域海草、红树植物和珊瑚的生物多样性状况

2.2 典型海洋生态系统健康状况

实施监测的河口、海湾、滩涂湿地、珊瑚礁、红树林和海草床等海洋生态系统中，受环境污染、人为破坏、资源的不合理开发等影响，处于亚健康和不健康状态的海洋生态系统分别占71%和10%。

2014年典型海洋生态系统基本情况

生态系统类型	生态监控区名称	所属经济发展规划区	生态监控区面积（平方公里）	健康状况
河口	双台子河口	辽宁沿海经济带	3 000	亚健康
	滦河口—北戴河	北戴河新区	900	亚健康
	黄河口	黄河三角洲高效生态经济区	2 600	亚健康
	长江口	长江三角洲经济区	13 668	亚健康
	珠江口	珠江三角洲经济区	3 980	亚健康
海湾	锦州湾	辽宁沿海经济带	650	不健康
	渤海湾	天津滨海新区	3 000	亚健康
	莱州湾	黄河三角洲高效生态经济区	3 770	亚健康
	杭州湾	长江三角洲经济区 浙江海洋经济发展示范区	5 000	不健康
	乐清湾	浙江海洋经济发展示范区	464	亚健康
	闽东沿岸	海峡西岸经济区	5 063	亚健康
	大亚湾	珠江三角洲经济区	1 200	亚健康
滩涂湿地	苏北浅滩	江苏沿海经济区	15 400	亚健康
珊瑚礁	雷州半岛西南沿岸	广东海洋经济综合试验区	1 150	亚健康
	广西北海	广西北部湾经济区	120	亚健康
	海南东海岸	海南国际旅游岛	3 750	健康
	西沙珊瑚礁	海南国际旅游岛	400	亚健康
红树林	广西北海	广西北部湾经济区	120	健康
	北仑河口	广西北部湾经济区	150	健康
海草床	广西北海	广西北部湾经济区	120	亚健康
	海南东海岸	海南国际旅游岛	3 750	健康



2014年典型海洋生态系统健康状况*

*海洋生态系统的健康状况分为健康、亚健康和不健康三个级别：

健 康：生态系统保持其自然属性。生物多样性及生态系统结构基本稳定，生态系统主要服务功能正常发挥。环境污染、人为破坏、资源的不合理开发等生态压力在生态系统的承载能力范围内。

亚健康：生态系统基本维持其自然属性。生物多样性及生态系统结构发生一定程度变化，但生态系统主要服务功能尚能发挥。环境污染、人为破坏、资源不合理开发等生态压力超出生态系统的承载能力。

不健康：生态系统自然属性明显改变。生物多样性及生态系统结构发生较大程度变化，生态系统主要服务功能严重退化或丧失。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

2.2.1 河口生态系统

监测的典型河口生态系统均呈亚健康状态。多数河口生态系统海水呈富营养化状态，长江口部分区域出现低氧区；部分河口生物体内镉和石油烃残留水平较高。双台子河口浮游动物密度偏低；滦河口-北戴河浮游植物密度偏高，大型底栖生物生物量偏低；黄河口浮游植物密度偏高；长江口大型底栖生物密度偏高；珠江口大型底栖生物密度和生物量偏低。与上年相比，滦河口-北戴河、黄河口、珠江口鱼卵仔鱼密度增加。

2.2.2 海湾生态系统

监测的海湾生态系统多数呈亚健康状态，锦州湾和杭州湾生态系统呈不健康状态。多数海湾生态系统海水中营养盐含量劣于第四类海水水质标准，呈富营养化状态；部分海湾生物体内镉、铅和石油烃残留水平较高。锦州湾浮游动物密度偏低；渤海湾浮游生物密度、大型底栖生物密度和生物量偏高；莱州湾浮游植物和大型底栖生物密度偏高，浮游动物密度偏低；杭州湾大型底栖生物密度和生物量偏低；乐清湾浮游植物密度偏低，大型底栖生物密度偏高、生物量偏低；闽东沿岸浮游植物密度偏高；大亚湾大型底栖生物密度和生物量偏低。

2.2.3 滩涂湿地生态系统

苏北浅滩滩涂湿地生态系统呈亚健康状态。部分区域海水中营养盐含量劣于第四类海水水质标准，溶解氧含量较低。浮游动物密度偏低，大型底栖生物密度和生物量异常偏高。生物栖息环境恶化趋势未得到有效遏制。

2.2.4 珊瑚礁生态系统

海南东海岸珊瑚礁生态系统呈健康状态，雷州半岛西南沿岸、广西北海和西沙珊瑚礁生态系统呈亚健康状态。造礁珊瑚盖度总体仍呈下降态势，雷州半岛西南沿岸和广西北海涠洲岛周边海域造礁珊瑚盖度下降较为明显，西沙造礁珊瑚盖度偏低。

2.2.5 红树林生态系统

广西北海、北仑河口红树林生态系统均呈健康状态，监测区域的红树林面积和群落基本稳定，红树林底栖生物密度和生物量较高。部分林区仍有虫害发生，外来物种互花米草仍对山口红树林的生长产生威胁。

2.2.6 海草床生态系统

海南东海岸海草床生态系统呈健康状态，广西北海海草床生态系统呈亚健康状态。与上年相比，海南东海岸海草床生态系统的海草盖度增加34%，密度增加1.6倍；广西北海海草床仍处于退化状态，海草密度下降81%。

2.3 海洋保护区生态状况

51个开展生态状况监测的国家级海洋保护区中，多数重点保护的海洋生物物种和自然遗迹保持稳定。

2014年部分重点保护对象状况

保护区类型	重点保护资源	保护区名称	变化状况
	红树	乐清西门岛国家级海洋特别保护区	平均密度保持稳定
		广西山口红树林国家级自然保护区	平均密度保持稳定
		广西北仑河口国家级自然保护区	平均密度保持稳定
	柽柳	山东昌邑海洋生态特别保护区	分布面积和平均密度保持稳定
	野生水仙花	南麂列岛国家级自然保护区	分布面积增加
	珊瑚	广东徐闻珊瑚礁国家级自然保护区	活珊瑚盖度下降
		海南万宁大洲岛国家级海洋生态自然保护区	活珊瑚盖度整体保持稳定
		海南三亚珊瑚礁国家级自然保护区	活珊瑚盖度下降
		广西涠洲岛珊瑚礁国家级海洋公园	活珊瑚盖度下降
	沙蚕	东营广饶沙蚕类生态国家级海洋特别保护区	种类、密度和生物量均下降

			对下降
海洋生物物种类	仿刺参	山东威海小石岛国家级海洋生态特别保护区	密度和生物量保持稳定
	贝类	山东乳山市塔岛湾海洋生态国家级海洋特别保护区	西施舌分布面积、密度和生物量保持稳定
		东营河口浅海贝类生态国家级海洋特别保护区	密度和生物量增加
	文昌鱼	昌黎黄金海岸国家级自然保护区	栖息密度和生物量总体呈下降趋势
		厦门珍稀海洋生物物种国家级自然保护区	栖息密度和生物量下降
	松江鲈鱼	山东文登海洋生态国家级海洋特别保护区	数量保持稳定
	鸟类	广西北仑河口国家级自然保护区	种类明显增加
		象山韭山列岛国家级自然保护区	数量增加
		乐清西门岛国家级海洋特别保护区	数量保持稳定
		南麂列岛国家级自然保护区	种类保持稳定
		普陀中街山列岛海洋特别保护区	数量保持稳定
	中华白海豚	厦门珍稀海洋生物物种国家级自然保护区	出现频次增加
海洋自然遗迹类	海岸沙丘	昌黎黄金海岸国家级自然保护区	脊线最高点向西北移动
	贝壳堤	天津古海岸与湿地国家级自然保护区	面积基本保持稳定
		滨州贝壳堤岛与湿地国家级自然保护区	面积基本保持稳定
	海底古森林	深沪湾海底古森林遗迹国家级自然保护区	古树桩数量及完整性基本保存完好
	沙滩	山东烟台牟平沙质海岸国家级海洋特别保护区	面积基本保持稳定
		山东海阳万米海滩海洋资源国家级海洋特别保护区	面积退化情况有所改观
		广东海陵岛国家级海洋公园	形态保持完整
		广东雷州乌石国家级海洋公园	形态保持完整
	岛礁	山东威海刘公岛海洋生态国家级海洋特别保护区	自然景观基本保持稳定
		渔山列岛国家级海洋生态特别保护区	自然景观基本保持稳定
海洋生态系统类	河口	东营黄河口生态国家级海洋特别保护区	生物多样性基本保持稳定水平
		龙口黄水河口海洋生态国家级海洋特别保护区	生物多样性基本保持稳定水平
		山东莱阳五龙河口滨海湿地国家级海洋特别保护区	生物多样性基本保持稳定水平
		江苏小洋口国家级海洋公园	生物多样性基本保持稳定水平
	滩涂湿地	山东莱州浅滩海洋生态国家级海洋特别保护区	生物多样性基本保持稳定水平
		山东蓬莱登州浅滩国家级海洋特别保护区	生物多样性基本保持稳定水平
	海岛	觉华岛国家级海洋公园	生物多样性基本保持稳定水平
		山东长岛国家级海洋公园	生物多样性基本保持稳定水平
		山东烟台芝罘岛群国家级海洋特别保护区	生物多样性基本保持稳定水平

		浙江洞头国家级海洋公园	生物多样性基本保持稳定水平
		福建湄洲岛国家级海洋公园	生物多样性基本保持稳定水平
		福建城洲岛国家级海洋公园	生物多样性基本保持稳定水平
	海湾	山东大乳山国家级海洋公园	生物多样性基本保持稳定水平
		福建长乐国家级海洋公园	生物多样性基本保持稳定水平

2.3.1 海洋生物物种类保护区

仿刺参、松江鲈鱼、柽柳、红树、贝类、鸟类等重点保护的海洋生物物种资源基本保持稳定。中华白海豚出现频次增加。文昌鱼栖息密度有所下降，部分保护区活珊瑚盖度下降。

广西山口红树林国家级自然保护区内共监测到红海榄、木榄、白骨壤、秋茄和桐花树等红树品种，平均密度为0.66万株/公顷，与上年相比基本保持稳定，部分红树受到虫害和外来物种的威胁。

厦门珍稀海洋生物物种国家级自然保护区共观测到中华白海豚204次、633头次，均较上年明显增加。

厦门海域中华白海豚

昌黎黄金海岸国家级自然保护区文昌鱼栖息密度为18个/平方米，生物量为4.1克/平方米。2002年以来，文昌鱼的栖息密度和生物量总体呈下降趋势，2014年文昌鱼栖息密度降至历史最低。文昌鱼栖息地砂含量变化及沉积物类型改变是导致文昌鱼栖息地退化的主要原因之一。

1999～2014年河北昌黎文昌鱼栖息密度及生物量变化趋势

2.3.2 海洋自然遗迹类保护区

海岸沙丘、贝壳堤、海底古森林、沙滩、岛礁等重点保护的海洋自然遗迹资源基本保持稳定。

昌黎黄金海岸国家级自然保护区的海岸沙丘最大高程为36.8米，鞍部高程为21.4米，与上年相比基本保持稳定，脊线最高点位置向西北移动2.65米。

滨州贝壳堤岛与湿地国家级自然保护区的贝壳堤主要分布于大口河、高坨子岛-棘家堡子岛和汪子岛。2014年监测到新生贝壳堤，现有面积为39.8公顷，比上年增加1.2公顷。

2.3.3 海洋生态系统类保护区

东营黄河口、山东龙口黄水河口、山东莱阳五龙河口、江苏小洋口等河口生态系统类保护区，山东莱州、山东蓬莱登州等滩涂湿地生态系统类保护区，觉华岛、山东长岛、山东烟台芝罘岛群、浙江洞头、福建湄洲岛、福建城洲岛等海岛生态系统类保护区，以及山东大乳山、福建长乐等海湾生态系统类保护区生物多样性水平总体保持稳定。

国家海洋局深入推进海洋生态文明建设

2014 年，国家海洋局深入贯彻党的十八大和十八届三中全会、四中全会精神，大力推进海洋生态文明建设，把海洋生态文明建设融入海洋事业发展的各方面和全过程。

一是系统深化海洋生态文明理论研究和制度建设。在深入专题调研的基础上，系统研究海洋生态文明理论框架、发展模式及中长期战略，提出"十三五"海洋生态文明建设的总体目标和路线图，出台了《关于建立海洋生态环境质量通报制度的意见》《海洋生态损害国家损失索赔办法》《国家级海洋保护区规范化建设与管理指南》等多项管理制度，为进一步推进海洋生态文明制度体系建设奠定良好基础。

二是全面推进海洋生态红线划定工作。继 2013 年底山东率先划定本省渤海海洋生态红线后，2014 年，辽宁、河北、天津先后划定了本省（市）的渤海海洋生态红线区，渤海海洋生态红线划定工作全面完成。在此基础上，系统总结渤海海洋生态红线划定的经验，积极推进黄海、东海、南海海洋生态红线划定相关工作。

三是试点开展海洋资源环境承载能力监测评估。为推动建立海洋资源环境承载能力监测预警机制，国家海洋局组织开展了相关专题政策研究、技术研发和试点评估工作，初步构建了海洋资源环境承载能力监测和评估方法体系，并选择沿海省、市、县 3 级行政区进行试点应用，重点开展了沿海县级行政区海洋资源环境承载能力的试评估工作。

四是继续推进海洋保护区建设。新批建国家级海洋保护区 14 处，新增保护区面积 1 548.55 平方公里，将典型河口湿地、海湾、海岛等生态系统、重要物种以及自然景观纳入保护范围。组织开展了国家级海洋保护区总体规划编制与评审工作。

Annex 871

China State Oceanic Administration, South China Sea Branch, "Communique on the Oceanic Conditions of the South China Sea Region in 2014" (28 May 2015), *available at* http://www.scsb.gov.cn/Html/2/13/article-1267.html (accessed 9 Mar. 2016)

[…]

Communique on the Oceanic Conditions of the South China Seas Region in 2014

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In accordance with requirements of *Marine Environment Protection Law of the People's Republic of China* and related duties of marine environment protection imposed by the state, the South China Sea Branch of the State Oceanic Administration has hereby formulated and promulgated the *Communique on the Oceanic Conditions of the South China Seas Region in 2014*.

[…]

[…]

The condition of the seawater environment in Zhongsha Islands at the central and southern sea region of South China Sea, as well as in sea regions surrounding Nansha Islands are maintained at a good level, with elements including pH, inorganic nitrogen, active phosphate, petroleum, chemical oxygen demand, dissolved oxygen, and heavy metals all meeting the criteria for the first grade of seawater quality.

Main bays

[…]

[…]

2.2.3 Coral reef ecosystem

In 2014, the eastern coast of Hainan Island has a healthy coral reef ecosystem; the southwest coast of Leizhou Peninsula in Guangdong, Beihai of Guangxi, and the Xisha Islands have healthy coral reef ecosystems. Compared to five years ago, the southwest coast of Leizhou Peninsula in Guangdong, Beihai of Guangxi, and the Xisha Islands have shown varying degrees of decline in terms of the number of coral types and the coverage of hermatypic coral. Of these areas, there was a 39.5% decline in coral types on the eastern shore of Hainan Island, 48.2% decline in coral coverage in the Xisha Islands; these declines are relatively significant. Fish density in coral reefs of Xisha Islands decreased by 22.3% compared to five years ago; there is a decline in the quantity of coral reef predators and the damaged surface area compared to in 2013.

[…]

2014年南海区海洋环境状况公报

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依据《中华人民共和国海洋环境保护法》规定和国家赋予的相关海洋环境保护职责，国家海洋局南海分局组织编制了《2014年南海区海洋环境状况公报》，现予发布。

国家海洋局南海分局局长：钱宏林

2015年**3**月　广州

概述

2014年，在国家海洋局领导下，国家海洋局南海分局全面贯彻落实党的十八大作出的"建设海洋强国"战略部署，组织广东省、广西壮族自治区、海南省和深圳市海洋行政主管部门，积极拓展南海区海洋生态保护和海洋环境监测工作，全力开展海洋生态文明建设，取得了较好的成效。

2014年南海区海水环境状况总体良好。海南东海岸珊瑚礁生态系统、广西北海和北仑河口红树林生态系统、海南东海岸海草床生态系统呈健康状态。南海区的国家级海洋保护区主要保护对象基本稳定。海水浴场、滨海旅游度假区、海水增养殖区、海洋倾倒区和油气开发区环境质量总体良好，符合功能区环境要求。

近岸局部海域水体污染和陆源入海污染物超标排放等环境问题依然突出。珠江口海域污染依然严重，大部分海域呈重度富营养化。部分珊瑚礁和海草床生态系统出现退化。陆源入海排污口达标排放率仍然不高，重点入海排污口邻近海域环境状况较2013年未见明显改善。受台风影响，监测岸段海岸侵蚀程度加重。

1海洋环境状况

1.1海水

2014年南海区完成了春季、夏季和秋季三个航次的海水环境监测，监测内容包括水温、盐度和海流等水文要素，无机氮、活性磷酸盐、石油类和化学需氧量等水质要素。

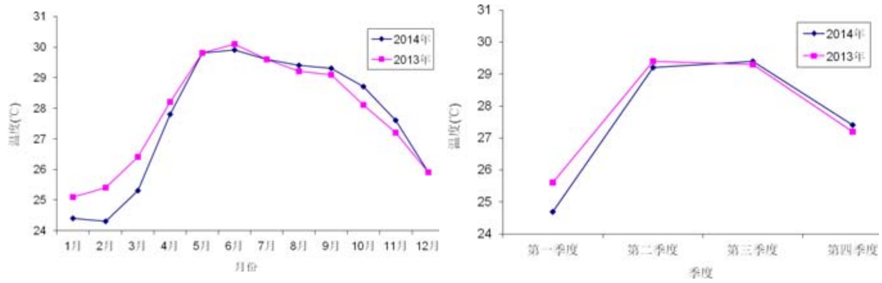
1.1.1海洋水文状况

海洋表层水温 南海区表层水温实测数据分析结果显示，其季节变化符合水温常年分布特征。

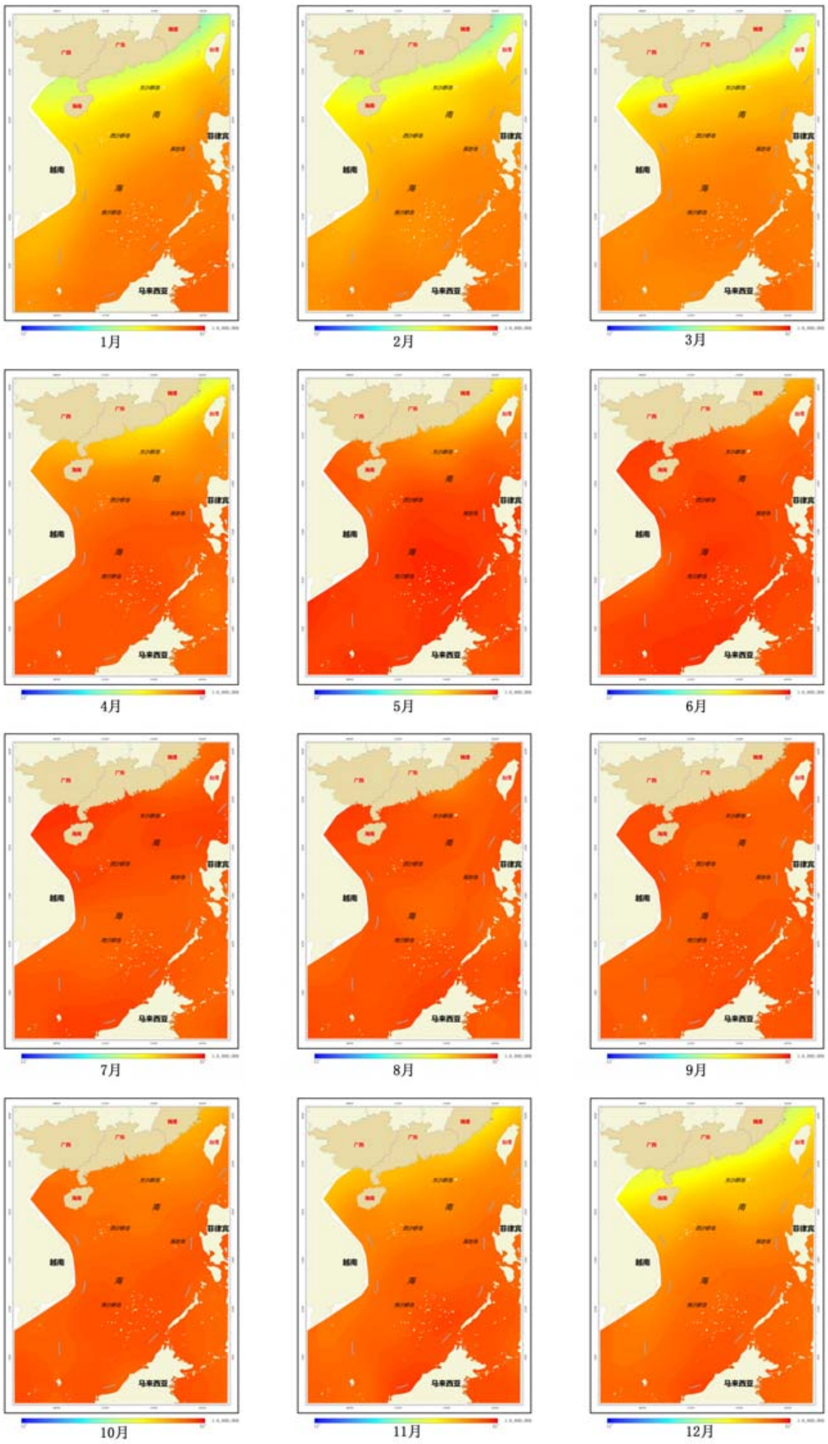
2014年南海区各月和各季度海洋表层平均水温（℃）

第一季度			第二季度			第三季度			第四季度		

1月	2月	3月	4月	5月	6月	7月	8月	9月	10月	11月	12月
24.4	24.3	25.3	27.8	29.8	29.9	29.6	29.4	29.3	28.7	27.6	25.9
24.7			29.2			29.4			27.4		

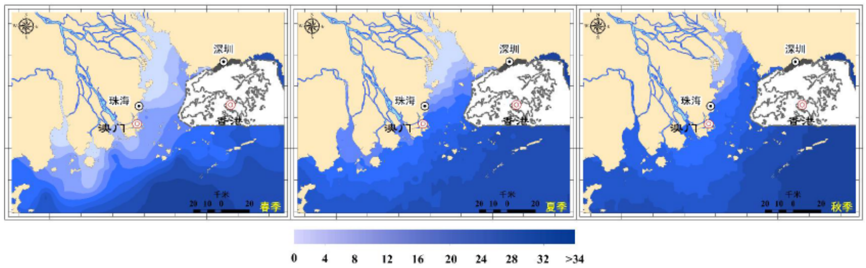


2013年和**2014**年南海区各月和各季度表层平均水温变化趋势图



2014年南海区各月表层平均水温分布图

海水表层盐度 南海区春季、夏季和秋季海水表层盐度较低区域主要分布在河口和近岸海域。春季和夏季低盐区低盐程度和范围较秋季大，珠江口等河口海域的低盐状况尤为明显。



2014年春季、夏季和秋季珠江口海域海水表层盐度分布示意图

1.1.2海水环境状况

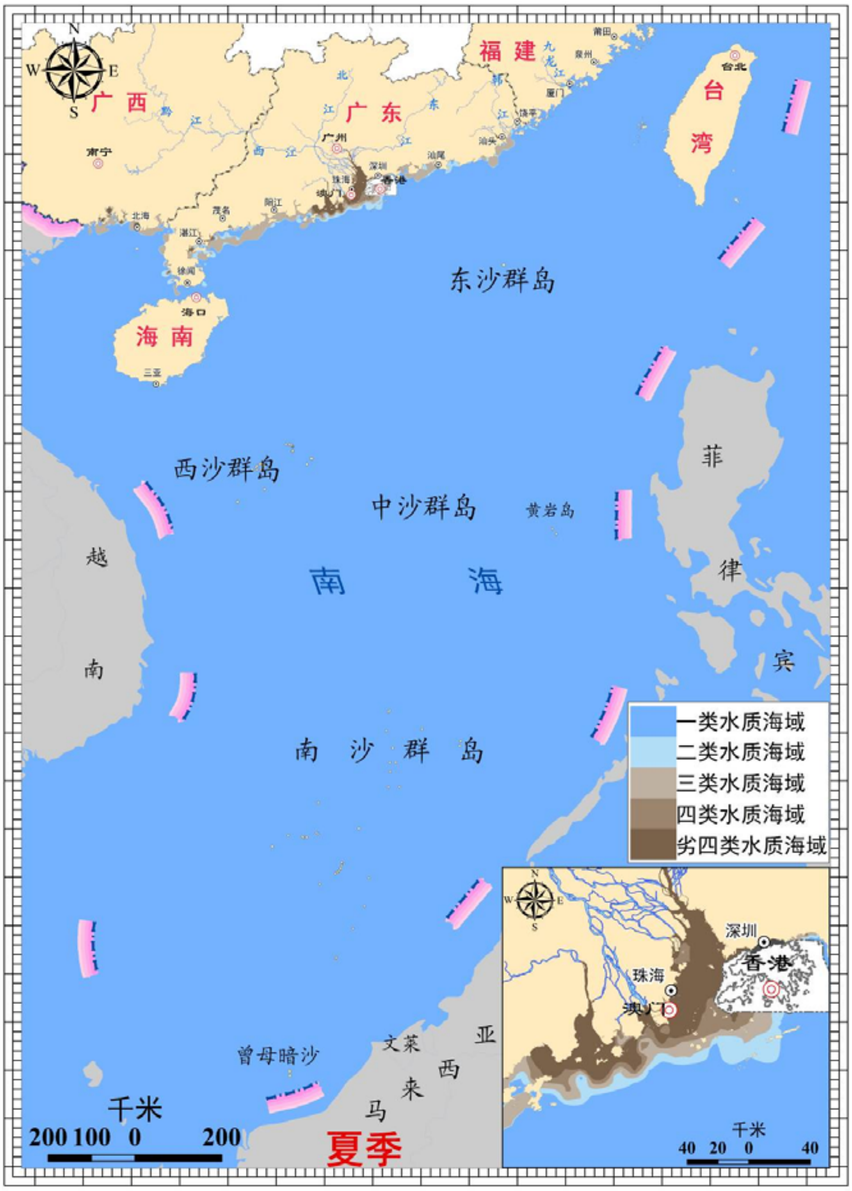
2014年南海区海水环境状况总体良好，近岸局部海域污染依然严重，主要污染要素为无机氮、活性磷酸盐和石油类。

南海区春季、夏季和秋季未达到第一类海水水质标准的海域面积分别为22 940平方千米、22 700平方千米和20 870平方千米，其中劣于第四类海水水质标准的海域面积分别为5 610平方千米、4 090平方千米和3 900平方千米。各季节劣于第四类海水水质标准的海域主要分布在珠江口海域，以及汕头近岸、广海湾、水东港、湛江港和钦州湾等近岸局部海域。

2010~2014年夏季南海区未达到第一类海水水质标准的各类海域面积（平方千米）

年 度	第二类水质	第三类水质	第四类水质	劣于第四类	合 计
2010	6 310	8 290	2 050	7 900	24 550
2011	3 940	7 370	1 160	2 780	15 250
2012	8 890	8 000	3 650	4 300	24 840
2013	8 450	4 380	2 200	7 530	22 560
2014	**5 120**	**11 900**	**1 590**	**4 090**	**22 700**

依据《海水水质标准》（GB3097-1997），按照海域的不同使用功能和保护目标，海水水质分为四类：
第一类：适用于海洋渔业水域，海上自然保护区和珍稀濒危海洋生物保护区。
第二类：适用于水产养殖区，海水浴场，人体直接接触海水的海上运动或娱乐区，以及与人类食用直接有关的工业用水区。
第三类：适用于一般工业用水区，滨海风景旅游区。
第四类：适用于海洋港口水域，海洋开发作业区。



2014年夏季南海区海域水质等级分布示意图

近岸海域

珠江口大部分海域呈重度富营养化。春季、夏季和秋季劣于第四类海水水质标准的站位比例分别为84.1%、90.0%和73.0%，主要污染要素为无机氮和活性磷酸盐。

徐闻至饶平近岸海域* 春季、夏季和秋季劣于第四类海水水质标准的站位比例分别为15.1%、7.6%和11.7%，主要污染要素为无机氮、活性磷酸盐和石油类。劣于第四类海水水质标准的海域主要分布在汕头近岸、广海湾、水东港和湛江港等局部海域。

北部湾近岸海域春季和夏季劣于第四类海水水质标准的站位比例为2.1%和10.4%，秋季未出现劣于第四类海水水质标准的站位。主要污染要素为无机氮、活性磷酸盐和石油类。其中劣于第四类海水水质标准的海域，春季主要分布在廉州湾局部海域，夏季分布在廉州湾和钦州湾等局部海域。

海南岛近岸海域春季、夏季和秋季未达到第一类海水水质标准的站位比例分别为13.0%、8.7%和6.5%，海南岛近岸海域海水水质均符合第一类或第二类海水水质标准。

近岸以外海域

南海北部海域春季、夏季和秋季符合第一类海水水质标准的站位比例分别为93.3%、100%和93.3%，三个航次的监测均未出现劣于第二类海水水质标准的站位。

北部湾近岸以外海域春季、夏季和秋季符合第一类海水水质标准的站位比例分别为100%、90.0%和96.7%，三个航次监测均未出现劣于第二类海水水质标准的站位。

南海中南部中沙群岛及南沙群岛周边海域海水环境状况保持良好，海水中pH、无机氮、活性磷酸盐、石油类、化学需氧量、溶解氧和重金属等要素均符合第一类海水水质标准。

主要海湾

广东海湾 春季、夏季和秋季，汕头港（湾）、广海湾、水东港和湛江港均出现劣于第四类海水水质标准的站位，主要污染要素为无机氮和活性磷酸盐；其余海湾海水环境状况较好。

广西海湾 钦州湾在春季和夏季出现劣于第四类海水水质标准的站位；廉州湾在夏季出现劣于第四类海水水质标准的站位。其余海湾在三个航次的监测中，海水环境状况均较好，均未出现劣于第四类海水水质标准的站位。

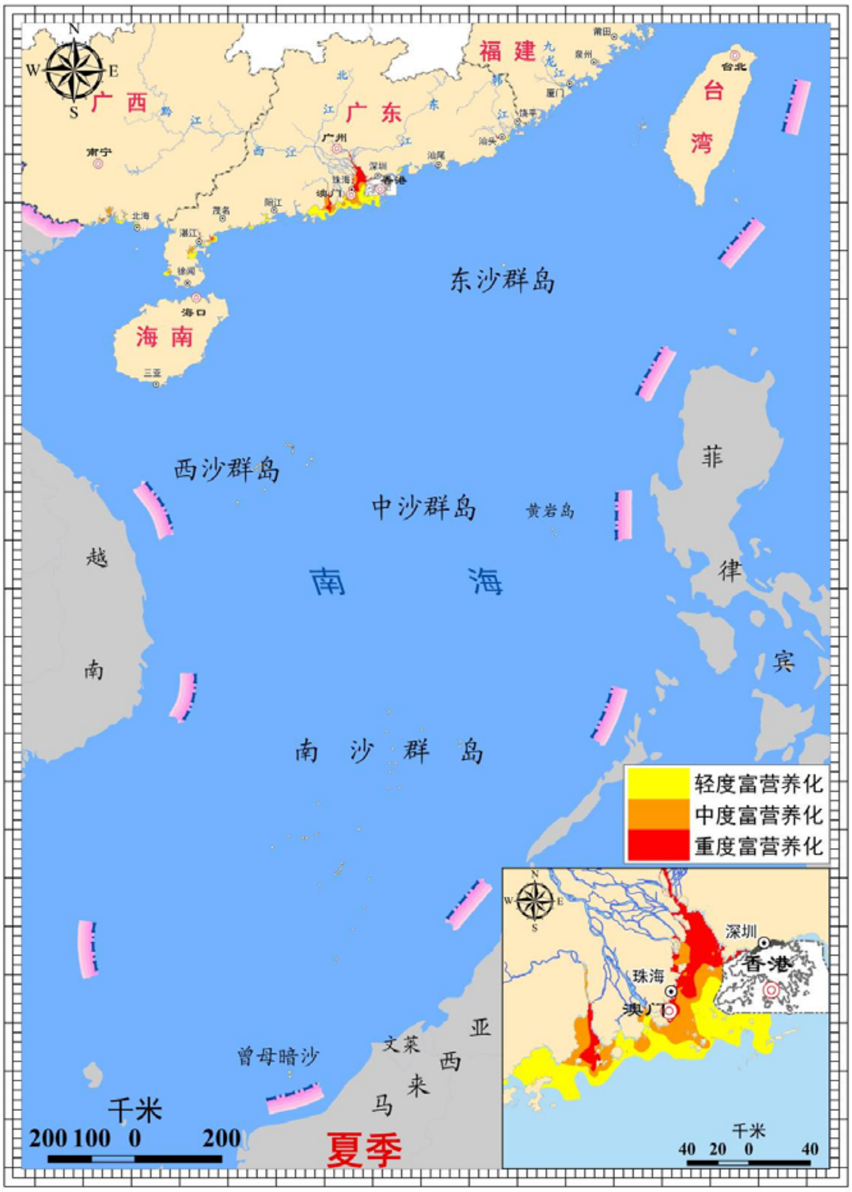
海南海湾 三个航次的监测结果显示，大部分海湾水质符合第一类或第二类海水水质标准。

海水富营养化状况

近十年监测结果显示，近岸局部海域水体呈富营养化状态。2014年春季、夏季和秋季南海区呈现富营养化状态*的海域面积分别为 9 780平方千米、6 920平方千米和6 480平方千米，其中重度富营养化海域面积分别为1 320平方千米、1 300平方千米和870平方千米。重度富营养化海域主要分布在珠江口海域，其次是汕头近岸、水东港、湛江

港和钦州湾等局部海域。

*富营养化状态依据富营养化指数（E）计算结果确定。该指数计算公式为E=[化学需氧量]×[无机氮]×[活性磷酸盐]×10^6/4500，其中E≥1为富营养化，1≤E≤3为轻度富营养化，3＜E≤9为中度富营养化，E＞9为重度富营养化。2014年夏季南海区海水富营养化状况示意图



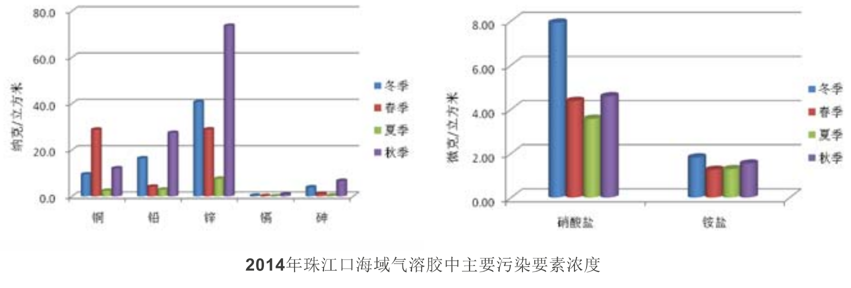
2014年海水富营养化状况示意图

1.2珠江口海洋大气污染物沉降状况

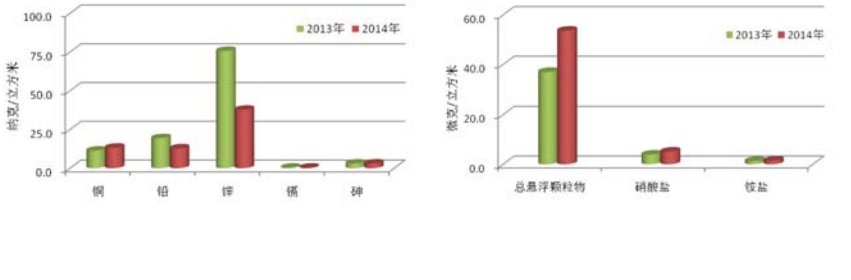
2014年，在珠江口大万山开展了海洋大气污染物的干沉降和湿沉降监测。

1.2.1海洋大气污染物干沉降

珠江口海域气溶胶中锌、铅和亚硝酸盐的年平均浓度分别为37.7纳克/立方米、12.7纳克/立方米和0.04微克/立方米，与2013年相比均有不同程度的降低；总悬浮颗粒物、硝酸盐、铵盐及铜的年平均浓度分别为44.9微克/立方米、5.11微克/立方米、1.47微克/立方米和13.2纳克/立方米，与2013年相比均有升高。镉和砷的年平均浓度分别为0.33纳克/立方米和2.99纳克/立方米，与2013年基本持平。气溶胶中铅、锌、镉、砷、硝酸盐和铵盐的平均浓度表现为秋、冬季高于春、夏季，污染物浓度季节性变化明显。



2014年珠江口海域气溶胶中主要污染要素浓度

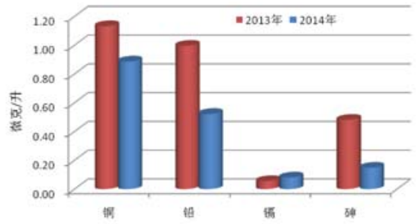


2013年~2014年珠江口海域气溶胶中主要污染要素浓度

1.2.2海洋大气污染物湿沉降

珠江口海域海洋大气湿沉降中铜、铅、砷的年平均浓度分别为0.89微克/升、0.52微克/升、0.15微克/升，与2013年相比略有降低。锌、镉、硝酸盐、铵盐和亚硝酸盐的年平均浓度分别为12.9微克/升、0.08微克/升、2.28毫克/升、0.32毫克/升和0.14毫克/升，与2013年相比均有不同程度的升高。

全年降水pH值的变化范围为4.27~7.60，年均值为5.18，与2013年相比，降水pH均值略有降低。



2013年~2014年珠江口海域湿沉降中主要污染要素浓度

南海区海-气二氧化碳交换通量监测

2014年在南海北部开展了冬季（**2**月）和夏季（**8**月）两个航次的海气二氧化碳交换通量断面走航监测工作。冬季，南海北部海域表现为大气二氧化碳的汇，监测海域吸收大气二氧化碳；夏季，南海北部海域表现为大气二氧化碳的源，监测海域向大气释放二氧化碳。

目前，南海区海-气二氧化碳交换通量监测体系已建成，在南海北部海域布设了**8**条船基走航断面，建成了大万山、博鳌和西沙**3**个岸-岛基站以及**2**个浮标站，初步形成了点、线、面相结合，断面走航监测与长时间序列定点监测相结合的海-气二氧化碳交换通量监测体系。

1.3海洋环境放射性水平

1.3.1核电站附近海域放射性状况

2014年，继续对运营的大亚湾核电站附近海域进行海水和海洋生物放射性监测，同时对在建的阳江核电站、防城港核电站和昌江核电站附近海域开展海洋放射性环境本底调查。

大亚湾核电站附近海域海水中铯-134未检出，锶-90和铯-137放射性核素比活度均在本底范围内，符合国家海水水质标准。海水中氚、总β比活度、总铀含量亦均在本底范围内。核电站附近海域海洋生物体中铯-134未检出，铀-238、钍-232、镭-226、钾-40、铯-137、总β的放射性水平与多年来的监测结果相比没有明显差异。

阳江核电站、防城港核电站和昌江核电站附近海域的海水、海洋生物中铯-134均未检出，其它放射性核素比活度与大亚湾海域海水、海洋生物中放射性核素比活度相比无明显差异，处于我国南海海洋环境放射性本底水平范围之内。

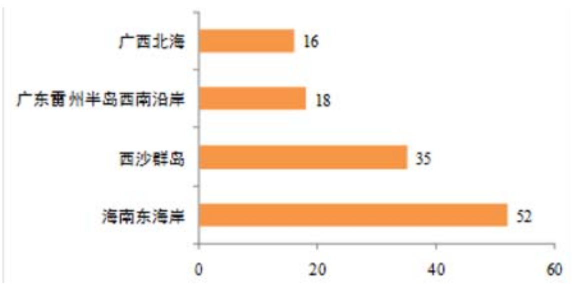
1.3.2珠江口和粤东海域放射性状况

2014年首次对珠江口和粤东海域进行海水放射性监测和海洋大气γ辐射剂量率监测。海水中铯-134均未检出，锶-90和铯-137放射性核素比活度均在本底范围内，符合国家海水水质标准。氚、总β比活度、总铀含量均在本底范围内。海洋大气γ辐射剂量率未见异常。

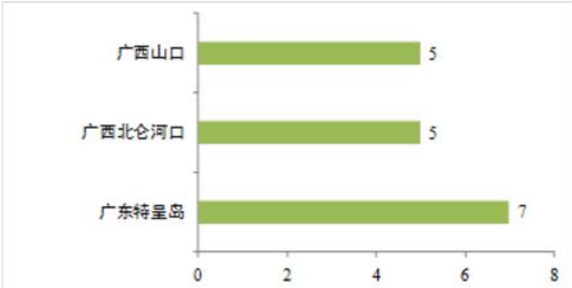
2海洋生态状况

2.1 海洋生物多样性

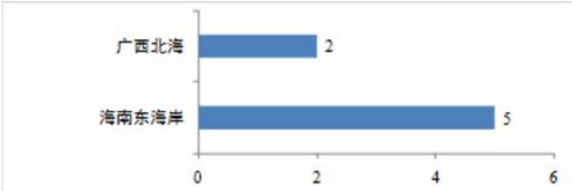
2014年春季和夏季，在南海典型海洋生态系统和重点生态区开展了海洋生物多样性状况监测，监测内容包括浮游生物、底栖生物、潮间带生物、珊瑚、红树植物、海草等生物的种类组成和数量分布等。南海区共鉴定出浮游植物487种，浮游动物551种，底栖生物?901种，造礁石珊瑚77种，红树植物9种，海草6种。



2014年各珊瑚礁监测区造礁石珊瑚种类数（种）



2014年各红树林监测区红树种类数（种）



2014年各海草床监测区海草种类数（种）

2014年夏季近岸趋势性监测海域*与近岸以外海域浮游生物和底栖生物群落状况

海区		生物类群	种数(种)	数量[c]	多样性指数	主要类群
近岸趋势性监测海域		浮游植物	229	9.20×10^{6}	2.45	硅藻、甲藻
		浮游动物	204	2.36×10^{4}	2.89	桡足类、枝角类
		底栖生物	266	83	1.80	软体动物、环节动物
近岸以外海域	南海北部	浮游植物	181	1.97×10^{7}	3.34	硅藻、甲藻
		浮游动物	393	143.7	4.70	桡足类、被囊类
		底栖生物	240	40	4.09	节肢动物、软体动物
	黄岩岛附近海域	浮游植物	55	0.80×10^{3}	3.11	硅藻、甲藻
		浮游动物	261	19.9	5.57	桡足类、被囊类

注： *浮游植物数量单位为个细胞/立方米，浮游动物数量单位为个/立方米，底栖生物数量单位为个/平方米。

2014年夏季珠江口和大亚湾海域浮游生物、底栖生物和潮间带生物群落状况

海域		大亚湾	珠江口
浮游植物	种数(种)	68	75
	数量(个细胞/立方米)	7.81×10^{5}	3.19×10^{6}
	多样性指数	2.00	1.67
	均匀度	0.53	0.50
	主要优势种	叉角藻、中心圆筛藻	尖刺伪菱形藻、丹麦细柱藻
浮游动物	种数(种)[a]	145	151
	数量 (个/立方米)	363	160
	生物量	219	138
	多样性指数[b]	3.48	3.48
	均匀度[b]	0.67	0.79
	主要优势种	鸟喙尖头溞、亚强次真哲水蚤	刺尾纺锤水蚤、鸟喙尖头溞

底栖生物	种数(种)[b]	179	167
	数量(个/平方米)	125.00	31.67
	生物量（克/平方米）	33.87	14.13
	多样性指数	1.93	1.20
	均匀度	0.78	0.61
	主要优势种	短吻长荚蛏、多丝独毛虫	无
潮间带生物	种数(种)[c]	98	66
	数量(个/平方米)	719	819
	生物量（克/平方米）	1 912	103
	多样性指数	1.89	1.31
	均匀度	0.79	0.57
	主要优势种	青蚶、撅目革囊星虫	无

注：[a]包括大、中和小型浮游动物种类，其余指标只以大型浮游动物计算；[b]幼体类不计；[c]包括定量和定性样品种类数.

*近岸趋势性监测海域包括广东、广西和海南近岸趋势性监测海域，不包括珠江口、大亚湾、珊瑚礁监测区、红树林监测区和海草床监测区。

2.2海洋生态系统健康状况

2014年，南海区重点监测的河口、海湾、珊瑚礁、红树林和海草床生态系统的健康状况评价结果显示，南海区典型海洋生态系统处于健康或亚健康状态。

2014年重点生态区海洋生态系统基本情况

生态系统类型	监测海域名称	所属经济发展规划区	监测海域面积（平方千米）	健康状况*
河口	珠江口	珠江三角洲经济区	3 980	亚健康
海湾	大亚湾	珠江三角洲经济区	1 200	亚健康
珊瑚礁	雷州半岛西南沿岸	广东海洋经济综合试验区	1 150	亚健康
	广西北海	广西北部湾经济区	120	亚健康
	海南东海岸	海南国际旅游岛	3 750	健 康
	西沙珊瑚礁	海南国际旅游岛	400	亚健康
红树林	广西北海	广西北部湾经济区	120	健 康
	北仑河口	广西北部湾经济区	150	健 康
海草床	广西北海	广西北部湾经济区	120	亚健康
	海南东海岸	海南国际旅游岛	3 750	健 康

***海洋生态系统的健康状况分为健康、亚健康和不健康三个级别：**

健 康：生态系统保持其自然属性。生物多样性及生态系统结构基本稳定，生态系统主要服务功能正常发挥。环境污染、人为破坏、资源的不合理开发等生态压力在生态系统的承载能力范围内。

亚健康：生态系统基本维持其自然属性。生物多样性及生态系统结构发生一定程度变化，但生态系统主要服务功能尚能发挥。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

不健康：生态系统自然属性明显改变。生物多样性及生态系统结构发生较大程度变化，生态系统主要服务功能严重退化或丧失。环境污染、人为破坏、资源的不合理开发等生态压力超出生态系统的承载能力。

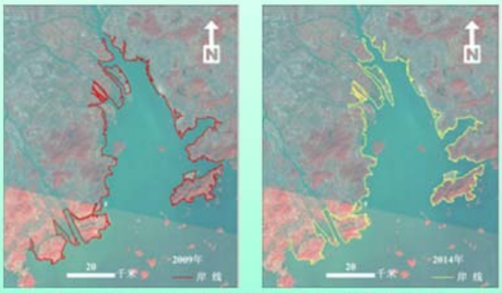
2.2.1珠江口生态系统

2014年，珠江口河口生态系统呈亚健康状态。珠江口海水中无机氮和活性磷酸盐含量偏高，沉积物质量良好，底栖生物栖息密度和生物量偏低。生物质量监测结果显示，珠江口局部区域存在重金属污染风险。近五年来，珠江口浮游植物种类数变化幅度较大，多样性指数呈下降趋势；浮游动物种类数维持稳定，生物量呈上升趋势；仔稚鱼密度呈上升趋势；底栖生物种类数变化较小，但栖息密度呈下降趋势。

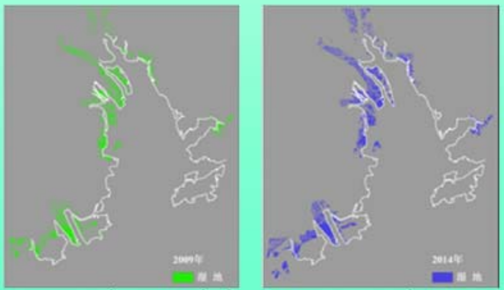
珠江口监测区岸线和湿地变化

珠江口流域经济发展迅速，人为活动频繁，岸线变化速度与幅度增加。受围填海、港口建设等海岸开发活动的影响，珠江口监测区的海岸线以平均每年 10 米的自然速度向海洋推进。

2009 年珠江口监测区域滨海湿地面积为 24 712 公顷，至 2014 年增加至 35 550 公顷，但滨海湿地景观格局发生明显变化，河口滩涂等天然湿地逐渐减少,而鱼塘等人工湿地增加。



2009年和2014年珠江口监测区岸线变化



2009年和2014年珠江口监测区湿地变化

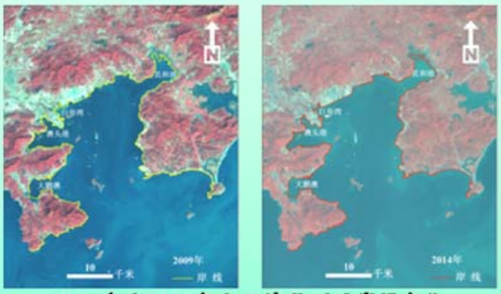
2.2.2大亚湾生态系统

2014年，大亚湾生态系统呈亚健康状态。海水中大部分站位的石油类含量超第一类海水水质标准，沉积物质量保持良好。大亚湾浮游植物密度年际间变化幅度较大，2014年的密度低于前五年。鱼卵和仔稚鱼的密度为近五年的最低水平，底栖生物密度和生物量均偏低，种类多样性指数在近五年有所下降。

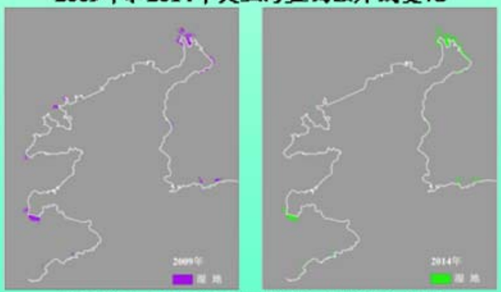
大亚湾监测区岸线和湿地变化

大亚湾沿岸开发利用程度不高，受人为活动影响较小，岸线变化不明显。2009-2014年岸线变化集中在白寿湾、澳头港以及大鹏澳南岸，主要与围填海、港口建设、养殖占海等海岸开发活动有关。

2009年大亚湾监测区滨海湿地面积为736公顷，2014年略微增加，面积为803公顷。2009年至2014年，滨海湿地景观格局发生变化，天然湿地逐渐转变为人工湿地。



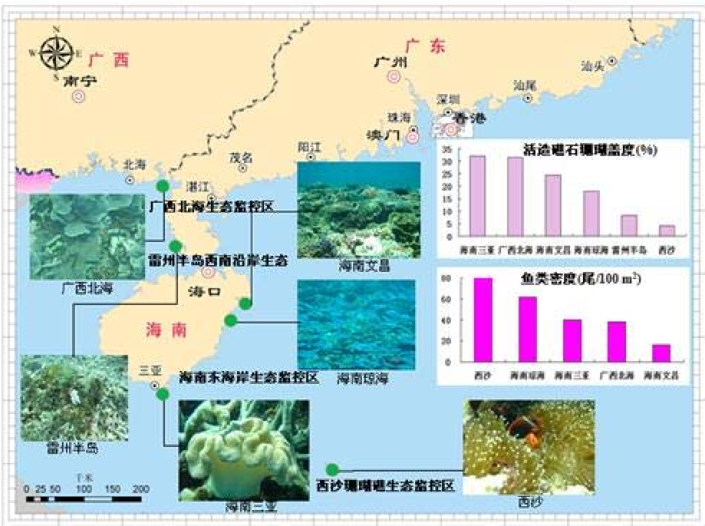
2009年和2014年大亚湾监测区岸线变化



2009年和2014年大亚湾监测区湿地变化

2.2.3珊瑚礁生态系统

2014年，海南东海岸珊瑚礁生态系统呈健康状态，广东雷州半岛西南沿岸、广西北海和西沙珊瑚礁生态系统均呈亚健康状态。与五年前相比，广东雷州半岛西南沿岸、广西北海和西沙珊瑚种类数和造礁石珊瑚盖度均有不同程度下降。其中海南东海岸珊瑚种类下降39.5%，西沙珊瑚盖度下降48.2%，下降幅度较明显。西沙珊瑚礁鱼类密度较五年前下降了22.3%。珊瑚礁敌害生物数量和侵害面积较2013年有所减少。



2014年各珊瑚礁监测区珊瑚盖度和鱼类密度

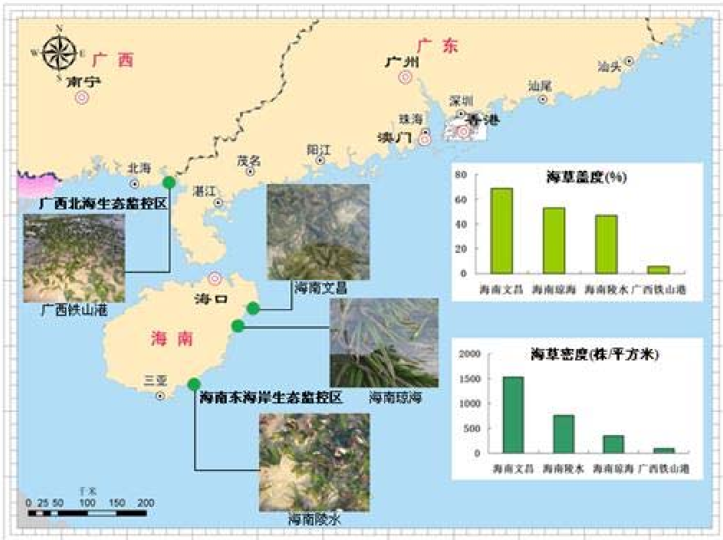
2.2.4红树林生态系统

2014年，广西山口和北仑河口红树林生态系统均呈健康状态，红树林面积保持稳定。北仑河口红树林底栖生物的栖息密度和生物量较去年略有下降。

2014年广西山口红树林现场监测

2.2.5海草床生态系统

2014年，广西北海海草床生态系统呈亚健康状态，海南东海岸海草床生态系统呈健康状态。广西北海海草床2014年海草平均密度为62株/平方米，较上年大幅下降。海南东海岸海草平均密度1 005株/平方米，海草盖度和密度较上年均有所增加。



2014年各海草床监测区海草盖度和海草密度

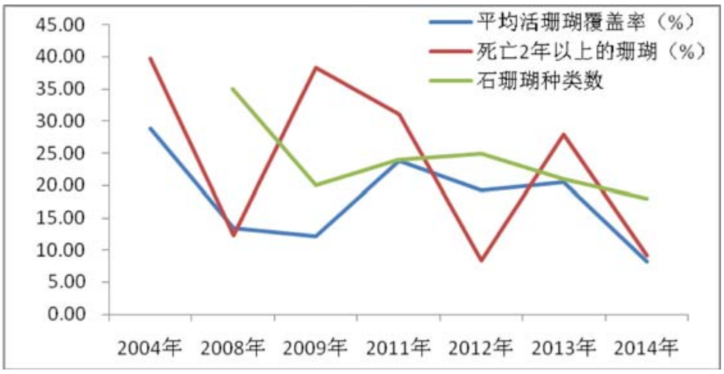
2.3海洋保护区生态状况

2014年，南海区对国家级海洋保护区开展了生境状况和主要保护对象的监测。多数保护区生境状况良好，区内珊瑚礁、红树林、典型海岛海洋生态系统以及海洋自然景观等主要保护对象或保护目标基本保持稳定，部分保护区活珊瑚盖度下降。

2014年南海区部分国家级海洋保护区主要保护对象变化状况

资源类型	主要保护对象	保护区名称	变化状况
海洋生物种类	珊瑚礁	广东徐闻珊瑚礁国家级自然保护区	活珊瑚盖度明显下降
		海南三亚珊瑚礁国家级自然保护区	活珊瑚盖度下降
		海南万宁大洲岛国家级海洋生态自然保护区	活珊瑚盖度保持稳定
		广西涠洲岛珊瑚礁国家级海洋公园	活珊瑚盖度下降
	红树林	广西北仑河口国家级自然保护区	平均密度保持稳定
		广西山口国家级红树林生态自然保护区	平均密度保持稳定
	鸟类	广西北仑河口国家级自然保护区	种类明显增加
海洋自然景观类	沙滩	广东海陵岛国家级海洋公园	形态保持完整
		广东雷州乌石国家级海洋公园	形态保持完整

广东徐闻珊瑚礁国家级自然保护区 2014年鉴定出造礁石珊瑚18种、软珊瑚1种，主要优势种为澄黄滨珊瑚、盾形陀螺珊瑚、秘密角蜂巢珊瑚和交替扁脑珊瑚。平均活珊瑚盖度与石珊瑚死亡率分别为8.2%与9.1%，活珊瑚盖度与2013年相比明显下降。该区珊瑚礁自2008年以来，珊瑚礁生态系统呈恢复趋势；2014年活珊瑚盖度大幅下降主要是受超强台风“威马逊”影响。



2004~2014年徐闻珊瑚礁保护区珊瑚礁群落的年际变化

广东省南澳县青澳湾国家级海洋公园获国家海洋局批准建立

青澳湾位于南澳岛东侧，海湾三面环山，一面临海，湾长 **2 400** 米，状似新月。海底坡度平缓，沙质洁白柔和，海水清洁无污染，被认为是国内顶级海滩和最好的海岸带资源组合、“中国最美丽海岸线”，素有“东方夏威夷”和“泳者天池”美称。拟建的青澳湾国家海洋公园面积共约 **1 246** 公顷，其中海域面积约 **1 182** 公顷，海岛面积约 **64** 公顷，将分梯次保护开发，更好地实现海洋资源与环境的可持续利用。拟在保护区海域营建以人工鱼礁及海草床为主体的海洋牧场，配合人工增殖放流，有效修复海洋生态系统，保证自然生态的延续性，确保水产资源的稳定和持续增长。

青澳湾国家海洋公园的建立有助于加强南澳—东山海洋生物多样性保护管理示范区和南澎—勒门列岛海洋生态自然保护圈的建设和管理，保护各种濒危海洋生物和鸟类的栖息环境。

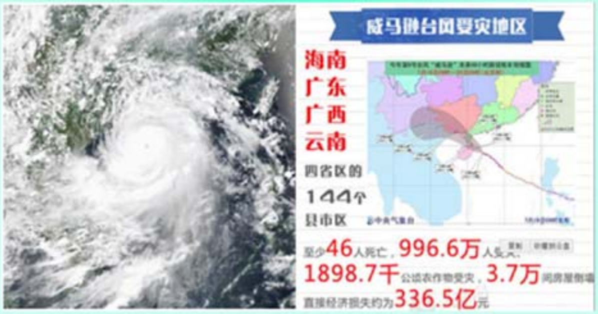
青澳湾沙质岸线

海南三亚珊瑚礁国家级自然保护区 2014年平均活珊瑚盖度与石珊瑚死亡率分别为16.0%与0.1%，活珊瑚盖度与2013年相比有所下降。部分站位珊瑚出现白化现象。2014年鉴定出大型底栖动物19种，平均栖息密度和平均生物量分别为67.6个/平方米和734.1克/平方米。

超强台风“威马逊”影响南海区珊瑚礁

2014年7月，第9号超强台风“威马逊”正面袭击海南、广东、广西，前后三次在海南省文昌、广东省徐闻和广西区防城港市一带登陆，是41年以来登陆华南的最强台风。“威马逊”登陆广东徐闻时的中心附近风速达60米/秒，最低气压达910百帕，这两个代表台风强度的指标，都超过广东有台风记录以来的极值。

2014年南海区徐闻、三亚和涠洲岛等三个珊瑚礁保护区的平均活珊瑚盖度均有不同程度的下降，其中徐闻珊瑚保护区的活珊瑚盖度从20.6 %大幅降至8.2 %，与超强台风“威马逊”的袭击有极大关系。



海南万宁大洲岛国家级海洋生态自然保护区 2014年平均活珊瑚盖度与石珊瑚死亡率分别为21.3%与0，活珊瑚盖度与2013年相比保持稳定。部分珊瑚出现白化现象。鉴定出大型底栖动物9种，平均栖息密度和平均生物量分别为69.3个/平方米和950.9克/平方米。岛上植被和林木基本保持原始状态，植被类型稳定，林木种类丰富，植被覆盖率达95%以上。

广西涠洲岛珊瑚礁国家级海洋公园

竹蔗寮近岸海域 鉴定出造礁石珊瑚8科13种，平均活珊瑚盖度与石珊瑚死亡率分别为22.7%与7.0%，活珊瑚盖度与2013年相比略为下降；橙黄滨珊瑚为绝对优势种，分布面积占32.8%。鉴定出珊瑚礁鱼类3种，平均密度为0.11尾/平方米。

牛角坑近岸海域 鉴定出造礁石珊瑚8科15种，平均活珊瑚盖度与石珊瑚死亡率分别为40.3%与4.0%，活珊瑚盖度与2013年相比有所下降；牡丹珊瑚属和刺孔珊瑚属为优势属，其分布面积占73.4%。鉴定出珊瑚礁鱼类5种，平均密度为0.72尾/平方米。

涠洲岛珊瑚礁监测

广西北仑河口国家级自然保护区 2014年红树林群落结构和类型基本保持不变，整体长势良好。鉴定出红树植物5种、半红树植物2种及滨海植物1种，分别为木榄、秋茄、桐花树、白骨壤、海漆、水黄皮、黄槿和露兜树，平均植株密度为1.06万株/公顷，与2013年相比基本保持稳定；底栖生物62种，平均栖息密度和生物量分别为216.2个/平方米和119.6克/平方米。本年度监测到鸟类99种，其中包括世界极危鸟类勺嘴鹬、国家Ⅱ级保护鸟类10种、新增鸟类记录20种。鸟类种数较2013年增加了25种，反映出鸟类栖息环境不断改善。

本区的主要生态问题仍为虫害。3月至6月，竹山和石角发生小面积的广州小斑螟和袋蛾虫害，危害的主要树种为白骨壤和桐花树。

红树林群落监测

勺嘴鹬

广西山口国家级红树林生态自然保护区 2014年红树林群落类型基本保持不变，继续维持原有的种类多样性和生境完整性。鉴定出红树植物5种，分别为桐花树、红海榄、木榄、秋茄和白骨壤，平均植株密度为0.66万株/公顷，与

2013年相比基本保持稳定；底栖动物29种，平均栖息密度和生物量分别为32个/平方米和40克/平方米。红树林土壤盐度范围为1.125~1.770，平均盐度1.517。

本区主要的生态问题为外来物种入侵和虫害。外来物种主要为互花米草和无瓣海桑。近年来互花米草加速扩展，现已有472公顷，入侵红树林群落中的面积达到171.5公顷；无瓣海桑的入侵扩张也较快。保护区对互花米草采取人工挖掘、物理化学和综合治理等多种方法进行清除，并砍伐了408棵无瓣海桑。4-6月，部分红树林遭受广州小斑螟和三点广翅蜡蝉虫害，受害树种为白骨壤、秋茄和桐花树。保护区工作人员采取灯光诱捕和喷洒石灰水等措施灭杀害虫，有效遏制了虫害。

山口保护区红树林群落及底栖生物监测

互花米草和无瓣海桑入侵红树林

红树林虫害监测及防治

广东特呈岛国家级海洋公园 2014年鉴定出红树植物7种，分别为白骨壤、海莲、红海榄、海漆、木榄、秋茄和红海芒，平均密度为0.37万株/公顷。

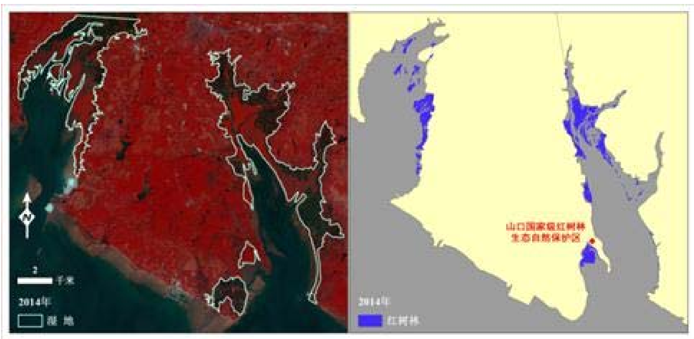
广西钦州茅尾海国家级海洋公园 2014年鉴定出潮间带大型底栖生物11种，平均栖息密度为232.7个/平方米，主要种类为钩虾、斜肋齿蜷和宁波泥蟹；鉴定出大型底栖生物10种，平均栖息密度为200个/平方米，主要种类为多毛类。潮间带大型底栖生物和大型底栖生物的平均栖息密度分别较2013年增长了100%和134%。

广东海陵岛国家级海洋公园 沙滩长2 500米，沙滩面积40.25 公顷，平均高潮线上的沙滩宽100米，形态保持完整。

广东雷州乌石国家级海洋公园 沙滩面积193 公顷，形态保持完整，但沙滩表面出现多条污水侵蚀沟。

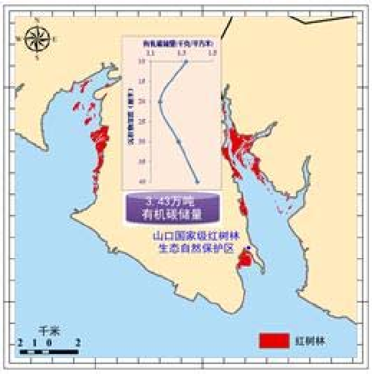
2.4滨海湿地试点调查

2014年以广西山口国家级红树林生态自然保护区为试点开展了滨海湿地调查。遥感分析结果显示，保护区的滨海湿地面积约为4 725公顷，其中红树林面积约为663公顷。红树林主要分布在丹兜海和英罗港，保护区内红树植物主要有红海榄、秋茄、白骨壤和桐花树等。



2014年广西山口国家级红树林生态自然保护区的滨海湿地和红树林分布

山口红树林沉积物具有固碳功能。该保护区沉积物中有机碳储量平均值为1.23千克/平方米；估算山口国家级红树林生态自然保护区沉积物（40厘米深）中有机碳储量为3.43万吨。



广西山口国家级红树林生态自然保护区沉积物有机碳储量分布

山口国家级红树林生态自然保护区内鸟类种类繁多，全年仅珍稀保护鸟类已发现黑脸琵鹭、黑翅鸢、白头鹞、鹊鹞等8种。

开展生态红线划定，推动生态文明示范区建设

为贯彻落实党的十八大关于生态文明建设的总体部署，大力推进海洋生态文明建设，国家海洋局于 **2013** 年 **2** 月公布首批 **12** 个国家级海洋生态文明示范区，广东省的横琴新区、徐闻县和南澳县成为首批建设的海洋生态文明示范区。

为更好地推动海洋生态文明示范区的建设，广东省 **2014** 年开展了三个国家级海洋生态文明示范区海洋生态红线的划定工作，三个示范区内共划定海洋保护区、特殊保护海岛、旅游娱乐用岛、人工鱼礁区、重要滨海湿地、重要滨海旅游区、重要渔业海域、砂质岸线及其邻近海域、基岩保护海域、自然景观与历史文化遗迹、重要功能保护区等 **11** 类海洋生态红线区，并针对不同的红线区制定了具体的管控措施。

生态红线划定成果可作为三个海洋生态文明示范区建设和管理的重要抓手，并能为省级海洋生态红线区划和管控体系的形成提供经验和技术参考，有利于进一步促进广东省海洋生态文明建设，为实现经济发展与环境保护的长期共赢提供制度保障。

3 海洋环境监管监测

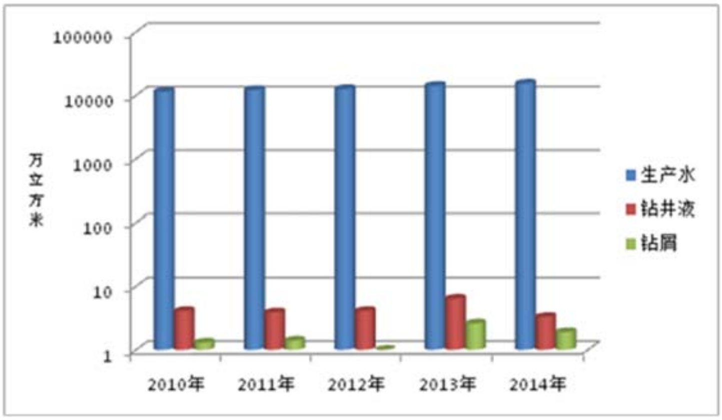
3.1海洋倾倒区

2014年，南海区实际使用倾倒区17个，发放倾倒许可证正本42本，倾倒量4 278万立方米。倾倒量较上年增加1 320万立方米，倾倒物质均为符合倾倒标准的疏浚物。

各倾倒区水深变化情况均未超出倾倒区选划或增量论证预测的变化范围，满足倾倒使用需求。倾倒活动未对所在海域的通航环境和锚地造成影响。各倾倒区海域海水和沉积物质量基本保持稳定。各倾倒区倾倒活动均未对其周边海域的海洋保护区、增养殖区、旅游度假区等海洋功能区及其他海上活动产生明显影响，可继续使用。

3.2海洋油气开发区

2014年，南海区海上油气开发区生产水排海量为15 337万立方米，钻井液排海量为33 699立方米，钻屑排海量为19 237立方米。与2013年相比，生产水排海量增加8.8%，钻井液和钻屑排海量分别减少47%和25%。



2010年~**2014**年南海油气开发区生产水、钻井液和钻屑排放状况图

2014年，对珠江口油气田、文昌油田、崖城气田、乐东气田、东方气田、涠洲油田等11个油气开发区开展了海洋环境监测。监测结果显示，南海区各油气开发区附近海域海洋环境质量基本符合海洋功能区的环境保护要求，未发现油气开发活动对周边海域海洋功能产生明显影响，没有发生重大溢油事件。

强化海洋石油开发管理，开展溢油风险防范专项大检查

为掌控海洋石油勘探开发各环节存在的溢油风险，防范溢油事故发生，国家海洋局南海分局于**2014**年度进一步加强海洋石油勘探开发溢油风险防范监督检查工作。

2014年**1**月至**3**月、**11**月至**12**月，分别开展了海洋石油开发油气输送管线环境保护专项排查整治活动和海洋石油勘探开发溢油风险防范监督检查工作。监督检查采取石油公司自查与管理部门抽查等方式，严格督促石油公司做到自查全覆盖、确保监督检查组抽查有重点。监督检查组选取了投产时间长、运营久的平台和管线连接复杂的平台作为重点抽查对象，现场检查围绕环境影响评价制度执行、环保措施和溢油风险防范措施落实、油气管线监测检测、油气管线巡护检查、油气管线档案管理、超期服役管线情况、溢油应急预案和执行等方面开展。

通过监督检查，进一步掌握了南海区石油勘探开发过程中存在的风险情况，并提出了切实可行的环境保护监督管理措施和建议，为进一步加强石油勘探开发过程中的环境保护管理提供了科学依据。

3.3主要河流污染物入海总量

2014年，南海区监测的9条主要河流污染物入海量分别为：化学需氧量（CODCr）196.5万吨、氨氮（以氮计）6.5万吨，硝酸盐氮（以氮计）53.6万吨，亚硝酸盐氮（以氮计）2.6万吨，总磷（以磷计）3.0万吨，石油类1.5万吨，重金属5 292吨（其中铜680吨、铅251吨、锌4 320吨、镉32吨、汞9吨），砷604.4吨。

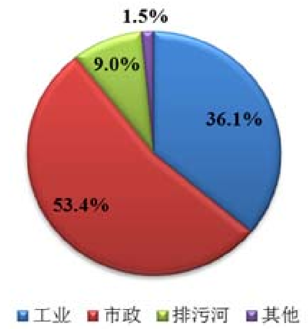
2014年南海部分河流排放入海的污染物量（吨）

河流名称	化学需氧量（COD_{Cr}）	氨氮（以氮计）	硝酸盐氮（以氮计）	亚硝酸盐氮（以氮计）	总磷（以磷计）	石油类	重金属	砷
珠江	1 162 800	22 766	514 080	24 266	24 847	12 240	4 781	581
东江	62 496	981	2 195	433	457	384	11	7

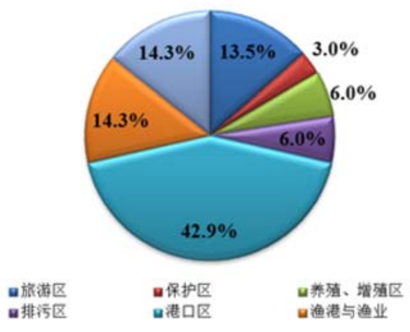
榕江	224 653	28 850	5 421	431	582	333	140	3
深圳河	46 552	5 009	2 326	317	357	304	11	1
南流江	188 300	3 415	5 068	565	2 963	577	191	6
大风江	41 950	331	643	32	212	136	44	0.4
钦江	19 691	528	298	82	130	393	23	1
防城江	24 377	650	466	12	118	64	34	1
南渡江	194 320	2 303	5 901	182	594	301	57	4
合计	1 965 139	64 833	536 398	26 320	30 260	14 732	5 292	604.4

3.4入海排污口及其邻近海域环境状况

2014年，对南海区133个陆源入海排污口开展了监督性监测，并对其中排污量大的16个入海排污口邻近海域的环境质量进行了监测。广东、广西和海南沿岸监测的入海排污口数量分别为82个、31个和20个，各占总数的61.7%、23.3%和15.0%。监测的133个排污口中，工业类排污口占36.1%，市政类排污口占53.4%，排污河占9.0%，其他占1.5%。



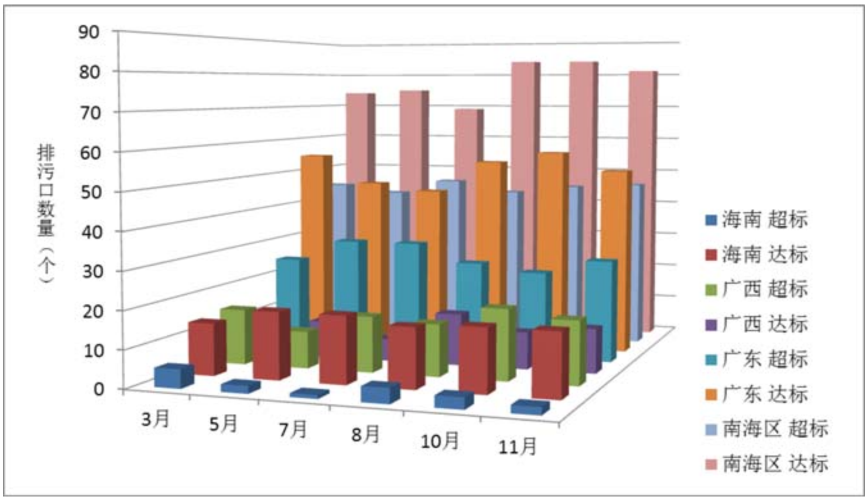
2014年南海区实施监测的不同类型入海排污口比例图



2014年南海区实施监测的入海排污口在各海洋功能区及周边的分布比例图

3.4.1入海排污口排污状况

2014年3月、5月、7月、8月、10月和11月入海排污口总达标排放率为63%，与2013年相比略有升高。其中，3月、5月、7月、8月、10月和11月的入海排污口达标排放比率分别为62%、64%、60%、66%、65%和63%。有37个入海排污口全年各次监测均达标，占监测排污口总数的28%，与2013年相比略有下降；有25个入海排污口全年各次监测均超标，占监测排污口总数的19%，与2013年基本持平。



2014年南海区入海排污口达标排放情况统计图

入海排污口排放的主要污染要素为总磷、化学需氧量（CODCr）、悬浮物和氨氮，各监测要素达标排放率依次为63%、83%、91%和94%。与2013年相比，总磷达标排放率略有上升，化学需氧量（CODCr）、悬浮物和氨氮达标排放率有所下降。

不同类型入海排污口的达标排放率从高到低依次为：工业类排污口77%、排污河63%、市政类排污口55%。

工业类排污口 48个工业类排污口全年251次监测达标排放率为77%。主要超标污染要素为总磷、化学需氧量（CODCr）和悬浮物。

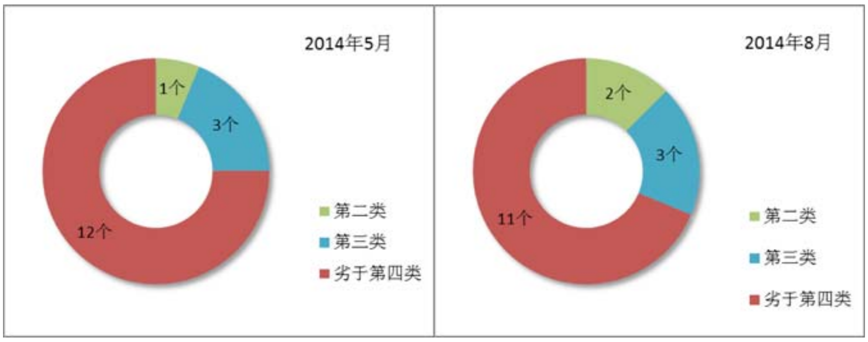
排污河 12条排污河全年70次监测达标排放率为63%。主要超标污染要素为化学需氧量（CODCr）、氨氮和悬浮物。

市政类排污口 71个市政类排污口全年408次监测达标排放率为55%。主要超标污染要素为总磷、化学需氧量（CODCr）、悬浮物和氨氮。

3.4.2入海排污口邻近海域环境状况

2014年，对16个重点入海排污口邻近海域进行了监测。

水质状况 16个排污口中，5月和8月均有13个排污口邻近海域水质不能满足所在海域海洋功能区水质要求，占监测总数的81％。5月，75%的排污口邻近海域水质劣于第四类海水水质标准；8月，69%的排污口邻近海域水质劣于第四类海水水质标准。主要污染要素为无机氮、活性磷酸盐和生化需氧量（BOD5），其次为汞、锌、石油类等。与2013年相比，有2个排污口邻近海域水质略有好转，其它排污口基本没有变化。



2014年**5**月和**8**月入海排污口邻近海域水质等级

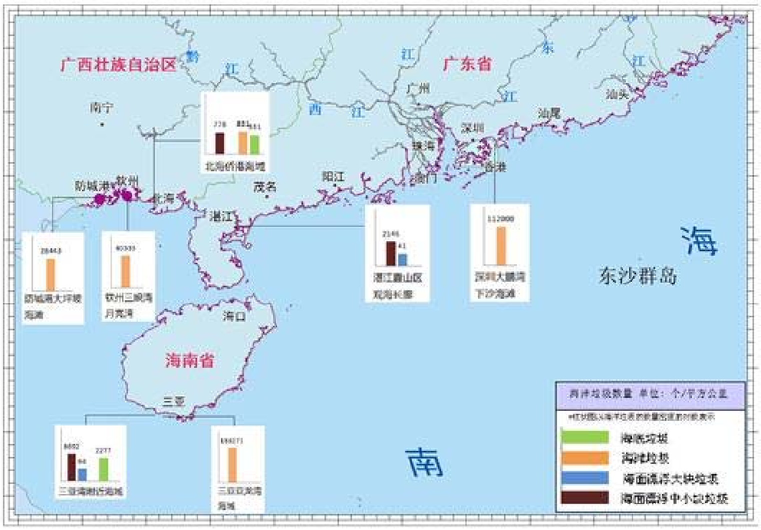
沉积物状况 监测的14个入海排污口中，有7个排污口邻近海域沉积物状况不能满足所在海洋功能区沉积物质量要求，占监测总数的50%。主要污染要素为石油类和汞，其次为硫化物、有机碳和镉等。与2013 年相比，排污口邻近海域沉积物质量状况没有明显变化。

3.5海洋垃圾

2014年，在南海近岸海域开展了海洋垃圾监测，监测内容包括海面漂浮垃圾、海滩垃圾、海底垃圾的种类、数量和来源等。

海面漂浮垃圾 深圳市大鹏湾海域、湛江市观海长廊海域、北海市侨港海域和三亚市三亚湾4个海域海面漂浮垃圾主要以塑料瓶、塑料袋、聚苯乙烯泡沫和木片（块）等为主。中小块漂浮垃圾的平均数量密度为438个/平方千米，平均质量密度约为0.16千克/平方千米。塑料类垃圾数量最多，占71.4%，其次为木制品类垃圾，占28.1%。大块和特大块漂浮垃圾的平均数量密度为24个/平方千米，其中塑料类垃圾数量最多，占52.0%，其次为木制品类垃圾，占20.0%。79.1%的海面漂浮垃圾来自陆地活动，20.9%的海面漂浮垃圾来自海上。

海滩垃圾 深圳市大鹏湾下沙海滩、北海市侨港海域海滩、钦州市三娘湾月亮湾海滩、防城港市大坪坡海滩、三亚市亚龙湾沙滩5个海岸沙滩的海滩垃圾的平均数量密度为2 908个/平方千米，以塑料类最多，占54.1%，其次为聚苯乙烯泡沫类、木制品等垃圾，分别占23.0%和15.3%；海滩垃圾的平均质量密度为93千克/平方千米，以塑料类、聚苯乙烯泡沫类和金属类等垃圾的密度最大，分别约为8.1千克/平方千米、7.8千克/平方千米和7.3千克/平方千米。99.5%的海滩垃圾来自陆地活动，0.5%的海滩垃圾来自海上。



2014年南海区监测海域海洋垃圾数量分布图

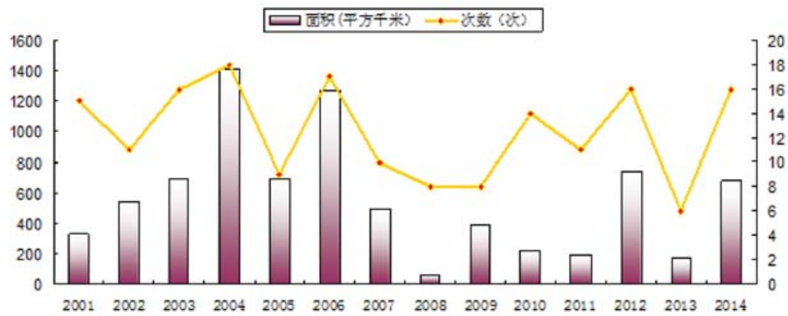
海底垃圾 北海市侨港海域和三亚市三亚湾2个海域的海底垃圾平均数量密度为620个/平方千米，主要为塑料类垃圾，约占90.9%；平均质量密度约为347千克/平方千米，其中木制品类垃圾的质量密度最大，约为338千克/平方千米。海底垃圾全部来自陆地活动。

4 海洋环境灾害及突发海洋污染事件

4.1 赤潮

2014年南海区通过航空遥感监测、船舶监测、监测人员巡视等方式在南海海域开展赤潮灾害应急监视监测工作。

2014年南海区共监测到赤潮16次，赤潮累计面积约684平方千米，赤潮生物种类为球形棕囊藻、红色赤潮藻、夜光藻、多纹膝沟藻、中肋骨条藻、赤潮异弯藻和条纹环沟藻，赤潮未造成明显经济损失。2014年两次较大面积的赤潮均发生在广东湛江港附近海域，赤潮种类为中肋骨条藻和夜光藻。从2001年以来南海区赤潮发生情况统计结果来看，2014年赤潮发生的面积较大，次数较多。



2001～2014年 南海区赤潮统计图

2014年南海区发生的赤潮统计

起止时间	发生海域	赤潮面积	赤潮生物种类
1月5日～1月17日	广东徐闻珊瑚礁国家级自然保护海域	87平方公里	球形棕囊藻 *Phaeocystis globosa*
2月8日～2月10日	深圳蛇口附近海域	2.5平方公里	赤潮异弯藻 *Heterosigma akashiwo*
2月9日	海南洋浦港至儋州海头港、昌江新港	——	球形棕囊藻 *Phaeocystis globosa*
2月27日～3月3日	深圳湾蛇口渔港附近海域	2平方公里	红色赤潮藻 *Gymnodinium sanguineum*
4月6日～4月6日	广东惠州市大亚湾马鞭洲一带海域	8平方公里	红色赤潮藻 *Gymnodinium sanguineum*
4月8日～4月12日	深圳大、小梅沙附近海域	2平方公里	多纹膝沟藻 *Gonyaulax polygramma*

4月11日～4月20日	深圳大亚湾坝光海域	3平方公里	多纹膝沟藻 *Gonyaulax polygramma*
4月11日～4月23日	广东惠州市大亚湾马鞭洲以北海域和澳头湾	100平方公里	红色赤潮藻 *Gymnodinium sanguineum*、多纹膝沟藻*Gonyaulax polygramma*
4月29日～5月4日	深圳大鹏湾小梅沙附近海域	1平方公里	多纹膝沟藻 *Gonyaulax polygramma*
6月18日～6月25日	深圳大、小梅沙附近海域	5平方公里	红色赤潮藻 *Gymnodinium sanguineum*
7月9日～7月28日	广东湛江港湾海湾大桥以南、特呈岛以北海域	33平方公里	中肋骨条藻 *Skeletonema costatum*
7月21日～8月13日	广东湛江港湾海湾大桥以南、特呈岛以北海域	140平方公里	中肋骨条藻 *Skeletonema costatum*
8月19日～8月25日	广东南澳前江湾内前江码头附近海域	0.2平方公里	条纹环沟藻 *Gyrodinium instriatum*
11月24日～11月27日	深圳大鹏湾大梅沙附近海域	0.05平方公里	夜光藻 *Noctiluca scintillans*
11月23日～11月27日	广东茂名博贺港西南侧放鸡岛附近海域	300平方公里	夜光藻 *Noctiluca scintillans*
11月30日～12月1日	广东珠海市香洲近岸海域	0.01平方公里	夜光藻 *Noctiluca scintillans*

注：“——”表示监测面积缺失。

全国海洋科普日暨全国赤潮研究与防治宣传日活动

2014 年 10 月 30 日，“全国海洋科普日暨全球赤潮研究与防治宣传日”活动在海口望海国际广场上举行。活动的主题为“科学认识棕囊藻赤潮，减少公众恐慌心理”，旨在宣传赤潮灾害科普知识，引导市民正确认识和应对赤潮灾害。

现场科普活动设计了棕囊藻赤潮宣传展板，图文并茂地向公众展示了棕囊藻赤潮的危害、研究和防治现状、海南省棕囊藻赤潮的发生现状、赤潮监测方法和监测体系建设等内容。科技工作人员向过往市民发放了棕囊藻赤潮科普知识宣传册，一对一地向感兴趣的市民详细介绍了活动的内容。此外，活动现场还设置了连接显微镜的电脑显示器将棕囊藻样本切片做了直观的动态展示，吸引不少市民上前观看。

赤潮发生时水体中的棕囊藻

市民了解赤潮知识

4.2 福岛核事故影响

2014年，在吕宋海峡及其周边海域组织实施两个航次的西太平洋海洋放射性监测预警工作，通过船舶定点与走航监测相结合的方式，开展海水、沉积物和大气的放射性监测。海水中的总铀、总β、氚、锶-90、铯-137、镭-226等核素放射性未见异常，铯-134、银-110m、钌-106、钴-58、钴-60、锰-54和锌-65等核素均未检出。海洋沉积物中总β、铀-238、钍-232、镭-226、钾-40、铯-137、锶-90、铯-134、钴-58、钴-60、银-110m、锰-54、铁-59和锌-65等核素放射性未见异常。海洋大气γ辐射空气吸收剂量率平均水平在本底范围之内。监测海域海水和沉积物暂未受到福岛核泄漏放射性污染影响。

4.3 海水入侵及土壤盐渍化

2014年，南海绝大部分监测区海水入侵和土壤盐渍化范围较小，程度较轻。

海水入侵状况 南海各监测区海水入侵范围较小，程度较低，海水入侵范围一般在距岸3.5公里以内。与2013年相比，广东湛江世乔和岭头监测区海水入侵范围有所扩大，其余监测区入侵范围和程度基本稳定。

土壤盐渍化状况 南海监测区土壤盐渍化范围较小，土壤盐渍化范围一般在距岸0.5公里以内。与2013年相比，广东湛江世乔断面土壤盐渍化范围有所扩大，其余各监测区盐渍化范围基本稳定。

2014年南海滨海地区海水入侵和土壤盐渍化范围及变化趋势

监测断面位置	海水入侵		土壤盐渍化	
	入侵距离（公里）	与2013年比较	距岸距离（公里）	与2013年比较
广东潮州饶平碧洲	—	⇔	/	/
广东潮州饶平大埕	—	⇔	/	/
广东茂名电白县陈村	0.4	⇔	/	/
广东茂名电白县龙山	0.4	⇔	/	/
广东湛江世乔	＞3.8	↗	>3.7	↗
广东湛江岭头	3.5	↗	0.1	↘
广西北海西海岸	0.3	⇔	—	↘
广西北海大王埠	1.4	⇔	0.3	⇔
海南三亚Ⅰ	0.5	⇔	0.4	↘
海南三亚Ⅱ	—	⇔	—	↘
图例说明：↗ 升高；⇔ 无明显变化趋势；↘ 降低；/ 无监测项目；— 未发生				

4.4 监测岸段海岸侵蚀

2014年，夏秋季南海区频繁受到台风侵扰，特别是强台风“威马逊”和“海鸥”等给海岸造成了灾害性地破坏，加剧了南海区海岸侵蚀程度。广东省雷州市赤坎村岸段、海南省海口市镇海村岸段和海南省海口市南渡江入海口东侧岸段均属于严重侵蚀，海岸侵蚀风险等级均为高风险 。

赤坎岸段位于雷州市龙塘镇赤坎村，为砂、石混合土质海岸。2013年在该岸段西侧堆填的简易防护堤已冲毁，大量岩石剥落，裸露出新鲜泥土，侵蚀岸段长约800米，侵蚀陡崖高约4-7米，沿岸植被损毁严重，根茎完全裸露，大片沙滩已经被侵蚀剥落下来的砂石完全覆盖。

广东雷州市赤坎村海岸侵蚀断面中上部强风化 中风化混合岩石

广东雷州市赤坎村海岸岩石大量剥落植物根茎裸露

2012年～2014年南海区重点岸段海岸侵蚀状况及变化趋势

监测岸段	海岸类型	监测内容	2012-2013年	2013-2014年	变化趋势
广东省雷州市赤坎村岸段	砂、石混合土质	侵蚀岸线长度（km）	0.4	0.8	↗
		最大侵蚀速度（m/a）	5.0	12.0	↗
		平均侵蚀速度（m/a）	2.0	5.0	↗
海南省海口市镇		侵蚀岸线长度（km）	0.8	0.9	↗

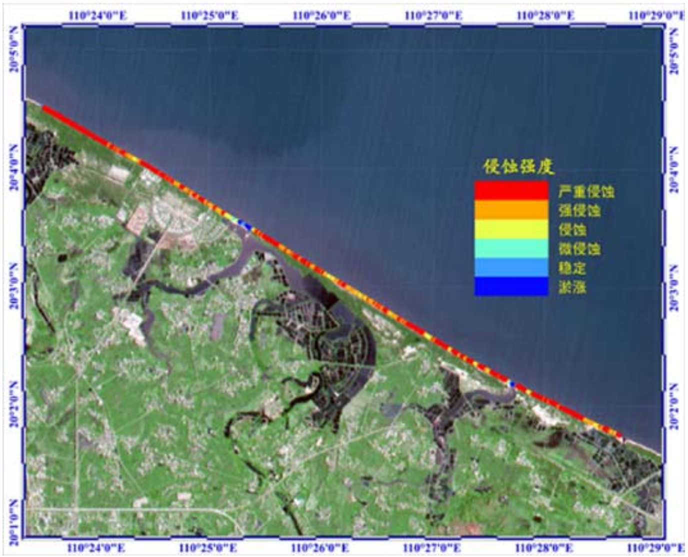
海村岸段	砂质	最大侵蚀速度（m/a）	12.0	10.0	↘
		平均侵蚀速度（m/a）	8.0	5.0	↘
海南省海口市南渡江入海口东侧岸段	砂质	侵蚀岸线长度（km）	-	10.5	-
		最大侵蚀速度（m/a）	-	8.3	-
		平均侵蚀速度（m/a）	-	3.9	-
图例说明 ↗ 升高 ↘ 降低 - 未做监测					

镇海岸段位于海南省海口市长流镇镇海村，为砂质海岸。该岸段西侧海岸侵蚀状况严重，镇海渔港弧形防波堤部分堤坝出现崩塌，筑堤石块四处散落，岩基也遭到破坏，沿岸树木倒塌。


海南海口市镇海侵蚀区西侧波堤毁损严重


海南海口市镇海侵蚀区西侧沿岸破坏倒塌的树木

南渡江岸段位于海南省海口市南渡江入海口东侧，为自然砂质海岸。根据遥感资料分析，2009年～2014年海岸侵蚀较严重，绝大部分海岸处于侵蚀状态，西北部岸段侵蚀最为严重，中部和东南部岸段侵蚀、强侵蚀和严重侵蚀3个等级交叉分布。

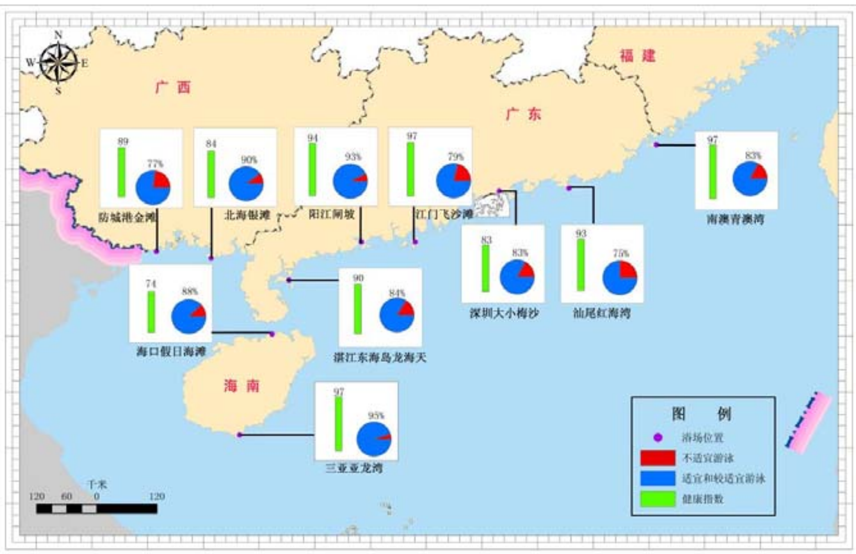


海南省海口市南渡江入海口东侧岸段海岸遥感影像图

5 公益服务

5.1 海水浴场环境状况

2014年，4月24日至10月31日对南海区10个海水浴场开展每日监测。监测要素主要包括与休闲活动相关的水文气象、水质、海面状况等。监测结果以预报信息的形式通过南海海洋预报网等媒体每日发布，部分浴场还在当地政府网站或浴场游人集中区域发布，为公众滨海休闲活动提供了重要的参考信息。



2014年南海区监测海水浴场状况

2014年，浴场监测结果显示环境状况良好。深圳梅沙滨海旅游度假区在4月底和6月下旬发生两次赤潮，共有8个监测日受到影响；此外，浴场休闲功能主要受天气和风浪等自然因素影响。

水质 海水浴场水质状况良好。其中，广东南澳青澳湾、海南三亚亚龙湾海水浴场每天的水质监测结果均为优；7个海水浴场全年水质监测结果均在良好及以上。

健康指数 90%的监测海水浴场的年度平均健康指数为优，浴场环境对人体健康潜在危害低。每日健康指数统计结果显示，深圳大小梅沙海水浴场由于受赤潮影响健康指数为良好及以上的监测天数比例为92%，其他海水浴场均达到99%以上。

游泳适宜度 游泳适宜度是综合海水浴场水文气象、水质、海滩环境、游泳健康指数做出的评价。10个海水浴场适宜和较适宜游泳的天数占总监测天数的比例在75%～95%之间。与2013年监测结果相比，深圳大小梅沙和防城港金滩海水浴场略有减少，除此之外，其他海水浴场均有增加。其中，深圳大小梅沙主要受赤潮和恶劣天气的影响，防城港金滩主要受到天气不佳的影响。

2014年南海区海水浴场综合环境状况

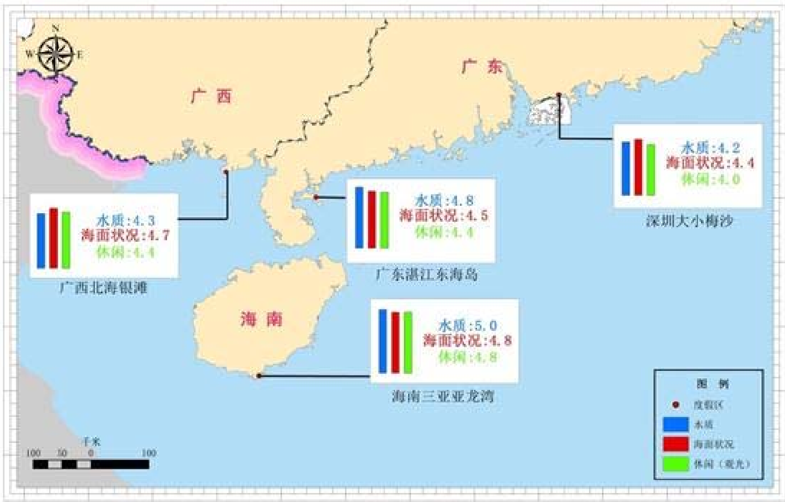
浴场名称	水质等级天数比例（%）			健康指数等级天数比例（%）			年度健康指数*	适宜和较适宜游泳的天数比例（%）
	优	良	差	优	良	差		
广东南澳青澳湾	100	0	0	100	0	0	97	83
广东汕尾红海湾	82	18	0	91	9	0	93	75
广东深圳大小梅沙	49	43	8	61	31	8	83	83
广东江门飞沙滩	88	12	0	100	0	0	97	79
广东阳江闸坡	96	4	0	97	3	0	94	93
广东湛江龙海天	80	20	0	83	16	1	90	84
广西北海银滩	13	87	0	75	25	0	84	90
广西防城港金滩	47	50	3	79	21	0	89	77
海南海口假日海滩	2	98	0	47	52	1	74	88
海南三亚亚龙湾	100	0	0	99	0	1	97	95

*注：健康指数不低于80时，指数等级为优，海水浴场环境对人体健康的潜在危害低；
健康指数低于80且不低于60时，指数等级为良，海水浴场环境对人体健康有一定的潜在危害；
健康指数低于60时，指数等级为差，海水浴场环境对人体健康的潜在危害高。

5.2 滨海旅游度假区环境状况

2014年，3月24日至10月31日对深圳大小梅沙、湛江东海岛、北海银滩、三亚亚龙湾4个滨海旅游度假区开展每

日监测。监测要素包括与休闲活动相关的水文气象、沙滩环境、水质、景观等。监测结果每日通过南海海洋预报网等相关媒体发布。



2014年南海区监测滨海旅游度假区状况

对各滨海旅游度假区环境状况、休闲活动条件状况进行年度统计评价。结果显示，滨海旅游度假区环境状况优良，各项指数均在良好以上，适宜开展休闲（观光）活动。各度假区各项指数总体要优于2013年。赤潮、台风等恶劣天气、风浪是影响各项休闲观光活动的主要因素。

水质状况 南海区监测的4个滨海旅游度假区水质指数均在4.2~5.0之间，水质均达到优良及以上。海南三亚亚龙湾水质指数5.0，全年水质极佳。

海面状况 各度假区全年海面状况指数在4.4~4.8之间，海面状况均达到优良及以上。各度假区本年度海面状况指数均高于2013年。

休闲观光条件状况 南海区各度假区休闲观光平均指数均高于4.0，很适合开展休闲观光活动。各度假区本年度休闲（观光）活动指数均高于2013年。

2014年滨海旅游度假区环境状况指数

度假区名称	环境状况指数		休闲（观光）活动指数							
	水质	海面状况	海底观光	海上观光	海滨观光	游泳适宜度	海上休闲	沙滩娱乐	海钓	平均指数
广东湛江东海岛	4.8	4.5	4.4	4.3	4.5	4.3	4.5	4.6	4.4	4.4
深圳大小梅沙	4.2	4.4	-	4.0	4.0	3.6	4.1	4.2	-	4.0
广西北海银滩	4.3	4.7	3.9	4.7	4.7	4.1	-	4.6	-	4.4
海南三亚亚龙湾	5.0	4.8	4.9	4.8	4.9	4.5	4.8	4.8	4.8	4.8

注：“—”表示未开展该项休闲娱乐活动。

环境状况指数（包括水质指数和海面状况指数）和休闲（观光）活动指数赋分分级说明（满分为5.0）：

5.0~4.5：环境状况极佳，非常适宜开展休闲（观光）活动；

4.4~3.5：优良，很适宜开展休闲（观光）活动；

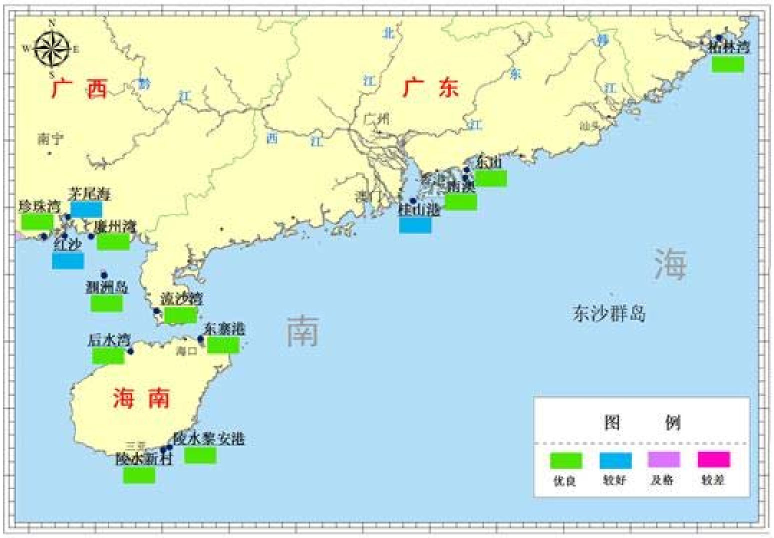
3.4~2.5：良好，适宜开展休闲（观光）活动；

2.4~1.5：一般，适宜开展休闲（观光）活动；

1.4~1.0：较差，不适宜开展休闲（观光）活动。

5.3 海水增养殖区环境状况

2014年南海区14个海水增养殖区水质、沉积物、生物质量监测结果显示，各海水增养殖区的环境质量均能满足养殖功能要求，综合环境质量等级为“优良”或“较好”。



2014年海水增养殖区综合环境质量等级示意图

水质状况 监测的海水增养殖区水质状况总体较好。各增养殖区海水中铜、铅、砷、铬符合功能区所要求的第二类海水水质标准的站位比例为100%。超过1/3增养殖区中的无机氮、活性磷酸盐、pH均出现超第二类海水水质标准。各个增养殖区中，水质状况较好的是广东深圳南澳海水增养殖区、广西防城港珍珠湾珍珠养殖区、海南临高后水湾海水增养殖区和海南陵水新村海水增养殖区，各监测要素均符合第二类海水水质标准。

沉积物质量状况 监测的海水增养殖区沉积物质量总体良好。各增养殖区沉积物中多氯联苯和六六六符合功能区所要求的第一类海洋沉积物质量标准的站位比例为100%。在超过第一类海洋沉积物质量标准的要素中，铜和石油类在增养殖区中超标率较高。各个增养殖区中，广西防城港珍珠湾珍珠养殖区、广西钦州茅尾海大蚝养殖区、海南临高后水湾海水增养殖区沉积物中各监测要素均未发现超标。

生物质量状况 监测的大部分增养殖区的生物质量状况较好。各增养殖区生物体中六六六符合功能区所要求的第一类海洋生物质量标准的站位比例为100%。各养殖区中石油烃、铜、铅、镉超标率较高，超第一类海洋生物质量标准。

综合环境质量等级 2014年综合评价结果显示，监测的14个增养殖区中，78.6%的增养殖区综合环境质量等级为“优良”，21.4%为“较好”。近三年监测结果显示，开展监测的海水增养殖区综合环境质量等级均为“较好”或“优良”。

南海增养殖区综合环境质量等级状况

增养殖区名称	2012年	2013年	2014年
广东深圳东山海水增养殖区	优良	优良	优良
广东深圳南澳海水增养殖区	优良	优良	优良
广东桂山港海水网箱增养殖区	较好	较好	较好
广东柘林湾海水网箱养殖区	较好	优良	优良
广东流沙湾经济鱼类养殖区	-	-	优良
广西北海廉州湾对虾养殖区	优良	较好	优良
广西钦州茅尾大蚝养殖区	较好	较好	较好
广西防城港红沙大蚝养殖区	优良	较好	较好
广西防城港珍珠湾珍珠养殖区	优良	优良	优良
广西涠洲岛海水增养殖区	优良	优良	优良
海南海口东寨港海水增养殖区	优良	优良	优良
海南临高后水湾海水增养殖区	优良	优良	优良
海南陵水新村海水增养殖区	优良	优良	优良
海南陵水黎安港增养殖区	优良	优良	优良

注：“—”表示未开展监测。

增养殖区综合环境质量等级

根据海水增养殖区的环境质量要求，综合各环境介质中的超标物质类型、超标频次和超标程度等，将海水增养殖区的综合环境质量等级分为四级。

优良：养殖环境优良，满足功能区环境质量要求；

较好：养殖环境较好，一般能满足功能区环境质量要求；

及格：养殖环境及格，个别时段不能满足功能区环境质量要求；

较差：养殖环境较差，不能满足功能区环境质量要求。

Annex 872

China State Ocean Administration, “Construction Activities at Nansha Reefs Did Not Affect the Coral Reef Ecosystem” (10 June 2015)

南沙岛礁扩建工程未对珊瑚礁生态系统造成影响

来源：国家海洋局 发布时间：2015-06-10 [打印本页] [关闭窗口]

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我周边海域珊瑚礁占全球珊瑚礁总面积的2.57%，位居世界第八位。由于全球海水升温，海水酸化、渔业资源的过度捕捞以及海岸带开发等原因，现代的珊瑚礁正处于急速退化中。同全球性珊瑚退化趋势一致，我国珊瑚礁也呈现出退化的趋势。多年来，我国非常注重珊瑚礁的保护和修复工作，获得了大量的研究成果和实践经验，并通过立法和建立保护区，对管辖海域范围内珊瑚礁的开发利用予以监管。南沙群岛自古以来就是我国固有领土，在南沙岛礁开展建设，在项目选址、施工和后期监管方面，均严格按照国内法律法规的要求，并进行了科学评估与论证，注重了对生态环境和渔业资源的保护。

1．在珊瑚礁区域开展建设活动在国际上有大量实践

珊瑚礁不仅对于海洋生态健康非常重要，而且对全球经济和社会发展也同样重要，人类对于珊瑚礁的开发利用随着工业化进程的推进一直在进行。当前，全球对珊瑚礁的开发利用方式主要有四类。一是用于国防军事设施建设。部分珊瑚岛礁因其特殊的地理位置和战略地位，往往用于建设机场、港口、中转站等军事设施。早在第二次世界大战期间的太平洋战场上，美日两国纷纷在珊瑚礁上实施填礁造陆、疏浚环礁和平整礁坪，用于建设机场、码头和防御阵地等。例如，依托珊瑚环礁建设的美军关岛基地一直沿用至现今。二是用于滨海旅游设施建设。珊瑚礁因其多姿多彩的造型，丰富多样的水生动植物以及美丽的沙滩，成为不可多得的旅游资源。世界著名的马尔代夫群岛、澳大利亚大堡礁、帕劳群岛和泰国普吉岛等都以美丽的珊瑚礁著称，每年吸引全球大量的游客前往。为了满足基础设施建设需求和防灾减灾需要，许多区域开展了旅游设施建设。例如，马尔代夫启动了人工岛建设、南美加勒比开曼群岛通过疏浚近岸珊瑚礁完成了游艇码头工程等。三是用于港口码头建设。巴哈马、苏丹和巴布亚新几内亚近年来在珊瑚礁海域开展疏浚来建设港池与航道；牙买加和美国迈阿密港近期拟启动改造和浚深珊瑚礁工程，以适应巴拿马运河新的船型；2013年澳大利亚为扩大昆士兰煤码头的靠泊能力，在大堡礁附近水域实施疏浚。四是用于海洋油气开采工程。珊瑚礁的分布往往与石油和天然气有密切关系。例如，澳大利亚曾在珊瑚礁上打桩建设海上石油开采平台，越南在中国南沙群岛万安滩海域进行非法油气勘探等。当然，在珊瑚礁区域开展建设，必须执行严格的保护标准。

2．南沙群岛珊瑚礁生态系统概况

南沙群岛呈现典型的热带珊瑚礁群岛的景观。为了做好该区域的生态保护和利用工作，我国有关部门自1955年以来就组织开展了大量科学考察和研究工作，对于珊瑚礁生态系统特征有了较为清晰的认识。据研究，南沙群岛海域拥有腔肠动物、多毛类环节动物、软体动物、甲壳动物、棘皮动物、苔藓动物、大型藻类等门类的底栖生物计309个科837属1444种。据估计，南沙群岛浅水造礁石珊瑚种类数目介于127种和200余种之间。珊瑚分布空间差异性明显，一般礁前向海坡、潟湖内的珊瑚种类多、覆盖率大；礁坪随潮汐周期而出露，水浅、外力作用较强，珊瑚种类最少，其覆盖度比潟湖内低。研究表明，南沙岛礁附近水域不是一个封闭的水域，其营养盐和饵

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料生物可不断从周围海域得到补充。

近百年来，由于珊瑚礁生态系统的环境因子包括水温、环流模式、海洋化学、海平面、热带气旋和异常的气候等发生了变化，严重影响了珊瑚礁生物群落的分布、结构和功能。加之过度捕捞、非法破坏、过度旅游开发活动等人类活动影响，全球珊瑚礁已发生严重退化。即使被认为保持原始状态最好的澳大利亚大堡礁也显示了系统的退化，加勒比海地区珊瑚礁发生灾难性退化。

我国南海的珊瑚礁数量和种群也呈现出急速下降的趋势。在西沙群岛和南沙群岛环礁和群岛海域，在过去10-15年中上述海域的珊瑚覆盖率已经从60%下降到20%左右。退化的原因以自然因素为主，人为因素主要为渔业资源的过度捕捞。

3．岛礁建设的生态保护措施

我国珊瑚礁主要分布在南海海域和海南岛、台湾岛、香港和广东广西沿岸。多年来，中国政府采取了一系列措施加强对珊瑚礁的保护。一是通过立法加强对珊瑚礁的保护。颁布了《海洋环境保护法》、《海域使用管理法》、《海岛保护法》和《防治海洋工程建设项目污染损害海洋环境管理条例》等法律法规，对珊瑚等生态系统的保护做出明确规定，如《海洋环境保护法》第二十条规定：“......保护红树林、珊瑚礁、滨海湿地.....等具有典型性、代表性的海洋生态系统......对具有重要经济、社会价值的已遭到破坏的海洋生态，应当进行整治和恢复”。二是积极履行《生物多样性公约》等国际公约的责任和义务，不断加大对珊瑚生态系统科学考察和保护的力度。三是建立了多个海洋保护区，对珊瑚礁予以保护，20世纪90年代以来已经建立了广东徐闻、广西的涠洲岛、海南三亚和万宁等4个国家级珊瑚礁保护区。四是积极开展珊瑚恢复研究和实践，在广东、西沙等地开展珊瑚修复，达到了预期效果。我国在部分南沙部分岛礁的扩建工程，依照国内有关法律法规的要求，进行了科学评估与论证，并采取了科学选址、严格环保标准施工、加强监测与评估等措施。

我国南沙岛礁的扩建工程经过了科学评估与论证，而这种评估和论证是建立在科学决策和广泛参与的基础上。科学评估与论证的数据资料，来源于自1955年开始至今近60年对于区域生态系统特征、物理海洋、地质、地貌的综合考察和研究的积累。根据我国法律法规的要求，在评估和论证过程中，着重研究分析了岛礁建设规模的适宜性、选址合理性、生态环境影响、渔业资源影响、工程地质、通航可行性等内容。对方案的优劣尤其是可能导致的生态环境以及渔业资源的影响进行了科学预测与评估，排除了对岛礁海洋生态环境影响大的方案，选择了最优的方案。不仅如此，建设方邀请了多名国内知名专家，多次召开咨询会议，对建设方案的合理性与可行性进行了深入论证。

科学确定建设位置。根据多年的研究，南沙岛礁珊瑚生态系统空间分布差异性显著，即：潟湖内生物多样性高于礁坪区，礁坪区物种种类小于潟湖区；礁坪造礁珊瑚覆盖率远低于潟湖内，而死亡率远高于潟湖内。根据这一特点，建设位置多选择在礁坪造礁珊瑚覆盖率最低或者已经死亡的区域。

考虑到国外在珊瑚礁填礁造陆等方面已经有较长的时期和经验，中国在岛礁扩建施工过程中，借鉴了国外类似建设工程的施工工艺和环境保护标准。建设方分析了世界上多个国家珊瑚礁填海造陆、清淤疏浚和开挖填埋等工程，借鉴了如巴哈马北阿巴科港（North Abaco Port）、牙买加金斯顿KCT码头、苏丹萨瓦金港、巴布亚新几内亚港等类似工程环境影响减缓措施和施工工艺等内容，并与国内相似岛礁开展了类比分析工作。同时，中国的工程建设公司积极参加国外珊瑚礁填海造陆和清淤疏浚工程，在实际施工中不仅掌握了大量先进环保的施工方法，还从中积累了宝贵的经验，为开展我国南沙岛礁建设奠定了坚实的基础。建设方严格环保标准进行建设：（1）尽可能减少围填和疏浚的面积；（2）在疏浚施工和围填过程中设置拦污屏；（3）合理安排施工进度，施工期尽量避开红笛鲷（4月中旬）、金枪鱼（高峰为6-8月）和鲣鱼（3-8月）的产卵期；（4）定期监测取砂区沉积物粒级变化，以保证取砂区始终是粗砂，避免细砂进入吹填区，维持珊瑚礁水域的水质；（5）尽量在南沙群岛和西沙群岛珊瑚生长的高峰季节减小施工强度；根据珊瑚的生长规律和生物特点，动态监测水体的浊度变化，合理调整疏浚时间间隔；（6）定期监测施工区珊瑚礁的生长和健康水平；定期监测珊瑚礁水域的游泳动物、浮游动植物种群、数量、多样性等指标；（7）施工人员和施工船舶产生的生活和生产污水、固体废弃物均是集中收集后，

统一到大陆海港处理；（8）施工船舶均使用年代较新的船型，确保无溢油事故发生；定期收听天气预报和海洋预报，提前做好应对台风和强浪等对工程水工建筑物袭击的防御准备工作，避免引起沙石流失。总之，在施工中采取一切应对措施，确保工程疏浚对珊瑚礁生态环境的影响降到最低。

在施工结束后，将开展生态补偿和珊瑚礁群落重建措施。经过多年的潜心研究和实践，国内外科学家尝试了多种珊瑚礁生态系统的恢复方法，设计了多种人工珊瑚礁的礁体结构，证明了只要采取有效措施，可以实现珊瑚礁群落的恢复。

4．南沙岛礁扩建工程对珊瑚生态系统健康的影响评估

中国海洋行业标准《近岸海洋生态健康评价指南》（HY/T087-2005）将珊瑚礁生态系统划分为健康、亚健康和不健康3 个等级。南沙岛礁的珊瑚礁已被列入亚健康等级。

对南沙岛礁扩建工程对于生态系统健康的影响予以综合评价表明，建设后仍为亚健康状态。因此，岛礁建设未改变南沙区域生态系统健康状况，未对珊瑚生态系统造成破坏。

事实上，南沙群岛的岛礁水域海流和波浪的作用力强，水体更新快，施工产生的悬浮泥沙很少，基本不影响珊瑚体内黄藻光合作用；加之由于建设选址多在造礁珊瑚覆盖率低或死亡的区域，因此扩建工程不会改变区域珊瑚群落结构。施工结束后，由于岛礁建设导致的海洋水文、底质状况改变仅限于建设区及其周围很小的范围，珊瑚发育生长的理化环境没有根本性的变化，仍能健康生长。浮游动物也会很快被补充。

从扩建工程对渔业资源的影响来看，一方面施工时间合理避开了区域内主要经济鱼类的产卵期，可最大限度的降低对渔业资源的影响，更何况一些经济鱼类如金枪鱼的产卵地主要为赤道海域，岛礁建设对金枪鱼的繁殖不会有影响；另一方面，研究表明，南沙岛礁水域不是一个封闭的水域，其营养盐和饵料生物可不断从周围海域得到补充，岛礁扩建工程不会改变渔业资源的生长环境。

研究结果还表明，珊瑚礁的生态恢复能力较强。一般来说，受到自然或人为破坏严重的礁区，只要采取有效措施，大约5-10年便可实现初步恢复，50-100年即可完全恢复优越的、具有复杂关系的、完整的生态系统。

上述分析表明，由于针对南沙岛礁及其周边海域生态环境特征，有针对性的采取了多项环保措施，岛礁建设未对区域珊瑚生态系统造成破坏，评价结果是客观的。尽管如此，岛礁建设结束后，还应加强区域生态环境的监测，并采取放流、珊瑚修复与移植等措施，以更好的保护区域珊瑚礁生态系统。

Construction Activities at Nansha Reefs Did Not Affect the Coral Reef Ecosystem

Source: State Oceanic Administration Issue date: 10 June 2015 [print] [close window]

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The coral reefs in China's waters account for 2.57% of the total area of coral reefs worldwide, ranking eighth in the world. Due to global seawater warming, ocean acidification, overfishing, development of coastal areas and other reasons, modern coral reefs are degenerating rapidly. The degeneration of our coral reefs is consistent with the global trend of coral reef degeneration. Over the years, the Chinese government has attached great importance to the protection and restoration of coral reefs and has obtained valuable research achievements and abundant practical experiences in the process. The Chinese government has been regulating the exploitation and utilization of coral reefs in waters within China's jurisdiction through legislation and establishing natural reserves. The Nansha Reefs have been an integral part of China's territory since ancient times. The site selection, construction and post-construction monitoring of the construction at Nansha Reefs are in all respects in compliance with domestic laws and regulations. The construction was undertaken with an emphasis on the protection of ecosystem and fishery resources, carried out after scientific assessment and feasibility studies.

1. There has been abundant global experience in construction in coral reef areas

Coral reefs are not only vitally important for maintaining a healthy marine ecosystem, but also equally important for world economy and social development. Human utilization of coral reefs has been deepening along with the industrialization process. Nowadays, coral reefs are utilized mainly for four purposes. First, for national defence and military purposes. Some coral reefs are often used for the construction of airports, port facilities, transit stations and other military facilities because of their special geographical location and strategic position. As early as in the Pacific Theatre during the World War II, both the United State of America and Japan had constructed airports, terminals and defence facilities through land reclamation as well as dredging and flattening atoll reefs. For example, the US military bases in Guam are still in use today, which was built on atoll coral reefs. Second, for coastal tourism development. Coral reefs are valuable for tourism purposes because of their wide variety of shapes, biodiversity, and beautiful beaches. The world famous Maldives Islands, Great Barrier Reef, Palau Islands and Phuket Island are all well known for their coral reefs, attracting lots of tourists from around the world every year. Tourist facilities are built in many regions to meet the infrastructural and disaster reduction needs. For example, the Maldives launched the project of construction of artificial islands and Caribbean Cayman Islands completed constructing port facilities by dredging inshore reefs. Third, for the construction of port terminals. Recently, Bahamas, Sudan and Papua New Guinea built harbours and channels by dredging coral reef areas. Jamaica and Port of Miami in the US are recently planning to renovate and further dredge the coral reef areas to adapt the Panama Canal to the new models of ships. In 2013, Australia dredged in the waters of the Great Barrier Reef to increase the berthing capacities of the coal terminal of Queensland. Fourth, for offshore oil and gas exploration projects. Distribution of coral reefs is often closely correlated to that of oil and gas. For instance, Australia used to pile and build oil exploration platforms on coral reefs. Vietnam had also carried out oil and gas exploration illegally in the waters near Wan'an Tan, one of the Nansha Reefs of China. Of course, rigorous protection standards must be complied with when carrying out construction in the coral reef areas.

2. General information on the Coral Reef Ecosystem of Nansha Reefs

Nansha Reefs present typical tropical reef landscape. To facilitate the ecological protection and development of the region, the Chinese government has conducted a large amount of research and scientific exploration since 1955 and obtained a relatively thorough understanding of the coral reef ecosystems. According to the studies, there are coelenterates, polychaete annelids, molluscs, crustaceans, echinoderms, bryozoans, algae and other categories of large benthos in the waters near Nansha Reefs, counted 309 families, 837 genera and 1444 species. It is estimated that there are between 127 and 200 species of shallow water reef building corals (hermatypic corals) surrounding the Nansha reefs.

There is sharp difference in the spatial distribution of corals. Generally speaking, there are more species and large coverage of corals on reef front slopes and in the lagoons; reef flats have the fewest species of corals and less coverage than in the lagoons because reef flats emerge from water periodically with the tides, have shallower water and are subject to stronger external force. Research has shown that the South China Sea is not a body of closed waters, therefore nutrients and food organisms can be replenished constantly from surrounding waters.

In the past century, the distribution, structure and function of coral reef communities have been seriously affected by the changes in coral reef ecosystems' environmental factors, including water temperature, circulation patterns, marine chemistry, sea level, tropical cyclones and climate anomalies. The severe degeneration of coral reefs worldwide has been exacerbated also by human factors such as overfishing, illegal destruction, excessive tourism development activities, etc. Even Australia's Great Barrier Reef, the pristine conditions of which were considered best preserved in the world, has shown signs of systematic degeneration. The Caribbean coral reefs are experiencing catastrophic degeneration.

The amount and number of species of coral reefs in China's South China Sea is also showing a tendency of rapid decrease. In the past 10 to 15 years, coral reef coverage in the waters of Nansha and Xisha has decreased from 60% to 20%, which reflects the global trend of coral reef degeneration. Such decrease is mainly due to natural factors, with overfishing being the major human factor.

3. Eco-protection measures implemented during the construction activities

China's coral reefs are mainly located in South China Sea and in the coastal areas near Hainan Island, Taiwan, Hong Kong, Guangdong and Guangxi Province. During the years, the Chinese government has implemented a series of measures to enhance the protection of coral reefs. First, enhance the protection through legislation. The Chinese government has promulgated laws and regulations such as *the Marine Environment Protection Law of the People's Republic of China*, *Law of the Peoples Republic of China on the Administration of the Use of Sea Areas*, *Island Protection Law of the People's Republic of China* and *Administrative Regulation on the Prevention and Treatment of the Pollution and Damage to the Marine Environment by Marine Engineering Construction Projects*. These laws and regulations specifically provide for the protection of various ecosystems, including coral reef ecosystems. For example, Article 20 of *the Marine Environment Protection Law of the People's Republic of China* provides that: " . . . typical and representational marine ecosystems . . . such as mangroves, coral reefs, and coastal wetlands shall be protected… destroyed marine ecosystems that have important economic and social values shall be restored . . . "; Second, actively fulfilling obligations under international conventions including the *UN Convention on Biodiversity*, step up efforts in the protection of and research on coral reef ecosystems. Third, establish marine natural reserves to protect coral reef ecosystems. China has established four national natural reserves since the 1990s to protect and preserve coral reefs in Xuwen of Guangdong, Weizhou of Guangxi, Sanya of Hainan and Wanning of Hainan. Fourth, actively conduct research on the restoration of coral reefs and put the result into practice. Coral reef restoration in Guangdong, Xisha, etc. has lived up to the expectation. The Nansha construction activities are in conformity with the relevant laws and regulations. The construction activities have gone through scientific assessment and consultations. Measures have been taken in conducting scientific site selection, implementing strict environmental protection standards and enhancing monitoring and assessments.

The construction activities have gone through scientific assessment and consultations. China has undertaken several consultations with a wide range of experts on potential environment impacts based on 60 years of data since 1955 on the characteristics of the regional ecosystems, marine physics, geology and landscapes, accumulated from comprehensive scientific exploration and research. In accordance with Chinese laws and regulations, these assessments put great emphasis on issues such as the suitability of the scale of the construction activities, the reasonableness in site selection, the impact on ecosystems, the impact on fishery resources, engineering geology and seismic factors, as well as navigational feasibilities. The government has evaluated all construction plans available and has chosen the optimal plan while excluded the ones that would have a bigger impact on marine environment. The government also engaged in a number of consultations with prestigious national experts on the practicality and feasibility of the plan chosen.

As to scientific site selection, based on years of research, the distribution of coral reef ecosystems in Nansha exhibits significant spatial difference: the biodiversity level is higher in the lagoons than in reef flat areas; the coverage of hermatypic corals is far lower in the reef flat areas while their death rate is a lot higher than in the lagoons. Due to this characteristic, most of the construction sites selected are located in reef flats with the lowest hermatypic coral coverage or where hermatypic corals are mostly dead.

Considering other countries have had a long history of and abundant practices in land reclamation in coral reef areas, China had drawn on the construction technology and environmental protection standards implemented in similar projects. The engineers analysed land reclamation, dredging, excavation and landfill projects in coral reef areas of many foreign countries, drawing on similar projects such as the Bahamas North Abaco Port, KCT terminals of Kingston of Jamaica, Sawakin Port of Sudan and Port of Papua New Guinea. The engineers analysed the construction technology and environmental impact mitigation measures, and undertaken comparison study with similar reefs in China. At the same time, China construction companies actively participate in foreign coral reef land reclamation and dredging projects. In this process, they not only mastered various advanced environment friendly construction technology, but also obtained valuable experiences as well, which set a solid basis for the construction at Nansha Reefs. The following specific environmental protection measures were implemented to minimize the impact on coral reefs, including:

1) minimizing the extent of the reclamation and dredging areas;
2) setting trash collecting screens;
3) timing construction reasonably, trying to avoid spawn periods of red snapper (mid-April), tuna (peak from June to August) and bonito (from March to August);
4) monitoring the change of grain size of sand sediments regularly, ensuring that the area where sands are taken always consists of grits and avoiding fine sands from going into reclamation areas to maintain the water quality of coral reef areas;
5) reducing construction intensity during the peak of growth of Nansha and Xisha coral reefs, monitoring the turbidity change of waters dynamically and adjusting dredging intervals in light of the biological characteristics of coral reefs;
6) monitoring the growth and health of coral reefs in construction areas and indicators such as species, population and diversity of swimming animals and plankton in coral reef areas;
7) centrally collecting the waste water and solid waste produced from life and construction to be sent for treatment at land facilities of harbours;
8) using newer vessels to ensure no oil spill happens; listening to weather and marine condition forecasts regularly and making prior preparation for typhoons and strong waves to avoid the loss of sands from structures.

To sum up, all measures had been taken during the construction to ensure minimum impact on coral reef ecosystems.

There will be measures to restore and remedy the harm done to the coral reef ecosystems after the constructions. After years of research and practice, domestic and international experts have experimented several ways to restoring coral reef ecosystems and designed multiple structures of artificial coral reefs, which proved that the restoration of coral reef communities could be realized should effective measures be taken.

4. Assessment of the environment impact of Nansha construction activities on coral reef systems

The *Guidance for the Assessment of Coastal Marine Ecosystem Health（HY/T087-2005）* classifies the health level of coral reef ecosystems as "healthy", "sub-healthy", and "unhealthy". The Nansha coral reefs were rated as "sub-healthy" before the construction.

After assessing the construction's environmental impact on coral reefs, the health of Nansha coral reefs were still rated "sub-healthy" after the construction was completed. Therefore, the construction activities neither affected the health of the ecosystems of Nansha nor harmed the coral reef ecosystems.

In fact, due to the strong currents and waves in Nansha waters, the water bodies are updated fairly fast so that little suspended sands are produced from the constructions, leaving the photosynthesis of corals largely unaffected. Because the sites are located in areas where coverage of coral reefs is low, the overall community structure of coral reefs is not changed. In addition, since oceanographic and sediment status changes are only limited to areas near the construction sites, the physical and chemical living environment of coral reefs are not fundamentally changed, therefore their health was not significantly harmed by the construction activities. Plankton would also be replenished fairly quickly.

As to the impact of reclamation activities on fishery resources, on the one hand, because the construction avoided the spawning seasons of the main economic species, the impact on fishery resources is reduced to the minimum. Since the main spawning ground of some of these economic species including tuna is in the equatorial waters, the construction would not affect the spawning of tuna. Studies have shown that South China Sea is not a body of closed waters, therefore nutrients and food organisms can be replenished constantly from surrounding waters. Thus, the reclamation activities have not significantly harmed fishery resources.

Research has also shown that coral reefs have strong capability of self-restoration. Generally speaking, coral reefs that have been severely damaged by natural factors or human activities can be restored initially in 5-10 years provided that effective measures are taken, and complex and complete ecosystems can be fully restored in 50-100 years.

The above analysis demonstrates that because various targeted environment protection measures have been taken based on the characteristics of Nansha reefs and their surrounding waters, the conclusion can be reached that the construction activities did not adversely affect the regional coral reef ecosystems. The assessments are objective. Even so, after the construction is completed, it is important to enhance monitoring of regional ecosystems and implement measures including release, coral restoration and transplantation in order to better protect the coral reefs.

Annex 873

Communication from the Ministry of the Interior of the Republic of China (Navy Command Headquarters) to the Ministry of Foreign Affairs of the Republic of China (8 May 1950), reprinted in *Archival Compilation on South China Sea Islands by Ministry of Foreign Affairs*, Vol. 2, Doc. No. III(2):013 (Republic of China Ministry of Foreign Affairs Research & Planning Committee, ed.) (1995)

English Translation

Archival Compilation on South China Sea Islands by Ministry of Foreign Affairs

(Volume II)

Compiled and printed by Ministry of Foreign Affairs Research & Planning Committee

May 31, 1995, Republic of China

[…]

III(2):013. “Regarding withdrawal of military stationed in Nansha Islands,” Ministry of the Interior by courier in place of telegram (May 8, Year of the Republic 39 [1950], TNDZ No. 1377)

From Ministry of the Interior by courier in place of telegram

To the Ministry of Foreign Affairs: This year, the May 2 message by courier in place of telegram from Navy Command Headquarters, YWXZ No. 995 stated, in short: The Xisha and Nansha Islands are far away on the ocean; even though they occupy vanguard positions in terms of national defense, they lack residents or production, and long-term military operations here are difficult due to the necessity of vessel supplies. We seek approval for recalling the military personnel stationed at Nansha Islands first, and then recall the military personnel stationed at Xisha Islands when necessary. We send a telegram requesting consideration for whether these measures would affect the protection against the Philippine government’s covetous intent regarding the Nansha Islands. We also request your further consultation with the Navy Command Headquarters.

[…]

外交部南海諸島檔案彙編
（下冊）

外交部研究設計委員會編印

中華民國八十四年五月三十一日

希注意隨時呈報爲要。外交部（東二）

III(2):013、「爲撤守南沙群島事」，內政部代電（民國三十九年五月八日　臺內地字第一三七七號）

內政部代電

外交部公鑒：准海軍總司令部本年五月二日螢舞許字第九九五號代電略稱：西沙南沙兩群島孤懸海外雖佔國防前哨地位但既無居民又乏生產且當此長期作戰運艦派遣時感不敷，經奉准先將南沙群島戍守員兵撤回，俟必要時再繼續撤回西沙群島等由。此種措施，對於防範菲國政府覬覦南沙群島一節，有無影響，特電請考慮，并請與海軍總司令部逕洽爲荷。

III(2):014、「關於呈奉核准戍守西、南沙兩群島之官兵撤回一案報請鑒察」，海軍總司令部代電（民國三十九年五月十二日螢舞許字第一〇八七號）

海軍總司令部代電

一、（卅九）五月八日螢舞許字第一〇四〇號代電計呈

二、茲據中勝軍艦晨齊航電略稱：

「(1)南沙島人員物資在職艦官兵協助下全部撤運上艦(2)職艦齊日晨離南沙島直駛左營(3)西南沙兩島國旗謹遵　鈞座指示仍高懸空中」

三、謹電鑒察

Annex 874

Ministry of Foreign Affairs of the Republic of China (Taiwan), *The position of the Ministry of Foreign Affairs on Taiwan's sovereignty over islands in the South China Sea* (28 Nov. 2007)

The position of the Ministry of Foreign Affairs on Taiwan's sovereignty over islands in the South China Sea

Date: 2007/11/28 Data Source: 公眾外交 調

Vietnam's Ministry of Foreign Affairs stated on November 15, 2007, that Taiwan's construction of an air strip on one of the Spratly Islands is a violation of Vietnamese sovereignty and heightens tensions in the area. The position of Taiwan's Ministry of Foreign Affairs (MOFA) is as follows: The Spratly Islands, the Paracel Islands, Macclesfield Bank and the Pratas Islands have always been an intrinsic part of Taiwan's territories, whether looked at from the perspective of history, geography, international law or plain fact. According to the principles of international law, the government of Taiwan's sovereignty over these islands is unquestionable and it enjoys all rights accordingly. Taiwan has long stationed troops on Taiping Island (known to Vietnam as Itu Aba), the largest among the Spratly Islands. Basic airport facilities were established on the island years ago to transport essential supplies, to safeguard marine resources and for emergency humanitarian rescue. As a nation with sovereignty over the South China Sea and all its islands, and on the basis of sovereign independence and respect for reality, Taiwan opposes any provocative actions. Taiwan also supports solving disputes through negotiations and dialogue, and developing resources in the South China Sea with cooperative partners. MOFA urges all countries to respect Taiwan's sovereignty claims over the islands in the South China Sea. (E)

Annex 875

Ministry of Foreign Affairs of the Republic of China (Taiwan), “Taiping Island is an island, not a rock, and the ROC possesses full rights associated with an exclusive economic zone and continental shelf in accordance with UNCLOS” (23 Jan. 2016)

Taiping Island is an island, not a rock, and the ROC possesses full rights associated with an exclusive economic zone and continental shelf in accordance with UNCLOS

Date: 2016/01/23 Data Source: Public Diplomacy Coordination Council

Press Release No. 023
January 23, 2016

In recent years, parties concerned have continued to be at odds over sovereignty disputes in the South China Sea. In January 2013, the Philippines initiated arbitration against mainland China concerning the South China Sea in accordance with Annex VII of the United Nations Convention on the Law of the Sea (UNCLOS). During the second hearing from November 24 to 30, 2015, the Philippines distorted the facts and misinterpreted the law to argue that Taiping Island is a rock and not an island, and that it therefore should not have any maritime entitlements beyond 12 nautical miles. The Executive Yuan and Ministry of Foreign Affairs of the Republic of China have issued statements on numerous occasions reiterating that, whether from the perspective of history, geography, or international law, Taiping Island, with an area of 0.51 square kilometer, is the largest naturally formed island in the Nansha (Spratly) Islands, can sustain human habitation and economic life of its own, and meets the criteria of an island as defined in Article 121 of UNCLOS. Therefore, with regard to Taiping Island, the ROC enjoys full rights associated with territorial waters, a contiguous zone, an exclusive economic zone (EEZ), and a continental shelf in accordance with UNCLOS.

On December 12, 2015, ROC Minister of the Interior Chen Wei-zen led a group of related government officials on a trip to Taiping Island to preside over a ceremony marking the opening of a wharf and lighthouse. During this visit, Minister Chen and the other members of the group drank water taken from a well on the island, proving that water quality there is very high. Moreover, the lunch they had that day consisted of local natural ingredients, products from livestock raised on the island, as well as vegetables and fruits grown by personnel stationed there. This clearly showed that the conditions on Taiping Island are such that it can sustain human habitation and economic life of its own.

ROC and foreign experts visit Taiping Island to conduct surveys, the results of which underline the fact it is an island

To provide further scientific evidence that Taiping Island qualifies as an island, the ROC Council of Agriculture invited a team consisting of water, soil, vegetation, and legal experts to survey Taiping Island from January 22 to 23, 2016, and conduct an updated examination of its natural and agricultural environment. In addition, a group of senior ROC government officials including Minister of Foreign Affairs David Y. L. Lin, Minister of the Mainland Affairs Council Andrew L. Y. Hsia, and Minister of the Environmental Protection Administration Wei Kuo-yen visited Taiping Island on January 23, 2016, to inspect wells, natural vegetation, agriculture, the Guanyin Temple, as well as the remains of past structures, and tour the island's solar power facilities, lighthouse, wharf, communications equipment, and Nansha Hospital. They were accompanied by ROC scholars including Prof. Chun-I Chen, Dr. Yann-Huei Song, Prof. Kuan-Hsiung Wang, Prof. Cheng-Yi Lin, and Dr. Lih-Torng Chen, as well as foreign experts including Mr. Jose Zaide, columnist for the Manila Bulletin, and Greg Poling, Director of the Asia Maritime Transparency Initiative of the US-based Center for Strategic and International Studies.

Water on Taiping Island is potable and of higher quality than groundwater on Penghu Island

The aforementioned survey team observed that, with regard to water resources, there are four operational groundwater wells on Taiping Island. The results showed that the temperature of the water in one of the wells was approximately 28 degrees Celsius, with electrical conductivity of 838 μmho/cm, and total dissolved solids of 418 mg/L. It can be concluded from these measurements that the water on Taiping Island is freshwater that can be used as drinking water, and is of higher quality than the groundwater found on Penghu Island.

Soil on Taiping Island is naturally formed and supports indigenous vegetation as well as agricultural crops

Meanwhile, samples were taken from five different areas—i.e., the sod area, coconut tree area, vegetable cultivation area, coastal forest area, and shrub area—in order to gain a better understanding of the basic properties and structural characteristics of the soil on Taiping Island. Field results revealed that soil on the island is naturally formed and supports indigenous vegetation as well as agricultural crops. The island's soil composition and soil-profile characteristics show two main types of soil. The first type is found mainly on the outer periphery of the island. Its topsoil is grayish black, with many dry twigs and fallen leaves, and no guano layer underneath. The first 20 centimeters of topsoil consists primarily of coarse sand with a mixture of dry twigs and leaves, has definite soil structure with an abundance of plant roots, and is calcareous. At a depth of 20 to 60 centimeters it consists of eroded coral materials. The second type is found chiefly in inland areas of the island: black topsoil with many dry twigs and fallen leaves. At a depth of 20 centimeters there is a guano layer. The topsoil down to 40 centimeters consists primarily of sand with many dry twigs and leaves, and a large amount of brown lumps of guano. It is calcareous with well-formed soil structure, a greater amount of organic matter, and an abundance of plant roots. Both types of naturally formed soil on the island support indigenous vegetation and agricultural crops.

Taiping Island possesses abundant natural resources, including 106 land-based plant species

As for vegetation and land use, onsite surveys were conducted to record the plant resources and different types of vegetation on Taiping Island, as well as the types and distribution of related products that can be used by island inhabitants for daily life needs or cultivation. The surveys revealed an abundance of indigenous natural vegetation. The primeval coastal forest area is fairly dense, with giant sword fern (Nephrolepsisbiserrata) growing in it, indicating a stable forest environment that can effectively hold water, preserve evaporation, and replenish soil humus. Wild coconut, papaya, and plantain are found all over the island and can be harvested throughout the year, enabling Taiping Island to sustain human habitation and economic life of its own. According to the scientific literature and the results of the onsite surveys, vegetation on the island is comprised mainly of tropical coastal drifting flora, with a total of 106 land-based plant species from 46 families, including 20 species of trees,16 species of shrubs, 17 species of lianas, and 53 species of herbaceous plants. There are 147 trees on the island taller than chest height with girths greater than 100 centimeters, belonging to four common tropical species: the Indian almond (Terminalia catappa), fish poison tree (Barringtonia asiatica), lantern tree (Hernandia nymphaeifolia),and Alexandrian laurel (Calophyllum inophyllum). Most of these trees are 100-150 years old. The largest is a lantern tree four to five stories high, with a girth of 907 centimeters (equaling the arm spans of several people). Other wild crops include coconut, papaya, and plantain. There are approximately 500 coconut trees on the island, producing about 1,500 wonderfully flavored coconuts each year. There are also approximately 50 papaya trees and 50 plantain trees that grow in shrub areas, producing 200-300 kilograms of high-quality papayas and plantains each year. Personnel stationed on the island have long utilized all types of resources on the island and cultivated various tropical vegetables and fruits, including staple foods such as corn and sweet potato as well as 10 other types such as okra, pumpkin, loofah gourd, bitter melon, and cabbage. These crops grow well on the island. In addition, six dogs, 12 goats, and 180 chickens live on the island. The dogs act as guards during the night while the goats and chickens provide sources of food that meet the needs of people on the island.

Guanyin Temple meets the spiritual needs of personnel stationed on Taiping Island, and tombstones show traces of past human activity

With regard to culture and history, members of the survey team visited the Guanyin Temple, built in 1959 to meet the spiritual needs of personnel stationed on Taiping Island. The original temple was built in the form of a big shrine using readily available materials, with its pillars made from cans strung together. It has since been renovated several times. Near the Guanyin Temple is a tombstone dating back to the Qing dynasty, as well as a stone marker erected during the time when Japan had incorporated Taiping Island and the Shinnan Gunto (part of the Nansha Islands) in Takao City of Takao Prefecture(today’s Kaohsiung City and Pingtung County), under the jurisdiction of the Japanese governor-general of Taiwan. Also in the vicinity is a memorial stele marking the recovery of the island by the ROCS Taiping on December 12, 1946. All of this demonstrates that humans have long been active on Taiping Island, offering powerful evidence that Taiping Island has sustained human habitation.

Eminent scholars participating in the trip to Taiping Island reaffirm that Taiping Island qualifies as an island

ROC scholars on the team stated that, during their visit to Taiping Island, they witnessed the achievements of the ROC government’s peaceful operations in the South China Sea. They also confirmed that Taiping Island, being able to sustain human habitation and economic life of its own, meets the criteria of an island as defined in Article 121 of UNCLOS. According to the scientific data mentioned above, wells on the island provide high-quality freshwater that can meet the needs of personnel stationed there. The soil is also of good quality, supporting natural plants and agricultural crops and producing enough grass to feed the goats on the island. The Guanyin Temple fulfills the spiritual needs of personnel while the remains of past structures show traces of human activity through the years. Based on all of this evidence, the ROC scholars unanimously agree that Taiping Island is an island that can sustain human habitation and economic life of its own, and is therefore not a rock as claimed by the Philippines.

ROC scholars have also noted that the Philippine interpretation of Paragraph 3 of Article 121 of UNCLOS is not widely accepted in the international legal community and is not supported by any international legal precedent. The Philippine line of argumentation is therefore not credible. In fact, if the Philippines’ interpretation were to be accepted, serious issues could arise, as several nations would no longer be able to claim EEZs of certain islands. These include the United States (Baker Island—uninhabited and without freshwater; Kingman Reef—land area above water during high tide only 0.012 square kilometer) and Japan (Okinotorishima— extremely small, with an area of roughly 8 square meters, uninhabited, and no fresh water or crops). Furthermore, numerous island nations that have little freshwater and rely on rainwater harvesting would not be able to claim EEZs. The arbitral tribunal should therefore address this issue with great caution, conduct a comprehensive study, and refrain from accepting the Philippines’ unilateral position, so that the interests of other members of the international community are not jeopardized and unnecessary disputes and conflicts do not emerge.

ROC government briefs scholars on peaceful efforts to safeguard its legal interests

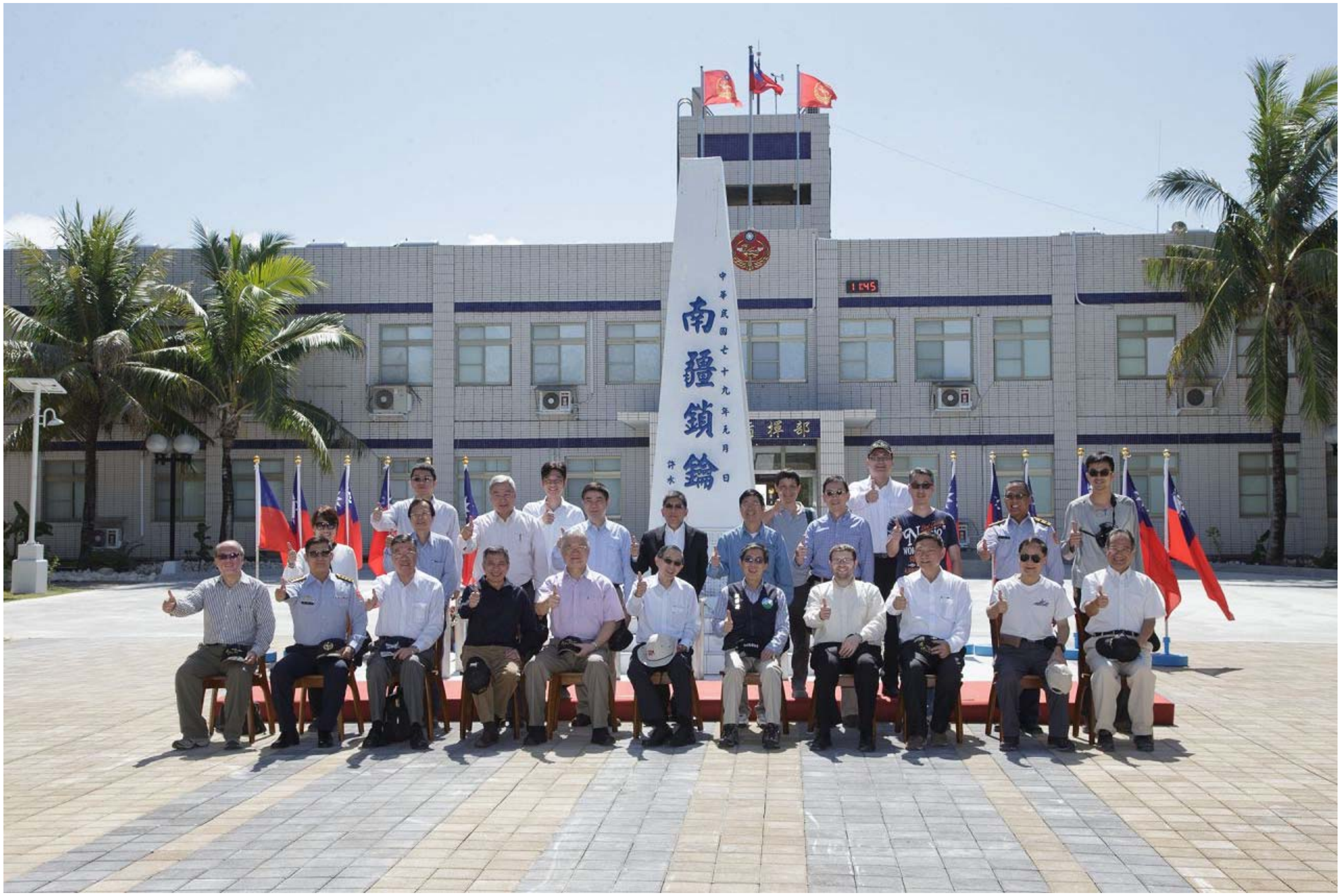
At the invitation of the ROC government, guests drank Taiping Island freshwater, enjoyed a meal prepared from locally produced ingredients, and visited the island’s facilities and cultural sites. The government elaborated on its efforts to protect its legal interests, as well as its operations in the South China Sea, through peaceful means. The ROC government urges the international community to support the South China Sea Peace Initiative it put forward on May 26, 2015, take note of the ROC presence and interests in the South China Sea, and include the ROC in related multilateral negotiation mechanisms in an appropriate manner, so as to safeguard peace and stability in the South China Sea.

Following the inspection visit to Taiping Island by the aforementioned group of experts and scholars, the ROC government once again reiterates that Taiping Island is the largest naturally formed island in the Nansha Islands, can sustain human habitation and economic life of its own, and meets the criteria of an island as defined in Article 121 of UNCLOS. The ROC government staunchly defends Taiping Island's status as an island. Attempts to undermine this status, as well as corresponding maritime entitlements accorded by UNCLOS, will not succeed. Any party that wishes to alleviate tension in the South China Sea should refer to the South China Sea Peace Initiative put forward by the ROC government and seek to resolve disputes through peaceful negotiations in accordance with the principle that, even though sovereignty cannot be divided, resources can be shared, so as to jointly transform the South China Sea into a sea of peace and cooperation.(E)

Commemorative stele with a quote by ROC President Ma Ying-jeou that reads “Peace in the South China Sea and our national territory secure forever”

Commemorative stele with a quote by ROC President Ma Ying-jeou that reads “Peace in the South China Sea and our national territory secure forever”

Standing near a commemorative stele with a quote by ROC President Ma Ying-jeou that reads “Peace in the South China Sea and our national territory secure forever”(3)



Group photo

Sample of the soil on Taiping Island

Sample of the soil on Taiping Island

Sample of the soil on Taiping Island

Dr. Zueng-sang Chen, soil environmental quality expert, tests the soil on Taiping Island

Dr. Ta-wei Chang, water quality expert, tests the well water of Taiping Island, confirming its high quality as drinking water

Well on Taiping Island

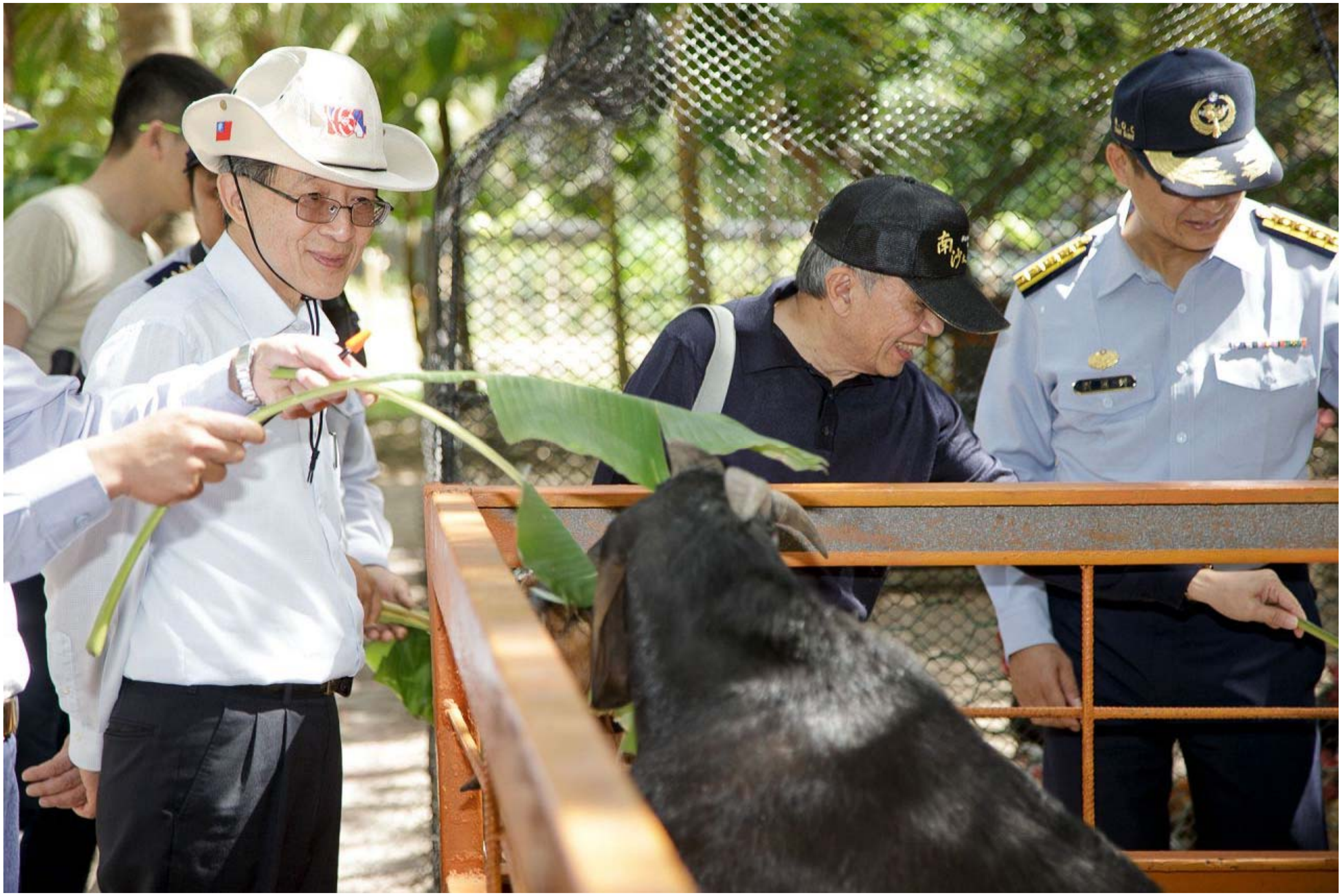
Water is drawn from a local well

Minister of Foreign Affairs David Y. L. Lin and domestic and foreign experts and guests listen to a presentation on water quality, and drink water from a local well

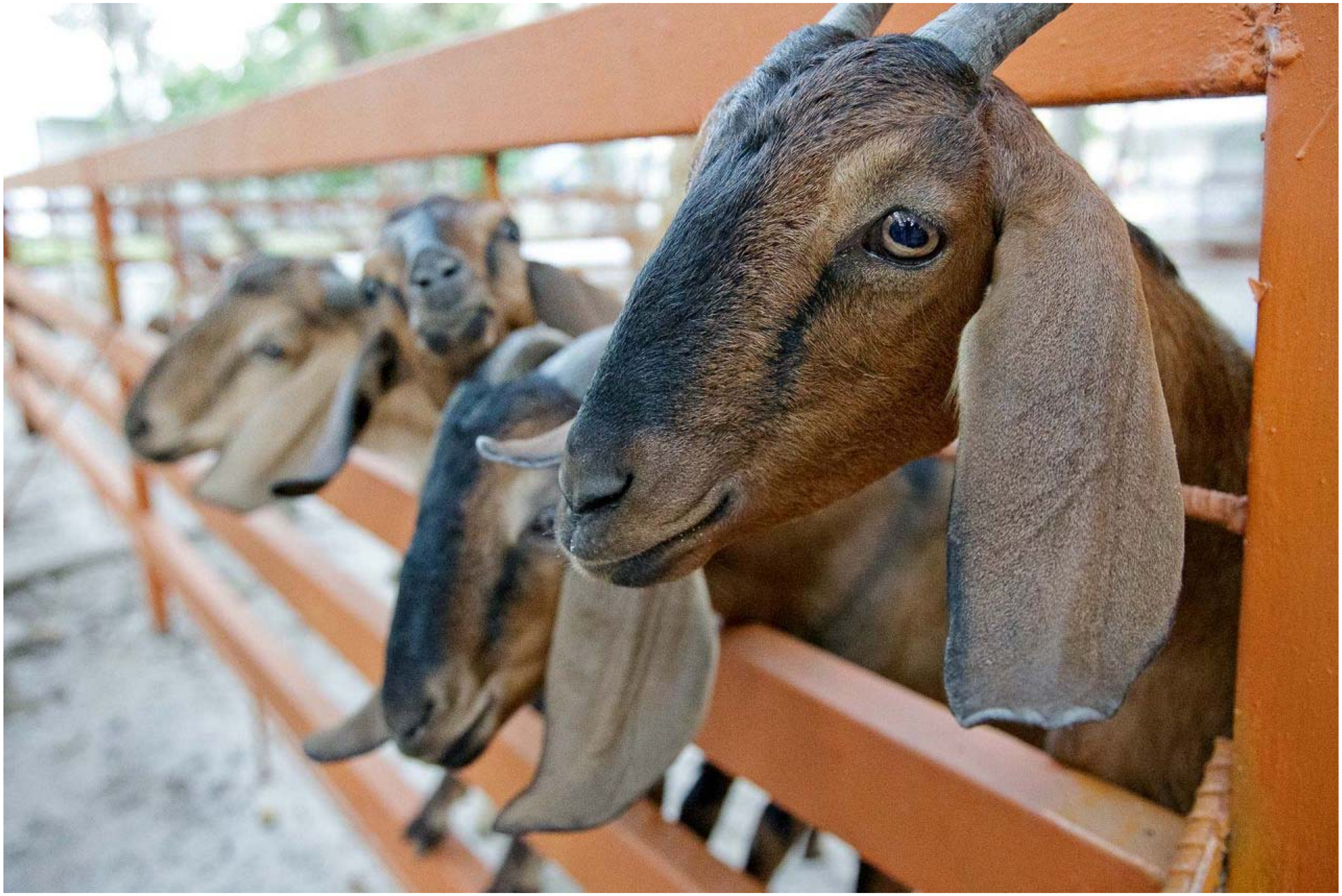
isit to island farm

Visit to island farm

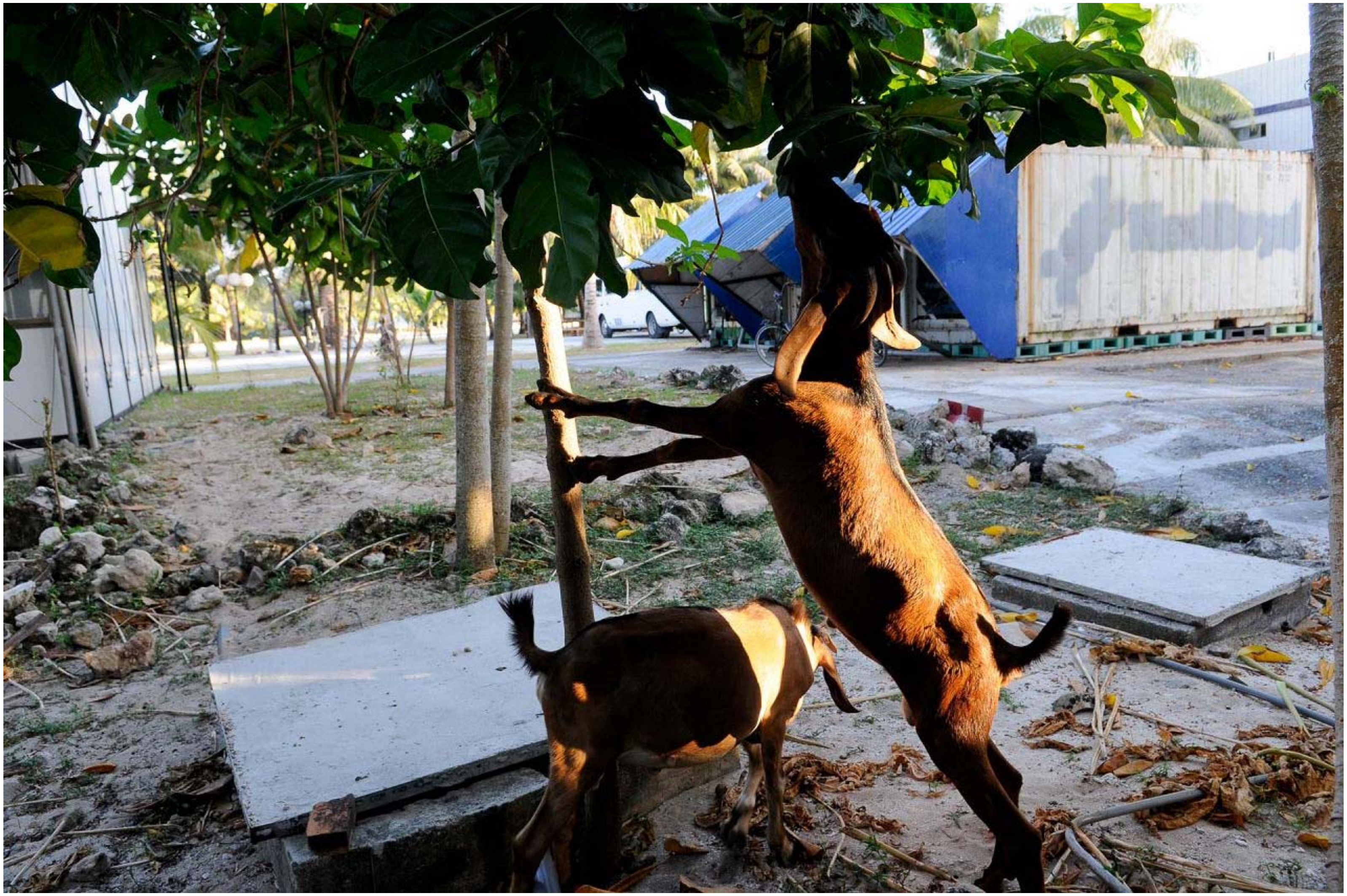
Visit to island farm



Visit to island farm



Goats on island farm



Goats on island farm

Chickens on island farm

Officials from the Ministry of the Interior and the Ministry of Foreign Affairs introduce the history of island recovery by the ROCS Taiping

Officials from the Ministry of the Interior and the Ministry of Foreign Affairs introduce a stone marker dating back to Japanese occupation during WWII

Memorial stele marking recovery of the island by the ROCS Taiping on December 12, 1946

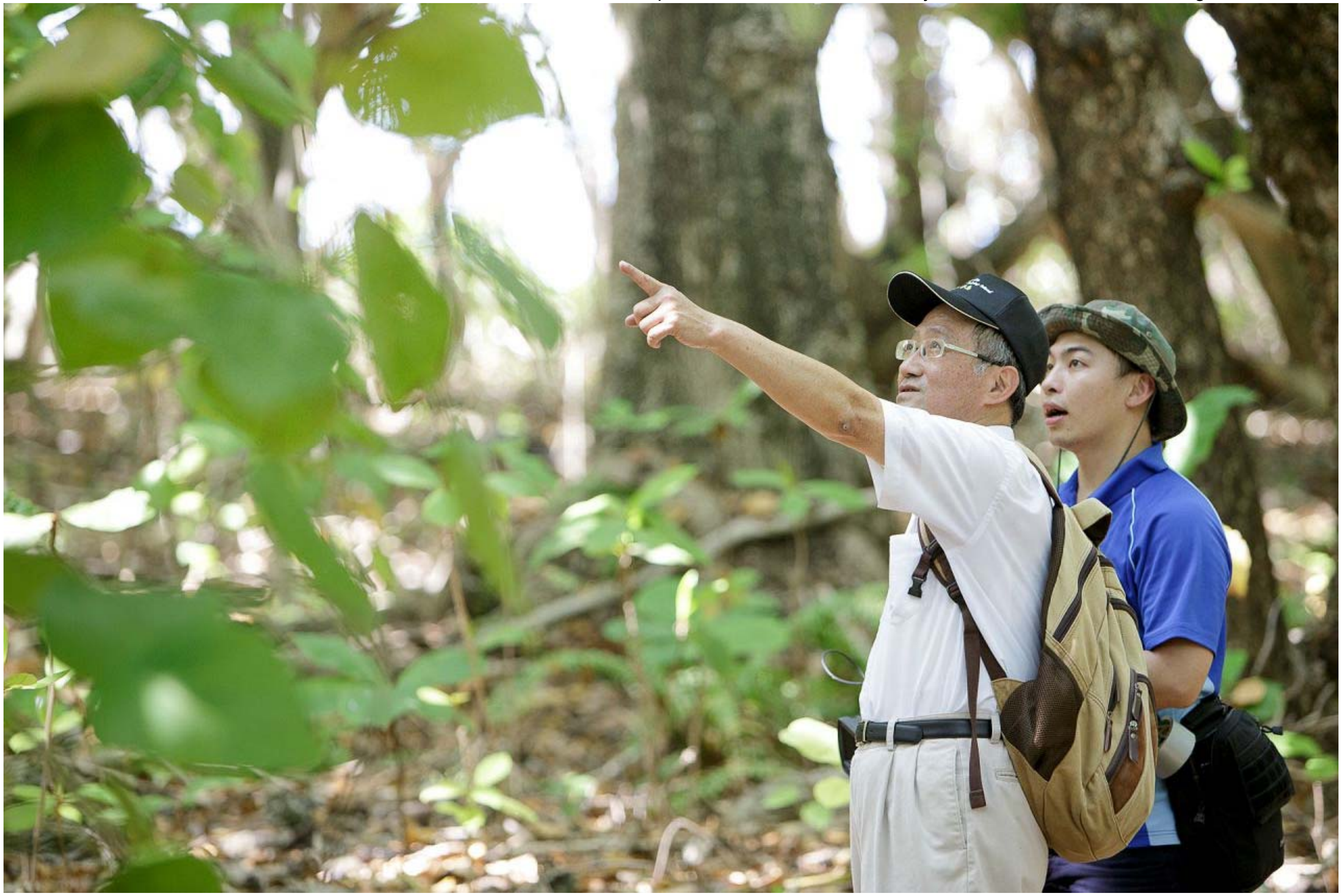
Stone marker dating back to Japanese occupation during WWII / Tombstone dating back to the Qing dynasty

Guanyin Temple

Minister David Y. L. Lin leads the group on a visit to the Guanyin Temple.j

It takes several people standing with open arms to fully encircle the largest natural Alexandrian laurel on the island

Dr. Chia-wei Li, Editor in Chief of Scientific American Taiwanese edition, points out the rich biodiversity of the dense forest, including abundant ferns.



Wild papaya trees_

Wild coconut trees

Lunch prepared with locally raised chicken and vegetables

Lunch box prepared with locally raised chicken and vegetables

Nansha Hospital serves as a station for humanitarian assistance and emergency rescue in the South China Sea_

Solar power facilities, part of efforts to make Taiping Island a low-carbon

Annex 876

Office of the President of the Taiwan Authority of China, “Remarks by President Ma on Taiping Island”, (28 Jan. 2016), *available at* http://english.president.gov.tw/Default.aspx?tabid=491&itemid=36616&rmid=2355 (accessed 9 Mar. 2016)

Remarks by President Ma on Taiping Island

Date	2016/01/28


On January 28, President Ma Ying-jeou led government officials and scholars to visit Taiping Island in the Nansha Islands. He explained the four objectives of visiting the island: first, visiting personnel stationed on the island ahead of the Lunar New Year; second, unveiling the South China Sea Peace Initiative Roadmap; third, explaining the purpose of peaceful use of Taiping Island; and fourth, clarifying the legal status of Taiping Island.

The following is an English translation of the president's remarks:

I am very happy to be here today on Taiping Island ahead of the Lunar New Year with all of you stationed in the Nansha Islands, part of the southern territories of the Republic of China. In addition to affirming your hard work and sacrifices, I want to wish everyone a happy new year. Before every Lunar New Year I pay special visits to our men and women in the military, police, fire departments, coast guard, medical services, and environmental protection. This year I am starting with our coast guard personnel stationed furthest from Taiwan proper, here 1,600 kilometers away on Taiping Island, to show the great importance we attach to you and your mission.

I. South China Sea Peace Initiative Roadmap

In response to the decades of dispute regarding sovereignty over the South China Sea Islands and maritime rights, we must state clearly that these islands were first discovered, named, and used by the Chinese in the Western Han dynasty (in the first century BCE). They were incorporated into the maritime defense system no later than 1721, in the Kangxi period of the Qing dynasty, with patrols and other management measures. After the ROC was founded in 1912, the government published maps of the South China Sea Islands in 1935 and 1947, reaffirming to the international community ROC sovereignty over the islands and their surrounding waters.

Whether from the perspective of history, geography, or international law, the Nansha (Spratly) Islands, Shisha (Paracel) Islands, Chungsha (Macclesfield Bank) Islands, and Tungsha (Pratas) Islands, as well as their surrounding waters, are an inherent part of ROC territory and waters, and the ROC enjoys all rights over these islands and their surrounding waters in accordance with international law. This is indisputable. To resolve disputes in the South China Sea, the ROC government has come up with a concrete approach: to safeguard sovereignty, shelve disputes, pursue peace and reciprocity, and promote joint development.

Based on this approach, on May 26, 2015, I put forth the South China Sea Peace Initiative, calling on all parties concerned to reduce tensions, increase dialogue, abide by international law, uphold the freedom of navigation and overflight, maintain peace and stability in the South China Sea, and settle disputes peacefully. The initiative and its principles for handling disputes have received widespread international support, including an expression of appreciation by the US State Department. We saw the first fruits of the initiative on November 5 last year, when the ROC and the Philippines signed the Agreement Concerning the Facilitation of Cooperation on Law Enforcement in Fisheries Matters, which will greatly reduce fisheries disputes in the overlapping waters of Taiwan and the Philippines.

Now I would like to announce the South China Sea Peace Initiative Roadmap, which is based on a framework of three yeses and three noes.

1. “Yes” to cooperation, “no” to confrontation: A cooperation and development mechanism that contributes to peace and prosperity in the South China Sea should first be established, and sovereignty disputes should be set aside for future resolution through peaceful means.
2. “Yes” to sharing, “no” to monopolizing: A cooperation and development mechanism should ensure equal participation and resource sharing among all parties concerned in the region in order to avoid undermining the rights and interests of any party.
3. “Yes” to pragmatism, “no” to intransigence: The initial focus should be on aspects which are beneficial to all parties concerned and on which consensus can be easily achieved; various cooperation items should be pragmatically and gradually promoted so as to avoid missing out on cooperation opportunities as a result of any party insisting on its position.

Next I will lay out the concrete content of the roadmap, including a viable path, two essential elaborations, and three phases of progress.

The viable path consists of shelving disputes, integrated planning, and zonal development.

The two essential elaborations are:

First, all parties concerned in the region should be included in the consultation mechanism for this initiative so that they can engage in cooperation and negotiations on integrated planning for the South China Sea.

Second, the cooperation and consultation mechanism proposed in this initiative should be a provisional arrangement of a practical nature, and should not undermine the position of any party concerned or jeopardize or hamper the reaching of a final agreement on the South China Sea.

Lastly, we've mapped out three phases of progress, namely short-term, mid-term, and long-term plans.

In the short term, we need to jointly shelve disputes. All parties concerned in the region should launch multilateral dialogue and consultations as soon as possible with a view to reaching a consensus that sovereignty disputes be shelved. In accordance with the spirit and principles of the UN Charter, the UN Convention on the Law of the Sea (UNCLOS), and other relevant international law, the parties should pledge to replace military confrontation with peaceful consultations, refrain from taking any actions that might affect stability and peace in the South China Sea, and ensure the freedom and safety of navigation and overflight through the South China Sea. After building sufficient mutual trust, the parties should negotiate codes of conduct regarding unexpected sea or air encounters in the South China Sea area, as well as the establishment of hotlines and other security mechanisms.

In the mid-term, we will push for integrated planning. All parties concerned in the region, in accordance with the spirit and principles of relevant international law, should jointly establish cooperation mechanisms so as to engage in coordination and cooperation on important issues such as living resources conservation and management, non-living resources exploration and exploitation, marine environmental protection and scientific research, maritime crime prevention, humanitarian assistance and disaster relief.

In the long term, as part of overall integrated planning, we look forward to the establishment of a mechanism for zonal development. Through bilateral or multilateral cooperation, parties concerned could designate specific maritime areas for provisional cooperation and development, with a view to establishing a joint management and monitoring mechanism so as to engage in cooperation and development on an area-by-area, stage-by-stage basis. Thus, fair and reciprocal win-win results can be achieved.

II. Peaceful use of Taiping Island

In accordance with the policy of safeguarding sovereignty, shelving disputes, pursuing peace and reciprocity, and promoting joint development, the ROC has advocated the peaceful use of Taiping Island. In fact, in 2000, the Coast Guard Administration (CGA) took over defense of Taiping Island from the ROC Marine Corps. This concrete action served to demonstrate our clear opposition to the militarization of the South China Sea.

To create opportunities for cooperation between parties concerned in the region, the ROC government, taking Taiping Island as the starting point for implementation of the South China Sea Peace Initiative, is working to transform it into an island for peace and rescue operations, as well as an ecologically friendly and low-carbon island.

With regard to making it an ecologically friendly island, the Ministry of the Interior and the Council of Agriculture have jointly conducted a water quality and agricultural environment survey project, so as to gain a better understanding of the natural resources on Taiping Island and help maintain its ecological balance. In addition, the CGA is conducting a survey of indigenous vegetation, classifying the different types of trees on the island in order to implement preservation work. Meanwhile, back in 1978, a station was set up on Taiping Island to monitor the winter monsoon as part of a large-scale global project conducted by the World Meteorological Organization (WMO). We will continue to upgrade the scientific research equipment on Taiping Island to monitor earthquakes and marine and weather patterns, survey the ecology on the island, and observe the quality of its environment. We aim to establish the Nansha International Research Station and initiate transnational scientific research projects, so as to strengthen the peaceful use of the island and expand international cooperation on ecological research.

As for making Taiping Island a low-carbon island, the Ministry of Economic Affairs and the CGA are jointly working on a project concerning the provision and management of water and electricity on the island. The purpose of this project is to expand solar power systems on the island and raise their ratio of total electricity supply on the island to 40 percent.

Taiping Island will thereby serve as a model for saving energy and reducing carbon emissions.

And as for making Taiping Island an island for peace and rescue operations, on December 12, 2015, the Minister of the Interior, the Minister of the CGA, as well as other relevant government officials, presided over a ceremony marking the completion of the renovation of the island's wharf and the construction of a lighthouse. The wharf has a length of 318 meters and width of 20 meters, and can accommodate 3,000-ton ships. In conjunction with the lighthouse, it can effectively shorten supply times and ensure safety of navigation in the waters surrounding Taiping Island. This benefits humanitarian assistance and rescue operations, fishing operations, as well as maritime navigation in the area. Moreover, renovation of the island's airstrip was completed on November 25, 2015, allowing C-130 Hercules transport planes to take off from and land on the island. Meanwhile, the data obtained from marine and meteorological observation stations can be used to monitor natural disasters and contribute to relevant warning mechanisms. We will also strengthen the facilities of Nansha Hospital and medical equipment on the island, and coordinate with international medical organizations to establish an emergency rescue center that can serve as a relay station for relevant operations. This will enhance our humanitarian assistance capabilities and help implement the spirit of the South China Sea Peace Initiative, thereby making Taiping Island an island for peace and rescue operations.

Through these concrete actions, we aim to demonstrate to the international community that the Republic of China is committed to fulfilling its international obligations and actively serving as a peacemaker and provider of humanitarian aid, so as to truly transform the South China Sea into a sea of peace and cooperation.

At the same time, we very much hope that parties concerned can set up coordination and cooperation mechanisms in the South China Sea concerning nontraditional security issues such as environmental protection, marine research, the fight against maritime crime, humanitarian assistance, and disaster rescue operations.

On January 19 this year, I attended the International Symposium on Oceanic and Atmospheric Research in the South China Sea. At this event, many domestic and foreign scholars and experts held wide-ranging discussions on scientific research in the South China Sea and on Taiping Island. In fact, the attendees showed great interest in the current development of Taiping Island and the vision for its future. We do not exclude the possibility of holding international seminars on Taiping Island in the future. Even though the conference room on Taiping Island can only accommodate about 30 people, through videoconferencing we can link to cities in Taiwan and around the world, thus sharing the Republic of China's efforts on Taiping Island to promote the peaceful use of the South China Sea with the rest of the world.

III. Freshwater, agricultural products, and status in international law

Taiping Island, an inherent part of the territory of the Republic of China, is, at 0.51 square kilometers, the largest island in the Nanshas, and the only natural island with a supply of freshwater. In December 1946, following World War II, our government dispatched the *ROCS Taiping* to recover Taiping Island. While our forces were withdrawn from the island starting in June 1950 due to supply issues, they have been on the island now for nearly 60 unbroken years starting in June 1956.

The Philippines sought arbitration with the Permanent Court of Arbitration in 2013 concerning competing claims with mainland China vis-à-vis the South China Sea. This arbitration is of particular importance to our country, yet we have not been invited to participate, nor has our opinion on the matter been sought. The Philippines holds that Taiping Island has no freshwater, and no arable soil, claiming that food and water must all be imported and human habitation is impossible. This, the Philippines says, means that it is not an island, but a rock, to which no claim can be made on territorial waters beyond 12 nautical miles. However, such statements find no basis in either science or fact; they are totally wrong. The economic, environmental, and cultural realms all provide evidence sufficient to show that the island has—and has had for over 100 years—ample resources to be self-sufficient.

Geological study of the island shows that Taiping Island was formed perhaps 3 million years ago. Roughly 20,000 years ago, it rose upward to 100 meters above sea level. Perhaps this sheds light on why Taiping Island became the only island in the Nanshas to have its own sources of potable water.

Annual rainfall on Taiping Island is roughly 3,000 mm. Rainwater is either trapped by the soil or seeps down into the coral below. The coral layer further down, having been there for a million years, has been lithified and become impervious to water, meaning that the island has a rich supply of groundwater. Water from the best well, the No. 5 well, has been tested by experts and found to be close to that marketed internationally under the brand name Evian in terms of conductivity and total dissolved solids. It can be drunk directly, and tastes as good as mineral water sold in stores.

Historical documentary evidence attests to the presence of freshwater on the island. The earliest appearance of such documents is in 1879, with the Royal Navy's *The China Sea Directory*, in which it attests to the use of Taiping Island by Chinese fishermen and the presence of wells, of which it states, "The water found in the well on that island was better than elsewhere." In 1939, a survey report on Taiping Island by a technician working at Taichu Prefecture (today's Taichung City, Changhua County, and Nantou County) states that "the island has abundant potable water, sufficient for both fishing vessels and for use on the island itself." In 1946, a report written during a survey of the Nansha Islands by an ROC naval flotilla states that "there are several wells on the island, the water drawn from which is excellent." In 1994, the Council of Agriculture, in a report on the ecology of the South China Sea, states that the freshwater at two places on Taiping Island is of better quality than that found in most rivers or lakes. The Coast Guard Administration, meanwhile, last December released "Living Conditions on Taiping Island," which states that of the four wells on the island, the water of one is used to raise tilapia, while the other three can provide 65 tons of freshwater daily, and that on the average freshwater accounts for 92 percent of water drawn from these wells. Water drawn from Well No. 5, meanwhile, is 99 percent freshwater of good quality. History thus attests to the plenitude and quality of freshwater on Taiping Island, sufficient to support human life.

The soil of Taiping Island has also been examined by experts. Entisols of some 20 cm in thickness have been formed over 1,000 years of wind erosion. The aggregate is lush with organic material. Guano has mixed with this, making for fertile soil amenable to the growth of both indigenous plants and agricultural products.

Due to its favorable soil and water conditions, Taiping Island has an abundance of natural vegetation. Its primeval coastal forest area is fairly dense, effectively conserving water resources, preventing forest transpiration, and replenishing soil humus. Purple-stalk sword ferns flourish among the undergrowth. As these ferns grow only in a stable forest environment, they further show that Taiping Island has an excellent natural ecological environment.

Taiping Island has as many as 106 land-based indigenous plant species. These include several hundred large tropical trees, such as the lantern tree (Hernandia nymphaeifolia), Indian almond (Terminalia catappa), and fish poison tree (Barringtonia asiatica), which are between 20 and 30 meters tall, have girths greater than 100 centimeters, and are more than 100 years old. Other wild crops, such as coconut, papaya, and plantain, grow in abundance all year round. There are approximately 500 coconut trees, producing about 1,500 wonderfully flavored coconuts each year. Some 200 to 300 kilograms of high-quality papayas and plantains are harvested annually. Personnel stationed on the island have long utilized the natural environment and cultivated over a dozen tropical vegetables and fruits on the island farm, including bitter melon, loofah squash, sweet potato, bottle gourd, pumpkin, okra, corn, cabbage, sweet potato leaves, and chili pepper. In addition, chickens (180 in number), goats (12), and dogs (6) live on the island. The dogs act as guards during the night while the goats, chickens, and eggs are a source of food that meets the nutritional needs of people on the island.

The Nansha Hospital on Taiping Island has two physicians and a dentist, three nurses, 10 hospital beds, and videoconferencing equipment connecting to hospitals in Kaohsiung. There is also a post office and a Guanyin Temple on the island. Aside from groundwater wells that provide water for daily use, water can also be obtained through seawater desalination, reverse osmosis, and recycling. Electricity is provided through diesel generators and a solar power system that generates up to 170,000 KWH per year. Other facilities supporting daily life such as mobile telecommunications; postal services; satellite television; an airstrip, wharf, and lighthouse; navigation facilities; household registration; and administration services are also complete. All this evidence fully demonstrates that Taiping Island is able to sustain human habitation and an economic life of its own. Taiping Island is categorically not a rock, but an island, and meets the criteria for an island as specified in Article 121 of UNCLOS. Therefore, in addition to territorial waters, we are also entitled to claim an exclusive economic zone and continental shelf. Moreover, that the island has been garrisoned and managed by the ROC over a long period is further proof of the ROC exercising its sovereignty over Taiping Island and the surrounding areas. That some in the international community doubt this may be due to the fact that they have never set foot on Taiping Island. We welcome these people to Taiping Island to see the truth for themselves.

IV. Conclusion

Lastly, I would like to wish everyone the best of health and happiness. May there be peace in the South China Sea, and may our national territory remain forever assured. Thank you!

Annex 877

Ministry of Foreign Affairs of the Republic of China (Taiwan), "Taiping Island Survey", YouTube Video (28 Jan. 2016), *available at* https://www.youtube.com/watch?v=Ne8gmN-496o&feature=youtu.be (accessed 8 Mar. 2016)

Annex 877 appears to be a video of a cite visit and survey on Taiping Island. The video was accessed and downloaded from the Ministry of Foreign Affairs of the Republic of China (Taiwan)’s YouTube channel at the following address on 8 Mar. 2016: https://www.youtube.com/watch?v=Ne8gmN-496o&feature=youtu.be.

The video is available as Annex 877 as an mp4 file.

Annex 878

Dr. Ryan T. Bailey, *Groundwater Resources Analysis of Itu Aba* (9 Mar. 2016)

Groundwater Resources Analysis of Itu Aba

By Dr. Ryan T. Bailey
Department of Civil & Environmental Engineering
Colorado State University
9 March 2016

1. My Background

My principal field of research is in groundwater hydrology, using both field methods and modeling methods to estimate both the quantity and quality of available groundwater resources. I have worked on aquifers located in the western United States, southeastern United States, Wales, Pakistan, and Pacific and Indian oceanic nations. For the latter, I have worked with groundwater supply for islands located in the Federated States of Micronesia, the Republic of Maldives, and the Republic of the Marshall Islands.

I have been involved with atoll island water resources and groundwater hydrology since 2006. I have taken several field trips to atolls in the Federated States of Micronesia (specifically, Ulithi Atoll in Yap State and Pingelap Atoll in Pohnpei State), collecting data from groundwater wells and observing geologic features that are a part of our modeling efforts. I have conducted annual training sessions and workshops on atoll island hydrology for government, environmental, and educational leaders in Micronesia since 2008. In 2012 I was contracted by the World Bank to perform a groundwater assessment for the atoll islands of the Maldives. This involved estimating groundwater supply under current climate conditions as well as future climate conditions. I have also developed a model for estimating the groundwater resources of atoll islands that, as discussed below, has proved to be very accurate when tested against field measurements.

A list of my publications, technical reports, funding, and workshops, many of which focus on atoll island groundwater hydrology, are contained in my CV which is attached as Appendix A.

2. Hydrology of Atoll Islands

Atolls are generally composed of a circular chain of reefs and small coral islands enclosing or nearly enclosing a shallow lagoon. **Figure 1** shows a plan view of Sapuahfik Atoll, located in Micronesia's Pohnpei State, which is representative of the general features of atolls. Several small coral islands, termed "atoll islands", surround the lagoon. Smaller islands typically form on the windward portion of the atoll, whereas larger islands typically form on the leeward portion of the atoll. Windward islands generally are made of coarser sediment due to the impact of high-energy waves, whereas leeward islands are somewhat protected from the wave action and are composed of finer sand.

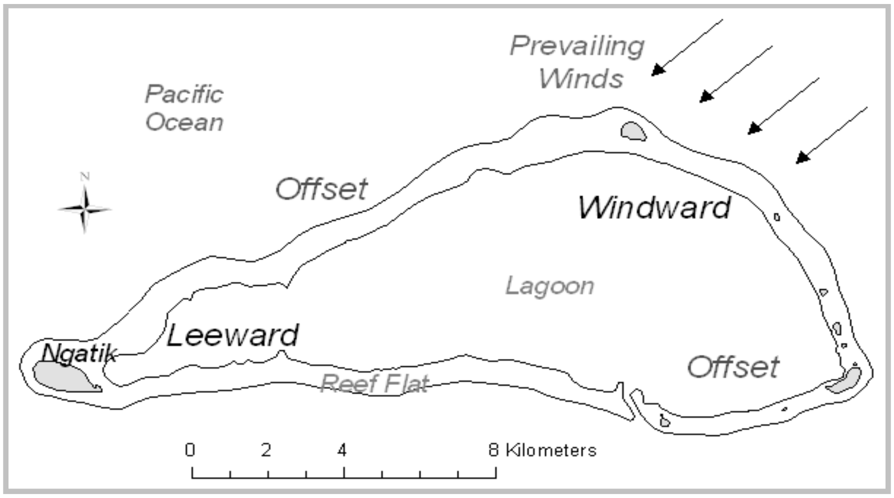


Figure 1. *Sapuahfik Atoll, Pohnpei State, Federated States of Micronesia*

Any groundwater on oceanic islands resides in a body of freshwater termed the freshwater “lens”, residing in the permeable sediments of the island subsurface and floating atop the underlying, denser seawater. A diagram showing a freshwater lens in a cross-section of an island is shown in **Figure 2**.

Rainwater that is not intercepted by vegetation, evaporated, transpired by plants, or captured by household rooftop catchment systems percolates through the soil until it reaches the water table. The water table has a height H above sea level, which due to differences in fluid density between freshwater and the underlying seawater can generate a layer of freshwater below sea level. The groundwater is continually moving from the center of the island to the perimeter of the island, where the groundwater is discharged to the ocean.

For atoll islands, which generally have elevations of several meters (m) maximum, the water table and any freshwater lens are accessible by shallow wells. Atolls island hydrogeology differs from that of the majority of oceanic islands in that they possess a dual aquifer system, in which a surficial particulate aquifer of Holocene age (approx. 11,700 BP to present) lies atop a highly-permeable, limestone aquifer of Pleistocene age (approx. 2.6 million BP to 11,700 BP). This feature is shown in **Figure 3**, which provides a more realistic representation of land surface topography and subsurface geology for atoll islands. The contact between the upper and lower aquifers is a solution discontinuity approximately 15-25 m below current sea level (Wheatcraft and Buddemeier 1981; Vacher, 1997). It is a prevalent feature of atolls across the Indian and Pacific Oceans, and is a remnant of ancient sea-level positions (Dickinson, 2004).

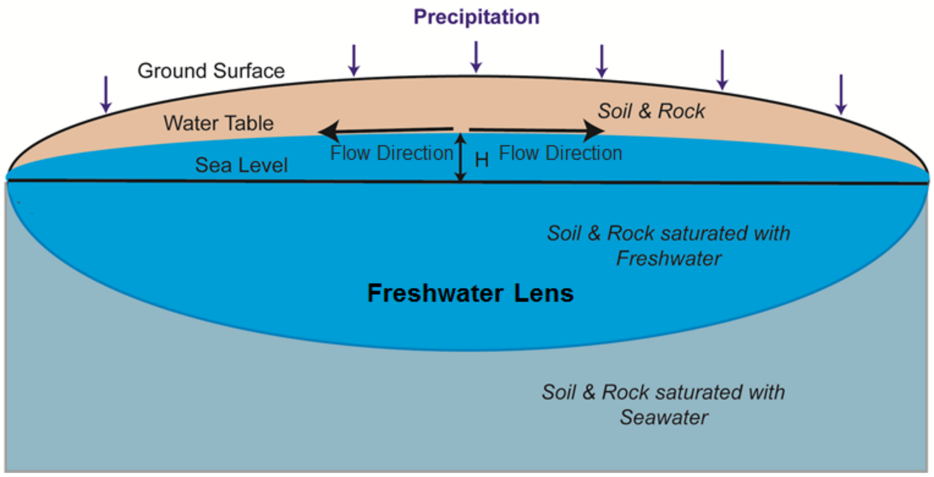


Figure 2. *Simplified representation of an island vertical cross-section, showing the ground surface, water table, and freshwater lens*

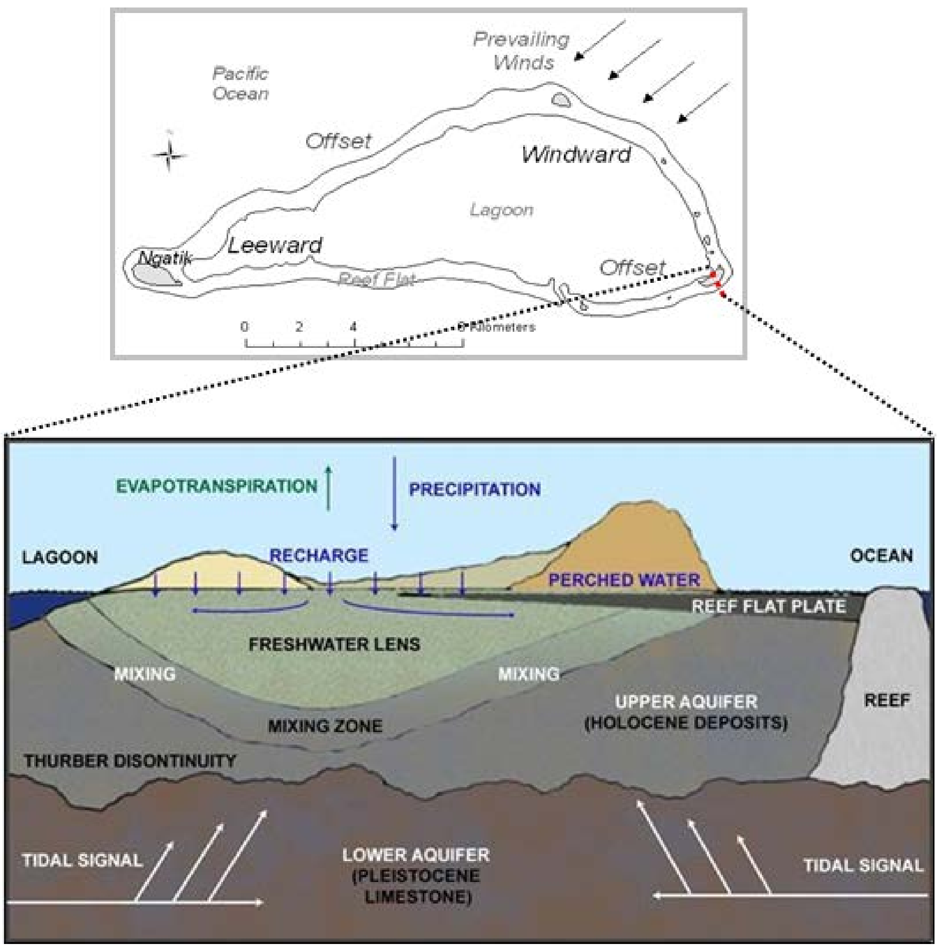


Figure 3. *Conceptual model of atoll island hydrogeology, as depicted in Bailey et al. (2010)*

For atoll islands, the position of the island on the atoll reef affects the development and thickness of the freshwater lens. Windward islands, which bear the high-energy impact of the prevailing wind and waves, are composed of coarser sediments than the more protected, leeward islands (Anthony, 1997; Spennemann, 2006). These coarser sediments allow groundwater to move more quickly through the aquifer as compared to leeward islands, and as a result the freshwater lens is thinner for windward islands.

This is shown in **Figure 4** for atoll islands throughout the Pacific and Indian Oceans for which lens thickness has been measured in the field. Atolls represented in the figure are from Micronesia, the Marshall Islands, the Cocos (Keeling) Islands in the Indian Ocean, Diego Garcia Atoll in the Central Indian Ocean, and Kiribati.

Figure 5 shows the same data, except with lens thickness plotted against island width, demonstrating that in general windward islands are smaller than islands on the leeward side of the atoll.

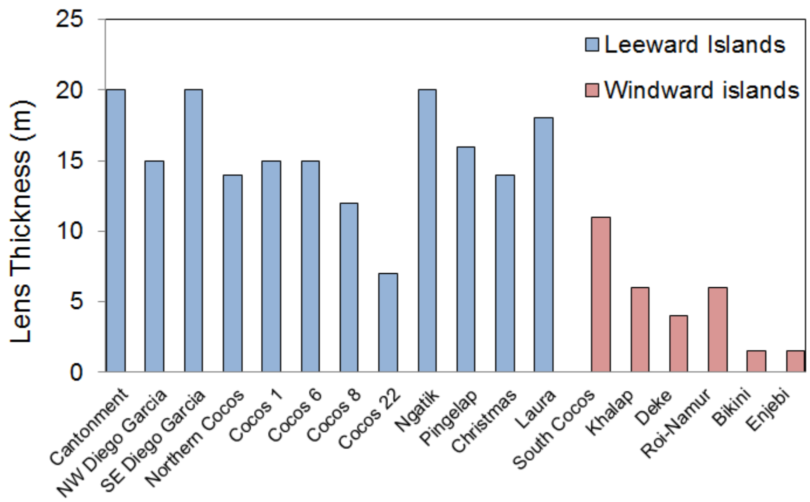


Figure 4. *Measured thickness of the freshwater lens under the center of the island for islands in the Indian and Pacific Ocean*

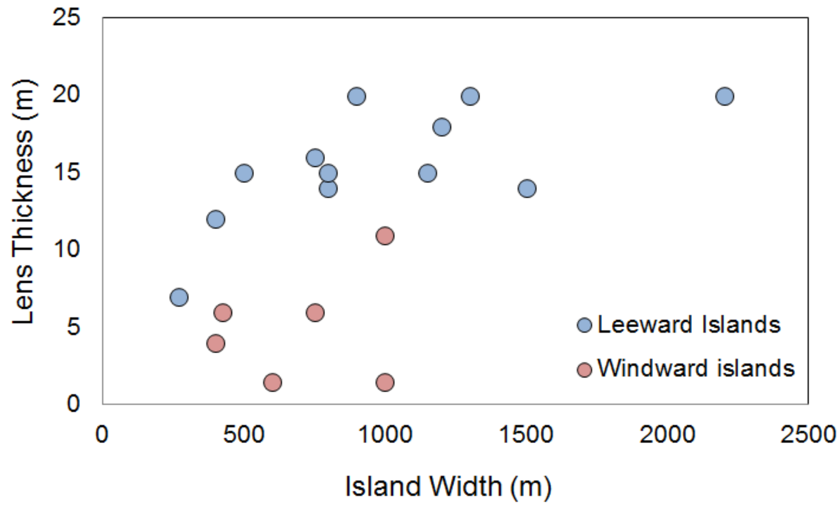


Figure 5. *Same data as shown in Figure 4, as a function of the width of each island*

The thickness and general shape of the freshwater lens on coral islands is controlled by the following environmental factors (Bailey et al., 2009):

- **The amount of infiltrating rainfall that reaches the water table.** This is referred to as "recharge". Typically the amount of recharge is between 30% and 50% of rainfall. For islands residing in areas with a distinct dry season, values usually range between 30% and 40% (Falkland, 2000; Bailey et al., 2009). For example, the percent of rainfall that becomes recharge for Maradhoo and Feydhoo islands in the Maldives is estimated to be 40% (Falkland, 2000). The percentage of rainfall that becomes recharge also is strongly dependent on the average annual rainfall. If low rainfall rates occur infrequently, thus leading to a low annual depth of rainfall, then the vast majority of the rainfall is used by vegetation or is evaporated from the tree canopy or ground surface. If, on the other hand, rainfall falls in frequent storms, then much of the rainfall can recharge any freshwater lens. This relationship is documented in Falkland and Brunel (1993). For example, for islands with 1,000 mm of annual rainfall, the annual recharge is approximately 200 mm (20% of rainfall), whereas for islands with 2,000 mm of annual rainfall, the annual recharge is approximately 700 mm (35%). Furthermore, for islands with heavy infrastructure, e.g. buildings, airstrips, other concrete structures, recharge can be less due to rainfall running off the structures and directly into the ocean.

- **Width and surface area of the island**. The thickness and volume of freshwater lenses are greater for larger islands.

- **Drought**. For many small coral islands, periods of low rainfall rates can completely deplete any freshwater lens. The groundwater is constantly flowing from the center of the island outward to the perimeter of the island and discharged to the ocean. During periods of little to no rainfall, and hence periods of no recharge, the freshwater lens thins and can become completely exhausted. For example, of the 105 atoll islands studied in Micronesia (Bailey et al., 2013), only six islands had available groundwater after the 1998 El Niño drought. No windward islands had any remaining groundwater. As discussed below, complete lens depletion for small windward islands can occur in as little as 2-3 months with little or no rainfall.

- **The hydraulic conductivity of the upper aquifer**. The hydraulic conductivity is a measure of the ease with which groundwater moves in the aquifer. Islands with coarse sediments in the aquifer, and hence a high hydraulic conductivity, have a much thinner lens than islands with fine sand sediment. Windward islands generally have a high hydraulic conductivity, and hence have thinner lenses.

Atoll island communities are extremely vulnerable to water scarcity due to their small surface areas, low-lying topographies, and geographic isolation (White and Falkland, 2010). When droughts exhaust rain catchment storage, groundwater provides the only natural source of freshwater although it, too, may become exhausted if the drought is severe and long-lasting. Moreover, groundwater reserves on atoll islands are vulnerable to other natural hazards, including physical erosion of the island (van der Velde et al., 2006) and salinization of the fresh groundwater (freshwater lens) from marine overwash events (Spennemann 2006; Terry and Falkland 2010), such as typhoons and other large storms. As stated by numerous agencies and researchers during the previous decades, atoll islands and their coral reefs have also consistently been identified as the natural systems most at risk from climate change (IPCC, 1996; Nurse et al., 1998; IPCC, 2001; Barnett & Adger, 2003; USGCRP, 2009).

Besides the controls on freshwater lens thickness and volume as outlined above, groundwater supply of atoll islands is under continual threat by over-use by island residents and by contamination. The low elevation of coral islands means that the water table is within close proximity (generally 2-2.5 m) of the ground surface, and fertilizers, pesticides, gasoline, and other chemicals and contaminants can easily leach through the high-permeable soil and into the freshwater lens. Over-pumping of groundwater, particularly during droughts periods when rainwater catchment storage is exhausted and no recharge occurs, can cause rapid salinization of the aquifer and destroy the freshwater lens.

3. Groundwater Resources of Itu Aba

This section presents modeling results for available groundwater resources of Itu Aba. The thickness of the possible fresh water lens is estimated using a tested model (Bailey et al., 2010). Section 3.1 will describe the freshwater lens model and how it has been tested in various atoll island nations and has proved robust. Section 3.2 will address the modeling results in regards to Itu Aba.

3.1 Calculating Freshwater Lens Thickness

The freshwater lens model was developed by Bailey et al. (2010) for assessment of the freshwater lens thickness of atoll islands as a function of (1) average annual rainfall rate (m/yr), (2) hydraulic conductivity of the upper aquifer (m/day), (3) width of the island (m), and (4) the depth to the contact between the upper and lower aquifer units. This contact is shown in Figure 3 (above). The influence of each of these factors on lens thickness under the center of the island is captured by the following equation (model), as presented in Bailey et al. (2010):

$$F = L(1 - e^{-bR})SC \qquad \text{(Equation 1)}$$

where F is the thickness of the lens under the center of the island (and hence the maximum thickness of the lens for the island), R is the average annual rainfall rate, L is the limiting lens thickness based on island width and the depth to the contact, b is a fitting parameter dependent on island width, and S is the hydraulic conductivity factor.

The freshwater lens model (termed the "algebraic model" in the literature) has been tested for atolls in Micronesia (Bailey et al., 2013), the Republic of Maldives (Bailey et al., 2014), and the Republic of Marshall Islands (RMI) (Barkey, 2015), with excellent results. For example, **Figure 6** shows the measured lens thickness (from field data collection) and modeled lens thickness for islands in Micronesia:

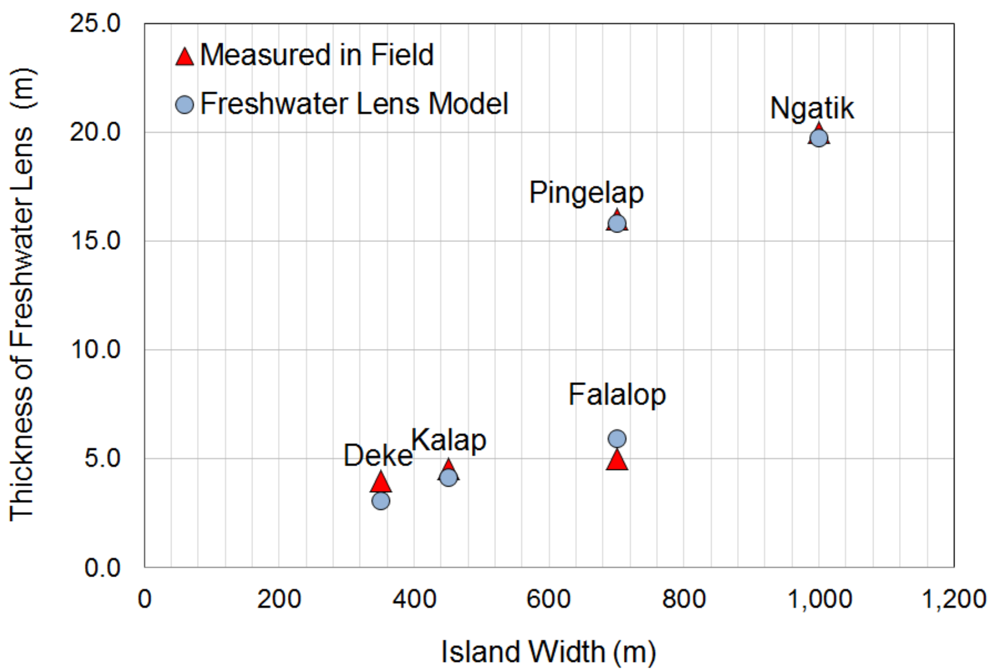


Figure 6. *Measured lens thickness and modeled lens thickness using the freshwater lens model for five islands in the Federated States of Micronesia. Data originally published in Bailey et al. (2013)*

3.2 Modeling Results for Itu Aba

The thickness of any freshwater lens under the center of Itu Aba was estimated using the freshwater lens model (Equation 1). As a small island exposed on all sides to oceanic waves, the hydraulic conductivity assigned to the aquifer on Itu Aba is 400 m/day, similar to windward islands in other oceanic regions (Bailey et al., 2009). As varying annual rainfall rates are reported in the literature (Huang et al., 1994), the model is applied to each rainfall rate to provide a range of expected lens thickness, depending on the type of climatic year (wet, average, dry). The lens thickness is analyzed for the cross-section shown in **Figure 7**, which is the maximum width (370 m) of the island.

Figure 7. *Cross-section (in yellow) for which the thickness of the freshwater lens was estimated for Itu Aba. The cross section is approximately 370 m*

Results of applying the model are presented in **Table 1**. The table shows annual rainfall rate (m/yr), estimated recharge rate (m/yr) based on the relationships presented in Falkland and Brunel (1993), and the estimated lens thickness (m) under the center of Itu Aba. The three rainfall rates (0.67 m/yr, 1.5 m/yr, 2.14 m/yr) are reported by the study of Huang et al. (1994) for the island, which represented the lowest, average and highest reported rainfall, respectively, over a period of five years.

In general, the freshwater lens is estimated to be very thin, ranging from only 0.35 m during the driest of the five years (0.67 m of total rainfall) reported by Huang et al., to about 1.6 m for the wettest of the five years reported (2.14 m of annual rainfall). It is important to note that these figures represent estimates of the *average* thickness of the freshwater lens over the course of the year, based on the total annual rainfall. The actual thickness will vary during the course of the year with periods of greater or lesser rain. These features also represent the potential thickness beneath the center of Itu Aba. Thickness would decrease quickly as one moves towards the perimeter of the island.

Table 1. *Estimated thickness of the freshwater lens under the center of the island, for varying rates of annual rainfall reported in the literature*

Annual Rainfall (m/yr)	**Annual Recharge** (m/yr)	**Maximum Lens Thickness** *m*
0.67[b]	0.15	0.35
1.5[b]	0.38	0.8
1.8[a]	0.55	1.1
2.14[b]	0.85	1.6
2.2[a]	0.85	1.6

[a] Xi (1947)

[b] Huang et al. (1994)

These values are typical of small windward islands (Bailey et al., 2013; see also Figure 5). Even if the hydraulic conductivity were lowered to 200 m/day, a figure which corresponds to an island in-between the windward and leeward sides of an atoll, the estimated average lens thickness beneath the center of the island is still only 1.3 m for the average annual rainfall rate of 1.5 m/yr.

Such a thin lens equates to an almost non-existent freshwater lens, as periods of little or no rainfall can result in rapid depletion of the lens as fresh groundwater, not replenished by recharge, discharges to the ocean. From modeling studies in Micronesia (Bailey et al., 2009; Bailey et al., 2013), complete lens depletion for small windward islands can occur in as little as 2-3 months with little or no rainfall. This is significant because sources agree that Itu Aba experiences distinct dry and wet seasons (Xi, 1947; Huang et al., 1994.) During the driest of the five years reported (0.67 m of total rainfall) it is reasonable to conclude to a high degree of certainty that Itu Aba experienced periods during which any freshwater lens was completely depleted.

Moreover, Huang et al. report only five years of data. Given that Itu Aba is subject to periodic El Niño, La Niña cycles during which even drier years are likely, it is also reasonable to conclude to a high degree of certainty that Itu Aba experiences more prolonged periods during which any freshwater lens would be expected to disappear entirely. By way of example, during the 1998 drought in eastern Micronesia (which has an average annual rainfall of 4.5 m, three times that of Itu Aba), the atoll island communities had to bring in water by ship from the large volcanic islands to meet their needs.

These effects would be exacerbated by the fact that Itu Aba has a large airstrip, covering approximately 10% of its surface area, running across its entire length. A significant amount of the rainfall that might otherwise recharge the groundwater will run off directly into the ocean.

This demonstrates why skimming wells, which require great skill and care to operate effectively, are used on the island. If wells are drilled or dug below 1.0 to 1.5 m below sea level, the bottom will fill with seawater and render the water non-potable. Furthermore, due to the thin nature of any lens on Itu Aba, localized pumping would rapidly cause “upconing”, in which underlying seawater is brought to the surface of the aquifer, salinizing surrounding freshwater. This also demonstrates why Taiwan has desalination facilities and also employs reverse osmosis and recycling.

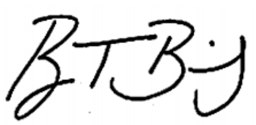
Overall, modeling results are consistent with reported and measured data for the groundwater of Itu Aba. In a recent trip to Itu Aba, scientists from Taiwan measured a total dissolved solids (TDS) concentration of 418 mg/L in one of the shallow wells. This concentration corresponds to a salt content of about 1.2% of that contained in seawater, which has an average TDS of 35,700 mg/L. Water with a salt concentration of approximately 900 mg/L, or 2.5% of the salt contained in seawater, typically is the maximum limit to receive he designation of “fresh”. The water at the top of the freshwater lens, therefore, is already approaching the limit of potable water in terms of salt concentration.

All data suggest that any freshwater lens on Itu Aba is, at best, a fragile source of freshwater that, if disturbed or affected by periods of low rainfall, would become completely exhausted. During such periods of exhaustion, Itu Aba would have no freshwater resources.

4. Conclusions

Like many small coral islands, any freshwater lens beneath Itu Aba is extremely thin under normal rainfall conditions. For an average rainfall rate of 1.5 m/yr, the maximum thickness of the lens beneath the center of the island likely is between 0.8 and 1.3 m, depending on the hydraulic conductivity of the aquifer. This equates to virtually non-existent freshwater, as periods of little or no rainfall will result in rapid depletion of the lens as fresh groundwater discharges to the ocean.

Moreover, the close proximity (< 2 to 2.5 m) of the water table to the ground surface poses a continual threat of contamination in the form of gasoline, fertilizer, pesticides, and other contaminants leaching to the water table and causing groundwater contamination.



Ryan T. Bailey, March 9 2016

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Annex 879

Dr. Peter P. Motavalli, *Expert Report on Soil Resources and Potential Self-Sustaining Agricultural Production on Itu Aba* (9 Mar. 2016)

Expert Report on Soil Resources and Potential Self-Sustaining Agricultural Production on Itu Aba

Dr. Peter P. Motavalli, Ph.D.

9 March 2016

I. Introduction

My name is Dr. Peter P. Motavalli and I have been a Professor in Soil Nutrient Management at the University of Missouri in Columbia, Missouri (U.S.A.) since 1999.[1] From 1994 to 1999, I taught and conducted research on soil nutrient management of Pacific Island soils, especially in the region of Micronesia, at the University of Guam.

I received my M.S. degree in Soil Fertility and Plant Nutrition from the University of Wisconsin (USA) and my Ph.D. in Soil Fertility and Plant Nutrition from Cornell University (USA). I have extensive experience over the past 27 years working with, and conducting research on, soil nutrient management in both temperate and tropical regions. Examples of relevant peer-reviewed research articles of which I have been an author include Fernandes et al. (1997), Motavalli and McConnell (1998) and Motavalli et al. (2000). My CV is attached in an appendix and includes a listing of my more recently published peer-reviewed scientific articles.

II. Soil Resources on Coral Islands/Atolls in the South Pacific

Pacific islands can be generally categorized into four main types: 1) volcanic islands (e.g., Hawaiian Islands), 2) low limestone islands (e.g., Marshall Islands), 3) raised limestone islands (e.g., Nauru), and 4) continental islands (e.g., New Caledonia) (Lobban and Schefter, 1997). This report will focus on the soil characteristics of low limestone islands, with a particular focus on one such feature: Itu Aba in the Spratly Islands.

The Spratly Islands consist of reefs, cays and islets in the South China Sea and cover an area of approximately 360,000 square kilometers. The geology of these features has not been

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[1] The content of this report does not reflect the official opinion or views of the University of Missouri. Responsibility for the information and views expressed in the report lies entirely with the author.

well-explored but most research indicates that underlying older rock when detectable has been overlain by a thick buildup of carbonates from marine activity (Hutchison and Vijayan, 2010).

Itu Aba (area of approximately 46 hectares) is of the low limestone type surrounded by reefs. It has an elevation of less than 5 meters above sea level. The climate on Itu Aba Island is tropical with a mean annual temperature of 26°C and a reported average annual precipitation of 1500 mm and strong southwest monsoon in summer months. Typhoons are most frequent between July and September.

Based on a botanical inventory conducted in 1994 (see Huang et al., 1994) the vegetation of Itu Aba includes coastal forest, shrubs and grassland areas with one-third of the island being badly disturbed due to human activity.

In general, soil formation in islands (pedogenesis) is affected by a number of factors, including: *parent material* (i.e., the original material such as rocks from which the soils form), *climate*, *biota* (i.e., the actions of living organisms including animals and human beings), *topography*, and *time*. The physical and chemical processes that break down parent material to form soil usually occur over a long period of time (over 1,000 years). This process is also affected by whether the soil develops from underlying parent material or from parent material which has been transported to the site.

In the case of many low limestone islands such as Itu Aba, continual deposition and removal of sand and other marine sediments due to wave and tidal action and strong winds and rain events reduces the rate of soil pedogenesis and soil profile development (i.e., the development of multiple soil layers or horizons that have different soil properties). Most of the soils present on such islands are, therefore, relatively young and contain few soil horizons.

The soils of low limestone islands are calcareous in nature (i.e., they contain calcium carbonate) and are alkaline (high pH).These chemical properties reflect the influence of the coralline limestone and marine parent materials from which the soils originated. The presence of a relatively high proportion of sand and coarse fragments (i.e. stones) is also common.

Vegetation and animal activity, such as guano deposits from sea birds, also have affected soil formation in most Pacific Islands (if vegetation is present and significant nesting has occurred). Guano can also be weathered over time with organic matter being decomposed and salts leached out. This process leads to the formation of guano-derived phosphate deposits which have been a significant economic resource historically for some Pacific Islands when mined and exported for agricultural uses. This weathered guano can be present in the soil of some of the islands and affects soil chemical properties.

III. An Assessment of the Soil Resources on Itu Aba Island

Precise information on the soil resources on Itu Aba Island is limited. This report therefore relies on the available sources, including scientific articles by Xi (1947) and Huang et al. (1994), as well as press release, video, and stills therefrom captured from information regarding Itu Aba Island recently produced by Taiwan.[2]

An in-depth inventory of the soil resources on Itu Aba Island would be required for a more thorough assessment of the suitability of the soil for sustainable agricultural production. This would include a detailed soil survey and physical, chemical and biological analysis of soil

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[2] These items are available at http://www.mofa.gov.tw/en/News_Content.aspx?n=1EADDCFD4C6EC567&s=542A8C89D51D8739, https://www.youtube.com/watch?v=AJjRHGBBniY, and http://english.president.gov.tw/Default.aspx?tabid=491&itemid=36616&rmid=2355, respectively.

properties, especially soil properties that are important to assess soil fertility for plant growth to produce food. Nevertheless, some descriptions and chemical properties of the soils on Itu Aba Island are provided in Xi (1947), which generally indicates that the soils are dominated by sand with some soils containing a layer of highly weathered guano that has combined with limestone to form guano-derived phosphate minerals.

Xi (1947) described three predominant soil series on Itu Aba Island, which he also mapped. The soil series he described were: 1) the "Spratly Series", 2) the "Itu Abo Series", and 3) the "Taiping Island" Series. The Spratly Series was primarily located on the coastal margins of the island near the beach. It was dominated by coarse sand mixed with coral and seashell fragments. The soil horizons described were alkaline (pH between 7.5 to 8.0) and showed indications of the presence of free calcium carbonate. This soil did not contain a guano layer. This region had sparse weeds and juvenile Barbados nut trees growing on it.

The Itu Aba Series was distributed in long strips on the inner side of the coastal banks and was dominated by medium fine to coarse sand with pH of 8.0 and indication of the presence of calcium carbonate. It also had a soil horizon with brown clumps of guano mixed with sand. Predominant vegetation growing on this soil series were morning glories and Barbados nut trees.

The Taiping Island Series was distributed more in the interior of the island and was also dominated by sand with pH between 7.5 to 8.0 and shows the presence of weathered fragments of guano and organic matter in the surface. It should be noted that the weathering of the guano reduces the fertilizer value of the guano due to the leaching of ammonia nitrogen from the material and the slowly soluble nature of the phosphorus in the material. As described by Xi

(1947), the vegetation growing in this soil were morning glories, castor oil plants and some planted coconut and banana trees.

Xi (1947) also described a relatively large proportion of the area in the interior of the island covered by solid and large pieces of rock phosphates.

The soils that Xi (1947) described would probably be classified in the Entisols soil order and possibly the Tropopsamments great group in U.S. Soil Taxonomy since they show limited soil development and are dominated by sand. Further information would need to be collected for a more definitive classification since factors such as soil color are important indicators and this information was not available for this report in any quantified way (i.e., the hue, value and chroma using the Munsell color charts).

Two of the soil series that Xi (1947) described appear to correspond to the soils described in the recently released video from a January 2016 field trip to Itu Aba by Taiwanese scientists. What Xi calls the "Spratly Series" may correspond to the "coconut tree area" described in the video; his "Itu Aba Series" may correspond to the "coastal forest area" in the video.

A third type of soil captioned in the video as the "Vegetable Cultivation Area" could possibly correspond to the soil named by Xi (1947) as the "Taiping Island Series". It bears noting, however, that this soil appears different than the soil located in the shade cloth covered site toured for staple food production. Based solely on surface features shown in the video, there are some indications that this shade cloth covered site was land-formed and may contain introduced soil materials and amendments placed in small beds. These indications include the rock surrounding the site and the different appearance of the surface soil with what may have been a soil amendment on the soil surface as compared to the appearance of the soil profile of the

“Vegetable Cultivation Area”. It is possible that the shade cloth site and the “Vegetable Cultivation Area” may be two different areas of vegetable cultivation. Further confirmation of this situation would require visiting the site.

IV. Opinion on Possibilities for Self-Sustaining Agricultural Production on Itu Aba

Low limestone islands such as Itu Aba with the climate, soil characteristics and soil distribution identified in this report present multiple constraints for self-sustaining agricultural production.

First, the dominance of sand in the soil profile reduces the capacity of the soil to retain plant-available water in the soil profile. Lack of plant-available water may cause water stress in-between rainfall events requiring use of irrigation to overcome moisture deficits. The dominance of sand in the soil profile also reduces the capacity of the soil to retain plant nutrients in the soil profile. Nutrient retention in soils occurs when there is sufficient cation exchange capacity (i.e., charge on the soil surface that causes some nutrient ions to be held in the soil) due to the presence of clay and organic materials in the soil. Without sufficient organic matter or clay, application of fertilizer or organic soil amendments would be necessary. The rapid infiltration of water and the permeability of sandy soils may also promote nitrate leaching loss out of the rooting zone thereby requiring frequent applications of nitrogen fertilizer which is required in the largest amounts in most crop plants. Low organic matter soils dominated by sand, like those found on Itu Aba, also have limited nutrient reserves and soil biological activity. This low biological activity reduces the rate of essential soil processes required for plant growth because soil microbes are responsible for many important nutrient transformations (e.g., conversion of plant-unavailable organic forms of nutrients into plant-available inorganic forms).

Second, the high pH, calcareous nature of the soils also poses a challenge for plant nutrition. Morrison (1990) indicated that the high pH nature of low atoll soils causes severe micronutrient deficiencies, including copper, iron, manganese, and zinc. Therefore, external applications of these nutrients are required. Morrison (1990) also stated that most of these soils are very low in potassium often resulting in severe potassium deficiency. In addition, despite the presence of phosphorus from guano, the calcareous, high pH properties of these soils causes phosphorus to be precipitated as calcium phosphate, making it less available for plant uptake. Nitrogen loss from ammonia volatilization is also greater in high pH soils especially if ammonium and urea fertilizer are applied without being incorporated into the soil.

Third, high winds may result in physical damage to plants and salt damage from sea spray. This is particularly true during severe storm events, which can also lead to coastal inundation and thus increase soil salinity shortly after inundation. Intense rainfall events common on many Pacific Islands can also cause physical plant injury of cultivated plants.

Fourth, intensive cultivation of a small area for agricultural production can result in soil degradation due to destruction of soil structure, reduction of soil organic matter and soil nutrients, and possible short-term soil salinity problems if irrigation water quality is low. In the case of most intensive cultivation, which would be required to produce meaningful quantities of food on Itu Aba, frequent tillage and heavy use of soil amendments, such as fertilizer, would be required to produce multiple crops. A readily available source of fresh water for supplemental irrigation would also be necessary.

The United Nations Food and Agriculture Organization (FAO) indicated that in 2006 the average area of cultivated land worldwide needed to feed one person was 0.22 hectares (FAO, 2011). The land area used to calculate this average includes soils which have a much higher native fertility level than soil resources available on Itu Aba. Furthermore, there are indications that environmentally damaging activities such as land clearing and construction for port and runway expansion are threatening these fragile ecosystems and reducing the already very limited area available for agriculture.[3] Since, at best, only a small proportion of the land area on Itu Aba is suitable for potential agricultural production, and even then only with use of extensive external inputs, this greatly constrains the potential capacity of the island to support any number of people without importing food and agricultural inputs.

Imported food would also be necessary to ensure food security when crop failure periodically occurs due to extreme climatic events or high incidence of crops pests and disease, which are often a problem for agricultural production in humid tropical Pacific Islands. Xi (1947) points to this problem when he says of the vegetables being grown that "there is pest damage." Climate change and sea level rise may also threaten this island's soil resources due to the relatively low elevation of the island and the destruction of the coral reefs due to construction activities.

V. Conclusions

- Based on the available evidence, this report concludes that soil resources on Itu Aba are typical of low limestone islands in the Pacific. They are generally characterized by sand and coral and seashell fragments. In some areas there are also clumps of guano-derived

[3] This is true for both Itu Aba (see Xi (1947) and a recent *Deutsche Welle* article for Itu Aba, available at http://www.dw.com/en/beijings-south-china-sea-projects-highly-disruptive-to-local-ecosystems/a-18387012) and more generally for the ecoregion of the South China Sea (see a recent report by the World Wildlife Fund, available at http://www.worldwildlife.org/ecoregions/im0148).

phosphate minerals. The soils have had limited soil development, are calcareous and exhibit a relatively high soil pH.

- Consistent with other low limestone islands in the Pacific, there appear to be several constraints for self-sustaining agricultural production on Itu Aba, including:

  ✓ The dominance of sand in the soil reduces water and nutrient retention, promotes nutrient leaching and decreases soil biological activity. To overcome these limitations, frequent application of nutrient sources such as fertilizers and organic soil amendments as well as the use of supplementary irrigation would be necessary to maintain long-term agricultural production.

  ✓ The high pH and calcareous nature of the soils poses a challenge for plant nutrition, including the availability of several micronutrients which are typically naturally deficient on Pacific Islands. These include copper, iron, manganese and zinc. This high pH soil condition also would limit phosphorus availability and increase risk of nitrogen loss. Overcoming these limitations would require extensive use of external inputs and intensive management.

  ✓ High winds and intensive rainfall events are seasonally common for the region and may result in physical damage to plants and salt damage from sea spray and coastal inundation may constrain agricultural production on this relatively small island.

  ✓ Intensive cultivation of the limited soil resources generally promotes soil degradation due to destruction of soil structure, reduction of soil organic matter and soil nutrients, and possible short-term soil salinity problems if irrigation water quality is low. Frequent tillage and heavy use of fertilizers would be required to produce multiple crops since native soil fertility levels are generally low and would be rapidly drawn down.

- ✓ The land area suitable for agricultural production (with use of external inputs) is limited due to the small proportion of arable soil on the island and the overall small size of the island. This area may also be decreasing due to land clearing and construction activities on the island. In general, there is an insufficient land base to sustain agricultural production to feed a human community and to provide food security in case of a crop failure, which in this environment may occur periodically. Climate change and sea level rise coupled with coral reef destruction may also limit the available land area suitable for possible agricultural production in the future since the island has a relatively low elevation.

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9 March 2016
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APPENDIX

Curriculum Vitae of PETER P. MOTAVALLI

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Ph.D., 1989, Soil Fertility and Plant Nutrition	Cornell University, Ithaca, NY
M.S., 1984, Soil Fertility and Plant Nutrition	University of Wisconsin, Madison, WI
B.S., 1982, Agronomy	University of Wisconsin, Madison, WI
B.S.F.S., 1978, Foreign Service	Georgetown University, Washington, DC

RESEARCH, EXTENSION AND TEACHING EXPERIENCE:

University of Missouri, Columbia, MO (Mar., 1999 – present). Professor of Soil Nutrient Management in the Dept. of Soil, Environmental and Atmospheric Sci., School of Natural Resources.

University of Guam, Mangilao, GU (Aug., 1994 – Mar., 1999). Associate Professor of Soil Science in the Agricultural Experiment Station, College of Agriculture and Life Sciences.

Colorado State University, Ft. Collins, CO and North Carolina State University, Raleigh, NC (Feb., 1992 - Jul., 1994). Post-doctoral fellow at the Natural Resource Ecology Laboratory at Colorado State University and Department of Soil Science at North Carolina State University.

PROFESSIONAL ORGANIZATIONS:

Soil Science Society of America
American Society of Agronomy

SELECTED AWARDS AND FELLOWSHIPS SINCE 2004:

2004	Outstanding Teaching Award, CAFNR, Univ. of Missouri
2004	Chair of Environmental Quality Division (A-5), Amer. Soc. of Agronomy
2005 - 2008	Undergraduate Advisor Chair, Dept. of Soil, Environ. and Atmos. Sci., University of Missouri
2008 - 2014	Director of Graduate Studies, Dept. of Soil, Environ. and Atmos. Sci., University of Missouri.
2009	Maxine Christopher Shutz Award for Distinguished Teaching, University of Missouri
2009 - 2012	Associate Editor, Div. S-4/S-8, Soil Science Society of America Journal
2010	Inducted into the Teaching Academy, College of Agric., Food and Nat. Resources, University of Missouri
2013	Selected as a Faculty Member of Sigma Xi Honor Society
2013	Excellence in Teaching with Technology Award, University of Missouri
2015	Writing Intensive Teaching Excellence Award, University of Missouri

PATENT ISSUED:

P.P. Motavalli and K.A. Nelson. Variable Product Agrochemicals Application Management. U.S. Patent No. 8,594,897. Granted on 26 Nov. 2013; International patent filed 29 Sep. 2011. This precision agricultural management tool has been developed and has been granted a patent in the U.S.A. International patent protection is pending.

SELECTED PUBLICATIONS SINCE 2010:

Zurweller, B.A., **P.P. Motavalli**, K.A. Nelson, and C. Dudenhoeffer. 2015. Short-term soil nitrous oxide emissions as affected by enhanced efficiency nitrogen fertilizers and temporarily waterlogged conditions. J. of Agric. Sci. 7:1-14. Doi:10.5539/jas.v7n12p1.

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Annex 880

Kuan-Hsiung Wang, “The ROC’s Maritime Claims and Practices with Special Reference to the South China Sea”, *Ocean Development & International Law*, Vol. 41, No. 3 (2010)

Ocean Development & International Law, 41:237–252, 2010

ISSN: 0090-8320 print / 1521-0642 online
DOI: 10.1080/00908320.2010.499282

Routledge
Taylor & Francis Group

The ROC's Maritime Claims and Practices with Special Reference to the South China Sea

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The South China Sea is an area of disputes on sovereignty and resource jurisdiction claims. As one of the six claimants, the Republic of China (Taiwan) has played an important role not only because it is the originator of the U-shaped lines, but also it has continuously occupied the largest island, Tai-Ping-Dao, in the Spratlys. This article reviews the ROC's position on the issues through an exploration of its maritime claims to the territorial sea, continental shelf, and exclusive economic zone.

Keywords maritime claims, People's Republic of China (China), Republic of China (Taiwan), South China Sea, U-shaped lines

Introduction

The littoral States surrounding the South China Sea claim sovereignty over all or part of the islands, rocks, reefs, or sandbanks in the area. The two Chinese Governments, the Republic of China (ROC) and the People's Republic of China (PRC),[1] have similar, or even the same, positions toward the legal status of the geographical features in the South China Sea because they draw on the same historic evidence and practices. There are also the U-shaped lines declared by the ROC Government in 1947. Many scholars have studied the definition, explanation, and legal situation of the U-shaped lines.[2] This article will review from a legal and historic perspective the position or maritime claims of the original creator of the U-shaped lines (i.e., the ROC Government) and detail the offshore zones and claims of Taiwan.

The ROC's Maritime Claims

Territorial Sea Claim

In July 1912, the year immediately after the Ching Dynasty was overthrown by Sun Yat-Sen and the Republic of China, the first republic in Asia, was established, the Department of the

Received 24 March 2010; accepted 10 April 2010.
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Navy, taking sea power into consideration, sent a memo to the Ministry of Foreign Affairs (MOFA) and suggested that:

> Normally, the limits of territorial sea is up to three nautical miles. This is correspondent to the range of cannon-shot in the past. Lately, the more advanced the technology is, the longer the cannon-shot can reach. ... Consequently, in order to protect our rights, the width of our territorial sea should be extended to this range.[3]

But the ROC Government took no action.

In May 1924, about 100 Japanese fishing boats engaged in fishing along the coast of Shantung (山東) Province. They destroyed the nets and equipment of the nearby Chinese fishermen. The Chinese Government intended to enter into negotiations with the Japanese over the issue, but the Japanese claimed that their boats were fishing on the high seas and had not intruded into the Chinese territorial sea. The situation worsened during 1929–1931 and the coastal provinces frequently requested the central Government to establish the territorial sea scheme and settle on its breadth.[4]

At the Hague Conference on Codification of International Law of 1930, the ROC, with 19 other States, took the position that the breadth of the territorial sea should be 3 nautical miles, measured from the low-water mark along the coast and that, within such area, the coastal State enjoyed full sovereignty, subject to the right of innocent passage by foreign vessels.[5] The breadth of the territorial sea was probably the most controversial topic considered by the 1930 Hague Conference. General agreements on the law of the sea were reached at the conference such as the high seas being free for the use of all; a narrow belt, generally 3 nautical miles in width, of territorial sea subject to the sovereignty of the coastal State; and a contiguous zone recognized for the control of sanitary, defense, immigration, and smuggling problems.[6]

Taking into account national security, the livelihood of fishermen, and in accordance with its position in the Hague Conference, the ROC Government declared the breadth of its territorial sea to be 3 nautical miles.[7] In addition, it also declared there to be an additional zone of 12 nautical miles, measured from the territorial sea baselines, within which there existed jurisdiction with regard to the arrest of smuggling.

Along with the international expansion of maritime jurisdiction after the Truman Proclamations in 1945,[8] the ROC Government became aware of the development of the law of the sea and took under consideration a 12-nautical-mile territorial sea. The Chinese delegate to the UN International Law Commission,[9] Shu-Hsi Hsu (徐淑希), said that the 12-nautical-mile territorial sea would meet the demands of most States.[10]

Following the beginning of the Third United Nations Conference on the Law of the Sea (UNCLOS III) in 1973, the issues of the breadth of territorial sea, the establishment of the exclusive economic zone (EEZ), as well as the definition on continental shelf were core areas of discussion. The ROC Government was anxious about the development of the international law of the sea and the possible impact on its fishing industry, especially distant water fisheries. Accordingly, on 9 December 1974, the ROC Executive Yuan[11] held a meeting and established an ad hoc committee, the Committee on the Territorial Sea Issues, to study those issues under the lead of the Ministry of the Interior.

The problems presented to the ROC by the international developments in the law of the sea were peculiarly difficult because of the adverse diplomatic situation that the ROC Government was confronting. Not only was the ROC excluded from UNCLOS III, but it did not have diplomatic relations with many countries. In the face of these difficulties, negotiating any solution to disputes that arise from time to time made it desirable for the ROC to take a cautious position on claiming rights or privileges.[12]

Nevertheless, the ROC was concerned by other coastal States' extending territorial seas and establishing 200-nautical-mile EEZs, especially after Philippine President Marcos declared in Presidential Decree No. 1599 a 200-nautical-mile EEZ on 11 June 1979.[13] The Philippine Decree had a significant impact on Taiwan because the northern limits of the Philippine EEZ, measured from its northernmost base point on the Yami Island, could cross through the middle of Taiwan Island and make all the waters south of that limit the Philippine EEZ. The ROC Executive Yuan responded by declaring an extension of the territorial sea from 3 to 12 nautical miles and the establishment of the 200-nautical-mile EEZ on 6 September 1979.[14] The Declaration was as follows:

1. The territorial sea of the Republic of China shall be measured from the baselines and shall extend to the outer limits of the water area of twelve nautical miles from such baselines.
2. The exclusive economic zone of the Republic of China shall be measured from the baselines from which the territorial sea is measured and shall extend to the outer limits of the water area of two hundred nautical miles from such baselines.

   A. The Republic of China shall have in the exclusive economic zone sovereign rights for purposes of exploitation, conservation and utilisation of the natural resources, and such jurisdiction the exercise of which are recognised under international law.
   B. Where the exclusive economic zone of the Republic of China extends over any part of the exclusive economic zones as proclaimed by other states, the boundaries shall be determined by agreement between the states concerned or in accordance with generally accepted principles of international law on delimitation.
   C. Other states may enjoy in the exclusive economic zone of the Republic of China the freedom of navigation and overflight and of the laying of submarine cables and pipelines, and engage in such other activities with respect to navigation and communication as permitted by international law.

3. The sovereign rights enjoyed by the Republic of China over the continental shelf contiguous to its coast as recognised by the Convention on the Continental Shelf of 1958 and the general principles of international law shall not be prejudiced in any manner by the proclamation of the present exclusive economic zone or the establishment of such zones by any other state.

This Declaration was endorsed by the Presidential Decree issued on 8 October 1979.[15] The Presidential Decree stated:

1. The territorial sea of the Republic of China shall be measured from the baselines and shall extend to the outer limits of the water area of twelve nautical miles from such baselines.
2. The exclusive economic zone of the Republic of China shall be measured from the baselines from which the territorial sea is measured and shall extend

to the outer limits of the water area of two hundred nautical miles from such baselines.

3. The sovereign rights enjoyed by the Republic of China over the continental shelf contiguous to its coast shall not be prejudiced in any manner by the proclamation of the present exclusive economic zone or the establishment of such zones by any other State.

The 1979 Declaration creates an overlapping EEZ area with that of the Philippines in the Bashi Channel. Moreover, due to sovereignty claims by the ROC over the Pratas Islands, Paracel Islands, Macclesfield Bank, and the Spratly Islands, Taiwan also has overlapping maritime claims with Malaysia, the Philippines, the PRC, and Vietnam in the South China Sea. There is no specific delimitation method mentioned in the Declaration but, according to paragraph 2(B): "the boundaries shall be determined by agreement between the States concerned or in accordance with generally accepted principles of international law on delimitation." This illustrated the ROC Government's aspiration and position in negotiating with its neighboring countries on maritime delimitation issues.

Continental Shelf Claim

Although the continental shelf had been an important issue in the field of international law of the sea and an international practice since the 1949 Truman Proclamation, scholars within East Asia and the Government of the ROC did not pay much attention to this topic until release in 1969 of the Emory Report that raised, for the first time, the hydrocarbon resource potential of the Asian seas.[16] Nonetheless, it is worthwhile examining the Taiwanese fishery industry's attitude toward the continental shelf.

When the 1956 International Law Commission Draft Articles on the Law of the Sea[17] were sent to States for comments, the Taiwanese fishing industry expressed the view that the sea area above the continental shelf should be considered as a part of the territorial sea and the coastal State should have the preferential rights and duties with respect to the living resources therein.[18] However, the ROC Government did not adopt this view and made no comments on the articles concerning the regime of the continental shelf.[19]

The ROC signed the 1958 Geneva Convention on the Continental Shelf on 29 April 1958.[20] No further action was taken to ratify the Convention. This changed after the release of the Emory Report, which stated that: "A high probability exists that the continental shelf between Taiwan and Japan may be one of the prolific oil reservoirs in the world. It also is one of the few large continental shelves of the world that has remained untested by the drill."[21] Soon after, the ROC Government asserted its claim to its adjacent continental shelf. In July 1969, the Executive Yuan issued a Declaration as follows:

> The Republic of China is a State signatory to the Convention on the Continental Shelf which was adopted by the UN Conference on the Law of the Sea in 1958. For the purposes of exploring and exploiting natural resources and in accordance with the principles embodied in the said Convention, the Government of the Republic of China declares that it may exercise its sovereign rights over all the natural resources of the seabed and subsoil adjacent to its coast outside its territorial sea.[22]

In early 1970, the Legislative Yuan decided to ratify the Continental Shelf Convention with the following reservation to Article 6:

With regard to the determination of the boundary of the continental shelf as provided in Paragraphs 1 and 2 of Article 6 of the Convention, the Government of the Republic of China considers:

1. that the boundary of the continental shelf appertaining to two or more States whose coasts are adjacent to and/or opposite each other shall be determined in accordance with the principle of the natural prolongation of their land territories; and
2. that in determining the boundary of the continental shelf of the Republic of China, exposed rocks and islets shall not be taken into account.[23]

With respect to the ROC reservation, its main point was regarding the Tiao-Yu-Tai (or 釣魚台 in Chinese and Senkaku Islands 尖閣諸島 in Japanese) issue or dispute with Japan. Both the ROC and Japan claim sovereignty over the Tiao-Yu-Tai Islands, which are situated on the edge of the continental shelf extended from Chinese mainland and the island of Taiwan. From the view of both the PRC and the ROC, these islands are continental in nature, appertaining to Taiwan, and are distinct from the oceanic Ryukyus in the east; therefore, claiming a continental shelf on the basis of natural prolongation would be favorable.[24] The Japanese Government takes the position that the status of Tiao-Yu-Tai Islands was *terra nullius* when it took control of the islands in 1895 as a result of the Treaty of Shimonoseki with the Chinese Government.[25] By denying the exposed rocks and islets' use as a base for claiming continental shelf, the ROC apparently was preparing its second line of defense (i.e., even if the ROC lost in the territorial sovereignty dispute over the Tiao-Yu-Tai Islands, it would still deny Japan's right to claim a continental shelf emanating from the islets). On the other hand, it can be pointed out that such a reservation would have had the undesirable effect of weakening the ROC claim to a continental shelf in the South China Sea region, if such continental shelf claim is to be based on the "exposed islets and rocks."[26]

Exclusive Economic Zone Claim

The ROC was reluctant to accept the concept of the EEZ when it first arose in the 1970s. The Executive Yuan held two meetings to examine the issues of the EEZ. Both meetings concluded that it was not appropriate to establish an EEZ or an exclusive fishery zone for three reasons:

1. The deep-sea fishery plays an important role in the ROC fishing industry. The Government deeply wishes that other States would not establish EEZs. Therefore, the ROC Government would not establish its own EEZ.
2. When the ROC Government ratified the Convention on the Continental Shelf, it declared that the delimitation of continental shelf boundary should correspond with the principle of natural prolongation of the land territory of coastal States.
3. If the ROC Government establishes EEZ, the disputes of delimitation would be arisen between it and Korea, Japan, and the Philippines. At this moment, none of those States had established any similar zone. Thus, the ROC should not establish any similar zone either.[27]

Nonetheless, as already noted, as a result of the 1979 Philippine EEZ Decree, the ROC Government declared its 200-nautical-mile EEZ on 6 September 1979. The EEZ declaration was welcomed domestically, especially by the fishing industry. The general feeling was that it was overdue because the neighboring countries, such as Japan and the Philippines, had already claimed similar zones.[28] Thus, the declaration made by the ROC Government was seen as a countermeasure to protect its fishing fleets, which had often been fined or seized by neighboring countries in disputed waters. Although the announcement did not solve the issues of maritime delimitation and fishery disputes, it did serve the purpose of notifying the neighboring countries of Taiwan's concern over these issues.

Related Legislation

Clear and unambiguous maritime zone laws and related regulations can serve the interests of both fishermen who fish in the marine environment and Government officials and administrators who may have to deal with potential fisheries conflicts or disputes.

The ROC Government declared the extension of the territorial sea and the establishment of EEZ on 6 September 1979, but there was no domestic law or regulation applied to such maritime zones so as to detail rights and obligations on the exploration and exploitation, conservation, and management of the natural resources within the EEZ in general, and to regulate fishing and other activities in particular. Moreover, without clear legal authorization, the relevant authorities may not be able to visit, inspect, detain, try, and punish those foreign vessels that intruded into the ROC's EEZ. For example, it is recorded that Japanese fishing vessels frequently intruded in and operated in the ROC's EEZ. For instance, on 19 September 1984, 40 Japanese fishing vessels were found operating in the EEZ of Pen-Chia-Yu Island.[29]

Owing to the growing concern over the lack of jurisdiction or authority to take action in the EEZ, on 11 September 1989 the ROC Ministry of the Interior convened an Ad Hoc Committee on Base Points and Baselines and Law of EEZ and Territorial Sea to study the issues. This committee, chaired by the minister of the interior, was composed of staff from the Secretariat of the Executive Yuan, the Deputy Ministers of Foreign Affairs, National Defence, Justice, Economic Affairs, Communications, Council of Agriculture, Administration of Environmental Protection, and scholars.[30] After almost 2 years of discussion and research, the committee produced two draft laws and sent them to the Legislative Yuan. The two drafts were the Draft of the Territorial Sea and the Contiguous Zone and Draft of EEZ and Continental Shelf.

The content of the two drafts was declarative rather than practical. Owing to the committee's consideration that the ROC's sovereignty and jurisdiction reaches the Chinese mainland, the baselines were drawn from the mouth of Yalu River[31] in the northeast along the coastal islands to the mouth of Peilun River in the southeast.[32] It also covers the Taiwan area, Nansha Chun-Tao (Spratly Islands) in the South China Sea, and the Tiao-Yu-Tai Islands in the East China Sea. The declaration of the sovereignty and jurisdiction over the Chinese mainland and Taiwan was a reiteration of the ROC's "Mainland Policy." As to the island groups in the South China Sea and the East China Sea, the draft laws served as a declaration of jurisdiction over them. With regard to the Spratly Islands in the South China Sea, Brunei, China, Malaysia, the Philippines, Taiwan, and Vietnam claim ownership over all or some of the islands. As for the Tiao-Yu-Tai Islands, China, Japan, and Taiwan claim sovereignty. The ROC declaration of the baselines of the territorial sea and its sovereignty over those areas would help to strengthen its position in negotiating with its neighboring countries. Nevertheless, the shortcoming would be that it was not practical to declare the ROC's sovereignty and jurisdiction over the Chinese mainland.

Only in January 1998 did the ROC Government promulgate the Law on the Territorial Sea and the Contiguous Zone, which declared its sovereignty over the territorial sea and the rights in the contiguous zone,[33] and the Law on the Exclusive Economic Zone and the Continental Shelf.[34]

Apart from the above legislation, the Executive Yuan declared, on 10 February 1999, "The First Part of the Baselines of the Territorial Sea of the Republic of China."[35] The way in which the islands in the South China Sea are described is noteworthy:

> All islands and atolls of the Nansha Islands surrounded by the Chinese traditional U-shape lines are the territory of the Republic of China. The delimitation of the baselines in this region shall be determined by a combination of straight baselines and normal baselines. The related information concerning names of the base points, their co-ordinates, and charts shall be promulgated in the future.[36] (emphasis added)

The ROC's Claim in the South China Sea: State Practice

The ROC Government was the first in the twentieth century to claim sovereignty over the Pratas Islands, Macclesfield Bank, the Paracel Islands, and the Spratly Islands, basing its claim on discovery and continuous patronage of these islands dating back to the first century.[37] When the Spratly Islands were "retroceded" to the ROC in 1946, the Kwangtung provincial Government was given jurisdiction over them.[38] In 1947, the ROC Ministry of the Interior's subsequent proposal to the central Government to "temporarily transfer jurisdiction of the islands to the ROC Navy" was approved.[39] In addition, an official map titled as "Map of the Location of the South China Sea Islands" was released that showed the Pratas Islands, Macclesfield Bank, Paracel Islands, and Spratly Islands within the 11 dotted U-shaped lines (Figure 1).

In 1948, the ROC dispatched warships to the archipelago to conduct surveys and erect landmarks.[40] In 1949, the ROC President promulgated the "Organisational Statutes Governing the Office of the Special Administrator of Hainan" and transferred the jurisdiction of the Spratly Islands from the Kwangtung provincial Government to the Hainan Special Administrative District.[41] Owing to its defeat in the civil war in May 1950, the ROC Government withdrew its forces from Hainan Island and the Paracels as well as the Spratly Islands.

According to the Treaty of Peace between the ROC and Japan signed on 28 April 1952, Japan "renounces all right, title, and claim to Taiwan (Formosa) and Penghu (the Pescadores) as well as the Spratly Islands and the Paracel Islands."[42] Although no sovereign successor was named in the Peace Treaty, the ROC claims that this treaty is proof that the ROC exercised complete sovereignty over these island groups.[43]

When, on 15 May 1956, a Philippine named Tomas Cloma claimed ownership, by discovery and occupation, of "Freedomland," the ROC Government immediately protested to the Philippine Government.[44] A naval contingent was sent to patrol the Spratly Islands, but found the Philippine had already left. Later, a Taiwanese garrison force of about 600 troops was sent to Tai-Ping-Dao (Itu Aba Island or 太平島), the largest island in the Spratly Islands, and has remained there ever since.[45] The Taiwanese Navy has patrolled Itu Aba Island and supplied the garrison there every 3 or 4 months ever since. In February 1990, the Executive Yuan placed Tung-Sha-Dao (Pratas Island) and Tai-Ping-Dao (Itu Aba Island) under the jurisdiction of the Kaohsiung city Government and set up a postal system on the

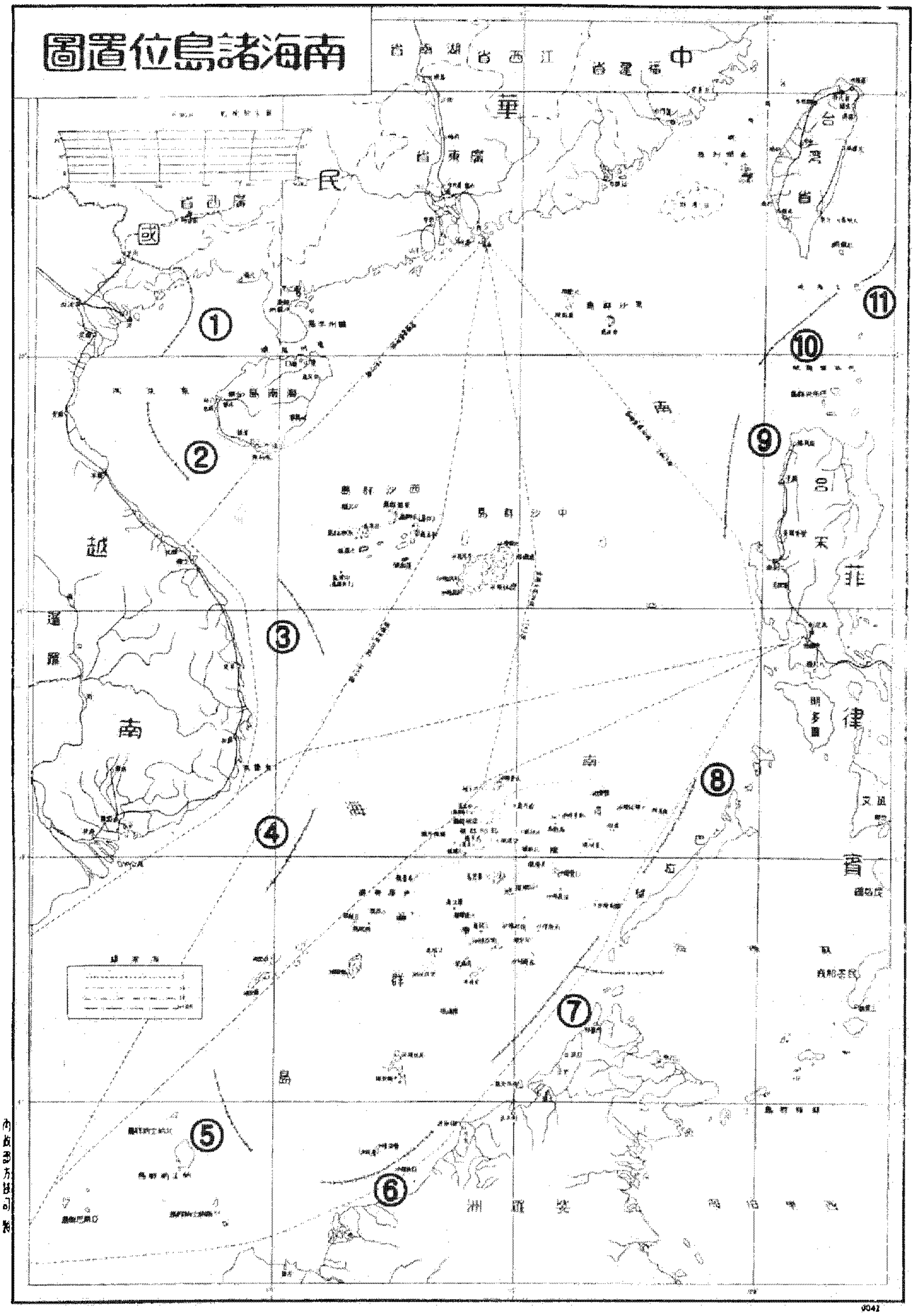

Figure 1. "Map of the Location of the South China Sea Islands" released by the ROC Government. (*Source:* See a reproduction of the original U-shaped lines map issued by the ROC Government on December 1946 in Nien-Tsu Alfred Hu, "South China Sea: Troubled Waters or a Sea of Opportunity", Figure 2, p. 6, in this Special Issue.)

islands as well as brought them under a unified administrative system.[46] In February 2000, the garrison shifted from the Marine to the Coast Guard Administration.[47]

On 13 April 1993, the ROC Executive Yuan approved the Policy Guidelines for the South China Sea, in which it stated that:

> In terms of history, geography, international law and facts, the Nansha Islands [Spratly Islands], Shisha Islands [Paracel Islands], Chungsha Islands [Macclesfield Islands], Tungsha Islands [Pratas Islands] are part of inherent territory of the Republic of China; the sovereignty over those islands belongs to the Republic of China. The South China Sea area within the historic water limit is the maritime area under the jurisdiction of the Republic of China, where the Republic of China possesses all rights and interests.[48]

In order not to create any unfavorable situation that would damage the ROC's legal claim, the MOFA has made numerous statements in response to the actions of other littoral States occurring in the South China Sea. The following are examples.

On 10 June 1997, in response to the election held by the Government of the Philippines for the village chief in the so-called Kalayaan Islands, the Government of the ROC stated that:

> The Nansha (Spratly) Islands, like the Chungsha (Macclesfield Bank) Islands, the Shisha (Paracel) Islands, and the Tungsha (Pratas) Islands, are an *integral part of the territory* of the Republic of China. The Government of the Republic of China has on numerous occasions reaffirmed its *sovereignty over these islands*.[49] (emphasis added)

Three days later, on 13 June 1997, the MOFA made almost the same statement of claiming sovereignty over the islands.[50] However, they did not touch on the status of the water area.

On 1 July 1999, the ROC lodged a protest against the occupation of Investigator Shoal and Erica Reef in the Spratly Islands by the Malaysian Government and the inclusion of the disputed Scarborough Shoal on a territorial map of the Philippine Government. In its statement, the ROC MOFA reiterated its position in the South China Sea with strong wording on both the islands and the water area.

> The Nansha (Spratly) Islands, like the Shisha (Paracel) Islands, the Chungsha Islands (Macclesfield bank) and the Tungsha (Pratas) Islands, is part of the territories of the Republic of China, whether legally, historically, geographically or in reality. *Its sovereignty undoubtedly belongs to the Republic of China.* No country or civilian group can claim or occupy these islands for any reason whatsoever.
>
> *The South China Sea is a body of water of the Republic of China. The Republic of China has all rights and privileges in the South China Sea.* Any activities (including the discussion on joint cooperation or on Code of Conduct, etc.) in the South China Sea region must acquire the approval of the Government of the Republic of China.
>
> *The Government of the Republic of China reiterates its aforementioned position and emphasises that its sovereignty, including rights and privileges,*

> *over the said islands*, cannot be altered by any regional bilateral agreements or unilateral resolutions made by the ASEAN Regional Forum or any other forms of organisations.[51] (emphasis added)

On 5 November 2002, the ROC MOFA made a statement concerning the Declaration on the Conduct of Parties in the South China Sea signed by the Association of Southeast Asian Nations (ASEAN) and the PRC in Cambodia.[52] The MOFA stated:

> 1) The Government of the Republic of China reiterates its *territorial sovereignty* over Dongsha (the Pratas Islands), Xisha (the Parcel Islands), Zhongsha (the Macclesfield Bank) and Nansha (the Spratly Islands) in the South China Sea, over which it has all lawful rights according to international law.[53] (emphasis added)

The ROC Government has undertaken construction of an airstrip on Tai-Ping-Dao since 2006. The Vietnamese Government took the view that was a violation of Vietnamese sovereignty and heightened tensions in the area. The ROC MOFA responded on 20 November 2007:

> The Spratly Islands, the Paracel Islands, Macclesfield Bank and the Pratas Islands have always been an intrinsic part of Taiwan's territories, whether looked at from the perspective of history, geography, international law or plain fact. According to the principles of international law, the Government of Taiwan's sovereignty over these islands is unquestionable and it enjoys all rights accordingly.
>
> Taiwan has long stationed troops on Taiping Island (known to Vietnam as Itu Aba), the largest among the Spratly Islands. Basic airport facilities were established on the island years ago to transport essential supplies, to safeguard marine resources and for emergency humanitarian rescue.[54]

In August 2008, the Malaysian deputy prime minister led media members to Swallow Reef (Layang-Layang Atoll in Malaysian) and proclaimed Malaysia's sovereignty over the island. The MOFA stated that:

> 1. *The Spratly Islands, including the Swallow Reef, are located in Taiwan's territorial waters*. From either a historical, geographical or international legal perspective, the Spratly Islands, Paracel Islands, Macclesfield Islands, Pratas *Islands and nearby waters are part of Taiwan's territory and territorial waters.*[55] (emphasis added)

In 2009 the Philippines adopted legislation incorporating Huangyan Dao (or the Scarborough Shoal for the Philippines), in Macclesfield Islands, and part of the Spratly Islands into Philippine territory.[56] The ROC MOFA declared that:

> 1. In terms of either history, geography, reality or international law, the Spratly Islands, Paracel Islands, Macclesfield Islands, Pratas Islands, as well as the surrounding waters, are the existent territories of the Republic of China. The fact that sovereignty of these areas belongs to our Government is undeniable, Taiwan enjoys and deserves all rights accordingly. Any sovereignty claims

over, or occupation of, these islands and their surrounding waters will not be recognized by the Government of the Republic of China.[57] (emphasis added)

On 6 May 2009, Malaysia and Vietnam filed a Joint Submission to the Commission on the Limits of the Continental Shelf of the United Nations, with respect to their proposed outer limits of the continental shelf beyond 200 nautical miles.[58] On 7 May 2009, Vietnam filed a Submission to the Commission, with respect to the proposed outer limits of its continental shelf beyond 200 nautical miles in the northern area of the South China Sea.[59] The ROC responded:

1. In terms of either historical, geographical or international legal perspective, the Nansha Islands (Spratly Islands), Shisha Islands (Paracel Islands), Chungsha Islands (Macclesfield Islands), Tungsha Islands (Pratas Islands), *as well as their surrounding waters, their respective sea bed and subsoil belong to the existent territories of the Republic of China.* The *sovereignty of these archipelagoes* belongs to our Government is an undeniable fact, Taiwan therefore enjoys and deserves all rights accordingly. Any sovereignty claims over, or occupation of, these islands and their surrounding waters will not be recognized by the Government of the Republic of China.[60] (emphasis added)

On 12 May 2009, in a statement on the outer limit of the continental shelf, the ROC MOFA declared that:

In terms of either historical, geographical or international legal perspective, Tiao-Yu-Tai Islands and the Nansha Islands (Spratly Islands), Shisha Islands (Paracel Islands), Chungsha Islands (Macclesfield Islands), Tungsha Islands (Pratas Islands), *as well as their surrounding waters, their respective sea bed and subsoil are the existent territories of the Republic of China.* The *sovereignty of these archipelagoes* belongs to our Government is an undeniable fact. The ROC enjoys and deserves all rights given by international law over the said islands and the surrounding waters, sea-bed and subsoil. Any sovereignty claims over or occupation of these islands under any reason or any means by any other country shall be null and void.[61] (emphasis added)

From the above statements made by the ROC Government, it is plain that there has been a moderation of position regarding the claims in the South China Sea. Recent ROC statements have focused more on the islands and the surrounding waters rather than the whole water body enclosed by the U-shaped lines. This shift will be discussed in the following section.

The U-Shaped Lines: Policy Implications

This section will examine the U-shaped lines on the 1947 map released by the ROC Government in the context of the aforementioned practices of the ROC Government. The map showing the U-shaped lines has taken on even greater importance since it was attached to communications from the PRC to the United Nations in 2009.[62]

First, what is the method utilized in the making of the U-shaped lines? An examination of the map titled "Map of the Location of the South China Sea Islands (*Nan-hi Chu-dao*

Wei-zhi Tu)" shows that there are 11 intermittent dotted lines encompassing most of the islands and islets in the South China Sea (See Figure 1). The series of lines starts from the estuary of Bei-Lun River, which is the boundary river between China and Vietnam. The first two segments go through the middle part of Tonkin Bay. The third and the fourth segments are located between Vietnam and the Paracel Islands as well as the Spratly Islands, respectively. Then, the fifth and the sixth lines take a circumgyration back toward the north. At the southernmost, the lines include James Shoal, which is claimed as the southernmost territory of China. The position of the seventh and the eighth lines are in the middle between the Spratlys and the north coast of Borneo as well as Palawan Island. The last three segments could be treated as a subseries of the U-shaped lines because they represent the continuation of the previous lines and they also imply a maritime division between Taiwan and the Philippines.

It is reasonable to derive that the median line principle was applied in making the U-shaped lines.[63] This presumption can be clarified by the seventh segment, which not only demonstrates the division between Spratlys and Sabah (the northern part of Borneo), but also shows a delimitation between the Philippine Balabac Island and Malaysian State of Sabah with a short side segment connected with the seventh one.[64]

Furthermore, the manner of depicting the dotted lines is the same as the one applied on the map to the national boundaries between China and Vietnam as well as Vietnam and Cambodia. However, the ROC Government took a conservative position by using dotted lines in an inconsecutive fashion. The implication for this is possibly to leave room for future negotiations with the respective countries.

Second, what is the status of the 11 U-shaped dotted lines? According to the 1982 UN Convention on the Law of the Sea, two baseline systems might be employed for measuring the breath of the territorial sea (i.e., the normal baseline or straight baselines).[65] In other words, the "low-water line along the coast as marked on large-scale charts officially recognized by the coastal States" or "straight baselines joining appropriate points." Examining the 1947 map, it is easy to recognize that its function was as a general description of the location of the different island groups within the U-shaped lines. Moreover, according to later practices, the ROC Government took the U-shaped lines to justify its position that they are a series of lines that embrace all the islands and represent sovereignty over those islands. This can be seen from the declaration made by the ROC Executive Yuan on 10 February 1999: "All islands and atolls of the Nansha Islands surrounded by the Chinese traditional U-shape lines are the territory of the Republic of China"[66] and other similar statements made by MOFA.[67] Under these circumstances, the ROC Government's intention when it produced the 1947 map was to demonstrate that sovereignty over the island groups belongs to the ROC.

Third, what is the status of the water body enclosed by the U-shaped lines? Some have argued that the water enclosed by the U-shaped lines are the internal waters. This is disputable. Article 8 of the LOS Convention provides that "[w]aters on the landward side of the baseline of the territorial sea form part of the internal waters of the State." Since the U-shaped lines are not a baseline system, either from the perspective of the normal baseline or straight baselines, then the fundamental basis for internal waters as well as territorial sea does not exist. Moreover, according to the theory and practices of international law of the sea, the coastal State enjoys full territorial sovereignty within its internal waters. Consequently, there is no right of innocent passage for any foreign ships through such water areas.[68]

Therefore, State practices in the South China Sea region do not support the claim of internal or territorial waters. The South China Sea constitutes one of the busiest sea transport routes in the world. As far as the living resources are concerned, the South China Sea is one of the most important maritime areas for commercial fisheries in the world. Stocks, such as scad and mackerel, and highly migratory species, such as tuna, are the most common and important commercial fish stocks. All these practices from the littoral States or other countries—heavy transportation, hydrocarbon resources exploration and exploitation, and fisheries resources management and conservation—create a detriment to claiming the water body enclosed by the U-shaped lines as a territorial sea, not to mention as internal waters.

Maritime claims to sovereignty over those islands and waters enclosed by the U-shaped lines could be a basis or leverage to advocate a claim to a territorial sea, contiguous zone, EEZ, and continental shelf surrounding the islands. Therefore, it is legitimate for the ROC Government to claim that all islands and atolls surrounded by the traditional U-shape lines are part of its territory.

Conclusion

The development of the law of the sea has been heavily influenced by national security concerns and economic interests. With regard to security interests, a broad band of territorial sea offers a form of security; in modern times, this is more of a psychological or political security than a practical defense against foreign attacks. In terms of economic interests, coastal States are primarily interested in the resources of their adjacent marine areas.

The ROC was the first country in the South China Sea region to claim sovereignty over the islands and islets enclosed by the unique U-shaped lines system. Moreover, there was no objection or protest against such claim when the ROC declared it, which could constitute estoppel for them.[69] Nonetheless, the ROC Government obscurely set out its claim to the status of the waters enclosed by the U-shaped lines, which has subsequently drawn more discussion and even challenges from other claimants.

It would be difficult to claim the water body within the U-shaped lines as internal waters or territorial sea since the South China Sea area is one of the busiest transport routes in the world. Because there is no restriction on the transport traffic administered by the ROC or the PRC, proclaiming sovereignty to the water area would be difficult. Therefore, from the examination of the 1947 map, the purpose of the U-shaped lines was to claim sovereignty over those islands and islets through applying the median line principle. Accordingly, claiming a territorial sea or contiguous zone surrounding those islands and islets might be justifiable for the ROC or the PRC. As to the possibility of extending EEZs or continental shelf from the islands, that would be the discussion as well as debate on the definition of islands or rocks in Article 121 of the LOS Convention.

Notes

1. For convenience, Taiwan will be used in reference to the Republic of China (ROC) and China will be used for the People's Republic of China (PRC).

2. See Yann-Huei Song, "Cross-Strait Interactions on the South China Sea Issues: A Need for CBMs," *Marine Policy* 29 (2005): 265–280; Zou Keyuan, "Maritime Boundary Delimitation in the Gulf of Tonkin," *Ocean Development and International Law* 30 (1999): 235–254; Yann-Huei Song and Zou Keyuan, "Maritime Legislation of Mainland China and Taiwan: Developments, Comparison, Implications, and Potential Challenges for the United States," *Ocean Development and International Law* 31 (2000): 303–345; Zou Keyuan, "Historic Rights in International Law and in China's Practice," *Ocean Development and International Law* 32 (2001): 149–168; Peter Kien-Hong Yu, "The Chinese (Broken) U-shaped Line in the South China Sea: Points, Lines, and Zones," *Contemporary Southeast Asia* 25 (2003): 405–430; Li Jinming and Li Dexia, "The Dotted Line on the

Chinese Map of the South China Sea: A Note," *Ocean Development and International Law* 34 (2003): 287–295; Peter Kien-Hong Yu, "Setting Up International (Adversary) Regimes in the South China Sea: Analyzing the Obstacles from a Chinese Perspective," *Ocean Development and International Law* 38 (2007): 147–156; Nguyen Hong Thao and Ramses Amer, "Managing Vietnam's Maritime Boundary Disputes," *Ocean Development and International Law* 38 (2007): 305–324.

3. Cited in Hwang Kang (黃剛), *The Republic of China's Territorial Sea and Its Related System* (*Jong-hwa-ming-gwo De Ling-hai Ji-jyh Shiang-guan Jyh-duh 中華民國的領海及其相關制度*) (Taipei, Taiwan: Commercial Press, 1973), 50.

4. Shih-Hao Lee and Juo-Tsian Chu (李士豪與屈若搴), *History of Chinese Fishery* (*Jong-gwo Yu-yeh-shyy 中國漁業史*) (Taipei, Taiwan: Taiwan Shan-Wu, 1970), 188–209.

5. See Conference for the Codification of International Law, Hague 1930, *Final Act*, Report of the Second Committee (Territorial Sea), reprinted in *American Journal of International Law* 24, Suppl. (1930): 234–235, 254; and Green Haywood Hackworth, *Digest of International Law*, Vol. 1 (Washington, DC: Department of State Publications, 1940), 628. See also C. J. Colombos, *International Law of the Sea*, 6th rev. ed. (London: Longmans, 1967), 99; and Y. L. Wu, ed., *China—A Handbook: Theory and Practice of International Law with Respect to Selected Issues* (New York: Praeger, 1973), 400.

6. See, generally, *Final Act*, supra note 5, at 234–247.

7. Ministry of Transportation and Communication, Decree No. 1612 of 20 April 1931. *Gazette of the Ministry of Transportation and Communications* (*Jiau-tong-bu Gong-bao 交通部公報*), No. 244 (9 May 1931), 1–2.

8. United States, Executive Order 9633 of 28 September 1945, 10 *Fed. Reg.* 12303, 59 *U.S. Stat.* 884.

9. Although the PRC was established in 1949, the ROC retained its membership status in the United Nations and other related organizations until 1971.

10. See *Yearbook of the International Law Commission*, Vol. 1 (1952), 153, para. 80; 158, para. 54; and Vol. 1 (1955), 154, para. 61; 172–173, para. 15; 186, para. 43.

11. The Executive Yuan is the highest administrative organ of the ROC Government and is led by the premier.

12. Joseph W. Dellapenna and A. Y. Wang, "The Republic of China's Claims Relating to the Territorial Sea, Continental Shelf, and Exclusive Economic Zones: Legal and Economic Aspects," *Boston College International and Comparative Law Review* 3 (1980): 357.

13. Philippine Presidential Decree No. 1599 of 11 June 1978 establishing an Exclusive Economic Zone and for other purposes available at www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/PHL_1978_Decree.pdf (accessed 18 March 2010).

14. Documents released at the Government Information Office Press Conference, 6 September 1979.

15. The Presidential Decree can be found in the *Gazette of the Presidential Office* (Tzoong-toong-fuu *Gong-bao* or *總統府公報*), No. 3575, 10 October 1979, 2. The Decree was issued with a document code (68)Tai-Tung(1)I-Tze No. 5046 ((六八)台統(一)義字第5046號令).

16. K. O. Emory, et al., "Geological Structure and Some Water Characteristics of the East China Sea and the Yellow Sea," *Technical Bulletin, Technical Advisory Group Report*, Vol. 2 (1969); and see infra note 21.

17. See "Report of the International Law Commission to the General Assembly," in *Yearbook of the International Law Commission*, Vol. 11 (1956), 254–301.

18. "Our Fishing Industry's Recommendation on the Law of the Sea (我漁業界對海洋法之建議)," *Yu-Yo* (*漁友*), No. 74 (August 1957), 13.

19. See UN Doc. A/CONF.13/5/Add 2, 29 January 1958, available at untreaty.un.org/cod/diplomaticconferences/lawofthesea-1958/docs/english/vol_I/8_A-CONF-13-5_PrepDocs_vol_I_e.pdf (accessed 19 March 2010).

20. Continental Shelf Convention, 499 *U.N.T.S.* 311.

21. Emory, supra note 16, at 39–41.

22. Reproduced in Hungdah Chiu, "Chinese Contemporary Practice and Judicial Decisions Relating to International Law, 1968–1970," *Annuals of the Chinese Society of International Law* 7 (1970): 84.

23. *Gazette of the Legislative Yuan* (立法院公報) 59, No. 64, 22 August 1970, 3.

24. For a more recent declaration made by the ROC Government concerning its position on the status of Tiao-Yu-Tai as well as the natural prolongation of continental shelf in the East China Sea area, see "Declaration of the Republic of China on the Outer Limits of Its Continental Shelf", 12 May 2009, available at www.mofa.gov.tw/webapp/ct.asp?xItem=38077&ctNode=1901&mp=6 (accessed 12 March 2010).

25. Japan Ministry of Foreign Affairs, "The Basic View on the Sovereignty over the Senkaku Islands," available at www.mofa.go.jp/region/asia-paci/senkaku/senkaku.html (accessed 16 March 2010).

Convention of Armistice Between Japan and China, 30 March 1895, reproduced in Clive Parry, ed., *Consolidated Treaty Series*, 1648–1918 (Dobbs Ferry, NY: Oceana, 1969), 198–199.

26. Hungdah Chiu, *Chinese Attitude Toward Continental Shelf and Its Implication on Delimiting Seabed in Southeast Asia* (Baltimore: School of Law, University of Maryland, 1977), 9–10.

27. *China Daily News* (*Jong-Gwo-Shyr-Bao* or 中國時報), 7 September 1979, 3.

28. Japan declared its EEZ in 1996. See *Law of the Sea Bulletin*, No. 35 (1997), 78. Prior to this, Japan had claimed a 200-nautical-mile fishing zone.

29. Pen-Chia-Yu is an island located in the northeast sea area of Taiwan. The sea area around that island provides an excellent fishing ground. The Taiwanese Navy had expelled those Japanese fishing vessels. See *United Daily News*, 20 September 1984, 5.

30. *Taiwan Daily News*, 10 September 1989, 2.

31. The Yalu River is the border river between China and North Korea.

32. The Peilun River is the border river between China and Vietnam.

33. Presidential Decree, 21 January 1998, with document code (87) Hwa-Tzoong(1)I-Tze No. 8700010340 ((87)華總(一)義字第8700010340號令).

34. Presidential Decree, 21 January 1998, with document code (87) Hwa-Tzoong(1)I-Tze No. 8700010350 ((87)華總(一)義字第8700010350號令).

35. See *Executive Yuan Gazette*, Vol. 5, No. 6, 10 February 1999, 36–37. For an English translation, see United States, Department of State, *Limits in the Seas*, No. 127, "Taiwan's Maritime Claims," 15 November 2005, Annex 2.

36. *Limits in the Seas*, *ibid.*

37. Pao-Min Chang, "A New Scramble for the South China Sea Islands," *Contemporary Southeast Asia* 12, no. 4 (1990): 22.

38. Government Information Office, ROC, "The Republic of China's Sovereignty over the Spratly Islands," Reference: ROC on Taiwan, No. RR-93-02, 30 April 1993, 2.

39. *Ibid.*

40. Chang, supra note 37, at 22.

41. *Ibid.*

42. Treaty of Peace Between the Republic of China and Japan, 1858 *U.N.T.S.* 38–44, art. II. See Gerardo M. C. Valero, "Spratly Archipelago Dispute: Is the Question of Sovereignty Still Relevant?" *Marine Policy* 18 (1994): 319.

43. Hungdah Chiu and Choon-ho Park, "Legal Status of the Paracel and Spratly Islands," *Ocean Development and International Law* 3 (1975): 14.

44. *United Daily News*, 24 May 1956, 1; and 25 May 1956, 1.

45. *Central Daily News*, 2 December 1992, 4. Itu Aba Island is 1,358 meters long and 350 meters wide, the total area is about 0.5 square kilometers.

46. *United Daily News*, 6 February 1990, 4.

47. *United Daily News*, 28 January 2000, 8.

48. "Policy Guidelines for the South China Sea (Nan-Hai Jeng-Tseh Gang-Liing or 南海政策綱領)," 13 April 1993. An unofficial English translation can be found in Kuan-Ming

Sun, "Policy of the Republic of China Towards the South China Sea: Recent Developments," *Marine Policy* 19 (1995): 408.

49. Statement made by the ROC MOFA on 10 June 1997, available at www.mofa.gov.tw.

50. Statement made by the ROC MOFA on 13 June 1997, available at www.mofa.gov.tw.

51. Statement made by the ROC MOFA on 1 July 1999, available at www.mofa.gov.tw.

52. Declaration on the Conduct of Parties in the South China Sea, 4 November 2002, available at the Web site of ASEAN at www.aseansec.org/13163.htm (accessed 19 July 2009); and as an appendix to Nguyen Hong Thao, "The 2002 Declaration on the Conduct of Parties in the South China Sea: A Note" *Ocean Development and International Law* 34 (2003): 282–285.

53. Statement made by the ROC MOFA on 5 November 2002, available at www.mofa.gov.tw.

54. Press Release, the ROC MOFA, 20 November 2007, available at www.mofa.gov.tw.

55. Press Release, the ROC MOFA, 15 August 2008, available at www.mofa.gov.tw.

56. The Philippines, Republic Act No. 9522, An Act to Amend Certain Provisions of Republic Act No. 3046, as amended by Republic Act No. 5466, to Define the Archipelagic Baselines of the Philippines, and for Other Purposes, approved 10 March 2009, available at the Web site of the Philippine Law and Jurisprudence Database at www.lawphil.net/statutes/repacts/ra2009/ra_9522_2009.html (accessed 8 August 2009). See also the Philippines, "PGMA Signs Baselines Bill into Law," 11 March 2009, available at the official Government portal of the Philippines at www.gov.ph/index.php?option=com_content&task=view&id=21961&itemid=2 (accessed 8 August 2009).

57. Statement made by the ROC MOFA, 6 February 2009, available at www.mofa.gov.tw.

58. Malaysia-Vietnam Joint Submission to the Commission on the Limits of the Continental Shelf pursuant to Article 76, paragraph 8, of the United Nations Convention on the Law of the Sea 1982 (1833 *U.N.T.S.* 397) in Respect of the Southern Part of the South China Sea, Executive Summary, May 2009, available at the Web site of the Commission on the Limits of the Continental Shelf at www.un.org/Depts/los/clcs_new/clcs_home.htm.

59. Vietnam Submission to the Commission on the Limits of the Continental Shelf pursuant to Article 76, paragraph 8, of the United Nations Convention on the Law of the Sea 1982, Partial Submission in Respect of Vietnam's Extended Continental Shelf: North Area (VNM-N), Executive Summary, April 2009, available at the Web site of the Commission, supra note 58.

60. Statement made by the ROC MOFA, 11 May 2009, available at www.mofa.gov.tw.

61. Chinese text version, available at www.mofa.gov.tw, translated by the author.

62. People's Republic of China, Letter to Secretary-General of the United Nations, Doc. CML/17/2009, New York, 7 May 2009; and Letter to Secretary-General of the United Nations, Doc. CML/18/2009, New York, 7 May 2009, available at the Web site of the Commission, supra note 58 (accessed 19 July 2009).

63. A *median line* is defined as every point of the line is equidistant from the nearest points on the baselines from which the breadth of the territorial seas of each of the two States is measured.

64. The maritime boundary delimitation is still a disputed issue between the Philippines and Malaysia. See Jonathan I. Charney, "Central East Asian Maritime Boundaries and the Law of the Sea," *American Journal of International Law* 89 (1995): 724–726.

65. LOS Convention, supra note 58, arts. 5 and 7.

66. "The First Part of the Baselines of the Territorial Sea," supra note 36.

67. See, for example, supra notes 48, 51, 53, 55, 57, 60, and 61.

68. Robin Churchill and A. V. Lowe, *The Law of the Sea*, 3rd ed. (Manchester, England: Manchester University Press, 1999), 61.

69. Kuen-Chen Fu, *A Study on the Legal Status of the ROC's Historic Waters in the South China Sea (我國南海歷史性水域法律地位之研究)* (Taipei, Taiwan: Research, Development and Evaluation Commission, Executive Yuan, 1992), 16–17.

Annex 881

Yann-huei Song, "The Application of Article 121(3) of the Law of the Sea Convention to the Five Selected Disputed Islands in the South China Sea", *Chinese (Taiwan) Yearbook of International Law and Affair*, Vol. 27 (2009)

THE APPLICATION OF ARTICLE 121(3) OF THE LAW OF THE SEA CONVENTION TO THE FIVE SELECTED DISPUTED ISLANDS IN THE SOUTH CHINA SEA

Yann-huei Song*

TABLE OF CONTENTS

I. INTRODUCTION

The South China Sea, located south of mainland China and Taiwan, west of the Philippines, north west of Sabah (Malaysia), Sarawak (Malaysia) and Brunei, north of Indonesia, north east of the Malay peninsula (Malaysia) and Singapore, and east of Vietnam, is the largest marginal sea in the world. It is a part of the Pacific Ocean, encompassing an area from Singapore to the Strait of Taiwan of around 3.5 million km^2. The South China Sea has a wide continental shelf to the south, runoff from several large rivers, and a deep basin over 3,000 meters deep. It is subject to the physical forces of the alternating southeastern Asian monsoons, typhoons, strong internal waves, El Niño and Southern Oscillation and is sensitive to climate change because of its location. Hundreds of islands,

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This article is a revised version of my paper entitled "The Application of Article 121 of the Law of the Sea Convention to the Disputed Islands in East Asia – A Tribute to Judge Choon-ho Park" that was presented at the Fourth Inha University – Law of the Sea Institute on the Law of the Sea and Ocean Policy, held at University of Hawaii, Honolulu, Hawaii, USA on August 27, 2009. This revised article was presented at the International Workshop on "The South China Sea: Cooperation for Regional Security and Development" held in Hanoi, Vietnam, November 26-27, 2009 and the First Cross-Strait Forum on International Law, held at National Chengchi University, Taipei, Taiwan, R.O.C. on December 19, 2009.

reefs, shoals, sands, or rocks, collectively known as the Pratas, Paracel, Macclesfield Bank, and Spratly archipelagos, are situated respectively in the northern, western, central, and southern parts of the South China Sea.

Within the sea, there are five islands, namely Yongxing Dao/Dao Phu Lam (Woody Island), Zhongye Dao/Dao Thi Tu/Pagasa (Thitu Island), Taiping Dao/Dao Ba Binh/Ligaw Island (Itu Aba, Taiping Island), Danwan Jiao/Celerio/Layang Layang/Dao Hoa Lau (Swallow Reef), and Nanwei Dao/Dao Troung Sa/Lagos (Spratly Island), that are subject to competing claims of sovereignty by China, Malaysia, the Philippines, Taiwan and Vietnam. While these islands have no permanent human habitation, no supply of natural fresh water (perhaps with the exception of Itu Aba), and arguably no economic life of their own at present, they all have runway and military or coastal guard personnel stationed there. One interesting legal question that can be raised is about the right of these islands to claim a 200 nautical mile exclusive economic zone (EEZ)[1] and continental shelf[2] under existing international law. Article 121, paragraph 3 of the United Nations Convention on the Law of the Sea (hereafter referred to as UNCLOS)[3] provides that "[r]ocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf." Should Yongxing Dao/Dao Phu Lam (Woody Island) be considered a "rock"? Does it have the capability to sustain human habitation or economic life of its own? Does it have the right to claim a 200 nautical mile of

[1] It is an area beyond and adjacent to the territorial sea, subject to the specific legal regime establishing in Part V of the 1982 United Nations Convention on the Law of the Sea, under which the rights and jurisdiction of the coastal state and the rights and freedoms of other states are governed by the relevant provisions of the Convention. In the EEZ, the coastal states has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources of the waters superjacent to the sea-bed and of the sea-bed, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds. In addition, within the zone, the coastal state exercises jurisdiction with regard to the establishment of artificial islands, installations and structures; marine scientific research; the protection and preservation of the marine environment. The EEZ should not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured. For more information about this legal regime, see United Nations Convention on the Law of the Sea arts. 55-57, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS].

[2] The continental shelf of a coastal state comprises the sea-bed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental shelf does not extend up to that distance. A coastal state exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources. For more information about this legal regime, see *id.* arts. 76, 77.

[3] The Convention, adopted April 30, 1982, opened for signature December 10, 1982, and entered into force on November 16, 1994. As of June 1, 2010, the convention had 160 parties. For a historical perspective of the convention, see Ocean and the Law of the Sea, Division for Ocean Affairs and the Law of the Sea, "The United Nations Convention on the Law of the Sea (A Historical Perspective)", http://www.un.org/Depts/los/convention_agreements/convention_historical_perspective.htm (last visited Mar. 18, 2011). For chronological lists of ratifications of, accessions and successions to the Convention and the related Agreements, see Ocean and the Law of the Sea, Division for Ocean Affairs and the Law of the Sea, "United Nations Convention on the Law of the Sea of 10 December 1982: Overview and Full Text", http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm (last visited Mar. 18, 2011). For the text of the convention with annexes and the agreement to implement Part XI of the convention, see "United Nations Convention on the Law of the Sea, Agreement Relating to the Implementation of Part XI of the Convention" http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm (last visited Mar. 18, 2011).

EEZ or continental shelf? These questions also apply to the other four disputed islands that are situated in the Spratly archipelago in the southern part of the South China Sea.

The purpose of this article is to examine the interpretation and possible application of Article 121, in particular its third paragraph, to these five disputed islands. Following this introductory section, a brief summary of the development of the "Regime of Islands" at the Third United Nations Conference on the Law of the Sea (UNCLOS III),[4] held between 1973 and 1982, will be given in Section II, focusing in particular on those proposals made by the participating delegations to amend or delete entirely Article 121(3) of the UNCLOS. In Section III, the views of the law of the sea experts on the interpretation and application of Article 121(3) will be examined. In Section IV, several examples of state practices with regard to the application or interpretation of Article 121(3) are discussed. This is to be followed by a discussion of the interpretation and possible application of Article 121(3) to the five disputed islands in Section V. The last section provides several suggestions for the possible amendment of Article 121 or policy measures to help deal with the confusion found in Article 121(3).

II. THE CONSIDERATION OF THE "REGIME OF ISLANDS" AT UNCLOS III

Before UNCLOS III (1973-1982) was held, a number of statements, suggestions and proposals relating to the issues of establishing a legal regime of islands had already been made or submitted by the delegations that attended the meetings of Sub-Committee II of the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction (abbreviated and known as the Sea-Bed Committee) between March 1971 and November 1973. These statements, suggestions and proposals constituted the preliminary groundwork for the work of UNCLOS III on the specific question of the regime of islands.[5]

Being considered "main trends" in the development of a legal regime of islands in the early 1970s, these statements, suggestions, or proposals indicated that: (1) the definition of an island as given in Article 10, paragraph 1 of the 1958 Convention on the Territorial Sea and the Contiguous Zone, that is, "[a]n island is a naturally formed area of land, surrounded by water, which is above water at high tide," should be retained; (2) the same criteria applicable for the delimitations of the territorial sea and the continental shelf of continental land masses should also be applied to islands; (3) islands, in the same manner as continental land masses, should also generate an EEZ or patrimonial sea of their own; and (4) for the purpose of determining the relevant maritime spaces

[4] The Third United Nations Conference on the Law of the Sea was held between 1973 and 1982 with 11 sessions in total that took place in New York, Caracas, Geneva, and Montego Bay. For more information about UNCLOS III, see United Nations Diplomatic Conferences, "Third United Nations Conference on the Law of the Sea, 1973-1982", http://untreaty.un.org/cod/diplomaticconferences/lawofthesea-1982/lawofthesea-1982.html (last visited Mar. 18, 2011).

[5] For details about these statements, suggestions and proposals, see *The Law of the Sea: Régime of Islands, Legislative History of Part VIII (Article 121) of the United Nations Convention on the Law of the Sea*, at 6-21, U.N. Sales No. E.87.V.II (1988) [hereinafter *Legislative History of Part VIII of the UNCLOS*].

of islands, a series of criteria should be taken into account, such as population, geomorphological structure and configuration, and the capacity requirements in particular concerning habitation and economic life.[6]

UNCLOS III started in 1973. While ten sessions had been held during UNCLOS III,[7] most of the statements, suggestions and proposals on the regime of islands were made during the second session of UNCLOS III in 1974.[8] Upon the conclusion of the sixth session of UNCLOS III in July 1977, the result of the work of the conference appeared in the Informal Composite Negotiating Text (ICNT), which was informal in character, served purely as a procedural devise, and only provided a basis for negotiation without affecting the rights of any delegation to suggest revisions in the search for a consensus.[9] The question of the regime of islands was dealt with in Part VIII of the ICNT, which contained only one article, namely article 121.[10]

Between the seventh and final session of UNCLOS III, held in 1978 and 1982, respectively a number of suggestions and amendments in relation to the regime of islands were submitted. Several states, including Japan,[11] Greece,[12] France,[13] Venezuela,[14] the United Kingdom,[15] Brazil,[16] Portugal,[17] Iran,[18] Ecuador,[19] and Australia,[20] proposed or gave their support for the deletion of Article 121, paragraph 3. At the same time, a number of states expressed their opposition against the proposal to amend or delete Article 121 (3), which included Ireland[21], Dominican Republic,[22] Singapore,[23] Germany,[24] the Union of Soviet Socialist

[6] *Id.* at 21.
[7] United Nations Diplomatic Conferences, *supra* note 4.
[8] *Legislative History of Part VIII of the UNCLOS*, *supra* note 5, at 23-81.
[9] Memorandum by the President of the Conference on Document A/CONF.62/WP.10, U.N. Doc. A/CONF.62/WP.10/Add.1 (July 22, 1977), *extracted from* 8 *Official Records of the Third United Nations Conference on the Law of the Sea*, U.N. Sales No. E.78.V.4 (1977), *available at* http://untreaty.un.org/cod/diplomaticconferences/lawofthesea-1982/Vol8.html (last visited Mar. 11, 2011).
[10] The article reads:

1. An island is a naturally formed area of land, surrounded by water, which is above water at high tide.
2. Except as provided for in paragraph 3, the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf of an island are determined in accordance with the provisions of the present Convention applicable to other land territories.
3. Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf.

[11] *Legislative History of Part VIII of the UNCLOS*, *supra* note 5, at 89, 105.
[12] *Id.* at 90, 105.
[13] *Id.* at 91, 95.
[14] *Id.* at 97, 103.
[15] *Id.* at 105.
[16] *Id.* at 107.
[17] *Id.*
[18] *Id.* at 108.
[19] *Id.*
[20] *Id.*
[21] *Id.* at 91.
[22] *Id.* at 98.
[23] *Id.* at 105.
[24] *Id.* at 106.

Republics (USSR),[25] Algeria,[26] Korea,[27] Denmark,[28] Mongolia,[29] Turkey,[30] and Colombia.[31]

Japan gave three reasons to support her position on the deletion of Article 121(3). First, "it was not right to make distinction between islands according to their size or according to whether or not they were habitable." Second, the 1958 Convention on the Continental Shelf made no distinction between habitable and uninhabitable islands. Third, many states which declared a 200-nautical-mile EEZ did not make such a distinction either.[32] France supported the Japanese proposal to delete Article 121(3), but without providing further explanation. The United Kingdom also proposed that Article 121, paragraph 3 should be deleted because there was no basis in international law to discriminate between different forms of territory for the purposes of maritime zone and such discrimination would conflict with the rights of states in respect of their territories.[33] Brazil gave her support to the British proposal on the ground that there was no logical explanation for Article 121(3).[34] However, Korea had difficulty in supporting the deletion of Article 121(3) because such deletion would undermine the delicate balance achieved through the long process of negotiations on the regime of islands.[35] The USSR was also opposed to amending Article 121 because doing so would destroy the compromise reached at the previous meetings.[36] Romania, the key country in the process of drafting Article 121 at UNCLOS III, submitted a proposal to amend Article 121 by adding a new paragraph 4, which read as follows: "[u]ninhabited islets should not have any effect on the maritime spaces belonging to the main coasts of the States concerned."[37]

Despite the efforts made by some delegations at the UNCLOS III, the regime of islands was dealt with in Part VIII of UNCLOS, which follows exactly the language of the previous draft as appeared in Part VIII of the ICNT. On April 30, 1982, the Convention was adopted. The United States was the only Western industrialized country to vote against the final treaty. Venezuela, Turkey and Israel also voted no. The USSR and most Soviet bloc countries abstained, as did a few highly industrialized Western nations. Most of the West, including France and Japan, joined the Third World and voted yes. Altogether, 130 nations voted to adopt the treaty and open it for signature. The Convention was opened for signature on December 10, 1982 in Montego Bay, Jamaica. It is worth noting that upon signature of the Convention, Iran placed on the records its understanding in relation to certain provisions of the UNCLOS. The main objective for the Iranian submission was to avoid eventual future interpretation of a number of

[25] *Id.*
[26] *Id.* at 107.
[27] *Id.*
[28] *Id.*
[29] *Id.* at 108.
[30] *Id.* at 109.
[31] *Id.*
[32] *Id.* at 90.
[33] *Id.* at 105.
[34] *Id.* at 107.
[35] Summary Records of the 171st Meeting, para. 4, 16 *Official Records of the Third United Nations Conference on the Law of the Sea*, U.N. Sales No. E.84.V.2 (1977).
[36] *Id.* Summary Records of the 170th Meeting, paras. 27.
[37] *Legislative History of Part VIII of the UNCLOS*, *supra* note 5, at 104.

articles of the Convention in a manner incompatible with the original intention and previous positions or in disharmony with national laws and regulations of the Islamic Republic of Iran. One of the understandings is related to Article 121(3), in which Iran stated that

> [i]slets situated in enclosed and semi-enclosed seas which potentially can sustain human habitation or economic life of their own but, due to climatic conditions, resources restriction or other limitations, have not yet been put to development, fall within the provisions of paragraph 2 of article 121 concerning "Regime of Islands", and have, therefore, full effect in boundary delimitation of various maritime zones of the interested Coastal States.[38]

Article 121 of the UNCLOS is concerned with the legal regime of islands. The Convention also contains the codification of the then existing customary rules of international law, which include the rights and obligations of the coastal and other states in the territorial sea, contiguous zone, EEZ, and the high seas. But the three paragraphs under Article 121 of the UNCLOS do not completely have customary international law properties. Paragraphs 1 and 2 of Article 121 stipulate the definition and regulations that regard islands as having territorial sea and contiguous zones. These two paragraphs should be considered customary law because of the observation of state practice after the adoption of the 1958 Geneva Convention on the Territorial Sea and Contiguous Zone, in which most nations accepted being bound by these regulations. Thus even non-parties to the UNCLOS are bound by Article 121, paragraphs 1 and 2. However, given that paragraph 3 of Article 121 has not evolved into a rule of customary international law, its application is restricted to the parties of the UNCLOS. The main reasons for the paragraph not becoming a rule of customary international law are: (1) the lack of state practice; and (2) the lack of *opinio juris*.[39] While Article 121(3) is not considered a rule of customary international law,[40] it is considered general international law[41] applicable to the entire continental shelf regime. Because the continental shelf regime is also an inherent part of the regime of EEZ, Article 121(3) is binding on states that are not parties to the UNCLOS with respect to the EEZ and continental shelf regimes.[42] In the *Jan Mayes* case (Denmark v. Norway), Judge Evensen, in his separate concurring declaration, explicitly affirmed the status of Article 121(3) as part of general international law.[43]

[38] For the declarations made on signature by Iran, see Ocean and the Law of the Sea, Division for Ocean Affairs and the Law of the Sea, "Declarations and Statements", *available at* http://www.un.org/Depts/los/convention_agreements/convention_declarations.htm (last visited Mar. 18, 2011).

[39] R. R. Churchill & A. V. Lowe, *The Law of the Sea* 164 (3d ed. 1999); Jonathan I. Charney, Note and Comment, "Rocks That Cannot Sustain Human Habitation", 93 *Am. J. Int'l L.* 863, 872 (1999).

[40] Customary international law results from a general and consistent practice of states followed by them from a sense of legal obligation.

[41] General international law applies to relations between all states and subjects of international law, such as international organizations. It is universally binding. Its legal basis is normally international customary law and multilateral agreements.

[42] Charney, *supra* note 39.

[43] Maritime Delimitation in the Area between Greenland and Jan Mayen (Den. v. Nor.), 1993 I.C.J. 38, 84 (June 14) (declaration of Judge Evensen).

III. OPINIONS OF THE SELECTED INTERNATIONAL LEGAL SCHOLARS REGARDING THE INTERPRETATION OF ARTICLE 121(3)

Jon M. Van Dyke and Robert A. Brooks have explained that Article 121 of the UNCLOS should be interpreted according to Article 31 of the 1969 Vienna Convention on the Law of Treaties, which provides that "[a] treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose."[44] Because the purposes for establishing coastal EEZs cannot justify claims to EEZs around uninhabited islands situated far away from their coasts, Van Dyke and Brooks have argued that it is not consistent with the main purpose for adopting the UNCLOS for remote rocks or reefs to generate extended maritime zones. Accordingly, only if stable communities of people live on the island and use the surrounding ocean areas, can islands generate ocean space, such as an EEZ or a continental shelf.[45] Van Dyke has argued that from the perspective of history, if a rock or reef cannot sustain human habitation permanently for 50 people, then it cannot claim an EEZ or a continental shelf.[46] Other international legal scholars such as Ely,[47] Pardo,[48] Gidel[49] and Hodgson[50] hold similar views.

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[44] Vienna Convention on the Law of Treaties art. 31, May 23, 1969, 1155 U.N.T.S. 331. Article 31 of the Convention provides:

1. A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose.
2. The context for the purpose of the interpretation of a treaty shall comprise, in addition to the text, including its preamble and annexes:
(a) any agreement relating to the treaty which was made between all the parties in connexion with the conclusion of the treaty;
(b) any instrument which was made by one or more parties in connexion with the conclusion of the treaty and accepted by the other parties as an instrument related to the treaty.
3. There shall be taken into account, together with the context:
(a) any subsequent agreement between the parties regarding the interpretation of the treaty or the application of its provisions;
(b) any subsequent practice in the application of the treaty which establishes the agreement of the parties regarding its interpretation;
(c) any relevant rules of international law applicable in the relations between the parties.
4. A special meaning shall be given to a term if it is established that the parties so intended.

[45] *See* Jon M. Van Dyke & Robert A. Brooks, "Uninhabited Islands: Their Impact on the Ownership of the Oceans' Resources", 12 *Ocean Dev. & Int'l L.* 265, 286 (1983).

[46] Jon Van Dyke & Dale Bennett, "Islands and the Delimitation of Ocean Space in the South China Sea", 1993 *Ocean Y.B.* 54, 79.

[47] Ely stated that "[i]f an island is too small or insignificant to have attracted its owner's national resources, in terms of population and investments, it is too small to serve as a baseline . . . ." Northcut Ely, "Seabed Boundaries between Coastal States: The Effect to be Given Islets as 'Special Circumstances'", 6 *Int'l Law* 219, 233 (1972), *quoted in* Van Dyke & Brooks, *supra* note 45, at 278.

[48] Ambassador Pardo argued that the "equity and reasonableness" that justify the allocation of ocean resources to a coastal state simply do not apply where "no population exists." Arvid Pardo, "An International Regime for the Deep Sea-Bed: Developing Law or Developing Anarchy?", 5 *Tex. Int'l L.F.* 205, 210 (1970), *cited in* Van Dyke & Brooks, *supra* note 45, at 279.

[49] "Gibel tried to define 'habitability' more precisely than others had by stating that to be an 'island' a land formation had to have 'natural conditions' that permitted 'stable residence of organized groups of human beings.'" Van Dyke & Brooks, *supra* note 45, at 286-87 (*citing* 3 B. Gidel, *Le droit international public de la mer* 684 (1934)).

[50] Hodgson stated specifically that he felt the word "rocks" in Article 121(3) should be defined in terms of whether a land formation is habitable. Robert D. Hodgson, "Islands, Normal and Special Circumstances", *in Law of the Sea: The Emerging Regime of the Oceans* 137 (John King Gamble & Giulio Pontecorvo eds., 1973); Robert D. Hodgson & Robert W. Smith, "The Informal Single Negotiation

Jonathan I. Charney adopted a broader interpretation towards the issue of whether rocks can enjoy rights to EEZs or continental shelves under Article 121(3). Charney held that rocks or reefs are a kind of island, and if they are not, then there is no need for Article 121(3) to be included in Part VIII of the UNCLOS. In addition, because Article 121(3) uses the word "or" between "human habitation" and "economic life of their own", it is only necessary to prove that an island or rock can sustain human habitation OR economic activity of its own to be able to claim an EEZ or continental shelf.[51]

After examining the *travaux preparatoires* of UNCLOS III, Charney argued that the habitation referred to in the article does not need to be of a permanent nature, and economic activity does not need to be capable of sustaining a human being throughout the year.[52]. In addition, the economic activity referred to in Article 121(3) can also include industry or exploitation of the living or mineral resources found in the territorial sea of the island or rock in question.[53] Moreover, Charney was of the opinion that this economic activity can be a future condition, based on future technological advances. Profits from ocean minerals could support the equipment and staff necessary to extract the resource and to import energy, food and water for a long period of time. Under these circumstances, can a rock claim an EEZ or a continental shelf according to Article 121(3) of the UNCLOS?[54]

Charney suggested that a feature would not be subject to Article 121(3) if it were found to have mineral resources, such as oil or gas, or other resources of value such as a newly harvestable fishery species, or even a location for a profitable business (such as a casino), whose exploitation could sustain an economy sufficient to support that activity through the purchase of necessities from external sources. Given the compatibility of the French, English, Spanish and Arabic texts of Article 121(3) as well as the ambiguity of the Russian text and the clarity of the Chinese text, Charney held that Article 121(3) of the UNCLOS should be interpreted as permitting the finding of an economic life as long as the feature can generate revenues sufficient to purchase the missing necessities.[55] Charney concluded that changes in circumstances may help those features (reefs or rocks) that are subject to the application of Article 121(3) to obtain the legal status of an island and the right to claim EEZs and continental shelves.[56]

Barbara Kwiatkowska and Alfred H.A. Soons observed that an increasing number of ocean law and policy commentators held the view that a lighthouse or other aid to navigation built on an island gives the island an "economic life of its own" due to its value to shipping.[57] When discussing the issue of when a rock is uninhabitable, E.D. Brown suggests,

Text (Committee II): A Geographical Perspective", 3 *Ocean Dev. & Int'l L.* 225 (1976), *cited in* Van Dyke & Brooks, *supra* note 45, at 283.

[51] Charney, *supra* note 39, at 868.

[52] *Id.*

[53] *Id.* at 869.

[54] *Id.* at 870.

[55] *Id.* at 871.

[56] *Id.* at 876.

[57] Barbara Kwiatkowska & Alfred H.A. Soons, "Entitlement to Maritime Areas of Rocks Which Cannot Sustain Human habitation or Economic Life of Their Own", 1999 *Neth. Y.B. Int'l L.* 139, 167-

> [t]he absence of sweet water might provide such a test; but what if supplies reach the rock from the mainland or a desalination plant is installed? ... [M]ust the rock be able to produce the minimum necessities of life independent of outside supplies before it can be regarded as habitable? Would the presence of a lighthouse keeper, supplied from without, provide evidence of habitability?[58]

Accordingly, Brown commented that " ... Article 121(3) in its present form appears to be a perfect recipe for confusion and conflict."[59]

Barry Hart Dubner cites the following activities in support of the argument that rocks may have an economic life of their own and therefore in accordance with Article 121(3) can generate EEZs and continental shelves: occupying and fortifying the rocks where possible; creating structures and markers; creating scientific research stations of sorts; incorporating the rocks into nearby provinces; publicizing maps showing their respective claims and releasing "historical documents" to back up the territorial claims; allowing tourists and journalists to visit the rocks; granting concessions to oil companies; arresting fishermen; and creating a "tourist resort" complete with hotel and airstrip.[60]

Alex G. Oude Elferink, a senior research associate at the Netherlands Institute of the Law of the Sea, indicates that only islands of a very small size would be characterized as a rock under Article 121(3) of the UNCLOS. While some small island may qualify as such a rock because of their size, they may still be able to sustain human habitation or economic life of their own. In addition, the available arguments indicate that the threshold that has to be met with regard to sustaining human habitation or having economic life of their own is "rather low and almost certainly is lower than the most far-reaching requirement, a stable community."[61] Accordingly, it is not necessary to meet both the requirements of human habitation and economic life at the same time, which indicates that "even if the former criterion is only met by the presence of a stable community, economic life of a rock without a stable community would result in it having an EEZ and continental shelf."[62]

Roger O'Keefe argues that the loose drafting of the regime of islands in the UNCLOS may confound the aspirations of many NIEO-inspired[63] delegates

68, *cited in* Robert Beckman & Clive Schofield, "Moving Beyond Disputes Over Islands Sovereignty: ICJ Decision Sets Stage for Maritime Boundary Delimitation in the Singapore Strait", 40 *Ocean Dev. & Int'l L.* 1, 10 (2009).

58 1 E.D. Brown, *The International Law of the Sea* 150 (1994).

59 *Id.* at 151.

60 Barry Hart Dubner, "The Spratly 'Rocks' Dispute – A 'Rockapelago' Defies Norms of International Law", 9 *Temp. Int'l & Comp. L.J.* 291, 304-05 (1995).

61 Alex G. Oude Elferink, "The Islands in the South China Sea: How Does Their Presence Limit the Extent of the High Seas and the Area and the Maritime Zones of the Mainland Coasts", 32 *Ocean Dev. & Int'l L.* 169, 174 (2001).

62 *Id.*

63 The New International Economic Order (NIEO) was a set of proposals put forward during the 1970s by developing countries through the United Nations Conference on Trade and Development to promote their interests by improving their terms of trade, increasing development assistance, developed-country tariff reductions, and other means. It was meant to be a revision of the international economic system in favor of Third World countries, replacing the Bretton Woods system, which had benefited the leading states that had created it – especially the United States.

at UNCLOS III, because the compromise text of Article 121 allows the appropriation by individual countries of vast swathes of the "common heritage of mankind." By citing the writings of several international legal scholars, O'Keefe indicates that

> [u]nless an unwritten requirement of "natural capacity" were to be imported, Article 121(3) seems to countenance the grant of maritime zones to almost any skerrick of land that is still high and dry when the tide is in. If a country is willing to spend enough money, most islands and even some rocks would be able to support at least token habitation in today's high-tech world.[64]

Jonathan L. Hafetz argues that marine conservation can constitute an economic use within the meaning of Article 121(3) because it can bring net economic benefits and sustainable development through devices such as the establishment of marine and coastal protected areas (MACPAs or MPAs). He gives the following example in support of the argument:

> . . . a State that establishes a marine park or protected area around a pristine coral reef should not be penalized by being forced to forego the expansion of its maritime jurisdiction that it would likely have gained from pursuing a more traditional form of economic development. Instead such States should be given an incentive to preserve the marine environment where such preservation is also economically beneficial and thus consistent with the "economic life" criterion of Article 121(3).[65]

Hafetz is of the opinion that a proposal to establish a marine preserve around a small island can represent an economically beneficial use of the natural resource. The measures taken by states that own the small islands, to protect their surrounding marine environment can yield economic benefits in various forms, including increased fishing stocks, tourist spending, products from coral reefs, and health benefits from reduced pollution. Hafetz indicates that such measures can and should satisfy the "economic life of their own" requirement of Article 121(3), therefore enabling a "rock" to achieve the formal legal status of an "island," and thereby potentially extending a coastal state's continental shelf and EEZ rights. In addition, Hafetz holds that his interpretation of Article 121(3) is consistent with the text of the UNCLOS, the objectives and aims of the Convention, subsequent developments in international law and the public policy of preserving the marine environment where it is economically beneficial to do so.[66]

[64] Roger O'Keefe, "Palm-Fringed Benefits: Island Dependencies in the New Law of the Sea", 45 *Int'l & Comp. L.Q.* 408, 412 (1996).
[65] Jonathan L. Hafetz, "Fostering Protection of the Marine Environment and Economic Development: Article 121(3) of the Third Law of the Sea Convention", 15 *Am. U. Int'l L. Rev.* 583, 626-27 (2000).
[66] *Id.* at 627.

IV. SELECTED EXAMPLES OF STATES PRACTICES

The most often cited disputes arising from the legal status of an island and its right to claim a 200-nautical-mile EEZ or a continental shelf is the dispute between the United Kingdom and its neighboring countries over the legal status of Rockall, which is situated in the North Atlantic Ocean, 160 kilometers from the north-west coast of Scotland and is claimed as English territory. In 1976 the United Kingdom passed the Fisheries Limits Act, drawing a 200-nautical-mile maritime zone extending from its baseline as its exclusive fishing zone. Subsequently, the United Kingdom's maritime maps showed a 200-nautical-mile maritime zone surrounding Rockall,[67] which led to objections being raised by Ireland, Iceland and Denmark. Ireland considered the United Kingdom's actions to be in violation of Article 121(3) of the UNCLOS, which stated that rocks without human habitation or economic life of their own were not entitled to an EEZ or a continental shelf.[68] In 1997, the United Kingdom gave up its claim to a 200-nautical mile EEZ for Rockall when it acceded to the UNCLOS.[69]

French claims of a 200-nautical-mile EEZ for Clipperton Island in the Eastern Pacific Ocean and the application and interpretation of Article 121(3) of the UNCLOS are also closely related to the issues studied in this article. Clipperton Island was named after the English pirate John Clipperton when he escaped to the island to hide. In 1858, France claimed the island. In 1897, Mexico occupied and claimed the island. Subsequently the two countries submitted the dispute to an arbitrator who ruled in favor of France in 1931.[70] In 1979, France proclaimed 200-nautical-mile EEZs around all its islands, including Clipperton Island. This island is an uninhabited coral atoll situated 1,120 kilometers from Mexico and has an area of 6 square kilometers. The only economic activity is tuna fishing in its adjacent waters.[71] In 2009, France submitted the preliminary information indicative of the outer limits of the continental shelf beyond 200 nautical miles of France's Clipperton to the Secretary-General of the United Nations, in which a map shows not only a 200-nautical-mile EEZ surrounding Clipperton, but also two areas of outer continental shelf.[72]

Another potential dispute can be found in Brazil's claim of an EEZ and a continental shelf for Saint Peter and Paul Rocks, which are made up of 12 small volcanic rocks situated in the South Atlantic Ocean, about 950 kilometers north east of Natal in Pernambuco State, Brazil. The tallest is Southwest Rock, 22.5 meters above the water. Saint Peter and Paul Rocks are distributed in an area at sea that is over 350 meters from north to south, and 200 meters from east to west, with a total size of approximately 10,000 square meters. A lighthouse was built on Northwest Rock in 1930, with a height of six meters. Twenty

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[67] Clive Symmons, *The Maritime Zones of Islands in International Law*, 261 (1979).

[68] *Id.* at 126.

[69] Robin Churchill, "United Kingdom Accession to the UN Convention on the Law of the Sea", 13 *Int'l J. Marine & Coastal L.* 263, 271-73 (1998).

[70] *See* Central Intelligence Agency (CIA), "The CIA World Factbook: Clipperton Island", https://www.cia.gov/library/publications/the-world-factbook/geos/ip.htm (last visited Mar. 18, 2011).

[71] *Id.*

[72] For the preliminary information, see "Informations Preliminaires Clipperton 2009 [2009 Clipperton Preliminary Information]", http://www.un.org/Depts/los/clcs_new/submissions_files/preliminary/fra2009infos_preliminaires_clipperton.pdf (last visited Mar. 18, 2011).

meters to the south of the lighthouse is a simple shelter for army personnel and researchers. Could these rocks generate an EEZ or a continental shelf according to Article 121 of the UNCLOS?

On May 17, 2004, Brazil made a submission through the UN Secretary-General to CLCS[73] in accordance with Article 76, paragraph 8 of the UNCLOS,[74] regarding the proposed outer limits of Brazil's continental shelf and its claim of a continental shelf for the Saint Peter and Paul Rocks.[75] There are three figures contained in Brazil's Executive Summary of the submission, which show a 200-nautical-mile EEZ and the outer limit of continental shelf surrounding the Saint Peter and Paul archipelago.[76] No third party notifications had ever been sent to the Secretariat of the United Nations in response to or to challenge Brazil's claim for a 200-nautical-mile EEZ and continental shelf for Saint Peter and Paul Rocks in accordance with Article 121(3) of the UNCLOS. On August 25, 2004, the United States sent a notification regarding Brazil's submission, which highlighted the issues of sediment thickness and the Vitoria-Trindade feature. The United States asked CLCS to examine Brazil's sediment thickness data carefully and to take a cautious approach with regard to the Vitoria-Trindade Feature. There was no mentioning at all about the legal status of Saint Peter

[73] The Commission on the Limits of the Continental Shelf (CLCS) is established in accordance with Annex II of the 1982 UNCLOS. It has 21 members, elected exclusively from states that have ratified the UNCLOS. Members are experts in geology, geophysics, or hydrography. They serve in their personal capacity for a five-year term and are eligible for re-election. The first election took place at the United Nations in March 1997. The Commission may, at its discretion, cooperate with the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization, the International Hydrographic Organization (IHO) and other competent international organizations to exchange scientific and technical information which may help to carry out its responsibilities. The purpose of the CLCS is to facilitate the implementation of the Convention in respect of the establishment of the outer limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured. Under the Convention, the coastal state should establish the outer limits of its continental shelf where it extends beyond 200 nautical miles on the basis of the recommendation of the Commission. The CLCS should make recommendations to coastal states on matters related to the establishment of those limits; its recommendations and actions should not prejudice matters relating to the delimitation of boundaries between states with opposite or adjacent coasts. For more information about the Commission, see UNCLOS, supra note 1, Annex II.

[74] UNCLOS, *supra* note 1, art. 76(8). Article 76(8) provides that

> [i]nformation on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted by the coastal State to the Commission on the Limits of the Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendations to coastal States on matters related to the establishment of the outer limits of their continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.

[75] For the Brazilian submission, see Commission on the Limits of the Continental Shelf (CLCS), "Outer Limits of the Continental Shelf beyond 200 Nautical Miles from the Baselines: Submissions to the Commission: Submission by Brazil", http://www.un.org/Depts/los/clcs_new/submissions_files/submission_bra.htm (last visited Mar. 18, 2011).

[76] For the figures, see "Executive Summary of the submission by Brazil", at 6-8, *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/bra04/bra_exec_sum.pdf (last visited Mar. 19, 2011); "Figure 1 – Chart of the Outer Limit of the Continental Shelf", *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/bra04/bra_outer_limit.pdf (last visited Mar. 19, 2011); "Figure 2 – Chart of Lines and Limits", *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/bra04/bra_lines_limits.pdf (last visited Mar. 19, 2011); "Figure 3 – Map with the Fixed Points at a Distance No Greater than 60M from Each Other", *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/bra04/brafix_ points.pdf (last visited Mar. 19, 2011).

and Paul Rocks.[77] In April 2007, CLCS adopted the "Recommendations of the Commission on the Limits of the Continental Shelf in regard to the submission made by Brazil on 17 May, 2004 on information on the proposed outer limits of its continental shelf beyond 200 nautical miles" by a vote of 15 to 2, with no abstentions.[78] In accordance with Article 76(8), these recommendations "shall be final and binding."[79]

Australia claims a 200-nautical-mile EEZ for Heard Island and the McDonald Islands, which are a volcanic group of barren Antarctic islands located in the Southern Ocean, about two-thirds of the way from Madagascar to Antarctica. There is no permanent human habitation and no indigenous economic activity on these islands. But the Australian government allows limited fishing in the surrounding waters. On 15 November, 2004, Australia made a submission to CLCS, which contained the information on the proposed outer limits of the continental shelf of Australia beyond 200-nautical-miles from the baselines from which the breadth of the territorial sea is measured. The claim included the areas of Australia's continental shelf beyond 200-nautical-mile in the Kerguelen Plateau Region, which extended seaward from the baselines of Heard Island and McDonald Islands.[80]

In April 2008, CLCS adopted its recommendations that confirmed the location of the outer limit of Australia's continental shelf in nine distinct marine regions and Australia's entitlement to large areas of shelf beyond 200 nautical miles.[81] Communications were sent to the Secretary-General of the United Nations by eight countries,[82] asking CLCS not to take any action with regard to the part of Australia's submission that related to the continental shelf appurtenant to Antarctica in the area covered by the Antarctic Treaty of 1959.[83] But no third party notifications had ever been sent by any countries to challenge Australia's claim to a 200-nautical-mile EEZ and continental shelf for the islands that have no permanent human habitation or economic life of their own, such as Heard Island and the McDonald Islands, in accordance with Article 121(3). However, it is worth noting that in the "Volga" case (Russian Federation v. Australia), Judge

[77] "United States of America: Notification Regarding the Submission Made by Brazil to the Commission of the Limits of the Continental Shelf", CLCS.02.2004. LOS/USA, Sept. 9, 2004, *available at:* http://www.un.org/Depts/los/clcs_new/submissions_files/bra04/clcs_02_2004_los_usatext.pdf (last visited Mar. 19, 2011).

[78] *See* "Statement by the Chairman of the Commission on the Limits of the Continental Shelf on the Progress of Work in the Commission – Nineteenth Session", CLCS/54, at 6, para. 22, *available at* http://daccess-ods.un.org/access.nsf/Get?Open&DS=CLCS/54&Lang=E (last visited Mar. 19, 2011).

[79] *See supra* note 74.

[80] *See* "Executive Summary of the Submission by Australia", at 12, *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/aus04/Documents/aus_doc_es_web_delivery.pdf (last visited Mar. 19, 2011).

[81] "Summary of the Recommendations of the Commission on the Limits of the Continental Shelf (CLCS) in Regard to the Submission Made by Australia on 15 November 2004: Recommendations Adopted by CLCS on 9 April 2008", *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/aus04/aus_summary_of_recommendations.pdf (last visited Mar. 19, 2011).

[82] They are: the United States, Russian Federation, Japan, Democratic Republic of Timor-Leste, France, the Netherlands, Germany, and India.

[83] For the communications delivered by the eight countries in response to Australia's submission, see CLCS, "Outer limits of the Continental Shelf beyond 200 Nautical Miles from the Baselines: Submissions to the Commission: Submission by Australia", http://www.un.org/Depts/los/clcs_new/submissions_files/submission_aus.htm (last visited Mar. 19, 2011).

Budislav Vukas of the International Tribunal for the Law of the Sea dissociated himself from all statements or conclusions in the judgment of the case which are based on Australia's claim to a 200-nautical-mile EEZ around Heard Island and the McDonald Islands.[84] Judge Vukas was of the opinion that Heard Island and the McDonald Islands have no right to generate a 200-nautical-mile EEZ in accordance with Article 121(3) of the UNCLOS. In his final remarks in the declaration, Judge Vukas wrote:

> . . . the establishment of exclusive economic zones around rocks and other small islands serves no useful purpose and that it is contrary to international law.
>
> It is interesting to note that Ambassador Arvid Pardo – the main architect of the contemporary law of the sea – warned the international community of the danger of such a development back in 1971. In the United Nations Seabed Committee he stated:
>
> If a 200 mile limit of jurisdiction could be founded on the possession of uninhabited, remote or very small islands, the effectiveness of international administration of ocean space beyond national jurisdiction would be gravely impaired.[85]
>
> The annexed map showing Australia's exclusive economic zone around Heard Island and the McDonald Islands . . . confirms that Ambassador Pardo's fear has been borne out.[86]

In November 2008, Japan made a submission to the CLCS, which contains the information on the proposed outer limits of the continental shelf of Japan beyond 200-nautical-miles from the baselines from which the breadth of the territorial sea is measured in seven distinct areas.[87] Japan's claim in the Southern Kyushu-Palau Region extends southwards from the insular feature Okinotorishima, which consists of "two eroding protrusions no larger than king-size beds"[88] and clearly have no permanent human habitation or economic life of their own.[89] As noted earlier, the Japanese claim was challenged in the third party notifications sent to the Secretary-General of the United Nations by China and the Republic of Korea in February 2009 respectively. By citing Article 121(3) of the UNCLOS, China and the Republic of Korea argued that

[84] The *Volga* Case (Russ. v. Austl.), Prompt Release, Case No. 11, Judgment of Dec. 23, 2002, Declaration of Vice-President Vukas, *available at* http://www.itlos.org/case_documents/2002/document_en_216.pdf (last visited Mar. 19, 2011).
[85] UN Sea-Bed Committee, Doc. A/AC.138/SR.57, p. 167.
[86] The *Volga* Case, Declaration of Vice-President Vukas, para. 10.
[87] They are: the Southern Kyushu-Palau Ridge Region, the Minami-Io To Island Region, the Minami-Tori Shima Island Region, the Mogi Seamount Region, the Ogasawara Plateau Region, the Southern Oki-Daito Ridge Region, and the Shikoku Basin Region.
[88] Jon Van Dyke, Letter to the Editor, "Speck in the Ocean Meets Law of the Sea," *N.Y. Times*, Jan. 21, 1988, at A26.
[89] "Executive Summary of Japan's Submission to the Commission on the Limits of the Continental Shelf", *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/jpn08/jpn_execsummary.pdf (last visited Mar. 19, 2009).

Okinotorishima is not entitled to any continental shelf extending to or beyond 200 nautical miles from the baselines because it is a rock.[90]

The last selected example of state practices concerns the legal status of Snake Island (or Serpents Island) that is situated in the north-western part of the Black Sea, approximately 20 nautical miles to the east of the Danube delta. The island is above water at high tide, has a surface area of approximately 0.17 square kilometers, and belongs to Ukraine. The status of Snake Island was important for delimitation of continental shelf and exclusive economic zones between Ukraine and Romania. If Snake Island were recognized as an island, but not a rock, Article 121, paragraph 2 of the UNCLOS should be applied, which would give Ukraine the right to claim a 200-nautical-mile EEZ and a continental shelf around Snake Island. On the other hand, if Snake Island were not an island, but a rock, then in accordance with Article 121, paragraphs 2 and 3 of the UNCLOS, it does not have the right to draw a 200-nautical-mile EEZ and a continental shelf, but only a 12-nautical-mile territorial sea.

On December 10, 1982, when signing the UNCLOS, Romania made a declaration, the relevant part of which reads as follows:

> Romania states that according to the requirement of equity – as it results from articles 74 and 83 of the Convention on the Law of the Sea – the uninhabited islands without economic life can in no way affect the delimitation of the maritime spaces to the mainland coasts of the coastal States.[91]

The declaration was confirmed upon Romania's ratification of the Convention on December 17, 1996.[92] On 16 September, 2004, the Romanian side brought a case against Ukraine to the International Court of Justice in the dispute concerning the maritime boundary between the two States in the Black Sea.[93]

During the proceedings, the two parties disagreed as to the status of Snake Island and its role played in the delimitation of the continental shelf and EEZs in the Black Sea. Romania claimed that Snake Island is a rock incapable of sustaining human habitation or economic life of its own, and therefore should have no EEZ or continental shelf, as provided in Article 121(3) of the UNCLOS. According to Romania, Snake Island should be treated as a "rock" because: "it is a rocky formation in the geomorphologic sense; it is devoid of natural water sources and virtually devoid of soil, vegetation and fauna."[94] Romania claimed that "human survival on the island is dependent on supplies, especially of water, from elsewhere and that the natural conditions there to not support the

[90] For China's reaction to Japan's submission, see Note Verbale CML/2/2009, *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/jpn08/chn_6feb09_e.pdf (last visited Mar. 19, 2011). For the Republic of Korea's reaction, see Note Verbale MUN/046/09, *available at* http://www.un.org/Depts/los/clcs_new/submissions_files/jpn08/kor_27feb09.pdf (last visited Mar. 19, 2011).
[91] For Romania's declaration, see Ocean and the Law of the Sea, Division for Ocean Affairs and the Law of the Sea, *supra* note 38.
[92] *Id.*
[93] Maritime Delimitation in the Black Sea (Rom. v. Ukr.), 2009 I.C.J. 61 (Feb. 3).
[94] *Id.* para. 180.

development of economic activities."[95] Romania added that "[t]he presence of some individuals, . . . because they have to perform an official duty such as maintaining a lighthouse, does not amount to sustained 'human habitation.'"[96]

Ukraine claimed that Snake Island is indisputably an "island" under Article 121, paragraph 2, of the UNCLOS, rather than a "rock." Ukraine contended that the evidence shows that Snake Island can readily sustain human habitation and that it is well established that it can have an economic life of its own. It was added that Snake Island has vegetation and a sufficient supply of fresh water, and that Snake Island "is an island with appropriate buildings and accommodation for an active population."[97] Ukraine also argued that Article 121(3) is not relevant to the delimitation of EEZ and continental shelf between Romania and Ukraine because this paragraph is not concerned with questions of delimitation but is, rather, an entitlement provision "that has no practical application with respect to a maritime area that is, in any event, within the 200-mile limit of the exclusive economic zone and continental shelf of a mainland coast."[98]

On February 3, 2009, the court delivered its judgment, which divided the sea area of the Black Sea along a line which was between the claims of each country.[99] Disappointedly, the court did not consider issues concerning whether or not Snake Island is an island or a rock, and whether paragraph 2, or paragraph 3 of Article 121 of the UNCLOS should be applied.[100]

V. THE APPLICATION AND INTERPRETATION OF ARTICLE 121(3) TO THE FIVE DISPUTED ISLANDS IN THE SOUTH CHINA SEA

Jonathan I. Charney considered the following existing disputes over the ownership of islands in East Asia to have the potential to give rise to the legal problem concerning the status of an island and its right to claim a 200-nautical-mile EEZ or a continental shelf, and therefore the possible application of Article 121 of the UNCLOS and its interpretation: the Pratas Islands, the Paracel Islands, Scarborough Shoal and the Spratly Islands in the South China Sea, the Diao-yu-tai/Senkaku Islands, Danjo Gunto and certain of the Ryukyu Islands in the ECS, and the Dokdo/Takeshima (Liancort Rocks) Islands in the Sea of Japan/East Sea.[101] In addition, there are other disputed offshore small islands or rocks in East Asia that have the same potential to give rise to the questions concerning the application and interpretation of Article 121(3) of the UNCLOS such as Suyan (Socotra Rock), Bach Long Vi Island, and Pedra Branca/Batu Buteh. If any of these features are "rocks" that fail the tests of habitation and economic viability, they will not be entitled to their own 200-nautical-mile EEZ or continental shelf.

Commentators hold different views on the legal status of the said features. Michael Richardson, for example, suggests that of the Spratly Islands in the

[95] *Id.*
[96] *Id.*
[97] *Id.* para. 184.
[98] *Id*, para. 184.
[99] *Id.* para. 219.
[100] *Id.* para. 187.
[101] Jonathan I. Charney, *supra* note 39, at 863.

South China Sea, perhaps only Itu Aba (Taipin Dao) would meet the definition of being a natural island and therefore can claim a 200-nautical-mile EEZ or a continental shelf.[102] Pan Shiying argued that Nanwei Dao (Spraty Island in English, and Dao Truong Sa in Vietnamese), one of the islands in the Spratly archipelago in the South China Sea, will past the tests contained in Article 121(3) of the UNCLOS, and therefore can have its own 200-nautical-mile EEZ and a continental shelf.[103] By citing the discussion in the writings of Jon M. van Dyke and Dale L. Bennett,[104] and Jeanette Greenfield,[105] Monique Chemillier-Gendreau stated that "most authors have tended to conclude that these islands [the Paracel and Spratly Islands] might well have a territorial sea but that they do not provide entitlement to an exclusive economic zone."[106] Detailed information and further examination are needed to consider the legal status of these disputed offshore islands.

In this section, Yongxing Dao/Dao Phu Lam, Zhongye Dao/Dao Thi Tu/Pagasa (Thitu Island), Danwan Jiao/Celerio/Layang Layang/Dao Hoa Lau (Swallow Reef), Taiping Dao/Dao Ba Binh (Itu Aba, Taiping Island), and Nanwei Dao/ Dao Troung Sa (Spratly Island), are selected for further discussion on the question concerning whether or not they can have their own 200-nautical-mile EEZ or a continental shelf. The positions held by the countries concerned on the status of these disputed offshore islands are also addressed.

Before proceeding to the analysis, it is important to note the following two points: (1) even if the selected disputed offshore islands can be considered as having passed the tests contained in Article 121(3) with regard to sustaining human habitation or having economic life of their own, and therefore can generate 200-nautical-mile EEZs and continental shelves, for these islands to be considered it would not necessarily be an important factor in delimiting the maritime boundary between the countries concerned in the Sea of Japan, the East China Sea, the South China Sea, or in the Strait of Singapore; (2) as pointed out by Ian Townsend-Gault, a logical approach to maritime boundary delimitation in the South China Sea would be to ascertain the 200-nautical-mile limit from the continental land mass or archipelagic baselines of the littoral states, and then ask what impact, if any, the islands in the South China Sea have on such claims.[107] However, it is very difficult to start the process of maritime boundary delimitation before the sovereignty issues are resolved.

A. Yongxing Dao/Dao Phu Lam (Woody Island)

Woody Island is the largest in the Paracel archipelago in the South China Sea. It has been occupied by China since 1974, but also claimed by Vietnam and

[102] Michael *Richardson, Energy & Geopolitics in the South China Sea: Implication for ASEAN & its Dialogue Partners* (2009), *available at* http://www.iseas.edu.sg/aseanstudiescentre/ASC8.pdf (last visited Mar. 19, 2011).
[103] Pan Shiying, *The Petropolitics of the Nansha Islands – China's Indisputable Legal Case* 162 (1996).
[104] Jon M. Van Dyke & Dale L. Bennett, *Islands and the Delimitation of Ocean Space in the South China Sea*, March 13, 1989, mimeographed paper, at 41.
[105] Jeanette Greenfield, *China's Practice in the Law of the Sea* 164 (1992).
[106] Monique Chemillier-Gendreau, *Sovereignty over the Paracel and Spratly Islands* 25 (2000).
[107] Ian Townsend-Gault, "Preventive Diplomacy and Pro-Activity in the South China Sea", 20 *Contemp. Southeast Asia* 171, 179 (1998).

Taiwan. Its size is 2.1 square kilometers, with an artificial harbor, an airfield with a 2,350 meter runway, a bank, post office, small hospital, library, county-level administrative office, and a small number of governmental officials and residents (less than 1,000, but most of them are fishermen). There is a 2,500 tons supply ship (*Qiong Sha 3*) that sails from Wenchang Harbor of Hainan Province to Woody Island twice a month with supplies such as drinking water, vegetables, fruit, meat, generators, toilet paper, etc., and about 300 visitors per trip. The distance between Wenchang Harbor and Woody Island is approximately 180 nautical miles and takes about 15 hours one way.

China issued a declaration on May 15, 1996, declaring straight baselines along parts of its coast, which contains two sets of straight baseline systems. One set of the system encompasses the Paracel Islands, in the northern part of the South China Sea, with 28 basepoints.[108] The archipelagic straight baselines established around the Paracel Islands has been challenged as an violation of the UNCLOS, which provides that only archipelagic states are entitled to the right to establish such baselines.[109] The United States contends that regardless of whose sovereignty the Paracel Islands comes under, straight baselines cannot be drawn in this area.[110] If the straight baselines cannot be established in the Paracel Islands, certainly China can employ the method of normal baselines for the purpose of measuring the breadth of the territorial sea for Woody Island. Based on the aforementioned information about the island, it appears that Woody Island can pass the tests contained in Article 121(3) of the UNCLOS and therefore can have its 200-nautical-mile EEZ and a continental shelf.

B. Zhongye Dao/Dao Thi Tu/Pagasa (Thitu Island)

Thitu Island, or Pagasa, or Zongye Dao in Chinese, and Dao Thi Tu in Vietnamese, is the second largest island, after Taipin Dao (Itu Aba), in the Spratly archipelago and is one of the nine islands occupied by the Philippines in the South China Sea. Its size is approximately 0.33 square kilometers and it is located about 480 kilometers west of Palawan. It has a 1.4 kilometers unconcretized airstrip (named Rancudo Airstrip) which serves both military and commercial air transportation needs. The Philippine Air Force regularly sends fighter jets from Palawan to make reconnaissance missions in Philippine-controlled regions in the Spratly archipelago. The presence of the airstrip in Thitu Island makes such reconnaissance missions easier. There is also a port, called Loneliness Bay. Around 30-50 Filipino soldiers are stationed on the island, together with about 300 civilian people at its height, and nowadays about 55. The Philippine navy vessel sails to Thitu Island once a month to supply the island's daily needs. The island has 20 houses, a community center, a clinic, an eight floor watch tower, desalination plant, several electricity generators, weather station, and mobile launch tower.[111]

[108] The Geographer, Office of the Geographer, Bureau of Intelligence and Research (U.S.), "Limits in the Seas, No. 117, July 9, 1996, China: Straight Baseline Claims", *available at* http://www.law.fsu.edu/library/collection/LimitsinSeas/ls117.pdf (last visited Mar. 19, 2011).

[109] *See* UNCLOS, *supra* note 1, arts. 46, 47.

[110] The Geographer, Office of the Geographer, Bureau of Intelligence and Research (U.S.), *supra* note 108, at 8.

[111] "Fei Lu Bin Chu Xin Ji Lu Qiang Zhan Huang Yan Dao [The Philippines Plans Aggressively to Occupy Huangyen Dao]", *Xinhuanet*, Mar. 3, 2009, http://big5.xinhuanet.com/gate/big5/news.

The island is claimed by China, Vietnam, Taiwan, and the Philippines. In response to the visit of Taiwan's President Chen Shui-bian to the disputed Taipin Dao (Itu Aba) in the Spratly Islands by C-130 cargo plan in February 2008, the Philippines began to renovate Pagasa airstrip in March 2008,[112] which was followed by the visit of Philippine Air Force Chief Lt Gen Pedrito S. Cadungog in May 2008.[113] He and his staff conducted an ocular inspection of the repair and sustained improvements of the Rancudo Airstrip and other minor facilities on the island. In addition, it was reported that the Philippines intended to develop Thitu Island into a tourist destination.[114]

Based on the aforementioned information, it appears that Thitu Island can sustain human habitation and an economic life of its own and therefore pass the tests contained in Article 121(3) of the UNCLOS. Accordingly, whichever country establishes sovereignty over the island can use it as a base point from which a 200-nautical-mile EEZ and a continental shelf are claimed.

C. Taiping Dao/Dao Ba Binh/Ligaw Island (Itu Aba, Taiping Island)

Itu Aba (Taiping Dao in China, Dao Ba Binh in Vietnam, and Ligaw in the Philippines) is the largest of the Spratly Islands in the South China Sea, with a total land area of 0.49 square kilometer. Itu Aba, disputed by China, Taiwan, Vietnam, and the Philippines, is controlled by Taiwan. Administratively it is under the jurisdiction of Kaohsiung City. The distance from Taiwan to the island is about 1,600 kilometers. There is a 1,150 meters long runway completed in late 2007. In February 2008, Taiwan's former president landed on the island by air force C-130 cargo plane to inaugurate the first use of the airstrip. At present, more than 200 coastal guard personnel and a number of soldiers from Taiwan's Navy and Air Force are stationed on the island. Taiwan's Navy and Coastal Guard send vessels regularly to the islands three to four times a year. Cargo vessels of private shipping companies also sail to Itu Aba once or two times a month to supply the island's daily needs. In 2007, the City Government of Kaohsiung, in accordance with Article 45 of Taiwan's Fisheries Law, promulgated the establishment of a sea turtle protected area in Itu Aba. In March 2008, it was proposed by the then presidential candidate May Ying-jeou in his ocean policy to establish a marine peace park in Itu Aba.

Itu Aba is the largest and the only island in the Spratly archipelago with fresh water, and has the capacity to sustain human habitation and economic life of its own. Accordingly, it can be established that it is an Article 121(2) island and thus can generate a 200-nautical-mile EEZ and a continental shelf.

xinhuanet.com/world/2009-03/03/content_10933164.htm. *See also* John M. Glionna, "Squatters in Paradise Say It's Job from Hell", *L.A. Times*, July 26, 2009, *available at* http://articles.latimes.com/2009/jul/26/world/fg-paradise-prison26.

[112] Teresa Cerojano, "Philippines to Fortify Airstrip, Troop Quarters in Spratlys", *The Irrawaddt*, Mar. 28, 2008, *available at* http://www.irrawaddy.org/article.php?art_id=11154 (last visited Mar. 19, 2011).

[113] PAF Press & Broad. Release, Pub. Info. Office, Headquarters Philippine Air Force, "PAF Chief; Staff Visit Pag-Asa", May 1, 2008, *available at* http://www.paf.mil.ph/hq/pio/PR%20MAY%20 2008/PALAWAN%20VISIT%2001MAY08.doc (last visited Mar. 19, 2011).

[114] "Spratly Islands Prepped to be Philippine Tourist Spot", *eTurbonNews*, Apr. 5, 2008, http://www.eturbonews.com/2012/spratly-islands-prepped-be-philippine-tourist.

D. Danwan Jiao/Celerio/Layang Layang/Dao Hoa Lau (Swallow Reef)

Swallow Reef, known as Layang-Layang Island in Malaysia, Danwan Jiao in China, Celerio in the Philippines, and Da Hoa Lau in Vietnam, is an oceanic atoll of the Spratly Islands situated in the middle of the South China Sea, approximately 300 kilometers northwest of Kora Kinabalu, Sabah. It takes a one hour flight from Kota Kinabalu to reach it. The total land area of Swallow Reef is approximately 0.1 square kilometers. In 1992, Malaysia began to develop the island into a scuba diving resort. At present, the island is divided into two sections - one is used by the Malaysian navy, and the other is a scuba dive resort. There is a navy base and a 1,000 meter runway on Swallow Reef.

The Layang Layang Island resort complex is made up of 6 blocks of tropical hardwood timber structure housing 86 well furnished guest rooms. All guest rooms are equipped with remote controlled air-conditioner, telephone, television with in-house videos & programs from regional satellite broadcasts, private hot/cold shower and toilet, 2 queen-sized beds and a private balcony. The reception block houses a lounge bar, reception counter, 150 seat restaurant and a fresh water swimming pool. International telephone and fax services are available. As all guests are on a full board basis, meals are presented daily in either a buffet setting or with set menus with a main focus on Asian cuisine intersperse with international favorites. The island scuba diving resort can also cater to seminars, meetings, conferences and incentive group functions. There are adequate conference and banqueting facilities, with the ability to host up to 200 persons.[115]

The island, claimed by China, Vietnam, Taiwan, and Malaysia, is under Malaysia's control. The Malaysian soldiers are stationed on the island and a number of civilian people, including diving masters and assistants from foreign countries are employed to help run the scuba diving resort from March to September, which are considered the most suitable season for scuba diving activities there. Marius Gjetnes argued that Swallow Reef lacks the capacity to sustain human habitation or economic life of its own, and therefore must be classified as an Article 121(3) rock.[116] However, based on the selected interpretations that were provided in Section III of this article, it seems that the scuba diving resort and the people working on the island can be used as proof of a sustainable human habitation and economic life of its own. Accordingly, it can be argued that Swallow Reef can have an EEZ and a continental shelf. However, it is not clear if the government of Malaysia has made this claim.

E. Nanwei Dao/Dao Troung Sa/Lagos (Spratly Island)

Spratly Island (proper), or Nanwei Dao in China, Dao Troung Sa in Vietnam, and Lagos in the Philippines, is one of the islands in the Spratly archipelago situated southwest of the South China Sea. It is the fourth largest of the Spratly

[115] For information about the Resort, see Layang Layang Island, http://www.avillionlayanglayang.com/ (last visited Mar. 19, 2011).

[116] Marius Gjetnes, The Legal Regime of Islands in the South China Sea (Fall 2000) (unpublished Masters Thesis of Law, University of Oslo, at 81, *available at* http://seasteading.org/seastead.org/localres/misc-articles/GjetnesThesis.pdf (last visited Mar. 19, 2011).

islands and the largest among the Vietnamese-occupied Spratly islands. Its land size is approximately 0.15 square kilometers and has a 600 meter runway, radio launch tower, heliport, two wharves, and about 550 soldiers and civilian people. The island is claimed by China, Taiwan, Vietnam and the Philippines. In 2004, a tourist trip was arranged by the Vietnamese government to visit the Vietnamese-occupied Spratly islands, including Nanwei Dao. It was reported that Vietnam has a plan to develop the island into a tourist site.

Based on the available data, it can be argued that Nanwei Dao can pass the tests contained in Article 121(3) and thus can generate a 200-nautical-mile EEZ and a continental shelf in accordance with Article 121(2) of the UNCLOS.

F. Findings and Suggestions

In order to answer as close as possible the question concerning whether or not the five disputed offshore features in the South China Sea are entitled to a 200-nautical-mile EEZ and a continental shelf under international law, relevant data have been collected and examined in accordance with the requirements provided for in Article 121(3) of the UNCLOS and other factors such as size, contiguity to the principal territory, and geological formation. As shown in Table 1, while the size of Yongxing Dao/Dao Phu Lam (the largest in the Paracel Islands), Taipin Dao/Dao Ba Binh/Itu Aba (the largest in the Spratly Islands), Zhongye Dao/Dao Thi tu/Pagasa/Thitu Island, and Nanwei Dao/Dao Troung Sa (Spratly Island) is smaller than 1 square kilometer, they all have airstrips and soldiers and some have civilian residents, post office, clinic, bank, library, community center and the potential to be developed into marine economic tourist sites; thus they do not appear to fall within Article 121(3). As far as Swallow Reef is concerned, while its size is less than 1 square kilometer, and the scuba diving resort on the island was developed as an a result of artificial construction works done by Malaysia since 1992, it seems that it could have its own 200-nautical-mile EEZ and a continental shelf because of the capability to sustain human habitation and an economic life of its own.

Table 1: Available data for the Five Disputed Offshore Islands in the South China Sea

	Size		Contiguity to the Principle Territory		Geological formation	Human Inhabitation		Economic life of its own				Facilities/ Structures		Maritime disputes
								Yes		No				
	< 1km²	> 1km²	At a greater distance from its principal territory	Within the EEZ of the countries concerned	Rocky elevation	Non-Inhabitated or not inhabitable	Inhabitated or inhabitable	now	future	now	future	Yes	No	Sovereignty Sovereign right Jurisdiction
Yongxing Dao/ Dao Phu Lam		2.1 km²	180 n. m. from Hainan, China	Within China's EEZ			< 1,000	F M E T	O & G			Air Field; bank; Post office; etc.		China, Vietnam & Taiwan
Zhongye Dao/ Dao Thi Tu/ Pagasa (Thitu Island)	0.33 km²		480km from Philippines	High seas or EEZ			300 civilian; 30-40 soldiers	F	M E T			Runway; watch tower; etc.		China, Vietnam, Taiwan, Philippines
Danwan Jiao/ Celerio/ Layang Layang/ Dao Hoa Lau (Swallow Reef)	0.1 km²		300km from KK, Malaysia	High seas or EEZ			Scuba diving resort serving people and diving tourists	M E T				Runway; Navy Base; resort		China, Taiwan, Vietnam, Malaysia
Taiping Dao/ Dao Ba Binh (Itu Aba, Taiping Island)	0.49 km²		1600km from Taiwan	High seas or EEZ			> 230 coast guard and soldiers		M E T			Runway; etc		China, Taiwan, Vietnam, Philippines
Nanwei Dao/ Dao Troung Sa (Spratly Island)	0.15 km²		(not-available)	High seas or EEZ			(Soldiers, but number not available)		M E T			Runway; wharf etc		China, Taiwan, Vietnam

Note: F = Fishing; MET = Marine Eco-Tourism; O&G = Oil and Gas.

VI. CONCLUDING REMARKS

At UNCLOS III, a number of states (including Japan, Brazil and France) proposed or gave their support for the entire deletion of Article 121, paragraph 3, of the draft law of the sea convention. The main reason for the proposal or its support was the concern about the possible maritime space extended from those states that have small but uninhabitable offshore islands located far from their coasts. As stated by Judge Choon-ho Park of the International Tribunal for the Law of the Sea, because islands have different geographical circumstances, ambiguities had to be allowed, in particular, in Article 121(3) of the UNCLOS.[117] Brazil, France and Japan ratified the UNCLOS on December 22, 1988, April 11, 1996 and June 20, 1996 respectively, and bear the treaty obligation to abide by the provisions of the convention, including Article 121(3). However, the lack of precision and official or authoritative clarification of Article 121(3) has led to inconsistent practices among states. The submissions made to the Commission on the Limits of the Continental Shelf by Japan, Brazil, Australia and France, and the recommendations adopted by the Commission to confirm the outer limit of the continental shelves of the states concerned have made it become more confusing with regard to the application and interpretation of Article 121(3). The decision made by the International Court of Justice in the *Case Concerning Maritime Delimitation in the Black Sea (Romania v. Ukraine)* in February 2009 is not considering the issue regarding whether or not Snake Island is an island or a rock also has left "some stones unturned," borrowing the words of Judge Choon-ho Park.[118]

If Japan, Brazil and France are able to claim a 200-nautical-mile EEZ and a continental shelf for the Okinotorishima, Saint Peter and Paul Rocks, and Clipperton Island, respectively, it is difficulty to prevent other countries from not making similar claims. Judging from the recent developments in the Sea of Okhotsk, the Sea of Japan/East Sea, the East China Sea, the South China Sea, and the Strait of Singapore, we can expect to see an increase of maritime disputes in the South China Sea and East Asian seas. Most, if not all, of these disputes will involve the application and interpretation of Article 121(3) of the UNCLOS. The sovereignty issues will further complicate such disputes. In particular, China's EEZ and continental shelf claims in the East China Sea and South China Sea will have great potential to influence maritime international relations in East Asia.

Since no official or authoritative clarification exists with regard to the application and interpretation of Article 121(3) of the UNCLOS, and there are no institutional apparatus established to review, monitor and supervise the signing states' performance of their obligations under the Convention, coastal states are exercising extensive powers to claim larger sea areas by applying or interpreting Article 121(3) in accordance with their national maritime interests. While the regular Meeting of the State Parties to the Law of the Sea Convention (SPLOS) does exist, it is geared toward administrative and financial matters.

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[117] *See* Choon-Ho Park, "The Changeable Legal Status of Islands and 'Non-Islands' in the Law of the Sea: Some Instances in the Asia-Pacific Region", *in Bringing New Law to Ocean Waters* 483, 490-91 (David D. Caron & Harry N. Scheiber eds., 2004).
[118] *Id.*

In addition, there is also an annual review of ocean issues and the law of the sea by the UN General Assembly, which relies on the report prepared by the Secretary-General of the United Nations as well as the recommendations of the Open-Ended Informal Consultative Process of Oceans and Law of the Sea. The General Assembly's annual review occasionally pays attention to national ocean policies and developments related to the UNCLOS, but it does not perform the multitude of tasks carried out by the compliance bodies that are established to assist states to meet the letter and spirit of the Convention's wording.[119] Accordingly, Timo Koivurova suggested that "[i]f UNCLOS had provided an institutional apparatus similar to that of modern conventions, national ocean policies and laws probably would have developed more uniformly and have been more closely related to the wording and expectations of the UNCLOS".[120]

It is hoped that this article has successfully demonstrated the need to develop an agreeable objective test so as to remove all doubt as to which rocks would be affected by Article 121(3). In addition, before Article 121 is amended, the states in the South China Sea area might want to consider the possibility of establishing a special regional organ, such as the institutional ocean space institutions that were proposed by Malta in 1971,[121] or conclude a regional agreement, such as a Regional Code of Conduct in the South China Sea that is being discussed between China and the members of the Association of Southeast Asian Nations (ASEAN), in which the application and interpretation of Article 121(3) is clarified. The coastal states in the region are also encouraged to deal with their maritime disputes by adopting the concept of a "common heritage of mankind" or by taking policy measures to preserve the marine environment through devices like the establishment of marine protected areas or a marine peace park. Last but not least, as suggested by Judge Choon-ho Park 18 years ago, the coastal states neighboring the South China Sea can also learn from the Canadian and American wisdom in dealing with their disputes over the ownership of Machias Seal Island that is situated about 10 miles off the northeast coast of Maine, USA.[122]

[119] Timo Koivurova, "A Note on the European Union's Integrated Maritime Policy", 40 *Ocean Dev. & Int'l L* 171, 172 (2009).

[120] *Id.*

[121] In 1971, a draft ocean space treaty was submitted by Malta to the UN Sea-Bed Committee, in which it was proposed to establish the International Ocean Space Institutions. The institutions may accept from any state the transfer to their administration of reefs, sandbanks, or islands with less than 10,000 permanent inhabitants. Reefs, sandbanks, or islands transferred to the administration of the Institutions shall be used by the Institutions only for international community purposes, such as scientific stations, nature parks or preserves, etc. *Legislative History of Part VIII of the UNCLOS*, *supra* note 5, at 7-8, para. 14(c).

[122] Judge Park wrote:

> Both Canada and the United States claim the ownership of the famous bird sanctuary. Canada has run the lighthouse since 1832, and the United States traces its claims back to the time of the American Revolution. The American and Canadian bird-watching businesses share the trade by landing bird-watching tourists on the disputed island by turns and paying taxes to their respective governments. This is no settlement of the dispute. If the present generation is not wise enough to settle territorial disputes as Chinese leader Deng Xiao-ping wisely noted on the occasion of his visit to Tokyo in October 1978, we in East Asia can learn from the Canadian and American wisdom.

See Choon-Ho Park, "Territorial Disputes Over Uninhabited Islands: The Case of South China Sea", Paper Presented at the South China Sea Meeting, Hong Kong, May 25-30, 1991, at 6.

Annex 882

Yann-Huei Song, "The Potential Marine Pollution Threat from Oil and Gas Development Activities in the Disputed South China Sea/Spratly Area: A Role that Taiwan Can Play", *Ocean Development & International Law*, Vol. 39, No. 2 (2008)

Ocean Development & International Law, 39:150–177, 2008

ISSN: 0090-8320 print / 1521-0642 online
DOI: 10.1080/00908320802013768

Routledge
Taylor & Francis Group

The Potential Marine Pollution Threat from Oil and Gas Development Activities in the Disputed South China Sea/Spratly Area: A Role that Taiwan Can Play

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This article examines the potential threat of marine pollution caused by offshore oil and gas development activities in the disputed areas of the South China Sea (SCS) and the Spratly Islands. After addressing the potential threat of marine pollution, it discusses the legal obligations and political commitment of the SCS littoral states regarding the protection of the marine environment in the area. The role that Taiwan can play in these matters is also examined.

Keywords marine pollution, oil and gas, South China Sea, Spratly Islands, Taiwan

Introduction

On March 14, 2005, representatives from national oil companies of China, the Philippines, and Vietnam signed a Tripartite Agreement for Joint Marine Seismic Undertaking in the Agreement Area in the South China Sea (hereinafter, SCS Tripartite Agreement).[1] Through this Agreement, the three parties expressed their desire to engage in joint research of the petroleum resource potential in the disputed South China Sea/Spratly area (SCS/Spratly area). The joint activities involve seismic work programs, covering an area of about 143,000 square kilometers that is defined in the Agreement by specific geographic coordinates. The Agreement is for 3 years (2005–2007). The three parties affirmed that the conclusion of the SCS Tripartite Agreement does not undermine the positions held by their respective governments on the SCS sovereignty and jurisdiction issues and that the Agreement will contribute to the transformation of the SCS into an area of peace, stability, cooperation, and development in accordance with the 1982 United Nations Convention on the Law of the Sea (hereinafter, UNCLOS)[2] and the 2002 Association of Southeast Asian Nations

Received 3 July 2007; accepted 1 September 2007.
This article was originally presented at the International Workshop on Transboundary Environmental Issues in Southeast Asia, 16–17 November 2006, Academia Sinica, Taipei, Taiwan. The workshop was sponsored by the Center for Asia-Pacific Area Studies, Research Center for Humanities and Social Sciences, Academia Sinica, and the International Institute for Asian Studies, the Netherlands.
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(ASEAN)-China Declaration on the Conduct of Parties in the South China Sea (hereinafter, SCS Declaration).[3]

Due to the conflicting territorial claims and the accompanied problem of overlapping maritime jurisdiction, there have been no oil and gas development activities in the disputed areas of the SCS and the Spratly Islands over the past three decades. Although in May 1992, China's National Offshore Oil Company (CNOOC) signed a contract with Crestone Energy Corporation of the United States in the area near Wan'an Tan (Vanguard Bank) in the Spratly Islands group,[4] no exploration activities were carried out in the contract area mainly because of strong opposition from Vietnam[5] and foreign policy considerations of the government of China.[6]

As a result of the 2002 SCS Declaration between China and ASEAN and the 2005 SCS Tripartite Agreement among the national oil companies of China, Vietnam, and the Philippines, together with the concerns of many countries about their rapidly increasing demand for energy and the potential impact of rising oil prices in the international market on the development of their economy, the likelihood of oil and gas development activities in the disputed SCS/Spratly area has increased significantly.

While the activity could help increase the supply of oil and gas within the region and thus reduce the dependency on importing oil (in particular, from the Middle East), the offshore activity could also lead to serious marine pollution problems in the SCS. Practically all stages of offshore oil and gas exploration and production are accompanied by discharges of harmful substances into the marine environment. Oil and gas development activities in the coastal area of the littoral states of the SCS have already been identified as one of the major sources of marine pollution in the region. The territorial disputes and overlapping jurisdictions within the SCS made it difficult for the countries to adopt an effective cooperative approach to counter the threat of marine pollution arising from offshore oil and gas activities.

The purpose of this article is to examine the potential threat of marine pollution caused by offshore oil and gas development activities in the disputed areas of the SCS and the Spratly Islands. The first section will review briefly the geography of the SCS and the Spratly Islands. After that, estimated oil, gas, and gas hydrates reserves in the SCS/Spratly area will be provided in the second section. This will be followed by a summary of the past and current oil and gas development activities by the main territorial claimants in the SCS/Spratly area (namely, China, Vietnam, the Philippines, and Malaysia) in the third section. The fourth section will look at the potential for oil and gas activities in the SCS/Spratly area. The potential threat of marine pollution in the SCS/Spratly area will be addressed in the fifth section. The sixth section will review the legal obligations and political commitment of the SCS littoral states regarding the protection of marine environment in the SCS/Spratly area. The last section will discuss the role that Taiwan can play in the matters related to prevention and control of marine pollution in the disputed SCS/Spratly area.

Geography of the South China Sea/Spratly Islands

Extending approximately from latitude 3° south to 23° north and from longitude 100° east to 120° east,[7] the SCS is the largest of the six marginal seas that lie between the mainland of Asia and the adjacent offshore islands.[8] The SCS has an area of 648,000 square nautical miles (about 1,200,096 square kilometers). It is surrounded by China, Taiwan, the Philippines, Brunei, Vietnam, Cambodia, Thailand, Singapore, Malaysia, and Indonesia. It connects the Pacific Ocean and the Indian Ocean by narrow outlets such as:

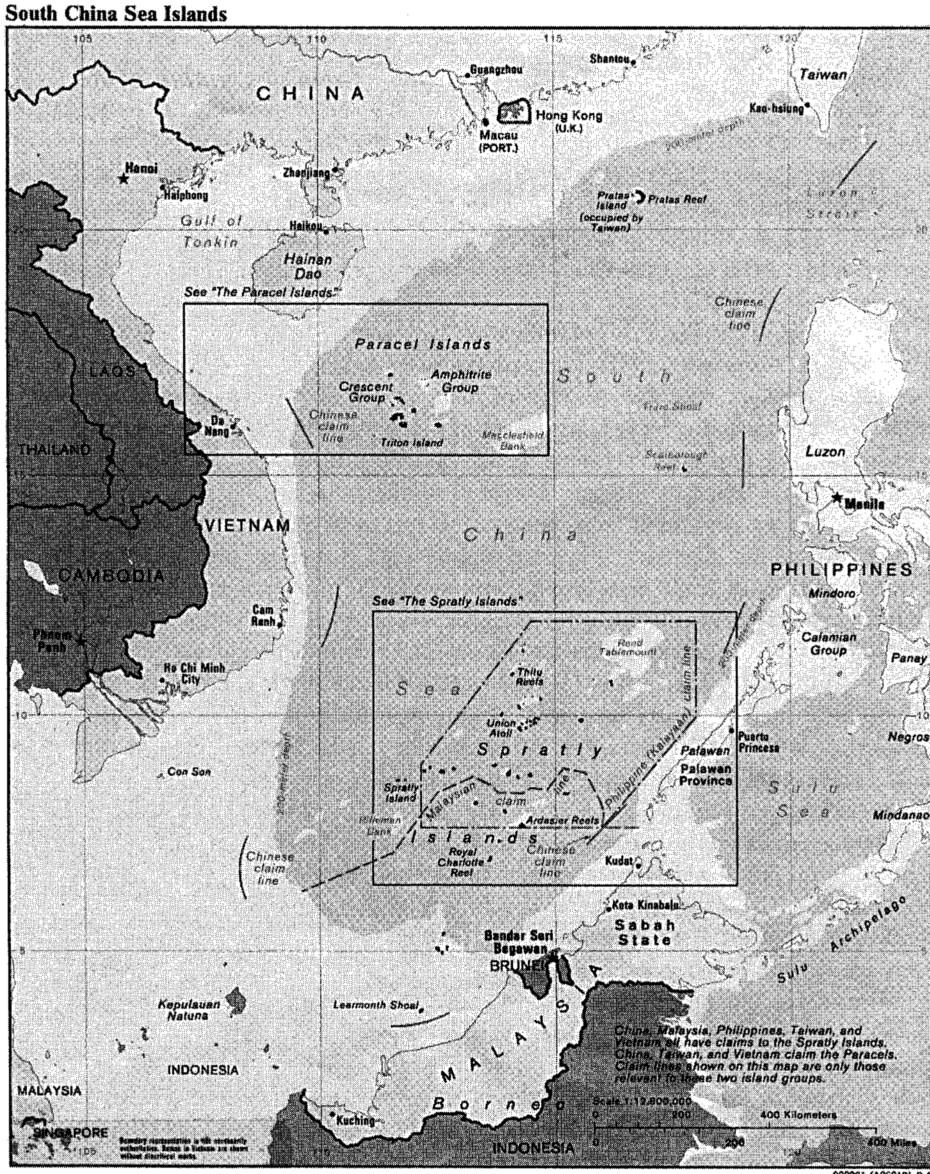

Figure 1. The South China Sea. (*Source:* http://www2.gol.com/users/hsmr/Images/Maps/South_china_sea.jpg).

the Bashi Channels in Luzon Strait, the Malacca Strait, and the Singapore Strait. It consists primarily of the territorial seas and exclusive economic zones (EEZs) of the littoral states mentioned above. The SCS, accordingly, is a semi-enclosed sea as defined in Article 122 of the UNCLOS.[9] (See Figure 1.)

A multitude of islands, atolls, banks, reefs, and shoals, some rising only slightly above the sea surface and others remaining submerged, abound throughout the SCS and are clustered into four large archipelago groups: the Pratas (Dongsha), the Paracels (Xisha in

Chinese, Hoang Sa in Vietnamese), the Macclesfield Bank (Zhongsha), and the Spratlys (Nansha in Chinese, Truong Sa in Vietnamese, and Kalayaan in Filipino).[10] Consisting of more than 235 features, the Spratly Islands are a chain of islands, isles, shoals, banks, atolls, cays, and reefs of which 148 have been named.[11] These features stretch approximately 500 nautical miles from north to south and 400 nautical miles from east to west. Many of these features are almost entirely below the high-tide watermark. Of the 20 islands that protrude above sea level at the high tide, the largest is Taiping Island (Itu Aba), which is only 0.43 square kilometers and has been under Taiwan's control since 1956. The Spratly Islands are situated in the center of the SCS, more than 900 nautical miles south of the Chinese island of Hainan, 230 nautical miles east of Vietnam's port of Nha Trang, 120 nautical miles west of the Philippine island of Palawan, and 150 nautical miles northeast of the Malaysian state of Sabah. The Spratly Islands have no permanent inhabitants and are too small to sustain permanent, independent settlement.

The land and population sizes, political systems, economic situations and performance, and military capabilities of the 10 governments that border the SCS vary markedly. However, they all depend heavily on the use of maritime space and the living and nonliving resources of the sea. In addition, all of the governments have, to a varying degree, disputes regarding the ownership of islands, maritime boundary delimitation, or conflicting maritime jurisdiction within the SCS. These include: the Paracel Islands dispute among China, Taiwan, and Vietnam; and the Spratly Islands dispute among China, the Philippines, Vietnam, Brunei, Malaysia, and Taiwan. Except for the brief periods when France and Japan occupied the Spratly and Paracel Islands during the 1930s,[12] until the mid-1960s there was relative peace and stability in the Spratly Islands and the SCS area. Since the publication of the Committee for the Coordination of Joint Prospecting for Mineral Resources in the Asian Offshore (CCOP) report in 1969, which suggested that there were hydrocarbon resources under the Yellow Sea, the East China Sea, and implicitly the South China Sea,[13] the Spratly Islands have attracted the interest of governments of the littoral countries; in particular, those of the Philippines, Vietnam, and Malaysia. The oil crisis of 1973 hastened the efforts of many of the SCS littoral countries to secure the area's resource potential. Military troops were sent by the Philippines, Vietnam, and Malaysia to occupy numerous of the insular features of the Spratly Islands group. The Philippines occupied Nanshan Island and Flat Island in 1970, Thitu Island, Loaita Island, Northeast Cay, and West York Island in 1971, Panata in 1978, and Commodore Reef in 1980. Vietnam occupied Nam Yit Island, Southwest Cay, Dunqian Shazhou, Spratly Island, Sin Cowe Island, and Amboyna Cay in 1973, and Ranqing Shazhou, Central Reef, and Pearson Reef in 1978. Malaysia occupied Swallow Reef and Ardasier Reef in 1977 and Mariveles Reef in 1979.[14]

In 1974, the Chinese military expelled Vietnamese forces from the Paracel Islands.[15] In March 1988, after a naval skirmish in the waters near Johnson Reef between the People's Liberation army navy and the Vietnamese navy, China began to send troops to occupy several islands in the Spratly archipelago. In 1995 China built octagonal structures, claimed to be fishermen's shelters, on Mischief Reef, which caused a serious dispute between China and the Philippines and raised the concern of the ASEAN member states over a possible escalation of conflict in the SCS/Spratly area.

Domestic legislative measures were also taken by the Philippines, Vietnam, and Malaysia to consolidate their sovereignty and maritime jurisdictional claims. In December 1979, for instance, Malaysia published a map showing its territorial waters and continental shelf boundaries[16] and, in May 1980, proclaimed a 200-nautical-mile EEZ.[17] In June 1978, the Philippines proclaimed Presidential Decree No. 1596, in which Manila declared 33 islands, cays, shoals, and reefs contained in a delimited area (known as Kalayaan) of the Spratly Islands to be Philippine territory.[18] Also in June 1978, under Presidential Decree No. 1599, the Philippines proclaimed a 200-nautical-mile EEZ, claiming sovereign rights over this economic zone for exploration, exploitation, conservation, and management of all natural resources, including the seabed and its subsoil.[19] In May 1977, after approval by its Standing Committee of the National Assembly, Vietnam declared the limits of the country's territorial sea, contiguous zone, EEZ, and the continental shelf.[20] Although no maritime legislative measures were taken by China to bolster its sovereignty and jurisdictional claims in the SCS area during the 1970s, as already noted, in 1974 military action was taken to remove Vietnamese troops from the Paracel Islands. In addition, the Chinese Ministry of Foreign Affairs reacted strongly to a Vietnamese paper entitled "Vietnam's Sovereignty over Hoang Sa (Paracel Islands) and Truong Sa (Spratly Islands) Archipelagoes," issued in September 1979 by the Vietnamese Ministry of Foreign Affairs.[21] The Chinese Foreign Ministry published a document in January 1980 intending to prove China's "indisputable sovereignty over Xisha (Paracel Islands) and Nansha (Spratly Islands)" and to explode "the fallaciousness of the Vietnamese authorities' claims."[22]

During the 1980s and 1990s, actions and counteractions were continuously taken by the countries concerned in the area in support of their sovereign claims in the SCS, such as: occupying certain of the features of the Spratly Islands group, detaining foreign fishing vessels in the disputed waters in the Paracel Islands, placing sovereign markers, constructing new structures on the occupied islands, and issuing political statements. The physical occupation of islands or reefs resulted in a naval skirmish between China and Vietnam in the Spratly Islands in March 1988. In 1995, it was discovered that China had built structures on Mischief Reef and, in 1998, Malaysia occupied three features of the Spratly Islands group. As a result, tension in the SCS/Spratly area escalated and the concern of the member states of ASEAN and non-SCS states (in particular, the United States) over the potential threat to peace and stability in the area increased. The increasing worries led the countries in the SCS area to begin considering the need for cooperative efforts to deal with the threat. In November 2002, ASEAN and the People's Republic of China signed the Declaration on the Conduct of Parties in the South China Sea, in which they agreed to undertake cooperative activities in the SCS in relation to marine environmental protection; marine scientific research; safety of navigation and communication at sea; search and rescue operations; and combating transnational crime such as illicit drugs, piracy and armed robbery at sea, and illegal traffic in arms.[23] There have been new cooperative efforts undertaken by China and the member states of ASEAN during the first half of 2007. However, a full examination of the nature of the overlapping claims within the SCS, the island ownership disputes, the machinations of the governments of the region to calm the dispute while simultaneously maintaining and improving their positions, the recent cooperative efforts undertaken by the countries concerned, and the proposal to conclude further SCS agreements is beyond the scope of this article.[24]

Estimated Oil, Gas, and Gas Hydrate Reserves in the South China Sea/Spratly Area

Although the exact amount of oil and gas deposits in the SCS is unknown, it is believed that the SCS will be a significant source of energy. According to the Ministry of Land and Resources of China, there are more than 200 oil- and gas-bearing structures and oil and gas fields in the SCS.[25] In 1987, the SCS Institute of Oceanology of China conducted a geophysical survey of portions of the Spratly Islands and confirmed the strong evidence of commercial oil fields.[26] In 1989, China conducted another seismic survey in the SCS and estimated that the Spratly Islands area held deposits of 25 billion cubic meters of natural gas and 105 billion barrels of oil.[27] A 2003/2004 Chinese preliminary estimate indicated that the potential oil resources of the SCS/Spratly area could be as high as 23 billion to 30 billion tons with natural gas reserves estimated to total around 980 billion cubic meters.[28]

In 1988, U.S. geologists estimated reserves of 2.1–15.8 billion barrels of oil in the Spratlys.[29] In 1993/1994 the U.S. Geological Survey estimated the sum total of discovered reserves and undiscovered resources in the offshore basins of the SCS at 28 billion barrels.[30] A study done by Russia's Research Institute of Geology of Foreign Countries in 1995 estimated that the equivalent of 6 billion barrels of oil might be held in the same area, of which 70% would be natural gas.[31] Table 1 shows the oil and gas reserves in the SCS compared with other regions.

In addition to oil and gas reserves, it is predicted that gas hydrate[32] reserves exist in 11 target areas in the SCS, which account for approximately half of China's total natural gas reserves onshore and offshore. The reserves are estimated at 40 billion tons of oil and gas equivalent.[33]

Oil and Gas Development Activities in the South China Sea/Spratly Area

The littoral governments of the SCS/Spratly area (in particular, the Philippines, Malaysia, Brunei, and Vietnam) began to explore and develop oil and gas resources in the 1970s. Most of these activities were conducted in areas close to their coasts and, therefore, involved no territorial or jurisdictional disputes with neighboring countries. The Philippines' national oil company conducted collaborative oil and gas activities with Western oil companies, such as Chevron, Texaco, Phillips, Champlin, and Salem, in the area northwest of Palawan. The Philippines also has been looking for oil and gas in the Reed Bank area of the disputed Spratly Islands group since 1976, but with no success yet.[34] Malaysia's oil production occurs offshore and is primarily near Peninsular Malaysia. Production takes place offshore of Sabah (East Malaysia) and Sarawak. Prior to 1976, Malaysia cooperated with foreign oil companies such as Shell, Exxon, and Mobil to explore and develop oil resources in oil fields located offshore Sarawak.[35] In 1976, Shell announced that gas reserves were found in the area 100 miles northwest of Sarawak's Bintulu. Malaysia's main natural gas production occurs in the lower part of the Gulf of Thailand in the Malaysia-Thailand Joint Development Area (JDA) managed by the Malaysia-Thailand Joint Authority (MTJA).[36] Malaysia's production of natural gas has recently been expanded to Sarawak by the Bintulu LNG complex.

Vietnam has developed three oil fields located in the western portion of the Spratly Islands area: Bach Ho (White Tiger); Dai Hung (Big Bear); and Zong (Dragon), which contain 27 million tons, 54–81 million tons, and 21 million tons of recoverable oil reserves, respectively. Another large oil field, Thanh Long (Blue Dragon), which lies next to Dai Hung, was estimated as having oil reserves of 68–204 million tons and a substantial amount of natural gas.[37]

China did not conduct oil and gas exploration and production activities in the disputed SCS/Spratly area in the 1970s and 1980s. All of its oil and gas development activities were carried out in offshore areas near the Pearl River, Hainan Island, and in the Gulf of Beibu (Gulf of Tonkin). The already noted proposed oil and gas exploration activities in 1992 between CNOOC and Creston in the contract area of Wan-an-bei-21 of the Spratly archipelago were not undertaken. Table 2 shows the proven oil and gas reserves as well as

Table 1
Oil and gas in the South China Sea in comparison with other regions

	Proven oil reserves (billion barrels)	Proven gas reserves (trillion cubic feet)	Oil production (barrels/day)	Gas production (billion cubic feet)
Caspian Sea region	15.4–29.0	236.0–337.0	1,000,000	2,846
Gulf of Mexico (U.S.)	2.7	29.4	1,014,000	5,100
North Sea region	16.8	156.6	6,200,000	7,981
Persian Gulf	674.5	1718.0	19,226,000	5,887
South China Sea	7.5	145.5	1,367,000	2,323
West Africa/Gulf of Guinea*	21.5	126.3	3,137,000	200 (est.)

*Region stretching from Côte d'Ivoire to Angola. Proved reserves as of 1/1/1998; 1997 production (Gulf of Mexico reserves 1/1/1997; production 1996).

Source: David Rosenberg, "Environmental Pollution Around the South China Sea: Developing a Regional Response to a Regional Problem," Resource Management in Asia-Pacific, Working Paper No. 20 (Feb. 1999), Table 6, p. 13.

Table 2
Proven oil and gas reserves and production of the South China Sea countries

	Proven oil reserves (billion barrels)	Proven gas reserves (trillion cubic feet)	Oil production (barrels/day)	Gas production (billion cubic feet)
Brunei	1.35	14.1	145,000	340
Cambodia	0	0	0	0
China*	1.0 (est.)	3.5	290,000	141
Indonesia*	0.2	29.7	46,000	0
Malaysia	3.9	79.8	645,000	1,300
Philippines	0.2	2.7	<1,000	0
Singapore	0	0	0	0
Taiwan	<0.01	2.7	<1,000	30
Thailand	0.3	7.0	59,000	482
Vietnam	0.6	6.0	180,000	30
Total	7.5 (est.)	145.5	1,367,000	2,323

*Only the regions near the South China Sea are included. Proved reserves as of 1/1/1998; 1997 production (except Indonesia, where data is as of 1996).

Note: There are no proved reserves for the Spratly and Paracel Islands.

Source: David Rosenberg, "Environmental Pollution Around the South China Sea: Developing a Regional Response to a Regional Problem," Resource Management in Asia-Pacific, Working Paper No. 20, Feb. 1999, Table 5, p. 12.

oil and gas production of the coastal countries in the SCS. Figure 2 provides the location of oil and gas exploration and production sites in the SCS.

In March 2003, China's Guangzhou Marine Geological Survey, Ministry of Land and Resources, signed a cooperation agreement with the German Leibniz Institute of Marine Science to conduct joint surveys of gas hydrate reserves in the continental slopes of Dongsha (Pratas) plateau and Xisha (Paracel) trough. In November 2003, CNOOC announced that a successful appraisal well, Weizhou ("WZ") 11–1-2 in the Beibu Gulf, confirmed commercial oil deposits in the area. In July 2004, China issued licenses to PetroChina for the exploration of 18 deepwater blocks in the SCS, including the Spratly area. The eastern South China Sea is already one of the important crude oil production bases for CNOOC. It is located in the southern part of China, directly southeast of Hong Kong. The crude oil produced in this region is mainly medium or light oil. By the end of 2005, CNOOC had a total of 342 million barrels of oil equivalent (BOE) of net proved reserves in the western SCS, accounting for 14% of the company's total. The average daily net production in the area amounted to 103,741 BOE, or 24% of the company's total. The western SCS is CNOOC's most important natural gas producing area. Two of CNOOC's largest natural gas fields, Yacheng 13–1 and Dongfang 1–1, are located in this region. The Dongfang 1–1 Phase II engineering project was completed in 2005 and commenced production in the first half of 2006. By the end of 2005, a total of 640 million BOE of net proved reserves were confirmed in the region, accounting for 27% of the company's total. The average daily net production amounted to 89,583 BOE, or 21% of the company's total. The major exploration areas in the western SCS include Beibu Gulf, Yinggehai Basin, and Qiongdongnan Basin.

In April 2005, China listed the SCS as one of its 10 major oil and gas strategic sites and decided to make greater efforts in prospecting for deep sea oil and gas reserves.[38] The

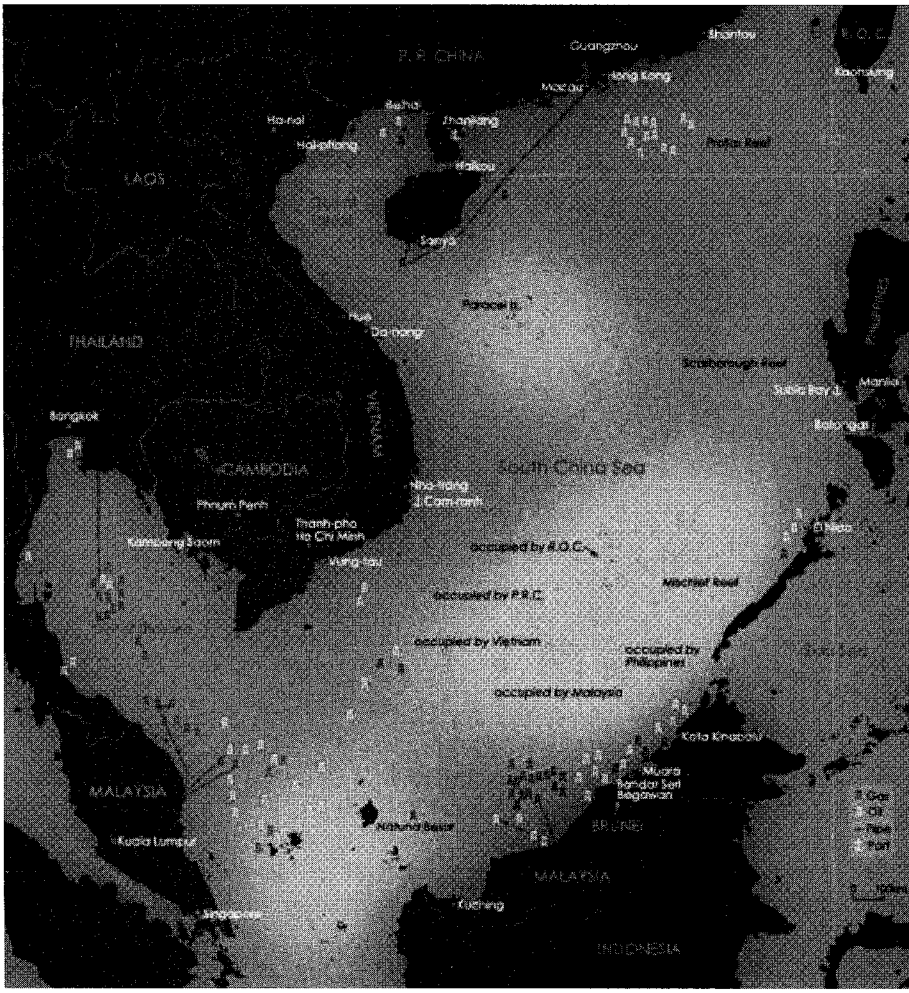

Figure 2. Locations of gas and oil exploration and production sites in the South China Sea. (*Source:* http://en.wikipedia.org/wiki/Image:South_China_Sea.jpg.)

Ministry of Land and Resources has started the work of assessing oil and gas reserves in 14 basins in the southern SCS. In December 2005, Devon Energy Corporation of the United States signed a production-sharing contract (PSC) with CNOOC, covering Block 42/05, approximately 6,939 square kilometers in the Pearl River Mouth Basin of the SCS.[39] In December 2005, ENI discovered an oil field in the SCS, located in offshore block 16/19 in the Pearl Mouth Basin, some 180 kilometers southeast of Hong Kong.[40] In June 2006, the discovery of natural gas reserves exceeding 100 billion cubic meters in the northern SCS in a prospect well numbered LW (Liwan) 3-1-1-, Block 29/26, in the Pearl River Mouth Basin, 250 kilometers south of Hong Kong was announced.[41] In August 2006, CNOOC announced that it will join hands with Husky Oil China Limited in exploring deepwater areas offshore China in the SCS. The two parties signed three PSCs for block 29/06 in the eastern SCS, and Blocks 35/18 and 50/14 in the western SCS.[42] In October 2006, CNOOC announced that it had successfully brought onstream Wei Zhou (WZ) 6-1, an independent

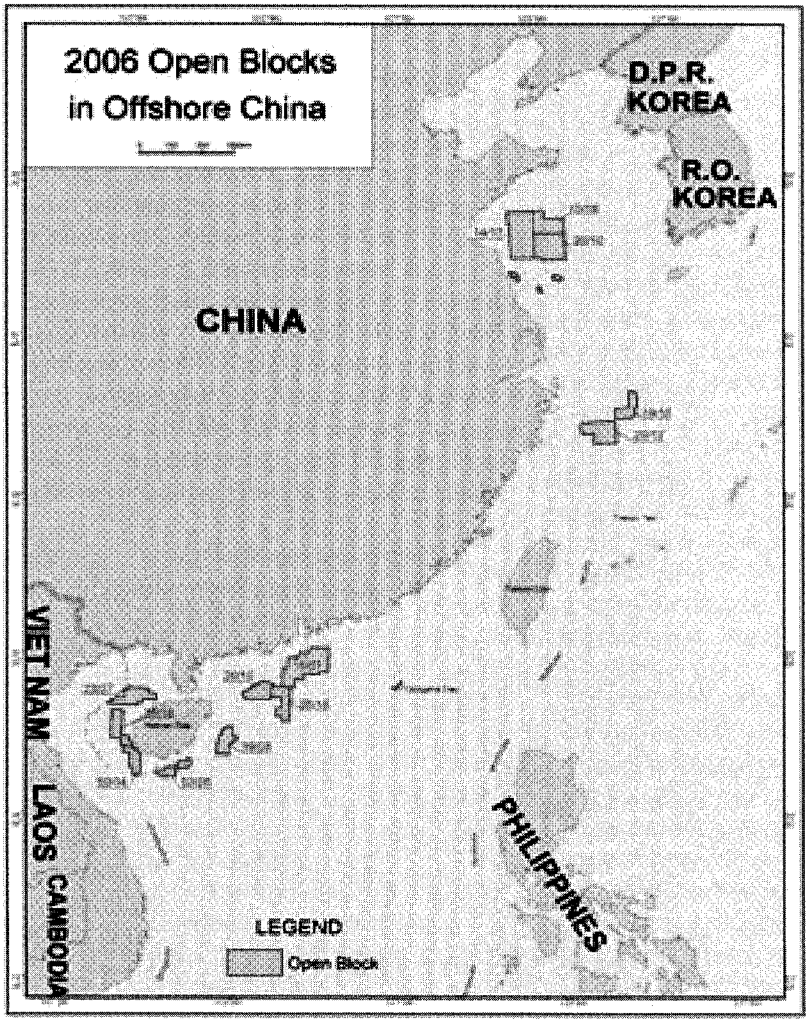

Figure 3. China's National Offshore Oil Company (CNOOC) 2006 open blocks in offshore China. (*Source:* http://www.cnooc.com.cn/defaulten.asp.)

oil field in the western SCS that is currently producing over 2,500 barrels of oil per day.[43] (Figure 3 shows CNOOC's 2006 open blocks in offshore China.)

It was reported in August 2006 that China plans to spend 800 million yuan (US$100 million) over the next decade to study the exploration of natural gas hydrates. China will team up with Germany to sample gas hydrate deposits in the northern part of the South China Sea.[44]

Future Oil and Gas Development Activities in the Disputed Areas of the South China Sea and Spratly Islands

Few oil and gas exploration and production activities have been conducted in the disputed SCS/Spratly area because of the territorial and jurisdictional issues. Without such activity, it is difficult to demonstrate conclusively that oil and gas reserves are indeed abundant in the area.

The few oil and gas production activities that have been conducted in the SCS include the already noted 1992 contract between China and Creston to explore for oil near the Spratly Islands in an area that Vietnam considered its continental shelf. In 1994, Crestone joined with a Chinese partner to explore China's Wan-an-bei-21 (WAB-21 block) in the Spratly Islands. In both cases, Vietnam registered its protest, claiming that the exploration was in Vietnamese waters. In April 1996, Vietnam leased exploration blocks to the U.S. firm Conoco, which covered half of the zone leased to Crestone by China. In March 1997, Vietnam protested after the Chinese Kantan-3 oil rig drilled near the Spratly Islands offshore Da Nang, in an area Vietnam called Block 113. In December 1997, Vietnam again protested after Exploration Ship No. 8 and two supply ships entered the WAB-21 exploration block. All three vessels were escorted away by the Vietnamese navy. In September 1998, Vietnam protested a Chinese report that stated that Crestone and China were continuing a survey of the Spratly Islands and the Tu Chinh region (Wan' Bei in Chinese).[45] More recently, in November 2004, Vietnam asked China to halt oil exploration operations in the Gulf of Beibu close to the Paracel Islands.[46]

There was also a dispute between Malaysia and Brunie, in May 2003, when a patrol boat from Brunei prevented Total FinaElf from undertaking exploration activities in an area offshore from northern Borneo disputed by the two countries.[47]

Despite the unresolved territorial and jurisdictional disputes, oil and gas development activities in the disputed SCS/Spratly area are expected to increase in the near future. Since the late 1990s, there has been an improvement of relations between China and the member states of ASEAN. China's decision not to devalue its currency during the 1997/1998 Asian financial crisis helped member states of the ASEAN regain control of their falling economies. This inaction was much appreciated by the Southeast Asian countries and has led to enhanced cooperative relations with China. In November 1999 at the ASEAN+3 Summit, China agreed to strengthen efforts to accelerate economic, monetary, financial, and political cooperation with member states of ASEAN.[48] In 2000, China issued joint statements respectively with Indonesia, the Philippines, and Vietnam, pledging to promote comprehensive cooperative relations for the twenty-first century.[49] In November 2001 at the Fifth ASEAN+3 Summit, China and the member states of ASEAN agreed to establish a China-ASEAN Free Trade Area.[50] This was followed by the Framework Agreement on China-ASEAN Economic Cooperation in November 2002 signed at the Sixth ASEAN+3 Summit, which serves as the fulcrum for establishing the China-ASEAN Free Trade Area by 2010 for the older members of ASEAN and by 2015 for the new members.[51]

As already noted, in November 2002 China and the member states of ASEAN also signed the Declaration on the Conduct of Parties in the South China Sea, in which the countries involved in territorial disputes in the SCS agreed to exercise self-restraint in the conduct of activities that would complicate or escalate disputes and affect the peace and stability in the area including, among others, refraining from inhabiting presently uninhabited islands, reefs, shoals, cays, and other features and to handle their differences in a constructive manner.[52] In addition, pending the peaceful settlement of territorial and jurisdictional disputes, the counties concerned agree to intensify efforts to seek ways to build trust and confidence between and among them. The Declaration notes that, pending a comprehensive settlement of the disputes, the parties concerned may explore or undertake cooperative activities, which may include marine environmental protection, marine scientific research, safety of navigation and communication at sea, search and rescue operations, and combating transnational crime, including but not limited to, trafficking in illicit drugs, piracy and armed robbery at sea, and illegal trafficking in arms.[53]

In addition to the improvement of political relationship between China and the member states of ASEAN (in particular, between the parties to the territorial and jurisdictional disputes in the SCS/Spratly area), another important reason for an expected increase in oil and gas development activities is the growing concern in the region about energy security and the increasing demand for oil and gas. China's economy could grow by 9% per year for the next 20 years, which would increase China's need for energy resources (in particular, oil and gas). In 2005, China accounted for 31% of the global growth in oil demand and this share is projected to increase to 45% during 2006–2011.[54] To meet the country's rapidly increasing demand for oil, Beijing has been encouraging its state-controlled companies (i.e., the China National Petroleum Corporation (CNPC), the China National Petrochemical Corporation (Sinopec), and CNOOC), to reach exploration and supply agreements with oil producing countries in the Middle East, Central Asia, Latin America, North America, Africa, and the Asia-Pacific. From June 2005 to June 2006, China signed 13 agreements with nine countries for investment in upstream reserves, which were worth a total of US$11.97 billion.[55] China has also expanded its efforts to explore and develop oil and gas resources in its coastal areas in Bohai, Yellow Sea, East China Sea, the Gulf of Beibu, and, in particular, the SCS. In addition, China is to explore gas hydrates resources in the northern part of SCS in May 2007, begin to drill the reserves in 2010–2015, and start commercial production in 2020.[56]

For other coastal states in the SCS/Spratly area, the concern about energy security and the growing demand for oil and gas are the same as China's. In June 2004, at the 9th Asia Oil and Natural Gas Conference, the participating energy officials and experts urged that in order to ensure energy security, Asian countries must establish oil reserve systems, explore new oil resources, and improve market mechanisms to attract foreign investment.[57] In his keynote speech, Datuk Seri Abdullah Ahmad Badawi, prime minister of Malaysia, stated that as traditional oil and gas reserves are depleted in the region, there is a need to explore and develop energy reserves located in remote frontiers and deeper waters. He urged the Asian national oil companies to work together to bridge the existing gaps in Asia's energy security.[58]

Less than 1 year after signing the 2002 South China Sea Declaration, the Philippines and China began to discuss the joint exploration and development of oil and gas reserves located in the Spratly Islands area.[59] In November 2003, CNOOC announced that it had signed an agreement with PNOC, the national oil company of the Philippines, to jointly explore for oil in the SCS/Spratly area.[60] In September 2004, CNOOC announced that an agreement was signed with PNOC, in which the two sides would spend 3 years jointly studying the oil and gas potential in the Spratly Islands area. Philippine officials stated that the agreement reflected the first concrete measure to implement the 2002 SCS Declaration and expressed the hope that Vietnam would also join the project. However, the Philippine officials stressed that the agreement should not be treated as a memorandum of understanding for developing oil in the SCS/Spratly area, but rather should be seen as a marine scientific cooperation project.[61]

The Vietnamese government opposed the China-Philippine agreements claiming that they encroached on Vietnam's sovereign rights. Vietnam's position changed after the visit of Chinese Premier Wen Jiabao to Hanoi in October 2004. In a Joint Communiqué, Vietnam and China indicated that they would abide by the objectives and principles of the 2002 SCS Declaration, exercise self-restraint, and avoid taking any unilateral actions that would complicate the dispute in the SCS/Spratly area.[62] In March 2005, Vietnam joined the Philippine-China cooperative project to study the oil potential in the SCS/Spratly area when its national oil company, PetroVietnam, signed the Tripartite Agreement for Joint Marine Seismic Undertaking in the Agreement Area in the South China Sea with China's CNOOC and the Philippines' PNOC-EC.[63] Under the SCS Tripartite Agreement, a Joint Operating Committee, consisting of executives and technical experts from the three companies, was established with CNOOC in charge of data gathering, PetroVietnam responsible for data consolidation and processing, and PNOC-EC responsible for analyzing the data. The Joint Operating Committee is to report to their respective governments with recommendations.

Vietnam has become more active in the offshore since the signing of the 2005 Tripartite Agreement. In July 2005, Vietnamese Prime Minister Phan Van Khai responded positively to Chinese Premier Wen Jiabao's proposal to speed up the agreed cooperative exploration project in the SCS/Spratly area, stating that Vietnam will cooperate with China and the Philippines to help make progress for the joint project.[64] Vietnamese President Tran Duc Luong made the same commitment during his visit to Beijing in the same month.[65] Cooperation on exploring and developing oil and gas resources in the Gulf of Tonkin between China and Vietnam has been enhanced since the entry into force of the maritime delimitation agreement for the Gulf of Tonkin between China and Vietnam in June 2004.[66] In October 2005, CNOOC and PetroVietnam signed a framework agreement for joint exploration and development of oil and gas resources in the Gulf of Tonkin[67] and, in August 2006, the two countries agreed to undertake more efforts to explore oil structures in the Gulf of Tonkin.[68]

In February 2006, it was reported that oil exploration and development activities would be carried out if the Philippines-China-Vietnam joint study showed that oil deposits existed in the SCS/Spratly area.[69] In April 2006, at the China Offshore Summit held in Shanghai, CNOOC announced that the first stage of the tripartite oil study was completed with positive results. The three state-owned oil companies were to discuss more details about further seismic studies and the signing of PSCs with foreign investment companies.[70] In January 2007, China and the Philippines issued a joint statement agreeing to upgrade the level of tripartite cooperation in exploring oil and gas resources in the agreed SCS/Spratly area.[71]

China has also been encouraging Malaysia and Brunei to join the Tripartite Agreement. While no agreements have been concluded, Malaysia and Brunei have responded positively to China's proposal. In the Joint Communiqué for Cooperation that followed the December 2005 meeting of Chinese Premier Wen Jiabao and Malaysian Prime Minister Abdullah Ahmad Badawi, the two sides stated that they supported the spirit of "putting aside dispute and jointly develop" and agreed to proceed to discussing possibility of joint survey and practical cooperation in the SCS/Spratly area.[72] In March 2006, Malaysia's prime minister again expressed his willingness to discuss the issue concerning joint development of oil resources in the SCS with China.[73] In October 2006, Brunei also agreed to consult with China over the issue of joint development of oil and gas resources in the SCS/Spratly area.[74]

In summary, more oil and gas development activities in the SCS and Spratly Islands, both in the disputed and nondisputed areas, can be expected given that the countries involved in territorial and jurisdictional disputes appear to be willing to put aside the disputes and embrace joint development of the hydrocarbon potential.

The Potential Threat of Marine Pollution in the South China Sea/Spratly Area

From exploration to development, offshore oil and gas operations have the potential to negatively affect the marine environment mainly because practically all the stages of the operations are accompanied by discharges of liquid, solids, and gases into the environment.[75] Four phases of offshore oil and gas development activities carry risks of environmental pollution:

- the preliminary seismic surveying of the potential resource,
- the rig installation and drilling,
- the hydrocarbon production, and
- the transportation of the oil or natural gas.[76]

Once a promising geological structure has been identified, the only way to confirm the presence of hydrocarbons is to drill exploratory boreholes. Wells that are drilled to discover hydrocarbons are called "exploration wells." Where hydrocarbons are discovered and the size of the field established, the subsequent wells drilled are called "development" or "production" wells. From drilling to recovery operations, there is always a risk of impact on the surrounding marine environment, depending on the stage of the process; the size and complexity of the project; the nature and sensitivity of the surrounding environment; and the effectiveness of measures to prevent, mitigate, and control pollution. Potential impacts on the environment from seismic operations (including seismic equipment and vessels) include: noise, emissions and discharges, and interference with other resource users such as fishing. When the exploratory and appraisal drilling processes begin, followed by development and production activities, the surrounding environment can also be affected by: discharges into the ocean (mud, cuttings, wash water, drainage, sewage, sanitary and kitchen wastes, spillages, and leakages); emissions from plant equipment, noise and light, solid waste disposal; by changes in sediment, water and air quality; and the loss of access and disturbance to other marine resource users.[77] Table 3 gives examples of possible sources and severity of marine pollution caused by offshore petroleum exploitation activities.

Due to rapid economic development and population growth, the littoral countries in the SCS/Spratly area are facing large-scale environmental degradation, including a serious problem of marine pollution. Attempts have been made to promote environmental cooperation since 1990 through the Informal Workshop on Managing Potential Conflicts in the South China Sea (the SCS Workshop),[78] under the 1995 ASEAN Cooperation Plan on Transboundary Pollution[79] and the 1997 Jakarta Declaration on Environment and Development,[80] and through the United Nations Environment Programme/Global Environment Facility (UNEP/GEF) project entitled Reversing Environmental Degradation Trends in the South China Sea and the Gulf of Thailand (the UNEP/GEF SCS Project).[81] Nevertheless, little progress has been made; in particular, regarding efforts to deal with the increasing threat of marine pollution in the SCS/Spratly area.

The 1995 ASEAN Cooperation Plan and the 1997 Jakarta Declaration did not address the issue of marine pollution caused by offshore oil and gas development activities. Although in March 2002 a cooperative project, named Expedition Anambas, was implemented under the sponsorship of the SCS Workshop, it was aimed at establishing a collection of the biological specimens as the basis for further studies of the biodiversity in the SCS and had little to do with the cooperative efforts to prevent marine pollution in the region.[82] The UNEP/GEF SCS Project, implemented between January 2002 and March 2007, also did not deal with the problem of marine pollution in the region. The UNEP/GEF project had three priority areas: the loss and degradation of coastal habitats, overexploitation of fisheries in the Gulf of Thailand, and land-based pollution.[83]

Thus far, cooperative measures to address pollution from oil and gas development activities have not yet been considered seriously by the littoral countries in the SCS/Spratly area. As a result of the fast-growing demand for energy resources, increasing efforts to search for offshore oil and gas and nontraditional resources such as gas hydrates, and the lack of national and regional management measures and environmental legislation, the problem of marine pollution in the SCS has and will become more serious and the need to address the threat will become more compelling. In 1999, David Rosenberg warned that the SCS "is becoming a sink for regional environmental pollution."[84] It was also reported, in June 2006, that marine pollution threatens the ecology of the SCS and the call was made for more environmental cooperation.[85]

To prevent and control pollution caused by offshore oil and gas development activities, there is a need to adopt measures that: regulate the level of air emissions; control the amount of liquid effluents discharged; remove solid and hazardous wastes; safely dispose of naturally occurring radioactive materials; and lead to the prevention and prompt correction of leaks from all equipment, facilities, pipelines, and storage facilities during drilling and recovery operations. An effective emergency response plan; oil spill response plan; and a monitoring, reporting, and supervision system are also required.[86] All of the above-mentioned regulatory measures can be taken at the national level. Under global and regional treaties and conventions, if ratified, national governments are obliged to implement the agreed pollution prevention, mitigation, and control measures through national legislation. Some important international environmental treaties include: the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL);[87] the 1982 UNCLOS;[88] the 1985 ASEAN Agreement on the Conservation of Nature and Natural Resources;[89] the 1989 Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (Basel Convention);[90] the 1990 International Convention on Oil Pollution Preparedness, Response and Cooperation;[91] the 1992 Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention);[92] the 1992 Convention on Biological Diversity;[93] and the 1992 United Nations Framework Convention on Climate Change.[94] Table 4 shows the status of ratification of these treaties by the countries bordering the SCS.

Examples of national legislation that may apply to oil and gas development activities are those laws, acts, regulations, or standards that are related to petroleum, planning, environmental protection, environmental impact assessment, clean air and water, waters catchment protection, marine pollution, noise, radiation, chemical exposure, pollution control, discharge and management of wastes, permitted chemicals, control of major hazards, storage and usage of chemicals, public and worker health safety, national parks or protected areas, fishery protection, and marine navigation and safety.[95] Table 5 shows the status of national legislation on land-based pollution of the seven countries that participated in the UNEP/GEF SCS project.

Most, if not all, of the littoral countries in the SCS/Spratly area have specific legislation related to the following type of contaminants: sewage, persistent organic pollutants, radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment, and litter. They also have specific legislation related to the following point sources of pollution: wastewater treatment facilities, industrial facilities, tourism facilities, construction activities, coastal mining, aquaculture, and habitat modification.[96] China, for example, has specific legislation related to the prevention and control of marine pollution caused by offshore oil and gas activities, which includes: the 1983 Regulations on Environmental Protection in Offshore Oil Exploration and Exploitation,[97] the 1996 Law on the Prevention and Control of Water Pollution,[98] the 1996 Law on the Prevention and Control of Environmental Pollution by Solid Waste,[99] and the 2006 Management Regulation

Table 3

Marine pollution likely caused by offshore petroleum exploitation

Operation	Pollution sources					
	Solid waste/ food residue from vessel	Cuttings disposed	Drilling mud discharged	Vessel wastewater drained	Produced formation water drained	Hydrocarbon leakage
Seismic survey	Minor	Nil	Nil	Minor	Nil	Nil
Drilling	Major	Major	Major	Minor	Nil	Major
Development	Major	Nil	Nil	Minor	Nil	Major
Production	Minor food residue	Nil	Nil	Minor	Major	Major

Source: Simon Chen, "Marine Environment Protection for Offshore Oil and Gas Exploration and Production," available at http://www.ncor.ntu.edu.tw/ODBS/odbs_old/iris/apecmrc2/cpc2.html.

Table 4

Status of ratification of selected international treaties related to oil and gas development activities by SCS littoral countries

Int'l treaties or conventions related to oil & gas development	Open for signature	Status of ratification by SCS littoral countries										
		Entry into force	B	C	Ch	I	M	P	S	Ta	Th	V
1. UNCLOS	12/10/ 1982	11/16/ 1994	r	s	r	r	r	r	r	n/a	s	r
2. UNFCCC	6/1992– 6/1993	3/21/ 1994		a	r	s	r	s		n/a	r	r
3. Basel Conv.	3/1989– 3/1990	5/5/ 1992		a	r	a	a	r	a	n/a	r	a
4. MARPO												
Annex I & II	6/1978–5/1979	10/2/1983	a	a	a	a	a	a		n/a		a
Annex III		6/4/ 1987			a	s			a	n/a		
Annex IV		12/31/1988			a				a	n/a		
Annex V		7/1/1992			a	s		a	a	n/a		
5. London Conv.	12/1972–12/1973	8/30/1975			a			r		n/a		
6. POP Conv.	5/2001–5/2002	5/17/2004	s	r	r	s	s	r	r	n/a	r	r
7. CBD	6/1992–6/1993	12/29/1993		a	r	r	r	r	r	n/a	s	r
8. OPRC	11/30/1990	5/13/1995			r		r		r	n/a	r	
9. OPRC-HNS	3/15/2000	6/14/2007							a	n/a		

Abbreviations: UNCLOS, 1982 United Nations Convention on the Law of the Sea; UNFCCC, 1992 United Nations Framework Convention on Climate Change; Basel Conv., 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; MARPO, 1973/1978 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 Relating Thereto; London Conv., 1972 Convention on the Prevention of Marine Pollution of Wastes and Other Matter; POP Conv., 2001 Stockholm Convention on Persistent Organic Pollutants; CBD, 1992 Convention on Biological Diversity; OPRC, 1990 International Convention on Oil Pollution Preparedness, Responses and Cooperation; OPRC-HNC, 2000 Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances; B, Brunei; C, Cambodia; Ch, China; I, Indonesia; M, Malaysia; P, Philippines; S, Singapore; Ta, Taiwan; Th, Thailand; V, Vietnam; a, accession; r, ratification; s, signature; n/a, not UN member and cannot sign or ratify.

Note: Tabulated by the author.

Table 5
The status of national legislation on pollution in the countries bordering the South China Sea

Legislative hierarchy	Country						
	Cambodia	China	Indonesia	Malaysia	Philippines*	Thailand	Vietnam
Legislation	S	G	G	S	S	G	S
Regulation	S	S	S	S	S	G	S
Guidelines	S	G	S	S	S	G	S
Local legal instruments**	G	S	S	S	4	G	S

*Local governments have the authority to issue local legislation in the Philippines.
**Local legal instruments include legislation, regulations, ordinance, bylaws, and declarations, and so forth.
Abbreviations: S, specific; G, general, but applicable.
Source: UNEP/GEF/SCS/RTF-L.1 (2003); Fifth Meeting of the Regional Task Force on Legal Matters for the UNEP/GEF Project, "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand," Batam, Indoensia, 18–21 Sept. 2006, UNEP/GEF/SCS/RTF-L.5/5, p. 3.

on Prevention of Pollution and Damage to the Marine Environment by Marine Engineering Construction Projects.[100]

Although most of the countries bordering the SCS/Spratly area have generally applicable or specific legislation, regulations, guidelines, or local legal instruments to prevent, mitigate, and control land-based pollution, there exist certain constraints and problems in dealing specifically with the threat of marine pollution caused by offshore oil and gas development activities in the disputed SCS/Spratly area. It is difficult, if not impossible, to adopt effective law enforcement measures to regulate the oil and gas development activities in the disputed area because the presence of enforcement officers can be seen as being a provocation. Even though the territorial and jurisdiction disputes can be set aside temporally for the purpose of joint development, there are problems to be resolved, such as conflicting national legislation and differences in law enforcement and management capability.

The SCS/Spratly area where oil and gas development activities are to be carried out is far away from the coastal area. It is beyond the capacity of national law enforcement to ensure effective prevention and control measures. If there are constraints and problems in the efforts to prevent, mitigate, and control pollution in the area close to the coast, more constraints and problems are certain to be found in the remote and disputed SCS/Spratly area.

In summary, there is a compelling need for the littoral countries in the SCS/Spratly area to establish a cooperative mechanism to help prevent and control marine pollution caused by the increasing oil and gas development activities.

Legal Obligation and Political Commitment to Protect the Marine Environment in the South China Sea/Spratly Area

All of the littoral countries in the SCS/Spratly area have ratified or acceded to the 1982 UNCLOS,[101] with the exception of Cambodia, Taiwan, and Thailand, and therefore are bound by the Treaty. As both Cambodia and Thailand signed the UNCLOS, and Taiwan announced that it will voluntarily abide by the Convention, they have indicated a commitment to act in accordance with UNCLOS. In addition, some parts of UNCLOS, such as Part XII (marine environmental provisions) are considered by some to be customary international law and thus even nonparties are bound by it. As already noted, the SCS falls within the legal definition of an enclosed or semi-enclosed sea as set out in Article 122 of the UNCLOS; thus, all of the countries bordering the SCS are bound by Article 123 to cooperate in the exercise of their rights and in the performance of their duties under the Treaty. To this end, the SCS countries should endeavor directly, or through an appropriate regional organization, inter alia, to coordinate the implementation of their rights and duties with respect to the protection and preservation of the marine environment.

Accordingly, the littoral countries bordering the SCS have an obligation to cooperate to adopt measures to prevent, mitigate, and control pollution caused by the oil and gas development activities in the disputed area. Pursuant to Articles 207(1), 212(1), 213, and 222 of UNCLOS, the SCS countries are to adopt laws and regulations on pollution from land-based sources and through the atmosphere, and enforce these laws and regulations. The countries bordering the SCS, under Articles 139, 208, 209, 210, and 214 of UNCLOS, should adopt laws and regulations and take other measures on pollution from seabed activities and from dumping, which should be no less effective than international rules and standards. In accordance with Article 199, they should cooperate in establishing contingency plans against pollution.

The need for measures to address pollution caused by offshore oil and gas development activities has been considered by the UN General Assembly and, for years, has been discussed actively within both the UN Commission on Sustainable Development (CSD) and the International Maritime Organization (IMO). While the CSD concluded in 1996 that "there is no compelling need at this time to further develop globally applicable environmental regulations in respect to exploitation and exploration aspects of offshore oil and gas activities,"[102] the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea, at its third meeting held in April 2002, considered the issue of pollution from offshore oil and gas activities and made a number of recommendations:

- The General Assembly should recommend that regional seas conventions and action plans in regions where offshore oil and gas industries are developing or are in prospect, and where installations do not exist, should develop programmes and/or measures to prevent, reduce and control pollution from offshore installations.
- The General Assembly should invite regional seas conventions and action plans that have developed such programmes and measures to make their information and experience available for this process.
- The General Assembly should invite International Maritime Organization (IMO), United Nations Environmental Programme (UNEP) and World Meteorological Organization (WMO) to undertake an initiative, involving the relevant regional organizations as well as the oil and gas industry, to develop guidance on the best environmental practices to prevent and control pollution from accidents on offshore installations and to mitigate their effects.[103]

There are a number of action plans and programs operating in the Asia-Pacific region, including the SCS/Spratly area that deal with marine environmental matters,[104] including: the Coordinating Body of the Seas of East Asia (COBSEA), East Asian Seas Action Plan and Long-term Strategy;[105] the UNEP/GEF SCS Project's Strategic Action Programme;[106] PEMSEA's Sustainable Development Strategy for the Seas of East Asia;[107] ASEAN's Vientiane Action Programme 2004–2010 (Section 3.3);[108] and Asia-Pacific Economic Cooperation (APEC) 1997 Action Plan for the Sustainability of the Marine Environment.[109] While these action plans involve political commitments to take actions to prevent and control marine pollution, they do not deal specifically with the marine pollution problems caused by offshore oil and gas drilling and recovery activities.

Due to the lack of public awareness of the potential threat, the lack of government commitment, the problem of territorial disputes and overlapping jurisdiction, the lack of domestic coordination and overlapping government authorities, inadequate funding and support facilities, and the lack of information, no subregional or regional cooperative mechanisms have been established to address the pollution from offshore oil and gas activities in the disputed SCS/Spratly area.

A Role That Taiwan Can Play to Deal with the Potential Marine Pollution Problem in the Disputed South China Sea/Spratly Area

Over 90% of Taiwan's oil is imported from the Middle East. As a result of rapid economic development, Taiwan's energy needs have increased from 38.1 million kiloliters of oil equivalent in 1984 to 134.06 million kiloliters of oil equivalent in 2004—an annual average growth rate of 6.5%.[110] Total energy consumption is estimated to increase from 107.8 million kiloliters of oil equivalent in 2004 to 146.3 million kiloliters of oil equivalent in the year 2020—with an average annual growth rate of 2.1%.[111]

To help increase security of its oil supply, the Taiwanese government has developed a plan to encourage offshore oil and gas development. During the 2004 fiscal year, Taiwan's state-owned China Petroleum Corporation (CPC) received funds to carry out the Tainan Kuan-Tien #2 drilling plan and an oil and gas exploration plan in the area of Tainan Basin and Chaoshan Trough located in the western part of the Taiwan Strait.[112]

Taiwan's efforts to explore and exploit oil and gas resources in the SCS/Spratly area have been restrained by the hostile cross-strait relations. The lack of official connections between the Taiwanese and Chinese governments makes it unlikely that they can talk about joint oil and gas development. Taiwan has not been able to develop cooperative plans with other SCS littoral countries that claim part or all of the islands situated in the Spratly archipelagos. Taiwan has been excluded from participating in the official dialogues concerning the SCS issues and from signing the 2002 SCS Declaration. Taiwan's state-owned oil company was excluded from participation in the 2005 Tripartite Agreement that aims to study petroleum resource potential in the disputed SCS/Spratly area.

Taiwan's participation in regional cooperative mechanisms that seek to protect the marine environment of the SCS has also been blocked by the People's Republic of China. The only regional cooperative mechanisms where Taiwan can discuss matters concerning the protection of the marine environment in the SCS/Spratly area are the SCS Workshop and the Asia-Pacific Economic Cooperation (APEC) Marine Resource Conservation and Fisheries Working Groups. However, the potential marine pollution threat caused by offshore oil and gas activities (in particular, in the disputed SCS/Spratly area) has not been considered by the SCS Workshop or the Marine Resource Conservation and Fisheries Working Groups under APEC.

Nevertheless, there exists an opportunity for Taiwan to play a role in the process of preventing the SCS from becoming one of the mostly polluted semienclosed seas in the world. To begin with, Taiwan can help collect information relevant to the offshore oil and gas development activities that have been conducted or are planned to be carried out in the disputed SCS/Spratly area. Taiwan can send vessels from the Coast Guard Administration to monitor and gather information. Taiwan's National Science Council (NSC), or other governmental agencies, such as the Bureau of Energy under the Ministry of Economic Affairs, could provide funding for the study of the potential marine pollution threat from oil and gas development activities in the disputed SCS/Spratly area. In order to promote public awareness of the oil pollution threat in the SCS/Spratly area and its potential impact on the ecological integrity of the SCS, Taiwan should circulate the collected information as widely as possible and publish the results of research projects in international journals. Taiwan can also consider helping to set up a networking system to connect the relevant stakeholders in both the public and private sectors who are concerned with the oil and gas development activities and the potential impact of the activities on the marine environment in the SCS/Spratly area.

Taiwan may also be able to make important contributions in the process of developing a regional or subregional cooperative mechanism that aims to prevent and control oil pollution in the SCS/Spratly area. Taiwan could host workshops, symposia, or conferences that could attract scientists, experts, and energy officials who are interested in studying or are in charge of oil and gas development activities and marine pollution issues. In addition, training programs could also be developed. If Taiwan can convince countries bordering the SCS (in particular, China) to accept the concept of an "environmental cooperative entity," which is similar to the concept of the fishing entity that is set out in Article 1 of the 1995 UN Fish Stocks Agreement[113] and has been accepted by members of the Western and Central Pacific Fisheries Commission (WCPFC),[114] the Commission for the Conservation of Southern Bluefin Tuna (CCSBT),[115] and other regional fisheries management organizations,[116] it would be possible to set up a subregional or regional political cooperative mechanism in which both China and Taiwan participate.

A proposal to enhance cross-strait cooperation to prevent and control oil and gas development activities in the Taiwan Strait and northern part of the SCS (in particular, the area close to the Pratas Islands) is timely because gas and hydrate development activities have been carried out and are certain to increase in the future. This kind of cooperative relationship between Taiwan and China is possible because: (1) no other countries will be involved, which helps to reduce the sensitive political issue; (2) both Taiwan and China are concerned about the potential threat of marine pollution; and (3) there already exist cooperative agreements between the two sides of the Taiwan Strait, which can be applied to the efforts to prevent marine pollution in the Taiwan Strait and the northern part of the SCS/Spratly area.

Conclusion

To meet the growing demand for and reduce the reliance on imported oil from the Middle East, the countries bordering the SCS have increased their efforts to develop potential oil and gas reserves in the waters that are subject to territorial and jurisdictional disputes with neighboring countries (in particular, in the SCS/Spratly area). China, Vietnam, Malaysia, the Philippines, and Brunei have undertaken activities to drill or recover hydrocarbon resources in the area near the Pratas Islands, Paracel Islands, and Spratly Islands. Multilateral efforts have also been taken to study the potential of oil and gas reserves in the disputed SCS/Spratly area, where it is believed that a large amount of hydrocarbon deposits exist.

Due to the improvement in China-ASEAN relations, the territorial and jurisdictional disputes of the SCS/Spratly area are being put aside in order to explore for and develop any oil and gas resources in the disputed area. Following the signing of the 2002 SCS Declaration and the 2005 SCS Tripartite Agreement, the likelihood for joint surveys and development of oil and gas resources in the SCS/Spratly area has increased significantly. It is possible that Malaysia and Brunei may join China, Vietnam, and the Philippines and begin to search for oil in the disputed area in the SCS and Spratly Islands.

While this trend may increase the oil supply for Asian countries, it also has the potential to affect the marine environment in the SCS/Spratly area because practically all stages of offshore oil and gas drilling and recovery operations are accompanied by discharges of liquids, solids, and gases into the environment. The marine pollution problem in the SCS region has already been identified and there have been calls to combat the threat. However, little has been done to prevent and control pollution from oil and gas development activities. Because the marine pollution problem in the SCS/Spratly area is expected to become more serious, there is an urgent need for the littoral countries to work together to deal with the threat.

Taiwan is one of the important stakeholders in the SCS/Spratly area. Although Taiwan has been excluded from the "first track" dialogue process regarding the SCS issues, its right to develop the marine resources in the SCS/Spratly area should be respected and its obligation to protect the marine environment of the area should be noted. To prevent the sensitive political issues from arising, Taiwan should consider the option of designing a flexible cooperative arrangement so that all of the countries concerned in the SCS/Spratly area (in particular, China) are willing to participate and work together.

In anticipation of a subregional or regional agreement establishing a cooperative mechanism to deal with the potential problem of marine pollution in the disputed SCS/Spratly area, Taiwan can take actions to watch closely the oil, gas, and gas hydrate exploration and production activities in the waters southwest of Taiwan, north of the Pratas Islands, and in the agreed tripartite joint seismic survey area in the Spratly Islands of the SCS. Actions can also be taken to assess the potential threat of marine pollution in the above-mentioned areas. Taiwan should speed up its search for energy resources in the SCS/Spratly area but, at the same time, consider the need to adopt relevant laws and regulations to deal with the potential threat of marine pollution caused by oil and gas development activities.

In terms of developing a subregional or regional cooperative mechanism to address the marine pollution from oil and gas development activities, Taiwan should raise the concern at regional organizations or programs that deal with marine environmental protection issues, such as APEC and the SCS Workshop. A new concept of "environmental cooperation entity" could be proposed to allow for the inclusion of Taiwan in any new subregional or regional cooperative mechanism to address the problem of marine pollution caused by oil and gas development activities in the SCS/Spratly area.

Notes

1. The details of the agreement are not available to the public due to the political sensitivity involved and considerations of commercial secrecy. See "Oil Companies of China, the Philippines and Vietnam Signed Agreement on South China Sea Cooperation," available at http://www.fmprc.gov.cn/eng/wjb/zwjg/zwbd/t187333.htm.

2. Adopted on April 30, 1982, opened for signature December 10, 1982, and entered into force November 16, 1994, 1833 *U.N.T.S.* 397. As of April 1, 2008, 155 countries or entities had ratified, acceded to, or accepted the Convention.

3. For the text of the declaration, visit the Web site of the ASEAN at http://www.aseansec.org/13163.htm.

4. See Barry Wain, "Beijing and Hanoi Play with Fire in SCS," *The Asian Wall Street Journal*, July 20, 1994, p. 5.

5. In July 1992, the Vietnamese Foreign Ministry issued a statement protesting that the contract between China's National Offshore Oil Company and the U.S. Creston Energy Corporation "seriously violated Vietnam's sovereign rights over its continental shelf and exclusive economic zone." See "China Stirs the Pot," *Far Eastern Economic Review*, July 9, 1992, p. 14.

6. In early 1992, Vietnam was about to be admitted to the Association of Southeast Asian Nations (ASEAN) and China was concerned about its overall relationship with Vietnam and the member states of ASEAN.

7. Hal Olson, "Marine Traffic in the SCS," *Ocean Yearbook* 12 (1996): 137.

8. The six marginal seas are: the Andaman Sea, the SCS, the East China Sea, the Sea of Japan, the Sea of Okhotsk, and the Bering Sea. J. R. V. Prescott, *The Maritime Political Boundaries of the World* (London: Methuen, 1985), 209.

9. Article 122 of the 1982 UNCLOS provides that "enclosed or semi-enclosed sea means a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States."

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14. See Pan Shiying, "The Nansha Islands: A Chinese Point of View," *Window*, Sept. 3, 1993, table on p. 29.

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Annex 883

I. White & T. Falkland, “Management of freshwater lenses on small Pacific islands”, *Hydrogeology Journal*, Vol. 18 (2010)

Management of freshwater lenses on small Pacific islands

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Abstract The nature of shallow aquifers and the impacts of seawater intrusion in small islands within the Pacific Ocean are reviewed. Many Pacific islands rely on shallow fresh groundwater lenses in highly permeable aquifers, underlain and surrounded by seawater, as their principal freshwater source. It is argued here that, in small islands, the nature of fresh groundwater lenses and their host aquifers coupled with frequent natural and ever-present anthropogenic threats make them some of the most vulnerable aquifer systems in the world. A simple steady-state approximation is used to provide insight into the key climatic, hydrogeological, physiographic, and management factors that influence the quantity of, and saline intrusion into freshwater lenses. Examples of the dynamic nature of freshwater lenses as they respond to these drivers are given. Natural and human-related threats to freshwater lenses are discussed. Long dry periods strongly coupled to sea surface temperatures impact on the quantity and salinity of fresh groundwater. The vulnerability of small island freshwater lenses dictates careful assessment, vigilant monitoring, appropriate development, and astute management. Strategies to aid future groundwater sustainability in small islands are presented and suggested improvements to donor and aid programs in water are also advanced.

Keywords Freshwater lens · Salinization · Island hydrogeology · Climatic variability · Groundwater management

Received: 28 February 2009 / Accepted: 2 September 2009
Published online: 11 November 2009

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Introduction

There are about 1,000 populated small islands in the Pacific Ocean, most of which are located in the tropical and sub-tropical zones of the central and southern Pacific (see Fig. 1). In many of these islands, groundwater is the main source of freshwater whose availability is often limited and whose quality is frequently compromised. Both the quantity and quality of island groundwater depend on the mixing and intrusion of seawater into the fresh groundwater and also on human activities. The amount of fresh groundwater available to island communities depends on a delicate balance between consumptive use and climatic, hydrogeological, and physiographic factors, particularly restricted island areas. The land area of many small islands is often less than 10 km^2 while in most atoll islands, areas are frequently less than 1 km^2 and their characteristic widths are often less than 1 km (Dijon 1983). Because of the high soil and regolith permeability of many small coral and sand islands, surface water is scarce or non-existent. Groundwater in small islands occurs as "fresh groundwater lenses", relatively thin veneers of fresh groundwater overlying seawater in highly permeable, phreatic aquifers. These lenses, which are vital to small island communities, are extremely vulnerable to both natural variations and changes and human-caused perturbations and, because of this, require careful assessment, vigilant monitoring, and astute management (White et al. 1999b; van der Velde et al. 2007).

This paper outlines the nature of freshwater lenses on islands in the Pacific Ocean, summarizes natural and anthropogenic threats to their groundwater resources, and describes management strategies to sustain these resources.

Some of the physical characteristics of selected Pacific Island Countries (PICs) are listed in Table 1. Most PICs in Table 1 have some very small islands and all use groundwater to some extent. There are many other small islands within larger countries near the Pacific Rim that have a similar range of geological types to those in Table 1. In some of these small islands, population densities can be as high as 12,000 people/km^2 posing major resource management problems, particularly for shallow fresh groundwater lenses (see Fig. 2).

This paper firstly discusses the nature and characteristics of freshwater lenses in small islands and uses a simple, steady-state analysis to demonstrate the key factors that determine the quantity of fresh groundwater and its salinity. Then examples are given of how both natural and anthro-

 DOI 10.1007/s10040-009-0525-0

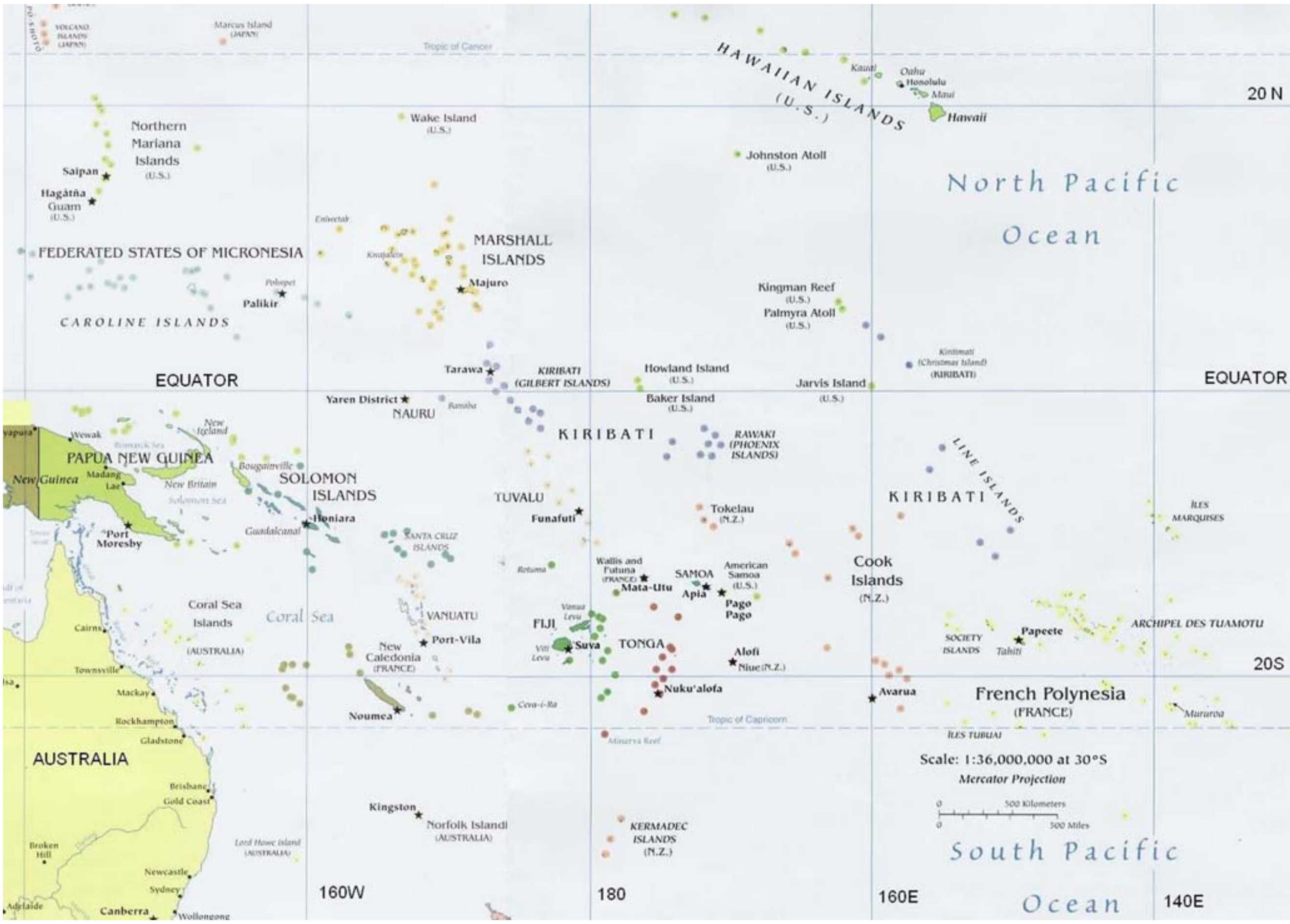

Fig. 1 Small island countries in the central and southern Pacific Ocean [with permission from Pacific Islands Applied Geoscience Commission (SOPAC)]

pogenic factors impact island groundwater and of the main threats to small island groundwater systems. Finally, strategies to conserve and manage fragile small island groundwater systems to ensure their sustainability are discussed.

Nature and characteristics of freshwater lenses

Freshwater lenses occur principally on low-lying carbonate islands where unconsolidated sands and gravels have been deposited unconformably on ancient karst limestone reefs as, for example, in Kiribati, Marshall Islands, Tuvalu, Tokelau, and parts of the Cook Islands, French Polynesia, Hawaiian Islands, Papua New Guinea, and Tonga (see Fig. 1). Others are on limestone islands of uplifted reef deposits as in the island states of Nauru and Niue and a number of islands in Tonga. An excellent overview of the geology and hydrogeology of carbonate islands is provided by Vacher and Quinn (1997). Less common are freshwater lenses on volcanic islands where variations in permeability of the regolith enable coastal aquifers to occur in some parts of the island but not in others. In Table 1, islands where freshwater lenses are known to occur are shown in *italics* in the right-hand column. Detailed field assessments and studies of the nature and dynamics of many freshwater lenses have been published, especially during the past 30 years, as cited in Vacher and Quinn (1997), UNESCO (1991) and other papers referenced here. Many other studies are described in unpublished reports.

The lower boundary between freshwater and underlying seawater in the thin lenticular groundwater body is not sharp as envisaged by the classical 'Ghyben-Herzberg' model (Badon Ghijben 1889; and Herzberg 1901). Rather, the lower boundary occurs as a wide transition or mixing zone where groundwater salinity increases with depth from freshwater to seawater (see Fig. 3) due to mechanical mixing and dispersion. The practical limit of the base of the freshwater zone of the lens is defined by some measure of groundwater salinity acceptable for human use such as the World Health Organization's drinking-water guidelines for chloride ion concentration of 250 mg/l (WHO 2004) or an equivalent electrical conductivity, EC (often reported in μS/cm) used routinely to measure groundwater salinity in the field.

Climatic, hydrogeological, and physiographic factors affecting freshwater lenses

A simple, steady-state analysis provides insight into the factors that influence the quantity and salinity of fresh-

 DOI 10.1007/s10040-009-0525-0

Table 1 Summary of island data for selected Pacific Island Countries (see Fig. 1). Islands where freshwater lenses are known to occur are shown in *italics*

Country	Sub-region	Approximate population (2006–2007)	Total land area (km^2)	Number of islands or atolls	Island type according to geology
Cook Islands	Polynesia	22,000	240	15	Volcanic, volcanic and limestone, *atoll*
Federated States of Micronesia	Micronesia	108,000	702	607	Volcanic, *atoll*, mixed
Fiji	Melanesia	919,000	18,300	300 (approx.)	Volcanic, limestone, *atoll*, mixed
Kiribati	Micronesia	108,000	810	33	*32 atolls or coral islands, 1 limestone island*
Nauru	Micronesia	11,500	21	1	*Limestone*
Niue	Polynesia	1,600	260	1	*Limestone*
Palau	Micronesia	21,000	458	200 (approx.)	Volcanic, some with limestone
Papua New Guinea	Melanesia	5,800,000	453,000	?	Volcanic,*limestone, coral islands and atolls*
Republic of Marshall Islands	Micronesia	62,000	181	29	*Atolls and coral islands*
Samoa	Polynesia	214,000	2,930	9	Volcanic
Solomon Islands	Melanesia	567,000	28,000	347	Volcanic,*limestone, atolls*
Tonga	Polynesia	117,000	748	171	Volcanic,*limestone, limestone and sand*, mixed
Tuvalu	Polynesia	12,000	26	9	*Atolls*
Vanuatu	Melanesia	212,000	12,200	80	Predominantly volcanic with coastal sands and limestone

Populations (shown to nearest 1,000 where greater than 20,000 and the nearest 100 for less than 20,000) are from data and estimates for 2006 or 2007 (SOPAC 2009). Land areas are from SOPAC website. The number of islands is from various sources including National Environment Management Strategies (NEMS) for PICs. Some numerical differences were noted between different data sources

water lenses on small islands. The expression for the maximum thickness of a freshwater lens to an assumed sharp interface between fresh and saltwater, H_u (m) in the centre of a circular uniform island is approximated by (Volker et al. 1985):

$$H_u = \frac{W}{2}\left[(1+\alpha)\frac{R}{2K_0}\right]^{1/2} \qquad (1)$$

where W (m) is the width of the island, $\alpha = (\rho_s - \rho_0)/\rho_0$ with ρ_S, ρ_0 the densities (tonne/m^3) of sea and freshwater, respectively, R (m/y) the mean annual groundwater recharge rate and K_0 (m/y) the assumed uniform, horizontal saturated hydraulic conductivity of the phreatic aquifer.

Equation (1) predicts that wider islands should generally have thicker freshwater lenses than narrower islands and islands with higher groundwater recharge rates should also have thicker lenses than those with lower recharge. Equation (1) also shows that islands whose phreatic aquifers have high saturated hydraulic conductivities should have thinner freshwater lenses than those with lower K_0. For a typical island 1 km wide with a recharge rate of 1 m/year and a K_0 of 1,300 m/year (~4×10^{-5} m/s), Eq. (1) predicts the average thickness of

Fig. 2 Betio Island, Tarawa Atoll, Kiribati has a population density of about 12,000 people/km^2. Pollution of the fresh groundwater lens by human settlement here has made it unfit for consumption

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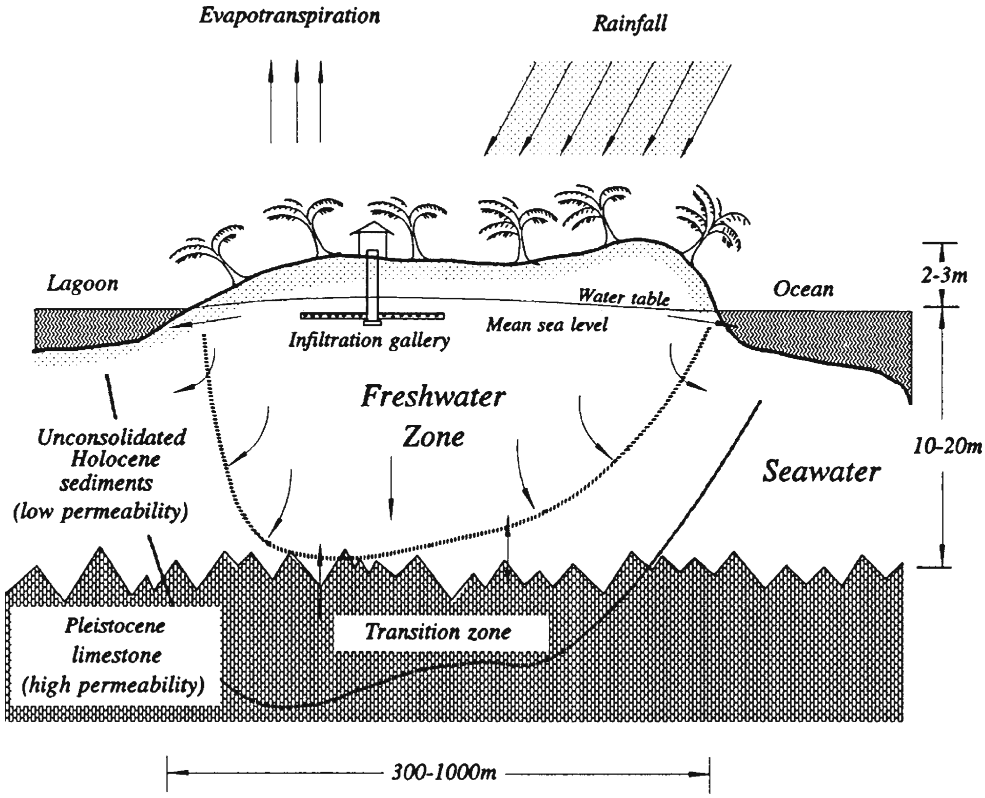

Fig. 3 Exaggerated vertical scale cross section through a small coral island showing the main features of a freshwater lens including the transition zone and the location of an infiltration gallery used for groundwater abstraction

the freshwater lens to the sharp interface should be about 10 m.

In the sharp interface model, the elevation of the water table above mean sea level (m.s.l.), h_0 (m) is governed by the density difference between fresh and seawater:

$$h_0 = \frac{\alpha}{\alpha + 1}.H_u \tag{2}$$

Water-table elevations are typically of order 0.2–0.5 m above m.s.l. and vary with changes in recharge.

In practice, islands are neither circular nor uniform. Islands lying within the cyclone belt generally have very coarse unconsolidated sediments and large hydraulic conductivities such as those in Tuvalu (Fig.1). These islands often have very limited or no viable freshwater lenses, consistent with Eq. (1). Freshwater lenses on atoll islands are often asymmetric with the deepest portion often displaced towards the lagoon side of the island (Figs. 3 and 4), due to cross-island differences in permeability. Figure 4 shows an example of an asymmetric freshwater lens on the island of Bonriki on Tarawa Atoll, Kiribati.

Islands in the Pacific are often subject to prolonged El Niño Southern Oscillation (ENSO) and related droughts of up to 44 months duration. To a first approximation, Eq. (1) can be used to estimate the impact of long droughts on the thickness of freshwater lenses. If H_d (m) is the thickness under a prolonged period of drought with recharge R_d (m/y), then: $H_d/H_u = (R_d/R)^{1/2}$. In a prolonged drought, if recharge is decreased to 25% of the mean recharge, the thickness of the freshwater lens should be reduced by about 50%.

Volker et al. (1985) provide an approximate, steady-state approach to predicting the width of the salinity transition zone under a freshwater lens based on the work of Wooding (1963, 1964) who examined two-dimensional flow in freshwater overlying saltwater. The ratio of the mean width, δ_u (m), of the transition zone to the mean maximum freshwater lens thickness at the center of a lens in a low coral island in the absence of pumping can be written as:

$$\frac{\delta_u}{H_u} = \frac{K_0}{R}\left(\frac{D}{\alpha\, WK_0}\right)^{1/2} \tag{3}$$

Here D (m^2/y), is the dispersion coefficient. Equation (3) predicts that the relative thickness of the transition zone will increase as K_0 increases and decrease with increasing island width and increasing recharge rate. At low recharge rates, the width of the transition zone may equal the thickness of freshwater. This is important if the lens is used as a freshwater source since the practical thickness of usable freshwater, H_{wu} is approximately $H_{wu} = H_u - \delta_u/2$. Usable freshwater zones are typically, about 5–20 m thick, with transition zones of similar thickness. Where freshwater zones are less than about 5 m thick, transition zones are often thicker than the freshwater zone. Useable freshwater lenses exist when $\delta_u < 2H_u$ or $R/K_0 > (1/2)(D/[\alpha WK_0])^{1/2}$.

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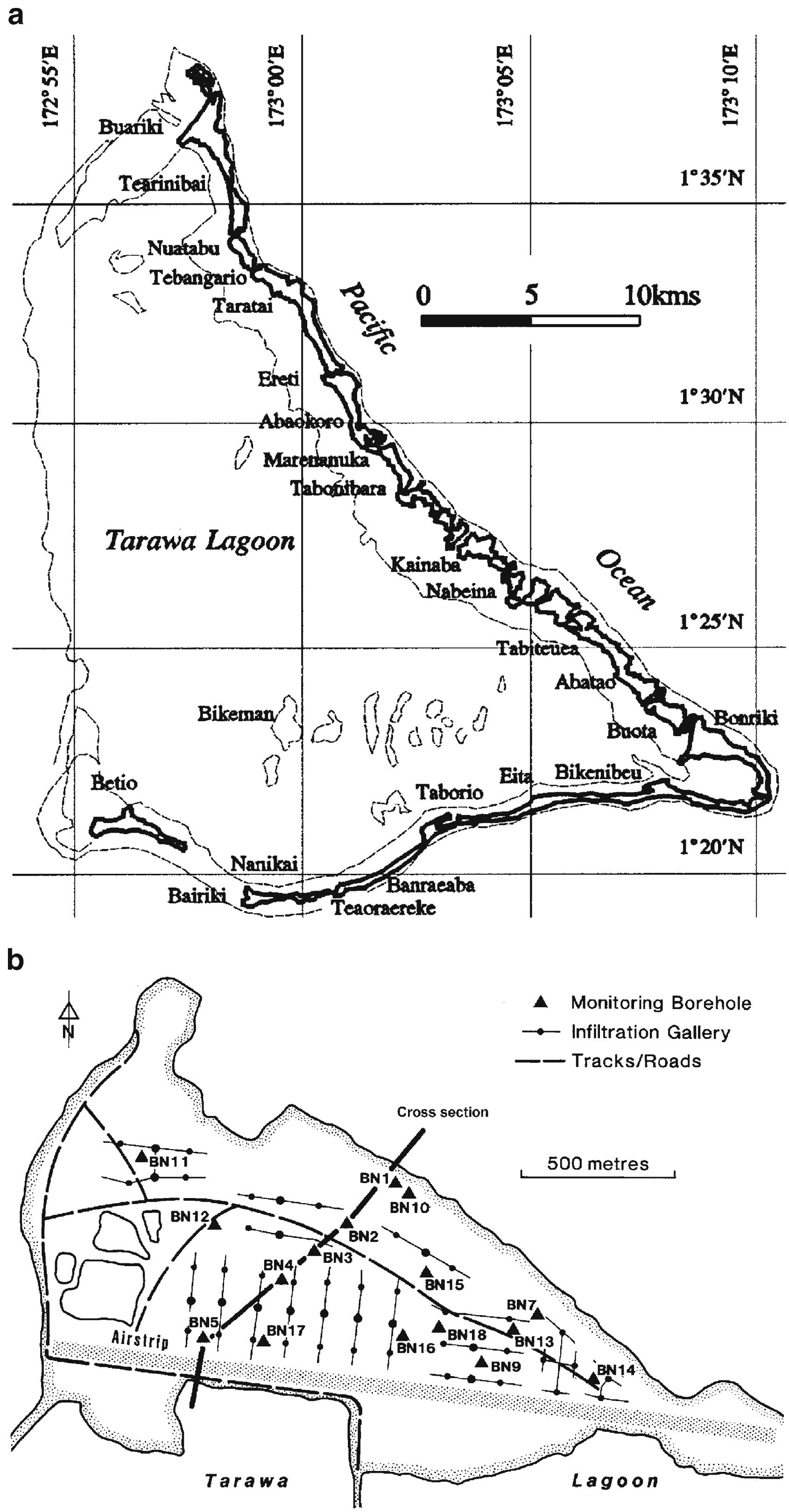

Fig. 4 Asymmetric freshwater lens on Bonriki Island, Tarawa Atoll, Republic of Kiribati. **a** Atoll map showing Bonriki in the southeast corner. **b** Plan of Bonriki showing several monitoring boreholes and infiltration galleries, and **c** cross section through boreholes BN1 to BN5, as shown in b, in the Bonriki freshwater lens showing depths to freshwater limit (EC taken as 2,500 μS/cm) and mid-point of transition zone (EC=25,000 μS/cm). Figure 4b and c are from Falkland and Woodroffe (1997) with permission from Elsevier

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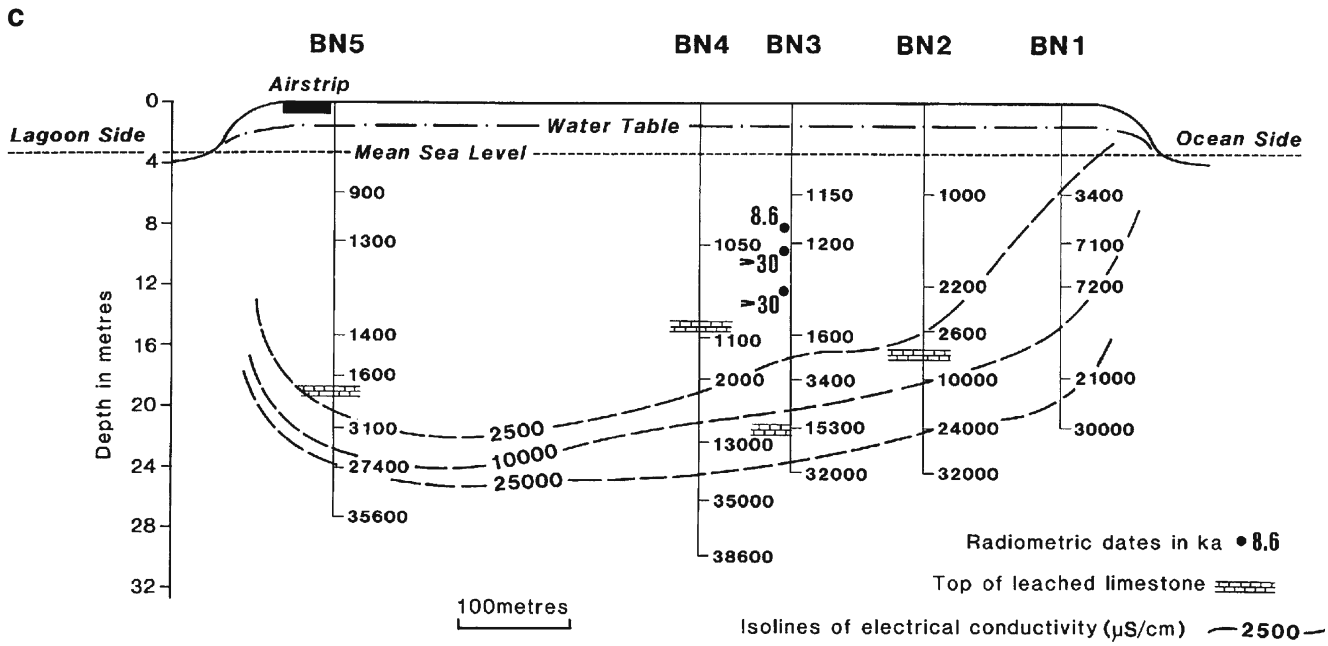

Fig. 4 (continued)

Equations (1) and (3) provide insight into the impact of long droughts on the width of the transition zone, δ_d(m). The ratio of the width in the drought to that under mean conditions is given by $\delta_d/\delta_u = (R/R_d)^{1/2}$. If recharge during a long drought is reduced to 25% of mean recharge then the width of the transition zone could be doubled. The practical thickness of useable freshwater during a drought, H_{wd} (m) is reduced by $H_{wd} = (R_d/R)^{1/2}\ (H_u - \delta_u[R/\{2R_d\}])$ and it is expected that the salinity of abstracted water should also increase during droughts. A useable freshwater lens will still exist provided $\delta_u < (2R_d/R)H_u$.

Equations (1) and (3) are steady-state approximations. Freshwater thickness and transition zone width, however, are dynamic, varying with fluctuations in rainfall recharge, land-use change and variations in groundwater abstraction.

Impact of pumping on freshwater lenses

When water is pumped at a constant rate, Q (m^3/s), from a freshwater lens of land area A (m^2), the steady-state analysis predicts that the maximum lens thickness to an assumed sharp interface between fresh and saltwater, H_p (m), at the center of an island is given by (Volker et al. (1985):

$$H_p = \frac{(1-q)^{1/2} W}{2}\left((1+\alpha)\frac{R}{2K_0}\right)^{1/2} = (1-q)^{1/2} H_u \qquad (4)$$

where q is the ratio of the specific pumping rate to recharge rate, $q = (Q/A)/R$. Equation (4) suggests that when the specific pumping rate is 50% of the mean recharge rate, the maximum thickness of the freshwater lens will be about 71% of the mean thickness of the unpumped lens.

During pumping, the increase in the width of the transition zone, δ_p (m), is given by:

$$\frac{\delta_p}{H_p} = \frac{1}{1-q}\left(\frac{K_0}{R}\right)\left(\frac{D}{\alpha\ WK_0}\right)^{1/2} = \frac{\delta_u}{(1-q)H_u} \qquad (5)$$

or $\delta_p = \delta_u/(1-q)^{1/2}$

So it can be seen that, as with drought, the width of the transition zone should increase, as should the salinity of the lens, as the pumping rate increases. The thickness of useable freshwater from a pumped lens, H_{wp} follows from Eqs. (4) and (5):

$$H_{wp} = H_p - \delta_p/2 = (1-q)^{1/2}(H_u - \delta_u/\{2[1-q]\}) \qquad (6)$$

Equation (5) indicates that when the specific pumping rate is 50% of the mean recharge rate, the transition zone will be 41% wider than that in an unpumped lens. So the effect of pumping is to decrease the lens thickness and to increase the width of the transition zone. This means that the practical depth of usable water under pumping is further reduced as in Eq. (6). A useable freshwater lens will continue to exist provided $\delta_u < 2(1-q)H_u$.

The approximate steady-state analysis above demonstrates how the freshwater lens thickness and the width of the transition zone at the base of the lens varies with: the effect of climate, through recharge, R; island physiography through the characteristic island width, W; aquifer hydrogeology through the saturated hydraulic conductivity, K_0; pumping through the non-dimensional specific pumping rate, q, seawater-freshwater interaction through the density ratio parameter α; and mixing through the dispersion

DOI 10.1007/s10040-009-0525-0

coefficient D. Several important dimensionless groups besides α emerge including R/K_0, $q = (Q/A)/R$ and an atoll Peclet number, $\alpha W K_0/D$. These factors determine the rate of inputs of water to the freshwater lenses, the rates of pumping losses, and the rate of mixing with seawater. The balance between these factors determines the viability of a freshwater lens as a source of potable water and illustrates why in small island hydrology it is essential to accurately assess recharge rates, hydrologic conductivity, and pumping rates. While this analysis can provide insights into the impacts of changes on freshwater lenses, it cannot describe the detailed dynamics of freshwater lenses in heterogeneous small islands. For those situations, dynamic models involving numerical solutions are required (see e.g., Underwood et al. 1992).

Freshwater lenses in raised limestone islands

Freshwater lenses in raised limestone islands, unlike low islands, are predominantly contained in highly permeable karst Pleistocene limestone aquifers and vary from extensive and relatively thick on some islands, such as Niue and Tongatapu in Tonga, to very small or absent on others, such as Banaba in Kiribati and Nauru (see Fig. 1). Groundwater investigations on Niue (Jacobson and Hill 1980; Wheeler and Aharon 1997; GWP 2006) and Tongatapu in Tonga (Furness 1997; White et al. 2009) show significant fresh groundwater resources available for pumping for urban and village water supplies. In comparison, groundwater investigations in 1987 after a heavy rainfall period found Nauru had a small freshwater zone (Fig. 5) which was then simulated by numerical models (Jacobson et al. 1997). Investigations in 2008 during a drought, however, found no freshwater lens in the center of the island at all and only a few small pockets of fresh to brackish groundwater at one end of the island. This demonstrates the dynamic nature of freshwater lenses, their vulnerability to climate variability, the fundamental importance of long-term monitoring of small islands, and the sensitivity of groundwater models to input or calibration data.

The simple steady-state model above assumes that the aquifer is uniform and deep. In practice, in low coral atolls and islands in the Pacific, where Holocene sands and gravels are deposited unconformably over karst Pleistocene limestones, the depth of the unconformity frequently determines the freshwater lens thickness because of the extremely high permeability of the karst limestone as further discussed below.

Natural influences on freshwater lenses

As the steady-state approximation above illustrates, the main natural influences on the occurrence of viable freshwater lenses on small islands are rainfall recharge to the groundwater system and the losses from the aquifer, including evapotranspiration by phreatophytes, the storage capacity of the freshwater lens, the hydraulic losses at the edges of the island, and mixing with underlying seawater. These influences are discussed below.

Climate variability

Climate, particularly rainfall and evapotranspiration are key drivers of recharge. Average annual rainfall and rainfall variability varies considerably throughout the Pacific. On Kiritimati Atoll in the dry equatorial zone of eastern Kiribati (Fig. 1), the average annual rainfall is less than 1,000 mm and the coefficient of variation (Cv) is greater than 0.7. In the western Pacific, near Funafuti Atoll in Tuvalu (Fig. 1), the average annual rainfall is over 3,500 mm and the Cv is much lower, near 0.2. Variations in monthly and annual rainfalls in the Pacific are influenced strongly by inter-annual El Niño and La Niña cycles as the Pacific warm pool migrates from the eastern to western equatorial Pacific. On many Pacific islands, there is a strong correlation between sea surface temperatures (SST) or the Southern Oscillation Index (SOI, a differential air-pressure indicator of sea surface temperature differences) and rainfall patterns (e.g., White et al. 1999a). Figure 6 shows the strong correlation between

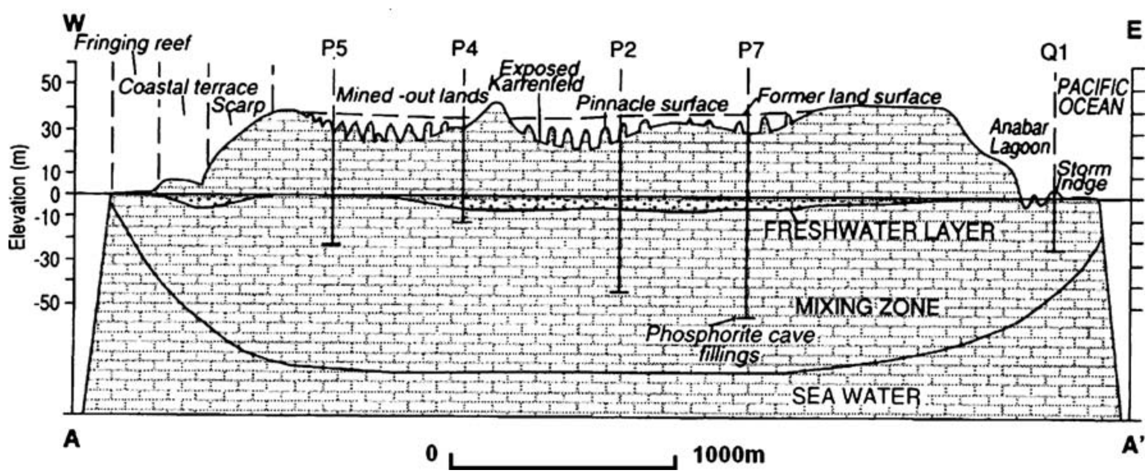

Fig. 5 Cross section through Nauru showing freshwater and mixing (transition) zones after heavy rainfalls in 1987 [from Jacobson et al. (1997) with permission from Elsevier]. Recent work in a dry period found no major viable freshwater lens

DOI 10.1007/s10040-009-0525-0

annual rainfall in Tarawa Atoll, Kiribati (Fig. 1) and the mean annual Niño Region 3.4 SST anomaly.

The frequency of low rainfalls in Tarawa and their strong correlation with negative SST anomalies are evident in Fig. 6. This correlation carries through to recharge. Groundwater salinity and the thickness of the freshwater lens are also correlated with SST or SOI (e.g., van der Velde et al. 2006; White et al. 2007a). Figure 7 shows the extent of sea water intrusion in a large atoll island lens that can occur during an ENSO-related, severe drought, raising groundwater salinity.

Evapotranspiration is a very important part of the hydrological cycle for small islands and can exceed more than half of the rainfall on an annual basis. It often exceeds rainfall for individual months or consecutive months during dry seasons or drought periods but the variability of evapotranspiration is much lower than that of rainfall. Typical annual potential evapotranspiration rates in the tropical areas of the Pacific are between 1,600 and 1,800 mm (Nullet 1987). Measurements of evapotranspiration on Bonriki Island, Tarawa Atoll suggested a lower annual rate closer to the equilibrium rate of about 1,420 mm due to the rapidly draining coral sands (White et al. 2002).

Island physiography

Island size, shape, and topography, particularly width and height of the island above mean sea level play a critical role in island water resources. Larger, higher, and wider islands are more likely to have either surface and groundwater resources or groundwater in greater quantities than smaller and narrower islands [Eqs. (1) and (3)].

Raised limestone islands are likely to have higher groundwater recharge for the same rainfall and vegetation conditions than low islands, as the roots of deep-rooted trees such as coconuts are unable to reach the water table and transpire water directly from the freshwater lens, as happens in low-lying atoll and reef islands. Where islands have narrow necks and peninsulas, the potential for seawater mixing and intrusion there is increased. Figure 8 shows a recent map of salinity distribution in Tongatapu, Kingdom of Tonga (Fig. 1) and shows areas where seawater intrusion increases groundwater salinity to the extent that the water is not fit for use.

Hydrogeological properties

As is demonstrated in the simple steady-state model, hydrogeological properties of the aquifer material have a direct bearing on the size, salinity, and sustainability of freshwater lenses on small islands. Small limestone islands are generally karst limestone, which has weathered from alternate periods of submergence and exposure due to fluctuating sea levels. Caves and solution cavities are often found along the shoreline and within the island. The hydraulic conductivity of the limestone is often greater than 1,000 m/day and, consequently, freshwater lenses are generally no more than about 10 m thick, even in wide islands such as Tongatapu (Fig. 8).

On atoll and reef islands, the aquifer material consists of two significant layers. The upper layer, consisting of recent Holocene sediments, mainly coral sands and fragments of coral, lies unconformably over an older Pleistocene karst limestone deposit (Woodroffe 2008). The unconformity, typically at depths of 10–15 m below mean sea level (Fig. 3), is one of the main controls to freshwater lens thickness (e.g., Hunt and Peterson 1980; Wheatcraft and Buddemeier 1981; Jacobson and Taylor 1981). Uranium-series dating of the older limestone in Tarawa Atoll indicates that it was formed 125,000 years ago (Jacobson and Taylor 1981). The upper unconsolidated sediments have been laid down over about the last 8,000 years with vertical accretion rates of order 5–8 mm/year. The freshwater zone is generally contained in the relatively low permeability coral sediments (with typical hydraulic conductivities of 5–20 m/day) as mixing of

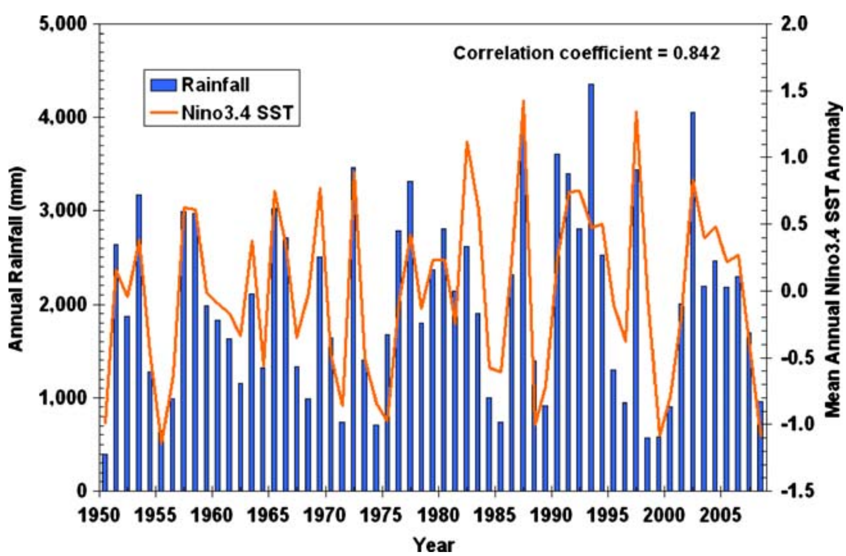

Fig. 6 The strong correlation between annual rainfall in Tarawa Atoll and the mean annual Niño Region 3.4 SST anomaly

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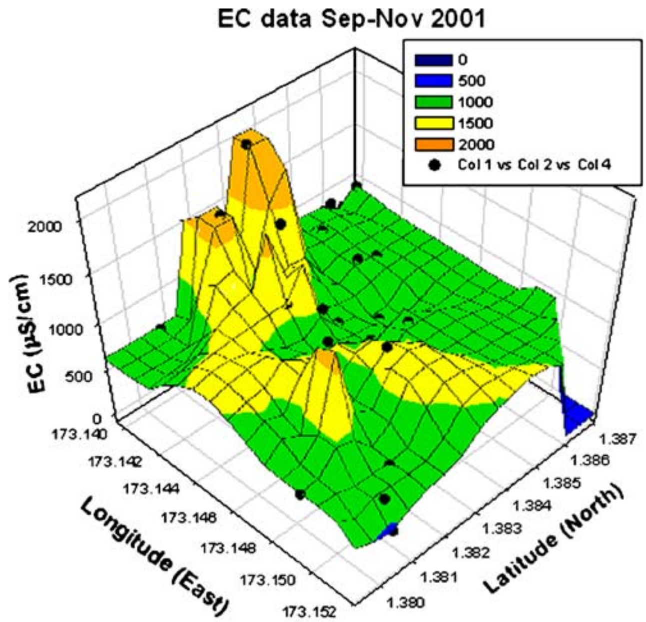

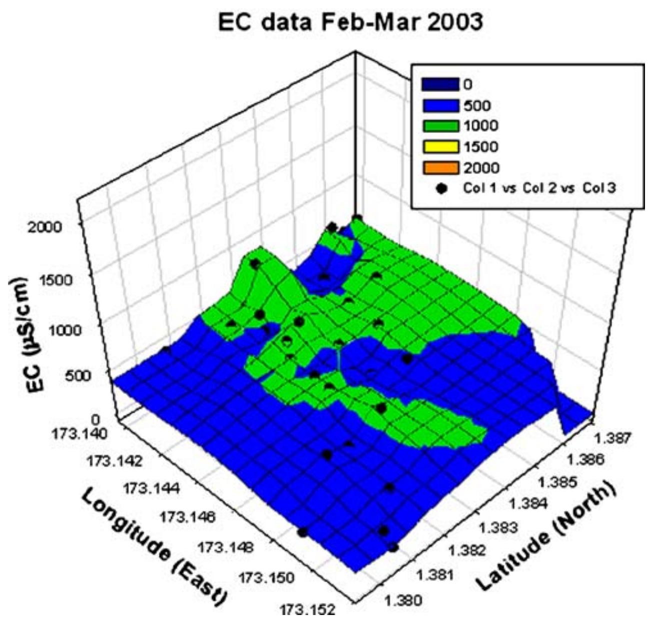

Fig. 7 Salinity (EC) distribution in Bonriki Island, Tarawa Atoll, Kiribati, showing seawater intrusion from the lagoon side at the end of the severe ENSO-related 1998–2001 La Niña drought compared with the distribution when the drought had broken (White et al. 2003). The Bonriki freshwater lens was being pumped at a rate of 1,300 m^3/day throughout this period

freshwater and seawater is rapid in the high-permeability karst limestone. Figure 9 shows the wide range of saturated hydraulic conductivities of the shallow, phreatic aquifers in the unconsolidated Holocene sediments on Bonriki and Buota Islands, Tarawa Atoll, Kiribati, estimated from pump drawdown tests in horizontal skimming wells or infiltration galleries (White et al. 2007b).

There are marked differences in hydrogeological properties of the upper sediments between atoll and reef islands located in areas that are prone to cyclonic activity and others in the central Pacific Ocean where cyclones do not occur. Islands within the cyclone belt such as Funafuti in Tuvalu and Pukapuka, Manihiki, Rakahanga and Penrhyn in the Northern Cook Islands (Fig. 1) are characterized, particularly on ocean sides, by high ramparts and coral rubble sediments with a significant proportion of boulders embedded in sands and gravels. Major changes occurred in Funafuti Atoll, including the deposition of a large amount of storm-driven boulders and reef blocks, as a result of Cyclone Bebe in 1972 (Woodroffe 2008). By comparison, islands in Kiribati and in the Maldives in the Indian Ocean, which are not within cyclone regions, have finer sediments with a much higher proportion of sand and gravel and very few boulder-sized particles. These finer sediments have lower hydraulic conductivities and, as predicted by Eq. (1), have thicker freshwater lenses for similar width islands. There are thicker freshwater lenses in the Gilbert chain of islands in the non-cyclonic region of western Kiribati (Fig. 1) than in the nearby cyclone-prone islands of Tuvalu, despite the higher and less variable annual rainfall in Tuvalu.

Tidal effects

On small islands, daily fluctuations in sea level, primarily due to tides, cause movement of the freshwater lens and promote mixing of fresh and seawater, increasing the transition zone thickness (Hunt and Peterson 1980; Wheatcraft and Buddemeier 1981). The classical theory of tidal signal propagation in continental coastal aquifers predicts that the ratio of the tidal amplitude in the groundwater to that in the sea, called the tidal efficiency, should decrease with distance from the coast. Correspondingly, the lag between the response of the groundwater to the tidal forcing should increase with distance from the coast. That is not the case in atoll islands where tidal lags and efficiencies in wells and boreholes in the unconsolidated sediments are independent of horizontal distance from the shore (e.g., Hunt and Peterson 1980; Wheatcraft and Buddemeier 1981; Ayers and Vacher 1986). Tidal lags and efficiencies on atolls are, however, greatly influenced by the depth of the boreholes. The reason for this apparent anomaly is the rapid transmission of the tidal pressure signal in the underlying high permeability karst Pleistocene limestone. Vertical propagation of tidal signals tends to be dominant in the middle of the island whereas both horizontal and vertical propagation are significant near the seawater margins. This aspect is important in developing conceptual models of groundwater flow in freshwater lenses and in their management, as described later. Figure 10 shows the response of water-table elevation to tidal forcing and to recharge on Bonriki Island.

The average tidal efficiency and lag on islands with finer-textured sediments are typically around 5% and 2.5 h, respectively (Peterson 1997; White et al. 2002) while those with coarser sediments can be approximately 45% and 2 h (Falkland 1999). In karst limestone islands, such as Nauru (Fig. 1), the tidal efficiency is generally higher, nearly 50% and the tidal lags shorter, around 1.5 h, than on atoll islands owing to the higher permeabilities.

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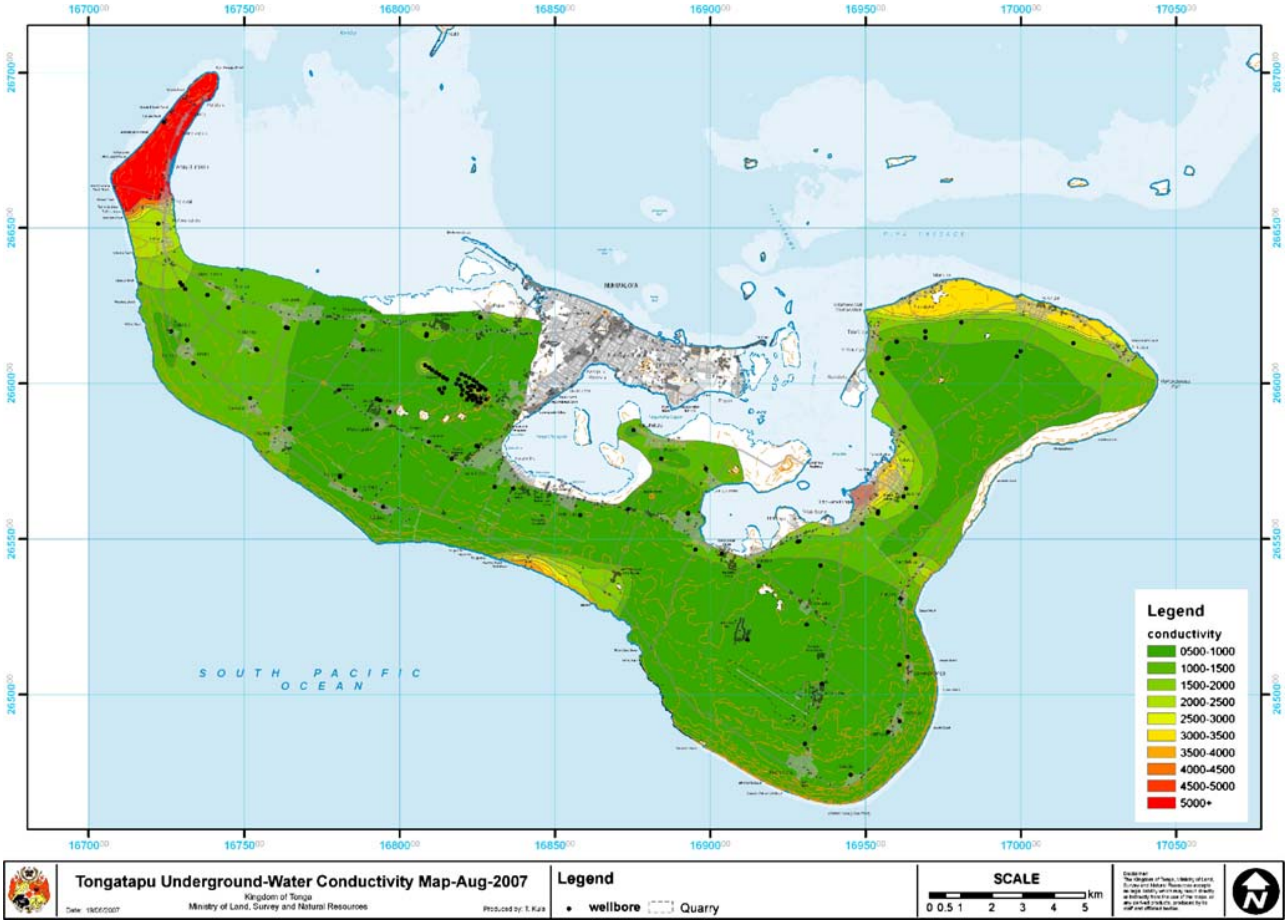

Fig. 8 Electrical conductivity (EC) distribution in the top 2 m of the groundwater sampled in vertical wells and bores (*black points*) in Tongatapu, Kingdom of Tonga, in August 2007 (White et al. 2009). *Grey areas* represent urban areas

Soils and vegetation

Soils and vegetation are important in groundwater recharge through their influence on evapotranspiration and infiltration. The high permeability soils of atoll, reef, and limestone islands promote rapid infiltration and lead to negligible surface runoff. Atoll and reef islands have only a thin surface soil covering above coral sands, which are generally deficient in organic matter and nutrients.

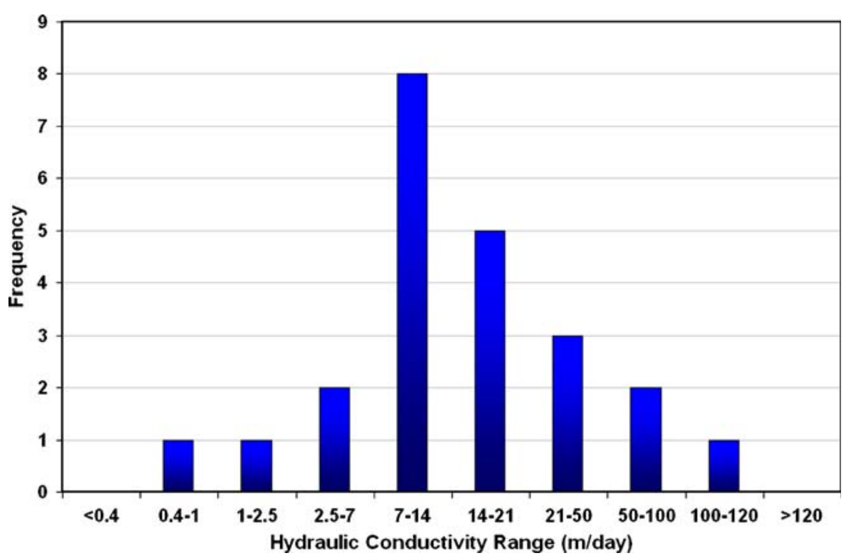

Fig. 9 Distribution of saturated hydraulic conductivity in the phreatic, unconsolidated Holocene aquifers, Bonriki and Buota Islands, Tarawa Atoll, Kiribati, measured by pump drawdown tests

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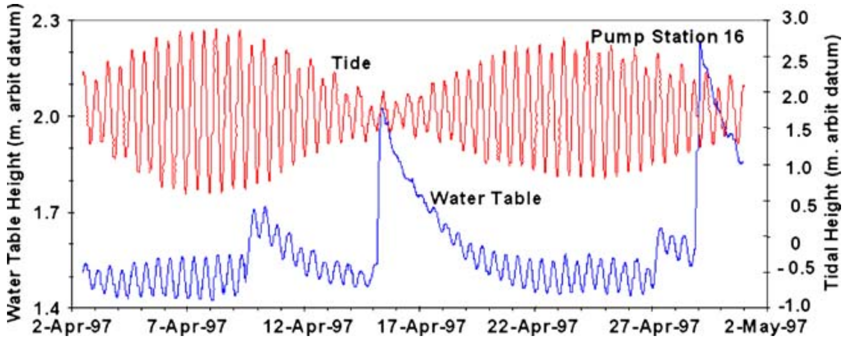

Fig. 10 Response of the water-table elevation in the pumping well of an infiltration gallery to tidal forcing and rainfall on 9, 15–16, and 29 April, Bonriki Island, Kiribati. This well is about 280 m from the ocean. Elevations are relative to arbitrary datums [from White et al. (2007b) with permission from Soil Science Society of America]

They have low water retention capacity and offer very little protection to underlying freshwater lenses from surface pollution sources. Soils on limestone islands are generally similar. Some have moderately thick to thick volcanic soils, such as the limestone islands of Tonga, due to past volcanic eruptions and these offer better protection from surface pollutants (van der Velde 2006).

The vegetation on small carbonate islands generally consists of a variety of trees, particularly coconut trees, and a limited range of bushes and grasses. The coconut tree is remarkably salt tolerant and can grow in water with relatively high salinity levels (Foale 2003). On a number of small islands, the native vegetation has been partially cleared and replaced with food crops. Vegetation both intercepts part of the rainfall and transpires water from the soil. Some deeper-rooted tree species such as coconuts can act as phreatophytes, transpiring directly from shallow groundwater. Both interception and transpiration decrease recharge and hence the amount of groundwater available for use. In dry periods, direct transpiration from groundwater significantly reduces the available groundwater. Measurements of individual coconut tree transpiration showed daily rates of 150 litres per tree and above on Tarawa Atoll (White et al. 2002). The high transpiration of coconut and other trees has management implications for freshwater-scarce areas where demand is high and groundwater abstraction needs to be maximized. Selective clearing can increase both recharge and the sustainable yield and decrease groundwater salinity.

Threats to freshwater lenses

Freshwater lenses and coastal aquifers on small islands are vulnerable to threats from both natural events and human activities.

Natural threats

The main natural threat to freshwater lenses on small islands are extended droughts (Scott et al. 2003) and, for low-lying islands, partial or complete overwash from storm waves or storm surge particularly those associated with major tropical cyclones (Terry 2007; Spennemann 2006). Tropical cyclones are a major problem for many small island communities (Terry 2007). They often cause widespread damage and can generate storm surges with overwash of parts or all of some islands, resulting in seawater intrusion into freshwater lenses. Climate variability associated with inter-annual El Niño and La Niña cycles has significant impacts on groundwater availability in small Pacific islands. There are major concerns that climate change may increase the severity and frequency of these threats in small islands with increased frequency of drought, enhanced cyclone activity, rising mean sea levels and increased risk of island overtopping (Ali et al. 2001).

Droughts in the Pacific are closely associated with El Niño and La Niña episodes (White et al. 1999a; Scott et al. 2003). Islands in the southern and northern part of the Pacific are largely drought-affected during El Niño events such as Tonga (van der Velde et al. 2006) while those in the central Pacific, particularly Kiribati, are impacted by droughts during La Niña events (White et al. 2007b). As discussed above, during droughts, the fresh groundwater lens contracts. Figure 11 shows the relationship between the depth of the freshwater lens at the edge of a coral atoll island in the central western Pacific and La Niña and El Niño events identified by the SOI.

In small islands, where mean rainfall is relatively low and where annual rainfall has a high Cv, such as in Kiritimati Island, Kiribati (Fig. 1), only large freshwater lenses remain viable at the end of major droughts. Some severe droughts have forced the abandonment of several very small islands when fresh groundwater was exhausted.

Overtopping of low islands from storm waves or by seawater inundation due to storm surges, sometimes associated with high sea levels has salinized fresh groundwater on low-lying islands (Richards 1991; Oberdorfer and Buddemeier 1984). Six months after a storm surge which sent waves across part of Enewetak Island in Enewetak Atoll, Marshall Islands, the salinity of the groundwater dropped sharply to 15–25% of the immediate post-storm values during a period of negligible rainfall (Oberdorfer and Buddemeier 1984), indicating that recharge was not the factor that decreased salinity. More recently, saline intrusion into freshwater lenses as a result of cyclone-generated waves and storm surge on the three islands on Pukapuka Atoll, northern Cook Islands in 2005

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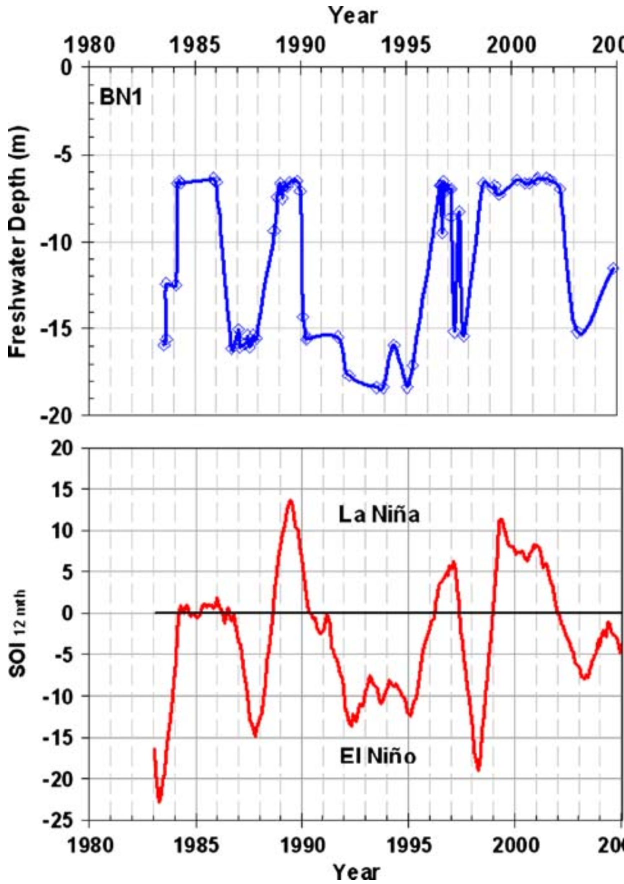

Fig. 11 Relationship between the depth of the freshwater lens below the land surface at the ocean edge of Bonriki Island, Kiribati, in the central western Pacific and La Niña and El Niño events identified by an average of the SOI over the previous 12 months

was found to have dissipated within 12 months due to density-driven downward migration of the seawater (Terry and Falkland, journal paper in preparation).

The impacts of droughts and overwash on freshwater lenses are temporary, as illustrated in Fig. 7. Freshwater lenses recover over periods of months or years after droughts or seawater inundation following recharge from significant rainfalls. More permanent changes occur with rising sea level and this is a major concern for the communities on low-lying islands of the Pacific (Ali et al. 2001; Burns 2002). The impacts on freshwater lenses from projected mean sea level rises and possible changes in recharge have been studied on several atoll islands using groundwater models. The two-dimensional model SUTRA (Voss 1984; Voss et al. 1997) has been used to analyze impacts for Enjebi Island, Enewetak Atoll (Oberdorfer and Buddemeier 1988) and Bonriki Island, Tarawa Atoll (Alam and Falkland 1997; World Bank 2000; Alam et al. 2002). It was found that sea level rises of up to 1 m would have little impact on freshwater lenses provided that land was not lost at the edges of the island. Indeed, the freshwater zone was predicted to slightly increase in thickness and volume as more of the freshwater lens will be within the upper, lower-permeability, Holocene sediments (Fig. 3). When, however, land is lost due to erosion at the edges of an island, then the island area is reduced, decreasing the volumes of freshwater lenses. Potential changes in recharge resulting from changes in rainfall were found to be more likely to have a larger impact on freshwater lenses. Further work is required to assess the relative vulnerability of different shorelines to sea level rise. Erosion is more likely to occur as the result of extreme events, such as storm waves, than gradual change in sea level (Woodroffe 2008).

In addition to the impacts of droughts, overwash and potential sea level rise, extreme events such as tsunamis and earthquakes can also impact small islands and cause disruption to groundwater resources. Groundwaters in many low-lying lands in the Indian Ocean were impacted following the Boxing Day tsunami (December 26, 2004). Tsunamis, which have devastated many islands and continents around the Pacific Rim, are not normally a major threat to mid-oceanic islands except where islands are close to tectonically active areas, such as Tonga, Samoa and Solomon Islands. Submarine landslides can also cause catastrophic changes to atolls with the loss of whole or parts of islands as have occurred, for example, on the atolls in the northern Cook Islands (Hein et al. 1997).

Threats from human activities

The main human threats to freshwater lenses are over-abstraction of groundwater and pollution from surface sources, particularly human, animal, and industrial wastes and spillages. Other threats include mining of sand and gravel for building materials from groundwater source areas and shoreline works which induce erosion. In PICs, rapidly expanding populations due to both natural growth and inward migration to urban centers are placing increasing demands on water supply systems which abstract groundwater from freshwater lenses. This is especially noticeable in population centers as, for example, on Tarawa and Kiritimati Atolls in Kiribati and, to a lesser extent, on Tongatapu in Tonga (van der Velde 2006). Significant water losses in piped distribution systems, sometimes up to 70%, place additional stress on the limited groundwater resources from the additional pumping required to cater for these losses.

Over-abstraction can be island-wide or localized. Localized over-abstraction is generally caused by inappropriate methods of pumping from vertical boreholes, which increases salinity through up-coning of the transition zone. Island-wide abstraction at greater than the sustainable yield of the island can be due to poor understanding, insufficient information or lack of regular monitoring, use of inappropriate pumping systems or demand pressures forcing management to pump at higher than sustainable rates. Figure 12 shows the change in pumping rate since 2003 compared to the estimated sustainable rate at Tarawa Atoll's groundwater sources when pumps at existing infiltration galleries were refurbished and additional pumps were installed at new infiltration galleries.

On Tarawa, population pressures and the limited land area for urban development place additional pressures on

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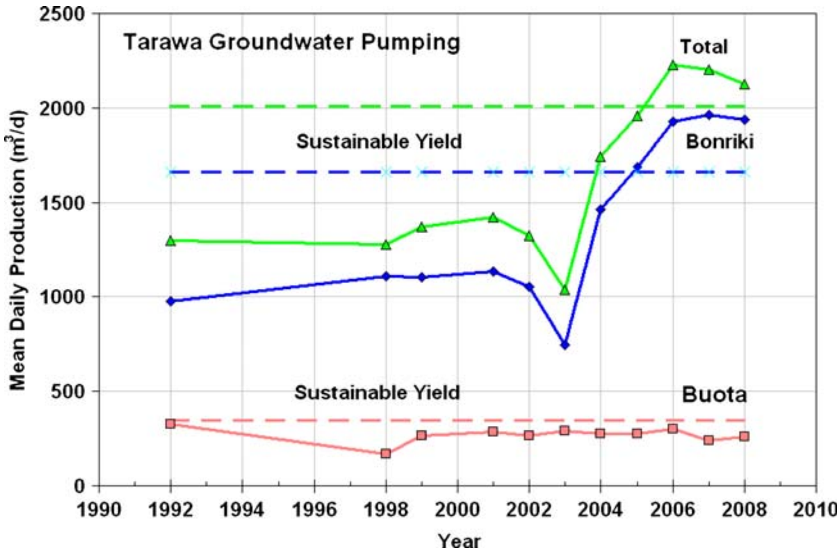

Fig. 12 Annually averaged mean daily groundwater abstraction rates using infiltration galleries from freshwater lenses in the islands of Bonriki and Buota, Tarawa Atoll, Kiribati (*solid lines and points*) compared with estimated sustainable yields (*dashed lines*). The rise in pumping rate was caused by the refurbishment of pumps and the installation of new infiltration galleries

the water reserve areas of Bonriki and Buota Islands used for groundwater abstraction. Illegal settlements and inappropriate land uses such as on the designated water reserves are major problems (White et al. 1999b, 2007a). Figure 13 shows the impact of encroachment on the quality of water produced from infiltration galleries in the Bonriki water reserve. This figure shows areas where comparative measurements between the ratio of dissolved organic carbon to total dissolved nitrogen in pumped water and the Redfield ratio for micro-organisms (C/N= 6.6 mole/mole) have been made.

Groundwater contamination on many small islands, caused by a variety of biological and chemical sources including sanitation systems, particularly pit toilets and septic tanks, animal wastes, rubbish disposal areas, cemeteries, fuel tanks, fertilizers, and agricultural chemicals (van der Velde et al. 2007), poses significant health risks. Detay et al. (1989) comprehensively reviewed pollution problems on small islands in the Federated States of Micronesia, the Marshall Islands, and Belau (Fig. 1), many of which are atoll islands. Human settlements over freshwater lenses are of major concern because of the potential for rapid pollution due to the shallow permeable soils and short travel times to the water table. This has caused the contamination of large areas of urban Tarawa so that groundwater is only fit for non-potable purposes (see Fig. 2). Specific pollution problems affecting the Bonriki and Buota freshwater lenses on Tarawa Atoll are outlined in White et al. (2005). Mining of sand and

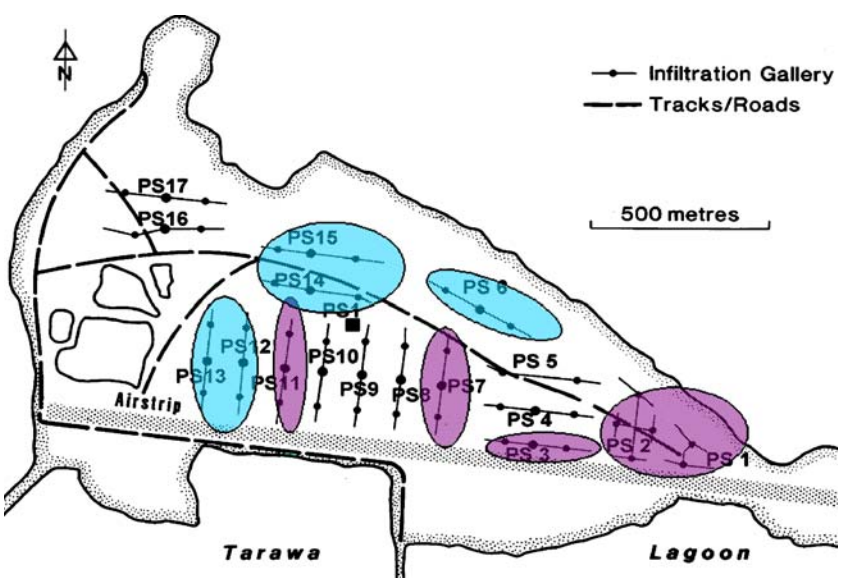

Fig. 13 Water from pumping galleries on Bonriki with dissolved organic carbon to total dissolved nitrogen ratios (i) close to the Redfield ratio for micro-organisms (*blue colored*) and (ii) significantly lower than (< 2.9) the Redfield ratio suggesting inorganic sources of total dissolved nitrogen (*purple colored*). Both colored areas correspond to land uses such as the raising of pigs, crop production, and cemeteries

 DOI 10.1007/s10040-009-0525-0

gravel from freshwater lens areas creates additional risks by decreasing the soil depth over the water table and increasing vulnerability to pollution and, in some cases, increasing evaporation losses directly from exposed groundwater.

In addition to these direct threats, fresh groundwater can also be vulnerable because of inadequate legislation and regulations, inappropriate policies and limited financial and human resources to manage water source areas and water supply systems. The provision of appropriate training to water resource personnel is a critical need in small islands.

Conservation and management of freshwater lenses

Despite their vulnerability, many PICs do not know the full extent and quality of their water resources. In order to conserve and manage freshwater lenses sustainably and to protect the security of vulnerable groundwater supply systems, appropriate institutions, careful planning and strategic management are required. Focused and clear policies and achievable implementation plans, effective legislation and regulations, and well-trained personnel are key elements. The fragility of groundwater lenses and the increasing demands on them need thorough resource assessment, a commitment to ongoing monitoring and analysis, suitable groundwater development to minimize salinity, effective management of groundwater source areas, targeted demand management, public participation, training and mentoring of staff and attentive management of the water abstraction and supply systems. The limited resources in some PICs mean that these are major challenges (van der Velde et al. 2007).

Assessment of freshwater lenses

Many PICs have limited information on the amount and quality of their water resources. There are a number of techniques for assessing the location and thickness of freshwater lenses which range from preliminary "desk top" assessments through empirical techniques (e.g., Oberdorfer and Buddemeier 1988; Underwood et al. 1992; Peterson 1997) to more detailed geophysical and groundwater drilling programs. Empirical techniques in the absence of field data can be misleading, as freshwater lens shapes vary from island to island due to variations in physiography, climate and hydrogeological properties (see Fig. 4c).

Geophysical surveys using electrical resistivity (ER) and electromagnetic induction (EM) methods (Stewart 1988) provide reasonably accurate and relatively quick and cheap assessments of the locations and thicknesses of freshwater lens and have been successfully used on many atoll islands and some low-lying limestone islands in PICs, including Kiribati, Cook Islands, Federated States of Micronesia and Tonga (e.g., Anthony 1992; IETC 1998). They are much less effective in raised limestone islands due to the depth to groundwater. Both ER and EM surveys can be equivocal even on low islands and are better used to interpolate freshwater thickness between appropriately constructed boreholes in which vertical groundwater salinity profiles have been measured.

Groundwater monitoring boreholes between 15 and 30 m below ground surface have been driven into or drilled on a number of small atolls (e.g., Hunt and Peterson 1980; Hamlin and Anthony 1987; Falkland and Woodroffe 1997; GWP 2006). In order to monitor salinity profiles in groundwater lenses it is essential to avoid open boreholes or continuously perforated casings as these promote tidally induced mixing and give exaggerated saline transition zones (Buddemeier and Holladay 1977). Figure 14 shows a single borehole system with multiple tubes terminated at a number of pre-determined depths, between which bentonite sealing plugs and gravel backfill are placed to prevent the tidal-mixing that occurs in open boreholes.

A shallow piezometer tube within these boreholes permits water-level measurements and collection of samples from the groundwater surface. Measurements of water-table height above mean sea level are useful for examining the effects of pumping, climate variations and tides. More detailed groundwater assessment methods for small islands and examples are provided in Dale et al. (1986), UNESCO (1991), IETC (1998), SOPAC (2005) and SOPAC (2006).

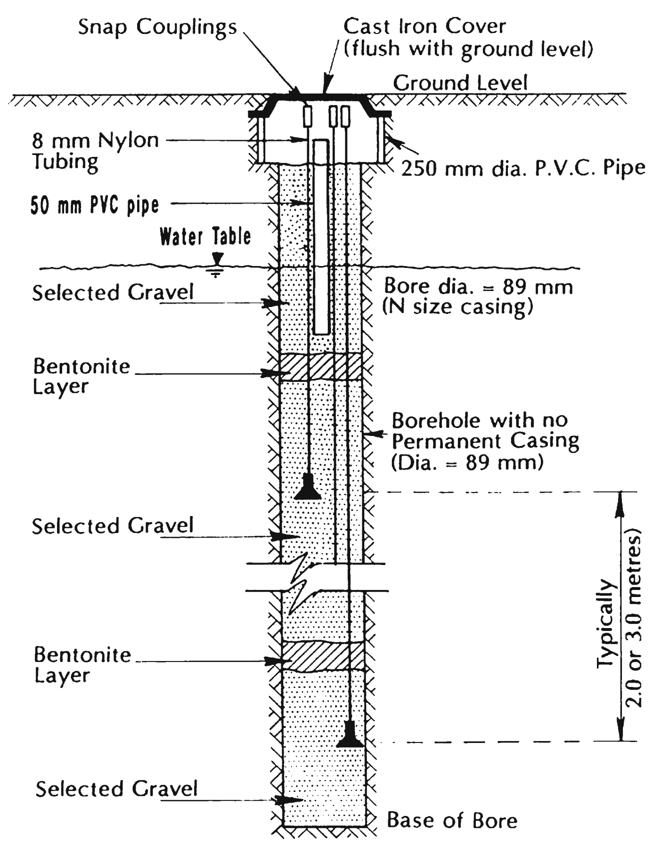

Fig. 14 Multi-level borehole monitoring system for measuring the water-table elevation and groundwater salinity at different depths in a freshwater lens. Bentonite layers prevent inappropriate tidal mixing

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Groundwater recharge and sustainable yield estimation

The impacts of large natural variations in rainfall in PICs (Figs. 6 and 7) mean that determination of the sustainable groundwater yields requires careful estimation. Knowledge of groundwater recharge is fundamental to estimating sustainable yields from freshwater lenses. Preliminary assessment can be made using empirical curves relating annual recharge to annual rainfall (Falkland and Brunel 1993) and maps based on estimates from several islands (Nullet 1987). Preliminary estimates of recharge can also be made using a chloride ion balance approach (Ayers 1981). As Chapman (1985), however, has pointed out, dry salt deposition in small islands complicates this measurement making it better to measure salinity in the surface soil water (White et al. 2002).

Continuous water level records in conjunction with tidal and barometric records and rainfall have been used to estimate recharge (Furness and Gingerich 1993). Removing the effects of sea level and pressure changes from the water level hydrograph, allows recharge to be estimated from the residual trace and estimates of the aquifer specific yield.

Detailed studies of groundwater recharge on Tarawa Atoll, Kiribati (White et al. 2002) used rain gauges, a climate station, sap flow sensors, soil moisture probes, and groundwater level recorders to quantify the water balance above the freshwater lens and to assess recharge. This also enabled calibration of a water balance model for recharge estimation on atoll islands using daily or monthly rainfall data and either estimates of monthly potential evaporation or measured pan evaporation data. Measurements of the drainage fluxes beneath the root zone, such as on the raised limestone island of Tongatapu (van der Velde et al. 2005), may also be used to assess groundwater recharge.

Preliminary estimates of sustainable groundwater yield are normally taken to be a fraction of mean annual recharge. This recognizes that only a proportion of recharge (of order 25–50%) can be abstracted leaving a significant amount for maintaining the integrity of the lens. More detailed estimates of sustainable yields have used water balance approaches (Falkland 1993) and groundwater models, most commonly two-dimensional variable-density models such as the SUTRA model (Voss 1984; Voss et al. 1997). Case studies using the SUTRA model in atolls are in Oberdorfer and Buddemeier(1988), Oberdorfer et al. (1990), Griggs and Peterson (1993), Peterson (1997), Underwood et al. (1992), Alam et al (2002) and World Bank (2000). Other two-dimensional and three-dimensional models have also been used (Jacobson et al. 1997; Mink and Vacher 1997).

Groundwater modeling to estimate sustainable yield relies on the availability of good quality medium to long-term climatic and groundwater data. The use of models with limited data can lead to erroneous results (Fig. 5). Table 2 shows the progressive estimates of sustainable groundwater yields for the major water supply lenses in Tarawa Atoll over the past 40 years, which have used a variety of modeling and field investigation techniques. The current estimate is equivalent to just over 43 l/person/day of treated freshwater and demonstrates the importance of accurate estimation of sustainable yield.

Long-term monitoring

In the face of the extreme ENSO-related variability, climate change and increasing population growth and demand faced by many PICs, long-term climate and regular groundwater monitoring and analysis of the data are essential for understanding and managing these fragile groundwater systems. Monitoring is a major problem in many PICs because of the lack of trained personnel and shortages of equipment and resources, such as access to transport. A failure to appreciate the importance of adequate water resources monitoring pervades government agencies responsible for water supply and regulation. In some cases, lack of clear definition of roles between government agencies and competition for limited resources are further impediments.

Some of these problems are being addressed through projects such as the Pacific HYCOS project (Pacific HYCOS 2009). Ongoing capacity building and training and mentoring of staff in PICs is, however, required (van der Velde et al. 2007).

Minimizing salinity of pumped groundwater

The delicate hydrostatic balance between freshwater and the surrounding and underlying seawater in small islands is easily disturbed by inappropriate groundwater development. The most common method of obtaining groundwater on low-lying, coral islands is from hand-dug dug wells typically 2–3 m deep and approximately 1 m below the groundwater level. Groundwater is abstracted by buckets, hand pumps, or small electric pumps. Such systems work well at household levels, provided abstraction rates are low.

Table 2 Successive estimates of the daily sustainable groundwater yield from Bonriki and Buota water reserves, Tarawa Atoll, Kiribati

Year	Estimates of sustainable yield (m^3/day)			
	Bonriki	Buota	Combined	Reference
1973	110			Mather (1973)
1978	<85	<85	<170	Richards and Dumbleton (1978)
1982	750	250	1,000	DHC (1982)
1992	1,000	300	1,300	Falkland (1992)
2002	1,350	350	1,700	Alam et al. (2002)
2004	1,660	350	2,010	Falkland (2004)

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For public water supply pumping systems, single or multiple dug wells or drilled boreholes have been used on some coral islands. These vertical abstraction systems can cause upconing of the transition zone and increases in salinity of the abstracted water. In some cases, the groundwater can become too saline for potable use. Pumping from horizontal infiltration galleries or skimming wells has proved a far better abstraction method, particularly in islands with thin freshwater lenses. Infiltration galleries, consisting of up to 300-m-long horizontal slotted pipes buried below the water table (Figs. 3 and 15), skim the fresh groundwater from the surface of the lens, and thus distribute the pumping drawdown over a wide area. In so doing, they avoid excessive local drawdown and upconing of saline water that occurs in pumping from vertical boreholes.

Freshwater lenses contract during major droughts, so it is important that the local impacts on the freshwater lenses caused by pumping are minimized. By maintaining a small drawdown at each gallery pump well, the impact of pumping on the freshwater lens and on the salinity of abstracted water is minimized. Infiltration galleries are used in Tarawa and Kiritimati Atolls, Kiribati; Majuro and Kwajalein Atolls (Peterson 1997) in the Marshall Island; Aitutaki Island, Cook Islands; and Lifuka Island, Tonga (Fig. 1). On Lifuka, replacement of boreholes with infiltration galleries significantly lowered the salinity of the water supply (Falkland 2000b).

Measurements in 25 Bonriki and Buota gallery pump wells in Tarawa Atoll, Kiribati, have shown that the average groundwater drawdown of all galleries is 33 mm when pumped at mean rates of 88 m^3/day (White et al. 2007b). This drawdown is less than the magnitude of groundwater fluctuations due to tidal influence there of typically 70–80 mm (see Fig. 16). It is also much less than the longer-term groundwater level fluctuations of about 450 mm between very wet and very dry periods (Fig. 10).

For limestone islands, where depths to the water table are greater than 10 m and up to 50 m or more, abstraction using vertical drilled boreholes is currently the most practical method of developing freshwater lenses. Examples are found in Tonga (Furness 1997), Niue (GWP 2006) and northern Guam (Mink and Vacher 1997). In the future, directional drilling from the surface may be an option for installing horizontal infiltration galleries on these islands.

Management of freshwater lens areas

Effective land-use planning and management is essential for the protection of shallow groundwater resources from contamination on low-lying carbonate islands. "Groundwater protection zones" or "water reserves" coupled with regulation of landuses in these reserves has been tested in some PICs. Human settlements, agriculture involving raising of livestock, the use of chemicals and fertilizers and mining of sand and gravel all increase the risk of groundwater contamination. Such reserves, however, are often difficult to manage owing to pressures on limited land areas in small islands and the problem of ownership of water, which traditionally was owned by landowners.

In most PICs, land over groundwater source areas is privately owned. Declaration of water reserves has generated major conflicts between government and private landowners. Their resolution requires appropriate administrative and financial provisions, the involvement of the local community in managing the reserve, or even the water supply system as in Tongatapu, and the provision of social services such as sports fields on the reserves (White et al. 1999a, 1999b). In islands where consumptive demand is approaching sustainable groundwater yield, the selective clearing vegetation, particularly coconut trees from the central parts of the islands, can decrease transpiration losses, enhance recharge, and increase the sustainable yield. This

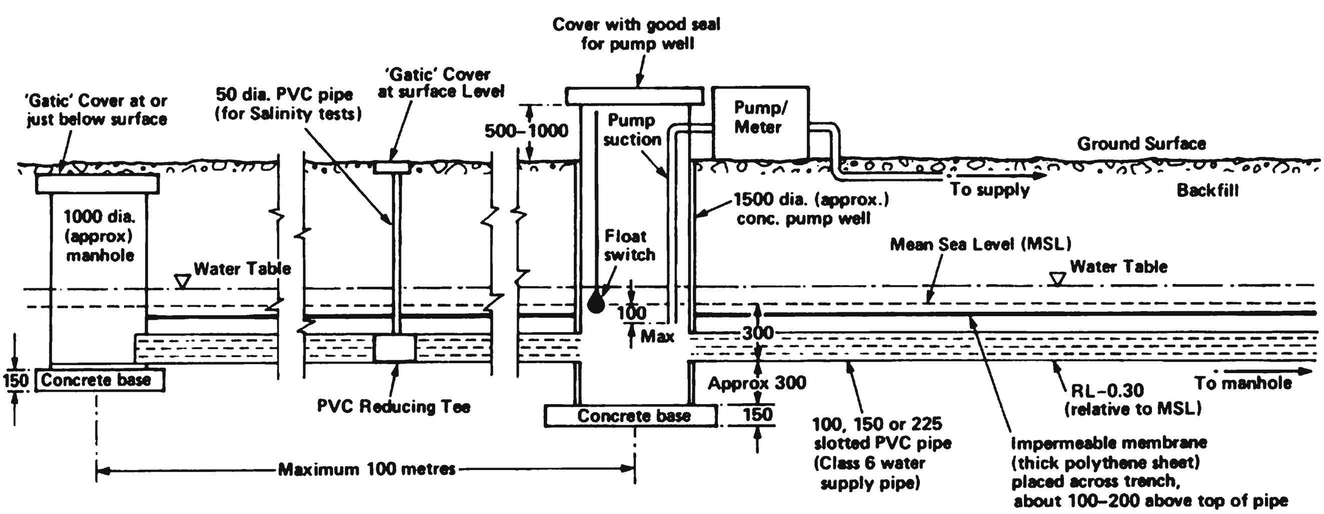

Fig. 15 Cross section through a typical infiltration gallery or skimming well [modified from Falkland and Brunel (1993) with permission from Cambridge University. Measurements are shown in millimeters

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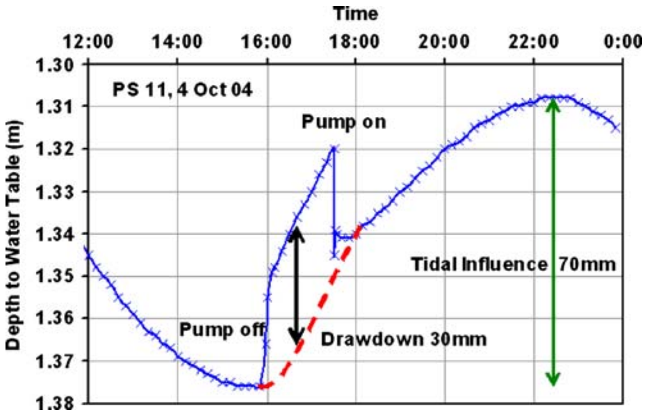

Fig. 16 Change in water-table elevation in an infiltration gallery pump well, Bonriki, Tarawa, due to the switching off and on of the pump. The pump drawdown is superimposed on the diurnal tidally induced fluctuation

leaves coastal margins in a natural state to ensure protection from erosion and to continue to provide a source of food, drink, and construction materials. In some islands, areas already cleared for airfields offer good opportunities for groundwater development.

Sanitation systems using septic tanks and pit toilets are a major source of biological contamination and health risks on many islands. In parts of some heavily populated atolls such as Majuro, Marshall Islands and Tarawa, Kiribati, piped sewerage systems using seawater for flushing, to conserve limited freshwater supplies, have been installed to overcome this problem. Compost toilets protect freshwater lenses as well as also conserving scarce water resources. These have been tested in a number of PICs including Kiribati, Tonga, and Tuvalu (Crennan and Berry 2002). While these toilets have many advantages and have been accepted in some communities, cultural attitudes have so far limited their widespread use in others. Other technical solutions are available including improved septic tanks and relatively simple effluent disposal and treatment systems. Further information is available, for instance, in Depledge (1997), UNEP (2002), Bower et al. (2005) and WHO (2008).

The most appropriate strategy is to ensure that human settlements including their sanitation systems are placed well away from freshwater lenses used for public water supply. A study using bromide tracer in Lifuka, Tonga, concluded there was no safe distance between pit latrines or septic tanks and water supply wells in an urban area because of the density of sanitation facilities (Crennan et al. 1998). Instead, it recommended that alternative strategies such as source control of pollutants as with composting toilets and water treatment are required.

Management of water supply systems

Water supply systems on islands that extensively use groundwater from freshwater lenses need careful management. Pumping rates should not exceed the sustainable yield, which requires metering and monitoring of pumps. Significant leakages, as high as 70% of extracted water from the reticulation system, are endemic in PICs. These leaks often occur in areas where the groundwater is saline or heavily polluted and are a waste of energy and water. Their minimization through regular detection and maintenance is a key step in increasing the availability of water. Demand management is a difficult issue in PICs as in many countries. There is both an aversion and an inability to pay for groundwater which traditionally was the property of landowners.

There is limited information on the proportion of rainwater used for domestic consumption in PICs. The conjunctive use of rainwater harvesting systems for potable purposes with groundwater reserved for non-potable uses offers an alternative and safer water supply than domestic shallow wells located beside pit toilets and pig pens. Domestic rainwater storages, however, are normally insufficient in long droughts but communal tanks, such as those in Tuvalu, are able to maintain modest supply. Incentives for increasing rainwater harvesting have proved valuable, although in some PICs there is a preference for groundwater.

The strong relationship between rainfall or groundwater salinity and climate indices such as Niño SST or the SOI in many PICs (Fig. 6) offers the potential to predict extremely wet and extremely dry periods. Use of simple rainfall deciles in Tarawa, Kiribati, enabled prediction of droughts up to 6 months before their maximum, with 50% accuracy (White et al. 1999a). Van der Velde et al. (2006) found that groundwater salinity in Tongatapu lagged 10 months behind the SOI. The Pacific Islands Climate Prediction Project (ABOM 2009) uses primarily SST measures of the ENSO cycle to generate probabilistic predictions or seasonal climate outlooks for rainfall, temperature or other climate related parameters in PICs.

Finally, attracting, training and retaining skilled staff in sufficient number in the water sector in PICs is difficult, as is assembling the necessary resources. Fortunately, there are regional organizations such as SOPAC that provide a resource and expertise base for PICs.

Future prospects

This paper has attempted to show that the climatic, hydrogeological, and physiographic factors compounded by human activities make fresh groundwater lenses used for water supply on small islands in the Pacific some of the most vulnerable groundwater systems in the world. Some small island population centers are already close to the limit of sustainable groundwater abstraction. Faced with climate change, rising sea levels, increasing frequency of extreme events, growing populations, restricted land areas, limited resources and capacity, their prospects appear bleak. Yet island populations have proved remarkably resilient in the past.

Desalination is seen by many as the solution to future water needs in small islands. Its success rate, however, in PICs to date has been poor. Desalination equipment is expensive to operate and maintain, often too complex for

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local technicians, and is energy intensive. Groundwater abstraction from lenses where the yield has been maximized by clearing deep-rooted vegetation, supplemented by domestic rainwater harvesting appears to be a more reliable and robust strategy. These enhanced-yield systems will require careful management and continued regular monitoring.

External donors and lenders have assisted and continue to assist PICs to develop and manage their groundwater resources. A number of aid and loan projects in the water sector, however, have had only limited success. Almost all projects have been relatively short-term and narrowly focused on infrastructure, and some have often been driven by the agendas of international agencies rather than the priorities of local populations. Many have also assumed that developed-world solutions, concepts, and "tool boxes" are universally transportable and applicable. Donor and aid programs that are sensitive to cultural nuances, recognize local priorities, value effective community participation, mentor staff in the water sector and appreciate the long time-scale for behavioral change are more likely to be successful (White et al. 2008).

Many of the pressing future problems can be addressed through six policy objectives:

- improve understanding and monitoring of water resources and their use;
- increase access to safe and reliable water supplies and appropriate sanitation;
- achieve financially, socially, and environmentally sustainable water resource management;
- increase community participation in water management and conservation;
- improve governance in the water and sanitation sector; and
- provide training opportunities for and mentoring of staff in the sector.

Village-level water committees have proven successful in rural areas in Tonga and Samoa and appear to offer a model for other PICs. They are appropriate for the cultural contexts in many PICs and would help return control of the protection and management of water resources to the local level in rural areas and outer islands. Such committees need, however, to be nurtured and resourced adequately.

The increasing complexity of water management as islands approach the limit of sustainable yield will pose difficulties for small islands, where sometimes only one or two people are responsible for water management. Regional organizations that pool expertise and local experience and provide training opportunities have and should continue to have a key role in supporting PICs in water management. It is important that these regional organizations are incorporated as partners into aid and donor programs in the water and sanitation sector in the Pacific.

Acknowledgements Parts of this work were supported by the Kiribati Adaptation Program Phase II supported by AusAID, NZaid, and the World Bank, by the European Development Fund, by the Pacific Islands Applied Geoscience Commission (SOPAC) and by the Australian Centre for International Agricultural Research Project LWR1/2001/050. We are grateful to our colleagues throughout the Pacific who have generously worked with us and have taught us a great deal.

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Annex 884

J. L. Deenik & R.S. Yost, “Chemical properties of atoll soils in the Marshall Islands and constraints to crop production”, *Geoderma*, Vol. 136 (2006)

Available online at www.sciencedirect.com
ScienceDirect
Geoderma 136 (2006) 666 – 681
GEODERMA
www.elsevier.com/locate/geoderma

Chemical properties of atoll soils in the Marshall Islands and constraints to crop production

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Received 9 July 2005; received in revised form 27 January 2006; accepted 3 May 2006
Available online 5 July 2006

Abstract

The sandy carbonatic soils of Pacific atolls are considered infertile and poorly suited to agriculture. The Republic of the Marshall Islands is comprised predominantly of atolls, and there is scant information on the fertility status of the Marshall Island soils. We conducted a survey of the soils to quantify chemical properties and determine significant trends related to soil distribution and climate. A total of 116 surface (0–15 cm) soil samples from 13 atolls and 42 subsoil (15–45 cm) samples from five of the atolls were analyzed for pH, electrical conductivity (EC), organic carbon (OC), total nitrogen (TN), cation exchange capacity (CEC), and nutrient levels. A missing element study in the greenhouse on a typical soil from Majuro Atoll was conducted to rank soil nutrient deficiencies. There were some strong differences in soil chemical properties between the two depths, but not necessarily between the two soil series constituting the sampled soils. Soil chemical properties were not affected by a strong rainfall gradient running from the southern (≈4000 mm) to the northern (≈1350 mm) atolls, but human activity had a significant effect on some properties. Soils located near the center of islands tend to show higher concentrations of OC than soils located along the ocean exposed shoreline. The missing element study indicated that the soil was deficient in Cu, P, N, S, and K. Potassium was the most serious nutrient constraint whereas the micronutrients Fe, Mn, Zn, and B did not limit maize growth significantly in a greenhouse pot experiment. Interpreting soil test data on atoll soils, however, remains difficult for two reasons: (i) the soil tests have not been calibrated with crop growth, and (ii) standard soil tests may not be applicable to the unique physical and chemical properties of atoll soils.

Keywords: Atoll soils; Marshall Islands; Chemical properties; Organic matter; Soil testing; Nutrient availability

1. Introduction

The Republic of the Marshall Islands, a remote archipelago comprised of 34 low-lying coral atolls and islands in the central Pacific Ocean, is struggling with food security issues. Rapid population growth combined with the demise of traditional agriculture since the end of World War II have left the small island nation largely dependent on imported processed food (Sommers, 1987; Rapaport, 1990). This dependency on processed food is a significant factor contributing to declining health associated with the rise of chronic diseases like hypertension and diabetes (Schoeffel, 1992; Finney and Laukon, 1993). The government has made increasing local food production a top priority. However, several factors interact to constrain food production opportunities in the Marshall Islands. First, the Marshall Islands has a limited land area of only 181 km^2. The lack of water also poses a serious threat to crop production especially in the northern atolls where drought conditions prevail between December and May. One of the most serious

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0016-7061/$ - see front matter © 2006 Published by Elsevier B.V.
doi:10.1016/j.geoderma.2006.05.005

constraints to good crop growth is the general infertility of atoll soils (Morrison, 1992; Stone et al., 2000). Atoll soils are considered poorly suited to intensive agriculture (Stone, 1951; Fosberg, 1954; Caiger, 1987; Finlay, 1987a; Laird, 1989; Morrison, 1990; Stone et al., 2000). Their extremely sandy texture promotes rapid drainage, low water holding capacity, and little cation exchange capacity.

The chemical properties of atoll soils have not been studied in much detail. Existing research has shown that these soils are deficient in N (Finlay, 1987b; Reddy and Chase, 1992) and exchangeable K (Bruce, 1972; Finlay, 1987a; Reddy and Chase, 1992; Gangaiya and Morrison, 1998), and that rapid drainage and low CEC demand that fertilizers be added in small frequent doses. The high soil pH resulting from the carbonate mineralogy predicts that P and micronutrient solubility in atoll soils should be very low (Morrison, 1992). However, few studies have confirmed P and micronutrient availability in atoll soils. High total soil P levels have been measured in some atoll soils and attributed to accumulation of guano from birds (Fosberg, 1954). A survey of chemical properties of soils on Tuvalu, an atoll country in the South Pacific found that Olsen extractable P concentration in the surface soil averaged 26.2 mg kg^{-1} (Caiger, 1987), but because this level was not compared with crop growth and yield, it is difficult to interpret.

The United States Department of Agriculture conducted a soil survey on five atolls in the Marshall Islands and identified two soil series (Laird, 1989). The Majuro series (Sandy–skeletal, carbonatic, isohyperthermic Typic Troporthents) occurs predominantly along the ocean side of the atolls. Its texture ranges from a cobbly, loamy sand to an extremely cobbly sand with 35–50% coarse fragments > 8 cm. The second, the Ngedebus series (Carbonatic, isohyperthermic Typic Ustipsamments) is found primarily in the interior and along the lagoon beaches of the atolls. Its texture ranges from a loamy sand to a very gravelly loamy sand with 0–25% coarse fragments > 8 cm. The Ngedebus series occupies approximately 64% of the area while the Majuro series comprises the remaining 36% of the area. According to the soil survey, surface soil pH was similar in both soil series ranging from 6.6 to 8.4. Subsoil pH in the Majuro series was similar to the surface soil, but the Ngedebus series showed higher pH values ranging from 7.4 to 9.0 (Laird, 1989). A pair of studies conducted fifty years ago investigated soil chemical properties on Arno Atoll (Stone, 1951) and the phosphate rich soils of Kwajalein, Bikar, and Jemo Atolls (Fosberg, 1954), but total nutrient analysis was determined and the data are difficult to interpret for fertility purposes because the soil test values have not been calibrated with crop growth.

Good crop production depends largely on nutrient availability in the soil. Where nutrients occur at suboptimal levels, management strategies are required to increase nutrient availability. One of the first steps in developing a nutrient management strategy is to characterize the chemical properties of the soil and identify potential fertility constraints to crop production. The chemical properties of the Marshall Island soils have not been well characterized. The present work was conducted to characterize the chemical properties, identify any significant trends in soil chemical properties related to soil distribution and climate, and to assess the fertility status of the soils of the Marshall Islands.

2. Materials and methods

2.1. Study area

The Marshall Islands comprise 29 low-lying coral atolls and five islands spread out over 2.1 million km^2 of the central Pacific Ocean. Atolls are the calcareous remains of coral growth that have accumulated over millions of years on the peaks of submerged mid-oceanic volcanic islands (Wiens, 1962). The Marshall Islands are all low-lying with a mean elevation of 2 m above sea level where the highest elevation, found on Likiep Atoll in the north, is only 6 m above sea level. The islands and islets are generally small and often very narrow. Most islets in the Marshall Islands are less than 1000 m long and 500 m wide (Wiens, 1962). The total land area of the Marshall Islands is 181 km^2.

The mean annual temperature in the Marshall Islands is 28 °C with temperature differences between the warmest and coolest months averaging less than 0.3 °C. This temperature regime coupled with abundant sunlight throughout the year generates favorable conditions for plant growth provided there is adequate water. Rainfall, on the other hand, is unevenly distributed across the archipelago with a distinct rainfall gradient running from north to south (Wiens, 1962). Precipitation in the southern atolls averages threefold higher than in the northern atolls. On Enewetok atoll in the north-west, rainfall averages about 1440 mm annually (SRDC, 2005) increasing to 2540 mm on centrally located Kwajalein (3D Research Corporation, 2005). The southern Marshalls are considerably wetter with annual precipitation on Majuro averaging 3300 mm (Marshall Islands Statistics, 2005). Available data indicate that rainfall can total as high as 4100 mm annually on Jaluit and is even higher on Ebon, the most southerly atoll (Spoehr, 1949). The northern and centrally located atolls receive the bulk of their rainfall from June through November and are prone to drought during the winter and spring months (Fig. 1). The atolls in the south, on the other hand, enjoy a moist climate throughout the year under normal conditions. However, drought conditions can occur on even the wettest atolls.

Large distances between the atolls, unreliable transportation, and government access restrictions prohibited sampling on all the atolls. Nevertheless, two technicians from the College of the Marshall Islands were able to travel to and collect soil samples from 12 atolls (Table 1). Six of the 12 atolls are in the Ratak Chain (eastern) covering most of the north south distribution, and the remaining six are in the Railik Chain (western) concentrated mainly in the southern and central portion of the distribution. Access to the northern most atolls in the Railik Chain (i.e. Bikini, Enewetok, and Rongelap) is restricted due to residual radioactive contamination from atomic bomb testing in the 1940s–1960s.

Table 1
Name, geographic location, land area, and population of the 13 atolls where soil samples were collected

Atoll	Latitude/ longitude	Chain	Land area km^2	Population[a]
Ailuk	10°13′ 169°59’	Ratak	5.4	617
Ailinglaplap	7°16′ 168°33’	Railik	14.7	2168
Arno	6°58′ 171°33′	Ratak	13.0	2093
Majuro[b]	7°09′ 171°12′	Ratak	9.7	27,776
Bikirin				
Laura				
Ebon	4°34′ 168°38′	Railik	5.8	937
Jabat	7°44′ 168°58′	Railik	0.6	142
Jaluit	5°47′ 169°24′	Railik	11.3	2160
Kili	5°37′ 169°7′	Railik	0.9	761
Likiep	9°48′ 168°58′	Ratak	10.3	609
Mili	5°53′ 171°42′	Ratak	15.9	1079
Mejit	10°16′ 170°52′	Ratak	1.9	562
Namdrik	5°35′ 108°5′	Railik	2.8	1029

[a] Source: Asian Development Bank (1997).
[b] Two locations on Majuro were sampled: Bikirin, a small uninhabited islet on the eastern side of the lagoon and Laura, a farming area on the northern–western tip of the lagoon.

2.2. Soil sampling, sample preparation and chemical analyses

A total of 116 surface (0–15 cm) soil samples were collected from the organic rich A horizon on 13 atolls. Forty-two subsoil (15–45 cm) samples were collected from 5 of the atolls (Table 1). Sampling was conducted on the main island of each of the atolls in a zig-zag pattern at nine locations (except Likiep where eight samples were collected). Samples were labeled Ngedebus or Majuro corresponding to the two soil series. Ngedebus samples were associated with the interior sections and areas along the lagoon shoreline, and Majuro samples were associated with the ocean side of the islands. Ninety-one or 78% of the samples represented the Ngedebus series and 25 or 22% of the samples came from the Majuro series. In addition, samples were categorized as forested (unmanaged native or coconut forest land) or farm (lands where human activity was apparent, i.e. gardens or lands adjacent to houses). Eight samples were collected from traditional taro pits. A subsequent sampling was conducted on Arno Atoll comprising six surface samples along three separate transects traversing uninhabited, forested lands on the main island from the ocean shoreline to the lagoon shoreline to identify the existence of specific trends in soil chemical properties.

The samples were packaged in airtight plastic containers on-site, and sent by airplane to the Agricultural Diagnostics Service Center (ADSC) at the University of Hawaii for laboratory analysis. The samples were air

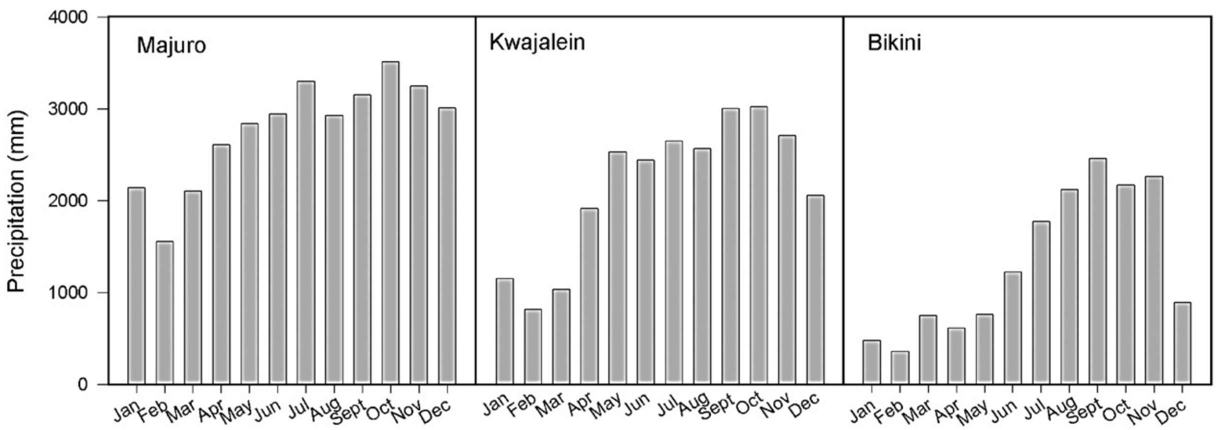

Fig. 1. Mean monthly precipitation for three atolls in the Marshall Islands illustrating the decreasing rainfall gradient from south (Majuro) to north (Bikini). (Sources: Gouveia et al., 2002; Horel, 2005).

dried and screened through a 2 mm stainless steel sieve. All samples were analyzed according to procedures developed by the ADSC to enable fertility interpretations (Hue et al., 2000). Soil pH was determined in a saturated paste equilibrated for one hour and measured with a pH meter. Electrical conductivity (EC) was determined in a 1:1 soil to water mixture with a conductivity bridge after shaking the slurry on a reciprocal shaker for 45 min and filtering. Soil P was determined by the Olsen P method (Kuo, 1996). Phosphorus in the filtered extract was determined by Inductive Coupled Plasma (ICP) on a Thermo Jarrell Ash, Atomscan 16 instrument. Total N was determined by Kjedahl distillation (Bremner, 1996), and OC by a revised Walkley Black method (Heanes, 1984). Exchangeable cations (K^+, Mg^{2+}, Ca^{2+}, Na^+) were extracted in a 1 M NH_4OAc at pH 7.0 solution with a soil-to-solution ratio of 1:20, shaken for ten minutes, and determined quantitatively by Inductive Coupled Plasma Emission (ICP). Sulfate (SO_4^{2-}–S) was extracted by shaking soil for 30 min in 1:5 soil water mixture (Fox et al., 1964), filtered and S determined quantitatively with ICP. Micronutrient content was determined by the DTPA method as outlined by Lindsay and Norvell (1978). Cation exchange capacity (CEC) was determined on selected samples by the leaching method where the saturating solution consisted of a 0.4 M NaOAc–0.1 M NaCl solution adjusted to pH 8.2 and the extracting solution was 0.5 M $MgNO_3$ to reduce Ca dissolution from the $CaCO_3$ rich parent material (Sumner and Miller, 1996). Particle-size analysis was determined by the pipette method with no additional pretreatment other than dispersion with $(NaPO_3)_6$ (Day, 1965).

2.3. Missing element study

A missing element study was conducted in the greenhouse using a surface soil from the Ngedebus series collected from Laura village on Majuro Atoll to help interpret results of the soil test in terms of nutrient availability. Soil chemical properties were determined according to the methods presented above and were as follows: pH (7.8), OC (69.9 g kg^{-1}), total N (5.2 g kg^{-1}), P (50.0 mg kg^{-1}), K (0.0 mg kg^{-1}), Ca (9455 mg kg^{-1}), Mg (221 mg kg^{-1}), SO_4^-–S (6.7 mg kg^{-1}), B (0.4 mg kg^{-1}), Fe (27.7 mg kg^{-1}), Mn (7.4 mg kg^{-1}), Cu (0.1 mg kg^{-1}), and Zn (3.4 mg kg^{-1}). Treatments and nutrient rates are outlined in Table 2. Nitrogen and K were added in solution form at a rate of 25 mg kg^{-1} N and K bi-weekly during the pot study for a total equivalent to 200 mg N and K kg^{-1}. The remaining elements were added separately in solution at the outset of the experiment and mixed thoroughly with 2.5 kg of soil (1.79 kg oven dry basis). Deionized water was added to achieve approximate field capacity, and six maize (*Zea mays* cv. super sweet #9) seeds were planted in each pot. The pots were set up in the greenhouse in a randomized complete block design with 3 replicates per treatment. Pots were watered daily with deionized water to maintain moisture status, and maize was thinned to two uniform plants per pot seven days after planting. The maize plants were harvested 4 weeks after planting, weighed for fresh weights, dried at 70 °C for 72 h, and weighed again for biomass. Tissues were then ground in a Wiley mill to pass through a 0.45 mm sieve, and analyzed for total N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, and B. Soils were air-dried, and analyzed for pH, EC, total N, OC, and extractable P, K, Ca, Mg, B, Fe, Mn, Cu, and Zn according to the procedures outlined above.

2.4. Statistical analyses

Statistical analyses including descriptive statistics, *t*-tests, and analysis of variance (ANOVA) on soil chemical properties and dry weights from the missing element study

Table 2
Treatments, nutrient application rates, and chemical composition of nutrient additions used in the missing element study

Treatment	Description
Check	No nutrients applied
Control	All nutrients applied (N, P, K, Mg, S, B, Cu, Fe, Mn, Zn)
–N	Control without N
–P	“P
–K	“K
–Mg	“Mg
–S	“S
–B	“B
–Cu	“Cu
–Fe	“Fe
–Mn	“Mn
–Zn	“Zn

Nutrient	Form of nutrient	Application rate	
		mg kg^{-1}	kg ha^{-1} [a]
N	NH_4NO_3	200	400
P	H_3PO_4	20	40
K	KCl	200	400
Mg	$MgCl_2$	35	70
S	H_2SO_4	10	20
B	$Na_2B_4O_7$	1	2
Cu	CuCl	5	10
Fe	FeEDDHA	10	20
Mn	$MnCl_2$	10	20
Zn	$ZnCl_2$	10	20

[a] Conversion from mg kg^{-1} to kg ha^{-1} assumes bulk density of 1.3 mg m^{-3} (Laird, 1989) and depth of 15 cm.

were generated using SAS Analyst (SAS Institute, 1999). Soils collected from traditional taro pits were not included in analyses to investigate effects of soil type, location, and rainfall on soil chemical properties. Linear regression using Proc Reg in SAS was performed to test the effect of the north–south rainfall gradient on soil chemical properties. Because rainfall data does not exist for most of the individual atolls, we used latitude as proxy variable for rainfall. Using mean annual rainfall data (Spoehr, 1949; Wiens, 1962; Raynor, 1992) for Enewetok (1350 mm), Kwajalein (2700 mm), Majuro (3500 mm), and Jaluit (4100 mm) we conducted regression analysis with latitude as the independent variable and we found that latitude accounted for 98% of the variation in rainfall.

3. Results and discussion

3.1. Soil chemical properties

Results for the chemical properties of the soil samples collected from the 12 atolls are summarized in Table 3. The data are arranged to reflect the mean value of the different chemical determinations by depth and by soil series. Soil pH in the surface and subsoil was high in both soils with a significantly ($P<0.05$) higher pH values in the subsoil. Lower pH values in the surface soil reflect the influence of the high organic matter content in the surface. Despite proximity to the ocean and the ubiquitous occurrence of salt laden sea spray, EC was relatively low in both soils at both depths due primarily to high infiltration and leaching rates that transport salts rapidly through the soil profile. The low values for EC indicate that soluble salt concentration in the soil profiles is low. The results for pH and EC are similar to those reported for soils of Tarawa (Morrison, 1990), Tuvalu (Caiger, 1987), and Palmerston and Manue Islands in the Cook Islands (Bruce, 1972). There were four samples with pH values below 7.0, three of which were sampled from traditional taro pits where organic matter was very high. These three samples also showed EC values above 4.0 dS m^{-1} suggesting saltwater intrusion into the excavated pits. Our results show a similar range in pH to those reported for Arno Atoll (Stone, 1951) and Rongelap (Gessel and Walker, 1992).

Organic C contents of the surface soils were higher than the subsoil with larger differences observed in the Majuro series. Measured differences in OC in the surface and subsoil for the Majuro soils were significant ($P<0.05$), but not for the Ngedebus soils. The occurrence of higher subsoil OC concentrations in the Ngedebus series is likely due the smaller proportion of coarse fragments than in the Majuro soil and the influence of denser vegetation towards the center of the islands promoting the accumulation of organic matter to lower depths. Surface soil OC concentrations varied from 11.0 to 490 g kg^{-1} with a median value of 44.2 g kg^{-1}. Ninety percent of the samples showed values between 11.0 and 90.0 g kg^{-1}. The three samples showing OC concentrations in excess of 300 g kg^{-1}were collected from traditional taro pits where the soil had been enriched with organic matter over many years. Mean OC concentrations (excluding soils from the taro pits) in the Ngedebus and Majuro soils are approximately 2 and 1 g kg^{-1}, respectively, greater than the concentrations recorded for the surface horizon of the Tuvalu soils (mean=35.9 g kg^{-1}). Almost 40% of the Marshall Island soils show OC levels greater than 50 g kg^{-1}. The higher levels of organic matter in the Marshall Island soils compared with other atoll soils (Hammond, 1969; Caiger, 1987; Morrison, 1990) is likely the effect of a wetter climate that promotes and sustains denser vegetation.

Table 3
Mean values and results of *t*-test comparing depths for selected chemical properties of the Negedebus and Majuro soil series at two depths

Soil	Depth	pH	EC	OC	TN	P[a]	K[b]	Ca	Mg	Na
	cm		dS m^{-1}	g kg^{-1}		mg kg^{-1}	cmol$_c$ kg^{-1}			
Ngedebus	0–15	7.9	0.8ns[c]	58.3ns	4.40ns	34.7	0.13ns	30.8ns	3.05ns	0.20
	15–45	8.2	0.8	41.1	3.07	16.2	0.08	29.7	3.00	0.36
Majuro	0–15	7.8	0.8	46.9	4.25	28.5ns	0.12	29.1	3.25	0.25ns
	15–45	8.2	0.4	10.8	1.35	18.3	0.02	23.3	2.04	0.15

Soil	Depth	B	Mn	Fe mg kg^{-1}	Cu	Zn
Ngedebus	0–15	0.6ns	2.9	11.8	1.5ns	22.1ns
	15–45	0.4	1.1	4.4	0.8	19.2
Majuro	0–15	0.6	3.2	11.4ns	2.9ns	27.6ns
	15–45	0.3	0.8	0.6	0.1	0.4

[a] Olsen extractable.
[b] Exchangeable cations.
[c] No significant difference between depths at $P<0.05$, pairs with no markings are significantly different ($P<0.05$).

Total soil N concentrations followed a similar pattern to OC with significantly higher values in the surface soils for the Majuro soils, but no difference in the Ngedebus soils. The range in the surface soils varied from 1.0 to 38.6 g kg^{-1} with approximately 90% of the samples having N levels less than 7.0 g kg^{-1}. Similar to OC, the range in total N was considerably wider than the 2.0–6.5 g kg^{-1} reported for the soils of Tuvalu (Caiger, 1987). The samples showing very high N levels (>10 g kg^{-1}) were obtained from the organic enriched soils from the traditional taro pits. Carbon:nitrogen (C:N) ratio varied from 7.6 to 34.1 in the surface soils with 20 samples (17%) showing C:N ratio greater than 15. The high C:N showed no clear relationship to soil type, management, or rainfall.

Olsen extractable P concentrations were relatively high at both depths and in both soils, with a significant difference in the Ngedebus surface soils compared to the subsoil. There was a wide range of extractable P concentrations for both surface soils with a few very high values that inflated the mean; the median concentration was 23.0 mg kg^{-1} for the Ngedebus soil and 21.0 mg kg^{-1} for the Majuro series. Three of the samples with very high P concentrations were associated with the taro pits indicating the effect of management. Caiger (1987) obtained similar results for Olsen extractable P for the surface soils of Tuvalu. Based upon current fertility recommendations that use a critical P concentration of 10 mg kg^{-1} to separate P deficient soils (Kuo, 1996), a median value of 23 mg kg^{-1} Olsen extractable P does not suggest a P deficiency. Using the current critical level, only 15 out of the 116 surface soils sampled would fall in the deficient category. These findings appear to contradict the expectation that extractable P would be low in calcareous soils with high pH. The higher than expected P concentrations may be associated with the high levels of organic matter, but there was no correlation between OC levels and extractable P.

As expected in soils dominated by coral sand, Ca^{2+} concentration was high in both soils at both depths with the surface soils showing slightly higher concentrations. Approximately 90% of the exchange complex is dominated by Ca^{2+} at both depths for the two soils. The significantly lower Ca^{2+} concentrations observed in the Majuro subsoil compared to the surface soil is likely associated with the lower OC contents of the subsoil. Soil Mg levels showed no difference between the surface and subsoils of the Ngedebus series, but significantly lower concentrations in the subsoil of the Majuro soils compared with the surface soils. The very low concentrations of exchangeable K in both soils stand out as a major constraint to crop growth. Low K concentrations appear to be characteristic of atoll soils (Caiger, 1987; Reddy and Chase, 1992; Gangaiya and Morrison, 1998) due primarily to the low K content of coral parent material, the predominance of Ca^{2+}, and exacerbated by the coarse texture of the soils which promote rapid leaching of K. Ngedebus subsoil Na levels were higher than in the surface soils, but showed the opposite trend in the Majuro soils. Electrical conductivity values were generally low in the surface soils with low concentrations of soluble salts. Similar results for cation concentration and distribution were reported for the soils of Tuvalu (Caiger, 1987) and Tarawa (Morrison, 1992).

We evaluated micronutrient (Fe, Mn, Cu, and Zn) availability with the DTPA soil test (Lindsay and Norvell, 1978), which was developed for calcareous soils. Extractable Fe, Mn, Cu, and Zn were consistently higher in the surface horizon for both soils with significant differences for Mn and Fe in the Ngedebus soil and Mn in the Majuro soil. Several high values tended to produce a skewed distribution of the data inflating the mean (Fig. 3). Median concentrations for Mn, Fe, Cu, and Zn in the surface soils were 2.5, 6.7, 0.2, and 4.3 mg kg^{-1}, respectively. The high concentrations for these nutrients were usually associated with samples collected from farmed areas. Extractable B concentrations were higher in the surface layer for both soils, and the occurrence of several high values in the surface layer tended to inflate the mean; median B concentration in the surface was 0.5 mg kg^{-1}. It is difficult to make fertility interpretations from these numbers alone for two reasons: first, there is no basis for comparison with previous work assessing micronutrient status of atoll soils because they measured the total micronutrient content of the soil with strongly acid extractants rather than the plant available fraction (Stone, 1951, Caiger, 1987); and second, the DTPA soil test was developed for calcareous clay soils and have not been calibrated for the sandy soils of atolls. Comparisons, however, with current ranges in critical levels (Sims and Johnson, 1991) for Mn (1.0–5.0 mg kg^{-1}), Fe (2.5 mg kg^{-1}), Cu (0.1–2.5 mg kg^{-1}), Zn (0.2–2.0 mg kg^{-1}), and B (0.1–2.0 mg kg^{-1}) reveal, surprisingly, that median micronutrient concentrations in Marshall Island surface soils fall within or above the established ranges. These findings disagree with the widely held opinion that atoll soils are deficient in micronutrients (Morrison, 1992; Widdowson and Trangmar, 1992).

The Ngedebus and Majuro soils were classified as two distinct series primarily because of measured differences in % coarse fragments (Laird, 1989). We compared both soil types to determine whether differences in particle size distribution influenced the chemical properties of the surface horizon. A *t*-test was performed on the soils located under native forest showing minimal human activity. The

Table 4
Results of *t*-test comparisons of chemical properties for Ngedebus and Majuro surface soils under forest vegetation and Ngedebus soils under forest vegetation and farm management

Property	Units	Ngedebus (n=69)	Majuro (n=20)	P value	Ngedebus		P value
					Forested (n=69)	Farm (n=15)	
pH		7.9	7.8	0.29	7.9	7.9	0.46
EC	dS m^{-1}	0.8	0.8	0.43	0.66	0.7	0.32
Org. C	g kg^{-1}	61.6	48.9	0.11	61.6	43.4	0.03
Total N		4.50	4.41	0.44	4.50	3.90	0.14
P	mg kg^{-1}	33.5	31.1	0.33	33.5	40.3	0.22
K		53.7	41.0	0.18	53.7	32.9	0.05
Ca		6185	5790	0.08	6185	6005	0.26
Mg		404	375	0.68	404	329	0.23
Na		70.4	84.3	0.83	70.4	59.2	0.23
B		0.6	0.7	0.69	0.6	0.6	0.94
Mn		3.0	3.4	0.77	3.0	2.7	0.35
Fe		10.5	8.5	0.30	10.5	17.8	0.07
Cu		1.1	0.3	0.02	1.1	3.1	0.09
Zn		15.5	6.0	0.03	15.5	52.4	0.08

results of the *t*-test indicated that the Ngedebus soils were generally richer in soil nutrients compared to the Majuro soils, but the differences were not statistically significant except in the cases of Cu and Zn which showed significantly higher concentrations in the Ngedebus soils (Table 4). The higher concentrations of Zn in the Ngedebus soils may be related to higher organic matter content in these soils, which increases Zn solubility. For Cu, the explanation is less apparent since organic matter tends to depress Cu availability in soils. The relatively large difference in OC between the two soil types (12.7 g kg^{-1} greater in the Ngedebus series) may not be statistically significant, but ($P<0.05$), but a P value of 0.11 indicates that 89% of the time you would expect OC levels to be higher in the Ngedebus soils. The tendency to show a difference is important since organic matter plays such a critical role in these sandy soils. On Arno Atoll, where an additional sampling occurred along three transects crossing the island from the ocean shoreline to the lagoon shoreline, most of the soil chemical properties varied only slightly depending on relative location (Table 5), but OC concentrations were significantly higher in the center of the island (Ngedebus soils) compared with the samples collected along the ocean coastline (Majuro soils). Similar trends showing organic matter accumulation in the center of islands covered with native vegetation were reported for Arno Atoll (Stone, 1951) and Rongelap Atoll in the northern Marshalls (Gessel and Walker, 1992). Both these studies showed that soils close to the ocean shoreline tended to have lower organic matter contents. The tendency for lower OC levels in the soils along the ocean side of the islands is likely associated with the reduction in vegetation density and growth due to the negative impacts of salt spray.

Some of the sampling sites occurred on lands that had been disturbed by human activity. We conducted a separate *t*-test to evaluate whether human activity has had an effect on the chemical properties of the Ngedebus soils (Table 4). Human activity appears to have had an effect on soil chemical properties. OC and total N levels in the altered soils were lower than in the forest soils; the slight decrease reflecting the effect of removing the native vegetation. Differences in soil P and soil cations were small, but much larger differences were measured in the case of the micronutrients. Significantly higher concentrations for Fe, Cu and Zn were measured in soils associated with human activity. The higher metal content in the human affected soils is most likely caused by the common practice of

Table 5
Results of ANOVA showing the effect of within island location on soil nutrient concentrations for the three transects collected on Arno Atoll (N=12). Values represent a mean of the three transects

Determination	Units	Location			
		Lagoon	Center	Ocean	P value
pH		7.97	7.85	7.93	0.33
EC	dS m^{-1}	0.31	0.30	0.29	0.95
Org. C	g kg^{-1}	39.2	58.0	28.9	0.03
N		3.97	5.33	4.13	0.32
P	mg kg^{-1}	15.7	34.3	35.5	0.20
K		31.6	32.5	12.2	0.08
Ca		6575	7323	7203	0.54
Mg		285	164	258	0.003
B	μg g^{-1}	0.37	0.29	0.28	0.38
Fe		2.10	8.78	13.4	0.35
Mn		3.75	6.82	3.68	0.17
Cu		0.03	0.07	0.17	0.34
Zn		0.66	0.41	13.2	0.28

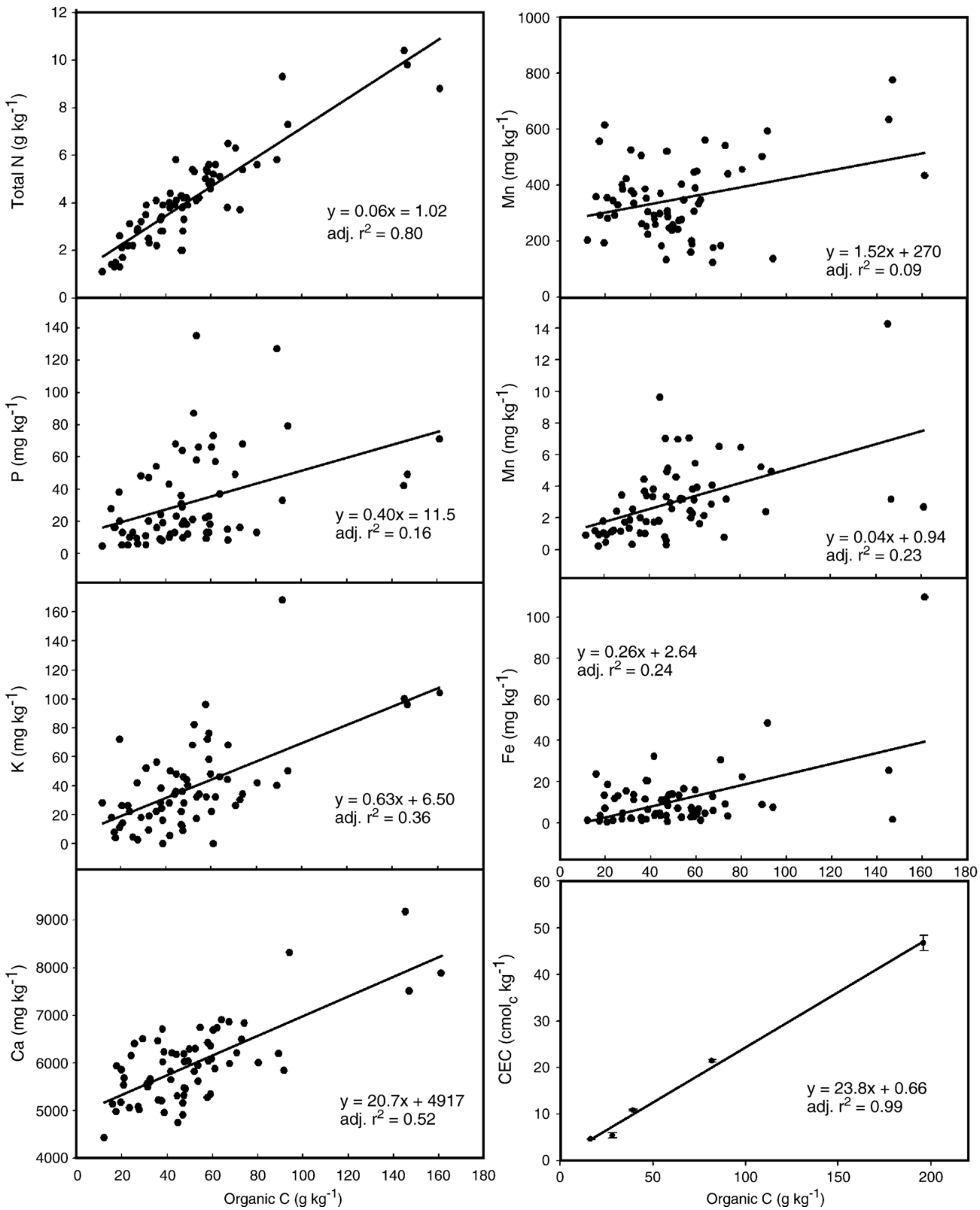

Fig. 2. Results of regression analyses for organic C and selected soil nutrients and CEC in Ngedebus surface soils (n=89).

discarding metal cans in garden and farm plots to overcome soil micronutrient deficiencies. Islanders commonly mix parts of metals can and other household wastes into their garden plots and fields.

3.2. Soil organic matter

Atoll soils are characteristically sandy with minimal clay content. Particle size analysis on an Ngedebus soil from Majuro Atoll, for example, found that it was composed primarily of sand (95.2%), a small quantity of silt (3.0%), and only 1.8% clay. In the absence of a clay fraction in atoll soils, organic matter is the main source and sink of nutrients, and should theoretically show a strong relationship with the nutrient status of the soil. Results of regression analysis on Ngedebus surface soils under native forest vegetation showed that this relationship is true only for some of the soil nutrients (Fig. 2). Surface soil OC concentration was a good predictor for total N and Ca^{2+}, but showed a less robust relationship with K, Mn, Fe, P, and Mg. Organic C was a poor predictor of soil B, Cu, and Zn (data not shown). Cation exchange capacity depends on clay and organic matter content, and in atoll soils, CEC depends almost entirely on the organic matter content. We measured CEC in soils where OC concentration ranged from 16.4 g kg^{-1} to 196 g kg^{-1} and found that CEC is entirely a function of organic matter content in these atoll soils (Fig. 2). From regression we estimated that organic matter contributes 238 cml_c kg^{-1}, a reasonable number when compared with the common number of 200 $cmol_c$ kg^{-1} associated with the CEC of organic matter (Brady and Weil, 2004). Cation exchange capacity ranged from 4.65 $cmol_c$ kg^{-1} to 46.7 $cmol_c$ kg^{-1} as OC increased. Caiger (1987) found a similar range in CEC for the surface soils of Tuvalu. Measuring CEC involves multiple steps, but in atoll soils CEC can be readily estimated by exchangeable Ca^{2+}, which explains 99.2% of the variation in CEC.

Climate gradients can often have a strong influence on soil chemical properties. Soil organic matter, for example, is strongly influenced by climate showing accumulation in wet environments (Brady and Weil, 2004). Because of its importance in determining soil behavior in atoll soils, we performed regression analysis to evaluate the effect of rainfall distribution on soil OC levels. Less than 10% of the variation in soil OC levels can be explained by rainfall. A wide range of OC levels can be found on each of the islands irrespective of mean annual precipitation or seasonality of precipitation. The highest mean OC concentrations were measured on two wet southern atolls (Ebon and Mili), but the two lowest levels were also measured on two wet southern atolls (Jaluit and Namdrik), and relatively high concentrations were measured on the two northern most atolls (Fig. 3). The low C levels on Jaluit and Namdrik are puzzling, but may be related to sampling on the most populated islands within the atoll where natural vegetation patterns have been altered most. Mean Zn concentrations on Jaluit are unusually high (147 mg kg^{-1}) compared to the median value for all the atolls (2.5 mg kg^{-1}) and suggest that human activity has significantly altered these soils.

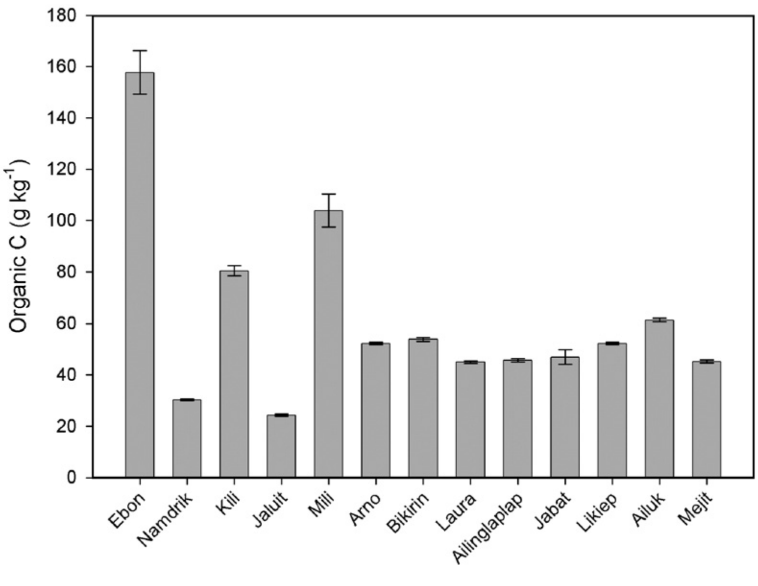

Fig. 3. Mean OC concentrations for surface soils of selected atolls in the Marshall Islands under native vegetation. Islands are arranged according to location from south to north (left to right). Error bar represents standard error of the mean.

Mean Zn levels for Namdrik are also relatively high (28.8 mg kg^{-1}) indicating the effects of human activity. Comparisons of Zn levels in samples from the uninhabited islet of Bikirin and the inhabited area of Laura from Majuro Atoll showed significantly higher ($P < 0.05$) Zn concentrations in the Laura soils (18.8 mg kg^{-1}) compared with the Bikirin soils (0.33 mg kg^{-1}) supporting the connection between human activity and effects on soil properties. These findings suggest that trend analysis across the atolls requires that sampling be limited to uninhabited islets.

Despite sampling on both human affected and unaffected soils, our results showed, as did the findings of Gessel and Walker (1992) that location within islands has a much stronger effect on soil OC levels than any variation in overall climate across the geographic region. High OC levels are generally associated with Ngedebus soils located in the center of the islands and C accumulation in these soils is associated with the historical occurrence of dense stands of *Pisonia grandis*, a common atoll tree, and other tree species, which deposited abundant litter (Manner, 1987).

3.3. Missing element study: yield and nutrient uptake

Multiple nutrient deficiencies were observed in maize grown in an Ngedebus soil from Majuro. Maize dry matter yields were significantly decreased in the –K, –S, –N, –P, and –Cu treatments (Fig. 4). The –K treatment showed the most dramatic decrease in maize growth; yields were 65% less than in the control treatment where the blanket nutrient solution was applied. The maize plants showed K deficiency symptoms by the second week of growth and by harvest they were lodging. Tissue K concentration was almost an order of magnitude below the minimum critical level established for maize (Fig. 5). Our results are in agreement with earlier reports that crop growth in atoll soils is severely limited in the absence of added K (Finlay, 1987a; Reddy and Chase, 1992; Gangaiya and Morrison, 1998).

Nitrogen deficiency symptoms were apparent by the second week of growth in the –N treatment, and dry matter biomass was 50% less than in the control. Our results agree with earlier studies showing that N deficiency is common in atoll soils (Reynolds, 1971; Finlay, 1987b; Reddy and Chase, 1992). Despite relatively high total N concentrations in these soils, the lower yields in the –N treatment showed that the N is immobilized in the stable organic fraction and remains unavailable for plant uptake. The tissue N concentration observed in the –N treatment confirms the unavailability of N in these soils (Fig. 5). Nitrogen tissue concentration in the –N treatment was three times lower than the established critical level for maize, and adding N at 200 mg kg^{-1} did not raise the tissue concentration above the minimum critical level of 3.5%. Nitrogen uptake results indicated that 153 mg kg^{-1} of the added N was taken up by the plants representing 61% of the total added N.

Maize growth in the –P treatment was reduced by 40% compared to the control treatment. Few studies exist documenting crop response to P in atoll soils (Weeraratna, 1992), but based on the carbonatic mineralogy and alkaline pH, P deficiency can be expected in these soils (Sample et al., 1980; Morrison, 1992). Olsen extractable P for this soil showed a relatively high concentration of

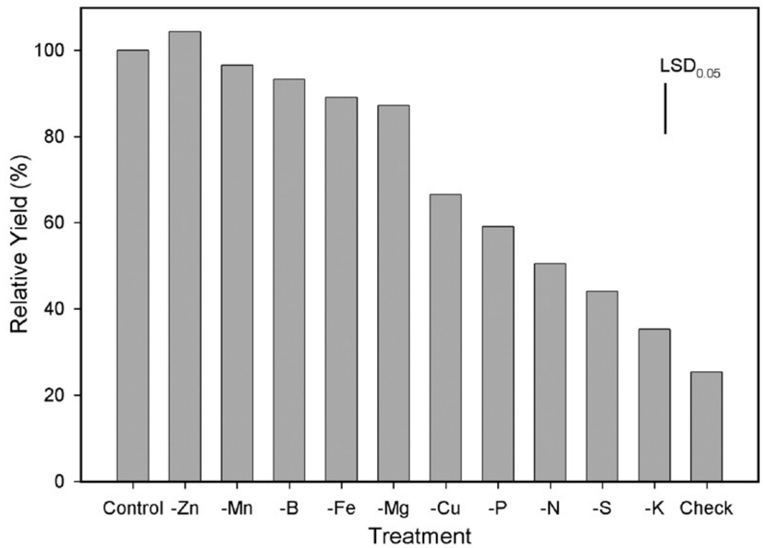

Fig. 4. Relative dry matter yield for corn tops grown in the greenhouse on a Ngedebus soil from Majuro Atoll with a soil alone treatment (check), complete fertilizer treatment (control), and with successive subtraction of each essential plant nutrient. Each bar is a mean of three replicates.

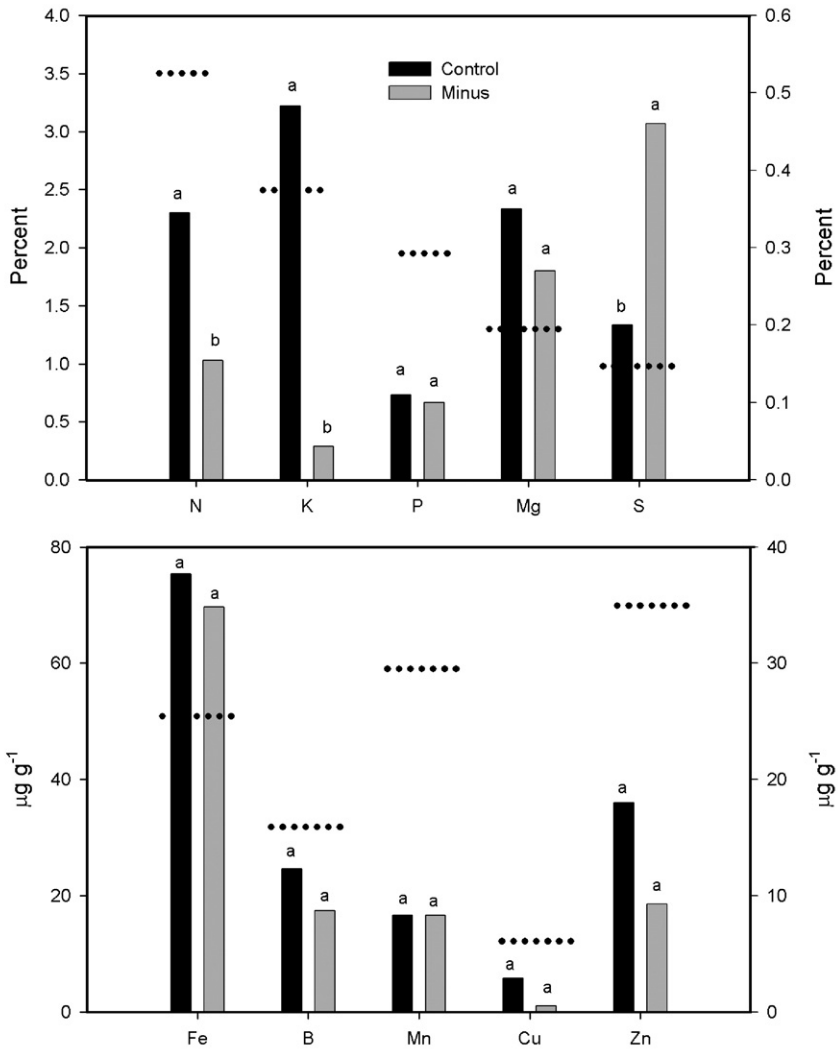

Fig. 5. Treatment effects on above ground biomass nutrient concentration for greenhouse grown corn on an Ngedebus soil. Bars with the same letter are not statistically different ($P < 0.05$). Dashed lines above each set of bars represent minimum critical concentration (Mills and Benton Jones, 1996). The second *y*-axis in the top graph corresponds to tissue concentrations for P, Mg, and S. In the lower graph, the second *y*-axis corresponds to B, Mn, Cu, and Zn.

50 mg kg^{-1}, which is considerably higher than the critical level of 10 mg kg^{-1} established for the Olsen soil test on calcareous soils (Kuo, 1996). The observed yield response to added P compared with the control treatment indicated a P deficiency and suggests that the established critical levels may not apply to atoll soil conditions. The exact mechanism contributing to the deficiency is not clear from the data. Previous research has shown that sandy soils with low P buffering capacity require higher levels of available P to maintain adequate plant growth (Fox and Kamprath, 1971; Zhou and Li, 2001), and may explain the observed P response in the Marshall Island soil. Phosphorus levels in the maize tissue from both the control and –P treatments showed no difference suggesting that the P addition rate was insufficient (Fig. 5). In both treatments, P tissue concentration was well below the critical levels for maize. Low P in the tissue in both the control and the –P treatment despite a relatively high value for extractable P makes it questionable to apply the current critical level for calcareous soils to atoll soils.

The –S treatment decreased yields by 56% compared with the control treatment. These results are difficult to explain from the data. The reason for the growth reduction cannot be assigned specifically to an S deficiency in the soil because S concentration in the maize tissue from the –S treatment was more than twice that of the control treatment. Isolating S deficiency is difficult, especially because it is often accompanied by N and P deficiency (Fox and Blair, 1986). The –S treatment also showed tissue N and P concentrations below the minimum critical level.

The following three properties of the Marshall Island soils may contribute, however, to a potential S deficiency: (i) the majority of the S derives from the organic fraction where it may be immobilized in stable organic substances resistant to microbial decomposition, (ii) the sandy texture of these soils and the absence of clay minerals capable of adsorbing SO_4 promotes rapid leaching and loss of SO_4 ions from the root zone, and (iii) the high $CaCO_3$ content will cause a certain amount of inorganic S to co-precipitate with $CaCO_3$ possibly making it unavailable for plant uptake (Trudinger, 1986). Under field conditions S deficiency in Marshall Island soils may not be a serious problem considering the continual deposition of SO_4–S from sea spray.

There was no significant difference in dry matter yield between the –Mg treatment and the control. Lower amounts of Mg was detected in the tissue of the –Mg treatment compared with the control, but Mg tissue concentration was above the minimum critical level in both treatments. Soil Mg levels are usually reported as percent saturation of the CEC or the concentration of exchangeable Mg; the generally accepted saturation critical level is 5% and yield response is not expected when exchangeable Mg concentrations approach 100 mg kg^{-1} (Haby et al., 1990). The Marshall Island soil had a Mg saturation percentage of 3.8%, which is below the 5% associated with optimum yields. On the other hand, exchangeable Mg concentrations in this soil was 221 mg kg^{-1}, which is more than double the concentration where crop response to added Mg is no longer expected. The absence of a significant growth response to added Mg and adequate concentrations of Mg in the tissue suggest that Mg deficiency is not likely to be a serious constraint to crop production.

The –Cu treatment was the only micronutrient treatment to show a significant yield decline compared to the control. Maize yields dropped by 34% when Cu was not added to the soil. Maize Cu tissue concentration was more than fivefold less in the –Cu treatment compared to the control, but showed no significant difference due to high variability between the replicates (Fig. 5). Adding Cu to the Laura soil raised the Cu concentration from 0.13 to 0.63 mg kg^{-1} and the rise in soil Cu levels was accompanied by an observed yield increase. There is considerable uncertainty regarding a critical level for Cu (Martens and Lindsay, 1990), but the current range in critical concentration for DTPA extractable Cu in calcareous soils is 0.1 to 2.5 mg kg^{-1} (Sims and Johnson, 1991). Using this range, we would expect a response to added Cu in the Laura soil. Given the low Cu concentration of the tissue in the control treatment, it appears that that a higher rate of Cu fertilizer is necessary.

Contrary to the widely held belief that micronutrient deficiencies are expected in atoll soils, our results showed no significant effect on yields when Fe, Mn, B, and Zn were not added to the Laura soil (Fig. 4). The initial Fe concentration in the Laura soil was 28 mg kg^{-1}, which is more than four times higher than the current upper limit of 5 mg kg^{-1} for the DTPA soil test (Sims and Johnson, 1991). The Fe concentration in the tissue was above the established critical limit in both the control and –Fe treatments with slightly higher concentrations in the control treatment. The high soil test values and adequate tissue levels combined with the lack of a yield decline in the –Fe treatment all suggest that native Fe levels in the soil were not limiting growth. The results for B, Mn, and Zn are less clear. Although initial soil concentrations for each of the nutrients fall within or above the established minimum critical ranges and there were no significant declines in corn yields in the minus treatments for each nutrient, tissue concentrations for the three nutrients were considerably lower than the established minimum levels for both the control and minus treatments (Fig. 5). The low tissue concentrations in the control treatments suggest that insufficient B, Mn, and/or Zn could have limited growth and explain why no differences were observed between the control and minus treatments. Amending the soil with B and Zn, however, significantly ($P<0.01$) increased the mean soil B and Zn concentrations from 0.37 to 0.71 mg kg^{-1} for B and from 3.4 to 4.8 mg kg^{-1} for Zn, but the increase in extractable nutrient was not reflected in significantly higher plant uptake (data not shown).

3.4. Fertility assessment using soil test results

We have used the results from the missing element study as an initial step to assess the reliability of correctly diagnosing nutrient deficiencies in atoll soils using standard soil tests. Table 6 summarizes the performance of the various soil tests in diagnosing soil nutrient deficiencies based upon the observance of a growth response in the greenhouse study. For K, Mg, B, Cu, Fe, Mn, and Zn expected response based on established soil critical levels and observed yield response determined by experiment were in agreement. For Mg, however, Mg sufficiency or deficiency can also be defined by the percent Mg saturation of the CEC where sufficient Mg concentrations are often achieved at 5–6% Mg saturation (Haby et al., 1990). According to the percent saturation approach, a yield response to added Mg was expected in the Laura soil with Mg saturation of 3.8%. For Zn and Mn, clear discrepancies between tissue concentrations and yield response as discussed in the previous section shed some doubt on the reliability of current critical levels for the DTPA soil test in atoll soils.

Table 6
Evaluating soil test suitability for nutrient deficiency diagnosis on an atoll soil based on missing element results

Element	Soil test	Critical level	Laura soil	Deficiency	
		$mg\ kg^{-1}$		Expected	Observed
P	Olsen ($NaHCO_3$)	10[a]	50.0	No	Yes
K	NH_4OAc pH 7.0	270[b]	21.3	Yes	Yes
Mg	NH_4OAc pH 7.0	100[b]	221	No	No
SO_4^{2-}–S	H_2O extractable	40[c]	66.7	No	Yes
B	Hot H_2O Extractable	0.1–2.0[d]	0.73	No	No
Cu	DTPA Extractable	0.1–2.5[d]	0.13	No	Yes
Mn	DTPA Extractable	1.0–5.0[d]	7.37	No	No
Fe	DTPA Extractable	2.5–5.0[d]	27.7	No	No
Zn	DTPA Extractable	0.2–2.0[d]	3.40	No	No

[a] Kuo, 1996.
[b] Haby et al., 1990.
[c] Fox et al., 1964.
[d] Sims and Johnson, 1991.

Expected response and observed response were not in agreement in the case of P. The critical level below which a P deficiency is expected under field conditions has been established at 10 mg kg^{-1} for the Olsens extraction (Thomas and Peaslee, 1996). Initial Olsen extractable soil P concentration in the Laura soil was 50 mg kg^{-1}, fivefold higher than the established critical level. Poor growth and low leaf P concentration in the –P treatment, however, clearly indicated that native soil P levels were inadequate to maintain good maize growth. The established critical level was developed on clayey calcareous soils extremely low in OC found in dry climates (i.e. Colorado). The soils in the Marshall Islands bear little resemblance to the soils for which the test was developed; they have little to no clay, high OC, and have developed in a wet climate. Sandy soils with low buffering capacity require higher concentrations of P in solution to satisfy crop P requirements (Fox and Kamprath, 1971), and this is a likely explanation for the observed response to added P despite relatively high initial extractable P. Clearly, the unique mineralogy and chemical nature of the Marshall Islands soils require that further work be carried out to determine a suitable critical level for the Olsen P extraction.

The observed yield response to added S was not expected given that the Laura soil had water extractable SO_4–S above the minimum critical level set for the test. Fox et al. (1964) applied the same test to a range of soils and found that field grown corn plants were S deficient when water extractable SO_4–S was below 40 mg kg^{-1}. They reported slight deficiency between 40 to 60 mg kg^{-1}. The Laura soil showed extractable SO_4–S just above the slightly deficient range proposed by Fox et al. (1964). In soils with appreciable amounts of weathered clay, S supply can be maintained as SO_4–S sorbed on clay surfaces is desorbed. In the Laura soil, however, there is no clay fraction capable of replenishing S taken up by the plant, and therefore, potential S deficiency is more likely. Like P, the low buffering capacity of these soils increases the likelihood of S deficiency. The organic matter fraction in these soils represents the most important source of S and procedures that can measure S in this fraction may be more appropriate. Heat soluble S may be a better measure of the S status in these soils because the organic matter plays such a critical role in nutrient dynamics (Fox et al., 1964).

Based upon the results of the missing element study and the evaluation of the soil test results, we have some basis to make a fertility interpretation of the soil test data from each island. We have used the median value for each island because a few large numbers in the dataset tend to inflate the mean. Median P concentrations (Table 7) are lower than the 50 mg kg^{-1} measured in the Laura soil used in the missing element experiment, and therefore, we would expect P deficiency on all the islands even though they are all above the established critical level of 10 mg kg^{-1}. Soil K is very low on all the islands with concentrations similar to that measured in the Laura soil; K is probably the most severe nutrient deficiency across all islands. Median Mg concentrations are always above 100 mg kg^{-1} and %Mg saturation averages around 9% for

Table 7
Median concentrations for selected nutrients in the surface soils from the sampled atolls

Atoll	P	K	Mg	B	Mn	Fe	Cu	Zn
$mg\ kg^{-1}$								
Mili	20.0	50.0	388	0.73	3.24	4.46	0.73	6.20
Likiep	16.5	31.0	334	0.72	2.68	13.2	0.74	52.8
Jobot	23.0	44.0	246	0.42	4.48	4.62	0.11	0.33
Arno	19.0	28.0	274	0.43	6.44	21.4	0.13	0.25
Ailuk	71.0	22.0	402	0.64	3.26	3.90	0.07	0.14
Ailinglaplap	13.0	32.0	286	0.46	2.12	2.46	0.07	0.16
Jaluit	28.0	19.0	334	0.50	1.07	15.7	10.0	122
Majuro (Laura)	31.0	34.0	342	0.46	2.12	4.40	0.19	5.66
Majuro (Bikirin)	13.0	68.0	344	0.60	3.52	3.56	0.13	0.26
Namdrik	20.0	19.0	336	0.37	1.26	11.6	0.18	5.06
Kili	56.0	72.0	418	0.82	2.84	3.44	0.29	4.04
Mejit	18.0	12.0	372	0.56	0.76	2.88	0.08	0.23
Ebon	33.0	36.0	352	0.36	2.68	12.6	0.56	16.9

all the islands suggesting that Mg is not likely a constraint to crop production.

For the micronutrients there is a range of concentrations below the levels which a response is expected. Median micronutrient concentrations for all the islands were usually above the minimum critical limit except for the islands of Ailuk and Ailinglaplap where Cu and Zn concentrations were below the minimum critical limit. Median B and Mn levels on Mejit were also below the minimum critical level. The concentrations for the micronutrients on all the islands, with the exception of Fe, were not above the upper range of critical limits. Although the results of the missing element study did not show obvious micronutrient deficiency, the low concentrations of these elements in the maize tissue, combined with the tendency for micronutrient concentrations to be close to the deficiency range, suggests that good crop growth will require fertilization to increase micronutrient availability in the Marshall Island soils.

4. Conclusions

Despite distinct differences in the physical properties of the Majuro and Ngedebus soils, their chemical properties do not differ dramatically. Our results indicate that Ngedbus soils located in the central portion of the islands tend to show higher levels of organic matter than Majuro soils along the ocean shoreline, but Ngedebus soils found close to the lagoon shoreline show similar organic matter contents to the Majuro soils. In agreement with the findings of Gessel and Walker (1992), our results indicate that vegetation density and distance from the shoreline are key factors determining organic matter content in atoll soils. The strong rainfall gradient across the Marshall Islands does not have a significant effect on soil chemical properties. Local vegetation cover and geographic location within the island override any climatic differences.

Our results provide further evidence highlighting the critical role of organic matter in atoll soils. We show that it is the primary source of CEC, it is highly correlated with soil N and Ca^{2+}, whereas soil K levels show a moderate relationship. Organic C levels, however, do not show a strong relationship with the other soil nutrients. Our work shows that organic matter levels tend to be highest in Ngedebus soils located in the center of the islands. With the combination of these data and the knowledge that soil moisture retention is proportional to organic matter levels (Morrison and Seru, 1986), we can explain why traditional agricultural activities were concentrated in centrally located areas (Thaman, 1992). Managing organic matter was and will continue to be fundamental to cropping systems in atoll soils.

The Marshall Island soils suffer from multiple nutrient deficiencies with N, P, K, and S being the most serious. Copper appeared to be the only micronutrient showing clear deficiency, but low concentrations of Mn and Zn in the corn tissue may indicate possible deficiencies also. Interpreting soil test data on atoll soils, however, remains difficult for two reasons: (i) the soil tests have not been calibrated with crop growth, and (ii) standard soil tests may not be applicable to the unique physical and chemical properties of atoll soils. Field experiments will be required to determine the boundaries between sufficiency and deficiency for P and the micronutrients. Increasing crop production in the Marshall Islands will require considerable nutrient inputs, which may be satisfied by identifying suitable locally available organic materials.

Acknowledgements

This research was made possible by a grant from the USDA and assistance from the SM-CRSP grant number LAG-G-00-97-00002-00 at the University of Hawaii. We acknowledge Dr. Andrew Kuniyuki, former Director of the Land Grant College at the College of the Marshall Islands, for guidance and assistance in the research. Special thanks go to Jabukja Aikne and Mosie Kanono for their tireless work in collecting the soil samples. We also thank Dr. Robert Gavenda, Resource Soil Scientist, NRCS Guam office, for his comments during the preparation of the manuscript.

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Annex 885

Lianzhi Xi, "Summary of Land of Guangdong Nansha Islands", *Soil Quarterly*, Vol. 6, No. 3 (1947)

English Translation

SOIL

Volume 6 | Published quarterly | Issue 3

Published in September of Year 36 [1947]

Soil survey commissioned by China Foundation for the Promotion of Education and Culture

Printed by Central Geological Survey, Ministry of Economic Affairs

Nanjing

Summary of Land of Guangdong Nansha Islands

Xi Lianzhi

(Including one soil map)

I. Foreword

At the beginning of this February, it has been several months after Navy Command Headquarters received and stationed at Xisha and Nansha Islands in the winter. There are plans to send ships for support and a new shift of officers and soldiers on the islands, and to use the opportunity to gather various personnel to investigate the island and learn about its resources to serve as a reference for construction and development. The author was given instructions to accompany the ship to Nansha Islands for a survey of the soil. On March 24th, I traveled from Nanjing to Shanghai and waited for the ship to depart. I was delayed and took the Zhongye Warship on April 18th, departing from Wusongkou traveling southward, passing through Kaohsiung of Taiwan and Guangzhou to receive supplies and equipment, staying five or six days at each location. On May 11th, I arrived in Yulin Harbor of Hainan Island. At the time, there was a low pressure area passing through the South China Sea, with powerful winds and heavy rain conditions, so the inclement weather was not conducive to sailing. We had to wait until the 18th before the rain passed and the skies cleared, then we continued to sail toward the Nansha Islands. On the evening of the 21st, we arrived at our destination of Taiping Island, where we stayed for two days. Since the typhoon season was upon us and the weather was highly variable, the warship did not intend to linger. After the supplies were unloaded, we returned on the 24th, again passing through Yulin and Guangzhou. We arrived in Shanghai on June 30th, and on July 2nd I returned to complete my mission. This trip took over three months, but only two days were used to engage in actual work. It goes without saying that a lot of time was wasted, and that since such a short period of time was used to investigate an area with which I was completely unfamiliar, it is only natural that my observations are broad and superficial. Other than the guano phosphate sample, which will undergo testing and research and will be covered in a separate report, I hereby submit this report based on my field observations as a reference for those concerned with the frontier of our southern territories, and I look forward to any feedback.

II. Geographical overview

The Nansha Islands were originally named Tuansha Islands; in the West, they are known as Spratly Island and Reefs. In the Song Dynasty, they were called Shierzishi. During the period of occupation by the Japanese, they were referred to as Shinnanguntō, under the jurisdiction of Kaohsiung City, Taiwan. It received its current name after being received and occupied by the navy of our country, and was subsumed under the jurisdiction of Hainan Island. The Nansha Islands are located between 4° and 12° North, and between 110° and 117° East. There are more than ninety large and small islands and reefs. Among them, twelve or thirteen are larger in surface area with trees and freshwater wells that may be utilized, ranging from 35 to 250 *mu* [0.0667 hectares].

The Nansha Islands are topologically flat, between 2-6 meters higher than the ocean surface at high tide. They are surrounded by coral reefs like breakwaters. The islands are comprised of coral and seashell fragments and sediment, with coral reefs below; the surfaces are covered in guano. Although each of the islands is small, they are extremely important due to their locations. Vietnam is just over three hundred nautical miles to the West, while to the northwest by way of Xisha Islands is approximately five hundred nautical miles to Yulin Harbor. It is a barrier to protect Taiwan, Guangdong, and Fujian, to control the islands in the South China Sea, and it is the key to European-Asian maritime trade. The islands are the southernmost frontier of our country and the vanguard of the territorial sea; they are of massive military value in terms of national defense.

The climate of these islands is tropical, and the islands are hot year-round, with a mean annual temperature of 26°C; the average highest temperature is 32°C while the average lowest temperature is 22°C. There are greater differences between day-time and night-time temperatures. During the day, the sun is bright and hot. When we were there, the temperature of the seawater was 37°C, thus the heat is imaginable; however, at night

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I would like to express my gratitude for having received a great deal of assistance from Navy Command Commander Yao Ruyu and Captain Li Dunqian and Vice-Capitan Yang Hongxiu of Zhongye Warship for this task.

the sea breeze is very refreshing. The islands have abundant rain, with the rainy season being June to October and the dry season being November to May. The annual rainfall is approximately 1800-2200 mm. Between May and September, the islands have southwest seasonal winds; between November and May, the islands have northeast seasonal winds. April and October are the transitional periods for the reversal of seasonal winds. Between February and May is the period with calmest winds and waves, during which low pressure storms are common, while typhoons are extremely rare. Typhoons are most frequent between July and September, thus rainfall is also highest in August and September.

The island we visited on this trip was Itu Aba Island, on the northwest corner of the islands. The Japanese call it Nagashima. Last winter, Taiping Warship was the first to land on this island to claim it, thus it is named Taiping Island in commemoration, in hopes of establishing eternal peace. Taiping Island and Sand Cay on its east and Namyit Island on its south (namely the so-called Kita Kojima and Minami Kojima, which have been renamed by the Navy to Dunqian Island and Hongxiu Island, to commemorate Captain Li Dunqian and Vice-Captain Yang Hongxiu of Zhongye Warship, who came with Taiping Warship to receive the islands), are connected with the three reefs of Pelley Reef, Eldad Reef, and Caven [Gaven] Reefs, forming an atoll, and is known as Tizard Bank. Tizard Bank is approximately 50 kilometers long and 15 kilometers wide, forming a lagoon in the center with hidden coral reefs. The lagoon is approximately 9-11 meters deep; this area is calm and is a natural fishing ground.

Taiping Island is located at 10°22’42” North, 114° 21’25” East, has an elevation of 2.5 meters. It is 1350 meters from east to west, and 350 meters from south to north. It is long and narrow, shaped like a sea cucumber. The surface area is 432,000 square meters, approximately equal to 650 *mu*. It is the largest island among the Nansha Islands, and is currently the site of our Navy’s Nansha Island Administration, equipped with a radio station and meteorological station.

III. The soil and guano of Taiping Island

We spent two days on Taiping Island and covered every corner of the island. Even though the time was short and we could not conduct in-depth analysis, we have a general idea of the island. Strictly speaking, if we consider the practical aspects, the Nansha Islands do not have soil; what they have is lithological soils. Generally, the islands are surrounded by sand washed up by ocean waves. Because of the rushing force of the waves, the margins are about 20-30 centimeters taller than in the central parts, forming low banks. This type of sand is all comprised to fragments of seashells and coral; the sands that touch the water are lighter in color. There are few grasses growing in the sand, and a cross-section does not show a guano layer. We refer to this as the Spratly Series. Sands on the inner side of the banks are lush in Barbados nut trees and morning glories. The superficial surface is gray, with a guano layer underneath, which we refer to as the Itu Aba Series. We now provide some examples and describe the characteristics of the cross-sections:

(1) Spratly Series—17489-91, field number AG-12, taken from the front of the Navy’s radio station on the southwest corner of Taiping Island, with sparse weeds and juvenile Barbados nut trees growing on it; the profile had lime reactions:

0-10 cm: light gray sand and coarse sand, mixed with coral and seashell fragments of red, white, and yellow colors; rich in plant root material; pH 7.5.

10-35 cm: same as the upper layer, but the color is white and there is a minute quantity of very light pink color, less plant root material, pH 7.5-8.0.

35 cm and below: grayer than the upper layer, but not as dark as the surface area; very few plant root materials, pH 7.5-8.0.

(2) Itu Aba Series—17492-95, AG-13, taken from the south side of Taiping Island, approximately 200 meters east of the Navy’s independent platoon, south of the fish-drying courtyard. The soil is covered in morning glories, and there are also many Barbados nut trees; the profile had lime reactions:

0-7 cm: light brownish-gray, with some red and white colored sand and a small amount of coarse sand; rich in plant root material; pH 8.0.

7-15 or 20 cm: brown clumps of guano, medium coarse to fine sand, with a softer upper portion in the form of loose clumps; the bottom part is more solid like a hard disc; contains plant root material, pH 8.0.

35-80 cm and below: very light pink or yellow color, with coarse and medium-fine sand, with tree-branch like coral fragments; pH 8.0.

This series is within the sand bank, approximately 15-35 meters from the sea, distribution in long strip form, with more in the eastern and northern parts of the island, and less on the southwestern side. This is a concealed cross-section, meaning in the later stages of guano sedimentation, the island surface had declined slightly at one point, and the surrounding was formed by sand sedimentation as caused by the tides.

Guano is the main resource of the Xisha and Nansha Islands, which has received great attention from the government; I have also closely observed this on this trip. When an island forms and before plants have started to grow on it, seagulls gather together and build nests on the island to raise their young. They live here for generations and many live here. They eat fish and other sea creatures. On average, each bird can produce 25-50 pounds of feces per year. The corpses of seabirds and leftover food also mix together and accumulate to massive quantities. Guano is also rich in fertilizer content, making it a valuable natural fertilizer. In dry areas, seabird feces rapidly dry without fermentation or degradation; the little rain is insufficient to cause leaching. Several hundred to thousand years later, guano can pile to several hundred meters high into hills, as produced in Peru. This is a true guano layer; other than evaporated water, it is not very different from fresh seabird feces. It is rich in the organic nitrogen, and is known as nitrogenous guano.

Composition of Peruvian guano (%)

Water	Organic matter	Ash	N	P_2O_5	K_2O	CaO
14.8	51.4	33.8	13	13	2.6	11.0

Conversely, in rainy areas, the organic matter in guano is broken down and washed away, or oxidized away. Some of the remaining mineral salts are also washed away, while some seeps downward to the coral limestone layer, forming guano phosphate.

The latter of these is produced in our Nansha Islands. Since this is an area with high temperatures and rains, due to the rinsing by rainwater and seawater, the soluble salt base and most of the organic matter in guano disappears, producing two-base and three-base phosphates, and phosphoric guano is primarily a mixture of calcium hydrogen phosphate, tricalcium phosphate, and calcium carbonate.

Other than in the hidden cross-section of the Itu Aba Series, guano on the main part of Taiping Island can be divided into two types:

(1) Taiping Island Series—17483-84, AG-9, seen in front of the Navy’s radio station, around the independent platoon, and near the Shinkai Kōgyō Kabushiki Gaisha commemorative stele; lush with morning glories; the coconut and banana trees are doing well, but not many have been planted; the castor oil plant grows very well and is unusually prosperous; the cross-section has the following characteristics: (A) 0-10 cm: blackish-brown fine sandy soil, granule structure, mixed with yellowish-brown and white grains of sand and small pebbles of irregular shapes (the fragments from lower layers); rich in plant root matter, pH 7.5-8.0; (B) 10-20 or 30 cm; clumps, irregular in shape, grayish because it is covered in organic matter; yellowish-brown, reddish-brown, or grayish-brown internally, comprised of adhered coral sand and seashell fragments, very similar to coarse sandy rock, but loose and quite light; lime reaction pH 7.5-8.0; (C) yellowish-brown coral limestone containing phosphoric acid below.

17485, AG-10, approximately 250 meters to the east of the radio station and slightly to the north, in the Barbados nut shrubs, there is a small vegetable patch of only slightly over 2 *mu*; the vegetables are growing decently but there is pest damage. The cross-section characteristics are similar to that of AG-9, but the superficial layer is thicker at approximately 20-30 cm. The soil color is slightly darker, of the Taiping Island Series planting type.

(2) Solid and large pieces of rock phosphate, ranging from a dozen to several dozen centimeters in diameter, and there are also pieces that connect into layers. Barbados nut shrubs grow above, and there are papaya growing very well by the street.

Table of components of guano phosphate on Taiping Island (%) (Note)

Sample number	Water content	Organic matter*	Total phosphoric acid P_2O_5	Lime CaO	Carbon dioxide CO_2	Nitrogen N	Remarks
17485	4.15	13.10	32.05	41.33	7.57	0.65	Taiping Island Series Cultivated Phase
17493	10.42	6.89	28.86	42.66	5.53	0.33	Guano layer of Itu Aba Series
17484	7.61	3.41	17.67	43.28	19.54	0.17	Taiping Island Series
34	5.91	2.30	19.58	47.42	22.46	0.11	Solid and large pieces containing phosphoric acid

(Note) Analyzed by Liu Zheng and Wang Kuihuai *Analyzed by Lu Faxi

The foregoing table shows that the guano phosphate in the Nansha Islands contains less than 1% total nitrogen, while total phosphoric acid is more than 17%, even above 30%. Therefore, it can be considered phosphoric guano. Moreover, in the samples, the lime content is all above 40%. Phosphoric acid is generally insoluble; its direct application to fields is not usable by plants, and too much sulfuric acid would be required to treat it as a raw material to produce phosphoric lime, making it uneconomical. Therefore, the ultimate application of this substance would have to await further testing and research.

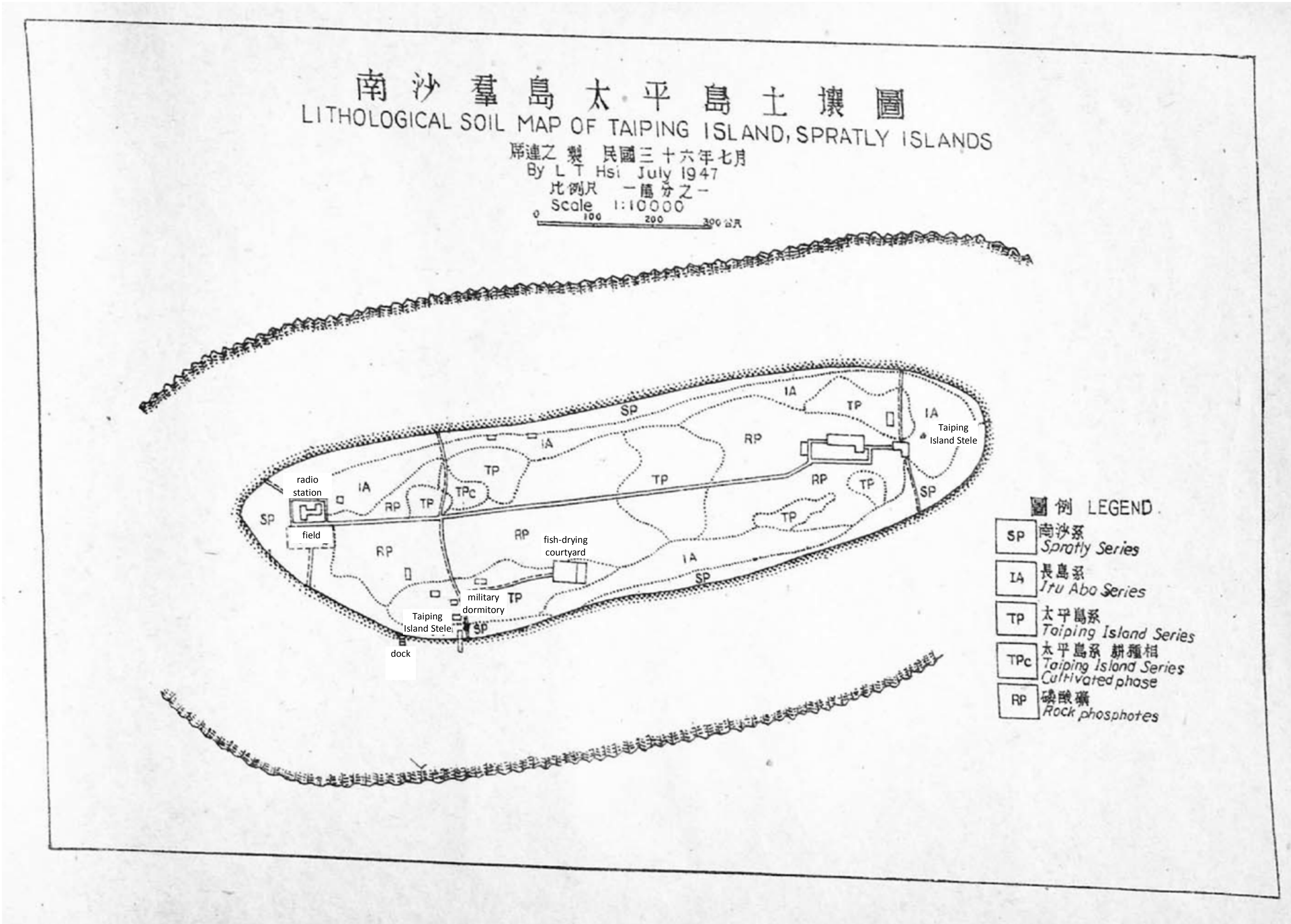
IV. Conclusions

As described above, the Nansha Islands do not have soil, but it is necessary to note that these islands are not devoid of vegetation. There are many tropical plants growing here—the land is covered in distinctly beautiful light purple and red morning glories, which are also common on the beaches of Taiwan. Morning glories are part of the Verbenaceae family (Lippia Nodiflora (L.) L. C. Rich), and its Chinese name is Guojiangteng (Quwucao). There are many Barbados nut (Nyctaginaceae family (Pisoniaalda Spanoghe), Chinese name Bishuang) and Yinye Zidan (Tournefortia ArgenfeaL, F, Boraginaceae family) (generally growing on sand by the beach (AG-12), and these plants grow very thickly. Barbados nut grows very quickly, but the timber is not solid; the trees have diameters over ten centimeters, which can usually be toppled by one person. It cannot be used for anything other than firewood. The islands also have coconut and banana, which taste good, but they are not numerous. Papaya and the castor oil plant also grow very well; these two may be planted in large quantities. The soldiers stationed on the island have cleared land to plant vegetables, which can grow, but there is a great deal of pest damage. The Taiping Island Series may be cultivated to provide fruits and vegetables to stationed troops with no problem; but it would not be meaningful to grow grains for consumption.

The reserve of phosphoric guano is estimated to be over 70,000 tons. However, the content of available phosphoric acid is too low and should not be directly applied. There is greater variation in content and quality is uneven, thus it is not suitable as raw material to produce phosphoric lime. Moreover, sulfuric acid is expensive, which would increase manufacturing costs to the point of being uneconomical. Furthermore, the Nansha Islands are over 600 nautical miles from Yulin Harbor. Transportation is inconvenient and uneconomical, and the phosphoric guano in the Nansha Islands is not very valuable. However, it is possible to transport guano back to Guangdong when ships supplying the island return. We plan to engage in research on usage of the phosphoric guano; if it is possible to improve its fertilizer efficacy, then it would meet the needs of lands in southern China, which are short on phosphate fertilizers.

We believe that in the Nansha Islands, the industry with the best prospects is fishing. The lagoon is calm and a good place to fish. The area is rich in skipjack tuna, abalone, pale fish, shark, sea cucumber, sponge, and kelp. The most valuable are big tortoises and sea turtles, as large as five to six hundred *jin* [600 grams]. They lay their eggs on the beach in moonlit nights in the spring and summer; this is the easiest time to catch them. Their meat is edible, tastes like beef, and is highly nutritious. Their eggs can be used to make highly valuable medicines. Since the Japanese have constructed a 30-square meters of fish-drying courtyard and refrigeration facilities on the island, there are great expectations for the fishery industry in this area.

English Translation



土壤

第六卷　　季刊　　第三期

中華民國三十六年九月出版

中華教育文化基金董事會委託土壤調查

經濟部中央地質調查所印行

南　京

南沙羣島土壤紀要

席　連　之

（附土壤圖一幅）

一、緣　起

本年二月初，海軍總司令部以西南沙羣島於去冬接收進駐後，時已數月，擬派艦運送給養及瓜代官兵赴島，趁便邀集各方人員赴島攷察，藉明資源，以備建設與開發之參考。著者奉所命隨艦前往南沙羣島調查土壤，三月二十四日由京赴滬，候船啓程，延至四月十八日始搭趁中業軍艦出吳淞口南航，經台灣高雄及廣州兩地裝載給養，各逗留五、六日；五月十一日到達海南島之楡林港，時值南中國海有一低氣壓經過，狂風暴雨，氣候惡劣，不利航行；候至十八日雨過天晴，出海向南沙羣島航進，廿一日傍晚到達吾人之目的地太平島，島上停留二日，因颱風季節將屆，氣候變幻無常，軍艦不願多事逗留，給養運卸完畢後，二十四日卽行回航，仍經楡林廣州，而於六月三十日抵滬，七月二日返所覆命。計此行耗於旅途者三月餘，而用於實際工作者僅二日，時間之曠費自無待言，且以如此短促之時間，而履一切景物完全生疎之區域，觀察之粗放與膚淺，自屬意料中事。除鳥糞磷礦標本，尙待試驗研究，將來另撰報告外，玆先就野外觀察所及，草成斯篇，以供關心南疆邊陲者之參考，幸垂敎焉。

二、地理概況

南沙羣島原名團沙羣島，西名斯巴特萊羣島（Spratly Island and Reefs）在昔宋朝稱爲十二子石。日寇佔領時期，稱新南羣島，隸屬台灣高雄市管轄；我國海軍接收進駐後改今名，劃規海南島轄治，位於北緯四度至十二度，東經110°——117°之間，計共有大小島嶼九十餘個，其中面積較大，有樹木水井，可資利用者約十二三個，面積由三十五至二百五十市畝不等。

南沙羣島地勢平坦，高出高潮面約2——6公尺，四周有珊瑚礁環繞，如防浪堤然，島由珊瑚與貝殼之遺骸或碎片堆積形成，其下爲珊瑚礁，表面則蓋以鳥糞。各島雖均低小，但以所據位置，形勢至爲重要，西去越南三百餘海里，西北經西沙至楡林港約五百浬，屏障□台粵閩，控制南洋羣島，握歐亞海運之樞紐，爲我國極南邊疆，領海之前哨，在國防上具有極大之軍事價值。

氣候屬熱帶氣候區，終年炎熱，年平均26 ℃. 最高平均32° 最低平均22°；日夜溫度相差較大，白晝烈日當空，驕陽如灼，吾人至時，海水溫度達37°，其熱可知；但夜晚

此項工作，承海軍總部姚指揮官汝鈺暨中業軍艦李艦長敦謙楊副艦長鴻庥協助頗多，謹申謝意。

海風吹來，甚感涼爽。雨量豐沛，六至十月爲雨季，十一月至五月爲旱季，年雨量約1800——2200mm.五至九月爲西南季候風，十一至三月爲東北季候風，四及十月爲季風之分野；二至五月間爲風浪最平靜之時期，低氣壓暴風雨常有而颱風極罕見；七至九月則爲颱風最多之時期，故雨量亦以八、九兩月爲最高。

吾人此次所到者爲群島西北角之Itu Aba Island，日人稱之爲長島；去冬太平軍艦首先來此登陸接收，定名太平島以資紀念，冀與永恆之太平也。太平島與其東面之沙島(Sandcay)南面之南鑰島(Namyit Island)(卽所謂北小島南小島，現海軍方面已分別更名爲敦謙島與鴻庥島，蓋所以紀念與太平軍艦同來接收之中業艦正副艦長李敦謙楊鴻庥二氏者也)，暨必利(Pelley Reef)伊爾達(Eldad Reef)及嘉文(Caven Reefs)等三礁相連，形成環礁(Atoll)，稱堤沙洲(Tizard Bank)。堤沙洲長約50公里，寬可十五公里，中爲礁湖(Lagoon)，湖內散布珊瑚暗礁，深入水中9——11公尺，風平浪靜，爲天然漁場。

太平島位於北緯10°22′42″，東經114°21′25″，拔海2.5公尺，東西長1350公尺，南北寬350公尺，狹長似海參，面積432,000平方公尺，約合650市畝，爲南沙群島中最大之島嶼，現爲我海軍南沙群島管理處所在地，設有電台及氣象台。

三、太平島之土壤與鳥糞

吾人在太平島上逗留二日，曾踏遍全島每一角落，雖以時間倉促，未得詳加推究，但亦已可略得概念，若從實用立場着眼，嚴格的說，南沙羣島無土壤，有之，均爲石質土(Lithological Soils)。大低四周皆海潮冲積之砂，由於海浪之冲力，致使地形較中部稍高20至30公分左右，略成低矮圍堤之狀。此類砂全係貝殼及珊瑚碎片，其在外緣卽接近海邊者呈色較淡，草類生長亦不茂盛，剖面中無鳥糞層，吾人稱之爲南沙系，其存在於沙堤內緣者，麻瘋桐及牽牛花繁茂，表層帶灰色，下有鳥糞層，是爲長島系，茲舉例分別略述其剖面性態如次：

(一)南沙系——17489—91，田間號碼 AG—12，採自太平島西南角海軍電台之前，上生稀疎雜草及幼小之麻瘋桐，全剖面石灰性反應：

0—10公分：淡灰色砂與粗砂，雜含紅白黃諸色之珊瑚貝殼碎片，富植物根，pH7.5強。

10—35公分：與上層同，唯色白而微帶極淡之粉紅色，植物根較少，pH7.5—8.0

35公分以下：較上層略帶灰色，然不及表層之深，植物根極少，pH7.5—8.0

(二)長島系——17492—95，AG—13，見於太平島南面，海軍獨立排部東約二百公尺，晒魚場之南，牽牛花遍地蔓生，麻瘋桐亦多，生長繁茂，全剖面石灰性反應：

0—7公分；棕灰色雜含紅白諸色砂及少量粗砂，富含植物根，pH8.0

7—15或20公分；棕色塊狀之鳥糞，中砂至細砂質地，上部較軟，成塊狀，易碎；下部較堅實如硬盤狀，含植物根，pH8.0強

15或20—35公分，受鳥糞層淋溶之影響呈淺棕色，含雜色之珊瑚砂及貝殼碎屑，富含植物根，pH8.0強

35—80公分以下；帶極淡之粉紅或微黃色，粗砂及中砂，含有樹枝狀之珊瑚碎塊，pH8.0強

本系分布於沙堤之內，距海約15——35公尺，狹條帶狀分布，島之東部及北面較多

，而西南面較少見。爲埋藏剖面，即於鳥糞堆積之後期，島面曾經一度略形下降，周圍復受海潮影響而再有沙之堆積覆蓋所成者。

海鳥糞爲西南沙群島之主要資源，當局對此，頗爲重視，吾人此次曾作詳細觀察。當島嶼形成，尚無植物生長之前，海鷗成群結隊，築巢棲居島上，孵育繁衍，世代相遞，爲數極多；捕魚及其他海產爲食，平均每只每年可產25——50磅之糞，加以海鳥屍體及賸餘之食物等混合堆積，其量至鉅，且富含肥料成分，故爲有價值之天然肥料。在乾旱之區，海鳥排泄物迅速乾燥，未經醱酵或分解作用，雨水稀少，不足引起淋溶，年積月累，千百年後，可堆高至百呎以上，成鳥糞山，如祕魯所產，此爲眞正之鳥糞層，其成分除水分蒸發外，與新鮮之海鳥糞無大差異，含多量之有機質氮素，稱氮質海鳥糞 (N tro enous Guanos)

祕魯海鳥糞之組成(%)

水分	有機質	灰分	N	P_2O_5	K_2O	CaO
14.8	51.4	33.8	13	13	2.6	11.0

反之若在多雨之區，鳥糞中之有機物分解流失，或氧化逸去，遺留之鑛物質鹽類亦有一部分爲水洗去，另一部則滲入其下之珊瑚石灰岩中而形成鳥糞磷鑛 (Guano Phosphate)

我國南沙羣島所產，屬於後者，蓋以本區高溫多雨，因雨水及海水之冲洗作用，鳥糞中之可溶性鹽基及大部分之有機質消失，產生磷酸二鹽基與三鹽基 (Two—ba o and Three—Base Phosphates) 是爲磷質海鳥糞 (Ph sphoric Guanos) 主爲磷酸二鈣，磷酸三鈣及炭酸鈣之混合物。

太平島之鳥糞，除上述長島系中之埋藏剖面外，島本部者，依形態可分二類：

(1)爲太平島系—17483—84,AG—9. 見於海軍電台前，獨立排部左右，及深海工業株式會社紀念碑附近等處，牽牛花蔓生密被，椰子香蕉均佳，惟種植株數不多，而蓖蔴子生長特佳，繁盛異常，其剖面性態如下：(A)0—10公分；黑棕色細砂壤土，粒狀構造，雜含黃棕暨白色砂粒，及不規則之小石塊（即下層之碎塊）富含植物根，pH7.5—8.0(B)10—20或30 公分；塊狀，不定形，外表因有機質包被而帶灰色，內部黃棕，紅棕，或灰棕色，由珊瑚砂及貝殼碎屑膠結而成，極似粗砂岩，唯疏鬆且甚輕，石灰性反應pH7.5—8.0(C)下爲黃棕色含燐酸之珊瑚石灰岩。

17485,AG—10，見於電台東微偏北，距離約250公尺處，蓖蔴桐叢林中，小片之蔬菜地，面積約僅二畝餘，青菜生長尚佳，但多虫害，其剖面性態與AG—9相似，唯表層較厚，約可20—30公分，土色略深，是爲太平島系耕種相。

(2)爲堅硬大塊之Rock Phosphate，徑約十幾乃至數十公分不等，亦有連續成層狀者，其上爲蓖蔴桐叢林，路邊有木瓜，生長具極榮茂。

太平島鳥糞磷礦重要成分表(%)(註)

標本號碼	水分	有機物*	全磷酸 P_2O_5	石灰 CaO	二氧化碳 CO_2	氮 N	備註
17485	4.15	13.10	32.05	41.33	7.57	0.65	太平島系耕種相表層
17493	10.42	6.89	28.86	42.66	5.53	0.33	長島系之鳥糞層
17484	7.61	3.41	17.67	43.28	19.54	0.17	太平島系
34	5.91	2.30	19.58	47.42	22.46	0.11	堅硬大塊之磷酸礦

(註) 劉 琤　王燮懷 分析　* 陸發熹君分析

觀上表，南沙群島所產之鳥糞磷礦，含全氮量不及百分之一，而全磷酸則在17%以上，有高達30%以上者，故可稱爲磷質海鳥糞，又各標本中石灰含量均在40%以上，磷酸多爲不溶解性，直接施於田間固不能爲植物利用，而若用作製造過磷酸石灰之原料又以需耗多量硫酸爲不經濟，是故對於此項礦產之究應若何利用，尙有待今後之試驗與研究也。

四、結　論

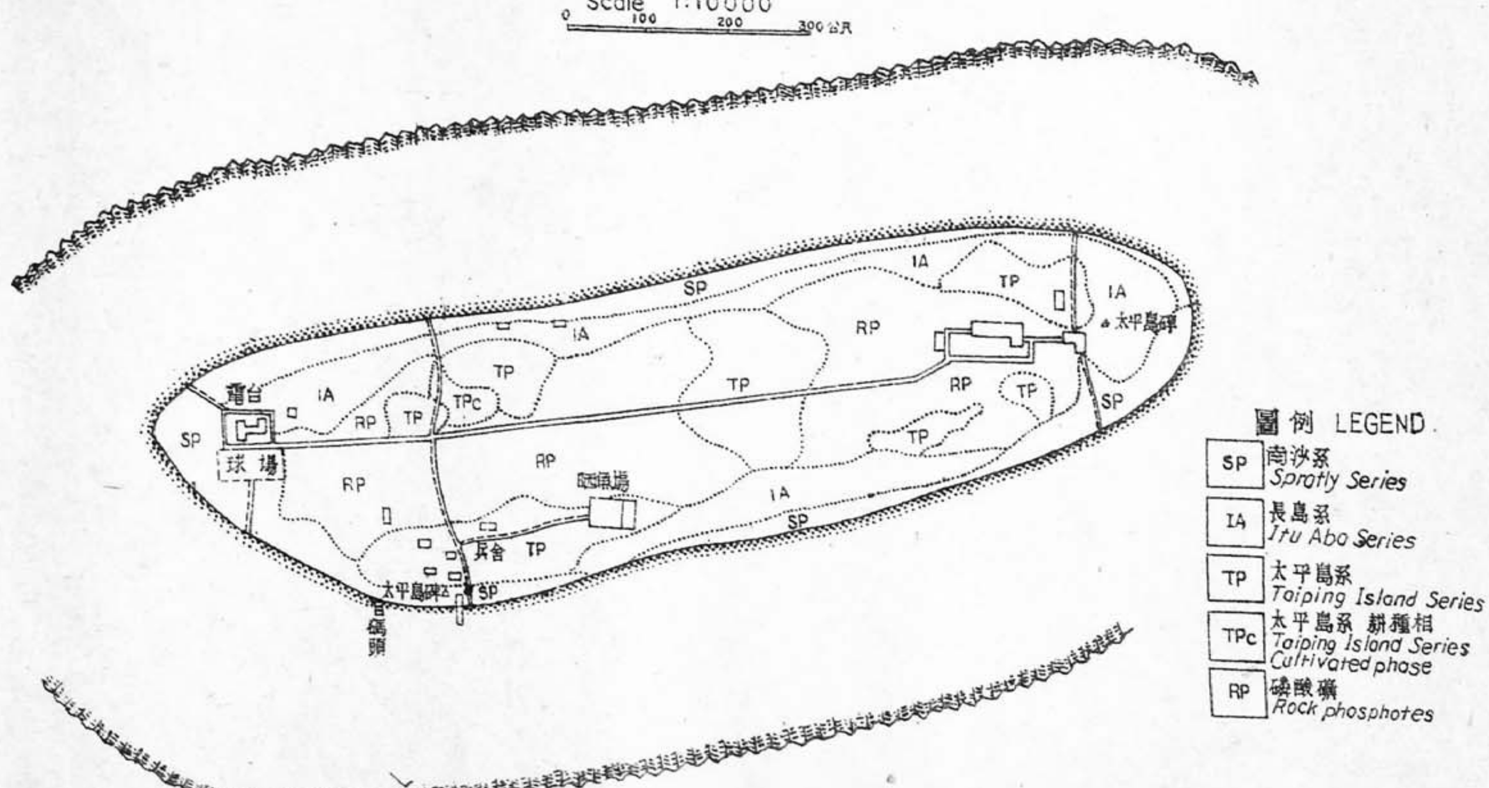
如上所述，南沙羣島並無土壤，但吾人須特別說明者，即此等島嶼，並非不毛之地，熱帶植物生長甚豐，牽牛花遍地蔓生，開淡紫紅色之花，美艷異常，台灣海濱之沙上亦多見之，俗名朝顏，屬馬鞭草科 (Lipp'a Nodiflora(L.)L.C.Rich)，中名過江藤(蛐蟮草)。瘋瘋桐（紫茉莉科 (Pisoniaalda Spanoghe) 中名避霜）與銀叶紫丹(Touvnefovfia ArgonfeaL,F, 紫草科)(多長於海邊之砂(AG—12)上)甚多，且極茂盛；瘋瘋桐之生長極速，但木材不堅實，直徑十餘公分之樹，往往一人之力即可推倒，除供燃料外無他用，椰子香蕉均有，味亦佳美，惟數較少耳。木瓜與蓖麻子尤旺，此二種可以大量種植。島上駐軍有闢地種蔬菜者，生長尙可，唯多虫害；太平島系均可墾種，供給島上駐軍之蔬菜瓜果，可無問題，若言農墾，耕種食糧則甚無意義。

鳥糞磷礦之儲量，估計尙有七萬餘噸，然以其含有效態磷酸過低，不宜直接施用，而成分變異較大，差參不齊，不適供製造過磷酸石灰之原料，加以硫酸價昂，製造成本太高，爲不合算；抑尤有進者，南沙距離楡林港尙有六百餘浬海程，交通不便，運輸殊不經濟，因之南沙之鳥糞磷礦，實無多大價値可言。惟可利用運送給養前往島上之艦隻，於回程時帶運鳥糞至廣東，吾人現正擬從事此項鳥糞磷礦利用之研究，若能覓得一簡便方法增進其肥效，則對缺少磷肥之華南各地土壤將頗爲需要也。

吾人以爲南沙群島最有希望者厥爲漁業，礁湖中風平浪靜，爲良好之捕魚場所，生產堅魚、鮑魚、倉魚、鯊魚等、海參、海綿海藻亦豐，其尤可貴者，爲大龜與玳瑁，龜之大者有五六百斤，每當春夏間之月夜至沙灘散卵，斯時捕捉最易，其肉可食，味如牛肉，極富滋養，其蛋更可製爲補劑，價値甚高。觀於日人在島上所建30公尺正方之曬魚場及其附近之冷藏庫設備，亦可想見此地漁業之大有希望也。

南沙羣島太平島土壤圖
LITHOLOGICAL SOIL MAP OF TAIPING ISLAND, SPRATLY ISLANDS

席連之 製 民國三十六年七月
By L T Hsi July 1947
比例尺 一萬分之一
Scale 1:10000



Annex 886

H. Chien-hua & J. Chung, “Taiping Island sees its first civilian register residency”, *Taipei Times* (31 Jan. 2016), *available at* http://www.taipeitimes.com/News/taiwan/archives/2016/01/31/2003638487 (accessed 9 Mar. 2016)

TAIPEI 台北時報 TIMES

Taiping Island sees its first civilian register residency

FIRST OF MANY? Chu Mei-ling's change of residence to the island would boost the morale of the staff on the island, coast guard officials said

By Huang Chien-hua and Jake Chung / Staff reporter, with staff writer Staff reporter, with staff wr
Sun, Jan 31, 2016 - Page 3

A nurse stationed on Itu Aba Island (Taiping Island, 太平島) on Thursday became the first civilian to register their residency on the island, with two of her colleagues planning to follow suit.

Itu Aba is the largest natural island in the Spratly Islands (沙 島), to which Taiwan, the Philippines, the People's Republic of China and Vietnam have overlapping claims.

The nurse, Chu Mei-ling (初美玲), registered her residence on Itu Aba in accordance with the National Health Administration's integrated delivery system project, first enacted in 1999, that helps provide medical relief to Taiwanese in remote areas or islands.

The project's primary goal is to provide medical services to residents who are paying National Health Insurance dues, but are comparatively deprived of available medical resources because of the remoteness of their locations.

The three medical staff assigned to the island are Chu, Pan Man-chi (潘曼琪) and Lin Fang-tsu (林芳慈), the Coast Guard Administration's southern coast patrol office said.

Both Pan and Lin are on vacation in Taiwan proper, but they plan to register their residencies on the island when they return to work, the office said.

Since the Coast Guard Administration took over the defense of the island in 2000, it has adhered to the spirit of keeping peace in the South China Sea, the office said, adding that it has also made efforts to ensure the island is peaceful, ecologically sustainable and has low carbon emissions.

Chu's change of residence to the island would boost the morale of the staff on the island and show that Taiwanese support the nation's claims of sovereignty in the South China Sea, the office said.

Chu's relocation of residence was praised by Ma when he visited the island on Thursday, the office said.

Published on Taipei Times :
http://www.taipeitimes.com/News/taiwan/archives/2016/01/31/2003638487

Annex 887

Jose Abeto Zaide, "Aba, Itu na ng aba?", *Manila Bulletin* (26 Jan. 2016), *available at* http://www.mb.com.ph/aba-itu-na-nga-ba/

Aba, Itu na nga ba?

by **Jose Abeto Zaide**
January 26, 2016

ITU ABA aka TAI PING aka LIGAW. We missed the red-letter day invitation of renewal of vows last Friday of our former UN Permanent Delegate Lauro Baja and Norma because Taiwan's envoy Dr. Gary Lin's invitation to visit a restricted outpost was advanced to catch the crack in better weather conditions.

Itu Aba is the international name of a former Japanese outpost. Tai Ping, meaning "peace," is its Taiwanese name. The Filipino name "Ligaw" has different meanings, depending on whether it is pronounced with accent on the first or on the second syllable. If accented on the first syllable, it means "courting"; if on the second syllable, it means "lost." ("Lost" in the sense of "lost & found" by the adventurer Tomas "Admiral" Cloma?)

It was a lumbering three-and-half hour flight from Pitung military airport in Southern Taiwan, cutting into Philippine air space, to Itu Aba. The party of 28 souls was led by Taiwan Foreign Minister David Lin, including Straits Relations Minister Andrew Hsia, Environment Protection Minister Kuo-yen Wei, the President's spokesman, deputy ministers, a former envoy to Manila, professors, research fellows, and media. Dr. Greg Poling, director of Center for Strategic and International Studies (CSIS-AMTI) and I were the only two foreigners. Dr. Hashim Djalal, Indonesian expert on Law of the Seas and author of a path-finding workshop on South China Sea, had accepted, but couldn't adjust to the advanced date.

I did not realize that accepting the invitation before seeing the program for Itu Aba was like "buying a cat in a sack." But our host had the kindness and sensibility to show the draft of the post-visit press release for my comments and gave me the option to join or not the press conference. (We would miss the late evening presscon because of the lateness of the hour – not because of diplomatic illness).

On arrival, we were refreshed with refrigerated coconut water drank from the shell. I asked the base commander if sugar was added. (Recalling how in the early '80's our congressmen were tripping over one another on quota of exports of coconuts to Taiwan, I asked if this excellent variety could be exported to PH. But the 500 coconut trees can provide only for home consumption.)

The commander briefed us on the metes and bounds of the outpost (noting that the 1,200 meter air strip for the C-130 doesn't change the profile of the abutting landmass). The coast guard which replaced the marine contingent (stress civilian authority) is charged with protecting marine life and the environment (tons of refuse cleaned annually). Within a decade, the command has rescued and repatriated Vietnamese and Malaysian fishermen. (Another source avers Filipino fishermen, too). The outpost has meteorological adjunct and solar power supplies 20 percent of energy needs (including air-conditioning).

Commander declared that four wells sustain vegetation and human life and that he would walk us through a virtual jungle. Lunch served a menu all declared to be sourced locally – marine soup, chicken, beef, and vegetables; (rice flown from Taiwan). We visited the source of victuals – a fenced poultry farm and next to it, the goat stable vegetables grown at nearby nursery. I quipped that under Philippine conditions, "mangagarit" would climb the trees to tap the heart for "tuba" (coconut vodka), and poultry of that size would create a pintakasi (cockfights).

Our guide showed diggings to reveal 30 centimeters of topsoil, some bird droppings, and a deeper layer of phosphate – describing a landmass accumulated over eons. One professor said that he is still trying to validate his theory that Itu Aba might have surfaced even earlier than Taiwan.

We quaffed water from one of the wells. A professor shared a photocopy of an entry in a book from the British Museum mentioning sailing ships drawing water from Itu Aba. A short distance from the abandoned Japanese-built pier is the recently finished deep water pier.

Visitors were awed. Much like everyone's surprise when astronaut Scott Kelly declared the

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blooming of the first zinnia in outer space. (NASA itself was mistaken in that boast, because Russian and Ukranian cosmonauts had bloomed flowers on their space stations way back in the late 1900s.) But, however dramatic, the experiment in space does not change conditions on the ground and it still remains for lawyers and diplomats to negotiate and define territory and possession.

(Former Ambassador Alberto Encomienda recalls that when he was head of our Marine Ocean Affairs Center [MOAC] and before the Taiwanese upgraded their present facilities and their air strip, they explored the possibility of access to Philippine medical care in case of emergency.)

When I asked Dr. Poling what he would say to Foreign Secretary Albert del Rosario and Defense Secretary Voltaire Gazmin when they meet, he replied that he's no lawyer. But he also has a helpful suggestion – that the next Filipino visitor to Itu Abu should be Mayor Jun Bito-onon of Pagasa, who promotes eco-tourism on the island. The mayor's avocation will complement the environment program of Itu Aba. A perfect fit to President Ma Ying-jeou peace initiative to set aside sovereignty and engage in joint cooperation in the South China Sea.

BTW, I may have flummoxed our hosts when I asked how Itu Abu voted at recent elections won by Taiwan's first Lady President Tsai Ing-wen. Maybe because, among the five claimants in the South China Sea, only Filipinos in Pagasa and the Kalayaan Island Group exercise suffrage. Feedback: joseabetozaide@gmail.com

Annex 888

Oliver Milman, "Government bans dumping from new dredging projects into the Great Barrier Reef", *The Guardian* (17 May 2015)

theguardian

Government bans dumping from new dredging projects into Great Barrier Reef

Environment minister Greg Hunt finalises ban ahead of a UN decision over whether the reef will be listed 'in danger'

Oliver Milman

Sunday 17 May 2015 03.41 EDT

The federal government has finalised a ban on the dumping of sediment from new dredging projects into the waters of the Great Barrier Reef, as a decision looms on whether the ecosystem will be listed as "in danger" by the UN.

Greg Hunt, the federal environment minister, said he has approved an amendment to the Great Barrier Reef marine park regulations to ban capital dredge spoil being dumped there.

The ban will apply to all past, present and future applications for dumping of new seabed excavations undertaken in order to expand ports and shipping lanes in the 344,400 sq km marine park.

However, it will not apply to maintenance dredging of existing projects nor will it apply to the reef's whole world heritage area, which is only slightly larger than the marine park but has been the site of most recent dumping. Hunt pointed out the Queensland government has pledged to ban dumping in the world heritage area, thus plugging this gap.

"Together, this means no capital dredge disposal can occur in any part of the world heritage area," Hunt said.

"Protecting the reef's immense biological, cultural and heritage values is a top priority for the Coalition government and we continue to build on our suite of protective measures."

Hunt approved a plan to dump five million tonnes of seabed sediment from the expansion of the Abbot Point port into the marine park in late 2013, only for an alternative land-based plan to be drawn up following an outcry.

The UN Educational, Scientific and Cultural Organisation (Unesco) added its voice to those concerned about the sea-based disposal of sediment, which scientists warned could smother corals.

Unesco's world heritage committee will meet in Bonn, Germany next month to decide whether to list the reef as "in danger". The ecosystem has lost half its coral over the past 30 years and is under pressure from climate change, chemical pollution and a plague of coral-eating starfish.

The Australian government has made strenuous diplomatic efforts to head off the “in danger” listing, which could negatively affect the $6bn-a-year tourism industry that relies upon the reef.

Government ministers or diplomats have visited 19 of the 21 countries that provide members to the world heritage committee in recent months to explain the measures Australia is taking to protect the reef, which is the world’s largest living entity.

On Friday the government announced it was introducing new restrictions on shipping in 565,000 sq km of the Coral Sea, to help ease concerns about increased ship movements near the reef.

An extra $100m has been pledged to help reduce chemicals flowing from farmland to the reef, as part of a $2bn package the government has touted as being spent on the reef’s health over the coming decade.

However, environmental groups say the funding is nowhere near enough and the $2bn figure is misleading.

“In fact nearly $500m, or a quarter of that $2bn, is being spent on maritime safety,” said Nick Heath, spokesman for the WWF. “It’s being spent on items like promoting maritime safety and providing a search and rescue service.

“Legitimate spending - but it is not money going directly to bringing back coral, sea grass, turtles and fish.”

Topics

Annex 889

Ufficio di Rappresentanza di Taipei in Italia, “Is there drinkable water and topsoil on Taiping island?” (2 Feb. 2016), *available at* http://www.roc-taiwan.org/IT/ct.asp?xItem=688229&ctNode=6333&mp=187 (accessed 9 Mar. 2016)

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Is there drinkable water and topsoil on Taiping Island?

Post Date:2016/2/2

http://amti.csis.org/is-there-drinkable-water-and-topsoil-on-itu-aba/

Yann-huei Song
January 25, 2016
South China Sea,Spratly Islands, Taiwan

I visited Itu Aba, or Taiping Island in Chinese, on December 12 alongside a group of high-ranking Taiwanese government officials to attend the opening ceremonies for new piers and a lighthouse. It was my fourth visit to the island.

These visits provided me an opportunity to answer for myself the following questions being asked of a tribunal considering the Philippines' case against China at the Permanent Court of Arbitration in The Hague: Is Itu Aba an "island" or "rock" under Article 121(3) of the United Nations Convention on the Law of the Sea (UNCLOS)? In other words, is it capable of sustaining human habitation or economic life of its own? And as a result, is the feature entitled to a 200 nautical mile exclusive economic zone (EEZ) and continental shelf?

The government of the Philippines argues in its arbitration case that none of the features in the Spratly Islands are capable of sustaining human habitation or economic life of their own, and are therefore legally "rocks." This includes Itu Aba, the largest feature in the Spratlys. Accordingly, none of the features generate maritime entitlements beyond a 12-nautical-mile territorial sea. The Philippines' claim is based on a number of arguments, including: (1) there is no fresh water on the island suitable for drinking or capable of sustaining a human settlement; and (2) there is no soil on the island capable of facilitating any kind of agricultural production that could sustain human habitation.

In accordance with Article 9 of Annex VII of UNCLOS, "[b]efore making its award, the arbitral tribunal must satisfy itself not only that it has jurisdiction over the dispute but also that the claim is well founded in fact and law." Is the Philippines' claim regarding fresh water and soil on Taiping Island well founded in fact? In my experience, no. On my four visits to Itu Aba, I ate crops grown on the island and drank from the skimming water well located near its small hospital.

During the second oral hearing in the arbitration case held in November 2015, the Philippines cited as the "most authoritative evidence" in support of its claim regarding the lack of fresh water and topsoil on Itu Aba a 1994 article entitled "The flora of Taipingtao [Itu Aba]." The article was written by three Taiwanese botanists and appeared in Taiwania: International Journal of Life Sciences, published by National Taiwan University's College of Life Science. The research behind the article focused on the flora on Itu Aba, not the quality of water or availability of topsoil. The three authors are botanist, not experts on water quality or soil, and the views expressed in the article do not in any way represent those of Taiwan's government. Given these facts, how can the article be cited as authoritative evidence that there is no fresh water or soil on Itu Aba?

It is interesting to note the reasons given by Professor Clive Schofield of the University of Wollongong, Australia, who spoke as an expert witness during the oral hearings at The Hague, to explain his change of opinion concerning the legal status of

Itu Aba. Schofield previously wrote that “water supply might be one of the most important factors in clarifying the situation [legal status of an island or a rock]. This is because the existence of fresh water is an important indication that human habitation could be sustained.” At that time, he was of the opinion that Itu Aba “may conceivably” be considered a full-fledged island. But during the hearing, Schofield said his “firm belief” is that Itu Aba is a “rock.” Why the sudden change? It seems he accepted the so-called “most authoritative evidence” provided by the Philippines’ legal team.

It is not convincing to cite the 1994 article in support of the Philippines’ claim that there is no drinkable water or topsoil on Itu Aba. Schofield accepted this publication at its face-value without any verification. In addition, he admitted that he has not had access to Itu Aba. But I suspect he would change his opinion if he were invited to visit the island and, like me, had the chance to drink fresh water from the skimming well and eat a lunch of cooked vegetables and fruits picked from the island’s garden.

During my four visits to Itu Aba, I have seen indigenous plants that are more than 32 feet (10 meters) tall. There is a nearly 4,000-foot (1,200-meter) runway, two piers, a guest-house building, a postal office, a small hospital, a big agricultural garden, livestock, and a temple. In addition to drinkable water that is available at the four skimming wells, indigenous soil on the island has also long been used for growing fruits, including banana, coconut, and papaya, and vegetables such as wild bitter squash, loofah, and cabbage. It should also be noted that internet and cell phone access are available on Itu Aba, along with solar power for electricity.

If the five arbitrators deciding the South China Sea case were invited to conduct a visit to Taiping Island, I suspect it would be very helpful in the tribunal’s efforts to meet the requirement under Article 9 of Annex VII of UNCLOS to “satisfy itself not only that it has jurisdiction over the dispute but also that the claim is well founded in fact and law.”

About Yann-huei Song

Yann-huei Song is a research fellow in the Institute of European and American Studies, Academia Sinica, Taipei, Taiwan. He has broad academic interests covering ocean law and policy studies, maritime security, and disputes in the East and South China Seas.

More information, please visit :
-South China Sea: http://amti.csis.org/category/south-china-sea/
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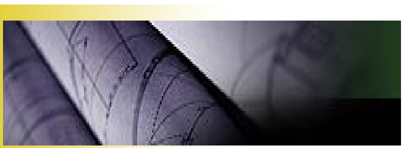
Annex 890

Mark Heyda, MBH Engineering Systems, *A Practical Guide to Conductivity Measurement* (2006), *available at* http://www.mbhes.com/conductivity_measurement.htm (accessed 8 Mar. 2016)



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A Practical Guide to Conductivity Measurement

by Mark Heyda

Units of Measurement

Electrical Conductivity is the ability of a solution to transfer (conduct) electric current. It is the reciprocal of electrical resistivity (ohms). Therefore conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The unit of measurement commonly used is one millionth of a Siemen per centimeter (micro-Siemens per centimeter or µS/cm). When measuring more concentrated solutions, the units are expressed as milli-Siemens/cm (mS/cm) i.e.- 10^{-3} S-cm (thousandths of a Siemen). For ease of expression, 1000 µS/cm are equal to 1 mS/cm. Often times conductivity is simply expressed as either micro or milli Siemens. However this unit of measurement is sometimes (incorrectly) referred to as micro-mho's rather than micro-Siemens. The expression "*mho*" was simply the word ohm spelled backwards.

Several means of conductivity expression have been adopted by various industries as a way of making the units of expression into whole numbers. The water softening industry refers to "grains" of hardness and uses TDS or total dissolved solids as a measurement scale. While TDS is really a gravimetric measurement, because in solution the solids are predominately present in ionic form, they can be approximated with conductivity. The TDS scale uses 2 µS/cm = 1 ppm (part per million as $CaCO_3$). It is also expressed as 1 mg/l TDS. While the method of measurement is the same, some conductivity meters can make the conversion and express the results of a measurement in many different units. This is helpful for users who are accustomed to one particular unit of measurement.

Table of Aqueous Conductivities

Solution	µS/cm	mS/cm	ppm

Totally pure water	**0.055**		
Typical DI water	**0.1**		
Distilled water	**0.5**		
RO water	**50-100**		**25-50**
Domestic "tap" water	**500-800**	**0.5-0.8**	**250-400**
Potable water (max)	**1055**	**1.055**	**528**
Sea water	**56,000**	**56**	**28,000**
Brackish water	**100,000**	**100**	**50,000**

Resistivity versus Conductivity

When the ionic concentration is very low (such as in high purity water), the measured conductivity falls below a value of one micro Siemens per centimeter. In order to express these numbers as whole numbers as opposed to fractions, the resistivity scale is often used. The numbers are exactly the inverse of each other. For example: the reciprocal of 0.10 µS/cm [or 1/(0.10 x 10^{-6} S/cm)] is then 10 x 10^{6} ohms-cm (10 MO-cm). This is also commonly referred to as "mega-ohms". Either unit of measurement can be used to state exactly the same value. Commonly the conductivity scale is more versatile as it can be used for a broader range of measurements.

Because air is soluble in ultra high purity water (18.3 MO-cm), the reading will not be stable in an open container.

Temperature Compensation

Temperature plays a role in conductivity. Because ionic activity increases with increasing temperature, conductivity measurements are referenced to 25ºC. The coefficient used to correct for changes in temperature, ß is expressed as a percentage per degree Celsius. For most applications, beta has a value of two. In order to establish the true value of beta a solution is measured at the elevated temperature (without temperature compensation). Then the solution is cooled and re-measured. ß can then be exactly calculated for that particular solution. Advanced meters allow for custom reference temperatures.

Probe Types and Polarization Errors

Amperometric

The probe used to measure conductivity was originally an *amperometric* system which had two electrodes spaced one centimeter* apart from each other. [* Probes with different electrode spacing allow measurement of various conductivities.]

The amperometric method applies a known potential (voltage, V) to a pair of electrodes and measures the current (I). According to Ohm's law: I=V/R where R is the resistance. The higher the current so obtained, the greater the conductivity. The resistance in this method unfortunately is not constant even though the distance may be fixed. Salt deposition on the electrodes due to electrolysis can vary the resistance. For low to medium levels of conductivity (< 2 mS/cm) this may be sufficient, but for greater accuracy and for higher levels, a different method is required.

Potentiometric

A *potentiometric* method is based on induction and eliminates the effects of polarization common to the amperometric method. The potentiometric method employs four rings: the outer two rings apply an alternating voltage and induce a current loop in the solution while the inner rings measure the voltage drop induced by the current loop. This measurement is directly dependent upon the conductivity of the solution. A shield around the rings maintains a constant field by fixing the volume of solution around the rings.

Because a potentiometric (4-ring) conductivity sensor is not limited by electrolysis which commonly affects amperometric probes, it can be used to measure a much wider range of conductivities. Practically, stainless steel rings can be used. But, the preferred metal is platinum because it can withstand higher temperatures and produces a more stable reading. Platinum sensors are also easier to clean. Advanced microprocessor conductivity instruments can vary the voltage applied to the sensor which enables them to extend the range of a potentiometric probe even further. This technique allows advanced meters to be able to measure both high and low conductivities as well as the ultra low conductivity of deionized water with one probe.

Inductive or Toroidal

Another method of conductivity measurement uses an inductive probe (sometimes referred to as a *toroidal* sensor). Typically these are found in industrial process control systems. The sensor looks like a donut (toroid) on a stick. The advantage of this technology is measurement without any electrical contact between the electrode and the process fluid. The probe uses two toroidal transformers which are inductively coupled side by side and encased in a plastic sheath. The controller supplies a high frequency reference voltage to the first toroid or drive coil which generates a strong magnetic field. As the liquid containing conductive ions passes thru the hole of the sensor, it acts as a one turn secondary winding. The passage of this fluid then induces a current proportional to the voltage induced by the magnetic field. The conductance of the one turn winding is measured according to Ohm's law. The conductance is proportional to the specific conductivity of the fluid and a constant factor determined by the geometry and installation of the sensor. The second toroid or receiving coil also is affected by the passage of the fluid in a similar fashion. The liquid passing thru the second toroid also acts as a liquid turn or primary winding in the second toroidal transformer. The current generated by the fluid creates a magnetic field in the second toroid. The induced current from the receiving coil is measured as an output to the instrument. The controller converts the signal from the sensor to specific conductivity of the process liquid. As long as the sensor has a clearance of at least 3 cm the proximity of pipe or container walls will have a negligible effect on the induced current.

Calibration

Most conductivity meters can be calibrated using a standard of a known value. Often a value of 1413 µS/cm is used. Some meters will allow the user to select from a wide range of pre-selected values. Calibration should be performed using a standard which is as close to the solution being measured as possible. More advanced meters will allow calibration at two, three, four or even five points. This results in good accuracy over a wider range of measured values. Some meters will even recognize the value a standard when the probe is immersed during calibration similar to auto buffer recognition in pH meters. This simply is another way a making a conductivity meter easier to use. Temperature is so important in conductivity measurement, it should also be calibrated at least one and preferably two different points.

US Pharmacopoeia and European Pharmacopoeia Standards

USP <645> with Stage 1,2 and 3 compliance is required for purified water and WFI (water for injection). Only a few resistivity/conductivity meters conform to these requirements. Some of these requirements are:

- Resolution of 0.1µS/cm or greater
- Accuracy at 1.3µS/cm of 0.1µS/cm
- Must be able to read with or without automatic temperature compensation
- Verifiable cell constant +/- 2%

The advanced HI 98188 will easily meet or exceed these criteria.

Portable and Bench Meters

Instruments which measure conductivity are available as portable field instruments which are hopefully waterproof since they are to be used in wet environments. Depending upon the model, the meters can:

- Used in various ranges of conductivities
- Incorporate a temperature sensor in the probe
- Auto-range to automatically express the results in the proper units
- Allow data logging of measurements with computer output port and data capture software
- Rechargeable batteries
- Offer automatic calibration from the keypad
- Include a potentiometric (4-ring) conductivity sensor

Laboratory bench meters normally will have all of the features available in the portable meters. Additionally, they often can express measurements in micro Siemens, milli Siemens, mega Ohms, TDS:

ppm or ppt, and salinity in PS, % or ppt. Look for features such as automatic time interval logging and log on demand plus automatic standard recognition during calibration. GLP (good laboratory practice) features allow the user to store and retrieve data regarding the status of the system. And for those on a tight budget, some conductivity bench meters will even include a pH meter with two separate electrodes. These combination meters share the same display.

Process Conductivity / TDS Controllers

For continuous measurement systems, a controller is used. These instruments are typically panel mounted and offer a host of excellent features including but not limited to: auto-ranging, control output relay(s), analog recorder output, in-line probe cleaning, diagnostic features and even a computer digital output with SMS (Short Messaging Service) or modem capabilities. Process controllers can also be divided into three general types depending upon the type of probe they employ. The first uses an amperometric probe for applications where cost is a consideration. The second uses a standard potentiometric type temperature compensated probe similar to those used with bench or portable meters. These are good work horses for most applications. However, the third type of controller uses an inductive probe. This probe has many advantages in an industrial setting. Common problems like contamination or polarization factors are eliminated because the sensor is has no electrodes in contact with the process fluid. Depending upon the application, users should select a controller and a compatible sensor suitable to the type of fluid and physical environment of use.

Annex 891

U.N. Food and Agriculture Organization, “Management of calcareous soils”, *available at* http://www.fao.org/soils-portal/soil-management/management-of-some-problem-soils/calcareous-soils/en/ (accessed 8 Mar. 2016)

Management of calcareous soils


Calcisol with cemented calcium carbonate layer near to the surface in a desert environment, USA

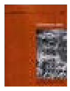
Calcareous soils have often more than **15% $CaCO_3$ in the soil** that may occur in various forms (powdery, nodules, crusts etc…). Soils with high $CaCO_3$ belong to the Calcisols and related calcic subgroups of other soils. They are relatively **widespread in the drier areas of the earth**.

The potential productivity of calcareous soils is high where adequate water and nutrients can be supplied. The high calcium saturation tends to keep the calcareous soils in well **aggregated form** and **good physical condition**. However where soils contain an impermeable hard pan (petricalcic horizon) they should be deeply ploughed in order to break the pan. This should be followed by the establishment of an efficient drainage system. Furrow irrigation is better than basin irrigation on slaking calcareous soils. On undulating lands, contour and sprinkler irrigations are better options than flood irrigation. Drip irrigation may also be practiced. Calcareous soils generally **have low organic matter content and lack nitrogen**. Nitrogen fertilizer may be applied any time from just before planting up to the time the plant is well established. **Application of nitrogen** through side-dressing to the growing crop is an efficient way of nitrogen application. Care should be exercised so as not to apply nitrogen close to the seed as it may prevent germination. Ammoniac sources of nitrogen and urea should not be left on the surface of calcareous soils, since **considerable loss of ammonia** through volatilization may occur, and they should be incorporated in the soil instead.

Phosphorous is often lacking in calcareous soils. Amounts to apply depend on how deficient the soil is and the crop requirements. Excess applied phosphorus may lead to deficiency of zinc or iron. To be effective on calcareous soils, applied phosphorus fertilizer should be in water soluble form. Band application of phosphate is more effective as compared to broadcast application. **Application at the time of seeding** has been found to be most appropriate since phosphorus is required mostly during the younger stages of plant growth.

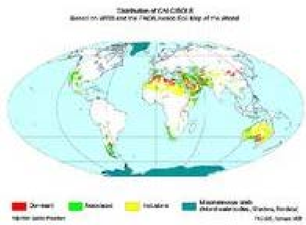
Calcareous soils usually suffer from a **lack of micronutrients**, especially **zinc** and **iron**. Zinc deficiency is most pronounced in maize, especially under high yield intensive cultivation systems. **Zinc sulphate** is an effective zinc source and is the most popular form in use. For soil application, zinc sulphate is broadcast and incorporated in soil. A **single application** lasts for several years. Foliar applications of zinc are used on fruit trees. **Heavy applications of animal manure** are helpful in preventing deficiency of iron and zinc.

Publications


Calcareous soils - FAO soils bulletin #21


INM for Sustaining Crop Yields in Calcareous Soils

Distribution of Calcisols



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Near East and North Africa

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Annex 892

Commonwealth of Australia, Queensland Government, Department of State Development, *Final Environmental Impact Statement for the proposed Abbot Point Growth Gateway Project*, *available at* http://www.statedevelopment.qld.gov.au/abbotpoint-eis (accessed 9 Mar. 2016)

Final Environmental Impact Statement

The final Environmental Impact Statement (EIS) for the proposed Abbot Point Growth Gateway Project (EPBC2015/7467), addressing matters of National Environmental Significance, is available below.

Consultation on the draft EIS was undertaken in August and September 2015. As part of the final EIS, the Queensland Government has considered these submissions and responded to them (see Volume 4: Supplement Report).

After considering the final EIS the Commonwealth Government has approved the project to proceed. 29 conditions apply for monitoring and managing these works.

In addition to this approval, the project also needs approval from state government agencies for onshore construction works and dredging works. The project cannot begin without these approvals.

The port authority, North Queensland Bulk Ports, will be responsible for the dredging and construction works.

If you have special communication needs, please phone 07 3452 6921.

- Volume 1: Executive summary (575 KB)
- Volume 2: Environmental Impact Statement (29.1 MB)

Volume 3: Appendices

- Appendix A - EIS Guidelines (166 KB)
- Appendix B - EIS Guidelines Cross-reference (98 KB)
- Appendix C - Engineering Drawings (3.1 MB)
- Appendix D - Dredged Material Containment Ponds Engineering Risk Analysis (653 KB)
- Appendix E - Soil Assessment and Management Plan (3.9 MB)
- Appendix F - Acid Sulfate Soils Investigative Report (4.5 MB)
- Appendix G - Contaminated Land Investigation (4.4 MB)
- Appendix H - Air Quality Assessment (1.6 MB)
- Appendix I - Greenhouse Gas Assessment (524 KB)
- Appendix J - Terrestrial Noise Assessment (2.7 MB)
- Appendix K - Underwater Noise Assessment (6.2 MB)
- Appendix L - Groundwater Assessment Report (11 MB)
- Appendix M - Marine Seagrass Light Requirements (611 KB)
- Appendix N - Hydrodynamic Modelling (11.4 MB)
- Appendix O - Hydrology Water Quality and Aquatic Ecology (6.3 MB)
- Appendix P - Terrestrial Ecology Report (11.6 MB)
- Appendix Q - Marine Ecology Assessment (17.4 MB)
- Appendix R - Social Impact Assessment (2.6 MB)
- Appendix S - Economic Impact Assessment (990 KB)

Appendix T - Fisheries Assessment (2.4 MB)

- Appendix U - Environmental Risk Register (47 KB)
- Appendix V - Outline Environmental Management Plan (3.3 MB)
- Appendix W - Outline Dredging Management Plan (3.6 MB)
- Appendix X - Preliminary Acid Sulfate Soil Management Plan (1 MB)
- Appendix Y - Preliminary Stormwater Management Plan (7 MB)

Volume 4: Supplement Report

Note: Volume 4 responds to public comments raised during consultation and provides further information on various topics.

- Part 1 (3.4 MB)
- Part 2 (9.7 MB)

In addition to matters of National Environmental Significance which are regulated by the Commonwealth Government, a number of other matters are regulated by the Queensland Government.

Key technical studies and impact assessment reports addressing State regulated matters which are relevant to development in the Abbot Point State Development Area are also available:

- Abbot Point TO, T2 and T3 Capital Dredging Sediment Sampling and Analysis Plan Implementation Report (5.35 MB)
- Acid Sulfate Soils Testing of Historical Offshore Samples (http://www.statedevelopment.qld.gov.au) (7.29 MB)
- Air Quality Assessment Report (1.51 MB)
- Road Transport Assessment Report (7.54 MB)
- Terrestrial Ecology Assessment Report (7.65 MB)
- Terrestrial Noise Assessment Report (9.53 MB)
- Wetland Flooding Report (19 MB)
- Wetland Hydrology Water Quality Aquatic Ecology Assessment Report (4.11 MB)

Last updated on 17 February 2016