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Offshore oil and gas in the SCS and the protection of the marine environment

Part 1
A review of the context and a profile of offshore activities

By Youna Lyons

Abstract

The intensity of media and political coverage of boundary disputes masks serious environmental risks from increasing offshore oil and gas exploration and development projects in the SCS and adjacent seas. It also distracts the region from cooperating and agreeing on a regional policy to assess and manage this risk. In this context it is critical to examine offshore developments in the SCS, the extent of the risk and review the tools available to manage environmental impacts. This paper discusses key geographic and location features of offshore oil and gas developments in the context of a holistic review of known, reported and potential environmental impacts. Developments and exploration located in areas subject to overlapping claims and the increase in deepwater installations are reviewed and discussed. The fixed or floating nature of installations, weight, age and location details including the depth and disputed fields are also outlined with a view to inform an environmental risk assessment. This paper highlights three points in the context of environmental risk management; the particularities of SCS platforms, the lack of environmental baselines and the need for specific and actionable research for the offshore oil and gas industry and policy makers.

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Introduction

Maritime boundaries and offshore oil and gas developments in the South China Sea (SCS) are currently the subject of much general and specialized media coverage. This includes the Chinese press on the launching of the deep-water oil rig CNOOC 981, due to start operation in the SCS in August 2011 as a part of CNOOC plans to invest 200 billion yuan and drill 800 deepwater wells and raise its deepwater oil and gas output to 500 million oil equivalent by 2020 [1]. Indeed, the large investment in deep-sea mining by China and its intention to extract hydrocarbons and minerals from the so far underexplored and underexploited SCS is exacerbating tensions between China and SCS coastal States, especially Vietnam and the Philippines[2]. The cutting of exploration cables of a PetroVietnam[3] exploration ship by a Chinese patrol ship in May 2011[4] and the on-going disagreement between the Philippines and China over the Reed Bank point to a serious risk of instability.

While tensions in the area may have slowed exploration and production of oil and gas in the last two decades, they have also blurred the geographical responsibilities of coastal States. More importantly, they have generally distracted attention from an overall increase in offshore oil and gas production with a potentially high environmental risk and prevented effective cooperation between coastal States on environmental risk management of the marine environment.

In this context it is critical to review the major developments in the SCS and the international and regional tools available to manage environmental impacts from offshore oil and gas activities. This paper is the first part of a general review of offshore oil and gas in the SCS and its potential environmental impact. A brief review of the geography, geopolitics and economics of offshore oil and gas for coastal States of the SCS sets the context in which to better understand the profile of current oil and gas offshore installations. The fixed or floating nature of installations, weight, age and location details, including the depth and disputed fields, are outlined based on industry information and specialized press coverage. Where no agreement could be reached on overlapping maritime boundaries, the difficulty has in some places been temporarily overcome through various agreements between States or less formal arrangements between national oil companies. These agreements are considered in the context of the protection of the marine environment in which they allow developments to occur.

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[1] As an example; After 3 years and nearly a billion dollars, jumbo deepwater rig delivered to CNOOC, Xinhuanet, 23 May 2011, available online at http://news.xinhuanet.com/english2010/indepth/2011-05/23/c_13889837.htm (last accessed on 25 July 2011); China gets massive deep-water rig, UPI.com (25 May 2011) available online at http://www.upi.com/Business_News/Energy-Resources/2011/05/25/China-gets-massive-deep-water-rig/UPI-49771306342335/ (last accessed on 26 May 2011); and China's largest metal trade to plunge into deep-sea mining, China Mining (19 March 2011) available online at http://www.gongchang.com/asia/industrytrends/2011-03-19/4518.html (last accessed on 29 April 2011).

[2] China surveillance ships roam PhI waters, Jun Pasaylo (1 June 2011), The Philippine Star, available online at http://www.philstar.com/nation/article.aspx?publicationSubCategoryId=63&articleId=691947 (last accessed on 6 June 2011)

[3] The national oil company of-Vietnam

[4] Binh Minh ship – another CGX case in East Sea?, by Nguyen Dang Thang, VietNamNet (31 May 2011) available online at http://english.vietnamnet.vn/en/special-report/8943/binh-minh-ship---another-cgx-case-in-east-sea-.html (last accessed on 1 June 2011)

This paper reviews environmental impacts from all offshore upstream activities: exploration for petroleum products, exploratory drilling, construction of offshore platforms and installations, offshore development and production, maritime ports, transportation from offshore production platforms, underwater pipelines, well abandonment and platforms and installation decommissioning. Not considered in this paper are the downstream activities impacting on the marine environment where they involve coastal developments (e.g. coastal refineries) or through pollution of the atmosphere.

The legal instruments available to address potential environmental impacts reviewed in this paper and the coastal States obligations in relation to environmental impacts from offshore oil and gas activities are the subject of a separate paper. That paper points to the obligations owed by coastal States to adopt adequate legislation with respect to pollution from seabed activities under international law and to the relevance of many shipping treaties. [5]

1. The SCS and adjacent seas

1.1 Geophysical characteristics

Physical geography defines the SCS as a semi-enclosed sea, as it is separated from other surrounding seas by shallow straits. The 1982 United Nations Convention on the Law of the Sea (UNCLOS)[6] gives the same definition from a legal perspective[7].

This analysis focuses primarily on offshore oil and gas production by coastal States in the SCS and adjacent seas. Included adjacent seas are the Gulf of Thailand, the Sulu-Celebes Sea, the Straits of Malacca and the Indonesian Seas, where oil and gas activity can be seen as a corollary of that happening in the SCS because it involves the same countries and connected bodies of water. Other surrounding seas have been excluded from the scope of this paper, namely the Yellow Sea, the East China Sea, the Timor Straits or the Bay of Bengal beyond the Andaman Sea, except where specified. The reason being that these seas present distinct geographical and/or political characteristics from those of the SCS. The roles played by Japan and South Korea in the Yellow Sea and the East China Sea change the geopolitics, dynamics and stage of development in the offshore oil and gas industry. This is also the reason for the exclusion of Taiwan's production, which should instead form part of a separate study on the East China Sea. The Timor Strait is also in a different stage of development and involves limited conflicts as it involves only Indonesia, Timor and Australia. As for the Bay of Bengal, it is both a large and distinct marine ecosystem and is dominated by India while also involving Sri Lanka, Bangladesh and Myanmar, the latter being seldom involved in the SCS boundaries disputes although it is a Member State of the ASEAN. Countries whose production has been reviewed are thus Brunei, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore and Vietnam.

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[5] Y.Lyons (2011) Offshore oil and gas in the SCS and the protection of the marine environment (Part 2): Legal and governance framework. Available on CIL website at http://cil.nus.edu.sg/publications/working-papers/

[6] Available online at http://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf (last accessed on 26 May 2011)

[7] Both criteria set out in Article 122 UNCLOS are met for the SCS: It *'is surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consistently entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States.'*

The surface area of the SCS[8] (3.6million km^2, with an average depth of 1,200m) is more than double that of the Gulf of Mexico (1.5 million km^2), itself double the North Sea (750,000km^2), which is 3 times larger than the Persian Gulf. 44% of the SCS is a deep basin with a maximum depth of 5000m.[9] By comparison, the North Sea is a shallow sea, half of which is 100m deep or less, 3 quarters is less than 200m deep and no point is below 1000m. It contained 440 platforms in 1999, more than half of which are on the United Kingdom's continental shelf, the largest producer. The Gulf of Mexico had around 4,000 platforms in 2005. Wu Shicun and Hong Nong reported in 2005[10] that, according to decades of research, there are 13 large and medium sediment bans in the SCS containing over 172 millions barrels of oil and 10 trillion cubic meter of natural gas. Recent press articles from China report a very different quantity of 366.5 billion barrels of oil and 20 trillion cubic meters of gas, illustrating the current interest for this sea.[11] Eight of these sedimentary basins are in the Spratly Islands, an area of 410,000km^2.

The location and geography of these seas, coupled with the number of coastal States determine the number of overlapping claims and thus the circumstances for development and activities within them. In contrast, the Indonesian seas, which are exclusively under Indonesian jurisdiction (as is the Sulawesi Sea, in the south part of the Sulu-Celebes sea) are exempt of territorial disputes and only limited by Indonesian regulation and relevant international and regional rules and standards.

1.2 Ecology and multi-uses

While they are among the most biodiverse ecosystems of the world, the SCS and its adjacent seas are also subject to intense competing uses. The region accounts for more than 40% of the world's total fish catch[12] and contains almost half of the world's coral reefs[13], 37% of the world's mangrove area and 72% of the world's seagrass.[14] The rich biodiversity also attracts a growing coastal tourism, which, paradoxically, is itself the source of environmental degradation and generally losses in ecosystem services. Most of the coastline surrounding the SCS is made of productive mangroves which are a key nursery ground for coral reef and coastal fisheries.[15] However, they are also very vulnerable to oil spills as well as to all disturbances to the water

[8] The Gulf of Thailand (400,000km^2) is included in this figure. For more details on this Large Marine Ecosystem (bathymetry, productivity, fisheries, socio-economic condition, etc.), refer to the report of S.Heileman (2009) VIII-15 South China Sea LME, available online at http://www.lme.noaa.gov/LMEWeb/LME_Report/lme_36.pdf (last accessed on 7 June 2011).
[9] NOAA website on Large Marine Ecosystems available online at http://www.emecs.or.jp/guidebook/eng/pdf/18southchina.pdf (last accessed on 29 April 2011).
[10] Wu Shicun and Hong Nong (2005) The Energy and security of China and oil and gas exploitation in the South China Sea: 149, in Recent developments in the law of the sea and China, Center for Oceans Law and Policy, by Koninklijke Brill NV, Leiden, The Netherlands
[11] Oil bonanza in South China Sea, in China Global Times, on 19 April 2011, available online at http://special.globaltimes.cn/2011-04/645909.html
[12] FAO (Food and Agriculture Organization of the United Nations), 2007, Review of the state of the world marine capture fisheries management: Pacific Ocean. FAO fisheries technical paper: T488/1
[13] C.R. Wilkinson (2008) Status of coral reefs of the world : 2008, Australian Institute of Marine Science, Townsville.
[14]For a map of coral, seagrass and mangrove biodiversity showing the SCS's relatively high biodiversity, refer to http://maps.grida.no/go/graphic/distribution-of-coral-mangrove-and-seagrass-diversity (last accessed on 25 July 2011)
[15] For a map of the mangroves of southeast Asia (excluding Vietnam's coastline), refer to http://mangroveweb.seafdec.org.ph/html/fshrimp.htm (last accessed on 25 July 2011)

flow, such as diversion of water, dredging or drainage.[16] Regional capture production began to plateau between 2004 and 2005.[17] Reporting on decrease in the mean size of fish being landed, value of catch, increased catch-per-unit effort and use of higher hand fishing gear capable of fishing deeper are signs of a high risk of fisheries crisis in the region.[18] The large increase in aquaculture production is also a source of pressure on fisheries as well as coastal degradations, as are coastal pollution and coastal developments. Coastal and marine resources are reported to be responsible for 40% of the GDP of the less developed economies of the region.[19] Shipping pollution is also a growing concern, given (i) the extreme density of shipping, including oil tankers, through the SCS, and; (ii) the vulnerability of many marine systems either sailed through or located within vicinity of the shipping lanes.[20] These numerous signs of environmental degradation are impacting the benefits gained. Environmental stress will grow and also shift to new areas as resource users compensate for the lost benefits.

The impact of climate change is yet again an additional stressor on the marine environment of the SCS. It has particular relevance to the offshore oil and gas activities in the context of the increase in intensity and frequency of extreme weather events already witnessed in the region, especially storms and typhoons, as well as sea-level rise and flooding for coastal installations, due to the oil and other chemical spills they can trigger.

In this context, the relative importance of the environmental stressors from offshore oil and gas activities are undetermined. However, any environmental impact assessment of such activities needs to take into account the combined impact with environmental stressors from other sources.

Much has been written on the need to protect the coastal and marine ecosystems of the South China Sea and better manage the numerous conflicts in uses. In addition to the political instability triggered by increasing conflict in uses, the exceptional marine biodiversity of the region has made it of particular interest for the rest of the world and the subject of much international scrutiny, as can be seen through the regional reports prepared by or funded with the participation of the United Nations Environment Programme (UNEP).

2 Offshore oil and gas industry

2.1 Offshore production

[16] The productivity of the mangroves system depends on a dynamic balance among water flows, sedimentation, erosion and species composition. IUCN (1993) Oil and gas exploration and production in mangroves areas, IUCN Gland, Swizerland Switzerland and Cambridge, UK, with E&P Forum, London, UK, available online at http://www.ogp.org.uk/pubs/184.pdf (last accessed on 25 July 2011)
[17] WRI (World Resource Institute) 2008, Coastal and marine ecosystems: searchable database, available online at http://earthtrends.wri.org/searchable_db/index.php?theme=1 (last accessed on 8 June 2011).
[18] UNEP/COBSEA (2010) State of the marine environment report for the East Asian Seas 2009, Ed. L.M. Chou, COBSEA secretariat Bangkok, 156p, available online at http://www.cobsea.org/documents/Meeting_Documents/Marine Litter/Marine Litter Report 2008.pdf (last accessed on 8 June 2011).
[19] UNEP/COBSEA (2010) Ibid, p.19
[20] UNEP/GPA (United Nations Environment Programme Global Plan of Action for the Protection of the Marine Environment from Land-based Activities), 2006 The State of the marine environment: Regional assessments, part 4, Seas of East Asia p.158-192

The production of non-living resources or sea mining is currently dominated[21] by the offshore oil and gas industry. However, the SCS is believed to also contain strategic resources in gas hydrates, the large scale exploitation of which is predicted to start within the next 10 to 15 years. Research projects for gas hydrates in the West Pacific by the National Natural Science Foundation of China and the Guangzhou Marine Geological Survey pointed to the high likelihood of abundant natural gas hydrates around the Paracel Islands, the Macclesfield Bank and the Pratas Islands.[22] Based on these promising results, estimated at an amount equivalent to 586.4 billion barrels of oil in an 8000km2 area, i.e. around half of China's current oil reserve, more survey and research has been since carried out.[23]

World economic crisis are reflected in oil and gas demand, market stability and forecast reliability. The International Energy Agency Project, in its New Policies scenario,[24] states that Non-OECE countries account for 93% of the projected increase in world primary energy demand, reflecting faster rates of growth of economic activity, industrial production, population and urbanization and the general lack of resources and expertise to develop carbon-free sources at a pace needed for development. Demand for oil and gas is comparatively greater per unit of energy consumption in ASEAN countries than in developed countries. China is expected to contribute 36% to the projected growth and remain the world's largest energy user, ahead of the US, both largely ahead of India.[25] The share occupied by oil and gas is also expected to vary depending on the demand for nuclear power and the impact of Japan's recent earthquake on the Fukushima power plant.

Oil and gas production forecasts for Southeast Asia are often included in regional forecasts for Asia-Pacific or East Asia, making it difficult to identify the share corresponding to offshore production in Southeast Asia alone or even overall production for Southeast Asia. When considering specific production and installation data for offshore oil and gas in the SCS and adjacent seas, it has to be noted that open source data is patchy. While information has also

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[21] Occasional news coverage of tin mining in Indonesia, especially on and off the coast of Bangka island. Profitable, illegal and deadly: Tin mining diving in Bangka-Belitung, published in the Jakarta Globe, 21 February 2010, http://www.thejakartaglobe.com/business/profitable-illegal-and-deadly-tin-diving-in-bangka-belitung/359950 and a more recent discussion from the University of Lampung http://blog.unila.ac.id/budikurniawan/2011/03/26/321/ (last accessed 29 April 2011) and sand dredging in Cambodia (Cambodia: Sand dredging prompts fishermen's protests, IRIN Humanitarian news and analysis, a service of the UN Office of the Coordination of Humanitarian Affairs, 15 July 2010 http://www.irinnews.org/Report.aspx?ReportID=89839 (last accessed on 29 April 2011) and Malaysia (B.M.Zamali and S.C.LEE (1991) Proposed management guidelines for offshore sand mining activities in South Johor, Malaysia: 365-373 In L.M.Chou et al. (eds) Towards an integrated management of tropical coastal resources. ICLARM Conference Proceedings 22, 455p, National University of Singapore), both occurring in territorial seas, suggest that there are important ongoing activities but information is scarce. R.Charlier (2002, Impact of the coastal environment of marine aggregates mining, International Journal for Environmental Studies 59(3): 297-322) refers to active mining in Malaysia and Southeast Asia, including dredging of tin-rich mud. Further investigation within each coastal State of the SCS would be necessary to identify the exact extent of underwater mining in the SCS.

[22] SS Fan and JY Wang (2006) Progress of gas hydrate studies in China, The Chinese Journal of Process Engineering, Vol.6 No.6: 997-1003, available online at http://www.jproeng.com/qikan/manage/wenzhang/205280.pdf (last accessed on 26 May 2011)

[23] Wu Shicun and Hong Nong (2005) Ibid

[24] This is the central scenario of the 2010 Outlook. It takes into account the broad policy commitments and plans that have been announced by countries around the world. However, these commitments are assumed to be implemented in a relatively cautious manner, reflecting their non-binding character and in many cases uncertainties in the effect of the measures taken.

[25] http://www.worldenergyoutlook.org/docs/weo2010/WEO2010_ES_English.pdf

been gathered from industry databases and updates by industry consultants, it remains indicative and subject to field verification and adjustment as drilling and production platforms move on. B. Twomey from Reverse Engineering Services Ltd highlights incomplete and conflicting information.[26]

Regional oil use reached an estimated 27.28mn b/d (million barrels per day) in 2010 and is forecast to rise to around 30.80mn b/d (compared to 21.42mn b/d in 2001). However, as regional production has not increased in the same proportions, imports have risen steeply.[27] The average production in Southeast Asia for 2006 was reported at 6.0789 mn b/d of oil and 8.293 trillion ft^3/d of natural gas.[28] By contrast, the SCS alone appears to be currently producing more than 85,000 barrel oil equivalent per day (or 11,596 tonnes oil equivalent) of natural gas, though the reliability of the source may be questioned.[29] Gas might in fact be the most abundant hydrocarbon resource in the SCS. Estimates of the U.S. Geological Survey indicate that natural gas would represent 60 to 70% of the region hydrocarbon resources.[30] Gas hydrates are also believed to be abundant.[31]

Although Brunei and Malaysia are the only net exporters of oil and gas in the region to date, oil and gas production has played, and still does play, a critical role in southeast nation's economics and country development. All the coastal States of the SCS have offshore oil and gas production, although Cambodia's production is only nascent.

2.2 Overview of offshore platforms and installations

This paper focuses on offshore platforms used for many for oil and gas activities, including offshore port terminals used as offloading and loading facilities.

Given the data patchiness and inconsistencies previously outlined, the analysis of platform profiles presented below is based primarily on Brian Twomey (2010)[32] and the 2010 industry World Offshore Field Development Guide Database for Southeast Asia.[33] While trends shown are reliable, the number of platforms will vary according to data availability, the classification

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[26] Brian Twomey (2010) Study assesses Asia-Pacific offshore decommissioning costs, Oil and Gas Journal, March 15: 51-55

[27] Malaysia is expected to become the only net exporter of the region by 2015 (Market Report, Malaysia Oil & Gas Report Q2 2011, outline available online at http://www.pr-inside.com/print2486557.htm, last accessed on 23 March 2011). These figures include Japan, India and South Korea in addition to the other countries focused on. They are consistent with Vietnam Oil and Gas Report for Q1 based on BP statistical review of world energy, June 2010, available online at http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2010_downloads/statistical_review_of_world_energy_full_report_2010.pdf (last accessed on 24 March 2011).

[28] EIA (Energy International Agency), South China Sea Energy Data, Statistics and Analysis – Country analysis briefs, available online at http://www.eia.doe.gov/cabs/South_China_Sea/pdf.pdf (last accessed on 24 March 2011)

[29] These very large discrepancies can be explained by differences in geographical scopes of the two assessments as well as the exclusion of onshore oil and gas production in the latter. The method and exact scope relied on for the computation of production data is unfortunately not disclosed. http://www.chinasignpost.com/2011/04/china-aims-to-more-than-triple-its-oil-gas-production-in-the-south-china-sea-over-the-next-10-years/ (last accessed 4 April 2011).

[30] Ibid note 2

[31] Natural gas hydrates found in the SCS: Report, Asia Pulse Pty Ltd. 2011. *HighBeam Research.* 22 March 2011

[32] Study assesses Asia-Pacific offshore decommissioning costs, Oil & Gas Journal Mar 15, 2010: 51

[33] World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010

adopted (e.g. whether several platforms connected together are counted as one or several and/or whether they are counted by reference to their mode of attachment or mooring to the seafloor), and the date of assessment (temporary installations or new installations).

It is estimated that today there are a minimum of 1350[34] platforms in the SCS and adjacent seas located within the geographical scope of this study. They are of a great diversity, ranging from the old model of small and fixed jackets in shallow coastal waters to large Floating Production, Storage and Offloading (FPSO) in deep water through gravity-base structure, production jack-up, semi-submersible production units, stacked-led structures, spars, monotowers and mobile offshore barges. Each platform design corresponds to the best fit to the extraction condition (especially depth, reservoir size and type of hydrocarbon extracted) at the time they were installed. The different types are presented in Diagram 1 below.[35]

Of the approximately 1350 platforms located in the SCS and adjacent seas, 1288 are fixed to the seabed (rather than moored). Indonesia has by far the greatest number of platforms, followed by Thailand and Malaysia. Together, these 3 countries have 74% of offshore installations in the SCS, and 86% with Brunei (Table 1 below).

Close to 80% of the platforms are less than 4000 tonnes. The Malay-Thai platforms are all below 400 tonnes. In Thailand, only 9 have a weight of 4000t or more. B.Twomey's estimation is that 78.7% of offshore platforms located in the SCS weigh less than 4,000 tonnes. The Malampaya platform is the heaviest (102,500t). China has the largest number of FPSOs, all located in the Gulf of Beibu and off Hong Kong.

Of Indonesia's 485 platforms[36], 276 platforms are more than 20 years old, which is more than half of its offshore facilities. 48% of Malaysia's offshore platforms are 25 years old or more, most of which are located off Sarawak and the remaining off Sabah region and off Peninsular Malaysia. Based on B. Twomey's study for Asia Pacific, on the whole, close to half of the platforms are over 20 years old (just under 675) and over 10% are over 30 years old.

With regards to the depth of the installations, 50% appear to be located in less than 50m and close to 75% within 75m water depth or less. Thailand and Brunei's installations are all in less than 90m of water. Deepwater drilling is currently located mostly off China's southern coast around the hydrocarbon fields of the Pearl River Delta (off Hong Kong, some fields average 1500m depth). However, based on the number of planned developments of deepwater fields and specialised press coverage, deepwater drilling is due to increase rapidly in the coming 5 years.[37] In addition to China's deepwater fields, the SCS today holds 26 deepwater fields (over 500m depth) granted for exploration and development, where production has started in the last 8 years or is due to start within the coming 2 to 5 years (as at 2010).[38] With two new

[34] According to Brian Twomey's calculations, it might be 127 platforms. As mentioned previously, data is inconsistent due to a lack of detailed public information including the location and particulars of platforms and installations.
[35] For a snapshot presentation of the different types of offshore platforms for oil and gas exploitation, refer to http://en.wikipedia.org/wiki/Oil_platform
[36] It is suggested that the number might be 530 in B. Twomey (2010).
[37] New Southeast Asia discoveries, drilling suggest growth in deepwater exploration, by Noel Tomnay, Offshore, 1 April 2003, available online at http://www.gslb.offshore-mag.com/index/article-display/173877/articles/offshore/volume-63/issue-4/technology/new-southeast-asia-discoveries-drilling-suggest-growth-in-deepwater-exploration.html (last accessed 5 July 2011)
[38] 2010 Industry offshore field development guide database for Southeast Asia, ibid

deepwater fields in production since 2003 (West Seno is 976m), Indonesia has another 11 deepwater fields (2 of which are 600m deep, 9 are more than 800 m deep or more) forecast to come into production in the coming 5 years.[39] Malaysia's 12 current deepwater fields are located off Sabah. 2 are in development and production (respectively Gumusut-Kakap, 1000m and Kikeh, 1342m), the other 9 are 1000m deep to 1465m on average (except one, 800m) and development is planned within the coming 5 years. The Philippines' Malampaya gas field is also located at 800 to 1200m water depth. Finally, blocks CA1 and CA2 located off Brunei and jointly managed under a joint commercial arrangement between Brunei and Malaysia are 1000 to 2720m deep and, together, cover around 10,000km^2 (see section 4.3 below).

While the size of offshore concession blocks in the SCS is variable, they are very large, generally in the range of 4,000 to 10,000 km^2.[40] The largest blocks are often located on the outer limits of the continental shelf.[41]

2.3 Coastal States' offshore installations

Brunei is the main oil producing country in the Asia-Pacific region with 161 platforms. The main exploitation area is situated in the Shaba basin (Map 6). Shell is the primary partner of the Brunei government in the joint management of several large oil and gas fields.[42] Offshore activities involve 35 fields at either discovery or production stage. Of the 18 fields in production, 12 of them include both oil and gas production (and condensate for some), 5 are gas only and 1 is oil only. Champion, in 30 m of water, holds 40 percent of the country's known reserves and produces around 100,000 barrels a day. The field already has more than 260 wells drilled from 40 platforms. A central field complex, Champion-7, has living quarters for about 160 personnel, gaslift and compression facilities and water injection facilities.[43] Some offshore fields are shared with Malaysia (such as Fairly Baram).

With 2 oil and gas fields, developed with Chevron, Mitsui and Caltex (MOECO Company Ltd), Cambodia is a new comer in the offshore oil and gas industry in the SCS.

Indonesia is an OPEC country and a main oil producer but became a net importer of oil in 2004. Oil production has been decreasing in the last 10 years but gas production is increasing.[44] Pertamina is the national oil company, though its monopoly on upstream activities and role as regulatory and administrative bodies have been transferred to other entities in a large privatization plan.[45] Numerous foreign oil and gas companies are operating on Indonesia's continental shelf. 83 of the platforms are operated by CNOOC while other foreign oil and gas

[39] At West Seno, Guendalo, Gehem and Tulip, the water depth ranges from 840 to 1823m (2010 Industry world offshore field development guide database for Southeast Asia, Ibid).
[40] Some are smaller. The rationale behind the map of concession blocks drawn by each coastal State has not been investigated.
[41] The surface area of the concession blocks is based on Map Vietnam General, Global Exploration and Production Service by HIS (May 2008) Ref. VN08E1GEN, and South China Sea Map 803425AI (G02257) 1-10.
[42] World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010 and http://www.pgs.com/upload/75106/brunei MC3D%5Bemail%5D.pdf (last accessed on 4 April 2010)
[43] https://www.bsp.com.bn/main/aboutbsp/about_oil_gas.asp and World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010
[44] The energy and mineral resources provide 25 to 30% of the country's tax income but a large portion comes from land rather offshore resources and only a small portion comes from the SCS (Shicun Wu and Nong Hong (2006) Ibid p.150)
[45] EIA, Country analysis briefs, Indonesia http://www.eia.gov/countries/country-data.cfm?fips=ID (last accessed on 27 April 2011)

companies operate around 200. Chevron is the largest foreign oil producer. Others include Total, BP, Exxon Mobile and ConocoPhillips. Of the 490 platforms located on what Indonesia considers to be its continental shelf, 97% are located in internal and archipelagic waters and 3% beyond[46]. Around 25 platforms are located off Sumatra in the Straits of Malacca.[47] Oil and gas fields involving potential frictions with other coastal States to date are the very large Natuna oil and gas field (largest offshore field for Southeast Asia[48]) and potentially fields located in the Sulu-Celebes sea in areas where maritime boundaries with Malaysia and the Philippines have yet to be determined.

Malaysia is a net exporter of oil and a large oil and gas producer with elaborate legislation and industry skills often considered as best practice in the region. The national oil company, Petroleam Nasional Berhard (Petronas), holds exclusive ownership rights to all oil and gas exploration and production project in Malaysia.[49] Unlike the other coastal States of the SCS, Malaysia has limited the involvement of foreign companies and opposes the internationalization of the SCS. Of 348 platforms[50] (or 249 depending on the source[51]) located on Malaysian concessions, only 39 are exploited by foreign oil and gas companies. Most of Malaysia's oil and gas production comes from the SCS (89% in 2000).[52] Malaysia has resolved most of its competing claims with Vietnam, Thailand, Brunei, and Indonesia[53] but not with China. 18 oil fields and 40 gas fields are located within China's U-shaped line.[54]

95% of the Philippines' oil is imported. Development of oil and gas production is critical to the development of the economy and decreasing the dependence on export. There are currently 8 platforms located on Philippines concessions. They are operated by Shell or Philodrill Corporation Ltd and mostly located off the coast of Palawan. The Malampaya's gas field has been critical in the development of commercial gas in the Philippines as it holds an estimated 2.7 trillion f^3 of natural gas. While current platforms are located outside China's U shaped line the Philippines are intending to develop gas reserves in the Reed bank in the near future, a move which is strongly opposed by China as it is located within the Spratly Islands area.

Thailand has 265 platforms mostly located in the Gulf of Thailand, 215 or so of which are operated by Chevron Corporation or Chevron Thailand Exploration and Production Ltd. They are mostly light and fixed in shallow waters (90m maximum).[55]

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[46] M.A.Ayoade (2002) Disused offshore installations and pipelines: towards "sustainable decommissioning", Kluwer Law International, Massachusetts, USA p.93
[47] Around 315 platforms are located in the Java Sea north of Jakarta, around 138 are located in East Kalimantan and 15 are located off Java (Surabaya, Gresik and Pasuruan).
[48] Reserves are estimated at 46 tf^3 of gas http://www.offshore-technology.com/projects/natuna/ (last accessed on 27 April 2011)
[49] EIA, Country analysis briefs, Malaysia http://www.eia.doe.gov/countries/cab.cfm?fips=MY (last accessed on 27 April 2011)
[50] World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010
[51] B.Twomey, Ibid
[52] Shicun Wu and Nong Hong (2006) Ibid p.150
[53] A.Salleh et al. (2009) Malaysia's policy towards its 1963-2008 territorial disputes, Journal of Law and Conflict Resolution Vol.1 (5): 107-116, available online at http://www.academicjournals.org/jlcr/abstracts/abstracts/abstract2009/Oct/Salleh et al.htm
[54] Shicun Wu and Nong Hong (2006) Ibid p.150
[55] B. Twomey, Ibid and World offshore field development guide database,– Vol.2: Asia, India, Australasia & Far East, OPL, 2010

Offshore oil and gas production has played a critical role in Vietnam's reconstruction and development in the last 30 years. Most oil and gas is exploited on the SCS continental shelf and the production has increased dramatically in the last 10 years.[56] Since the enactment of the 1989 Law on Foreign Investment, Petrovietnam has signed Production Sharing Contracts, Joint Operating Contracts and Business Cooperation Contracts with over 50 international oil and gas companies.[57] Its most productive area to date is the Bach Ho field on Block 9, in the Cuu Long Region, Vietnam's (Map 5 below). Vietnam's oil and gas industry is state controlled. Petrovietnam is the government vehicle, which, together with its Vietsovpetro JV, provides the bulk of the country's oil production. BP Vietnam and Conocco Phillips are the most important foreign operators. The most recent estimate of Vietnam's proven oil reserves is 4.50bnb according to BP Statistical Review of World Energy, June 2010. PetroVietnam also expects to find up to 110mn boe between 2011 and 2015, with partner companies such as Soco International and Premier Oil. Two discoveries were announced in Vietnam in September 2010. The Hoang Long Joint Operating Company (HLJOC), a joint venture involving PetroVietnam and Soco, hit hydrocarbon reserves in southeast Vietnam while Malaysia's Petronas Carigali discovered oil and gas in northern Vietnam. Vietnam has 66[58] (or 46[59]) platforms, none of which are operated by China National Offshore Oil Corp (CNOOC)[60]. Vietnam has partnered with Petronas and operators from Korea and Japan to manage at operate at least 17 platforms.

China became a net oil importer in 1983.[61] Given its increasing reliance on imported oil and gas to sustain economic development, security of energy supplies is a strategic priority. In this context and that of a growing international competition for oil, unrest in the Middle East and unresolved overlapping territorial claims, the currently underexploited oil and gas fields in the SCS are the subject of increased sensitivity and conflicting national interest.[62] Recent press releases and specialized articles emphasize China's position in relation to the Philippines and Vietnam.[63] CNOOC indicated that it will step up exploration in the SCS in 2011 and plans on raising deep-sea oil production to 10% of global production.[64] The recent launching of CNOOC 981 or the HYSY 981 rig has increased tensions with SCS coastal States. To date China has no direct oil or gas production in or around the Spratlys area[65]. Current oil and gas development fields in the SCS are located in three main areas located in the north of the SCS, off Hong Kong

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[56] It exported 88. 7 million barrels of oil in 1998, over 106 million barrels in 1999 and 19 billion cubic feet of gas according to 2002 statistics from Energy Information Agency of America.

[57] The focus of Vietnam has been so far to strengthen its petroleum laws and business environment to make it attractive to foreign investors and catch up with other producing countries Vietnam Oil and Gas Report Q1 2011, published by Business Monitor International, ISNN 1748-4375, London, UK, available online at http://www.businessmonitor.com (last accessed on 1 June 2011)

[58] World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010

[59] B. Twomey, Ibid

[60] China's largest offshore oil company

[61] L. Buszynski and I. Sazlan (2007) Maritime claims and energy cooperation in the South China Sea, Contemporary Southeast Asia: A Journal of International and Strategic Affairs, Vol.29 #1: 143-171 and Vivian Louis Forbes, Conflicts and cooperation in managing maritime space in semi-enclosed seas (Singapore: Singapore University Press, 2001).

Wu and Hong (2006) The energy security of China and oil and gas exploitation in the South China Sea, in Recent developments in the law of the sea and China, Center for Oceans Law and Policy, by Koninklijke Brill NV, Leiden, The Netherlands

[63] For instance, Oil bonanza in South China Sea, in China Global Times, on 19 April 2011, available online at http://special.globaltimes.cn/2011-04/645909.html

[64] Minmetals to plunge into deep-sea mining, China Daily, 17 March 2011, available online at http://www.chinadaily.com.cn/business/2011-03/17/content_12184630.htm (last accessed on 29 March 2011)

[65] Though it granted a concession, the Wan'an Bei 21, to Crestone Energy Corporation in 1992 on the west of the Spratlys (see below section 3.2.2).

and the Pearl River delta (oil and gas), in the Beibu Gulf (off Hainan, for oil and gas) and in the Yinggeh Sea Bassin (mostly gas), in the Gulf of Tonkin. This latter area is the only contentious one where developments occur close to or over the area considered by Vietnam as its continental shelf and beyond the Chinese-Vietnamese agreed maritime boundary (refer to section 3.2.2 below). 47 fields are at a production and development stage, 49 are at a discovery and probable development stage and one was shut down in 2009.[66] It must be noted however that China, through CNOOC, has many interest in SCS development fields, including joint venture agreements with other coastal States of the SCS, particularly Indonesia and Malaysia. [67]

2.4 Forecast in offshore production and prospective reserves

It is estimated that if over the next 20 years oil consumption rises by 2.7% annually[68] (as expected, in order to meet the demand in fuel needed for development), from 14.8 million barrels per day in 2004, oil demand will reach nearly 29.8 million bb/day by 2030[69] and would more than double the current consumption by 2020.[70]

China's position is that the potential in oil resources (not proven reserves) in the SCS would be 213 billion barrels, 105 billions of which would be located off the Spratly and Paracel Islands. In contrast, the U.S. Geological Survey estimated 28 billion barrels to include discovered and undiscovered oil reserves in the SCS.[71] Given the difficulties in carrying out exploratory drillings until clear agreements have been reached, and the general secrecy surrounding results, there is no proven oil reserve estimates for the Spratly and Paracel Islands to date. Attempts have led to political incidents and interruption of exploratory operations.[72]

Press coverage suggests an aggressive stance taken by China with respect to offshore oil and gas in the SCS.[73] China discovered 180 oil and gas fields in the SCS with depth between 500-2,000m according to the Director of the South China Institute of Oceanology of the Chinese Academy of Sciences[74] and the CNOOC project to start deep-water drilling in June 2011 CNY6 billion). This new deep-water drilling rig is 137m high, 30,000 tons and can work at depth of

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[66] World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010
[67] World offshore field development guide database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010
[68] Forecast is higher for the ASEAN Member States alone (without China and Taiwan) reaching 3.9% annually according to the Second ASEAN Energy Demand Outlook (2009), available online at http://www.energycommunity.org/documents/SecondASEANEnergyOutlook.pdf
[69] M.H.Nordquist, J.N.Moore and K.C.Fu (2005) The energy and security of china and oil and gas exploitation in the south china sea, in Recent developments in the law of the sea and China, Center for Oceans Law and Policy, by Koninklijke Brill NV, Leiden, The Netherlands
[70] See for instance the commonly referred to website Global Security, article titled 'South China Sea / Spratly islands', available online at http://www.globalsecurity.org/military/world/war/spratly.htm (last accessed on 6 June 2011)
[71] M.H.Nordquist, J.N.Moore and K.C.Fu (2005) Ibid
[72] A recent example is recounted in the oil and gas journal Upstream (7 March 2011): available online at http://www.upstreamonline.com/live/article244607.ece (last accessed on 21 March 2011)
[73] See for example, China steps up drilling, intimidation, by Michale Richardson, The Japan Times (1 June 2011), available online at http://search.japantimes.co.jp/print/eo20110601mr.html (last accessed on 1 June 2011) or China aims to more than triple its oil and gas production in the SCS over the next 10 years, by G.C.Collins and A.Erickson, China SignPost (3 April 2011), available online at http://www.chinasignpost.com/2011/04/china-aims-to-more-than-triple-its-oil-gas-production-in-the-south-china-sea-over-the-next-10-years/
[74] China discovers 180 oil and gas fields in South China Sea, expert, in Trading Markets, 25 June 2010, http://www.tradingmarkets.com/news/stock-alert/ceo_china-discovers-180-oil-and-gas-fields-in-south-china-sea-expert-1005599.html (last accessed on 21 March 2011)

3000m[75]. Current drillings tend to be now deeper as development progressively moves further from shore to new reserves.

3 Disputed oil and gas fields

Competing needs for hydrocarbon resources in the SCS are acting as a catalyst for tension and security incidents in the context of overlapping maritime claims in the SCS. The occurrence of such incidents can carry high political, financial and human risks and has so far limited exploration and development in areas subject to overlapping claims, except on their outskirts.

3.1 Outline of boundary disputes in the SCS

Overlapping maritime claims in the SCS are not a new topic. They have evolved with the history of the region, especially in the waves of foreign occupations and colonialism in the XIXth and early XXth century. The current claims (Maps 1 and 2 below) arose after the second world war and the 1951 San Francisco Treaty.[76] Despite the fact that the resources of the South China are now so critical that they make a solution desirable, a solution is yet to be found. Many see the 2002 Declaration on the Conduct of Parties in the South China Sea adopted between China and the ASEAN Member States[77] as the beginning of a new promising phase in the boundaries discussions based on the idea that it would signify an acceptance of multilateral negotiations.[78] This was further strengthened in 2003 by China signing the ASEAN 1976 Treaty of Amity and Cooperation[79], which includes the commitment not to engage in threatening activities and to resolve disputes peacefully.

UNCLOS grants coastal States sovereign and exclusive rights for the exploration and exploitation of all natural (living and mineral) resources[80] in and under the continental shelf located up to 200nm (off their coast or the limit of their archipelagic waters[81]) or up the edge of the continental shelf if it extends further, up to 350nm maximum.[82] However, the proximity of the coastal States, the size of the semi-enclosed seas of Southeast Asia and sovereignty disputes over the Spratlys area~~s~~ results in overlapping claims in much of the SCS. The Spratlys were claimed by China on several grounds including one of historic rights over this area but China's recent *Note Verbale* filed on 14 April 2011 with the UN suggests that the argument might have shifted to apply UNCLOS.[83] The Spratly~~s~~ Islands area is also claimed by 6 other States on

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[75] Trading Markets, 18 February 2011, CNOOC to start offshore oil 981 in June
[76]For the history of the successive claims and political incidents relating to maritime boundaries in the South China Sea: L. Buszynski and I. Sazlan (2007) Maritime claims and energy cooperation in the South China Sea, Contemporary Southeast Asia: A journal of international and strategic affairs, Vol.29 #1: 143-171 and Vivian Louis Forbes, Conflicts and cooperation in managing maritime space in semi-enclosed seas (Singapore: Singapore University Press, 2001).
[77] Available online at http://cil.nus.edu.sg/2002/2002-declaration-on-the-conduct-of-parties-in-the-south-china-sea-signed-on-4-november-2002-in-phnom-penh-cambodia-by-the-foreign-ministers/
[78] For instance L.Buszynski and I.Sazlan, Ibid.
[79] http://www.asean.org/1217.htm
[80] Article 77 UNCLOS
[81] Article 76 (1) UNCLOS requires that the distance of 200nm be calculated from the baselines from which the breadth of the territorial sea is measured, as defined in Part II, Section 2 on the limits of the territorial sea and Part IV, Article 47 on archipelagic baselines.
[82] As provided for in Article 76 (4) and (5) UNCLOS
[83] The *Notes verbales* from China and the Philippines in response to the joint submission from Vietnam and Malaysia is available at
http://www.un.org/Depts/los/clcs_new/submissions_files/mysvnm33_09/chn_2011_re_phl_e.pdf

various grounds including that of sovereignty over some of the islands. The two key questions are (i) the determination of sovereignty over features located in the Spratlys area, and; (ii) the determination of conditions required for claimed features to be considered as "islands" according to Part VIII of UNCLOS relating to the regime of islands and therefore awarded a territorial sea and an exclusive economic zone This will include the interpretation of Article 121 (3) according to which 'Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf'.

Article 83 of UNCLOS mandates States with opposite and adjacent coasts to agree on the delimitation of their respective continental shelf. Where no agreement can be reached, States can resort to the dispute resolution mechanism provided for in the Convention. However, China opted out of this provision when ratifying UNCLOS and it is thus not an option for the SCS, as a solution cannot be envisaged without China. Pending a solution, States 'shall make every effort to enter into provisional arrangements of a practical nature'[84]. This provision is seen as providing the legal basis for Joint-Development Agreements (JDAs) for exploration and production of hydrocarbons, pending a solution on the dispute. JDAs can also be entered into for areas located over an agreed boundary where coastal States choose to proceed in this way, for instance to avoid disputes over hydrocarbon reservoirs straddling a boundary line.

Whilst some area which are the subject of overlapping maritime boundary claims are being managed by JDAs, many areas are not, notably around the Spratly Islands (some parts of which are claimed by Vietnam, Indonesia, Malaysia, Brunei, Philippines, China and Taiwan). Overlapping claims involve different parties depending on the location concerned in the Spratlys area. Islands, rocks and reefs are still occupied by military forces of five of the claimants in what looks like a 'quilt like pattern' and occasional military incidents arise regularly.[85] The difficulties in reaching agreements for exploration and production until now led to a temporary status quo where coastal States have mostly refrained from exploiting much of the resources, whilst continuing with exploration and production of fields located on the outskirts of the disputed area or in areas which are only slightly overlapping. The Indonesian Natuna oil and gas field is a typical example. However, this so far acceptable 'leaking' status quo relies on the assumption that parties will avoid a conflict judged too costly, both economically and politically. It can become unstable and risky if the relationship between the parties change and the balance upset, as a result, for instance, of increasing national needs or a change in the regional paradigm.[86] Furthermore, there is a strong argument that the existence of overlapping claims on any part of a continental shelf bars the claimants from drilling wells and taking any actions that would create a permanent change in the marine environment, whether for exploration or production.[87]

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[84] Article 83 (3) UNCLOS

[85] M.J. Valencia and J.M. Van Dyke (1998) Comprehensive solutions to the South China Sea disputes: Some options in boundaries and energy: Problems and prospects, G.H. Blake, M.A. Pratt, C.H. Schofield, eds: 90 411 0690 1: Kluwer Law International; printed in Great Britain

[86] Ibid, notes 6 and 7 above

[87] This is the position taken by the arbitral award rendered in the Guyana-Surinam international arbitration case, on the basis of Article 83(3) UNCLOS. The arbitrators took the view that the duty of claimants to make every effort…not to jeopardise or hamper the reaching of the final agreement would preclude the unilateral conduct of activities that cause a permanent physical change of the marine environment. Whilst unilateral seismic surveying would be allowed, drilling would not be. The unilateral installation of fixed platforms on the seabed would not be a permissible act either under this construction of Article 83(3) of the UNCLOS. Refer to the ~~a~~rbitral award rendered on 17 September 2007, in the Case between Guyana and Suriname, para.466 to 468 available online at http://www.pca-cpa.org/upload/files/Guyana-Suriname Award.pdf (last accessed on 21 July 2011)

3.2 Interference with offshore oil and gas exploration and development [88]

3.2.1 The Spratlys area, including the Reed Bank

The area located on the western outskirt of the Spratlys and is the subject of an on-going dispute between Vietnam and China is discussed in the next section.

Surveys carried out in the eastern part of the Spratlys revealed that the Reed Bank might be very rich in natural gas reserves. The Sampaguita gas field claimed by the Philippines as a result of this is expected to hold more than Malampaya gas field, located Southwest of it.[89] Despite a military incident in March 2011, showing the failure of the letter of intent signed in 2003 between China Offshore Oil Company (COOC) and the Philippine National Oil Company for joint exploration and agreement to establish a program to "review, assess and evaluate relevant geographical, geophysical and other technical data available to determine oil and gas potential in the area". The Philippines recently reiterated its intention to develop the Sampaguita gas reserves.[90] Out of the 15 new exploration blocks put up for tender, 2 would be also located within the boundary traced by China's dotted line.[91]

3.2.2 West SCS, off Vietnam

In 1992, China granted the Wan'an Bei 21 block (a.k.a. WAB 21) off Vietnam to Crestone Energy Corporation, a US oil and gas company. The difficulties this created with Vietnam led Crestone Energy Corporation to flee. Harvest Natural Resources replaced them in 1996. The WAB 21 block, which is located within 200nm of Vietnam's baseline, overlaps with concessions granted by Vietnam. Talisman Energy is jointly exploring blocks 133 and 134 with its partner Petrovietnam [92]while Exxon Mobil has been granted the 3 blocks located east of these, which

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[88] A strategic location, overlapping claims on the Scarborough Reef are for the moment not concerned with oil and gas activities, but fisheries and location. Biggest atoll in the SCS, it is located 170nm east of Macclesfield Bank and 115nm off west Luzon island. However, most of it is submerged, with less than 2m above water at high tide, for the biggest island (according to K.Zou referring to Chinese books in Law of Sea in East Asia: Issues and prospects, chapter 4 Dispute over the Scarborough Reef, note 1). Abundant marine living resources are the target of Chinese and Filipino traditional fishing. Newspapers articles reported in 1997 that approximately 300 ships pass in the vicinity of the reef daily at the time and that Japan uses this route to transport 80% of its petroleum from the Middle-East (K. Zou, Law of the sea in East Asia, issues and prospects, Routledges Studies in International Law, 2005 ISBN 0-415-35074-3).

[89] Outlook Forum Energy, Edison Investment Research (14 April 2010), available online at http://www.forumenergyplc.com/DocumentLibrary/ForumOutlook140410.pdf (last accessed on 15 July 2011)

[90] On 2 March 2011, the Philippines sent 2 military observation planes in response to reports of harassment from Chinese patrol boats, which allegedly threatened to ram the Research Vessel M/V Venture if it continued seismic survey in the Reed Bank area. See for instance on this, China warns against South China Sea oil exploration, Rigzone website, Dow Jones Newswire, Thursday 24 March 2011, available online at http://www.rigzone.com/news/article.asp?a_id=105427 (last accessed on 29 March 2011) or Philippines halts tests after China patrol challenge, available on BBC news at http://www.bbc.co.uk/news/world-asia-pacific-12672889 (last accessed on 29 March 2011)

[91] Philippines to test South China Sea agreement, by Daniel Ten Kate, 25 July 2011 in Bloomberg, available online at http://www.bloomberg.com/news/2011-07-24/clinton-calls-for-global-response-to-rising-s-china-sea-risks.html (last accessed 25 July 2011)

[92] Investor open house, May 2010, Southeast Asia Operations, Talisman Energy, available online at http://www.talisman-energy.com/upload/oh_presentation/19/02/southeast_asia_operations.pdf (last accessed on 15 July 2011) or Annual information form for the year ended December 31, 2010, February 28, 2011, Talisman

include the most part of WAB 21. While Talisman is currently exploring with Petrovietnam, Harvest Natural Resources[93] appears to be waiting for some solution to the overlapping claims prior to proceeding.[94] Exxon's position is unknown at this stage. Different corporations adopt a different position on the maritime disputes and risk taking.

Located on the outskirt of China's 9 dotted lines and within 200nm of Vietnam's baseline, off Da Nang, another concession has been the subject of public disagreement between Vietnam and China. Despite this, Exxon Mobil has confirmed its intention to start exploratory drilling in April 2011[95] in the same area. However, given the lack of indication in the press on the exact block(s) subject to China's claim 'off Da Nang', the oil and gas company concerned remains unclear.[96] Generally the lack of clear arguments and understanding of respective claims also compromise useful negotiations.

To be also noted is the cutting, on 26 May 2011, of exploration cables of Petrovietnam exploration vessel Binh Minh 02, by sailors on a Chinese patrol vessel. The Binh Mihn ship is reported to have been conducting seismic surveys 120 nm off Vietnam's coast (off Dai Lanh Cape in the central province of Phu Yen) on block 148 at the time of the incident.[97] This area is located over 300km south of the Da Nang exploration reported above. In the aftermath of this incident, Vietnam announced the increase in capability of Dai Hung platforms and installations in September 2011. This field, also called Big Bear, seems to have been the subject of dissensions with China in the past.[98] Future developments are likely to be linked to the fate of current negotiations on maritime boundaries and recent incidents such as those off Da Nang and Dai Lanh Cape as well as possibly current negotiations between China and the Philippines over the Sampaguita gas field.

Many other exploratory drilling or production sites are located within China's dotted line and the oil and gas industry is accustomed to disturbances in their prospection or development. One example is that of the blocks granted to SiberGas, a Russian Oil and Gas company. It reports that in October 2008 it entered into a 30 year contract with Petrovietnam for exploration, development, production, and sales of petroleum products from blocks № 129, 130, 131, and 132.[99] While these blocks are located less than 200nm off Vietnam coast, they are within China's claimed U shape line. Information on these concessions and related incidents is generally not publicly available.

Energy, available online at http://www.talisman-energy.com/upload/editor/File/Annual Information Form.PDF (last accessed on July 15 2011)

[93] Website of Harvest Natural Resources: http://www.harvestnr.com/operations/china.html

[94] South China Sea oil rush risks clashes as U.S. bolsters Vietnam, Daniel Ten Kate, Bloomberg Businessweek May 27, 2011, available at http://www.globalsecurity.org/org/news/2011/110527-south-china-sea.htm (last accessed on 15 July 2011)

[95] http://vietnamnews.vnagency.com.vn/Economy/209863/ExxonMobil-to-start-exploration.html

[96] China: Vietnam's oil exploration 'violates consensus', 31 May 2011, in Oil and Gas Eurasia, available online at http://www.oilandgaseurasia.com/news/p/0/news/11483 (last accessed on 31 May 2011)

[97] Binh Minh ship – another CGX case in East Sea?, by Nguyen Dang Thang, Vietnam net (31 May 2011) available online at http://english.vietnamnet.vn/en/special-report/8943/binh-minh-ship---another-cgx-case-in-east-sea-.html (last accessed on 1 June 2011)

[98] Vietnam to boost Dai Hung output, Upstreamonline (News wire 30 May 2011) available online at http://www.upstreamonline.com/live/article258897.ece?WT.mc_id=rechargenews_rss (last accessed on 1 June 2011)

[99] Information available on SiberGas website at http://sibergas.com/reserves_of_oil_and_gashtml.html (last accessed on 1 June 2011).

3.2.3 Paracel Islands

Vietnam and China have overlapping claims over the Paracel Islands. While no oil and gas reserves are reported in this area at this stage, large quantities of gas hydrates have been reported (refer section 2.1 above).[100] Current conflicts are triggered by fisheries activities.

3.2.4 Sulu-Celebes Sea

In 2002, the International Court of Justice determined that the Sipandan and Litigan islands (South of Sabah) are under Malaysian sovereignty.[101] While this decision does not solve the overlapping claims of Indonesia and Malaysia on the Ambalat block located south of these islands, it pushed the Malaysian boundary southward, prompted Indonesia to review its baselines and in that way strengthened Malaysia's overlapping claim on the Ambalat. The presence of oil in the Ambalat area has led to minor military clashes in 2009 between Indonesia and Malaysia. The countries have since tried to settle the dispute and agreed for joint military exercises in order to avoid clashes. However, the overlapping claims remain unresolved.[102] Indonesia's intentions to start exploratory drillings nevertheless might have been frustrated as there has been no recent public coverage.[103]

4. Areas under joint exploration and/or development

There exists a large and diverse number of development agreements between states or oil and gas companies aimed at exploring and/or producing hydrocarbon resources in areas subject to conflicting territorial claims. They range from short agreements geographically bound and limited in use and time, such as joint seismic surveying for a given time and space, to ambitious agreements including boundary setting and joint-development of the resources under set rules. These should not be confused with joint-exploration or joint-development by several national oil companies in an area which is not the subject of overlapping claims. Cooperation in such situations consists in agreements between commercial partners. Joint Development Agreements signed between national oil companies seem to be especially successful due to the flexibility they allow. However, the wording and modalities are generally not available for public scrutiny. The map of cooperation agreements signed to date can be divided between that of the Gulf of Thailand, the Gulf of Tonkin and the Southern South China Sea.

4.1 The Gulf of Thailand

Five distinct continental shelf boundaries between the four coastal States are encompassed in the Gulf of Thailand, namely between Thailand and Malaysia, Thailand and Vietnam, Thailand and Cambodia, Vietnam and Malaysia and Cambodia and Vietnam. Independent agreements have been signed for each, sometime even several for each boundary. Agreements include partial or complete determination of the boundaries and/or a joint exploitation regime for

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[100] SS Fan and JY Wang (2006) Progress of gas hydrate studies in China, The Chinese Journal of Process Engineering, Vol.6 No.6: 997-1003, available online at http://www.jproeng.com/qikan/manage/wenzhang/205280.pdf (last accessed on 26 May 2011)
[101] Judgement of 17 December 2002, Case concerning sovereignty over Pulau Litigan and Pulau Sipadan (Indonesia/ Malaysia), available online at http://www.icj-cij.org/docket/index.php?p1=3&k=df&case=102&code=inma&p3=4 (last accessed on 3 June 2011)

[102] http://www.tempo.co.id/hg/nasional/2009/06/02/brk,20090602-179380,uk.html
[103] http://www.thejakartaglobe.com/business/minister-stands-firm-on-keeping-eni-in-ambalat/311791

hydrocarbons located in the overlapping claim area. Malaysia signed 2 Joint-Development Agreements (JDA) with Thailand and Vietnam respectively, but agreements reached by Cambodia with the same two countries, Thailand and Vietnam are only 'in principle' agreements to jointly develop hydrocarbon resources.

Malaysia and Thailand first agreed on a Memorandum of Understanding (MoU) in 1979[104], though implementations took longer to negotiate and instruments of ratifications were only exchanged on 30 May 1990. The MoU[105], which is valid for 50 years or indefinitely if no agreement is reached on boundaries, creates a Joint Authority[106] and extends beyond hydrocarbons exploration and exploitation in recognizing the rights of both countries in relation to fishing, navigation, hydrographic and oceanographic surveys and to the prevention of pollution in the overlapping area.[107] The principle of cumulative application of national laws provided for in the MoU for a 'Joint Development Area' could technically also apply to pollution and obligation of conservation attached to the rights dealt with the MoU. However, the countries intentions and plan of action cannot be extrapolated from the text of the agreement. It should be noted that the countries agreed a criminal jurisdiction line.

In contrast the 1992 Malaysia-Viet Nam MoU, which deals with a smaller overlapping area (the 'Defined Area') and is limited to joint exploration for and development of hydrocarbons, uses a different and arguably more pragmatic and flexible management model where national oil and gas companies are the primary actors. The first exploitation under the agreement came as early as July 1997 from the Bunga Kekwa field. In a commercial arrangement signed in 1993, Petronas and Petrovietnam (with agreement of the respective governments) established a Coordination Committee composed of 8 members equally composed of members nominated by each of them and in charge of decisions for the management of the Defined Area. They also agreed on the application of the laws of Malaysia to the Defined Area for petroleum operations. As in the MoU between Malaysia and Thailand, sharing of all costs, expenses, liabilities and benefits from petroleum operations are key principles. While the 1990 agreement between Malaysia and Thailand is generally viewed as an especially successful example of a comprehensive joint-development agreement, the dynamism in implementation of the 1992 MoU between Malaysia and Vietnam deserves particular attention. Unlike the 1979 MoU, it has been very quickly implemented. The behind the scenes involvement of Petronas and Petrovietnam in the 1992 MoU might explain this dynamism in implementation as well as the 2000 tripartite arrangement (extending this relationship to Pertamina) reviewed below.

The 2001 Cambodia-Thailand MoU sets the basis for a joint utilization regime but it was denounced by the Thai government in 2009[108]. The initial MoU only included agreements in principle to define a joint development area and delimiting the two contiguous territorial seas.

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[104] The first agreement signed in 1972 was only partial as the countries could not agree on the application of delimitation rules over the islet of Ko Los, a Thai islet standing 1.5meters high above sea level and supporting no economic life of its own. Nguyen Hong Thao (1999) Joint development in the Gulf of Thailand, IBRU Boundary and Security Bulletin Autumn: 79-88 Available online at http://www.dur.ac.uk/resources/ibru/publications/full/bsb7-3_thao.pdf (last accessed on 8 April 2011).
[105] Text in J.I. Charney and L.M. Alexander, International maritime boundaries (Dordrecht: Martinus Nijhoff Publishers, 1993) Vol1: 1099-1123
[106] The chairmanship of the Authority alternates between the 2 countries every 2 years.
[107] Nguyen Hong Thao (1999) Ibid
[108] 2009 developments in Khmer press: Move to ditch maritime MoU short-sighted, in The Nation, published on November 2009, available online at http://www.nationmultimedia.com/2009/11/09/politics/politics_30116161.php (last accessed on 8 April 2011)

While Cambodia has been granting oil and gas concessions for some time, exploitation is only just starting.

The 1982 Cambodia – Vietnam agreement on Historic Waters of Vietnam and Kamputchea consists in the designation of an area jointly claimed as historic waters and includes a provision for joint development.[109]

Thailand and Vietnam reached agreement on 9 August 1997 for the delimitation of their respective continental shelf and exclusive economic zone in the Gulf of Thailand, but no JDA nor agreement in principle was reached.

4.2 The Gulf of Tonkin (or Gulf of Beibu)
The 2000 Agreements on Maritime Boundary Delimitation and on Fisheries Resources signed by China and Vietnam**[110]** set the basis for the 2005 Framework Agreement on Oil and Gas Cooperation between CNOOC and Petro Vietnam. However, it is unclear to what extent the latter agreement have been implemented as press articles report up-coming, rather than on-going, joint-exploration efforts[111], despite further announcement in 2006 to undertake more efforts for exploration in the Gulf of Tonkin[112].

Despite these developments, the area located south of the boundary delimitation, on the outskirts of the Gulf, is subject to strong tensions as shown by the recent dispute over exploratory drilling in an offshore field located off Da Nang.[113]

4.3 The Southern SCS
Following the signature of a Tripartite Cooperation Agreement in November 2000, Petrovietnam, Petronas and Pertamina entered into production sharing contracts both in areas subject to overlapping claims and areas which are not.[114] Other joint development areas would be considered and this successful collaboration is said to be paving the way for a new era of intra ASEAN knowledge and information sharing designed to upgrade skills and expertise.[115]

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[109] For more details on this agreement and others in the Gulf of Thailand, refer to Clive Schofield (2007) Unlocking the ~~S~~seabed resources of the Gulf of Thailand, Contemporary Southeast Asia 29(2): 286
[110] Zou Keyuan, Cooperative development of oil and gas resources in the South China Sea
[111] For instance, Xu Yihe, Duo steps up efforts, Upstream online, 28 March 2008.
[112] In a joint-press statement issued after the visit of Vietnam's Communist Party leader to Beijing on 24 August 2006, reported in Y.H. Song (2008) The potential of 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 and International Law 39: 162
[113] Vietnam: ExxonMobil to drill in South China Sea Block 119, energy-pedia news (from AFP), 1 April 2011, available online at http://www.energy-pedia.com/article.aspx?articleid=144823 and Vietnam, China vow to work on disputed sea pact, 21 April 2011 available online http://www.energy-daily.com/reports/Vietnam_China_vow_to_work_on_disputed_sea_pact_999.html, and Exxon Mobil to drill off Vietnam, Institute of Southeast Asia Studies, 31 March 2011 http://web1.iseas.edu.sg/?p=2983
[114] Blocks that are not subject to overlapping claims seem to also fit within the scope of this framework agreement: in 2001 over Blocks 10 and 11.1 located off Vietnam and later in 2003 over block SK305 off Serawak. Petrovietnam, Petronas, Pertamina to explore two blocks off Vietnam, by Robert Piepul, 9 January 2001, PennEnergy, http://www.pennenergy.com/index/petroleum/display/131688/articles/oil-gas-journal/exploration-development/petrovietnam-petronas-pertamina-to-explore-two-blocks-off-viet-nam.html and http://rigzone.com/news/article.asp?a_id=7027 (last accessed on 7 April 2011)
[115] For more recent news coverage: http://www.ethiopianreview.com/news/48192 (last accessed on 7 April 2011)

Following long negotiations, Brunei and Malaysia proceeded to an exchange of letters on 16 March 2009 recognizing Brunei's sovereign rights over disputed blocks L and M (according to Malaysia, blocks K and J for Brunei) located off Sabah (Map 5). These blocks have been since renamed CA2 and CA1. The terms of this exchange included also a 40-year Commercial Arrangement Area (CAA) Agreement over these blocks organising for joint exploration and exploitation.[116] This was implemented through the signing of two Deeds of Agreement for a Production Sharing Agreement (PSA) between Petronas and PetroleumBRUNEI respectively on 22 September 2010 for CA1 and 13 December 2010 for CA2 these blocks.[117] CA1 and CA2 each cover an area of around 5,000km^2 with depth ranging from 1000 to 2720m. The oil and gas companies having an interest in the PSAs include Petronas, Total, BHP Bilton (for CA1) and Shell Deepwater Borneo, Mitsubishi, ConocoPhillips, Murphy Oil (for CA2).[118]

The three years tripartite Agreement for Joint Marine Seismic Undertaking (JMSU) in the Agreement Area (part of the Spratly Islands area) signed on 14 March 2005 between CNOOC, PNOC and Petrovietnam appears to have been less successful, based on: (i) 2009 press coverage announcing the intention to abandon development plans for the area[119] and the alleged corruption scandal surrounding the signature of the JMSU in the Philippines[120]; (ii) the current tensions over the Reed Bank; and (iii) more generally over Vietnam exploration and development off Da Nang and off Dai Lanh Cape (refer to section 3.2 above). However, it has to be noted that this new period of tension follows a few years of discussions (2005-2008) presented in the media as in academic journals as a constructive period where coastal States were willing to put aside their disputes and embrace joint-development of the hydrocarbon potential.

The common element in the joint development arrangements summarized above is that they are temporary solutions to allow for oil and gas exploration and/or extraction despite overlapping claims on the continental shelf.[121] Sustainable exploration and extraction and management of pollution of the seabed from oil and gas activities are not built in the agreements nor implied. This is quite a natural situation when considering that these concerns are recent, compared with the date the MoUs were negotiated. Compared with the Gulf of Mexico, the North Sea, the Baltic Sea or the Persian Gulf, hydrocarbon activities in the SCS are still at an early stage. While Malaysia's petroleum legislation, built up over years, is today one of the most sophisticated in the region, national legislations are often still rudimentary and

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[116] Brunei has sovereign rights over 2 oil-rich areas: Wisma Putra, The Star online 3 May 2010, available at http://thestar.com.my/news/story.asp?sec=nation&file=/2010/5/3/nation/20100503123605 (last accessed on 15 July 2011)
[117] Deals sorted, good year for oil and gas, by Goh De No, Brunei Times, 25 December 2011, available at http://www.bt.com.bn/business-national/2010/12/25/deals-sorted-good-year-oil-gas (last accessed on 15 July 2011)
[118] Y.H. Song (2008) The potential of 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 and International Law 39: 150-177
[119] Philippines: Spratlys oil exploration deal on hold, energy-pedia news, 1 January 2009, available online at http://www.energy-pedia.com/article.aspx?articleid=133302 (last accessed on 3 June 2011)
[120] China's claim over the Reed Bank is viewed in the Philippines has a result of the JMSU, which contributes to a negative perception of the JMSU. JDV and GMA should answer for selling out the country to China, Ellen Tordersillas, 16 June 2011 http://www.ellentordesillas.com/?p=16550 (last accessed 5 July 2011)
[121] Note that this comment concerns primarily the agreements between Malaysia and Thailand, Malaysia and Vietnam and Brunei and Malaysia. It does not apply to agreements reached over areas stretching over delimited boundaries or based on delimited boundaries, namely the CAA between Malaysia and Brunei and the agreement between China and Vietnam for the Gulf of Tonkin.

currently being drafted and completed. The level of development of Malaysian petroleum legislation compared with Vietnam's was one of pragmatic reasons why Vietnam agreed to the application of Malaysian law to the Defined Area.

5. Environmental impacts from oil and gas activities

This section focuses first on the findings of the investigations on known and reported potential and actual impacts from offshore oil and gas in the SCS. Given a general lack of available data, it subsequently reviews potential environmental impacts at different stages of offshore exploration and exploitation of oil and gas resources in general, prior to reviewing potential impacts and their relevance in the region.

5.1 Current reporting

With regard to offshore oil and gas activities, reporting on environmental impacts can originate from a diversity of stakeholders: the industry itself, national public agencies, groups of interests, NGOs, journalists and others. Issues brought to the attention of the public include accidental well blowouts, accidental leakage or spills and the need for decommissioning of oil and gas platforms after extraction has been completed. Interestingly, very few blowouts and spills could be found when investigating public media, industry journals and research journals. The blowout of the drillship Petromar V in 1981 is the only blow out reported.[122] Some oil spills are also occasionally reported. Recent and substantial oil spill events occurred in the north part of the Yellow Sea in June 2010 and, further south, in the East China Sea, in June 2011. They are worth mentioning despite their location north of the SCS. The first one occurred after the explosion of a pipeline in the oil terminal of the port of Dalian[123]. This explosion triggered the rupture of a second pipeline, a crude oil spill and a fire which destroyed a 90,000 tons capacity oil tank. The percentage of oil recovery and the extent of the environmental impact after the large cleaning effort was completed are the subject of a debate between the authorities, the industry, the ecologists, fisheries and other stakeholders. The following characteristics of the June 2011 oil spills in the East China Sea are also worth noting: (i) the potential extent of the environmental impact; (ii) the fact that several spills occurred consecutively[124] (the first two at the Penglai 19-3 oilfield was followed by a third one, apparently smaller, at the Suizhong 36-1 oilfield, another large deepwater field); (iii) the joint CNOOC-ConocoPhillips China management of the Penglai field[125] (ConocoPhillips is also an important operator in the SCS); (iv) media criticism of lack of transparency evidenced by the discrepancy between CNOOC's reporting of 200m^2 as opposed to local press and environmentalists now reporting that water quality would be affected in an area of 3,400km^2, while they were referring earlier to an 'oil belt'

[122] The drillship would have encountered an uncontrolled sub-sea blowout which caused the capsize of the drill-ship. Offshore drilling accident; Oil rig disasters: http://home.versatel.nl/the_sims/rig/petromar5.htm (last accessed on 20 April 2011)

[123] Examples of the Chinese press coverage from the xinhua network include Getting the sea back, on 3 August 2010 available at http://news.xinhuanet.com/english2010/indepth/2010-08/03/c_13427452.htm (last accessed on 25 July 2011). For a discussion on this accident: Crying over spilt milk: responses to oil spills in East Asia, NTS Alert October 2010, a publication of the Centre for Non-Traditional Security Studies of the S. Rajaratnam School of International Studies, available online at http://www.rsis.edu.sg/nts/HTML-Newsletter/alert/NTS-alert-oct-1002.html (last accessed on 25 July 2011). For an environmentalist view: Greenpeace says Chinese oil spill much bigger than reported, Voice of America, 30 July 2010, available online at http://www.voanews.com/english/news/asia/Greenpeace-Says-Chinese-Oil-Spill-Much-Bigger-Than-Reported-99626134.html (last accessed on 25 July 2011)

[124] CNOOC's new oil spill in Bohai Bay, Zhou Yan and Wan Qian, China Daily, 13 July 2011, available online at http://www.chinadaily.com.cn/bizchina/2011-07/13/content_12891346.htm (last accessed on 25 July 2011)

[125] ConocoPhillips China is the operator.

around 3km long and 30m wide[126]; and (v) the unexpected source of the three leaks[127].These leaks are reported as triggering amendments in the operating practices in the oil fields concerned and in the platform spill response planning[128]. However, these spills can provide a useful guide in the assessment of the risks from current practices in the SCS given the commonalities between operators, conditions and possibly practices. Given the sensitivity of the marine environment surrounding some of the oil fields located in the SCS, prevention of serious risks would be preferable. However, the sources of the oil spills noticed to date in the SCS are generally undetermined[129]. Conversely, there is very little literature considering the environmental impact from the oil and gas industry outside the industry itself. S.Kloff and C.Wicks report that in 2004, a medium-sized oil spill washed ashore Kalimantan's shoreline covering the coastline and aerial roots of the mangrove forest in oil. But none of the oil companies active off the coast volunteered nor accepted responsibility.[130] The research found is either industry or engineering driven, and focuses on processes and procedures in place or desirable or it is natural science driven (physical, chemical, geological or biological oceanography), focusing on very specific issues in a specific location, such as the impact of drill cutting in the North Sea[131]. The analysis below relies on this literature to present a comprehensive picture of potential environmental impacts from the oil and gas industry in the SCS, prior to considering the legal instruments available and the gaps to be filled.

Land-based pollution is currently the number one priority in the SCS. Given the semi-enclosed nature of this sea and limited renewal capacity through the straits and the large input in freshwater and discharges from many large rivers (including the Mekong and Red Rivers and the Pearl River), the relative importance of land-based pollution is simple to understand.[132] However, the proportion and quantification of pollution from the oil and gas industry is unclear. It is relevant to note in this context that pollution from oil and gas activities in the North Sea was estimated to account for 32% of overall marine pollution in 1995, whilst land-based pollution accounted for 50% and maritime traffic for 18%.[133] Furthermore, the extent of environmental impact depends on the location of the source and the relative sensitivity and importance of the ecosystems exposed. Finally, it should be noted that environmental impacts from offshore oil and gas activities are most likely to be greater where environmental

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[126] New oil spill reported in Bohai Bay, CNTV, 15 July 2011, available online at http://www.china.org.cn/video/2011-07/15/content_22996393.htm (last accessed on 27 July 2011).
[127] The first leak noticed on 4 June 2011 appears to have come from an unknown natural fault of a rare kind in this field and possibly linked to water injection in oil reservoirs. The third one, which came from a field operated by CNOOC, would be due to a malfunction at the central control system (CNOOC's report on a statement from the field's operator).
[128] China orders offshore oil risks review after the spill, Nogtec Oil and Gas News, 8 July 2011, available online at http://www.nogtec.com/headlines/china-orders-offshore-oil-risks-review-after-spill/ (last accessed on 27 July 2011) and CNOOC updates Bohai Bay platform spill response, 6 July 2011, World Oil Online, available at http://www.worldoil.com/CNOOC_updates_Bohai_Bay_platform_spill_response.html (last accessed on 25 July 2011)
[129] http://www.unepscs.org/forum/f-vietnam-oil-spill-18/t-the-vietnam-oil-spill-15.html
[130] S.Kloff and C.Wicks (2004) and J.Wills (2000) Muddied waters: A survey of offshore oilfield drilling wastes and disposal techniques to reduce the ecological impact of sea dumping, for Ekologicheskaya Vahkta Sakhalina (Sakhalin Environment Watch), available online at http://www.alaskaforum.org/other/muddiedwaters.pdf (last accessed on 18 April 2011)
[131] F.Olsgard and J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf, Marine Ecology Progress Series 122: 277-306 and A.Grant and A.D.Briggs (2002) Toxicity of sediments from around a North Sea oil platform: are metals or hydrocarbons responsible for ecological impacts?, Marine Environmental Research 53: 95-116
[132] UNEP (2007) Land-based pollution in the South China Sea, UNEP/GEF/SCS Technical Publication No10
[133] S.Kloff and C.Wicks (2004) Ibid

regulations are less stringent and seldom enforced.[134] In this context, a particular attention needs to be granted to the marine ecosystems of the SCS and all potential impacts from oil and gas activities need to be considered. Dismissing some as intuitively less relevant would challenge the reliability of the conclusion.

Analysis of storm tracks in East Asia in the context of climate change impact on the marine systems of the region suggests that while the southern part of the SCS is less exposed, the northern part of it would be subject to an increase in intensity and frequency of storms.[135] No report on the impact of this developing risk on the offshore oil and gas industry in the region was however found. Further research is advised to identify mechanisms in place or needed to ensure precautionary measures be taken by the industry to mitigate this risk along with other climate change induced risk (likely to harm the marine environment).

5.2 Stages in offshore oil and gas exploration and production and environmental risk sources attached

Offshore oil and gas activities over an area often unfold over 30 years or more from initial geophysical surveys designed to identify commercially viable reserves to the end of production and eventual decommissioning. The main stages can be described as: (i) geophysical surveys; (ii) appraisal drillings; (iii) development; and, (iv) decommissioning.[136]

5.2.1 Geophysical surveying

Pressure waves sent from survey vessels below the sea surface are measured (with trailed hydrophones, sometimes additional floating streamers or even a combination of those and geophones disposed on the seabed) to assess the subsurface and sediments geological structures and determine the location of potential reservoirs in areas previously identified. These operations generally involve two survey vessels for wave emission and recording and additional vessels to liaise with fishermen and avoid collision and interference with other vessels including fishermen and fishing gear. Seismic censors are sometimes fixed to the seabed to allow for repeated surveys over the same area needed for more detailed surveys. The timeline of geophysical surveying is extremely variable.

Environmental impacts at this stage are essentially linked to the interference between the sound waves and marine macrofauna, especially where they rely on echolocation. Physical disturbances from cables, floating censors or network of censors fixed to the seabed, pollution from vessel operations (atmospheric, waste, etc.), risks of collision and interferences with other users are also potential impacts.

5.2.2 Appraisal drillings and wellhead setting

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[134] S.Managi et al. (2005) Environmental regulations and technological change in the offshore oil and gas industry, Land Economics 81: 303-319

[135] P.Charlebois et al. (2010) Steering the course towards safer shipping and cleaner seas, Tropical Coasts, Vol.16 No2 Dec 2010: 35, available online at http://beta.pemsea.org/sites/default/files/tc_v16n2.pdf (last accessed on 19 April 2011)

[136] An overview of offshore oil and gas exploration and production activities (2001) United Kingdom Department of Trade and Industry; can be accessed online at http://www.offshorecenter.dk/log/bibliotek/SD_SEA2EandP%5B1%5D.pdf (last accessed on 19 April 2011), M.A. Rose (2009) The environmental impact of offshore oil drilling, The Technology Teacher, Feb: 27-32 and S.Kloff and C.Wicks (2004) Ibid.

Exploratory drilling is necessary to confirm surveys' results and determine eventual well location. Different structures are used according to the depth, geological and environmental condition as well as regulatory and operational constraints. Exploration wells are made from mobile drilling rigs, either jack-up rigs, tender rigs, semi-submersible rigs or drill ships. These mobile rigs are presented in Diagram 2 below. The first one is generally used up to a depth of maximum 100 to 150m. It rests on the legs lowered to the seabed after being towed to the desired location. Tender rigs, which are very popular in Southeast Asia, are a lighter structure completed by a floating barge or vessel. They are also used to develop marginal fields off fixed platforms because they offer a more economical solution. Semi-submersible and drill ships are maintained in place by anchors. Drilling duration is variable. It can take from one week to 5 months. Out of the 68 drillings currently reported in the region[137], 39 use jack up rigs mostly in a water depth of 100 to 120m. 12 of the drillings are occurring at 2000m depth or more. Data on distance of these drilling rigs from shore is however not available.

Once the rig is fixed in position, a well is commenced and steel casing is cemented into place to prevent the well from caving in. The well is then adorned with a wellhead (a.k.a. christmas tree). Depending on the amount of hydrocarbons found, the well is cleaned and tested, suspended or abandoned. In case of suspension or abandonment, the well is plugged with cement.
Drilling wastes from the drilling phase are hydrocarbon and additives contained in drilling fluids and contaminated produced water. Drilling muds (of specific compositions protected by fabrication secret), which assist in removing cuttings from the hole and cool the drill bit, get mixed with rock and sediment fragments to form the drill cuttings. The drill cuttings attached to the drill bit can be treated to separate the mud from the rocks and sediments. Cuttings are then often discharged into the sea underneath or adjacent to the platform. As much mud as possible is recovered for re-use, however some adheres to the cuttings and is also discharged. These discharges often accumulate into a 'drill cuttings pile'.[138] Oil, water and chemical-based drilling fluids also contain additives that are potentially harmful to the marine environment where they bio-accumulate. Contaminated produced water disposed off of the platform can also be source of substantial pollution, depending on the concentration of contaminants contained in the produced water (mostly oil). Production water consists primarily of relatively warm water from the oil/gas reservoir, containing dissolved and dispersed oils, high salt concentrations, heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs), no oxygen and on occasions naturally occurring radioactive material.[139] The concentration in oils and PAHs and other minerals tends to increase as older oilfields pass their peak production.

Well cleaning and testing generate waste generally disposed of or burned. Treatment depends on applicable standards. Other environmental impacts include atmospheric emissions from other activities on and around the platforms, underwater noise and physical presence and disturbance of the seabed, waste from the platform and surrounding vessels as well as risk of collision and chemical spills.

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[137] Industry data from drill zone as at 21 February 2011. This figure includes drillings, whether exploratory or for development but not wells in production. Inland swam drillings are also included (5 out of 68, all in Indonesia).
[138] S.Gerrard, A.Grant, R.Marsh and C.London (1999) Drill cuttings piles in the North Sea: Management options during platform decommissioning, Centre for Environmental Risk, Research Report No 31, School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, ISBN 1 873933 11 8 available online at http://www.uea.ac.uk/~e130/cuttings.pdf
[139] S.Kloff and C.Wicks (2004) Ibid and J.Wills (2000) Muddied waters: a survey of offshore oilfield drilling wastes and disposal techniques to reduce the ecological impact of sea dumping, for Ekologicheskaya Vahkta Sakhalina (Sakhalin Environment Watch), available online at http://www.alaskaforum.org/other/muddiedwaters.pdf (last accessed on 25 April 2011)

5.2.3 Development for production and export and production
The decision to develop the field and contracting for a rig often takes 2 to 3 years. Development is a staged process starting with a substantial preparation time prior to the construction work offshore, including concept and detailed design, procurement and where applicable Environmental Impact Assessments. Field development generally involves additional development wells to be drilled for production, the number of which depends on nature and size of the reservoir. Injection wells (for water and gas) and disposal wells (for cuttings, produced water or gas) can also be drilled, along with production wells. For example, over 40 wells have been drilled on the Natuna field (refer to Diagram 1 and Table 1 and developments under section 2.2 above for further details on platform types). Storage of produced oil is a key part of the production phase. Pollution risks from flaring, oil spills and collision are also greater during this phase.

In the SCS, a growing national and transboundary network of gas pipelines brings gas production to shore, while oil is still mostly transported by tankers, which requires storage and offloading facilities on site (Map 4). Long pipelines are made of sections of steel welded together and positioned by anchored barges progressing along the pipeline route relying on 12 anchors redeployed in sequence by anchor handler vessels. Disturbances to the seabed depend on many factors including anchor type, size and weight, nature of the seabed sediments, crew skill, weather and sea condition and equipment. Dynamically positioned vessels can also be used to maintain the barge in position and they have the advantage of not getting in contact with the seabed although they generally generate more underwater noise. In Vietnam alone, several new 400km gas pipelines are planned[140]. The increasing demand for hydrocarbons in the region translates to development of the downstream infrastructure (export, terminals, refineries, etc).

Environmental impacts attached to the development and production stages can be grouped as follows:
- atmospheric emission (from gas venting and flaring, combustion for power generation, terminals, aircraft and vessels operations);
- discharges into sea (produced water, oily drainage, deck drainage and washing for construction, antifouling protection from construction vessels, chemicals for well maintenance and repair, injected chemicals and other wastes);
- physical disturbance, light and noise
- accidental collisions and spills

This grouping does not reflect the relative likelihood and importance of potential environmental impact in the two distinct stages of development and production, which requires site specific analysis to be accurate. It will however be useful in the context of identification of relevant regulation.

5.2.4 Platform abandonment and decommissioning
A platform's economic production life lasts from less than 10 to more than 25 years. Once production is terminated, the well(s) is (are) plugged and removal of the platform and connected structures has to be considered due to its interference with safety of navigation and

[140] From the Cuu Long Basin to south Vietnam, from the Nam Con Son Basin, offshore the southwest coast to the coast, from the Bạch Ho and Rang Dong oil fields

the potential environmental hazard it creates. The high cost of decommissioning/abandonment[141] and removal of offshore structures or installations (including considerations over environmental and safety costs from incidents occurring during decommissioning operations) has led to the current more flexible decommissioning regime that allows for partial decommissioning depending on circumstances.[142] The first initial option is still total removal of the platform, which involves at the minimum: (i) well abandonment through cementing of well bores; (ii) separation of the platform from conductors (sometimes with explosive); (iii) removal of the topside (upper part of the rig, including accommodation) from the jacket; and, (iv) removal of the jacket from the seabed with explosives.[143] The second alternative is one of partial removal which involves the first 3 steps of a total removal but not the removal of the jacket, which is left in place. The third option is to leave the platform in place after proper well abandonment, stripping and cleaning. Navigational aids must also be added according to the option chosen.

According to B.Twomey, the Asia-Pacific region has had 91 offshore installations removed since 1975, many in Japan and Australia, thus outside the SCS. However, Brunei Shell Petroleum (BSP) has had 23 small platforms removed between 1975 and 1984 and either brought onshore for scrapping or disposed off in deep water after bringing the topsides onshore. A new rigs-to-reef policy has been adopted in Brunei since 1988, and BSP started disposing of abandoned structures as artificial reefs in an area located outside shipping lanes, known as the Two Fathoms Rock Artificial Reef. It is now a diving site.[144] Six platforms appear to have been disposed off in this location.[145] B.A.Hamzah reports that a conservative estimate of the cost of removal of around 200 platforms located in Malaysia to amount to around 8 billion Malaysian ringgit (i.e. more than USD2 billion).[146]
A recent publication estimates that 600 to 900 platforms would now be over 20 years old in Malaysia.[147] B.Twomey estimates that 831 platforms are more than 20 years old in the Asia-Pacific region. These inconsistent figures all coming from industry sources show (i) that there is a high number of platforms in need of decommissioning in the SCS, especially for Malaysia, Indonesia and possibly Brunei; and, (ii) that there is a need for independent public studies to be carried out, if possible with the assistance of the relevant entities or institutions in the coastal States of the SCS.

5.3 Key potential environmental issues in the SCS

Key potential environmental issues identified in the different stages reviewed above have been grouped below in categories designed to fit within the legal qualifications used in existing legal instruments and prospective discussions.

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[141] For a discussion on the origin of these two terms and their respective meanings, refer to B.A.Hamzah (2003) International rules on decommissioning of offshore installations: some observations, Marine Policy 27: 339-340
[142] As an example of a discussion on the topic safety risk management in decommissioning: Time to take decommissioning safety risk in hand, by S.Phipps, Decomworld, 9 December 2010, available online at http://social.decomworld.com/industry-insight/time-take-decommissioning-safety-risk-hand
[143] D.M.Schroeder and M.S.Love (2004) Ecological and political issues surrounding decommissioning of offshore oil facilities in the Southern California Bight, Ocean and Coastal Management 47: 21-48
[144] http://www.panagadivers.com/Diving/Reefs.htm or http://www.relax.com.sg/relax/news/389438/_Great_Barrier_Reef_in_Brunei.html
[145] B.Twomey (2010) Ibid
[146] B.A.Hamzah (2003) Ibid
[147] Decomworld, 9 February 2011, available online at http://social.decomworld.com/qa/malaysia's-decommissioning-market-ramp-24-months (last accessed on 29 April 2011)

5.3.1 Noise and vibrations from seismic survey, underwater explosions, construction noises and other activities

While impact of underwater noise and vibration and marine mammals is the subject of much research and publications, the scale of the disturbance and extent of the impact on behaviour appears to vary according to species, size and location. Potential effects range from disturbance that may lead to displacement from feeding or breeding areas to auditory damage and potential mortality.[148] Cetaceans' behaviour can be affected up to 300km away from emission. Research also proposes that underwater noise also affects fish eggs and juveniles, spawning and behaviour.[149]

5.3.2 Physical disturbances from presence of fixed or floating rigs or platforms and vessels involved

The presence of offshore structures or installations impact the bottom sediments as well as local flora and fauna, especially where the structures are located on the migratory path of macrofauna such as turtles, whales and some fish species. Siltation is one of the observed processes locally impacting biomass and composition of both fauna and flora.

5.3.3 Drilling waste including drilling fluids (hydrocarbon and additives, drilling cuttings and contaminated produced water

Potential chemical pollution from produced water and drilling fluids and other impacts of drill cuttings formation on the benthic environment are a known issue that has led to several waves of new regional and national regulations and standards in the North Sea.[150] The ecological effects of oil pollution have been observed to extend for several kilometres from some platforms and be detected up to 10km from discharge points.[151] Reference made exclusively to North Sea research in a 2010 research for the SCS for a theoretical oil and gas exploration and development sites located 100km off Sabah in 150m deep water, suggests that the knowledge to treat this issue is still in its infancy in the region.[152] Knowledge of pile number, size and hydrocarbon concentration in the SCS would be very useful.

Drilling cuttings can be treated on site in order to separate and, where possible, re-use as much as possible of the drilling mud with the rest being either brought to land for disposal or disposed at sea. Where drilling cuttings are disposed at sea, the formation of cuttings piles depends on current strengths and tide in that location. In deeper basins where currents tend to be weaker, more piles tend to form. Heavy metals are another important component of drill cuttings. However, the impact on the environment is still unclear, especially in the SCS given the lack of available data. Gerrard et al.'s independent research shows that half of the North Sea is less than 100m deep, a commonality with part of the SCS, which may render some of the abundant research made in the UK relevant to the SCS, though many deferring parameters also need to be taken into account including very different, more diverse and potentially more

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[148] R.Compton et al. (2008) A critical examination of worldwide guidelines for minimising the disturbance to marine mammals during seismic surveys, Marine Policy 32: 255-262 and E.C.M.Parsons et al.(2009) A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best Practice?, Marine Pollution Bulletin 58:643-651

[149] J.Gordon et al. (2003) A review of the effects of seismic surveys on marine mammals, Marine Technology Society Journal 37(4):16-34

[150] Relevant provisions of OSPAR are described in J.Wills *Ibid*

[151] Observations from the North Sea, J.Wills (2000) *Ibid*

[152] Hock Lye Koh and Su Yean The (2010) Simulating drill cuttings dispersion and deposition in the South China Sea, available online at http://www.iaeng.org/publication/IMECS2011/IMECS2011_pp1501-1506.pdf

resilient ecosystems. This report also shows the relevance and utility of comprehensive environmental assessment including the impact of the cutting piles on the surrounding food chain.[153] Potential health and safety risks are also attached to drill cuttings and monitoring, assessment and standards and regulations are necessary.

S.Kloff and C.Wicks' report for the West African Marine Eco Region[154] points to the particular vulnerability of low energy habitats reached by oil pollution such as wetlands due to the low circulation resulting in accumulation of pollution.

A very key element arising from the North Sea experience is that defining threshold and limits for components of drilling muds is a difficult task that might be best fulfilled through an evolving method building in trial and errors, whereby new rules are set and verified based on regular impact monitoring. Evolution in technological solutions is also key to limiting these environmental impacts.

5.3.4 Marine discharge (oil and other compounds) from platforms and ships and Alien Invasive Species

These two large categories of vessel-source pollution are distinct and dealt with by different legal instruments. However, they have in common that they are not ~~be~~ specific to offshore oil and gas activities. They are a corollary of all shipping activities. The main question in this context is that of the application of shipping conventions to these to oil and gas platforms and installations.

5.3.5 Gas and gas pipelines

Most of the literature on the impact of the offshore oil and gas industry on the marine environment focuses primarily on oil production where gas is mostly dealt with as a by-product of oil production contributing to atmosphere pollution directly or through the different gases released from flaring. However, the SCS has as many gas fields if not more than oil fields and the impact of gas production and export/transport has to be considered separately (Map 4). The composition of natural gas varies depending on the origin, type, genesis, and location of the deposit, geological structure of the region and other factors. Components are first, methane and its homologues, then carbon dioxide, hydrogen sulfide, nitrogen and helium in generally smaller concentration. [155]

The change in seawater chemistry resulting from the escape of natural gas into the sea can change the composition and biomass of the water fauna and cause mass mortality of fauna and flora, including fish and molluscs. Such escape can occur at all stages of drilling for oil or gas, as a result of drilling accidents such as blow outs, as well as from damaged gas pipelines, whether it is from corrosion processes, seismic activities or earthquakes. Dramatic gas escape from two drilling accidents in the Sea of Asov that increased the concentration of methane in surface water up to 10 to 100 times, have been documented. However, based on the published literature, this topic appears to be largely understudied at this stage and is generally not even discussed when considering environmental impact from oil and gas activities. Such research

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[153] *Ibid*

[154] Ibid referring to NRC (2002) National Research Council of the National Academies, Oil in the sea III: inputs, fates and effects, The National Academies Press, Washington D.C.

[155] Stanislav Patin, Natural gas in the marine environment, from http://www.offshore-environment.com/naturalgas.html

would be especially useful for the SCS given the large proportion of gas production, increase in production and growing gas pipelines network (Map 4). [156]

5.3.6 Decommissioning of platforms

This concerns fixed rather than mobile platforms. Different environmental impacts are attached to the type of decommissioning chosen (full removal, partial removal or leaving in place). Explosives are especially needed for the removal of the topside and the jacket and generate intense shock waves that cause instantaneous lethal impacts for marine life on and near the structure and adverse effects on macro fauna located further away (such as marine mammals, sea turtles and seabirds)[157]. The relative impact of these compared to the impact of leaving the structure in place would need to be considered.[158] Where total or partial removal is chosen, other decisions have to be made with respect to environmental impact including the mode of disposal of the removed parts: dismantling and scrapping onshore, reusing and reconditioning or towing to a site and reefed.

Options of reusing abandoned platforms, their foundations and other structures have been the subject of an active discussion and much published literature in the last ten years and several countries have adopted popular 'rig-to-reefs' programs aimed at transforming former oil and gas platforms into artificial reefs, as a new habitat for marine life to settle on (like BSP did in Brunei and other examples off California Southern Bight and in the Gulf of Mexico). One of the benefits put forward is a positive impact on fisheries, although other authors emphasize the interference and destruction of fishing gear from abandoned offshore platforms or fragments.[159] Platforms can also be reused for aquaculture and other marine activities.

Another question is that of the removal of drill cuttings piles, where there are some. Opinions differ as to the respective impacts of removal vs. leaving the piles *in-situ*, with or without on site treatment. If cuttings piles are to be left *in situ,* then predictions need to be made about the extent of leaching of hydrocarbons (and, possibly, metals), the continued effect of this on SCS ecosystems and about natural or artificially enhanced biodegradation. If treatment of piles *in situ* is being considered, then the cost and effectiveness of the alternative technologies needs to be established (including bioremediation, capping, dispersal, and entrenchment) · If the piles are to be removed, then technologies for doing this need to be evaluated in addition to the potentially disruptive effect of the process of removal. The method and location of final disposal of the removed cuttings also needs to be taken into account. Once removed, the cuttings may be injected down existing wells ('reinjection'), or shipped ashore for treatment on land (whether landfill, land spreading or heat treatment).[160] Each solution has different relative environmental costs and benefits. Criteria are necessary to assess the options including ecological impact, energy usage, health and safety, public perception, technical feasibility, timescales, flexibility *vis-a-vis* information gaps, and cost.

5.3.7 Extreme weather events

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[156] Stanislav Patin, Ibid
[157] M.A.Ayoade (2002) Ibid p.31-32
[158] There is now on-going research into finding a balance between the lethal impacts of explosive detonations and the surrounding marine ecology. M.A.Ayoade (2002) Ibid p.32
[159] S.Patin, Decommissioning, abandonment and removal off obsolete offshore installations, available online at http://www.offshore-environment.com/abandonment.html (last accessed on 29 April 2011)
[160] S.Gerrard et al., *Ibid*

Studies from the USA indicate that Hurricanes Katrina and Rita in 2005 were responsible for the destruction of 113 platforms (out of 4000), damage to 600 offshore pipelines and 124 reported oil spills from crude oil from platforms, rigs and pipelines (amounting to 17,700 barrels).[161] Hurricanes Gustav and Ike were responsible for the destruction of 60 platforms out of 2127 exposed platforms (3800 in the Gulf of Mexico).[162] Given the exposure of the SCS to extreme weather events, an increase in density of the offshore oil platforms also increases the exposure to such events and increases the risk of environmental disasters. Systematic monitoring and reporting in the SCS would also be useful in this regard.

5.3.8 Compounded impact with other uses of the same marine systems and conflict in uses
While conflicts between the offshore oil and gas industry and fisheries is a known issue, though little studied in the SCS, conflicts with other uses of the sea in the same area are less explored. Community, health and ethical issues such as rights and indigenous people are not included in this environmental review focused on ecological impacts. Apart from the traditional environmental issues, new issues arising from socio-economics, cultural impacts, indigenous people and human rights are arising from social science research. Sea Indigenous people commonly named Sea gypsies are numerous in the SCS. They include for instance: (i) Bajau, an indigenous ethnic group residing in Sabah, eastern Malaysia, Brunei, Indonesia, the Philippines, and parts of Sarawak, sometimes including the people who speak Makassar, and Bugis; (ii) Moken, also known as the Selung, Salone or Chalome and Chao Ley or Chao nam, an Austronesian ethnic group with about 2,000 to 3,000 members who maintain a nomadic, sea-based culture around the Adaman islands (although they are geographically outside the scope of this paper, they help demonstrate the relevance of the topic) ; (iii) Orang Laut, or Bajau Laut, a group of Malay people living in the Riau Islands of Indonesia and (iv) Urak Lawoi, coastal dwellers of Thailand. The presence of 'young sea-gipsies' off the new Malaysian Malakai gas fied (off Sabah) is shown in a picture published in specialized press on the new Malaysian Malakai gas field.[163] The lifestyle of Bajau people, traditional fishing methods and limited connections to land, have been the subject of recent documentaries.[164] Despite the fact that such impact has been little researched so far, examples from terrestrial communities such as the disaster of the Ok Tedi gold and copper mine can help in analyzing the nature of the risk incurred.[165]

Environmental impacts from oil and gas activities result from a combination of the potential risks highlighted above. However, the relative importance of these risks in the SCS are difficult to measure at this stage, given the lack of available research on practices in the SCS, reported

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[161] Minerals Management Services (MMS) (2006, May 1) MMS updates hurricanes Katrina and Rita damage. Available online at http://gomr.boemre.gov/homepg/whatsnew/newsreal/2006/060501.pdf
[162] MMS completes assessment of destroyed and damaged facilities from hurricanes Gustav and Ike http://gomr.boemre.gov/homepg/whatsnew/newsreal/2008/081126a.pdf
[163] Rivals go head to head in Malikai bid: Giants vying for tension-leg wellhead contract in Malaysia, by R.Searancke and H.H.Tan, Upstream, 18 March 2011: 12
[164] Unsustainable sea-farers: the last Bajau sea nomads, 20 September 2010, Guardian, available online at http://www.guardian.co.uk/environment/gallery/2010/sep/20/bajau-sea-nomads -/?picture=366866794&index=10 (last accessed on 31 May 2011) and What freediving does to the body, 12 January 2011, BBC, available online at http://www.bbc.co.uk/news/science-environment-12151830 (last accessed on 31 May 2011)
[165] This mine, located high in the rain forest covered Star Mountains of Papua New Guinea, was built on the world's largest gold and copper deposit (gold ore capping the main copper deposit). It was originally envisaged that the mine tailings would be stored in a dam, and after the settling of solid particles, clean water would flow down the Ok Tedi River, then into the Fly River for the 1 000 km journey to the sea. However, the half-built tailings dam collapsed in 1984 and the mine went ahead without a waste disposal plan. Details can be found online at http://www.grid.unep.ch/waste/html_file/18-19_consumption_oktedi.html (last accessed on 25 April 2011)

impacts and accidents linked to oil and gas. The legal framework in place to handle the environmental impacts indentified can be found in a subsequent paper from the author.[166]

Conclusion

This paper has highlighted three trends. The first is that the evolution of the current maritime boundary disputes is and will continue to be a critical factor in offshore oil and gas developments in the SCS . This will also determine the context in which coastal States might cooperate for the protection of the marine environment.

Secondly, monitoring environmental impact remains difficult given the limited access to offshore oil and gas data on installations and on their environmental impact. With regard to the latter, the lack of baseline and published impact analysis of offshore oil and gas activities does not allow for an independent assessment of impact to the marine environment, despite clear environmental hazards and coastal degradation risks. While this might benefit the industry in a short-term management perspective, it prevents public information, dialogue with other stakeholders and independent research and assessment, all key to responsible and accountable policy making. Unless the offshore industry is carrying out independent research and acts upon the results to mitigate risks, there is a strong risk that the current lack of transparency in the activities will play against it when the first massive disaster occurs.

Finally, this paper highlights three high and increasing risks to the marine environment and other users: aging and abandoned fixed platforms in need of decommissioning (just under 675 are over 20 years old); the growth in deep-water fields that increase both risk of occurrence of environmental disaster and potential magnitude; and, the increase in underwater pipeline network to service the industry.

Given the regional reliance on living marine resources from the SCS, further exploitation of non-living marine resources must be balanced with the protection of marine living resources. Coastal States would be well placed to insist that the oil and gas industry applies in the region the best practice required elsewhere and based on the lessons learned from past ecological disasters. This should be the case even where national compliance regimes are not at the same relative level of development.

[166] Youna Lyons (2011) Offshore oil and gas in the SCS and the protection of the marine environment, Part 2 – Legal and governance framework, In Press

Diagrams, Maps and Tables

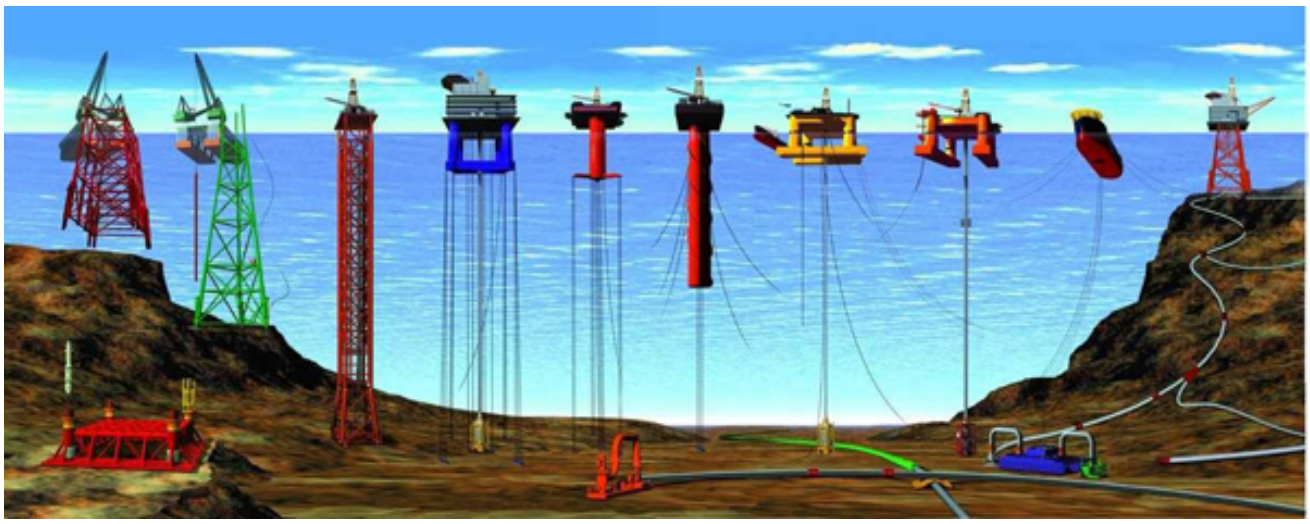

Diagram 1 – From NOAA Ocean Explorer referred to in Wikipedia 'Oil Platform'
Types of offshore oil and gas structures include: 1, 2) conventional fixed platforms (deepest: Shell's Bullwinkle in 1991 at 412 m/1,353 ft GOM); 3) compliant tower (deepest: ChevronTexaco's Petronius in 1998 at 534 m /1,754 ft GOM); 4, 5) vertically moored tension leg and mini-tension leg platform (deepest: ConocoPhillips' Magnolia in 2004 1,425 m/4,674 ft GOM); 6) Spar (deepest: Dominion's Devils Tower in 2004, 1,710 m/5,610 ft GOM); 7,8) Semi-submersibles (deepest: Shell's NaKika in 2003, 1920 m/6,300 ft GOM); 9) Floating production, storage, and offloading facility (deepest: 2005, 1,345 m/4,429 ft Brazil); 10) sub-sea completion and tie-back to host facility (deepest: Shell's Coulomb tie to NaKika 2004, 2,307 m/ 7,570 ft).

Diagram 2 – Drilling rigs (from www.seadrill.com)

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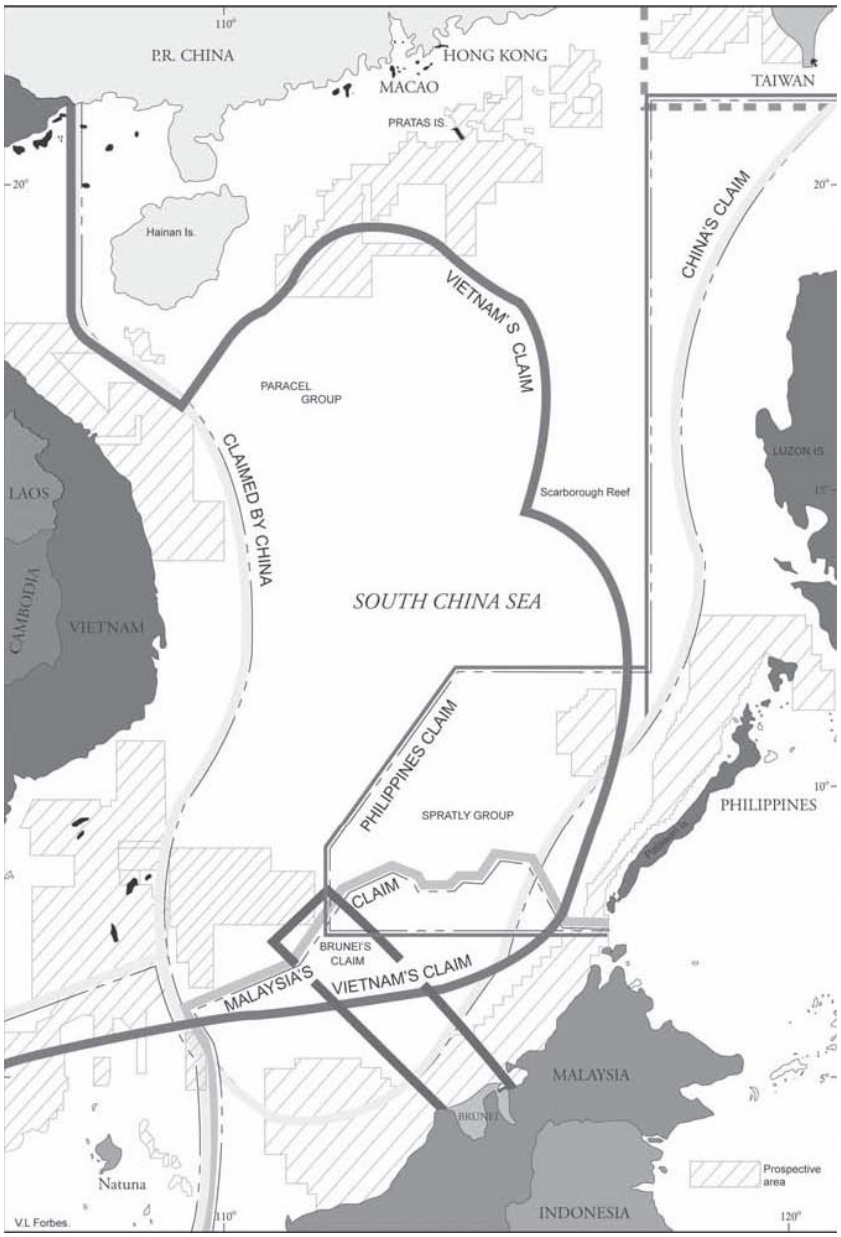

Map 1 - **Map of the South China Sea Claims**
From Vivian Louis Forbes, Conflicts and Cooperation in Managing Maritime Space in Semi-enclosed Seas (Singapore University Press, 2001) p.136

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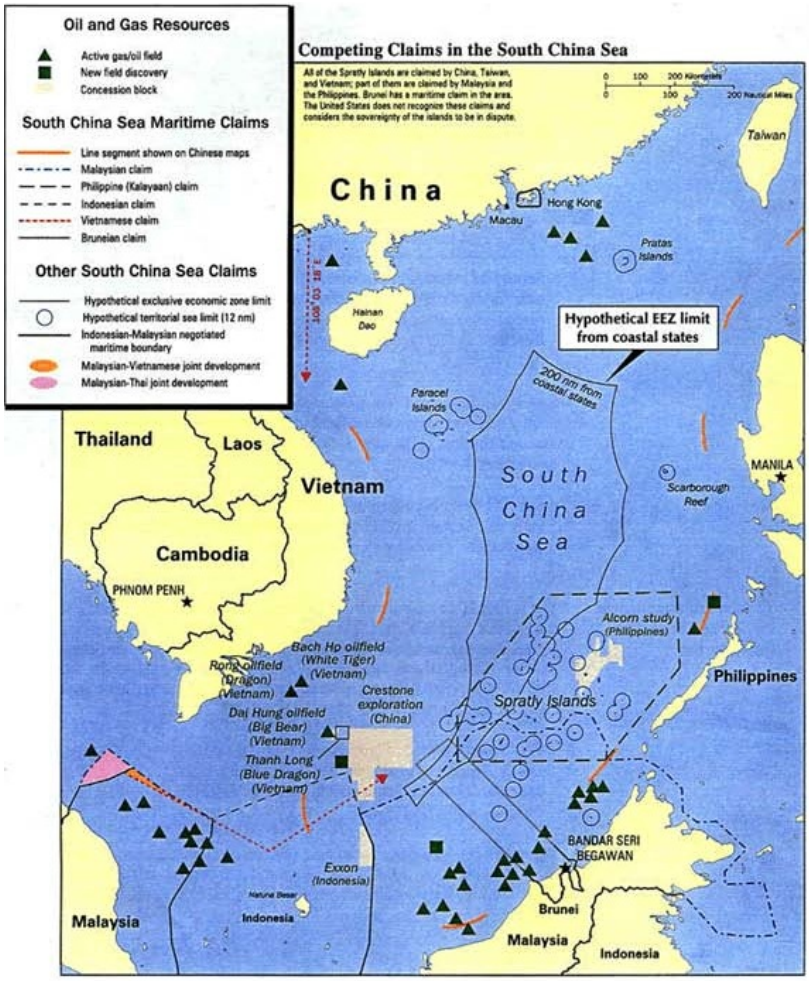
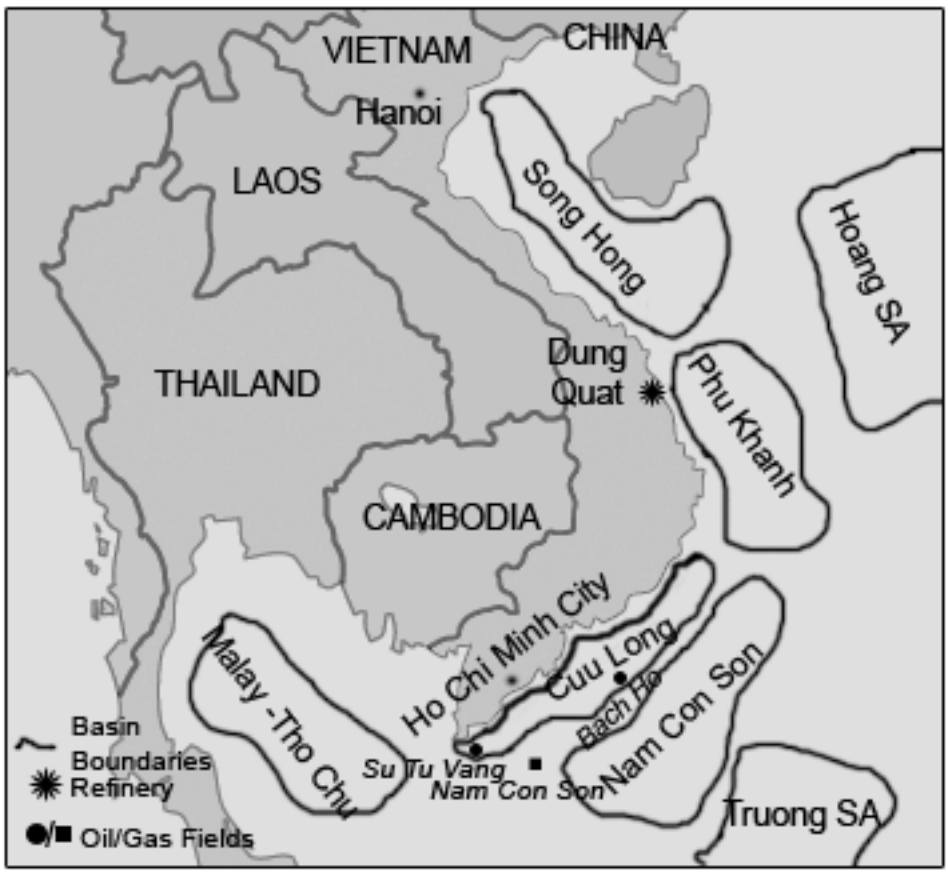


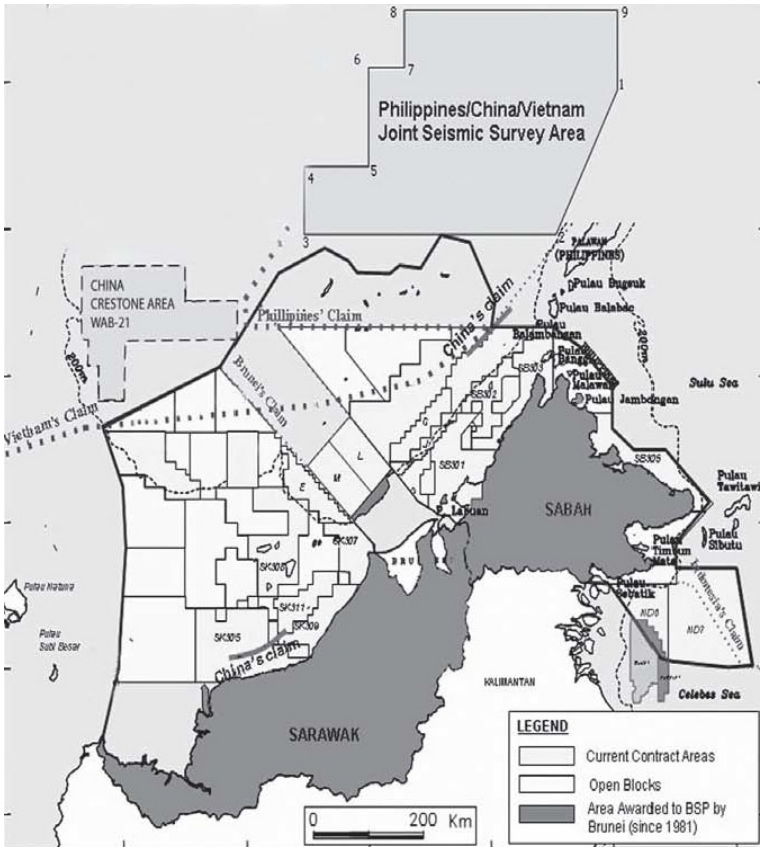
Map 2 - South China Sea Maritime Claims
(Public map from the US Energy Information Administration, available onlineat http://ei-01.eia.doe.gov/emeu/cabs/South_China_Sea/pdf.pdf

Map 3 – CNOOC's map of China's open blocks in the South China Sea
(http://en.cnooc.com.cn/data/html/news/2010-05-07/english/301292.html, last accessed on 21 April 2011)

Map 4 – Southeast Asia Pipeline Map
(available online at http://www.theodora.com/pipelines/southeast_asia_oil_gas_products_pipelines_map.html, last accessed on 20 April 2011)



Map 5 – Vietnam offshore basins
From Vietnam Oil and Gas Report Q1 2011, p.12, published by Business Monitor International, ISNN 1748-4375, London, UK, available online at http://www.businessmonitor.com (last accessed on 1 June 2011)



Map 6 – SE South China Sea showing areas considered for exploration
(From L.Buszynski and S.Iskandar (2007) Maritime claims and energy cooperation in the South China Sea in Contemporary Southeast Asia Vol.9 No1: 143-171)

Country	Total	Fixed	Mobile
Indonesia	485	463	13
Thailand	265	260	5
Malaysia	249	237	12
Brunei	160	160	
Vietnam	46	40	6
China	120	98	22
Malaysia-Thailand JDA	15	14	1
Philippines	8	7	1
Cambodia	2		2
Total	**1350**	**1278**	**72**

Table 1 – Estimation and types of oil and gas platforms and installations in the South China Sea and adjacent seas
Data compiled from Brian Twomey (2010) Study assesses Asia-Pacific offshore decommissioning costs, Oil and Gas Journal, March 15: 51-55 and completed with the World Offshore Field Development Guide Database – Vol.2: Asia, India, Australasia & Far East, OPL, 2010