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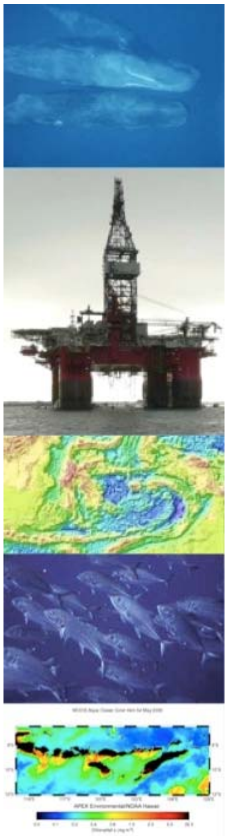

Marine Conservation Planning and the Offshore Oil & Gas and Deep-Sea Mining, and Shipping Industries in the Coral Triangle and South West Pacific:

Large-Scale Spatial Analysis of the Overlap between Priority Conservation Areas with Marine Extraction Blocks and International Shipping Lanes.

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April 2013[3]

APEX Environmental
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A Technical Report prepared
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[3] Please address all correspondence regarding this technical report to BK. Further details on this study - incl. regional and industry characteristics, spatial analyses of numerous PCA categories, species and habitats, spatial scenarios on food security and livelihoods methodology, database metadata, full references, as well as recommendations can be found in the 50-slide PowerPoint presentation Kahn and Vance-Borland 2012 (with extensive research notes for each slide) accompanying this report.

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Introduction

The Project: Mapping the Marine Extractive Blocks of the Offshore Industry and assessing its overlap with marine Priority Conservation Areas to identify areas of maximum overlap and high risk of environmental impacts (hotspots).

This innovative project marks a new approach for this large-scale region. It starts to assess the overlap between Priority Conservation Areas (PCAs) and Species of Concern with Marine Extraction Blocks (MEBs) and International Shipping Lanes (ISLs).

This project included significant addition of new data for the region by sourcing offshore block maps and digitizing these in GIS compatible format. The outcomes are a “first pass” of a vast geographical area, and conducted with limited resources and within a short time span (one month). Hence, the spatial analyses are indicative only.

Based on various sources and by digitizing new data, the project was able to address various management gaps and included many ‘firsts’ for the region:

- 1st detailed maps of oil and gas / deep-sea mining block locations and subsequent identification of clusters of activity by the offshore industry (as indicated by the extensive block coverage in several regions)
- 1st detailed analysis of coastal (reefs) and deep-sea yet near-shore habitats (migration corridors, canyons, seamounts) overlap with MEBs
- 1st detailed analysis of potential risk of MEBs to Species of Concern for which adequate data was available (marine turtles, sperm whale, blue whale, and dugong.
- 1st preliminary analysis of potential risk of MEBs to other maritime industries (tuna fisheries, marine tourism).
- 1st detailed digitization and quantification of the region's international shipping lanes. This has laid the groundwork for an in-depth spatial analysis of the potential impact of shipping with all other data layers. The possible interactions of maritime transport with priority conservation areas have not been studied to date in the CT-SWP region.

Project Objectives

1. To provide an initial analysis of the overlap between natural marine assets (PCAs) and areas officially designated for marine oil & gas and deep-sea mining activities (MEBs) in the Coral Triangle-Southwest Pacific region.

2. To identify "hotspots," that is areas of significant overlap between offshore activities and marine conservation values, for each PCA category (see below) and ultimately to identify cumulative hotspots for each region.

3. To identify "coolspots," that is, areas with minimal overlap, which may provide opportunities for marine conservation planning.

4. To provide recommendations on:
    a. How the outcomes of this first stage study can be best integrated with key existing GIS platforms and/or be used in future CT/SWP conservation planning and general mapping work.
    b. How this baseline and indicative study can be improved upon, with emphasis on more accurate and detailed spatial analysis and livelihood scenario's that can be conducted with relative ease, building on the wealth of data collected to date.

Geographical Scope of the Project

The project used scientifically-determined and ecologically-based boundaries for the spatial analyses, as PCAs are often determined at ecoregional or provincial scales (e.g., WWF 2003, 2004). The scientific boundary for the Coral Triangle, and the marine ecoregions it encompasses, were used in all the spatial analyses for this region as most data were available and PCAs where defined in the past using this boundary. All the sovereign nations covered by the study have been identified (Figure 1). The SWP boundary was determined by a CBD-organized expert workshop held in Fiji (CSIRO in prep). The Fiji expert workshop's GOODS marine provinces (UNESCO 2009) were also chosen as the summary units for this study) and extensive biophysical and ecological data have been obtained for this vast region (data agreement with CSIRO, Australia). These data will be publicly available in 2013 from the CSIRO Australia website www.csiro.gov.au.

Further analyses including the implementation boundary of the Coral Triangle Initiative, which includes all national and EEZ waters of all the six member states, are planned, and the current project provides a sound basis for this (relatively straightforward) expansion in geographical coverage to provide both the CTI and national perspectives on MEB overlap with priority marine conservation areas. This would likely affect Indonesia and Malaysia the most, as significant oil and gas activity occurs there outside the scientific boundary. It should be noted that for all EEZ waters of the Coral Triangle there is a major data deficiency on the ecological significance of these offshore areas. Hence, minimal PCAs are currently known for the CT's EEZ. Therefore the overlap with MEBs will likely be underestimated and the percentages 'diluted' due to the inclusion of the national and EEZ waters which are part of the CTI implementation boundaries.

Methods

Spatial Analysis for all priority data layers

Data for priority ecologically or biologically sensitive areas was collected from a wide selection of sources. Subsequently, spatial analyses were conducted for the following Priority Conservation Areas (PCAs) within the CT - SWP:

1. Marine Protected Areas (MPAs)
2. Coral Reefs
3. Marine Corridors
4. Seamounts
5. Canyons
6. Tuna High Catch Areas
7. Seamounts with elevated tuna catches
8. Green turtles
9. Leatherback turtles
10. Sperm whales (Historical captures, Townsend 1935)
11. Blue whale critical habitat for breeding/calving
12. Dugong
13. PCAs identified in various ecoregional workshops

For each of these PCA categories numerous analyses were done including

1. Areas and percentage of each PCA category for each Ecoregion
2. Overlap (areas and percentages) with two MEB types in each ecoregion:
    a) Oil and gas blocks
    b) Deep-sea mining blocks

The GIS analytical process included the following steps

- Collect existing spatial data on species, habitats, boundaries, PCAs, shipping, human population, etc., from regional cooperators and online sources, including ESRI Ocean Basemap;
- Hand-digitize Marine Extraction Block polygons in ArcGis and Quantum GIS, based on jpeg maps of oil, gas, and mining blocks obtained from the internet;
- Hand-digitize migratory corridors, tuna high catch areas and shipping lanes incl. ship traffic densities;
- Re-project all spatial data into World Cylindrical Equal Area projection;
- Intersect data layers to find areas of overlap between MEBs and PCAs, species and habitats;
- Raster-based analysis including sea-lanes, shipping densities, human population, and marine mammal richness.

Descriptions of each spatial dataset can be found in Appendix 1, and more detailed information on GIS methods and programs used can be found in Appendix 2.

Outcomes

The main project outcome is the systematic identification of areas with significant overlap between priority values for conservation and the offshore industry, including international shipping. These “hotspots” have not been mapped and quantified before, let alone with such a comprehensive set of underlying physical, biological and ecological data layers.

Furthermore, through various spatial analyses this project has started to categorize and rank such hotspots according to specific species and habitats, as well as marked areas with “extreme overlap.” In addition, we have conducted an initial assessment of the potential socio-economic risks of extractive industry activities to other industries and livelihoods (tuna industry, reefs, marine tourism) based on a spatial analysis of a deep-well oil spill scenario in three locations. Finally, we have included numerous recommendations on possible follow-up studies.

The major outcomes from different perspectives

From a marine conservation perspective…

The total area coverage of all Marine Exploitation Blocks in the Coral Triangle equals 1,162,194 km2. This means that Oil & Gas and Deep-Sea Mining blocks combined are 21.14% of the whole CT area (5,498,774 km2 – as delineated by the scientific boundary). By comparison, the total coral reef area within the same CT area equals 1.15%. Thus the CT has a very significant offshore industry component within its Marine Spatial Plans. Total area coverage of all MEBs is 2.65% for the South West Pacific. The special characteristics of this overlap are discussed in detail for each region in the following sections.

Overall 26.1% of *all* PCA polygons analyzed (n=548) included an overlap with MEBs. This substantial overlap for the vast CT-SWP region is a clear indication of:

1. The prevalence of MEBs in Marine Spatial Planning (Douvere 2008) throughout the region, and
2. The energy and mining sectors’ increasing technical capacity to operate in remote

and/or deep and ultra-deep locations.

Furthermore, *all* priority data layers had substantial overlap (ratio of counts of individual PCAs with and without any MEB overlap). The percentage of overlap between PCAs and MEBs is likely to increase substantially in the period 2012-2015, if the oil and gas industry continues to rapidly increase its operational scope in the CT as it has in the recent past, and if/when deep-sea mining activities ramp up in the large-scale exploitation blocks already allocated in the SW Pacific.

From an MPA perspective…

Of the 338 MPA polygons represented in the spatial data obtained for the six Coral Triangle countries combined, a substantial 14.8% of MPAs (n = 50) have overlapping boundaries with MEBs. The number of MPAs in each of the six CT countries which overlap with MEBs is extremely variable (range 0-100%).

Two countries have total 100% overlap (Timor Leste and Sabah/Malaysia), two countries have no overlap (PNG and SI) and their MPAs have no direct spatial conflict with the offshore industry (and especially deep-sea mining which is the main block type in those countries). For both the Philippines and Indonesia, there is considerable overlap and potential for conflicting usage (16% and 37% respectively).

From an energy sector and offshore industry perspective…

For the CT region, a significant 39.5% of the *total area* within all MEBs is also designated as PCAs. Close to 40% of the total area within CT Oil and Gas blocks is designated as PCA (37.5%). Over 50% of the total area within CT Deep Sea Mining blocks is also designated as PCA (50.1%). Thus although DSM is considered an offshore activity and is not associated with the coast, when overlap is compared by block type there is *relatively more overlap* with PCAs for CT DSM blocks than the Oil and Gas blocks. This is likely to be due to

- The overlap of DSM with the habitats of wide-ranging marine life such as marine turtles, oceanic cetaceans and tuna fisheries, and
- DSM proximity to several important marine corridors (in the Bismarck Sea, which has the highest density of DSM tenements in the CT).

In the much larger South West Pacific region there are few Oil & Gas blocks and none of them overlap with PCAs. However, 10.9% of the area of DSM blocks in the SWP is also designated as PCAs. Thus from an industry perspective it seems reasonable to expect that this study will provide companies with a better awareness of the scale of overlap, and the need to work towards mitigation of potential risks to sensitive species and habitats.

Regional Overview of PCA and MEB Overlaps

Main outcomes:

- A rapidly expanding offshore industry has resulted in medium to maximum overlap in all Coral Triangle ecoregions and two SW Pacific Provinces.
- The PCA-MEB overlap occurred with *all types* of PCAs – including a significant

overlap with Marine Protected Areas (MPAs) - and *all species* habitat maps.

- Overall 26.1% of *all* PCA polygons analyzed for the CT (n = 548) included an overlap with MEBs.
- Overall 39.5% of the *total area* within all MEBs for the CT region is also designated as PCAs.
- Oil and Gas (OG) blocks are prevalent throughout the shallow- to medium-depth waters throughout the eastern CT.
- Deep-sea mining (DSM) blocks are operational in the Bismarck Sea (PNG), and fully licensed for the SI and vast areas of the SWP. DSM is completely absent from the western and central CT.
- This geographical separation of block type is important for management and mitigation of potential impacts.
- MEBs overlapping with MPAs have been documented and quantified per CT country and ranges from 0 to 100%.

While the offshore industry is active throughout the CT-SWP, the project identified:

- 5 hotspots for oil and gas (O&G) overlapping with PCAs, and
- 4 hotspots for deep-sea mining (DSM) with PCAs

Oil and Gas Hotspots (percentage overlap of the ecoregion's total area noted):

1. Makassar Strait and the Berau region - 26%
2. Tomini Bay (NE Sulawesi) – 59.4 %
3. South and western Sulu Sea including Sabah and Palawan (Palawan/N Borneo) – 57%
4. All of the Bird's Head region, (Papua Ecoregion) – 41.4%, including Raja Ampat and Cendrawasi Bay (industry activity is moving to nearby seas including Aru and Kei region)
5. N coast of the Papua New Guinea mainland, Bismarck Sea Ecoregion - 7.8 % (all in one recent 2012 O&G licensing round, DSM % separate).

Oil and Gas "Coolspots" (marine areas without oil and gas overlap): It is important to note that oil and gas blocks are *not prevalent* (as of November 2012) for the Lesser Sundas (except Timor Leste), the Flores and Banda Seas, the islands off PNG and all of the Solomon Islands. We recorded O&G blocks for only one SWP province, the Non-Gyral SW Pacific, where O&G blocks comprised 2.5% of the province area.

Deep-Sea Mining Hotspots (percentage overlap of these Provinces' vast total area noted):

1. Bismarck Sea and especially the waters north of Kimbe Bay – this is the pioneering area and spearhead for this new ultra-deep offshore industry sector (Bismarck Sea, CT – 27.3 %)
2. New Georgia offshore block (Solomon Sea, CT - 4.0%)
3. The Clipperton Zone. A combined area of 2.2 million square km (equal in size to 3/4 of the EU (spanning the North Central Pacific Gyre, SWP – 8.2% and Eastern Tropical Pacific Zone – 6.8%)
4. Fiji Offshore. The large-scale cluster of blocks to the east of Fiji (South Central

Pacific Gyre, SWP – 1.1 %)

Deep-Sea Mining "Coolspots" (marine areas without deep-sea mining overlap): It is important to note that DSM blocks are extremely large and designated clusters may equal large countries and even continents in size. Thus while vast areas of the enormous South West Pacific marine region do not have DSM blocks, if/when the industry is proven economically viable it may expect large tracts of seafloor to be allocated to seafloor mining. No DSM blocks where recorded for the central and western CT.

The Hotspots in detail
This study has found substantial overlaps between *all Priority Conservation Area* categories and MEBs. The hotspots are throughout the CT-SWP regions and, as expected, are different for different PCAs such as MPAs, coastal and oceanic habitats and species. In addition, both regions have specific activities associated with them, which may have broader ramifications for the whole study area. Nonetheless, the study has identified cumulative hotspot areas for both the CT and SWP regions.

Marine Extraction Blocks (MEBs) in the Coral Triangle: Expansive coverage by Oil and Gas

MEBs by type in the CT (area of total MEBs, in square kilometers – km2):

SubTotal area oil and gas	976,591.4 km2
SubTotal area mining	185,602.3 km2
Total area MEB	1,162,193.8 km2

The ratio and general distribution of offshore activity in the Coral Triangle is as follows (Figure 2):

Oil and Gas: 84 %
Deep-Sea Mining: 16%
Western CT waters: All Oil and Gas blocks.
Eastern CT waters (PNG and SI): Predominantly Deep-Sea Mining blocks.

Thus the Overlap Hotspots between PCAs & MEBs in the Coral Triangle are (Figure 2):

1. Makassar Str/Palawan/N Borneo Papua - The complete eastern coast of Borneo, spanning both Indonesia and Malaysia (Sabah), as well as all of Palawan (Philippines).
2. NE Sulawesi – This is a relatively small ecoregion and Tomini Bay has an exceptionally large percentage of MEB areas.
3. Papua, incl. Kaimana, Raja Ampat and Cendrawasi Bay;
4. Lesser Sundas Eastern region incl. Timor Leste, Alor, Wetar
5. Bismarck Sea
6. N coast Papua New Guinea
7. Solomon Archipelago

Marine Extraction Blocks (MEBs) in the South West Pacific: Introducing Deep-Sea Mining (DSM)

The deep-sea mining industry is being pioneered in the SW Pacific and in particular in the Bismarck Sea of PNG. The Solomon Island and Fiji also have attracted substantial interest from the new industry with numerous tenements being awarded to date. All major stakeholders in the offshore energy sector are paying close attention to the outcomes of the frontrunners with deep-sea mining operations in the field, and have already indicated their interest in major investment programs once a better understanding is gained of the operational and commercial challenges.

The enormous geographical scale of these DSM tenements in the SW Pacific is a unique characteristic of the operating environment of this offshore industry sector (Figure 3). The total area of CT-SWP deep-sea mining blocks is approximately 2.6 million square km (km2); 2.2 million km2 of that are in the large blocks of the Clipperton Zone (as regulated by the International Seabed Authority ISA). In comparison, the area of the UK is 0.24 million km2; Papua New Guinea is 0.4 million km2; Australia is 7.6 million km2 (WA equals 2.5 million km2); Indonesia is 1.9 million km2; and the EU is 3.4 million km2 (http://data.worldbank.org/indicator/AG.SRF.TOTL.K2)

The Overlap Hotspots between PCAs & MEBs in the South West Pacific (Figure 3) are:

1. S. Central Pacific Gyre - Fiji (northern national waters and eastern EEZ waters); Tonga
2. N. Central Pacific Gyre - Clipperton Zone (large-scale Deep-Sea Mining in international waters)
3. Non-gyral SW Pacific – Vanuatu, New Caledonia

More details on each South West Pacific hotspot - as well as all PCAs, species and habitats included in this study - can be found in the PowerPoint presentation accompanying the report (including research notes for each slide).

The “Coolspots” – Minimal overlap between between PCAs & MEBs

Despite the significant extent of MEB-PCA overlap throughout the CT-SWP regions, it is important to note that there remain large-scale areas with MINIMAL overlap between MEBs and *PCAs.* These “Coolspots” are especially abundant and vast throughout the SWP region, where MEBs are much more limited and clustered in hotspot areas such as the Clipperton Zone and the Bismarck Sea. Thus outside the well-defined SWP hotspots there remain huge areas of no overlap and therefore and we have not listed any specific Coolspots as such.

For the CT the Coolspots are more limited, as MEB-PCA overlaps are more substantial throughout this region. For the CT, seven Coolspots have been identified, all located in deep waters. This may suggest there is a technical reason for the limited oil and gas blocks in these deep waters as of December 2012, but rapid technological advances within the offshore industry will overcome any such limitations within the next five years. CT Coolspots include (Figure 4):

1. Sulawesi Sea – This large and deep sea has minimal MEB activity to date (excluding the western waters bordering Makassar Str/Borneo,which do have extensive overlap).
2. Lesser Sunda - Eastern region (excluding Timor Leste’s southern coasts and the

waters of the Timor Trench, which do have extensive overlap).

3. Banda Sea - This large and deep sea has minimal MEB activity to date (excluding the eastern waters bordering Papua, which do have extensive overlap).
4. N Bismarck Sea
5. N offshore Papua New Guinea
6. Solomon Sea
7. Solomon Archipelago

Sea Lanes and Ship Traffic Density

For the CT in particular, ship traffic is predicted to increase many fold due to the resources boom in Australia (WA and QLD "Resource Routes"), with the supply of gas, oil, coal, bauxite, precious metals, export goods and livestock to Asia cutting through the CT-SWP on a south-north course. In addition, both national and ASEAN regional shipping growth will substantially increase the overall ship traffic density, including medium to small cargo vessels, passenger ferries and a large fishing fleet.

The energy sector component alone will have a major effect on Australia-Asia shipping along both the east and west coasts of Australia and their "innocent passage" routes through the waters of Indonesia, Timor Leste, Philippines, Papua New Guinea and Solomon Islands especially. Intense shipping traffic may bring both acute and long-term impacts including risks to marine life, PCAs and local livelihoods.

The main outcomes of this innovative approach to mapping and quantifying the potential impacts of shipping on PCAs include the following (Figure 5):

1. There is significant overlap of sea lanes with PCAs and MEBs for the CT, much less so for the SWP.

2. Highest densities of ship traffic are in and near narrow yet deep migratory corridors (including use by blue and sperm whales) as both ships and marine life move through the same well-defined inter-island passages.

3. Shipping traffic can cause acute disasters as well as chronic pollution (constant noise, debris, ballast and bilge water discarded along routes), affecting PCAs as well as local community food security and livelihoods.

4. The Australia-Asia "resource route" is part of the energy sector and a major contributor to traffic and is scheduled to increase ten-fold as mega-projects come online in Queensland and Western Australia.

5. The centralized management of ships through the International Maritime Organisation (IMO) may offer an effective management opportunity, with ready-made conservation tools available. IMO's Particularly Sensitive Sea Areas, or PSSAs, are large-scale marine areas in which stricter shipping regulations have been implemented. PSSAs have been identified as a possible mechanism to mitigate many of the potential impacts from international shipping in the CT. National shipping traffic and port development would require separate attention. (PSSAs are also a part of WWF programs in other parts of the world).

The Overlap Hotspots identified for sea lanes are (Figure 5):

1. Lesser Sunda migration corridors: Bali-Lombok, Solor-Alor, Ombai-Wetar Straits and Timor Trench (Indonesia, Timor Leste)
2. Bismarch Sea corridors – Vitiaz Strait and New Ireland Passage (PNG)
3. Blue whale critical habitat in the Banda Sea; offshore New Georgia
4. Makassar Strait (Indonesia) – major overlap with one of areas most *active MEB clusters*

Shipping Lanes overlap with Sperm and Blue Whales Critical Habitat and Migratory Corridors.

The impact of shipping on marine ecosystems and endangered marine life is becoming better understood. This is the first indicative study for the CT-SWP region to quantify areas of overlap between sea lanes and PCAs and identify the hotspots where shipping may impact most on the marine environment (Figure 5). All sea lane sections have been categorized according to documented ship traffic density. Main outcomes are discussed above. Subsequent spatial analyses and scenarios can begin to assess chronic and acute shipping-related threats to PCAs and overlap with endangered species management and blue whales, in particular:

- Direct strikes
- Noise pollution (masking of environmental cues, acoustic habitat degradation)
- Marine pollution from bilge and ballast waters (MARPOL)
- Exhaust emissions (sulphur loading -IMO)

Other shipping impacts upon the marine environment include:

- Accidental ship collisions at sea
- Accidental ship wreckage on coasts (oil spills on reefs)
- New port development – numerous plans for ship support infrastructure have been approved throughout the CT region.

The hotspots are listed in the species section for blue and sperm whales but include the passages of the eastern Lesser Sundas, Indonesia and Timor Leste (including the transboundary Ombai Strait) as well as Vitiaz Strait in Papua New Guinea.

Spatial Analyses: Priority Conservation Areas

Marine Protected Areas and MEBs in the Coral Triangle and South West Pacific.

Several overview maps produced by this study were in fact compiled from the six *country* MPA databases in the CT Atlas, as well as several other web-based data sources such as the IUCN World Commission on Protected Areas website (see Appendix 1 for a full listing of databases used). There is no single regional MPA database or GIS shapefile for *all* MPAs in the Coral Triangle (CT). Reduced counts of MPAs and reduced area coverage within MPAs is evident for Papua New Guinea (PNG) and the Solomon Islands (SI). However, there are numerous Local Marine Management Areas, or LMMAs, which are too small to view at the regional scale. The Philippines is also characterized by numerous small-scale MPAs and two medium-scale MPAs in the Sulu Sea.

Of the 338 MPA polygons we obtained for the six Coral Triangle countries combined, a substantial 14.8% of them (n = 50) have overlapping boundaries with MEBs (Figure 6). The number of MPAs in each of the six CT countries which overlap with MEBs is extremely variable (range 0-100%): PNG and SI have no overlap, Timor Leste and Sabah/Malaysia have total overlap, and for both the Philippines and Indonesia there is considerable overlap (16% and 37% respectively) and potential for conflicting usage.

MPA data for the South West Pacific is harder to obtain and available sources so far list numerous very small MPAs and local marine management areas (LMMAs) which, once plotted on a regional map, would not be visible. Overall, there is less than 1% overlap between MPAs and MEBs in the SWP. This is due to the oceanic nature of the deep-sea mining block locations.

MPA – MEB overlap renegotiated to 0%: A case study from West Papua, Indonesia

It is important to note that in certain areas of the CT actions have been taken to reduce the overlap between PCAs and MEBs. As of 2012, Conservation International has initiated negotiations in Kaimana, Papua, with both district government and industry stakeholders with the common goal to reduce the extreme overlap of oil and gas blocks with the local MPA network. There has been significant progress and changes have been approved to the boundaries of both MEBs and shallow turbid-water sections of the MPA network, so that in the near future the Kaimana/Triton Bay MPA network will not be included in any MEBs. The exceptional biodiversity of these waters, together with high biomass, as well as the important habitats for Bryde's whales and coastal cetaceans and dugong in Triton Bay, were all important conservation values which convinced both government and industry that a revised spatial plan was justified, with the aim to ensure 0% overlap.

Tuna High Catch Areas and MEBs

The Coral Triangle tuna industry is worth close to 1 billion USD annually (WWF 2012 brochure on Tuna in the Coral Triangle). The Tuna High Catch Areas (THCAs) are some of the largest-scale polygons used in this study (Figure 7) and derived from five key reviews which all identify the same or similar regions as THCAs (see tuna reference section). Catch volumes for the three species targeted (yellow-fin, big-eye and albacore tuna) within the CT and SWP waters are exceptionally high on a *global scale.* All of the major THCAs have substantial overlap with MEBs, both oil and gas and deep-sea mining blocks. The THCA-MEB overlap hotspots identified are (Figure 7):

1. Bismarck Sea - 35%
2. SW Sulawesi Sea - 7.7%
3. Palawan/N Borneo - W Sulu Sea - 31.2%
4. W Banda Sea (overlap expected in next 1-5 years)

The region of maximum overlap is located in the Bismarck Sea, northern PNG. This overlap is almost entirely due to deep-sea mining leases. In addition there is a relatively new large-scale oil and gas block released off the northern mainland near the Indonesia / PNG EEZ border. Significant overlap is also apparent in the south-eastern waters of the Sulawesi Sea (towards the Derawan-Berau region) and the western and northern waters of the Sulu Sea.

For the top three of the hotspots the polygons are an approximation of the areas. This is because for these areas the relative catch figures from various sources are displayed so prominently (as CPUE or other catch units are all well above global averages) that they almost completely overlap and blot out the coasts and islands as geographical reference points. This is not expected to affect the outcomes of this indicative spatial analysis.

The potential impacts of MEB activities on the catch rates and market value of the tuna fisheries could be significant (i.e., habitat displacement of tuna affecting catches; perceptions of pollution or contaminated fish reducing export demand after an oil spill or accident). Thus this overlap may have far-reaching ramifications for long-term food security and coastal livelihoods throughout the Coral Triangle, especially in case of a large-scale accidental oil spill from a deep-sea well blow out (see the spatial scenario of the presentation for more details).

Spatial Analyses: Habitats

Coral Triangle Reefs and MEBs

The area of coral reefs that overlap with Oil & Gas and mining blocks equals 13,726 km2 or 21.8% of all reef area in the Coral Triangle, and less than 1% of reefs in the SW Pacific. When the Reefs at Risk 2011 (R@R) reef health status data are incorporated in the CT analyses of reef areas with Oil & Gas and mining overlap, then the percentages of overlapping reef area by health status are as follows:

- 6.03% is low threat status;
- 64.72% is medium threat status;
- 21.44% is high threat status;
- 7.81% is very high threat status.

Thus over 70% of the areas of reefs that are overlapped by oil, gas, and mining blocks in the CT are made up of low to medium threat levels – that is, relatively healthy reefs – while nearly 30% (or approximately 4,000 km2) of the CT reefs that are overlapped by MEBs have high or very high threat status. While there has been some allocation for offshore activities in the Reefs at Risk data, the actual contribution of oil and gas to the overall threat level is not available.

A preliminary analysis as presented above, coupled with several close-up maps of key regions where overlap is maximal (Figure 8) indicates that oil and gas does *not* have a clear impact on reef health status. In fact many low threat and medium threat reefs are located within the hotspot regions identified. **Thus there is an opportunity to ensure that any oil and gas activities in the future do not negatively impact the relatively good health status of nearby reefs.**

SW Pacific Reefs and MEBs

Significant and high biodiversity reef ecosystems do occur along many SWP Islands. However, reef habitat ratios for these vast provinces are minimal (less than 1% of the total

SWP area) due to the oceanic characteristics of the SW Pacific. Even so, for two Provinces - Non-Gyral SW Pacific and South Central Pacific Gyre - the overlap of reefs and MEBs is 5%, which is substantial. Reef and MEB overlap in the other 4 SWP provinces is minimal to zero. The overlap hotspots include:

1. South Central Pacific Gyre – Fiji 4.75% and 957.7 sq km reef area
2. Non-gyral SW Pacific – 5.4 % and 457.7 sq km

Note on SW Pacific Provinces: These are extremely large-scale marine provinces. Three of these have 50-60% of their areas classified as Priority Conservation Areas: E Tropical Pacific (58%), Equatorial Pacific (63%) and Non-gyral SW Pacific (49%). Another two provinces (South Central Pacific Gyre and Tropical Convergence) have 23% and 33%, respectively, classified as PCAs. Oil and gas blocks are largely absent from this region; all MEBs are deep-sea mining tenements except for an oil and gas area along the Gulf of Papua on the S-SW coast of PNG.

Migration corridors and MEBs

Migration corridors (n=60) provide access to the CT region from both the Pacific and Indian Oceans. These relatively narrow yet deep inter-island passages are critical habitats for blue and sperm whales and other large marine life (Kahn 2006, 2008, 2009a, 2012) as well as whale sharks (M. Meekan, pers.comm). Although this study found that several important corridor sites are not overlapping with MEBs (Solor-Alor/Savu Sea; New Ireland; Northern Solomon Island passages including Indispensible Strait; and the main corridors into the Sulawesi sea off Northern Sulawesi and Mindanao respectively), substantial interaction does occur, with an overall 25% of corridors overlapping with MEBs (Figure 9). The identified hotspots of migration corridor-MEB overlap include:

1. Lesser Sundas - Timor Leste - 7.5%
2. Makassar Strait - 42.4%
3. Papua - 59.3%
4. Palawan/N Borneo – Sabah - 67.7%
5. Bismarck Sea – 46.9% (Vitiaz Strait, New Ireland)

Migration Corridors and MEBs per CT country:

Indonesia and Timor Leste

- The major blue whale corridors of the Lesser Sundas are not overlapping with MEBs (i.e. Solor – Alor region; Ombai and Wetar Straits); however the Timor Trench blue whale corridor has significant overlap with active MEBs all along the Timor Leste south coast and southern EEZ which borders Australian waters (including the joint production areas such as Sunrise).
- The Indo-Pacific corridor of the Makassar Strait has maximum overlap with MEBs including the Balikpapan region.
- The migration corridor of Papua, Dampier Strait, has maximum overlap with MEBs.
- The corridor off Buru/Ceram sea has considerable overlap with MEBs.

Sabah and the Philippines

Both corridors of the southern Sulu Sea (Sabah) have maximum overlap with MEBs

Papua New Guinea and the Solomon islands.
The main migratory corridor for PNG (and the AU - Pacific gateway Vitiaz Strait) has maximum overlap with MEBs allocated to deep-sea mining activities. This also applies, to a lesser extent, to the major Solomon Island corridor.

Seamounts, Canyons and MEBs

These habitats are important for oceanic cetaceans, large migratory marine life, billfish, tuna and food security (i.e. seamounts with enhanced tuna catches). The CSIRO seamount and canyon data supplied was limited to 118 degrees east. Thus a small section of the western Coral Triangle is missing from this study (see data gaps section in report for more information). The maximum depth gradients and exceptional “near-shore yet deep-sea” habitat characteristics of the CT (Figure 10) and the opportunities to integrate these habitats with MPA networks is further detailed in Kahn 2008 and Kahn 2012.

The main areas of overlap between seamounts and canyons and MEBs are located on the northern and southern coasts of the PNG mainland (oil and gas blocks); off Raja Ampat and Kaimana; south-western Sulawesi; and Derawan and the southern Sulu Sea. Seamount and canyon overlap hotspots, respectively, include:

1. Bismarck Sea - 45.3% & 31.1%
2. Solomon Archipelago - 11.6% & 4.2 %
3. North Borneo/Palawan - 37.3% & 53.5%
4. Papua - 0.1% & 37.1%

Interestingly, large regions with an abundance of seamounts and canyons still occur without overlap with MEBs: northern Sulawesi, Savu Sea, the Ambom-Buru complex in the Banda Sea, north and central Philippines and most of the southern archipelagic islands of PNG and the Solomon Islands.

Spatial Analyses: Species

Green turtle offshore habitats and MEBs

Data for green turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) offshore foraging habitat areas was provided by WWF Indonesia. The overlap between green turtle habitats and MEBs is extensive throughout the western CT but much less so in the remainder of the study area. Maximum overlap occurs in these hotspots (Figure 11):

1. Northeast Sulawesi - 79.1%
2. Palawan/N Borneo - Sabah and the western Sulu Sea off Palawan - 64.9%
3. Makassar Straits – Derawan - Berau region (also a major nesting site of regional importance) - 31.1%
4. Papua, including Kaimana and Raja Ampat and Cendrawasi Bay - 28.2%
5. Banda Sea – scattered within the ecoregion including the northern waters of the Arafura Sea, Tanimbar, Aru and Kei isle - 24.8%

The preferred and critical habitats have minimal overlap with MEBs in the central and western Banda Sea, Flores Sea and Savu Sea.

Data on nesting beaches and migratory routes including satellite tracks (obtained through a WWF-SWOT [State of the World's Sea Turtles] agreement for limited use by WWF) could also be included as an additional layer but have been omitted as they already overlapped with the green turtle habitat polygons. Nesting beaches would not have any direct overlap with MEBs, as they are all land-based, however nesting beaches should be included in future buffered spatial analyses so that potential impacts from an oil spill or other accident at a range of distances away can be modeled and assessed.

Leatherback turtles and MEBs

The overlap between leatherback turtle offshore habitats and MEBs is limited throughout CT, especially when compared to the green turtle. However, it occurs near two types of priority habitats for the critically endangered Pacific population, nesting beaches and corridors. Significant overlap occurs in these hotspots:

1. Banda Sea- Kei - 42%
2. Bismarck Sea - 27.1%
3. Papua Ecoregion - 21.1% (Raja Ampat and Cendrawasi Bay)

It is important to note that in the Banda Sea's major foraging ground for leatherbacks - Kei Island located at the northern waters of the Arafura – a total of 42% of this priority habitat overlaps within MEBs. The data for PNG indicates some overlap with MEBs occurs in the vicinity of Vitiaz Strait. On the other hand, the preferred and critical habitats of the central and western Banda Sea, Flores Sea and Savu Sea have minimal overlap with MEBs.

Data for leatherback turtles was provided by WWF and a WWF-SWOT data agreement for limited use. The data included information foraging habitats and migratory routes including satellite tracks. Nesting beaches could also be included here as a data layer.

IMMAs – Important Marine Mammal Areas

Dugong and MEBs – A proxy for species with wide-ranging coastal distributions

The IUCN Redlist.org data bank includes distribution maps for many species of marine mammals. However, these distribution maps are often "wall to wall" within the region and thus not meaningful for our project. However, several marine mammal species with limited regional distributions were available from the IUCN site, including coastal species such as the dugong (*Dugong dugon*) and the Indo-Pacific humpbacked dolphin (*Sousa chinensis*). For this study, the dugong was selected. The dugong is an herbivorous sea cow and has a broad coastal distribution throughout the CT, and to a lesser extent in the SWP region (according to the IUCN data base). As such this species can be considered a proxy for other widely-ranging yet coastal species and the overlap of such species with MEBs. Once more fine-scale habitat data becomes available for coastal marine mammals it will be relatively straight-forward to amend this indicative overlap map.

Even with such broad-scale and general distribution data, it becomes very clear that the dugong could be severely affected by MEBs as there as numerous, extensive and maximum overlap areas in both the CT and SWP, but especially in these CT ecoregions (Figure 12):

1. Papua - 54.2%
2. Makassar Straits/Palawan/N Borneo - 59.2%
3. NE Sulawesi - 62.5%
4. Banda – S Sulawesi - 31.7%
5. Bismarck Sea - 37%
6. Solomon Sea - 19.3 %

Overall, the major dugong-MEB overlap areas include the waters of several nations including:

- Indonesia
    - Papua Barat, including Kaimana, Bintuni bay, Raja Ampat and Cendrawasi Bay
    - West Timor
    - South Sulawesi
    - Both coastal sides of the southern Makassar Strait
    - Central Sulawesi especially Tomini Bay
- The complete eastern coast of Borneo, spanning both Indonesian and Malaysia (Sabah).
- Timor Leste
    - All southern coastal regions of Timor Leste
- PNG
    - Coastal regions of N and SE Papua New Guinea
- Philippines
    - Palawan all coastal areas

Sperm whales and MEBs

This unique analysis of sperm whale (*Physeter macrocephalus*) overlap with MEBS spans over 200 years. It is based on the historical sperm whale catch data from the 19th Century Yankee whaling fleet, as first mapped by Townsend 1935, and then intersected with the 21st Century offshore industry data layer generated by this study. The overlap hotspots include:

1. Palawan/ N Borneo, especially W Sulu Sea - 53.1%
2. Bismarck Sea, especially N coast PNG - 28%
3. Banda Sea - 16.5%

The PNG hotspot has been identified as an exceptional oceanic PCA. It extends north for several hundred kms, and becomes part of the largest 19th C sperm whale catch area for the whole CT-SWP region. Sperm whales can function as a general proxy for deep-diving toothed cetaceans, and the MEB related ocean noise issues that may impact them as a group, including seismic surveys. This PCA is also includes a vast seabird IBA and elevated tuna catches. The project's recommendation on fieldwork states that this oceanic hotspot needs to be further investigated.

Coolspots, areas with high sperm whale catches and minimal MEBs overlap, include:

1. N Banda Sea - Obi
2. Solomon Sea

3. Top N Waigeo and N offshore Bird's head

Blue whales and MEBs: A fascinating case study

The blue whale (*Balaenoptera musculus*) is the largest animal that ever lived on Earth and is classified as an endangered species. Although highly migratory, these whales spend a considerable period of time (i.e. 2-3 months) within CT waters.

The southern hemisphere migration patterns within the region have only recently become better understood; (pygmy) blue whales migrate from the Southern Ocean to Australia (W and E coast) and to the Coral Triangle - Indonesia and Solomon Islands (Kahn 2006b). Different calling patterns suggest an E-W and thus Indian vs. Pacific Ocean population boundary at Tasmania (McCauley, R. pers. comm).

Part of the the Indian Ocean pygmy blue whale population migrates along the western Australian coast towards the Savu Sea (Double et al. 2012), and passes through the critical Lesser Sunda migration corridors (Kahn 2006a, 2009b; included in this study as a separate spatial data layer). These whales make their way into Indonesia's Banda Sea (Kahn 2005, 2007, Double et al. 2012) where they travel extensively and may remain for 2-3 months. The Banda Sea is the destination of this large-scale migration route and is suspected to be a breeding and/or calving area (Kahn 2007, 2009b, Double et al. 2012). If confirmed it would be one of the few blue whale critical habitats of this type that are known worldwide.

Despite the data deficiency on this species throughout the Indo-Pacific, several blue whale – MEB overlap hotspots were identified (Figure 13):

- Solomon Sea (16.6%)
- Solomon Archipelago (5.8%)
- Banda Sea (0.7%)

The overlap of critical blue whale habitats with MEBs incudes BOTH types: Oil and gas blocks (Indonesia) and Deep-Sea Mining blocks (SI). For the Solomon Islands the exact habitat use needs to be confirmed (Kahn, B. 2006b and P. Gill, pers. comm.).

Recent blue whale strandings in Sabah, Malaysia, may indicate significant overlap between blue whale habitat and MEBs in this very active offshore region as well, but more ecological research on blue whales needs to be conducted in these Malaysian waters to better understand any interaction. For Indonesia, additional threats to blue whales include shipping (the "*AU-ASIA resource routes and international* sea lanes which overlap with corridors and migratory destination habitats), fisheries interactions including net entanglements and reef bombing (Kahn 2009a).

PCA & MEB overlap: Socio-economic implications

Although this project's primary focus is to investigate overlap between conservation values and offshore industries – MEBs and international shipping - it has identified potential risk from MEBs to other marine industries, food security and livelihoods for local communities. For the Coral Triangle in particular, MEBs overlap substantially with:

1. Maritime transport – international sea lanes and ship traffic density,
2. Tuna fisheries
3. Nature-based tourism destinations

In certain areas a high risk for impact is possible, both from chronic as well as acute scenarios. One such spatial scenario included in this study, and described below, is of a large-scale oil spill from a deep-well blow out, to examine and illustrate the devastating consequences of such a disaster. Due to the limited time span and resources of the project, the major issues for MEB overlap with food security and livelihoods are noted for further analysis in the recommendation section of this report.

Spatial scenario: A large-scale oil spill by a deep well blow-out affects three different industry sectors and interest groups (fisheries, tourism conservation).
Scenario brief: A scenario that all stakeholders want to avoid.

A blow out of a deep-water oil well or rig (wellhead platform) would be one of the worst-case scenarios for PCA overlap with MEBs. Technically challenging to fix for even advanced nations, the resulting large-scale spill would last for months with devastating environmental and socio-economic consequences. It is the scenario that all stakeholders want to avoid through careful project planning and strict adherence to operational regulations.

Yet in the last three years both the USA and Australia have experiences their worst oil spill disasters to date (Deepwater Horizon and Montara respectively). The Montara oil spill of NW Australia's Timor Sea entered the Indonesian EEZ (Savu Sea) and was thus a transboundary marine pollution event. As a result of the socio-economic and environmental damages, and the widespread public condemnation of these accidents, some national regulators have introduced far-reaching new legislation and stricter operational regulations for the offshore energy industry.

In the CT-SWP there is no capacity at all to contain a spill, or attempt to fix a deep-water well blow-out. Thus prevention is the only viable strategy to manage this risk. The three scenarios for an oil spill are selected to include three different industry sector and interest groups (fisheries, tourism, conservation), are in areas recognized globally for their unique yet different values and have MEBs nearby (Figure 14).

Scenario 1 - Sulu Sea: tuna hotspot

- A major tuna fishing area; real or perceived contamination of tuna in this scenario would devastate the industry worth nearly one billion USD.

Scenario 2 – Bali: tourism hotspot

- One of the major tourism attractions of the region, depending in large part on clean beaches and marine tourism (the oil spill "handle" extends towards Komodo National Park).

Scenario 3 – Raja Ampat: MPA Network and marine conservation hotspot

- A marine protected area network and conservation priority of global significance.

The Bali scenario has a realistic context: A significant oil and gas field is under development in waters just to the north of the island and this field coincides with one of the busiest shipping lane sections of the region as well. The other two areas have been identified as MEB hotspots in this project already.

The oil spill polygon is based on the size and shape of the Deepwater Horizon oil spill from the website: http://www.ifitweremyhome.com/disasters/bp, and estimated 2015 population data are from the Center for International Earth Science Information Network (CIESIN) at Columbia University. Directly affected population estimates for 2015 range from:

- Sulu Sea - 185,603 people directly affected (a relatively large population number for a spill in an open sea environment)
- Raja Ampat - 281,469 people directly affected (mostly remote local communities, some urban centres)
- Bali - 7,960,550 people directly affected (Bali, Lombok, parts of Sumbawa and moving towards Komodo National Park)

These numbers of *directly affected* people living in coastal communities give a clear indication on how technically challenging, costly and extremely damaging such a pollution event would be to:

1. Fisheries - Food security
2. Local livelihoods
3. Marine wildlife in oil spill region
4. Marine conservation programs (including high priority sites, MPA networks and long-term investments already made).

More comprehensive analyses of these and other scenarios (e.g., effects of extreme weather events; risk mitigation effects if certain no-go oil and gas zones were implemented for example) could not be conducted due to the time constraints of the project, but may be added as a follow-up.

Spatial Analyses: EEZs

Overview by CTI Implementation Area and individual member states (CT6).

Industry Summary

MEBs (Marine Extraction Blocks): Oil & Gas and Deep-Sea Mining combined.

Overall 17.4% of the total Implementation Area of the Coral Triangle has oil, gas or deep-sea mining leases assigned to it (Figure 15). This is split between oil and gas (15.5%) and deep-sea mining (1.9%) blocks. The range between CT6 countries varies between 4.2%-73.2% of waters under national jurisdiction (incl. EEZ) covered by MEBs (Appendix 3, Table 1). Deep-sea mining deserves a special mention as it is a new industrial activity worldwide, and is currently being trialed in Coral Triangle eastern waters.

Considering the vast area of the combined national and EEZ waters of the six CT countries (the geographical Implementation Area of the Coral Triangle Initiative spans over 12,319,658 km^2), the marine spatial footprint of the offshore energy sector is a significant percentage of CT waters as well as actual area leased to date: 2,138,310 km^2.

The two types of offshore energy extraction blocks have a distinctly different distribution: Oil and gas block dominate the western waters of the CT; there are no deep-sea mining tenements at all in Indonesia, Malaysia, Timor Leste and Philippines.

On the other hand, the eastern waters of the CT are dominated by deep-sea mining MEBs. The CT's eastern-most country, the Solomon Islands, has no oil and gas blocks in its waters at all. Papua New Guinea holds a unique position worldwide in that its waters include oil and gas leases (by far the dominant type by percentage and area) as well as deep-sea mining tenements. Hence, PNG is the only country in the offshore industry where any potential cumulative effects of these two activities on the marine realm can be anticipated.

The field development and operational activities of the offshore extractives sector have numerous interactions with the marine environment and may have a high risk of potential impacts on certain species and habitats, especially in regions of extensive overlap between priority conservation areas and marine extraction blocks (Figures 16-22). Tables 1 and 2 in Appendix 3 provide summaries of this overlap, both per country and per PCA.

International Sealanes and Shipping Density.

For international shipping the CT lies in the heart of a rapidly expanding economic region. With access to both the Indian and Pacific Ocean routes it is no surprise maritime transport is a prominent stakeholder of CT's marine use (Figure 18). The north-south axis of the CT is dominated by energy-related trade between Australia and Asia (the 'resource route' – see below). Ship traffic consists mostly of bulk carriers and tankers, as well as general cargo and livestock shipments. The east-west axis of the CT is dominated by vessels heading to or from Singapore – one of the busiest ports in the world.

Overall, shipping lanes cover 10.4% of the total Implementation Area of the Coral Triangle. The range between CT6 countries varies between 2.1 - 30.5% of waters under national jurisdiction (incl. EEZ) covered by international sea lanes (Table 1).

Considering the vast area of the combined national and EEZ waters of the six CT countries (the geographical Implementation Area of the Coral Triangle Initiative spans over 12,319,658 km^2), the marine spatial footprint of the international sealanes sector is a significant percentage of CT waters as well as actual area: 1,278,576 km^2 (excluding regional and national shipping, some other limitations as explained below). Furthermore, nearly 21.3% of the total CT sealanes area (272,155 $km^{2)}$ runs through MEBs. This overlap indicates there is a relatively high potential for interactions between these offshore industry sectors.

Finally, over 1/4 of the total sealanes area directly overlaps with PCAs (28.8%) of the CT (Figures 18-22). This significant overlap is a strong indication of the high potential for risks posed by shipping on PCAs, especially in regions with even higher proportions of overlap. It is important to note that the impacts of sealanes on PCAs emanate far beyond the ship's actual tracks. While ship strikes are a direct and often deadly impact for species such as whales and turtles, other impacts such as chronic pollution of legally discharged oil and ballast waters under MARPOL along the sealanes (Halpern et al. 2008) as well as ocean noise (Kahn and McCauley pers.comm) disperse wide and deep throughout the CT regions with the highest shipping densities.

International vs. regional and national shipping activity

The sealanes and shipping densities mapped in this report are a known and significant *underestimate.* The data source – one of the few global studies on sealanes and shipping impacts on the marine environment (Halpern et al. 2008) - is from 2004-2005 and is based on a voluntary reporting scheme that has since been stopped. This limitation is further detailed in Halpern et al. (2008). In addition to the underestimate of international shipping, we have not included any regional or national shipping routes, nor have we accounted for regional or national shipping density, as such data were not available.

For Indonesia, a country which has close to 6,000,000 km^2 of sea space - almost half of all CT waters – the registered shipping fleet is estimated to increase 20-fold in the next 2-3 years as new legislation on strict national flag requirements for all vessels operating in Indonesian waters come into full effect. In addition, the complex maze of the main Indonesian inter-island shipping lanes is well illustrated by the routes of the national Pelni ferry service, which is still regarded as an important lifeline for remote provinces (Figure 23).

Accurate data on national and regional shipping in the CT is not available from a centralized agency. Thus a considerable effort is recommended to source and analyze the regional and national shipping components within the CT, as inter-island trade within two of world's largest archipelagic states, as well as increased ASEAN trade and booming ASEAN –China sea commerce, would have significant impact on both the routing and ship density throughout the CT.

Despite these limitations, the sealanes digitized and quantified in this study remain the major routes used by all international ships. Although the volume of traffic will have increased manifold since the mid-1980's, the spatial overlap analyses with PCAs remain valid and provide crucial insights on shipping hotspots in the CT. The key potential impacts areas identified will be even more pertinent for adequate mitigation and management attention today.

Cruise ships

Cruise ships increasingly ply the waters of the CT. Although these vessels will not add significantly to shipping density, the characteristics of the cruise business means these vessels have the potential to cause substantially more impacts per voyage than cargo vessels:

- The natural 'wilderness' values promoted in cruise itineraries means these ships routinely include stopovers at sites that have numerous PCAs.
- Coastal sightseeing increases risk of a grounding
- Several thousand passengers and crew living on board for extended periods leads to waste management and disposal challenges.

<u>Country summaries</u>

<u>Indonesia</u>

Industry summary

The 5,970,398 km^2 of sea area under Indonesian jurisdiction (national and EEZ boundaries) make up almost half (48.5%) of the Coral Triangle Implementation Area. Overall, Oil and Gas MEBs cover 17.2% and Deep-Sea Mining 0% (Figure 15). Indonesia's MEBs have considerable overlap (19.4%) in total area with PCAs (Figures 16-22). This corresponds to a vast area for the CT, and is a strong indication that offshore activities can impact on marine conservation priorities on an eco-regional scale.

While this percentage of territorial waters in MEBs is close to average for the CT (17.4%), Indonesia stands out in the total size of the areas already assigned to offshore energy exploration and production, which is unrivalled in the CT: to date over 1 million km^2 of its sea floor has been licensed as oil and gas blocks. This coverage will expand substantially as Indonesia is aggressively working to revitalize its own oil and gas production in the coming years (it was a former member of OPEC but is now importing most of its energy supplies).

For sea lanes and shipping density, Indonesia has a unique geographical position as it includes both the Indian and Pacific Ocean shipping routes (Figure 18). The N-S axis of the CT is dominated by energy-related trade between Australia and Asia and the majority of this traffic runs through the eastern waters of the archipelago. Hence, Indonesia is a prominent stakeholder of the CT marine transportation network and its waters are extensively used by international ships in transit (i.e., "innocent passage").

A high proportion of the total area of the sea lanes in Indonesia (23.4%) overlaps with the country's PCAs, including extensive overlap with specific PCAs such as marine corridors and green turtle habitat (Figures 18-22). Furthermore, 18.0% of sealanes run through the country's MEBs, which is a relatively high level of potential interactions between these two offshore industry sectors.

Summary of Indonesia PCA-MEB overlaps (see also Appendix 3).

The spatial analysis for the Indonesian waters highlights the following overlap hotspots between MEBs and PCAs (over 20% or/and 500,000 km^2 in bold; CT maxima are underlined in *italics*). Due to Indonesia's vast overlap areas this list is more extensive than most other CT6 countries:

Analysis (based on spatial overlap in $km^{2)}$	Percentage overlap	Area overlap km^2	Comments
Oil and gas - overlap with all waters	17.2	***1,028516***	
Sealanes - overlap with all waters	10.2	***609,131***	
All PCAs - overlap with all waters	15.6	***931,211***	
All PCAs - overlap with oil and gas	**21.5**	*199,802*	
All PCAs - overlap with sealanes	15.3	*142,204*	
MPAs - overlap with oil and gas	17.1	*27,998*	
MPAs - overlap with sealanes	6.4	*10,478*	
HABITATS			
Reefs – overlap with oil and gas	18.6	*6,390*	
Reefs – overlap with shipping	4.7	*1,610*	
Tuna high catch area – overlap with oil and gas	2.3%	4,835	
Seamounts – overlap with oil and gas	3.6%	**10,906**	
Canyons - overlap with oil and gas	**26.3**	5,797 (km)	
SPECIES			
Green turtle habitat - overlap with oil and gas	**20.7**	*331,337*	
Green turtle habitat - overlap with sealanes	8.7	*139,101*	
Leatherback turtles – overlap with oil and gas	14.7	*40,913*	
Leatherback turtles – overlap with sealanes	1.4	4,013	
Dugong – overlap with oil and gas	**27.7**	***539,253***	
Dugong – overlap with sealanes	8.5	*165,250*	Proxy for widely distributed coastal spp.
Sperm whales – overlap with oil and gas	15.7	70 (count)	
Sperm whales – overlap with sealanes	9.4	42 (count)	Based on historical catches
Blue whales – overlap with oil	0.7	1,873	

and gas			
Blue whales – overlap with sealanes	7.67	***<u>21,202</u>***	
KEY INDUSTRY PERSPECTIVES			
Oil and gas – overlap with all PCAs	19.4		
Oil and gas – overlap with marine corridors	16.4		
Shipping – overlap with all PCAs	**23.4**		
Shipping – overlap with Green Turtles	**22.8**		
Shipping – overlap with marine corridors	**22.3**		
Shipping – overlap with oil and gas	18.0		

<u>The Philippines</u>

Industry summary

The 1,828479 km^2 of sea area under Philippines jurisdiction (national and EEZ boundaries) make up 14.8% of the Coral Triangle Implementation Area. Overall, Oil and Gas MEBs cover 15.3% and Deep-Sea Mining 0% (Figure 15). This percentage is close to average for the CT (17.4%), and is mostly located in the Sulu Sea and waters surrounding Palawan. The Philippine's MEBs have maximum overlap (40.5%) in total area with PCAs, a strong indication that offshore activities can impact on marine conservation priorities (Figures 16-22).

For sea lanes and shipping density, the Philippines has an important geographical position as the majority of vessel traffic to and from Asia (Japan, Korea, China) passes very close along both the W and E coasts of islands facing the Pacific Ocean and South China Sea (Figure 18). In addition, the northwestern boundary of its EEZ includes a section of the Singapore – Asia shipping route which is one of the busiest in the world. Thus, the Philippines' coasts that are facing open ocean have some of the densest shipping traffic in the CT, all passing nearby or overlapping with coastal PCAs such as reefs (Figure 20). These sea lanes hold inherent risks of grounding and also increase the likelihood of any spill resulting from a shipping accident at sea reaching its outer shores. This risk is amplified by the dangerous weather systems such as typhoons that frequently hit this region.

A substantial proportion of the total area of the Philippines sealanes (14.8%) overlaps with the country's PCAs (Figures 18-22). Furthermore, 18.3% of sealanes run through the country's MEBs, and which is a relatively high level of potential interactions between these offshore industry sectors.

Summary of Philippines PCA-MEB overlaps (see also Appendix 3).

The spatial analysis for Philippine waters highlights the following overlap hotspots between MEBs and PCAs (over 20% or/and 500,000 km^2 in bold; CT maxima are underlined in *italics*).

Analysis (based on spatial overlap in km^2)	Percentage overlap	Area overlap km^2	Comments
Oil and gas - overlap with all waters	15.3	279,971	
Sealanes - overlap with all waters	14.8	271,176	
All PCAs - overlap with all waters	**22.7**	415,252	
All PCAs - overlap with oil and gas	**27.3**	113,412	
MPAs – overlap with oil and gas	8.6	809	
HABITATS			
Reefs – overlap with oil and gas	**29.6**	59,818	
Tuna high catch area – overlap with oil and gas	**21.5**	4,835	
Corridors – overlap with oil and gas	**28.8**	41,674	
Corridors – overlap with sealanes	***20.8***	30,130	
Seamounts – overlap with oil and gas	8.9%	18,549	
Canyons - overlap with oil and gas	**22.7**	1,782 (km)	
SPECIES			
Green turtle habitat - overlap with oil and gas	**51.3**	50,168	
Green turtle habitat - overlap with sealanes	19.7	19,303	
Dugong – overlap with oil and gas	**26.9**	175,890	Proxy for widely distributed coastal spp
Dugong – overlap with sealanes	11.5	75,122	
Sperm whales – overlap with oil and gas	**35.4**	61 (count)	Based on historical catches
Sperm whales – overlap with sealanes	12.2	21 (count)	
KEY INDUSTRY PERSPECTIVES			
Oil and gas – overlap with all PCAs	19.4		.
Shipping – overlap with all PCAs	**23.35**		
Oil and gas – overlap with all	**40.1**		

PCAs			
Oil and gas – overlap with MPAs	8.6		
Oil and gas – overlap with shipping	17.7		
Shipping – overlap with all PCAs	**20.0**		
Shipping – overlap with Dugong	**27.7**		
Shipping – overlap with marine corridors	11.1		
Shipping – overlap with oil and gas	18.2		

<u>Malaysia</u>

Industry summary

The 449,701 km^2 of sea area under Malaysian jurisdiction (national and EEZ boundaries) makes up 3.7% of the Coral Triangle Implementation Area, yet it has maximum overlap with both offshore energy and shipping. Overall, Oil and Gas MEBs cover 73.2% and Deep-Sea Mining 0% (Figure 15). Malaysia's MEBs have a medium level of overlap (11.0 %) in total area with PCAs (Figures 16-22), which indicates that offshore activities can impact on marine conservation priorities, especially in waters of Borneo where offshore projects are concentrated (see below).

Malaysia is the CT frontrunner in developing its oil and gas resources with "the majors": multinational oil companies such as Exxon Mobil, Eni, Statoil, Chevron, BP, Shell and ConocoPhilips - the latter two alone are currently investing billions of dollars in projects off NE Sabah. The industry activities are mainly focused in the waters off Sabah, Borneo. Projects are varied and include several large-scale deep-sea field developments in depths over 1500m with complex subsea installations for production wells located more than 100km offshore.

For sea lanes and shipping density, Malaysia has an important geographical position as the majority of vessel traffic from the extremely busy route to and from Singapore (to Japan, Korea, China) passes along the Malaysian mainland and Borneo (Sabah and to a lesser extend Sarawak) (Figure 18). Also for this offshore industry sector the overlap is extreme: close to half of the total area of the Malaysian sealanes (49.3%) overlaps with the country's PCAs (Figures 18-22). Furthermore, 54.4% of sealanes run through the country's MEBs, which is the highest level of potential interactions between these offshore industry sectors in the CT.

Summary of Malaysia PCA-MEB overlaps (see also Appendix 3).

The spatial analysis for Malaysian waters highlight the following overlap hotspots between MEBs and PCAs (over 20% or/and 500,000 km^2 in bold; CT maxima are underlined in *<u>italics</u>*).

Analysis (based on spatial overlap in km²)	Percentage overlap	Area overlap km²	Comments
Oil and gas - overlap with all waters	***73.2***	328,991	
Sealanes - overlap with all waters	***30.6***	137,375	
All PCAs - overlap with all waters	**32.7**	783,881	
All PCAs - overlap with oil and gas	**45.2**	36,266	
All PCAs - overlap with sealanes	***49.3***	39,548	
MPA – overlap with oil and gas	***47.0***	619	
MPA – overlap with sealanes	**48.5**	639	
HABITATS			
Reefs – overlap with oil and gas	***68.0***	1,838	
Tuna high catch area – overlap with oil and gas	***43.7***	835	
Corridors – overlap with oil and gas	**48.6**	35,890	
Corridors – overlap with sealanes	***52.9***	39,003	
Seamounts – overlap with oil and gas	***73.6***	1,191	
Canyons - overlap with oil and gas	***91.3***	746 (km)	
SPECIES			
Green turtle habitat - overlap with oil and gas	***53.0***	27,196	
Green turtle habitat - overlap with sealanes	**34.5**	17,724	
Dugong – overlap with oil and gas	***55.7***	94,343	Proxy for widely distributed coastal spp.
Dugong – overlap with sealanes	***34.3***	58,165	
Sperm whales – overlap with oil and gas	***79.1***	19 (count)	Based on historical catches
Sperm whales – overlap with sealanes	16.7	4 (count)	
KEY INDUSTRY PERSPECTIVES			
Oil and gas – overlap with all PCAs	11.0		.
Oil and gas – overlap with shipping	**22.5**		
Oil and gas – overlap with Green Turtle	8.3		
Oil and gas – overlap with	**28.7**		

Dugong			
Shipping – overlap with all PCAs	**28.8**		
Shipping – overlap with oil and gas	***<u>54.0</u>***		
Shipping – overlap with Dugong	**42.3**		
Shipping – overlap with marine corridors	**28.4**		

<u>Timor Leste</u>

Industry summary

Timor Leste has 74,827 km^2 of sea area under its jurisdiction (national and EEZ boundaries), which makes up 0.6 % of the Coral Triangle Implementation Area. Timor Leste has the smallest sea area of any nation in the CT, yet it has extensive interests in both offshore field development for oil and gas (including joint production agreements with Australia) (Figure 15) as well as shipping (Figure 18). To date over 72.3% of its sea floor has been licensed as oil and gas blocks, and this percentage is well the average proportion of EEZ area for the CT6 (17.4%). This maximum coverage may expand substantially as Timor Leste will further develop its oil and gas potential in the coming years. More than half of TL's MEBs acreage (55.8%) overlaps with PCAs (Figures 16-22), with marine corridors being especially exposed to potential impacts from oil and gas as well as shipping.

For sea lanes and shipping density, Timor Leste has a unique geographical position as it includes important international sealanes along 100% of its coasts on both sides of the country and cover 7.7% of national and EEZ waters (Figure 18). Timor Leste waters get a disproportionally large amount of vessels traversing the N-S axis of the CT. This shipping activity is dominated by energy related trade between Australia and Asia (the "resource route"). In addition TL is positioned at a 90 degree crossing of shipping routes; the sealanes from N Australia to Indonesia and Singapore pass close to the northern most cape country (and the location of its only Marine Protected Area).

Marine survey work to assess its marine biodiversity and identify PCAs has only just commenced in 2012. Despite this data-deficiency a total area 11.3% of Timor Leste's sealanes overlaps with the country's PCAs (Figures 18-22). Furthermore, 0.3% of sealanes run through the country's MEBs, and which indicates relatively low level of potential interactions between these offshore industry sectors.

Summary of Timor Leste PCA-MEB overlaps (see also Appendix 3).

The spatial analysis for Timor Leste waters highlight the following overlap hotspots between MEBs and PCAs (over 20% or/and 500,000 km^2 in bold; CT maxima are underlined in *<u>italics</u>*).

Analysis (based on spatial overlap in km^2)	Percentage overlap	Area overlap km^2	Comments

Oil and gas - overlap with all waters	**72.3**	54,077	
Sealanes - overlap with all waters	7.7	5,760	
All PCAs - overlap with all waters	***67.0***	50,113	
All PCAs - overlap with oil and gas	***60.2***	30,164	
All PCAs - overlap with sealanes	11.3	5,663	
MPA – overlap with oil and gas	3.1	15	
MPA – overlap with sealanes	***49.6***	239	
HABITATS			
Reefs – overlap with oil and gas	8.4	7.0	
Reefs – overlap with sealanes	***22.8***	18	
Corridors – overlap with oil and gas	***60.3***	30,164	
Corridors – overlap with sealanes	11.3	5,640	
Canyons - overlap with oil and gas	**56.9**	313 (km)	
SPECIES			
Green turtle habitat - overlap with sealanes	***100.0***	522	
Dugong – overlap with oil and gas	***32.8***	6,855	Proxy for widely distributed coastal spp.
Dugong – overlap with sealanes	***27.4***	5,739	
KEY INDUSTRY PERSPECTIVES			
Oil and gas – overlap with all PCAs	***55.8***		
Oil and gas – overlap with Dugong	12.7		
Shipping – overlap with all PCAs	***98.3***		
Shipping – overlap with Dugong	***99.6***		
Shipping – overlap with marine corridors	***97.9***		

Papua New Guinea

The 2,398,392 km^2 of sea area under Papua New Guinea's (PNG) jurisdiction (national and EEZ boundaries) makes up almost 1/5th (19.5%) of the Coral Triangle Implementation Area. By sea area, PNG is the second biggest CT nation after Indonesia. Overall, MEBs account for 15.6% of its sea area (Figure 15). Oil and Gas covers 8.6% and Deep-Sea Mining 7.2%. As noted above, PNG has a unique mix of these two offshore industries.

PNG's Oil and Gas blocks have significant overlap (29.2%) in total area with PCAs (Figures 16-22). In addition, its Deep-Sea Mining blocks have 49.0% overlap with PCAs (Figures 16-22). Because of PNG's position as the second largest sea state in the CT, these percentages equate to a vast area. Thus there is a strong indication that the two offshore activities can impact on marine conservation priorities on an eco-regional scale.

PNG is the most prominent stakeholder of the eastern CT's marine transportation network and its waters are extensively used by international ships in transit (i.e. "innocent passage") (Figure 18). For sea lanes and shipping density, PNG includes the region's eastern section of the N-S shipping axis going through the CT. Its international shipping is dominated by energy-related trade between Australia and Asia (the "resource route") and the majority of this traffic runs through the eastern waters of the archipelago. Ships exit PNG's northern waters through two restricted and narrow island passages.

More than half of the total area of PNG's sealanes (53.6%) overlaps with the country's PCAs (Figures 18-22) including extensive overlap with specific PCAs such as leatherback turtle habitat and marine corridors (Figures 18 and 21). Furthermore, 10.0% of sealanes run through the country's MEBs, which is close to the CT average level of potential interactions between the offshore industry sectors. The interaction between international sealanes and Deep-Sea Mining activities may warrant special attention, as there is no precedent outside the CT.

Summary of Papua New Guinea PCA-MEB overlaps (see also Appendix 3).

The spatial analysis for Papua New Guinea waters highlights the following overlap hotspots between MEBs and PCAs (over 20% or/and 500,000 km^2 in bold; CT maxima are underlined in *italics*).

Analysis (based on spatial overlap in km$^{2)}$	Percentage overlap	Area overlap km^2	Comments
Oil and gas - overlap with all waters	8.6	206,717	
Deep-sea mining - overlap with all waters	7.2	173,032	
All MEBs - overlap with all waters	15.8	379,749	
Sealanes - overlap with all waters	9.2	221,292	
All PCAs - overlap with all waters	**32.7**	**783,881**	
All PCAs - overlap with oil and gas	**7.7**	60,334	
All PCAs - overlap with deep-sea mining	**10.8**	84,736	
All PCAs - overlap with sealanes	15.1	118,505	

HABITATS			
Reefs – overlap with MEBs	10.2	1,338	
Reefs – overlap with sealanes	7.8	1,016	
Tuna high catch area – overlap with MEBs	12.4	201,846	
Corridors – overlap with MEBs	**33.2**	45,409	
Corridors – overlap with sealanes	**34.3**	46,817	
Seamounts – overlap with MEBs	**18.9**	32,731	
Canyons - overlap with MEBs	**27.3**	2,444 (km)	
SPECIES			
Green turtle habitat - overlap with oil and gas	12.9	1,378	
Dugong – overlap with MEBs	***28.9***	139,360	Proxy for widely distributed coastal spp.
Leatherback turtles – overlap with sealanes	15.4	38,541	
Sperm whales – overlap with sealanes	12.3	37 (count)	Based on historical catches
Blue whales – overlap with sealanes	12.9	2,377	
KEY INDUSTRY PERSPECTIVES			
MEBs – overlap with all PCAs	**29.2**		.
MEBs – overlap with shipping	10.0		
MEBs – overlap with Dugong	**36.7**		
Shipping – overlap with all PCAs	**53.6**		
Shipping – overlap with MEBs	17.2		
Shipping – overlap with Dugong	**28.8**		
Shipping – overlap with Leatherback turtles	17.4		
Shipping – overlap with marine corridors	**21.1**		

Solomon Islands

The 1,597,860 km^2 of sea area under the Solomon Island's (SI) jurisdiction (national and EEZ boundaries) make up 13.0 % of the Coral Triangle Implementation Area waters. Overall, MEBs account for 4.2% of its sea area; Oil and Gas covers 0% and Deep-Sea Mining 4.2% (Figure 15). To date SI is unique on the world in that its offshore block licensing is completely made up of Deep-Sea Mining tenements.

Overall, the waters of the SI do not have the same level of MEB coverage as the other five CT countries. Yet SI's Deep-Sea Mining tenements have significant overlap (12.8%) in total area with PCAs (Figures 16-22). This overlap is likely to increase as more PCAs are identified in the relatively unknown SI waters. Thus there is a serious indication that this new offshore industry, on trial in the eastern CT, may impact on the country's marine conservation priorities.

For sea lanes and shipping density, SI has a similar albeit less intense sealane and shipping density characteristic as does PNG (Figure 18). SI waters include the eastern-most section of the N-S shipping axis going through the CT. Its international shipping is also dominated by energy related trade between Australia and Asia (the "resource route"), with some traffic to and from New Zealand as well. The majority of this traffic runs through the western and central waters of the archipelago. Ships exit SI's northern waters through several restricted island passages.

Close to a quarter of the total area of SI's sealanes (24.8%) overlaps with the country's PCAs (Figures 18-22) including extensive overlap with specific PCAs such as leatherback and green turtle habitats and marine corridors (Figure 21). Only 2.0% of sealanes run through the country's MEBs. Even though this overlap is minimal, the interaction between international sealanes and Deep-Sea Mining activities may warrant special attention, as there is no precedent outside the CT.

Summary of Solomon Islands PCA-MEB overlaps (see also Appendix 3).

Analysis (based on spatial overlap in $km^{2)}$	Percentage overlap	Area overlap km^2	Comments
Deep-sea mining - overlap with all waters	4.2	67,007	
Sealanes - overlap with all waters	2.0	33,841	
All PCAs - overlap with all waters	12.3	195,682	
All PCAs - overlap with deep-sea mining	4.4	8,543	
All PCAs - overlap with sealanes	4.3	8,397	
HABITATS			
Tuna high catch area – overlap with deep-sea mining	4.1	32,098	
Corridors – overlap with deep-sea mining	10.0	3,999	
Seamounts – overlap with deep-sea mining	12.8	37,665	
Canyons - overlap with deep-sea mining	7.3	240 (km)	
SPECIES			
Leatherback turtles – overlap with sealanes	5.0	5,056	
Dugong – overlap with deep-sea mining	4.7	10,157	Proxy for widely distributed coastal spp.
Sperm whales – overlap with sealanes	5.4	2 (count)	Based on historical catches
Blue whales – overlap with deep-sea mining	6.0	4,089	

Blue whales – overlap with sealanes	11.7	7,896	
KEY INDUSTRY PERSPECTIVES			
Deep-sea mining – overlap with all PCAs	12.75		.
Deep-sea mining – overlap with marine corridors	6.0		
Deep-sea mining – overlap with Dugong	**15.2**		
Shipping – overlap with all PCAs	**24.8**		
Shipping – overlap with Blue whales	**23.3**		
Shipping – overlap with Leatherback turtles	14.9		

In conclusion

This project has made use of comprehensive data on coastal and deep-sea bio-physical, ecological and migratory species habitats, ranging from reefs to seamounts, and spanning from tropical tunas to oceanic whales. We have started to address a major knowledge gap on the overlap between offshore activities and marine conservation priorities. This indicative study provides science-based input towards an urgent marine management need. It is spearheading this approach for the region as a whole and has produced broad-ranging and emerging partnerships (support and GIS data sharing from numerous organisations and individuals).

It is worthwhile to note the “investment” aspect of this first-pass approach. This study, while indicative, has provided a solid foundation to build on and recommends a) next steps to engage key stakeholders including industry and regulators and b) additional follow up work, with emphasis on the most pressing issues identified for each ecoregion and/or priority site.

There are several value-adding analyses that can now be done with relative ease and cost-effectiveness. These more fine-scale and targeted spatial analysis would provide important insights on how best to proceed with specific marine spatial management approaches. Again, this would be one the first such studies for the region as a whole and additional work will ultimately lead to the development of an important decision support tool.

Key recommendations

Detailed review of existing databases and fine-scale adjustments of MEB data layers to enhance the spatial analyses and scenario mapping for priority overlap areas.

This project can be regarded as indicative only, and in the short time span allocated it provided an excellent basis to source and access various data, consolidate and process the data in various ways, address data gaps and conduct spatial analysis on overlap of numerous biodiversity targets with marine extractive industries – both oil and gas as well as deep-sea mining.

Hence a detailed follow up study would be warranted and could add much more depth and insights to the data already obtained, and obtain additional data (some databases have been granted access to after being reviewed internally, i.e. Bird International's seabird atlas; NOAA's oceanic currents data for the Indo-Pacific).

A follow-up study would also add new components to ensure a high-quality and comprehensive management and decision making tool for interactions with increasingly important stakeholders in the marine realm: offshore industry and shipping.

Build a comprehensive meta-dataset for the MEBs in the CT – SWP

While a lot of individual block information has been downloaded already, it is far from complete and has not yet been consolidated into a database (block name, type of resource, operator structure, status of operation, expected start of operations if not currently active, expected output, and so on). These data will be crucial to engage industry associations or individual operators if conflicts in the field need to be resolved. MEBs with extreme overlap with biodiversity values would need such high resolution data to assist with management and mitigation as well.

Address the data gaps for priority habitats and species.

With better quality distribution ranges for Species of Concern, we would be able to provide more accurate overlay maps and better pinpoint where potential risks may occur.

Commercial fish species

We have included preliminary maps for tuna, and there could be much finer-scale analysis with the data already obtained. This includes the seamounts with higher tuna catches data sets, which are not yet included in this project. Additional tuna datasets, as well as distribution and abundance of other commercial fishes, and locations of pelagic and coastal spawning aggregations (SPAGs) are of importance to obtain a better understanding of the interactions between MEBs and food security and local livelihoods. The project's emerging partnerships on data sharing with several fisheries management agencies will aid in effective execution of this task.

Ecosystem services

Socio-economic data is available to the CT-SWP region and would greatly increase the project's scope into potential risks to local livelihoods and food security. Due to time constraints, the current project has hardly been able to delve into the available data resources for this vital part of any marine spatial planning initiative.

Spatial scenarios

These would include detailed spatial analysis for:

- Ecoregions shortlisted as having high or extreme overlap between conservation values and industry activities (PCA-MEB overlaps).
- Individual or clusters of MEBs with high biodiversity values.
- Impact of climate change on PCA – MEB interactions and risk management:
- Extreme weather scenarios (i.e. how could the industry avoid or mitigate major storm damage and resulting pollution).
- Reef health and additional, cumulative stressors from oil and gas development.
- Protective management and mitigation scenarios.

Shipping

Accurate data on national and regional shipping in the CT is not available from a centralized agency, and thus additional desktop research is recommended to source and analyse the regional and national shipping components within the CT. This is needed as inter-island trade within two of world's largest archipelagic states – Indonesia and the Philippines - as well as increased inter ASEAN trade and booming ASEAN –China sea commerce would have significant impact on both the routing and ship density throughout the CT.

This study has identified extensive overlap between shipping and PCAs in the CT. To better understand and provide input for management options we recommend several case studies (all with a high likelihood the data is available to obtain better insight on specific sectors of the industry:

The AU-Asia "resource run"
Indonesian shipping – inter-island trade
Cruise liners in the CT

Education and outreach

Identify and assist with the development of appropriate educational and outreach materials highlighting key outcomes for the CT6 countries and the PCAs.

Acknowledgements

We are grateful to the many colleagues, scientists, and GIS staff throughout the CT-SWP region that very generously provided advice on data sources for this comprehensive project. Several organisations and individuals kindly enabled us to incorporate limited access data, others volunteered data to be shared. The resulting emerging partnerships are indeed an important outcome of the project itself and can be considered an investment aspect for any follow-up on this first pass and innovative approach. In particular we would like to note the contributions of:

- World Wildlife Fund - WWF Australia (with a special thanks to Paul Gamblin)
- WWF - Indonesia (with a special thanks to Lida Pet-Soede and Tetha Hitipeuw)
- WWF - US (with a special thanks to Charles Huang and Helen Fox)
- WWF - Fiji
- WCS – Fiji (with special thanks to Stacy Jupiter)
- TNC - The Nature Conservancy (with a special thanks to Nate Peterson, Annick Cros and Wen Wen)
- Coral Triangle Atlas
- CSIRO - Commonwealth Scientific and Industrial Research Organisation Australia (with a special thanks to Piers Dunstan)
- Worldfish Centre (with a special thanks to Stanley Tan, CGIAR)
- FAO - Food and Agricultural Organisation
- SWOT- The State of the World's Sea Turtles (with a special thanks to Bryan Wallace)
- NOAA – National Oceanographic and Atmospheric Administration (with a special thanks to Tomoko Acoba)
- Birdlife International

Figures

Corresponding maps on each section can be found in the 50-slide PowerPoint presentation accompanying this technical report (with extensive research notes for each slide).

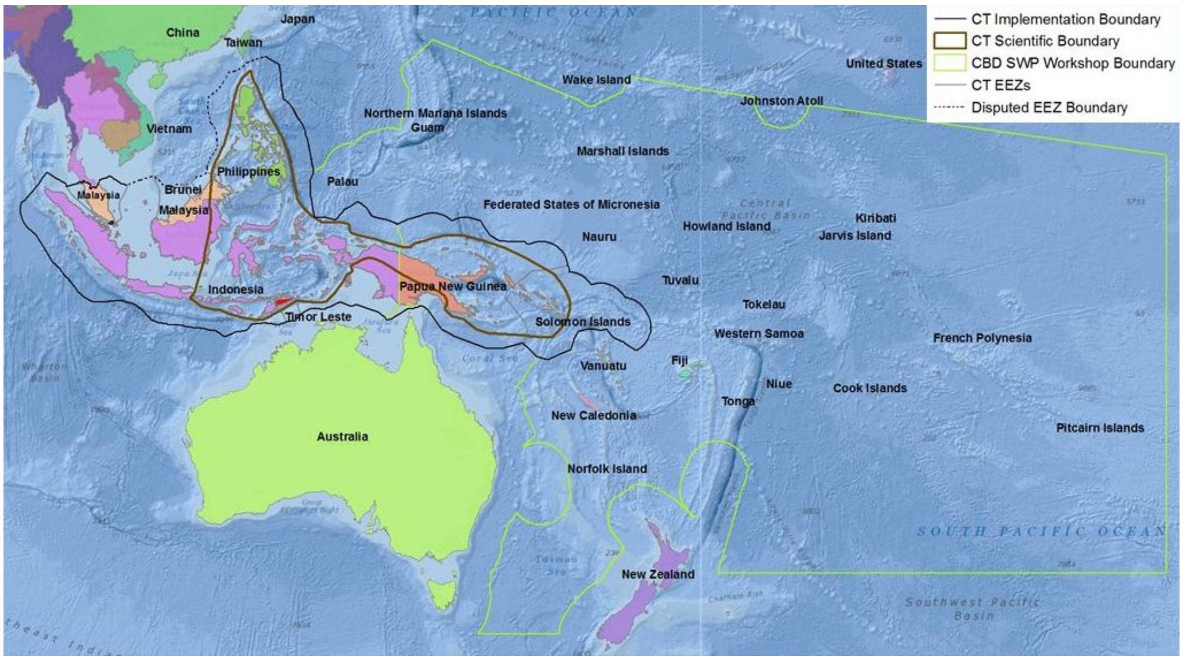

Figure 1: Geographical scope of the project.

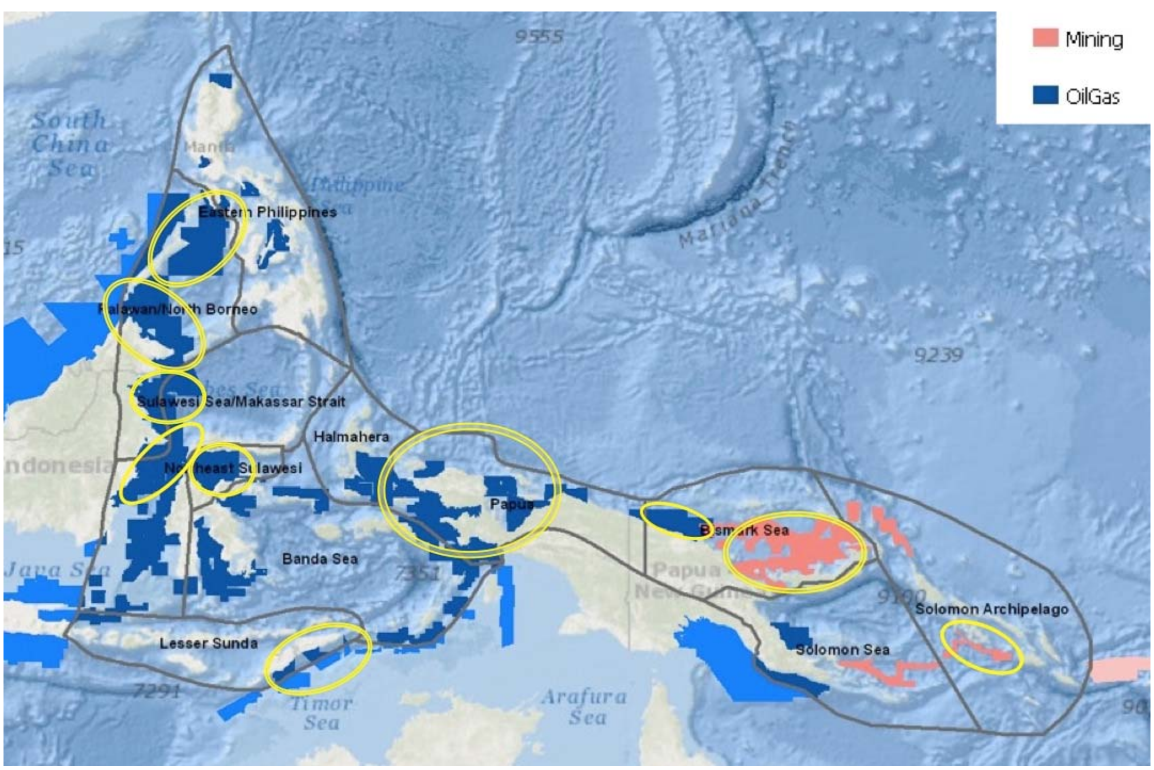

Figure 2: Overlap hotspots between PCAs & MEBs in Coral Triangle marine ecoregions.

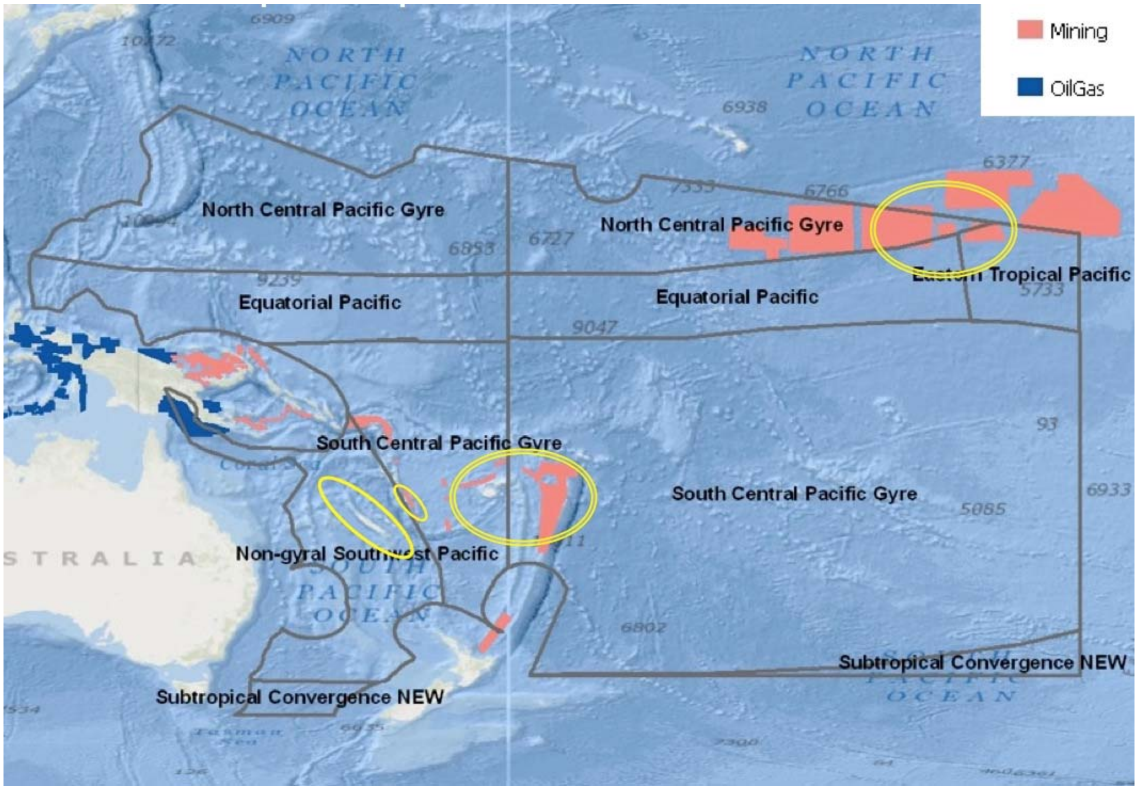

Figure 3: Overlap hotspots between PCAs & MEBs in South West Pacific provinces.

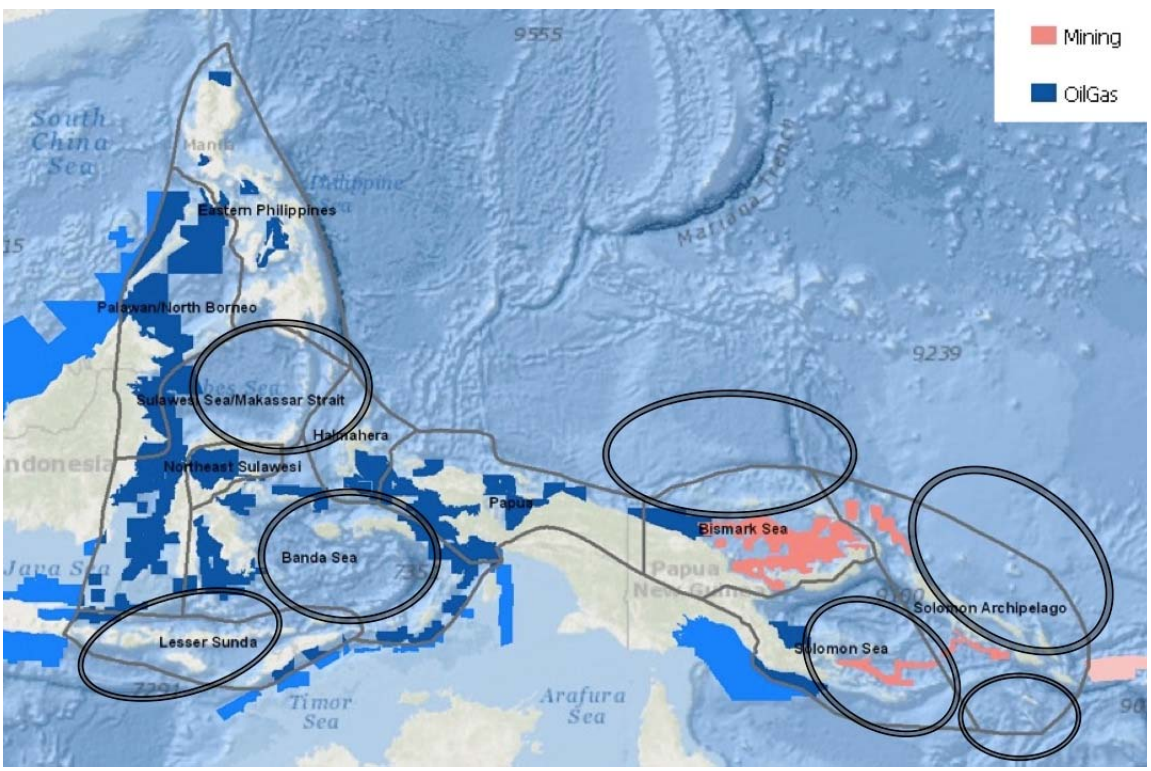

Figure 4: The "Coolspots": Minimal overlap between between PCAs & MEBs.

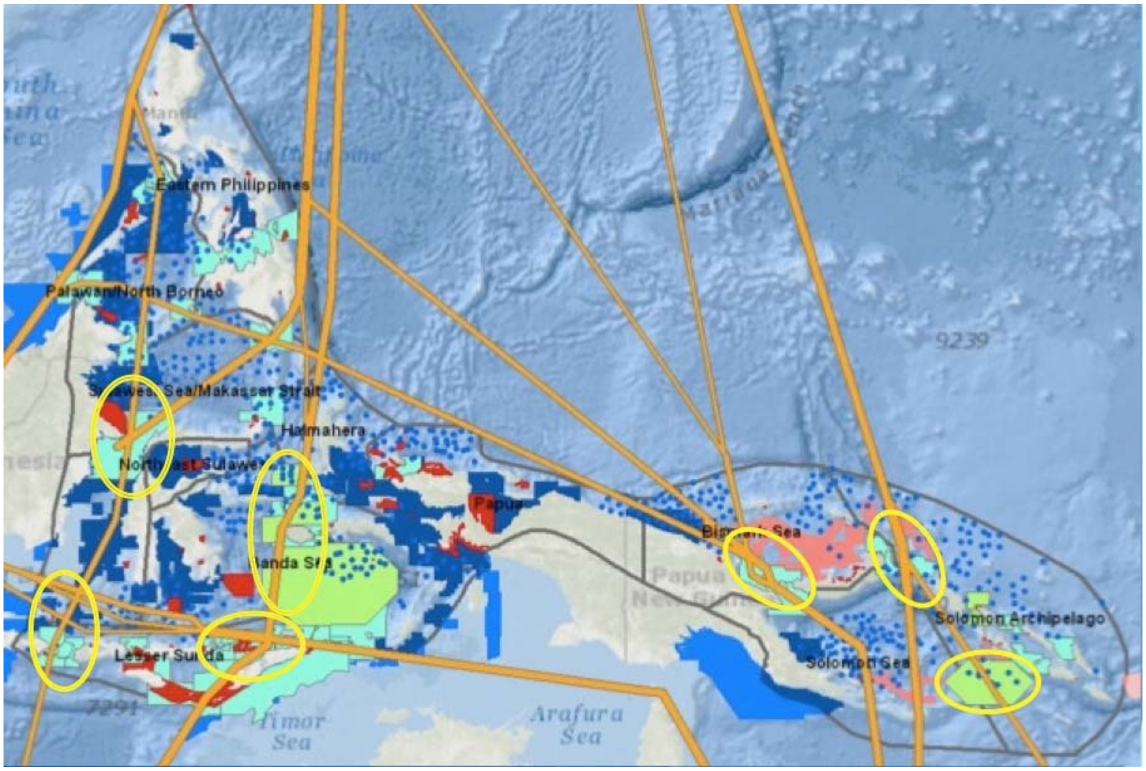

Figure 5: Sea Lanes and ship traffic density. Hotspots of overlap with MEBs (dark blue), MPAs (red), Blue Whale habitat (green), sperm whale habitat (blue dots) and migratory corridors of regional conservation importance (light blue).

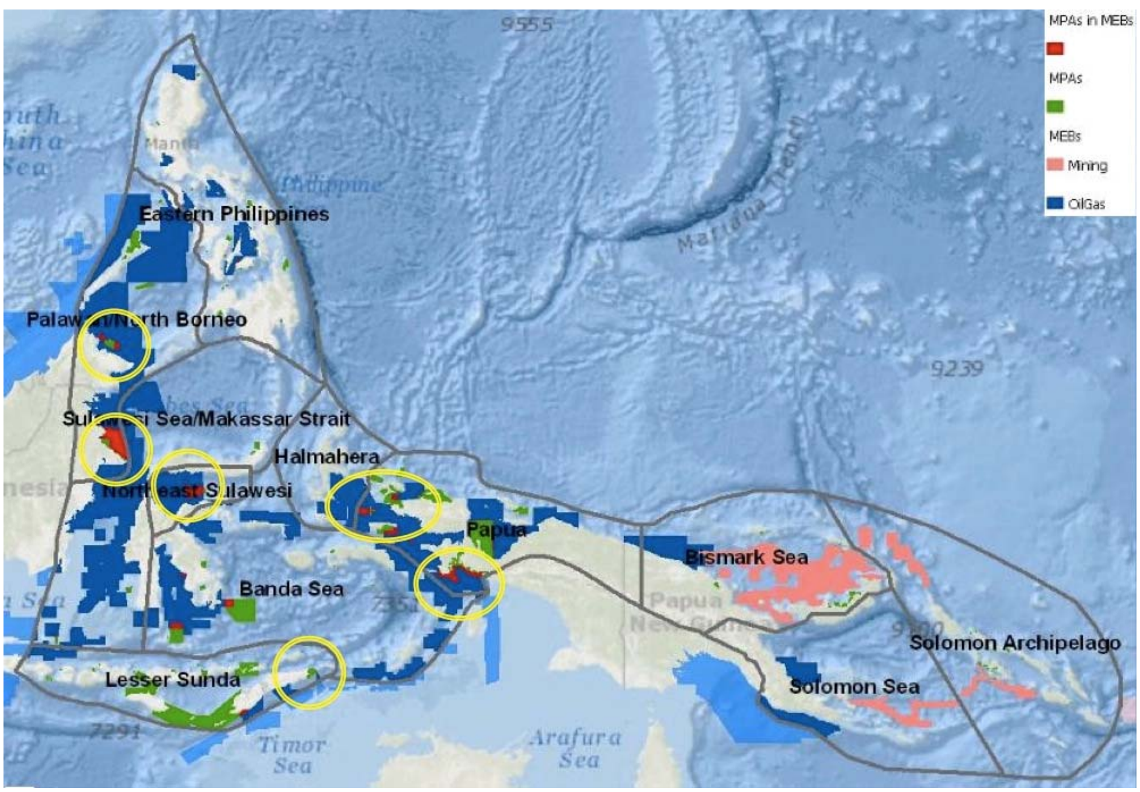

Figure 6: Marine Protected Areas and MEBs in Coral Triangle ecoregions.

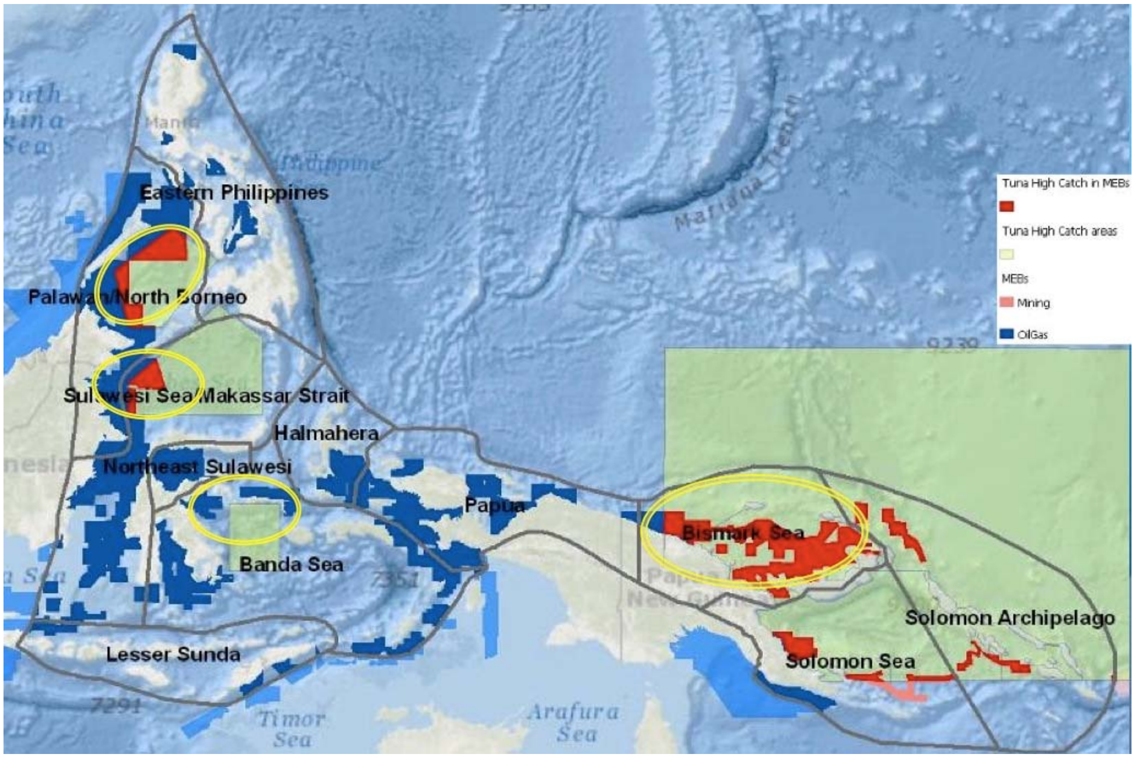

Figure 7: Tuna High Catch Areas and MEBs in Coral Triangle ecoregions.

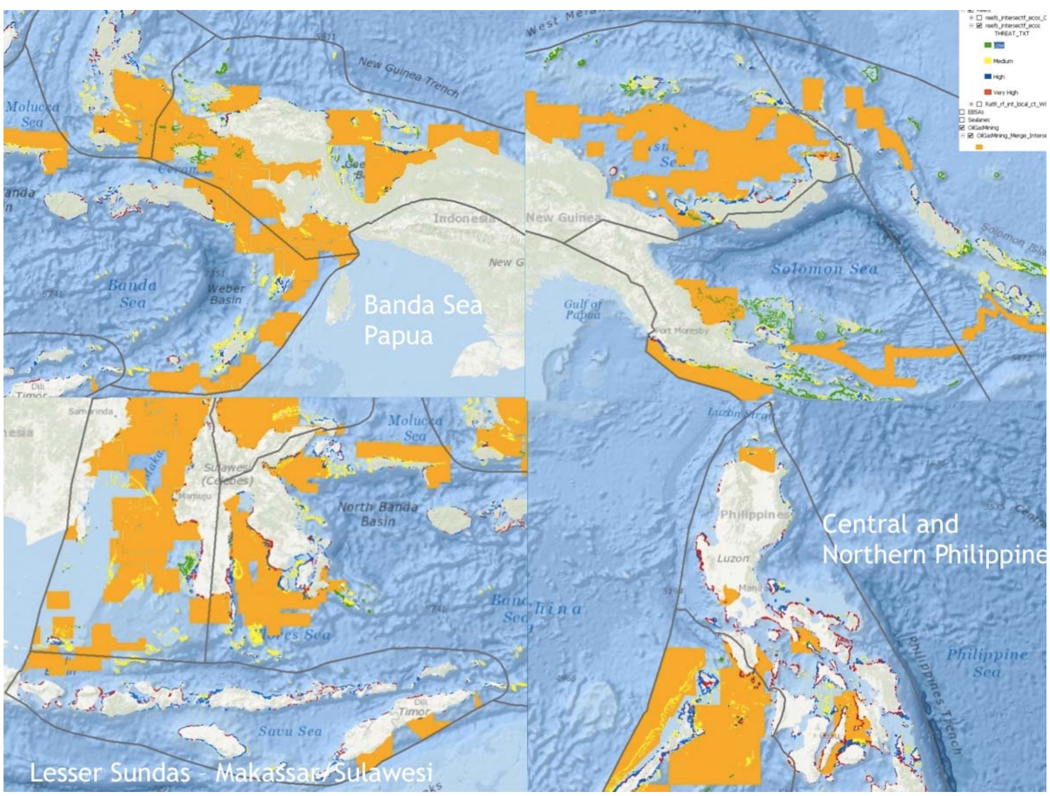

Figure 8: Reefs and MEBS in the Coral Triangle.

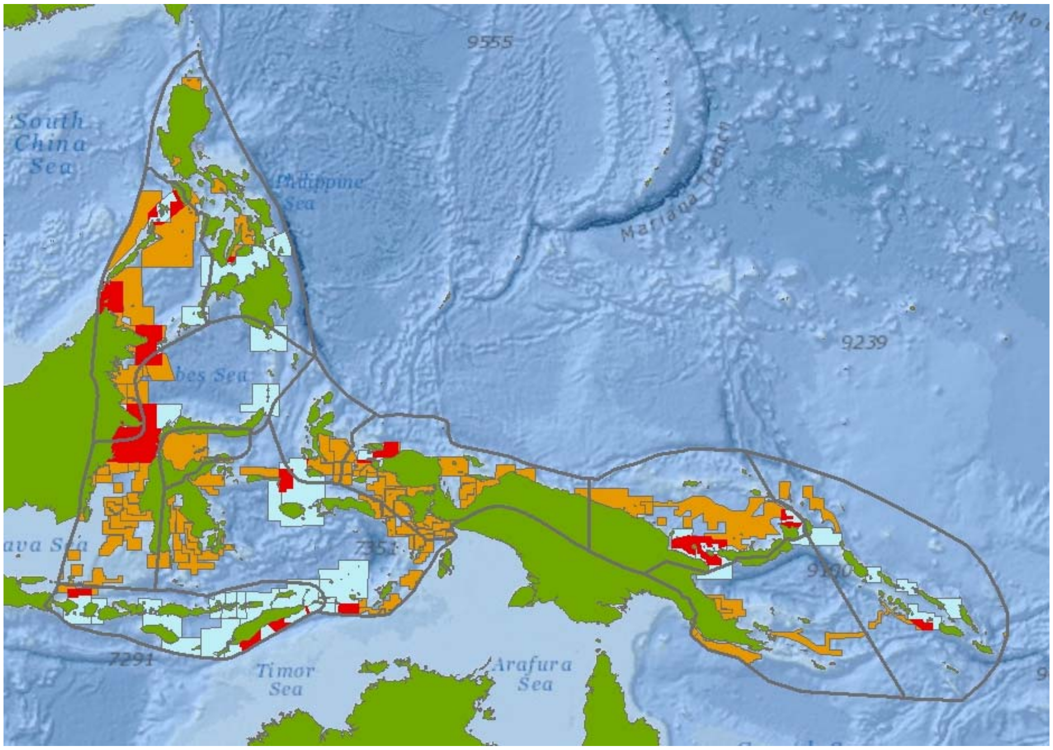

Figure 9: Migration corridors (blue) and MEBs (orange) in the Coral Triangle (overlap-red).

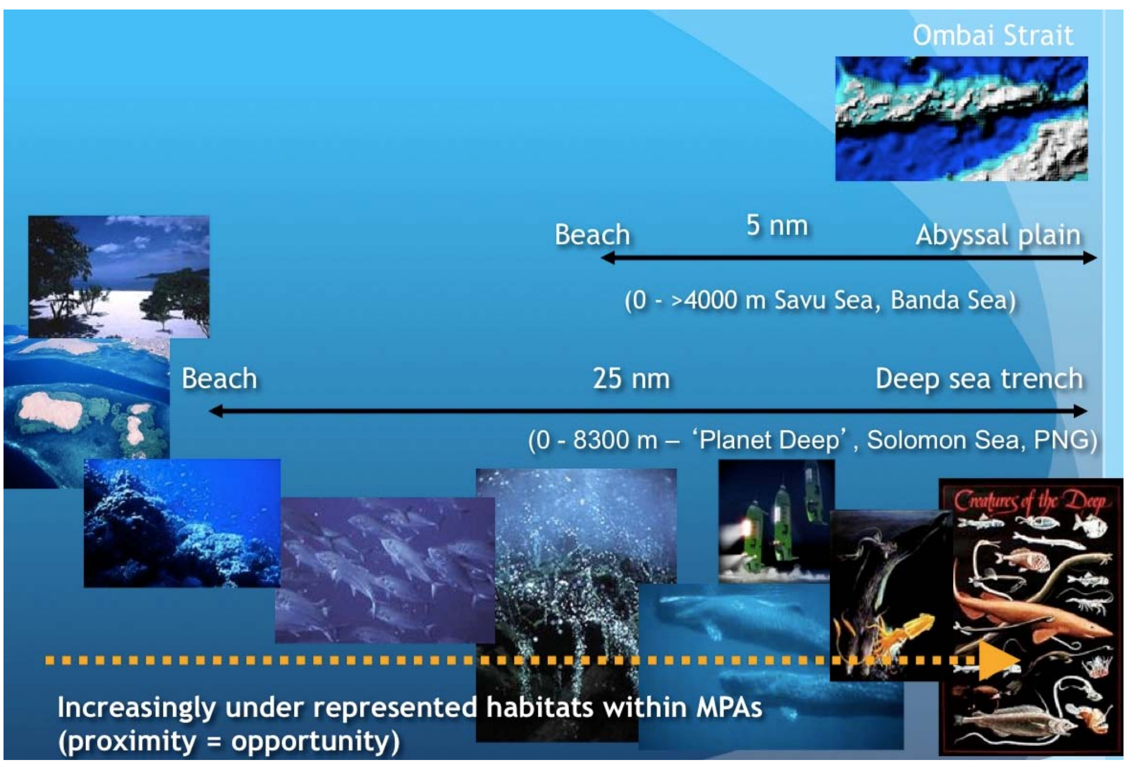

Figure 10: Example of coastal-oceanic ecosystem proximity within the Coral Triangle - deep-sea yet near-shore habitats (adapted from Kahn 2012).

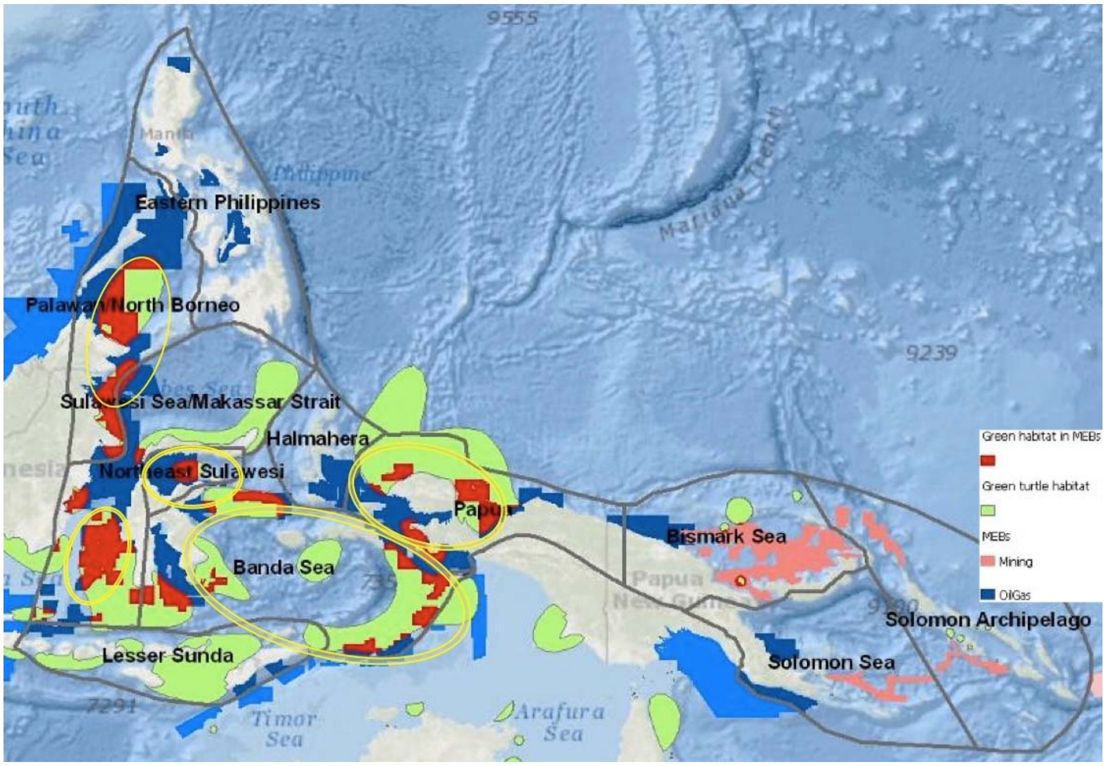

Figure 11: Green turtle offshore habitats and MEBs in Coral Triangle ecoregions.

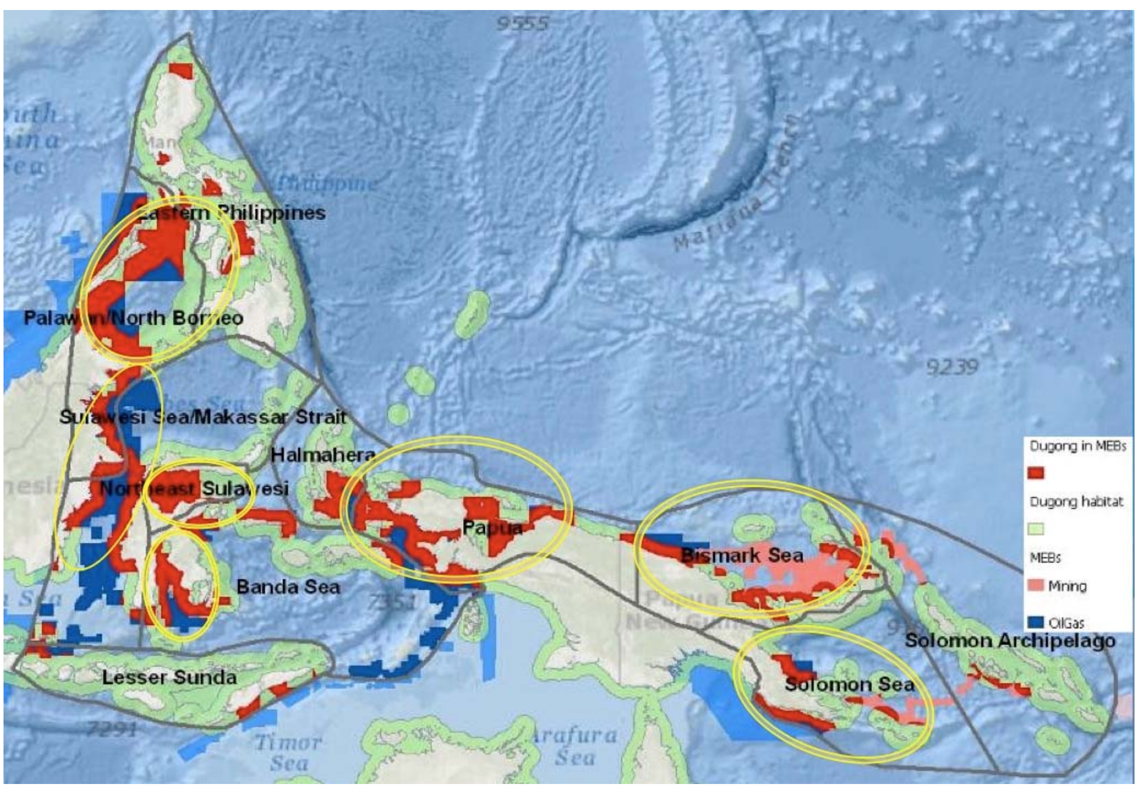

Figure 12: Dugong and MEBs in Coral Triangle ecoregions.

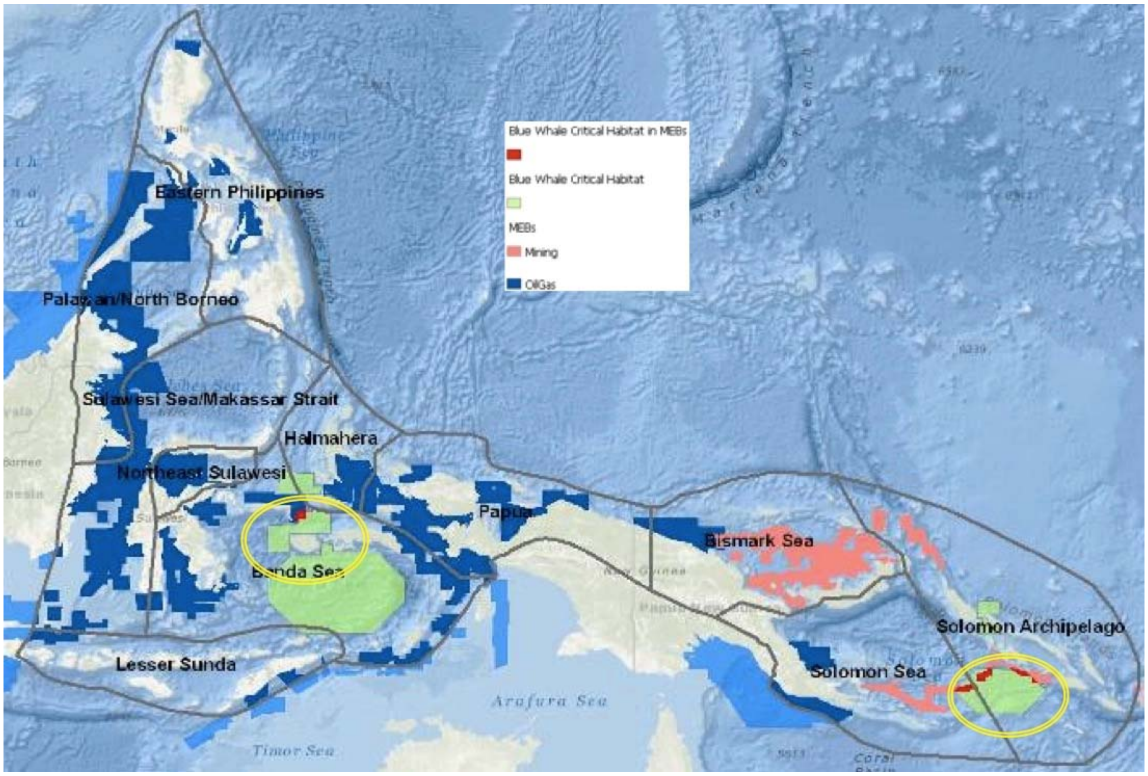

Figure 13: Blue whales critical habitat and MEBs in Coral Triangle ecoregions.

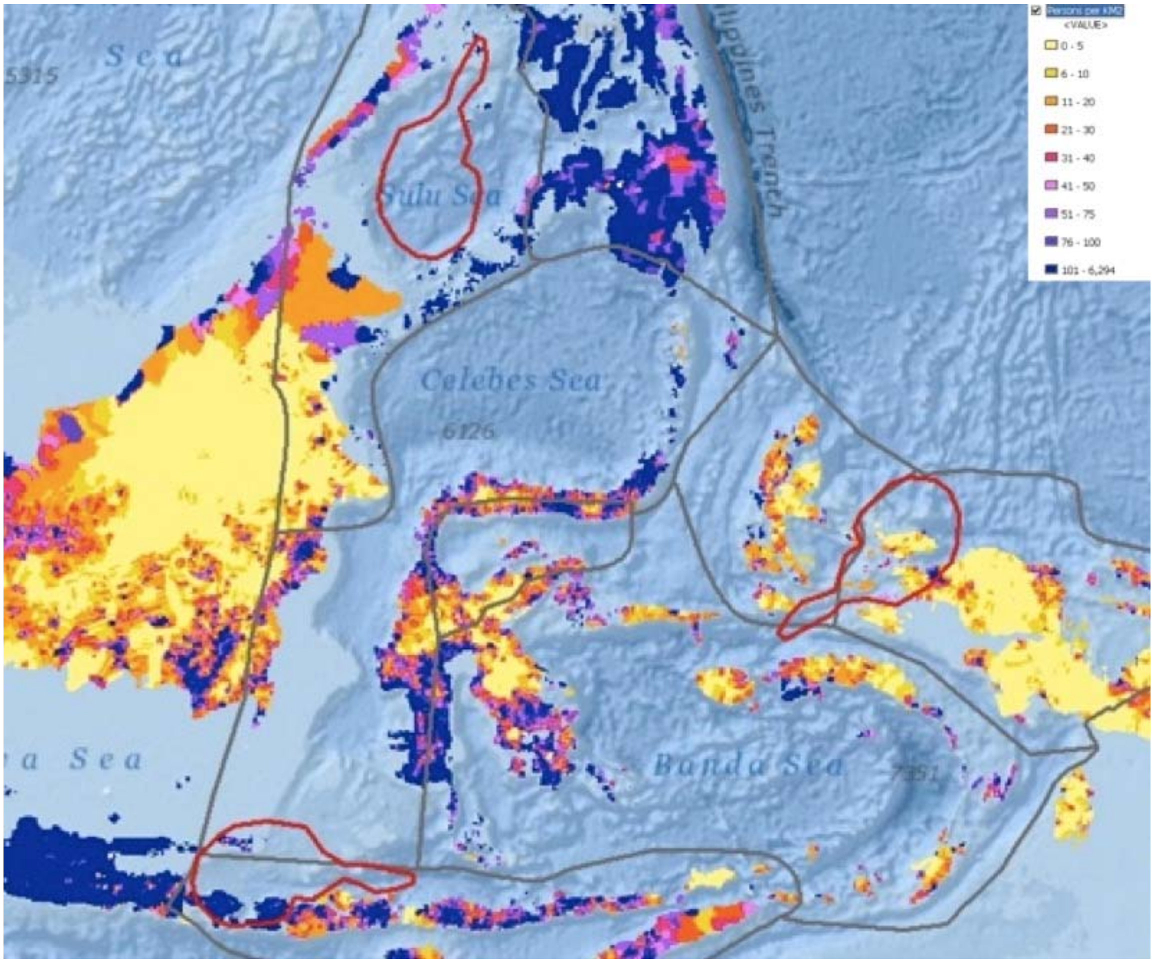

Figure 14: Spatial scenario of a large-scale oil spill by a deep well blow-out affects three different industry sectors (fisheries, tourism conservation).

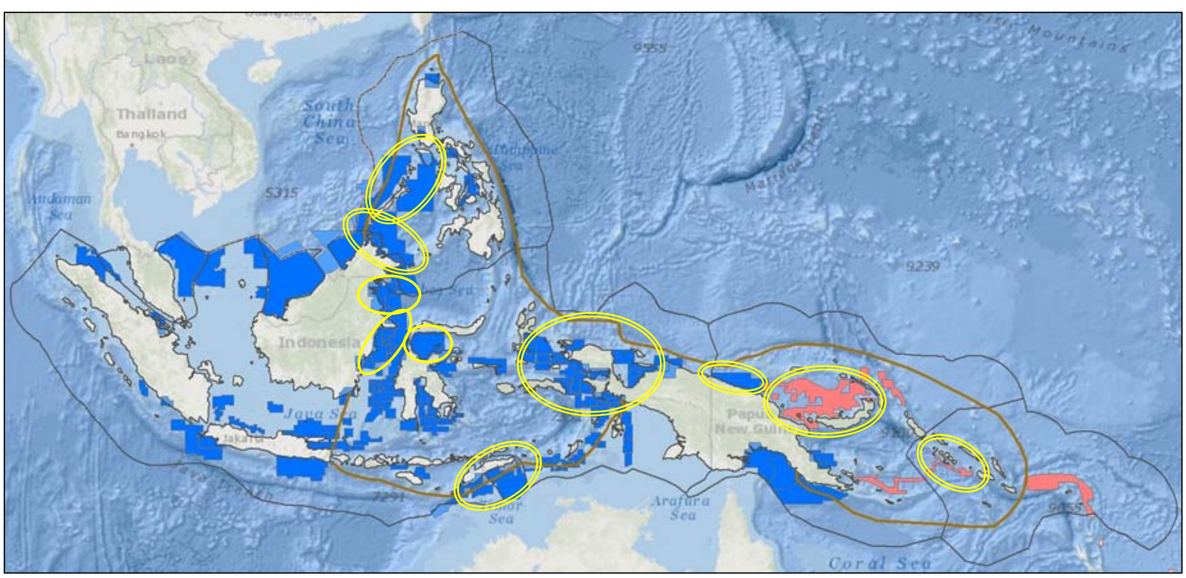

Figure 15a: Coral Triangle implementation area oil & gas (blue) and deep-sea mining (pink) leases. Brown line is CT scientific boundary; black lines are EEZ boundaries; hashed lines are disputed EEZ boundaries.

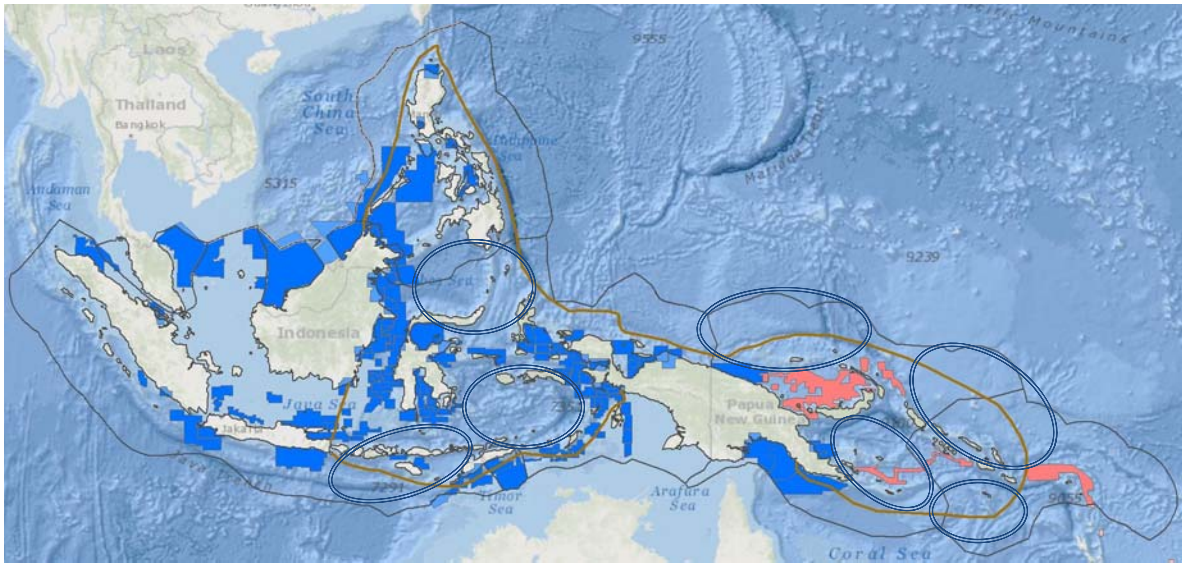

Figure 15b: The “Coolspots” of minimal overlap between PCAs & MEBs in the Coral Triangle implementation area.

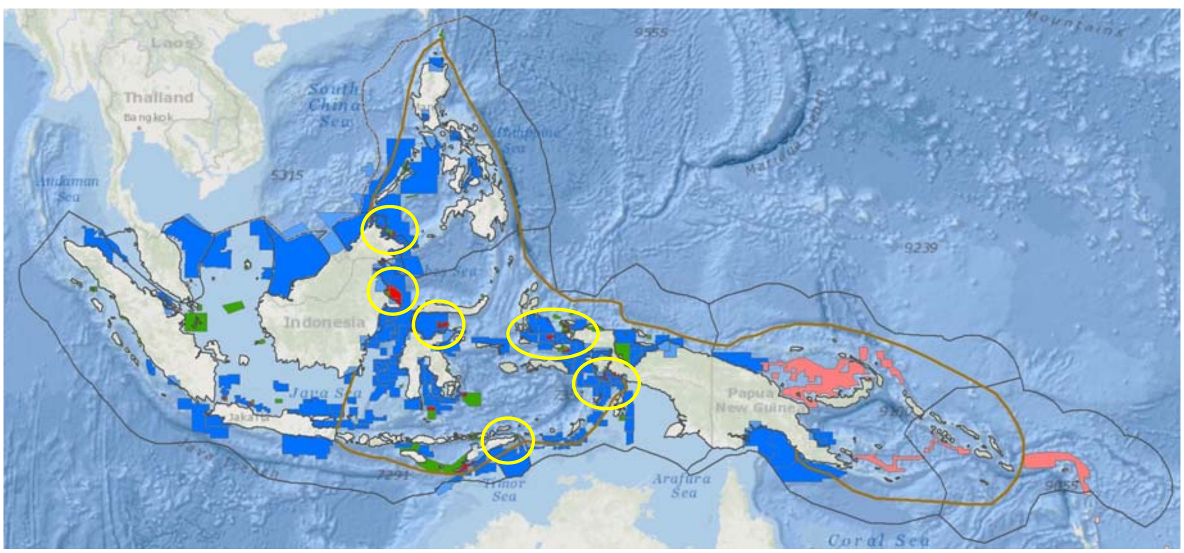

Figure 16: Marine Protected Areas (green; red where overlapped with MEBs) and MEBs (blue, oil & gas; pink, deep-sea mining) in the Coral Triangle implementation area EEZs.

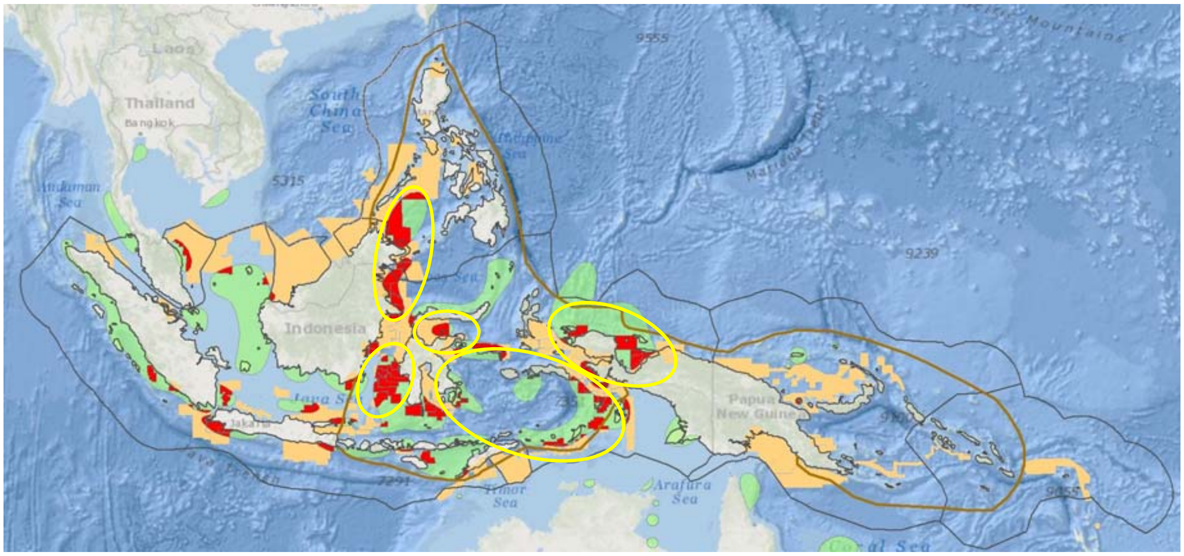

Figure 17: Green turtle offshore habitats (green; red where overlapped by MEBs) and MEBs (orange) in Coral Triangle implementation area EEZs.

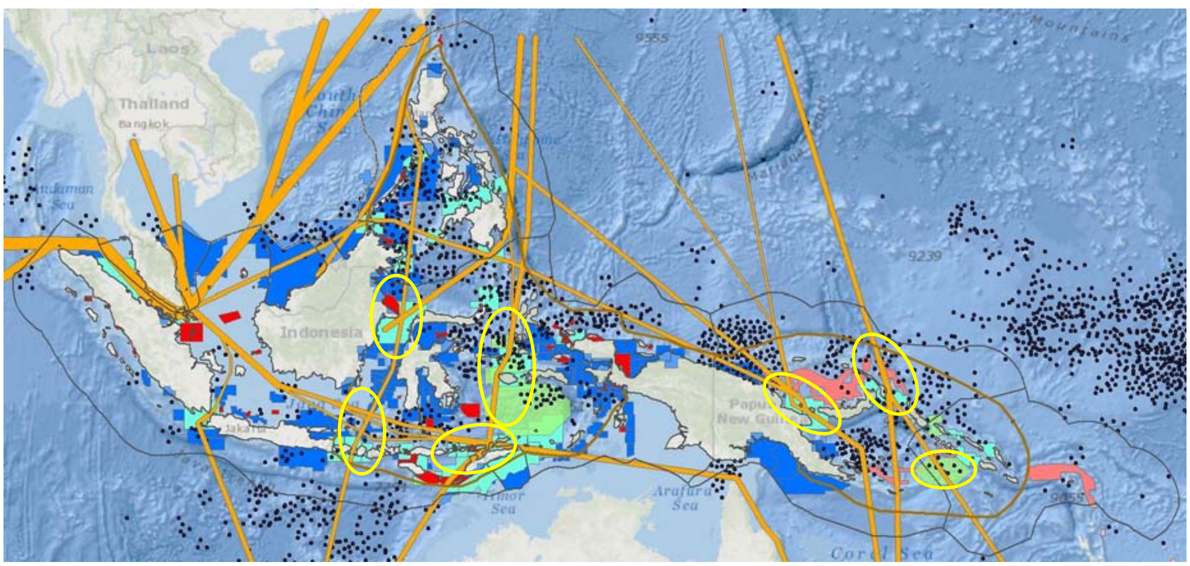

Figure 18: Sea Lanes and ship traffic density in the CT implementation area, with hotspots of overlap with oil & gas blocks (blue), deep-sea mining blocks (pink), MPAs (red), blue whale habitat (green), historic sperm whale capture locations (blue dots) and migratory corridors of regional conservation importance (light blue).

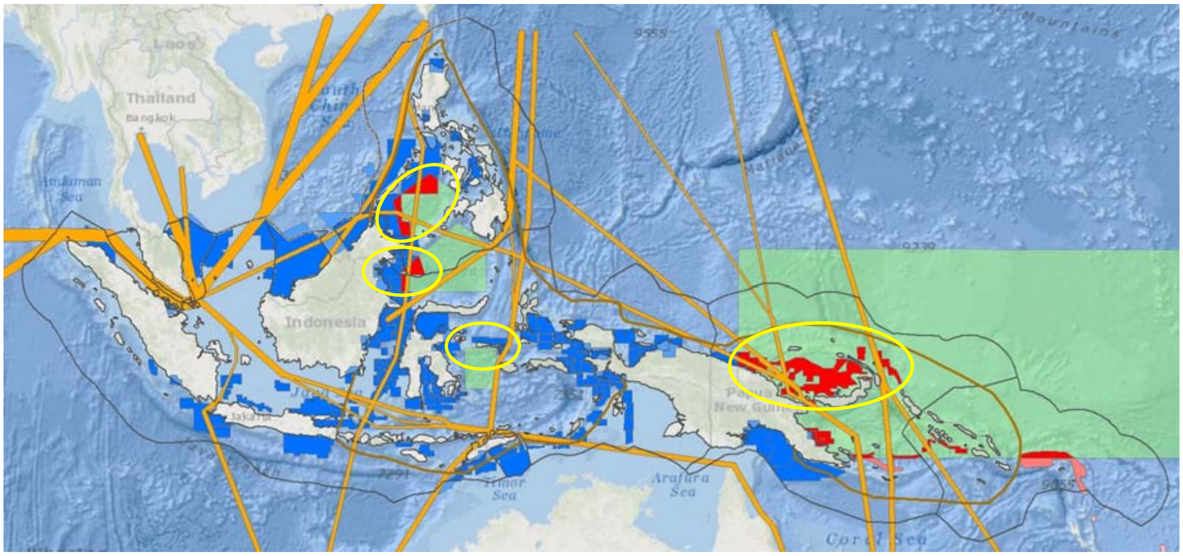

Figure 19: Tuna High Catch Areas (green; red where overlapped by MEBs), sealanes, and MEBs (oil & gas blue; deep-sea mining pink) in Coral Triangle implementation area EEZs.

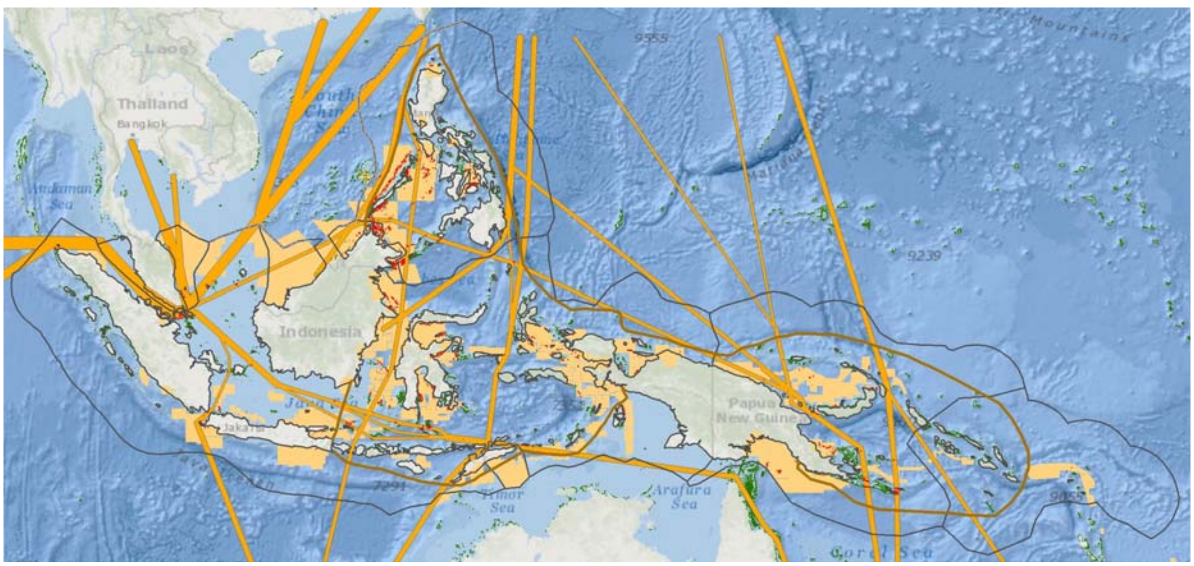

Figure 20: Reefs (green; red where overlapped by MEBs), sealanes, and MEBs (orange) in the Coral Triangle implementation area EEZs.

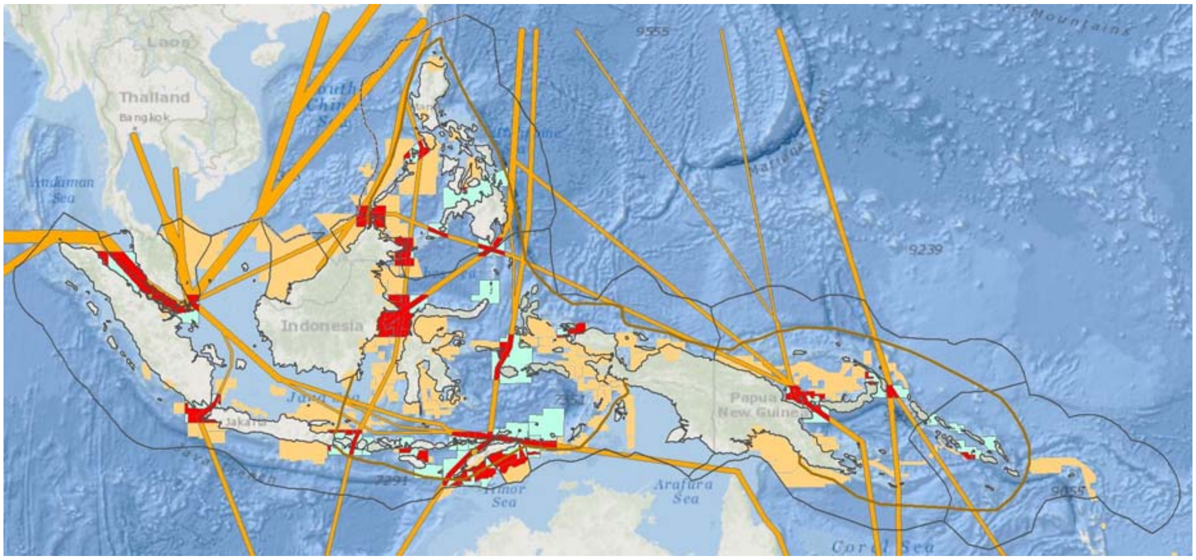

Figure 21: Migration corridors (blue; red where overlapped by MEBs), sealanes, and MEBs (orange) in the Coral Triangle implementation area EEZs.

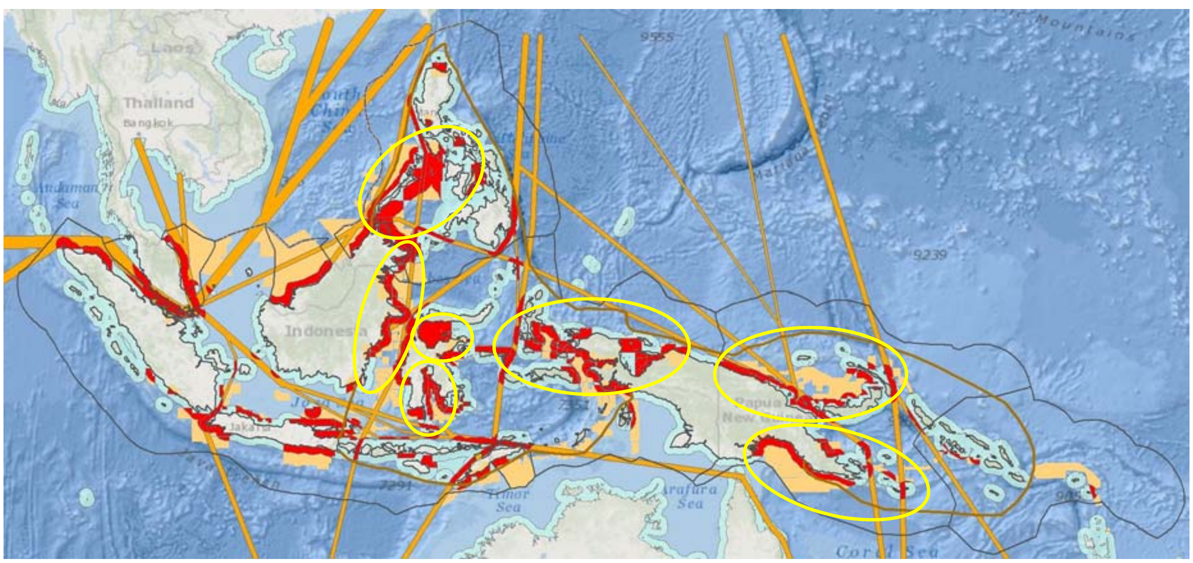

Figure 22: Dugong habitat (blue; red where overlapped by MEBs or sealanes), sealanes, and MEBs (orange) in Coral Triangle implementation area EEZs.

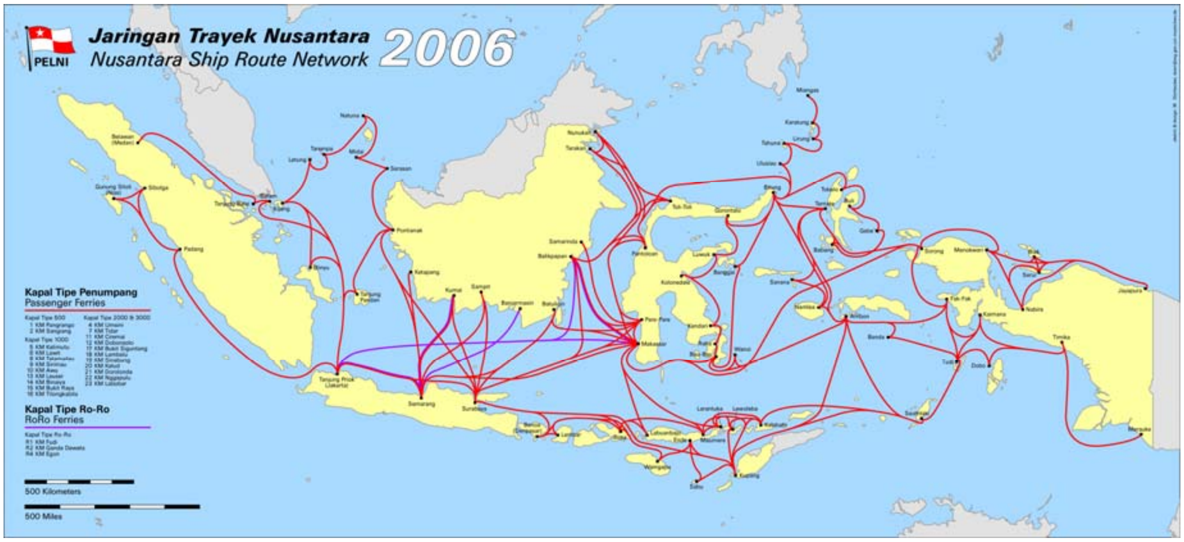

Figure 23: Routes of the Indonesian national Pelni ferry service.

Appendices

APPENDIX 1: Databases included in the report with brief descriptions and sources.

A. Priority Conservation Areas:

1) Dataset: MPAs_Phl_poly_Project.shp
   a) Description: "This dataset is a compilation of Marine Protected Areas for Coral Triangle area by The Nature Conservancy. Last updated: February 2011."
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

2) Dataset: MPAs_Mys_poly_Project.shp
   a) Description: "This dataset is a compilation of Marine Protected Areas for Coral Triangle area by The Nature Conservancy. Last updated: February 2011."
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

3) Dataset: MPAs_Indo_poly_Project.shp
   a) Description: Marine Protected Areas for Indonesia
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

4) Dataset: MPAs_PNG_poly_Project.shp
   a) Description: "This dataset is a compilation of Marine Protected Areas for Coral Triangle area by The Nature Conservancy. Last updated: February 2011."
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

5) Dataset: MPAs_SlmIs_poly_Project.shp
   a) Description: "This dataset is a compilation of Marine Protected Areas for Coral Triangle area by The Nature Conservancy. Last updated: February 2011."
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

6) Dataset: MPAs_Tmr_poly.shp
   a) Description: "This dataset is a compilation of Marine Protected Areas for Coral Triangle area by The Nature Conservancy. Last updated: February 2011."
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

7) Dataset: kvanceborland-search-marine-protected-areas-1353132742456
   a) Description: 74 more marine protected areas in the Solomon Islands.
   b) Source: UNEP WCMC http://www.protectedplanet.net/

8) Dataset: Priority_area.shp
   a) Description: 58 priority areas mapped during a WWF-organized 'Bismark Solomon Seas Vision Workshop' in 2003 (WWF 2004).
   b) Source: Charles Huang, WWF-US, via Google Drive.

9) Dataset: PNGCNA_MarinePriorities.shp
   a) Description: 30 marine priority areas mapped in a PNG Conservation Needs Assessment in 2003.

b) Source: Nate Peterson, TNC, via TNC's Secure File Transfer.

10) Dataset: ssme_corr_pr.shp
   a) Description: 16 priority corridors mapped in a WWF-sponsored "Workshop to Formulate the Biodiversity Conservation Vision for the Sulu-Sulawesi Marine Ecoregion," March 2001 (WWF 2003).
   b) Source: Charles Huang, WWF-US, via Google Drive.

11) Dataset: ssme_lgar_pr.shp
   a) Description: Priority polygons for wide-ranging species mapped in a WWF-sponsored "Workshop to Formulate the Biodiversity Conservation Vision for the Sulu-Sulawesi Marine Ecoregion," March 2001 (WWF 2003).
   b) Source: Charles Huang, WWF-US, via Google Drive.

12) Dataset: ssme_smar_pr.shp
   a) Description: Priority areas of outstanding biological importance mapped in a WWF-sponsored "Workshop to Formulate the Biodiversity Conservation Vision for the Sulu-Sulawesi Marine Ecoregion," March 2001 (WWF 2003).
   b) Source: Charles Huang, WWF-US, via Google Drive.

13) Dataset: Marine_Corridors.shp
   a) Description: Migration corridors critical for blue and sperm whales and other large marine life, whale sharks.
   b) Source: Benjamin Kahn hand-digitized.

14) Dataset: EBSARegions_20111214_0t360_dis.shp
   a) Description: The UNEP CBD "Executive Secretary convened, in collaboration with the Secretariat of the Pacific Regional Environment Programme (SPREP), the Western South Pacific Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas (CBD 2008), in Nadi, Fiji, from 22 to 25 November 2011. The Government of Australia provided support, through the Commonwealth Scientific and Industrial Research Organisation (CSIRO), to the Secretariat of the Convention on Biological Diversity and SPREP in their scientific and technical preparation for the workshop."
   b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package.

15) Dataset: PIPAsketch.shp
   a) Description: Approximate boundaries of the Phoenix Islands Protected Area.
   b) Source: Ken Vance-Borland hand-digitized based on an image from http://www.phoenixislands.org/.

16) Dataset: World_EEZ_v6_1_simpliefiedcoastlines_20110512.shp
   a) Description: Exclusive Economic Zone boundaries.
   b) Source: http://www.marineregions.org/downloads.php

17) Dataset: CookIslandsEEZ_SouthHalf.shp
   a) Description: Approximate boundaries of the Cook Islands Marine Park. According to http://news.wildlife.org/featured/new-caledonia-government-announces-large-contribution-to-marine-preserve-2/, "On August 28, Cook Islands Prime Minister Henry Puna announced the creation of a 1.065 million square kilometer marine

park covering the entire southern half of the nation's waters in the South Pacific Ocean."

b) Source: Ken Vance-Borland copied the Cook Islands EEZ polygon from World_EEZ_v6_1_simpliefiedcoastlines_20110512.shp (see above), split it approximately in half, and this dataset is the southern half.

18) Dataset: NewCaledoniaEEZ.shp

a) Description: Boundaries of the New Caledonia Marine Protected Area. According to http://news.wildlife.org/featured/new-caledonia-government-announces-large-contribution-to-marine-preserve-2/, "The government of New Caledonia recently announced its decision to preserve 1.4 million square kilometers of marine habitat as part of the Coral Sea Marine Protected Area." The area of the New Caledonia EEZ is 1.4 million square kilometers, so this boundary approximates (or equals) the New Caledonia MPA.

b) Source: Ken Vance-Borland copied the New Caledonia EEZ polygon from World_EEZ_v6_1_simpliefiedcoastlines_20110512.shp (see above).

19) Dataset: PalauEEZ.shp

a) Description: Boundaries of the Palau Marine Sanctuary. According to http://www.upi.com/Science_News/2010/10/26/Palau-declares-its-oceans-a-sanctuary/UPI-13931288131547/, "The Republic of Palau…is declaring all its oceans, more than 230,000 square miles, a marine sanctuary."

b) Source: Ken Vance-Borland copied the Palau EEZ polygon from World_EEZ_v6_1_simpliefiedcoastlines_20110512.shp (see above).

B. Habitats:

20) Dataset: rf_int_local_ct.shp

a) Description: "Reef polygons…classified by present integrated local threats to coral reefs (combined threat from coastal development, marine-based pollutions and damage, watershed-based pollution, and overfishing/destructive fishing)." World Resources Institute, Washington, DC. 'Reefs at Risk Revisited in the Coral Triangle.'

b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx: Reefs at Risk in the Coral Triangle.

21) Dataset: global_canyons_0t360_spebsa.shp

a) Description: Dataset TITLE Global Canyons. "Geoscience Australia has undertaken the compilation of the global occurrence of large submarine canyons to provide context and guidance for discussions regarding canyon occurrence, distribution, geological and oceanographic significance and conservation. Based on an analysis of the ETOPO1 data set, this study has compiled the first inventory of 5,849 separate large submarine canyons in the world ocean, and has established associated statistics for the dataset including: head Depth, sinuosity, dendricity, slope, margin type etc." Dataset AUTHOR(S) Whiteway, T., Harris P., Lawson, C., Butler, P., Woods, M., and Hatch, L. Dataset CUSTODIAN Geoscience Australia

b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package.

22) Dataset: seamountsknolls_0t360_spebsa.shp

a) Description: “Seamounts and knolls are ‘undersea mountains’, the former rising more than 1000 m from the seafloor. These features provide important habitats for aquatic predators, demersal deep-sea fish and benthic invertebrates.” Yesson, C., et al., The global distribution of seamounts based on 30 arc seconds bathymetry data. Deep-Sea Research I (2011), doi:10.1016/j.dsr.2011.02.004.
b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package.

C. Species:

23) Dataset: spermwhale_v1_g_0t360_spebsa.shpA
   a) Description: catch locations of the 19th Century Yankee whaling fleet
   b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package. See UNEP/CBD/RW/EBSA/WSPAC/1/2 “Compilation of Submissions of Scientific Information to Describe EBSAs in the Western South Pacific Region” http://www.cbd.int/kb/record/meetingDocument/83720?Event=RWEBSA-WSPAC-01 and UNEP/CBD/SBSTTA/16/INF/6.

24) Dataset: Blue_Whales_Critical_Habitat_Breeding_Calving.shp
   a) Description: Blue Whale Critical Habitat
   b) Source: Benjamin Kahn hand-digitized.

25) Dataset: Dugong.shp
   a) Description: Dugong distribution
   b) Source: MAMMMARINE.shp. IUCN 2010. *IUCN Red List of Threatened Species. Version 2010.4*. http://www.iucnredlist.org>. Downloaded 29 October 2012.

26) Dataset: habitat_green.shp
   a) Description: Green sea turtle habitat areas.
   b) Source: WWF Indonesia.

27) Dataset: habitat_loggerhead.shp
   a) Description: Loggerhead turtle habitat areas.
   b) Source: WWF Indonesia.

28) Dataset: TunaHighCatch_areas.shp
   a) Description: Areas with high tuna catch based on Silbert and Hampton, and other sources.
   b) Source: Benjamin Kahn hand-digitized (see reference section on THCAs for literature maps used).

29) Dataset: MoratoFig1Data_SM-with-higherCatchRates_pointspt_spebsa.shp
   a) Description: “significant seamounts for tuna in the western and central Pacific Ocean.” Morato T, Hoyle SD, Allain V, Nicol SJ (2010) Tuna Longline Fishing around West and Central Pacific Seamounts. PLoS ONE 5(12): e14453. doi:10.1371/journal.pone.0014453
   b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package.

D. Marine Extraction Blocks:

30) Dataset: Offshore Blocks - Oil and Gas.shp
   a) Description: Approximated boundaries of oil and gas marine lease blocks of the Coral Triangle areas of Malaysia, Indonesia, Timor Leste, and Papua New Guinea.
   b) Source: Benjamin Kahn hand-digitized based on jpeg maps of oil and gas lease blocks obtained from the internet (see reference section on MEBs for sources of maps used).

31) Dataset: OffshoreBlocksOilAndGasKVB.shp
   a) Description: Approximated boundaries of oil and gas marine lease blocks of the Coral Triangle areas of the Philippines.
   b) Source: Ken Vance-Borland hand-digitized based on jpeg maps of oil and gas lease blocks obtained from the internet (see reference section on MEBs for sources of maps used).

32) Dataset: OffshoreMiningBlocks.shp
   a) Description: Approximated boundaries of deep-sea mining blocks of the South West Pacific, including Papua New Guinea and areas to the east.
   b) Source: Ken Vance-Borland hand-digitized based on jpeg maps of marine mining blocks obtained from the internet (see reference section on MEBs for sources of maps used).

E. Other:

33) Dataset: Marine_Ecoregions.shp
   a) Description: Ecoregions of the Coral Triangle, by The Nature Conservancy.
   b) Source: The Coral Triangle Atlas Dataset http://ctatlas.reefbase.org/ctdataset.aspx

34) Dataset: CBDWorkshopBounaries_20111122_erased_0t360_dissolved_mod.shp
   a) Description: Boundaries of the geographic area considered during the CBD "Western South Pacific Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, in Nadi, Fiji, from 22 to 25 November 2011"
   b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package.

35) Dataset: Pelagic_Provs_GOODS_0t360_spebsa.shp
   a) Description: "A new biogeographic classification of the world's oceans has been developed which includes pelagic waters subdivided into 30 provinces" UNESCO. 2009. Global Open Oceans and Deep Seabed (GOODS) biogeographic classification. Paris, UNESCO-IOC. (IOC Technical Series, 84.) (http://ioc-unesco.org/index.php?option=com_content&task=view&id=146&Itemid=76).
   b) Source: Piers Dunstan, CSIRO. CBD SWP Workshop Package.

36) Dataset: Shipping
   a) Description: ArcInfo grid, produced by National Center for Ecological Analysis and Synthesis: "Commercial shipping activity can lead to ship strikes of large animals, noise pollution, and a risk of ship groundings or sinkings. Ships from many countries voluntarily participate in collecting meteorological data globally, and therefore also report the location of the ship. We used data collected from 12

months beginning October 2004 (collected as part of the World Meteorological Organization Voluntary Observing Ships Scheme; http://www.vos.noaa.gov/vos_scheme.shtml) as this year had the most ships with vetted protocols and so provides the most representative estimate of global ship locations."

b) Source: http://www.nceas.ucsb.edu/globalmarine/impacts (The 'raw' version of the shipping dataset was used.)

37) Dataset: BK_sealanesWCEA_BufferTest.shp

a) Description: Major marine shipping lanes in the greater Coral Triangle region, based on the NCEAS 'shipping' dataset (see above).

b) Source: Benjamin Kahn hand-digitized shipping lines based on concentrations of ship locations in the NCEAS 'shipping' grid, and classified the lines as 2 through 10 according to the amount of shipping shown in the 'shipping' grid. Ken Vance-Borland then buffered the shipping lines by 10 kilometers times the line classification, based on measurements taken from the 'shipping' grid, to produce sealane polygons that varied between 20 and 100 kilometers in width.

38) Dataset: DeepwaterHorizonSpillSketch.shp

a) Description: A polygon representing an area the size of the Deepwater Horizon oil spill.

b) Source: Ken Vance-Borland hand-digitized this polygon based on the size and shape of the Deepwater Horizon oil spill superimposed over the Solomon Sea in the website: http://www.ifitweremyhome.com/disasters/bp.

39) Dataset: ocds15ag

a) Description: An ArcInfo grid representing estimated number of persons per square kilometer in the year 2015.

b) Source: Center for International Earth Science Information Network (CIESIN), Columbia University; United Nations Food and Agriculture Programme (FAO); and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded Population of the World: Future Estimates (GPWFE). Available at http://sedac.ciesin.columbia.edu/gpw.

40) Dataset: Country.shp

a) Description: Countries of the world.

b) Source: Part of the ESRIDATA spatial dataset distributed with installations of ArcGIS software.

41) Dataset: Ocean_Basemap.lyr

a) Description: "The ocean basemap includes bathymetry, surface and subsurface feature names, and derived depths. This service is designed to be used as a basemap by marine GIS professionals and as a reference map by anyone interested in ocean data."

b) Source: "A layer package (LPK file) referencing the Ocean basemap" available at http://www.arcgis.com/home/item.html?id=6348e67824504fc9a62976434bf0d8d5.

APPENDIX 2: Methodology in detail including limits of such methods

Methodology and limits of MEB polygons:

One of the foundational spatial datasets needed for this project was unavailable to us: detailed GIS polygons of marine extraction blocks for oil, gas and mining. If those data were publicly available from the countries and/or corporations engaged in Marine Exploitation Blocks or MEBs, they would have provided the most accurate delineation of those areas available. Our alternative was to hand-digitize these block areas based on a large number of jpeg maps that BK downloaded from numerous websites. The majority of data was gathered from government websites which included general maps of licensing rounds for offshore oil and gas blocks and deep-sea mining tenements. These map varied considerably in clarity, resolution, and information content. Thus in order to have a standardized approach for the whole region, we decided to limit our block data to location, indicative boundaries and areas only.

The process was to draw polygons in Quantum GIS (BK) or ArcGIS (KVB) by comparing our GIS basemaps of shorelines, latitude and longitude grids, etc., to features shown on the jpeg maps and their positions relative to the MEBs we were attempting to represent. While we made strong efforts to draw the MEBs as accurately as possible, it was not possible to precisely align them with the available maps. Thus our MEBs remain an estimation of the legal boundaries of the true blocks, or even with the detailed shorelines of the lands they abutted. Furthermore, many of the jpeg maps depicted a level of detailed subdivision of blocks into different leaseholders, time periods, project stages, and other block characteristics, which we did not have the time or resources to attempt to incorporate into the project. Instead, in several cases we drew the 'outline boundaries' of adjoining aggregations or clusters of blocks as accurately as possible.

Methodology and limits of PCA polygons:

The other category of essential spatial data for this project is PCAs: The Priority Conservation Areas as previously identified by various marine stakeholders. These include: legally established Marine Protected Areas (MPAs and MPA Networks); priority marine conservation areas identified in various ecoregional planning processes; important habitat areas for a range of marine species - including marine turtles, sperm and blue whales, dugong, tropical tuna species; and important marine habitats such as coral reefs, seamounts, canyons and the major migration corridors within these archipelagic and oceanic regions.

We were fortunate to obtain a number of existing datasets within the brief timeframe of this project (see acknowledgements for main contributors), although not all data types that we hoped to include actually were available. Some of those datasets apparently don't exist (e.g., detailed spatial data on many commercial fish species), and some that do exist we could not obtain in time (e.g., Important Bird Areas; long-term patterns in major ocean currents like the Indonesian Throughflow and Papua New Guinea current gyres). In addition, some of the datasets we obtained were or may have been incomplete. For example, we downloaded a number of MPA datasets from the Coral Triangle Atlas dataset and the Protected Planet site of the WCMC, but we are not confident that they include all legally established MPAs across the entire vast study area. In fact, there were almost no

MPAs listed for the SWP. Thus we either hand-digitized MPA areas (i.e., Phoenix Islands Protected Area) or used Exclusive Economic Zones (Palau, Cook Islands, New Caledonia) to represent the large-scale MPAs that have been declared by these SWP nations. Also, one of our important sources of data, the CSIRO Workshop Package that was used for the CBD SWP EBSA mapping, included many spatial datasets (e.g., seamounts and canyons) that did not extend westward to cover the complete Coral Triangle (to 112 degrees east) but ended at 118 degrees east. Thus for a small triangular section of the SW Coral Triangle (the waters to the N-NE of Bali) these data are missing. There were two other types of PCAs that were unavailable but that we felt were essential to include, migratory corridors for large marine animals and tuna high catch areas, so we (BK) hand-digitized polygons representing those categories of areas. We (BK) also hand-digitized sealanes in the greater Coral Triangle regions. However, because of our timeframe our initial polygons were drawn up as best estimates, and it would be important to refine (and possibly add to) them based on expert review.

Spatial Analyses:

We projected all of our spatial data sets (see Appendix 1) into the World Cylindrical Equal Area projection, which does not distort polygon areas near the equator and which is a metric coordinate system, allowing us to find the areas, in square kilometers, of overlap between MEBs and PCAs. We did our overlap analysis in two separate processes, first for the Coral Triangle and then for the South West Pacific. This separation was driven by differences in the datasets we had for the two regions. In general, we had more data for the CT than for the SWP and most of the CT datasets did not include the SWP; also, some of the SWP datasets did not extend into or covered the full CT area (scientific boundary). We used the ‘intersect’ tool in ArcGIS to find areas of overlap. As our project had to provide technical advice during a meeting scheduled for late November 2012, we were not able to overlap shipping lanes with MEBs and PCAs. This is a clearly defined database and we are confident that special analyses will provide for accurate outcomes and useful insights for this rapidly increasing maritime industry. We did identify several general overlap areas for shipping and PCAs, as well as shipping and MEBs.

APPENDIX 3: Summary tables of MEB, International Shipping, and PCA overlaps in the Coral Triangle Implementation Area

Table 1. MEBs and Shipping in CT6 EEZs

CTI Implementation Area (incl CT6 EEZs)			Industry - Marine Extractive Blocks (MEBs)					
	Geography		Oil and Gas		Deep-Sea Mining		All MEBs combined	
Country	**EEZ Area (km^2)**	**% of CTI area**	**Total Area (km^2)**	**% of National and EEZ Waters**	**Total Area (km^2)**	**% of National and EEZ Waters**	**Total Area (km^2)**	**% of National and EEZ Waters**
East Timor	74,827	**0.6**	54,077	**72.3**	0	**0.0**	54,077	**72.3**
Indonesia	5,970,398	**48.5**	1,028,515	**17.2**	0	**0.0**	1,028,515	**17.2**
Malaysia	449,701	**3.7**	328,991	**73.2**	0	**0.0**	328,991	**73.2**
Philippines	1,828,479	**14.8**	279,970	**15.3**	0	**0.0**	279,970	**15.3**
Papua New Guinea	2,398,392	**19.5**	206,717	**8.6**	173,031	**7.2**	379,748	**15.8**
Solomon Islands	1,597,859	**13.0**	0	**0.0**	67,006	**4.2**	67,006	**4.2**
Total - CT6 incl EEZ	12,319,658	**100.0**	1,898,272	**15.4**	240,038	**1.9**	2,138,310	**17.4**

			Industry - International Sealanes and Shipping Density					
	Geography		Sealanes		Industry Interactions - Area Overlap (based on km^2 for MEBs and Shipping)			
Country	**EEZ Area (km^2)**	**% of CTI Area**	**Total Area (km^2)**	**% of National and EEZ Waters**	**Sealane Area within MEBs (km^2)**	**Sealane % within MEBs**	**% MEBs Area within Sealanes**	
East Timor	74,827	**0.6**	5,760	**7.7**	18	**0.3**	**0.0**	
Indonesia	5,970,398	**48.5**	609,130	**10.2**	109,747	**18.0**	**10.7**	
Malaysia	449,701	**3.7**	137,375	**30.5**	74,119	**54.0**	**22.5**	
Philippines	1,828,479	**14.8**	271,176	**14.8**	49,555	**18.3**	**17.7**	
Papua New Guinea	2,398,392	**19.5**	221,292	**9.2**	38,043	**17.2**	**10.0**	
Solomon Islands	1,597,859	**13.0**	33,840	**2.1**	671	**2.0**	**1.0**	
Total - CT6 incl EEZ	12,319,658	**100.0**	1,278,576	**10.4**	272,155	**21.3**	**12.7**	
Notes on Industry Interactions	Management Questions/Industry Perspectives:							

Sealane % within MEBs	What percentage of CT sealanes total area (km^2) overlap with (i.e. cut through) MEBs in the CT?
% MEB Area within Sealanes	What percentage of the Marine Extraction Blocks total area (km^2) in the CT has overlap with sealanes?

Table 2. PCAs, MEBs, and Shipping

	Geography			All MEBs combined			Industry - International Sealanes and Shipping Density		
Priority Conservation Area (PCA, incl. ecologically and biologically sensitive areas or EBSAs)	Type	EEZ Area (km^2)	% of CTI area	Total Area Overlap with all MEBs combined (km^2)	Total % Overlap of PCA with all MEBs combined	% of MEBs (total area) overlap with PCAs	Total Area Overlap with Sealanes (km^2)	% of PCA (total area) overlap with Sealanes	% of Sealanes (total area) overlap with PCAs
	Habitats								
All EBSAs	Area	2,456,316	19.9	533,256	21.7	24.9	368,559	15.0	28.8
MPAs Only	Area	176,410	1.4	29,440	16.7	1.4	11,850	6.7	0.9
Reefs (3 threat levels available)	Area	74,827	0.6	15,163	20.3	0.7	3,609	4.8	0.3
Marine Corridors	Area	1,153,880	9.4	325,268	28.2	15.2	257,463	22.3	20.1
Tuna - High Catch Areas	Area	2,902,628	23.6	299,429	10.32	14.0	234,043	8.06	18.3
Seamounts	Area	982,520	8.0	101,042	10.3	4.7	106,975	10.9	8.4
Canyons	Km	43,530	N/A	11,322	26.0	N/A	3,466	8.7	N/A
	Species								
Green Turtle	Area	1,770,491	14.4	410,080	23.16	19.2	178,216	10.07	13.9
Leatherback Turtle	Area	641,919	5.2	54,758	8.53	2.56	47,610	7.42	3.7
Dugong	Area	3,485,227	28.3	965,858	27.7	45.2	368,669	10.6	28.8
Blue Whale (Critical habitat)	Area	362,517	2.9	8,338	2.3	0.4	29,097	8.0	2.3
Sperm Whales (Historical catches Townsend 1935)	Count	980	N/A	179	18.27	N/A	106	10.8	N/A
Notes on	Management Questions/Industry Perspectives:								
% of MEBs (total area) overlap with PCAs	What proportion of MEBs (total area) has overlap with PCAs in the CT?								
% of Sealanes (total area) overlap with PCAs	What proportion of PCAs (total area) has overlap with the sealanes of the CT?								

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B. References for data sources used in hand-digitizing GIS data layers and maps (in addition to Appendix 1).

Tuna High Catch Areas (THCAs)

Ref nr	website	Ref paper	Key figures	Data resolution[4]
T1	http://www.spc.int/TAGGIN	Skipjack Survey and Assessment	Figure 1. Geographical distribution of total catches of	4

[4] Data resolution is categorized as 1(minimal) to 5 (maximum) depending on the data quality and quantity available in the source maps and websites (For example, T4 has a maximum score of 5 as this figure not only has data on tuna catch distribution - which we used for this study - but also includes species-specific relative abundances for the 3 tuna species caught and seasonal patterns for all catch data).

	G/en/programs/ssap	Programme - SSAP	albacore, bigeye, skipjack and yellowfin tuna, 1999-2003. The red line indicates the eastern boundary of the Western and Central Pacific Fisheries Convention Area.	
T2	doi:10.1371/journal.pone.0014453	Morato T, Hoyle SD, Allain V, Nicol SJ (2010) Tuna Longline Fishing around West and Central Pacific Seamounts. PLoS ONE 5(12): e14453.	Figure 1. Location of seamounts with significant higher catch rates of tuna.	4
T3	http://www.fao.org/docrep/005/T1817E/T1817E05.htm	A REVIEW OF THE BIOLOGY AND FISHERIES FOR YELLOWFIN TUNA (THUNNUS ALBACARES) IN THE WESTERN AND CENTRAL PACIFIC OCEAN Ziro Suzuki National Research Institute of Far Seas Fisheries Shimizu-shi, Japan	Figure 1. Distribution of larval yellowfin tuna by plankton net survey; after Nishikawa et al. (1985).	3
T4	http://www.fao.org/docrep/007/y5242e/y5242e0d.htm#TopOfPage	BIOLOGICAL OVERVIEW OF TUNAS STOCKS AND OVERFISHING by Dr Alain Fonteneau	Figure 2: Map showing the average distribution of recent tuna catches (major species only) Figure 5: Average tuna catches by the purse seine fleets worldwide (yellowfin, skipjack and bigeye) during 3 periods: 1970-1973 (upper figure), 1982-1985 (middle) and 19941997 (lower figure. These maps well show the increase of fishing zones by purse seiners during the last 30 years.	5
T5	www.sciencedirect.com/science/article/pi	Marine Policy Volume 27, Issue 1, January 2003,	Fig. 1. Distributions of tuna catch by surface fisheries (upper panels) during 1979−1982 (left)	4

	i/S0308597X0200057X	Pages 87–95 Mobility of tropical tunas and the implications for fisheries management John Sibert[a], , John Hampton[b]	and 1996−1999 (right), and distributions of tag releases (bottom panels) during the SSAP (left) and RTTP (right). The catch was primarily by pole-and-line in 1979−1982 and by purse seine in 1996−1999.	
T6 N PN G EB SA	http://www.fao.org/docrep/005/T1817E/T1817E07.htm	STATUS OF KOREAN TUNA LONGLINE AND PURSE-SEINE FISHERIES IN THE PACIFIC OCEAN Yeong Chull Park, Won Seok Yang and Tae Ik Kim National Fisheries Research and Development Agency Republic of Korea.	Figure 9. Annual distribution of CPUE (mt per set) for tunas by Korean tuna purseseine fishery in the western Pacific Ocean, 1988–1989.	3

Marine Exploitation Blocks (MEBs).

Note on mapping of offshore blocks:

Offshore industry data is hard to obtain in GIS format without considerable expense. Thus freely available maps (low resolution) were used from websites of government departments or industry services websites. Block sizes and locations were estimated from figures and all polygons are indicative only. Map locations were cross-referenced to islands and capes or other features that could be identified on both maps. Occasionally block boundaries occurred to nearest degree lines. Occasionally several blocks were drawn in a single polygon as complex borders or joint fields would have been too time consuming to separate each neighbouring block within a large field to be developed. Each polygon was assigned a unique identifier and reference link to the corresponding figure was included in the metadata. Each figure in turn was referenced to the corresponding website source in dedicated tables for each shapefile which was drawn up. Blocks that continued over land were drawn that way.

Keywords routinely used in searchable offshore industry sites:

All CT and SWP Country names included in this study.
Regional activity types: seismic, exploration, offshore blocks, blocks on offer, offshore tenements, licensing round, offshore acreage.
PSC – Production Sharing Contract.

On Google Images, these keywords were combined and then imagery scanned for relevant areas. Such images where then traced to the original website and both downloaded. (Specific project names and/or companies involved were *not used* as keywords).

Ref nr	website	Description of data source	Data resolution
OG 1	http://www.rigzone.com/news/image_results.asp	Rigzone has an extensive library of maps which is searchable by region, country and occasionally specific projects.	1
OG 2	http://www.energy-pedia.com/articles.aspx?filter2=7	Extensive searches by year (2003 – last 7 days), region, country, industry activity type (general; exploration; development and production; licensing; seismic). These news articles often contain maps.	3
OG 3	http://www.offshore-technology.com/projects/region/asia/	THE project area provides a repository of past, present and future projects within the industry. As well as providing an overview of the changing market landscape, this section offers access to the suppliers involved in each project.	3
OG 4	http://www.offshoreenergytoday.com/category/regional-news/asia-pacific/	Offshore Energy Today has reachable news by region and keywords	3
OG 5	http://www.psg.deloitte.com/NewsLicensingRounds_ID.asp	Deloitte Petroleum Services site includes a dedicated overview page on licensing rounds. This page has links for each country and often shows the maps of the separate years in which offshore blocks where offered.	2
OG 6	http://subseaworldnews.com/category/regional_news/asia_pacific/	*Subsea World News* delivers expert coverage of the industry sectors and can be searched specifically for the Asia-Pacific region. This includes news and updates on operations, projects, markets, equipment, vessels, research, companies, contractors and the authorities dominating these markets.	3
OG 7	http://www.derrickpetroleum.com/2011/09/22/indonesia-awards-nine-exploration-blocks/	Derrick Petroleum Services has regular updates on blocks to be released.	2

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