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Rigs-To-Reef (R2R): A new initiative on re-utilization of abandoned offshore oil and gas platforms in Indonesia for marine and fisheries sectors

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Abstract. Indonesia has more than 600s offshore oil and gas platforms spread in its territorial waters and of that amount, about 50 % were built around 1980s. Since the first generation platform was built almost half a century ago, decommissioning the offshore structures is something that has never been done before in Indonesia. The assets are now approaching their end of production and touching a point of minimum economic viability. Therefore, the dismantling of those structures is unavoidable issues in the near future. However, this process is not easy and presents many challenges, e.g. status of assets, costs, etc. The current regulations have not been able to get the operators to dismantle and write off their assets so that many of them are left abandoned and endanger for the sea traffic for instance. There is a trend that these abandoned and idle offshore structures have now become "a fashionable donation" project from oil companies to coastal state to be re-used as artificial reefs or also known as Rigs-to-Reef (R2R). This study is attempting to improve the visibility of R2R as a potential decommissioning solution in Indonesia that provide good benefits not only for the environment but also for the coastal community while at the same time offer effective and efficient way out for oil and gas companies. The feasibility study of platform placement was done in the provincial marine conservation areas (Kawasan Konservasi Perairan Daerah, KKPD) in Bontang, East Kalimantan.

1. Introduction

Research and Markets has announced that the global offshore decommissioning market is expected to grow at a CAGR of 5.05%, from 2017 to 2025[1], to reach a market size of USD 8.76 billion by 2025. This growth is attributed to increasing focus on mature oil and gas fields and aging offshore platforms. There are more than 500 offshore platforms in Indonesia, which show active oil and gas development compared with its surrounding countries (Figure 1). About 70% of those platforms are approached the end of productive life. These figures show that there is an urgent need to determine the removal of the aging offshore installations of Indonesia (Table 1).

The decommissioning of those platforms is unavoidable issues at some point in the future as the platform reach end of their useful production lifetimes. Indonesia at the moment has not specific

[1] [1] htpps://www.prnewswire.com/news-releases/offshore-decommissioning-market-to-grow-at-505-cagr-to-2025-676971053.html

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blanket regulations in detail requiring obsolete structure to be removed. Decommissioning projects require consideration of a number of factors including regulatory requirements, technical feasibility, health, safety, socio-economic, environmental impacts, economics and strategies implemented by oil and gas operators. In addition, the operators are trying to launch a decommissioning project, but it is not yet in the implementation stage.

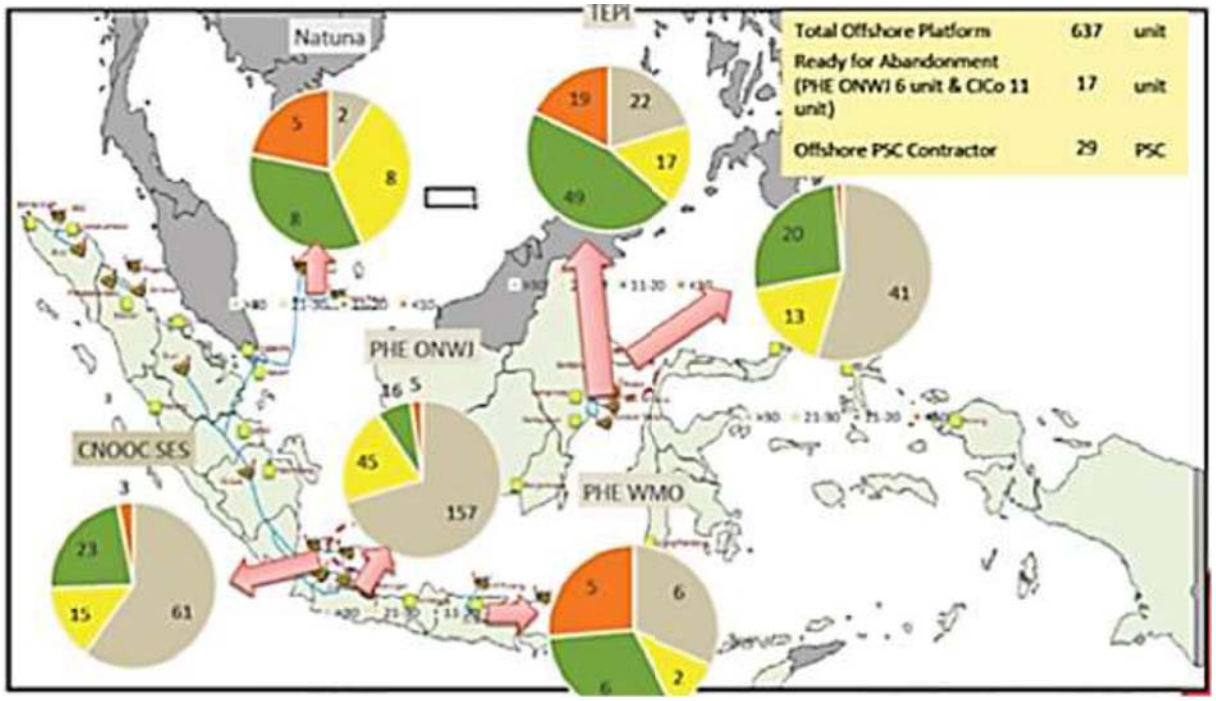


Figure 1. The distribution of oil and gas wells drilling and platforms. Source: [1]

Table 1. Number of offshore oil and gas platforms based on age and existing PSC contractors in Indonesia.

The age of platforms (years)	CNOOC	PHE ONWJ	PHE WMO	Natuna	TEPI	CICo	Total
< 10	3	5	5	5	19	1	38
10-20	23	16	6	8	49	20	122
21-30	15	45	2	8	17	13	100
> 30	61	157	6	2	22	41	289
Total	102	223	19	23	107	75	549

Source: Aryana [1]

Ministry of Energy and Mineral Resources (ESDM) ministerial regulation No. 35/2006, Article 17 and 18 stated that Minister of Energy and Mineral Resources could propose the elimination of operating items (including offshore oil and gas platforms) to be used, transferred, or destroyed with the approval of the Minister of Finance. To be able to exploit oil and gas platforms for other functions, exhaustive research must be performed, both concerning the technical issues, the standard rules, the environment, and the legislation in force. However, there have been no platforms dismantled and removed before in Indonesia since the installation of the first platforms for almost half of century. Therefore, the Dismantlement, Repair and Engineering (DRE) process in Indonesia is an important issue and it will be a benchmark on next DRE project in the future.

While the dismantling process also can be seen an opportunity to obtain greater a profit from the investments by converting the idle platforms to other uses that has economic value or scientific benefits. A new perspective that is currently considered easier, effective and efficient is that

decommissioning of offshore rigs structures will provide an opportunity to conserve a large part of the biological communities that inhabit in the surrounding area of the offshore platforms, thus preserving ecological resources and contribute to both local and regional biological production. Finally, decommissioning can be an opportunity for Indonesia as well as the oil and gas companies, to achieve financial benefits through its share of decommissioning costs that are avoided, thereby increasing available resources to support environmental outcomes and socio-economic benefits.

The objective of this paper is to outline options of decommissioning to effectively dismantle or re-use abandoned platforms in Indonesia. There are some options to reutilize the platforms in Indonesia considering the needs of marine and fisheries. Moreover, this study will highlighted that the conversion of abandoned oil and gas offshore platforms for reefing area (R2R) is the most sustainable and prospective solution to be carried out in Indonesia by considering the effectiveness and efficiency of project that are not only able to provide a significant reduction of the decommissioning costs but also deliver added value to conservation of marine environment and coastal communities economy. The target platforms for feasibility study are three abandoned platforms located in the ATTAKA fields, East Kalimantan that ready to be converted into decommissioning. These seven platforms are belonging to Chevron Indonesia Company (CICo) that at the end of 2016 has submitted a plan to dismantle both of the platforms. We conducted research by obtaining material and advice from SKK Migas, University and the operating Company.

2. Material and Methods

2.1. Evaluating Alternative Option for Decommissioning

As it already mentioned above, there are a number of potential dismantling options that could be implemented by government and oil companies when their assets reach the end of economic production. These various options need to be considered and a description based on comparative assessment will be used to evaluate the relevant alternatives.

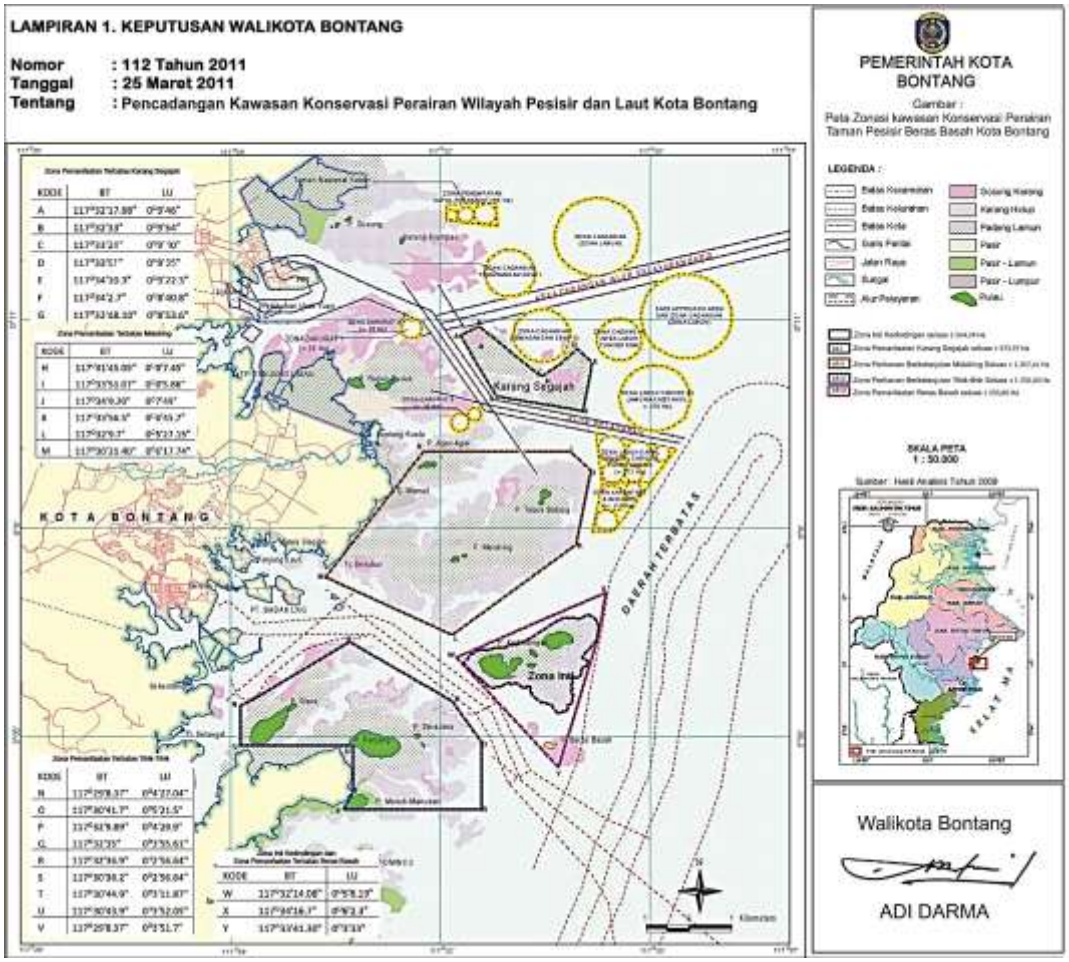
The Agency for Marine and Fisheries Research and Human Resources (Ministry of Marine Affairs and Fisheries, Republic of Indonesia) collaborated with Korean Maritime and Ocean University Consortium (KMOUC) (Republic of South Korea) conducted a joint research on development of marine and fisheries scientific and technical cooperation on abandoned oil platforms in Indonesia. The purpose of the cooperation is conduct a feasibility study on Dismantle, Re-utilization and Engineering Project of abandoned oil and gas platforms in Indonesia and to suggest project consistent with Indonesia policy among the various options of decommissioning of the offshore platforms. Some aspects that have been studied are policy, calculation of costs demolition and feasibility study (FS) for offshore platforms on Attaka block (Attaka I, EU, AB) in Bontang City, East Kalimantan.

2.2. Field work measurement

A study was carried out around the marine conservation area (KKPD) Bontang as the candidate location for the placement of rig structures. Marine conservation area in Bontang, which has an area of 5,121.38 hectare, has been established based on the major decision no 112 of 2011. This marine conservation area consists of the core zone of Kedingdingan (562.24 ha), use zone of Karang Segajah (379.97 ha) and Beras Basah (203.66 ha), sustainable fisheries zone of Melahing (2,207.41 ha) and Tihik-Tihik (1,700.03 ha) (Figure 2a).

In this paper, the offshore field for decommissioning of platforms is located in ATTAKA. The fields are located in east Kalimantan offshore and there are three platforms (I, EB and UA) for decommissioning in ATTAKA field. ATTAKA field is located to the west of Kalimantan Island in water depths around 200 ft. Several platforms produce oil and gas from wells. Product from the north area and deep-water operation is shipped to Santan Terminal and product from the south area is shipped to Lawe Lawe (Figure 2b).

(a)



(b)

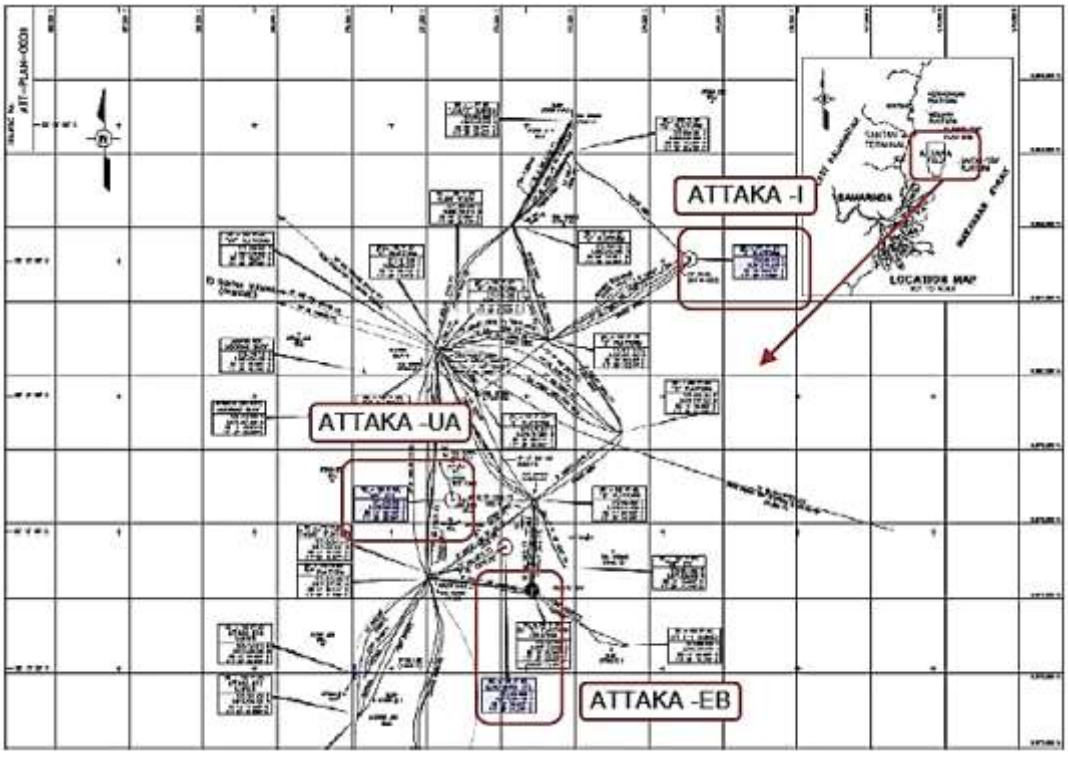


Figure 2. (a) Marine Conservation Areas in Bontang and (b) ATTAKA field layout.

This paper also tries to assess the suitable location for the rigs placement based on several criteria. A field measurement was conducted in the surrounding area of utilization zone of Karang Segajah in order to locate the best suitable geographical site for the R2R. The site selection for R2R should take accounts the following criteria (Table 2):

Table 2. Principal site selection criteria for R2R.

Criterion	Optimum	Consideration
Depth	40-50 m	With 85 feet or 26 meter clearance for shipping channel and the width of the rigs (vary) when it is toppled on the seabed
Slope	$< 1^0$, Flat topography	Avoid collapse of rig structures
Bottom type	Hard or solid rock	Avoid sinking into the sea-floor
Distance to closest natural resources	> 0.5 miles	Ecosystem connectivity (supported by numerical model of larvae dispersal)
Distance to coast	> 5 miles	Reduce wave effect and human interference
Current velocity	< 1 knot (0.5 m/s)	Avoid the scrapping effect from the strong current
Placement area	No interference with other activities	Appropriate to its purposes stated in zonation plan

The water depth for R2R placement should not be too shallow as this artificial reef built from huge structure of oil platforms therefore it must consider the safety of sea traffic. The optimal water depth should range from 40-50 m by paying attention to the clearance distance (26 m from the surface) to avoid impeding shipping cruises and the width of the rig when it is toppled. The suitable location for R2R must have a flat and wide seabed consisting of sedimentary material such as pebbles or sand with shells and a topographic slope of not more than 1^0 to ensure the structure of the rigs is stable and does not collapse or shift in these areas. Moreover, areas exposed to strong ocean currents or tidal velocities greater than 1 knots or 0.5 m/s should also be avoided to prevent the artificial reef structures from being destroyed or would raise difficulties during the deploying operation and facilitate the monitoring and evaluation processes.

One of the considerations to place decommissioned rigs in locations that will maximize ecological benefits is knowledge of larval dispersal trajectories [2] as it will increase recruitment success and help retain larvae (coral) that would otherwise be “lost” to inhospitable substrates [3]. The coral populations will depend on the distance of rig placement and natural source habitat and the minimum distance of rig placement to intercept larval recruits from natural sources is less than 65 km. Understanding the pattern of connectivity in conservation areas is very important to know the effectiveness of marine conservation areas. The magnitude of the impact of resilience on reefs in conservation areas depends on the effectiveness of connectivity between reefs within the conservation area. The connectivity between conservation areas depends on the pattern and strength of larval spreads that serve to protect biodiversity and enhance fisheries through on going recruitment [4].

The use of the biophysical model, one of the modules in MIKE 21 has been initiated to study the connectivity of conservation areas. Biophysical modelling has been used to get recruitment scenarios and traces of larval spread. This modelling is increasingly being used as a predictor of the spread of larvae to assess connectivity between conservation areas and for general evaluation of various factors that play a role in the movement of larvae. This biophysical model can also be used to estimate area connectivity on spatial as well as temporal scale, so that the utilization of biophysical models can provide optimal results related to the utilization of marine conservation areas.

3. Results and Discussion

3.1. Decommissioning in Indonesia

In terms of the dismantling of the abandoned platforms, government has a vital role, as it has been described by some international rules that the decommissioning of sea installations and structures is

the duty of the state. Even though, in the practice, the obligations were not entirely run by the state or government, the oil contractors or Management Company is also one of the main elements in the decommissioning activities. Moreover in Article 33 of Law No. 32/2014 on Marine that it states the government serves as a regulator and supervisor for the decommissioning activities. *"The government is responsible to supervise the activities of the dismantling of the buildings and installations in the sea that are not functioning."* This supervision task is carried out by an agency or task force that set up by the government through the Article 2 of Presidential Regulation No. 9/2013 on the Implementation of Upstream Management on Oil and Gas hereinafter in this Presidential Regulation referred as SKK Migas.

Where there are some standards in these guidelines that need to be considered on dismantling the installation, which are as follows [5]:

1. All installations or structures which are abandoned or disused that standing in water depths less than 75 meters and weighing less than 4000 metric tons should be dismantled as a whole except the "deck" and "superstructure". Start from 1st January 1998 all the requirement will be applied and apply to all installations that stood at depths less than 100 meters and weighing less than 4000 metric tons and placed on the seabed at 1st January 1998 and thereafter except "deck" and "superstructure";
2. The dismantle must be done in such a way to prevent the emergence of huge losses to the marine environment and shipping safety;
3. Effective as of January 1st 1998 there is no installation or building can be erected on the continental shelf or the exclusive economic zone unless the design and construction is such that the overall demolition can be carried out after installation or building was abandoned or is not used anymore so on.

While in Indonesia the technical specifics on dismantling of the offshore installation is set in ESDM Ministerial Regulation No. 1/2011 about The Guidelines of Technical Matter on Offshore Oil and Gas Platform Decommissioning which referring that the decommissioning is a work of partial or total dismantle of installation and removing it to a specified location.

From the legal aspect, Indonesia has several regulations on platform decommissioning and it's ready to do a decommissioning project. However, until now there is no platform that has been dismantled on purpose either entirely or partially. This is more due to the bureaucracy in the government that quite long and time consuming. Therefore, in this paper we try to provide alternative solutions that can be used by the stakeholder.

3.2. Best option for Indonesia's decommissioning

Even though the offshore platform decommissioning never been implemented in Indonesia, a new initiative of decommissioning has been proposed and implemented by several countries to not only reducing the dismantling cost but also gain added values from the disused structures. A comparative assessment has been conducted by comparing the options with several factors such as technical (rigs structures), economic (initial investment, operational and maintenance costs, revenue, duration of the BEP), security (risk and safety) and liability (ownership and responsibility). The result of the assessment can be seen in Table 3. Not all alternative uses are technically, economically and politically feasible. Those must be evaluated on a case-by-case basis and weighed against many different factors. All the options, excluded R2R need not only the jacket but also the topside as a logistic base and accommodation for hotel resort/military base/research station or modify to use wind or waves sequences to create electrical power for renewable energy hub as well as for fish cold storage.

Table 3. Reutilization options of obsolete rigs structures.

No	Reuse Options	R2R	Fish Farm	Sea adventure	Fishery Cold Storage	Renewable Energy Hub	Research Station	Military Ba
1.	Reused part	Jacket	Jacket	Topside/ Jacket	Topside/Jacket	Topside/ Jacket	Topside/Jacket	Topside/Jacket
2.	Safety at sea	Good	Not good	Not good	Not good	Not good	Not good	Not good
3.	Capital Investment (facilities required)	No	High (Cage, automatic feeder, seed, etc.)	High (Infrastructure etc.)	Yes (Electricity, refrigerator etc.)	Yes (Turbine, generator, etc.)	Yes (Sensors)	Yes (military facilities)
4.	Operational and Maintenance cost	No	Yes (food, man hour etc.)	Yes (Electricity, man hour, etc.)	Yes (electricity, man hour, etc.)	Yes (Man-hour, corrosion, etc.)	Yes (Man-hour)	Yes (man hour
5.	Benefit proven/economic benefit	Yes	Case by case (visible business/High)	Case by case (Tourism/ Moderate)	Case by case (fish stock/Moderate)	Case by case (Electricity/low)	Case by case (Data/low)	Case by case (sea security/low)
6.	BEP (min year)	10	2 or 3	Case by case	Case by case	N/A	N/A	N/A
7.	Risk (damage, malfunction)	Low	High	High	High	High	Moderate	High
8.	Ownership	Clear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
9.	Responsibility for ultimate removal	Clear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear

Source: Marine Research Center (MRC) [6]

In business point of view, the cold storage, military base and research station do not seem bring economic benefits. Fish farm (both submerge and floating cage) is considered here in case of reusing platform jacket without its removal (only the topside to remove) and reengineering of it. The option has the potential of creating an environment for farming of coastal fish. We have calculate that the fish cage give high return for only 2 or 3 year (BEP) however, this alternative brings its own obstacles including placing and retrieving the cages from within the structure, overall safety considerations, high capital investment as well as the operational and maintenance costs. Likewise with the floating hotel, even converting the industrial platform to a comfortable hotel such Seaventures dive spot in Malaysia would be a good destination for tourist but with little interest from the investor or visitors no economic viability guaranteed.

Among of the options, R2R is the preference that gets best review and can be proposed to be implementing in Indonesia (Table 3). From the perspective of fisheries, the most interesting alternative activities today are changing the structure of the sea into an artificial reef or R2R program. Artificial reefs are known as one of the ways the most effective approach to increase the productivity of coastal waters with provide additional habitat for marine life. Offshore structures can attract many species that migrate for food, shelter, and place to reproduce. Above all it is important to understand that, except for the partial removal and artificial reefing option, all other uses merely postpone, but do not do away with, the need to eventually remove platforms when they reach the end of their structural lifetimes. The ownership and responsibility for completely removal after the utilization over would become major issue later. Therefore, R2R is the best solution for sustainable decommissioning while at the same time gain revenue for coastal community and environmental production.

3.3. Site selection for R2R placement

A multibeam Echo sounder was applied to identify the seabed morphology and acoustically classify marine landscapes and benthic ecosystem in the surrounding area of Karang Segajah. The Two flat and wide areas were found that are proper for the rig placement (Figure 3 and Figure 4). Alternative 1 is located in coordinate of latitude 0:9:14.524 U, longitude 117:34:39.896 T (564289.86 mT, 10017026.32 mU) with depth of 46.47m. In Figure 4a the blue line has 144m of distance and has slope about 0.12^{o} (0.12 degrees). The location of alternative 1 exactly is in the south-west of last border of anchoring area. The red line is the North border of anchoring.

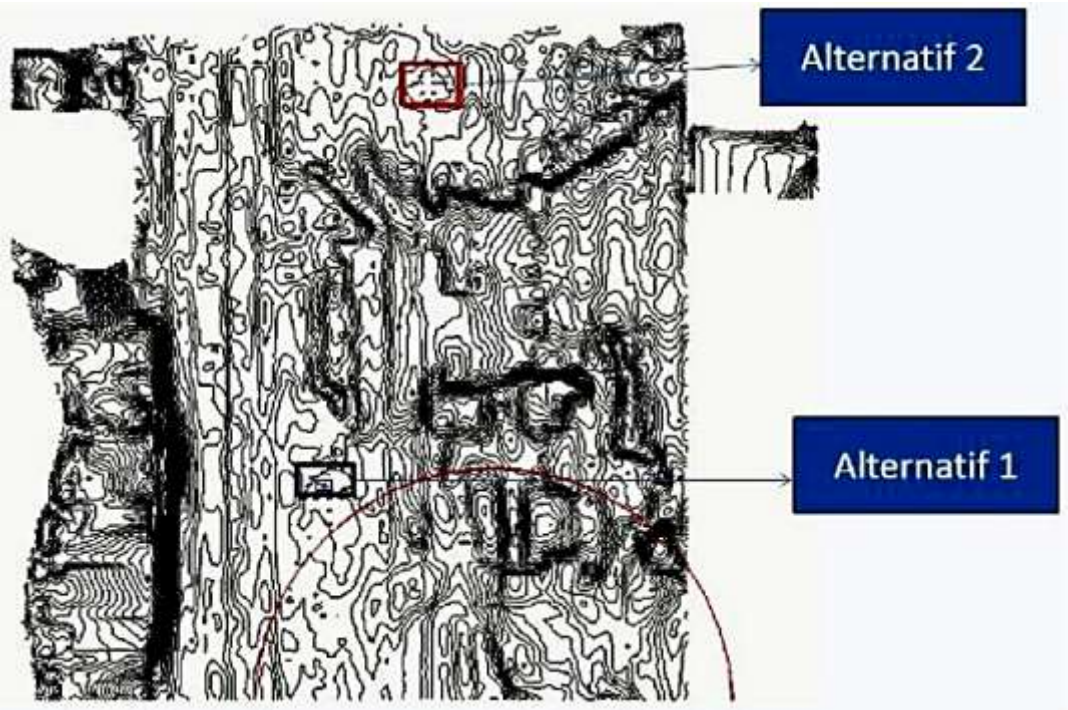


Figure 3. The Relative flat Alternative Area.

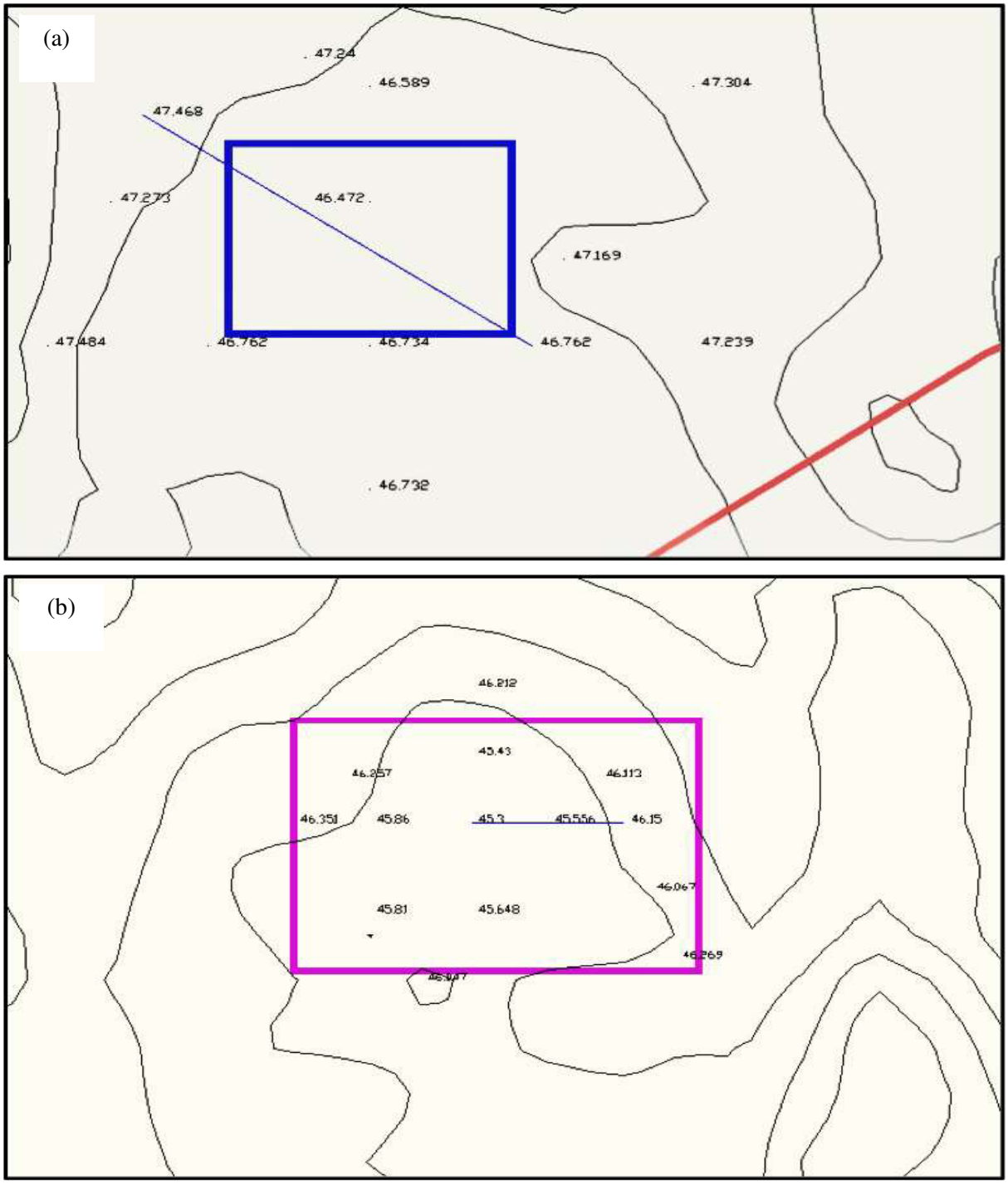


Figure 4. Bathymetric Map Screenshot in the Location of Alternative (a) and (b).

Alternative 2 is in coordinate of latitude 0:10:5.005 U, longitude 117:34:53.485 T (564709.86 mT, 10018576.32 mU) with depth 45.30 m. The distance to the border of anchoring is about 1.5 km. In Figure 4b, the blue line has distance 60 m and slope about 0.8^{o} (0.8 degrees). The abandoned platform form ATTAKA will be transported to Bontang using barge and dropped in that candidate sites in Karang Segajah (Figure 5).

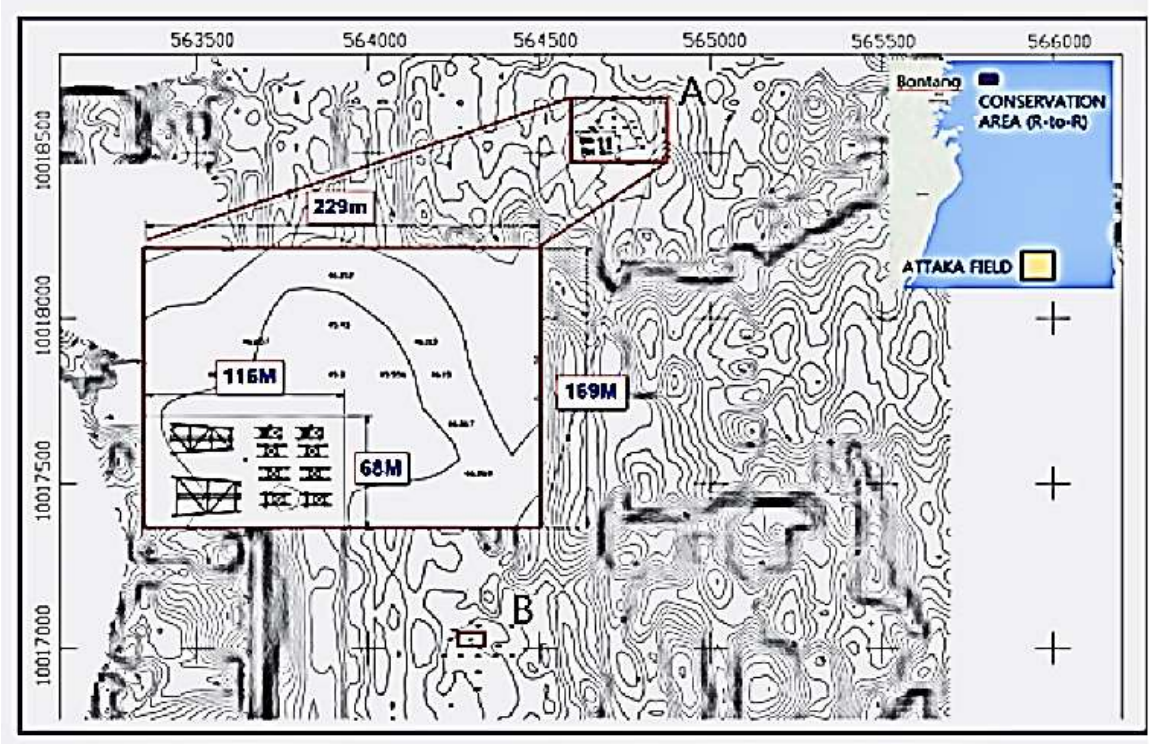


Figure 5. Final location of Rig-to-Reef jackets of ATTAKA in conservation area.

The simulation of larval distribution is made by using Agent Based Modeling (Passive Drifter) module, by first making the hydrodynamic of ocean surface current in Bontang's marine conservation area (Kawasan Konservasi Perairan Daerah, KKPD, Bontang) using Mike 21 Flow Model FM. The larvae trajectory will be focused on the two candidate sites for rig placement that obtained from multi-beam survey. The input data for this model are bathymetry, tide and wind data. In the simulation, the larval motion uses some assumptions due to limited primary and secondary data for input the model.

The results of the larvae distribution model indicate that the process of spreading coral larvae in the Bontang conservation area is influenced by surface currents generated by tidal and wind variations during those periods. Based on the simulation results, there are differences in the pattern of larval distribution in each season mainly related to its distribution to both placement sites for rig to reef. Simulation of larval movement conducted for 30 days in west season (January) showed that the larvae would reach first candidate site on the 15th day. This condition will end at the 21st day of simulation. While the movement of larvae reach the second site on the 16th day and end within 17 hours. The larvae will spread back to the second site on the 19th day (Figure 6).

To sum up, the simulation models can show the difference in movement patterns of coral larvae and connectivity between the original natural sources of larvae with the new sites. Both of the sites are best location for the rig placement as the larvae can reach those places.

3.4. The social and economic benefits of R2R

Based on the general assumption of discount rate (4.02%), future rate of money value (5.98%) and duration of time of the program over 30 years and the result of cost-benefit analysis of economic feasibility of platform conversion plan of offshore oil and gas become coral reef artificial (Table 4).

Table 6 shows that the NPV value with 11-year program duration, a discount rate of 4.02% and a future rate of money of 5.98%, was Rp 859.64 billion. This value indicates that within 30 years of the project, a platform conversion program of former offshore oil and gas platforms to become an artificial reef ecosystem can be declared feasible.

Table 4. Result of economic feasibility analysis.

No	Feasibility components	Value	Unit	Feasibility
1	Net Present Value (NPV)	859637.46	Million Rupiah	Feasible
2	Net Benefit-Cost Ratio (NCBR)	2.58		Feasible
3	Internal Return Rate	10.32	%	Feasible
4	Pay Back Period (PBP)	11.61	Year	Feasible

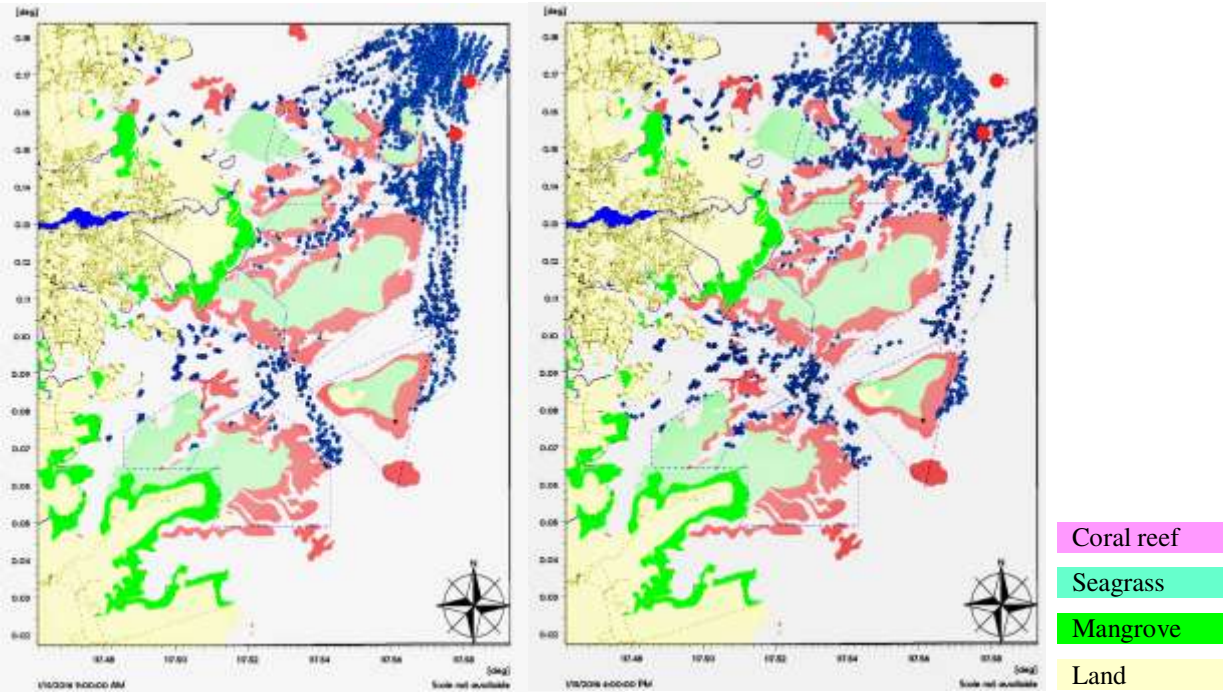


Figure 6. The spread of coral larvae at the initial condition of simulation.

4. Conclusion

Indonesia as an oil and gas producing country will face problems when its oil and gas platforms, especially those located offshore, reach the end of their production period. These situations makes dismantling process in Indonesia far from completion and tends to stagnant even bring negative impacts on the environment and shipping safety. One of the potential solutions for sustainable decommissioning is converting the abandoned rig structures into artificial reefs. The option is not only beneficial for oil companies as well as for coastal communities because R2 will raise the economy in the tourism sector in particular.

However, this R2R Initiative needs to be supported with regulation and policy from all stakeholders, especially the government, which in this case are Ministry of Energy and Mineral Resources who the one have responsibility in regulating the decommissioning process with SKK Migas as the implementer. On the other hand, Ministry of Marine Affairs and Fisheries also can contribute in supporting the R2R implementation since the purpose of the R2R is to create new ecosystem to support marine and fisheries. This interest is reflected in the new draft of Government Regulation on Marine Installation and Structure where the R2R explicitly mentioned as one of alternatives platform re-utilizing.

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