BIG SIZE ARTIFICIAL REEFS FOR FISHERIES ENHANCEMENT IN MALAYSIA

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SEAFDEC/MFRDMD Chendering Terengganu
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12-13 November 2013, Singapore

Size: 3.75 m (L) x 3.75 m (W) x 3.85 m (H)
Weight: 42 mt
Name: SOFT BOTTOM ANTI-TRAWLER

Size: 3.75 m (L) x 3.75 m (W) x 3.85 m (H)
Weight: 32 mt
Name: SOFT BOTTOM ANTI-TRAWLER
Outline

• Introduction
• ARs program in Malaysia
• Why Big Size Artificial Reefs?
• Post Deployment Monitoring/Success Story
• Conclusion
Artificial Reefs (ARs) program in Malaysia

A. Fishery Use

I. Conservation
To enhance coastal fisheries resources, to provide firm substrate for marine fauna and flora to grow, to deter the encroachment of prohibited inshore areas by trawlers (DoFM not allowed any fishing activities within 0.5 nm from the ARs site.)

DoFM, DoFSabah, Dept. of Marine Park (DPM), Sarawak Forestry Cooperation

II. Fishing
To aggregate scatter fish; (save time and fuel for searching fishing area. Fishing activities allowed.)

DoFM, DoFSabah, LKIM*, APMM, DMP, SIRIM Bhd, Fishermen, recreational anglers, etc

B. Non Fishery Use

Provide firm substrate for marine fauna and flora to grow, enhance marine resources (recreational: SCUBA, snorkeling). Fishing activities allowed if AR sites outside Marine Protected Area

DMP, NAHRIM, University, Chalet operators, MNS, Reef Check, SIRIM Bhd, LHDN, Private company, etc

*LKIM=Fisheries Development Board of Malaysia
### Budget Allocated to DoFM and LKIM for Construction and Deployment of ARs and Unjam-Unjam (1976-2010)

<table>
<thead>
<tr>
<th>Malaysian Plan</th>
<th>Duration</th>
<th>DoFM (RM)</th>
<th>LKIM (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Malaysia Plan</td>
<td>1970-1975</td>
<td>0*</td>
<td>0</td>
</tr>
<tr>
<td>3rd Malaysian Plan</td>
<td>1976-1980</td>
<td>116,000</td>
<td></td>
</tr>
<tr>
<td>4th Malaysian Plan</td>
<td>1981-1985</td>
<td>524,000</td>
<td>199,656.87*</td>
</tr>
<tr>
<td>5th Malaysian Plan</td>
<td>1986-1990</td>
<td>8,240,000</td>
<td>2,123,880.38</td>
</tr>
<tr>
<td>6th Malaysian Plan</td>
<td>1991-1995</td>
<td>9,400,000</td>
<td>3,831,275</td>
</tr>
<tr>
<td>8th Malaysian Plan</td>
<td>2001-2005</td>
<td>2,524,344</td>
<td>60,377,893</td>
</tr>
<tr>
<td>9th Malaysian Plan</td>
<td>2006-2010</td>
<td>32,004,162</td>
<td>21,224,385</td>
</tr>
<tr>
<td>Total Budget Received</td>
<td></td>
<td>RM 55,560,459</td>
<td>RM 99,192,722</td>
</tr>
<tr>
<td>Total year</td>
<td></td>
<td>34</td>
<td>27</td>
</tr>
<tr>
<td>Average budget received</td>
<td></td>
<td>1.6 million/yr</td>
<td>3.6 million/yr</td>
</tr>
</tbody>
</table>

*Note: DoFM and LKIM started ARs and unjam-unjam program in 1975 and 1983 respectively. In 1975 DoFM initiate research on ARs using budget under ecology study (not specific for ARs)*
<table>
<thead>
<tr>
<th>No</th>
<th>Agencies</th>
<th>Duration</th>
<th>Material</th>
<th>Budget Spent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LKIM</td>
<td>(1983-2010) 27 yrs</td>
<td>Reinforced Concrete, tyre, ceramic, FRC, fiberglass, others</td>
<td>RM99,192,722</td>
</tr>
<tr>
<td>2</td>
<td>DoFM</td>
<td>(1976-2010) 34 yrs</td>
<td>Reinforced Concrete, tyre, pvc, fishing vessel, ceramic, others</td>
<td>RM55,560,459</td>
</tr>
<tr>
<td>3</td>
<td>Marine Park</td>
<td>(1994-2012)</td>
<td>Reinforced Concrete, Bio rock, war ship, fishing vessel, PVC, fiberglass, others</td>
<td>&lt; RM 1,000,000*</td>
</tr>
<tr>
<td>4</td>
<td>APMM</td>
<td>(2005-2012)</td>
<td>Confiscated fishing vessel</td>
<td>&lt;RM 100,000*</td>
</tr>
<tr>
<td>5</td>
<td>SIRIM BHD</td>
<td>(2010-2012)</td>
<td>Ceramic</td>
<td>&lt; RM 500,000*</td>
</tr>
<tr>
<td>6</td>
<td>NAHRIM*</td>
<td>(2009- )</td>
<td>Reinforced Concrete</td>
<td>&lt;RM100,000*</td>
</tr>
<tr>
<td>7</td>
<td>USM</td>
<td>(2011- )</td>
<td>Reinforced Concrete (for sea cucumber)</td>
<td>&lt;RM100,000*</td>
</tr>
<tr>
<td>8</td>
<td>LHDN</td>
<td>2013</td>
<td>Steel</td>
<td>&lt;RM100,000*</td>
</tr>
<tr>
<td>9</td>
<td>DoF Sabah</td>
<td>1980’s</td>
<td>Tyres, old vehicle, fishing vessel, etc</td>
<td>&lt;RM500,000*</td>
</tr>
<tr>
<td>10</td>
<td>Sarawak Forestry Cooperation</td>
<td>1977-</td>
<td>Reef ball</td>
<td>&lt;RM500,000*</td>
</tr>
</tbody>
</table>

*Estimated figure. Note: Looking for information on the budget spent by respective agencies.
# Budget Spent from 1976-2010 by DoFM and LKIM for Construction Small and Medium, and Big size ARs

<table>
<thead>
<tr>
<th>Duration</th>
<th>DoFM (Small and middle size ARs (RM))</th>
<th>DoFM (Big size ARs (RM))</th>
<th>LKIM (Small and middle size unjam-unjam (RM))</th>
<th>LKIM (Big size unjam-unjam (RM))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-1980</td>
<td>116,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1981-1985</td>
<td>524,000</td>
<td>0</td>
<td>199,656.87</td>
<td>0</td>
</tr>
<tr>
<td>1986-1990</td>
<td>8,240,000</td>
<td>0</td>
<td>2,123,880.38</td>
<td>0</td>
</tr>
<tr>
<td>1991-1995</td>
<td>9,400,000</td>
<td>0</td>
<td>3,831,275</td>
<td>0</td>
</tr>
<tr>
<td>1996-2000</td>
<td>2,751,953</td>
<td>0</td>
<td>11,435,631.87</td>
<td>0</td>
</tr>
<tr>
<td>2001-2005</td>
<td>2,524,344</td>
<td>0</td>
<td>58,981,998 (97.7%)</td>
<td>1,395,900 (2.3%)</td>
</tr>
<tr>
<td>2006-2010</td>
<td>9,419,832 (29.4%)</td>
<td>22,584,330 (70.6%)</td>
<td>11,369,385 (53.7%)</td>
<td>9,855,000 (46.4%)</td>
</tr>
</tbody>
</table>

Overall budget spent for construction and deployment of Big Size ARs:
DoFM: RM 22.58 million (40.6%) from RM 55.5 million (1976-2010)
LKIM: RM 11.25 million (11.3%) from RM 99.2 million (1985-2010)
Total Number of Big Size ARs and Unjam-Unjam Sites in Malaysia until 2010

- LKIM: (Red) : 15 sites
- DoFM: (Black): 64 sites
- Total: 79 sites

No of module/site: 10-72
What is Big size ARs?

Very subjective!

For DoFM classification are based on Size, Weight, Material and Design.

• Minimum size: 2 m (L) X 2 m (W) X 2 m (H)
• Weigh: > 10 metric tonnes (reinforced concrete)
• Steel ship: war ship, commercial and fishing vessel Zone C and above
• Wooden boat: similar size as vessel Zone C and above
• Others: Petroleum structures
Classification of ARs size by DoFM (Fabricate reinforced concrete)

<table>
<thead>
<tr>
<th>Category</th>
<th>Measurement (in meter)</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small size</td>
<td>&lt; 1m (1 X 1 X 1)</td>
<td>&lt; 5 mt (300 kg)</td>
</tr>
<tr>
<td>Medium size</td>
<td>1-2 m (1.8 X 1.8 X 1.8)</td>
<td>5-10 mt (5 mt)</td>
</tr>
<tr>
<td>Big size</td>
<td>&gt; 2 m (3 x 3 x 3.6)</td>
<td>&gt; 10 mt (19 mt)</td>
</tr>
</tbody>
</table>

Small ARs | Medium ARs | Big ARs
### BIG SIZE SOFT BOTTOM ARs: DoFM (2006-2010)

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Grade Concrete</th>
<th>Year Produced</th>
<th>Measurement (in meter) (LxWxH)</th>
<th>Weight (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soft bottom 1 (SB 1)</td>
<td>40</td>
<td>2006</td>
<td>3.0 x 3.0 x 3.6</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Soft bottom 2 (SB 2)</td>
<td>50</td>
<td>2007, 2008</td>
<td>3.0 x 3.0 x 3.6</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Soft bottom 3 (SB3)</td>
<td>50</td>
<td>2009, 2010</td>
<td>3.75 x 3.75 x 3.85</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Soft bottom anti-trawler (SB-AT)</td>
<td>50</td>
<td>2010</td>
<td>3.75 x 3.75 x 3.85</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>Soft bottom juvenile (SB-J)</td>
<td>50</td>
<td>2010</td>
<td>3.75 x 3.75 x 3.85</td>
<td>42</td>
</tr>
</tbody>
</table>
# BIG SIZE CUBE ARs (2009-2012)

1. **Cube-2009**
2. **Cube-J :2010**
3. **Cube-AT: 2012**

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Concrete grade</th>
<th>Year Produced</th>
<th>Measurements (in meter) (LxWxH)</th>
<th>Weight (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cube</td>
<td>40</td>
<td>2009</td>
<td>2.5 x 2.5 x 2.5</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Cube juvenile (Cube-J)</td>
<td>40</td>
<td>2010</td>
<td>2.5 x 2.5 x 2.5</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Cube anti-trawler (Cube-AT)</td>
<td>40</td>
<td>2012</td>
<td>3.5 x 3.5 x 3.5</td>
<td>22.5</td>
</tr>
</tbody>
</table>
## BIG SIZE CUBOID ARs (2007-2010)

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Concrete grade</th>
<th>Year Produced</th>
<th>Measurement (in meter) (LxWxH)</th>
<th>Weight (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cuboid</td>
<td>40</td>
<td>2007</td>
<td>2.0 x 2.0 x 3.0</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Cuboid juvenile</td>
<td>40</td>
<td>2010</td>
<td>2.0 x 2.0 x 3.0</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Cuboid Bio-active</td>
<td>40</td>
<td>2010</td>
<td>2.0 x 2.0 x 3.0</td>
<td>14</td>
</tr>
</tbody>
</table>
### Classification of Unjam-Unjam Size by LKIM

<table>
<thead>
<tr>
<th>Category</th>
<th>Measurement (in meter) (LxWxH)</th>
<th>Weight (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small size</td>
<td>0.73 X 0.73 X 0.73</td>
<td>&lt; 5 mt (&lt;100kg)</td>
</tr>
<tr>
<td>Medium size</td>
<td>3.0 X 3.0 X 4.6</td>
<td>5-10 mt (5 mt ?)</td>
</tr>
<tr>
<td>Big size</td>
<td>3.0 X 4.6 X 3.5</td>
<td>&gt; 10 mt (13 mt)</td>
</tr>
</tbody>
</table>

1. Cube

2. Bio ceramic

3. Protek
Other Big Size ARs Confiscated: fishing vessel and retired war ship

Wooden fishing vessel:
Lifetime: < 3 yrs

*Excavator: Near Bidong Island/ Accident occurred during deployment of tetrapods ARs
Big size but shorter lifetime (not recommended by DoFM)

Bus: Deployed by NGOs

Lorry: Deployed by NGO

Bidong Island, Terengganu

Bidong Island, Terengganu

Wooden vessel
Why DoFM Focus on Big Size ARs

School of bigeye snapper swimming close to a small mollusc

15 cm
Almost all (31 tails) aggregating around a mollusc (15 cm height)
What happen if we place this ARs measured (3 m X 3 m X 3.6 m) at the same place?
We estimate about 2000 tails of *Lutjanus lutjanus* and *Lutjanus vitta* around or within a module of big size ARs.

This picture taken 11 months after deployment of cuboid ARs measured: 2 m X 2m x 3 m (in Terengganu)
Smaller ARs normally shorter life span and aggregating less fish as compared to bigger ARs.
PREPARATION OF TENDER/ QUOTATION DOCUMENTS
for Construction and Deployment of ARs by DoFM

• Followed the British Standard 8110
• Column and beam rebar – Y12 x 4
• Link – R8 @ 200mm c/c
• Slab reinforcement – BRC A10/Y10
• Concrete cover – 50mm
• Ready-mixed concrete from batching plant – (grade 50 for soft bottom ARs and grade 40 for other types of ARs)
• Cube test after 7 and 28 days age of construction
Site selection before deployment

- Side scan sonar
- Phleger corer
- Smith Mc Intyre grab
- Sub bottom profile/Echo sounder
Transportation and Deployment/Placement

After verification using side scan sonar, echo sounder and soft bottom, the exact coordinate were submitted to (National Hydrography Center) for their references and for the safety of submarine during sailing and operation.
Devices used during the placement of ARs on the seabed
Verification of coordinates and condition of ARs using side scan sonar, echo sounder and sub bottom profiler
(Collaboration with Institute of Oceanography and Environment, University Malaysia Terengganu)
Big size ARs will induce up-welling in coastal water, fertilize the ocean with nutrients. Plankton bloom will attract many species of pelagic fish.
Image of ARs on the seabed and fish schools (pelagic) recorded by sub bottom profiler (Kuala Selangor)
Images of big size soft bottom ARs modules recorded by Side Scan Sonar near Pulau Besar, Melaka.
Deterring the encroachment of trawlers into inshore areas

Nets and entangled cod ends on big size ARs
The larger size ARs, are superior to the smaller ones in attracting more marine flora and fauna.

Increase no of sites for recreational activity especially SCUBA diving. Surface of ARs covered by soft coral.

*Note: Deployed in 2006 and pictures taken in 2010.
Marine life on Tetrapod ARs after 4 yrs
Tetrapod ARs after 4 yrs
Tetrapod ARs after 4 yrs
Sea cucumber near ARs (Phylum Echinodermata)

- **Stichopus ocellatus**
- **Stichopus horrens**
- **Bohadschia marmorata**
- **Stichopus horrens**
- **Euapta sp**
- **Holothuria pardalis**
Phylum Porifera (Sponges)
Commercial species
(More than 80 species)

sweetlips

stingray

shark

crab

lobster

grouper

sweetlips
snapper
Stingrays
snapper
Puffer fish
snapper
squit
sweetlips
grouper
grouper
Coral fishes
(more than 30 species)

flagfish

Blueringed angelfish

Lion fish

Cardinal fish

frogfish

Blueringed angelfish
Hiding site for green turtle during inter-nesting period (Kemaman, Terengganu)
Socio economy study on the impact of deployment of big size ARs to traditional fishers income (Sep-Dec 2011)

Result

1. 487 respondents (97%) Agreed: Encroaching of Illegal trawler fishing into traditional fishing areas significantly decreased after placement of big size ARs
2. 497 respondents (98%) Agreed: The larger size ARs are superior to the smaller ones in attracting more marine flora and fauna

Number of Respondent 502 : Number of Fishing Village 52
Gear used: Hook and line and trap
Socio economy study on the impact of deployment of big size ARs to traditional fishers income (Sep-Dec 2011)

46 respondents (9.1%) said their income has DECREASED

155 respondents (30.6%) said INCREASED but less than RM100/month

158 respondents (31.2%) said INCREASED but less than RM100/month

65 respondents (12.8%) said their income has NOT CHANGE

33 respondents (6.5%) said INCREASED more than RM300/month

49 respondents (9.7%) said INCREASED BY RM200-RM300/month

Conclusion: 78% said their income Increased and 22% said unchanged or decreased
## Costing effective of Big Size ARs
*(Expected lifetime > 50 yrs)*

<table>
<thead>
<tr>
<th>Type of Big size ARs</th>
<th>Grade concrete</th>
<th>Total Cost (RM)</th>
<th>No of Module</th>
<th>Average Cost/Module (RM)</th>
<th>Average Cost/Module (USD)</th>
<th>Average cost for one year/Module (RM)</th>
<th>Average cost for one year/Module (USD)</th>
<th>Daily Cost/module (for 50 years) (RM)</th>
<th>Daily Cost/module (for 50 years) (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>4 million</td>
<td>521</td>
<td>7,677</td>
<td>2559</td>
<td>153</td>
<td>51</td>
<td>0.42</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>800,000</td>
<td>72</td>
<td>11,111</td>
<td>3703</td>
<td>222</td>
<td>74</td>
<td>0.61</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>300,000</td>
<td>25</td>
<td>12,000</td>
<td>4000</td>
<td>240</td>
<td>80</td>
<td>0.65</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1 million</td>
<td>75</td>
<td>13,333</td>
<td>4444</td>
<td>267</td>
<td>89</td>
<td>0.73</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>540,000</td>
<td>36</td>
<td>15,000</td>
<td>5000</td>
<td>300</td>
<td>100</td>
<td>0.82</td>
<td>0.28</td>
<td></td>
</tr>
</tbody>
</table>

Construction Followed: British Standard 8110.
Concrete Grade 40: Pressure test >40 N/mm² after 28 days
Concrete Grade 50: Pressure test >50 N/mm² after 28 days
Conclusion

1. The larger size ARs, are superior to the smaller ones in attracting more marine flora and fauna.
2. The large size designs are excellent in performing the dual functions of creating new habitats and deterring the encroachment of trawlers into inshore areas.
3. Most ARs modules placed on coarse sand seabed were stable and no scouring occurred. The AR design allowed the passage flow of current above the module base, thus facilitating current flow with little resistance across the module at the bottom.
4. Good designs do attract more marine flora and fauna.
The highest steel ARs in Japan (until 2010) is 40 m, weight 92 mt, Location: Japan Sea, Yamagata Prefecture, water depth 63 meter, Target species: sea bream, horse mackerel, yellow tail.
Thank You