Review of Fishing Technology to Reduce Bycatch in Asia

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Contents

- Catch & Bycatch of Asia
- Bycatch Reduction Technology
  (Gillnet, Pot, Towed Gears)
- Conclusion
Catch = Marine capture production (Total 93,494 million ton)

Area Grand total 360.7, Asia Sub Total 85.9 (million km²), 23.8%

Data from FAO (2011)
## Global catch by fishing area, 2011

<table>
<thead>
<tr>
<th>Region No.</th>
<th>Nominal regions</th>
<th>Catch (1,000MT)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>Northwest Pacific</td>
<td>21,437</td>
<td>22.93</td>
</tr>
<tr>
<td>71</td>
<td>Western Central Pacific</td>
<td>11,521</td>
<td>12.32</td>
</tr>
<tr>
<td>57</td>
<td>Indian Ocean, Easten</td>
<td>7,212</td>
<td>7.71</td>
</tr>
<tr>
<td>87</td>
<td>Southeast Pacific</td>
<td>12,254</td>
<td>13.11</td>
</tr>
<tr>
<td>27</td>
<td>Atlantic, Northeast</td>
<td>8,021</td>
<td>8.58</td>
</tr>
<tr>
<td>51</td>
<td>Indian Ocean, Western</td>
<td>4,212</td>
<td>4.50</td>
</tr>
<tr>
<td>67</td>
<td>Northeast Pacific</td>
<td>2,950</td>
<td>3.15</td>
</tr>
<tr>
<td>77</td>
<td>Eastern Central Pacific</td>
<td>1,913</td>
<td>2.05</td>
</tr>
<tr>
<td>41</td>
<td>Atlantic, Southwest</td>
<td>1,759</td>
<td>1.88</td>
</tr>
<tr>
<td>31</td>
<td>Atlantic, Western Central</td>
<td>1,497</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>20,718</td>
<td>22.16</td>
</tr>
<tr>
<td></td>
<td>Global Total</td>
<td>93,494</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>Asia Total</td>
<td>40,170</td>
<td>42.96</td>
</tr>
</tbody>
</table>

- Asia Total: include Region No 57,61,71
- Area Grand total 360.7, Asia Sub Total 85.9 (million 扈), 23.8%

Data from FAO yearbook. Fishery and aquaculture statistics Yearbook (2011)
Sea Food Culture of Asia

Salted seafood

Fish sauce

SeaFood

Dried fish products (pollack)

Salted fermented seafood

Surimi

Fish meal
By-catch and Discards are not a new problem, it exists since fishing began.

Alaska Sea Grant - “bycatch” include retained incidental catch, fishery discards, and unobserved mortalities as a result of direct encounters with fishing gear.

Pre-Historical Record of By-catch Issue from the BIBLE


13:47 "Again, the kingdom of heaven is like a net that was cast into the sea that caught all kinds of fish.

13:48 When it was full, they pulled it ashore, sat down, and put the good fish into containers and threw the bad away.

(Prof Arimoto, FAO/SEAFDEC Workshop on by-catch and discards 2003 Bangkok)
### Estimated global discards by countries (1000 tons)

<table>
<thead>
<tr>
<th>Asian countries</th>
<th>Discards (1000 tons)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>China</td>
<td>74.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>270.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Japan</td>
<td>918.4</td>
<td>13.5</td>
</tr>
<tr>
<td>Korea</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Malaysia</td>
<td>10.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Myanmar</td>
<td>27.4</td>
<td>0.4</td>
</tr>
<tr>
<td>North Korea</td>
<td>1.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Philippines</td>
<td>7.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Thailand</td>
<td>27.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>17.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Others</td>
<td>5463.1</td>
<td>80.1</td>
</tr>
<tr>
<td><strong>Global Total</strong></td>
<td><strong>6819.2</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Formulated on data from Kelleher (2005)

MATSUOKA T., 2009, Negative impacts in capture fisheries: bycatch and discards and derelict fishing gear and ghost fishing. PICES meeting.
By-catch ratio to shrimps caught by shrimp trawler in the Arafura waters, Indonesia (1992~2001)

<table>
<thead>
<tr>
<th>Sub Area</th>
<th>Ratio By-Catch:Shrimp</th>
<th>References</th>
</tr>
</thead>
</table>
## Growth overfishing and trash fish landings, Malaysia

<table>
<thead>
<tr>
<th>AREA</th>
<th>Trash fish landings (tonnes)</th>
<th>% trash in trawl Landings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trawlers</td>
<td>All methods</td>
</tr>
<tr>
<td>West Coast Peninsular Malaysia</td>
<td>132,304</td>
<td>169,709</td>
</tr>
<tr>
<td>East Coast Peninsular Malaysia</td>
<td>58,777</td>
<td>60,599</td>
</tr>
<tr>
<td>Sabah, Sarawak &amp; Labuan</td>
<td>23,899</td>
<td>31,362</td>
</tr>
<tr>
<td>Whole Malaysia</td>
<td>214,980</td>
<td>261,670</td>
</tr>
</tbody>
</table>

Nuruddin & Isa (2013)
Accumulation of data by researches on Ghost Fishing (GF) by gillnets on flat seabed

<table>
<thead>
<tr>
<th></th>
<th>Kaeser et.al.</th>
<th>Erzini et.al.</th>
<th>Nakashima-Matsuoka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net length (m)</td>
<td>90</td>
<td>100</td>
<td>72</td>
</tr>
<tr>
<td>Net height (m)</td>
<td>3.0</td>
<td>2.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Mesh size (mm)</td>
<td>100</td>
<td>60</td>
<td>60〜99</td>
</tr>
<tr>
<td>Major GF species</td>
<td>Cat-sharks</td>
<td>Scorpionfishes</td>
<td>Threadsail filefish</td>
</tr>
<tr>
<td></td>
<td>Nursehound</td>
<td>Sea breams</td>
<td>Dragonet</td>
</tr>
<tr>
<td>GF duration (days)</td>
<td>141</td>
<td>56</td>
<td>142</td>
</tr>
<tr>
<td>GF mortality (number)</td>
<td>334</td>
<td>318</td>
<td>455</td>
</tr>
</tbody>
</table>

GF : Ghost fishing.

MATSUOKA T., 2009, Negative impacts in capture fisheries: bycatch and discards and derelict fishing gear and ghost fishing. PICES meeting.
## Bycatch Reduction Methods

<table>
<thead>
<tr>
<th>Fishing Gear</th>
<th>Selectivity (Mesh, Bar etc.)</th>
<th>Vent</th>
<th>BRD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gillnet</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pot</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Dredge</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Trawl</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
</tbody>
</table>

- **BRD**: Bycatch Reduction Devices
- **TED, Fish eye, BED, JTED, ETC...**, 

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**Note:** The table above outlines the selectivity and vent options for various fishing gears, with BRD indicating the presence of bycatch reduction devices.
Bycatch Reduction in Snow Crab Gillnet, Korea

Snow crab 97.12%

Spinyhead sculpin 0.81%

Pacific cod 0.18%

Catch rate of major species in snow crab gillnet

Park et al. 2003
- Used mesh size: 180 ~ 300 mm (5 steps)
- Retention Probability 0.5 \(\rightarrow\) RL/m = 0.356

(RL: Maximum carapace length, m: mesh size)

- Snow crab CL 90mm \(\rightarrow\) optimal mesh size 253mm
## Advanced Management efforts for snow crab

<table>
<thead>
<tr>
<th>Item</th>
<th>Before 2002</th>
<th>After 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesh size of gillnets</td>
<td>180 – 270 mm</td>
<td>240 mm ≤</td>
</tr>
<tr>
<td>Fishing season</td>
<td>11.01 ~ 05.31</td>
<td>12.01 ~ 05.31</td>
</tr>
<tr>
<td>Landing size (carapace length)</td>
<td>90mm</td>
<td>90mm</td>
</tr>
<tr>
<td>Female</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
Use of escape vents to improve size and species selectivity of collapsible pot for *Portunus pelagicus* in Thailand

- Collapsible crab pot: box shaped with size of $36 \times 54 \times 19$ cm

- Escape rate: **Square**(70%) > **Circle**(18%) > **Rectangular**(10%) > **Ellips**(2%)

- Escape Position: **4**(84%) > **1**(14%) > **2**(2%)

- Square-shaped escape vents were located at five pairs of different positions: on the lower slope panel at the corner (1) and center (2), on the side panel at upper (3) and lower (4) positions, and at the top panel corner (5) to observe escape behavior of crabs from the same pot for the vent position experiment

Boutson et al. [2005] immature blue swimming crab catch: 32–42%
First maturity size of crab : 46 mm CL
L50% (vent 35 × 45 mm) = 46.9 mm
Reducing catch of immature crab: 70.5 → 11.0%

- Blue swimming crab size sampled with conventional pots (open columns) and vented pots (shaded columns)

- Size selectivity of 35 × 45 mm escape vent for blue swimming crab from the field trials with L50% = 46.9 mm, a = -25.9403, b = 0.5528, and SR = 4.0 mm, in comparison with the result from the laboratory observation.

Boutson et al. (2009)
Size selectivity of red queen crab traps in Japan

- Specification for the vents trap used in experiment

**Landing size (CL): 90mm, L50 escape vent dia: 93mm**

- Red queen crab trap with vent.
- Mesh size 130mm, vent dia 95mm

Selectivity of Venus Clam Dredge in Korea

- Beam of dredge: 1,200L × 370H mm, net 4m
- Bar space: 12, 16, 20, 24, 35 mm
- Mesh size of net: 22, 24, 30, 41, 47 mm

KIM & Jo (2001)
(b) Selection shell length

- Selection curves for Venus clam, *Gomphina melanaegis*.

- **First maturity length** 25mm
- **Optimum mesh size for 25mm Venus clam**: 40.5mm
- **Regulation**: mesh size $\geq 40$mm, bar space $\geq 15$mm,

  **Landing size of Venus Clam** $\geq 35$mm

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KIM & Jo (2001)
Crab separator for flatfish seine

- Developed to exclude snow crab while retaining flatfish
  
  **Snow crab reduction : approx. 90 %**

  **Flatfish retention : approx. 85%**

Selectivity of grid separator with horizontal bars for beam trawl fishery in Tokyo Bay

- Plan of codend and schematic diagram of codend and grid separator used in the fishing experiment.

Ohata et al. (2008)
landing size:

- Selectivity of grid separator for marbled flounder Pleuronectes yokohamae plotted against a function of (body width) / (bar space) and that for white-spotted conger Conger myriaster plotted as a function of (head height) / (bar space),
  - □: bar space 13 mm,
  - △: bar space 15 mm
  - ▲: bar space 20 mm,
  - ○: bar space 24 mm.

- Proportion retained of each bar space from the master curve. Three arrowed lines indicate the range of head height from 8 to 14 mm for white-spotted conger Conger myriaster.

A grid of 15 mm bar space reduced juvenile discards of marbled flounder by 40% and caught most of the white-spotted conger

marbled flounder- 15 cm total length, with 11-21 mm

white-spotted conger- 35 cm total length, with 5-17 mm

Ohata et al. (2008)
Development of JET
(Jellyfish excluder for Towed fishing gear)

Nemopilema nomurai Bell diameter 25~106 cm

Lee et al., (2007)

Producing area of Nemopilema nomurai

Takayanagi (2007)
Jellyfish (damaging to fishery)

Distribution ratio of fish and jellyfish in survey trawl (2004~2007)

Development of the JSS

Park et al., 2010, The performance of a wedge type jellyfish excluder device inserted in a trawl net. J. Kor. Soc. Fish. Tech., 46 (4), 302–312.
Experiment Results

<table>
<thead>
<tr>
<th></th>
<th>Cod-end</th>
<th></th>
<th>Cover-net</th>
<th>Jellyfish Exclusion rate</th>
<th>Catch loss rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jellyfish (kg)</td>
<td>442.0</td>
<td>Fish (kg)</td>
<td>3,184.3</td>
<td>157</td>
<td>87.8% (74.0–92.7)</td>
</tr>
<tr>
<td>Fish (kg)</td>
<td>330.9</td>
<td></td>
<td>157</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Park et al., 2010, The performance of a wedge type jellyfish excluder device inserted in a trawl net. J. Kor. Soc. Fish. Tech., 46 (4), 302–312.
Method of designing and manufacturing JET (Jellyfish excluder for Towed fishing gear) for various towed fishing gears

- Separation of Jellyfish from target species by JET.

- A part of towed fishing gear where JET is inserted.

Research on by-catch of shrimp trawl fishery in Arafuru Sea
(volume, reduction devices, and utilization of discarded by-catch)

Ari Purbayanto, Ph.D
Professor in Fishing Technology
Department of Fisheries Resource Utilization
Faculty of Fisheries and Marine Sciences
BOGOR AGRICULTURAL UNIVERSITY

• The by-catch is still the main problem on shrimp trawl fishery in Arafuru sea, Indonesia.
• A large volume of the by-catch is discarded
• Presidential decree No. 39/1980 to ban the operation of Trawl Net in Indonesia waters
• BED - Equipped Trawl(shrimp trawl) is permitted to be operated only in Arafuru sea at geographic position of 130º E to the east
• Bycatch Excluder Device (BED) or Turtle Excluder Devices (TED) – must be attached on shrimp trawl net during operation
Mahiswara (2004) reported that:

TED super shooter decreased bycatch/towing/hour by 5% (12 cm grid space) and by 60% (4 cm grid space).

<table>
<thead>
<tr>
<th>TED performance (815 shots, 3 years period)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>turtle reduction</td>
<td>99%</td>
</tr>
<tr>
<td>stingray reduction</td>
<td>96%</td>
</tr>
<tr>
<td>large shark reduction</td>
<td>80%</td>
</tr>
<tr>
<td>sponge reduction</td>
<td>80%</td>
</tr>
<tr>
<td>shrimp loss</td>
<td>2 – 38%</td>
</tr>
</tbody>
</table>

*Source: Eayrs (2006)*

Kind of Bycatch Reduction Devices

(a) TED super shooter (US type)  
Bar distance 100mm

(b) Square mesh window  
Mesh opening 22.50mm 31.75mm

(c) Fish eye  
Height : 600mm  
Diameter : 450mm

Purbayanto et al. (2007)
## Comparison between BRDs in reducing by-catch

The by-catch reduction and shrimp loss of the BRDs tested compared to the control net

<table>
<thead>
<tr>
<th>Percent reduction by weight</th>
<th>US-TED</th>
<th>Square Mesh Window</th>
<th>Fish Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>By-catch reduction</td>
<td>-(4.66)*</td>
<td>5.98</td>
<td>13.36</td>
</tr>
<tr>
<td>Shrimp loss</td>
<td>32.29</td>
<td>22.13</td>
<td>21.25</td>
</tr>
</tbody>
</table>

*) The bycatch increase compared to the control net.

Purbayanto et al. (2007)
JTED bar 1.75 mm saved 33 % young fish (Juvenile and Trash Excluder Device)

Utilization of discarded by-catch

utilizing the discarded by-catch

Increasing efficiency of fisheries resource utilization in order to sustain biodiversity, environment, and food security for people prosperity

Development of environmentally friendly fishing tech.

Processing technology to utilize discarded by-catch

Fishing

Target species

By-catch

Surimi

Peptone

Food industry

Export

Food Security

Feed industry

People prosperity

Selective, non-selective and balanced fishing

Petri Suuronen¹, Pingguo He², Michael Pol³, Norman Graham⁴, and Dave Reid⁴

Mean trophic level analysis as indicator for balanced harvesting - Cast study on Japanese-type set-net, in Thailand


Simplified representation of a trophic pyramid of aquatic ecosystems. In balanced harvest, fishing mortality should be proportional to productivity across trophic levels (and productivity of species).

Drawing modified from Jeppe Kolding
Suuronen P. (2014)

Photo from Arimoto T. (2014)
Conclusions

- Development & Application of Bycatch Reduction Methods has been promoted in Asian Countries.
  - Key factors: Selectivity, Escapement Devices
  - Reduction of Bycatch by Selective Fishing & New Approach of Balanced Harvesting are important Factors for Sustainable Utilization of Healthy Ecosystem