Standardization of CPUE for bigeye (*Thunnus obesus*) and yellowfin (*Thunus albacares*) tunas of Korean longline fishery in the Indian Ocean

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Background

Annual catches of bigeye and yellowfin tunas

FAO, 2007
Background

Korean longline fishery

FAO, 2007
Objective

- Used Japanese and Taiwanese fishery data for stock assessment

Offer a standardized CPUE of Korean longline for stock assessment in the Indian Ocean
• Fishery: Korean longline
• Period: 1987 - 2006
• Year/quarter
• $5 \times 5$ latitude/longitude
• Area
• Number of hooks between float (HBF)
  
  $< 10: 1, 10 - 15: 2, 16 - 20: 3, 20 < : 4$

• Environmental factors
Regional structure

Modified from Okamoto and Shono, 2006
Spatial distribution of annual CPUE

Bigeye tuna

2006

Yellowfin tuna

2006
### Annual catch and CPUE by sub-area

**Bigeye tuna**

<table>
<thead>
<tr>
<th>Year</th>
<th>Area 1</th>
<th>Area 2</th>
<th>Area 3</th>
<th>Area 4</th>
<th>Area 5</th>
<th>Area 6</th>
<th>Area 7</th>
<th>Area 8</th>
<th>Total</th>
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<tbody>
<tr>
<td>1987</td>
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</tbody>
</table>

**Catch (no. × 10^3)**

- Area 1: Catch $r=0.69$, $P<0.01$
- Area 2: Catch $r=0.73$, $P<0.01$
- Area 3: Catch $r=0.54$, $P=0.01$
- Area 4: Catch $r=0.56$, $P<0.01$
- Area 5: Catch $r=0.29$, $P=0.21$
- Area 6: Catch $r=0.78$, $P<0.01$
- Area 7: Catch $r=0.71$, $P<0.01$
- Area 8: Catch $r=0.71$, $P<0.01$

**CPUE (no./hook × 10^3)**

- Total: CPUE $r=0.77$, $P<0.01$
Annual catch and CPUE by sub-area

Yellowfin tuna

Area 1
r=0.45, P=0.04

Area 2
r=0.33, P=0.16

Area 3
r=0.61, P<0.01

Area 4
r=0.68, P<0.01

Area 5
r=0.64, P<0.01

Area 6
r=0.64, P<0.01

Area 7
r=0.85, P<0.01

Area 8
r=0.27, P=0.25

Total
r=0.40, P=0.08

Catch (no. x 10^3)

CPUE (no./hook x 10^3)

Year

Year
Generalized Linear Model

$$\log(CPUE_{ijk} + c) = \mu + YRQTR_{(i)} + AREA_{(j)} + HBF_{(k)}$$

+ environmental factor + interactions

CPUE: catch in number of fish per 1000 hooks,
c: 10% of overall mean of CPUE,
$\mu$ : intercept,
YRQTR: effect of year quarter,
AREA: effect of sub-area and
HBF: effect of number of hooks between float
Generalized Linear Model

**Case I**

\[
\log(CPUE + 0.1) = \mu + YRQTR + AREA + HBF + SST \\
+ (YRQTR \cdot AREA + YRQTR \cdot HBF + YRQTR \cdot SST \\
+ AREA \cdot HBF + AREA \cdot SST + HBF \cdot SST)
\]

**Case II**

\[
\log(CPUE + 0.1) = \mu + YRQTR + AREA + SST \\
+ (YRQTR \cdot AREA + YRQTR \cdot SST + AREA \cdot SST)
\]

**Case III**

\[
\log(CPUE + 0.1) = \mu + YRQTR + AREA + HBF \\
+ (YRQTR \cdot AREA + YRQTR \cdot HBF + AREA \cdot HBF)
\]
**Generalized Linear Model**

**Standardized CPUE**

\[
U_y = \frac{\sum_{a=1}^{8} YRQTR_{y,a} \cdot W_a}{\sum_{a=1}^{8} W_a}
\]

- \(U_y\): standardized CPUE for year \(y\)
- \(YRQTR_{y,a}\): standardized CPUE for year \(y\) and area \(a\)
- \(w_a\): relative size of area \(a\) to the overall studied area \(a\)

**Relative size of area**

<table>
<thead>
<tr>
<th>Area</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative size</td>
<td>0.57</td>
<td>0.85</td>
<td>0.73</td>
<td>0.78</td>
<td>1.02</td>
<td>0.85</td>
<td>3.64</td>
<td>1.56</td>
</tr>
</tbody>
</table>
Standardized CPUE

Bigeye tuna

Case Ⅰ

$\text{Nominal} - \text{Standardized}$

$r = 0.82, P < 0.01$

Case Ⅱ

$r = 0.84, P < 0.01$

Case Ⅲ

$r = 0.81, P < 0.01$
Standardized CPUE

Yellowfin tuna

Case I

-8 -6 -4 -2 0 2

Nominal - Standardized

r=0.29, P=0.22

Case II

r=0.28, P=0.24

Case III

r=0.28, P=0.23

CPUE (no./hook×10³)
Standardized CPUE

Bigeye vs Yellowfin

Nominal

Case I

Case II

Case III

Bigeye tuna

Bigeye tuna

Yellowfin tuna

Bigeye tuna

y = 0.591 x + 0.789

R² = 0.668

y = 0.619 x + 0.855

R² = 0.780

y = 0.544 x + 0.973

R² = 0.663

y = 0.086 x + 4.352

R² = 0.004
Maximum Sustainable Yield

Yellowfin tuna

Nominal
Case 1
Case 2
Case 3

MSY = 607,458 inds.
MSY = 318,482 inds.
MSY = 253,645 inds.
MSY = 352,000 inds.
MSY = 318,482 inds.
Summary

- Decrease of annual CPUE, continually
- HBF would be an important variable in CPUE standardization by GLM
- Estimated high MSY from nominal CPUE
- Ecological interactions such as spatial competition or prey availability between bigeye and yellowfin tunas would be considered to standardize CPUE