Problems with interpreting catch-per-unit-of-effort data to assess the status of individual stocks and communities: is integrated stock assessment, ecosystem modeling, management strategy evaluation, or adaptive management the solution?

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The importance of appropriate interpretation and analysis of data

• “… by the illogic of the old paradigms … yet another randomized trial … was performed … and resulted in 25 more infant deaths …” Royal 1997
“…large predatory fish biomass today is only about 10% of pre-industrial levels.”

Myers and Worm 2003
Pacific Ocean Tuna Catch Data

By species

By method

By area

Myers and Worm data
Spatial expansion of the longline fishery

**FIGURE 1.** Geographical expansion of the Japanese longline fishery (solid curves) and the surface fishery in the eastern Pacific (dotted curves). Numerals denote calendar year.
Change in targeting: from albacore to bigeye

Albacore --- tropical

Blue is total catch, green is Taiwan CPUE, red is Japan CPUE
CPUE is inconsistent with catch and population dynamics

Blue is total catch, red is CPUE
One species dominates

![Graph showing CPUE of different species over time]

- **Total temperate**
- **CPUE**
- **Billfish**
- **Southern bluefin**
- **Yellowfin**
- **Bigeye**
- **Albacore**
More often than not community CPUE declines faster than abundance

\[ \frac{\partial B_i}{\partial t} = r_i \left( 1 - \frac{B_i}{K_i} \right) B_i - q_i E B_i \]

\[ \frac{\partial B_i}{\partial t} = r_i \left( \sum q_i K_i \right)^2 > \sum K_i \sum q_i^2 K_i \]

\[ \sum q_i^2 K_i^2 + 2 \sum q_i q_j K_i K_j > \sum q_i^2 K_i^2 + \sum \left( q_i^2 + q_j^2 \right) K_i K_j \]

\[ \frac{r_i}{r_j} < \frac{q_i}{q_j} < 1 \forall i, j \text{ pairs} \Rightarrow \text{Biomass declines faster than CPUE} \]
Integrated stock assessment models

- Uses all data
- Determine if data is consistent
- Fishery versus environment
- Fishery impact by gear
- Use more information for longer predictions
- Estimate management quantities
- Determine yield efficiency of gear
- Investigate management options
- Can be combined to calculate community abundance
Is data consistent

Catchability higher in the early period to describe rapid decline in CPUE

Recruitment anomaly

Bigeye (Pacific)

Yellowfin (10°-40°S, 160°E-150°W)
Fishery versus environment for yellowfin tuna in the EPO

![Graph showing biomass over years with fishing and no fishing lines.](image)
Fishery Impact on EPO bigeye tuna

![Graph showing fishery impact on EPO bigeye tuna from 1975 to 2003. The graph depicts the impact of different fishing methods: Longline, Floating object, and Small discards. The impact is measured on a scale from 0.0 to 1.0. The graph shows an increasing trend in fishery impact from 1975 to 2003.]
Relative abundance of bigeye tuna in the EPO

![Graph showing relative abundance of bigeye tuna from 1975 to 2005. The graph compares integrated stock assessment and CPUE data.](image-url)
Estimate management quantities
(how useful they are?)
Determine increase in yield by changing fishing methods: Yellowfin tuna in the EPO

<table>
<thead>
<tr>
<th>Method</th>
<th>MSY ('000 t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>285</td>
</tr>
<tr>
<td>Floating Object</td>
<td>194</td>
</tr>
<tr>
<td>Unassociated</td>
<td>243</td>
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<tr>
<td>Dolphin associated</td>
<td>320</td>
</tr>
<tr>
<td>longline</td>
<td>386</td>
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Predict effects of management

The graph shows the comparison between 'No closure' and 'Closure' in tons (Toneladas) over the years from 1975 to 2009. The 'Closure' line consistently shows a higher output compared to 'No closure', especially in the later years, indicating a significant effect of management on production.
Abundance of tunas in the Pacific Ocean

Integrated models

Japanese longline CPUE
Management of fish stocks

- Sustainable fisheries management is based on surplus production.
- Surplus production increases as the abundance falls towards $B_{MSY}$.
- $B_{MSY}$ is often much less than half the unexploited level.
- $B_{MSY}$ and MSY are dependent on many factors.
- CPUE alone tells us nothing about the above.
Management of communities and ecosystems

• Cannot maximize yield of two species caught simultaneously by the same gear because their productivities and catchabilities differ

• What would be the impact on the ecosystem if all commercially valuable stocks were fished at their single species MSY
Adaptive management, management strategy evaluation, and ecosystem models

- Adaptive management provides information for integrated stock assessments and has been used for yellowfin tuna in the EPO.
- Management strategy evaluation can be used to compare integrated stock assessments to other approaches (e.g. raw CPUE). Operating model is often based on integrated stock assessment.
- Multispecies and ecosystem models can be used to investigate how species interactions may influence single species integrated stock assessments and management.
Conclusions

• Integrated stock assessment provides a much broader picture than simple CPUE
• Integrated stock assessment can provide many insights into managing a fishery
• Integrated stock assessment is not the answer to everything, other methods may provide alternative perspectives
• Management strategy evaluation provides a method to compare Integrated stock assessment with alternatives
The End