

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

The interpretation and analysis of data can have important consequences. However, in ecological studies it might not be as obvious as the deaths of children. The catastrophic effects may not be as obvious for fisheries problems

“...large predatory fish biomass today is only about 10% of pre-industrial levels.”

Myers and Worm 2003

For example, this recent statement that has been widely reported in the media could have important consequences.

If they are right and we don't act or if they are wrong and we do act, it may mean the collapse of fisheries and local economies.

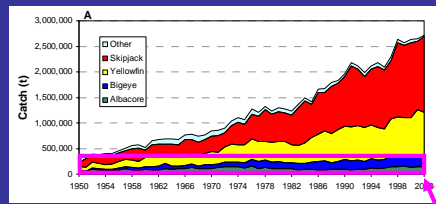
However, if they are wrong and we do act we may unnecessarily cause the economic and social collapse of local communities and even possibly whole countries.

We have to ask ourselves, have they interpreted and analyzed the data appropriately?

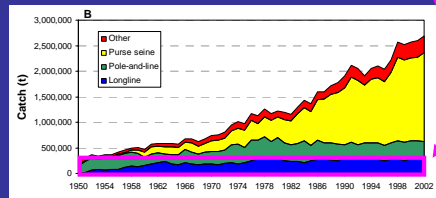
Much of Myers and Worms conclusions were based on raw CPUE data from the Japanese long line fishery for tuna

Pacific Ocean Tuna Catch Data

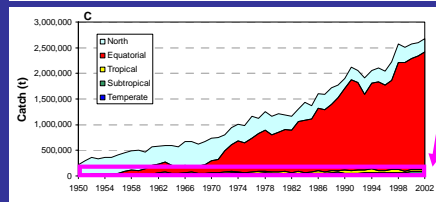
By species



By method



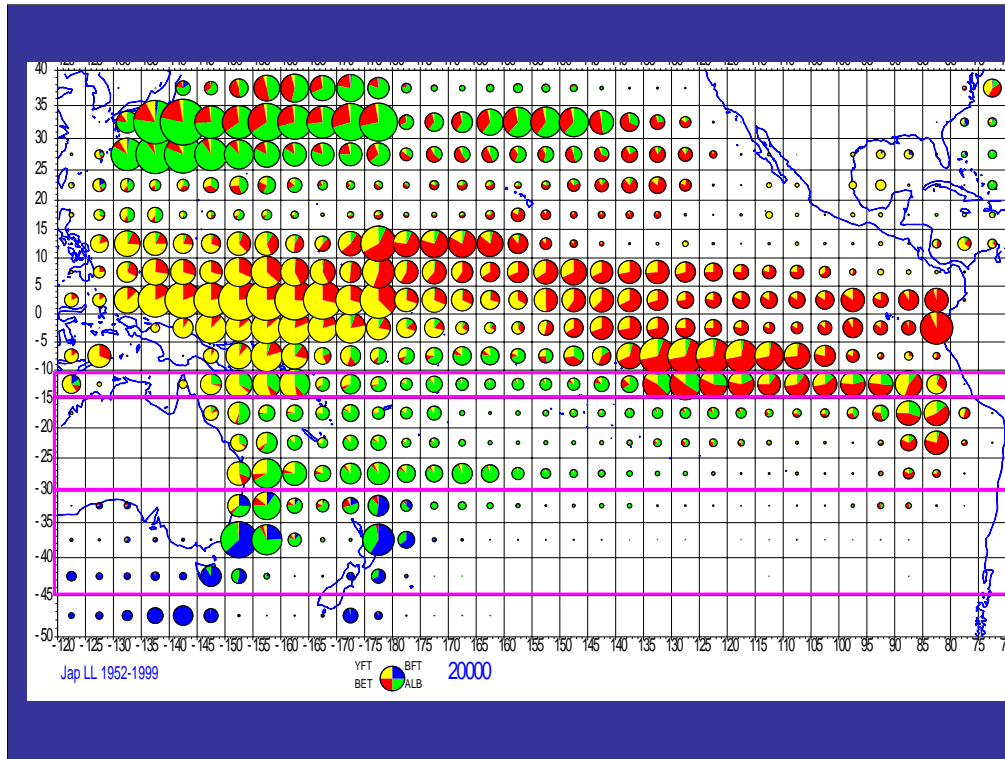
By area



Myers and Worm data

This slide represents the catch of tunas in the Pacific Ocean which was part of the Myers and Worm analysis. The catch is presented by species, method and area. The details are not important.

If we look at the data the Myers and Worm used they only cover a very small portion of the data, which raises some questions about the appropriateness of the analysis.

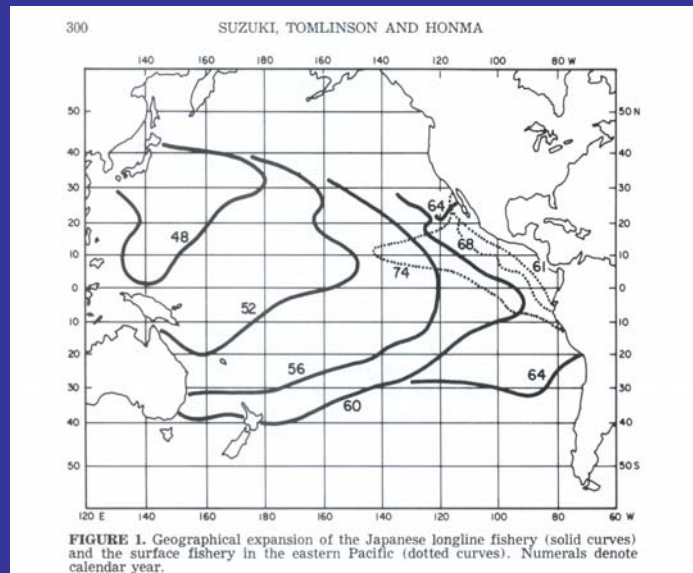


This figure represents the distribution of tuna catch from Japanese longline vessels, the data Myers and Worm used, in the pacific ocean averaged over 1952 to 1999. Yellow is yellowfin, red is bigeye, green is albacore, and blue is bluefin.

You can see that the different species contribute more in some area and not in others.

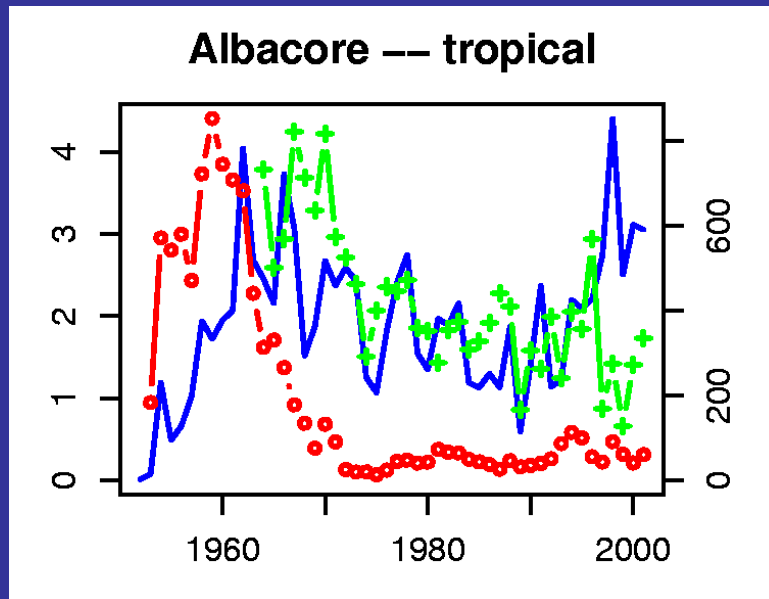
These are the three areas of data that Myers and Worm analyzed. As you can see, the Myers and Worm analysis was spatially restricted and there was substantial variation in species composition from east to west within a strata.

Spatial expansion of the longline fishery



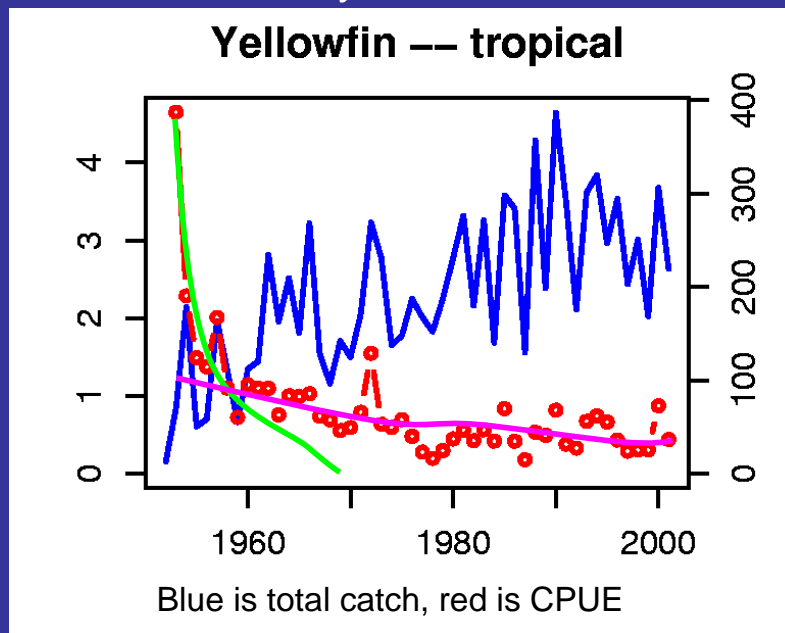
This figure shows how the Japanese longline fishing effort (solid lines) expanded from Japan into the EPO. Given the distribution of species one would expect that the expansion had a large influence on the species caught and the CPUE.

Change in targeting: from albacore to bigeye



Blue is total catch, green is Taiwan CPUE, red is Japan CPUE

CPUE is inconsistent with catch and population dynamics



So it may be more useful to consider single species.

This figure shows the total catch (in blue) and the CPUE (in red) for Yellowfin tuna in the tropical area.

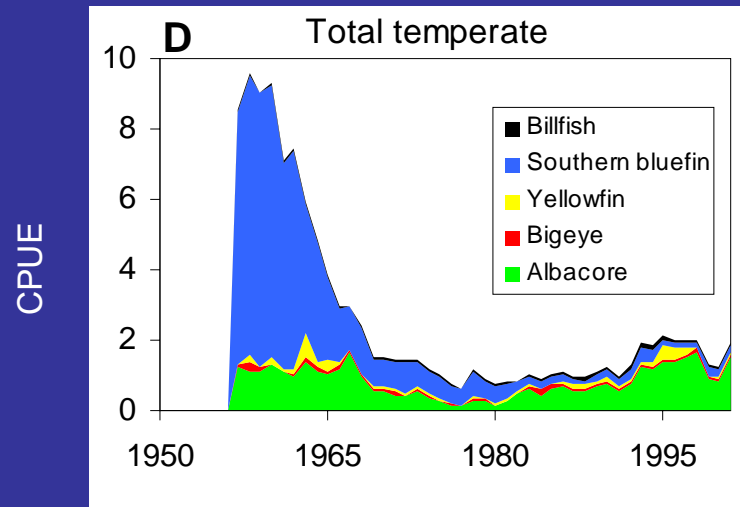
As illustrated here, many species show that the initial declines in CPUE when catches were small are inconsistent under current population dynamics theory with the large catches and stable CPUE in the latter part of the times series.

In other words a traditional fisheries stock assessment model does not fit the data.

It either can not fit the first few years

Or if forced to fit the first few years the population crashes

One species dominates



More often than not community CPUE declines faster than abundance

$$\frac{\partial B_i}{\partial t} = r_i \left(1 - \frac{B_i}{K_i} \right) B_i - q_i E B_i \quad \frac{B_{ss}}{\sum_i K_i} < \frac{CPUE_{ss}}{\sum_i q_i K_i}$$

$$\frac{q_i}{q_j} < 1 \quad \frac{\partial B_i}{\partial t} = 0 \quad \left(\sum_i q_i K_i \right)^2 > \sum_i K_i \sum_i q_i^2 K_i \quad \frac{\sum_i \frac{q_i}{r_i} K_i}{\sum_i K_i} > \frac{\sum_i \frac{q_i^2}{r_i} K_i}{\sum_i q_i K_i}$$

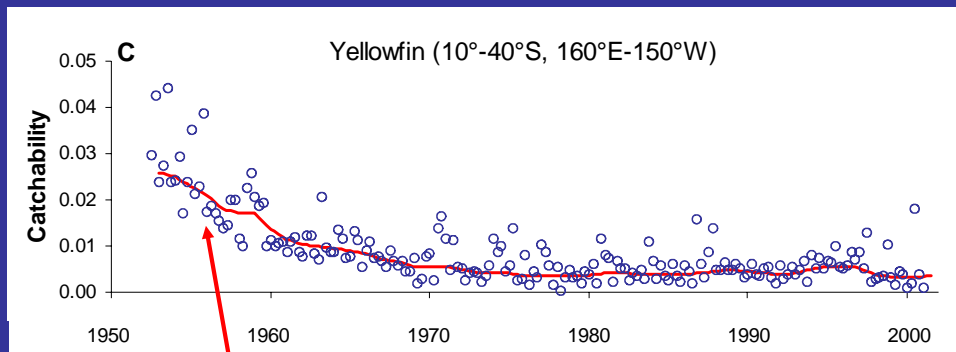
$$\sum_i q_i^2 K_i^2 + 2 \sum_{i < j} q_i q_j K_i K_j > \sum_i q_i^2 K_i^2 + \sum_{i < j} (q_i^2 + q_j^2) K_i K_j$$

$$\frac{r_i}{r_j} < \frac{q_i}{q_j} < 1 \forall i, j \text{ pairs} \Rightarrow \text{Biomass declines faster than CPUE}$$

Integrated stock assessment models

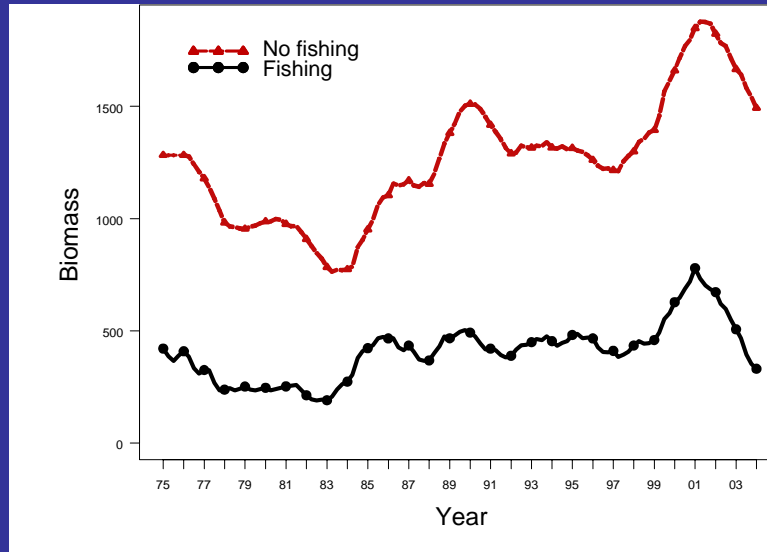
- Uses all data
- Determine if data is consistent
- Fishery versus environment
- Fishery impact by gear
- Use more information for longer predictions
- Estimate management quantities
- Determine yield efficiency of gear
- Investigate management options
- Can be combined to calculate community abundance

Is data consistent

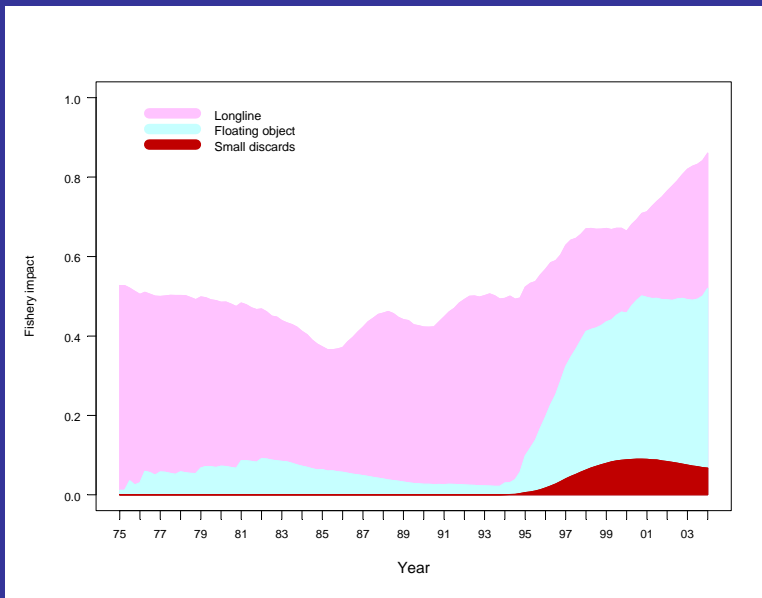


Catchability higher in the early period to describe rapid decline in CPUE

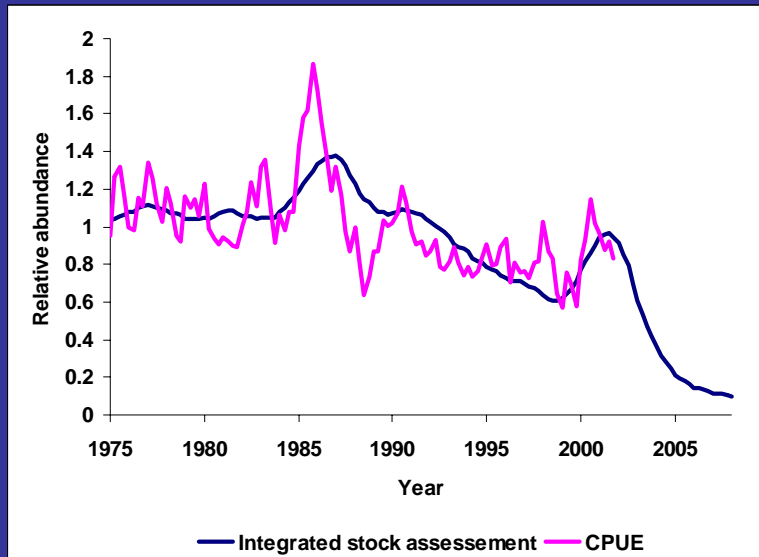
Fishery versus environment for yellowfin tuna in the EPO



Fishery Impact on EPO bigeye tuna



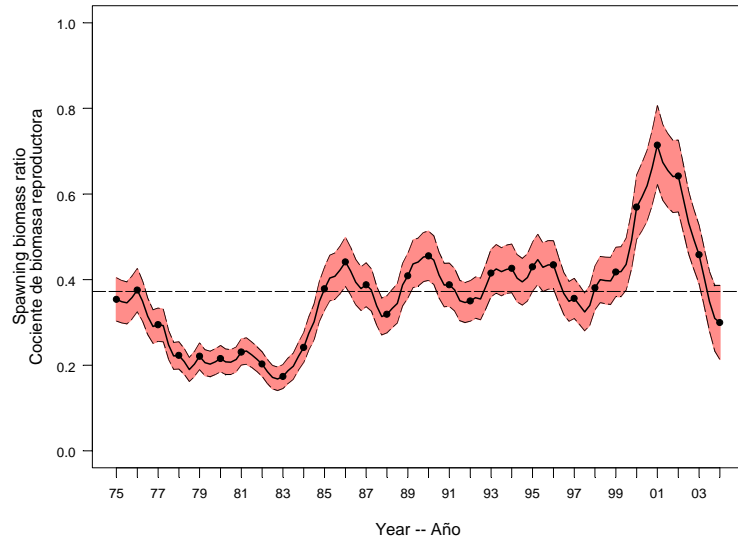
Relative abundance of bigeye tuna in the EPO



Because estimates of recruitment come from data from other fisheries can estimate decline in liongline CPUE before it happens

Estimate management quantities

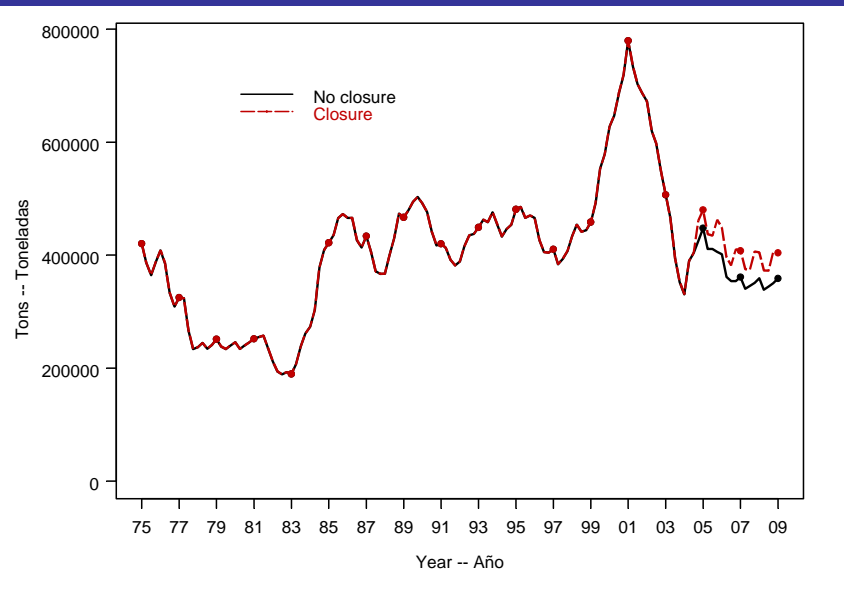
(how useful they are?)



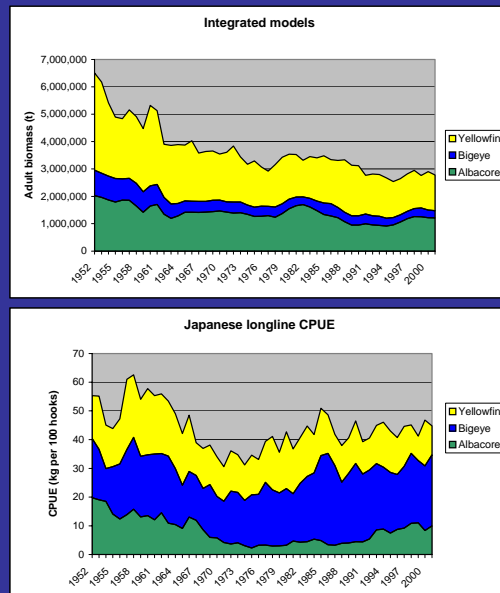
Determine increase in yield by
changing fishing methods:
Yellowfin tuna in the EPO

Method	MSY (‘000 t)
All	285
Floating Object	194
Unassociated	243
Dolphin associated	320
longline	386

Predict effects of management



Abundance of tunas in the Pacific Ocean



To determine the changes of abundance of a community you need to have estimates of catchability for each species. The only current method to derive that is through the use of stock assessment models.

This figure shows the abundance levels of tuna in the Pacific Ocean as estimated from individual stock assessments for each species and that based only on CPUE.

There is a significant discrepancy between these two methods.

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