Expanding Oxygen Minimum Zones, Tropical Pelagic Predators, and the Atlantic LL Fisheries that Exploit them.

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This paper links 50 years of ongoing ocean scale deoxygenation trends in the tropical Atlantic Ocean to changes in vertical habitat use of large pelagic predators, and the Atlantic LL fisheries that exploit them.

(1) Assess which of the primary ICCAT stock assessment species were impacted by the OMZ habitat compression over the study duration based on historical LL effort and catch inside and outside of the OMZ area;

(2) Provide insights into the OMZ ecosystem trophic structure and possible stock assessment consequences of overly optimistic OMZ catch rate estimates derived from surface fishing gears.
Tropical tunas and billfish have high a performance physiology

- They are all obligate ram ventilators;
- They require large amounts of dissolved oxygen; and,
- Start exhibiting physiological stress below DO concentrations of about 3.5 mL L$^{-1}$, the hypoxic threshold used in this study.
Compression Impacts and the Stock Assessment Process
Oxygen Minimum Zones at 100 m depths by Decade 1960-2000

1960
1955-1964

2000
1995-2004

Sq. Km = 12,177,100
Cubic Km = 613,690

Sq. Km = 12,728,900
Cubic Km = 692,900

Dissolved oxygen (mL L$^{-1}$)
4.2 billion hooks - 1995-2004
Pelagic Longline Effort (millions of hooks)
Bigeye Tuna LL Catches in 1000’s of mt
Nocturnal

Diurnal

Matsumto et al. 2004

Bigeye tuna 15932 depth
Estimated 155cmFL

Date


Depth (m)

0  100  200  300  400  500

Data for tag No. 15932.
Swordfish LL Catches in 1000’s of mt
Blue marlin LL bycatch in 100's mt
Albacore LL catches in 1000’s mt

1955 - 1964
500 1000 2000 4000 >8000
(Metric ton)

1995 - 2004
500 1000 2000 4000 >8000
(Metric ton)
Bluefin tuna LL catches in 100’s mt
### Impacts to Pelagic Predators

<table>
<thead>
<tr>
<th>Severely Impacted</th>
<th>Minimally Impacted</th>
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<tbody>
<tr>
<td>Bigeye Tuna (FE/OE)</td>
<td>Bluefin Tuna (OE)</td>
</tr>
<tr>
<td>Yellowfin Tuna (PS) (OE)</td>
<td>Albacore Tuna (FE?)</td>
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<tr>
<td>Skipjack Tuna (PS) (FE/OE)</td>
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<tr>
<td>Swordfish (FE/Rebuilt/?)</td>
<td></td>
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<tr>
<td>Blue Marlin (OE)</td>
<td></td>
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<tr>
<td>White Marlin (OE)</td>
<td></td>
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<tr>
<td>Sailfish (ART) (OE)</td>
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GENERIC CONCLUSIONS

• Seven of nine ICCAT primary stock assessment species are impacted by ETA OMZ.

• BET have become primary target species for Atlantic LL fishery. The rich prey assemblages at night in the SML not only includes preferred prey community, it also includes the DSL community. No surprise the largest BET in the Atlantic are caught within the OMZ. This caters to the lucrative Sushi market.

• Overall, both LL effort and catch have progressively increased over the past 50 years. Coalescence of LL gear within the OMZ supports to need for ICCAT to identify the equatorial Atlantic as a separate statistical area.

• The upper ocean layer exceeding 3.5 ml l DO has diminished at a rate of about <1 m yr\(^{-1}\) over the 50 year duration. This amounts to a 15% increase in the Atlantic OMZ size from 1960-2000.

• We feel it is incumbent upon the stock assessment community to incorporate the habitat compression impacts into the assessment process. We are investigating the potential of scaling catchability coefficients to the decadal OMZ surface mixed layer volume estimates over the past 50 years to improve the CPUE standardization.
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