Using satellite data to predict fishery performance

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Hawai’i-based longline bigeye tuna fishery – 2019

• 146 vessels
• 61 million hooks
• > 15 million km²

• Total landings
  • $90 million (9th in US)
  • 29 million pounds (23rd in the US)
  • 46% of US tuna landings – 2018
  • 63% of US tuna landings revenue – 2018

• Importance of bigeye to the fishery
  • 19% of all fish caught
  • 32% of all fish retained
  • 53% of catch in weight
  • 66% of ex vessel revenue
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• Bigeye face an uncertain future
  • Intermittently experiencing overfishing
  • Assessments include noted uncertainty


NOAA National Marine Fisheries Service; WPRFMC 2020: Annual SAFE Report Pacific Island Pelagic FEP 2019

FishWatch.gov
Uncertainty and challenges surrounding bigeye tuna
Uncertainty and challenges surrounding bigeye tuna
Focusing on the Hawaiʻi-based fishing grounds
Recruitment Index

**CPUE:**
catch per unit effort

**WPUE:**
weight per unit effort

**Effort:**
hooks set

Wren and Polovina, In Review
WPRFMC 2021: Annual SAFE Report Pacific Island Pelagic FEP 2020
Recruitment Index

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Coherent stock structure
Fig. 133. Composition in point of age of spring herring for the years 1907–1914; average of all samples examined in each year. For 1914 only samples from February included.
Larvae and young fry stages.

We must therefore look to the later stages of the eggs to find the conditions which determine the numbers of individuals in any year class. This again leads us to the question, at which stage of development the most critical period is to be sought. Nothing is known with certainty as to this; such data as are available, however, appear to indicate the very earliest larval and young fry stages as most important.

Fig. 133. Composition in point of age of spring herring for the years 1907—1914; average of all samples examined in each year. For 1914 only samples from February included.
Median phytoplankton mass, $M_{B50}$:

$$\log_{10}(M_{B50}) = 0.929 \log_{10}(chl-a) - 0.043 \text{(SST)} + 1.340$$

Median phytoplankton size, $M_{D50}$:

$$M_{D50} = 2.138 (M_{B50})^{0.355}$$

- $M_{D50}$ calculated for each monthly grid cell
- Averaged annually to match management time frame and over the spatial domain of the fishery
Larger phytoplankton

Larger zooplankton (better prey for young fish)

More young fish survive

Higher catch rates and larger fish
Estimated phytoplankton size
Estimated phytoplankton size

[Graph showing estimated phytoplankton size from 1998 to 2024, with notable decreases in 2005 and 2016.]
Comparison between CPUE, WPUE, and 4-year-lagged $M_{D50}$

$r = 0.57$, $r = 0.66$

Comparison between CPUE, WPUE, and 4-year-lagged $M_{D50}$

![Graph showing the comparison between CPUE, WPUE, and 4-year-lagged $M_{D50}$]
Bigeye Tuna Catch Rate Forecast

Based on linear regression

Able to forecast 4 years into the future due to the average age of fish landed
Forecast skill: \( \sum |\text{forecast} - \text{observation}| \)

Three forecast methods tested:

- **Plankton-based**, shown here
- **Persistence**, assuming each year’s catch rate will be equal to the prior year’s
- **Climatology**, assuming each year will be equal to the average of all prior years
Forecast skill: $\sum |\text{forecast} - \text{observation}|$

**CPUE skill (# fish per 1,000 hooks)**
- Plankton-based: 6.6
- Persistence: 9.0
- Climatology: 8.2

**WPUE skill (kg per 1,000 hooks)**
- Plankton-based: 175
- Persistence: 298
- Climatology: 335
Next steps

Specific to Hawaiʻi’s deep-set longline fishery and bigeye tuna
• Additional estimates of juvenile mortality, e.g., purse seine catch
• Advanced statistical approaches
• Evaluating the influence of climate variability

Advancing stock assessments
• Working with stock assessment program on swordfish assessment
• Potential for use with other species and regions

Verification of methods
• Upcoming cruises to verify the methodology and hypothesized mechanism in oligotrophic and equatorial waters across the fishery’s footprint
Conclusions

- Satellite-derived estimates of phytoplankton size can be used to skillfully forecast bigeye tuna catch rates up to four years into the future.

- Working to incorporate the underlying ecological relationship in additional fishery applications.

- Upcoming cruises to verify algorithm and ecosystem size structure.