Growth, mortality, and reproductive seasonality of California Halibut (*Paralichthys californicus*): a biogeographic approach

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California

Paralichthyidae

67 lb  (30.4 kg)  2011

photo: E. Villareal

Alaska

Pleuronectidae

482 lb  (218.6)  2014

photo: Devin Brown
Varied Environmental Conditions Lead to Distinct Biogeographic Regions

Allen et al. 2006
Marine Fishes with Widespread Distributions Leads to Development of Metapopulations
California Halibut, *Paralichthys californicus*

photo: Joe Leauseau
California Halibut Widespread Distribution
Spans Multiple Biogeographic Regions

Allen et al. 2006
California Halibut Widespread Distribution Spans Multiple Biogeographic Regions

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Sea Surface Temperature

Chlorophyll A

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Point Conception

cenCA

soCA

CeNCOOS (NOAA Coast Watch Program) 2014
California Halibut Stock Assessment
Region-specific Stock Models

- sex-structured estimates included:
  - growth
  - mortality
  - selectivity

- limited composition data for central California
  - some parameters fixed using soCA data

photo: Liza Schmidt

Maunder et al. 2011
Master’s Thesis Research Question
Do life history characteristics differ by region?
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- Growth
- Reproductive seasonality
- Mortality
Master’s Thesis Research Question
Do life history characteristics differ by region?

- Growth
- Reproductive seasonality
- Total mortality
Methodology: Study Design

Sample sizes:
- cenCA = 1296
- soCA = 760

Locations:
- Moss Landing
- Monterey
- Santa Cruz
- San Francisco
- Morro Bay
- Port San Luis
- Santa Barbara
- Ventura
- Oxnard
- Marina Del Rey
- San Pedro
- Dana Point
- La Jolla
- Point Conception
Methodology: Growth
length-at-age data, von Bertalanffy growth curves

reproductive seasonality
growth
total mortality
Results: von Bertalanffy Growth Curves
female California Halibut, both regions

\[
L(t)_{cenCA} = 1049 (1 - e^{-0.21t}) \\
L(t)_{soCA} = 1304 (1 - e^{-0.12t})
\]

n (cenCA) = 743  n (soCA) = 615
Results: von Bertalanffy Growth Curves
female California Halibut, both regions

\[ L(t)_{cenCA} = 1049 \left(1 - e^{-0.21t}\right) \]
\[ L(t)_{soCA} = 1304 \left(1 - e^{-0.12t}\right) \]

Central California: \( n (cenCA) = 743 \)
Southern California: \( n (soCA) = 615 \)
Results: von Bertalanffy Growth Curves

male California Halibut, both regions

\[
L(t)_{cenCA} = 820 \left(1 - e^{-0.25t}\right) \\
L(t)_{soCA} = 1048 \left(1 - e^{-0.15t}\right)
\]

\[n (cenCA) = 553 \quad n (soCA) = 145\]
Results: von Bertalanffy Growth Curves
male California Halibut, both regions

\[ L(t)_{\text{cenCA}} = 820 \left(1 - e^{-0.25t}\right) \]
\[ L(t)_{\text{soCA}} = 1048 \left(1 - e^{-0.15t}\right) \]

\[ n (\text{cenCA}) = 553 \quad n (\text{soCA}) = 145 \]
Results: von Bertalanffy Growth Curves
California Halibut, both sexes and regions
Results: von Bertalanffy Growth Curves
California Halibut, both sexes and regions
Methodology: Reproductive Seasonality
temporal spawning and larval density data

- Reproductive seasonality
- Growth
- Total mortality
Results: Reproductive Seasonality
peak spawning, regional comparisons

mean Gonadosomatic Index

- central CA

n (cenCA) = 97
Results: Reproductive Seasonality  
peak spawning, regional comparisons

Corrected Mean Laval Density (no. per 10 m$^2$)

- central CA
- southern CA

Mean Gonadosomatic Index

larval density data, CalCOFI 1980 to 2011
Results: Reproductive Seasonality
peak spawning, regional comparisons

Mean Gonadosomatic Index

Corrected Mean Larval Density (no. per 10 m²)

central CA
southern CA
Mexico

larval density data, CalCOFI 1980 to 2011
Results: Reproductive Seasonality
peak spawning, regional comparisons

Mean Gonadosomatic Index

- central CA
- southern CA
- Mexico

cenCA?

Corrected Mean Laval Density (no. per 10 m²)

larval density data, CalCOFI 1980 to 2011
Results: Reproductive Seasonality
peak spawning, regional comparisons

Mean Gonadosomatic Index

- central CA
- southern CA
- Mexico

Corrected Mean Larval Density (no. per 10 m$^2$)

larval density data, CalCOFI 1980 to 2011
Methodology: Mortality

age frequency data, catch curve analysis

reproductive seasonality

growth

total mortality
Methodology: Mortality

age frequency data, catch curve analysis

ANCOVA

\[ p_{(slope)} = Z \]

\[ p_{(intercept)} = \text{relative abundance} \]

slope = Total Mortality (Z)

not fully recruited to the fishery
Results: Instantaneous Total Mortality
female California Halibut, both regions

ANCOVA

-y = -0.34x + 6.34
R² = 0.623, p = 0.011

-y = -0.36x + 5.79
R² = 0.826, p < 0.001

p_(mortality) = 0.854
p_(relative abundance) = 0.063
Results: Instantaneous Total Mortality
male California Halibut, both regions

ANCOVA

\[ p_{\text{mortality}} = 0.734 \]
\[ p_{\text{relative abundance}} = 0.061 \]
Results: Instantaneous Total Mortality
California Halibut, both sexes and regions

![Graph showing the Instantaneous Total Mortality of California Halibut for both sexes and regions.](Image)

- **x-axis**: Age (yr)
- **y-axis**: LN Frequency

Lines represent:
- **cenCA M**
- **cenCA F**
Results: Instantaneous Total Mortality
California Halibut, both sexes and regions
Master’s Thesis Research Question

Do life history characteristics differ by region?

CALIFORNIA HALIBUT

central California

southern California

photo: CitySkylines
Results Summary: California Halibut
Results Summary: California Halibut

- cenCA Halibut grow faster, but attain smaller maximum sizes than soCA Halibut
Results Summary: California Halibut

- cenCA Halibut grow faster, but attain smaller maximum sizes than soCA Halibut

- California Halibut spawn earlier at lower latitudes during summer
  1) MX: May
  2) soCA: June
  3) cenCA: July
  - relatively protracted spawning south of Point Conception?
Results Summary: California Halibut

- cenCA Halibut grow faster, but attain smaller maximum sizes than soCA Halibut

- California Halibut spawn earlier at lower latitudes during summer
  1) MX: May
  2) soCA: June
  3) cenCA: July
  - relatively protracted spawning south of Point Conception?

- there is no difference in California Halibut mortality by sex or region
Informing the Next Stock Assessment

- region-specific estimates provided to CDFW
- new data available for central stock model

photo: Richard Scangarello
Acknowledgments

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Questions?