Mechanisms Influencing Growth and Size-at-Age of Pacific Halibut

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Introduction

Pacific halibut (*Hippoglossus stenolepis*) are culturally and commercially important flatfish in the North Pacific Ocean. The commercial fishery for halibut began in 1888, and they have been actively managed in the U.S. and Canada by the International Pacific Halibut Commission (IPHC) since 1923. The length at a given age (size-at-age) of Pacific halibut has declined significantly since the 1990s, but interestingly, current size-at-age is similar to the size-at-age observed in the 1920s (Fig. 1). We explore mechanisms influencing growth and size-at-age and discuss implications to conservation and management.

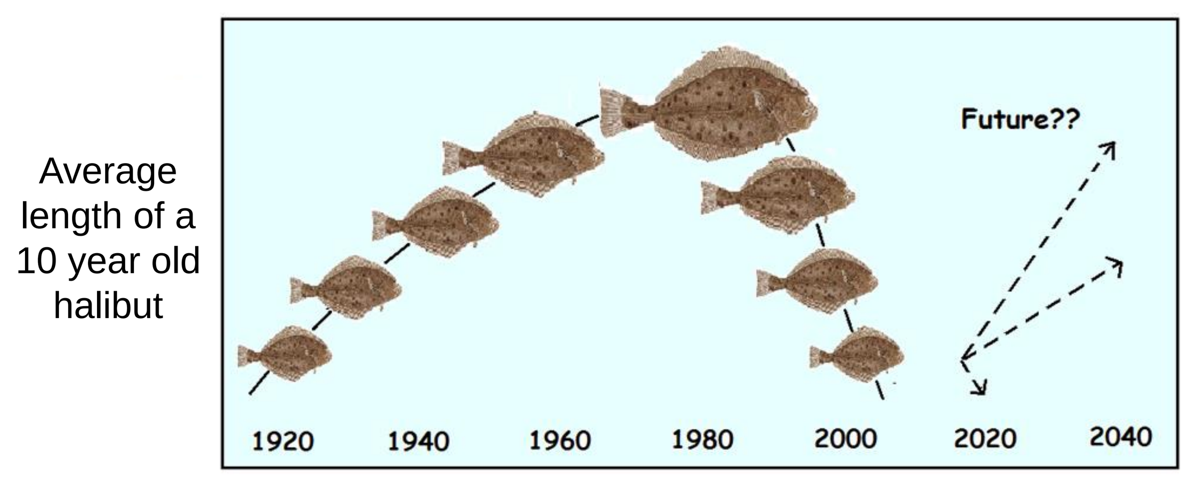


Figure 1. This example shows how the average length of age-10 halibut has changed since 1914. The same trend has been observed for ages 5 & older.

Objectives

1. Describe temporal and spatial patterns in size-at-age and growth of Pacific halibut since 1914 (Fig 3A).
2. Identify potential ecological and environmental factors that explain variation in size-at-age, including competition and temperature (Figs. 3B, 3C, and 3D).

Methods

- Size-at-age can be expressed as length-at-age or weight-at-age
- Pacific halibut length-at-age data are available from 1914 to 2013 from IPHC and NOAA surveys
- Length-at-age is converted to weight-at-age using $W = \alpha L^{\beta}$, where α=6.83e-6 and β=3.24
- Summaries of weight-at-age are calculated by sex and regulatory area (Fig. 1)
- Time series of ecological and environmental variables are compiled from the literature

Preliminary Results

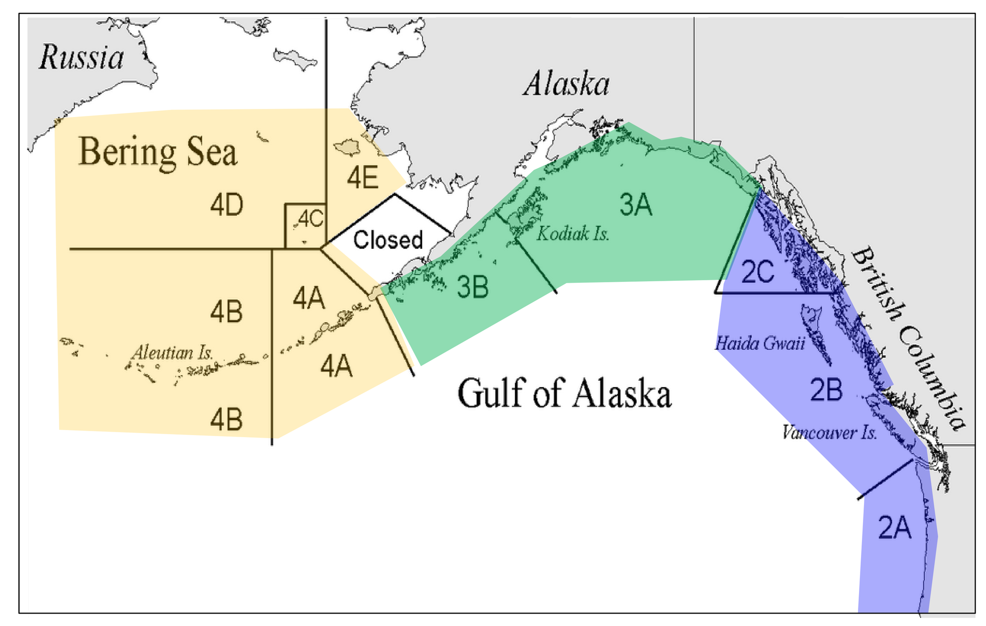
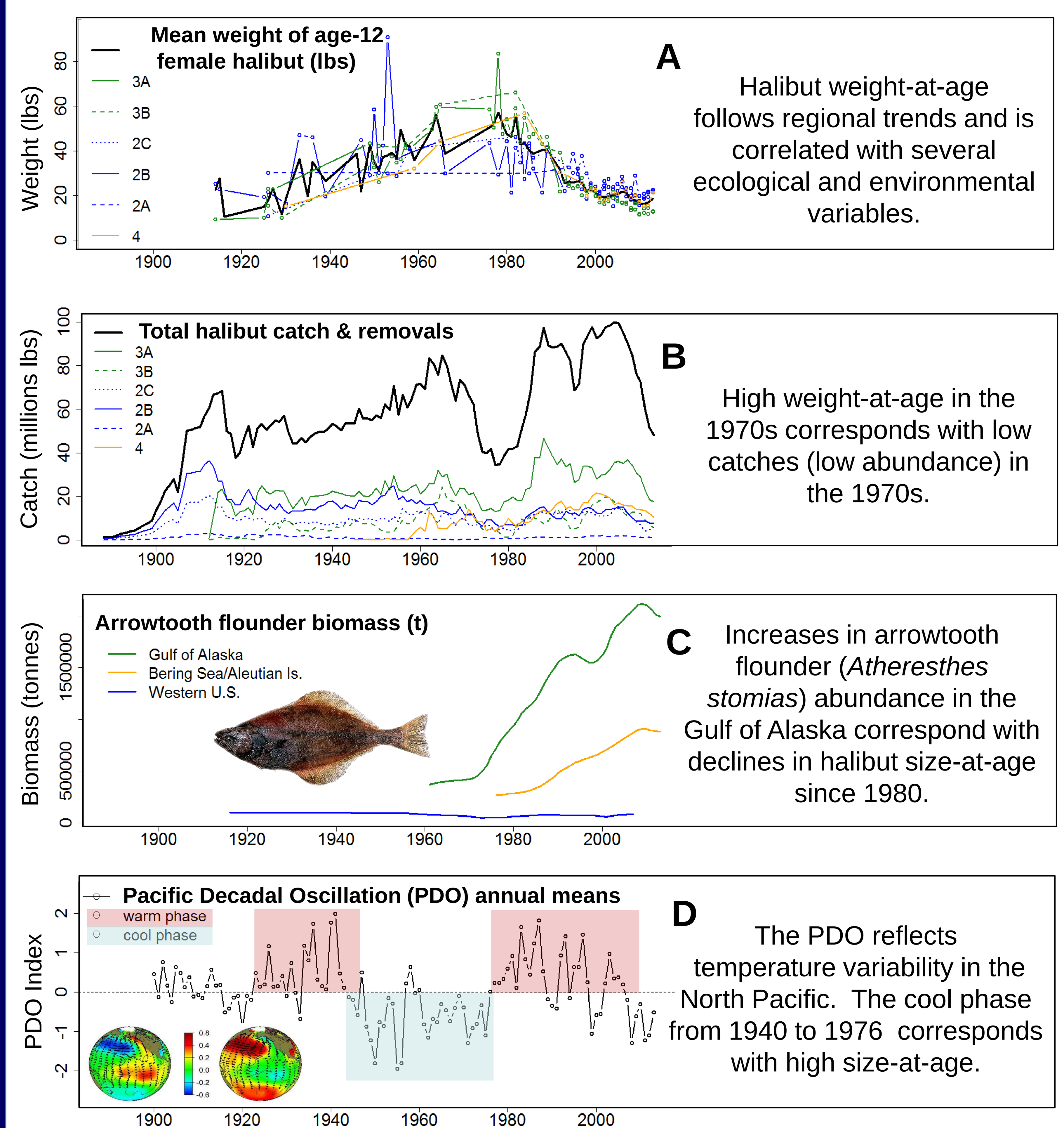


Figure 2. Map of IPHC regulatory areas. Regions are color-coded and correspond with the figures below.

- Halibut weight-at-age varies substantially among regions and years (Fig. 3A)
- Weight-at-age declines are highest in the central and western Gulf of Alaska (areas 3A and 3B)
- Weight-at-age declines are lowest in the eastern Gulf of Alaska (areas 2B and 2C)

Ecological & Environmental Variables (1914 – 2013)



A: Halibut weight-at-age follows regional trends and is correlated with several ecological and environmental variables.

B: High weight-at-age in the 1970s corresponds with low catches (low abundance) in the 1970s.

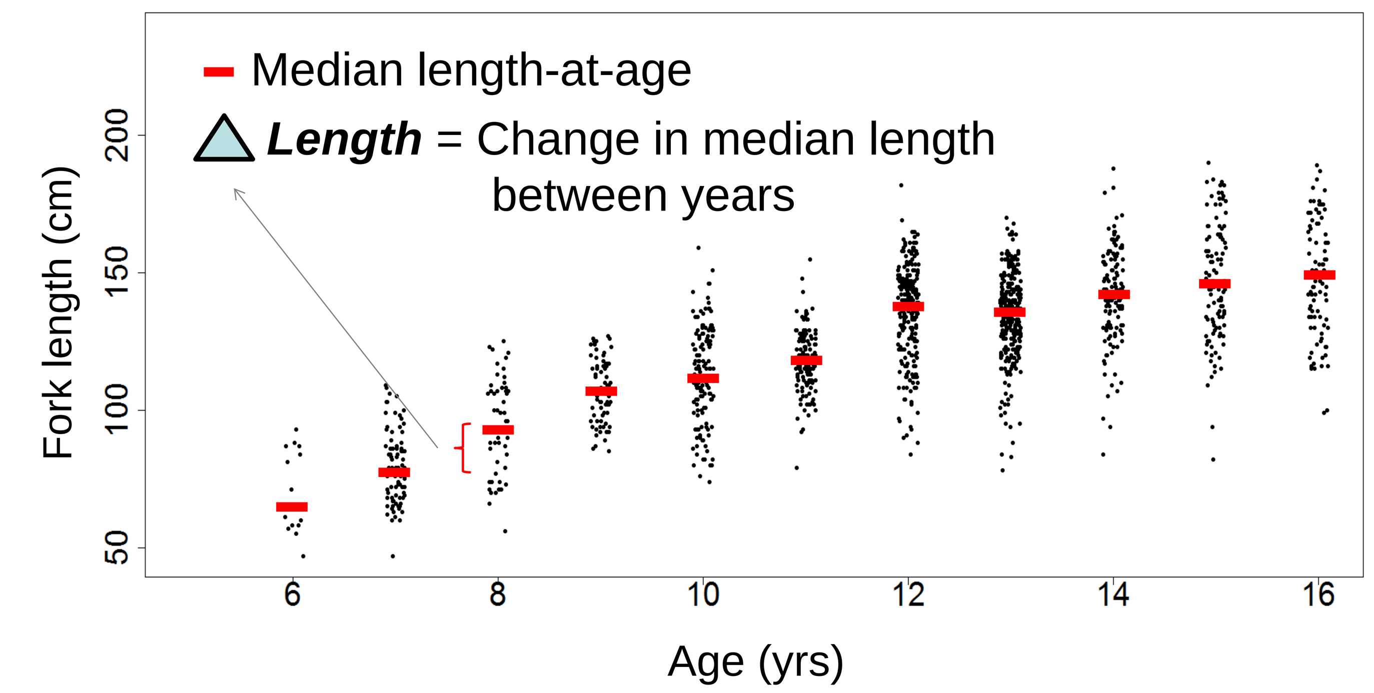
C: Increases in arrowtooth flounder (*Atheresthes stomias*) abundance in the Gulf of Alaska correspond with declines in halibut size-at-age since 1980.

D: The PDO reflects temperature variability in the North Pacific. The cool phase from 1940 to 1976 corresponds with high size-at-age.

Figure 3. (A) Mean weight of age-12 female halibut by regulatory area; (B) Total halibut removals (Stewart 2014); (C) Arrowtooth flounder biomass by region (Spies & Turnock 2013, Spies et al. 2014, Kaplan & Helser 2007); (D) PDO (http://jisao.washington.edu/pdo/)

Future Analyses

We will use regression models to determine which variables best explain halibut growth.



Δ ***Length = Age + Sex + Birth Year + Sampling Year + Region + Arrowtooth flounder biomass + Halibut harvest + Temperature + PDO***

Conclusions

- Evidence of intraspecific competition (density-dependent growth) (Fig. 3B), interspecific competition (Fig. 3C), and temperature effects (Fig. 3D) on halibut size-at-age
- Likely these variables work synergistically to influence large scale variability in size-at-age
- Other mechanisms to consider include size-selective fishing, bioenergetic effects, and genetic selection

Implications

- Slow growing fish take longer to reach minimum legal size → Fewer fish available for harvest
- Fewer fish available for harvest leads to heightened conservation concerns over halibut bycatch in Alaskan trawl fisheries

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