

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



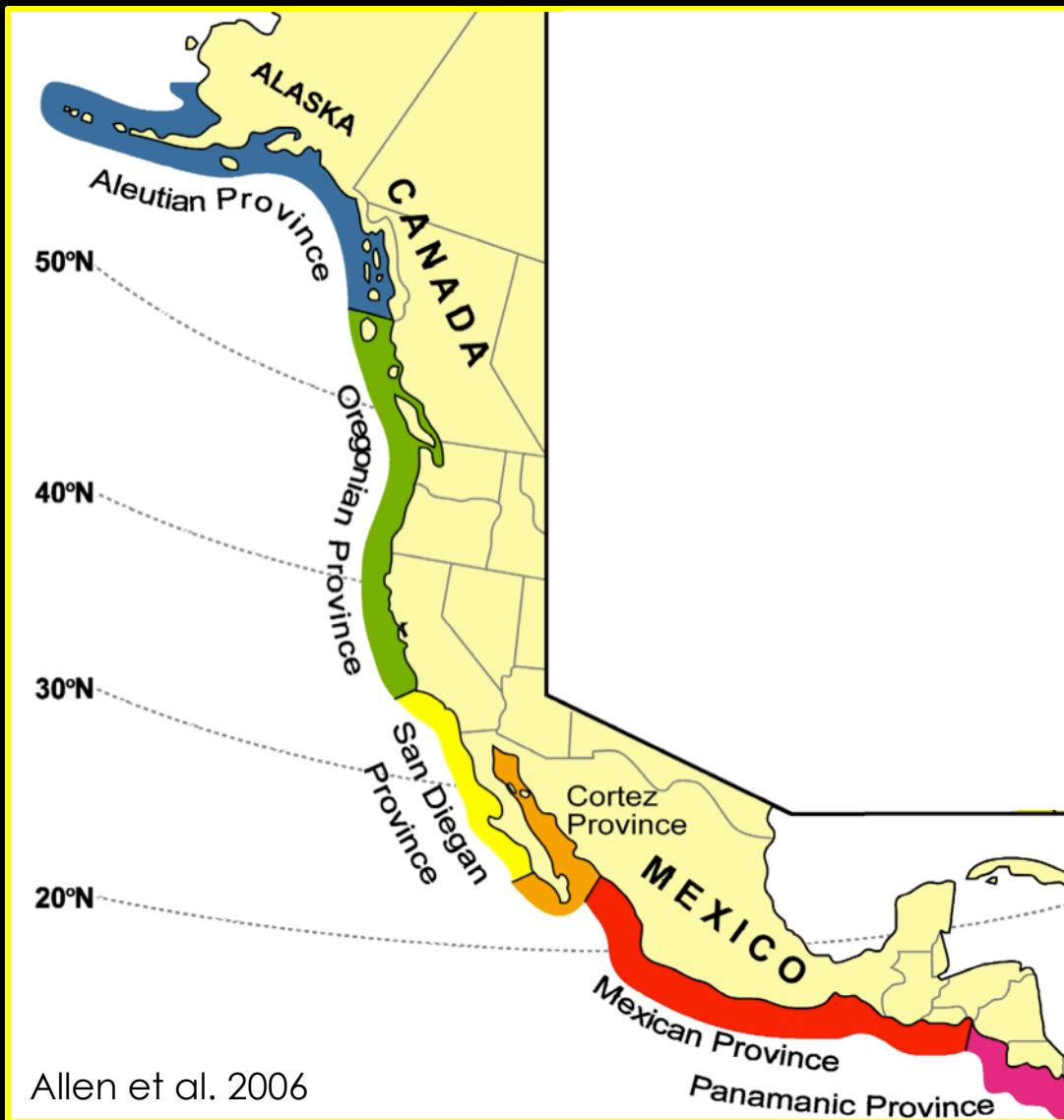
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Collaborators
Travis Tanaka, CDFW
Kristine Lesyna, CDFW

Varied Environmental Conditions Lead to Distinct Biogeographic Regions



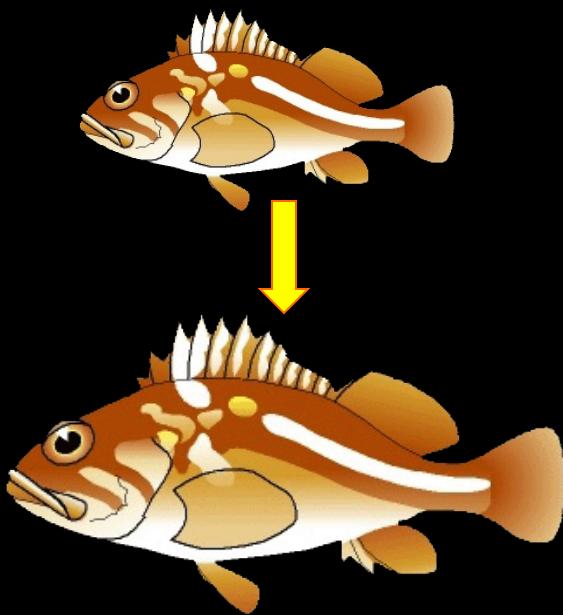
Marine Fishes with Widespread Distributions Leads to Development of Metapopulations



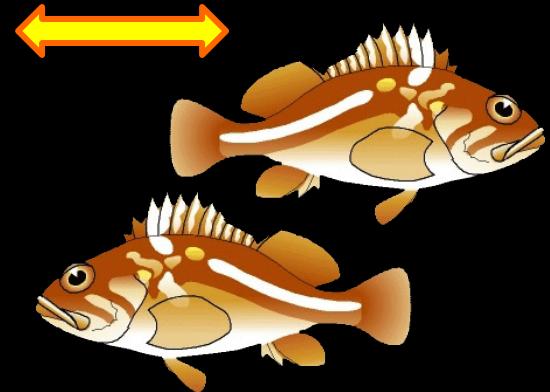
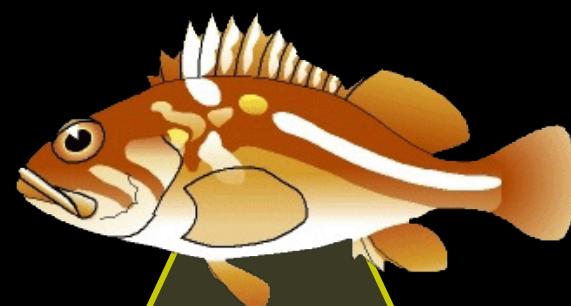
all fish drawings from Allen et al. 2006

Population Responses to Biogeography

growth, maturation



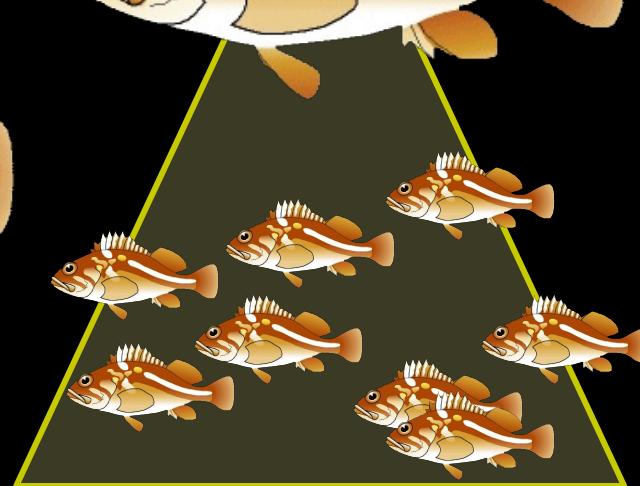
feeding, movement



mortality



productivity
settlement, recruitment



California Halibut, *Paralichthys californicus*



photo: Joe Leauseau

CA Halibut Life History

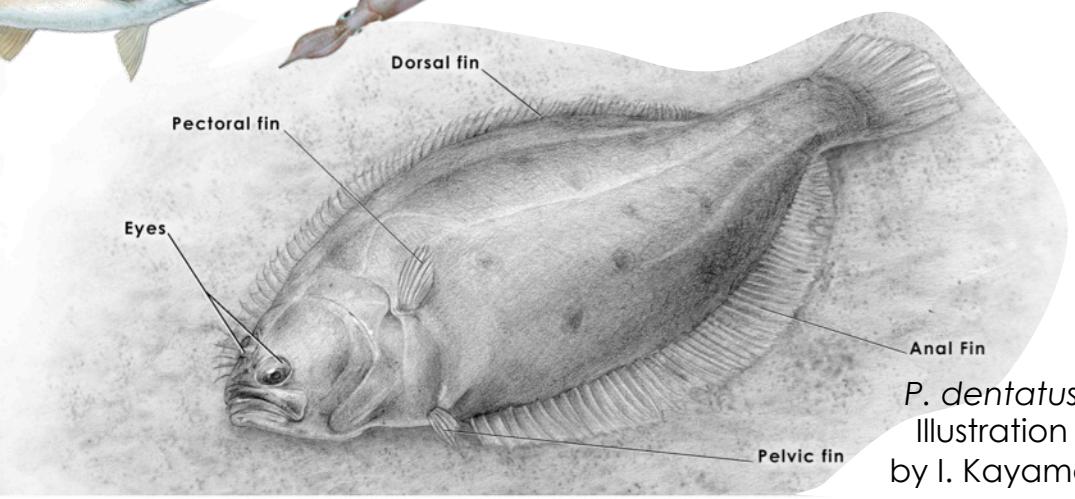
heterochronal (multiple)
broadcast spawners

20 to 29 day
pelagic larval duration

benthic juveniles reside
in bays and estuaries

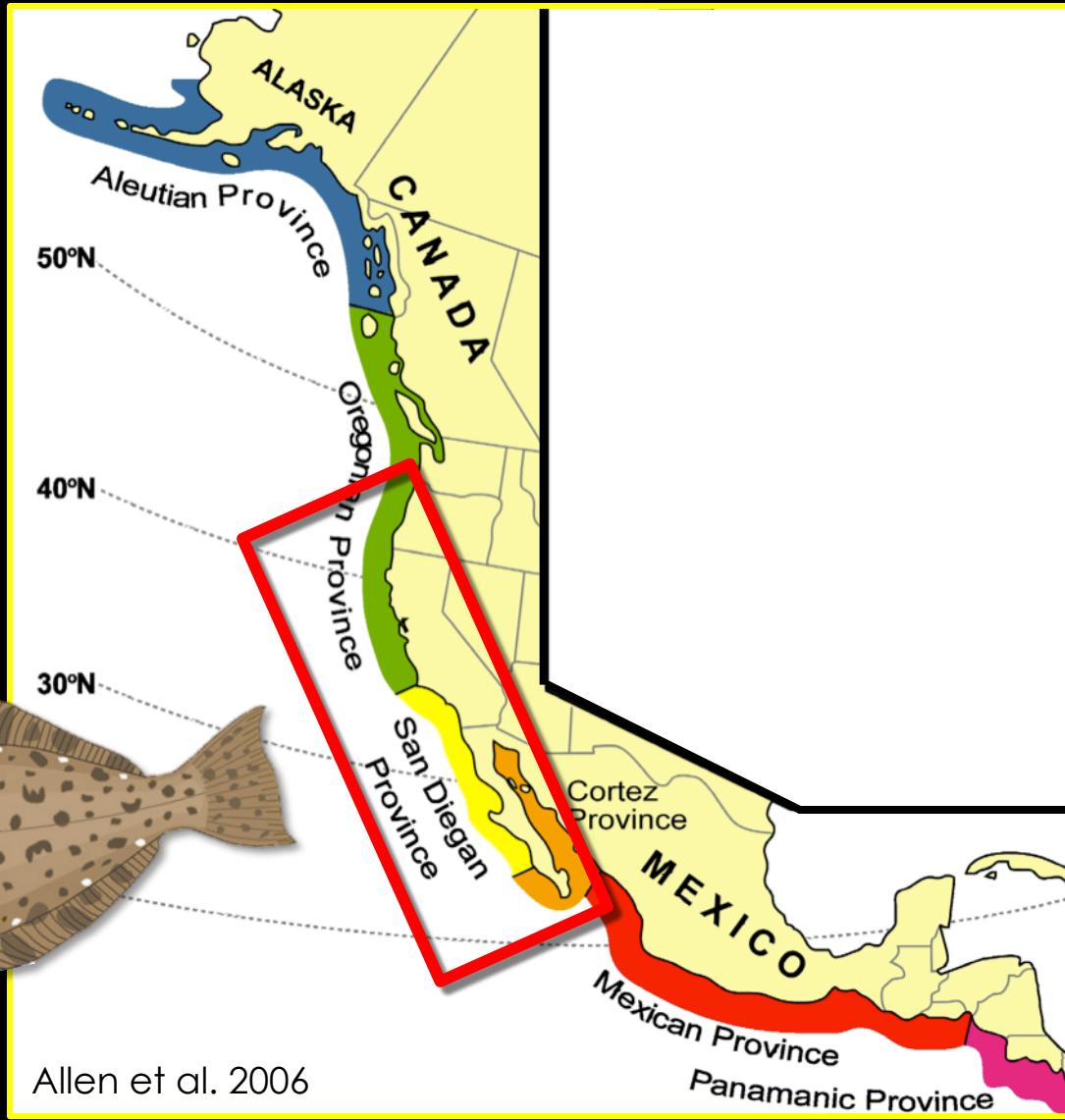
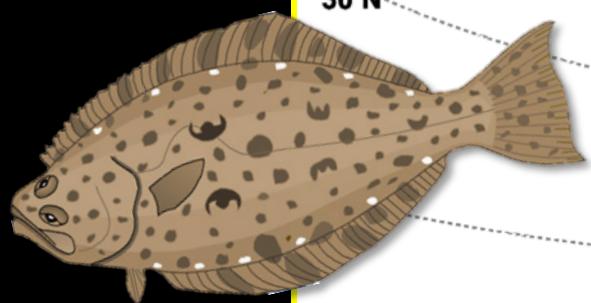
adults found along
the open coast

Clark 1930, Frey 1971,
Allen 1988, Kramer 1991

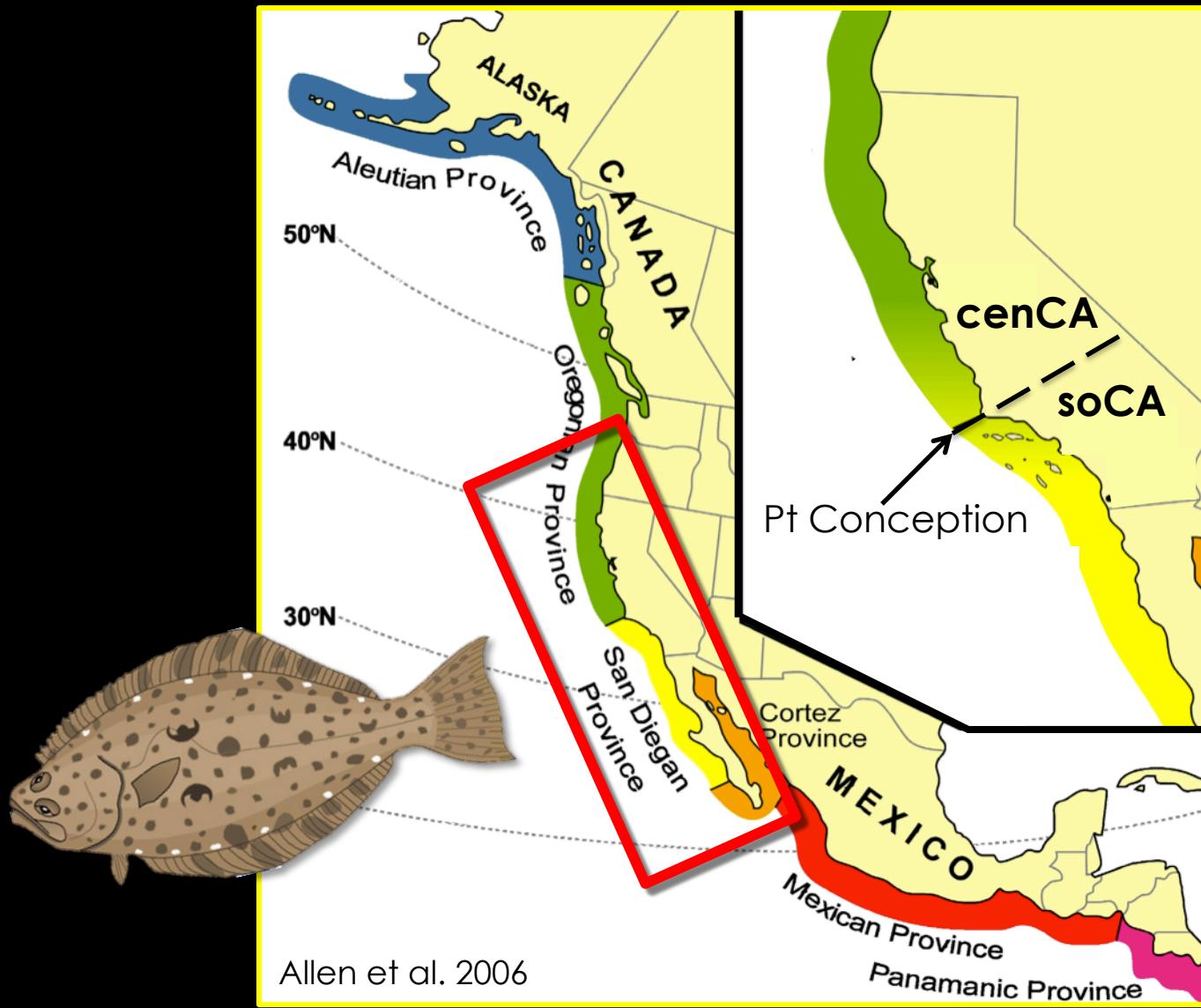


P. dentatus
Illustration
by I. Kayama

California Halibut Widespread Distribution Spans Multiple Biogeographic Regions

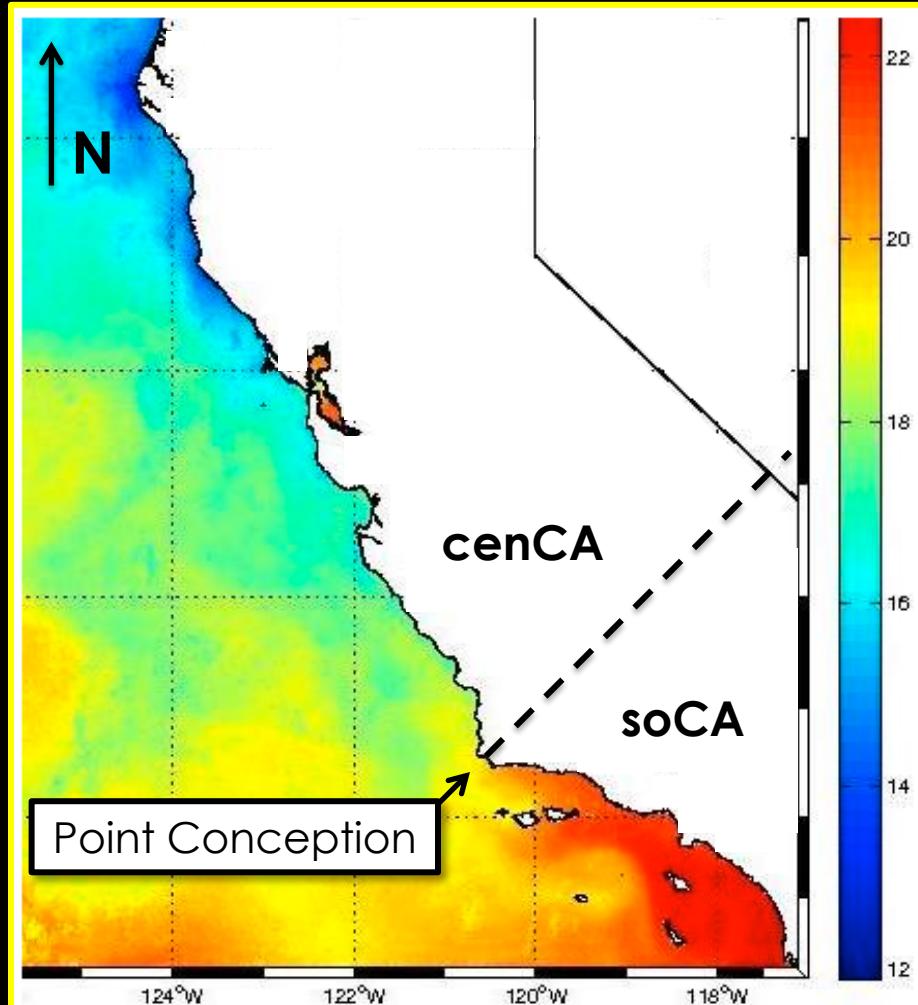


California Halibut Widespread Distribution Spans Multiple Biogeographic Regions

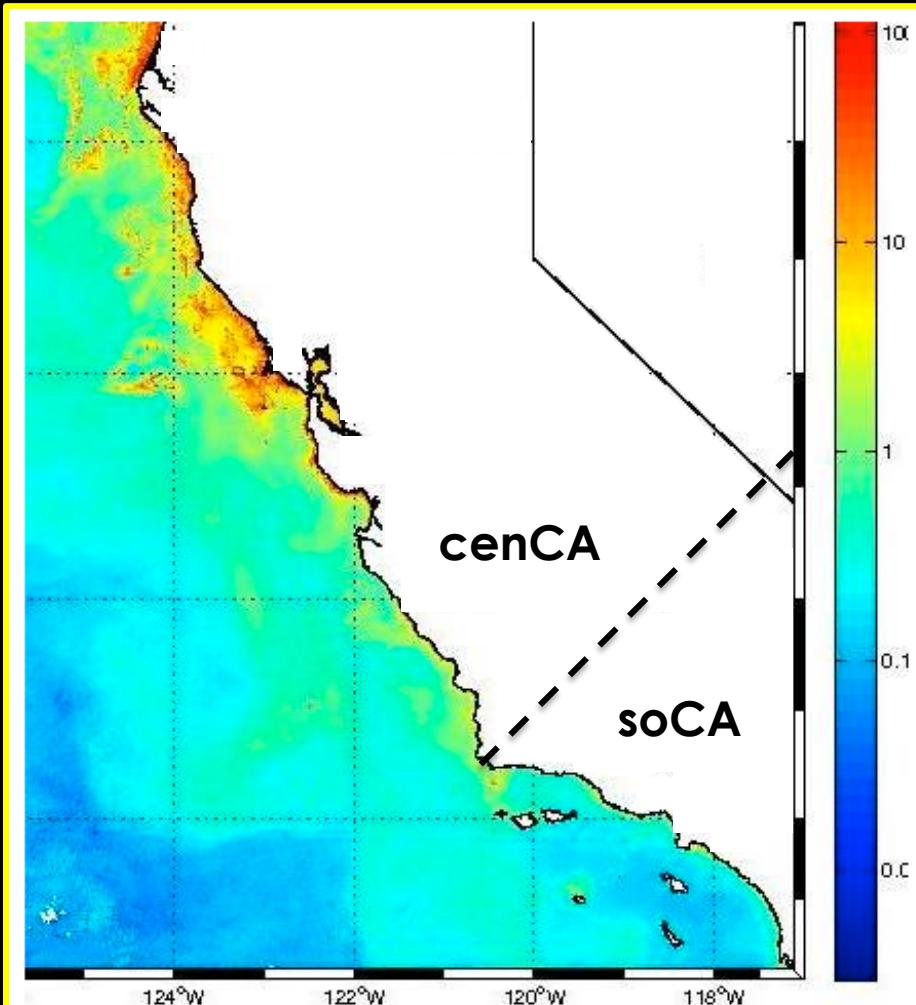


California Halibut Widespread Distribution Spans Multiple Biogeographic Regions

Sea Surface Temperature



Chlorophyll A



California Halibut Stock Assessment

Region-specific Stock Models

Maunder et al. 2011

- sex-structured parameters included:
 - growth
 - mortality
 - selectivity
- limited composition data for central California
 - some parameters fixed using soCA data



photo: Liza Schmidt

Master's Thesis Research Question

Do life history characteristics differ by region?



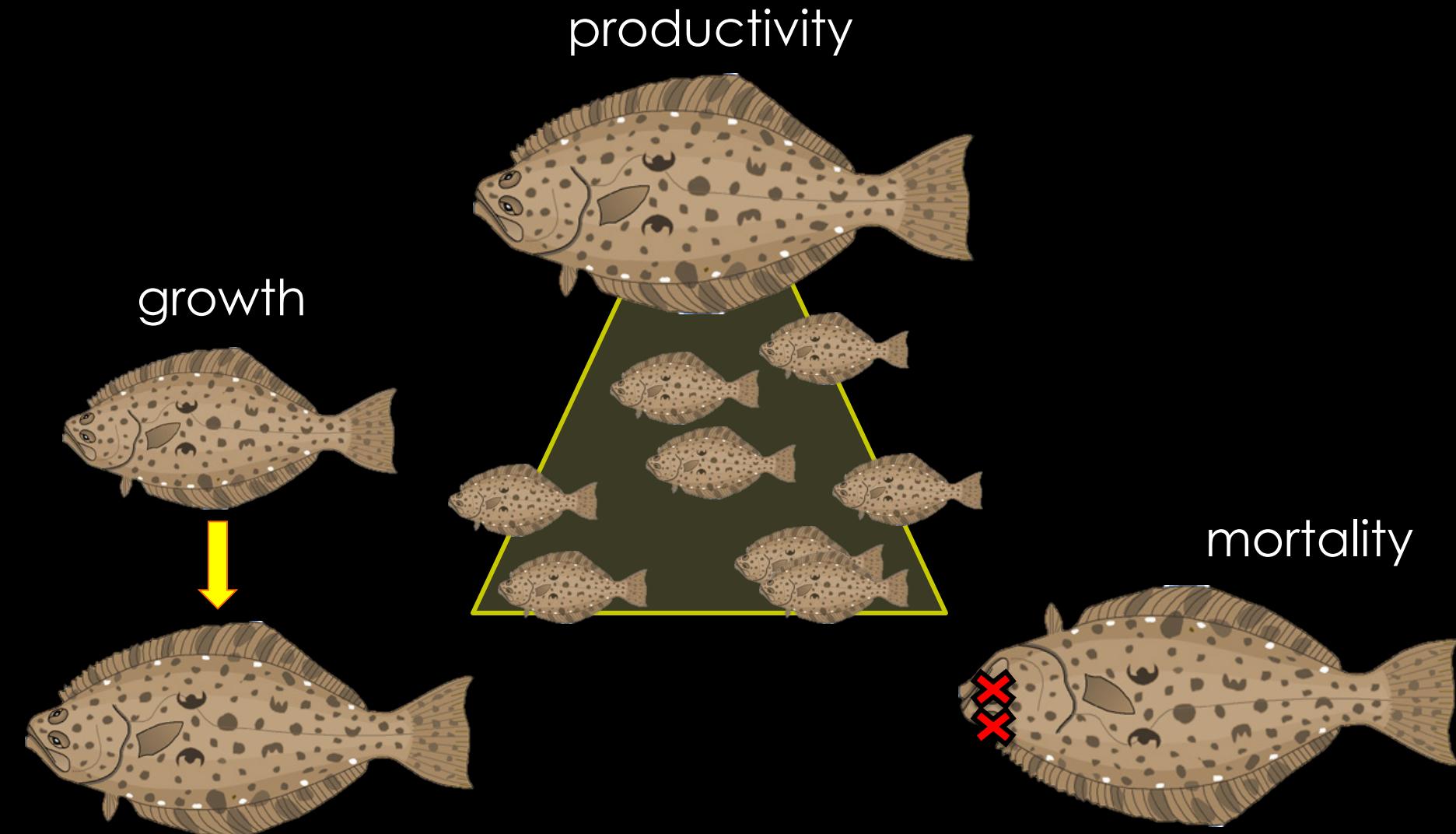
central California



southern California

Master's Thesis Research Question

Do life history characteristics differ by region?

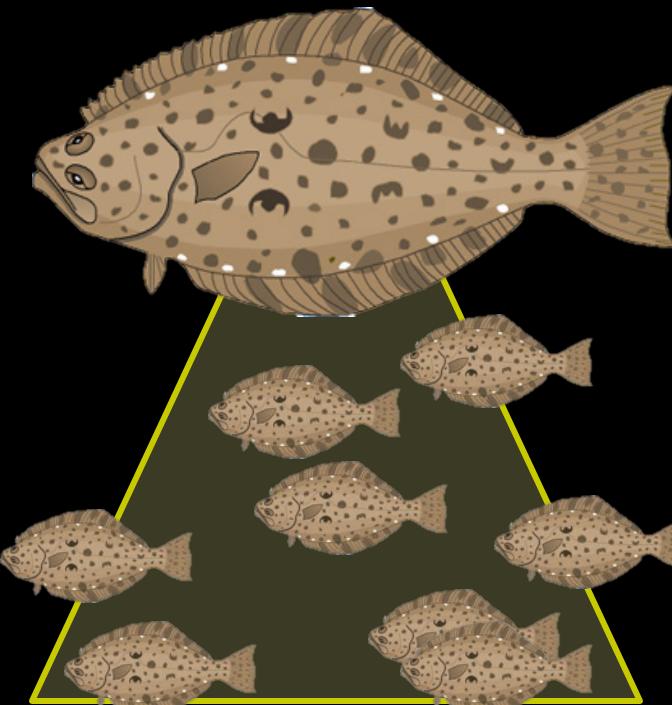
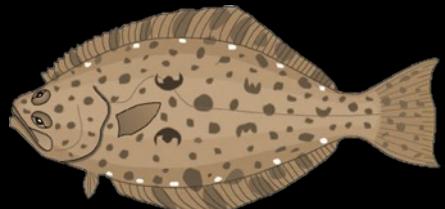


Master's Thesis Research Question

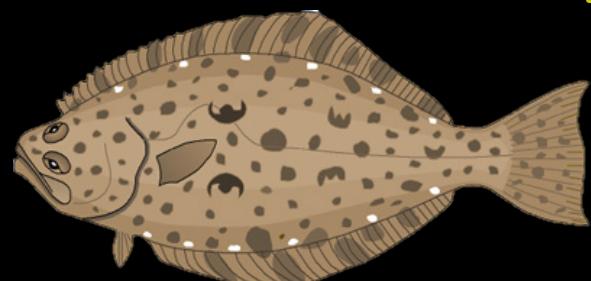
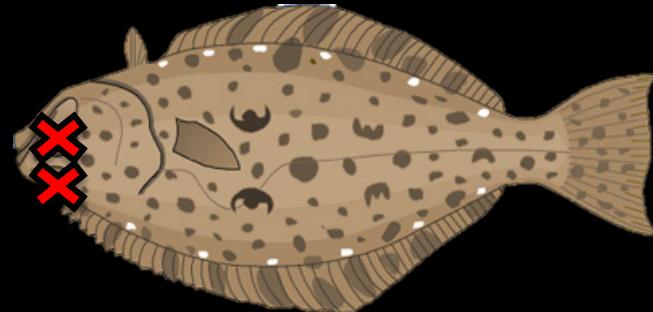
Do life history characteristics differ by region?

reproductive seasonality

growth



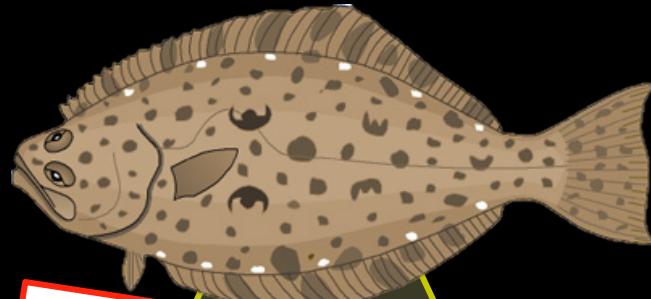
mortality



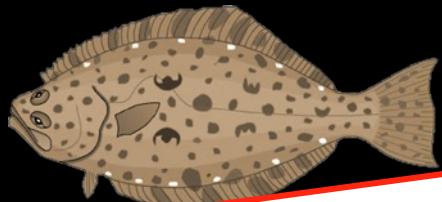
Master's Thesis Research Question

Do life history characteristics differ by region?

reproductive seasonality



growth



faster growth:
soCA

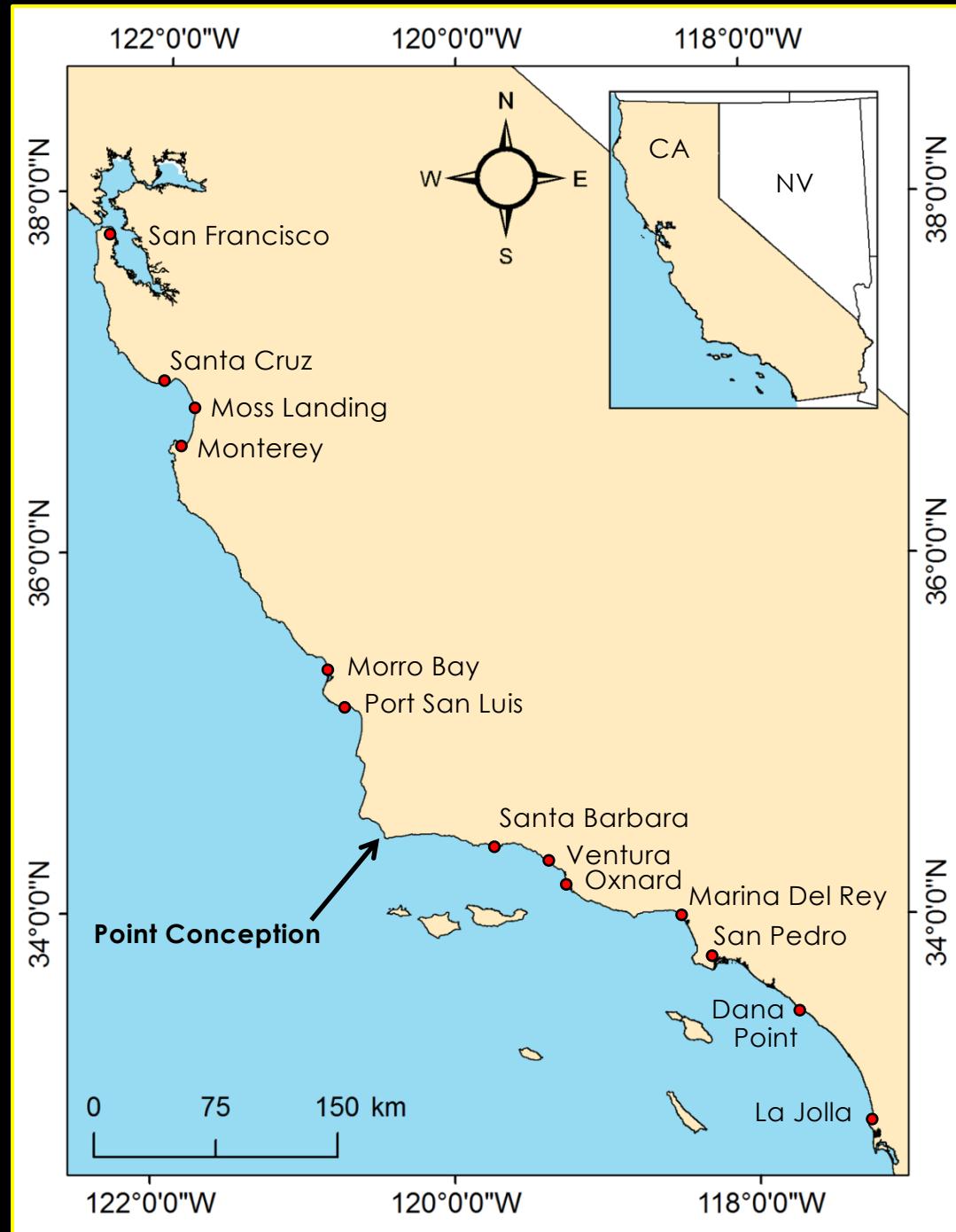
earlier spawning:
soCA/MX

total mortality



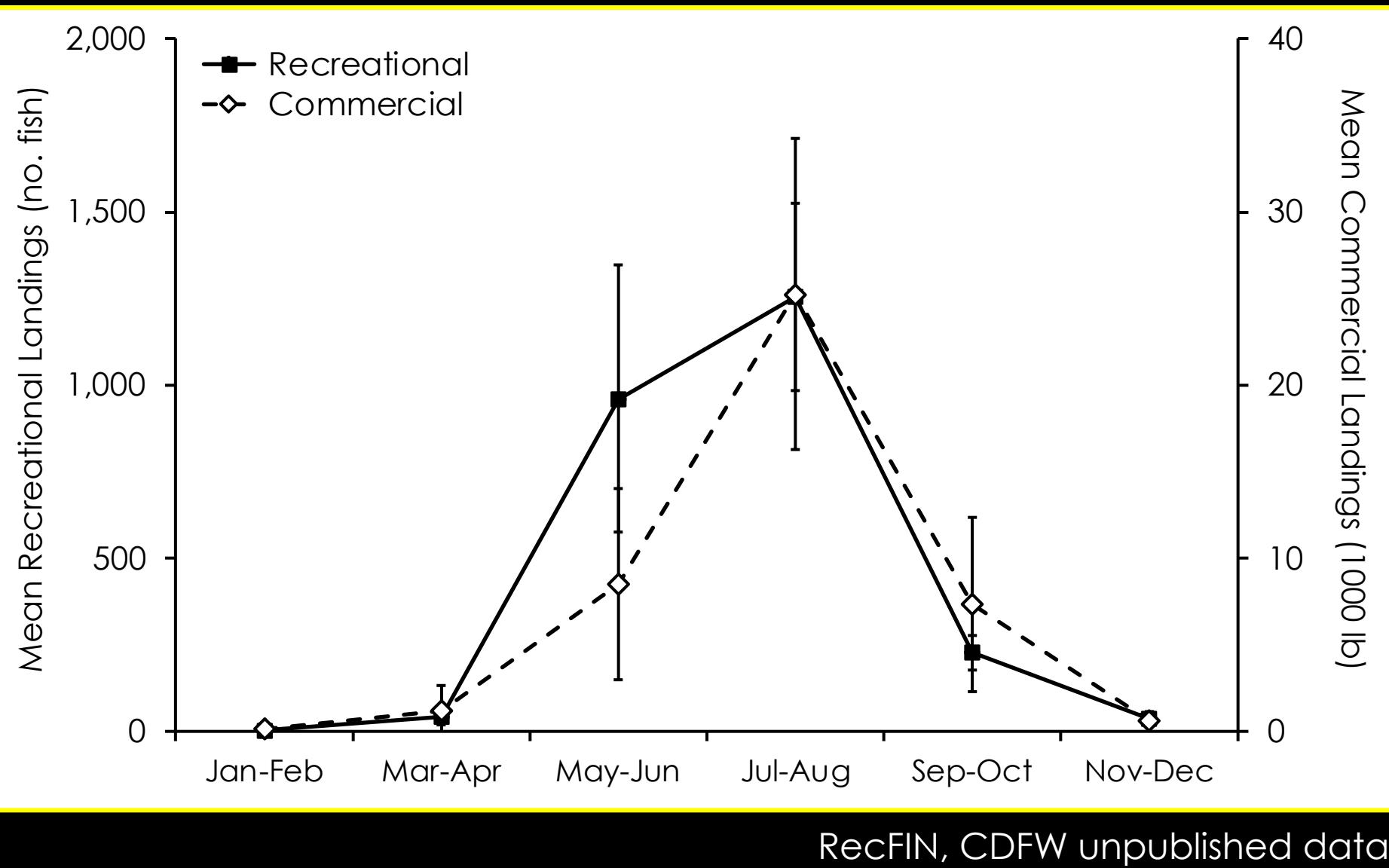
greater mortality:
soCA

Methodology: Study Design



Methodology: Study Duration

May through October, 2012 and 2013



Results: Specimen Collections

Method	central CA		southern CA	
	female	male	female	male
Commercial	293	269	571	134
Recreational	359	218	19	1
Research	72	50	22	10
Incidental	19	16	2	0
Total	743	553	615	145

photo: Ed Burrell

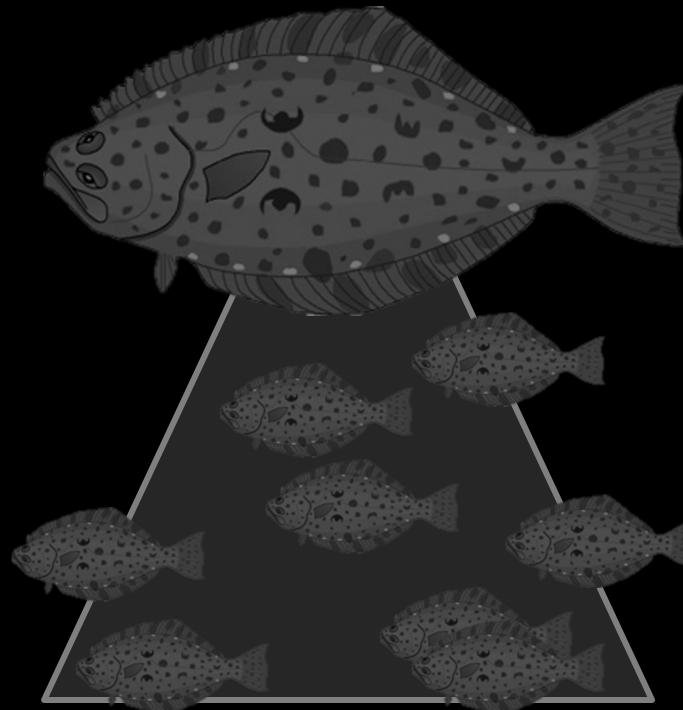
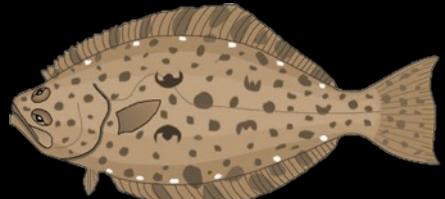


Methodology: Growth

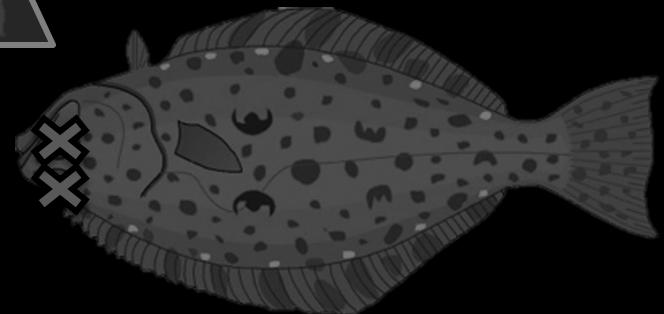
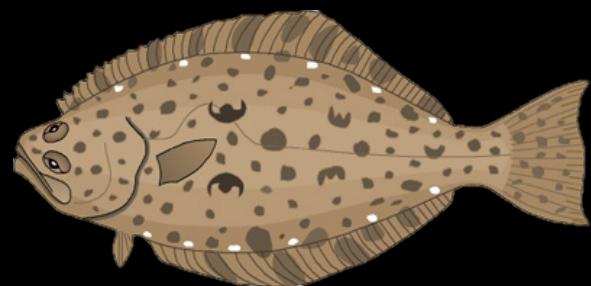
length-at-age data, von Bertalanffy growth curves

reproductive seasonality

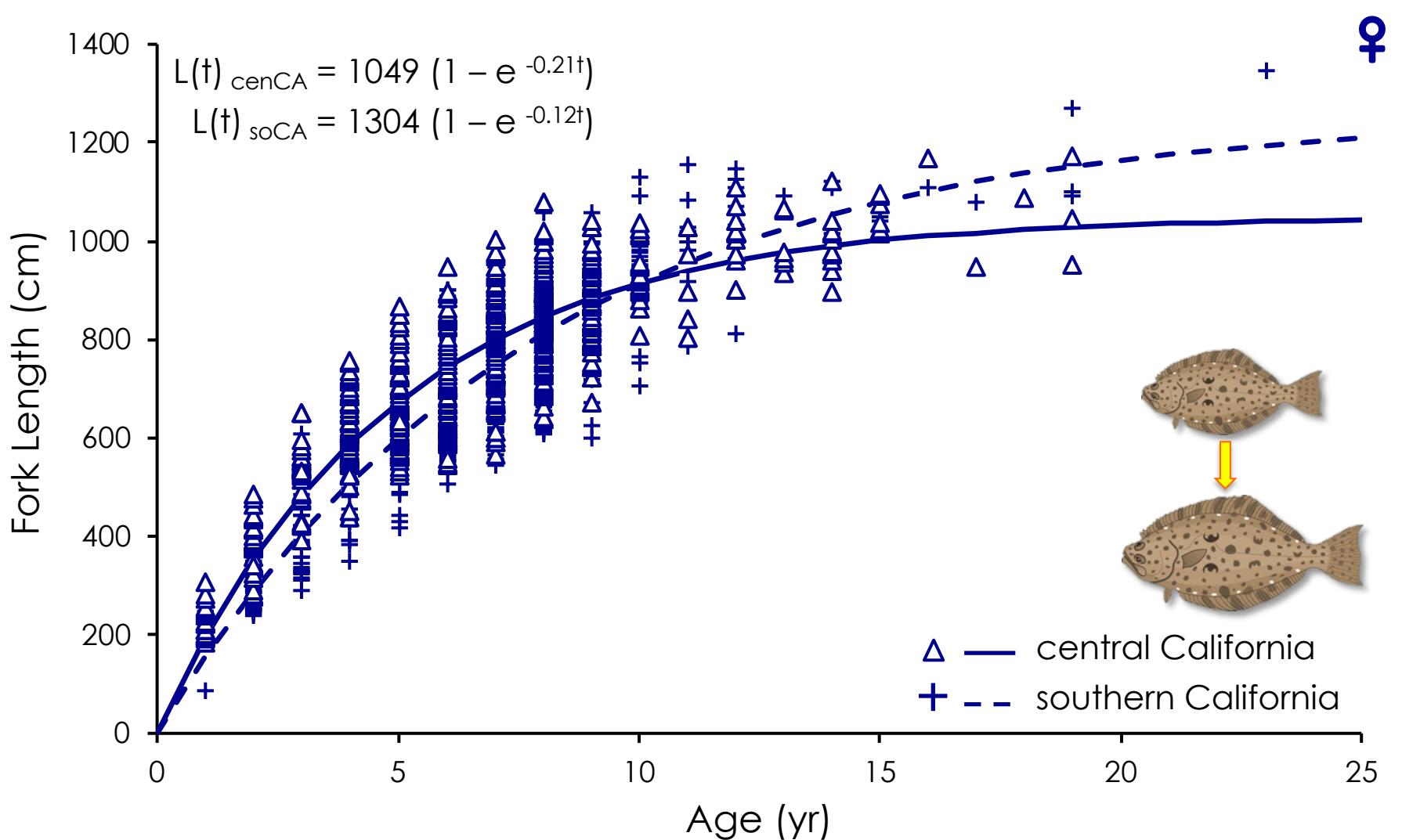
growth



total mortality

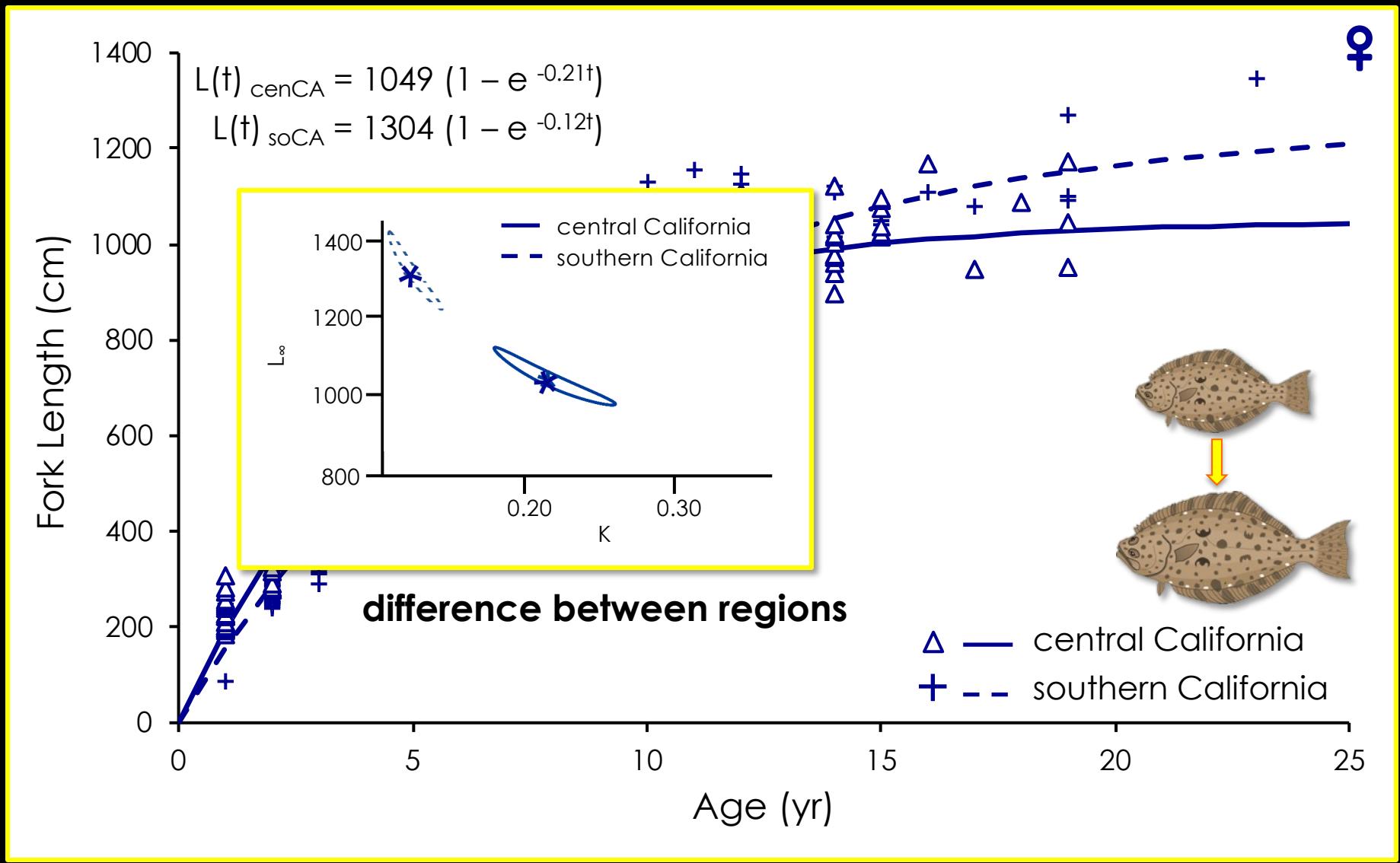


Results: von Bertalanffy Growth Curves female California Halibut, both regions

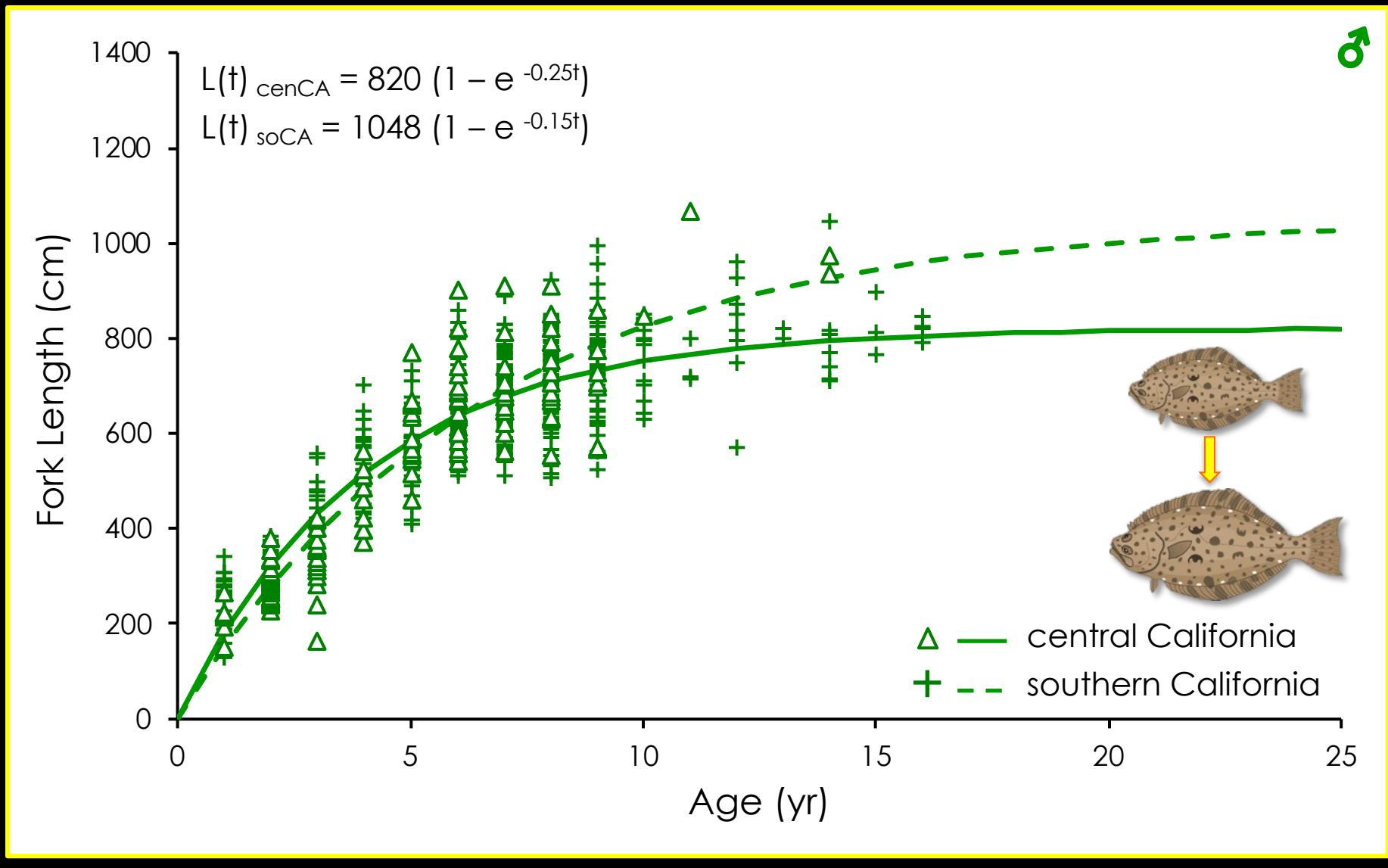


n (cenCA) = 743 n (soCA) = 615

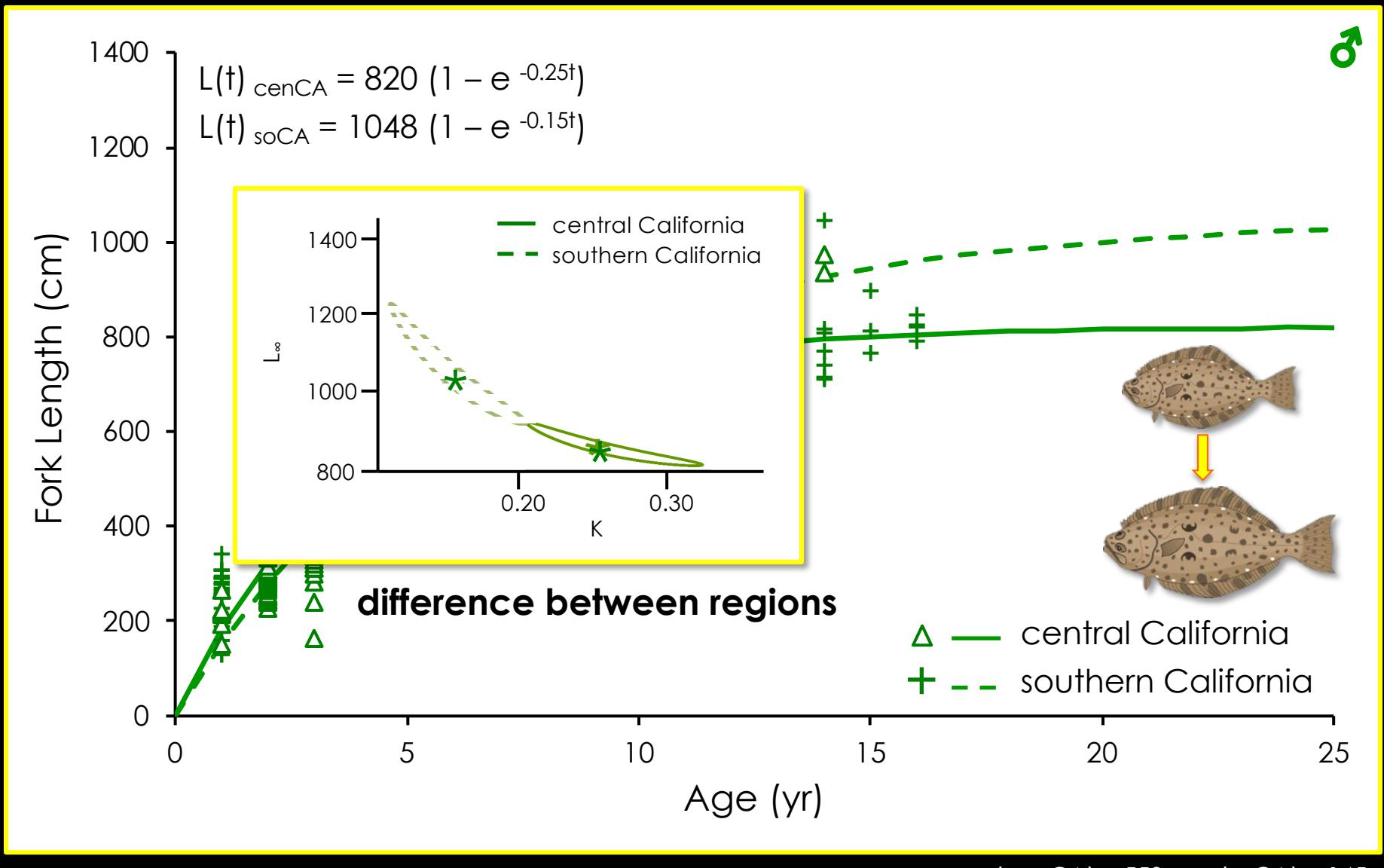
Results: von Bertalanffy Growth Curves female California Halibut, both regions



Results: von Bertalanffy Growth Curves male California Halibut, both regions

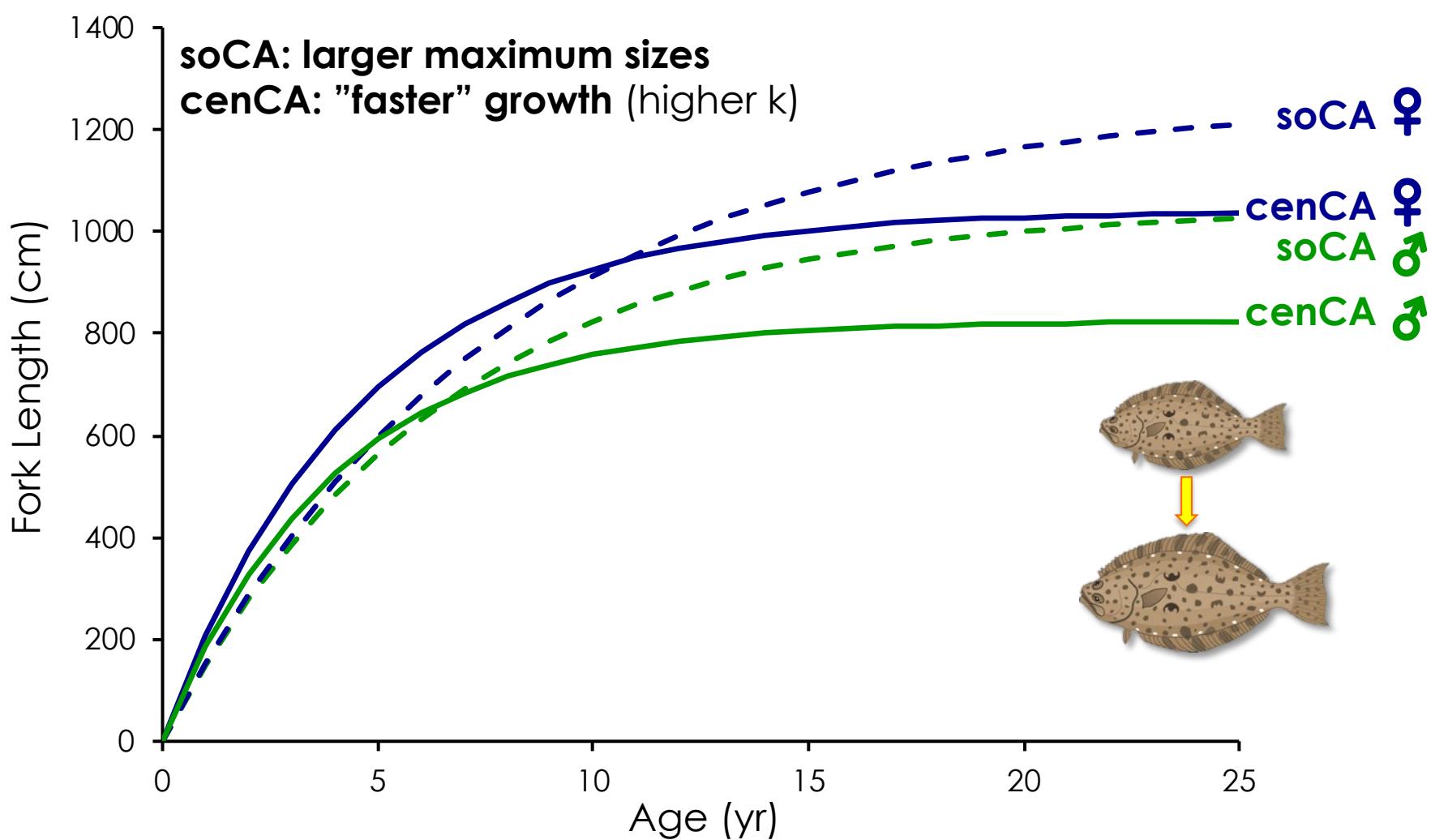


Results: von Bertalanffy Growth Curves male California Halibut, both regions



Results: von Bertalanffy Growth Curves

California Halibut, both sexes and regions



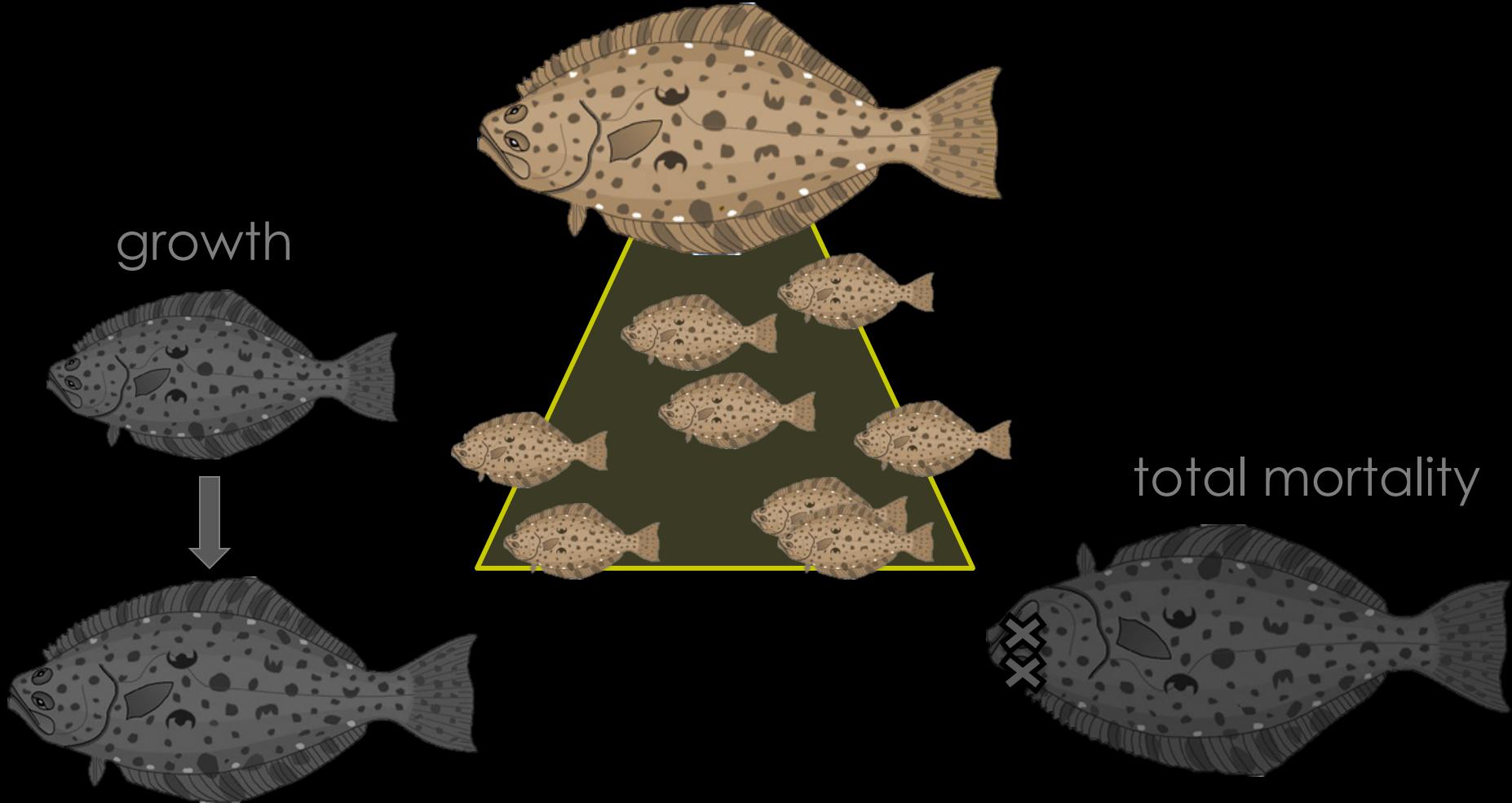
Methodology: Reproductive Seasonality

temporal spawning and larval density data

reproductive seasonality

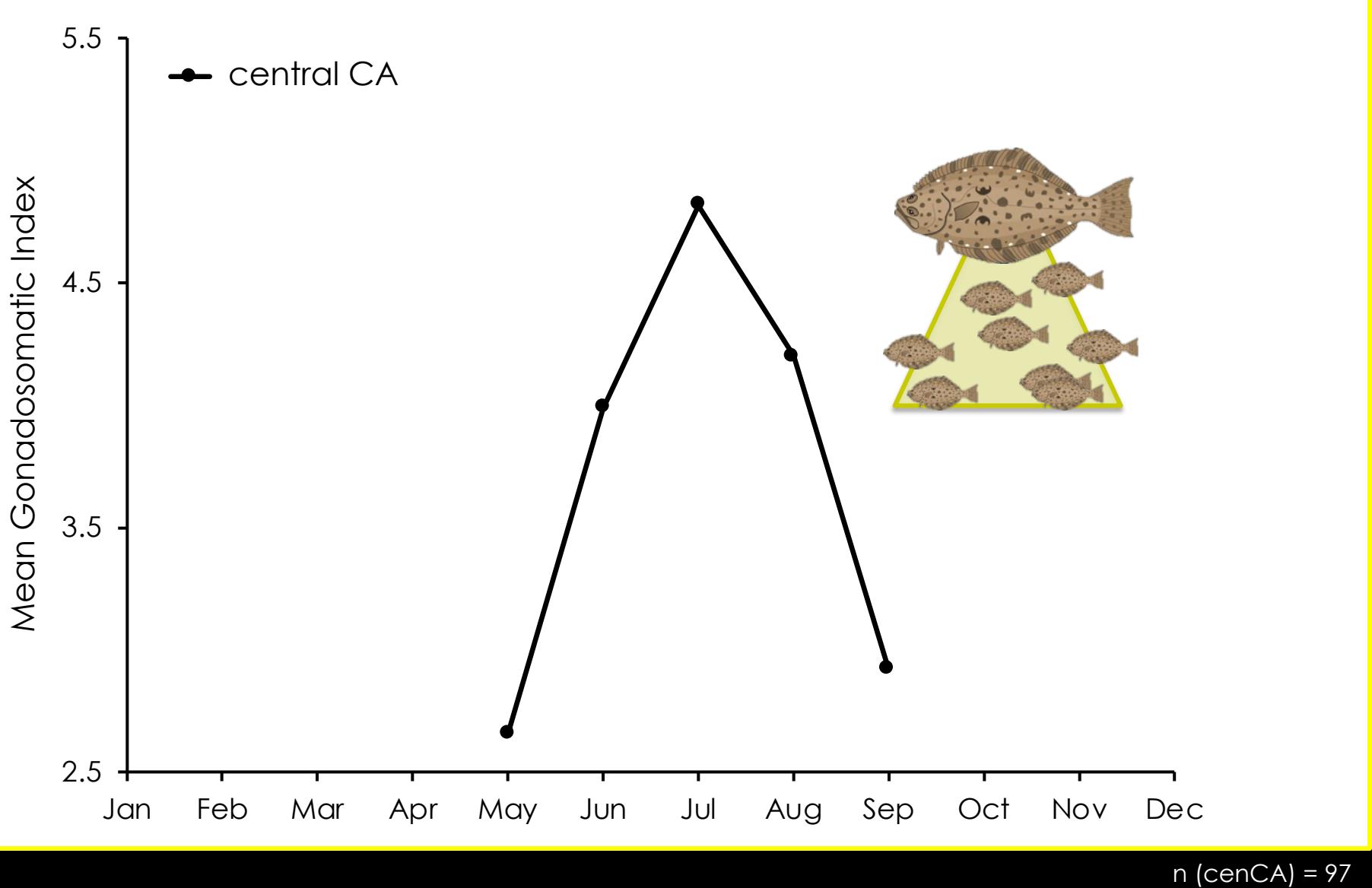
growth

total mortality

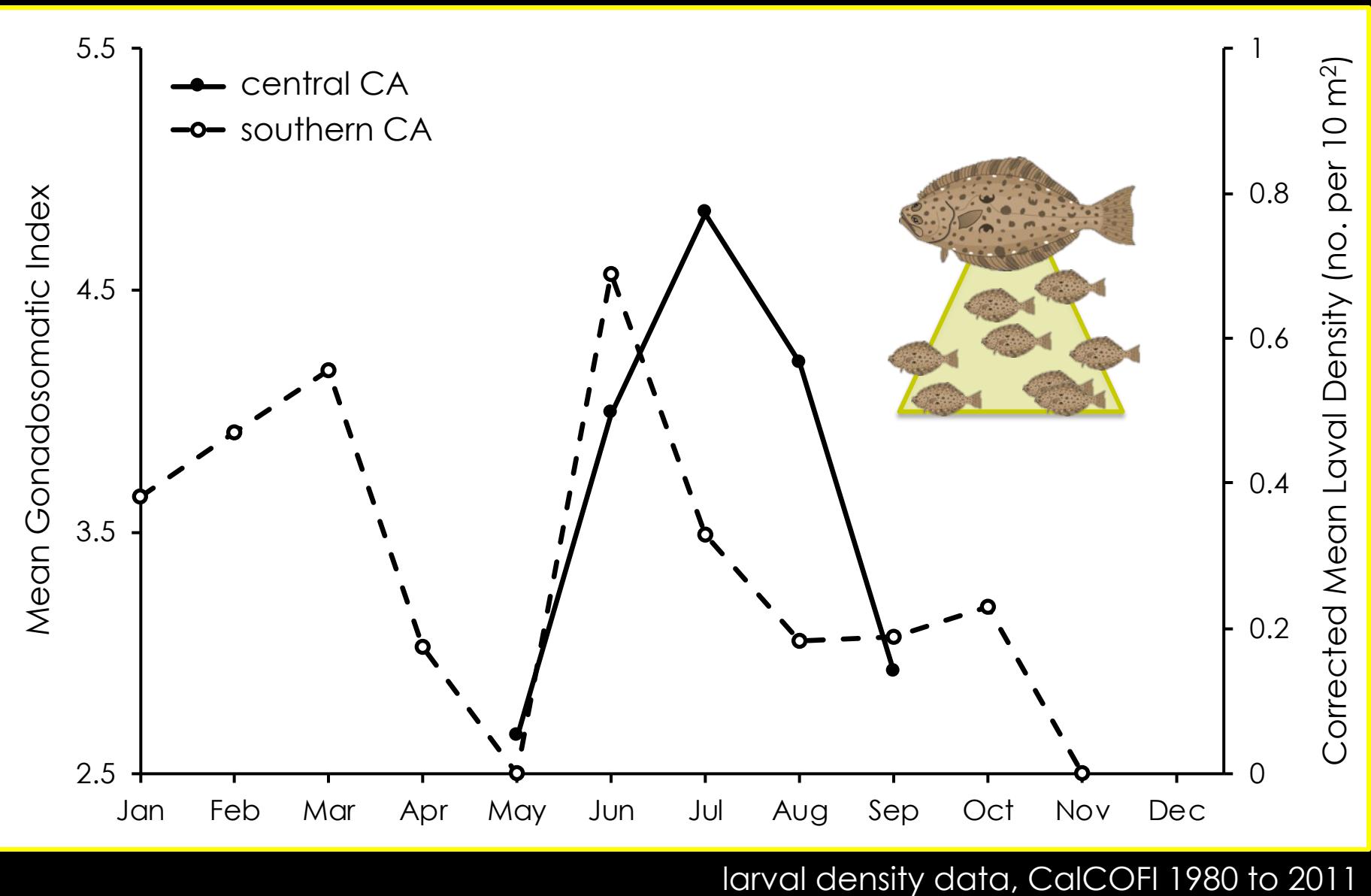


Results: Reproductive Seasonality

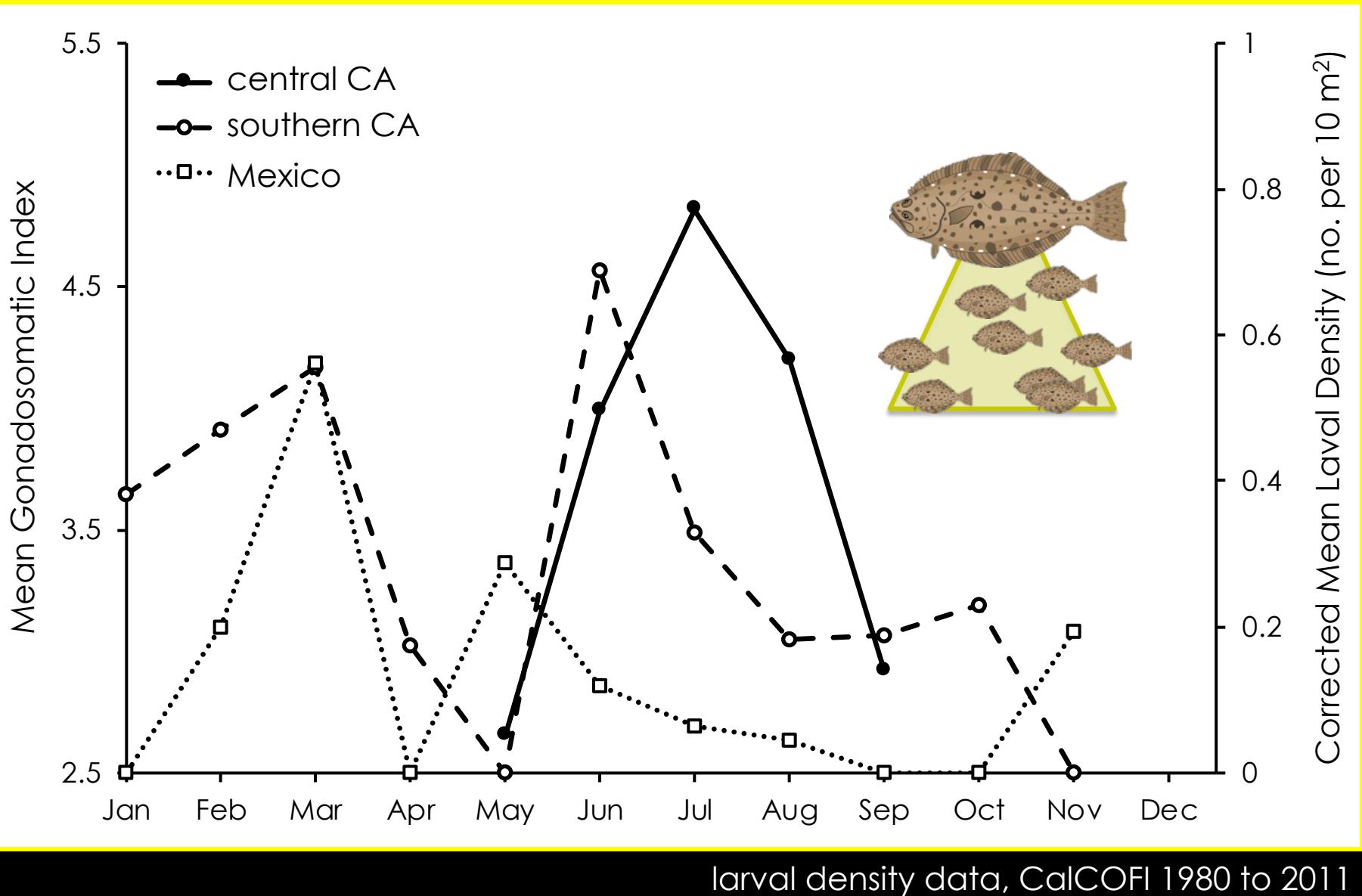
peak spawning, regional comparisons



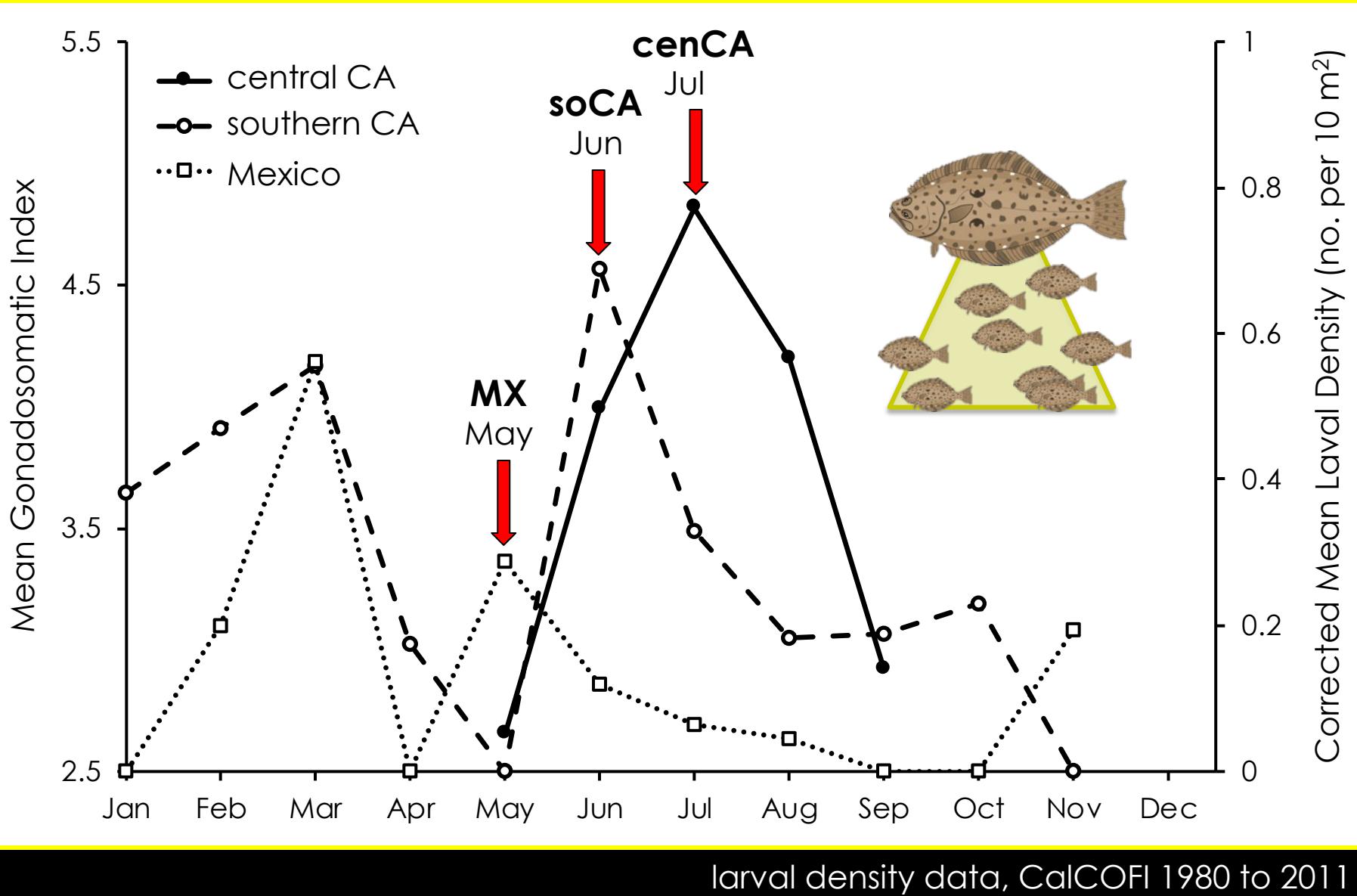
Results: Reproductive Seasonality peak spawning, regional comparisons



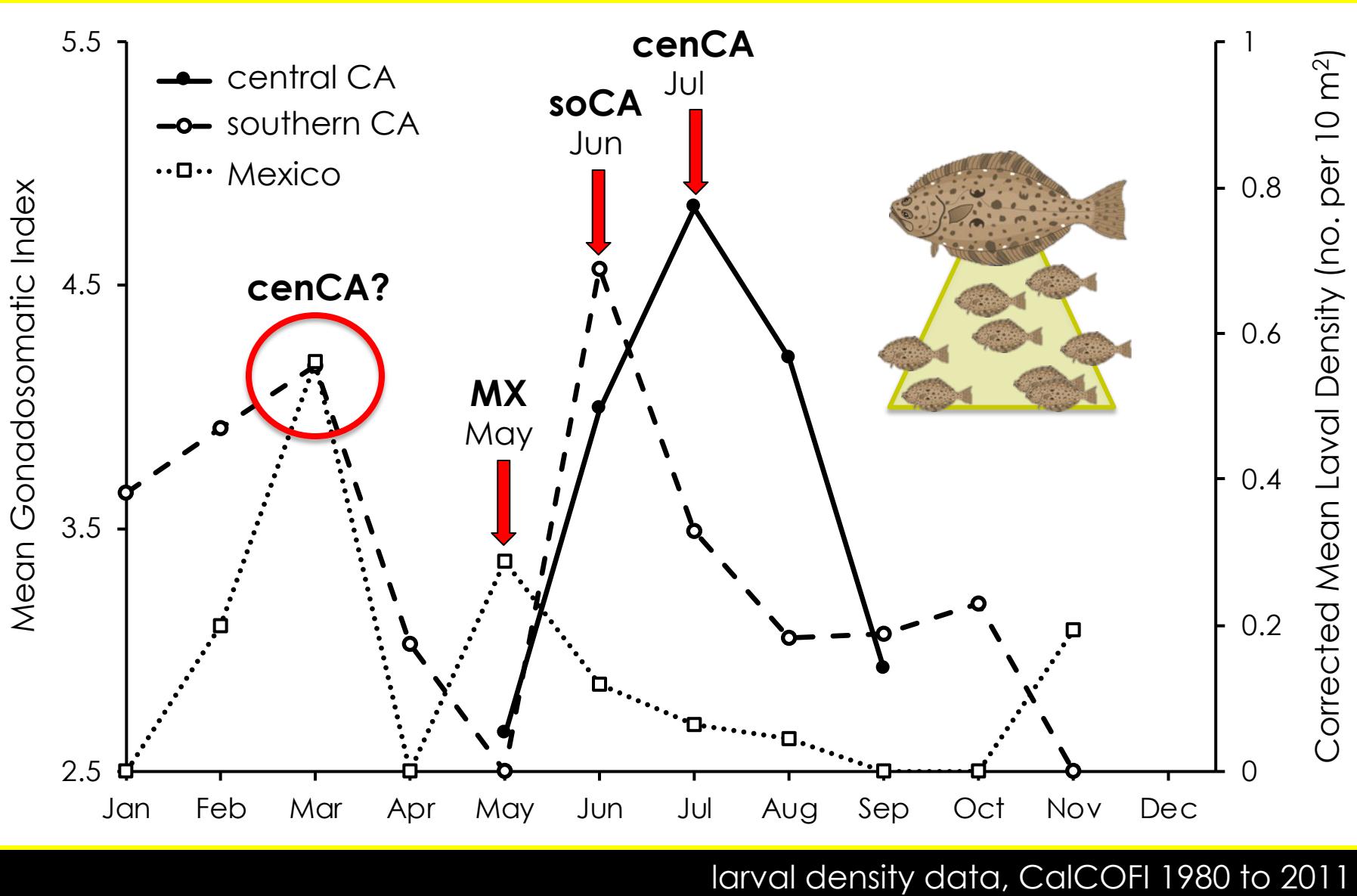
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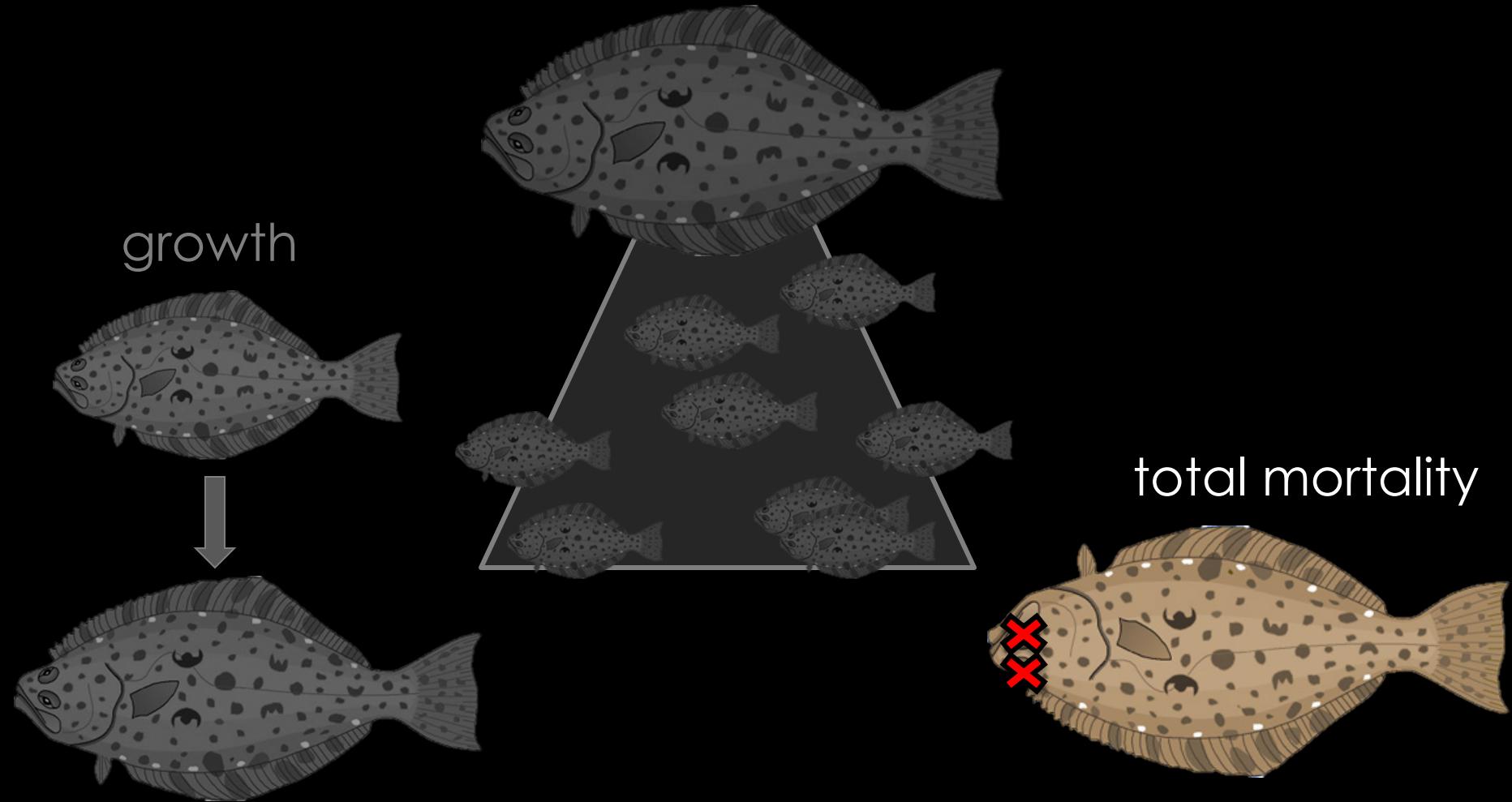
Results: Reproductive Seasonality peak spawning, regional comparisons



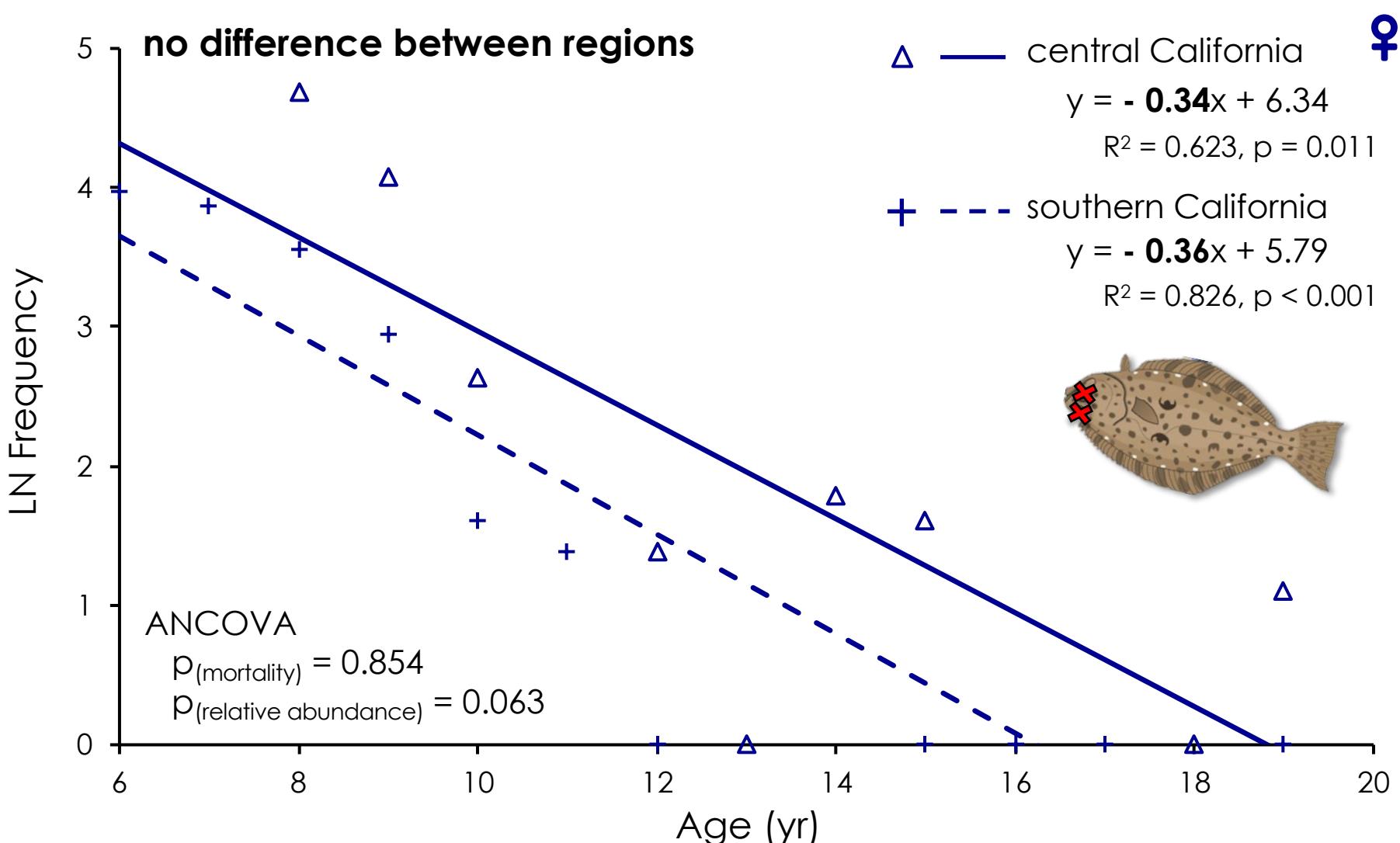
Methodology: Mortality

age frequency data, catch curve analysis

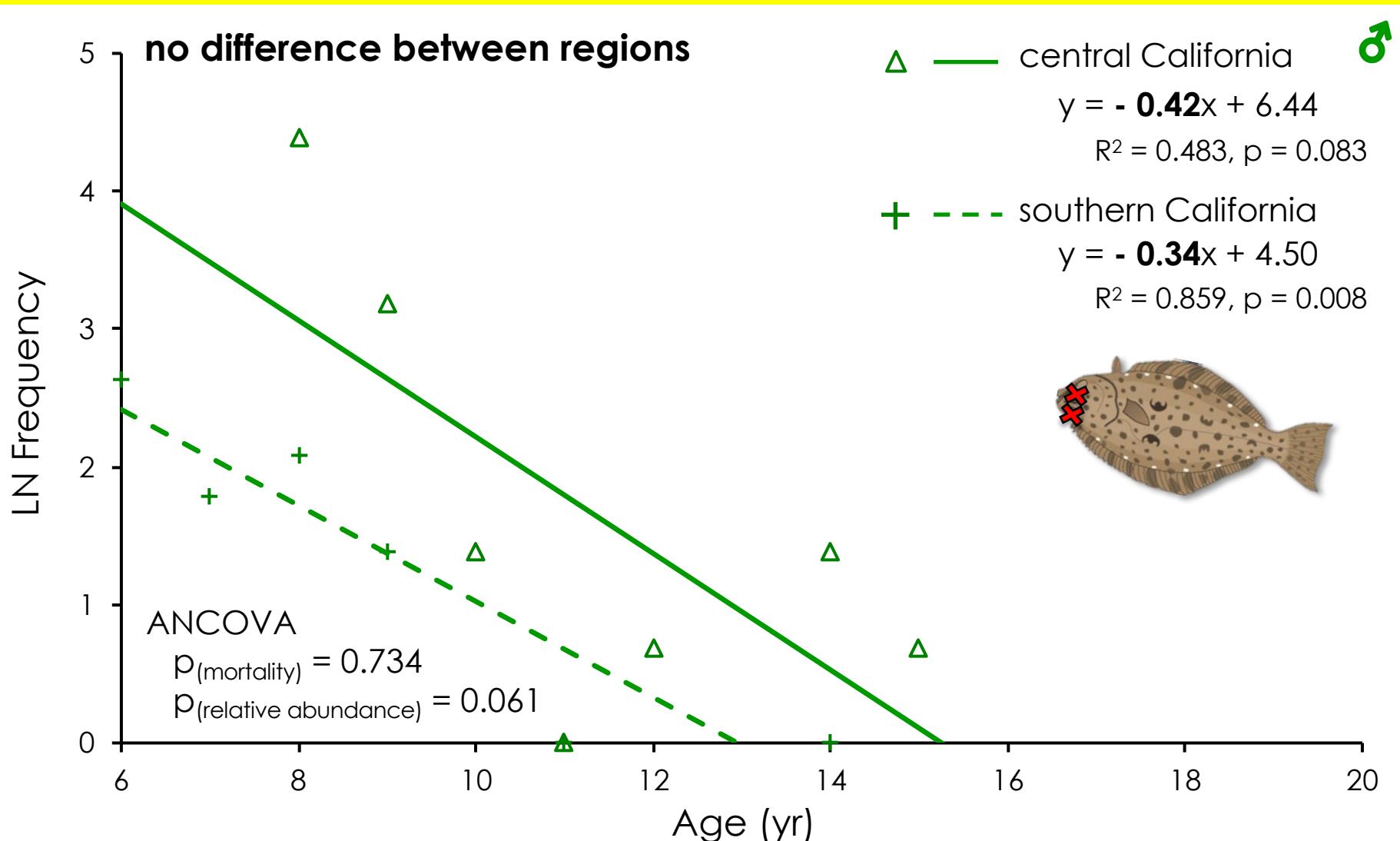
reproductive seasonality



Results: Instantaneous Total Mortality female California Halibut, both regions

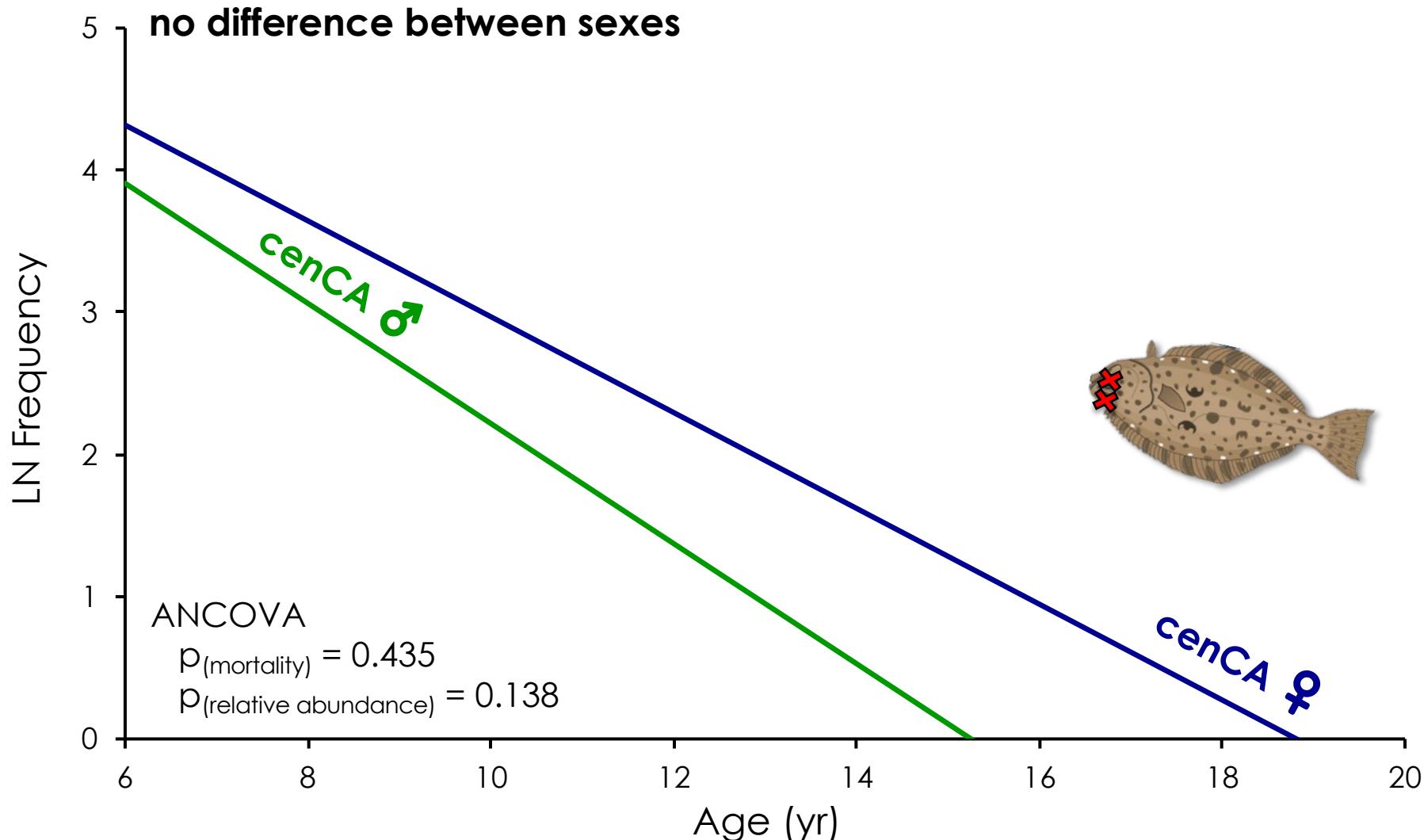


Results: Instantaneous Total Mortality male California Halibut, both regions



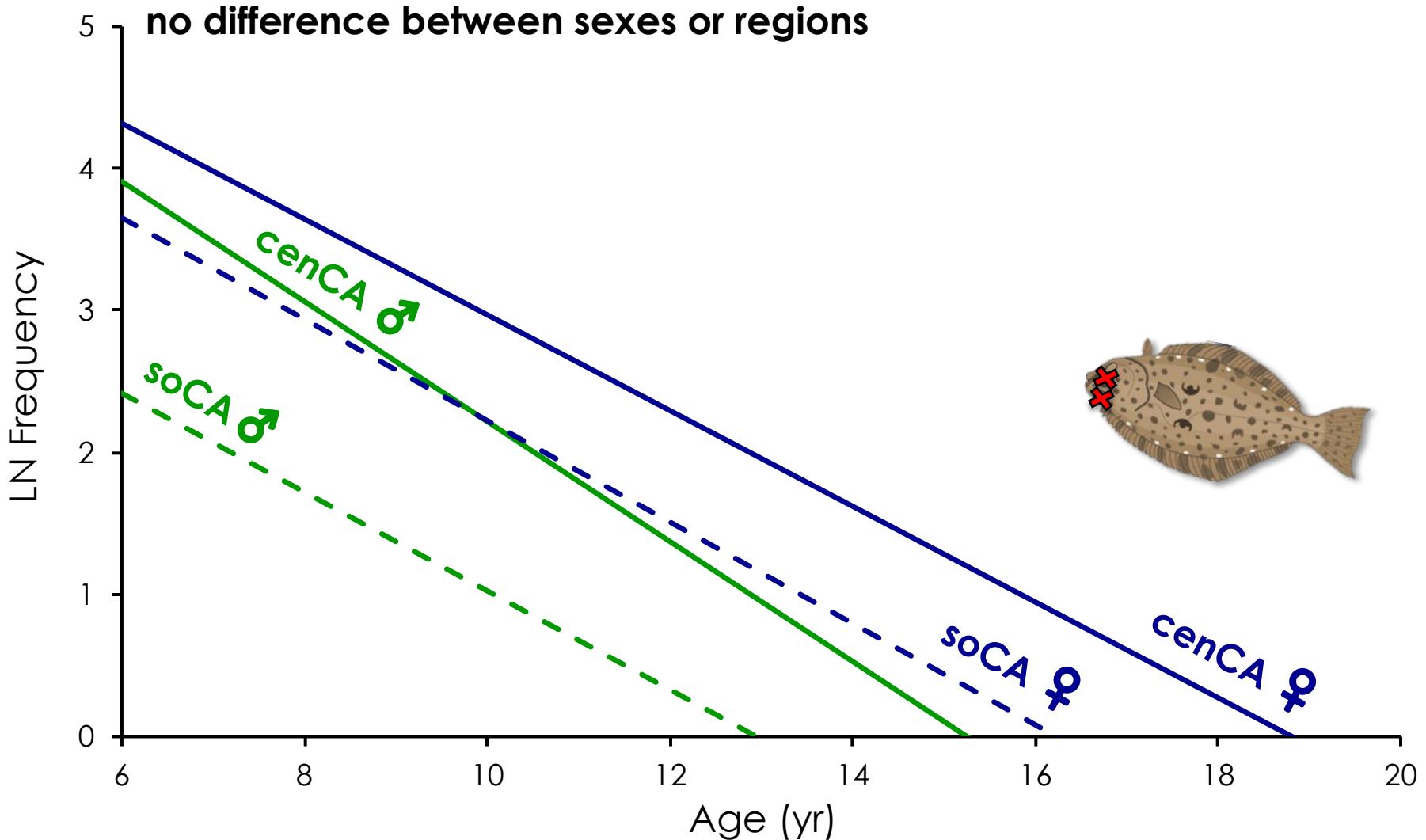
Results: Instantaneous Total Mortality

California Halibut, both sexes and regions



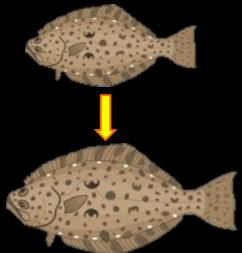
Results: Instantaneous Total Mortality

California Halibut, both sexes and regions



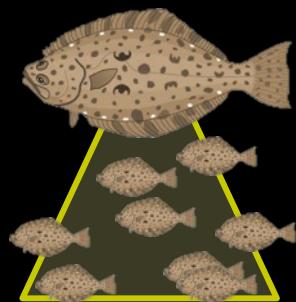
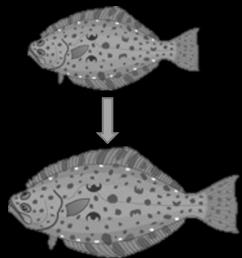
Results Summary: California Halibut

Results Summary: California Halibut



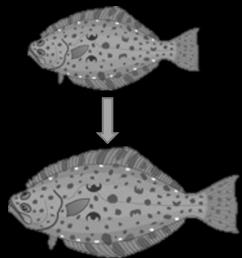
- cenCA Halibut grow faster, but attain smaller maximum sizes than soCA Halibut

Results Summary: California Halibut

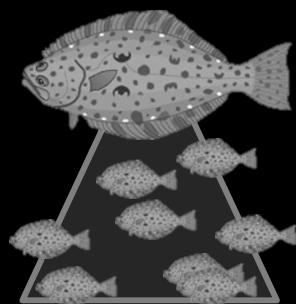


- cenCA Halibut grow faster, but attain smaller maximum sizes than soCA Halibut
- California Halibut spawn earlier at lower latitudes during summer
 - 1) MX: May
 - 2) soCA: June
 - 3) cenCA: July
 - relatively protracted spawning south of Point Conception?

Results Summary: California Halibut



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

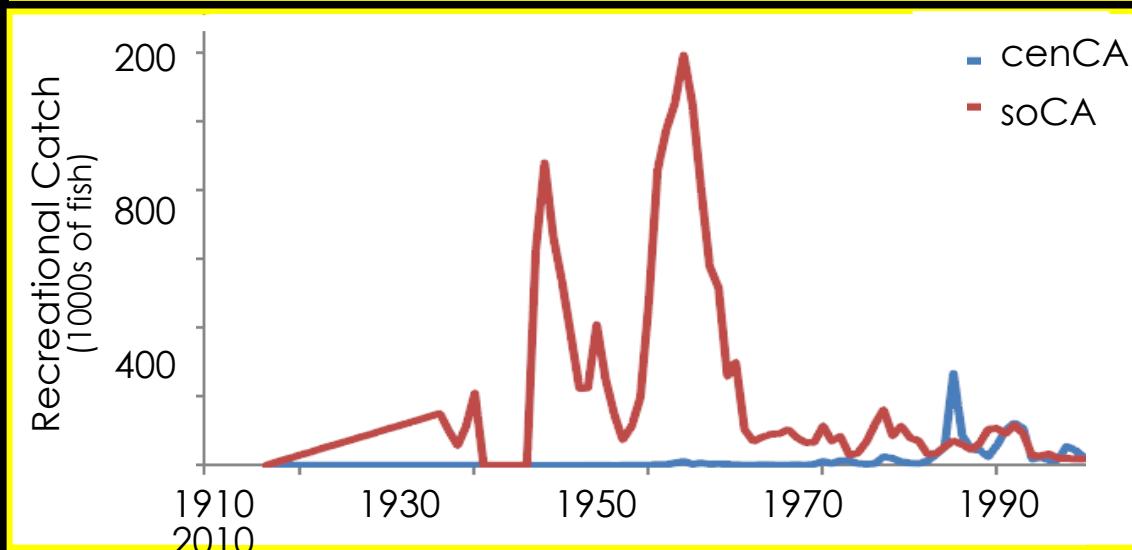
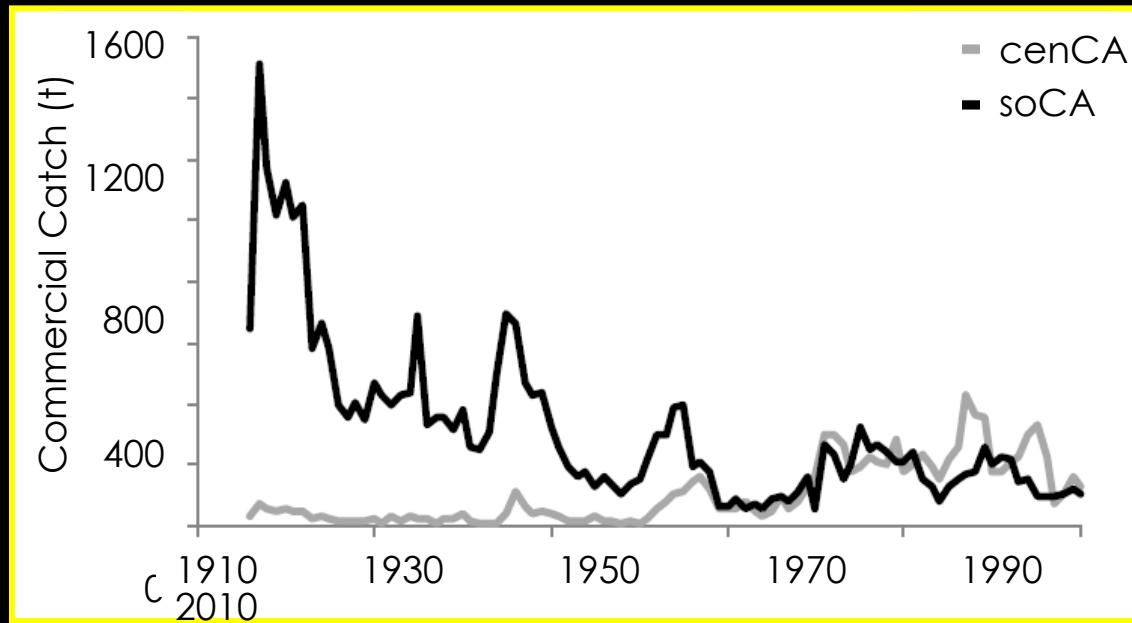


- California Halibut spawn earlier at lower latitudes during summer
 - 1) MX: May
 - 2) soCA: June
 - 3) cenCA: July
 - relatively protracted spawning south of Point Conception?



- there is no difference in California Halibut mortality by sex or region

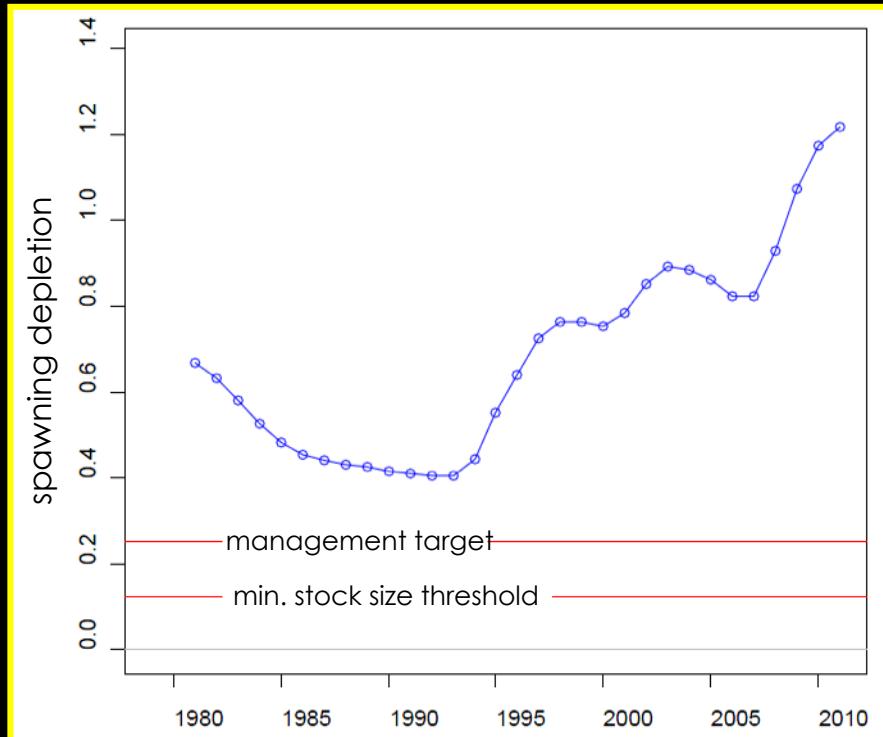
CA Halibut Stock Assessment Results: Region-specific Catches



CA Halibut Stock Assessment Results: Region-specific Depletion Trends

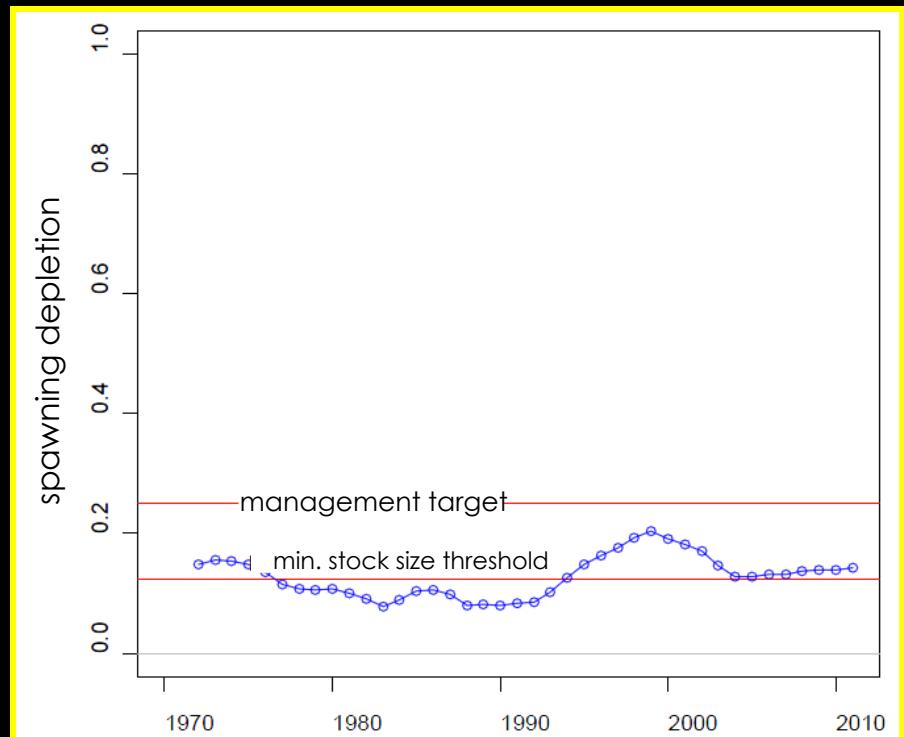
Central California

- $B > B_{MSY}$ $F < F_{MSY}$
- recent recruitment high



Southern California

- $B = 14\%$ unexp. (still $> B_{MSY}$)
- recent recruitment low



Informing the Next Stock Assessment

- region-specific estimates provided to CDFW
 - new data available for central stock model
 - inform mechanisms for different population trajectories



photo: Richard Scangarello

Informing the Next Stock Assessment

- region-specific estimates provided to CDFW
 - new data available for central stock model
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BARNES ET AL.: GROWTH, MORTALITY, AND REPRODUCTIVE SEASONALITY OF CALIFORNIA HALIBUT (*PARALICHTHYS CALIFORNICUS*)
CalCOFI Rep., Vol. 56, 2015

GROWTH, MORTALITY, AND REPRODUCTIVE SEASONALITY OF CALIFORNIA HALIBUT (*PARALICHTHYS CALIFORNICUS*): A BIOGEOGRAPHIC APPROACH

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photo: Richard Scangarello

Informing the Next Stock Assessment

- region-specific estimates provided to CDFW
 - new data available for central stock model
 - inform mechanisms for different population trajectories

California Fish and Game 102(3):79-99; 2016

Assessment of length- and age-at-maturity for California halibut (*Paralichthys californicus*), including a histologically-based description of the reproductive cycle

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REPRODUCTIVE TACTICS OF CALIFORNIA HALIBUT (*PARALICHTHYS CALIFORNICUS*)
CalCOFI Rep., Vol. 59, 2018

REPRODUCTIVE TACTICS OF CALIFORNIA HALIBUT (*PARALICHTHYS CALIFORNICUS*): COMBINING SPAWNING SEASON, INTERSPAWNING INTERVAL, AND BATCH FECUNDITY TO ESTIMATE ANNUAL REPRODUCTIVE OUTPUT FOR A MULTIPLE-BATCH SPAWNING FISH

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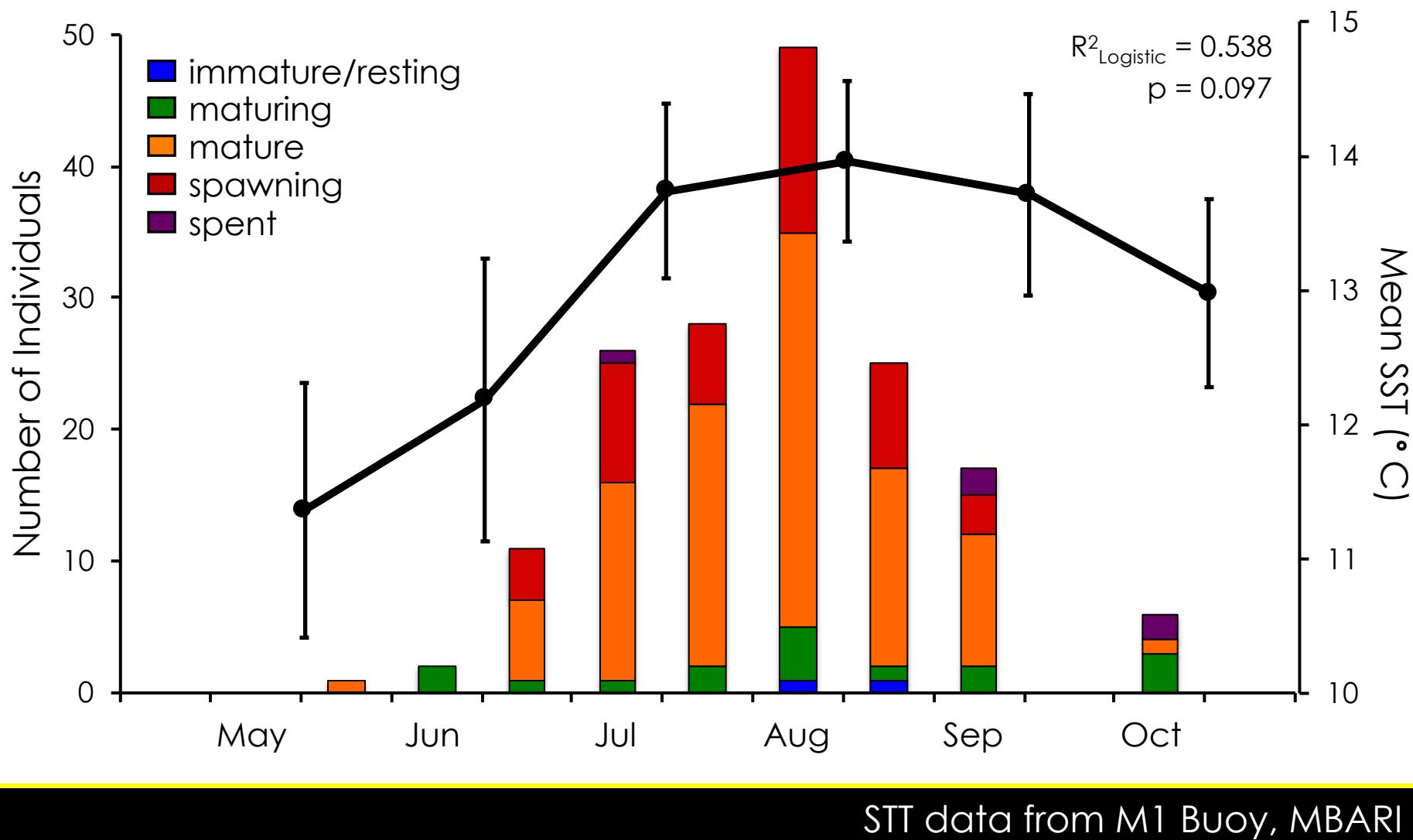
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Research Needs: California Halibut



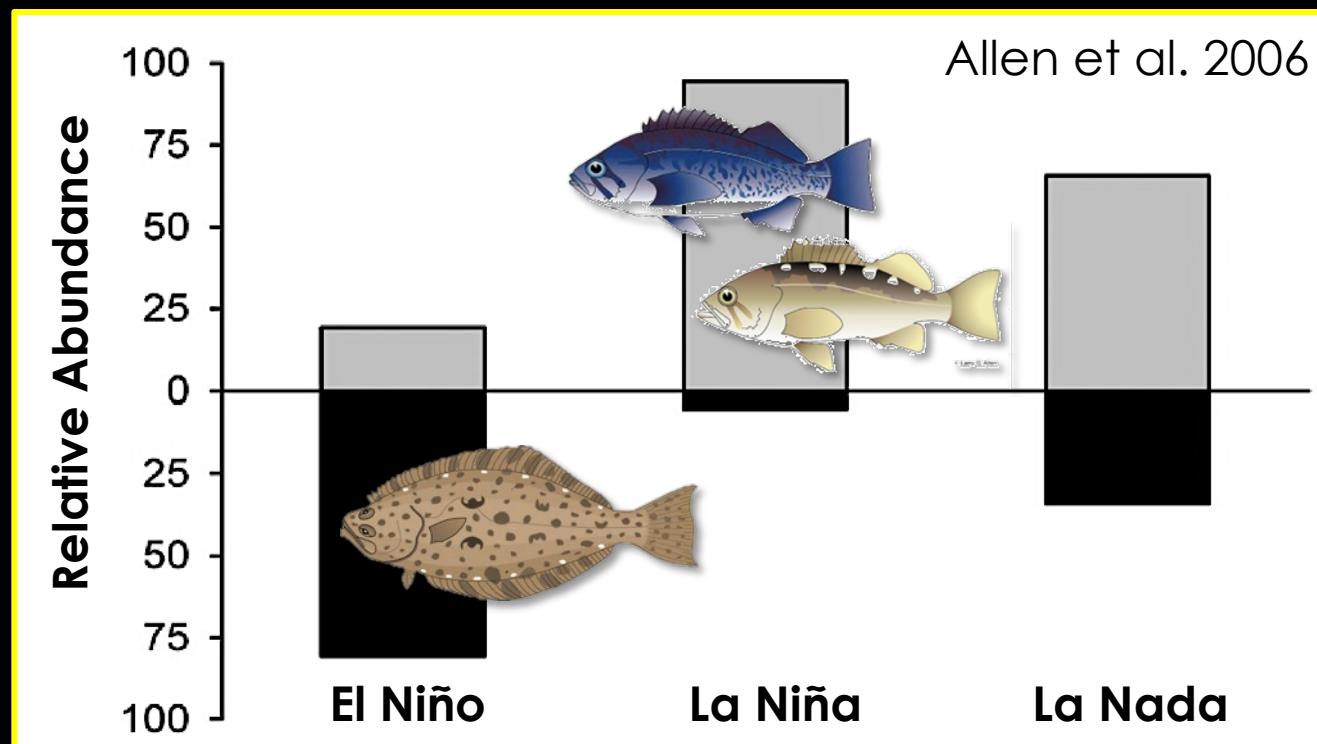
- spawning behavior
 - specific timing of events
 - environmental cues
- movement patterns and stock connectivity

Research Needs: Movement seasonal inshore / offshore migrations?



Research Needs: California Halibut

- continued catch curve analysis (esp. males)
 - distinguish natural vs. fishing mortality
- in-depth evaluations of recruitment



Acknowledgments

Thesis Committee

Rick Starr
Jim Harvey
Scott Hamilton
Paul Reilly

CA Department of Fish and Wildlife

Travis Tanaka
Kristine Lesyna
CDFW Port Samplers
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Ichthyology Lab
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James and Billy Cochran
Gary Adams
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Allen Bushnell
Andrew Harmer
David 'Shorty' Reins
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Chris Giordano
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Nikki Siababa
Aaron Sloan
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Will Fennie
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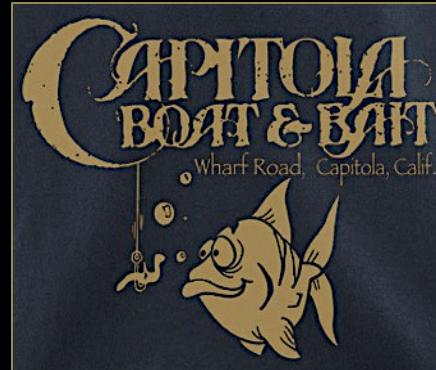
Additional Financial & Logistical Support



Graduate Equity Fellowship



C. F. and L. V. Burmahln Scholarship
Associated Students Advocacy Award



Dr. Earl M. Myers and Ethel M. Myers
Oceanographic and Marine Biology Trust



MLML Scholar Award
Xiphias Martin Scholarship

