

# Reproductive biology of California Halibut (*Paralichthys californicus*): results from the central coast

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## Introduction

In 2011, the California Department of Fish and Wildlife (CDFW) conducted its first stock assessment for California Halibut (*Paralichthys californicus*). However, data regarding the reproductive potential of this commercially- and recreationally-important species were spatially restrictive (i.e., obtained primarily from southern California) or non-existent.

In an effort to provide additional information for the next stock assessment (estimated to take place in 2016), we are evaluating the spawning activities of California Halibut along the central coast. Using existing model sensitivities, we plan to incorporate new fecundity data into Stock Synthesis, evaluate the revised results, and interpret their potential impact on management strategies.

## Results

All but five males (i.e., 97.9%) were spawning at the time of capture, whereas 19.9% of females possessed hydrated oocytes ready for release. The duration of the summer spawning season in both 2012 and 2013 was 75 d. Spawning frequency ranged from 3 d in 2012 to 7 d in 2013. GSI for both sexes was greatest in July and early August, displaying a peak in reproductive activity at that time. HSI reflected GSI for females, which utilize the liver in both somatic and reproductive processes. HSI fluctuated to a lesser extent and in opposition of GSI for males, which do not make use of the liver during reproduction, but instead trade off energy allocation between the two processes.

sex ratio	3 ♂ : 5 ♀
proportion of reproductive females	0.899
duration of summer spawning season	75 d
spawning frequency	4.5 d
batch fecundity	TBD

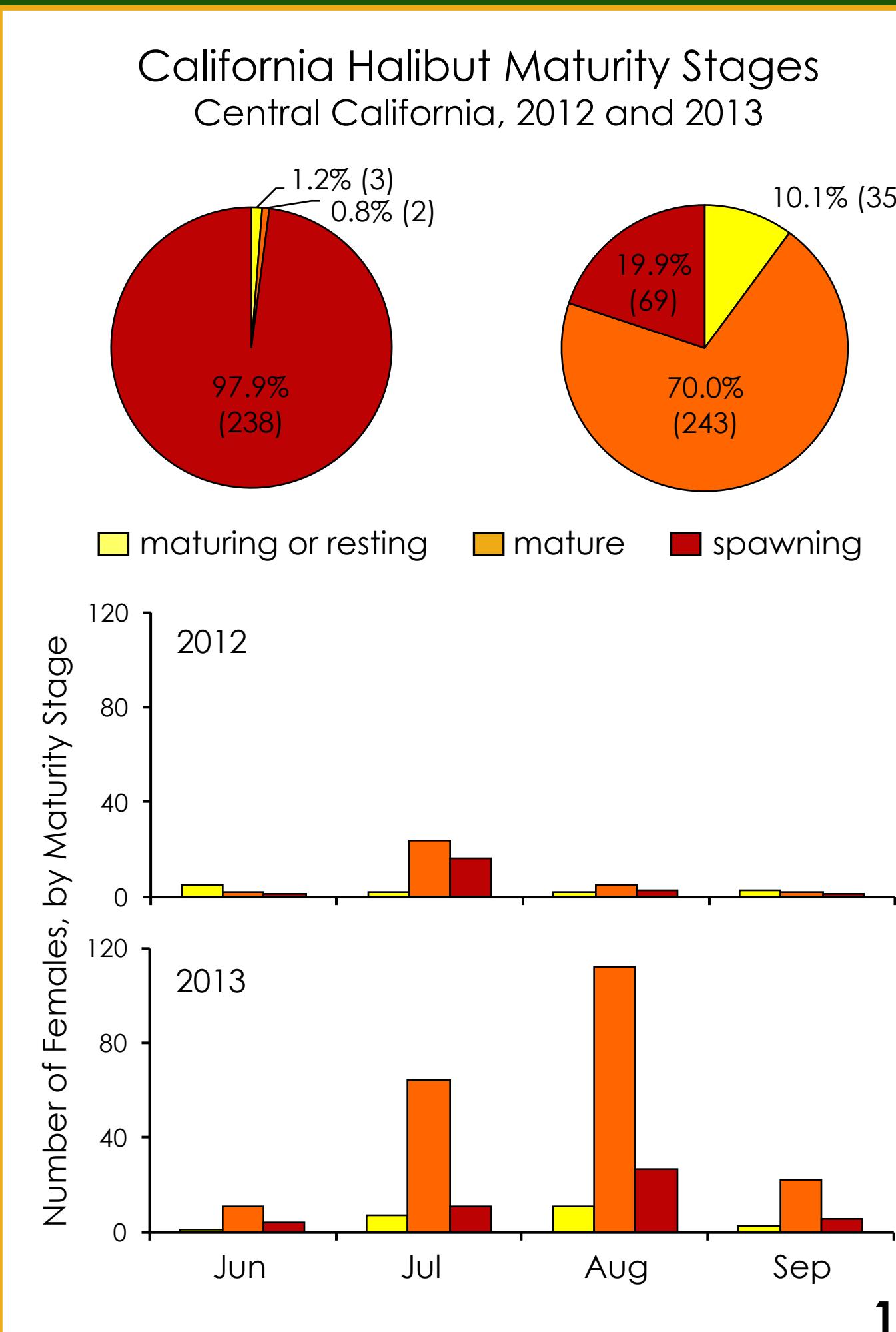
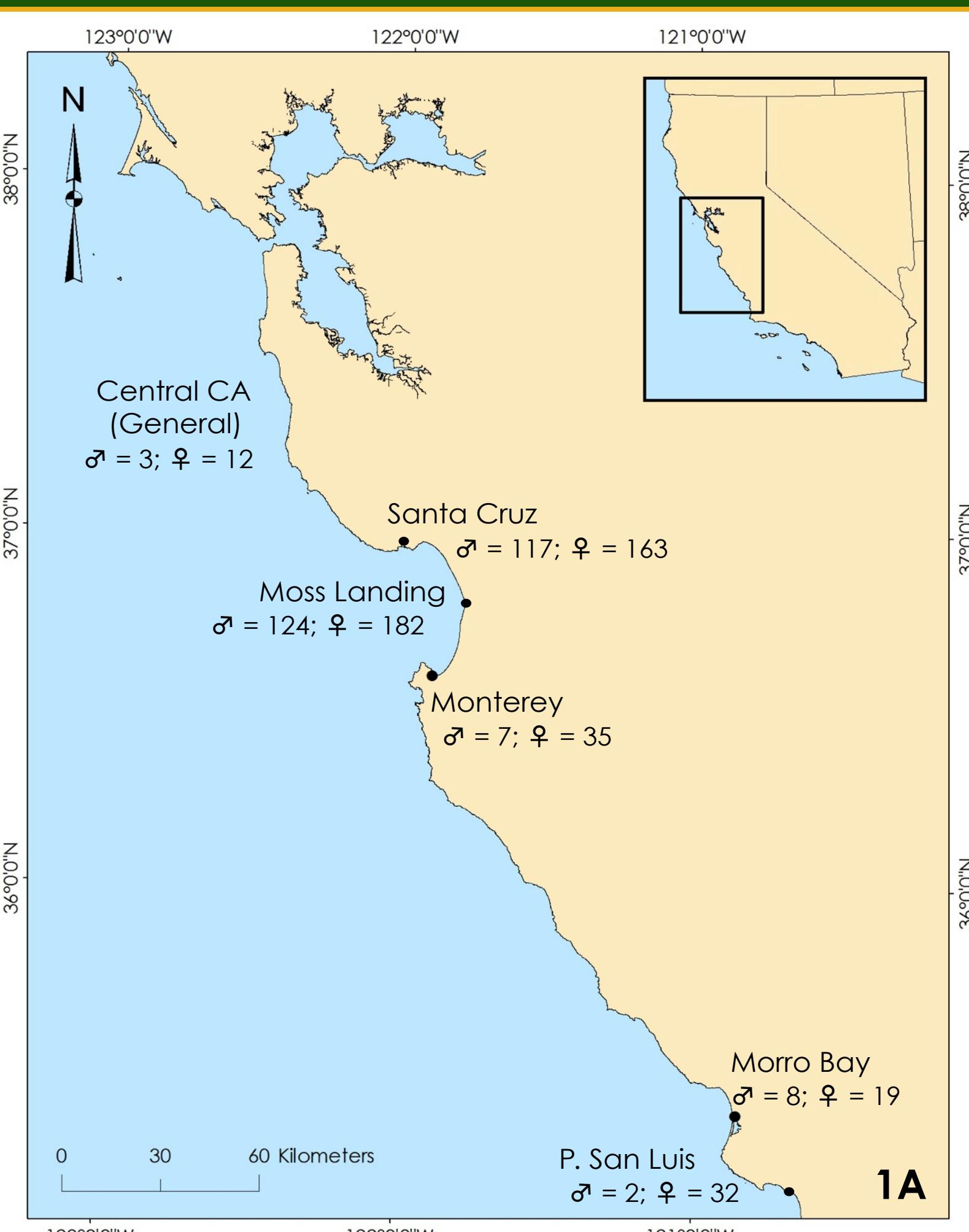


Figure 1

- map of study area; sample sizes listed by sex (♂: male, ♀: female) and site
- maturity stage proportions by sex (upper) and number of females sampled by month and maturity stage (lower)
- participating anglers showcasing their catches at Moss Landing Harbor prior to donating filleted carcasses
- California Halibut dissection to remove, weigh, and preserve internal organs (photo credit: Paul Muehlenbeck)

## Methods

In 2012 and 2013, 704 California Halibut (261 males and 443 females) were collected from recreational anglers, commercial hook-and-line fishermen, SCUBA divers, and seafood processors throughout central California.

Specimens were measured, weighed, and sexed. Sagittal otoliths were retained to construct age-composition information. Where possible, maturity stages were assigned macroscopically and ovaries were preserved to estimate batch fecundity. Gonads and livers were weighed to calculate gonadosomatic (GSI) and hepatosomatic (HSI) indices for evaluating temporal variation in energy allocation. The biweekly fraction of spawning females was used as a proxy for spawning frequency. The start and end of a particular spawning season was determined by the first and last occurrence of spawning females.

## Acknowledgments

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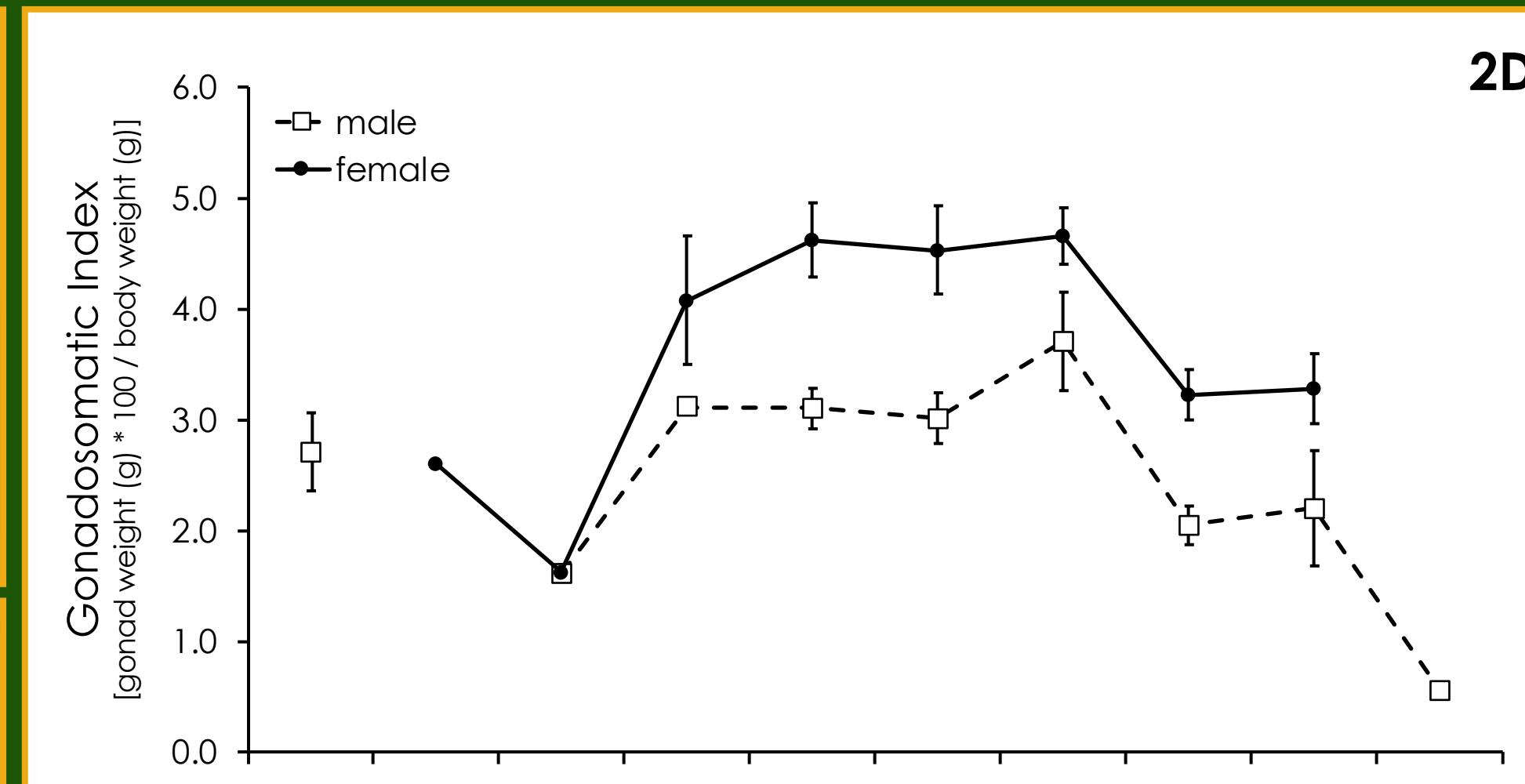
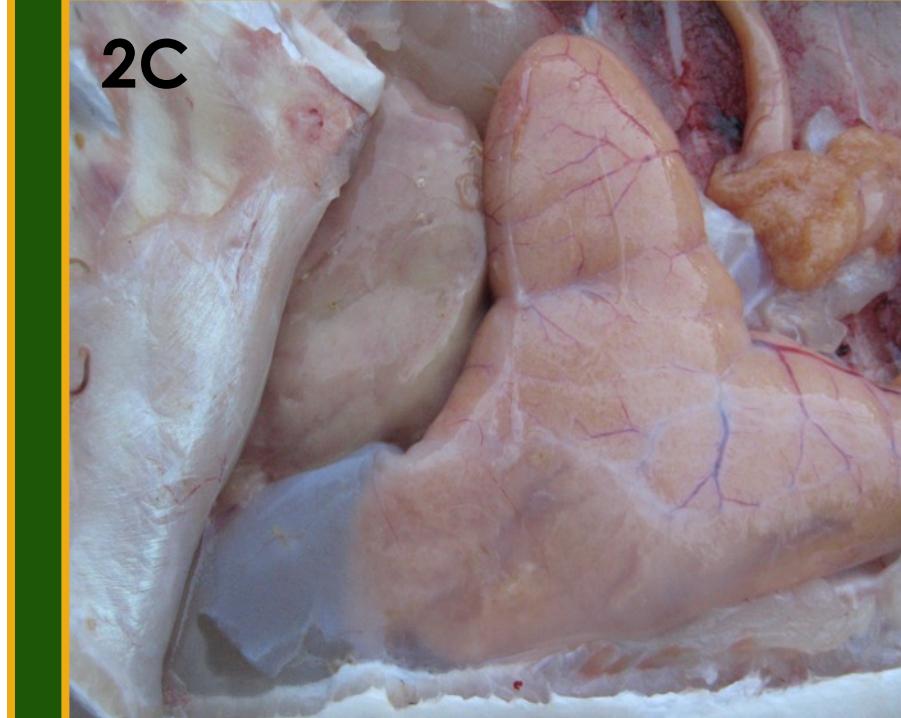
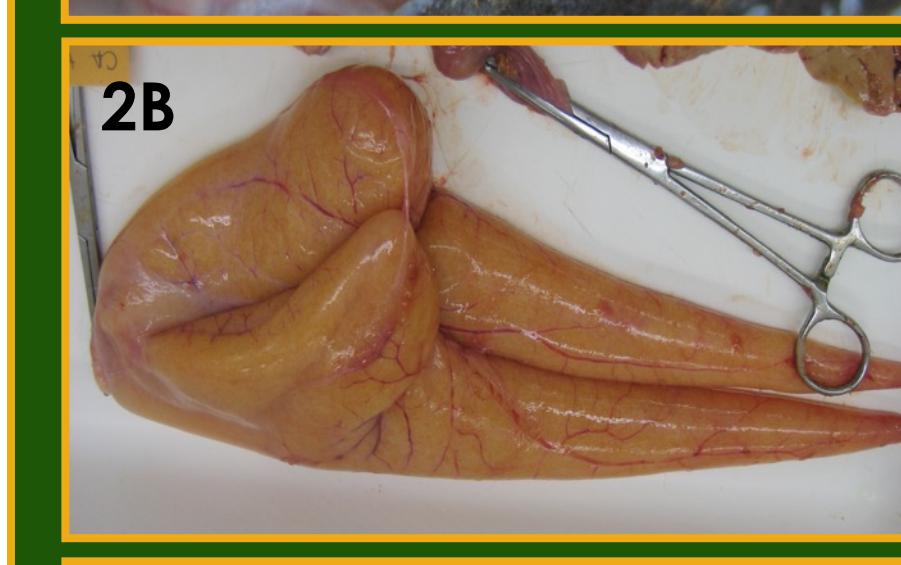


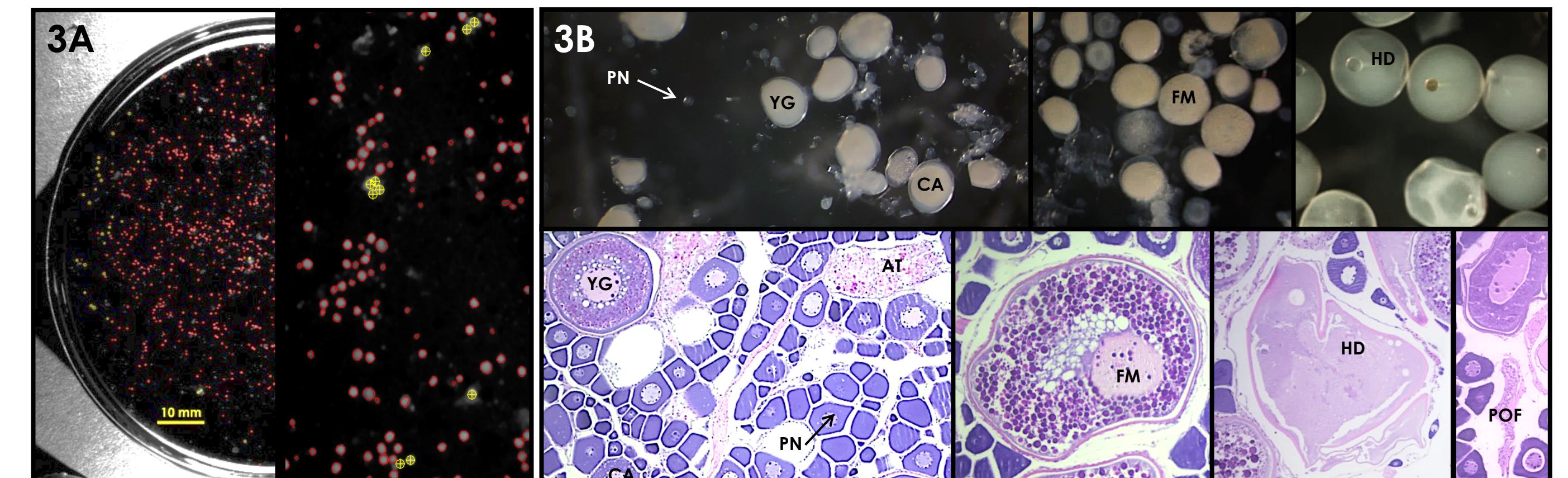
Figure 2

- maturing or resting ovary exhibiting light blood vessels and oocytes invisible to the naked eye
- mature ovary with dark blood vessels and yolked, non-hydrated oocytes visible to the naked eye
- spawning ovary with hydrated eggs anteriorly present and distinguishable from non-hydrated oocytes
- mean GSI (upper) and HSI (lower) for mature females and spawning males in 2013, by month \*

\* error bars denote one standard error above and below the mean

## Future Directions

Batch fecundity will be estimated by combining stereological, autodiametric<sup>1,2</sup>, and gravimetric<sup>3</sup> techniques. Histology will also be employed to evaluate macroscopic maturity stage assignments and to estimate rates of atresia. Sex ratio, proportion of reproductive females, duration of the summer spawning season, spawning frequency, batch fecundity, and rates of atresia will then be combined to provide an approximation of realized annual fecundity.



Given that 2012 and 2013 resulted in different spawning patterns (e.g., spawning frequency), intra-annual growth will be measured from thin-sectioned otoliths and analyzed along with environmental data (e.g., temperature, photoperiod) to gain insight into how California Halibut life history parameters respond to exogenous factors. Finally, synthesized data will be made available for incorporation into the California Halibut fishery management plan and future stock assessments.

## Selected References

- Kurita and Kjesbu 2009
- Korta et al. 2010 / Thorsen and Kjesbu 2001
- Hunter and Goldberg 1980

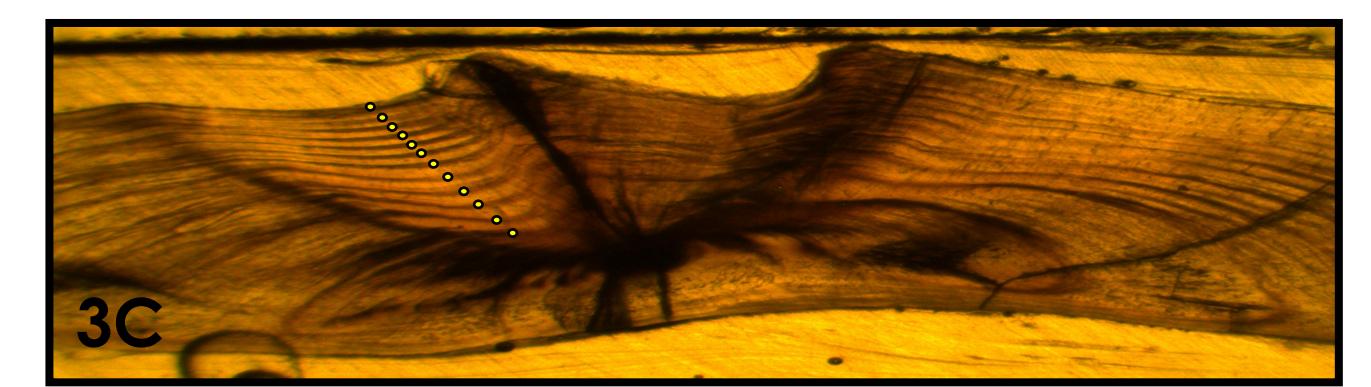


Figure 3

- digitally processed images of California Halibut oocytes (25% zoom - left; 100% zoom - right); red outlines indicate automated measurements; yellow cross-hairs denote manual additions (for use in counts only)
- whole-mount (upper: 25x) and histological (lower: 100x) images of oocyte developmental stages  
PN: perinuclear, CA: cortical alveoli, YG: yolk granule, FM: final maturation, HD: hydrated, AT: atretic,  
POF: postovulatory follicle (histological slides provided by Kristine Lesyna, CDFW)
- thin-sectioned otolith; circles depict individual annuli (photo credit: Travis Tanaka, CDFW)