Linking climate variability to rockfish recruitment.

Pacific ocean perch in the Queen Charlotte Sound as a case study.

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Effects of Climate Change on the World's Oceans, March 2015

Context and objectives

Context

- Stock assessment
- Global change
- Ecosystem approach to management

Objectives

- Identify association between climate and recruitment
- Developing quantitative tools
- Incorporate tools to the Ecosystem approach to management

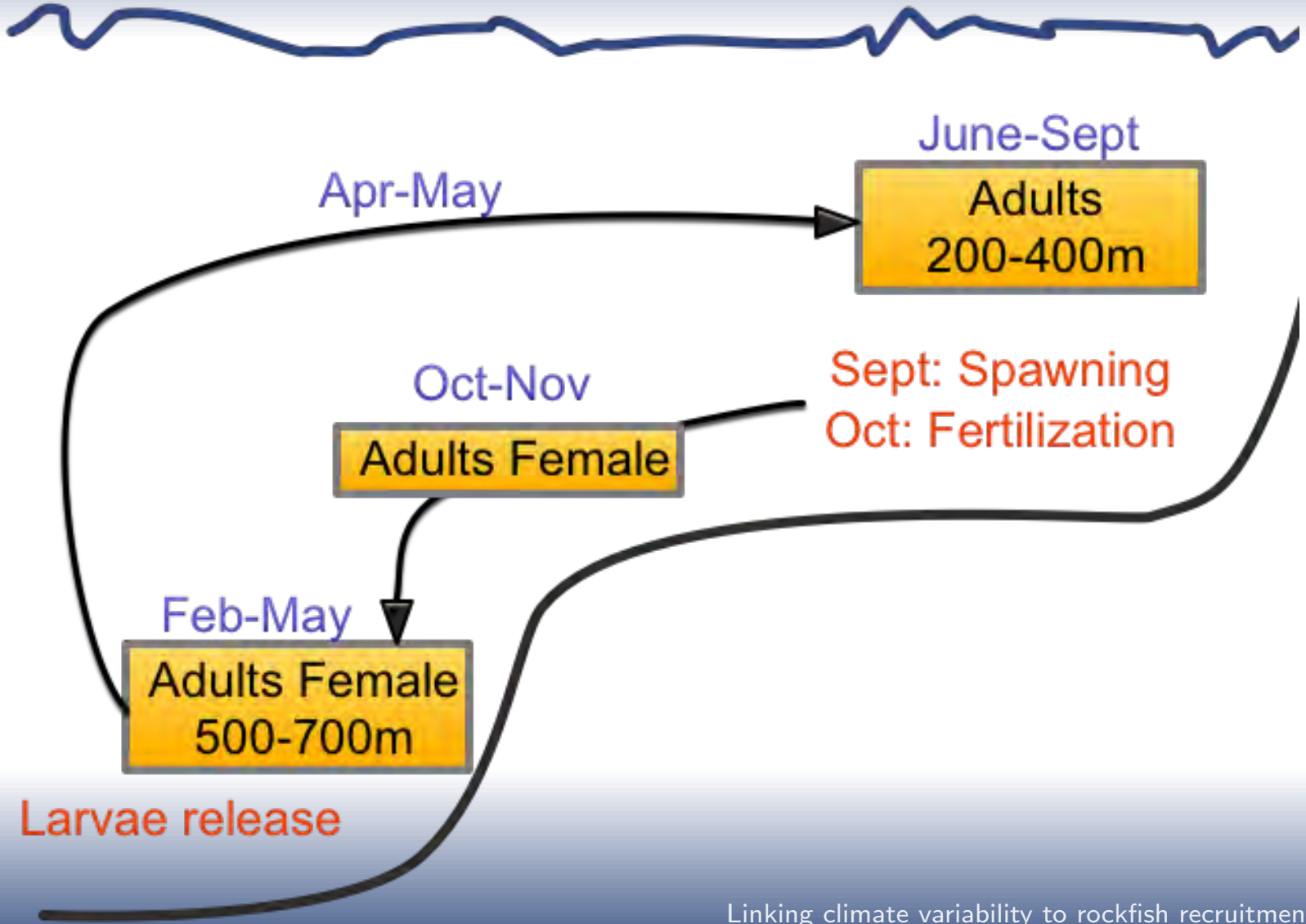
Fisheries and Oceans Canada

CRSNG NSERC

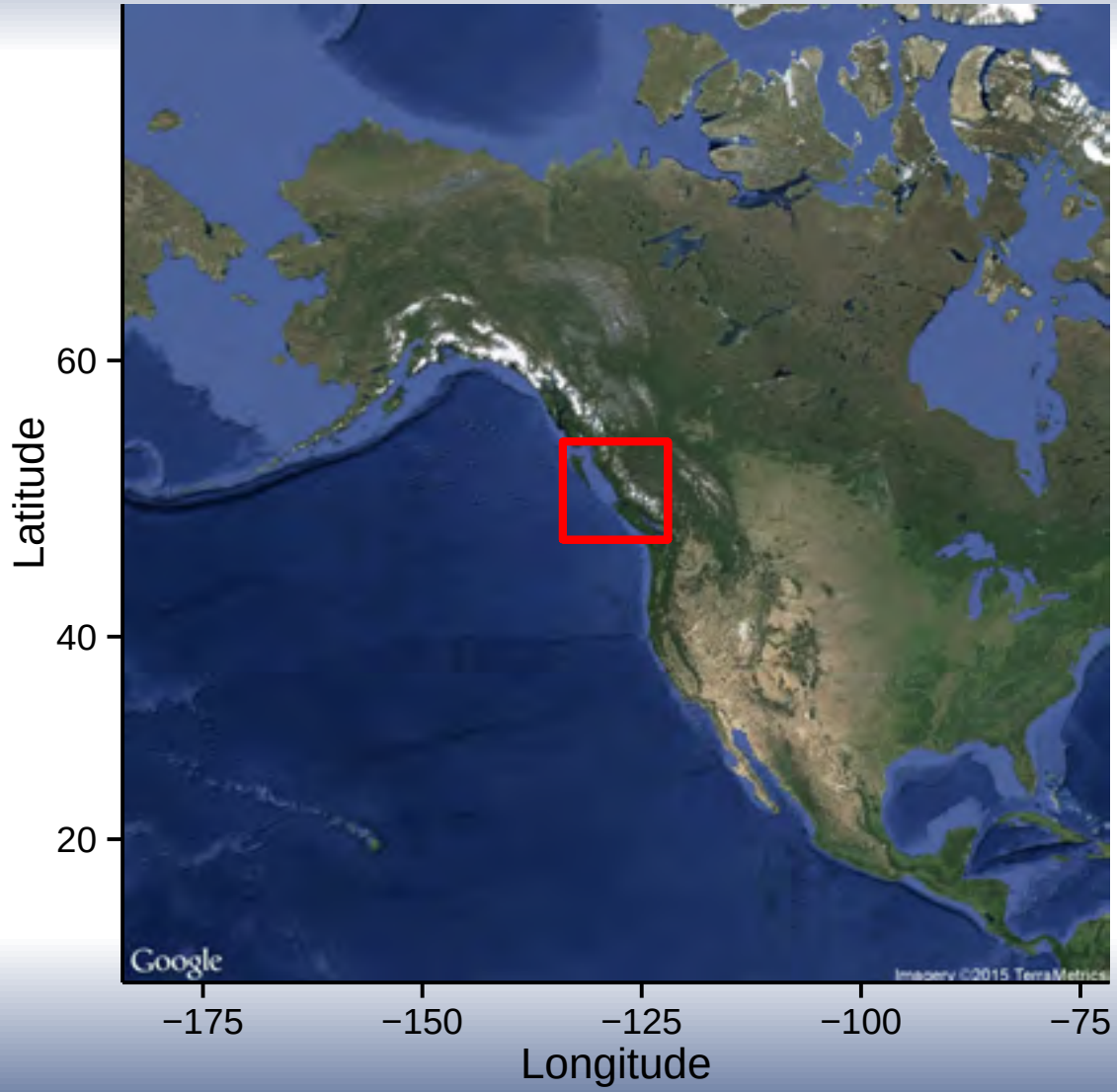
Pacific Ocean Perch

- most abundant rockfish species on Canada's west coast
- coast-wide landed value of $4.4 million per year
- females up to maximum 1.8kg, 48cm, males 1.4kg, 44cm
- two specimens >100 years old

Reproduction



Study area


Latitude
60
40
20
−175
−150
−125
−100
−75
Longitude
Google
Imagery ©2015 TerraMetrics

Study area

Dixon Entrance
Learmonth Bank
Rose Spit
Brown Passage
Prince Rupert
Masset
Graham Island
Edye Pass
Skeena River
Kitimat River Estuary
Kitimat Arm
British
Columbia
Queen Charlotte City
Moresby Island
Queen Charlotte Islands
Hecate Strait
Princess Royal Channel
Hakuchi Narrows
Spiller Inlet
Cousins Inlet
Dean Channel
Bella Coola River Estuary
Bella Coola
North Bentinck Arm
South Bentinck Arm
McInnes Island
Roache Inlet
Ocean Falls
Bella Bella
Fisher Channel
Burke Channel
Moses Inlet
Cape St. James
Queen
Hakai Passage
Calvert Island
Sea Otter Group
Fitz Hugh Sound
Rivers Inlet
Smith Inlet
Beltine Inlet
Alison Sound
Frederick Sound
Seymour Inlet
Broughton Archipelago
Knight Inlet
Pacific
Ocean
Cook Bank
Triangle Island
Scott Islands
Cape Scott
Queen Charlotte Strait
Port Hardy
Rupert Inlet
Quatsino Narrows
Call Inlet
Discovery Passage
Port Alice
Johnstone Strait
Vancouver
Island
Campbell River
Brooks Peninsula

A catch at age model

Inputs

- Commercial catch
- Biological data
- Ageing data:
  Capture high recruitment events

Bayesian catch-age model

Each year, fish:

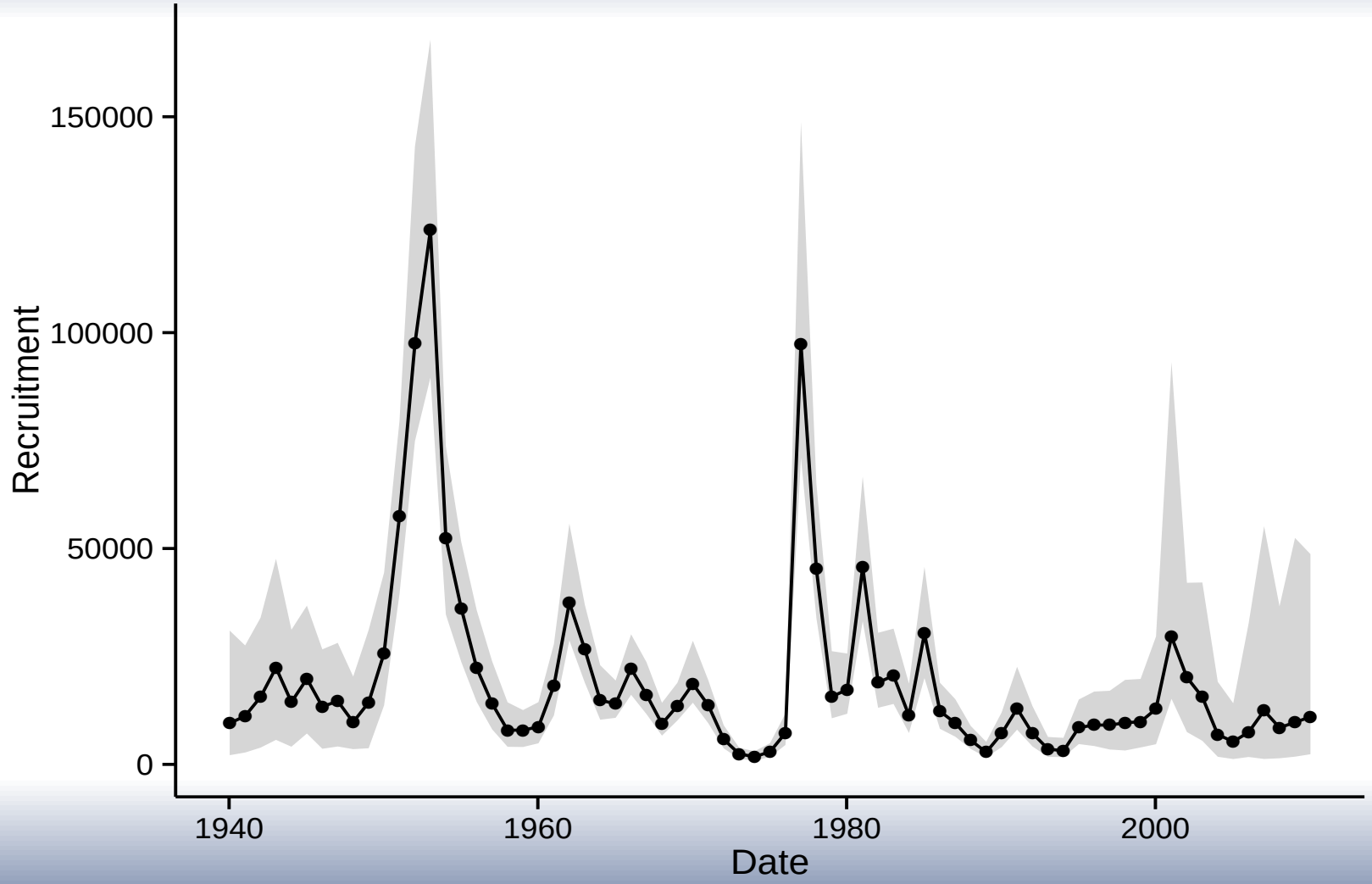
- die naturally
- are caught
- survive
- reproduce

- age classes 1 to 30+
- males and females
- starts in 1940
- 5 years projections

Outputs

- Estimated historical spawning biomass & recruitment
- Projections of future spawning biomass
- Probabilities of performance indicators for decision tables

Model outputs: Recruitment



Environmental linear effects

The log of the recruitment (R) at year t is normally distributed with mean μ_t and variance σ^2:

$$log(R_t) \sim Normal(\mu_t, \sigma^2)$$

$$\mu_t = \alpha + \beta * Covariate_{t-1}$$

- α intercept
- β environmental covariate effects
- Bayesian inference

Environmental non-linear effects

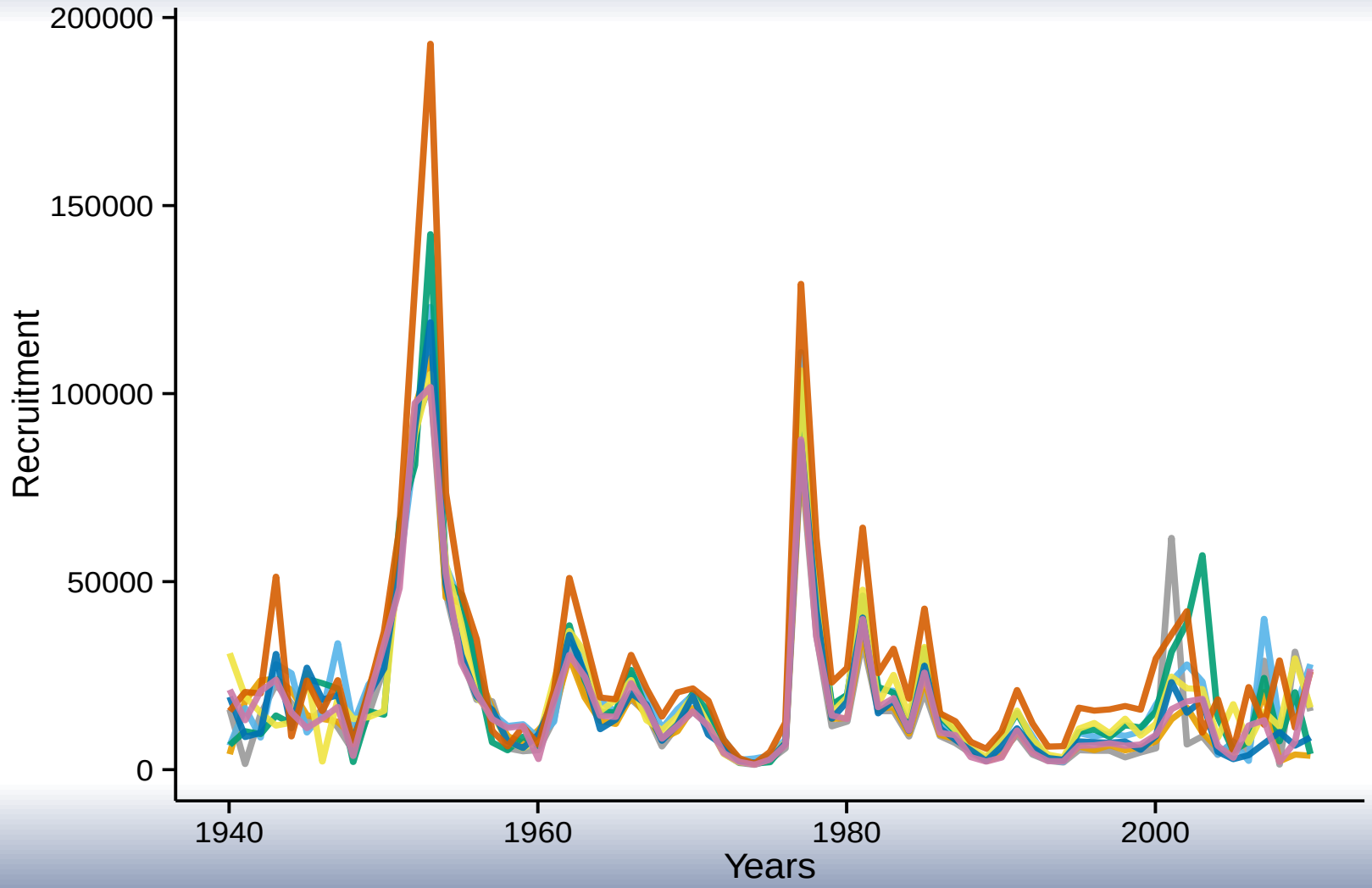
The log of the recruitment (R) at year t is normally distributed with mean μ_t and variance σ^2:

$$log(R_{i,t}) \sim Normal(\mu_{i,t}, \sigma^2)$$

$$\mu_{i,t} = \alpha + \beta_i * Covariate_{t-1}$$

- α intercept
- β_i covariate effect of class i
- $Covariate_{t-1}$ are split into classes $i = 1, ..., N$
- Bayesian inference

Bayesian approach accounts for uncertainty



Environmental variables available

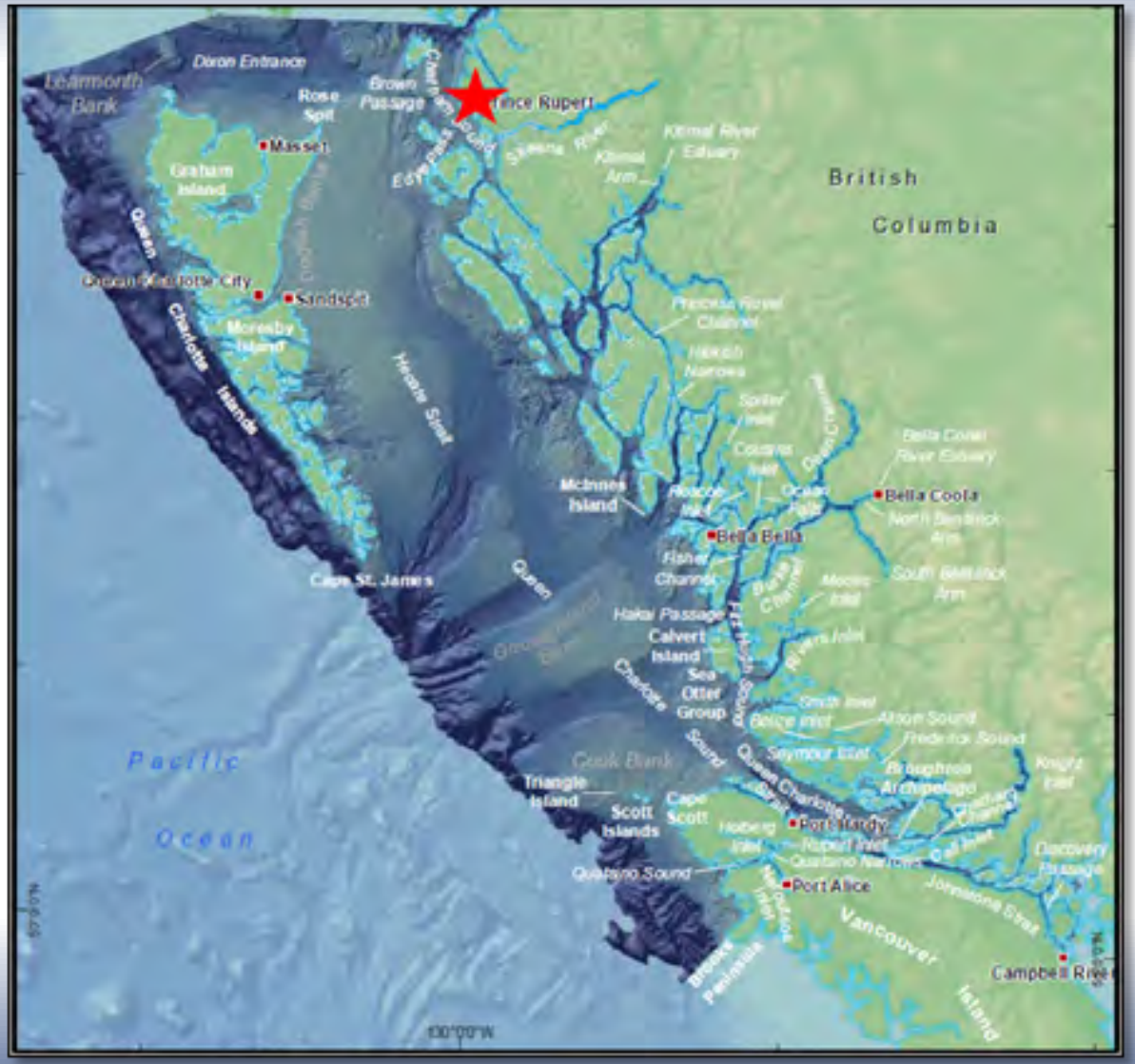
Regional variables:

- Sea level at Prince Rupert (BC): 1940-2010
- Haida eddies cover area: 1993-2010

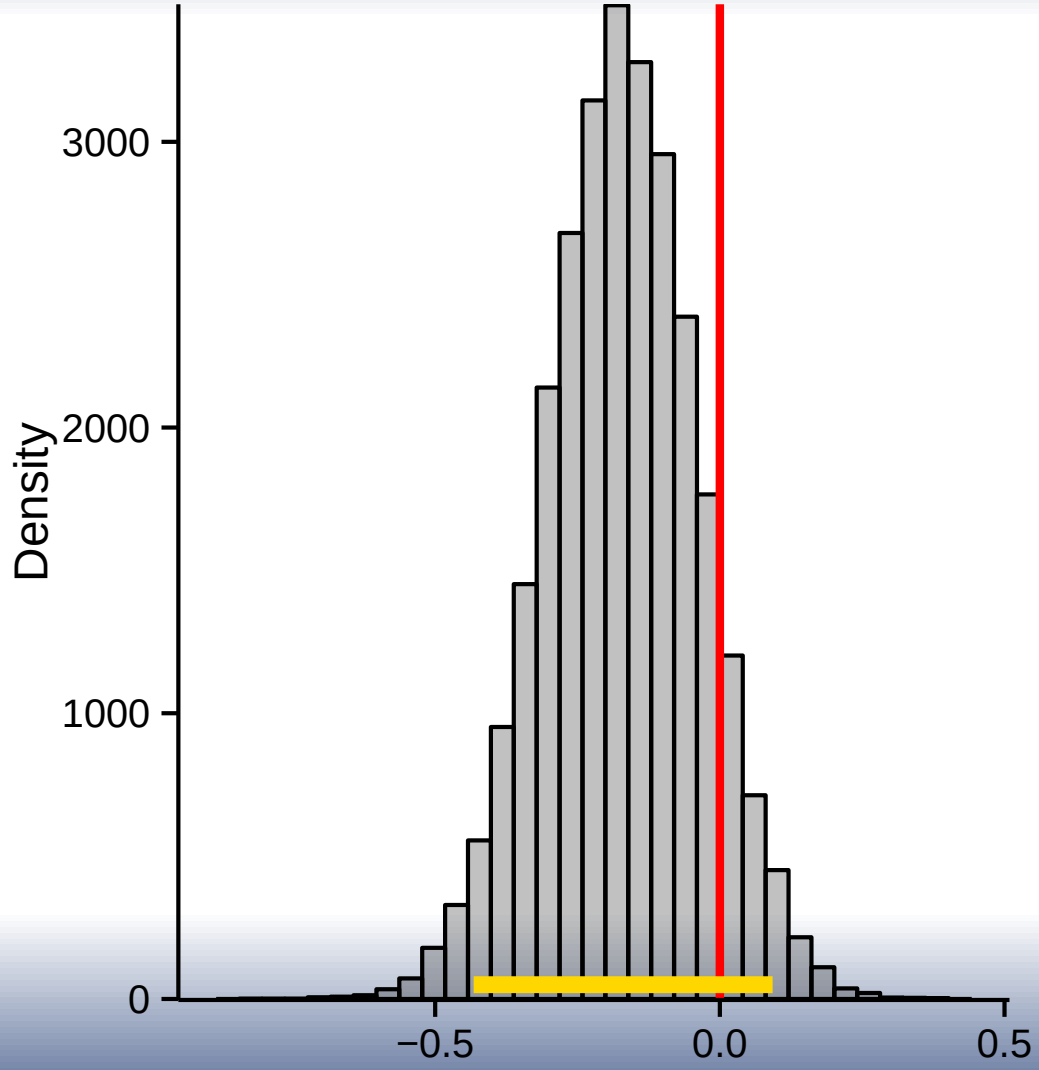
Large scale variables:

- East Pacific/North Pacific Oscillation: 1950-2010
- North Pacific Gyre Oscillation Index: 1950-2010
- Pacific Decadal Oscillation Index: 1950-2010

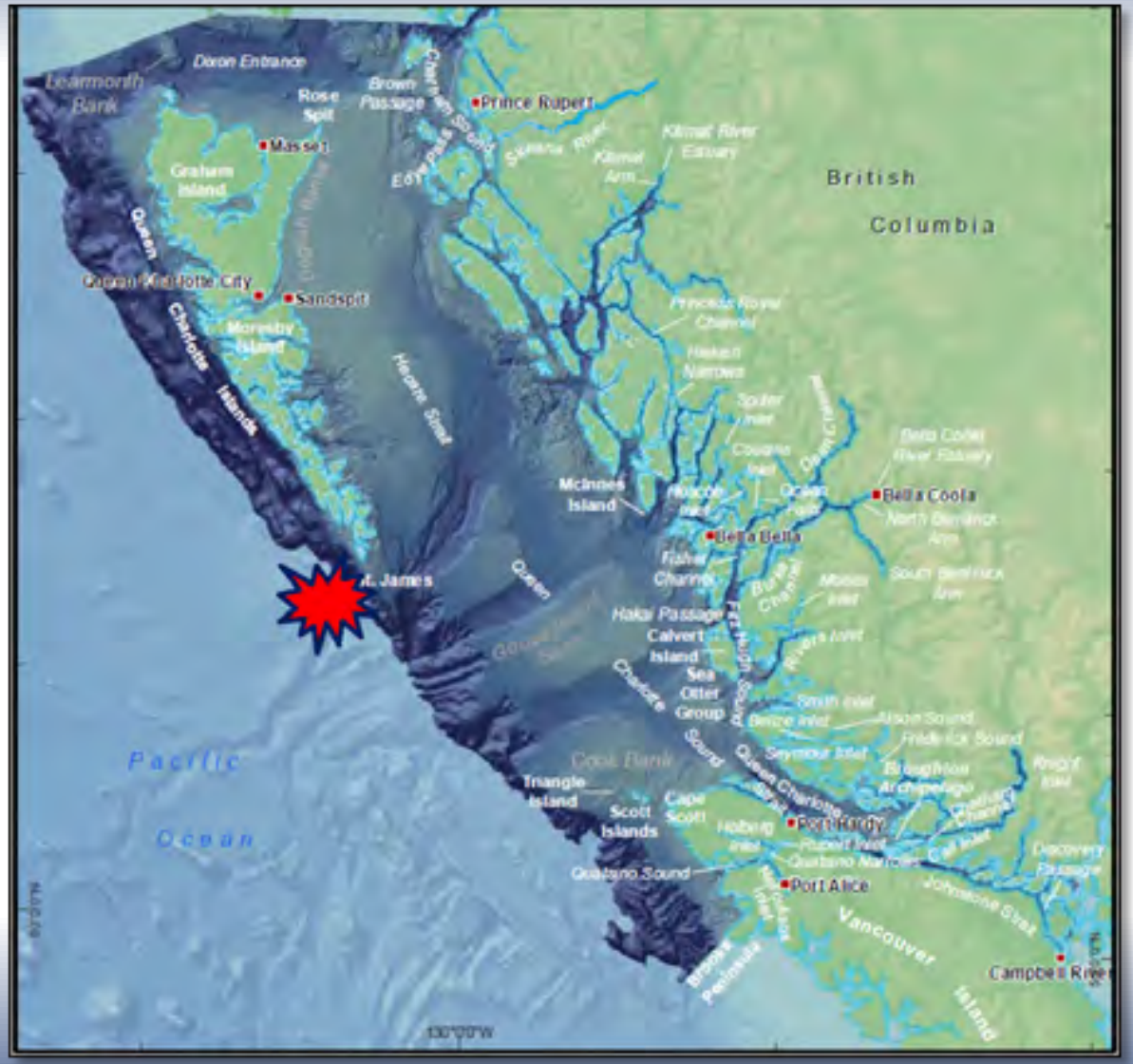
Sea level at Prince Rupert



Sea level at Prince Rupert



Location of Haida eddies



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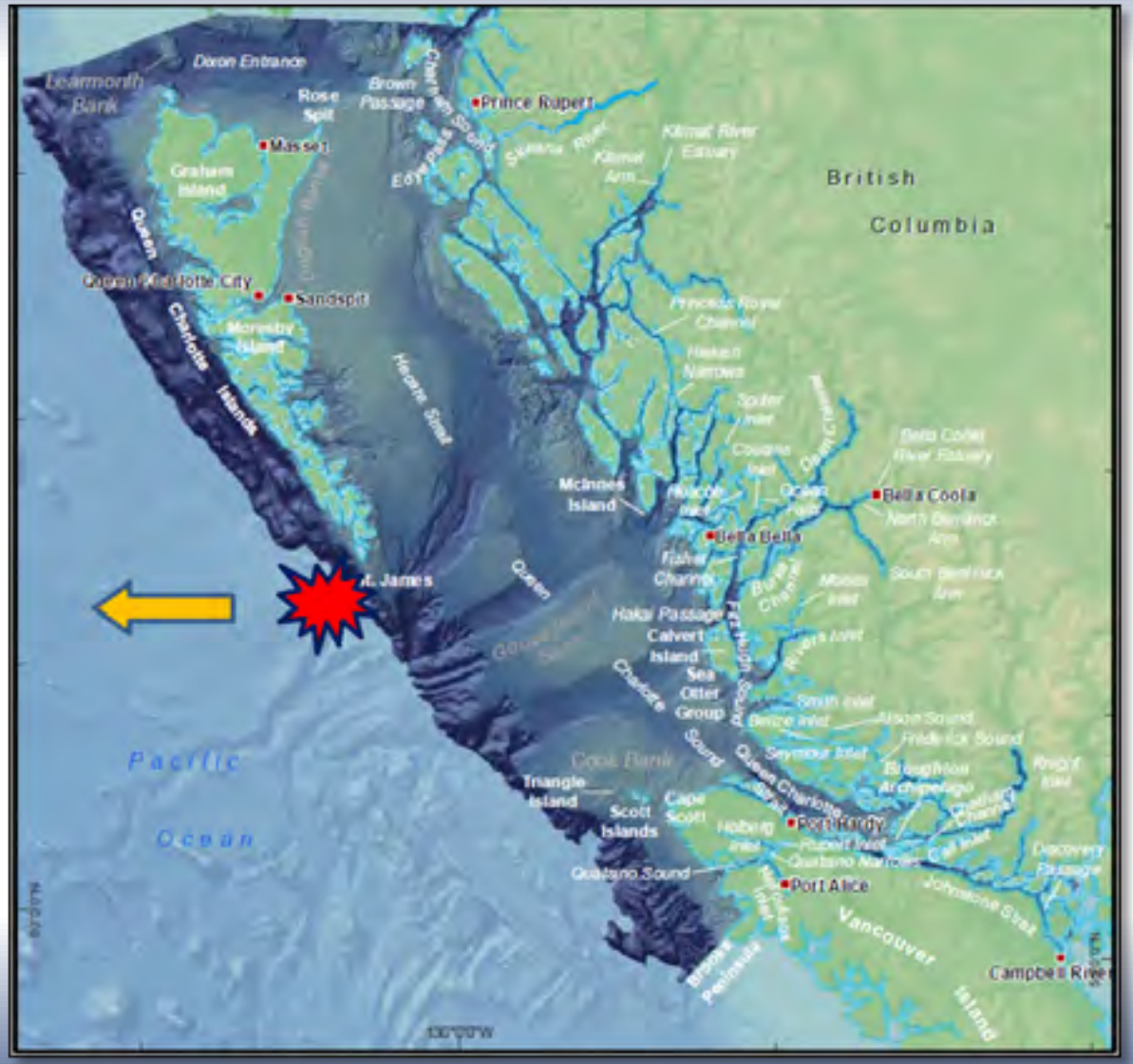
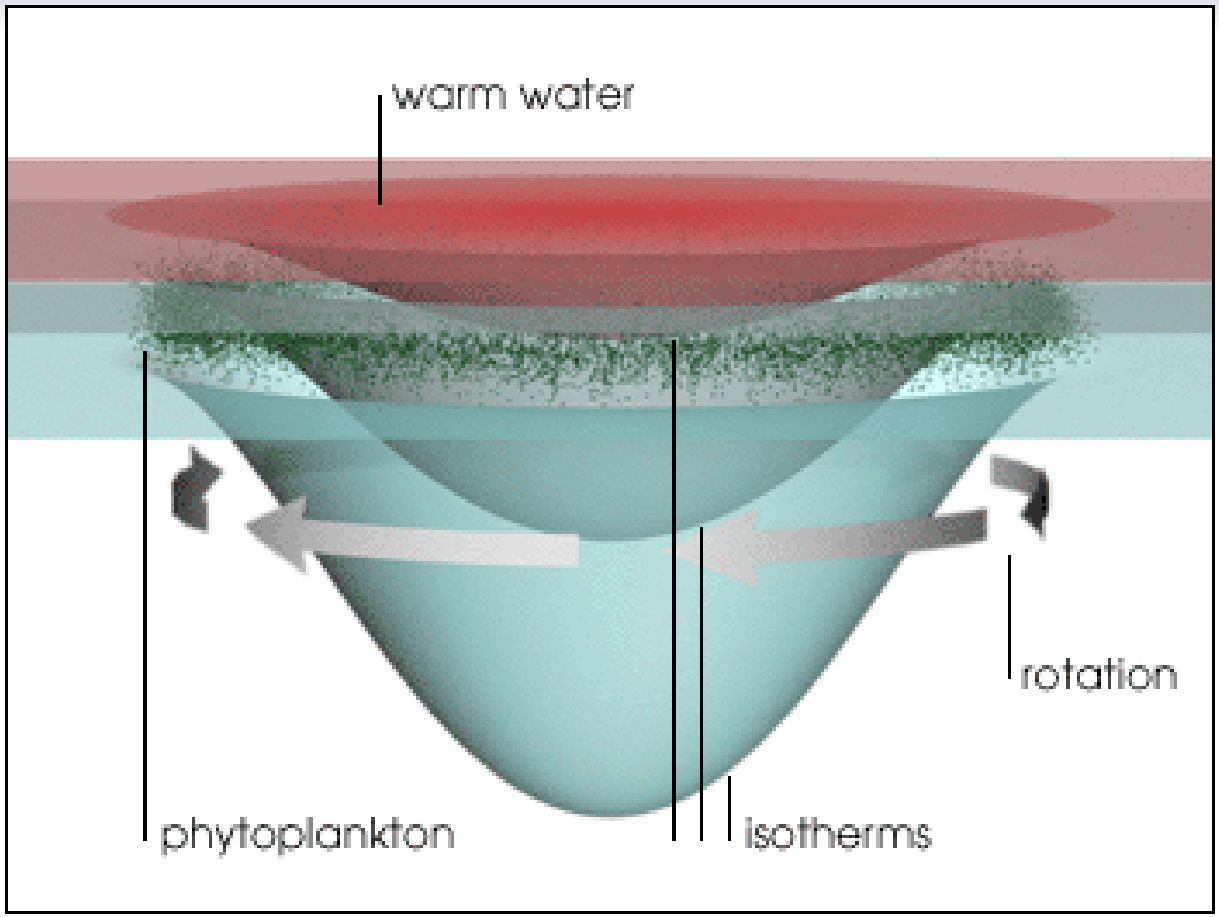


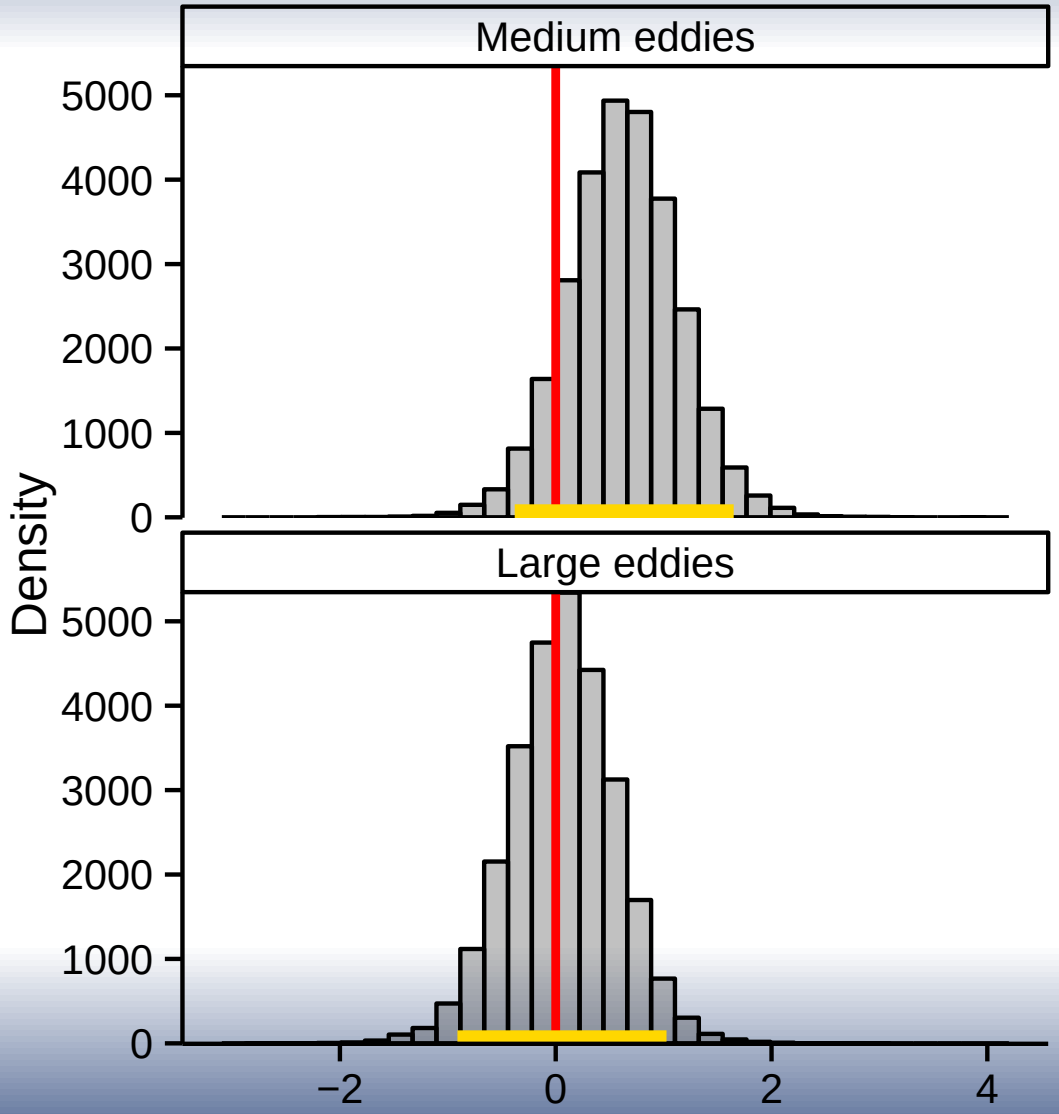
Structure of Haida eddies



Credit: *Robert Simmon*

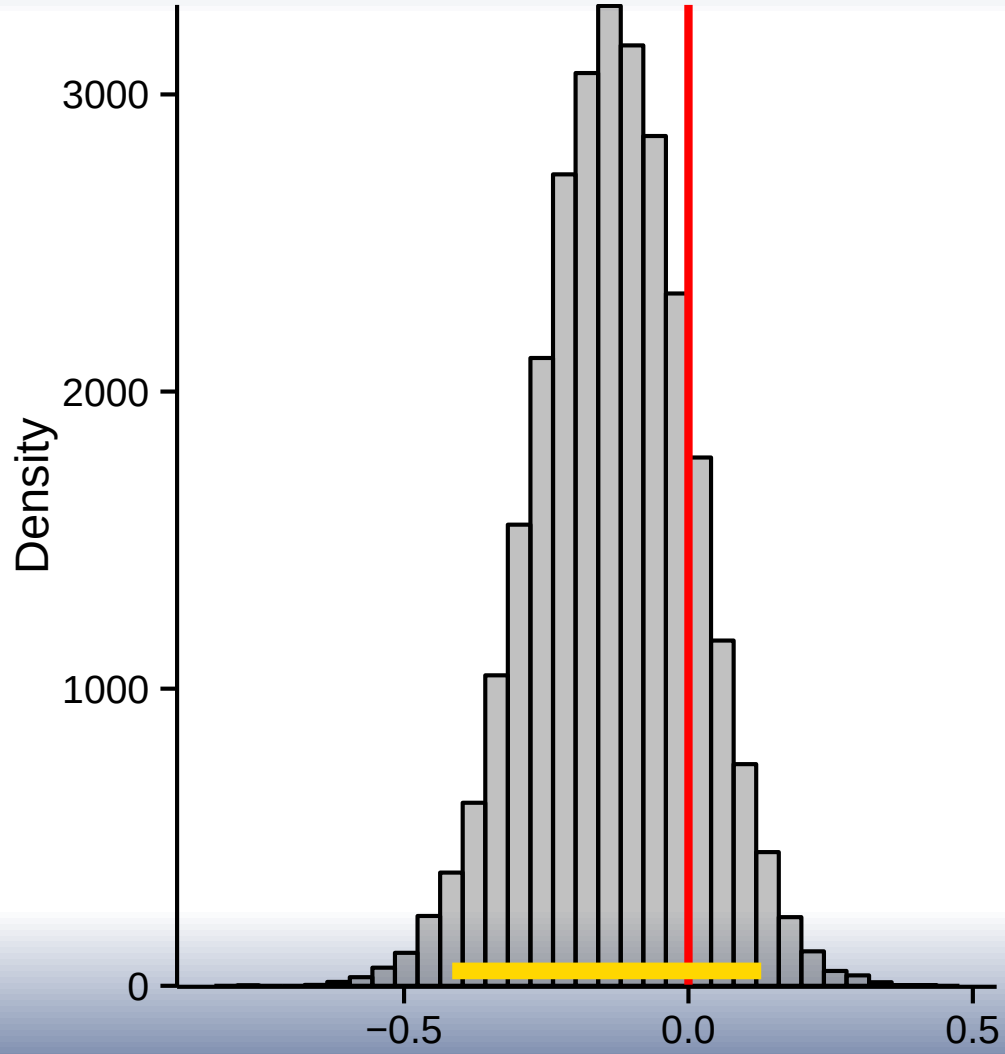
- Anticyclonic rotation
- $\sim 200km$ diameter
- Form in late winter

Non-linear effect of Haida eddies

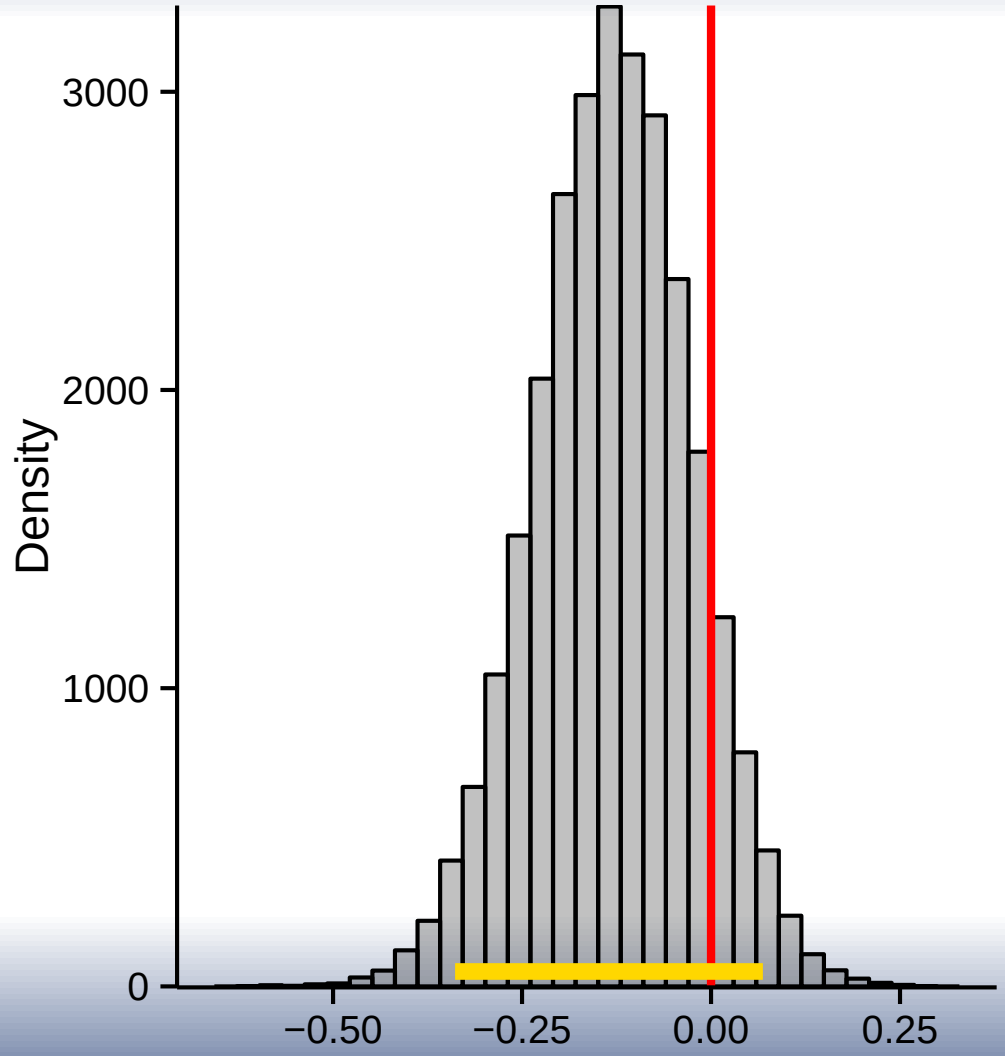


- No effect of the small eddies
- Positive effect of the medium eddies
- No effect of the large eddies

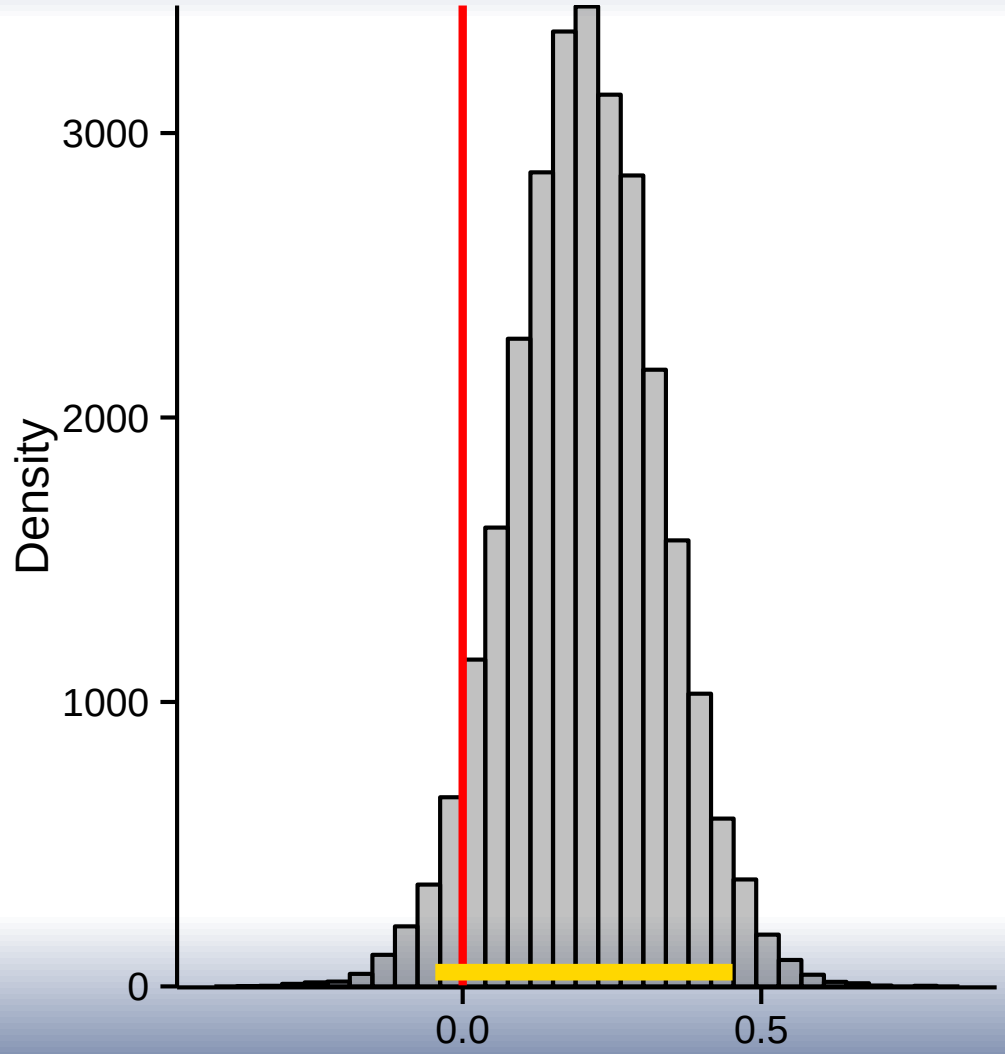
East Pacific/North Pacific Oscillation



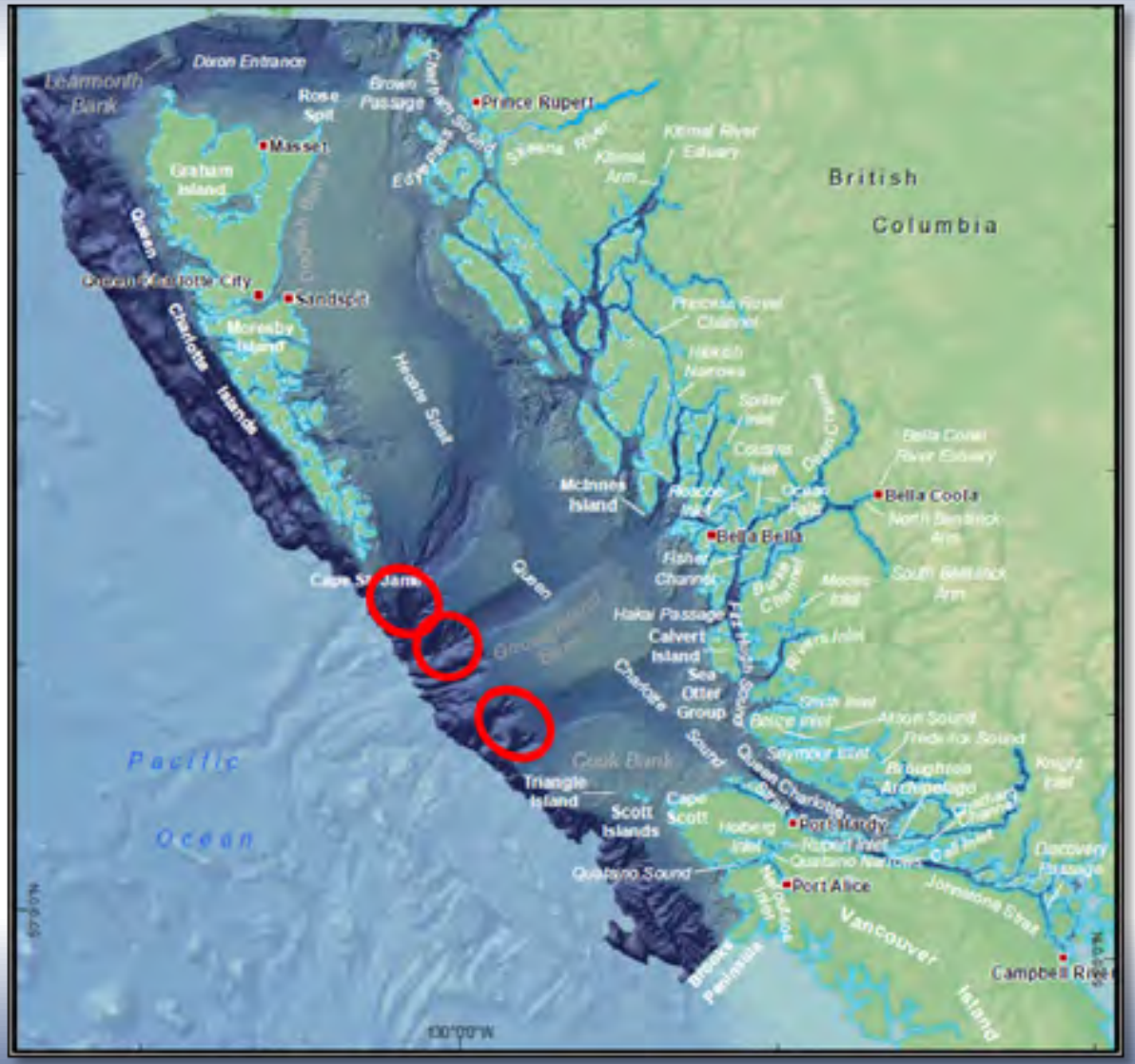
Pacific Decadal Oscillation Index



North Pacific Gyre Oscillation Index



Larvae release locations



Medium Haida eddies effect

Medium Haida eddies effect

Favorable conditions

EP/NP
Negative phase

NPGO
Positive phase

PDO
Negative phase

Main contributions

Bayesian approach:

- Used for explanatory analysis
- Flexible approach
- Fully account for uncertainty

Conceptual mechanism:

- Qualitative relations between environment and recruitment
- Regional and large scale environment variables

Perspective: Describe this conceptual mechanism in a Bayesian network to test climatic/global change scenario

Thank you for your attention.