Geographic and Ontogenetic Variation in the Trophic Ecology of Lingcod (*Ophiodon elongatus*) Along the U.S. West Coast

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Western Groundfish Conference 2023

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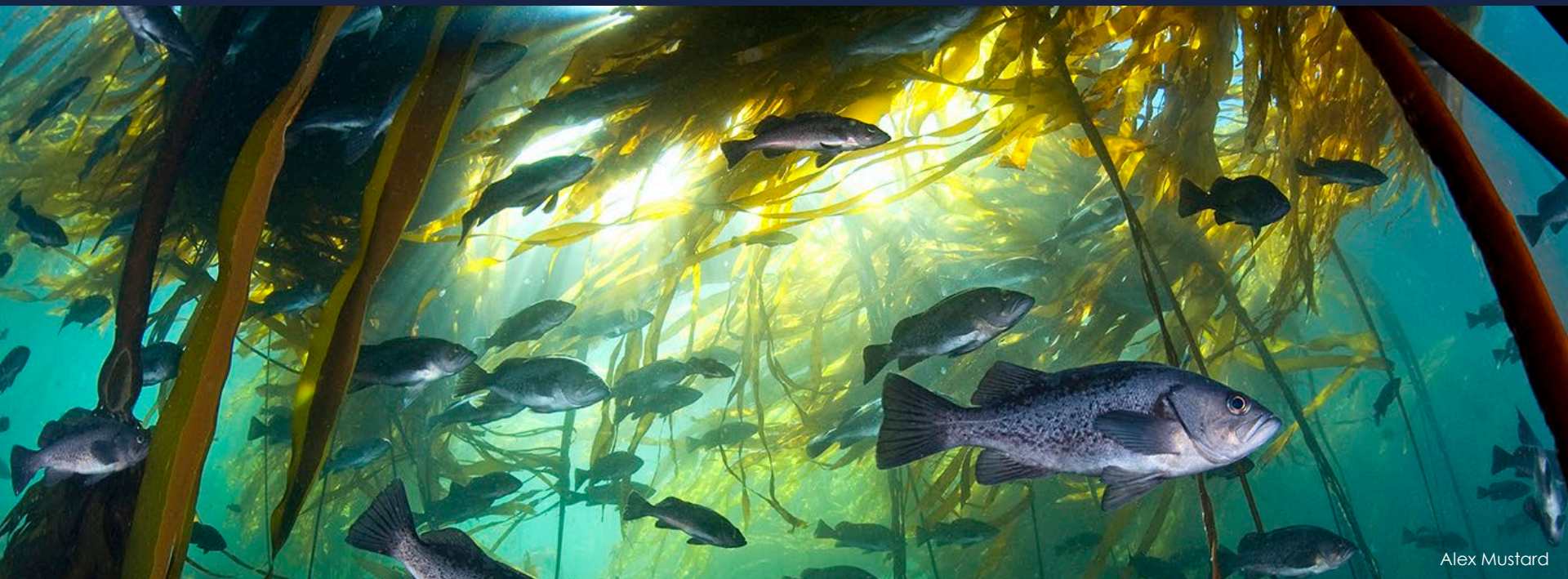
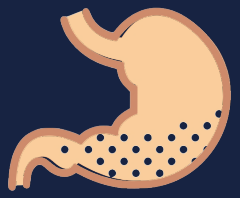
Why study diet? – It's important!

- Provide a better understanding of predator-prey interactions
  - levels of connectivity
  - prey distributions
- Fill in data gaps on food webs
- Valuable in Ecosystem-Based Fisheries Management (EBFM)

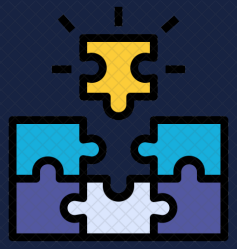


How is diet assessed?



- Gut Content Analysis
  - identify/enumerate prey items found in stomach
  - "snapshot"

- Stable Isotope Analysis
  - analyze a tissue sample
    - ^{13}C (source of primary production)
    - ^{15}N (trophic level)
  - long-term, integrated



- Complementary methods

Images: shareicon.net, cleanpng.com, iconscout.com

Lingcod

* ecologically & economically important
* quick to mature and grow
* sexually dimorphic
* ontogenetic shifts

wikipedia

Results from previous lingcod diet studies:

Washington

Beaudreau & Essington 2007

Rockfishes, sculpins, greenlings, Pacific sand lance

Oregon

Tinus 2012

Pacific herring, Pacific sand lance, shrimps, octopuses

California

Anderson 2016

Octopuses, rockfishes, anchovies, flatfishes

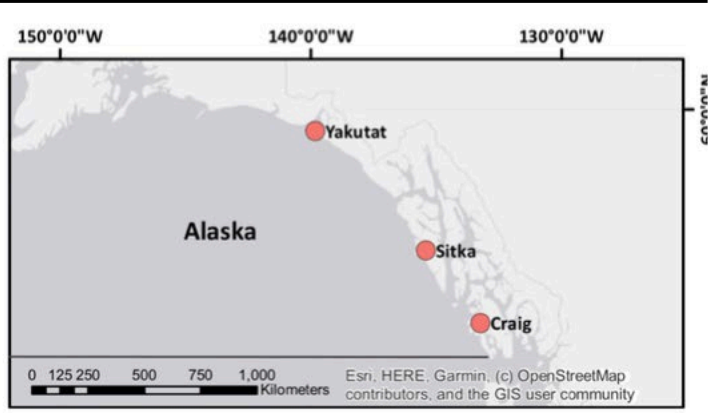
Images: WDFW, inlandseafood.com, alchetron.com

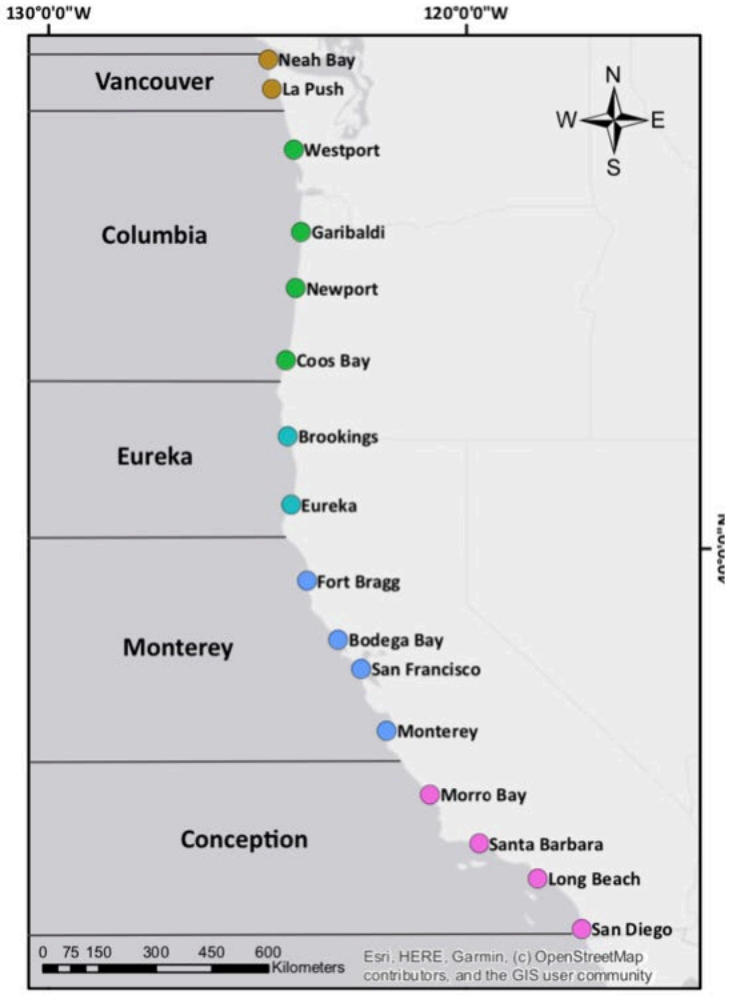
Could other factors be attributing to differences in lingcod diets?

* Location
* Sex
* Size (i.e. length)
* Environmental factors (i.e. depth)

Field Methods

- Summer 2016, May 2017
- 19 ports, 6 regions
- Hook & Line
- Party Boats (CPFVs)
- Goal: 100 Lingcod/port





Dissections
&
Lab Work

Dietary Metrics

* %N – abundance by number
* %W – abundance by weight
* %PN – prey-specific abundance by number
* %PW – prey-specific abundance by weight
* %O – frequency of occurrence
* %PSIRI – prey-specific index of relative importance

Results – collections & gut contents

Region	Total # of Stomachs	# of Stomachs for Analysis
Alaska	196	140
Vancouver	197	160
Columbia	427	323
Eureka	201	158
Monterey	541	239
Conception	387	238
All Regions	1,949	1,258

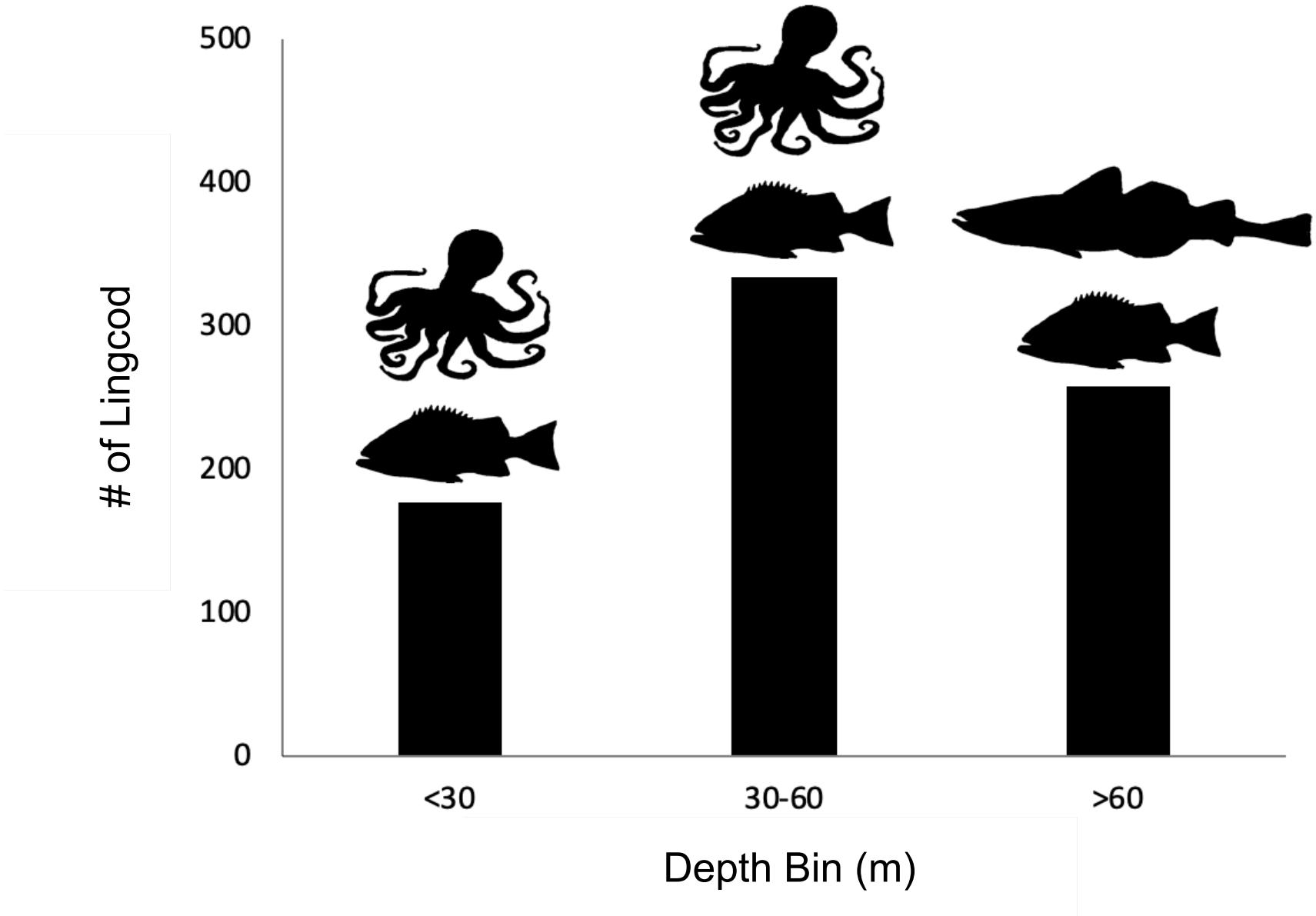
Describing diet using %PSIRI

- Unidentified Teleostei
- Cephalopoda
- Scorpaenidae
- Gadiformes
- Crustacea & Gastropoda
- Demersal Fishes
- Semi-Pelagic Fishes
- Pleuronectiformes

Gut Content Analysis: PERMANOVA highlights depth, region, sex

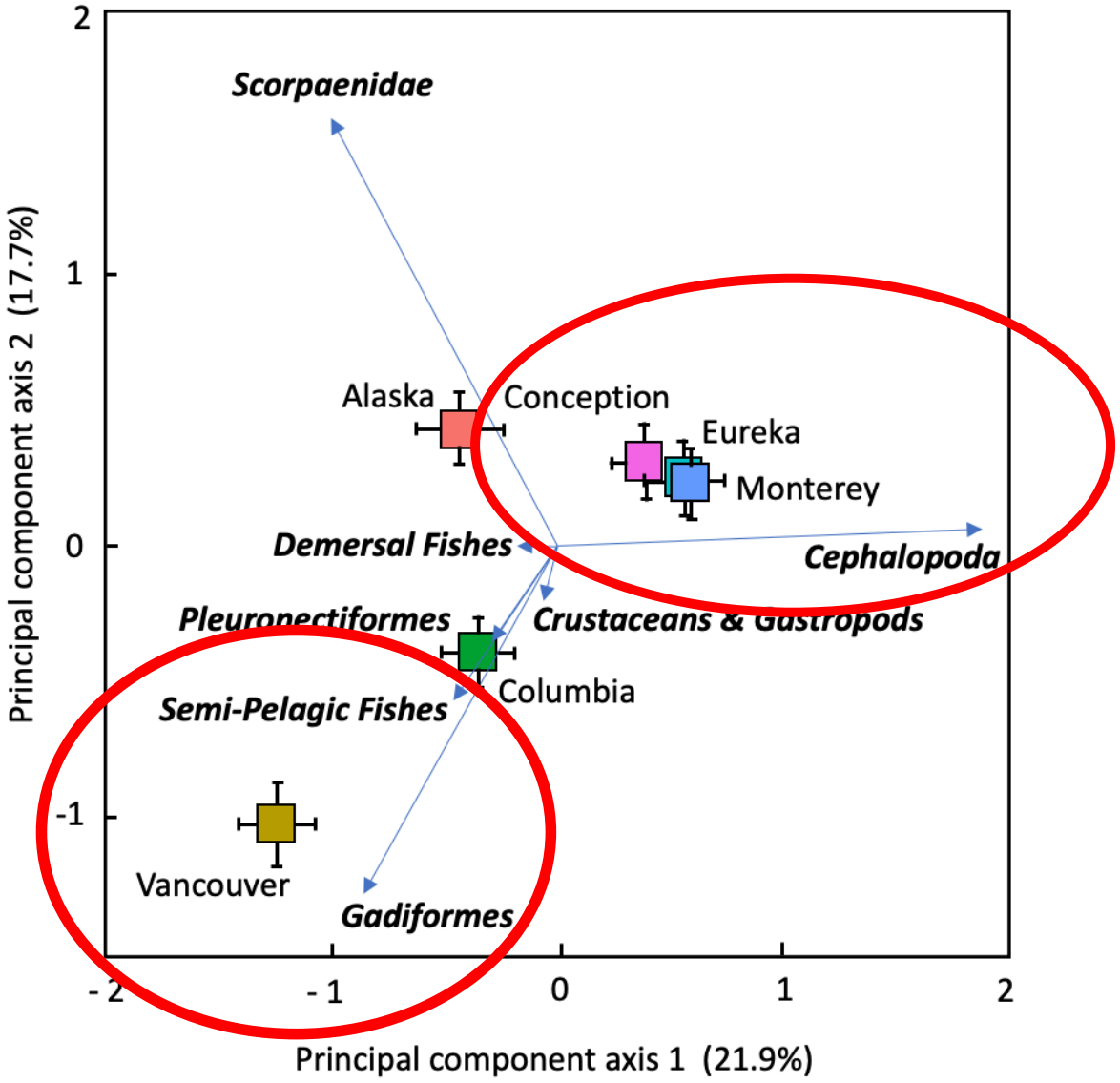
Model	Variable	df	*p*- value
7 Prey Groups	Depth	1	**0.0001**
	Region	5	**0.0001**
	Sex	1	**0.0123**
	Depth x Region	5	**0.0001**
	Residuals	754	

Differences in diet by depth

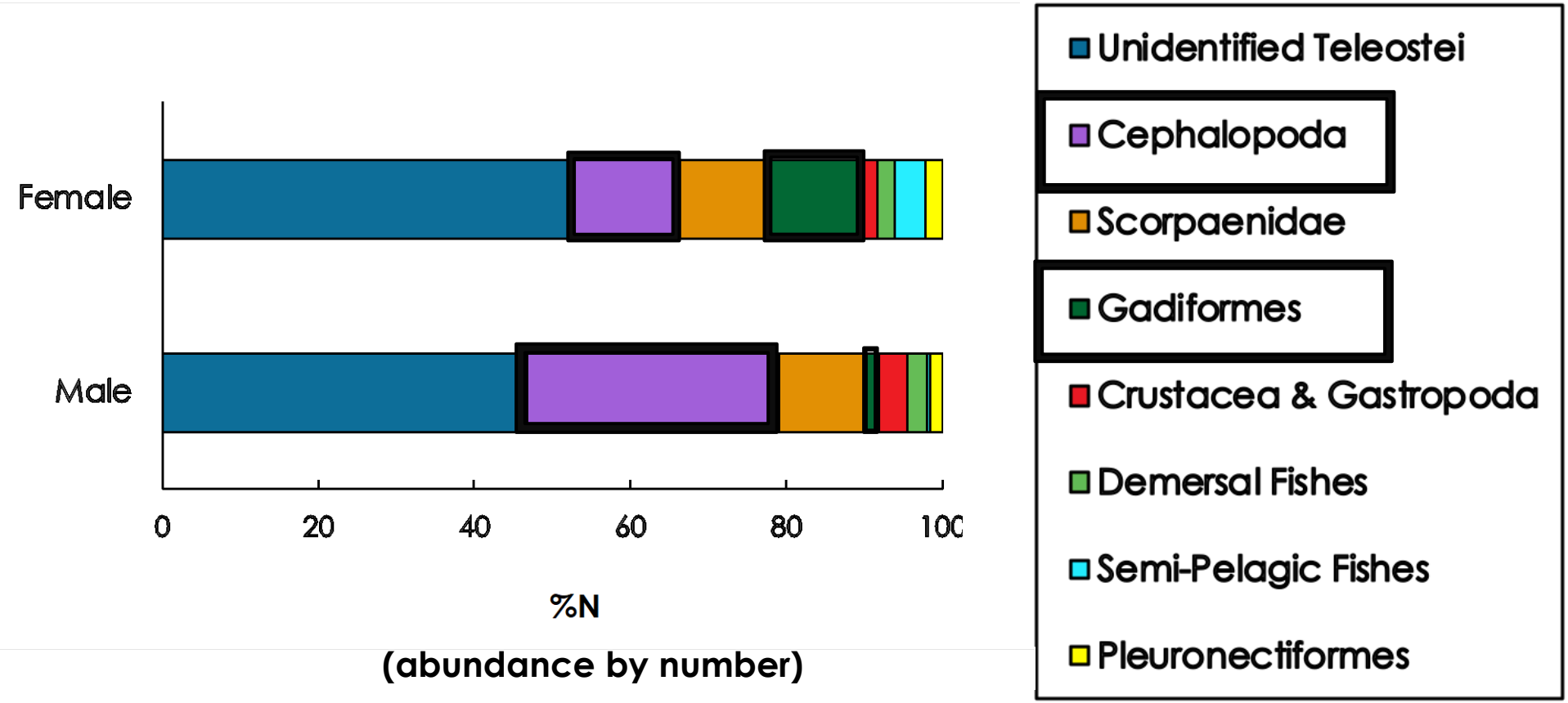


Differences in diet by region

Principal Component Analysis (PCA)



Differences in diet by sex



Stable Isotope Analysis

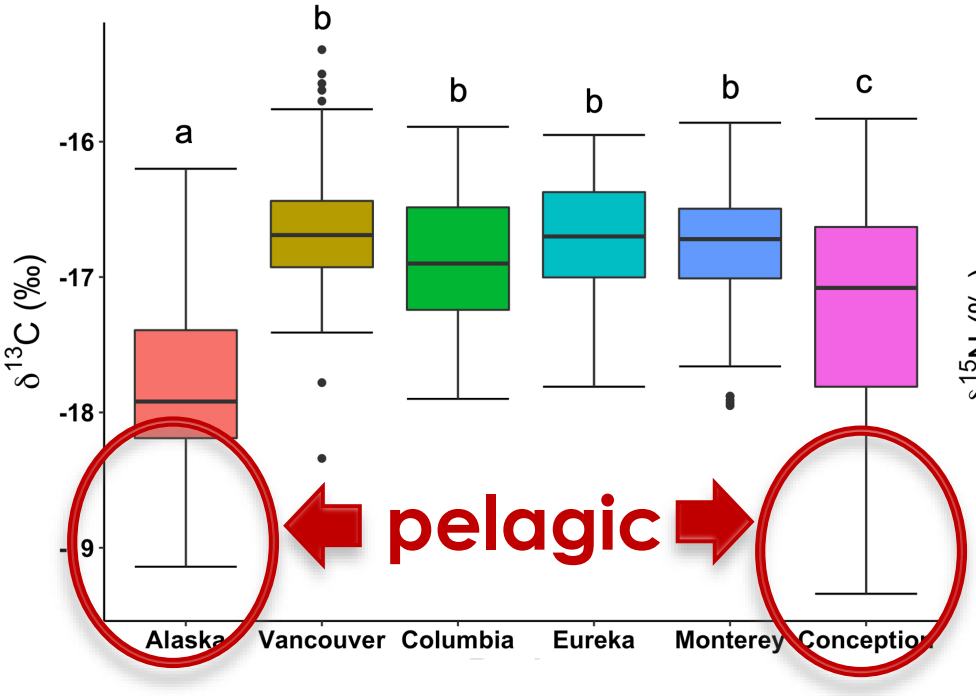
Region	# Lingcod Used for SIA from White Muscle Tissue
Alaska	66
Vancouver	50
Columbia	72
Eureka	94
Monterey	130
Conception	107
All Regions	519

Stable Isotope Analysis: Generalized Linear Models (GLMs) highlight region, depth, sex, length

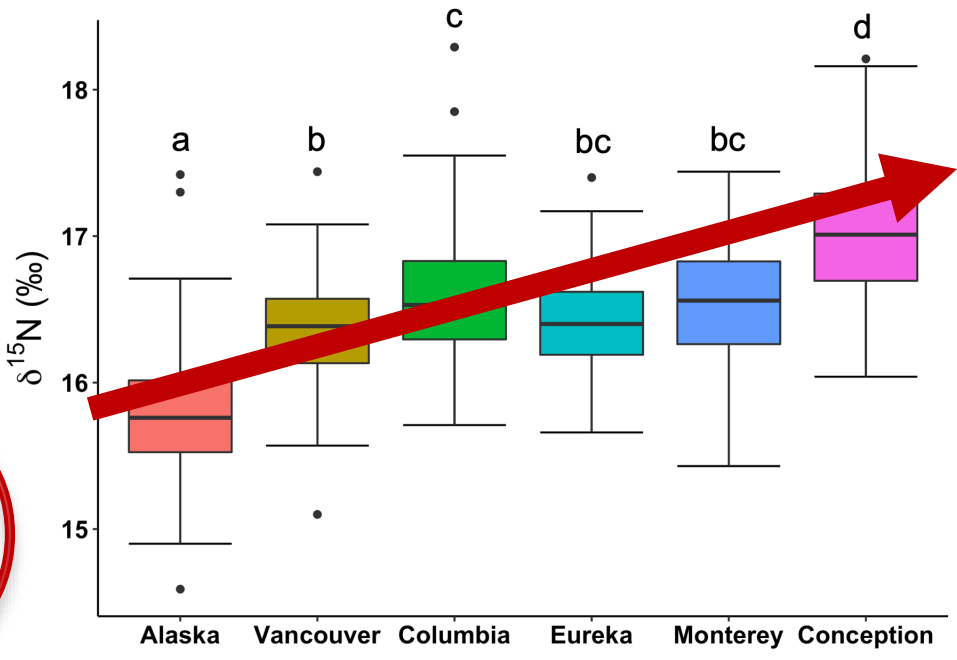
Model	Variable	p-value
Carbon	Depth	0.6
	Sex	0.2
	Length	0.9
	Region	**<0.001**
Nitrogen	Depth	**<0.001**
	Sex	**0.004**
	Length	**<0.001**
	Region	**<0.001**

Differences in stable isotopes by region

Carbon



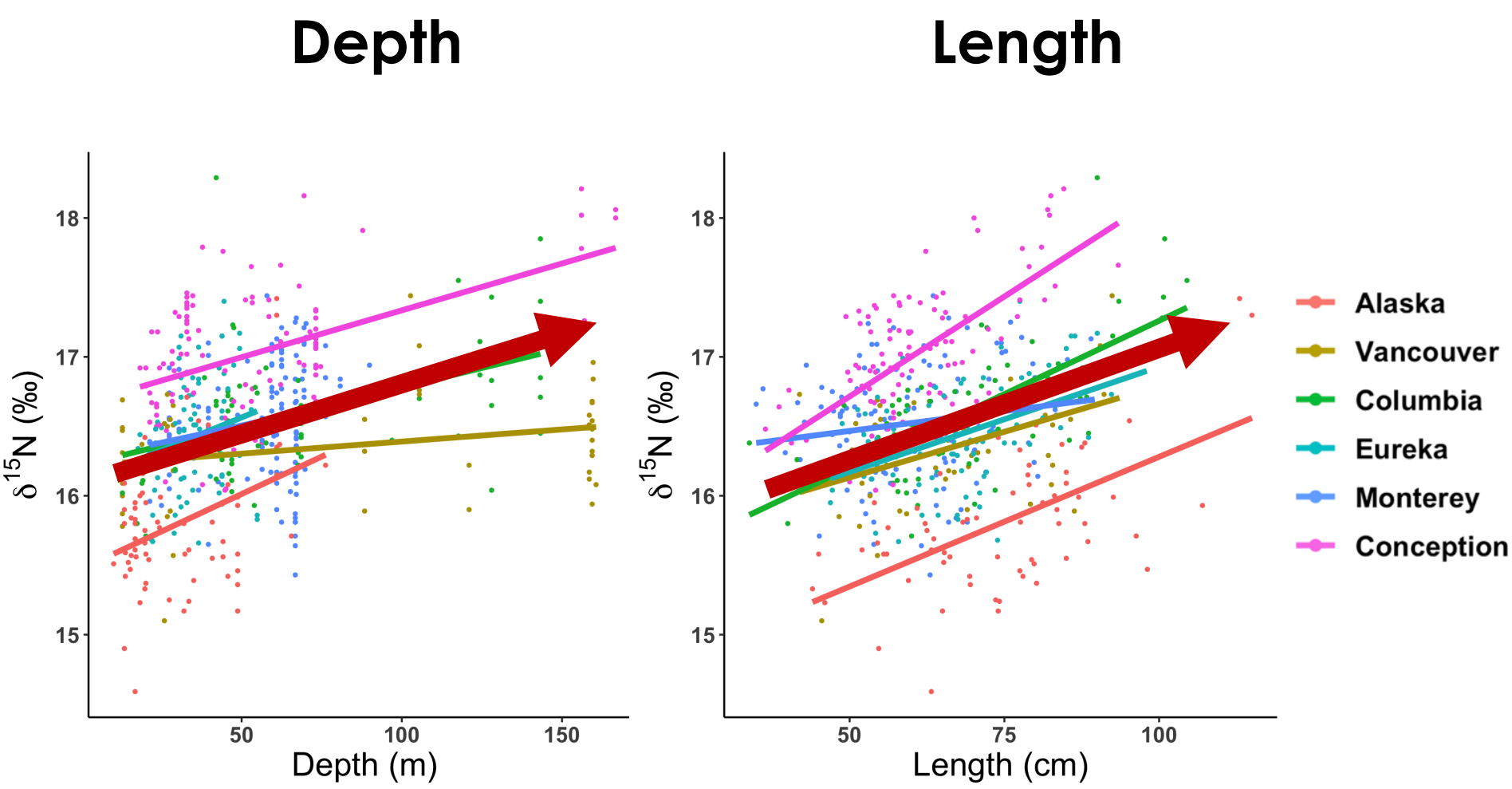
Nitrogen



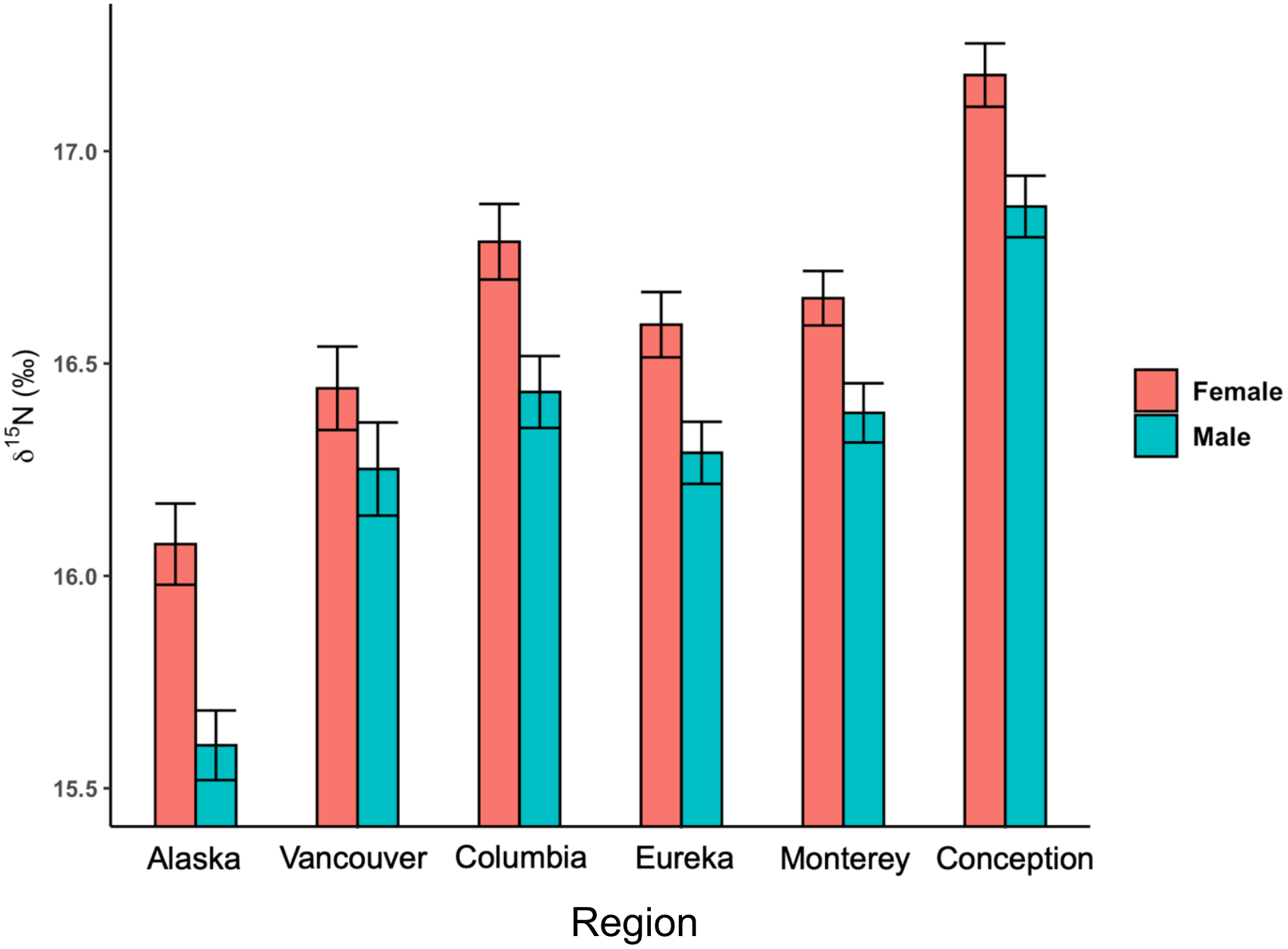
Alaska & Conception were more heavily influenced by pelagic carbon sources

Nitrogen stable isotope values increased from North to South

Larger lingcod caught at deeper depths eat higher trophic level prey



Female lingcod eat at higher trophic levels



Previous Studies

Washington

Oregon

California

My Study

Alaska

Vancouver

Columbia

Eureka

Monterey

Conception

Images: ODFW, WDFW, inlandseafood.com, alchetron.com

Feeding Strategies

* Generalists and Opportunists
* Sampled during an El Niño
  * Pelagic Red Crabs
* Changing oceans,
  ...changing diets

Recommendations for future studies:

* Narrower sampling period, more locations
* Directed prey collections
  * Prey mixing model
  * Isotope baseline to standardize across isoscapes

Take Home Messages

- Lingcod consume a wide variety of prey
  - Primarily fishes, then octopuses
- Generalists & Opportunists
- Geographic and ontogenetic variations in diet
- Important variables:
  - depth, region, sex, length
- Ecosystem-Based Fisheries Management
  - Filled in data gaps

Acknowledgements

Thesis Committee
Rick Starr
Scott Hamilton
Kenneth Coale

Lingcod Crew
Laurel Lam
Jameal Samhouri
Kelly Andrews
Greg Williams
Gary Longo
Trevin Li
Bailey Warren
Kevin Critchlow
Emily Doyle
Nina Zimmermann
All the captains, crew, volunteer anglers!

Collaborators
Makah Tribe & Sitka Tribe of AK
Rachel Zuercher
Bruce Finney
Million Hailemichael
Anne Beaudreau
Aaron Galloway
Joe Bizzarro
MLML Community
FCB Lab

Funding
MLML Wave Award
Archimedes Scholarship
Sonia Linnik Hamilton Scholarship
Simpkins Family Marine Science Scholarship
International Women's Fishing Association Scholarship
Ryan Kelley Memorial Scholarship


Questions?
FCB Lab

Auxiliary Studies

- Longo et al. 2020 - Genetics
- Lam et al. 2021 – Age & Growth
- Galloway et al. 2021 – Blue & Fatty Acids
- Wood et al. 2021 – Blue & Parasites

  More papers in prep!

- Diet data contribution to
  California Current Trophic Database (CCTD)
  https://oceanview.pfeg.noaa.gov/cctd/


HL1779
HL1779


HL0125


Wydoski & Whitney 2003