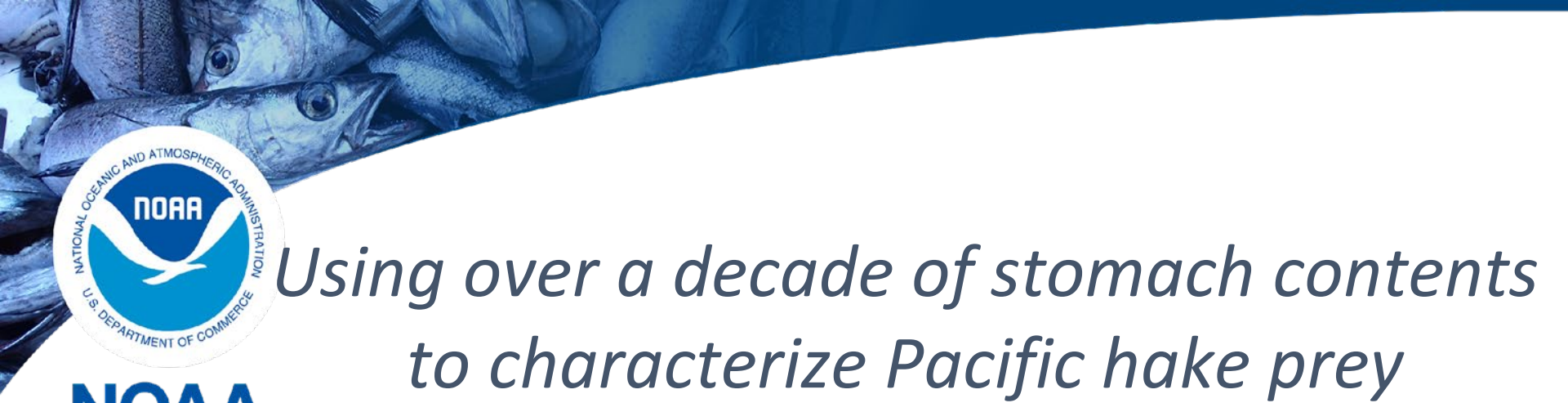
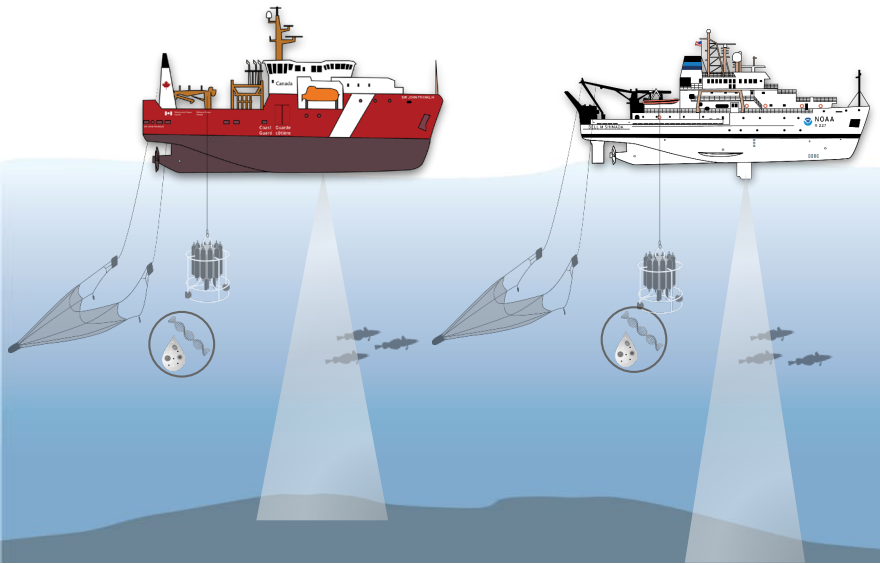


Using over a decade of stomach contents to characterize Pacific hake prey consumption in the California Current

Western Groundfish Conference April 26, 2023

Alicia Billings, Elizabeth Phillips, and Julia Clemons
NOAA Northwest Fisheries Science Center
Fisheries Engineering & Acoustic Technologies Team

The US-Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey



Joint effort between NWFSC and Fisheries and Oceans Canada (DFO) to produce biomass estimate for stock assessment

→ *Collect diet information from fish caught in trawls*

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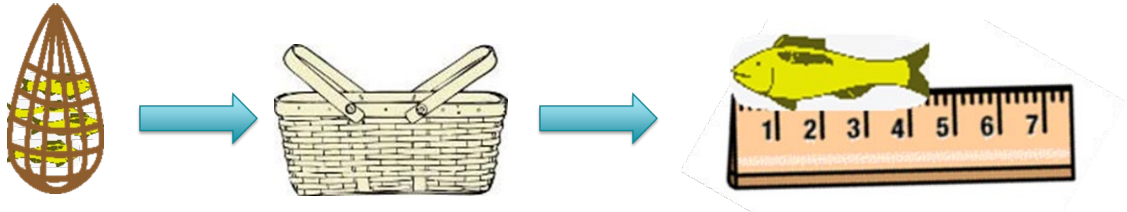
Collecting samples at sea

Randomly select 10 'good' stomachs

- *5 for at-sea examination*
- *5 for laboratory examination*
- *No regurgitation or barotrauma present*



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Why look at Pacific Hake diet?

Variation in diet provides insight on potential growth and recruitment, and ecological relationships which can inform Ecosystem-Based Fisheries Management (EBFM)

Photos taken by Dan Kamikawa

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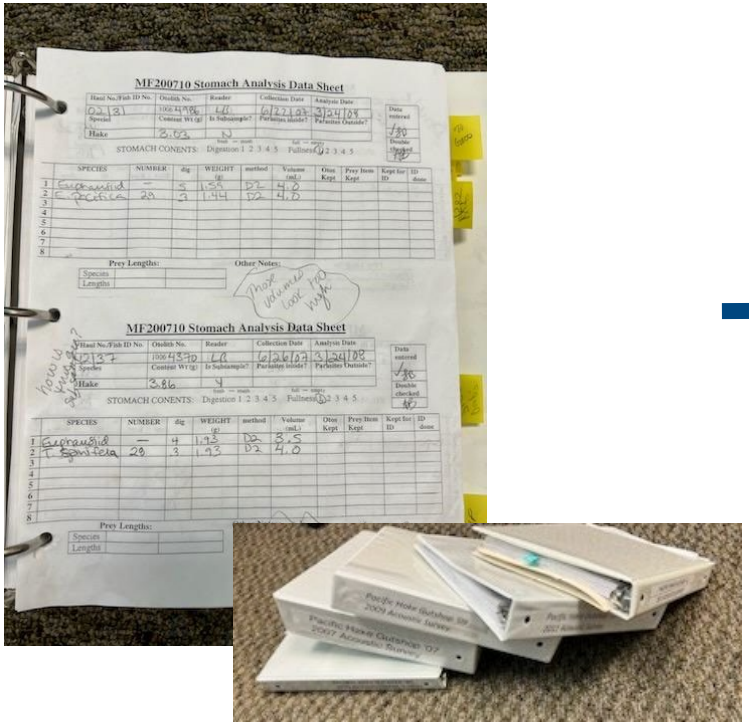
Decades-old data are messy…



Work

- Digitize data sheets
- Standardize prey names
- Build database

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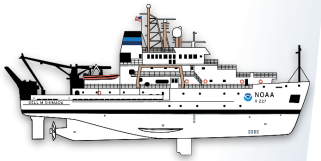
Decades-old data are messy…



cruise_numl	operation_num	predator_sp	pred_sci_name	pred_com_n	pred_len	pred_wt	pred_sex	pred_mat	pred_age	prey_sp	prey_sci_name	collection_type	cont_wt
200509	10	22500	Merluccius productus	Pacific hake	36	0.3	Female	Immature	2	405814	Euphausiidae	formalin sample	0.18
200509	10	22500	Merluccius productus	Pacific hake	33	0.22	Female	Immature	2	405814	Euphausiidae	formalin sample	0.47
200509	10	22500	Merluccius productus	Pacific hake	44	0.52	Male	Inactive	6	405814	Euphausiidae	formalin sample	1.5

cruise_numl	ship_code	cruise_investigator	operation_numl	inpfc_area	country	td_latitude	td_longitude	hb_latitude	hb_longitude	avg_bottom_depth	avg_gear_depth
200509	21	NWFSC - FEAT	2	Monterey	US	36.3962	-121.9706	36.4177	-121.987	117	81
200509	21	NWFSC - FEAT	3	Monterey	US	36.7386	-121.9859	36.7387	-121.998	654	186
200509	21	NWFSC - FEAT	4	Monterey	US	37.0714	-122.6627	37.0733	-122.6642	204	155

Result

Internal database with easy to access views

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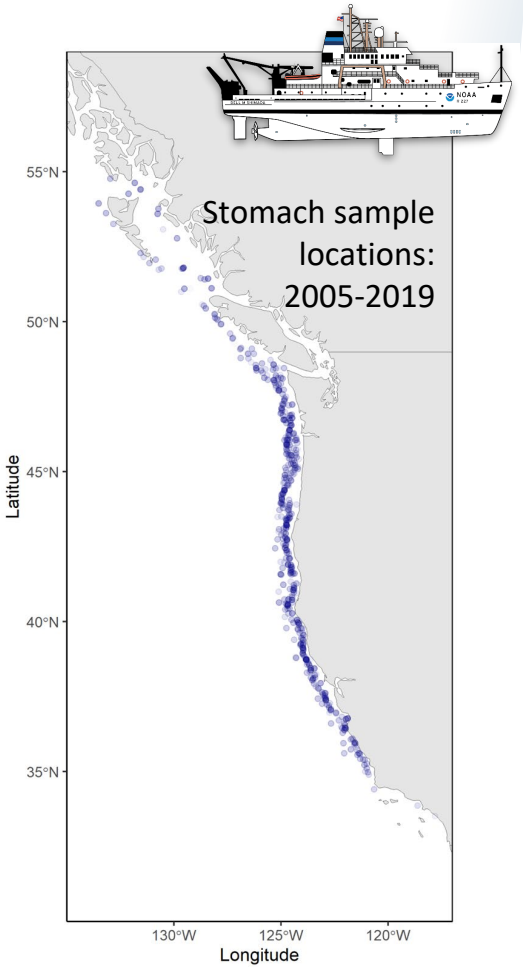
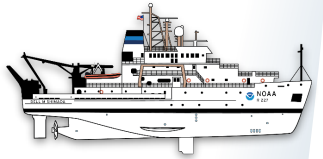
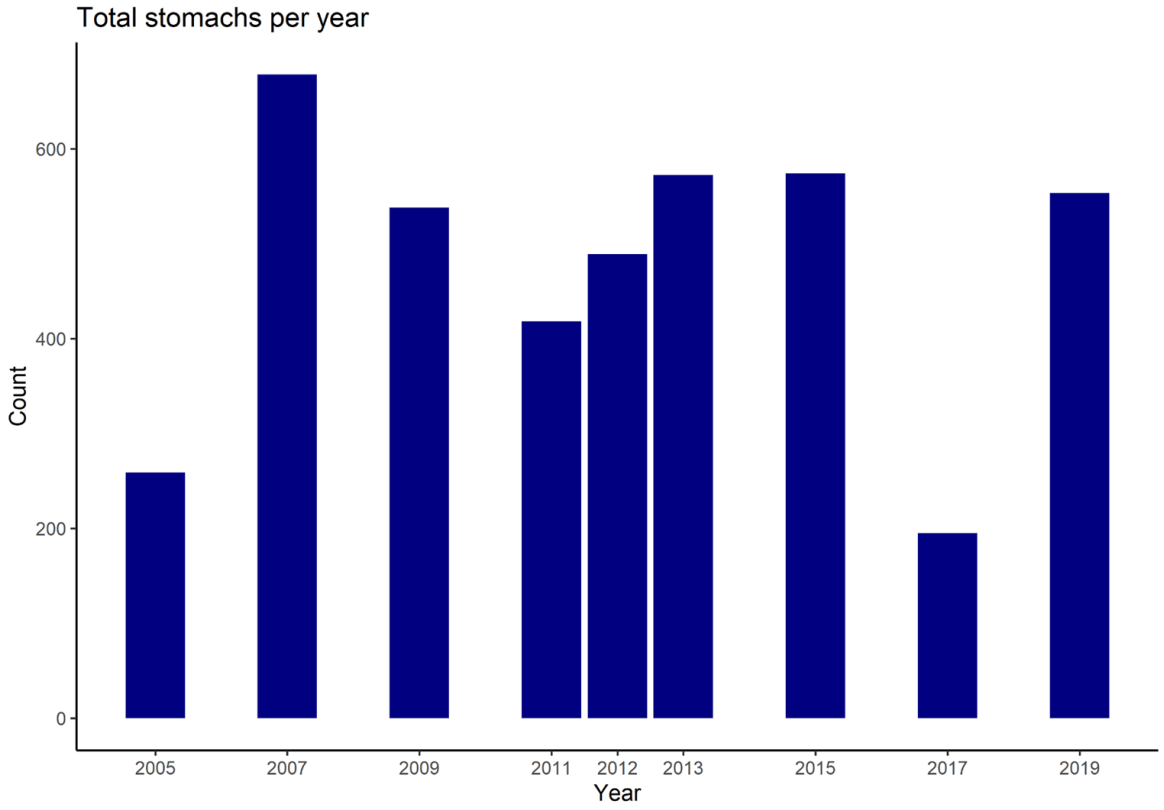
Data summary (as of April 2023)

Total stomachs (#)	4,276
Hake size range (cm)	15 - 80
Hake ages (yr)	1 - 19
Latitude range (°N)	33.5 - 54.7
Fishing depth (m)	23 - 488
Bottom depth (m)	54 - 2,676



Overall sample summary





Average of ~425/year

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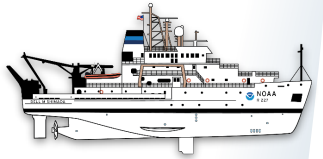
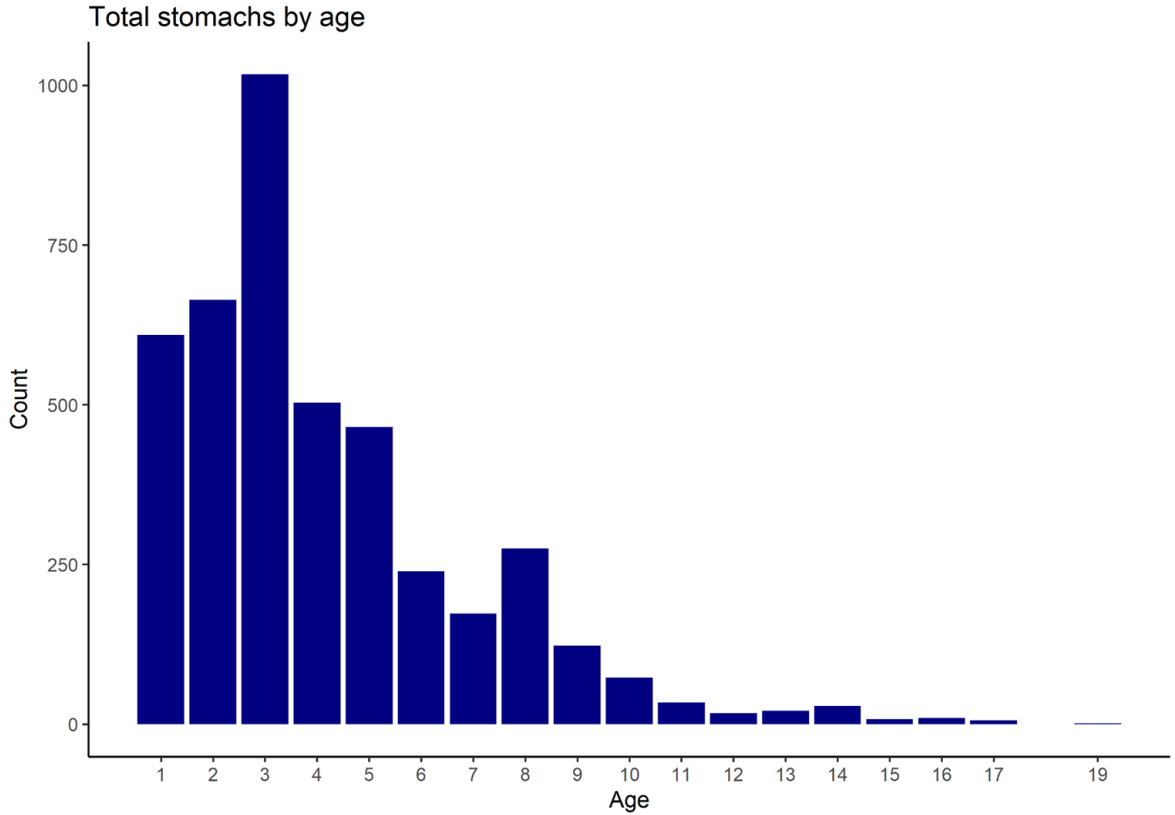
Overall sample summary





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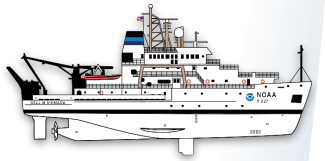
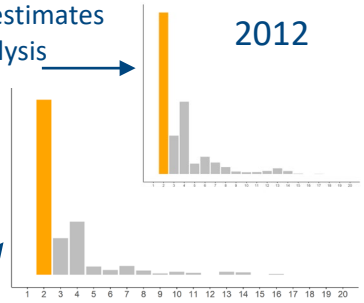
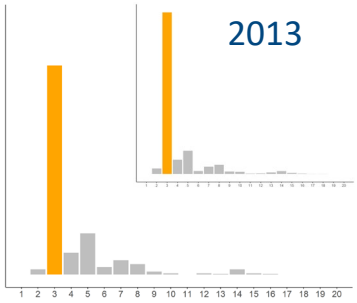
Samples match dominant age classes of population

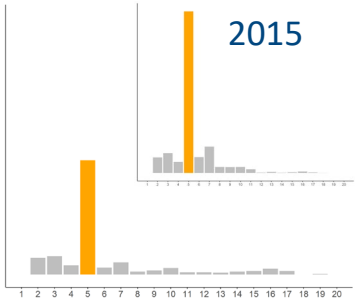


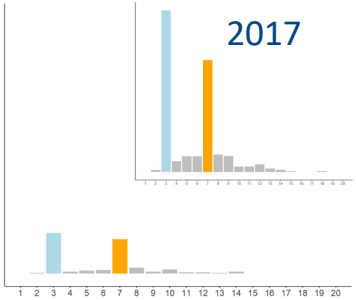
Number at age estimates after survey analysis

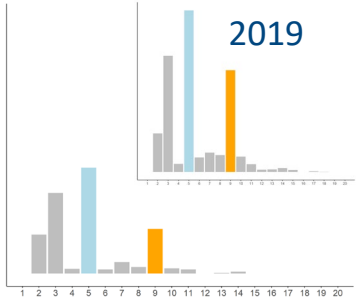
Stomachs collected by age











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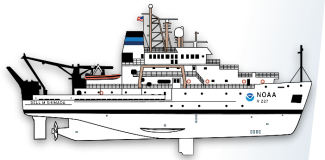
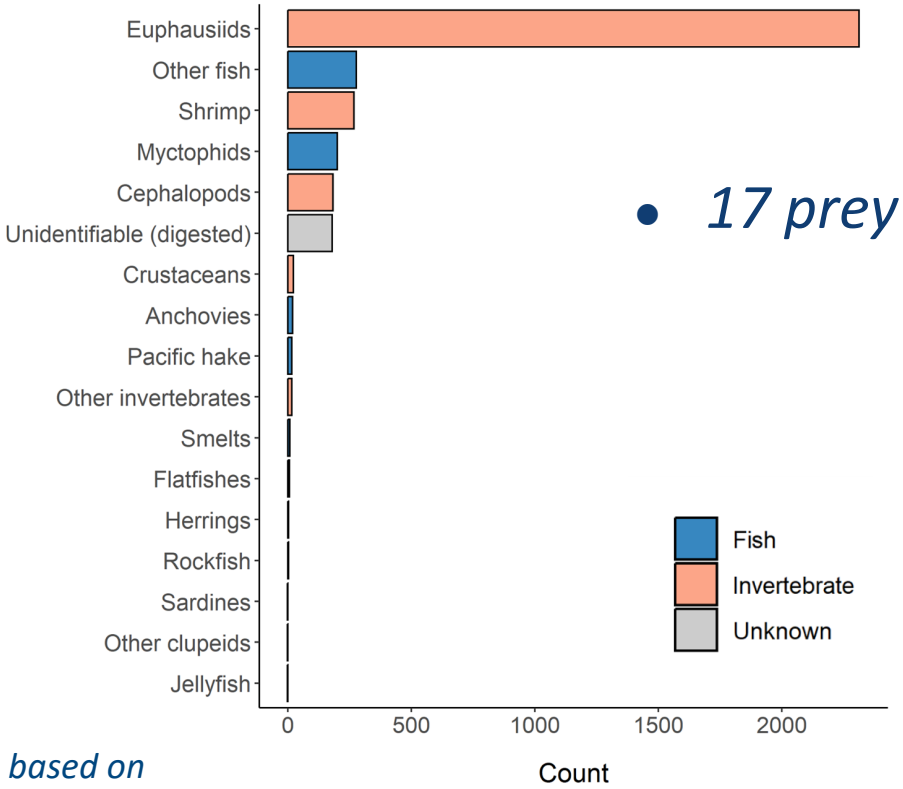
Summary of prey items observed





- *17 prey groups represented*

Taxonomic groups based on Bizzarro et al. (2017) Enviro. Biol. of Fishes 100: 375-393

Empty stomachs excluded

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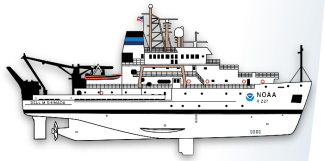
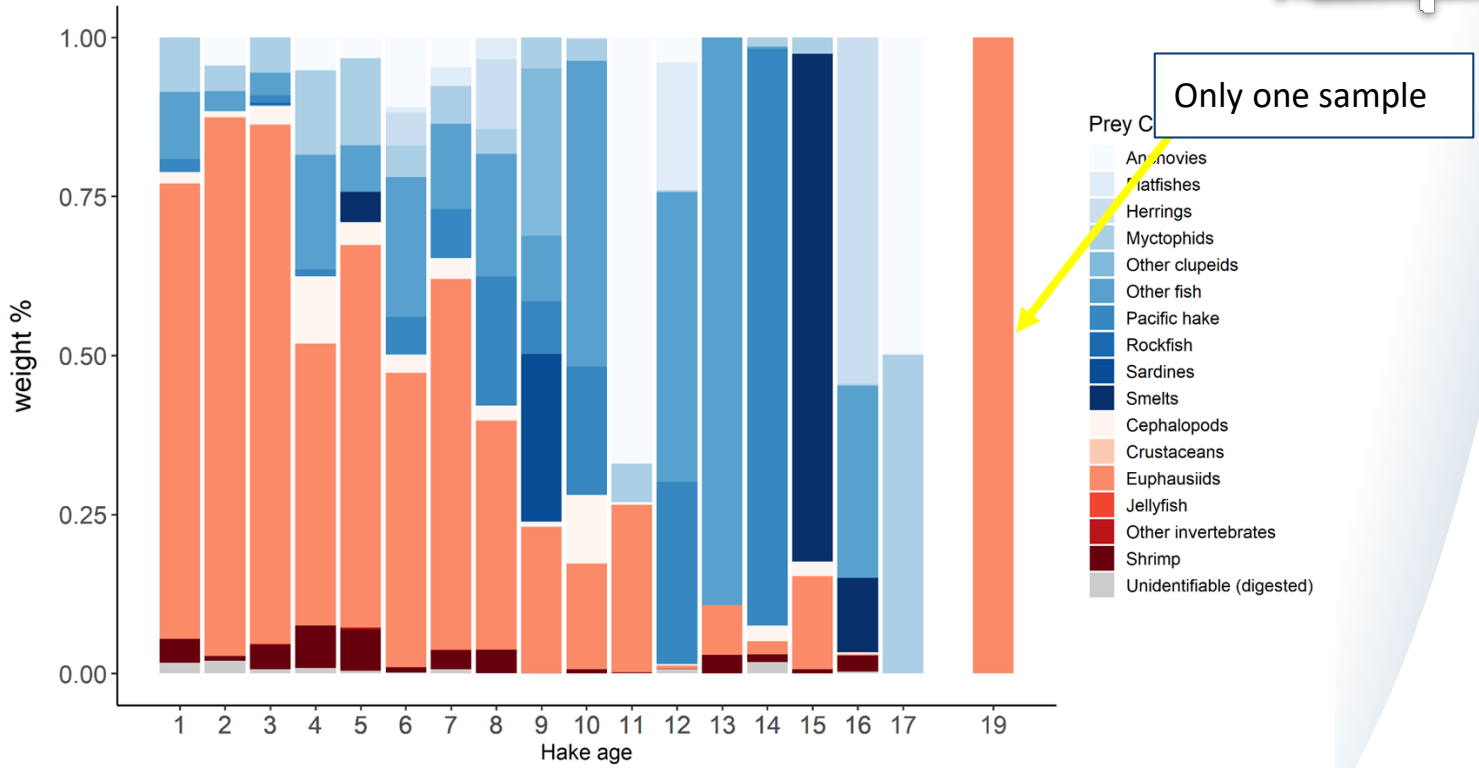
Age-specific diet patterns



Prey switching



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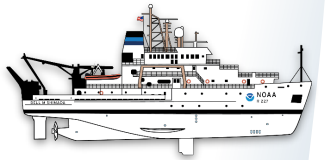
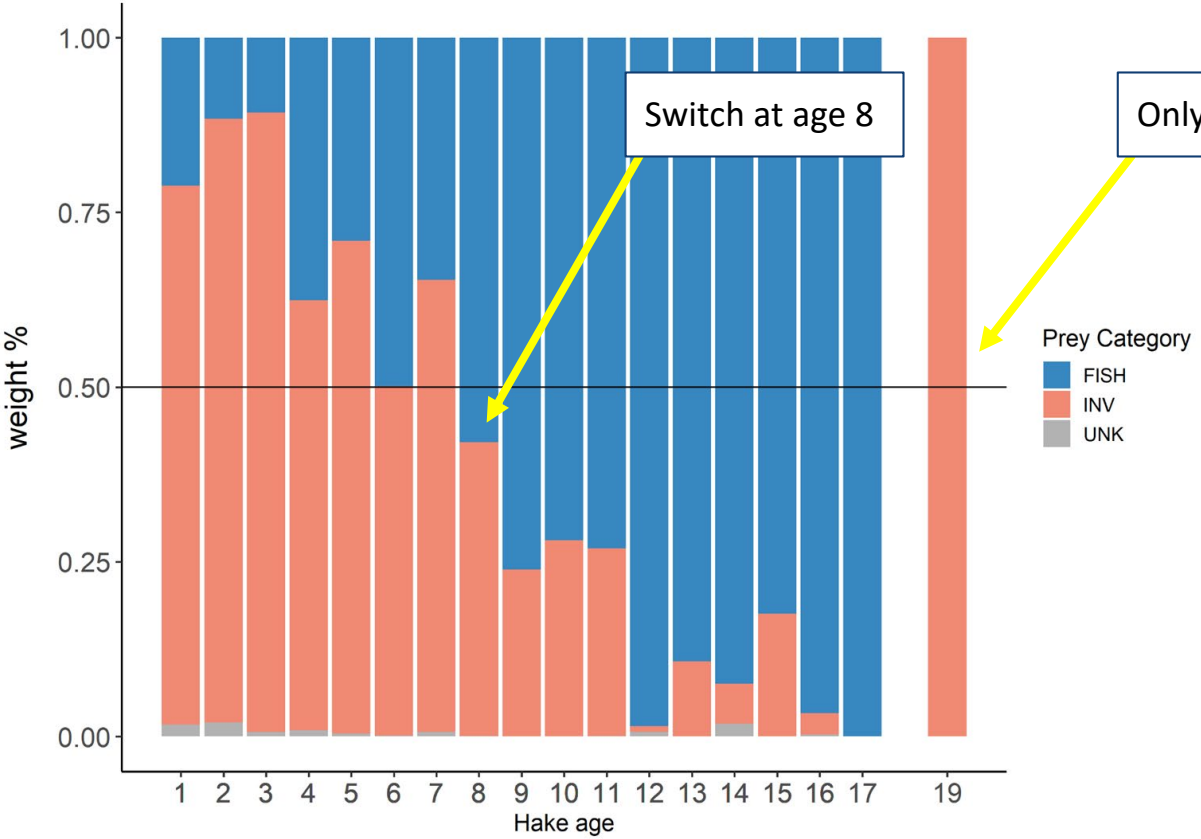
Age-specific diet patterns



Prey switching



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Why do hake diets vary over time?

Could the availability of prey effect hake diets?

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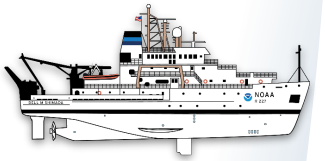
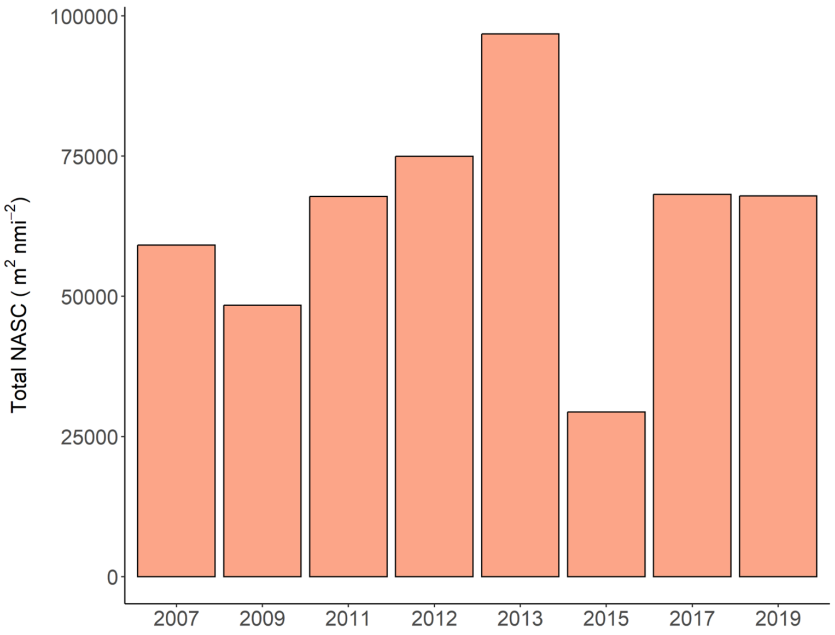
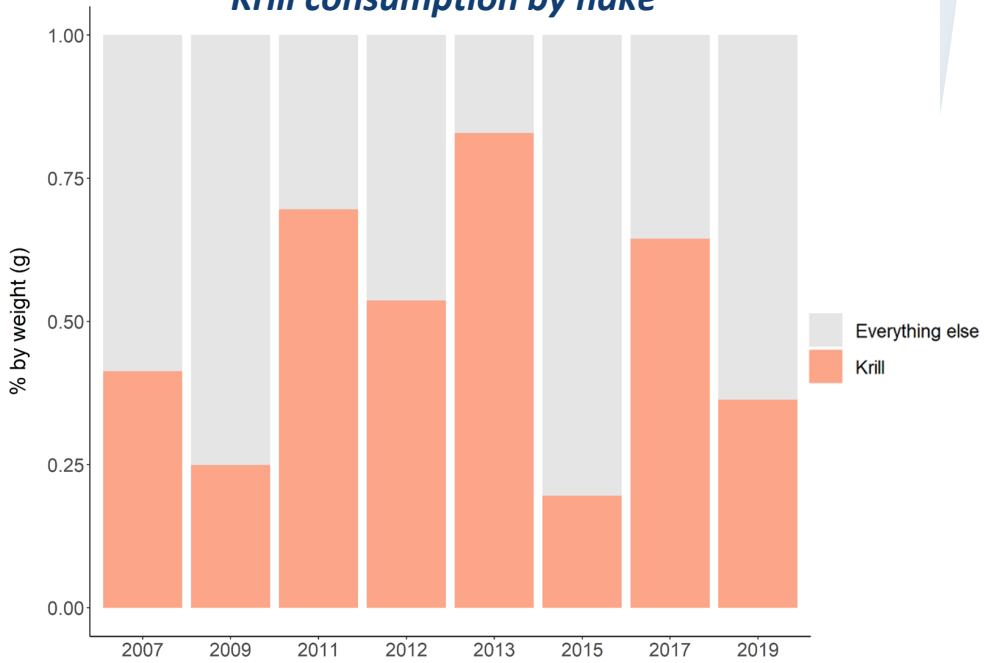
Krill availability vs. consumption



Acoustic index of krill abundance



Krill consumption by hake



See Phillips et al. 2022 ICES JMS for details - https://doi.org/10.1093/icesjms/fsac055

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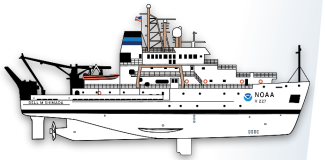
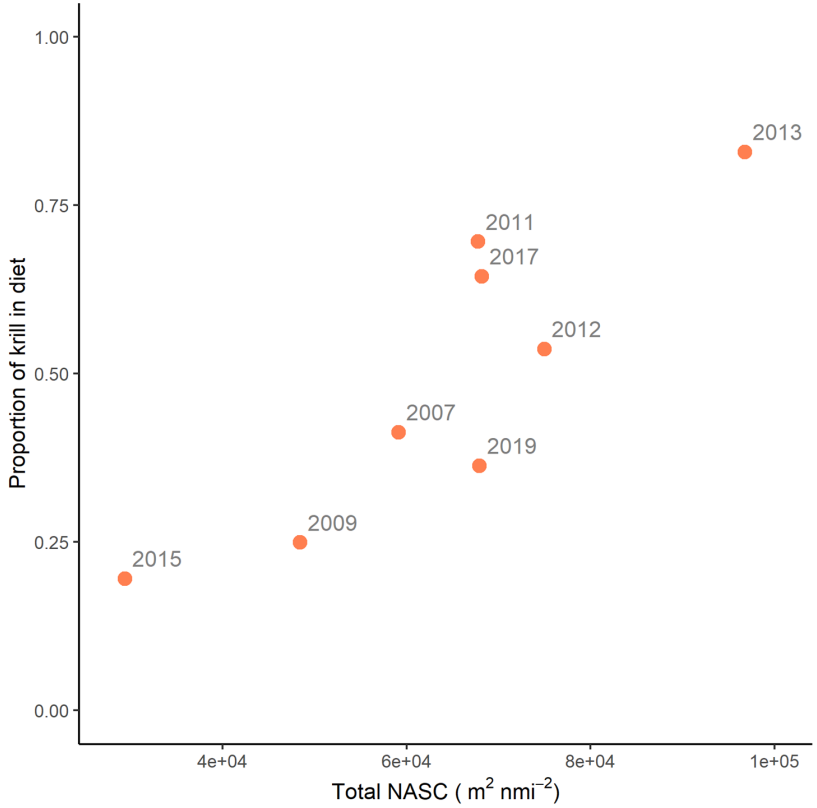
Krill availability vs. consumption



Positive correlation between krill abundance and consumption



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Why do hake diets vary over time?

Does the diversity of their diet change over time?

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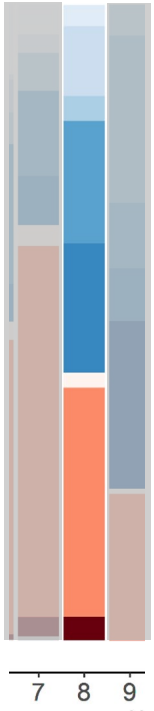
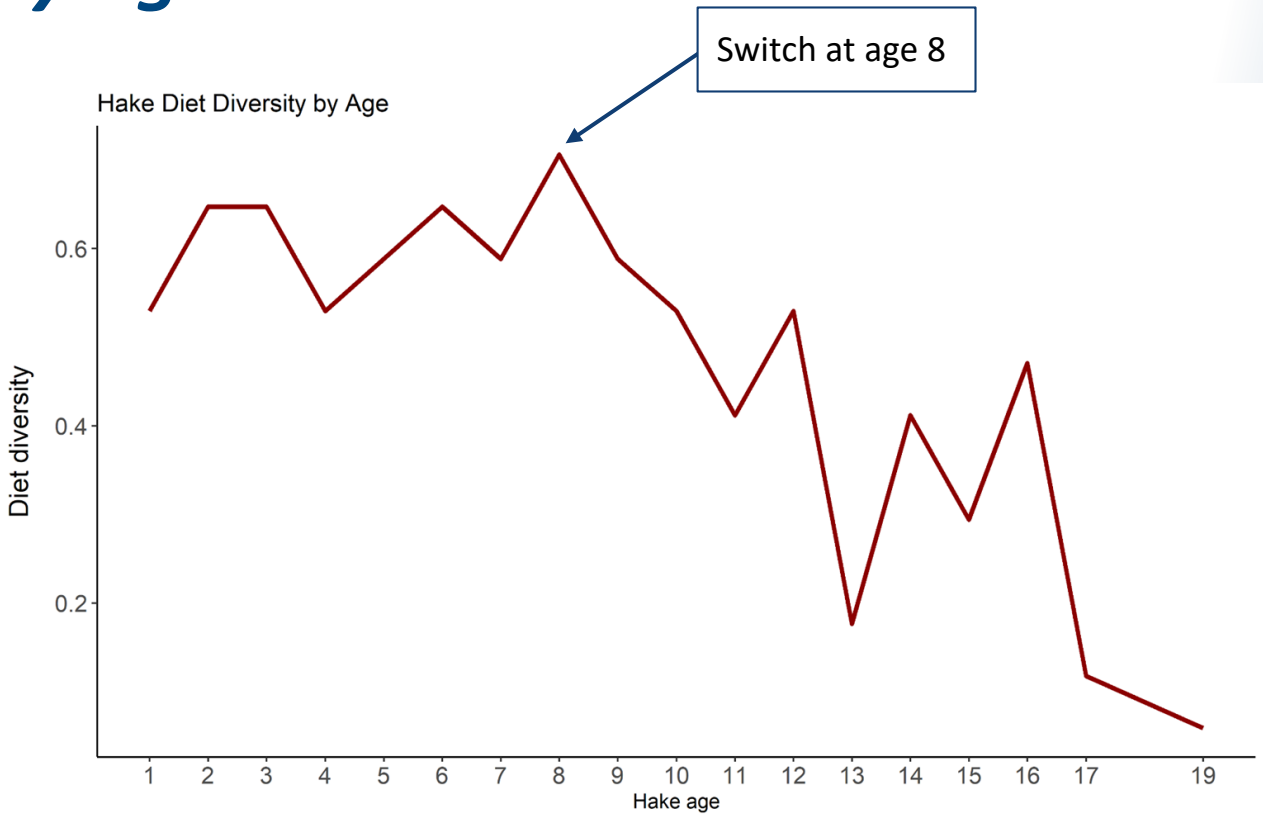
Diet diversity by age



Anchovies
Cephalopods
Crustaceans
Euphausiids
Flatfish
Herrings
Myctophids
Other fish
Other invertebrates
Pacific hake
Shrimp
Unidentifiable



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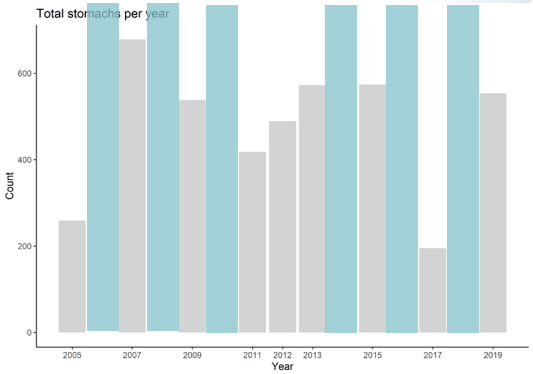
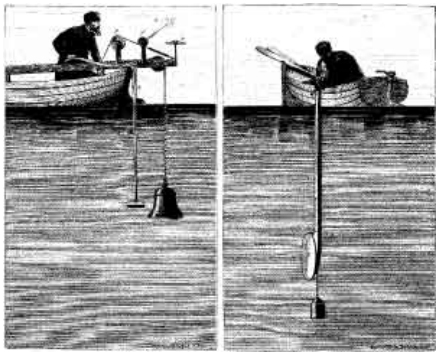
What's next? - Expand dataset

- From 2021 survey
- From the Canadian vessel
- From non-survey years
- From older survey data





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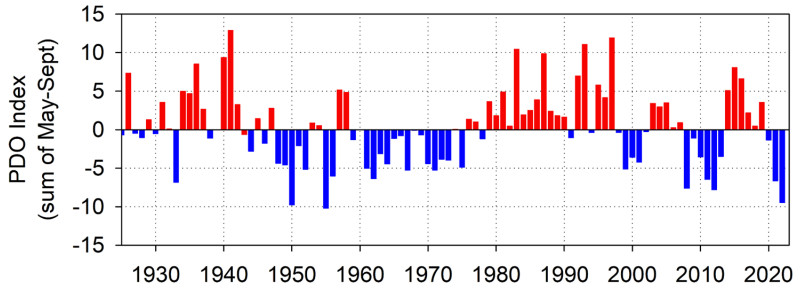
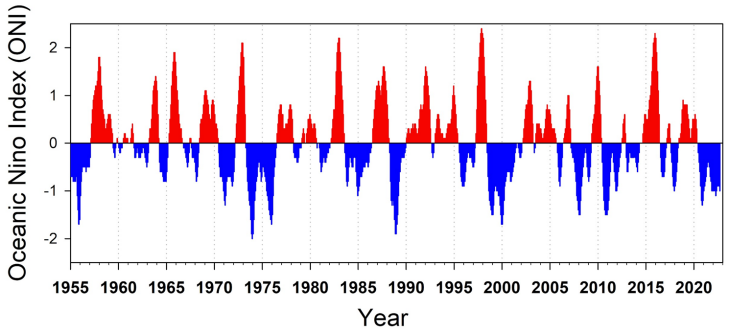
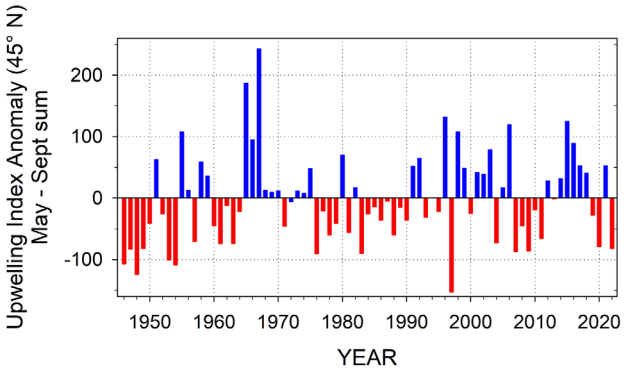
What's next? - Analysis

- Explore relationships to ocean conditions
  - Upwelling index
  - Pacific Decadal Oscillation (PDO)
  - Oceanic Nino Index (ONI)
- Spatiotemporal analysis







Upwelling image from
https://www.fisheries.noaa.gov/west-coast/science-data/local-physical-indicators
PDO and ONI images from https://www.fisheries.noaa.gov/west-coast/science-data/climate-and-atmospheric-indicators

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Questions?

**Special thanks to all of the scientists who have collected samples and contributed analysis, including (but not limited to):*

Steve deBlois
Justin Ainsworth
Melanie Johnson
Dan Kamikawa
Ethan Beyer

Alicia.Billings@noaa.gov

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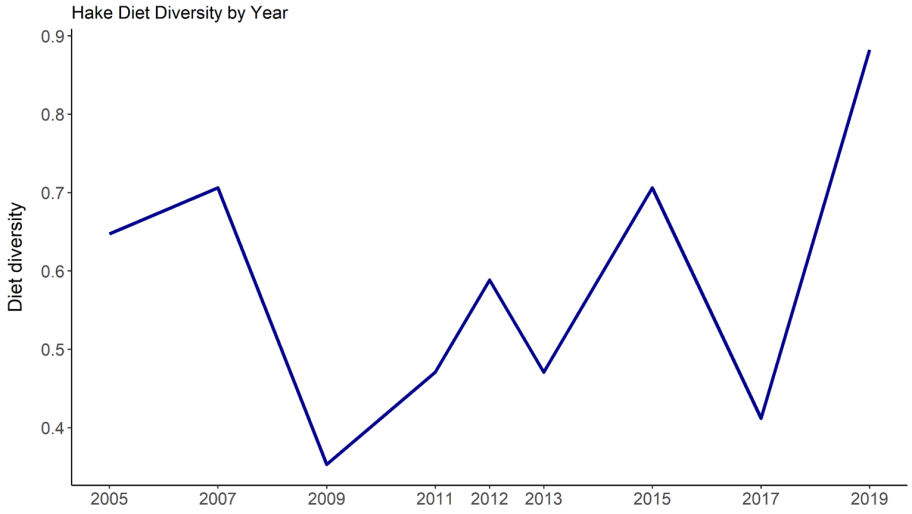
Diet diversity index by age

- *Plot(s) on the diet diversity index by age*



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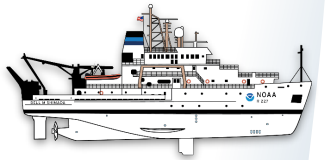
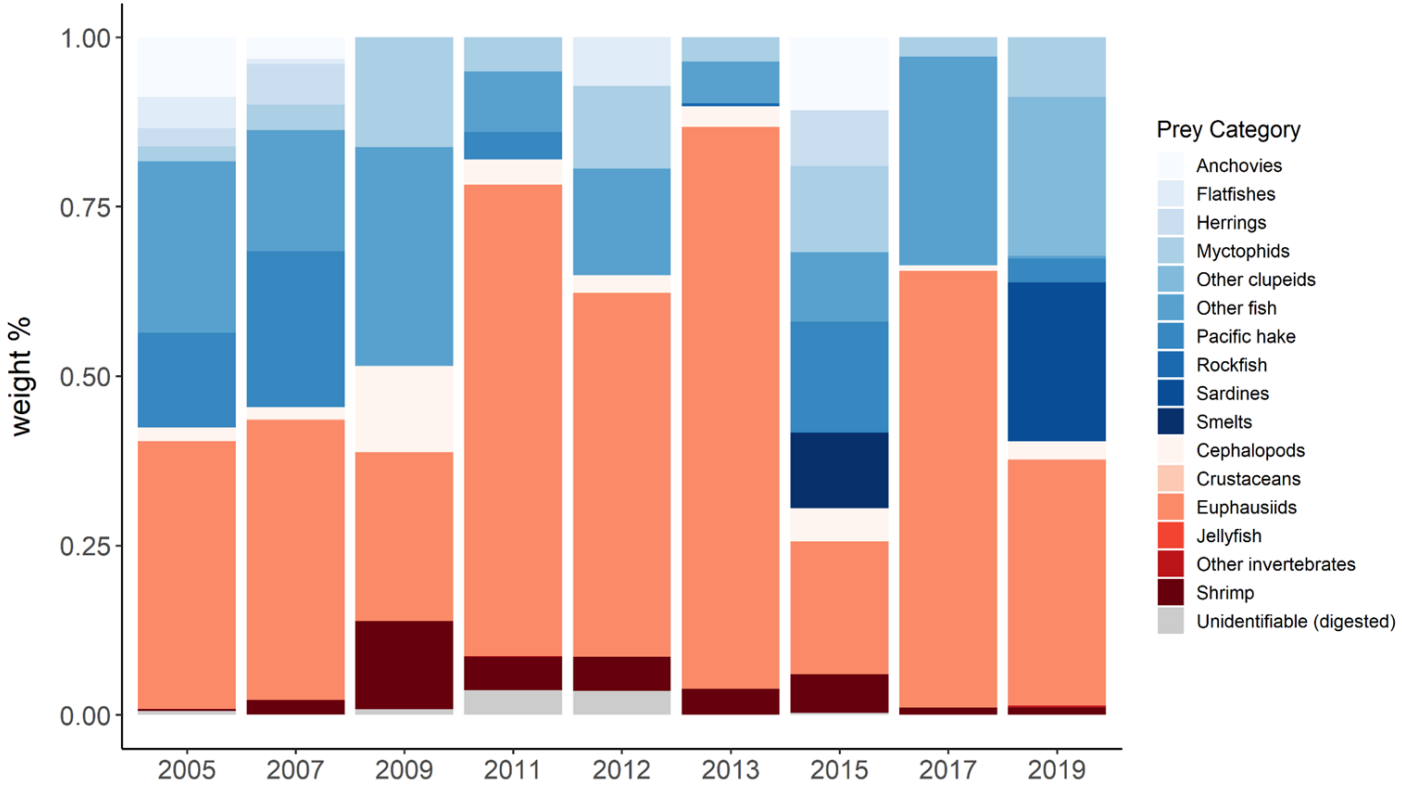
Interannual patterns in prey consumption





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