TROPHIC GUILDS OF THE EASTERN CHUKCHI SEA DEMERSAL FISH COMMUNITY

G Andrew Whitehouse | Joint Institute for the Study of the Atmosphere and Ocean (JISAO), University of Washington, Seattle, WA, USA, email: gaw@uw.edu
Troy W Buckley | Resource Ecology and Fisheries Management, Alaska Fisheries Science Center, NMFS, NOAA, Seattle, WA, USA
Richard E Hibpshman, Caroline L Robinson, Sean K Rohan, Kimberly A Sawyer | School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, USA

Introduction

Fishes form an important link in Arctic marine food webs, connecting production on lower trophic levels to upper level predators, including people. Fishes in the Alaskan Arctic prey on a variety of pelagic and benthic invertebrates and other fishes, and are themselves an important prey for seasonally abundant and resident marine mammals and seabirds.

Objective

Assess the summer diet composition of demersal fishes in the eastern Chukchi Sea, and identify distinct trophic guilds and underlying patterns in guild diet composition that can be explained by predator size and other environmental variables.

Methods

Study Site and Specimen Collection

- Our study area is the US territorial waters of the eastern Chukchi Sea between the Bering Strait in the south and Pt. Barrow in the north (Figure 1).
- Stomach samples were collected during a summer bottom trawl survey in 2012.

Diet Analysis

- Species diet compositions are described as percent weight of prey.
- Ward's Minimum Variance Method was used to cluster species into trophic guilds based on a Bray-Curtis similarity matrix.
- Constrained Analysis of Principal Coordinates (CAP) was used to identify underlying patterns in the composite diets of the identified trophic guilds. The constraining variables are predator length (mm), latitude, longitude, bottom depth (m), and water mass (Table 1). The significance of CAP models was tested with a Monte Carlo global permutation test.

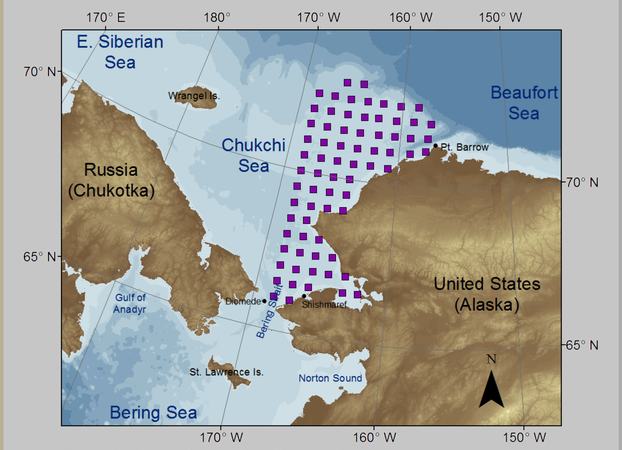
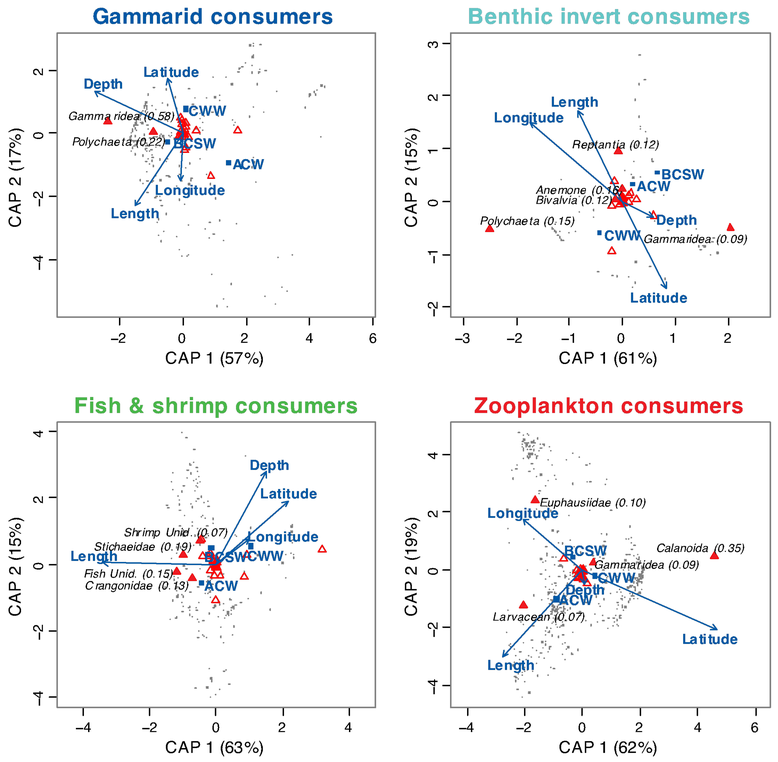


Figure 1. Stomach sample collection locations

Table 1. Temperature and salinity boundaries for water masses present at bottom trawl stations (oceanographic data credit Seth Danielson (UAF)).

Water mass	Temperature (°C)	Salinity (psu)
Alaska Coastal Water (ACW)	7-12	20-32
Bering/Chukchi Shelf Summer Water (BCSW)	0-7	30-33.5
Chukchi Winter Water (CWW)	-2-0	30-33.5

Results



CAP – The correspondence of the guild diet data with the explanatory variables is displayed in the CAP triplots. Stomachs that are closer together have similar contents (gray dots) and are dominated by prey types closest to them (red triangles). Continuous explanatory variables are shown with blue vectors and water masses are represented with blue squares.

Gammarid amphipod consumers-Consumption of their primary prey, gammarid amphipods, is positively associated with latitude and negatively correlated with the ACW.

Benthic invertebrate generalists-This guild preyed upon a variety of benthic invertebrates with no single dominant prey taxa. Consumption of crabs was positively correlated with predator length and ACW, while the consumption of polychaetes was negatively related to the ACW.

Fish & shrimp consumers-Consumption of important fish and shrimp prey groups are positively correlated with predator length and negatively related to presence of CWW.

Zooplankton consumers-Consumption of their most important prey type, calanoid copepods, is positively correlated with latitude and CWW. In contrast, consumption of euphausiids is negatively related to latitude and CWW, and positively related to longitude.

- All CAP models explained a significant ($p<0.005$) proportion of the variance in the guild diet compositions, ranging from 7 to 25% of the total variation.

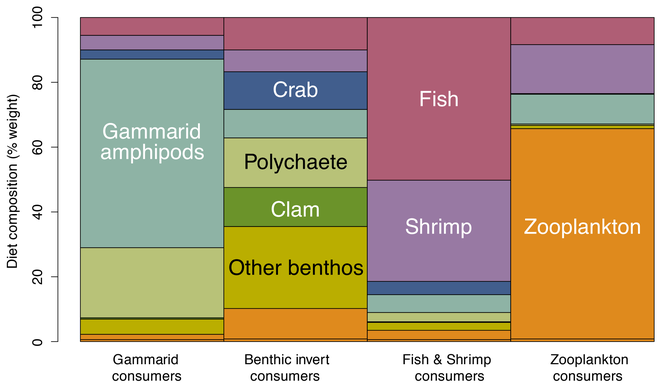
Trophic guild	Proportion of variance explained
Gammarid consumers	0.07
Benthic invert generalists	0.25
Fish & Shrimp consumers	0.11
Zooplankton consumers	0.09

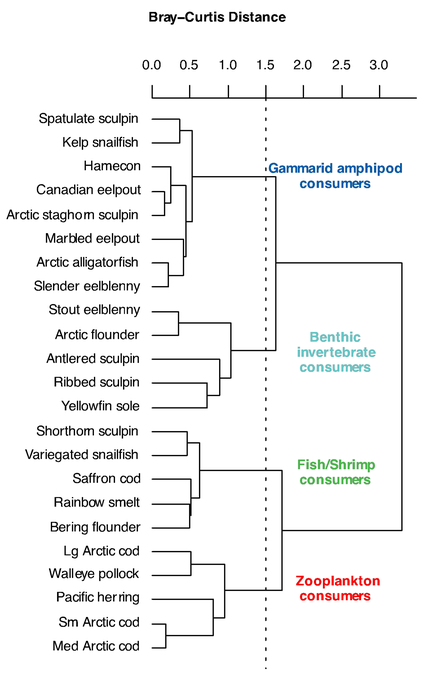
Study species sampled for diet analysis

Family	Species name	Common name	Non-empty stomachs	Size range (cm)
Clupeidae (herrings)	*Clupea pallasi*	Pacific herring	21	12-26
Osmeridae (smelts)	*Osmerus mordax*	Rainbow smelt	28	10-30
Gadidae (cods)	*Boreogadus saida*	Small Arctic cod	224	5.7-10.2
	Boreogadus saida	Medium Arctic cod	435	10.3-14.7
	Boreogadus saida	Large Arctic cod	38	14.8-19.3
	Eleginus gracilis	Saffron cod	82	6.4-31
	Gadus chalcogrammus	Walleye pollock	13	8-12
Cottidae (sculpins)	*Artediellus scaber*	Hamecon	21	6-8
	Enophrys diceraus	Antlered sculpin	14	9.2-18
	Gymnocanthus tricuspis	Arctic staghorn sculpin	102	3-17
	Icelus spatula	Spatulate sculpin	21	3.2-11
	Myoxocephalus scorpius	Shorthorn sculpin	57	7.4-29
	Triglops pingeli	Ribbed sculpin	46	3.8-15
Agonidae (poachers)	*Ulcina olrikii*	Arctic alligatorfish	43	3.6-6.1
Liparidae (snailfishes)	*Liparis gibbus*	Variegated snailfish	54	8.2-31
	Liparis tunicatus	Kelp snailfish	94	2.8-15.6
Zoarcidae (eelpouts)	*Lycodes polaris*	Canadian eelpout	16	4.2-22
	Lycodes raridens	Marbled eelpout	11	3.5-30
Stichaeidae (pricklebacks)	*Lumpenus fabricii*	Slender eelblenny	143	5.6-27
	Lumpenus medius	Stout eelblenny	24	5.2-14
Pleuronectidae (flatfishes)	*Hippoglossoides robustus*	Bering flounder	94	3.4-24
	Limanda aspera	Yellowfin sole	13	7.5-18
	Liopsetta glacialis	Arctic flounder	13	10.1-16

Guild Identification

- We identified four trophic guilds from the clustering algorithm: gammarid amphipod consumers, benthic invertebrate generalists, fish & shrimp consumers, and zooplankton consumers. Guild names are based on the dominant prey types in the composite guild diets.





Conclusions and future work

- A trophic guild structure is present amongst the demersal fish community during summer in the eastern Chukchi Sea.
- CAP models were effective at identifying underlying regional patterns in the trophic guild summer diet compositions.
- A portion of the variance in trophic guild diet composition could be explained by water mass, predator size, bottom depth, and location.
- Regular monitoring of the food habits of the demersal fish community (e.g., every few years) will be required to improve our understanding of the spatial and temporal variation in diet composition.
- Regular sampling will also improve our ability to identify and predict the impacts of climate change and commercial development on the trophic relationships of fishes in the Chukchi Sea.

Acknowledgments
This work was conducted as part of the Arctic Ecosystem Integrated Survey (Arctic Eis, https://web.sfos.uaf.edu/wordpress/arcticeis/) and was funded [in part] by the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM) through Cooperative Agreement M12PG00018 between BOEM, Alaska Outer Continental Shelf Region and the NOAA Alaska Fisheries Science Center. Thank you to Seth Danielson (University of Alaska Fairbanks) for providing oceanographic data. Thanks to Geoff Lang (NOAA) for data management. Thank you to all Arctic Eis survey participants who helped with stomach sample collection and the collection of oceanographic data. We would also like to extend our thanks to the Captain and crew of the F/V Alaska Knight, and the Captain and crew of the F/V Bristol Explorer for their efforts.