Diet compositions and trophic guild structure of the demersal fish community in the eastern Chukchi Sea

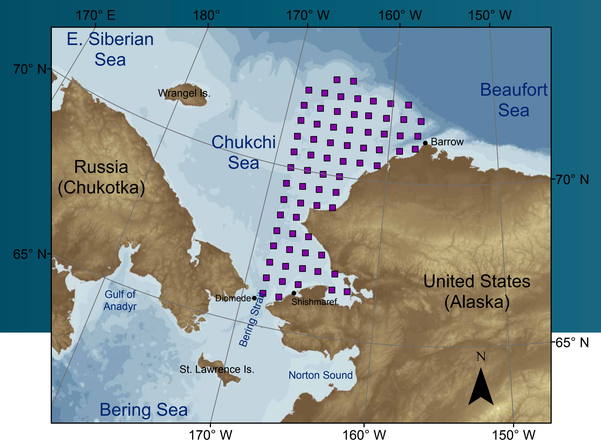

Figure 1. Map of stomach sampling locations in the eastern Chukchi Sea. All stomach samples were collected between 14 August and 18 September, 2012.

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Introduction

Fishes are an important link in the Chukchi Sea food web, connecting production on lower trophic levels to apex predators. Despite their central position in the food web, there are few studies examining the trophic ecology of demersal fishes in the Chukchi Sea. This study addresses this gap by conducting a comprehensive study of the food habits of demersal fishes of the eastern Chukchi Sea that exhibit a variety of feeding strategies. A convenient method for summarizing food habits data is through the use of trophic guilds, grouping together species exploiting the same resources. The use of trophic guilds in food web studies can simplify an otherwise complex web of interactions between numerous species to a more manageable food web.

The primary objectives of this study are to provide information on the feeding ecology of demersal fishes in the eastern Chukchi Sea, to identify distinct trophic guilds among the demersal fish community, and to describe differences and similarities in the trophic guild diet compositions.

Methods

- Stomach samples were collected during a benthic survey of the eastern Chukchi Sea in the summer of 2012. A total of 1,773 stomachs from 39 species of fish, were collected from 72 sampling stations (Figure 1). Predator sample sizes ranged from very low (n=1) for rarely encountered species, to greater than 100 for ubiquitous species.
- Diet compositions (as % weight) of fish species with adequate sample sizes (n ≥ 10 stomachs) were submitted to hierarchical agglomerative cluster analysis to identify trophic guilds (Table 1). Preliminary analysis indicated sized-based shifts in Arctic cod (*Boreogadus saida)* diet (perMANOVA, F=9.54, p<0.001). Therefore, they are divided into 3 size classes, small, medium, and large.
- Diet similarity was calculated with the Bray-Curtis (B-C) Similarity Index. Ward's Minimum Variance Method was used to cluster species into trophic guilds.
- Prey items that contributed most to dissimilarities between the diets of trophic guilds were identified with similarity percentages (SIMPER).
- The species diet compositions and clustering results are depicted in ordination space with the use of non-metric multidimensional scaling (NMDS).

Table 1. Total stomachs included in cluster analysis. The trophic guilds were identified from the cluster analysis. The abbreviations are used in the NMDS ordination.

Trophic guild	Common name	Abbreviation	Non-empty stomachs
Gammarid consumers			
	Canadian eelpout	CANAPOUT	16
	Marbled eelpout	MRBLPOUT	11
	Spatulate sculpin	SPATSCUL	21
	Hamecon	HAMECON	21
	Arctic staghorn sculpin	ASTAGSCL	102
	Arctic alligatorfish	ARCALGTR	43
	Kelp snailfish	KELPSNLF	94
	Slender eelblenny	SLNDREBL	143
Benthic invert consumers			
	Antlered sculpin	ANTLSCUL	14
	Ribbed sculpin	RIBDSCUL	46
	Stout eelblenny	STOUTEBL	24
	Arctic flounder	ARCTFLND	13
	Yellowfin sole	YLWFNSOL	13
Fish/Shrimp consumers			
	Rainbow smelt	RAINSMLT	28
	Saffron cod	SAFRNCOD	82
	Shorthorn sculpin	SHTHRNSC	57
	Variegated snailfish	VARISNLF	54
	Bering flounder	BERIFLND	94
Zooplankton consumers			
	Lg Arctic cod	LGARCCOD	39
	Med Arctic cod	MDARCCOD	435
	Sm Arctic cod	SMARCCOD	223
	Walleye pollock	WPOLLOCK	13
	Pacific herring	PHERRING	21

Results

- A phenon line was placed on the dendrogram at a dissimilarity of 1.25 resulting in four clusters (Figure 2). The four clusters were named based on the dominant prey types found in the composite guild diets; Gammarid amphipod consumers, Benthic invert consumers, Fish/shrimp consumers, Zooplankton consumers (Figure 3).
- Pairwise SIMPER analysis of trophic guild diet composition identified Gammarid amphipods, polychaete worms, and calanoid copepods as prey groups that contributed most to dissimilarity between trophic guilds (Table 2).
- NMDS ordination supported the cluster results and showed species were generally located nearest to other species from the same trophic guild (Figure 4). Species tended to be located near significant prey vectors (p<0.01) from their trophic guild diet composition. The areas in ordination space occupied by the four clusters are fairly distinct, with only the convex hulls from the gammarid consumers and benthic invert consumers having any overlap in the two-dimensional space (Figure 5).

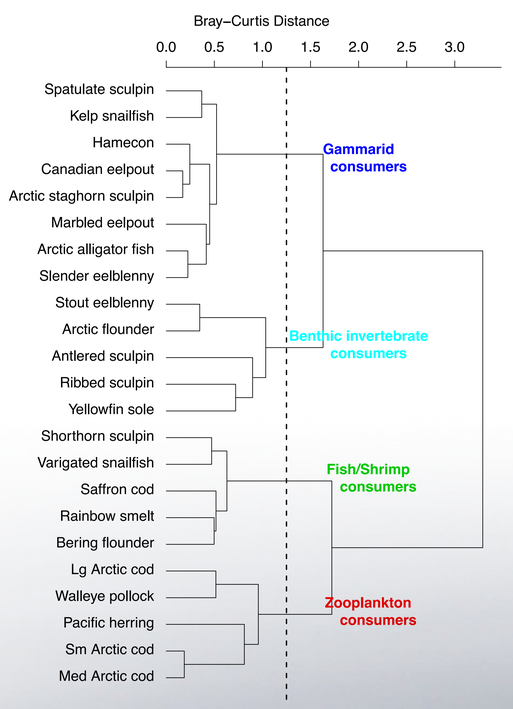

Figure 2. Dendrogram depicting the results of hierarchical agglomerative cluster analysis of the species diet compositions using Ward's Minimum Variance Method (cophenetic correlation 0.77, p<0.001, Mantel test).

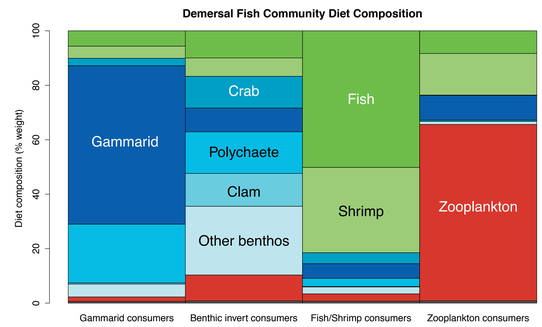

Figure 3. Diet composition of the trophic guilds identified with cluster analysis.

Table 2. SIMPER analysis of diet dissimilarities between trophic guilds identified in the cluster analysis. Below the diagonal are the groups that contributed most to dissimilarity in the pairwise comparison. Above the diagonal is the cumulative contribution the identified prey type made to between cluster dissimilarity. The guilds are GM (Gammarid consumers), BI (Benthic invert consumers), FS (Fish/Shrimp consumers), and ZP (zooplankton consumers).

Cluster	GM	BI	FS	ZP
GM		0.33	0.30	0.28
BI	Gammaridea		0.21	0.22
FS	Gammaridea	Polychaeta		0.17
ZP	Gammaridea	Polychaeta	Calanoida	

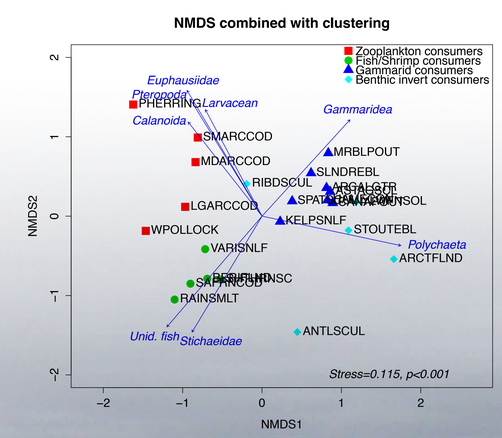

Figure 4. NMDS ordination constructed from the B-C matrix of diet dissimilarities. Loading vectors of significant prey types (p ≤ 0.01) are included (blue vectors and prey names) to aid interpretation of ordination results.

Conclusions

- The demersal fish community of the eastern Chukchi Sea has at least 4 distinct trophic guilds.
- Gammarid amphipods, polychaete worms, and calanoid copepods contribute most to dissimilarity between trophic guilds.
- A key limitation of this study is that predator diets are only described for a narrow window during summer and any seasonal changes in diet composition and thus, trophic guild membership are unknown.
- 18 of the 39 species of fish collected for diet analysis during this study had sample sizes too low (n < 10) to be included in the cluster analysis. Future stomach collections should focus on these poorly sampled species to develop a more robust understanding of trophic guild structure.

Acknowledgements

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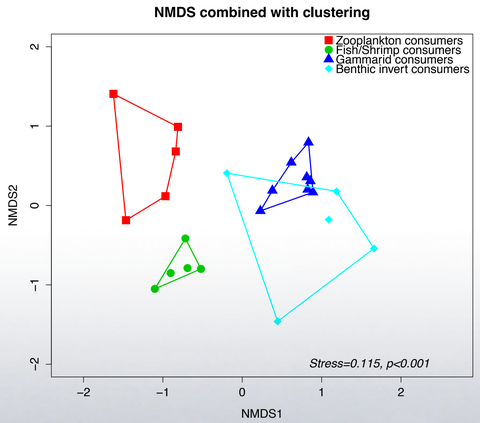

Figure 5. Two-dimensional NMDS ordination showing the convex hulls of the four trophic guilds identified in the cluster analysis.