Comparing Laboratory and at-Sea Analysis of Stomach Contents in Alaska

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Introduction:

Quantifying food web linkages is essential to understanding energy flow in the ecosystem and how external forces such as fishing and climate change may cause unanticipated shifts in ecosystem composition. For several years, the Resource Ecology and Ecosystems Modeling group of the Alaska Fisheries Science Center has conducted Stomach Content ANalysis at Sea (SCANS) in addition to regular collection and preservation of groundfish stomach samples (to be analyzed in the laboratory) during surveys of the Gulf of Alaska and Aleutian Islands regions (Figure 1, background).

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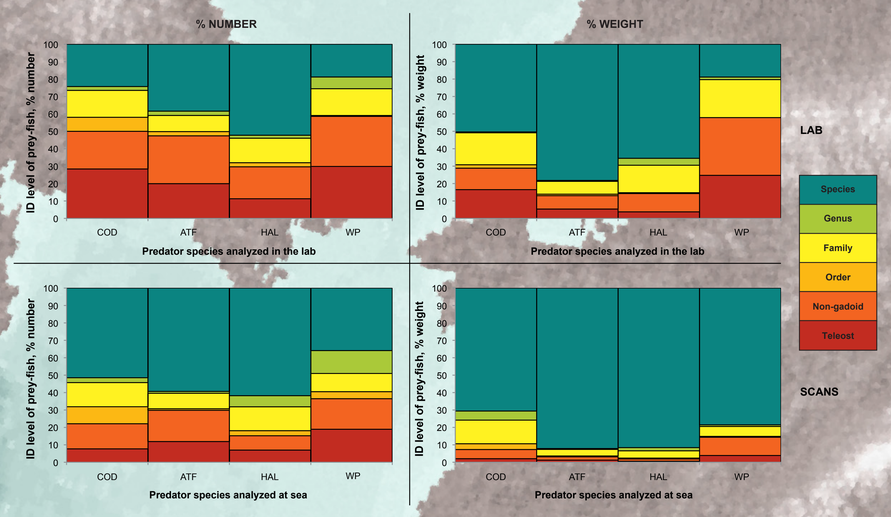

Figure 2. Identification levels of fish prey in the diets of four predators, Pacific cod (COD), arrowtooth flounder (ATF), Pacific halibut (HAL) and walleye pollock (WP), averaged from three surveys where stomach content analyses were performed in the laboratory (upper panels) and at sea (lower panels). The numeric distribution of the fish prey among the identification levels is shown in the two panels on the left side, and the weight distribution of the fish prey among the identification levels is shown in the two panels on the right side

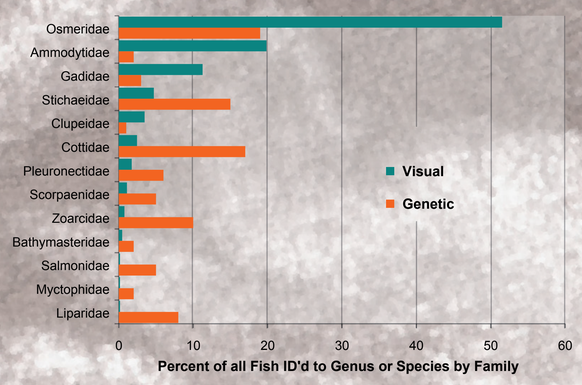

Figure 3. The composition (aggregated by family) of fish prey identified to genus or species from the stomachs of Gulf of Alaska groundfish in 2009 and 2011. For example, 51.5% of fish prey that were visually identified at least to genus were in the family Osmeridae. A subsample of the visually unidentifiable fish prey were then genetically identified. Families having ≤1% of the composition in both methods are not shown.

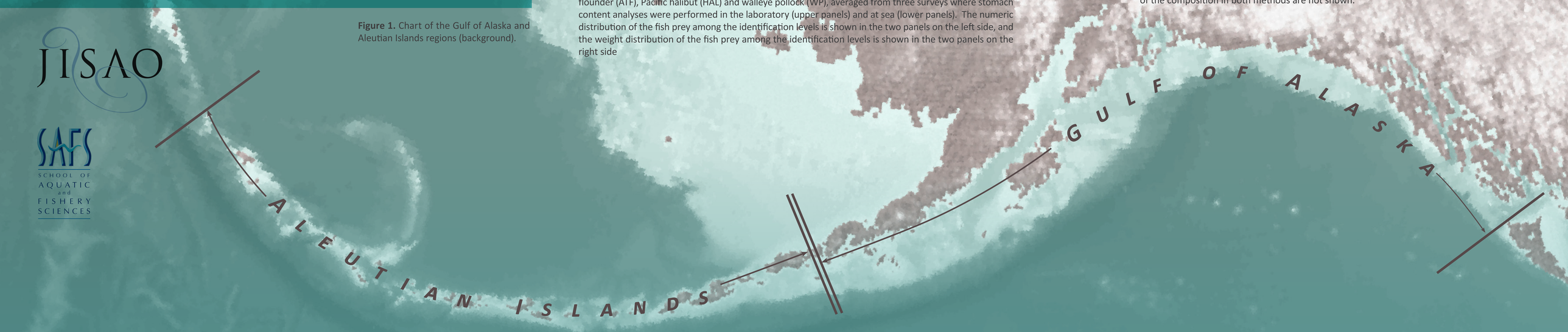

Figure 1. Chart of the Gulf of Alaska and Aleutian Islands regions (background).

Soft-bodied prey:

Identification of coelenterates (Cnidaria and Ctenophora) and pelagic urochordates (Thaliacea and Larvacea) differs between the two methods for some zooplanktivores. SCANS more frequently detected coelenterates in the diets of dark rockfish, dusky rockfish, prowfish and sablefish, but not in the diets of walleye pollock or Atka mackerel (Table 1). Dissolution of ctenophore tissues sometimes occurs during the preservation process and is likely the main factor in the differences observed. Neither method of analysis commonly detected coelenterates in the diets of walleye pollock or Atka mackerel indicating coelenterates are not common prey of these two species. Pelagic urochordates were more frequently identified in the preserved and laboratory examined stomachs of walleye pollock in 2009, but not in 2007 or 2010. It is unclear if one method is better than the other at detecting urochordates in stomach samples.

Table 1. The percent frequency of occurrence (%FO) of coelenterate prey and urochordate prey in the diets of zooplanktivorous groundfish in the Aleutian Islands and Gulf of Alaska. Pair-wise comparisons indicate significant some differences (*P = 0.01, **P = 0.005, ***P = 0.001).

			Sample size		Coelenterates %FO		Urochordates %FO	
Predator	Year	Region	Lab	Scan	Lab	Scan	Lab	Scan
Dark Rockfish	2010	AI	10	17	0.0	52.9*	0.0	17.6
Dusky Rockfish	2010	AI	8	4	0.0	100.0**	12.5	0.0
Prowfish	2010	AI	2	18	0.0	100.0*	0.0	5.6
Sablefish	2007	GOA	113	119	4.4	18.5**	0.9	3.4
Sablefish	2009	GOA	225	109	4.0	16.5***	0.9	0.9
Sablefish	2010	AI	13	11	30.8	36.4	0.0	0.0
Atka Mackerel	2007	GOA	23	11	0.0	0.0	21.7	63.6
Atka Mackerel	2009	GOA	17	15	0.0	0.0	11.8	13.3
Atka Mackerel	2010	AI	283	107	0.0	1.9	15.9	13.1
Walleye Pollock	2007	GOA	347	442	0.0	1.8	20.2	18.3
Walleye Pollock	2009	GOA	659	359	0.0	0.3	38.8***	11.1
Walleye Pollock	2010	AI	284	137	0.4	1.5	27.1	24.1

Fish prey:

The identification level of fish prey differs between the two analysis methods for some piscivores. The percentage of fish identified to species was higher using SCANS of Pacific cod, arrowtooth flounder, Pacific halibut, and walleye pollock (Figure 2). Analysts benefit from being able to examine the color and texture of the unpreserved, partially digested tissues. Another contributing factor is the reduced ability to detect unidentifiable fish during SCANS, such as partially digested, larval-stages and residual hard parts from fully digested fish prey, without the aid of a microscope. Visual identification of some digested fish to narrow taxonomic categories can be difficult. Numerically, large percentages are not identified to species, but these are mostly well digested fish with few parts remaining in the stomach, so when weight is considered, the percentages that are identified to species are larger for both methods (Figure 2). An exception to this appears to be walleye pollock analyzed in the laboratory, and suggests a greater uniformity in the size of fish prey, regardless of the level of digestion, in these stomach samples.

Genetic identification of visually unidentifiable fish prey:

Genetic identification of fish prey that could not be visually identified at least to order (non-gadoid or unidentified teleost categories) indicated a species composition that was different than the fish prey that were visually identified (Figure 3). Several common forage fish can be identified to species at all levels of digestion because of distinctive bones and otoliths that remain intact throughout the digestion process, while other fishes become indistinguishable through visual means after very little digestion occurs. When diet composition data is being compiled for ecosystem energy flow models, the assumption that the unidentified fish portion of the diet can be represented by the composition of the identified fish prey is unlikely to be true.

Acknowledgements: We thank all the AFSC survey participants, and especially those who collected and analyzed the stomach contents of thousands of Alaskan groundfish used in this study.

Conclusions:

Using both stomach content analysis methods will result in better descriptions of the marine foodweb linkages in Alaskan waters than using either method alone.

Predation rates on coelenterates may be underestimated for some fishes when based on preserved stomach samples, and corrections may be necessary.

The species composition of unidentified fishes in the diet is different than the species composition of the visually identified fishes.

Benefits of each method:

Preservation and laboratory analysis:

- Higher sample sizes per species; especially important when diet is diverse.
- Potentially more species can be sampled.
- Minimal training is required to collect samples.
- Less affected by weather conditions.
- Greater ability to detect small prey types and small parts of prey.
- Greater precision in weight measurements of prey.
- Easier access to a wide range of taxonomic references and expertise.
- Potentially greater contribution to other survey duties.

Stomach Content ANalysis at Sea (SCANS):

- Faster delivery of data used in management and ecosystem models.
- Higher detection of coelenterates in the diet of predators that consume them.
- Identifications aided by characteristics of prey color, tissue color/texture, and catch.
- Allows for genetic identification of prey that are not visually identifiable.
- Reduced purchase, transportation, storage and use of chemicals.
- Lower volumes of sample storage capacity are required.

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