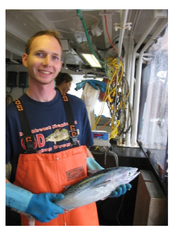
Comparing Methods for Food Habits Data: "Sea-truthing" At-sea Stomach Sampling with Laboratory Processing

Brian E. Smith and Jason S. Link

National Marine Fisheries Service, Northeast Fisheries Science Center, Food Web Dynamics Program, Woods Hole, Massachusetts, USA

ABSTRACT

As part of an ongoing multispecies and ecological surveying program of the Northeast U.S. continental shelf, the Northeast Fisheries Science Center has examined fish stomach contents at sea or in the laboratory. Identifying fish food habits at sea for a large marine ecosystem is challenging, particularly due to logistical constraints, sample size limitations, prey taxonomic resolution, and identification of highly digested prey. This study evaluated food habits data collected and processed both at sea and in the lab during 2004-2005. We particularly wanted to evaluate issues such as prey identification accuracy, prey taxonomic resolution, accuracy of prey volume estimates, and frequency of empty stomachs. We compared the food habits data from approximately 8,000 stomachs examined at sea with over 600 stomachs collected concurrently but processed in the lab. We detected only few significant differences in the quality of food habits data collected at sea and processed in the laboratory. As expected, the chief differences were the increased taxonomic resolution of invertebrate prey and increased precision of estimated prey weight from stomachs processed in the lab. Overall these results show that differences are minor, and represent acceptable compromises given the large spatial and temporal scope of our sampling and programmatic objectives.

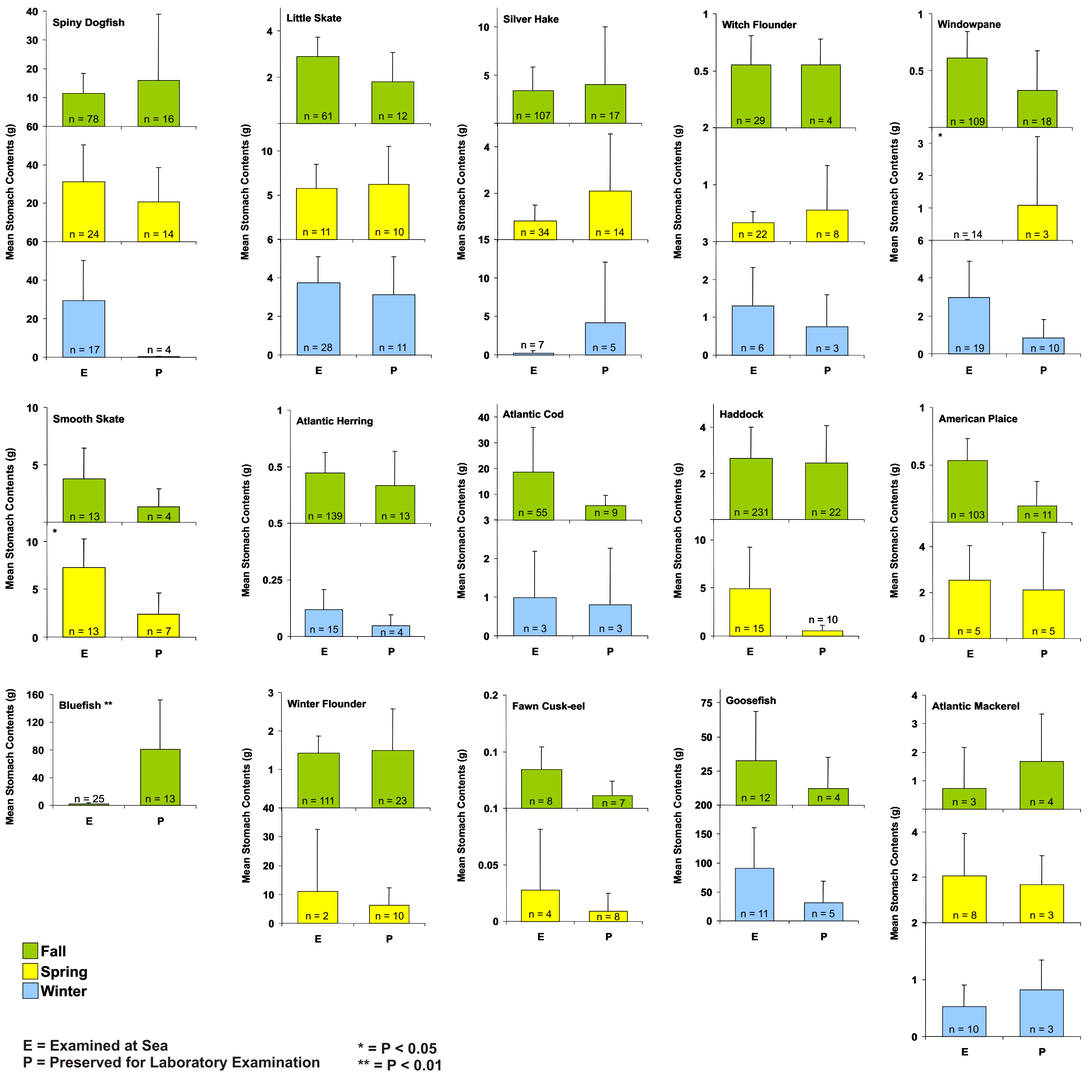


METHODS

The stomach samples for this study were examined at sea and preserved for laboratory inspection during the multispecies bottom trawl survey (BTS) conducted by the Northeast Fisheries Science Center (NEFSC) from 2004-2005. BTS are conducted seasonally (Spring, Fall, and Winter) each year, sampling 300-400 (Spring and Fall), and 100-200 (Winter) randomly selected stations within a depth-stratified region (NE US continental shelf). Approximately every 25th station stomachs routinely sampled at sea were preserved for laboratory inspection. At-sea volumes for total prey amount were converted to grams using the conversion 1.1cm^3 to 1g (Link and Almeida 2000).

At sea, total stomach contents were estimated as volumes (nearest cm^3). In the lab, stomach contents were estimated as mass (nearest 0.01g). Analyses for this study explored a suite of metrics to compare at-sea VS in laboratory stomach contents from 27 predators. We grouped the data by species, season, strata, and predator size class to account for expected seasonal, geographic, and ontogenetic feeding variations. The metrics used include mean stomach content (g), percent frequency of occurrence of empty stomachs, percent diet composition by weight of well digested prey, and percent diet composition by weight for the major prey items identified for each predator by season. Mean stomach contents (g) were compared using a t-test (error bars represent 95% CI). To test for the significance between the percent frequency of empty stomachs among predators we employed a chi-square test with Yates correction for continuity. The percent diet composition of well digested prey was tested using the arcsin transform for percent well digested prey and variance followed by a t-test. The percent diet composition of major prey for each species by season was quantitatively evaluated using 95% CI. Individual sample sizes are provided.

Comparison of Seasonal Mean Stomach Content Amount (g) by Species

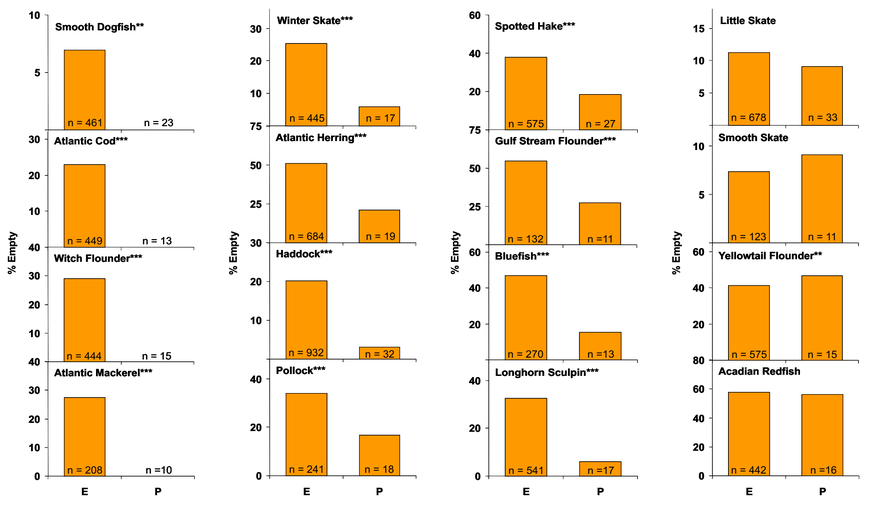


E = Examined at Sea
P = Preserved for Laboratory Examination

* = P < 0.05
** = P < 0.01

- The amount of food consumed at sea was generally similar to that measured in the laboratory.
- Out of 27 species there were only three species that had significant differences in the amount of stomach contents.
- Only one species (bluefish) was significantly different in the fall while two species (smooth skate and windowpane) were significant in the spring.
- This suggests reasonable accuracy in estimating stomach contents at sea when compared to estimates in the lab.

Percent Frequency of Occurrence of Empty Stomachs by Species



E = Examined at Sea
P = Preserved for Laboratory Examination

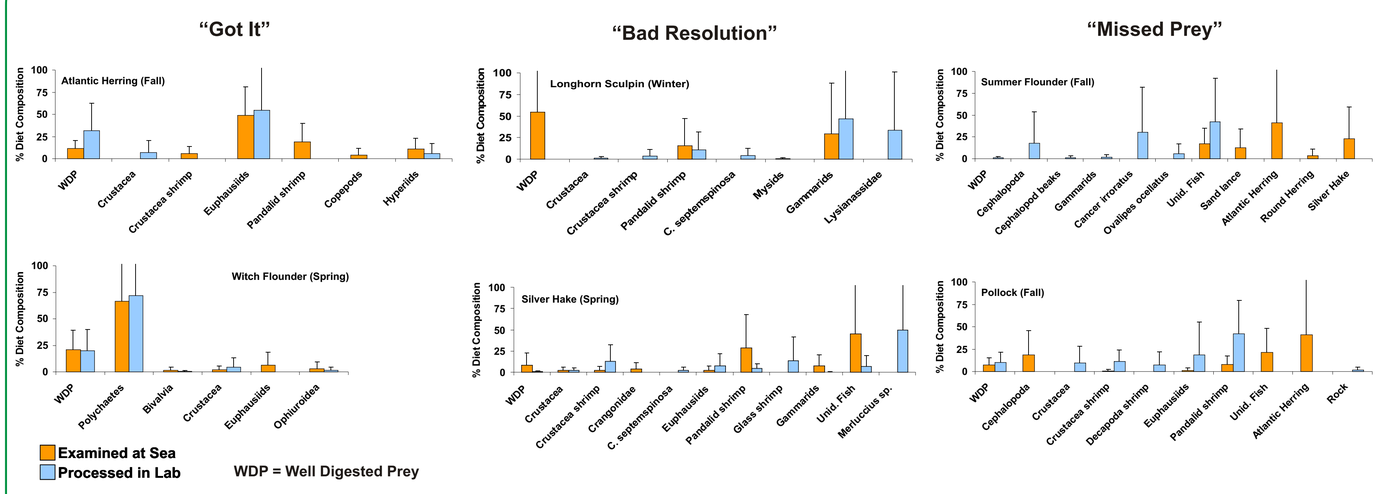
** = P < 0.01
*** = P < 0.001

Ratio of Percent Empty Stomachs Examined at Sea (E) VS Percent Empty Stomachs Examined in the Lab (P) by Species

Smooth Dogfish	NA
Spiny Dogfish	1.580771
Winter Skate	4.316854
Little Skate	1.233038
Smooth Skate	0.804878
Atlantic Herring	2.423611
Silver Hake	1.230922
Atlantic Cod	NA
Haddock	6.454936
Pollock	2.041494
White Hake	0.614393
Red Hake	1.324304
Spotted Hake	2.047304
American Plaice	1.649322
Summer Flounder	1.148064
Fourspot Flounder	1.48
Yellowtail Flounder	0.88323
Winter Flounder	1.642651
Witch Flounder	NA
Windowpane	1.220209
Gulf Stream Flounder	2
Atlantic Mackerel	NA
Bluefish	3.057407
Acadian Redfish	1.025641
Longhorn Sculpin	5.499076
Fawn Cusk-eel	1.835681
Goosefish	1.583981

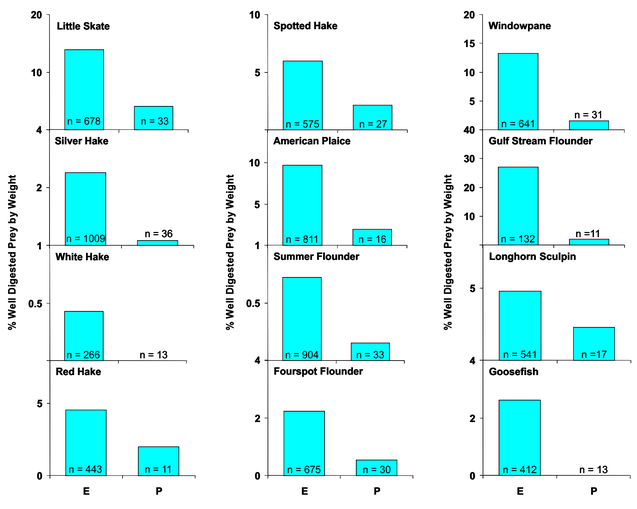
- A higher percent frequency of empty stomachs was observed at sea compared to in the laboratory.
- For a few species (smooth dogfish, Atlantic cod, witch flounder, and Atlantic mackerel) no empty stomachs were recorded in the laboratory.
- Other species that are particularly noteworthy are species with a ratio of at-sea to laboratory percent frequency of > 2 (winter skate, Atlantic herring, haddock, pollock, spotted hake, Gulf Stream flounder, bluefish, and longhorn sculpin)
- Twenty-four out of 27 species had a significant difference between at-sea VS laboratory examination.
- These results indicate small amounts of prey (<0.01 g) may be overlooked at sea.
- Overall, observing a greater amount of empty stomachs at sea VS in the laboratory is not surprising given the conditions of working at sea (e.g. macroscopic inspection, sea-state conditions, and time).

Prey Comparison: Percent Diet Composition by Weight for each Species



- In general, the taxonomic resolution for invertebrate prey was better for stomachs examined in the laboratory.
- For the 27 fish species studied, 13 species had similar diet compositions when comparing at-sea VS laboratory examination ("Got It": Atlantic herring and witch flounder).
- Eight species had prey ID that were similar, but had slightly greater taxonomic resolution in the lab ("Bad Resolution": longhorn sculpin and silver hake).
- Six species had notably different diet compositions ("Missed Prey": summer flounder and pollock).
- This suggests the overall quality of the stomach sampling performed during 2004-2005 was acceptable, though we may consider a higher degree of laboratory processing for certain species (longhorn sculpin), and the concern for overlooked prey items (summer flounder and pollock).

Percent of Well Digested Prey by Weight for each Species



E = Examined at Sea
P = Preserved for Laboratory Examination

Ratio of Percent Well Digested Prey Examined at Sea (E) VS Percent of Well Digested Prey Examined in the Lab (P) by Species

Smooth Dogfish	1.873878
Spiny Dogfish	0.593863
Winter Skate	1.720721
Little Skate	3.426096
Smooth Skate	0.496629
Atlantic Herring	0.612557
Silver Hake	15.675
Atlantic Cod	0.293738
Haddock	0.854378
Pollock	1.086
White Hake	NA
Red Hake	2.301363
Spotted Hake	2.773129
American Plaice	5.037824
Summer Flounder	4.786667
Fourspot Flounder	4.173258
Yellowtail Flounder	0.459451
Winter Flounder	1.633976
Witch Flounder	1.141734
Windowpane	8.983696
Gulf Stream Flounder	14.16448
Atlantic Mackerel	0.772789
Bluefish	0.265271
Acadian Redfish	1.210626
Longhorn Sculpin	2.101354
Fawn Cusk-eel	1.320564
Goosefish	NA

- In general, a greater amount of well digested prey was observed at sea VS in the laboratory.
- Out of 27 species, none were significantly different when comparing the percent of well digested prey observed at sea and in the lab.
- Ratios of at-sea to laboratory percents of well digested prey >2 (little skate, silver hake, white hake, red hake, spotted hake, American plaice, summer flounder, fourspot flounder, windowpane, Gulf Stream flounder, longhorn sculpin, and goosefish) identify predators with a relatively high percent of well digested prey examined at sea.
- These results suggest some predators where we should enhance our food habits training.

CONCLUSIONS

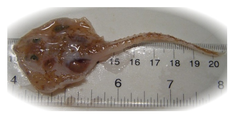
Overall our food habits sampling at sea appears to be adequate. This study has identified further areas for refinement and improvement.

The higher percent frequency of empty stomachs at sea suggests we need to improve our prey detection ability. However we are not significantly missing any commercially important prey items. Most of what we detected in the lab and missed at sea were small invertebrates (e.g. amphipods, mysids, and other small crustaceans).

The fact that the amounts of food estimated at sea VS in the laboratory are similar suggests that this sampling protocol is reasonable.

The lower taxonomic resolution and higher percent frequency of well digested prey at sea identifies certain predators for which we could enhance our food habits training.

When executing a study like this there are obvious tradeoffs between sampling at sea and in the laboratory. This study highlights the strengths and weaknesses of both approaches. This study also demonstrates some acceptable compromises to implementing a food habits sampling program of this scale and scope.



Literature Cited

Link, J.S. and Almeida, F.P. 2000. An Overview and History of the Food Web Dynamics Program of the Northeast Fisheries Science Center, Woods Hole, Massachusetts. *NOAA Tech. Memo. NMFS-NE*-159; 60p.