Overview and metadata of the Food Web Dynamics Program

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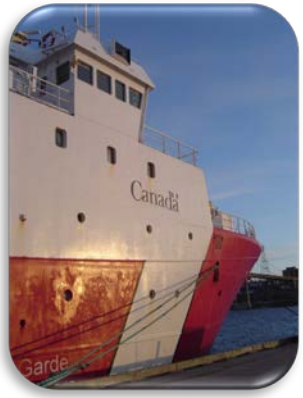
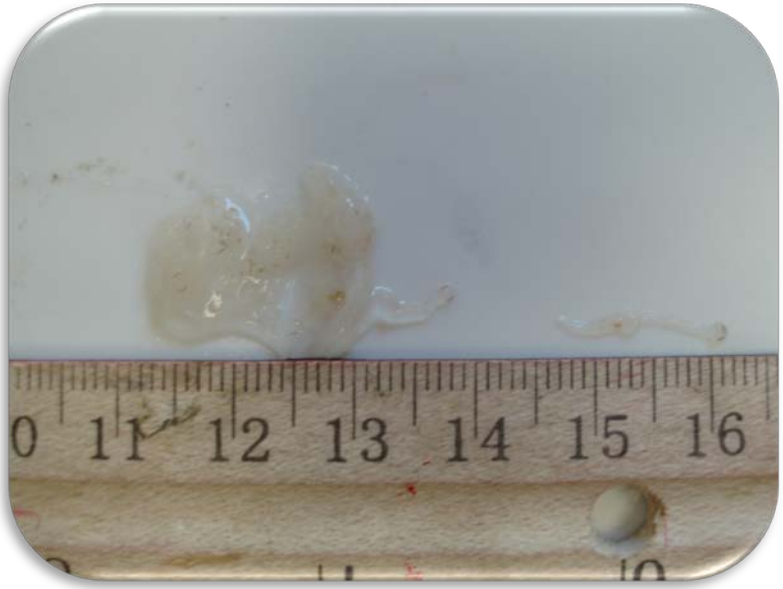


CCGS Teleost



Identifying fish stomach contents

Tagging yellowtail flounder

Program Objectives

1. Quantify fish trophic interactions of the NE U.S. continental shelf.
2. Estimate predation mortality, and model species interactions that influence the status of commercial fish stocks.
3. Relate diet variability to changes in population- and community-level processes.

Diet Sampling

1. Fish diet monitoring program:
   - Ongoing, seasonal fish diet sampling.
   - Primary data.

2. Process-oriented studies:
   - Address specific questions.
   - Time-limited.

Diet Monitoring

1. Bottom trawl sampling with depth-stratified, random design.

2. From 1973 to present, primarily cod, hakes, flounders.

3. From 1977 to present, expand to 195 total predators, but 31 sampled throughout time series (4000+ stomachs), mainly groundfishes, pelagic finfish, and elasmobranchs.

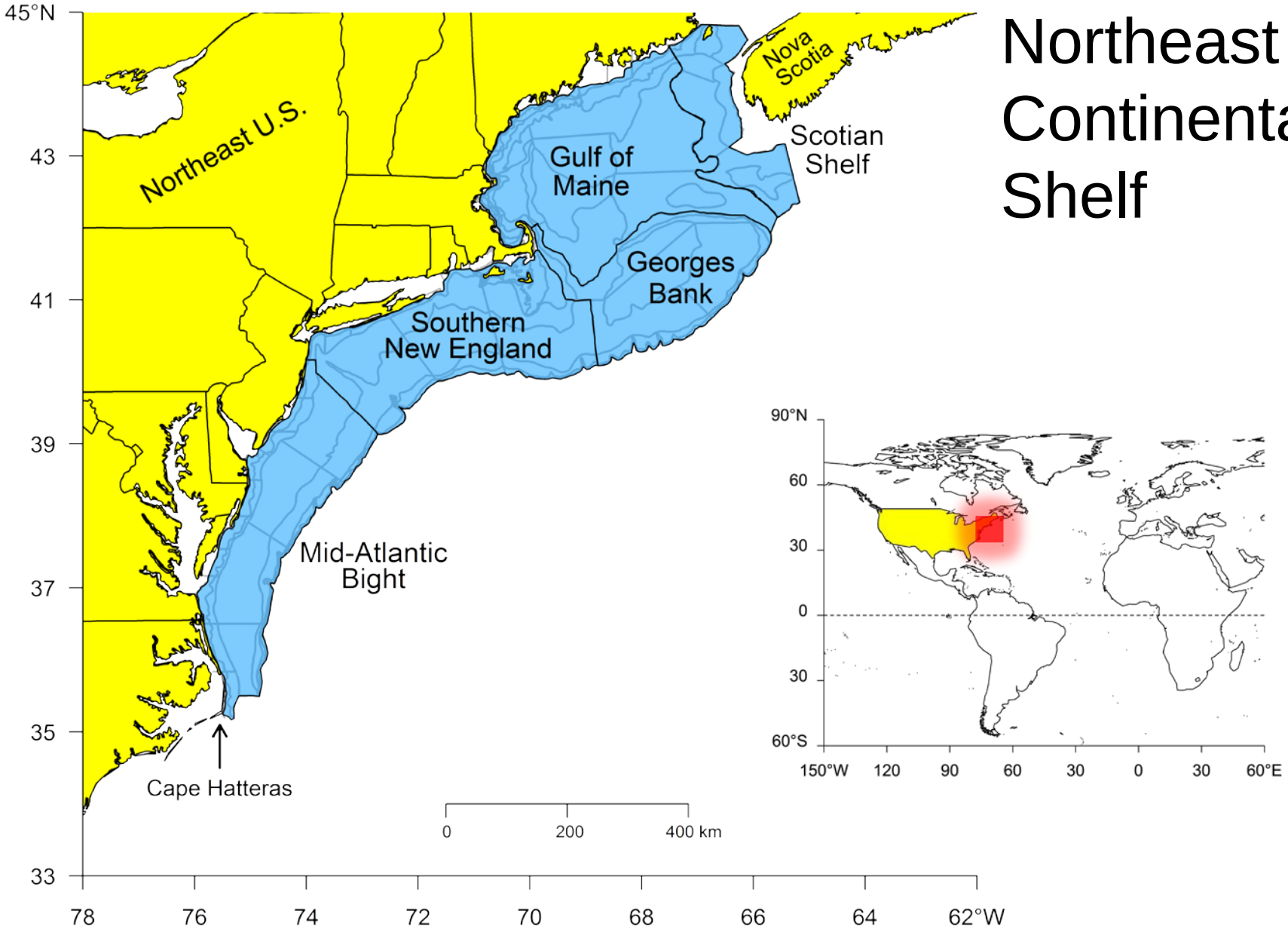
Diet Monitoring

1. Two primary seasons: spring, fall, but winter (1992-2008) & summer (1977-1981, 1991-1995) also available.

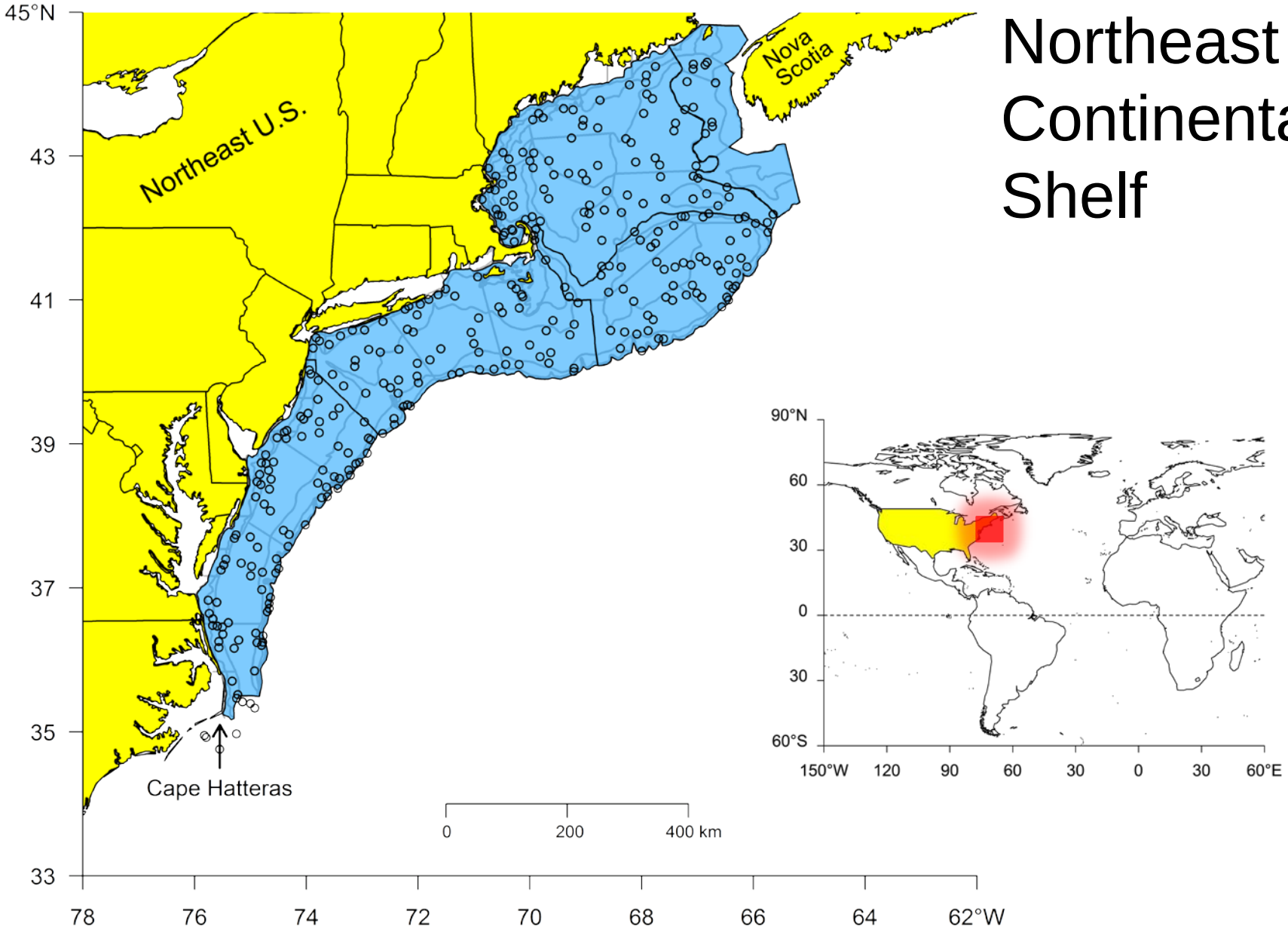
2. Broad geographic coverage of NE US continental shelf.
   – Cape Hatteras, North Carolina to Nova Scotia.

3. Collect ~ 15,000 – 20,000 stomachs annually.

Northeast U.S. Continental Shelf



Northeast U.S. Continental Shelf



At-sea Biological Sampling

Length

Weight

Age & Growth

Sex & Maturity

Diet Monitoring

Special Sampling

Station Complete

Time

At-sea Diet Monitoring

1. Predator selection based on bottom trawl catches.
2. Currently ~ 60 predators of interest.
3. Sampling protocols are length-based (1 per 1, 5, 10, or 20 cm), depend on fish abundance and diet sampling history.
4. Number of stomachs collected per predator depends on length distribution per tow (no maximum).

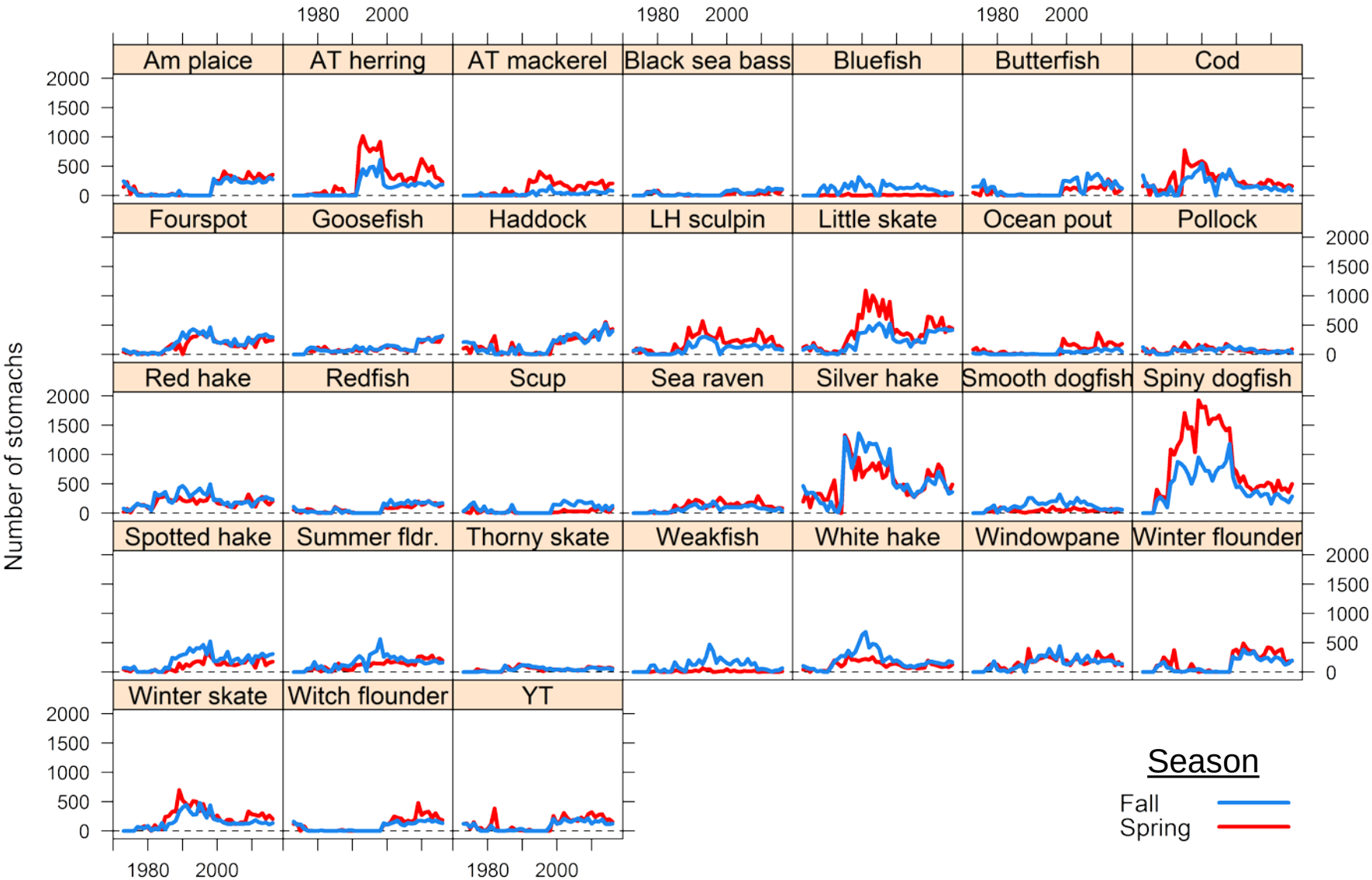
At-sea Diet Monitoring (macroscopic)

1. From a selected subset of trawl catch.
2. Stomachs eviscerated, individual samples.
3. Total volume measured.
4. Prey taxa separated, % estimated.
5. Prey digestion noted (Fresh, Partial, Well).
6. Prey abundance estimated.
7. Prey lengths measured for key prey.
8. Prey comments (parasites, trawl feeding).

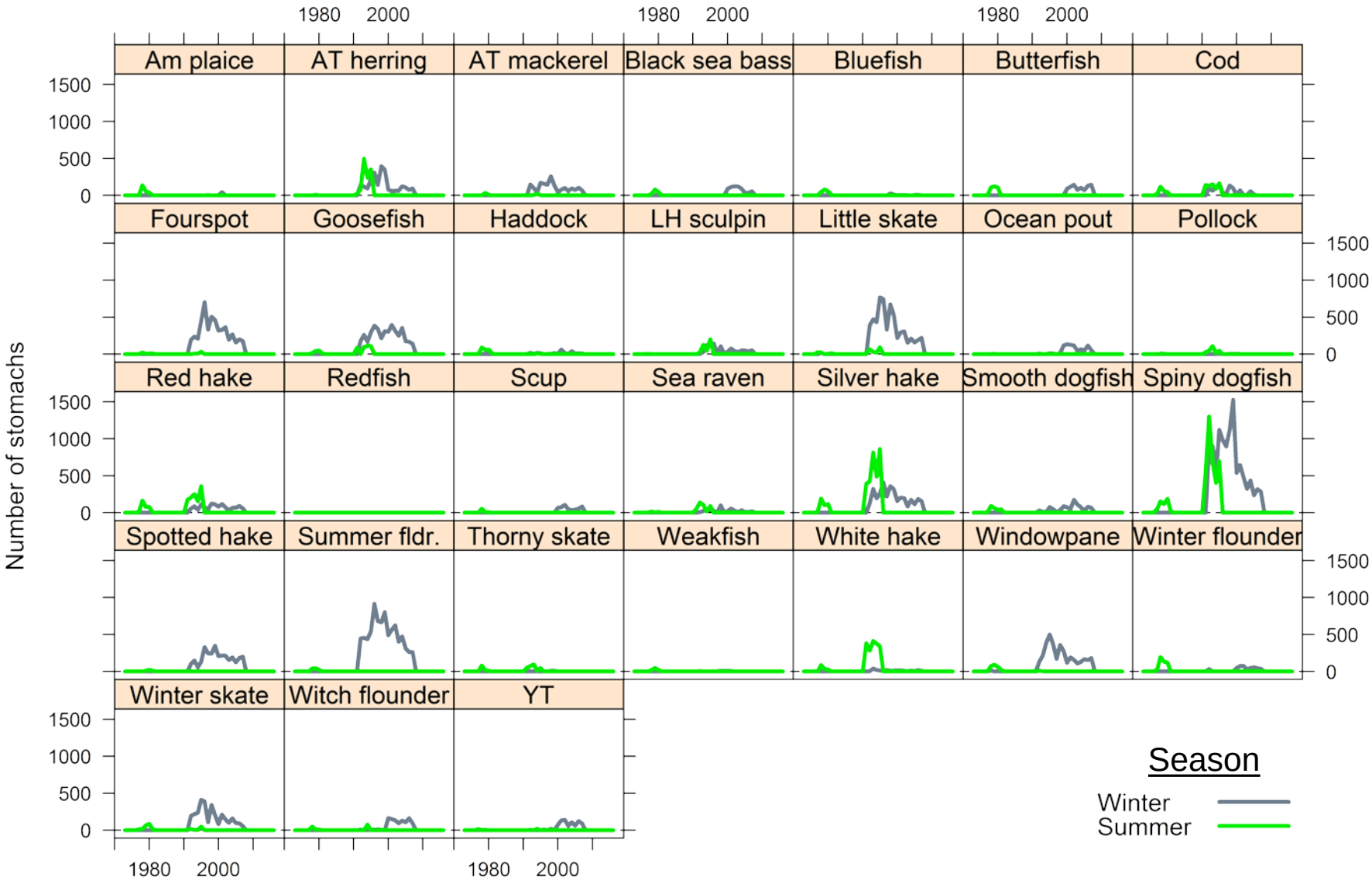
In-lab Diet Monitoring (microscopic)

1. Individuals <12.5 cm preserved for laboratory sampling.
2. Microscopic examination.
3. Prey taxa separated, weighed, % and total weight calculated.
4. Reduces challenges at sea, and allows identification of small prey.

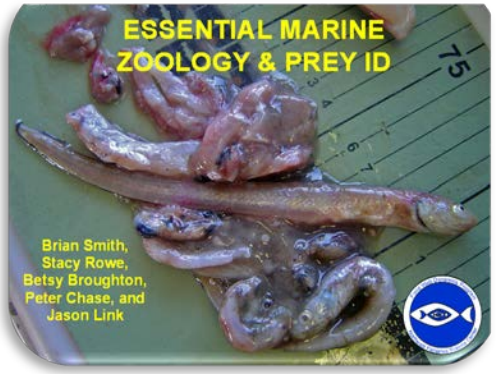
Sampling by Species and Season



Sampling by Species and Season



Prey Taxonomic Resolution



1. Most of our acceptable taxonomic resolution levels are reasonable even for novices; usually class or order (some family) for most inverts, genus or species for most fish.
2. Over 1,300 distinct prey taxa in database.
3. Offer marine taxonomy/prey id (lecture) and “hands on” (lab) workshops each year.

Prey Taxonomic Resolution

1. Prey taxa are requested to be at the most resolved taxonomic level a scientist is comfortable reporting.
2. Advice is to choose a taxonomic level with most confidence.
3. Tradeoff of lower taxonomic resolution vs greater speed of stomach processing (and thus greater # of stomachs).

QA/QC Diet Monitoring

S. Pike

1. Every 25th station, 2004-2010.
2. All samples that would have been processed at sea are brought back to the lab for microscopic examination.
3. Prey taxa separated, weighed by taxa, % and total weight calculated.
4. Prey abundance and lengths measured.

QA/QC Diet Data

Digested Ctenophora

1. At-sea data auditing (real-time checks for required data and data limitations).
2. In-lab, Program staff run data audits (15 error checks for missing data, taxonomic accuracy, sampling accuracy, etc.).
3. Clean data are loaded into data structures (R, SAS, and Oracle) and entire time series monitored for inconsistencies.

Diet Data Gaps

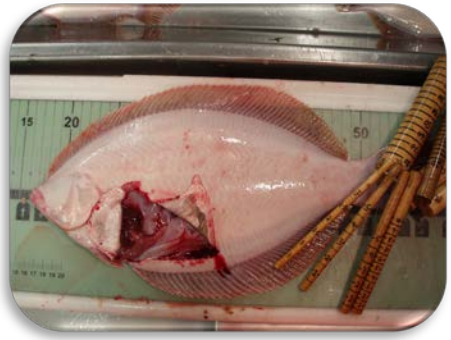
A. Miller

1. Summer and winter seasons for all species.
2. Inshore areas along NE coast.
3. Other geographic regions of importance (e.g. canyons, closed areas).
4. Data specific to bottom trawl survey.
5. Aim to provide a broad understanding of fish trophic ecology to address many predators and prey over entire continental shelf.

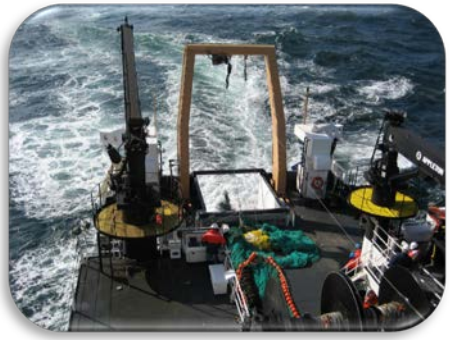
Rationale for Protocols

1. 1950s – 1960s benthic research program identified prey of haddock and other gadids to explore their declines.
2. Mid 1960s, ad hoc diet studies on bottom trawl surveys for commercial groundfish.
3. Late 1960s – early 1970s, multispecies considerations first formalized, ad hoc sampling.
4. Systematic diet sampling began in 1973 with creation of predecessor groups to FWDP.

Rationale for Protocols



1. Late 1970s – mid 1980s, diet sampling shifted from in-lab to at-sea.
2. Sampling time and staffing costs questioned with increases in sampling.
3. At-sea sampling more cost- and time-efficient particularly for fish prey and informing stock assessments.
4. Mid 1980s to present, primarily sampling at sea, targeting more predators and less samples per predator. Staff levels reduced.



Funding and Support

1. Program includes two permanent federal employees, occasional contractors and post-docs.

2. Funding for Program staff falls under mission critical objectives and current strategic plans.

3. Funding for primary sampling (ship time and staff) is part of overall budget for NEFSC bottom trawl survey (high priority).

L. Smith

Major Lessons Learned

1. Important to sample ecosystem of predators rather than limiting sampling to predators with commercial value.

2. At-sea versus in-lab sampling tradeoffs (considering diet, number of predators, predator sizes, data needs, data density needs, and associated costs), yet both present similar challenges.

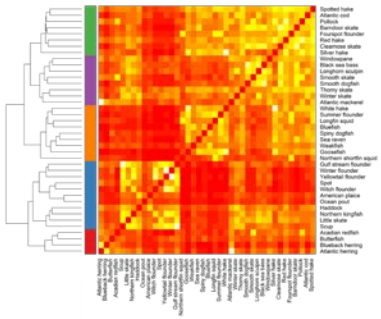
3. Diet variability and uncertainty.

4. Finding a “happy medium.”

Process-oriented Studies

1. Designed to answer specific feeding questions (time- and location-specific) and often in collaboration with other researchers.

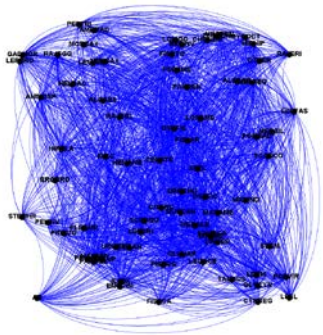
2. Recent examples:
   - Diadromous fish predation study (coastal Maine).
   - Examining fish predation with molecular techniques (cooperative with industry).
   - Dietary effects of bottom fishing disturbance (Georges Bank).
   - Fine-scale diet of Atlantic cod (cooperative with industry).



Trophic Grouping

Statistical Analyses

1. Multivariate by design considering multiple predators, prey, and potential drivers (numerous tests available).
2. Time series trends and analyses.
3. Fishes as samplers of non-adequately sampled prey (e.g. benthos and plankton).
4. Bayesian/MCMC and other computer-intense methods to avoid typical statistical assumptions and data transformations.



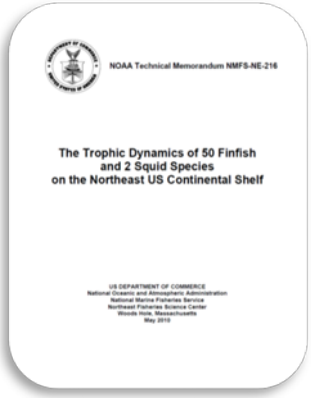
Food Web

Analytical Products

1. Time series of diet indices and measures of consumption (quantity removed) for informing natural mortality in fish stock assessments.
2. Linking dietary changes to prey availability and anthropogenic and environmental drivers.
3. Assessing shelf-wide predatory responses of major dietary guilds of fishes.
4. Witnessing changes in the importance of prey over time.

Databases

1. Food Habits Database: predator, prey, and prey length tables.
2. > 655,000 stomachs, > 1.5 million records in entire database.
3. Primary database in Oracle, and create R, SAS, and other data structures to use the data.
4. Database has 66 (85 total) fields, is relational and maps to other Oracle tables.



Primary Data Users

1. Food Web Dynamics Program (publications, reports, informing stock assessments, data mining).

2. Internal Branches and post-docs: Ecosystem Dynamics and Assessment, and Population Dynamics.

3. External: Academics, graduate students, other U.S. federal agencies and foreign counterparts.

D. Chevrier

Conclusions

1. Maintaining a diet sampling program is challenging, but achievable with multi-level support from field and IT staff to Center Leadership with clear mission objectives.
2. As we push towards an ecosystem-understanding of continental shelves, monitoring predator-prey interactions is critical.
3. Globally, one of the largest fish diet databases available (i.e. data density and temporal coverage).

A. O'brien

Thank you!

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https://www.nefsc.noaa.gov/femad/pbb/fwdp/