Integrative Assessment of the Quality of Shallow Tributary Forage Habitats for Striped Bass in Chesapeake Bay

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Goals and objectives

Project goals: To quantify the quality of shallow tributary habitats of Chesapeake Bay as foraging habitat for Striped Bass and to identify key prey species in those habitats across life-history stages.

Objectives:

1. Collect Striped Bass at 5 sites in early summer, late summer, fall
2. Assess age and size structure, condition, growth, and parasites
3. Quantify diet and nutrition (morphology, genetics, isotopes)
4. Relate diet, condition, growth, parasitism, and environmental variation to assess habitat quality

Coastal Development: Status and Future Trends

Current shoreline hardening – Bulkhead/Riprap
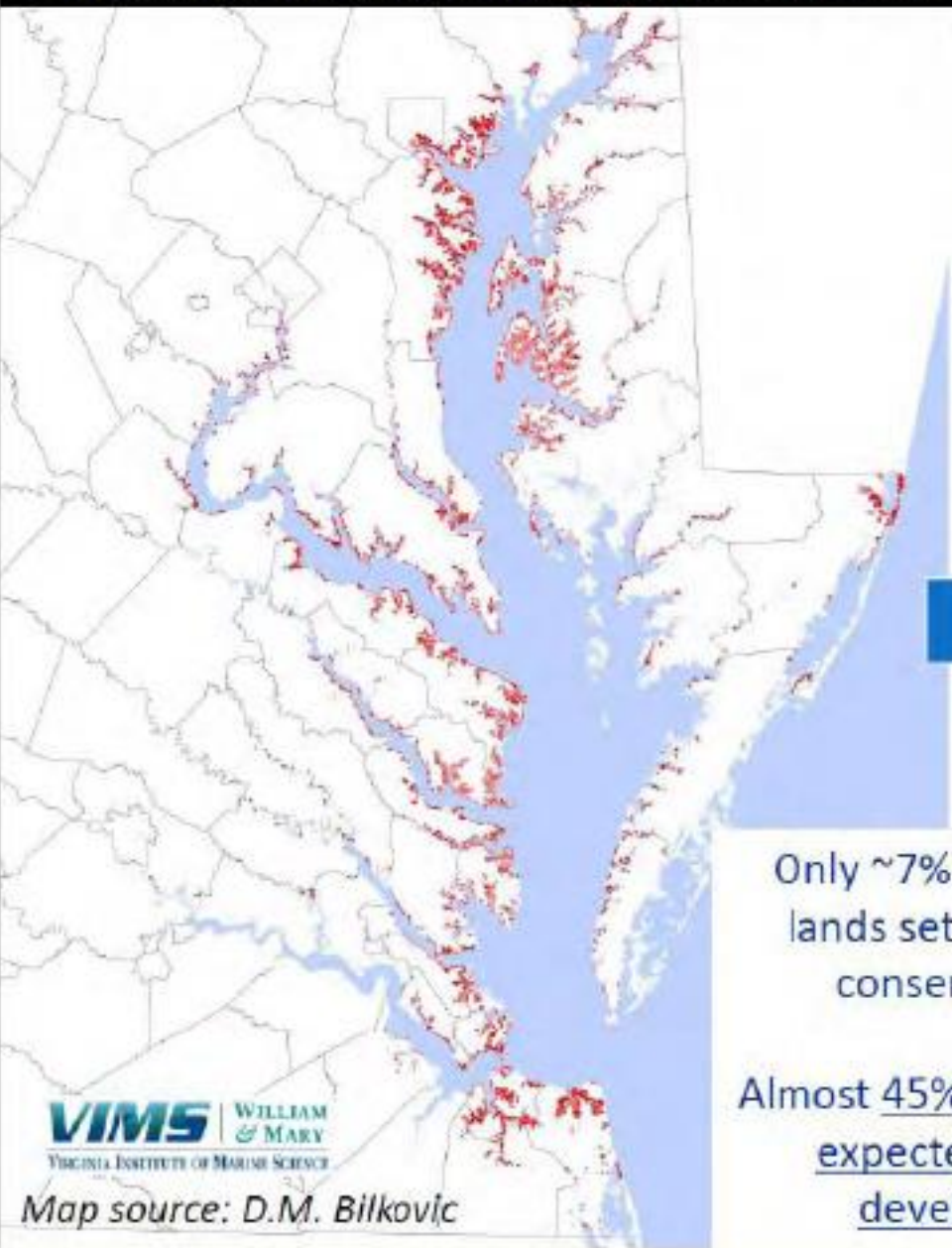
Future shore protection
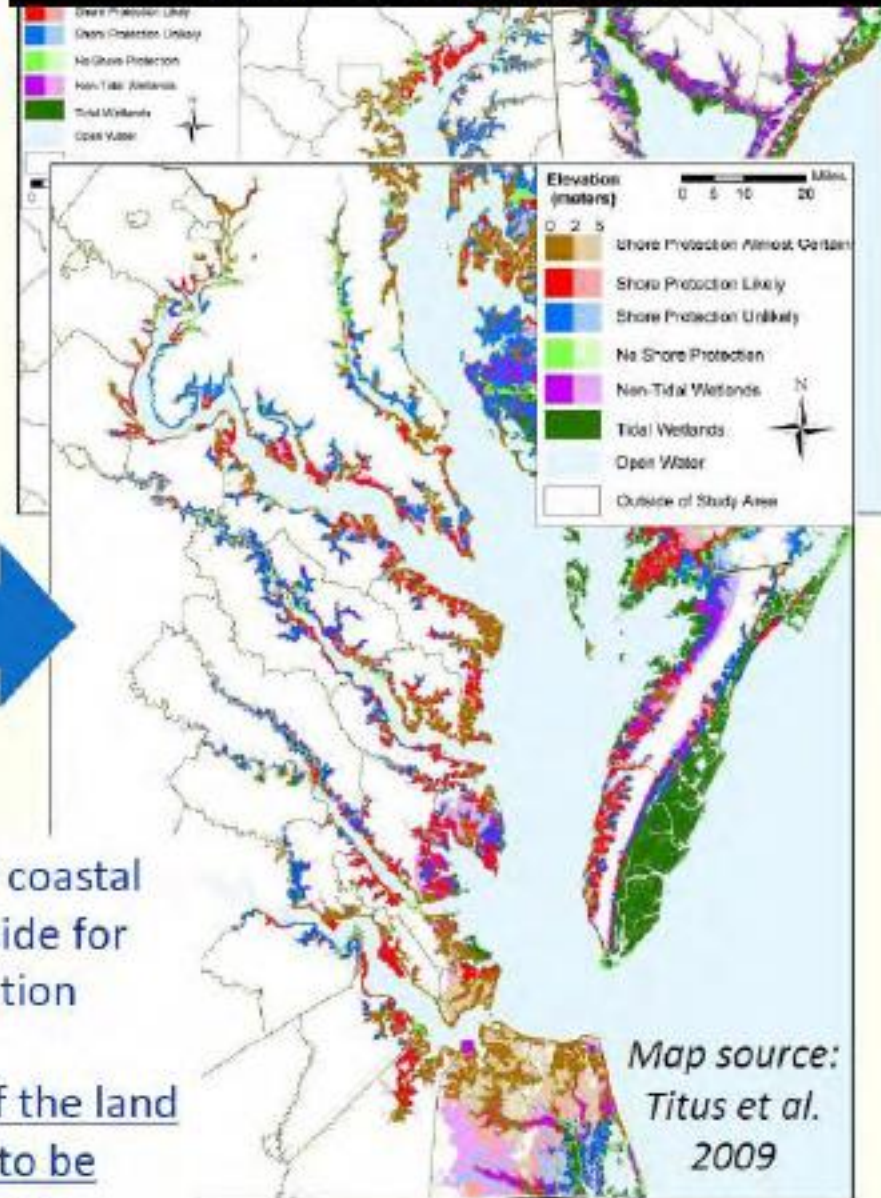
Only ~7% of coastal lands set aside for conservation

Almost 45% of the land expected to be developed

Map source: D.M. Bilkovic

Map source: Titus et al. 2009

Ihde et al. 2015
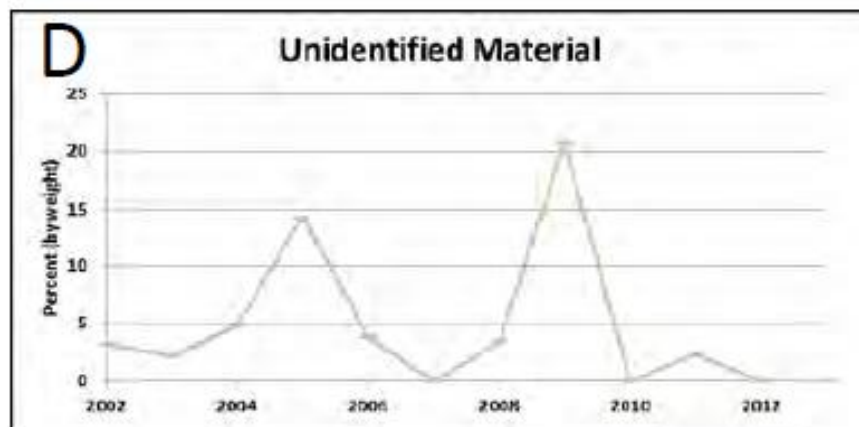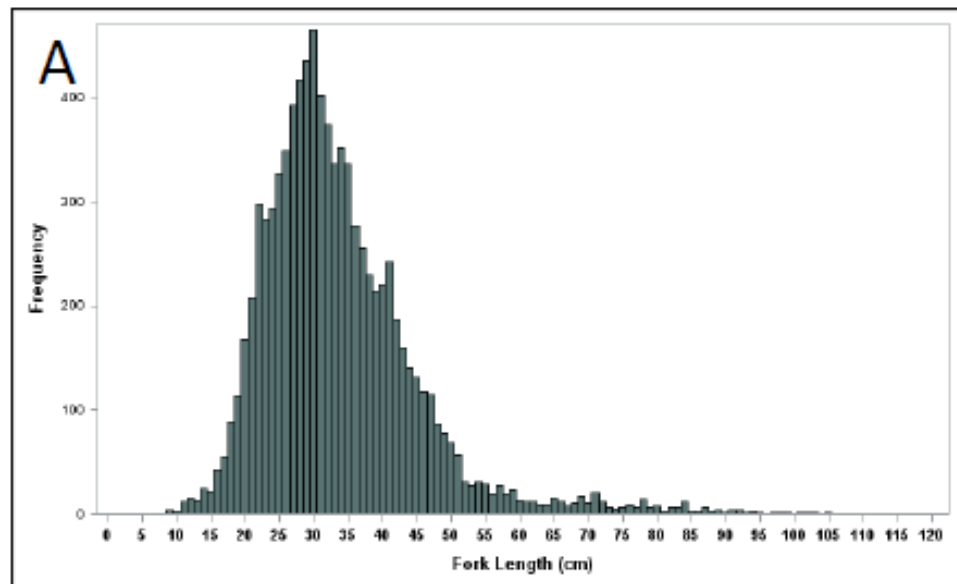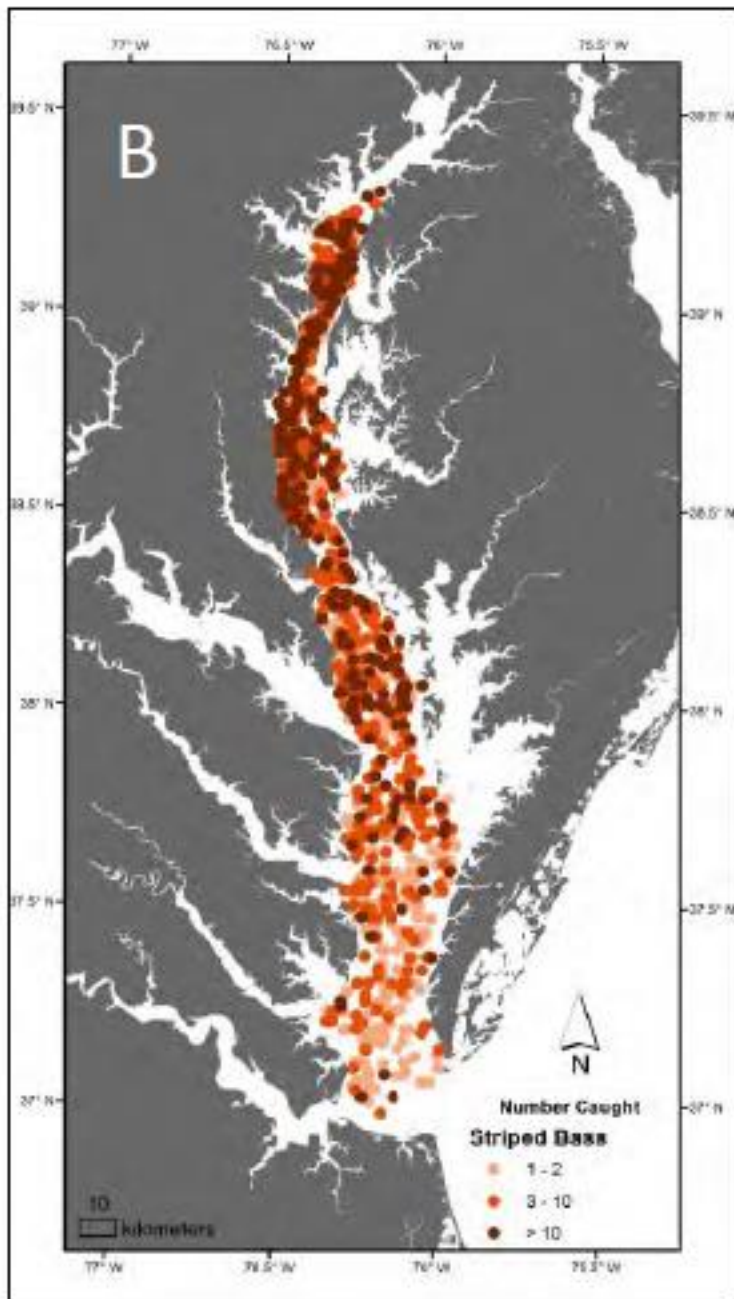
Methods

Collect young-of-year (YOY), juvenile, and subadult fish using gillnets and fish provided by the Maryland DNR Striped Bass Seine Survey (N=50 per collection)

Up to 30 adult fish will also be accepted that suffer incidental mortality during Maryland Striped Bass Spawning Survey

Morphological gut content analysis for 50% of fish, genetic analysis for the rest

Visual inspection for body condition and parasites

Otolith ageing for growth rate
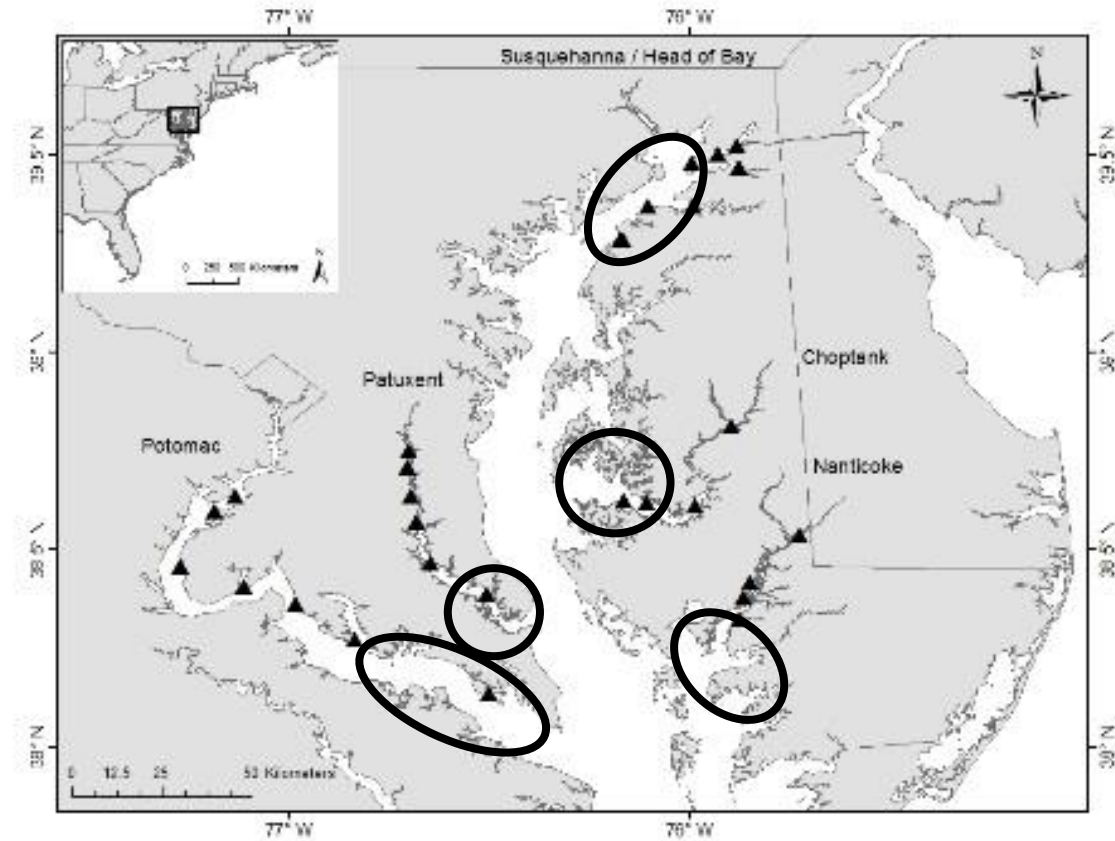
Species Identification using Genetic Barcoding

Sequence: 655bp
CCTATATCTAGTATTTGGCGCTTGAGCTGGTATAGTCGGCACTGCTTTAAGCCTTCTTAT
TCGAGCAGAGCTGAGCCAACCGGGCGCCCTCCTTGGCGACGATCAGATCTATAATGTGAT
CGTTACCGCACACGCATTTGTAATAATCTTTTTTATAGTTATACCAATTATGATTGGAGG
GTTTGGAAACTGACTAATCCCTTTAATGATTGGGGCGCCAGACATGGCATTCCCCCGAAT
AAACAACATGAGTTTTTGACTACTTCCTCCATCTTTCCTTCTCCTTCTGGCCTCTTCTGG
TGTCGAAGCTGGAGCCGGAACCGGCTGAACCGTCTATCCCCCACTTGCAAGTAACCTTGC
ACACGCAGGAGCATCCGTAGATTTAACAATTTTCTCCCTCCATCTGGCCGGGATTTCCTC
GATTTAGGGGCCATTAATTTTATTACAACTATTATTAACATGAAGCCCCCCGCTATCTC
CCAATATCAAACCCCTCTGTTCGTATGGGCAGTCCTAATTACAGCCGTCCTCTTACTTCT
CTCTCTCCCCGTCCTTGCAGCTGGAATCACTATATTACTTACAGACCGAAACCTTAATAC
CACCTTCTTCGACCCTGCAGGGGGAGGGGACCCCATTCTTTACCAACATCTTTTC

BIN →

BOLD

BLAST

Chesapeake Bay Barcode Initiative

https://serc.si.edu/projects/species-diversity-chesapeake-bay
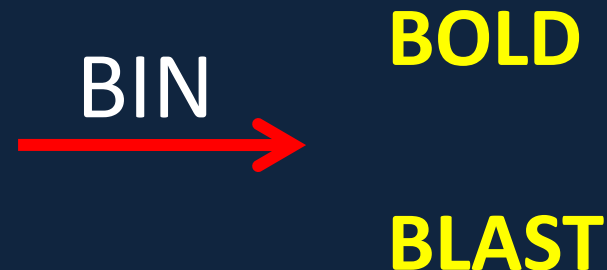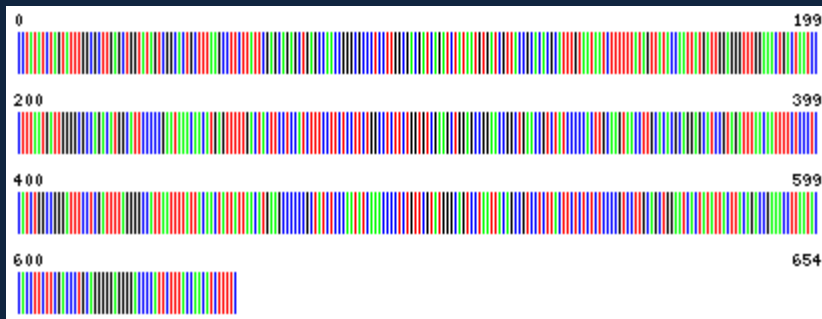
Percentage of Expected Species Collected

Fish — NE=315

Decapoda — NE=65

Gastropoda — NE=80

Bivalvia — NE=55
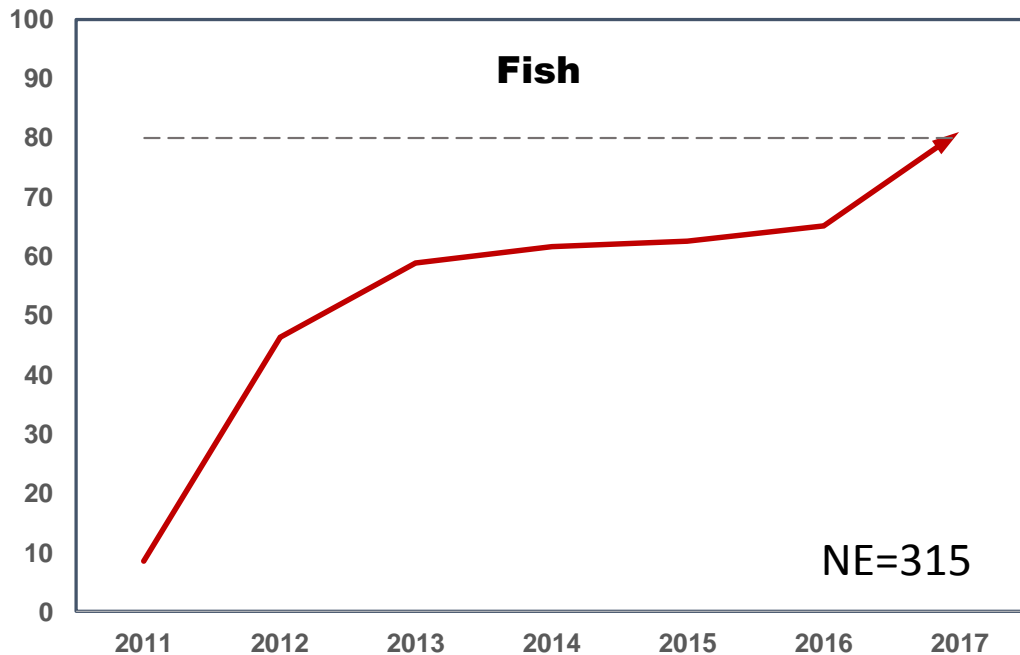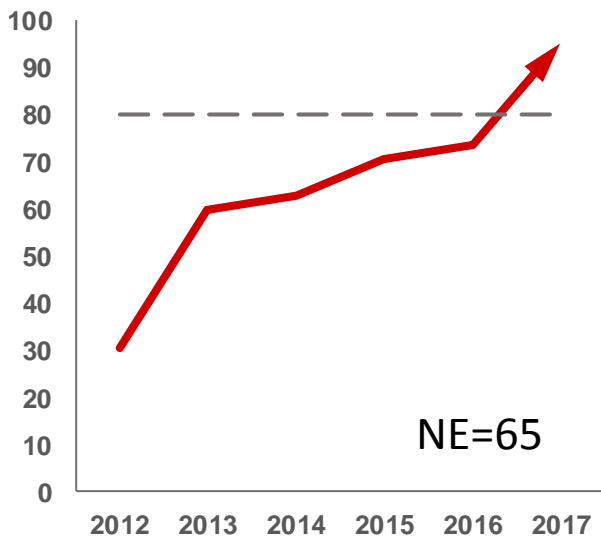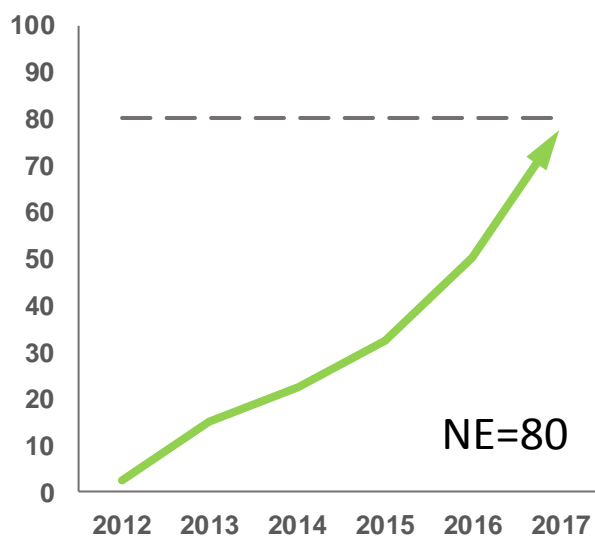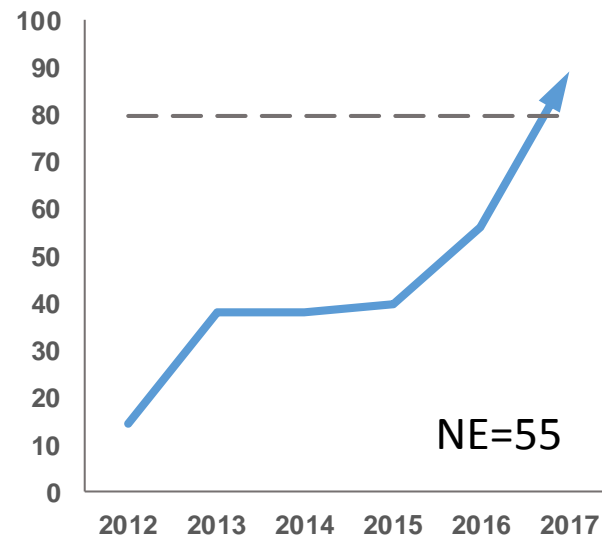
Barcoded   Goal

Percent of Other Inverts
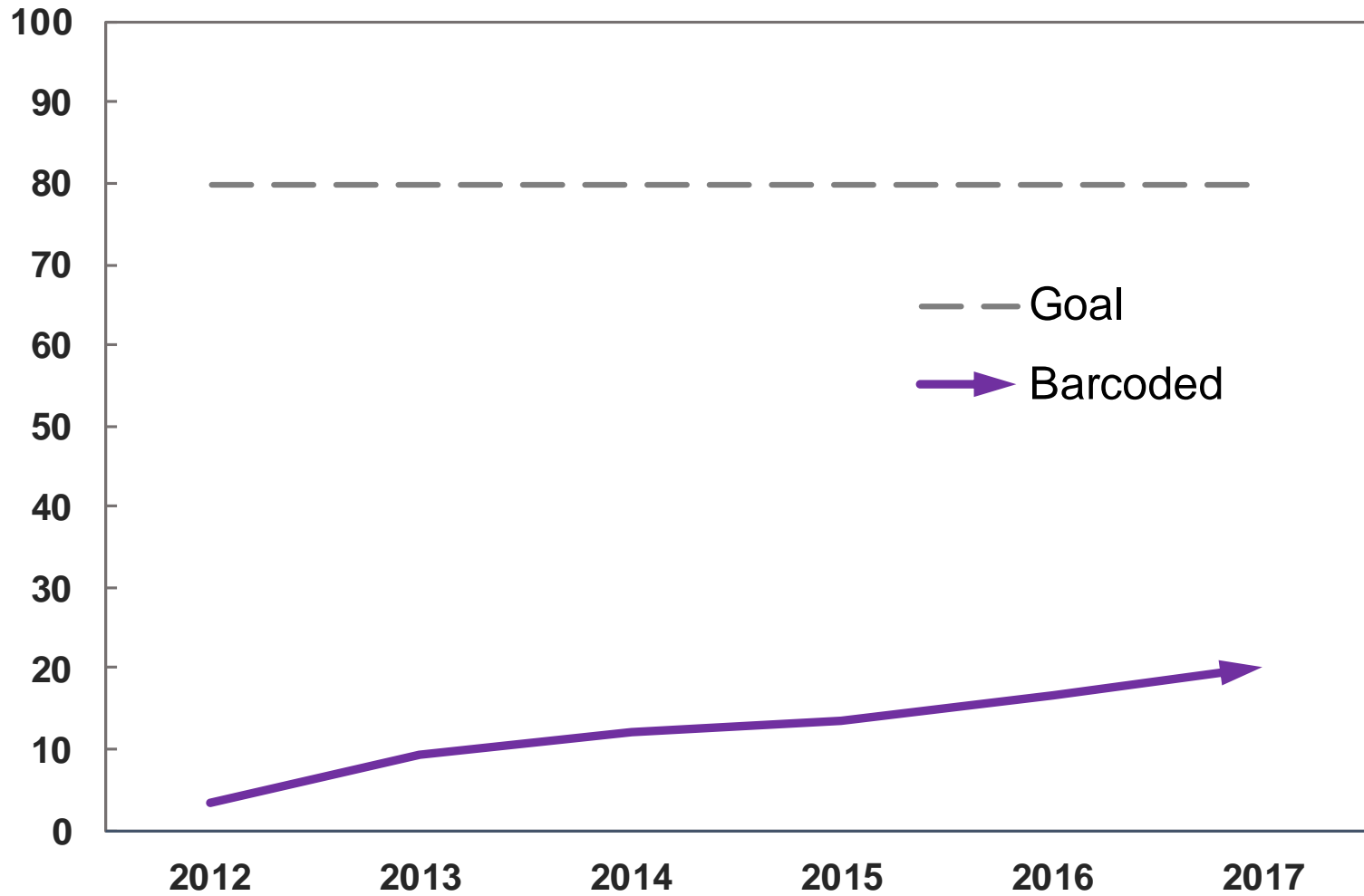
Based on estimated 800 species (not including decapods and mollusks)

Methods

Homogenize gut contents, then extract genomic DNA using standard DNA Extraction kit

Use two-step PCR method to generate amplicon libraries
    - COI and 18S genes for comprehensive assessment of prey items present

Dual-indexing to increase # of samples we can put on single run

Sequencing on Illumina Miseq platform

Two-step PCR Method

A Target-specific PCR
B Addition of indices and sequencing adaptors by PCR
C Final amplicon ready to be sequenced

P5   Index 1   Insert to be sequenced   Index 2   P7
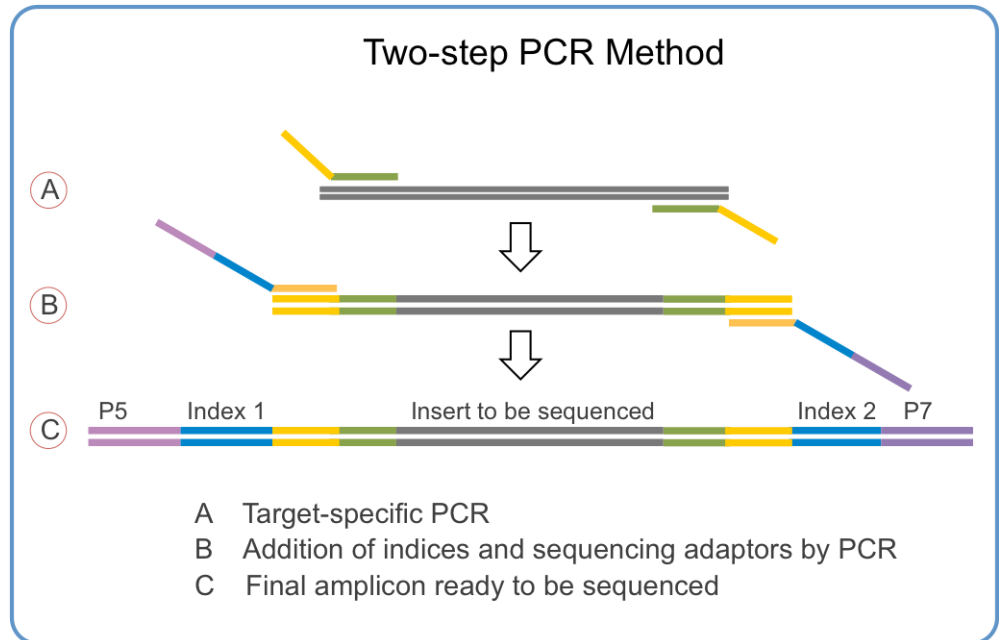
Methods

Generate OTU tables using USEARCH pipeline

Includes UPARSE for removing chimeras and clustering OTUs
      -parameters changed for the two amplicon types

Taxonomy will be assigned first with the RDP classifier using Chesapeake Bay Barcode Initiative sequences, then with GenBank for the COI sequences and the RDP classifier with the PR2 database for the 18S sequences

QIIME and R will be used for analyses of the OTU table to compare the diversity and connectivity of OTUs across sites, individuals, and size classes

Metabarcoding Results: Species Abundance Tables

#OTU ID	CB16S	CB18S	CB24S	CB25S	CB26S	CB27S	CB28S	CB29S	TXC07S	TXC08S	TXC15S	TXC19S	VMT28S	VMT29S	VMT30S	VMT31S	VMT32S	taxonomy
OTU_10	27	549	109	153	8106	242	59	683	4	34	37	199	31	1390	143	72	117	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-I: Dino-Group-I-Clade-1: Dino-Group-I-Clade-1_X
OTU_100	0	0	13	79	5	14	157	1	2	0	11	4	0	0	3	1	1	Eukaryota: Stramenopiles: Ochrophyta: Chrysophyceae-Synurophyceae: Chrysophyceae-Synurophyceae_X: Clade-F: Paraphysomonas: Paraphysomonas_b
OTU_1000	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	Eukaryota: Stramenopiles: Stramenopiles_X
OTU_10000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Unclassified
OTU_10001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Filosa-Granofilosea: Filosa-Granofilosea_X: Novel-Gran-234: Novel-Gran-234_X: Novel-Gran-234_X_sp.
OTU_10003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_X: Dinophyceae_XX
OTU_10006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa
OTU_10007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Endomyxa: Vampyrellida: Penardia-lineage
OTU_1001	0	1	0	0	0	0	0	0	0	0	0	11	0	1	0	2	10	Eukaryota: Stramenopiles: Ochrophyta: Bolidophyceae-and-relatives: Bolidophyceae-and-relatives_X: Bolidophyceae-and-relatives_XX: Bolidophyceae-and
OTU_10013	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_X: Dinophyceae_XX
OTU_10017	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Amoebozoa: Lobosa: Discosea-Flabellinia: Dactylopodida: Paramoebidae: Pseudoparamoeba: Pseudoparamoeba_sp.
OTU_1002	0	1	5	3	1	5	6	15	0	5	1	5	0	1	2	0	0	Eukaryota: Opisthokonta: Fungi: Basidiomycota: Pucciniomycotina: Microbotryomycetes: Rhodotorula: Rhodotorula_mucilaginosa
OTU_10022	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10023	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_X: Dinophyceae_XX: Neoceratium
OTU_10029	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Archaeplastida: Chlorophyta: Nephroselmidophyceae: Nephroselmidophyceae_X: Nephroselmidaceae: Nephroselmidaceae: Nephroselmi
OTU_1003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Eukaryota: Alveolata: Ciliophora: Spirotrichea: Choreotrichia: Dictyocystidae: Codonellopsis
OTU_10032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_X: Dinophyceae_XX
OTU_10034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa
OTU_10038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-II: Dino-Group-II-Clade-3
OTU_1004	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	Eukaryota: Apusozoa: Hilomonadea: Planomonadida: Planomonadidae: Planomonadidae_Group-1: Ancyromonas: Ancyromonas_indica
OTU_10043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Hacrobia: Centroheliozoa: Centroheliozoa_X: Pterocystida
OTU_10046	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	Eukaryota: Stramenopiles: Ochrophyta: Bacillariophyta: Bacillariophyta_X: Raphid-pennate: Fistulifera: Fistulifera_saprophila
OTU_10047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Hacrobia: Centroheliozoa: Centroheliozoa_X: Pterocystida
OTU_10053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	Eukaryota: Stramenopiles: Ochrophyta: Dictyochophyceae: Dictyochophyceae_X: Pedinellales: Apedinella: Apedinella_radians
OTU_10054	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	Eukaryota: Opisthokonta: Fungi: Zoopagomycota: Zoopagomycotina: Zoopagomycotina_X: Piptocephalis: Piptocephalis_corymbifera
OTU_10056	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Filosa-Sarcomonadea: Cercomonadida: Paracercomonadidae: Paracercomonas
OTU_10056	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	Unclassified
OTU_10057	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	Eukaryota: Opisthokonta: Fungi: Chytridiomycota: Chytridiomycotina: Chytridiomycetes: Chytridiomycetes_X
OTU_10058	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Noctilucales: Noctiluca: Noctiluca_sp.
OTU_10059	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_XX: Neoceratium: Neoceratium_fusus
OTU_10061	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Ciliophora: Oligohymenophorea: Peritrichia: Zoothamniidae
OTU_10064	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	Eukaryota: Amoebozoa: Lobosa: Tubulinea: Tubulinea_X: Tubulinea_XX: Tubulinea_XXX: Tubulinea_XXX_sp.
OTU_10065	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	Eukaryota
OTU_10066	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-II: Dino-Group-II-Clade-1: Dino-Group-II-Clade-1_X
OTU_1007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	7	Eukaryota: Rhizaria: Cercozoa: Filosa-Imbricatea
OTU_10070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophysiales: Dinophysaceae_Oxyphysaceae: Dinophysis
OTU_10071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Endomyxa: Vampyrellida
OTU_10076	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa
OTU_1008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Stramenopiles: Stramenopiles_X: Labyrinthulea: Labyrinthulales: Labyrinthulaceae: Labyrinthula: Labyrinthula_sp.
OTU_10081	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	25	0	Eukaryota: Archaeplastida: Chlorophyta: Pyramimonadales: Pyramimonadales_X: Pyramimonadales_XX
OTU_10087	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Endomyxa: Vampyrellida
OTU_1009	0	0	0	0	0	27	0	0	0	0	0	7	0	0	0	1	6	Eukaryota: Rhizaria: Cercozoa: Filosa-Sarcomonadea: Glissomonadida: Sandonidae: Sandona: Sandona_sp.
OTU_10090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Stramenopiles: Ochrophyta: Pelagophyceae: Pelagophyceae_X: Pelagophyceae_XX: Pelagococcus: Pelagococcus_subviridis
OTU_10098	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_X: Dinophyceae_XX
OTU_101	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Eukaryota: Hacrobia: Telonemia: Telonemia_X: Telonemia_XX
OTU_1010	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-II
OTU_10101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Stramenopiles: Ochrophyta: Bacillariophyta: Bacillariophyta_X: Polar-centric-Mediophyceae: Skeletonema
OTU_1011	0	0	0	0	0	44	0	0	0	0	0	1	0	1	0	1	2	Eukaryota
OTU_1012	0	0	0	1	0	1	0	0	0	0	6	0	0	19	0	0	0	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-I: Dino-Group-I-Clade-5: Dino-Group-I-Clade-5_X: Dino-Group-I-Clade-5_X_sp.
OTU_10125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Hacrobia: Haptophyta: Prymnesiophyceae: Prymnesiales: Chrysochromulinaceae: Chrysochromulina: Chrysochromulina_sp.
OTU_10128	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Filosa-Thecofilosea: Ebriida: Botuliformidae: Botuliformidae_X: Botuliformidae_X_sp.
OTU_10129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_1013	0	0	0	2	5	1	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa: Filosa-Thecofilosea
OTU_10130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-II: Dino-Group-II-Clade-1: Dino-Group-II-Clade-1_X
OTU_10131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Syndiniales: Dino-Group-II-Clade-10-and-11: Dino-Group-II-Clade-10-and-11_X: Dino-Group-II-Clade-10-an
OTU_10132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Amoebozoa: Lobosa: Tubulinea: Nolandida: Nolandellidae
OTU_10133	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Stramenopiles: Stramenopiles_X: Bicoecea: Bicoecales: Bicoecaceae: Bicosoeca: Bicosoeca_vacillans
OTU_10135	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota
OTU_10136	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Eukaryota: Alveolata: Dinophyta: Dinophyceae: Dinophyceae_X: Dinophyceae_XX: Dinophyceae_XXX_sp._strain39
OTU_10137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Eukaryota: Rhizaria: Cercozoa

Project impacts

Identify key forage species for Striped Bass in tributary forage habitats, especially YOY fish

First comprehensive diet analysis in Chesapeake Bay using DNA barcoding and Chesapeake Bay Barcode Initiative database

Test the hypothesis that metabarcoding increases efficiency in diet studies

Provide the first comprehensive data on diversity and importance of free-living protists and parasites in the Striped Bass food web in Chesapeake Bay